THE METHODS OF FIRE-MAKING.

By WALTER HOUGH,
(*Department of Ethnology, U. S. National Museum.*)

The study of any art includes a knowledge of the materials, the apparatus, the processes, and the finished products. In a former paper* the apparatus of fire-making having been discussed, attention will here be given to the handling of the apparatus, the mechanical principles, the physics, and the chemistry of fire-making.

All mechanical methods of generating fire take advantage of the law that motion, apparently destroyed by friction, is converted into heat. These methods can be grouped under three classess, viz: (1) Wood friction; (2) percussion of minerals; and (3) compression of air.

Three other methods exhaust the entire range of usages in fire-making, and they are with one exception, perhaps, recent. These may be arranged in the following classes: (4) chemical; (5) optical; (6) electrical; but these are also the exhibition of friction in its higher manifestations.

I.—FRICTION ON WOOD.

There are three well-defined variations in the method of making fire artificially by friction on wood, viz: (1) By twirling or reciprocating motion; (2) by sawing; (3) by plowing.

1. FIRE-MAKING BY TWIRLING.

Three kinds of apparatus are used in producing fire by the reciprocating motion, viz: (*a*) Simple two-part hand drill; (*b*) bow and cord four-part drills; and (*c*) the pump-drill.

(*a*) *Simple two-part hand drill.*—This apparatus consists of two parts, a vertical and a horizontal element called the spindle, and lower socket pieces; the latter may be called the hearth, which all the machines under this class agree in possessing. The twirled hand-drill is the simplest form of fire-making tool, and is, without doubt, primitive.

The Eskimo of Labrador, Point Barrow, and other localities, also bore holes with this form of drill. The Haida Indian carpenters, of

* Smithsonian Report 1888, II, pp. 531–587.

Vancouver Island, employ it. The Indians of the Rio Negro, Amazon, and Oronoco Rivers in South America pierce the hardest stones with a twirling stick and sand. It is found also in Japan and Madagascar, giving it a range coextensive with the simple fire-drill.

Fig. 51 shows the working of this drill in making fire.

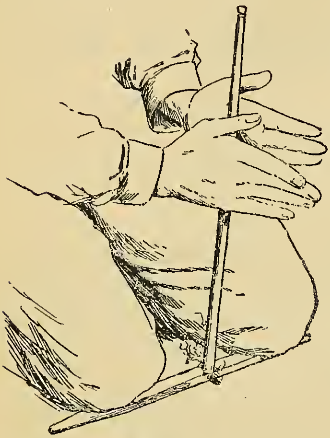

Fig. 51.

MAKING FIRE WITH SIMPLE, TWO-STICK APPARATUS OF THE HUPAS.

(Cat. No. 77193, U. S. N. M. Hupa Indians, California. Collected by Lieut. P. H. Ray, U. S. A.)

A shallow depression is first made near the edge of the hearth in order to give the spindle "bite." From this depression a slot is cut down the side of the hearth as a duct for the wood débris which has been ground off. The operator then takes the spindle by its upper end between the palms of his hands and inserts the lower end in the shallow depression. In twirling, a strong downward pressure is given to the spindle. The hands, which necessarily move down through the combined pressure and the back and forward motion, must be returned quickly to the top of the spindle without allowing the air to get under the lower end of the latter. After continued friction, evidences of combustion are seen in the ground off wood meal. In shaping the lower end of the spindle, it is absolutely necessary that its point should be in contact with the bottom of the shallow depression, otherwise it will "bind" against the edges of the depression and defeat the object.

The usual statement that a spark is ground out, igniting the dust, shows an error of observation. The heap of dust collected in the slot, which is an essential feature, smoulders until enough heat has been evolved to produce ignition by spontaneous combustion.

Flame is never directly secured by this apparatus; the coal must be placed in contact with tinder, or other ignitible substance and fanned into a blaze with great caution. Usually much smoke is generated in the operation.

Great dexterity and quickness are often shown by the natives in starting fire from the glowing coal. This part of the process requires as much care and skill as the securing of the spark. The selection and preparation of tinder must be carefully made and everything must be ready beforehand as in a chemical experiment.

(*b*) *Cord and bow four-part drills.*—Several improvements of the simple drill have been made by savage inventors. These improvements are shown in the cord drill, the bow, or mouth-drill, and the pump-drill. The first is used by the Eskimo, by some tribes of North American Indians, and by Dyak tribes. It adds to the spindle of the simple drill an upper bearing, called a hand-rest, and it revolves the spindle by a cord with handles alternately pulled (Fig. 52). Two men are required to work this drill.

