THE HELLGRAMMITE.

BY PROFESSOR C. V. RILEY.

Few insects excite more curiosity than the gigantic fly (*corydalus cornutus*, Linn.), to which I desire to introduce the readers of the SCIENTIFIC AMERICAN. It is our largest *neuropteron*, or nerve-winged insect, belonging to the family *sialidæ*. Of not unfrequent occurrence over the Atlantic, Middle, and Western States, it is most often met with along water courses, and is vulgarly called the "hellgrammite" in the Mississippi Valley; and this cognomen, the origin of which is somewhat obscure, has been generally adopted by entomologists. There is a certain formidable look about the creature; and though it is absolutely harmless, a great many people have a superstitious dread of it.

The supposed eggs of this fly were first found by the late Benjamin D. Walsh, of Rock Island, Ill., and were figured and described in the *American Entomologist* (Vol. I.), and in the fifth "Entomological Report" of the writer, as "oval, about the size of a radish seed, of a pale color with some dark marks," and "deposited in the summer months in closely set patches of fifty and upward, upon reeds and other aquatic plants growing along running streams." How it was that Mr. Walsh referred these eggs so confidently, and without qualification, to this particular species, it is impossible now to say. Walsh was a most careful observer and writer, and the accuracy of his conclusions in this instance was never questioned either by myself or others. Yet the eggs of our hellgrammite are, in reality, totally different. In passing up the Mississippi last July, between Bushberg and St. Louis, my attention was attracted to a number of white splashes on the leaves of vines and trees overhanging the water, which splashes looked at a short distance very much like the excrement of some large bird. But upon closer inspection each splash had a more or less regular, circular or oval bulging about the middle; and upon procuring some of the leaves thus laden, a glance sufficed to show that each swelling was in reality an egg mass. Within the distance of a mile I obtained over thirty of these egg masses, there usually being one to a leaf, and that on the upper side, but sometimes three or four, and in one instance eight—five on the upper and three on the lower surface. They were found alike on cottonwood, sycamore, elm, and grape vine, but in every instance on leaves over-hanging the water, thus indicating that they belonged to some aquatic animal, and that the leaf was but a temporary place of attachment. The mass is either broadly oval or circular in circumference, flat on the attached side, and plano-convex on the exposed side. It averages 21 millimeters (¾ inch) in length, and is covered with a white or cream-colored albuminous secretion, which is generally splashed around it on the leaf or other object of attachment.

