DILATANCY.*

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Comparatively few papers read at meetings of the British Association for the Advancement of Science receive the compliment of a request for a second reading. Such action was taken upon Prof. Osborne Reynolds' paper "On the Dilatancy of Media composed of Rigid Particles in Contact," by the Association at its Aberdeen meeting, last September. The author illustrated by experiments, brilliant from their very simplicity, some of the theoretical properties of an ether that would act as a producer of electric and gravity strains. Such illustrations must be received cautiously. It will not do to accept an experiment with solid matter as proof that a hitherto theoretical ether has an existence or is in any sense composed of incompressible volumes. But when it is remembered that many of the best minds have come to the conclusion that the causes of gravitation and electricity will never be discovered, anything

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that hints at an explanation is most welcome. It is for this reason that Prof. Reynolds was so well received by his associate members. On Sept. 10, 1885, he read his paper before Section A; and by request, on Sept. 15, he read it again before Section B of the Association. The original paper, giving the mathematics of the subject, and pointing out its possible explanations of some of Clerk Maxwell's theories, is given in the *Philosophical Magazine* for December, 1885. This paper may be confidently recommended to our readers.

But apart from the theoretical bearing of the newly discovered law, its experimental illustrations are so simple and striking that they will interest all. In the cuts are shown some of the experiments that may be performed with such simple apparatus as an India rubber bag and a glass tube.

In Fig. 1 is shown an illustration of two orders in which solid particles may be arranged, the close order and the loose order. The dotted lines in the loose order show the size of the including cube. It will be seen that the particles in loose order occupy much the larger volume. The phenomena of dilatancy depend on the power of rigid particles of any shape to arrange themselves in loose or close order.

Let an India rubber bag, such as is used for toy balloons (one which has been inflated, and thereby stretched well, is the best) be filled with dry sand. The thinner and more elastic the bag, the better. Then by a perforated cork secured tightly in its neck a bent glass tube is connected, opening into its interior, as in Fig. 2. The bag is first shaken in the palm of the hand, so as to bring about a close order of the sand. The end of the tube is dipped into water. Now, the question may be asked, What will happen if the bag is squeezed? The most natural answer is that air will be driven out; but on compressing the bag no such action takes place. As the bag is squeezed, water rises up into the tube and by properly proportioning the relative sizes, the fluid may be drawn over the bend of the tube and into the bag. Extraordinary as the result seems, it is easily explained. The sand originally was in the close order, by squeezing it was brought into the loose order, the open spaces between the particles were dilated, and water rose under the influence of the partial vacuum.

A larger bag, such as is sold in the India rubber stores for use as an invalid's ice bag, is better. These are made of thin white India rubber, of good quality and highly elastic. The neck may be closed with an India rubber cork, secured by very tight winding with string or by a strong rubber band. Such a bag, containing sand and then filled with water, is represented in Fig. 3. The sand must first be put in until the bag seems about full, then water must be poured in until the air is entirely displaced. A bent tube, as before, is inserted in the cork, and the end dipped in a vessel of mercury. The bag is now strongly squeezed (Fig. 4). Any excess of water that was collected above the sand disappears. The India rubber around the cork becomes shrunk and wrinkled under the tension, and the mercury begins to rise, until, if all is properly conducted, a full, or nearly full, vacuum is shown. To produce a full vacuum, absolutely no air must be contained in the bag; the space not filled with sand and the tube around its bend and above the mercury must be full of water. The sand has been disturbed, and brought out of a condition of close into one of loose order. When the bag is pressed and the excess of water disappears, it becomes comparatively rigid. It seems quite unamenable to pressure.

