expenditure of labor. The lights being interchangeable facilitates the removal of the structures when necessary, and also renders them more easy to repair. The invention, it will be seen, is a very simple thing, but it will, says the author, be found an improvement in the construction of garden frames and other horticultural appliances.

SPIDERS' WEBS AND SPINNERETS.

The exterior parts of the silk-producing organs of spiders are called spinnerets. They are four, six, or eight papillæ, or sometimes, instead of papillæ, flat plates, situate on the under side of the end of the abdomen, in a little depression adapted to their size and shape. As far as I am aware, no British spider has a less number than six. On the ends of each spinneret are little funnel-shaped tubes, *a* and *b*, Fig. 1, from which the silk is emitted, and which I call silk tubes, being ignorant of their proper name. The spinnerets lie in pairs, and are naturally divisible into two sets, an upper and a lower. There are two pairs in the upper set, one above the other, which I therefore name the first and second pairs, the one pair in the lower set being distinguished as the third pair. The spinnerets of the first pair have two joints, and their silk tubes are situated sometimes on the end of the second joint, and sometimes irregularly down its inner side. The second spinnerets have but one joint. They are smaller than the first, and have the silk tubes on and around the ends. The construction of the third pair differs a little from that of the other two. Like the first they have two joints, but the basal joint is always much larger than the terminal, which is very short. Their silk tubes are on a retractile plate at the end of the second or terminal joint, which, when not in use, is drawn inwards until the tips of the silk tubes are nearly level with the end of the spinneret. This plate has a thickened rim, and on the interior margin, where the rim is broadened for the purpose, are a few holes and two silk tubes of unusual size. The exact use of these I have been unable as yet to determine. The spinnerets of a spider are mobile, and their movements are effected by longitudinal muscles.

The first and second spinnerets always produce plain or non-adhesive threads; if the spider be of a species that spins viscid threads, these are always emitted by the third pair. There is one family of British spiders which has an extra and very remarkable pair of spinnerets in the lower set, which produce threads of a peculiar character; they are described further on.

Fig. 1. Fig. 3. Fig. 4.

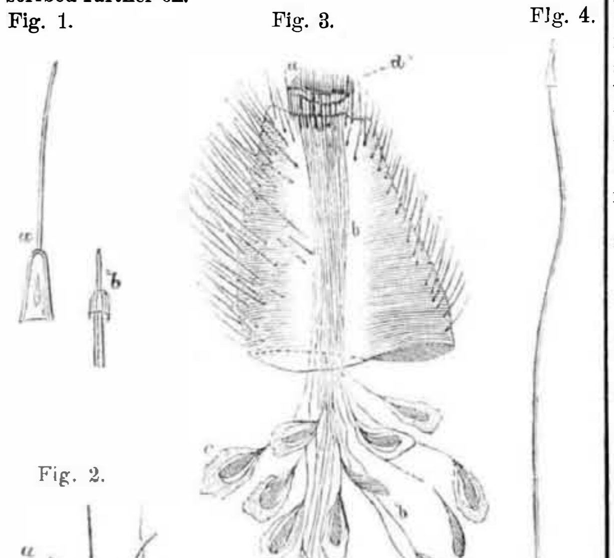
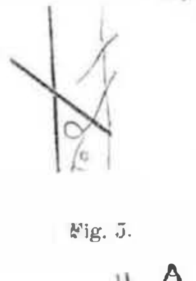


Fig. 2.

Fig. 5.

A



SPIDERS' WEBS AND SPINNERETS.

In Fig. 1, *a* and *b* are silk tubes of first and third spinnerets of *tegenaria domestica*. Fig. 2 shows the web of the same × 150; *a*, first threads, *c*, third threads. Fig. 3 shows the under spinneret, with glands attached, ×38. *a* are the common silk tubes; *b b*, ducts; *c c*, glands; *d*, silk tube of unusual size. Fig. 4 represents the silk tube, duct, and gland of the first spinnerets, × 38. Fig. 5 represents the gland of third spinnerets; *a*, gland; *b*, bag or case; *c c*, coating of epithelial cells.

As may be supposed, I selected the commonest spiders for observation, and house spiders happened to come handiest. The web of a tegenaria, and I believe of every spider, contains three sorts of threads, not two only, as usually stated. Two of these are plain, and stretched taut from point to point (*a*, Fig. 2), and they differ in nothing but size, being spun by the first and second spinnerets, of which in all spiders the first is larger than the second, although in some instances it has a fewer number of silk tubes. The third thread (also shown on Fig, 2) is exceedingly elastic, and studded with viscid globules, or, if these be absent (as in the web selected for illustration), it is slack, irregular, and sometimes much curled.

