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HALF HOURS OF

SCIENTIFIC AMUSEMENT.

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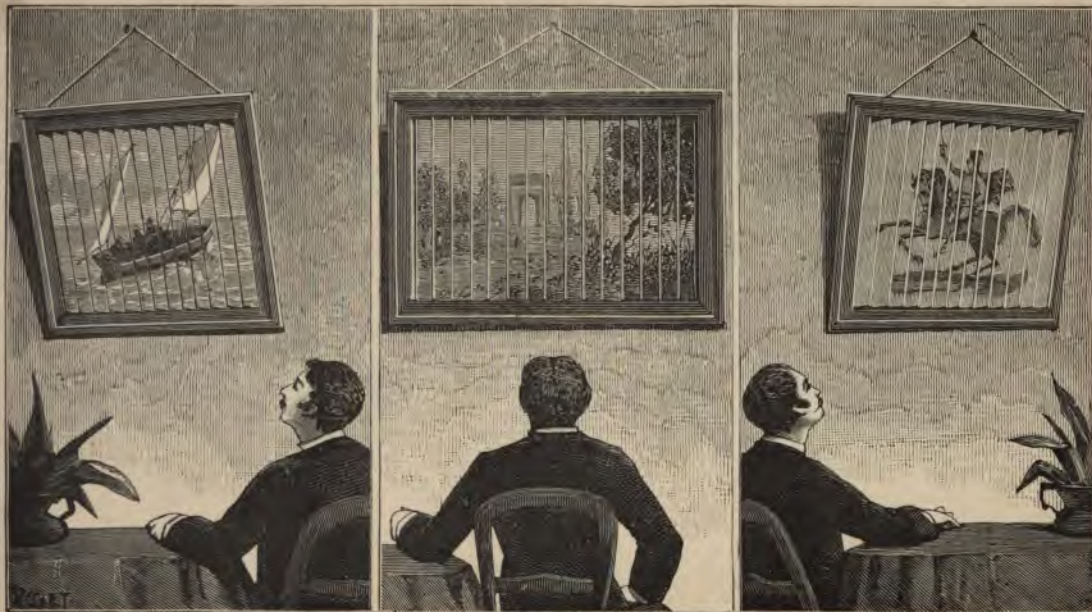

The Magic Picture. [See page 133.

HALF HOURS OF SCIENTIFIC AMUSEMENT;

OR,

Practical Physics and Chemistry without Apparatus.

TRANSLATED FROM THE FRENCH OF
GASTON TISSANDIER.

BY
HENRY FRITH.

WITH UPWARDS OF ONE HUNDRED ILLUSTRATIONS.

WARD, LOCK, & CO.
LONDON, NEW YORK, AND MELBOURNE.
1890.

UNIFORM WITH THIS VOLUME.

The Marvels of the Elements.
Marvels of Heat, Light, and Sound,
Marvels of Invention, and Scientific Puzzles.
Marvels of Earth, Air, and Water.
Marvels of Geology and Physical Geography.
Marvels of Animal and Plant Life.
Marvels of Electricity and Magnetism.
Marvels of Astronomy.

LONDON: WARD, LOCK, & CO.

PREFACE.

YOUNG people of both sexes, and persons of all ages who have leisure and a taste for that which is ingenious as well as instructive and amusing, may be commended to this remarkably interesting collection of experiments, nearly all of which can be readily performed by an unskilled person who will carefully follow out the directions given. It is surprising how near we are to the most fundamental principles of science when we perform some of the simplest operations. The act of balancing oneself on one foot may be made to illustrate most instructively the principle of gravitation and the centre of gravity. The musical (or unmusical, as the case may be) performance of whistling illustrates the power of air in motion, and the effects of vibrating cords (the vocal cords) in a limited space. The toasting of a piece of bread is an example of evaporation of water, change of structure owing to heat, and the appearance of a black substance out of a white one by a change in chemical combination. It is so in a multitude of the common occupations of life, and especially in the amusements in which children take so great a delight. The schoolboy's sucker exemplifies the effect of the external pressure of the atmosphere; his top, coerced to move circularly by the effect of a string wound round it in a spiral fashion, illustrates the effect of a spinning turn long after the force has been applied. A large number of experiments with coins—piercing a halfpenny with a needle, revolving a penny in a lampshade, catching coins held on the elbow in the hand, rotating a coin between two pins, and the like, show to how many amusing incidents these may give rise. Inertia, the bane of too many boys and men, is seen to prevail in the physical world in the experiment of projecting one or two draughts from a heap of them (page 18), and in removing a domino, as on page 20. The strange effects which can be produced by virtue of the principle of the centre of gravity are seen in the pencil and knife balanced on the point of the former, the match puzzle (page 30), the poising of a tumbler upon three sticks, each having one end in the air, the suspension of a bucket of water from a stick resting on a table, etc.

Hydrostatics, the study of the effects of fluids, supplies many interesting facts and illustrations to this little book. The ascent of wine in an inverted glass of water, the floating of a needle, and the lobster syphon, are among these. The maintenance of various bodies in the air by currents of air, and the phenomena of vortex rings of smoke, are equally striking and instructive. Various experiments on the pressure of the air and with compressed air, and the properties of air and gas balloons, complete the section dealing with pneumatics.

The conduction of heat by metals, and their dilatation by heat, furnish several striking phenomena of which the placing of a red-hot coal on a muslin handkerchief encircling a copper globe, without setting fire to the handkerchief, is one of the most notable. Even more remarkable, perhaps, are the optical illusions, effects of refraction, etc., explained in Chapter VI. How to make a florin appear like five shillings and sixpence appeals strongly to the cupidity of mankind; but it must not be imagined that this book will enable any one to buy five shillings and sixpence worth of goods for a florin. It is astonishing how many optical illusions may be produced by the varied arrangements of lines, points, and squares, and these are here duly set forth. The "imp on the ceiling" illustrates the persistence of impressions on the retina.

Electricity and magnetism, as is only to be expected in these days of the electric light, supply us with some most interesting subjects. The "dance of the paper puppets," and the "magnetised magician," are examples of these. Chemistry without a laboratory introduces us to the air and its elements, the formation of salts, instantaneous crystallisation, the "Tree of Saturn," the production of gas, and the graven eggs.

Mathematical games, as here expounded, are capable of affording no small amusement. Many of the best mechanical toys invented in recent years are described in Chapter XI., such as the acrobatic ape, the magic glass, the Fantoccini top, the mechanical paper bird, the magic picture with three faces, and the mechanical fly. Every one may take his friend's portrait by the *silhouette* process given on pages 85, 86, while the formation of typical portrait sketches by the combination of implements used in any given craft is amusingly shown on pages 139-141. Thus it will be evident that a vast amount of amusement, combined with instruction, is to be got out of the attentive perusal of the following pages.

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CHAPTER VI.—LIGHT, OPTICAL ILLUSIONS, ETC.

CHAPTER VII.

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HALF HOURS OF SCIENTIFIC AMUSEMENT.

CHAPTER I.—PROPERTIES OF BODIES.

STRENGTH—ELASTICITY—POROSITY—PERMEABILITY—RESISTANCE OF SUBSTANCES—HARDNESS—CENTRIFUGAL FORCE—THE PRINCIPLE OF INERTIA.

STRENGTH.

EVERYONE who practises experimental science knows how useful it is to unite with his theories the manual dexterity which practice in experiments gives. Chemists and physicists should in every way be stimulated to construct their own apparatus. In numerous cases it will be found possible to put together even delicate apparatus at a very small cost; and these will be found quite as useful as the most expensive ones.

Is it not then even more useful to lay down the elements of a course of experimental physics *without apparatus?* This is just what we are about to do in a recreative guise. Our first experiment will be on *falling bodies.*

THE HALFPENNY AND THE PIECE OF PAPER.

Take a sou—a halfpenny—and a piece of paper cut into the same shape as the coin. Let these two bodies fall at the *same moment* side by side, as shown in the illustration (Fig. 1). You will find that the coin will reach the ground a long while before the disc of paper. But now place the piece of paper upon the upper surface of the halfpenny and permit them to fall together in a horizontal position, as in illustration (Fig. 2). You will find that the two bodies will reach the ground at the same time! Why? Because the piece of paper is protected from the action of the air by the halfpenny!

The weight of the bodies counts for nothing in their fall. It is the air only which prevents them from falling

Fig. 1.—Fall of a Halfpenny and a Piece of Paper cut to same Shape.

Fig. 2.—Fall of the same Bodies. The Paper placed upon the Coin.

with the same velocity. Under the receiver of an air-pump both bodies would fall with the same speed.

THE TWO PIECES OF PAPER.

Take a sheet of paper, fold it in half, and cut it so that you obtain two pieces of exactly the same size and weight. Rub one into the shape of a ball, and leave the other in its former condition. Then let both fall together. The rolled-up paper will reach the ground before the *other piece!*

TO BREAK A NUT WITH A FALLING KNIFE.

Attach, lightly, a penknife to the upper framework of a wooden door by inserting its point in the wood as shown in the illustration (Fig. 3) herewith. The knife must be suspended so that it can be detached by a blow of the fist on the frame of the door. If a nut be placed

Fig. 3.—Experiment with Falling Bodies.

beneath, at the exact spot on which the handle of the penknife will strike the floor, the nut will be cracked immediately.

"Yes; but how are we to determine the exact spot?" you will *say. I will tell you.*

Moisten the end of the knife-handle with water in a glass in the manner shown in the illustration (Fig. 3). A drop of water will adhere to the handle and fall to the floor. On the spot thus indicated the nut must be placed. The illustration indicates the manner in which this experiment should be made. On the left is seen the knife suspended above the nut. On the right is the glass by which the positions of the two bodies can be ascertained.

ELASTICITY.

THE UNALTERABLE PELLET OF BREAD.

Knead between your fingers a piece of the crumb of

Fig. 4.—Pellet of Crumb of Bread modelled for the Demonstration of the Elasticity of Bodies.

a *fresh* loaf in such a manner as to impart to it the spiny appearance of the figure in illustration (Fig. 4). Place this moulded pellet on a wooden table and strike the pellet on top with your hand. You will find that you cannot alter its shape! No matter how violent your blows, the elastic material, for an instant flattened, will always return to its formation again.

Again, take the pellet and throw it violently on the *ground.* The shock will not permanently deform it any more than your blows did, and it will resume its shape again, because its elasticity has preserved it from injury! The experiment will not succeed unless the bread be perfectly fresh.

A band of india-rubber gives a very striking illustration of the elasticity of bodies. If all bodies are not elastic to the same extent, they are, nevertheless, all capable of some degree of expansion. If force be applied, they can be more or less extended; they will return again, when released, almost to their normal shape.

POROSITY. PERMEABILITY.

A BLOTTING-PAPER FILTER.

Place a piece of blotting-paper on the mouth of a tumbler; pour upon it some water darkened with charcoal or other such substance. The water will filter into the tumbler in a perfectly clear condition; the blotting-paper will retain all the solid impurities of the charcoal or coal. This experiment is illustrated in Fig. 5.

TO PASS STEAM THROUGH CARDBOARD.

Take two tumblers or goblets of equal capacity; place one of them on the table, and pour into it a small quantity of hot, almost boiling, water. Then cover the tumbler with a piece of cardboard, and place over the cardboard the other tumbler, as in the illustration (Fig. 6). Care must be taken that the upper glass is perfectly clean and free from moisture.

Now wait a while, and you will perceive that the steam from the boiling water in the lower vessel will penetrate the cardboard, the porosity and permeability of which will thus be clearly demonstrated, and the vapour will in time fill the upper glass. Wood, cloth, or woollen substances may be experimented upon in succession, and will gi the same result. But there are other textures which a *impermeable*, and will not permit the transmission of tl vapour ; such, for instance, as vulcanized india-rubbe of which waterproofs are made.

Fig. 5.--The Blotting-paper Filter.

This experiment tends to explain why fog is, as it well said, " so *penetrating*." It passes through the tiss of our cloth coats and our flannels, and thus com into contact with our bodies. A waterproof will prote us from its action.

RESISTANCE OF SUBSTANCES.

AT WHICH SIDE WILL THE MATCH CATCH FIRE?

Take four "safety" matches from a box, and insert › of them in the spaces which are apparent when the

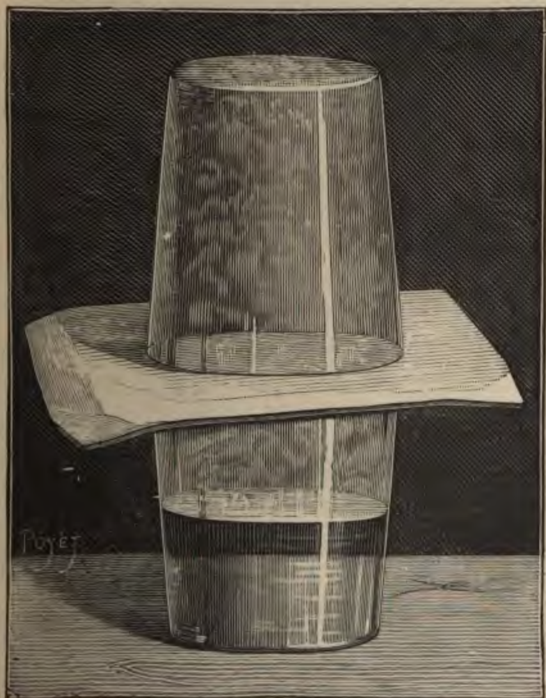

Fig. 6.—Steam passing through Cardboard.

x is partly opened; the third match should be placed tween the two former, when the whole will appear as the annexed figure (Fig. 7). Care must be taken that *third match is firmly* gripped between the other two,

which will be bent outwards, but must not be broken
by the contact.

The fourth match should then be struck, and the thir
(the horizontal) match lighted by it *in the centre.* Th
question for the spectators to solve now is :—Which o

Fig. 7.—The Match Problem.

the two supporting side matches will be fired first
That on the right or that on the left ? Will it b
that side at which we have two ends tipped with pho
phorus, or the side at which there is only one phosphor
end ? The reply must be—At neither of them. Th

side matches will not ignite at all, because immediately the centre of the horizontal match is burned, the two side matches will spring back and throw off the third match, which will fall to the ground and be extinguished.

HARDNESS.

TO PIERCE A HALFPENNY WITH A NEEDLE.

Everyone knows that if of two bodies one is harder than the other the former will scratch the latter. A piece of glass will scratch marble ; a diamond will cut glass. The glass is harder than the marble, the diamond harder than the glass. A bit of steel—a knife, for instance—will scratch copper. It is not impossible to pierce a halfpenny with a needle, because it is harder than the coin.

The problem may appear impossible of solution, for if we endeavour to drive a needle through a halfpenny as we would drive a nail through a board we shall fail every time, because we shall break the needle, which, though it possesses great durability, is also very brittle. But if by some method we can manage to maintain the needle in a rigid and upright position above the halfpenny, we can drive it into the coin with a hammer !

In order to perform this experiment successfully we must have a cork which is of the same height as the needle, and into which the latter must be driven. Thus the needle is maintained in a perfectly rigid condition, and may be struck violently in the direction of its axis without being broken.

Now place the needle (buried in the cork) above a halfpenny, which may rest either upon a "bolt-washer," or even on a wooden table, which will not be injured by the experiment. Then with a somewhat heavy (lock smith's) hammer strike the cork decidedly.

If the blow be delivered straight and strong the need will pass right through the halfpenny.

The experiment can be made equally well with an

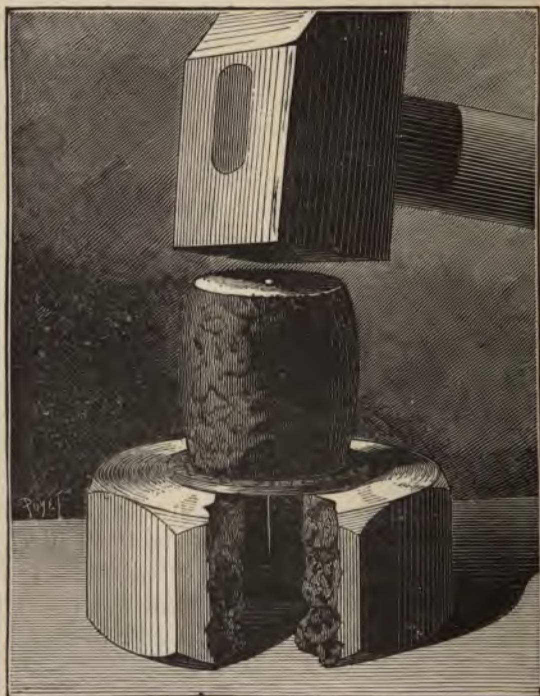

Fig. 8.—How to pierce a Halfpenny with a Needle.

other piece of money. We must, however, add that th experiment may not succeed at the first attempt; may be necessary to repeat the trial many times; bu it is capable of accomplishment, and we have beside some coins which have been pierced by needles in th *manner above* described.

