[For the Scientific American].

TUSSOCK-MOTHS.

[By Edward C.H. Day, of the School of Mines, Columbia College].

The group of Spinners or *Bombycidæ,* as it is scientifically termed, among the night-moths, is by far the most important to mankind of all the subdivisions of the Lepidopters. It is among these that we find caterpillars possessing pre-eminently the power of secreting silk, and of inclosing themselves, as they pass into the chrysalis stage, in a cocoon of silken fibers. In many of them, especially the larger forms—and some of the largest of Lepidopters occur in this group—the silk-secreting glands are immensely developed, and man reaps the benefit of this extraordinary provision of nature. But the greater number are unfortunately insects injurious to vegetation. Even the worm that strips the mulberry tree of its leaves would have to be accounted as a devastator, had not the ingenuity of man discovered its value as a most economic and inimitable manufacturer of raw material, producing an article otherwise unattainable. It is only in a very few of the spinners that the silk is secreted in sufficient quantities or is of a character fit for our purposes; and among those whose destructiveness is not in any way palliated by such a return of good for the evil done by them, is the insect that forms the subject of the present article. Every one with eyes for such things, must have often noticed on our shade trees in the summer "little slender caterpillars," such as here depicted, "of a bright-yellow color, sparingly clothed with long and fine yellow hairs on the sides of the body and having four short and thick brush-like, yellowish tufts on the back, that is, on the fourth and three following rings, two long black plumes or pencils extending forward from the first ring, and a single plume on the top of the eleventh ring. The head, and the two little retractile warts on the ninth and tenth rings, are coral-red; there is a narrow black or brownish stripe along the top of the back, and a wider, dusky stripe on each side of the body." (Harris). From the tufts on the back, these caterpillars obtain the name of Tusscoks, and the moths are called Tussock-moths. The scientific name for the genus is *Orgyia,* and the common indigenous American species, to the caterpillar of which the above description applies, is called *O. leucostigma,* or the "white-spot" Tussock-moth. The one here figured is the common European form, *O. antiqua,* which, however, according to Harris has been naturalized in this country, along with many other undesirable immigrants. Both species have a bad character for the damage they do to the trees they infest.

The male moth is the insect on the wing in the center of the picture, but the female—we hear you ask—where is she? Here on the tree on the left hand, depositing her eggs. "That! why that is a wingless creature?" In effect, she is so; though on close examination of the actual insect, you would discover little scale-like rudiments of wings. She not merely cannot fly, but she exemplifies, in the fullest degree, the law that the perfect insect is but the reproductive stage of its entire life; she escapes from the cocoon on the tree side, she there receives the attentions of the males, lays her eggs upon the very cocoon from which she has but now emerged, and dies! But the males, as we see, are gay flutterers—"Vaporers" is one name by which they are known—free to rove at will, to make love to as many of these very stay-at-home ladies as they can, or to visit their clubs, if they have any, just as much as they please. So much for female rights among the Tussock-moths! But the lady moths have no reason to complain, if they cannot go in search of their husbands, they do as well by attracting their husbands to themselves. In fact all the female spinsters exert some attraction so subtile yet so far-reaching that we fear that the idea of Mormonism must exist reversed among them. What this attraction is, or how the males perceive it, we gross mortals can scarcely conjecture. The attraction is generally supposed to be a scent, and the sense of smell in moths has been supposed to reside in the antennæ. These are in the male spinners, generally speaking, very large and plumelike, and from experiments seem to be essential as guides to the progress of the insect. Others, however, consider the antennæ as organs of hearing, and place the organs of smell elsewhere. Be this as it may, it certainly is, as Professor Blanchard remarks, a wonderful fact that a scent so subtile that we cannot perceive a trace of it when close at hand, should be perceptible to the insects, at the distance of several kilometers; from the center of a city, to the woods and fields of the suburbs; nor will the supposition that a sound and not a scent be the attraction, at all diminish the incomprehensible nature of the phenomenon. It was only a short time since that a cocoon in the house of the writer gave forth a female of the Polyphemus moth, one of our largest native spinners—frequently measuring six inches across the wings. The wings being but imperfectly expanded, she was left in a tray covered by another tray. At night we were agreeably surprised, for somehow in this instance we had forgotten the probability of such consequences, by the visits of twelve fine male moths which came flapping in through the open windows during the course of the evening, and several followed on subsequent evenings. A friend informed us some time since that under similar circumstances, ninety-six male moths, of one of our largest species, were (we speak from memory) captured in one house, attracted by one female in the course of twenty-four hours. We should have hesitated to quote the above number from memory without verification, had not Professor Blanchard supplied us with an instance that throws even these figures altogether into the shade. He tells us that M. Jules Verreaux having one day, in Australia, captured the female of a small spinner and placed it in a box, and the box in his pocket, was accompanied home by a gradually increasing flight of males, until, when he entered his house, two hundred moths followed him in!