The apparatus by means of which a spider forms its silk is a series of glands within the abdomen, near and attached to the spinnerets, and immediately beneath the liver and intestinal canal. The glands of the upper and lower sets of spinnerets differ somewhat in character and shape, as is noted below. Fig. 3 is a drawing of one of the third spinnerets of *tegenaria domestica*, with its glands, of which only a few are shown. These communicate with the silk tubes by ducts, *b*. They vary in size in different individuals, but in a large tegenaria $\frac{1}{10}$ of an inch is an average length. Each gland has its own duct and silk tube. On the first pair of spinnerets there are about 60 silk tubes; on the second pair, although the spinnerets are smaller, about 80. The silk tubes on these two pairs are alike; but they differ in shape from those of the third pair and are much larger (see Fig. 3, *a* and *b*). There are nearly 220 tubes on the third pair, thus making altogether about 360 on the six spinnerets.

The glands, likewise, which are proper to the first and second pairs of spinnerets differ from those belonging to the third. Fig. 4 represents one of them with its duct and silk tube, drawn to the same scale as Fig. 3, for the sake of comparison. It is a simple sac, closed at one end, and terminating at the other in the duct, which carries the secretion to the silk tube. On the surface of the gland is a coating of cells, probably epithelial, which are surrounded by a very delicate membrane. The points of difference in the silk glands of the third spinnerets are these: They are smaller (about one quarter the length), of a different shape, and chiefly, they are enveloped by a bag or case interposing between the actual gland and the epithelium (see A, Fig. 5, *b* and *c*), which bag is wanting in the other glands; while the epithelium is apparently without the membranous covering by which, in them, it is always surrounded. This case, continued as a tube, surrounds the duct for some distance, in all probability as far as the silk tubes, but I have not been able to trace it so far.

It has been argued that the drops of liquid silk coalesce as they emerge from the spinnerets, and so form a simple, homogeneous thread, but various observations have convinced me that such is not the case. The following also tends to contradict this theory, namely: When a garden spider has caught a fly, as every one knows, she very expeditiously binds it in a covering of silk. Until I saw the exact process, I often wondered how she could manage to accomplish this so quickly. She places the tips of her six spinnerets almost in a line, at the same time seeming to erect each separate silk tube, and thus puts forth, not a single thread, but a broad band of many detached threads, which is rapidly wound round the unfortunate fly. The examination of the web of a house spider, under a high magnifying power, will show that many of its main threads are frayed, like a rope worn by use; this could not occur if they were homogeneous.—*H. M. J. Underhill, in Science Gossip.*

Correspondence.

The Scientific Treatment of Criminals.

To the Editor of the Scientific American:

Your remarks on the "Scientific Treatment of Criminals," on page 224 of your current volume, strike me as being, in the main, profound and sensible. You omit, however, to take account of one grave fact, which is a weighty factor in determining society's method of the treatment of criminals.

It is this: Each one of these "ill-regulated machines" is a generator of other and worse regulable machines, and generally the prolificness is in inverse ratio to the regulability. This is a state of facts which the modern theory of dealing with the criminal class takes no account of. We send a badly constructed locomotive to the repair shop, and if it can be tinkered up at all it may have some degree of utility. The case, I imagine, would be very different if each locomotive were the spawner and perpetuator of its own defects to all futurity. The mode of dealing would then be the summary breaking up in the shop for the sake of the old material. This is just what human society has done in all past time with its own failures, and to this process of "moral selection" we unquestionably mainly owe the advance which the race has made in moral evolution. It is only in the most recent times that the retrograde course has been adopted, chiefly for sentimental reasons under false theories. Having reached a plateau of comparative security, society kicks down the ladder by which its moral eminence has been in part attained, and ignores the horrid depths from whence it commenced its ascent toward the light.