It will be a very difficult matter to withdraw the needle from the coin after the experiment. The adhesion is very great.

CENTRIFUGAL FORCE.

TO KEEP A PENNY REVOLVING IN A LAMP-SHADE.

Grasp a lamp-shade in the right hand, as shown in the illustration (Fig. 9). Now, with the left hand, twirl

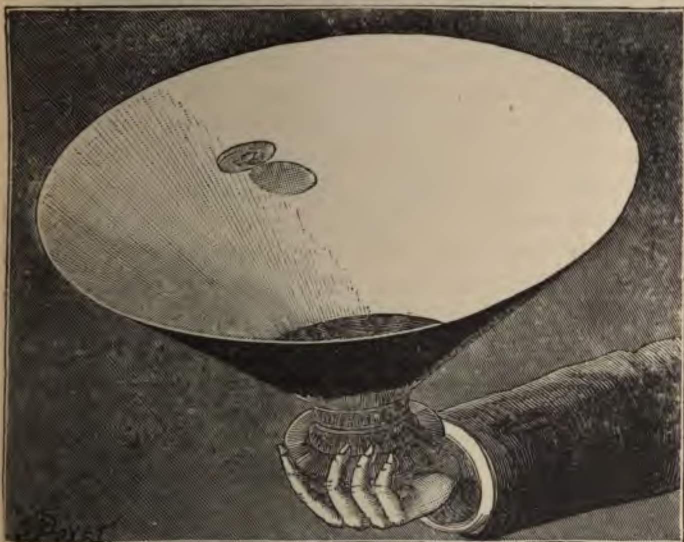

Fig. 9.—Twirling a Penny in a Lamp-shade.

a coin on its edge into the shade, and at the same moment cause the shade to rotate in the right hand in the opposite direction. The coin will roll round without falling.

If the movement of the shade be gradually slackened, the coin will by degrees rotate towards the lower part of the lamp-shade; if the speed be augmented, the coin will by degrees ascend the cone towards the upper circumference. The movement of the coin will continue just as long as the twirling motion of the shade is kept up. The money is maintained by the action of centrifugal force, and moves in an inclined position similar to that of a rider in the circus. With practice one can roll two pieces of money in the lamp-shade at the same time.

The experiment we have described is very easy to perform ; only a slight movement of the hand is needed. Although some dexterity is required in launching the penny into the lamp-shade at first, still no particular skill on the part of the performer is required. We ourselves have done the trick with ease, and have taught many persons inexperienced in sleight of hand to perform it.

If a lamp-shade be not available, we may use a basin, or pan, or a salad-bowl ; but the cardboard lamp-shade is lightest and most handy, and should be chosen in preference to all other articles. A Japanese umbrella will also suit.

EFFECTS OF CENTRIFUGAL FORCE.

The effects of centrifugal force are manifested under a great variety of circumstances, and we may frequently observe them.

When a railway is run round a sharp curve, the outer rail is always raised above the inner, so that the train when passing round the curve may retain its position on the metals.

If you run rapidly round a small circular track you will find it necessary to incline your body towards the centre, so that your course may thus become the more rapid.

The effects of centrifugal force are otherwise frequently *observable,* as, for instance, when a carriage-wheel is revolving rapidly the mud which adheres to the tire is flung away from the wheel by the action of centrifugal force.

It is centrifugal force which sometimes causes millstones to split when revolving at a high speed. It is the same force which causes the tiny drops of water to

Fig. 10.—The Cane-sling.

fly out of the wicker basket in which lettuce is being washed, dried, and shaken.

THE SLING.

When *one launches* a stone from a sling, the stone escapes from the circle which it has been made to describe as soon as one string of the sling has been let go, and it flies off at a tangent with the same velocity that has been imparted to it at the moment it was released.

TO THROW A POTATO TO A GREAT HEIGHT.

When the writer was a schoolboy and used to walk in the country, he substituted an ordinary walking-stick for the sling, and for the stone a potato, and in the following manner he succeeded in his experiment. He fixed a potato at the end of his cane in a firm way, and then, whirling the stick as he would whirl a sling, he suddenly stopped the motion when the end of the stick pointed upwards. The potato was thus hurled to an immense height in the air.

THE PRINCIPLE OF INERTIA.

In treatises on mechanics and physics, "inertia" is defined as a property of matter by which bodies tend to preserve a condition of repose, and by which a body in motion is prevented from modifying of itself the movement which has been imparted to it.

A PIECE OF MONEY ROLLING ON AN UMBRELLA.

We will first give an illustration of the feat performed by some jugglers—viz., the circling of a half-crown upon a Japanese umbrella, as shown in the engraving. The umbrella is turned rapidly round, and, to all appearance, the half-crown is running along the surface; but it is *really* the umbrella that is moving beneath the piece of money. This is an example of the principle of inertia. The experiment is performed very cleverly by the Japanese jugglers.

TO CUT A PEACH, WITH ITS STONE, RIGHT THROUGH.

Take an almost ripe peach, of medium size, and insert in it a table-knife so that the blade may be in contact with the edge of the stone. If the peach be too ripe

Fig. 11.—Half-crown rolling over an Umbrella.

to remain suspended on the blade it can be fastened by a thread, but only on the condition that the knife-blade remains in contact with the edge of the stone.

The knife with the peach attached is then grasped in the left hand tightly and firmly, and with another table-knife a *blow is struck by* the right hand—a smart, violent blow—on the knife, close to the fruit. If the knife ha been properly inserted into the fruit, so that the shoc is transmitted in the direction of the centre of gravity c the peach, the stone will be cut normally to its axis, a well as the tissue which encloses it, and moreover in a very neat manner indeed.

Fig. 12.—How to cut through a Peach.

In performing this experiment it will be well to suspen the peach over a table, and to use common knives, whic are not likely to be damaged.

Many games based upon "inertia" are practised. On of them consists in placing in the midst of a certai circumference a pipe, at the upper end of which some pieces of money are placed. The pipe, when thrown at with quoits or a stick, lets the coin fall to the ground within the circle; but if the pieces must be struck beyond the circle, it is necessary to avoid hitting the pipe. (On this principle the "cocoa-nut throwing" is practised at fairs.)

It is by virtue of the inertia of matter that the particles of dust are beaten out of our clothes, every particle being in a condition of repose. When the shock of the sudden stroke puts in motion the stuff in which the particles are resting, they remain behind, and at once fall down released from the clothes.

When a piece of cord is vigorously flourished and then suddenly checked in the moment of its greatest impulse, the extreme end, which has the greatest velocity, has a tendency to escape from the other sections, and in its attempt a noise is produced. This is the *cracking of the whip*. It is on the same principle that the drops of water will run from the lettuce-leaves when forcibly shaken in a wicker basket. In this there is also an illustration of centrifugal force, as already mentioned.

Facts of this nature may be multiplied exceedingly. A bullet shot from a rifle will go through a pane of glass and leave a round hole in it; but if the ball be thrown by the hand, at a much less speed, the glass will be shivered into fragments.

The flexible stem of a plant may be severed by a switch horizontally thrown at it with great force. The velocity in this case is very high, and the molecules directly struck attain also a speed so great that they separate themselves from the surrounding molecules before they have had time to communicate their velocity to the latter.

TO PROJECT ONE OR TWO "DRAUGHTSMEN" FROM A HEAP OF THEM.

This experiment is a variation of one which we have explained in another place. It is performed by means of draughts or backgammon "men," but instead of a piece of wood, another disc is used as a projectile.

Build up a column of ten or twelve pieces, as in

Fig. 13.—The Draughtsmen.

the illustration, and with the thumb and forefinger propel the single disc violently against the pile, causing the disc to strike the column (Fig. 13). The piece thus launched out will strike tangentially the pile in one of two ways—either it will hit it at the point of contact of two discs, in which case two will be projected from the column; *or it will strike* a single disc, as shown in the illustration, in which the black piece only will be projected from the pile, without disturbing the stability of the other pieces.

THE CARD AND THE COIN.

Place on the forefinger of your left hand, held upright, a card; on the card place a halfcrown or other good-

Fig. 14.—The Card and the Coin.

sized coin, and offer to remove the card without disturbing the coin. To do this you must "fillip" the card forcibly with the middle finger of the right hand; the pasteboard will be propelled across the room, and the coin will remain upon the finger. In performing this trick, care must be taken to flip the card in a plane perfectly horizontal to the coin—*as shown in* the illustration (Fig. 14).

EXPERIMENT OF INERTIA MADE WITH DOMINOES

Place two dominoes upright at their highest eleva with their faces towards each other, and then another p horizontally across them, forming a door. Upon third—the horizontal—domino place a fourth, the b

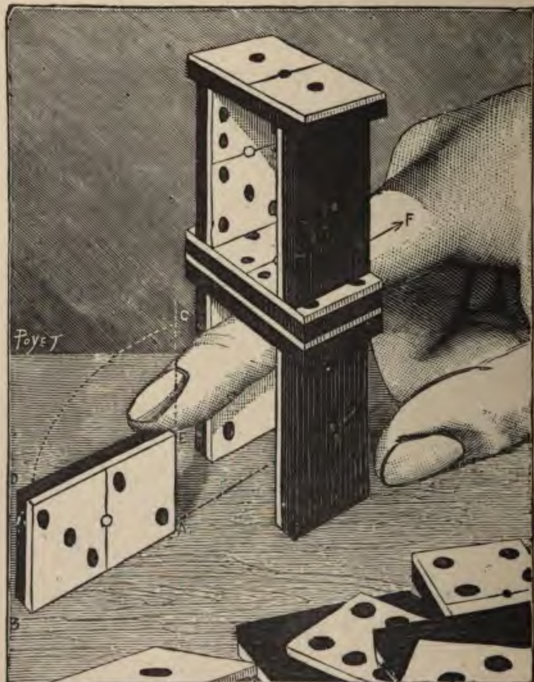

Fig. 15.--Experiment of Inertia.

surfaces being in contact. Finally upon this fo domino set two others in the same manner as the pair, face to face, then a seventh piece over all, a illustration (Fig. 15).

The experiment consists in detaching rapidly the lo horizontal domino from the building, without disturbing the remainder of the erection. To do this you must place another domino in front of the building lengthwise (A-B), at such a distance that it can be conveniently reached by the forefinger passing beneath the first storey. The end E of this domino is then sharply pulled down

Fig. 16.—The Plate and the Coins Experiment.

backwards, by which movement the corner D describes a curve in the direction of the dotted line to C.

If this movement be properly accomplished, the angle D will suddenly strike the lower horizontal domino and project it *in the direction of* the arrow F. This displacement will be followed by the instantaneous descent of the upper horizontal domino upon the two lower perpendicular pieces, in place of the domino removed, and the structure will remain otherwise undisturbed.

THE PLATE AND THE PILE OF COPPERS.

Put a dozen coins in a plate and propose to deposit them at one movement in the same order upon the table. People who have never tried this experiment will essay it in vain. To accomplish it you must raise the plate about a foot above the table, suddenly depress it, as shown in the illustration, and draw it towards you. The coins, not finding any support, will fall to the table in the same position as they left the plate.

It is by no means an easy task to let the pile of money fall as here described without separating them. With practice and skill you will surely accomplish the task, in performing which it is best to let the coins fall or slide off the plate upon a cloth, which is more elastic than a bare table. The cloth will lessen the shock of propulsion.

THE MONEY ON THE ELBOW.

This is another experiment which the writer has frequently performed. It is managed by holding the arm back upwards, the elbow being almost flat and the hand open, palm upwards, as in the illustration (Fig. 17). On the arm, close to the joint, place the coin or coins. Perhaps one at first will be sufficient, in case of failure and possible loss. If the hand be suddenly brought down with a circular sweep, the pile of money—or the single coin—will be left for an instant in space, and be at once clasped in the palm coming down upon it.

It will be found easy and possible to catch a pile of a dozen pence or halfcrowns in this way, after a little preliminary practice, without letting one coin escape.

Care must nevertheless be taken that no breakable articles are in front of you when you are practising this

Fig. 17.—Catching the Pile of Money.

experiment, for, if you do not succeed in catching the coins, they will be struck by the hand with very considerable force, and may do damage to the surroundings; they also may roll out of sight!

TO CUT AN APPLE IN A HANDKERCHIEF WITHOUT INJURING THE LATTER.

In this instance the apple is wrapped up in the ha kerchief and suspended by a cord, as indicated in

Fig. 18.—The Apple in the Handkerchief.

illustration (Fig. 18). Take a sabre or a strong k the plan of which is indicated in the right-hand u corner. The edge of the blade should be very sh *the more* polished and the sharper the blade the r likely is the experiment to succeed. The cut must be given without sawing, and perpendicularly to the point of suspension. If the blade be rather thick, the apple will jump up slightly and then the handkerchief will enter with the blade and be uncut.

In 1887 there were some clowns at the circus in Paris who used to perform this trick very neatly indeed, and with great dexterity.

THE STONE-BREAKER.

By great acquired force, or inertia in repose, one is enabled to break stones with the fist. This feat is performed by men at fairs in the manner following:—

The right hand is carefully wrapped in a bandage, and in the left is held a piece of flint of rounded form, which the operator places upon a larger stone or upon an anvil; then with the right hand he strikes the flint some very powerful blows, always taking care to raise it a little from the anvil when he is about to strike. Thus the object struck acquires the force of the fist that has struck it, and as it comes in violent contact with the anvil it is quickly broken. Simple as the feat is it never fails to evoke great astonishment from the spectators (Fig. 19).

TO UNCORK A BOTTLE WITHOUT A CORKSCREW.

Take a bottle of wine or beer, or any other liquid, and having folded a dinner napkin into a pad, strike the bottom of the bottle violently against it, as in the illus-

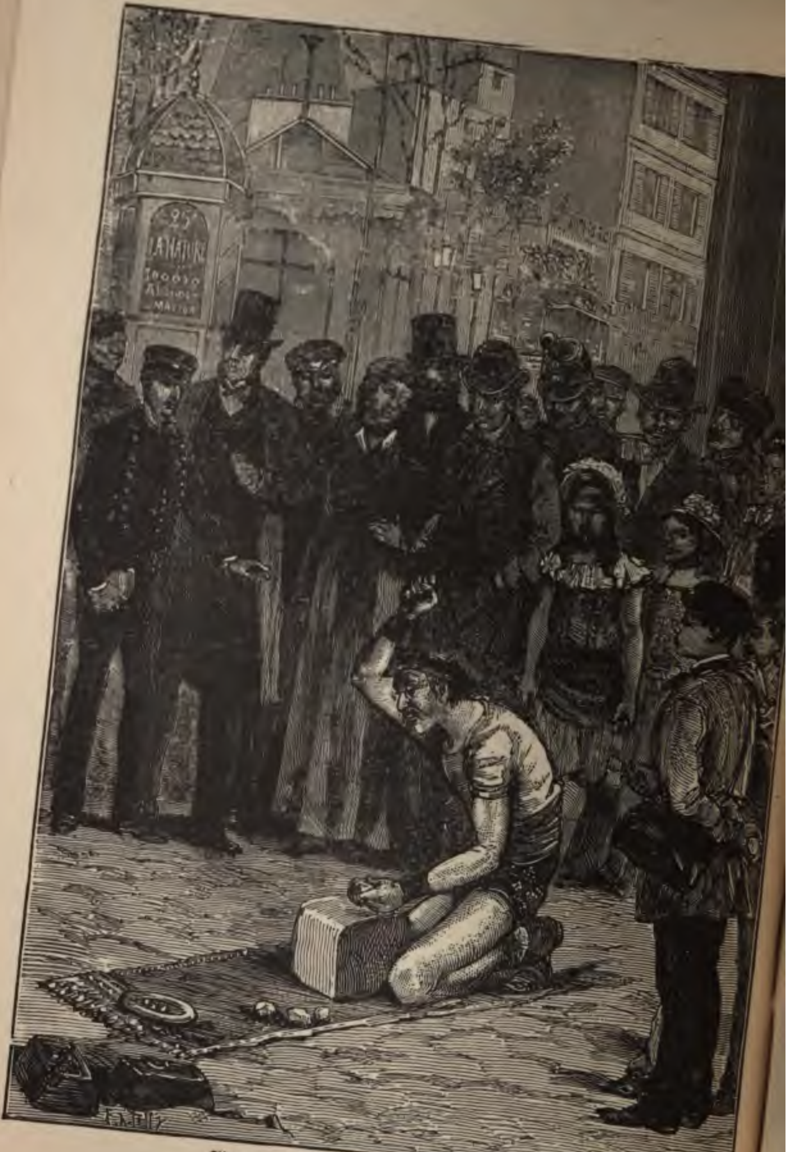

Fig. 19.—Experiment of Acquired Force.

tration (Fig. 20), on the wall. By virtue of the principle of inertia the liquid in the bottle will force out the cork. If the contents be beer or gaseous water, it will come out with considerable force, and carry some of the liquid

Fig. 20.—A New Way of uncorking a Bottle.

with it over the spectators. This fact will enchance the success of the experiment, with which we will end our chapter on the inertia of matter.