Verily wives must be at a premium among moths as well as men at the Antipodes! From a scientific point of view, however, it would be most interesting to know whether the female exercises any preference among such a choice of suitors, or whether the most vigorous males are always the successful ones. In fact, the whole history is most suggestive of thought to the inquiring naturalist.

METAMORPHOSES OF THE "STARRED TUSSOCK-MOTH"—*Orgyia antiqua.*

Singular Phenomenon in Heating Diamonds.

"A jeweler of Marseilles," says the *Scientific Review,* "having to enamel a piece of work, thought that he could without inconvenience bring it to the temperature of his muffle without taking out the valuable diamonds which were set in it. The operation succeeded perfectly several times, and then an accident occurred—the diamonds became perfectly black. M. Morren, the dean of the faculty of Marseilles, was called in to investigate the cause, and he ascertained that the successful operations had all been made with coke, while when the diamonds were blackened coal had been used, and he concluded that the black color was due to the fixation of carbon by the action of the diamond on the hydrocarbon gas. He repeated the experiment on a small scale, and found the result answer his expectations, and that by repolishing the diamonds recovered their normal appearance. He then tried the effect of oxidizing gases. A diamond heated in oxygen by means of the blow-pipe did not swell at all. But at a not very elevated temperature it took fire, and the flame could then be withdrawn without interfering with the combustion, which continued by itself. It will be seen that the result differs considerably from that noticed when a diamond is heated by voltaic electricity, and that here the first action of the heat is to transform the diamond into graphite."

Lilliputian Firemen.

A writer of an intensely interesting article in *All the Year Round,* upon the habitations of ants, thus describes the extinguishment of a fire in an ant city of the *Formica rufa,* or wood ants:

"It was composed mainly of twigs, straw, and pine spiculæ, and swarmed with insect life. Poking our walking-sticks into the top of the mound, and laying bare the upper surface, the formicans, who up till then had been wholly unaware of our presence, began to understand that calamity had come upon them. Betaking themselves, as is their wont, to the care of the young, countless thousands of them suddenly appeared, each carrying a cocoon much bigger than itself, which it was evidently anxious to deposit in some place out of the reach of a danger which, although they could not comprehend, they knew to be both formidable and imminent Such a hurry skurry, such a running to and fro, such a getting up and down stairs, as the song says, such a commotion could scarcely have been known even at Brussels on the memorable night of the ball, on the eve of the great battle of Waterloo, when it was suddenly announced to the officers of the allied armies that the French were advancing upon the city—

> When thronged the citizens with terror dumb,
> Or whispering with white lips, 'The foe—they come! they come!'

"We all looked on with interested curiosity, and one of my companions having finished his first cigar, drew a box of lucifers from his pocket, and leisurely proceeded to light a second. This done, he carelessly threw the burning match upon the ant-hill. It was an act as cruel as it would have been in Lemuel Gulliver, had that mountainous traveler willfully set fire to the city of Liliput. The formicans were for an instant confused, and appeared not to know what to do. But their perplexity was of short duration. In less than half a minute scores and hundreds of ants rushed upon the blazing beam—for such it must have appeared in their eyes—and exerting their strength simultaneously upon it, endeavored to thrust it from their city. Many of them were burned to death in the gallant endeavor, but the survivors, nothing daunted, pressed forward over their dead or writhing bodies, as if conscious that there was no safety for those who still lived as long as the awful combustible was permitted to blaze and crackle in the midst of them. I was apprehensive that the whole mound, built as it was of dry twigs, would take fire; but the mists had lain upon the mountain and the valley, the air was moist, and the flame of the match burnt upwards. Onwards rushed the resolute firemen, score upon score, hundred upon hundred, till at last they rolled the match over and over, and out of their precincts, charred and blackened, and incapable of further mischief. We all, more or less, mistrusted our eyes, and the youngest, most thoughtless, and therefore the most cruel, of our company suggested that if there were intelligence and design on the part of the ants in acting as we supposed they had done, there would be no harm in making a second experiment. No sooner said than done. Another match was ignited and thrown upon the heap, and again, precisely as on the first occasion, the ants rushed pell-mell upon the blazing intruder, to prevent a conflagration, which, had it taken firm hold, it would have been impossible for them to extinguish. Again, some of the foremost champions of the public safety lost their limbs, and many more of them their lives; and again by the mere force and pressure of numbers acting with a common purpose, the match was extruded before much harm had been done. I opposed myself to a third renewal of the experiment and succeeded in persuading my companions, although not without difficulty, that enough had been done for curiosity and natural history; that the truly merciful man was as merciful to the smallest as to the largest of God's creatures; and that we had no right, in the mere wantonness of scientific observation, to take away the life which it was impossible for us to bestow."