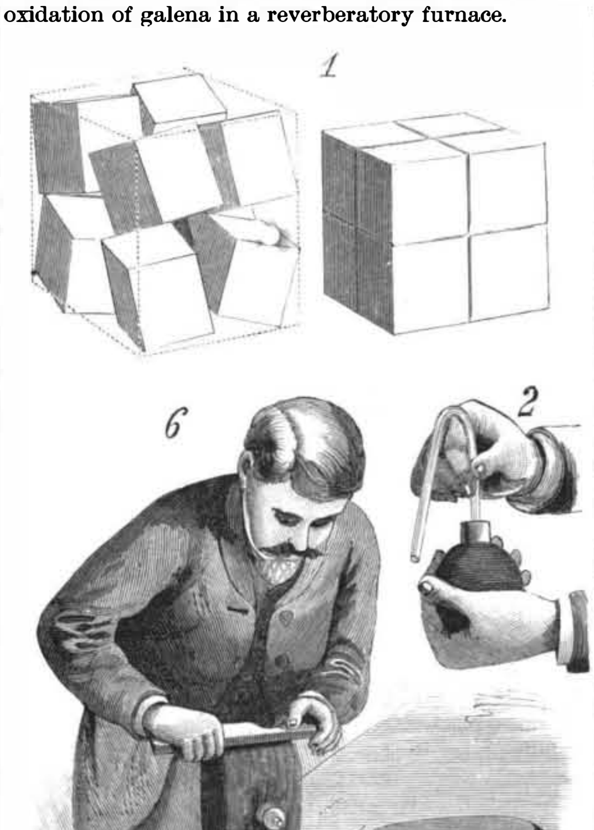
But if the pressure be accompanied by shaking, then the sand is kept in its close order, and any shape can be given to the bag. This operation is shown in Fig. 5. The bag can be rolled into an irregular cylinder, or can be kneaded into a disk without trouble, provided it is shaken continually. When made into a disk, if it is placed on its edge and subjected to pressure, it will yield a little, but ultimately take its final shape, as in Fig. 6, when the entire weight of the experimenter can be supported by it. In this way hard rigid blocks, such as shown in the same cut by the side of the observer, are produced. When one of these blocks is placed cork uppermost, or in the position it occupied while being shaken, and the least agitation applied, it settles down instantly into the soft mass of sand and water that it was originally. For these experiments the perforation in the cork must be closed.

In all these cases, the force that is brought into action is the atmospheric pressure. By changing the order of the grains the tendency is to an enlargement of volume, which would produce a vacuum. Hence the conservation of the shape by the weight of the atmosphere appears.

The resistance offered by a cloth or canvas bag of sand to change of shape, utilized in supporting bridge centers, and the sudden drying of wet sand around the foot upon the sea shore, receive a ready explanation in this law. As a rule, all manner of rigid particles inclosed in or by a movable boundary display it in some degree. It even has its bearing on the angle of repose of different sands.

The experiments can be performed with shot or marbles or any small particles, as well as sand, but on account of its lightness and fineness the latter is generally preferable. We have only given a few of the experiments. Our readers will see that there is room for many others. Small bags of sand and water can be shaped into disks and rolled the length of the room. Large marbles ¾ of an inch in diameter can be substituted for sand. The great point and difficulty is to prevent air leaking into the bag. It interferes, in degree only, with the success of the work.

* See SCIENTIFIC AMERICAN, April 10, 1886, for a review of a recent lecture on this subject by Prof. Osborne Reynolds.



EXPERIMENTS IN DILATANCY.

Manufacture of Mineral Colors in the United States.

The following particulars, taken from the "Report of the United States Geological Survey on the Mineral Resources of the States," have been furnished to the *Chemical News* by the author, Dr. Marcus Benjamin.