CHAPTER II.—EQUILIBRIUM OF BODIES.

THE CENTRE OF GRAVITY.

IDEAS relative to the centre of gravity and to the equilibrium of bodies can be demonstrated by means of a number of every-day objects. When we find a box of soldiers in which each warrior is gifted with a small piece of lead at his feet, we have an illustration of the centre of gravity. We know that the cylinders, roughly representing soldiers, will always resume their upright position when one endeavours to overturn them.

It has been stated that it is possible, with patience and lightness of hand, to make an egg stand on one end. To accomplish this the egg must be placed upon a perfectly plane surface—a marble chimney-piece, for instance. The egg must be shaken to mingle the yolk with the white, and then if one succeed in making the egg stand upright, one of the most elementary principles of physics is illustrated thereby; for the centre of gravity is at the point of contact at the end of the egg, and the plane surface on which it rests. We will give some illustrations of this.

TO BALANCE A PENCIL ON ITS POINT.

The arrangement of the pencil and the knife, the blade of which is buried in the wood, is held in equilibrium at the point of the finger, because the centre of gravity of e arrangement is situated in the vertical, beneath the int of contact (Fig. 21).

THE MATCH PUZZLE.

Slit a match at one end, and insert into the groove

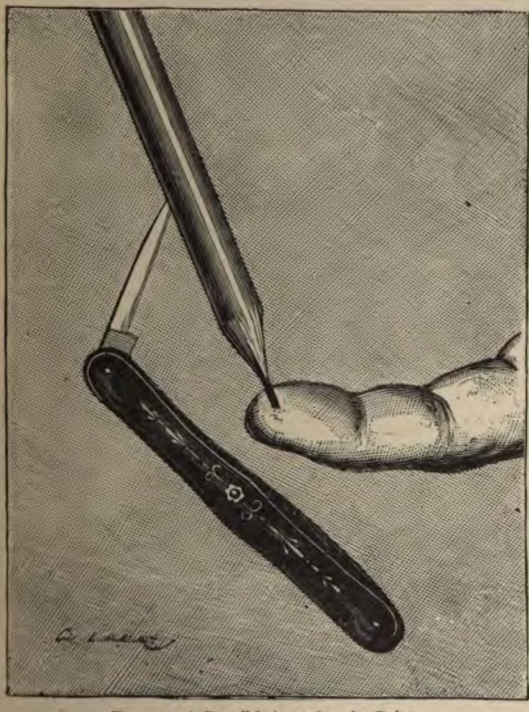

Fig. 21.—A Pencil balanced on its Point

other, so that the pair shall form a certain angle. Place em on a table, angle upwards, tent fashion; and let a ird match rest *against* them as in Fig. 22. Now all is *dy for the experiment.* Take a fourth match, and handing it to one of your audience, request him to lif three others with it.

If the *Seeker*, the interesting paper from which borrow this pleasing problem, be correct, the solutio the puzzle will test the patience of many an architec

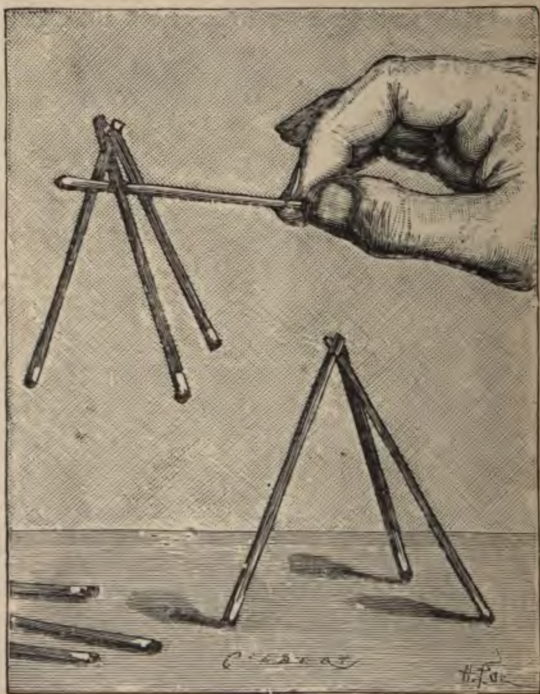

Fig. 22.—Problem of the Four Matches.

builder who is not previously acquainted with the ex ment.

The upper diagram in the illustration explains mode of proceeding. The way the trick is perfor *is to allow* the third match to fall lightly against *match you* hold, and then lower the hand until this match enters within the angle formed by the first pair; then lift your fourth match and you will find that the other matches will rest crosswise on your match, No. 1 and 2 on one side, and No. 3 on the other.

Fig. 23.—The Tumbler and the Sticks.

TO POISE A TUMBLER UPON THREE STICKS, EACH ONE OF WHICH HAS ONE END IN THE AIR.

Ozanam, in his "Mathematical and Physical Recreations in the 16th Century," laid down the following problem: "Place three sticks on a horizontal plane, so that each one shall have one end resting on the plane and the *other end unsupported*."

To perform this experiment, and even to place a weight on the sticks thus poised, you must carefully proceed as follows :—Place in a sloping position one stick with one end resting on the table and the other elevated. Put another in a similar fashion above, and resting *on* the first. Then form a triangle by means of the third stick poised in the same way but passing *under* one and *above* the other of the two sticks already laid down. The three sticks will in this manner prove of mutual support to each other, and will not give way even if a tumbler or other weight be placed upon them over the points of contact, as in Fig. 23.

THE WATER-BOTTLE AND THE THREE KNIVES.

In almost the same manner as above illustrated, we can place three knives upon three wine-glasses as represented in Fig. 24. The knives not only support each other blade to blade, but they will sustain as heavy an object as a filled water-carafe upon the triangle at their intersections.

TO SUSPEND A BUCKET OF WATER FROM A STICK RESTING ON A TABLE.

Here is another very old-fashioned experiment on the "centre of gravity," which consists in suspending by the handle a bucket filled with water passed over the stick *A B*, which is laid on the table. To succeed in this experiment, which appears almost impossible to perform, we must fix a switch *C D* of convenient length between the point *B* of suspension and the bottom of the pail. The arrangement thus consolidated forms, virtually, one object—a whole, and the pail or bucket is easily main-

Fig. 24.—The Glasses and the Knives Trick.

tained in the position shown in the illustration, because the centre of gravity of the whole mass is beneath the point of suspension situated almost at the centre of the stick *A B* (*Fig. 25*).

THE FORKS AND THE COIN.

Place two forks with their prongs one set *over* the other, and slip a coin—a five-franc piece or a halfcrown—between the middle prongs of the forks. Then place the coin flat on the rim of a wineglass or tumbler,

Fig. 25.—Pail of Water suspended from a Stick.

pushing it outwards until the two circumferences sh[a]
be touching externally. In this position, as shown
the accompanying engraving, the forks will remain
equilibrio, and the water may be poured steadily fro

the glass into another without disturbing the coin or the two forks. (See Fig. 26.)

We have now indicated almost all the recreative experiments connected with the centre of gravity and the laws of equilibrium. We will, however, explain another problem requiring skill, which can be worked out with a box of dominoes.

Fig. 26.—Experiment of Equilibrium on the Centre of Gravity.

EXPERIMENT WITH DOMINOES.

The illustration shows how the contents of a box of dominoes can be supported upon one of their number. We must begin by placing three of the pieces on the table so as to form a solid base; the first domino being laid upon three *supports*. When the edifice is finished, as in the illustration, the two outside dominoes must be withdrawn and very gently placed upon the top of the construction. The erection will remain *in equilibrio* provided that the perpendicular drawn from the centre of gravity of the system passes through the base of

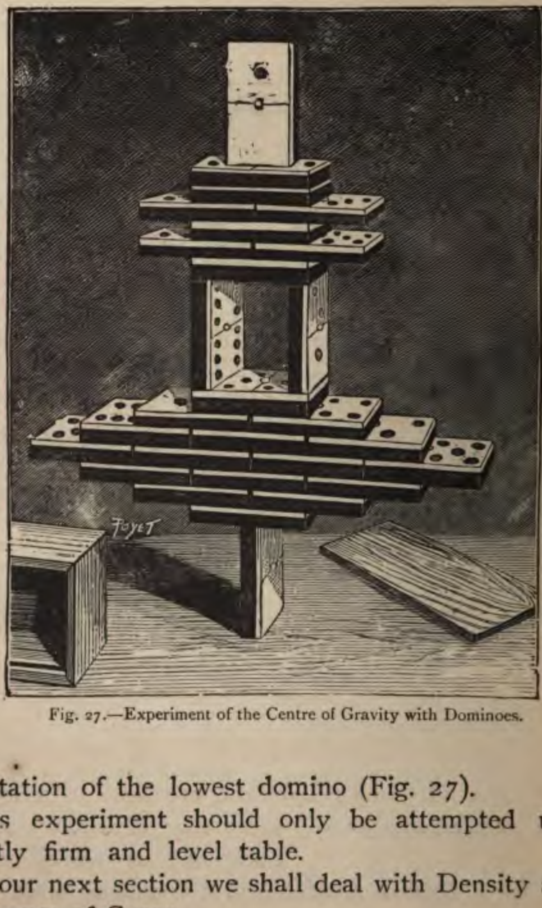

Fig. 27.—Experiment of the Centre of Gravity with Dominoes.

sustentation of the lowest domino (Fig. 27).

This experiment should only be attempted upon perfectly firm and level table.

In our next section we shall deal with Density and th *Movements* of Gases.

HOW TO SIT WITHOUT CHAIRS.

This amusing feat can be performed by a number of persons arranging themselves as you see them in the illustration, the last in the ring sitting on the knees of the first. While the circle is being formed it would be advisable for the first to be seated on a chair, which can

Fig. 28.—Sitting without Chairs.

be slipped away when the ring is completed. This plan was adopted by French soldiers in Algeria, when they found themselves in any place where the soil was marshy, and where it would have been unwise for them to sit down on the ground.

CHAPTER III.—DENSITY, HYDROSTATICS, ETC.

HYDROSTATICS—THE MOVEMENTS OF GASES—RESISTANCE OF THE AIR.

HYDROSTATICS.

THERE is no necessity to dwell upon the density of bodies here: it is well known that, considered as possessing the same volume, bodies have different weights. We shall consider this subject at greater length in the subsequent part of the work, when dealing with the properties of metals.

The principles of hydrostatics, which we intend to consider now, can be easily explained. It is very easy to understand the principle of Archimedes. Take any body of irregular form,—a stone will do,—and having attached to it a thread, let it dip into a vessel filled to the brim with water. The water will overflow in volume equivalent to the bulk of the stone; as can readily be proved by weighing the glass partly emptied of water and the stone against another similar glass full of water.

ASCENT OF WINE IN AN INVERTED GLASS OF WATER.

Dip two wineglasses into a basin of water, and before taking them out, place the brims together, so that they may remain full, but one over the other. Then move em slightly, so that a very small space may intervene tween the rims. Take a third glass and drip from it me wine in such a manner as it may spread slowly er the surface of the inverted glass, as shown in the

Fig. 29.—Experiment on the Density of Liquids.

ustration (Fig. 29). When the wine has trickled down the line of separation, you will perceive the ruddy ops filtering into the glasses and ascending into the per one, in consequence of the difference in the densities *wine and water.*

THE GRAPE-SEED IN THE GLASS OF CHAMPAGNE

If we place a grape-seed, quite dry, at the bottom glass, and fill it with champagne, we shall see the bub attaching themselves to the seed, and it will rise to

Fig. 30.—The Grape-seed in the Glass of Champagne.

surface of the wine, where the bubbles burst and disap Then the seed will fall to the bottom of the glass a The seed in this instance has been raised to the su by the aid of the air-bubbles, which play the part of balloons in bringing it to the top of the liquid (Fig. 3

HOW TO MAKE A SYPHON WITH A COMMON BOIL LOBSTER.

Take a glass filled with water, and attach a lobst *it, plunge* the tail as far as possible into the liquid, le he body and head hang over the side of the glass; it is necessary also to cut the antennæ, so that they shall not touch the vessel on which the glass of water stands. The moment that the lobster is hooked on to the edge of the glass, small globules of water will be seen to form at the

Fig. 31.—The Lobster Syphon.

end of the antennæ, which eventually form themselves into a trickling stream, which lasts as long as the tail of the lobster remains immersed in the water.

TO MAKE A NEEDLE FLOAT.

Take an ordinary needle and put it upon a fork, and slowly lower the fork into a tumbler of water; the needle will then float just like a piece of straw. The reason of this is that a *meniscus*, or bed, convex on one side, and concave on the other, is formed upon the surface of the water; and the surface of this *meniscus* being large in

Fig. 32.—The Floating Needle.

comparison with that of the needle, the latter is supported by it, so that scarcely any part of the needle is touching the water; of course, if the water penetrated the needle's eye, the weight of the fluid would cause the thing to sink immediately. Another method is to put a leaf of cigarette or *tissue paper* on the surface of a tumbler of water, lay a needle very gently upon the paper, which will soon become soaked and sink to the bottom of the glass, leaving the needle floating on the top of the water.

Fig. 33.—Direction of Candle-flames under the influence of Air-currents.

THE MOVEMENTS OF GASES.

AËRIAL CURRENTS.

Hot air is much lighter than cold air, and the differences in density of the air-strata play a very important part in the movements of the atmosphere. Air is warmed in the Equatorial, and cooled in the Polar, Regions.

It is easy to understand the differences in density o the aërial currents if we open the door of a warm room which is entered from a cold hall.

A candle held to the upper part of the open door will show the direction of the warm current, while the course of the cold air will be demonstrated by the flaring flame of a candle placed on the floor. The currents pass in opposite directions, out and in (Fig. 33).

Fig. 34.—Extinguishing a Candle placed behind a Bottle.

BLOWING OUT A CANDLE BEHIND A BOTTLE.

Put a lighted candle on the table, and in front of it, about 10 inches removed, a bottle like the one in the engraving (Fig. 34). Then blow on the bottle at a distance of 8 or 9 inches, and the light will be extinguished just as though there was nothing between it and your breath. The breath divides into two currents on the smooth surface of the bottle, one going right, the other left, which join each other just at the flame of the candle.

Fig. 35.—Rotation of Coin between Two Pins.

TO REVOLVE A COIN BETWEEN TWO PINS.

It is not necessary to have recourse to the action of warm air to produce aërial motion. We have in ourselves an apparatus which is capable of producing gaseous currents, and which will assist us in our Scientific Amusements—viz., our mouths! Place a halfcrown flat on the table, then seize it between two pins held at the extremities of the same diameter. You may raise it thus without any trouble. Blow against the upper surface, and you will see the coin revolving with considerable speed between the pins. The illustration (Fig. 35) shows the manner in which this feat can be accomplished. The coin can be made to revolve (by blowing on its upper surface) with such rapidity as to make it appear a metallic sphere. In this we have an illustration of the persistence of impressions on the retina, of which we shall speak hereafter.

TO KEEP A PEA IN EQUILIBRIUM BY MEANS OF A CURRENT OF AIR.

Choose as rounded a pea as you can find, and soften it, if dry, in water. Then skilfully impale it on a pin, so as not to damage its exterior surface and shape. Then get a pipe, of very small bore, and place the pea

Fig. 36.—Pea sustained in the Air by blowing through a Tube.

on one of its extremities, where it is maintained by the pin which has been inserted in the tube. Throw your head back until the pipe is in a vertical position, and then blow gradually and slowly through it. The pea will rise up; then blow more forcibly, and it will be sustained by the current of air turning on itself when the breath strikes the pin (Fig. 36).

Here is another experiment of the same kind :—

Take a metallic penholder which is closed at one of its ends. At a little distance from the closed extremity drill a tiny hole. Then blow up through the aperture, thus formed, regularly and steadily. A small bread pellet, perfectly round, can then be kept up, as shown in the illustration (Fig. 37).

The pellet should be as spherical as possible, its size varying with the density of the material of which it is

Fig. 37.—Bread Pellet sustained by a Current of Air.

composed and the size of the aperture in the tube. Many other experiments can be made by any means which will ensure a constant, even, supply of air, or gas, or steam from the extremity of a pipe.

By analogous means an egg-shell can be maintained at the upper extremity of a jet of water, on which it will revolve without falling off. [A wooden ball can also *be kept up in revolution* in the same manner.]

TO MAKE A PLANK ADHERE TO A TABLE BY MEANS OF A NEWSPAPER.

