

SCIENCE IN TOYS.

v.

Among the many toys illustrating the phenomena of light, the simplest is the water bulb magnifier.

It consists of a small hollow sphere of glass filled with water and provided with a pointed wire arm for supporting the object to be examined. It is a Coddington lens lacking the central diaphragm. It answers very well as a microscope of low power, and illustrates the principle of refraction as exhibited by lenses. It receives the rays diverging from the object placed at its focus, and refracts them, rendering them convergent upon the opposite side of the bulb; but all of the rays do not converge exactly at one point, so that the image, except at the center of the field, is distorted and indistinct. This effect is spherical aberration.

The prism is found in the list of toys as well as among scientific instruments. It decomposes light, recombines the dispersed beam, again forming white light.

When placed in the sunlight, it yields a gorgeous spectrum. Even an ordinary prism may be made to exhibit several Fraunhofer's lines by arranging it in front of a narrow slit, through which a beam of sunlight is admitted to a darkened room. One side of the prism in this experiment must be adjusted at a very small angle with the incident beam. The spectrum will contain a number of fine dark lines, known as Fraunhofer's lines.

These lines tell of the constitution of the sun. The principle illustrated by this experiment is the one upon which the spectroscopy is based.

A plano-convex glass, having a number of facets formed on its convex face, constitutes the toy known as the polyprism.

The facets form slightly different angles with the



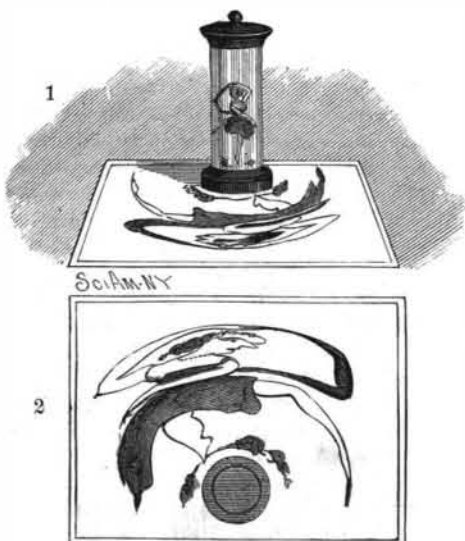
POLYPRISM.

plane face of the glass, so that the rays are refracted differently by each facet, producing an image. One man seen through this instrument appears like a congregation. A coin viewed through it is multiplied as many times as there are facets, and a grate fire appears like the conflagration of a city.

The cylindrical mirror shows an ordinary object very much contracted in a horizontal direction.

The pictures accompanying these mirrors are distorted to such an extent as to render the object unrecognizable until viewed in the mirror, which corrects the image.

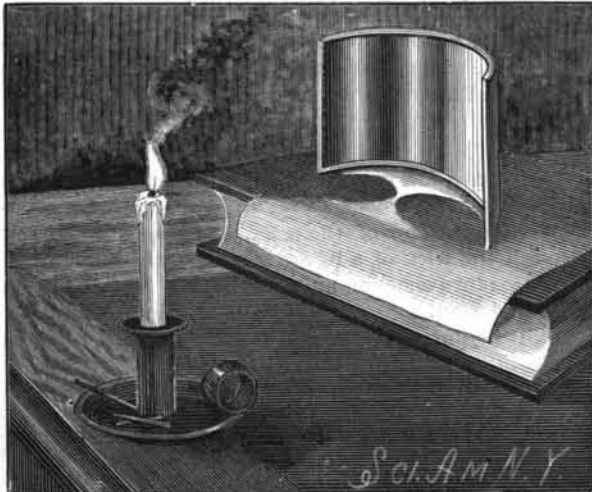
By tracing the incident ray from any point in the picture to a corresponding point in the image in the



1, CONVEX CYLINDRICAL MIRROR. 2, DISTORTED PICTURE TO BE VIEWED IN MIRROR.

mirror, then tracing the reflected ray from the same point in the mirror to the eye, it will be found that in this, as in all other mirrors, the simple law of reflection applies; that is, that the angle of incidence and the angle of reflection are equal.