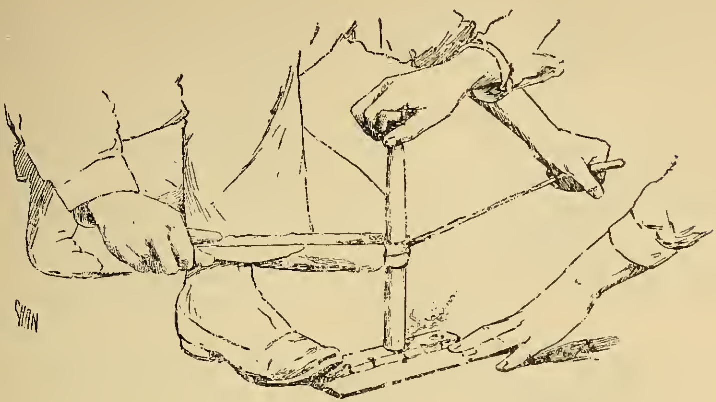

Fig. 52.
USING THE ESKIMO CORD DRILL.
(Cat. No. 36325, U. S. N. M. Chalimute, Alaska. Collected by E. W. Nelson.)

An improvement on the four-part apparatus, just described, rendering it easy for one man to make a fire unaided, belongs exclusively to the Eskimo. The upper bearing, held in the hand in the case of the cord drill, is shaped for holding between the teeth (Fig. 53). The cord is strung on a bow, so that in working this apparatus one hand of the operator is free to apply the tinder or hold the lower piece.

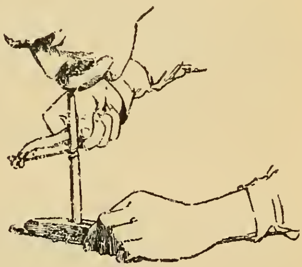

Fig. 53.
USING THE ESKIMO MOUTH DRILL.
(Cat. No. 1327, U. S. N. M. Anderson River, British Columbia. Collected by C. P. Gaudet.)

While the cord drill is a vertical adaptation of the Egyptian breast drill, for the purpose of fire-making, the mouth piece is used exclusively by the Eskimo. The four-part fire drill was rarely found among the North American tribes. The Dyaks of Borneo also have the four-part drill.

(*c*) *Pump or weighted drill.*—The problem of a one-handed drill has also been worked out in the invention of the pump-drill (Fig. 54). This tool has a widespread use for piercing substances necessitating light, even pressure, such as perforating wood, horn, shell, turquoise, etc. The Klamath, Pueblo, and other Indian tribes manufacture shell-beads with the pump-drill at present, and it is probable that its use was prevalent in North America in former times. Its connection with the weaver's spindle is marked. In only two localities in the world, as far as is known, has it been adapted to fire-making, viz, among the Chukchis of Siberia, and the Iroquois Indians of New York and Canada.

This pump-drill is said to have been used in making new fire in the white-dog feast of 1888 by the Onondagua Iroquois of Canada. Elm wood is employed. Sometimes a sapling with a straight tap root was selected and dressed down, leaving the large portion at the junction of the root and stem for a fly-wheel.

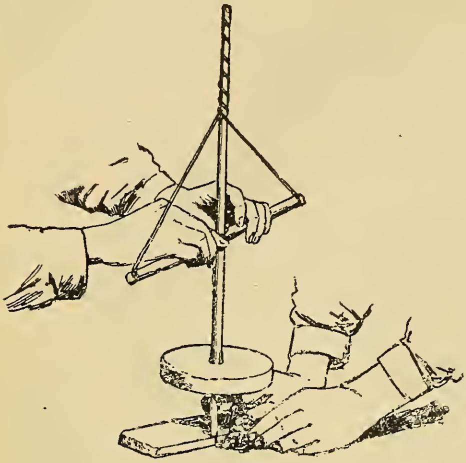

Fig. 54.

IROQUOIS PUMP DRILL FOR MAKING FIRE.

(Cat. No. 150403, U. S. N. M. Onondagua Indians, Canada. Collected by J. N. B. Hewitt.)

Although one person can manipulate this apparatus, others usually assist.

Essential points in wooden fire-making apparatus.—There are several points about the lower member of the wooden fire drill that are worthy of consideration. It will be observed in Fig. 54 that the spindle is cutting on one edge of the hearth and the dust has run out through a slot down the side into a little heap.

This canal collects the particles worn off by the spindle and also keeps the air away for a short time. This feature, or something analogous, is found, one may say, in every fire-making device that depends on the friction of wood. The dust must be in such mass and confined in one place, so that the heat may be fostered until it ignites the powder.

In Eskimo apparatus fire is usually made in the middle of a block of wood (1) in cavities along a groove that collects the wood meal; (2) in holes that overlap by connecting holes; or (3) in cavities that have canals leading to a step. These devices are to prevent the dust falling off into the snow.