Take a thin plank, about a quarter of an inch thick, and eight inches wide, and twenty-eight in length. Place this plank on a table slightly out of the horizontal, and it

Fig. 38.—Experiment in Equilibrium.

will be evident that the least touch will bring it to the ground. On the plank thus balanced place a newspaper sheet ; and then if you strike the portion of the plank which extends beyond the table you will be surprised to find that the plank will resist the blow absolutely, as if it had been nailed to the table. If you strike hard you will perhaps hurt your hand or break the plank, but you will not raise the sheet of newspaper which holds it. The quick compression of the air which is exercised on a considerable surface is sufficient to explain this phenomenon (Fig. 38).

Resistance of the Air.

THE AUSTRALIAN BOOMERANG.

Everyone has heard of the Australian boomerang. It is a weapon formed in the shape of an arc of hard wood, which the Aborigines and inhabitants of Australia throw with unerring skill at some object—an enemy or quarry. When the boomerang strikes the object aimed at, it

Fig. 39.—The Boomerang.

returns to the hand which launched it. One may quickly learn to throw this weapon after a few trials.

Fifteen years ago M. Marcy, of the Paris Institute, published an interesting paper on this subject in the *Aëronaut*, in which journal were discussed questions relative to the resistance of the air. The learned professor then *prepared—unconsciously*—a little chapter for Scientific

Amusements, and we will reproduce the gist of his remarks.

A piece of cardboard shaped into a crescent, the corners of which are rounded off, should be placed on the tip of the finger, or, still better, supported between the nail and the finger tip, so that the cardboard be inclined at an angle of 43°, or so. Then, with a vigorous flip of the finger of the right hand at the extremity of the toy, it is impelled into the air with a rotatory motion. The cardboard crescent then appears as a wheel, and moves in an oblique ascending direction, stops, and without turning a somersault, returns in the same trajectory, if the experiment be successful, but more frequently it will come back in front or beside the point of departure, and always retrograding. The illustration (Fig. 39) will explain the method of procedure. We may add that it is preferable to place the crescent with its horns *towards* the experimentalist, not as in the illustration.

Now why does the boomerang return thus in the same direction with reference to the plane of the horizon? Here come in the notions which Foucault has already given us respecting the preservation of the plane of oscillation by the pendulum, and by the plane of gyration of the gyroscope.

"The boomerang receives from the thrower a double movement—viz., rapid rotation and a general impulse. The rotation given to the implement obliges it to retain its plane: it whirls obliquely in the air until its impulse is exhausted. At a given moment the weapon turns without advancing in space, and then its weight causes it to fall. But as the projectile continues to turn, still maintaining its inclined plane, the resistance of the air causes it to fall back in a direction parallel to this plane—that is to say, towards its point of departure."

WHIRLING RINGS.

If you bore a hole in a box made of playing cards, and fill this box from your mouth with tobacco smoke, and then tap at the bottom of the box you will cause the smoke to rise in rings from the orifice with remarkable regularity (Fig. 40).

Fig. 40.—Mode of making Smoke-rings.

Every one has seen smokers making pretty white diadems which they watch turning in the air with great satisfaction. It is a matter of daily observation that a drop of soapy water escaped from the tip of the finger enlarges itself in the basin in the form of a perfect ring, which slowly grows larger as it reaches the bottom.

These observations are applicable to the phenomena of whirling rings; they are not futile, and can be made interesting. There is nothing commonplace for him who can use his eyes, nothing different to him who is able to observe.

We can also project the rings or diadems of smoke by

Fig. 41.—Crowns of Tobacco Smoke (after picture by Branwer in the Louvre).

projecting puffs from a cigarette through a tube. But some precautions are necessary to assure the success of the experiment. Any draught must be avoided, and to prevent the action even of the air currents, which ascend in the proximity of the body, we should operate at a table as shown in Fig. 44. The rings which float beyond the table will not be sensibly influenced by the warm

Fig. 42. Fig. 43.
Aspects of Smoke-rings (42, gently emitted; 43, emitted with some force).

Fig. 44.—With a little Smoke some Distance from the Tube.

air-currents. A tube formed from a sheet of ordinary note-paper will suffice to produce some elegant rings (Fig. 44).

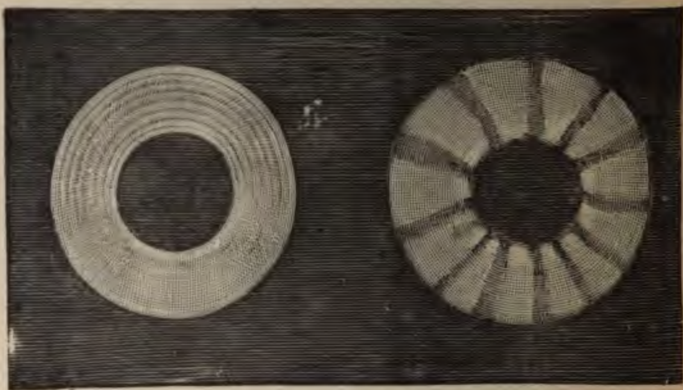

Fig. 45.—Dissipation of Smoke-rings (general aspect).

The better to watch these rings they should be

Fig. 46.—Dissipation of Smoke-rings (magnified ring).

propelled to the darker side of the room, towards a dark

CONDUCTI...

HEAT

CHAPTER IV.—PRESSURE OF THE AIR.

PRESSURE OF THE AIR—EXPERIMENTS WITH COMPRESSED AIR—AËRONAUTICS.

PRESSURE OF THE AIR.

THE MAGDEBURG HEMISPHERES.

TAKE two tumblers of the same size. Be careful that they fit closely when one is placed on top of the other. Light a piece of wax candle, and place it within the tumbler on the

Fig. 47.—The Adhesive Tumblers.

table. Place on top of it a piece of rather thick paper saturated with water. Then place upon it the other tumbler, as in the illustration (Fig. 47). The tumblers will then be found to adhere closely. The candle will be extinguished ; but while burning it has dilated the air contained in the lower tumbler, and this air has, therefore,

Fig. 48.—The "Sucker."

ecome rarefied. The exterior pressure of the atmosphere ill fix the tumblers as closely together as the classical lagdeburg hemispheres are united. It is possible to aise the undermost tumbler by holding up the upper one. he paper may be scorched on the under side, but the uccess *of the experiment* is not thereby imperilled.

THE "SUCKER."

This is a plaything familiar to all schoolboys, and has, no doubt, served as the text for many a dissertation on the pressure of the air. Readers are aware that the "sucker" is formed of a piece of leather, in the centre

Fig. 49.—The Schoolboy Inventor of the Air-pump.

of which a cord is fixed. This piece of leather pressed upon the pavement forms a kind of "cupping-glass" arrangement, and considerable force must be exercised to draw it away from the pavement. Large stones may be lifted by these means. The piece of leather should be first wetted, and the cord attached to it, so that no air may penetrate through the aperture in which the string is inserted. A circular piece of leather seems to act best.

THE PENHOLDER AND A VACUUM.

The schoolboy who first exhausted the air from a tube penholder and made it cling to his lip, by reason of the exterior pressure of the air, was perhaps the first to discover the air-pump. To perform this little experiment, you must have a penholder with one closed end. Put the open end in the mouth, exhaust the air by aspiring it, and then permit the end in the mouth to slide on to the lip, which seals it hermetically.

EXPERIMENTS WITH COMPRESSED AIR.

TO EXTINGUISH A CANDLE BY MEANS OF A BOTTLE.

Take an ordinary bottle, the neck of which is about three-quarters of an inch wide. Hold the bottle in the right hand, and cover the neck with the ball of the thumb of the left hand, leaving only a small aperture (see *A*, Fig. 50). Care must be taken to leave only a small aperture. Then apply your mouth to the opening, so as to cover it completely, and breathe into the bottle gradually but forcibly, so as to compress the air in it. Under these circumstances it is evident that, in consequence of the communication which exists between the interior of the bottle and the lungs, an equilibrium of pressure will be established. Three or four seconds suffice for the action. At that moment, by a movement, close the bottle completely, by applying ball of the thumb to the orifice, displacing the lips.

Then place the bottle in an inclined position,

Fig. 50.—Position of the Hands before the Compression of the Air by the Mout

Fig. 51, mouth downwards, and bring it within abo inch and a half of a lighted candle. Loose the th and permit the compressed air to escape from the through an aperture as nearly the same size as po *to the opening* through which the bottle was filled.

flame of the candle will be blown aside and perhaps extinguished.

THE PAPER BAG FILLED WITH AIR.

After the experiments with a vacuum, we may next

Fig. 51.—Mode of holding the Bottle in order to extinguish, or blow aside, the Flame.

speak of those which refer to the compression of gases. Let us recall the experiment of the bag, full of air, which is broken by a blow of the hand.

The compressed *air bursts* the bag, and produces an *explosion.*

AËRONAUTICS.

A MONTGOLFIER BALLOON.

Make a hollow cylinder, about the size of an ordi cork, with a sheet of silver-paper or cigarette-paper. edges of the cylinder must be somewhat bent over, s to make it retain its form. With a lighted match set

Fig. 52.—Compressed Air.

to the cylinder at its upper part. The paper will and be converted into a thin layer of ashes. This re *enclosing* rarefied air suddenly rises, and mounts ra for several feet like a Montgolfier balloon (Fig. 53).

AIR AND GAS BALLOONS.

Take a glass tube, about three-quarters of an inch in diameter, and about eight inches long, or, in default of it, a roll of ordinary notepaper, which will enable you to

Fig. 53.—Demonstration of the Principle of the Ascent of Balloons by means of Heated Air.

blow bubbles as big as a man's head. Dip the end of the tube in a solution of soap, and blow rapidly and strongly through the tube. The bubble, filled with the warm air from your lungs, will soon ascend. Without letting it go, follow it in its ascending movement, turn the end of the tube gradually upwards until you touch off the drop suspended at the bottom of the bubl Your balloon, fully inflated, will only want to be releas if it has not already freed itself. If the temperature low, the bubble will break against the ceiling; in contrary case, it will descend slowly, as soon as it becor somewhat chilled.

Fig. 54.—Soap-bubble lifting a Paper Aëronaut.

Let a small, thin paper-figure be cut out, and faster by a thread to a disc of paper; it can be made to adh to the bubble, as shown in Fig. 54. If the bubble th be released, it will carry the figure up with it (Fig. 5 If smaller tubes be used, bubbles of smaller size will *produced.* The paper tubes must be replaced by oth *when wet* and soddened, but glass tubes are preferable.

By inflating soap-bubbles with hydrogen gas we can

Fig. 55.—Soap-bubble inflated with warm Air. Mode of fixing an Aëronaut.

represent the ascents of gas balloons, which differ from warm air balloons.

CHAPTER V.—HEAT.

THE CONDUCTIBILITY OF METALS—DILATATION OF BODIES BY HEAT.

THE art of producing fire or of procuring heat artificially is one of the most profitable of human industries, since it has given us the means of moving machinery in manufactures, locomotives, and steamboats. The impression which produces the sensation of heat in our organism is a subjective phenomenon, and the impression which we convey when we say that a body is hot or cold is relative. When we enter a cellar in the summer when the exterior air is warm, we find the cellar cold; if we enter during the wintry weather, we find the temperature rather warm. Nevertheless it remains about the same heat all the while.

Suppose that we hold the right hand in a vessel containing hot water, and the left hand in a vessel containing cold water; if we then withdraw our hands at the same moment and plunge them together into a third vessel full of tepid water, we shall then experience two different sensations, heat and cold, proceeding from water of a certain temperature.

The study of heat and caloric can be immediately undertaken without any apparatus, as we have seen when dealing with other branches of physics.

The Conductibility of Metals.

A BURNING COAL ON A MUSLIN HANDKERCHIEF.

Take a globe of copper, about as large as the globular ornaments which one sees at the bottom of a staircase. and wrap it in muslin or in a cambric handkerchief.

Fig. 56.—A Burning Coal placed on a Handkerchief wrapped round a Copper Globe. The Handkerchief is not scorched.

Place on this metallic bowl, thus enveloped, a red-hot coal, and it will continue to glow, without in any way damaging the muslin wrapper. The reason is this: the metal being an excellent conductor absorbs all the heat developed by the combustion of the coal, and as the handkerchief has not absorbed any of the heat, it remains at a lower temperature to that at which it would be injured (Fig. 56).

Fig. 57.—Gas Jet (Metal) wrapped in a Cambric Handkerchief, tightly stretched. The Flame will burn above the Handkerchief without injuring it.

TO MAKE GAS BURN UNDER A HANDKERCHIEF.

Take a batiste handkerchief, and wrap it round a copper gas jet. The jet must be of metal. This is indispensable. Turn on and light the gas, which will burn *above the* handkerchief without injuring it (Fig. 57). To succeed in this experiment it is necessary that the handkerchief should fit quite closely to the metal without any crease whatever. It will be found advantageous to tie the batiste with a thin copper wire.

THE METAL IN THE PENHOLDER.

There is another very easy way of evidencing the

Fig. 58.—Carbonization of Paper on the Wooden Portion of a Penholder.

conductibility of metals for heat. Take a wooden penholder with a metallic end, and fix a piece of paper partly on the wood and partly on the metal. Heat the paper above the flame of a lamp. The paper will carbonize at the side on which it adheres to the wood—a bad conductor of heat—but it will remain unchanged, and preserve its whiteness on the side which is in contact *with the* metal.

Metals strike cold when we place them in our palms; by their conductibility they draw the heat from our hands. We do not experience the same effect when we touch wood or cloth.

A silver spoon will be burning hot after being dipped in a cup of boiling coffee, but an ivory or wooden spoon will not be so heated.

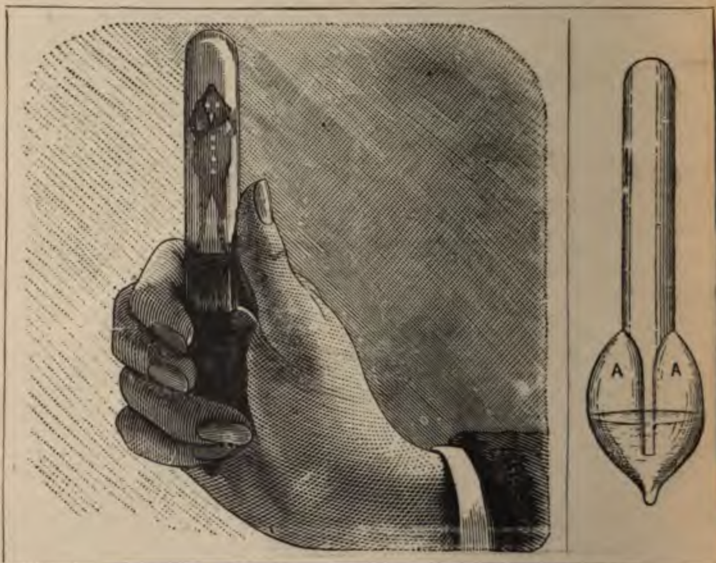

Fig. 59.—The Captive Imp.

Dilatation of Bodies by Heat.

THE CAPTIVE IMP.

This consists of a tube of thin glass, like a shade, as in illustration, the lower extremity being rendered opaque by a coat of black varnish. The lower portion being held *in the hand*, the liquid with which the receptacle is filled

ʼill immediately rise and sustain the small image of blown ǀlass which is contained in the tube.

All gases expand under the influence of heat. Now ʼe perceive in the section of the apparatus (Fig. 59) that the upper tube terminates in a capillary tube which is

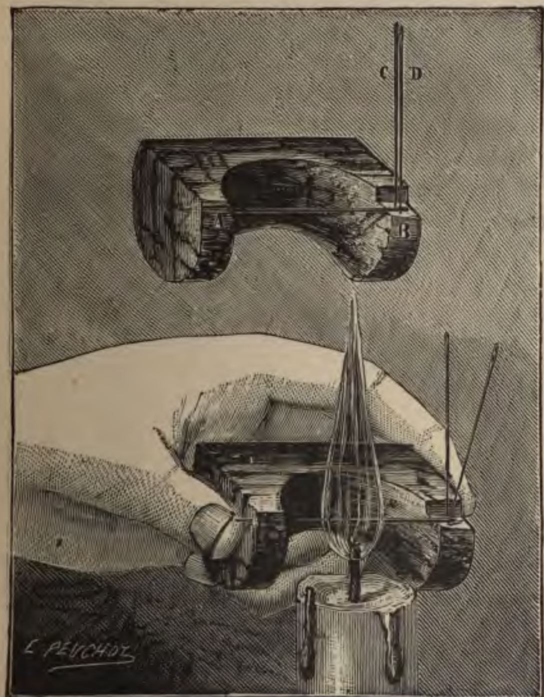

Fig. 60.—Experiment in Linear Dilatation.