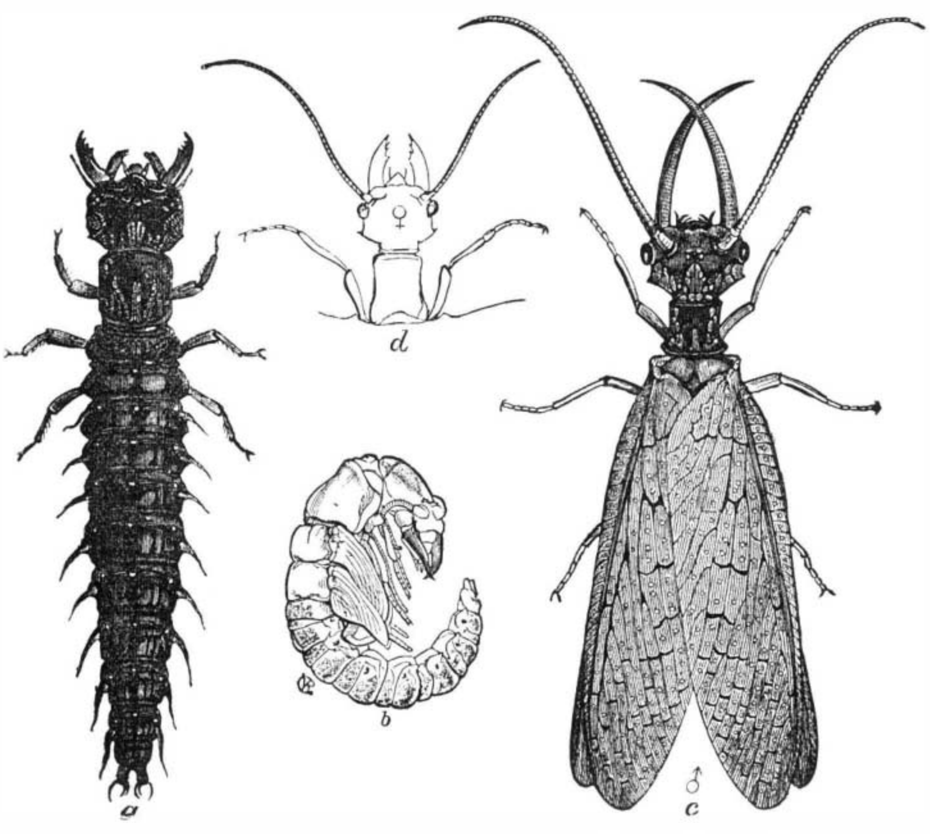

Fig. 1.—HELLGRAMMITE:—*a*, full grown larva; *b*, pupa; *c*, male fly; *d*, head of female fly.

Each mass contains from two to three thousand eggs, the outer layer forming a compact arch, the eggs placed side by side with the anterior ends inside, and the hind ends showing like so many faint dots through the white covering. Those of the peripheral row lie flat upon the object of attachment, and the others gradually diverge at their outer or hind ends, so that those in the center of the arch are at right angles to said object. Beneath this vaulted layer the others are packed on a plane with the object, those in contact with it arranged in concentric rows, the rest packed in irregularly. Each egg is 1/20 inch long, about one third as wide, ellipsoidal, translucent, sordid white in color, and with a very delicate shell; and each is surrounded and separated from its neighbors by a thin lining of the same white albuminous substance which covers the whole. Before hatching, the color of the eggs deepens into fuliginous, and contrasts more strongly with the intervening white. Now the nature of these eggs not only puzzled myself but every prominent entomologist in the country to whom I referred them. The eggs of all the larger water beetles are known and described, and those of our hellgrammite were also supposed to be. There is a large water bug (*belostoma grandis*), but these eggs were evidently not heteropterous. No dipterous insect was large enough to produce them, and the *hymenoptera*, *lepidoptera*, and *orthoptera* were out of the question. In fact, Walsh's blunder threw me off the track, and I had to patiently await development. Presently, to my great joy, the young began to hatch; and being perfectly familiar with the full grown larva of *corydalus* in all its details, I at once recognized this species in my young curiosities. For the first time it struck me that Walsh had made a mistake. An examination of the contents of the abdomen of a gravid hellgrammite in my cabinet at once settled the question, and made it manifest that the eggs that had just hatched belonged, without any question, to this gigantic fly.

As to the nature of the eggs that have hitherto been mistaken for them, and which are represented in Fig. 3, we can only surmise. The specimen from which the engraving was made was destroyed with the Walsh cabinet in the Chicago fire; but I have a clear recollection of them, and am of the opinion that they belong to the large water bug (*belostoma grandis*), the eggs of which are still undescribed.

The full grown larva of our hellgrammite is well known to fishermen, who, in this part of the country, call it a "crawler," and esteem it as bait. It measures from three and a half to four inches in length, is of a dark brown color variegated with light brown, the abdominal joints being tough and leathery, and the head and thoracic joints horny and polished. Though this larva can live for some time out of water, even when young, yet until it attains its growth it is strictly aquatic, abounding most in rapid-flowing streams, and especially such as have a rocky bottom, upon which it crawls slowly about, feeding upon other aquatic insects. Mr. J. H. Comstock, of Cornell University, who has been making some interesting anatomical studies on this insect, generally finds it in the most rapid portions of the streams about Ithaca, where it dwells mostly under stones. He has captured numbers by turning over large stones, and allowing the current to wash the larvæ into a dip net; and he is of the opinion, which my own observations support, that the species live three years in this larval condition. Most aquatic larvæ transform to the pupa state within the water, but this larva quits the water when full fed, as do the others of the same family, and crawls about for days seeking a place wherein to transform. We find, therefore, that Nature has abundantly fitted it for living in both elements, by giving it, first, two rows of nine breathing holes or spiracles, placed in the usual way along the sides of the body, which enable it to breathe out of the water;* and, secondly, two sets of nine gills or *branchiæ*, in the shape of lateral slightly hairy filaments which enable it to breathe in the water. These gills or respiratory filaments are placed just below the spiracles, one on each side of each abdominal joint, except the ninth, and one on the terminal subjoint. Besides these lateral filaments there is, ventrally, a pair of rust-brown spongy masses of short fibers, one on each side of joints 4—10, and a somewhat similar central patch on the terminal joint and sub-joint. These have been regarded as accessory gills, but they probably assist the creature in adhering to the surface of stones at the bottom of swift-flowing waters. The lateral filaments assist in swimming, and the tip of the body is provided with a pair of curved double hooks, which assist in climbing, or in moving backward. The newly hatched larva is almost colorless, and has the structural characters of the full-grown individuals, except that the legs and the branchial filaments are relatively longer, and the body of more uniform diameter. The sponge-like ventral masses of fiber are, however, obsolete, and the lateral filaments are smooth and not hairy. In hatching, the young do not gnaw through the vaulted covering, but creep from beneath the sides of the mass, which is somewhat loosened and raised by their pressure. They at once drop from the leaf, and crawl actively, with tails hoisted in the air, over whatever surface they may fall upon. It is doubtless their habit to drop at once to the water and sink to the bottom, where they can anchor by means of the anal hooks, or find lodgment under some stone or rock. In an aquarium, in which I endeavored to rear and study them, they would float readily, with the body curved in the water and the head bent so as to rest at the surface. They also swam readily by sudden jerks of the body, especially by striking the abdomen beneath, very much resembling the actions of the common mosquito wriggler in descending, but ascending head foremost, more like the pupa of that species. They did not seem to need to rise for air, and would congregate most at the bottom of the aquarium, and under such stones as were placed therein.