It appears that some hearths do not possess this feature. The Torres Straits Islanders and the natives of Queensland do not make the slot in the drill-hole.* The Aino drill-hearth, the fire-making set from East Greenland, and one set from Alaska figured in the Smithsonian Report (1888, pt. II, pp. 551, 558, and plate LXXVIII, respectively) show no grooves or canals. The Ainos require 2 to 2½ hours to make fire on their apparatus, and the spark at last is caught by sucking a current of air through the porous spindle. This points markedly the difficulty of making fire without the groove. The drawing of the Eastern Greenland outfit is rather obscure in the plate from which the illustration was taken. The artist, as is often the case in ethnological drawings, probably omitted some details. If the Eskimo, according to

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* Prof. A. C. Haddon. Jour. Anthrop. Inst., Great Britain and Ireland, XIX, May 4, 1890, p. 451.

Holm, made fire in less than half a minute on this apparatus, it must have been with the aid of grooves. In the Alaskan drill spoken of, the holes in the hearth had been worn too deeply for drilling easily, and the margins had all been cut down level before the collector procured the specimen. In the original piece the holes in all probability connected.

Often holes are bored on small rods of wood, allowing the spindle to cut over one edge, forming in a few rotations a notch by which the dust is collected. In all the specimens and drawings of fire-making apparatus examined for the preparation of the paper cited * the Aino drill is the only one with unslotted or ungrooved center holes.

This statement in regard to the essential value of the slot is not advanced to disprove that fire can be made without the use of that feature.

Fire can so be made, but it is a difficult process and must be accomplished by mechanical means, such as are found in the Eskimo drill. The wood must be suitable, and the grinding end of the spindle must have the outline of a flattened arch. Great care is required to avoid dispersing the ring of dust that rolls out under the edge of the spindle. The author believes that the slot is essential to simple hand-drills.

2. Fire-making by sawing.

The second method in wood friction is that of sawing, practiced by the Burmese, Malays, some Australian tribes, and pretty generally

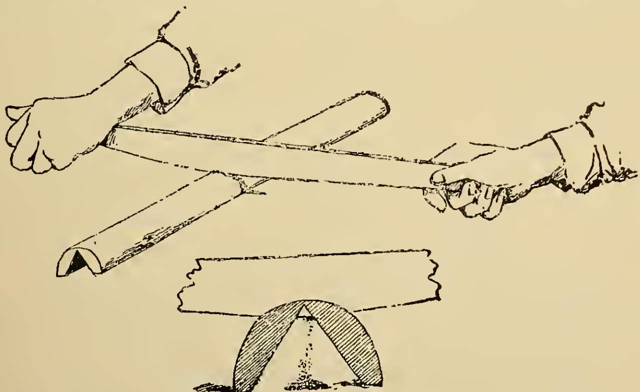


Fig. 55.

Fire-making by Sawing, after the Burmese and Malay Method.

(From photograph in the National Museum.)

throughout the East Indies. It consists of a rubber and horizontal piece, both parts of bamboo usually, but sometimes hewn out of a branch of a tree. A notch is cut across the convex side of the lower piece, almost penetrating it. A rubber is prepared having a sharp or knife edge. This rubber is drawn across the lower piece in the groove until the latter is pierced and the heated particles fall through. (Fig. 55.)

* Smithsonian Report, 1888, II, Fire-making Apparatus in the National Museum, pp. 531-587.

In most cases the heated particles are not allowed to fall the whole distance to the ground beneath, which would cool them rapidly, but they drop upon tinder held up to the orifice by slivers of bamboo started from the under side of the lower piece. In some localities the process is reversed and the convex piece holding tinder is sawed upon the knife placed upright. Bamboo is excellent friction material; the siliceous coating is favorable for the development of great heat, while the soft medullary substance on the interior is very inflammable.

Dr. R. M. Luther contributes the following description of the Burmese method of making and using the fire-saw: "A Burmese found a branch of the oil tree (*Dipterocarpus*), hewed in it a V-shaped cavity with his *dah*, cut a knife of iron-wood, sawed with it across the branch, and in less than 3 minutes had a coal of fire underneath. This was taken in some dry leaves, wrapped in a bunch of grass, and whirled around the head, giving a flame in a 'jiffy.'"

The distribution of this method is of great interest. It ranges from Siam across the East Indies into Australia—in many localities, however, in conjunction with other methods of fire-kindling.