ımersed in the bulb underneath. A certain quantity of ŗ is enclosed in the portion A A in the bulb. If this ıpply of air be warmed by the hand it expands, presses ɔon the water in the tube, and it rises with the floating ıp.

LINEAR DILATATION.

Cut a cork in the manner shown in the illustration (Fig. 60), so as to form a plane surface, and "scolloped" out in a semi-cylindrical form. In one of these hollowed spaces at A place a needle A B, the head of which is supported at B, and at a slightly less elevation at that end. Through the eye of this needle pass another, and insert its point lightly in the cork. Parallel to it, and behind it, place another needle of the same length. If we hold a lighted candle beneath the horizontal needle, we shall see the needle B C incline sideways, as in the illustration.

CHAPTER VI.—LIGHT, OPTICAL ILLUSIONS, ETC.

REFRACTION—VISION AND OPTICAL ILLUSIONS—PERSISTENCE OF IMPRESSIONS ON THE RETINA.

REFRACTION.

TO illustrate refraction we have only to plunge a stick into water and it will appear broken. We can also place a piece of money at the bottom of a basin and stoop until the coin is no longer visible. If then some one pours water into the basin the coin will appear, as if the bottom of the basin had been raised.

THE MIRAGE.

Amongst the optical experiments easy to make we may instance those relating to the curious phenomenon of the mirage. If we warm an iron plate, and look beyond the column of heated air which arises from the plate, we shall see the object we are gazing at deformed, or its image will appear in a different place from the true object. These effects are due to the difference in the density of the air-strata through which the visual rays pass. This is the effect whereby the traveller in the desert is deceived when the sun is very hot.

HOW TO MAKE A FLORIN APPEAR LIKE FIVE SHILLINGS AND SIXPENCE.

This experiment requires for its performance a tum-

These optical illusions are numerous, and present to usmany opportunities for amusement ; as follows :—

THE WHITE AND BLACK SQUARES.

The illustration herewith presents to us (Fig. 62) a white square on a black ground, and a black square on a white ground. Although the squares are precisely of the same dimensions, the white one appears to be the larger.

Fig. 62.—The White appears larger than the Black.

Fig. 63.—The Angles of the White Squares seem to Unite.

For designs formed of white and black squares, like those of the draught-board (Fig. 63), the angles of the white squares unite by irradiation, and separate the black squares. If we look at a draught-board in its entirety the effect will be more fully appreciated.

THE DIVIDED LINES.

We will now show an experiment of another kind which gives rise to some comment.

A divided space appears larger than when it is not

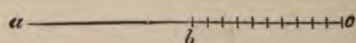

Fig. 64.—*a b* appears equal to *b c*.

divided. So thus in the cut (Fig. 64) one would say hat the length *a b* is equal to *b c*, while in reality *a b* is nger than *b c*.

The reader may satisfy himself of the exactitude of the measurement ; when the lines are drawn on a larger scale the illusion is more striking. We recommend our readers to try the effect for themselves.

LINES AND ANGLES.

The illusions relative to parallel lines are appreciable when the distances to be compared take different directions. If we look at A and B (Fig. 65), which are both

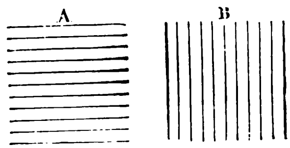

Fig. 65.—A and B are perfect Squares.

perfect squares, A appears higher than it is wide, and B appears wider than it is high.

It is the same with angles. Look at Fig. 66. The angles 1, 2, 3, 4, are *right angles*, and ought to appear so when examined with both eyes. But 1 and 2 seem to

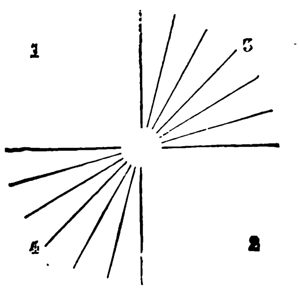

Fig. 66.—The Angles 1—4 are equal.

be acute, and 3 and 4 obtuse angles. The illusion will be intensified if the diagram be looked at with the right eye.

Certain analogous illusions are daily presented to us.

For instance, an empty room appears smaller than wh furnished, a papered wall appears larger than a naked w a dress striped crossways makes the wearer appear big than when the dress is striped downwards—lengthways.

Fig. 67.—The Height of the Hat.

THE HAT EXPERIMENT.

A simple amusement consists in requesting some to measure the height of your hat on the wall from floor. Generally the person addressed will indicate and a half times the actual height if unacquainted w *the trick.* In drawing the illustration (Fig. 67) for experiment we were astonished to find that the design reproduced the same illusion. The plinth in the illustration is exactly the same height as the hat, but one would scarcely think so when looking at the two objects. The measurement can be verified with a compass.

THE THREE GREAT MEN.

Which is the tallest of the three figures in the annexed illustration ? (Fig. 68.)

If you trust only to your eyes you will certainly reply, "Number 3." Well, then, take a graduated scale and measure the figures, and you will ascertain that your vision has been playing you a trick, and that Number 1 is the tallest of all.

M. Viallard, Professor of Physics at Dieppe, who brought this curious effect to our notice, gave us at the same time the explanation of it, which is as follows :—

Placed in the midst of carefully calculated vanishing lines the three *silhouettes* are not in perspective. Our eyes, accustomed to perceive objects diminish in proportion to their distance from us, and believing that Number 3 is elevated, come therefore to the conclusion that the third figure must be the tallest of the three. It is an optical delusion.

There is in this illustration, then, a fault in drawing, purposely committed, which deceives the spectator, and produces in his vision an inverse effect from that which would be obtained with a correctly-drawn sketch.

The origin of the design is not less curious than the drawing itself. It did not emanate from the portfolio of a scientist, but from the warehouse of a firm of Soapmakers who printed their name in perspective between the vanishing lines, and published the drawing in a number of newspapers in Great Britain and America.

Fig. 68.—Optical Illusion—Which is the tallest of the Three?

(By permission of Messrs. A. and F. Pears.)

The Soap-merchants completed this telling advertisement by giving the three figures the "counterfeit presentiments" of Lord Randolph Churchill (1), Lord Salisbury (2), and Mr. Gladstone (3). We have reproduced the illustration by permission of the proprietors of the picture.

THE MAGIC RINGS.

Fig. 69.—The Magic Rings.

The rings, which we reproduce from a photograph, give birth to a curious illusion, which may be included in the class of phenomena which we have been studying. These rings are made of metallic coils, each alternate "strand" being of a golden and silvern hue, and brilliantly polished.

The rings are of equal diameters, the coils of equal thickness, *and absolutely* parallel. Now when we look at one of the rings sideways, the coils seem to come closer near the bottom, and the ring appears thinner there than at the top, and when the ring is turned round the finger the illusion is produced at the same point. The ring at the left of the illustration gives some notion of the illusion, but the effect is much greater in the real ring.

In the three-coiled ring shown in the centre of the illustration the middle coil appears to lean aside, but the design does not reproduce the illusion as it is in actual practice. The right-hand ring merely shows the arrangement of the coils. It is not very easy to give an explanation to these facts.

The phenomenon is in great measure due to the reflection of the light on the rounded threads of the metallic coils. The light is reflected on the exterior border of the upper part, and in the middle of the coil in the lower part of the ring. The left-hand ring shows this plainly.

Other objects probably would facilitate the study of this illusion. Skeins of silk of various colours rolled round a hoop or ring would afford the same effect. It would be necessary to be careful in the blending of the colours so as to produce the proper result. By adopting this suggestion many amusing experiments may be attempted. But in any case, the ring represented can be obtained at most jewellers' shops at a small cost, and the experiment may be tried.

Persistence of Impressions on the Retina.

THE IMP ON THE CEILING.

This experiment, which can be performed with the aid of the next illustration, is one appertaining to the principle of persistence of impressions on the retina, to which must be added that of complementary colours.

Look steadily with both eyes at the white figure in the illustration, on a black ground, particularly keeping your gaze fixed on the band in the centre ; then, just when your eyes are beginning to feel tired—say in half a minute—look up to the ceiling, and in a few seconds you will perceive the outline of the imp, in grey, on the ceiling, repeatedly.

This experiment will gain by being made in a strong

Fig. 70.—Figure for Experiment of Persistence of Impressions on the Retina.

light. If the imp be *red* in the *silhouette* the impression will come out in *green*, which is the complementary colour of red. It is rather comical when a number of people try the experiment simultaneously, all with heads in the air waiting for the imp to appear. A card, such as the ace of hearts, may replace the design, and instead of the ceiling, a sheet of white paper may be looked at after the figure has been studied. This experiment be varied to any extent—a white, black, or green im will be reproduced in the complementary blue, white red. If painted green on a red ground the result appear as red on green. The annexed illustration colou will suffice for any experiments.

Fig. 71.—The Mule Rigolo.

THE MULE RIGOLO.

We have seen on the boulevards a very simple troptic apparatus represented in the cut above (Fig. It is composed of four panels of cardboard, mounte a right angle around a hollow axis. This cardbo arrangement can be put on a vertical stem, fixed on a pedestal, on which it turns with ease. Each panel contains a zootropic design, and the impression of each figure on the retina gives the spectator the idea of a single figure with different action ; at the different periods of a movement comprised between its extreme limits.

Fig. 72.—The *Silhouette* Portraits.

THE SILHOUETTE PORTRAITS.

Take a large sheet of paper, black on one side and white on the other. Fix it by means of pins to the wall so that the white surface is outermost. On a table close by place a good *lamp*, and let the person whose portrait you wish to take stand between the lamp and the sheet of white paper. You can then outline the profile with a pencil. Cut out the design, and, turning the paper, gum the drawing black side outwards on another sheet of (white) paper. Your portrait will then be mounted, and the *silhouette* will show very well in black.

TO VARY THE SIZE OF A HALFPENNY.

Take a rectangular box of white wood, and in one side

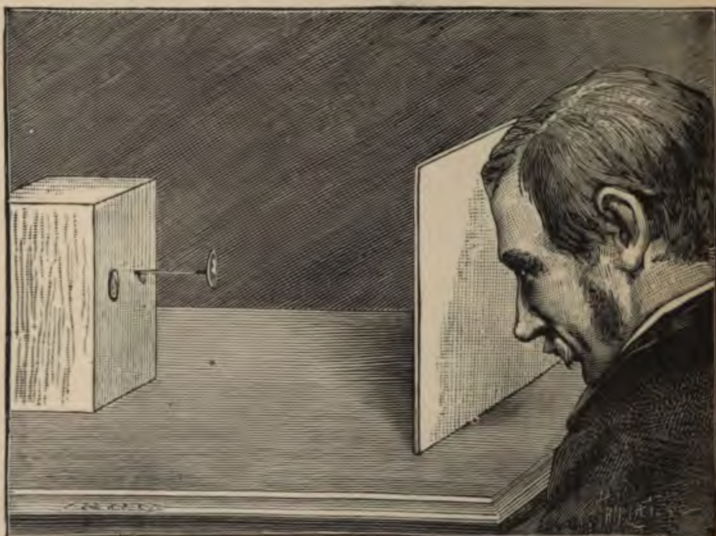

Fig. 73.- Mode of Equalizing the size of larger and smaller Coins.

of it fix a nail or bodkin, to which attach, with wax or other substance, a halfpenny. Beside this halfpenny, but *on the surface of the box*, fasten a farthing. If you gaze at these two pieces of money through a small circular hole in a piece of cardboard (as in Fig. 73), you will not be able to distinguish one coin from the other. They *will both* appear the same size.

Of course the distance at which the coins must be placed will depend upon the powers of vision of the spectator. It is as well to fix the cardboard screen, and then move the box farther or nearer, as may be desirable. A time will come when the two coins will appear of equal size; but by gradually lessening the distance the farthing will actually appear larger than the halfpenny.

This experiment demonstrates that the eye under the conditions indicated is unable to appreciate the distance between two objects. By a similar phenomenon the moon, when viewed through an astronomical telescope, appears smaller than it looks to the unaided eye, while as a matter of fact it is magnified by the telescope.

CHAPTER VII.—ELECTRICITY AND MAGNETISM.

WE will now reproduce a few experiments in electricity, and commence with

THE ELECTRIFIED PIPE.

Fig. 74.—Pipe attracted by an Electrified Glass.

Place a clay pipe in equilibrium on the edge of a glass in such a manner that it may oscillate freely. The problem now is to make the pipe fall without touching it, blowing upon it, or agitating the air, and without moving the table.

Take another glass, similar to that which supports the pipe, and rub it rapidly on the sleeve of your coat. The glass will be electrified by the friction, and when you have rubbed it well bring it close to the pipe without touching it. You will then see it turn after the glass and follow it till it falls from its support.

THE PAPER PUPPETS.

We will now explain the means of obtaining some electrical manifestations of great simplicity in performance, such as the "dance of the paper puppets."

Procure a square of glass and two volumes sufficiently large to support the plate of glass in the manner shown in the picture (Fig. 75), about an inch from the table. Then cut out of rice-paper or silver paper any figures you choose—frogs, men, women, children, or any animals. These little figures should not exceed three-quarters of an inch in height. We give some specimens of larger size in the upper part of the illustration. They can be cut out of different coloured papers, which will improve the experiment.

Place these little people in their ball-room—that is to say, beneath the glass which you have supported above the table, lying side by side on it. Then rub the plate of glass vigorously with a silk rubber (silk is best), and after a while you will see the paper figures jump up to the ceiling of their "ball-room," attracted by the electricity which you have developed in the glass by rubbing. They fall again and are again attracted, impelled to an extravagant *dance*. Even when the rubbing ceases the dancing will continue for a certain time, and the contact of your hand with the glass will be sufficient to animate the little dancers.

To ensure the success of this experiment the glass must be *perfectly dry*, as well as the handkerchief or

Fig. 75.—The Dance of Dolls.

rubber with which you operate; and if the table be warmed the manifestation will be more successful. Silk is better than cloth for rubbing purposes.

THE MAGICIAN.

The little toy depicted in the illustration is based on the property of repulsion possessed by the opposite poles of magnets. It consists of a magician, or "diviner," fixed on a pivot upon which he turns easily. A series of questions are written on the pieces of cardboard, which are introduced into the pedestal on which the magician stands. These cards contain magnets properly placed,

Fig. 76.—The Magnetized Magician.

and when a card is put into the pediment of the figure the magician turns the magnet in the form of a horseshoe (U) hidden in his dress, obeys the influence of the other magnet in the card, and with his magic wand he indicates a number in the circle which surrounds him. The number corresponds to those on a list of answers supplied *with the* apparatus.

CHAPTER VIII.—CHEMISTRY WITHOUT A LABORATORY.

WE have in foregoing pages shown the possibility of practising a course of physics without apparatus; we now propose to perform some experiments in chemistry without the aid of a laboratory, and only with the assistance of a number of simple and inexpensive articles. The preparation of gases, such as oxygen, hydrogen, and carbonic acid gas, is very easy and very inexpensive. We have merely to procure some glass tubes, a few phials, and a number of sound corks, which we can pierce with a round file called a *rat's tail.*

For "furnace" we can easily make a spirit lamp from an ordinary penny glass ink-bottle, which we fill with spirits of wine, and fit with a metal top, in which we punch a hole to permit the wick to ascend through a metallic pen-holder. Our heating-apparatus is then complete.

OXYGEN AND HYDROGEN

The ancients believed that earth, air, fire, and water were the four elements; but they were mistaken, for each of these so-called elements is composed of other bodies. Thus—water is composed of two gases, oxygen and hydrogen, which we may now proceed to prepare. To make oxygen it is only necessary to warm in a glass tube a mixture of chlorate of potash and the bi-oxide of manganese. Oxygen is contained in water, but it is also contained in air; it supports the respiration of animals and the combustion of burning substances. After we have warmed our glass tube for a while we may perceive the escape of the oxygen from it by putting the incandescent point of an extinguished match in the tube: the match will at once be re-lighted, and burn under the influence of the oxygen.

Fig. 77.—Preparation of Oxygen.

To prepare hydrogen gas—another of the constitutional elements of water—we must decompose the water by a metal, such as zinc or iron, under the action of sulphuric acid. Procure a glass vessel with three tubes, which can be closed with corks. One of these is furnished with a funnel, into which we may pour sulphuric acid and water; another tube is furnished with a removable tube with a *fine point, through* which the hydrogen gas escapes. The glass vessel is half filled with zinc filings. When the sulphuric acid and water come in contact with the zinc filings an effervescence due to the disengagement of the gas is produced.

Care must be taken that the air in the glass receptacle for the hydrogen gas is expelled, else there will be an explosion, for air and hydrogen gas form an explosive

Fig. 78.—Iron Filings burning in a Jet of Air.

mixture. When the air has been withdrawn the hydrogen gas can be lighted at the extremity of the tube.