Fig. 3.—Supposed eggs of corydalus.

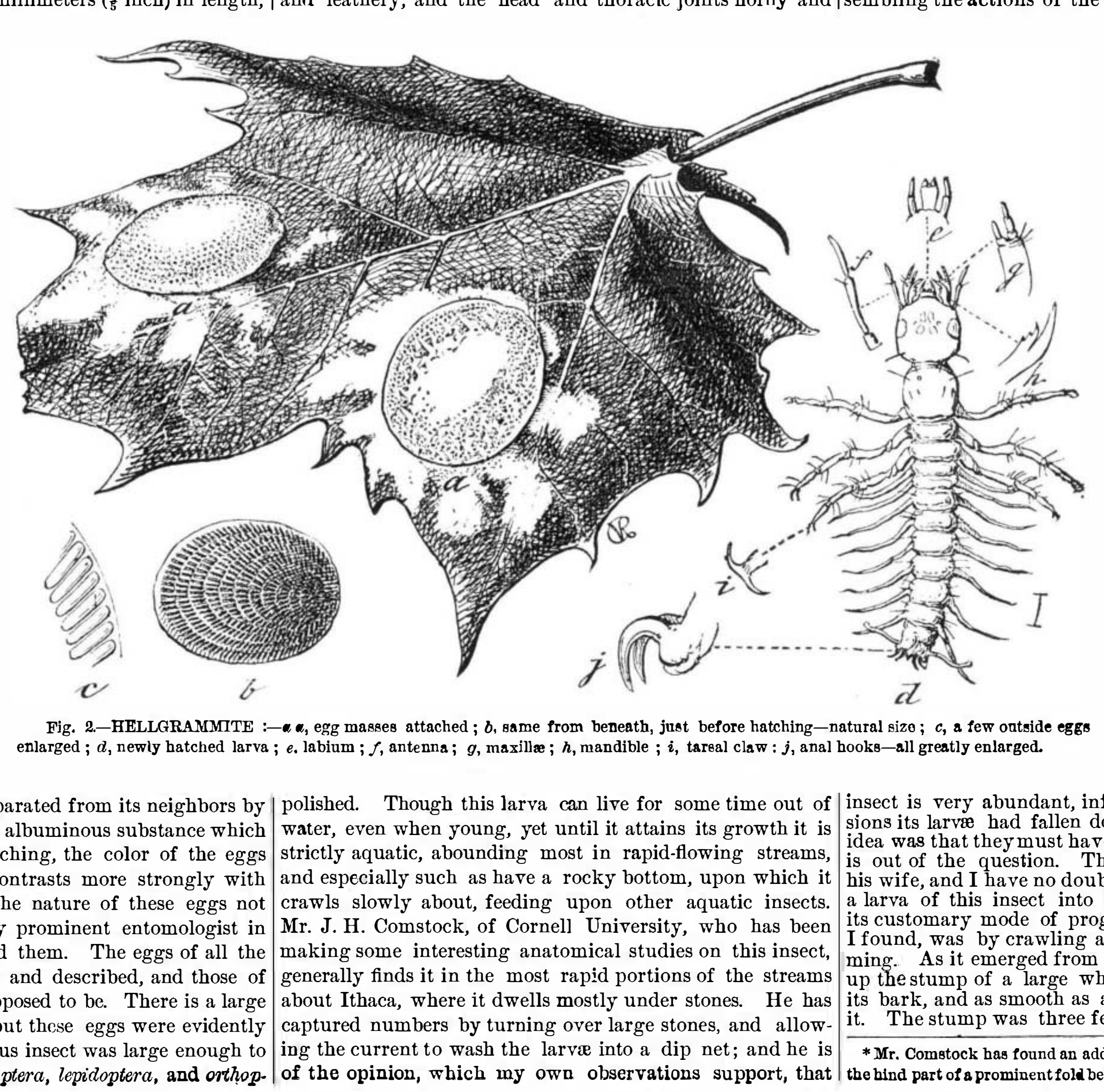

Fig. 2.—HELLGRAMMITE :—*a a*, egg masses attached ; *b*, same from beneath, just before hatching—natural size ; *c*, a few outside eggs enlarged ; *d*, newly hatched larva ; *e*, labium ; *f*, antenna ; *g*, maxillæ ; *h*, mandible ; *i*, tarsal claw : *j*, anal hooks—all greatly enlarged.

They none of them could be made to survive more than three days in such standing water, and the necessity of fresh running water to their well-being will always render difficult the study of the insect in its infancy.

After leaving the water, about the beginning of June, this larva travels, in the night-time, sometimes to comparatively great distances, having been found nearly a hundred feet from its former *habitat*.

Mr. Walsh mentions a most curious incident in connection with its larval wandering, which I quote in full:

"A most respectable man, who keeps the toll bridge over Rock River, where this insect is very abundant, informed me that on several occasions its larvæ had fallen down one of his chimneys. His idea was that they must have bred there, but that, of course, is out of the question. The statement was confirmed by his wife, and I have no doubt of its truth. In 1863, I threw a larva of this insect into the Mississippi to examine into its customary mode of progressing in the water, which, as I found, was by crawling along the bottom, not by swimming. As it emerged from the water, it climbed with ease up the stump of a large white elm, which was stripped of its bark, and as smooth as any carpenter could have planed it. The stump was three feet high and upright, and when

* Mr. Comstock has found an additional pair of rudimentary spiracles on the hind part of a prominent fold between the mess and metathoracic joints.

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it had reached the top it commenced descending on the opposite side; but, after a while, lost its foothold and fell into the water again. The pair of two-clawed appendages at the tail are used with much effect to assist it in climbing. The building which it must have climbed to reach the chimney, down which it is stated to have fallen, was only a low, one-story wooden one."