Floriculture at Erfurt in Germany.

A correspondent of the *Evening Post* thus speaks of the immense horticultural establishments in Erfurt, Germany:

Erfurt has been given the name of the "Garden City of Germany," and, according to recently published statistics in Upper Consistorial Councilor von Tettau's "Erfurt, Past and Present," she well deserves the title. The area devoted to horticultural purposes in and around the city is over 2,000 Prussian morgens (0·65 of an acre). About 600 morgens of this are devoted to market horticulture; 220 morgens of the latter again are devoted to the production of flower seeds; and 210 morgens to vegetable seeds. The houses for the culture of exotic plants, and the hot and cold beds, possess glass covering to the extent of 250,000 square feet.

There are 36 independent horticulturists, of whom 27 do only a wholesale trade, besides 120 market gardeners, altogether employing over 500 assistants. The vegetable and seed trade depends almost entirely upon the larger cities of Germany. Over 300,000 catalogues and price lists are annually printed for the wholesale producers, at a cost of $10,000; 50,000 of these are wholesale catalogues, and half of the latter are prepared for England and America. The amount of postage paid on these catalogues, some of which are pamphlets, and on the letters containing seeds, is very great.

For the transmission of these seeds a vast number of linen and paper bags and paper, are required, involving an annual outlay of over seven thousand dollars. Both these articles are manufactured in the surrounding villages, giving employment to a great many poor people. As all these bags must be provided with the name of the dealer, a great amount of printing is also required. An incredible number of boxes and baskets are needed for packing purposes; the latter are made by the poor people in the neighboring villages; the former are made in the Thuringian Forest. Many poor families do

nothing else during winter but make wooden tickets and stocks for the flowers.

A number of little Thuringian villages are almost upheld by the manufacture of flower pots for Erfurt alone. About 600,000 are planted yearly with about 3,600,000 stock-gilly-flowers. These placed in a single row would reach nearly fifty miles! In the year 1863, 150,000 pots were planted with 1,550,000 gillyflowers for seed, and these brought in an income of nearly fifty thousand thalers. The production of the gillyflower in sixteen varieties and over two hundred colors established the horticultural fame of Erfurt ever since 1810.

The cultivation of vegetables for the market is chiefly carried on in the so-called "Dreienbrunn," an area of nearly two hundred acres, which was formerly a great swamp, and used only for the production of watercress. In the fifteenth century the market gardens were all within the city walls; in the last century the watercourses in the "Dreienbrunn" were regulated, and the whole swamp changed into an immense vegetable garden. About twenty acres are still reserved for the production of cress. Before the era of railroads the Erfurt market was limited to the surrounding cities; but now the Thuringian Railroad takes the produce to Cassel, Leipsic, Halle, Nuremburg, Weimer, Gotha, and other places. Of the seeds, fifty-eight per cent is sent to Austria, twenty-four per cent to Germany, and eighteen per cent to other lands of Europe, to England and America. A large trade in dried flowers is also carried on. In some of the gardens it is very difficult to get even a single bouquet. Agriculture is also prosperous in and around Erfurt, the farmers also devoting their attention to the production of field vegetables.

THE FRICTION OF STEAM ENGINES.

[From The Engineer].