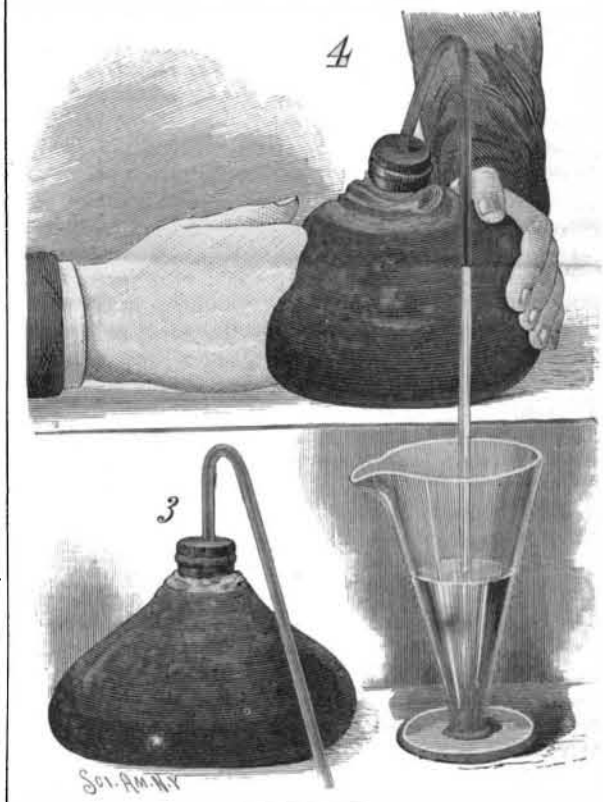
There are in the States 31 white lead works, in all of which the so-called Dutch method is followed, the material used being pig lead. The total produce during the year 1884 was about 65,000 tons.

A "sublimed lead" is made in Missouri by the direct oxidation of galena in a reverberatory furnace.

Zinc white was manufactured in the same year to the extent of 12,000 to 15,000 tons. It is used not only as a color, but in the manufacture of India rubber, in pottery, and in the paper trade.

Barium sulphate (heavy spar) was raised to between 25,000 and 30,000 tons. Barium compounds are used as paints under the names of blanc fixe, satin white, etc., and in the form of peroxide for bleaching purposes. Barium sulphate, both the natural and the precipitated, is largely used as an adulterant.

Terra alba (ground gypsum) is imported from Nova



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Scotia, while a superior quality is brought from France. In addition to its legitimate use in making white pigments of a low grade, it serves for adulterating a variety of commercial articles.

The quantity of red lead produced in the United States could not be ascertained, but the imports at New York amounted to 198,588 pounds.

The American production of litharge is also an unknown quantity. The imports were only 54,183 pounds.

Concerning ochers, it is said that with the possible exception of the deposits recently opened up near St. Louis, the American production is inferior to the imported qualities. "American ochers for the most part lack strength or tinting properties, and require too much oil for grinding." The annual consumption in the United States is estimated at 10,000 tons, of which about 3,000 tons are imported.

American umbers are inferior to those imported from Italy and Turkey. Sienas are found to a small extent in Virginia and Pennsylvania, but most of that used is imported from Italy.

There is no mention of lapis lazuli having been found in the United States, but there are two American manufactories of artificial ultramarine, with a yearly output of 1,400 tons.

Ground slate is used as a pigment to the extent of 2,000 tons yearly, and occurs in four colors—green, red, slate, and drab

An Improved Developer.

Dr. A. A. Mantell, in the *British Journal of Photography*, recommends the following formula:

1.

Pyro	1 drachm.
Citric acid	5 grains.
Sulphite of soda	1 drachm.
Water	10 ounces.

2.

Carbonate of potash	1 ounce.
Water	20 ounces.

3.

Bromide of ammonium	2 scruples.
Liquor ammoniæ fort.	1 drachm.
Rain water	20 ounces.

For development, mix equal parts of 1, 2, and 3; in cold weather a little more of 3 may be used.

The advantages obtained by its use are: 1st. Greater rapidity in development than when soda and potash are used alone or in combination. 2d. Comparative freedom from the yellow tinge caused by soda. 3d. Greater density than can be obtained by ammonia alone. 4th. Greater detail than can be got by soda alone.

MR. THERON E. PLATT, of Fairfield county, Conn., has raised two hundred varieties of potatoes on his farm during the past year. The study of fungoid pests of the potato has also occupied his attention, and his discoveries respecting certain diseases of this plant are likely to prove serviceable.