This larva can pinch with its formidable-looking jaws, but not forcibly enough to draw blood. In preparing for the pupa state, it burrows into the earth, where it forms an oval cell; or it hides under some large stone, piece of wood, or other substance. Here, in about two weeks, it casts its tough larval integument and assumes the pupa form, lying in a curved position in its cell, with the head, wing-pads, and legs deflexed on the breast. The color is yellow, with traces of the brown mottlings of the larva and of the lateral filaments. The spiracles are more conspicuous, and the upper jaws stronger than in the larva, and olive green. The pupa state lasts but a few days, and the perfect insect issues during the month of July. It is nocturnal in habit, and hides, for the most part, in obscure places during the day. It is sluggish at this time, and, if approached, will drop sooner than fly, or raise its head and abdomen and open its jaws menacingly.

The sexes differ greatly in this perfect state. The male is remarkable for having his upper jaws—which in the female are normal and fitted for biting—prolonged into incurved, prehensile appendages of the form of a grain cradle finger, and smooth and cylindrical, except at the tips, which are pointed, and minutely notched. As I have shown in my 5th report, there is no perceptible sexual difference in larva or pupa, unless it is, as stated by Haldeman, in the rather larger size of the jaws of the male. This feature cannot, however, be relied on. This similarity of the sexes, especially in the pupa, is the more remarkable that in the imago state they differ so greatly. The subsequent modification of the male jaws is assumed at the last molt; and if the jaws of a male pupa be dissected, the future finger-like jaws will be found crowded within them, like the "wrinkled finger of a glove pushed into a thimble," as Mr. Comstock expresses it. This modification in the male is evidently to enable him to embrace the soft body of the female, as it cannot well have any other use. The body of the hellgrammite is soft, and were the jaws of the male horny, and armed with teeth, in securing the female they would injure her, and thus defeat rather than aid procreation. In the large stag beetle or "buck-bug" (*lucanus elaphus*, Linn.), on the contrary, where both sexes have very hard, horny bodies, the upper jaws in the male are greatly prolonged, but very stout, and armed with sharp prongs, the better to enable him to seize the female.