The concave cylindrical mirror in its behavior is the reverse of the mirror just described. It produces a laterally expanded image of a narrow picture, and while the convex cylindrical mirror disperses the light from a distant source, the concave mirror renders it convergent; but, as in the case of the water bulb,



CONCAVE CYLINDRICAL MIRROR, CAUSTICS.

the reflected rays do not focus at a single point, but cross each other, forming caustic curves. These curves may be exhibited by placing an ordinary cylindrical concave mirror edgewise on a white surface, and placing a small light, a candle, for example, a short distance from the mirror, as shown in the engraving. A concave mirror is not necessary to this experiment. The same phenomenon may be witnessed by observing a glass partly filled with milk, arranged in proper relation to the light. The inner surface of the glass serves as a mirror, and the surface of the milk serves the same purpose as the white paper. A cylindrical napkin ring will show the curves under similar conditions. In fact, any bright concave cylindrical surface will do the same thing.

The convex spherical mirror distorts to a remarkable degree. A silvered glass globe held in the hand yields an image of the experimenter something like that shown in the engraving.



SPHERICAL MIRROR.

Those parts nearest the mirror are enormously exaggerated, while other parts are disproportionately diminutive.

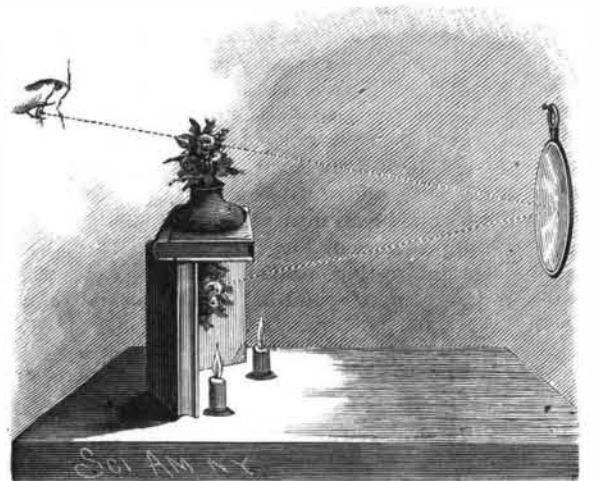
The image in a convex mirror is apparently behind the reflecting surface, and always smaller than the object itself.

The spherical concave mirror produces effects which are the reverse of those just described; and while, in this case, as in the other, the *virtual* image appears behind the mirror, the image is a magnified one. The *real* image, which appears in front of the concave mirror, may be either larger or smaller than the object itself, depending upon the position of the object relative to the mirror and the observer. It is inverted, and is formed in the air. A candle placed between the center of curvature of the mirror and the principal focus forms an inverted image in air, which is larger than itself.

The phantom bouquet, an interesting and very beautiful optical illusion, is produced by placing a bunch of flowers (either natural or artificial) in an inverted position, behind a shield of some sort, and projecting its image into the air by means of a concave mirror. A magnifying hand glass answers the purpose, if of the right focal length, and a few books may serve as a shield. Two black covered books are placed upon one end and arranged at an angle with each other, and a third book is laid horizontally on the ends of the stand-

ing books. The bouquet is hung top downward in the angle of the books, and a vase is placed on the upper book, over the hanging bouquet.

The concave mirror is arranged so that the prolongation of its axis will bisect the angle formed by lines drawn from the top of the vase and the upper part of the suspended bouquet, and it is removed from the