Hydrogen is a *combustible* gas ; oxygen is a *supporter of combustion.* The latter is the active constituent of the air, and by its aid iron filings can be burned in the flame of a candle driven by the action of a blow-pipe, formed by a common clay pipe, as in the foregoing illustration (*Fig 78*).

AIR AND ITS ELEMENTS—CARBONIC ACID.

Air contains oxygen and azote (nitrogen), a heavy gas which extinguishes bodies in combustion ; the air also contains a small quantity of carbonic acid, which we

Fig. 79.—Soap-bubble floating on the Surface of a Layer of Carbonic Acid Gas.

can ascertain by a very pleasing experiment, at the same time proving the density of gas and the equilibrium of floating bodies.

Take a large glass—a soda-water glass or some wider tumbler—and support it on a tripod or in some other secure way. At the bottom of the glass vessel put a thin layer of bi-carbonate of soda and tartaric acid, mixed in equal quantities. The quantity of the powder employed will depend upon the thickness of the carbonic acid atmosphere which you wish to produce. One must proceed on the basis that the bi-carbonate of soda contains half its weight of carbonic acid, and consequently we must dissolve four grammes of the bi-carbonate to produce a litre of carbonic acid gas.

Over the glass vessel place a cardboard covering so as to fit it closely. The centre of this covering should be perforated so as to admit a small glass tube long enough to reach to the bottom of the vase and rise above the cardboard. By this tube and a small funnel we can pour in the *small* quantities of water, which must be successively introduced in order that the effervescence may not become too violent, and so that the powder may be quite covered with water. When the carbonic has ceased to disengage itself the glass tube may be withdrawn.

It must be supposed that a good lather of soap has been prepared beforehand, and with this mixture a bubble some two inches in diameter may be blown; then carefully let the bubble fall into the glass vessel perpendicularly. If this fall be from a certain height the bubble will rebound as if it had been repelled by a spring; then it re-descends and again ascends many times, and executes many vertical oscillations before it becomes motionless. At that moment the covering should be replaced, so that no agitation is produced within the vessel. The soap bubble floats upon the stratum of carbonic acid gas, which is invisible.

FORMATION OF SALTS—INSTANTANEOUS CRYSTALLIZATION.

We are aware that caustic soda or *oxide of sodium* is an alkaline production endowed with very energetic properties; it blisters the skin and destroys organic matter.

Sulphuric acid is endowed with not less destructive properties: a drop falling on the hand will produce intense pain, and cause a terrible burn; a piece of wood plunged into this acid is carbonised immediately.

If we mix forty-nine grammes of sulphuric acid and

Fig. 80.—Bottle containing a Saturated Solution of Sulphate of Soda. Crystallization is shown in the Decanter to the left of the Illustration.

thirty-one grammes of caustic soda a most intense reaction will set in, accompanied by a considerable increase of temperature; after the mass has cooled we find a substance which may be handledwith impunity; the acid and the alkali have combined and their properties have been reciprocally destroyed. The combination has given birth to a salt which is *sulphate of soda*. The result of the union exercises no action on litmus paper ; it in no respect resembles its parents.

In chemistry there is an almost infinite number of salts, which result from the combination of an acid with an alkali, or *base*. Some, like the sulphate of copper, or

Fig. 81.—Preparation of a Saturated Solution of Sulphate of Soda.

the chromate of potash, are coloured ; others, like sulphate of soda, are colourless.

The last-mentioned product, like the majority of salts, can assume a crystalline form, and if it be dissolved in *warm* water and the solution be permitted to remain *undisturbed* it will quickly precipitate in remarkable transparent crystals. This product, discovered by Glauber, is called the "admirable" or Glauber salts.

Sulphate of soda is very soluble in water, and at a temperature of thirty-three degrees the best effect is obtained. If we pour some oil on a saturated solution of Glauber salt and let the liquor remain undisturbed it will not deposit any crystals; but if we plunge into the solution a glass rod, penetrating the layer of oil, the crystallization will be instantaneous. (Fig. 80.)

This experiment is still more striking when the solution is acted on in a tube of glass, hermetically sealed, after having exhausted the air by the ebullition of the liquid. (Fig 81.)

As soon as the tube is closed the crystals will not form even at the freezing point; nevertheless, the salt being less soluble in a cold than in a heated atmosphere is in proportion ten times stronger than under ordinary conditions. If the point of the tube be broken crystallization immediately ensues.

TREE OF SATURN.

Lead, like tin, is capable of assuming a beautiful crystalline form. The crystallization of lead represented in Fig. 82, page 100, is known as the *Tree of Saturn*. The experiment is performed as follows. Form a solution of acetate of lead in proportions of thirty grammes of salt to a litre of distilled water, and pour the liquid into a cylindrical vase. Into the cork of this vase fit a piece of zinc, to which are attached five or six brass wires separated from each other; plunge these into the solution, and you will soon perceive the brass wires becoming covered with spangles of scintillating crystals of lead, which increase day by day. Alchemists who were aware of the experiment believed that there was a transformation of copper to lead, while it is really only a substitution of one metal for another. The copper is dissolved in the liquid and is replaced by the lead which is deposited, but no metamorphosis takes place. One may vary at will the form of the vessel and the disposition of the wires which

Fig. 82.—Tree of Satu n.

support the crystals of lead, and form letters, figures, etc., at pleasure.

TO PRODUCE GAS FOR LIGHTING PURPOSES.

If we burn, on a perfectly clean plate, a sheet of paper *we need* no more to convince us of the phenomenon of carbonization (the paper is transformed into a black mass) and the formation of empyreumatic products under the action of heat. Beneath the burned paper we shall find a yellow deposit, which clings to the fingers, formed by the oil of the paper produced in contact with the air by a kind of distillation.

We may produce coal gas very easily by filling a common clay tobacco-pipe with small coal dust, and covering


Fig 83.—Production of Gas with a Paper Cone.

the bowl up with fire-clay. Place the bowl of the pipe in the fire, and after a while the gas will evolve from the aperture in the stem. It can then be lighted. If the pipe be not available you may have recourse to a large piece of wrapping paper, which you must fold into a "horn of plenty" as in illustration. This will suffice for your "gasometer." Hold the folded paper by its pointed end, after having punctured a small orifice in the cone, near the upper part of it. Light the paper, it burns; but the heat developed by the flame produces distillation of the materials of the paper; the empyreumatic and gaseous products rise into the cone and escape by the orifice, where the gas can be lighted by a match. (Fig. 83.)

This experiment only lasts a few seconds, but its duration, brief as it is, will suffice to demonstrate the production of gas for lighting purposes by the distillation of organic matter. Of course fire must be guarded against when this experiment is tried, which it should not be in the vicinity of any inflammable matter.

THE GRAVEN EGGS.

Some time ago a man was seen selling eggs engraved with names and various devices. This egg-engraving recalls to us a curious historical fact.

In the month of August 1808, during the Peninsular War, there was found in the cathedral of Lisbon an egg, on the shell of which was engraven a prediction of the expulsion of the French. This caused considerable excitement, and nearly led to a riot.

The French commander caused a counter irritant to be applied, in the shape of thousands of eggs denying the prediction. The people did not know what to think; thousands of eggs denied the accuracy of one. Besides after a while posters were placarded on the walls giving the particulars and directions for working the miracle. The means are very simple.

Write your name or legend on the egg-shell on bees-wax or varnish, or even with tallow. Plunge the egg into a weak acid—vinegar will do, or diluted hydro-chloric acid, or *aqua fortis*. Wherever the shell is not protected by the covering material it is decomposed, and the design stands out in relief. There is no difficulty in this experiment, but some precautions are necessary.

As "blown" eggs are generally experimented upon it will be necessary to close up the ends with yellow or white wax; and as these eggs are necessarily very light they must be weighted to keep them in the acid bath, or

Fig. 84.—Manner of engraving an Egg.

held down with a glass rod. If the acid be very much diluted the operation, although it will occupy more time, will be more complete. Two or three hours will be sufficient to bring out the tracing.

Thus the miracle of the sorcerer has become an amusing and easy experiment in chemistry.

CHAPTER IX.—MATHEMATICAL GAMES.

THE DICE TRICK.

THIS trick, which always astonishes people who have not previously witnessed it, is based upon a very simple calculation. Few people know that dice are made and "printed" on a certain plan, which is that every face with the number of dots on the side immediately opposite shall, added together, make *seven*. This is the whole point of the trick. If there are two dice the total of the points on the opposed faces will be fourteen.

This ascertained, we may proceed and throw the dice. We find six, for instance, and we seize the cubes between the thumb and index finger (Fig. 85, No. 1). The performer knows at once that the total of the under faces is nine, but he takes good care not to show them. He quickly turns his hand to reach the position shown in Fig. 85, No. 2, but during the movement he has taken a "quarter turn" of the dice in his fingers, by slightly raising the thumb and lowering his fore-finger (as in No. 2). He then exhibits to his audience the points, eight, for instance, which the spectators think was the total underneath, but which is, in truth, the total of one of the lateral faces.

This point established the operator quickly resumes position No. 1, and replaces the dice in their first position by manipulation which is easily acquired by practice. Then he says, "I have just shown you that the points underneath are number eight, now I am going to add a point." Requesting a spectator to touch the dice so as to ensure the addition of the required unit, the operator takes his fingers from them to show that he will not alter their position (No. 5) when the dice are taken up. The sub-total is found to be nine instead of eight as before.

It is evident that in some cases points must be subtracted and not added. If one has begun with twelve, for instance, and that the *false* total is shown as nine, though

Fig. 85.—A Trick with Dice by a Turn of the Hand.

the *true* total is two, the performer must request an assistant to efface seven points instead of adding any.

Again, there are circumstances in which the true and false points are *equal*. Thus, when the upper total is ten the lateral face against the thumb is *double* five; and the *false* total will be four by the double two, while the *true* total will also be four, by three and one. So no addition or subtraction can be requested. In such a case one of the thousand deceptions practised by prestidigitators must be employed, and by simply letting the dice fall, "by accident," you may begin over again, and with another total.

THE TOWER OF HANOÏ AND THE QUESTION OF TONQUIN.

This game, which has attained great success, is in the form of a small pasteboard box, on which is inscribed the Tower of Hanoï, a real Chinese puzzle, brought from Tonquin by Professor Claus of Siam, Mandarin of the College of Li-Sou-Stian. A real puzzle truly, but interesting. M. H. de Parville was the first to introduce it. We borrow his lively description of it.

It is related that, in the great temple at Benares, beneath the dome which marks the centre of the world, one may see fixed in a brass-plate three diamond needles, a cubit high and as thick round as the body of a bee. On one of these needles God at the creation placed sixty-four discs of pure gold, the largest disc resting on the brass slab, and the others smaller and smaller to the top one. This is the Tower of Bramah. Night and day the priests are continually occupied in transferring the discs from the first diamond needle to the third, without infringing any of the fixed and immutable laws of Bramah. The priest must not move more than one disc at a time, he must only place this disc on an unoccupied needle, and then only on a disc larger than it. When according to these rules the sixty-four discs shall have been transferred from the needle on which the Creator placed them to the third needle, the tower and the Brahmins will all crumble into dust, and that will be the end of the world.

It was this legend evidently that inspired the Mandarin of Li-Sou-Stian. The Tower of Hanoï is the Tower of

Bramah, only the diamond needles are replaced by nails, and round blocks of wood substituted for the golden

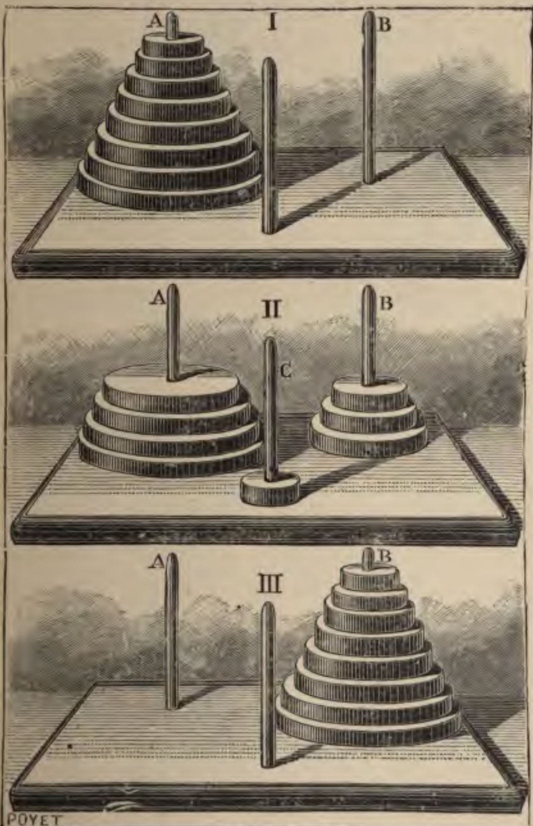

Fig. 86.—The Tower of Hanoï.

I. Beginning of the Game : the Tower complete. II. Process of Transposition : the Discs are placed Successively on the Sticks A, B, C. III. End of the Game : the Tower is rebuilt at B.

discs. The blocks of wood, of decreasing circumferences, are only *eight in number*, and that is quite sufficient. If the trick were to be attempted in the manner of the Brahmins, with sixty-four discs, it would be necessary

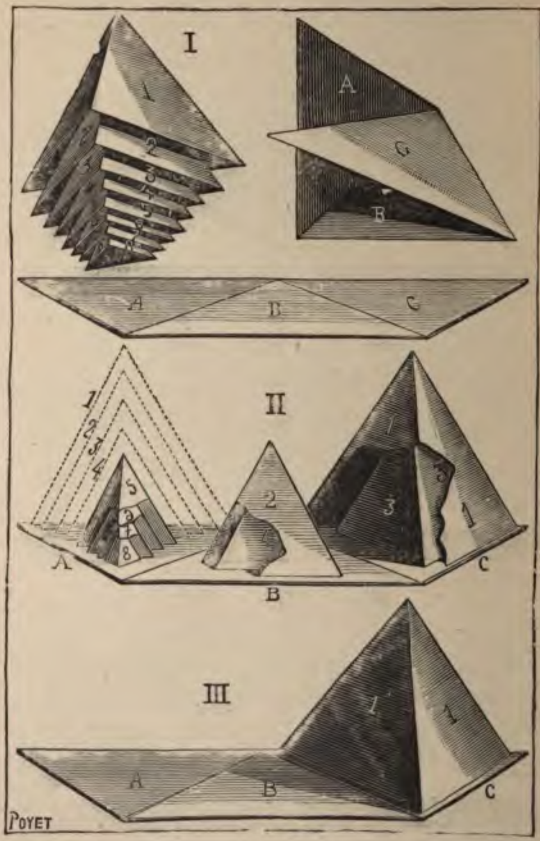

Fig. 87.—The Question of Tonquin.

I. Cardboard Pyramids 1—8 with their Supports A, B. C. II. Course o Proceeding, showing the Superposition of the Pyramids, which must tak place in Transit. III. End of the Game: the Pyramid is rebuilt at C.

to move them as many times as expressed i the bewildering row of figures following—viz.

8,446,744,075,709,651,615—a task which would occupy ore than five thousand millions of centuries in accomlishment.

With eight discs it is necessary to make two hundred nd five transpositions, and allowing for each movement ne second of time, four minutes will be required to ansport the "tower." Let us put this into practice. It ill be conceded that in order to transfer two discs three novements must be made, for three discs seven movenents, that is to say double each number of discs noved *plus* 1. For four discs fifteen movements—louble *plus* 1, and so on. So to move all the eight locks we must make two hundred and fifty-five moves.

This ingenious game is founded upon the elementary problem of combinations. Newton gave the world a general and now well-known formula—the Binomial Theorem. But the ancients long before his time knew how to find the correct expression for the number of combinations which they could obtain with eleven letters of the alphabet. The number of combinations possible with four letters is equal to 2^4 minus 1; with five letters t is equal to 2^5 diminished by a unit, and so on. With eight letters, or eight discs, the same rule holds; 2^8 diminished by one unit is equal to 254. A tower of nine discs would necessitate the same double number of displacements *plus* 1, or what is the same thing—$2^9—1$, hat is 513 moves, and so on.