In these two cases we see how wonderfully the homologous organs have been modified in opposite directions to accomplish the same end. We find in Nature innumerable such curious contrivances and modifications, which at once excite our wonder and admiration. To quote Mr. Walsh's own eloquent words: "In so elaborate and diversified a manner does Nature adapt her plans and patterns to the ever-varying conditions of animated existence; and with such consummate care has she provided that the great fundamental law shall everywhere be carried out: 'Increase and multiply and replenish the earth.'"

It is worthy of remark that in both these large insects, in which the male upper jaws are so modified, this sex is far more common than the other. It is probably owing to the fact that the female seldom wanders away from her breeding place, and is, therefore, less often seen than her more restless and adventurous mate.

The Allen Governor.

The Allen governor, an extended illustrated description of which we published some time ago, is meeting, we are gratified to learn, with the substantial success to which, through its many merits, it is justly entitled. Over 2,000 of these governors are now in operation in this country and abroad, and the demand is constantly increasing. The manufacturers exhibit a series of testimonials, from those who have the machine in use, on all sorts of engines and under a great variety of conditions ; and there seems to be but one opinion as to its great sensitiveness and general efficacy. We see from an advertisement in another column that agents are desired for the sale of the governor.

On the Estimation of Alum in Bread.

"For a long time past the old Normandy or soda process for the estimation of alum in bread, has been condemned on account of the great difficulty experienced in re-dissolving the aluminic hydrate or phosphate, after its precipitation, together with tri-calcic phosphate, etc. This has led to the production of several processes, most of which are very complicated. By a slight modification in the usual method of procedure, the Normandy method can be rendered as accurate in its results as any of those which have replaced it. This consists in adding the boiling acid solution of the charred bread to a boiling solution of sodic hydrate, containing a large excess. I proceed as follows: 1,000 grains of bread are burnt down to a small bulk, powdered with about 100 grain measures of hydric chloride, and warmed for a few minutes; about two ounces of water are then added, boiled for five minutes, filtered, etc. A solution containing about 250 grains of pure sodic hydrate is made in a very little water; and to this solution, when boiling, is very cautiously added the boiling acid solution of the charred bread, the whole boiled for a few minutes, filtered, and washed. The filtrate, after the addition of a few drops of a concentrated solution of disodic phosphate, is slightly acidified with hydric chloride, and subsequently rendered just alkaline with ammonic hydrate and boiled. The precipitate is collected, washed, and weighed as aluminic phosphate.

"To test the accuracy of this method, I had four loaves of bread made in my kitchen, one with no alum, the others with varying quantities. Care was taken to leave as little as possible of the dough adhering to the sides of the vessel in which it was made, so that each loaf contained, practically, all the alum that was dissolved in the water with which it was made. The loaves were weighed when one day old, and 1,000 grains taken of each:

	Weight of loaf.	Grains of alum put in.	Weight of Al. PO^4 from 1,000 grains.	= grains of alum in loaf.
1..	2 lbs.	0	0·07 grains.	3·50
2..	$1\frac{1}{2}$ lbs.	10	0·32 grains.	12·39
3..	2 lbs.	20	0·46 grains.	23·80
4..	$2\frac{1}{4}$ lbs.	40	0·76 grains.	44·20

"It will be seen that the method leaves nothing to be desired in point of accuracy, and will favorably compare with any other in respect to simplicity.

"Since devising the above process, I have been informed by Mr. Heisch that he, and he thinks others, have for many years applied the same principle (namely, the addition of the acid solution to an excess of boiling alkali) to the separation of aluminic hydrate from other gelatinous precipitates, having found it impossible completely to re-dissolve the aluminic hydrate by any amount of sodic hydrate if it were once precipitated."—*W. C. Young, F.C.S., in The Analyst.*

Mount Carmel, Ill , Destroyed by a Tornado.