It is highly questionable whether, sentiment aside, the profit to society from the maintenance of costly prisons and reformatories is greater than the old, simple, and inexpensive methods. For cases other than the most incurable and hopeless failures, however, there seems to be no reason for abandoning the reformatory and punitive modes of treatment, simply on account of a better philosophical hypothesis. The presentation, by society, of powerful motives of action has been, next to selection, a most efficient agent in moral evolution. Now, on the mechanical theory, or any other, it is certain that these motives act, namely, fear of punishment, hope of reward, love of approbation. This is a mere matter of observation. Where, then, does human responsibility to society cease? To be alarmed on this score is to imitate the consternation of the old lady, who, when told that red flames 10,000 miles high had been discovered in the sun, exclaimed: "Now we shall all be burned up alive!" The truth is that the machine is just what it always has been, complex beyond calculation, full of numberless antagonistic springs and coördinating devices, adapted to be played upon by the minutest objective and even subjective phenomena, and capable, to a certain small extent, of a choice of motives. In this lies its responsibility. It is clear that some of the motives by which the components of society have in the past been powerfully influenced and molded may become less potent or disappear. Such transformations are continually going on as society progresses; but there can be no fear that, while the machinery remains constituted as it is, that portion of it which is so wonderfully susceptible to the influence of motives, namely, the imagination and the passions, will, as in the past, be also the prolific generator of new motives sufficient to control the action of all for the general good. H. H.

Washington, D. C.

Small Boat Engine.

To the Editor of the Scientific American:

I have taken an interest in the small engine question, and I wish to say that I have a small engine in a boat 17 feet long and 5 feet wide. It is an upright engine; the cylinder is 2 x 3 inches, and drives a propeller 18 inches in diameter. The boiler is a common upright one with 22 tubes. I can run for four hours with one fire; in a whole day's run, it consumes about 4 buckets of coal. The boat's general rate of speed in still water is about 6½ miles per hour.

Barrytown, N. Y. J. ASPINWALL.

[In descriptions of engines, further particulars would be useful—such as dimensions of boiler, pressure of steam, pitch of screw, and revolutions of engine per minute.—EDS.]

Ice Lenses of Unlimited Size.

To the Editor of the Scientific American:

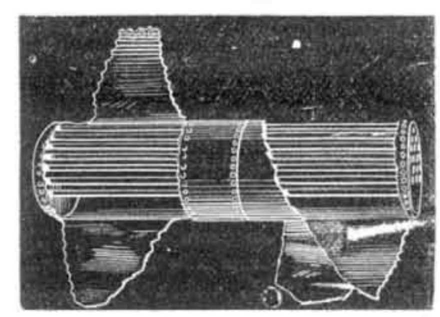
If you had lived in Minnesota and seen our ice, you would not think me foolish in suggesting the possibility of freezing filtered water so as to make a perfectly achromatic lens of unlimited size, to be used in a telescope during the winter months; but as you are used to New York ice, I shall only expect you to think that I am somewhat visionary in this last thought. C. RIDGWAY SNYDER.

Minneapolis, Minn.

Remarkable Boiler Explosion.

To the Editor of the Scientific American:

A fatal boiler explosion occurred in this city at 9 A. M., on October 2, in the factory of the Dubuque Cabinet maker's Association. The engineer and another man were instantly killed, and a third severely scalded. The cause of the explosion cannot be ascertained. The boiler was new (not much over a year in use); it was 15 feet long by 4 feet diameter, with 38 four inch flues. It burst in a queer way, both heads remained on the flues, but the shell of the boiler



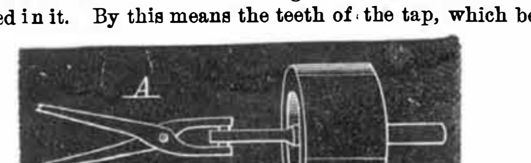
burst along the rivet holes nearly all around both heads, leaving a wreck as shown in the engraving.

Dubuque, Iowa. M. A. KELLER.

Hardening and Tempering Tools.

To the Editor of the Scientific American:

Upon the above subject permit me, in conclusion, to say that, since I withdraw the tube from the fire before inserting the tap, the products of combustion do not interfere with my operation of tempering; and since the tube is shorter than the tap, some part of the latter is at all times exposed to the air, as here illustrated, at A, it being obvious that the tap must be moved endwise through the tube as well as revolved in it. By this means the teeth of the tap, which be



come heated more quickly than its middle, impart the heat to the body of the tap, making its temperature, and hence its temper, even all through, the color of the temper being plainly, at all times, discernible; and perfect access of the air is permitted. The sand bath process I have objected to from the first, for reasons then stated, to which Mr. Hawkins has given his endorsement.

In tempering dies, I do not permit them to lie more than a few seconds on either face, excepting at the end of the operation, when I lay the back edge (the one furthest from the teeth) for several seconds on the hot iron, making the back a little softer than the teeth, and thus strengthening the die. JOSHUA ROSE.

New York city.

To the Editor of the Scientific American:

Enclosed find a tap, or rather the pieces of a broken tap, a quarter inch in diameter, with twenty threads to the inch, with a very deep wire thread (round top and round bottom This tap has tapped over two hundred thousand hot forged