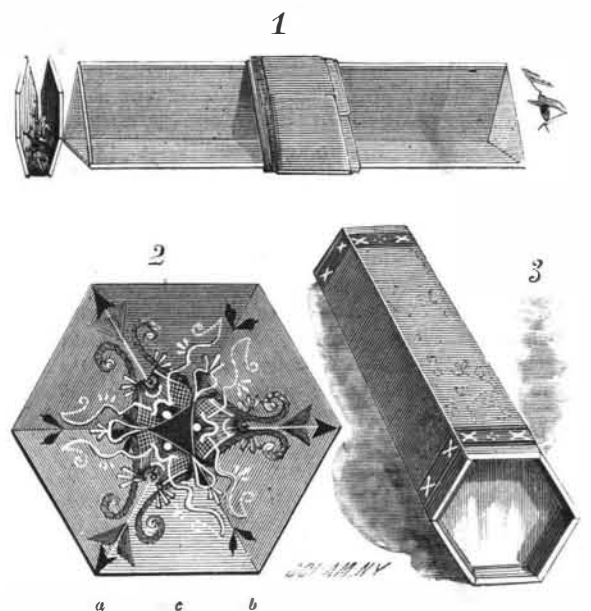
CONCAVE MIRROR.

bouquet and vase a distance about equal to its radius of curvature.

A little experiment will determine the correct position for the mirror. When the proper adjustment is reached, a wonderfully real image of the bouquet appears in the air over the vase. With a good mirror and careful adjustment, the illusion is very complete. The bouquet being inverted, its image is erect. A very effective way of illuminating the bouquet, which is due to Prof. W. Le Conte Stevens, of Brooklyn, is shown in the engraving. It consists in placing two candles near the bouquet and behind the shield, one candle upon either side of the bouquet. In addition to this, he places the entire apparatus on a pivoted board, so that it may be swung in a horizontal plane, allowing the phantom to be viewed by a number of spectators.

This simple experiment illustrates the principle of Herschel's reflecting telescope. In that instrument the image of the celestial object is projected in air by reflection and magnified by the lenses of the eyepiece.

The kaleidoscope is one of the most beautiful and inexpensive of optical toys. It can be purchased in the ordinary form for five or ten cents. It is sometimes elaborately mounted on a stand and provided with specially prepared objects. It consists of a tube containing two long mirrors commonly formed of strips of ordinary glass, arranged at an angle of 60°, with a plain glass at the end of the mirrors, then a thin space and an outer ground glass, the space being partly filled



1, PARTS OF KALEIDOSCOPE. 2, THE FIGURE. 3, KALEIDOSCOPE.

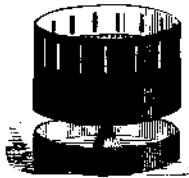
with bits of broken glass, twisted glass, wire cloth, etc. The mirrors may be arranged at any angle which is an aliquot part of 360°. When the mirrors, *a* *b*, are inclined at an angle of 60°, as in the present case, the number of images will be six, if the object, *c*, be counted as one.

The images adjoining the object are formed by the first reflections of the object. The images in the second sectors are formed by second reflections, and two coincident images in the sector diametrically opposite the object are formed by third reflections.

In most kaleidoscopes a third mirror is added, which multiplies the effects.

The zootrope, or wheel of life, is a common, but interesting, optical toy. It depends for its curious effects upon the persistence of vision. It consists of a paper box mounted on a pivot, and having near its upper edge a series of narrow slits, which are parallel with its

axis. Against the inner surface of the wall of the box is placed a paper slip, carrying a number of images of the same object arranged in as many different positions, each image differing slightly from the adjoining images, the successive positions of the several images being such as to complete one entire motion or series of motions.



ZOOTROPE.

When these pictures are viewed through the slits, as the box is turned, the eye glimpses the figures in succession, and retains the image of each during the time of eclipse by the paper between the slits and until the next figure appears. The images thus blend into each other, and give the figure the appearance of life.

Some very interesting studies for the zoetrope have been produced by the aid of instantaneous photography.

G. M. H.

Simple Chemical Experiments.

BLUE AND WHITE CRYSTALS.

Take $\frac{1}{2}$ oz. powdered alum and $\frac{1}{2}$ oz. sulphate of copper; dissolve in 1 oz. of boiling water; put into a glass tube or phial, and on cooling you will see the colorless crystals of alum are formed side by side with the blue crystals of sulphate of copper.