The town of Mount Carmel, Ill., was visited on the 4th instant by a terrible tornado, which laid nearly the entire place in ruins. About 20 business houses and 100 residences were either destroyed or badly damaged by the fury of the gale, and by the fires which broke out at various points. The storm came from the southwest, and, from its track, seems to have been a cyclone traveling at an estimated velocity of 150 miles per hour. During its prevalence, the air was filled with flying roofs, lumber, clothing, etc., some of the *débris* being carried miles away. Thirteen persons are reported as killed, many others injured, and some seventy families were rendered homeless. The loss of property is said to amount to nearly $500,000. No warning whatever was afforded of the approach of the storm. It seems to have struck the town and to have passed over it within two minutes, preceding a heavy rainfall.

Mount Carmel has about 3,000 residents, and her industries were largely mechanical. The SCIENTIFIC AMERICAN has many subscribers among those who have been afflicted, for all of whom we have the heartiest sympathy.

The Meeting of the American Association for the Advancement of Science.

The twenty-sixth meeting of the American Association for the Advancement of Science is to be held at Nashville, Tenn., on August 29. Sessions will take place in the Capitol. Special arrangements are being made for decreased railroad fares, etc., and for the accommodation of members in the city. The permanent subsections of chemistry, microscopy, and anthropology are to be continued, and the co-operation of students of these sciences is requested. The Entomological Club will meet on the day preceding the meeting of the Association.

Inventions Patented in England by Americans.

From May 15 to May 24, 1877, inclusive.

BATH OVERFLOW, ETC.—Valve and Faucet Company, New York city.
BOOK.—J. Clemens, Hartford, Conn.
BOOT-NAILING MACHINE.—L. R. Blake, Boston, Mass.
BOTTLE STOPPER.—N. Thompson (of Brooklyn, N. Y.), London, England.
CAR COUPLING.—E. Miller, New York city.
ELASTIC BAND.—F. Armstrong, Bridgeport, Conn.
LAMP.—J. H. Lewars, Philadelphia, Pa.
LAMP.—N. L. Rigby *et al.*, Winfield, Kan.
METAL CARTRIDGE SHELLS.—J. H. Bullard, Springfield, Mass.
MOTOR FOR ROCK DRILLS, ETC.—E. S. Winchester *et al.*, Boston, Mass.
ORNAMENTING GLASS, ETC.—S. M. Adams, New York city.
PAPER BOX, ETC.—E. B. Beecher, Westville, Conn.
PARING FRUIT, ETC.—W. H. Goodchild *et al.*, New York city.
PORTABLE BOAT.—C. A. Fenner, Mystic River, Conn.
POSTAGE STAMP, ETC.—A. B. Foster, Providence, R. I.
POSTAGE STAMP, ETC.—J. Sangster *et al.*, Buffalo, N. Y.
REFINING STEEL, ETC.—J. E. Sherman, Boston, Mass.
SCISSORS.—C. M. Meserole, New York city.
SCREW MACHINERY.—E. Nugent, Brooklyn, N. Y.
SCREW-THREADING MACHINERY.—S. S. Townsend, Philadelphia, Pa.
SCREW WRENCH, ETC.—B. L. Walker, Sing Sing, N. Y.
SEWER GAS TRAP.—B. P. Bower *et al.*, Cleveland, Ohio.
SEWING MACHINE.—L. Dryfoos, New York city.
SPLINT.—D. Ahl, Newville, Pa.
TORPEDO APPARATUS.—H. S. Ross (of Chicago, Ill.), London, England.
TOY HORSE.—J. H. Nolan, Boston, Mass.
TREATING SLUDGE OIL.—W. P. Jenney, Brooklyn, N. Y.

DECISIONS OF THE COURTS.

Supreme Court of the United States.

PATENT STONE-CRUSHING MACHINE.—JOHN ROBERTSON, CHARLES C. MARTIN, AND AUSTIN H. SMITH, APPELLANTS, *vs.* ELI W. BLAKE. ELI W. BLAKE, APPELLANT, *vs.* JOHN ROBERTSON, CHARLES C. MARTIN, AND AUSTIN H. SMITH.

[Appeals from the Circuit Court of the United States for the Eastern District of New York.—Decided October term, 1876.]

The patent granted to Eli W. Blake for a stone breaker, June 15, 1858, reissued January 9, 1866, and extended June 15, 1872, is not anticipated by the earlier patent to Hobbs and Brown for "improvements in the application of well known mechanical means for the purpose of crushing ice," and to Hamilton for "crushing and grinding quartz or other substances," they not containing any of the essential element of Blake's invention.

The substitution of one part of the operating mechanism, of a combination the equivalent of that omitted, does not avoid an infringement.