3. Fire-making by plowing.

The mechanics of the third method of fire-making on wood remains to be considered. A short cylindrical stick and a larger billet of wood are required. The smaller stick is clasped between the hands at an angle of about 45 degrees and projected toward and from the body, forming a groove on the lower piece (Fig. 56). The slant at which the plowing stick is held is the angle of greatest friction consistent with command of the rubbing portion of the apparatus. The action of the rubber wears off particles of wood and pushes them along into a heap at the end of the groove, and by acceleration of the motion the dust is brought up to ignition point. The soft hibiscus wood, *H. tiliaceus*, with a rubber of harder wood is usually employed in the Polynesian islands, although this feature is immaterial. This method, as far as known by the author, is exclusively Polynesian, and, strangely, the only one practiced, since most peoples possess more than one fire-making device. Representatives of all stocks in the Oceanic area also practice the plowing method, which was, perhaps, originally Polynesian. This apparatus has advantage of simplicity of parts, but it is rather difficult to work. Flame is said to be sometimes procured by the first operation, without the use of tinder.

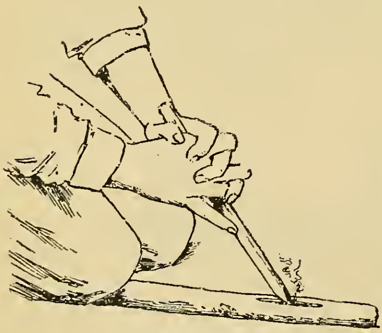


Fig. 56.

Fire-making by Plowing. (Drawn from Specimen in the National Museum.)

(Cat. No. 130675. U. S. N. M. Samoa. Deposited by Harold M. Sewell.)

II.—PERCUSSION OF MINERALS.

(*a*) *The flint and steel briquet, or strike-a-light.*—The employment of the strike-a-light is familiar still, although long since antiquated. There are few children that have not knocked stones together to see the evanescent glimmer produced. It has been thought that the concussion of two pieces of flint will cause a spark capable of igniting tinder. This is proven to be a mistake, and it is found that an effective spark is due to the presence of iron in some form in the minerals struck together.

The nature of the spark evolved from flint and iron is thought to be chemical; that is, a particle of metallic iron is scraped off by the silica, and, receiving the energy of the blow into its small mass, is heated to incandescence, burning with the oxygen of the air to an oxide. Whether silica enters into the composition of the spark is not known. Silica is a non-conductor and does not abstract heat at the time of the blow.

Upon the introduction of iron, probably, that element replaced the iron pyrites (FeS_2) that had been used in early times.

(*b*) *Flint and pyrites.*—The blow of the flint on the pyrites converts enough energy into heat to fuse the latter, setting free sulphurous fumes with a small amount of sulphureted hydrogen. These pellets are not incandescent, but glow at a dull red heat, about 450 degrees, and ignite only "quick" tinder.

The pyrites method at present is limited to a few tribes among the Eskimos and Aleuts and the Fuegians. Some Algonkian tribes bordering upon the Eskimo may have adopted the method from the latter people. The prehistoric use of pyrites for fire-making in several European localities seems to be proven, as far as the finding of bruised nodules and flint-scrapers indicate the purpose for which they may have been intended. Perhaps the limited use of the pyrites *briquet* at the present means that it is a survival from ancient times on the verge of extinction.

III.—COMPRESSION OF AIR.

The fire syringe.—This instrument is, strangely enough, found both in the hands of the physicist and of the various tribes of Dyaks and Burmese. From lack of definite proof to the contrary, it might be classed as a native method of fire-making. Among some tribes the apparatus has a primitive appearance; in others its construction depends on complex manipulation in metallurgy. It varies thus from a cylinder of buffalo horn with a hole bored into it for the piston, to a tube of brass lined with lead, or an ornamented cylinder of cast lead (Fig. 57).

The principle on which the fire-syringe operates is the compression of air which gives up heat under reduction of volume. When this is done under proper conditions, in a non-conductor, the heat is communicated to tinder setting it on fire. This is accomplished by the Dyak thus: "A small piece of tinder is placed in the hollowed end of the piston which is inserted in the mouth of the cylinder. Holding the cylinder in the left hand the knob of the piston is smartly struck with the open hand with sufficient force to drive the piston home. The

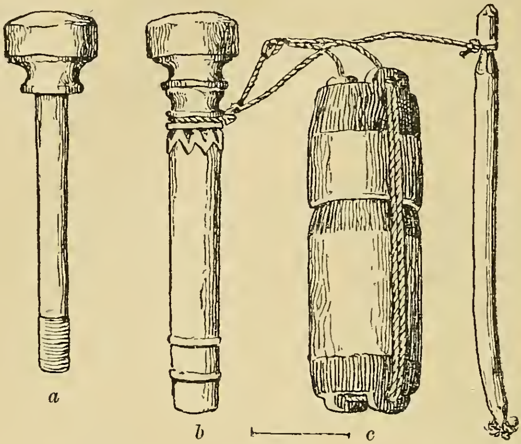


Fig. 57.

DYAK FIRE SYRINGE, OR BESIAPI.

One-half natural size.

a, PISTON; *b*, CYLINDER; *c*, TINDER-BOX; *d*, CLEANING STICK.