H. J. DEAN, Chesham.

TO ENGRAVE ON STEEL.

Requirements.—A box containing powdered cupri sulph., and labeled "The Powder."

Directions.—Dissolve some of the powder in a small quantity of water; rub the surface of the steel over with a piece of wetted soap, so as to cover it with a thin coating; then dip the point of a pencil into the solution, and with it write or draw the required design on the steel. After a few minutes wash, and the steel will be found to be beautifully and permanently engraved.

F. FREEMAN.

INVISIBLE INKS—BLUE AND BROWN.

Requirements.—Ferri sulph., labeled "For Blue Ink;" cupri sulph., labeled "For Brown Ink;" and potass. prussias flav., labeled "The Developer." They may also bear the Nos. 1, 2, and 3 respectively.

Directions.—Make separate solutions of Nos. 1, 2, and 3, and preserve in bottles for use. With a clean quill pen write with the solution of either No. 1 or No. 2, and allow to dry. The writing will remain invisible. Dip a feather or small brush into No. 3, or the "developer." The writing will then appear distinctly written—in blue if No. 1 ink has been used, or in brown if No. 2 was used.

F. FREEMAN.

THE FLOATING BEACON.

Requirements.—A cardboard box containing a half dozen or dozen small pyramid-shaped pieces of camphor labeled "The Beacons."

Directions.—Take one of the beacons, place it on the surface of some clean water in a basin, ignite the point with a match. The flaming beacon will then commence darting about on the surface of the water, and will continue doing so till burnt out.

F. FREEMAN.

BLOOD WRITING.

Requisites.—A pill box containing red iodide of mercury, and labeled "Magic Powder."

Directions.—Take some of the "Magic Powder," and rub it over the surface of a sheet of note paper with a piece of cork. Take the paper so prepared and hold it over the flame of a candle or lamp, slowly moving it to prevent burning. The red color will quickly disappear. Anything now written or drawn on the paper with a pointed piece of wood will appear as if written in blood.

F. FREEMAN.

SUN PRINTING—FOR TAKING TRUE COPIES OF TRACINGS, LEAVES, PATTERNS OF LACE, ETC.

Requirements.—Ferri ammon. cit., 3 ij; liq. potass. ferrocyanid., 3 ij; aquæ dest. ad 3 ij. M. ft. sol. Sig.: "The prepared solution." "To be kept in the dark." Inclose camel hair brush.

Directions.—By candle light take a sheet of writing paper and brush one side of it over with the solution; hang it up to dry in a dark room or cupboard. When dry, place the object to be copied next the prepared surface, in a printing frame; then expose to direct sunlight for a few minutes till the prepared paper has turned gray; take it out and wash the paper in clean water; the printing will then become permanently fixed. Instead of a printing frame, the object and paper may be inclosed between a piece of glass and flat wood tightly bound together.

F. FREEMAN.

THE SKELETON IN THE CUPBOARD.

Requirements.—A bottle of phosphorized oil, labeled "The Phantom Light," and a small brush, packed in cardboard box.

Directions.—Get a large sheet of paper, and then, with the aid of the brush dipped into the phantom light, roughly sketch the outline of the human skeleton; then attach it to the wall in an empty cupboard, shut the door, take your friends into the room in which the cupboard is (the room being quite dark), and ask one of them to go to the cupboard. He will, no doubt,

run back greatly alarmed. Other devices may be adopted at the will of the operator.

F. FREEMAN.

BEAUTIFUL CRYSTAL ORNAMENTS.

Requirements.—Various boxes containing the following powdered chemicals: Ferri sulph., cupri sulph., alum sulph., pot. bichrom., potassæ nit., and common salt.

Directions.—Dissolve any one of the powders contained in the box in some hot water, so as to form a strong solution, pour the solution into an open tumbler. In the solution now suspend a piece of coke, a clinker, or any ornament with a rough surface; allow it to remain suspended a few days, and as the liquid evaporates, beautiful crystals will form and continue to grow on it. The color and appearance of the crystals will depend upon the salt used.