When an original machine and an improvement upon it are both patented, neither patentee can use what does not belong to him without the requisite authority from the owner.

The complainant was found entitled to nominal damages only, the burden of proof being upon him; and it appearing that the proof was meager and indefinite, but four machines made, no established license fee, the profits made being due in part to inventions covered by other patents, and no distinction made between profits accruing from the use of complainant's invention, and that from the other inventions and manufacturers' profits.

Mr. Justice Swayne delivered the opinion of the court:

These are cross-appeals in the same cause. Both involve questions in mechanics. These being determined, the legal propositions which apply are so well settled as to admit of no controversy.

A patent was granted to Blake on the 15th of June, 1858, by the United States, for a stone breaker. On the 9th of January, 1866, the same authority reissued the patent to him, with amended specifications. It was extended on the 15th of June, 1872. The bill in this case is founded upon the latter patent. It charges infringement.

The answer avers that the machine described is of no practical utility, denies the novelty of the invention, and also the alleged infringement.

The description in the specifiation sets forth three things as the essential characteristics of the machine:

(1.) Two jaws within which the stones are to be broken. Their faces are to be so nearly in an upright position that the stones will descend between them automatically. The jaws are to be so far convergent that the interspace at the top ill be sufficient to receive the stones, and that at the bottom only such as will allow the fragments to escape when broken of the required size.

(2.) A revolving shaft driven by steam or other motive power, imparting to one of the jaws a continual vibratory movement, causing it alternately to approach toward and recede from the other jaw, through a short and definitely limited space, so that when a stone is put in the movable jaw will advance and crush it, then receding liberate the fragments, which again descend, and, if too large, are rearrested and crushed again, and so on until the fragments have passed out through the open space at the bottom. The distance between the jaws is to be adjustable at pleasure, so that the stone can be broken of any desired size.

(3.) A flywheel is combined with the revolving shaft and movable jaw for the purpose of rendering the strain upon the power more equal.

The claim is for—

A combination of a stone-breaking machine of upright converging jaws with a revolving shaft and mechanism imparting a definite reciprocating movement to one of the jaws from the revolving shaft, the whole being and operating as set forth.

The combination in a stone-breaking machine of the upright movable jaw with the revolving shaft and flywheel, the whole being and operating as set forth.

In combination with the upright converging jaws and revolving shaft, imparting definite limited vibration to the movable jaw, so arranging the jaws that they can be set at different distances from each other at the bottom, thus producing fragments of every desired size.

A moment's glance at the model furnishes a sufficient answer to the objection of the want of practical value. It would be passing strange if a machine of that character could have gone through the severe conflicts of litigation which this patent has encountered and have come forth victorious from every contest. It has proved equal to every ordeal to which it has been subjected. The number sold by the complainant, as shown by the record, is conclusive upon the subject.

The patent to Hobbs & Brown of the 4th of Septemb r, 1849, and the patents to Hamilton of the 30th of January, 1854, and the 5th of January, 1855, antedate the patent to Blake. It is insisted that each of them is for a machine substantially the same with the one described in Blake's patent, and that they are fatal to his claim of the requisite novelty of his alleged invention.

The machine for Hobbs & Brown is for—

Improvements in the application of well known mechanical means for the purpose of crushing ice. * * * The improvements consist in applying a hopper with one diagonal fixed side and two parallel sides to contain the ice, and compressing the ice by a movable fourth side, the fixed diagonal side and moving side having within them dental projections cut or cast on, to operate downward and prevent the ice from rising in the hopper when compressed, and also to enter and split the ice.

The machine is operated "by the combination with these parts of a lever fitted with an eccentric or cam-formed point."

There is in this description neither of the ingredients nor the compound of the Blake machine. Every element and the combination are both wanting. There is no mention of the converging adjustable jaws, of the revolving shaft, nor of the flywheel. The differences are as marked in the mode of operation as in the structural elements of the machine.

The Hobbs & Brown machine does its work by the downward and sweeping movement of the jaw and the grasping and splitting by the teeth. The motive power is supplied and applied by a hand lever, which gives a motion irregular and varying with the var ing exigencies of the ice during the process to which it is subjected.

The Blake machine performs its functions by the short, regular, and unvarying vibrations of the smooth-faced adjustable jaw driven without intermission by the revolving shaft.

It is obvious that the Hobbs and Brown machine could not be applied with effect to the purpose of breaking stones without essential changes of principle and details.