(From plate in Jour. Anthrop. Inst., Great Britain, XIX, 1890.)

piston is instantly and quickly withdrawn and the tinder is seen to be alight. Gently breathing on the spark it spreads, fresh tinder is applied, which catches fire immediately; more blowing increases the fire, and first scraped wood and then small sticks catch alight and a fire is produced.

It looks very easy but I never succeeded * * * ."*

The probabilities are very much against the fire-syringe being an invention of even barbarous peoples of the rank of the Dyaks and Burmese.

IV.—CHEMICAL METHODS.

The modern lucifer-match is superior to all other devices for producing fire, since it combines in one instrument the arrangements for the creation of the spark, for catching it on tinder, and for starting a blaze; steps requiring separate operations in the primitive machines.

The nearest prototype, of closest resemblance to the friction-match, was the splint of inflammable wood tipped with sulphur which accompanied the tinder-box; prior to this brimstone-match were all the obsolete, or well-nigh obsolete, tinder and slow matches.

The invention of the flint and pyrites and flint and steel strike-a-light necessitated some device to convert the spark into a flame. The Eskimo applies a wick soaked in oil and blows it alight; the Chinese slow match, *maidzu*, as Mr. W. Woodville Rockhill has noticed, only blazes at a quick, dextrous puff of breath. There are many easily ignitible sub-

* S. B. J. Skertchly, Jour. Anthrop. Inst., Great Britain, XIX, 1890, p. 448.

stances used for tinder which will support a blaze. Vegetable products excellent for tinder, however, reach such a condition of oxidization and decomposition that they will not feed a flame, and hence matches are required to complete the operation. The brimstone-match is found in Japan as a broad, thin shaving tipped with sulphur (Fig. 58), and in

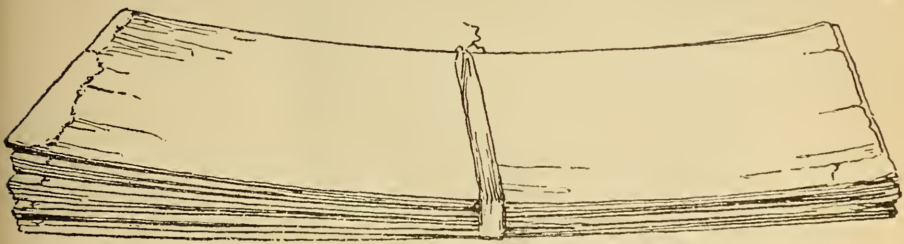


Fig. 58.

BUNDLE OF SHAVING-MATCHES.

(Cat. No. 128136, U. S. N. M. Japan. Japanese Department of Education, Tokio.)

Mexico it is a cotton wick dipped in sulphur (Fig. 59). In other countries different forms were manufactured.

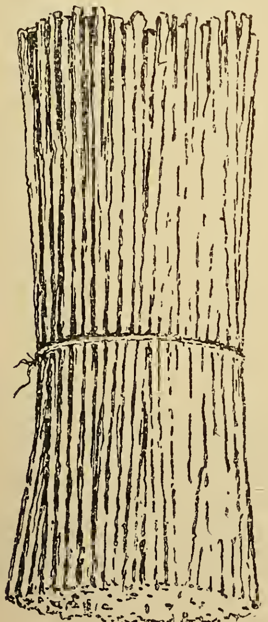


Fig. 59.

SULPHUR-WICKS.

(Cat. No. 76494, U. S. N. M. Oaxaca, Mexico. Collected by L. H. Aymé.)

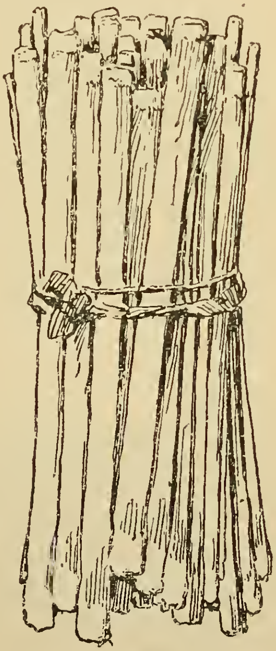


Fig. 60.

SULPHUR "SPUNKS." (Original Bundle.)

(Cat. No. 130309, U. S. N. M. Philadelphia, Pennsylvania, 1830. Presented by George G. Fryer.)