F. FREEMAN, West Dulwich.

NIHILIST BOMBS.

Introduce a few drops of water into some small glass bubbles, having a neck about an inch long, and afterward close the end of the neck. This neck being put through the wick of a burning candle, the flame boils the water into a steam, and the glass is broken with a loud explosion.

Might be put up in small cardboard boxes, a dozen bombs in a box, labeled "Nihilist Bombs," with directions inclosed.

GEO. E. PEARSON, Northallerton.

FACIAL TRANSFIGURATOR.

Dissolve some salt and saffron in spirits of wine, dip a little tow in it, and set fire to the tow. By this light those who are of a fair complexion will appear green, and the red of the lips and cheeks will turn to a deep olive color.

Might be put in a 1 oz. bottle, and packed in cardboard box with directions and fancy label, labeled "Facial Transfigurator."

GEO. E. PEARSON, Northallerton.

LUMINOUS BOTTLE OR WATCH LIGHT.

Place a piece of phosphorus the size of a pea into a long glass phial, and pour boiling oil carefully over it till the phial is one-third filled. The phial must be carefully corked, and when used should be unstopped a moment to admit the external air, and closed again. The empty space of the phial will then appear luminous, and give as much light as a dull ordinary lamp, and just sufficient to see the face of a watch. Each time that the light disappears, on removing the stopper it will instantly reappear. In cold weather the bottle should be warmed in the hands before the stopper is removed. A phial thus prepared may be used every night for six months.

GEO. E. PEARSON, Northallerton.

TO COAT COPPER WITH SILVER, IRON WITH COPPER, AND TIN WITH IRON, FROM ONE SOLUTION.

Directions.—Pour half the solution from the bottle into a wine glass and put into it the piece of copper wire; it will in a few minutes become coated with a thin layer of silver. If it is allowed to remain in the solution until the previously colorless solution becomes green, and the copper then taken out, a piece of iron wire put into the solution will become coated with copper in about twenty minutes; a piece of zinc put in when the iron is taken out will become covered with a thin coat of iron.

Explanation.—The first solution is one of nitrate of silver. When copper is put into it, it is attacked by the nitric radical (nitric acid), and forms a solution of nitrate of copper, throwing out the silver which previously was held in solution by the nitric acid. Iron put into the solution of copper is in turn attacked by the nitric acid and leaves a solution of nitrate of iron, throwing out the copper. Zinc put into this solution is attacked, and leaves a solution of nitrate of zinc, throwing out the iron.

Materials Required.—Make a solution of nitrate of silver, gr. xx to 3 j, put it into a 1 oz. phial, labeling it "Poison." Wrap round the bottle a paper descriptive of the experiments, etc. (as above), and also advertising other experiments and their prices. Wrap up the pieces of copper wire, iron wire, and zinc with the bottle, put all into a cardboard box, and label outside: "Christmas Novelties. Chemical experiments free from danger. How to cover copper with silver, iron with copper, and zinc with iron, all from one solution. Price, 1s. (Name and address.)"

R. A. BELLAMY, Bedale.

A MYSTERIOUS EGG; OR, HOW TO PUT AN EGG INTO A BOTTLE.

Directions.—Soak an egg in the liquid, when it will gradually become soft; it may then be put into a bottle whose neck is very small. When washed well with cold water, it will again become hard, and will much astonish any one not in the secret.

Explanation.—When an egg is soaked in acetic acid, it becomes softened, and may be pressed into any form. Water will again harden it.

Acid, acet. fort., and aqua, equal parts, in a 6 oz. bottle, labeled materials, "The egg conjuring liquid." Wrap round a paper containing description, and advertising other experiments, put into box as in experiment No. 1, and label outside: "Christmas Novelties. Chemical experiments free from danger. Price, 6d.

The Mysterious Egg; or, how to put an egg into a wine bottle without breaking either the egg or the bottle."

R. A. BELLAMY, Bedale.

TO GET AN EXACT COPY OF ANY COIN OR METAL; AND HOW TO MAKE A SEAL OR ANY DEVICE IN COPPER.

