CENTRIFUGAL FORCE.

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The tendency of modern physicists is to drop the term centrifugal force, that has for so many years done service in the text books. The true force developed by a body moving in a curve is due to tangential velocity, and one of the components of this velocity represents centrifugal force. But the convenience of the expression and the popular acceptance of the term justify its use, and it may be adhered to, as carbonic oxide is called carbonic acid and carbonous oxide is still termed carbonic oxide by the chemist. The inconvenience and confusion caused by changing old terms often causes the use of such as are incorrect, or rather correct by convention only.

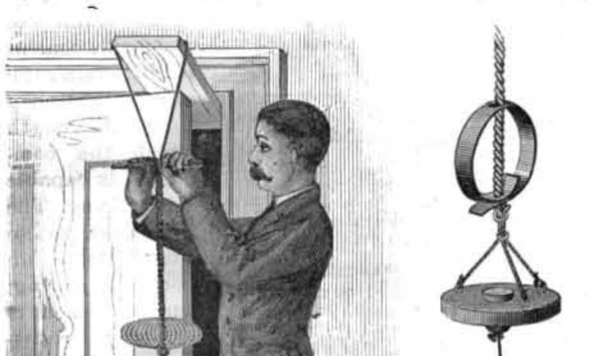
If a body is rotated, it tends by virtue of this force to fly away from the center of rotation. Every particle of the body tends to place itself as far as permitted from this point. By the use of fluids, granular solids, and bodies of different shapes very characteristic effects can be produced. The phenomena produced can all be accounted for by known laws, and exactly what will take place under any given conditions can be foretold. The variety of the experiments and the familiar objects that can be used in them make them most interesting. If proper apparatus is obtainable for rotating different articles, the number of variations that can be produced is endless.

The usual machines for inducing rapid rotation, such as the twirling table, are quite expensive. By utilizing a twisted cord as motor in the way to be here described, the experiments can be executed perfectly well at home with the most primitive appliances.

A piece of strong cord, about two yards long, is doubled and its ends are tied together, and the object to be rotated is tied to it.

One hand is passed through the doubled string, allowing the object to hang down, and the string is twisted a number of times. Then, by drawing a pencil or other smooth rounded body down against the twisted portion, an exceedingly rapid rotation can be started. The rotation lasts in one direction until the cord is unwound and rewound, the body comes for an instant to rest, to resume its rotation, but in the opposite direction. The pencil is again to be inserted to accelerate the speed, and the process may be kept up indefinitely. Smooth, round, and hard cord should be employed, and the part of the pencil coming against the cord may with advantage be lubricated with a little soap.

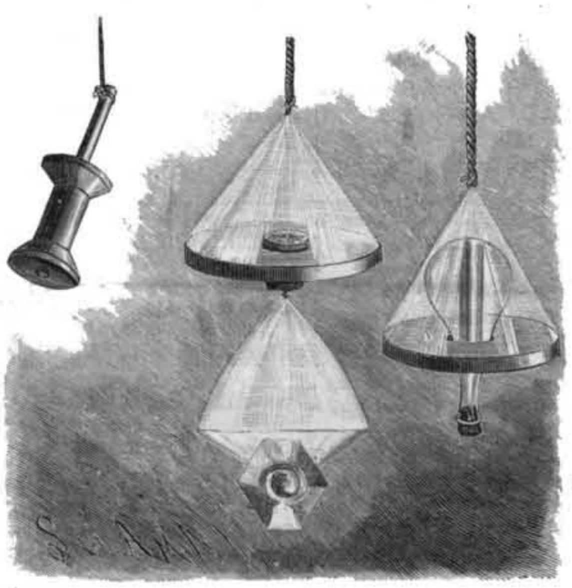
As an object to begin with, a glass containing a little water, suspended as shown, may be used. As it gains speed, the water, under the effect of centrifugal force, forms a cup, sinking in the middle and rising around the walls of the glass. The outline of this cup is a parabola. The appearance of the water just as the



HOOP AND DISK EXPERIMENT.

rotation is changing its direction is interesting, while the perfect glassy cup formed by the fluid in rapid motion is not less so. Great care must be taken that the glass revolves steadily and not too fast, or it will tip on one side and throw water in all directions. A goldfish globe, about four inches in diameter, is better, as it does not tend to shower its contents about to the same extent. In the drawing such a globe is shown rotating, and containing either sand and water or shot and water. All alike are forced outward against its walls, but the heavier substance goes to the greatest distance and forms a central zone, with similar areas of water above and below, while if a proper quantity of water is used, the bottom of the globe will be entirely exposed and free from water.

A lot of keys, the contents of a paper of tacks, or a watch chain, may be placed in the globe, and the water may be colored with a little ink. Taking into account



SPOOL AND FLASK EXPERIMENTS.

the probability of some water being thrown out, it is perhaps as well not to color it.

A solid symmetrical body may be rotated in the same way, but it is better to secure some more steady arrangement. This can be done by employing a disk of wood, about six or eight inches in diameter, and an inch thick. It is suspended from three points near its periphery, staples being used to fasten the string to. In its center a hole is bored, and a cork is supplied fitting this aperture. By suspending it by the rotating cord from some fixed point, so as to leave both hands free, a very high velocity can be given to it. As, moreover, it is often undesirable to have the direction of rotation change so frequently, a well oiled swivel may be placed above the twisted string immediately under the general point of suspension. When once started under these conditions, the disk will rotate for some time in the same direction, and come gradually to rest. Otherwise it will wind the cord up very tightly, rising most curiously as the twist tightens, with attendant danger of breaking the cord. The disk, in virtue of the tendency of rotating bodies to remain in their plane of rotation, gives a steady basis for the attachment of different objects. Before fastening anything to it, it may be set into strong motion, and moving like a pendulum, when, under the effects of gyroscopic forces, it will describe the most curious curves.