The "spunk" (Fig. 60), the common name of the splints tipped with sulphur, was in general use in this country prior to 1825, and lingered in out-of-the-way places long after the introduction of matches. In parts of France it is still in use with the *briquet*, being much more economical to people of simple habits than matches (Fig. 61). The *briquet* has not

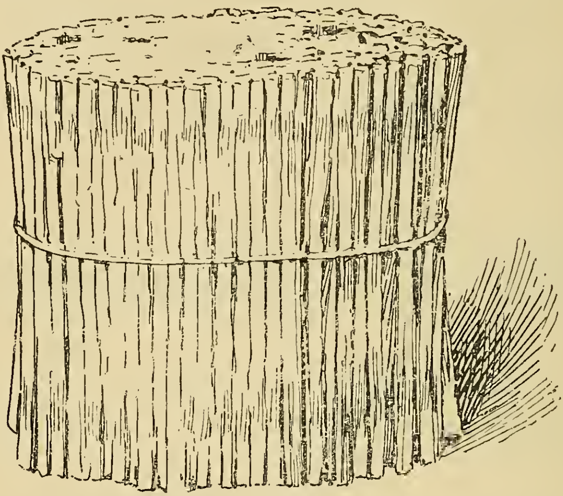


Fig. 61.

SULPHUR "SPUNKS."

(Cat. No. 151438, U. S. N. M. France. Collected by Edward Lovett.)

been altogether superseded by matches. Hunting parties and exploring parties to distant countries carry, besides matches, strike-a-lights for use in case matches are exhausted or meet with some of the many accidents to which they are liable. Patents are still sought, from time to time, for pipe-lighting contrivances, involving the use of silex and steel struck together by some more or less simple mechanical device.

A variation of the "spunk" match was curled shavings tipped with sulphur (Fig. 62).

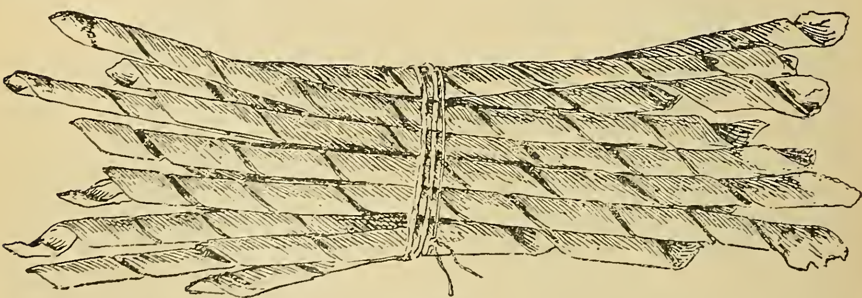


Fig. 62.

SHAVING MATCHES. (Original Bundle.)

(Cat. No. 130308. U. S. N. M. Philadelphia, Pennsylvania. Gift of George G. Fryer.)

It is not strange that there was a prejudice against matches at first, because they were poorly made, hung fire, easily absorbed moisture, emitted noxious odors, and were costly. The worst ones were, however, more expeditious than the tinder-box, and the improvements soon made the invention all that could be desired in point of effectiveness. It is, however, worthy of inquiry whether the alarming deterioration of the teeth of the present generation may not be due to phosphorous matches more than to soft food.

Attempts to supersede the clumsy *briquets* produced the tinder pistol, the tinder wheel, and, later, the first chemical match. Dussauce says: "When for the first time a match could be inflamed by dipping it into a bottle full of phosphorous mastic mixed with oxide of phosphorus, the results were fine, but were far from those now obtained. This primitive invention is due to Cagniard de la Tour, and is the foundation of the actual industry of matches inflammable by friction."*

This invention is interesting as marking the first employment of phosphorus in the problem of easy fire-producing. The next invention was called the "Instantaneous light-box," or "Eupyrion," also called "dip splint," said to have been invented in Vienna in 1809. The only United States patent of this device was in 1814, called "match-light box." It consisted of a tin box, or wooden receptacle, containing a glass bottle filled with asbestos soaked with sulphuric acid, and wood splints tipped first with sulphur and then dipped into a paste made of chlorate of potash 6 parts, powdered sugar 2 parts, and gum Arabic 1 part, the mass mixed with water and colored with some material. The splints were lighted by dipping them into the acid. Victor Hugo describes the outfit under the name of "Fumade's fire-producer," in Les Miserables, where Gavaroche, after several trials, succeeds in eliciting a "sputtering light" in his lodging in the interior of the Elephant, a statue in Paris. Hugo's plot was laid in 1832, but the invention was made public in 1825 or 1826. Owing to great cost in the first instance and to the subsequent loss of value by the decline of strength in the acid, as well as to the hygroscopic nature of the composition on the splints, it had a limited popularity.†

Another fire-producer on this order was the "Prometheans," tubes of glass filled with sulphuric acid surrounded with an inflammable mixture made chiefly of alum and sugar. On being broken they gave an instantaneous light. Another promethean was composed of equal parts of chlorate of potash and sugar mixed with a solution of gum. The sulphuric acid was ingeniously contained in a small glass bead, imbedded in the paste and rolled up in gummed paper. After the bead was crushed with a pair of pliers the acid came in contact with the chlorate and flame resulted.‡

Still another invention of this period was the German "Döbereiner," named for the inventor, a chemical apparatus also known as the hydrogen lamp. A light was obtained by allowing a jet of hydrogen gas to

* H. Dussauce: Fabrication of Matches. Phila., 1864, p. 73.