Directions.—First take the impression of the medal to be copied by softening the wax before the fire, and carefully pressing it on the coin; when it is cold, remove it cautiously, and cover it thinly, but completely, with a covering of black lead. Pour the solution into the bath (one solution to each side); put the zinc plate into the colorless liquid, and attach to the other end of the copper wire the wax impression which you wish to copy, and allow it to dip into the solution of sulphate of copper, taking care that the wire is in contact with the black lead. In the same way you can cut any device, initials, etc., into the wax, and coat with copper.

Explanation.—This experiment is really depositing copper on the impression by electricity, the electricity being produced between the two solutions through the porous division. Care must be taken to have a good connection between the copper and the black lead on the impression, the black lead being a conductor of electricity and the wax not. The slower the copper is deposited, the firmer and harder will be the resulting deposit.

Materials.—A fully saturated solution of sulphate of copper crystals (about 6 or 8 oz.), and about 6 or 8 oz. of acid sulph. (1) and aqua (3) for the other side. A small wooden box lined with pitch, with a thin cardboard partition in the middle. A piece of zinc about 2 in. by $\frac{1}{2}$ in., with a piece of copper wire soldered on and bent over the partition, to hold the impression in the sol. of cupri sulph. A piece of wax (preferably a thin sheet). A camel hair pencil and some powdered black lead. Put the solutions in bottles, and the other things in the box; wrap up, with the particulars of the experiment, and advertising other experiments. Label: "Christmas Novelties. Chemical experiments, free from danger. Price 1s. 6d. Complete apparatus to take an exact copy of any coin or medal. To make a fac simile seal, or produce in solid copper any desired device or image."

R. A. BELLAMY, Bedale.

WHAT HOLDS IT UP?

Materials.—A small tumbler or ale glass, a bit of sponge, and methylated spirit.

Directions.—See that the hand is large enough to well cover the mouth of the glass, moisten the bit of sponge with spirit, light it, and drop it into the glass, which at once cover with the naked hand. The flame will be immediately extinguished, but the glass will remain suspended to the hand, without any visible support. Unless the glass is jerked it will require a strong, steady pull to free it from the hand.

ARCHIBALD PATERSON, 133 Govan Road.

—Chemist and Druggist.

Mr. Beecher on English Railways.

Rev. Henry Ward-Beecher has been talking to a reporter about traveling in England, and in reference to a query as to whether he enjoyed it, said:

"No. The railroads themselves, their bridges, their stations, are incomparably better than ours. They seem as if built for eternity. But there it ends. The cars are short, so that they have but six wheels, two here, two there, and two beyond, and one is, obviously of necessity, always over a grinding iron wheel. Then they oscillate so that they almost always make one seasick, and always give a feeling of nausea. My test consists in conversation and reading, and I found that in the one I had to raise my voice, and in the other my eyes became tired, and it was impossible for me to read with any degree of comfort. Now, here I do both with perfect ease. My eyes are strong and I am well, but I could neither talk nor read in the English cars. American cars would be very much better. There are a few palace cars over there, but they are not popular as yet. There is but a faint beginning of comfort for the engineers and stokers. For a long time they have been compelled to do their arduous work exposed to the elements; and even now they have nothing but a glass frame over them, open in front, affording a most imperfect protection against the moist, cold, chilly climate, so they bundle up like so many mummies. It is the same way on the Cunard line of steamers. They are so afraid the pilots will be lazy if they are afforded any conveniences or comforts, that they keep them exposed at the wheel. The English people are very slow to accept improvements in engineering, but they are very prolific in invention, too. I saw in the Liverpool Exposition some most interesting and instructive sights, such as models of all the great ships of the various lines, and some of the finest castings that those wonderful mechanisms demand—duplicate shafts and cranks built for great ocean racers."

THE acquisition of learning without study is like the acquisition of wealth without labor. It is as necessary for the mechanic to study out his problem when it comes to him to be studied as it is for him to finish his task by his handicraft.