Hamilton's machine was "for crushing and grinding quartz or other substances."

In the specification annexed to his original patent, he says:

My invention consists in the use of a cylindrical nut or pestle in a similarly formed basin, the pestle haying a partial rotary and crushing motion communicated to it by means of a lever attached thereto.

A is a basin, the lower part of which is made circular, and the sides parallel to each other; *b b* are flat ends or heads secured to the basin by bolts. C is the shaft carrying the cylindrical pestle, *d*. E is a lever attached to or formed with the pestle, *d*, the upper end being connected by a joint, 2, to *a* pitman, passing to a crank, eccentric, or other suitable mechanical contrivance to give the arm, E, an oscillating movement, and the pestle a partial rotary motion on its shaft, C.

The claim of this patent is for—

The means herein described and shown for crushing and grinding metallic ores, consisting of the cylindrical pestle, *d*, provided with grooves in its upper part to crack the lumps of ore and set a shaft, C, on which it has a partial rotary motion, and operating in connection with the basin, A, in which said pestle moves to grind the ore into powder by the gradual approach of the sides of said basin to the cylindrical pestle, said p stle being also provided with a scraper or agitator, 5, in its lower surface to operate as specified.

The second patent is declared to—

Consist in providing means for keeping the pestle down with sufficient force to pulverize the material operated on, and also to prevent the pestle from grinding too finely, *i.e.*, to furnish material for simply cracking the ore or other material into small lumps of any desired size instead of grinding the same to a powder, thereby adapting the machine to different characters of metallic ores or other substances.

We have here no reflex or embodiment of either of the ideas that found expression in the Blake machine. The converging jaws, the revolving shaft, and the flywheel are all wanting, as in the Hobbs & Brown machine. Instead, there is a cylindrical nut or pestle, having a partial rotary and crushing motion communicated to it by means of a lever attached thereto. The pestle rotates on a central axis within an eccentric concave. The work is done by this pestle. There is nothing of the vibratory motion of a movable jaw, alternately advancing and receding, as in the Blake invention.

The difference is not that of mere mechanical equivalents. It is radical and goes to the essence of the organisms. These considerations are so obvious that further remarks npon the subject are unnecessary.

The proofs show that but two of the Hamilton machines were ever made. Practically the invention was abandoned.

This brings us to the question of infringement.

There are numerous points of similarity, and, indeed, of identity, in the respondent's machine, which are not controverted. It is for breaking stone. It has two upright jaws for this purpose, one fixed and the other movable. The jaws converge. The breaking is effected by the convergence. The movable jaw alternately approaches toward and recedes from the fixed one. This movement is produced by a short and powerful vibratory motion communicated by a revolving shaft with a flywheel upon it. There is an opening at the upper end of the jaws where the stones are received, and one below where they are discharged.

The only point of diversity insisted upon by the respondents is that the vibratory movement in the Blake machine is limited and unvarying, while in the machine of the appellants it is not of this invariable character.

In the Blake machine the movable jaw receives its movement from the revolving shaft through iron rods and levers. In the respondents' machine it is communicated from the revolving shaft through a confined column of water.

In the appellant's model the revolving shaft is not shown. In their machine it works the plunger of the pump from which the water is conveyed to a cylinder behind the movable jaw, whence it is applied to that jaw by means of a ram, the ram taking the place of the piston in an ordinary engine. Thus the vibrating arm, the toggle, the toggle joint, and the pintles in the Blake machine are dispensed with, and their place supplied by the hydraulic arrangements we have described.

What is so employed in the appellant's machine is the obvious and exact equivalent of what is so dispensed with in the Blake machine. The liability of the packed joints to leakage is a serious objection to such use of water. Any considerable leakage would stop the machine. It could not be used while that condition existed. Constant care and vigilance are necessary in such cases to prevent the frequent occurrence of this evil. Water does not escape from a safety valve with the same celerity or effect as steam.

The Blake machine has a decided advantage in the greater simplicity and cheapness of its equivalents.

It is difficult to resist the conclusion that the change had no motive or purpose but evasion.

If there be no extraneous obstruction, the vibratory motion will be exactly the same in both cases. If there be such obstruction, the safety valve in the appellant's machine might possibly be brought into use with good effect. But if this were so, the valve would be only an addition and an improvement of the machine. The valve, therefore, is, in any view, quite immaterial to the inquiry we are pursuing.

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