† See also "Little Dorritt," by Dickens, II, p. 271.

‡ Brande's Encyclopædia, p. 997.

impinge against spongy platinum, which becomes incandescent through some obscure and little understood action, in which the power of platinum to cause the combination of gases plays an important part. The döbereiner consists of a glass jar filled with dilute sulphuric acid, having a flat trap cover, from the center of which hangs down a glass bell, in which are suspended beads of zinc strung on iron wire. On the top of the cover is a jet and stop-cock opening out of the bell, and in front of it is a small chamber containing a bit of spongy platinum. The acid acts on the zinc, producing hydrogen gas as soon as the cock is opened. When the cock is closed, the action ceases, as the acid is forced out of the bell by gas pressure, and the zinc is not acted upon. The jet of gas plays on the platinum, quickly rendering it incandescent and easily setting fire to a splint. (Compare Volta's electric hydrogen lamp.) The döbereiner was rather extensively used in Germany and in other countries. It is still found in laboratories and can be purchased from instrument-makers.

The first United States patent for friction-matches was issued in 1836. It was a chlorate match.

The splints were made by sawing or splitting blocks of wood into slivers slightly attached at the base and dipping the whole bunch. These were known as slab or block-matches (Fig. 63), and, although the first patent, they are in favor in parts of the country to the present day, notably in Maine. Their chief advantages are that they are noiseless and will not leave a mark when scratched on a white wall.

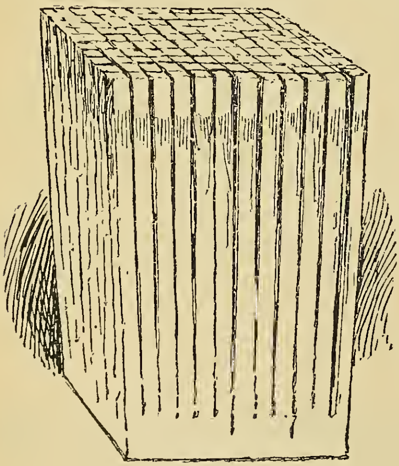


Fig. 63.
BLOCK MATCHES.
(Cat. No. 131260, U. S. N. M. Collected by Walter Hough.)

John Walker, of Stockton-upon-Tees, is said to have been the inventor of friction-matches in 1829. The eighth edition of the Encyclopedia Britannica does not give the name of the inventor, and states that matches were invented in 1832. Dussauce states that they were of German invention, and perhaps before 1830.*

The first friction-matches, "lucifers," were made by dipping splints first into melted sulphur and then into a paste of chlorate of potash and sulphide of antimony, mixed with gum water. The paper box contained perhaps one hundred matches and two pieces of fine sandpaper. They were lighted by folding the sandpaper over the end and giving the match a quick pull. The Museum collection contains a specimen of these matches (Cat. No.

* H. Dussauce. Fabrication of Matches. Philadelphia, 1864; preface, p. iv.

129973, U. S. National Museum), secured from the Essex Institute at Salem, by Prof. F. W. Putnam. The date is about 1833, and they were made in England (Pl. LI.) Quite a common name for them was "loco-focos," evidently of Roman derivation. At first the chlorate of potash lucifers were called "congreves" on account of crackling like a congreve rocket. The composition in many of these matches melted and dropped while burning. These defects, however, were soon remedied with the production of "noiseless lucifers."

The next step was to employ phosphorus, rendering matches easily ignitible with lower temperature and less exertion. A phosphorous match will ignite at 140 degrees, while it is probable that the lucifer required at least 200 degrees. The use of phosphorus for matches dates probably from 1832, being 172 years after the discovery of that element by Brandt, a Hamburg chemist.

Ghan and Scheele have the credit of preparing phosphorous, commercially, from bone. The manufacture of phosphorous matches was attended with great danger to workmen from the fumes, which caused necrosis of the jaw. Many persons were poisoned from carelessness in handling these matches, and many conflagrations occurred on account of the ease with which they ignited. The "parlor match" (name significant that other matches were hardly suitable for that section of the house) really began with the manufacture, in 1848, of Schrötter's red or amorphous phosphorus. This product is of a scarlet-red color, has neither odor nor taste, is not poisonous, so far as is known, and does not take fire at ordinary temperatures. It is said, however, to absorb moisture from the atmosphere. There are many formulas for the composition of matches at present used by manufacturers that give good results.