The Tower of Hanoï brings to our recollection the ring uzzle, which appears in a volume which we have already nentioned, entitled *Mathematical Recreations*, by Mr. Edward Lucas, Professor at the College of St. Louis. This reminiscence comes to me very opportunely, as I hink I have discovered the name of the Mandarin, the nventor of the Tower of Hanoï. One is only betrayed y himself. A Mandarin who conceives a game founded on combinations would be perpetually thinking of and seeing combinations everywhere. Now, in examining the letters inscribed on the box containing the Tower of Hanoï, it seems to me that without much difficulty we

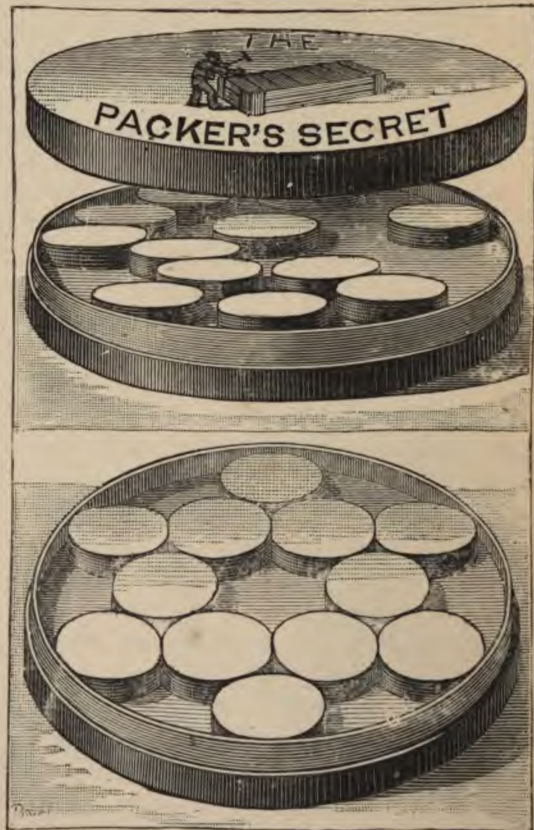

Fig. 88.—A Mathematical Game—The Packer's Secret.

can transpose St. Claus (of Siam) Mandarin of the College of Li-Sou-Stian, into Lucas d'Amiens, Professor of the *College* of Saint Louis! Have I also solved my problem, *I wonder?*

Since the conception of the Tower of Hanoï we have found another analogous game, called the *Question of Tonquin*, a game of Chinese hats. This puzzle is composed of pasteboard pyramids of decreasing sizes (as in Fig. 87 on page 108), which must be manipulated in the manner already related with references to the discs and the foregoing illustrations.

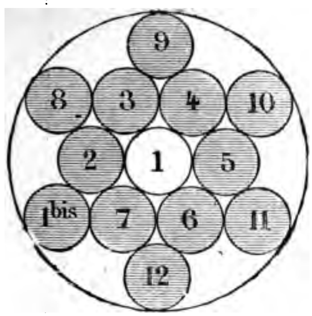

Fig. 89.—Explanation of Method of Packing.

THE PACKER'S SECRET.

This ingenious game consists of a cardboard box containing twelve wooden discs, which lie loosely in their receptacle as on the upper portion of the foregoing illustration (see Fig. 88, page 110). The problem to be solved is this. Place the twelve pieces in the box in such a manner that they will remain immovable, and will not fall out even when the box is turned upside down without the lid.

The solution consists in placing the discs tangentially, and the puzzle can be performed by arranging them as shown in the cut above (Fig. 89). All the "men" thus sustain each other by gentle pressure, and the box may be shaken without any one of them falling out. To *perform this puzzle* one must understand, in some measure, the packer's secret (see Fig. 89). We place one disc (No. 1) in the centre, and dispose around it six other discs, 2, 3, 4, 5, 6, 7. Steady these with the left hand, so that they will not move except *en bloc*, and then insert the remaining pieces 8, 9, 10, 11, 12 around them, next the circumference of the box. Then remove the disc No. 1 from the central place, and put it where 1^{bis} is resting. The twelve discs will then remain firm in their places. The puzzle is solved!

CHAPTER X.—NATURAL SCIENCE IN THE COUNTRY.

THE manner of constructing an aquarium has already been described, but we will here show a charming apparatus which will be both aviary and aquarium combined. Procure a large melon-glass, as shown in Fig. 91, page 114; and into it introduce a cylindrical glass vase, in which you have

Fig. 90.—Aviary Aquarium.

previously placed some pieces of lead or other metal painted green, etc., so as to suggest the bed of a fountain or a clear stream. Upon the bottom of this vase rest a movable "perch" with a foot—a metal one will serve. Over the mouth of the melon-glass place a wire-work

Fig. 91.—Birds in an Aquarium.

screen, with meshes wide enough to admit air to the birds, and finally place pots of flowers around the grill to embellish it. Place the aquarium glass thus prepared on a pedestal or rest suitable to your apartment, and when all is ready introduce gold and silver fish into the melon-glass and a pair of birds into the cylindrical vase within it. The flowers will close the mouth of the glasses, so you will possess an aquarium, aviary, and garden in one ;

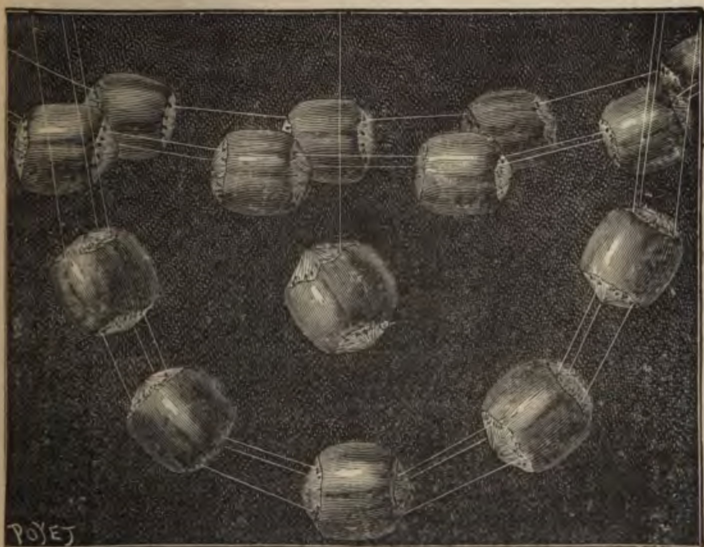

Fig. 92.—Necklace of Nuts suspended by Hairs.

and also produce a curious effect, as the birds will be seen living apparently in the water with the fishes.

We can also produce a still more surprising effect as shown in Fig. 90. A balloon-glass is reversed into an ordinary glass aquarium vase. The neck of the inner vase, sufficient to admit air, is concealed at the foot of the aquarium by plants and by the opaque base, which seems to support the globe. When the water and the glass are clear the illusion is perfect.

A COLLAR OF NUTS.

If we closely examine a nut we shall perceive clearly some inequalities on its surface which look like little cavities. Not only are they cavities, but they also correspond to small excavations which traverse the nut within—little tunnels, in fact. If you scratch the superficial cavity with a penknife you will open up the entrance to the little tunnel, and you will be able to pass a hair through it, fastening it by its root, which will not penetrate the nut. To pass a hair through a nut, and even to pass many hairs through nuts, were problems which we confess we at one time regarded as visionary: but we have seen them performed by skilful hands. With dexterity and patience, with some lady's hair, we can make collars and necklaces like those shown in the illustration.

This proves that nuts are full of perforations, and whether the fact be known or not to botanists, amateurs may derive some amusement from the exercise of their dexterity on the fruit.

CHAPTER XI.—MECHANICAL TOYS, ETC.

ACROBATIC APE.

AMONGST the most amusing of modern mechanical toys this takes a foremost place. The inventor has succeeded in reproducing very effectively all the movements of a man climbing up a rope. Hitherto the puppet has always been more or less stiff in his movements, but in the toy under notice it is completely independent and free. Just suspend the cord or hold it in the left hand and pull it with the right hand—the puppet will then ascend. Notwithstanding the complicated nature of the movements produced the system is very simple: it requires only a single articulation at D to permit the motions of the limbs. A kind of catch or spring V, in which the cord fixes at certain times, simulates the grasping of the hands. The movement of the legs towards the body is effected by the india-rubber band R (No. 2), fixed in the chest and thigh of the figure.

We must now proceed to explain the mechanism which produces the ascending movement of the puppet. Suppose the cord suspended, the figure is at the lower end: we can describe the cycle of ascent in three phases.

First Phase.—The figure is in the position indicated in No. 1 in the illustration; his limbs are drawn up by the tension of the india-rubber band. You will see that when the string is pulled the limbs will pivot round the points A and B, and the puppets will assume the position represented in No. 2, the body having slid along the cord, which it cannot get away from because of the peg C, which only permits a movement along the string. It is the movement of a climber moving upright on his legs. The fork V stops the cord at the end of the climb imitating the prehensile movement of hands.

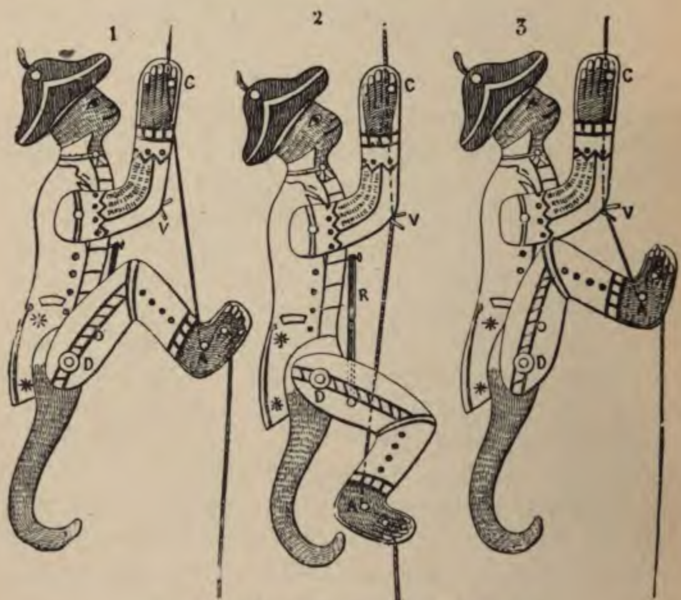

Fig. 93.—A Mechanical Toy. The Acrobatic Ape.

1. Position at starting : pull the Cord and the Puppet will assume Position 2.
2. End of Ascension Motion. The String is caught at V. The India-rubber pulls up the Legs (3).
3. Puppet suspended by V. Pull the Cord, and the Figure resumes Attitude No. 1.

Second Phase.—When we loose the cord the puppet remains suspended by V, the limbs being again drawn up by the india-rubber, and it assumes the position as in No. 3. This is the climber suspended by his hands, and *gathering* up his legs.

Third Phase.—If we pull the cord again it escapes from V and reassumes the position as in No. 1, as already described. By pulling the string the various motions are continued until the puppet has reached the end of his tether.

It is important that the cord should in the first phase be pulled until it is finished in V. If not the puppet will slide down again as soon as the pull is intermitted,

Fig. 94.—The Road Locomotive, illustrating the Principles of Inertia and Motive Power.

because it will have to be in the position of a man who has not gripped the rope with his hands.

THE ROAD LOCOMOTIVE.

Every one is aware that to impart a certain velocity to a given mass a certain amount of energy must be deve loped—an energy in proportion to the mass and to th square of the velocity which is imparted to it. We als know that bodies thus animated do not return to a condition of repose until they have exhausted the power or force imparted to them, and in the cases of bodies whose friction is reduced to a minimum the energy will be slowly exhausted ; the motion will continue for a long time.

We can utilize this force by putting in motion a wheel by a system of impulse by pulling, finally producing progression, as evidenced in the little apparatus illustrated (Fig. 94). It is composed of a fly-wheel V, to which a rapid rotatory movement is imparted by a thread or string wound round it. The wheel acts on the two trailing wheels of the engine, furnished with adhering tires. The axle which acts on the wheels is about $\frac{1}{20}$th of an inch in diameter, and the wheel about two inches, so it results that the velocity of the small wheel is much greater than the larger, and the latter moves only $\frac{1}{40}$th as fast as the former. The initial velocity of the small wheel is, however, very great, and the machine moves with considerable speed until its impetus dies away. On a level floor it will run rapidly and for a long while. The same principle has been applied to many other toys popular in England and France. The hind wheels are the motive power, the others are only supporters.

TO LIFT A MAN WITH FIVE FINGERS.

This is a school-boy pastime, and consists in one individual being lifted and sustained by the fingers. Two operators put their index fingers under the person's boots, two others place their fingers under each elbow, and a fifth under the chin of the subject. At a given signal each person lifts his hand and the person is easily lifted up *(Fig. 95)*. The result may seem very surprising, but it is *only* a question of the equal sub-division of weight. The ige human being weighs about 70 kilogrammes, or eleven stone; so each finger has only to sustain about bs. weight (10 kilogrammes) which is nothing extraiary.

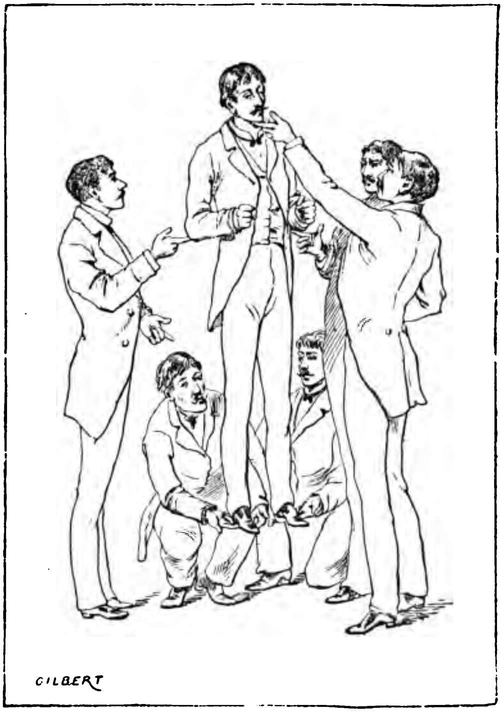

Fig. 95.—A Man held up by Five Fingers.

ATTRACTION.

Take a cork and fix in it three hairpins, so as to for pecies of tripod. In the centre fix a knitting-nee on this fasten a sheet of paper cut as shown in stration Fig. 96.

We have now two surfaces of paper A and B, s ordinary sulphuric acid of commerce. When it is s cientiy liquefied the figure should be traced on the g with a quill-pen. Leave it for a few minutes—five to at the most. Wash the glass and dry it well. T when it is breathed upon the figure or design will app

Fig. 98.—Fantoccini Top.

A little experience will decide the length of time requ for the proper production of the figure: the acid if too long will eat into the glass, and the design will re *visible even* on the dry surface.

A FANTOCCINI TOP.

This apparatus is composed of four small triangular mirrors, whose surfaces form a square-based pyramid. The sides of this base are precisely double the height of the pyramid. The mirrors are set at an inclination of 45°.

At the apex of the pyramid, which is somewhat truncated, are placed successive discs of cardboard, on which are painted divers figures in various attitudes. Rotation at a moderate speed, by means of the handle at the upper extremity, will bring the reflections of the figures in succession before the eyes of the spectators, and every figure will appear to be moving. So a girl skipping, a dancer, or a gymnast on a trapèze, a horse leaping a bar, etc., may all be seen in rapid succession.

A SMALL LOOM MADE WITH CARDBOARD.

When we see a weaving-machine at work we admire the ingenious mechanism, but we are unable at first to seize the fundamental principles of its working. We will now endeavour to show the working of the loom by the very best method that can be imagined, viz., that which consists in making the apparatus for oneself, and weaving a piece of tissue with it.

Two pencils, a visiting-card or playing-card, some thread, a good knife, and, if you please, a wooden paper-knife,—that is the whole of the material for our apparatus. Our loom consists of two pencils, which serve for beams; a comb (or "heddles") cut out of the card by the penknife into a kind of grating, on which longitudinal openings alternate, with small circular holes. The apparatus is completed by two shuttles cut from the same cardboard, on which are wound the cotton for the weft which is destined to pass across the warp-threads.

Place the pencils at the edge of a table, and, supported by some books, as shown in the illustration herewith (Fig. 100). Then you may commence by attaching to one of the pencils one end of the thread of the warp, and by means of a needle pass it through the first slit in the "comb," then turn it around the second pencil, returning below it and passing it through the first circular hole in the comb. Then around the first pencil and

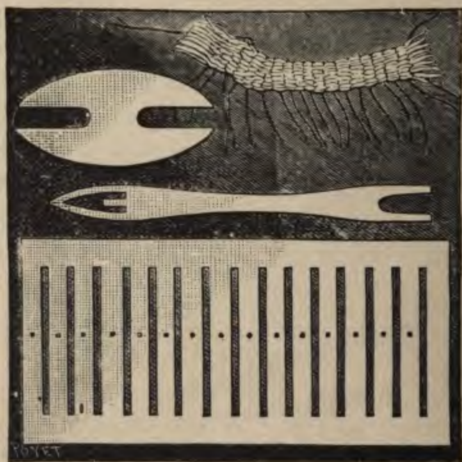

Fig. 99.—Shuttles and Comb cut from Card; above is a Specimen of the Material wov…

through the second longitudinal opening, and so on, until the last hole in the comb is reached, as represented in the illustration (Fig. 100).