A cover of a tin box has a hole punched through it near its edge, and is suspended thereby to the cork, a pin bent at the headed end acting as a hook to which to fasten the suspending cord. On rotating it, the cover rises up into a horizontal position, and appears almost as if it were motionless. A coin may be thrown into it, and will lie quietly there as long as rapid rotation continues. This horizontal position is taken because in it the particles of the box assume the greatest average distance within the limits of the figure from the center of rotation. Above the disk a flexible hoop of thin India rubber tubing, or of writing paper, may be fastened, its upper perimeter being free to rise or fall. On rotation, this will flatten into an ellipse, illustrating the cause of the ellipsoidal shape of the earth. As shown in the other cut, a spool may be suspended and rotated, a stick or piece of pencil being forced into its central aperture and the suspending string being fastened to that. Obeying the same principle, this will approximate to a horizontal position in rapid rotation and will present a most curious appearance, that of a central globe surrounded by hazily outlined figures of two crossing spools.

The object of the cork as a point of attachment is clear. It will be found a great convenience as adapted to so many objects. A bunch of keys, a loop of heavy cord, of chain, or a skein of silk, may be attached to it, and the effect observed. If properly managed, they will open into ellipses. A turnip, hung by the extremity of one of its long diameters, will be thrown up into the horizontal position, as was the box cover. A moistened sponge or piece of blotting paper will shower water in all directions if pinned to the cork and rotated, even when comparatively dry. This is a good illustration of the methods used in large laundries for drying clothes, and in sugar houses for separating sugar from the sirup from which it has been crystallized.

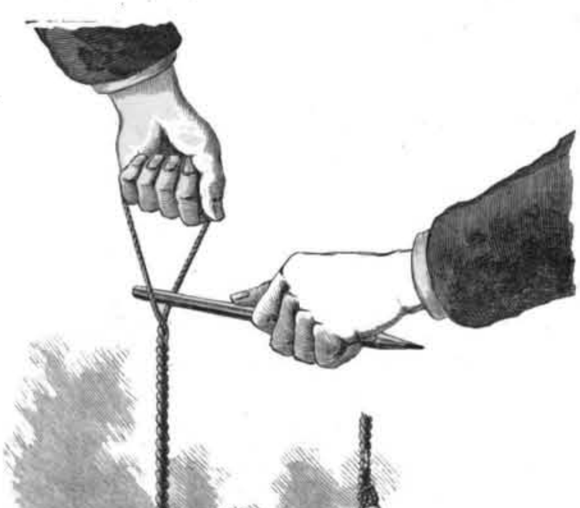
A small flask nearly filled with water is corked and inverted in the hole in the disk, and secured by tying or otherwise. On rotation the water is driven outward, and the air draws down into a cylindrical shape. If very little air is contained, and the rotation is extremely rapid, it will descend and form a spherical bubble in the center of the flask. It is well-nigh impossible to obtain sufficient velocity for this last.

Enough has been shown to illustrate the fact that this very simple apparatus will perform nearly all the ordinary experiments in centrifugal force. A light weight may be made to lift a heavy one; a model of the steam governor may be mounted on it, and numberless experiments tried. It is really a substitute for a piece of apparatus that costs as many dollars as this costs cents.

Departing from the line of centrifugal force, it is adapted for another class of experiments—those in which rotation alone is in question. Thus, all color disk comparisons, such as described in Prof. Rood's article in this journal (vol. liv., No. 23), may be executed with it. Wires bent into various shapes may be rotated with excellent effect, producing images of vases and the like.

Foundations.

The modern architect has at his command means and appliances of the greatest utility, which were unknown to men in former times. Steam can be brought to aid in driving timber piles, and simple applications of water or air will sink hollow iron piles with comparative ease. The old Eastern plan of forming deep wells and then filling them up with concrete has been too much neglected. Modern well sinkers will go down in any strata almost to any depth—certainly to any depth required in practice; and a secure foundation may thus be made for the loftiest structure in the most difficult ground. Masses of concrete or of brick or stonework placed on a compressible substratum, however cramped and bound, may prove unsafe. Solidity from a considerable depth can alone be relied on. Enlarging the area of a base or foundation by footings can be resorted to; but mere enlargement of area may not in itself be sufficient. A lofty structure which is to stand secure must have solidity sufficient to maintain each part in the position in which it is first placed. Foundations are too frequently slighted, or labor and material are wrongly applied. The compressibility of oolitic and tertiary clays can only be overcome by piling, deep sinking, heavy ramming, or heavy weighting. The point of bearing must be carried below any possibility of upward reaction. A heavy embankment or heavy pile of building frequently disturbs the surface ground at a distance of many yards, the subsidence causing a corresponding rise around or on either side, as the



EXPERIMENT WITH FLUIDS.

case may be. A tall chimney or tower of like proportions, built on such a foundation, if not made safe to a sufficient depth, would most likely become a "leaning tower," if not actually a falling tower. Probably the depth of a foundation in compressible ground ought not to be less than one-fourth the intended height above ground; that is, for a shaft of 200 feet the foundation should be made secure to a depth of 50 feet. This could easily be done by piling, or by well sinking and concrete.—*Sir R. Rawlinson in the Architect.*