The latest important invention in matches secures the separation of the chemicals, which, in combination, are always more or less dangerous. The safety-match was invented by a Swede named Lundstrom, at Jöndköping, Sweden, in 1855 or 1856. The head of the safety-match contains chlorate of potash and sulphur, while the friction-paper is spread with a paste of amorphous phosphorus and antimony. This is a return to first principles as shown in the splints and acid of the "light box."

There are many varieties of matches now in vogue. The most notable are the "Vestas," of which the splint is waxed cord; "fusees," for lighting in a wind, with a thick, short splint tipped with a large mass of chlorate of potash composition; "natural gas" matches, with a very long splint for lighting natural-gas fires. Besides these there are as many brands of matches as of cigars.

PRODUCTION OF MATCHES.

What was formerly a small industry, or the domestic duty of the "handy" boy, has grown to a manufacture of enormous and rapidly increasing proportions. Electricity, however, seems destined to limit the use of matches as it does other methods of illumination. The use of matches and of gas increases perhaps in a greater ratio than the spread of the electric light, so that it will be a long conflict between them for supremacy.

The manufacture of splints in great quantities began with the invention of Reuben Partridge's splint-cutting machine. Previously matches had been split by hand by means of a collection of blades. Block or slab matches, common 20 years ago, were cut with a tool in such a way as to leave the splints in a bunch, attached together at some distance above the lower ends.* The whole bunch was dipped in sulphur-chlorate composition and the matches could be separated at will. Often the whole bunch took fire upon the separation of a single match, destroying them almost instantly. Modern splints are cut and forced through dies to give them a round shape.

At present, splint-cutting is a separate industry; the splints are sold by the hogshead at the match factories, and one machine will cut ten millions a day.

V.—OPTICAL METHODS.

The powers of the lens and the hollow mirror have been known for ages by the civilized nations around the Mediterranean. In the classics of Greece and Rome there are allusions to the employment of mirrors and lenses for producing fire.† Wherever plane mirrors were known, probably concave focusing mirrors had been discovered. Among the several ways of producing "pure" fire the mirror and lens presented a worthy method to those ancient cultured nations possessing instruments for focusing light. It can scarcely be said that this was a widespread and popular plan for producing fire, but probably was a thing known to priests and scientific men of the day, and viewed as a mystery or curiosity.

The writer has seen hunters use the "burning glass" to light pipe or fire, and has heard of many cases where it was brought into requisition in the absence of matches, the object glass of a telescope often furnishing the lens. However, this method was very limited, and was pursued in defiance of "better light."

VI.—ELECTRICAL METHODS.

Up to 10 years ago scarcely anything had been accomplished toward applying this new and rapidly widening feature of our era to the communication of a spark for starting a light. Strangely enough, Volta

* See Fig. 13.

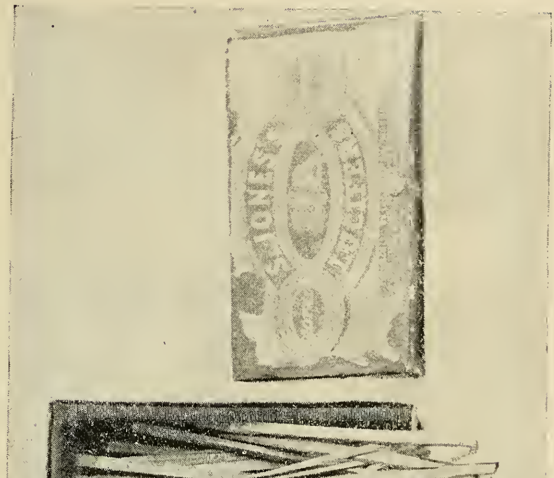
† M. H. Morgan. De Ignis Eliciendi Modis Apud Antiquos. Harvard Studies in Classical Philology, Vol. I, pp. 1–64. This is a complete presentation and discussion of what the classics preserve with regard to the methods of making fire among the ancients.

invented, in 1777, an apparatus for producing a light in which an electric spark was made to ignite hydrogen gas. He also invented an electric pistol on the same principle. This hydrogen lighter was an application about 100 years in advance. It is interesting to note that the introduction of gas illumination prevalent in this country rendered this minor adaptation of electricity practicable in the same way that Volta proceeded.

Lighting gas by electricity has been accomplished for some years, and is now becoming more and more common, and will perhaps be widely used before electrical lighting shall supplant other methods, as has been assumed by some writers.

Recently the gas jets of most of the large audience rooms, theaters, churches, etc., of this country are lighted by electricity at the pressure of a button. In residences with modern improvements gas can be lighted or extinguished in the halls and rooms on different floors from a switchboard situated at a convenient location.

No practicable portable electrical lighter has yet been devised.



THE FIRST FRICTION-MATCH, OR LUCIFER, "LOCO FOCO."

From a photograph (Cat. No. 129973, U. S. N. M.) of an original box in the Essex Institute, Salem, Massachusetts