Now, to proceed to our weaving, we have only to raise and lower the comb alternately; and we shall perceive that the only threads engaged will be those which are drawn through the holes. It now remains for us to pass, between each movement, the shuttle full of the thread of *the weft* between the two lines of the warp threads placed at different elevations. We may use the paper-cutter as a "batten" to drive home the shot. This little apparatus will enable you to comprehend the mechanism of the loom, and may be regarded as at once a medium of amusement and of information. With patience we may weave some material by its aid.

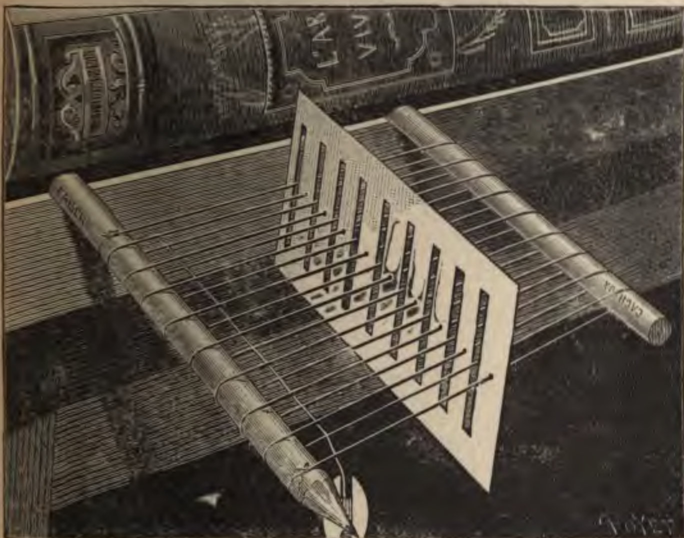

Fig. 100.—The Loom ready: showing the "Comb" between the Pencils. The Warp is extended between the Pencils: the Thread of the Weft passes transversely by the Aid of the Shuttle.

THE PAPER RINGS.

This little arrangement, whichwe are abo ut to explain will create some astonishment amongst those who have not been initiated in the manner of performance; it gives rise to some very interesting geometrical questions. We will show how it is done.

Look at the illustration (Fig. 101). Here are three paper rings. They ought to be in reality of much great

diameter in proportion to their length, but in the cut w
have reduced the circumference so as not to insert such
large picture as would be necessary if the true dimensio
were given.

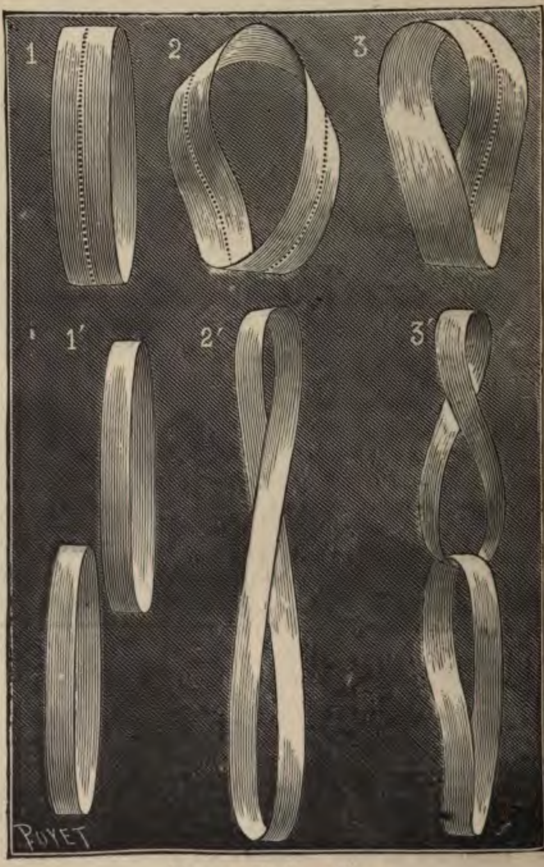

Fig. 101.—The Paper Rings.

Firstly, I give you ring No. 1 with a pair of scisso
and request you to cut it as indicated by the dott
ne. You will then obtain two rings, as shown unde

neath—No. 1′. The dotted line will not be in the paper bands in practice.

Then I request you to cut ring No. 2 in the same manner; but this time you will be surprised to find in your hands, when you have finished cutting round the ring, not two rings, as at first, but one long ring—No. 2′—twice as large as either of the former rings.

Now for No. 3′. There is another surprise in store. As you cut the third ring you will be astonished with the result. You will again obtain two rings, but one will be looped inside the other, as in No. 3′. Let us explain this trick.

You must prepare paper bands 0.05 mètre in width, and 1 or $1\frac{1}{2}$ mètres in length. Take the first strip, cut and join its ends directly in the ordinary manner, as shown in fig. 1, so that the same side of the paper forms the exterior of the ring all round. The second band is united after it has been twisted on itself, so that one of the ends is united with the opposite surface of the other extremity; as for the third band, you must give it two turns before you unite the ends. Let the gum dry, and then your apparatus will be ready. The larger the rings are the less apparent will be the turns in them.

A MECHANICAL PAPER BIRD.

The art of making paper articles would necessitate a long study on our part, and we do not intend to enter on the various phases of it here. We know that many things can be made in paper, but the particular object which we are about to explain is a mechanical bird introduced by the Japanese jugglers—a bird which will flap its wings when manipulated. The illustration shows the action of the hands, which, approaching and separatin alternately, make the bird flap its wings. The other designs indicate the progress of construction as follows:—

Take a sheet of ordinary writing paper and cut it so that it will form a perfect square. Fold this, as indicated in No. 1, by the middle and the angles, and then turn down the angles as in 2, emphasizing the fold strongly, following *a b* only, and operating in this way on both sides of the four angles. You will then have turned down eight folds like *a b*, and your paper will have assumed the

Fig. 102 —The Paper Bird.

appearance of No. 3 diagram. Then fold the paper as No. 4, so as to accentuate the folds, which can be pressed with the nail; it will then be easy by fastening the folds around the centre *c* tc obtain fig. 5 from 4. Then turn the paper upside down, and bring up the two opposite folds as in diagram 6, and proceed to raise the points right and left, thus forming diagram 7. By extending the points *d* and *f* to right and left you will produce the appearance of the bird as in diagram 8. The head of the bird can be supplied by turning down the point *d*. If now you hold the figure tenderly by the extremities, *m* and *n*, you may produce the flapping of the wings. The

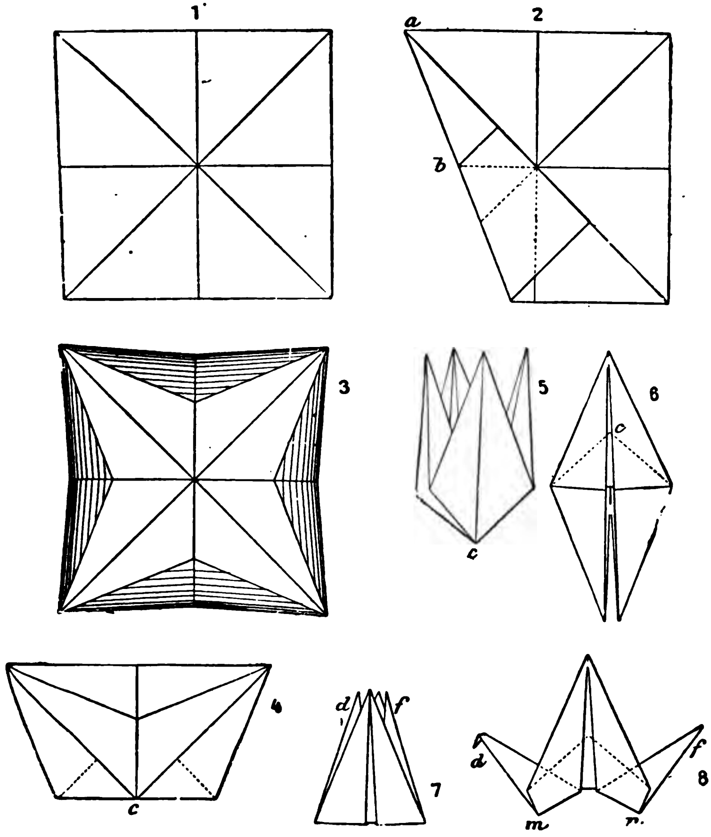

Fig. 103.—Mechanical Paper Bird—Manner of Construction.

same movement may be made by holding the bird at *m*, and pulling its tail *f*. This toy requires little application to perfect—anyone may succeed in making it.

TO CUT A CORD WITH THE HANDS.

We have often seen grocers' assistants and others breaking the twine which they have tied round parcels

Fig. 104.—Manner of cutting a Cord with the Hands.

by a sudden pull, and you may have fancied this j sufficient to break the string. Well, try ; you will inj or cut your hands and will not break the end. To succ you must get the cord into a certain position, which *will tell you.*

Place in the left hand the cord you want to break, and pass one end of it over the other in the form of a cross, and wind round the fingers the end forming the small arm of the cross—you must leave it sufficiently long to make several turns. The other end is then wound round the right hand, with some distance between the two hands. If your arrangement be correct the string ought to form a Y in the centre of the hand, as seen in the lower part of the illustration. Then grasping the end tightly in the right hand as in the upper part of the cut, bring the hands close and jerk them quickly apart, and the cord will be cut at the point of intersection of the arms forming the Y, which act as a knife. If the cord be quickly jerked, the shock will not have time to communicate itself to the hands ; this is an interesting demonstration of the principle of inertia.

Cords of considerable thickness can be thus severed without any ill effects. The most delicate hands may succeed in this experiment, provided the jerk be sudden and the twine properly arranged. With a little practice it can be done rapidly, and the shop-assistants, who are very expert at it, never use knife or scissors.

THE MAGIC PICTURE WITH THREE FACES.

The following is the most simple method of making the toy. Cut three chromo-lithographs, which we will call A B C, on thin paper and of the same size, into strips. These strips being numbered right to left, we paste them down side by side upon a large sheet of this, paper, which is of the same height as one of the chromon but as long as all three together. We thus obtain a very extraordinary picture, in which are mixed up people landscapes, flowers, and every other detail. The bands or strips only appear distinct in this uniform order— a^1, b^1, c^1, a^2, b^2, c^2, and so on (Fig. 105). The gum being dry, we fold our picture accordion-fashion as in Fig. 105; fastening each to each behind, *a b*, etc., by the edges, the dihedral angle also appears, and we have then a series of small plans perpendicular to the ground plan.

Seen full-face this picture presents the plan C, which seems to mark somewhat a grille formed by the edges of the two other plans. We then step a pace to the left of

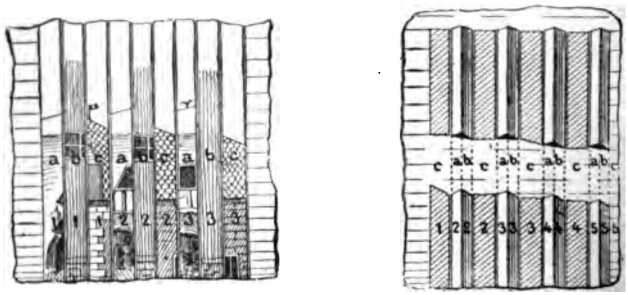

Fig. 105.—The Magic Picture with Three Faces.

the picture, and our eye passes in succession from the exterior edge of the facet a^1 to the interior edge of the other facet a^2, from a^2 to a^3, and so on, and perceive then the plan A without dissection, but lightly covered with a series of lines which in no wise detracts from its clearness. One pace to the right and we see in the same manner the section B—(See Frontispiece).

IMITATION THUNDER.

Ask some one to place his hands over his ears and pass have the hands around his head a cord in the manner shown in the illustration below (Fig. 106). If you rub the string lightly between the finger and thumb, drawing the hand along the cord, the subject will hear a loud rolling as of thunder. To properly produce the desired effect some precautions are necessary. We will mention them. Before reaching the end of the string you must seize it with the other hand at the point of departure;

Fig. 106.—The Rolling of Thunder Imitated.

by so doing it will be possible to prolong the experiment for some time.

If you grasp the string with the nails and draw the hand back by jerks you will produce short sharp peals of thunder, which can be changed into rolling peals at will by continuous rubbing.

THE MECHANICAL FLY.

This fly, made of polished metal some three inches long, is suspended from the ceiling or chandelier by a long thread. The "animal" contains a band of india-rubber, which is twisted round by a kind of handle. The untwisting of the india-rubber sets in motion a screw at

Fig. 107.—The Mechanical Fly.

the other end, by means of the cogged wheel delineated in the lower part of the illustration herewith (Fig. 107). A catch permits the release of the machinery at the desired moment. The screw imparts a rapid movement to the fly, and makes it fly in a circle around the point of suspension.

THE DOUBLE MARBLE.

Place the middle finger of the hand under the index, and touch a marble with them in the manner shown below (Fig. 108). You will then experience the sensation of touching two marbles. In normal conditions the

Fig. 108.—The Double Marble.

ball cannot be touched at the same time by the exteriors of two fingers of the same hand. When we cross our fingers, however, the normal conditions are changed, but the instinctive interpretation remains the same, so much so that the frequent repetition of the experiment does not confirm the first impressions. In fact, if the experiment be frequently repeated the illusion will become less and less marked.

EXPERIMENT IN SOUND—ACOUSTICS.

Sound is a sensation which affects our ears; it is produced by a cause exterior to the organ itself—generally by vibration of a body. This vibration is transmitted by the medium serving as a means of communication between nerves of hearing and the object vibrating.

There are three different ways of producing sound—by percussion, when objects strike each other; by rubbing,

Fig. 109.—Wooden Whistle, which a Lad may make for Himself.

as when a bow of a violin is drawn across the strings; and by twanging the strings of an instrument.

It is easy to prove that sound is transmitted in a perceptible space of time from one place to another. When at a distance we see a man hammering a nail, we perceive that the noise occasioned by the striking of the object does not reach our ears until some seconds after the moment of contact. We see the flash of a cannon before we hear the sound of the discharge, and lightning before thunder.

We need not give any particular experiments here save one—the *Wooden Whistle*, a toy much in vogue amongst school-boys.

Take a piece of lilac or willow-wood, and cut the bark round it with a penknife in a circle. Moisten the bark, and then beat it on your knee with the handle of the knife. Then hollow out the pith, and you will have an ordinary whistle, as in a key, A, or by cutting the

Fig. 110.—The Fruiterer.

Fig. 111.—The Cobbler.

wood (as shown in B and C) a true whistle can be fashioned (Fig. 109).

An excellent whistle can be produced with the cowl of an acorn, which forms a small cup. Place this cup between the first and middle fingers, and close the fingers so that only a very small orifice is left. If you blow into this opening a whistle will result.

PORTRAITS UNDER TWO ASPECTS.

Drawings from two points of view, so to speak, have already had considerable success; and chance has recently put in our possession a work by an artist named Galliot, published in Berlin. The author, under the title *Arts and Professions*, has drawn very amusing figures, which are really the result of a combination of the tools and utensils belonging to the trades or professions of the

Fig. 112.—The Alchemist.

Fig. 113.—The Brewer.

people they represent. We reproduce some of these essentially original compositions. The Fruiterer (Fig. 110) is composed of a melon, which forms the head; an artichoke, the stem of which forms the nose in profile; a basket makes the bust, while some vegetables form a collarette, etc. The Cobbler (Fig. 111) is likewise represented by the tools of his trade, notably the nose and chin: the Alchemist (Fig. 112) is obtained by means of a furnace and retorts; the Brewer (Fig. 113) with a jug, a tub, a cask, and a funnel; the Artist (Fig. 114) with the palette and box of colours; the Sportsman (Fig. 115) is composed of a gun, a powder-flask, and a hunting-horn; and so on. We have here some amusing pictures, with which we may fitly conclude our recreations.

Fig. 114.—The Artist.

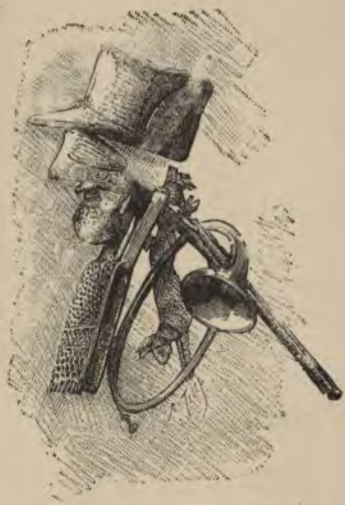

Fig. 115.—The Sportsman.

The talented reader can exercise his pencil in other compositions.

With these illustrations we bid our friends Farewell. We have endeavoured to indicate to them how they can occupy their leisure profitably, and with amusement to themselves at the same time.

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