If we did not believe that it is easy to say something new on a subject which has been in a very peculiar sense worn threadbare by the inventors of cylinder lubricators and steam greasers this article would never have been written. So far as we are aware, all the information regarding the resistance of steam engines due to friction is to be found in the circulars of inventors, one or two papers read before engineering societies by the advocates of particular methods of lubricating engines, certain theoretical disquisitions contained in text-books of mechanical science, and perhaps a report or two in the *Journal of the Royal Agricultural Society*. It is almost needless to say that the subject is one of very considerable importance; but it may be worth while to bring this importance home in a tangible form to the employer of steam power. It may be stated, in pursuance of this object, that it by no means follows that an engine giving a very high indicated duty per pound of coal is really the most economical that a manufacturer can use, for the simple reason that the power required merely to drive the engine may be so great as to render the saving in fuel valueless. A case in point suggests itself. An experiment was made some time since with a compound engine, the general particulars of which are before us. This engine was of the annular type; the large cylinder about 35 inches diameter, the inner cylinder about 15 inches, the stroke of both pistons was the same, about 5 feet, the piston rods both laying hold of the same crosshead, which was connected with an overhead beam. The experiment consisted in shutting the steam off from the inner cylinder and driving with the outer annular piston alone. It was found that the engine, then indicating the same horse-power as before, failed to drive the machinery at the proper speed; and it was not till the indicated horse-power was augmented nearly 40 per cent that the engine would do the work. On permitting the steam to find its way to the inner cylinder as before, the indicated horse-power fell to the original point, the machinery being driven at the proper speed. We shall not pretend to explain why this was the case. It is indeed difficult to understand why the fact that the inner cylinder, though open to the atmosphere, took no steam, should so enormously reduce the effective power of the engine. The facts are as we have broadly stated them, and there is no reason to think they would now want explanation if engineers had in times past devoted a little attention to the study of the phenomena of friction in the steam engine. We have no doubt whatever that many so-called economical engines are doing very bad work indeed; nor that many so-called wasteful engines as far as coal is concerned, are giving out a far higher duty than is generally believed. The entire subject is wrapped up in mist—a mist which can only be dispelled by careful experiments, extending over long periods, and properly and fairly analyzed. That a few engineers have conducted experiments on the friction of steam engines and other machines is certain; but it remains to accumulate in a single volume the statistics which these gentlemen possess, and to put them into a form which may render them generally useful. In pursuance of this object we have for some time past been accumulating data, as yet infinitely far from being complete. But these data have, at all events, done this much—they have satisfied us that ordinary theories regarding friction in steam engines based on investigations concerning the coefficients of friction between lubricated surfaces, apply most irregularly and imperfectly. In other words, there is no theory at present in existence which will enable us even approximately to predicate with certainty what the loss of effect by friction in any given engine may be. In certain cases, calculations made with this object will correspond, with surprising exactitude, with the results obtained through the indicator and dynamometer. But the engineer, resting satisfied with such occasional coincidences, is mistaken in his views. In scores of other instances enormous discrepancies will be found to exist between theory and practice—the almost total absence of frictional resistance in some engines contrasting strangely with the expenditure of power absolutely wasted, in others. It is not the mere loss of fuel alone—although that is bad enough—that has to be considered in dealing with this subject. We find engines unable to do their work overloaded and worn out; boilers burned and overtaxed; grease and oil wasted; indeed, we go so far as to hold that every horsepower unnecessarily spent in overcoming the frictional resistance of a steam engine costs three times as much as if it were spent in doing useful work, and this without taking at all into account the fact that useful work returns money, while what we may term the internal work of the steam engine returns none.

The difficulties which lie in the way of ascertaining by actual experiment what the frictional resistance of an engine is are very great, and to this cause no doubt is to be attributed the greater portion of the existing ignorance of the subject. The obstacles in the way are of two kinds. In the first place, it is very difficult to put a dynamometer or brake, on large engines, whereby to ascertain their duty; and, in the second place, the amount of friction varies not only in different engines, but in the same engines in a very extraordinary way. As regards the first difficulty, we can, in the case of pumping engines, ascertain precisely how many foot-pounds of work an engine actually gives out in the shape of useful effect, while the indicator shows the work done on the piston; but from these data it is impossible to calculate engine friction exactly, because our calculations are complicated by the greater or less efficiency of the pumps. It is possible that nothing can be more deceptive than the results obtained from pumping engines, and therefore we have no hesitation in rejecting their aid in dealing with questions of engine friction. Practically speaking, the only generally available test is the indicator, used with the engine light and the engine loaded; but diagrams taken thus do not account for the extra friction due to the performance of work, though useful to some extent in their way; but no investigation of the qualities of an engine can be regarded as complete unless the dynamometer is used as well as the indicator.

As regards the variation in the loss by friction in the steam engine, a very great deal might be said which we shall not attempt to say now. It may induce others to experiment for themselves, however, if we place a few facts curiously illustrative of the peculiar phenomena of engine friction before our readers. In one case we conducted the experiment personally; for the results of the other we are indebted to a gentleman who, in superintending the replacement of ordinary boilers by the now well-known Howard boiler, has occasion to indicate a very large number of engines and on whose accuracy we can rely with certainty. In the first experiment which we shall cite we found the full power exerted by a rolling mill engine in the north of England—where, it is unnecessary to specify—to be 291·5-horse. This included the resistance due to a fly weighing thirty tuns, a bar mill with two pairs of rolls working on heavy orders, and the requisite gearing. Engine and mill empty required, according to one set of diagrams, 74·8-horse power to run them at the working speed; but according to another set of diagrams, the frictional resistance of engine and mill is less than 35-horse power, and all the diagrams were taken within a few hours. We cite this case only to illustrate the difficulties engineers have to contend with in endeavoring to estimate the friction of engines under ordinary circumstances.

The other experiment is very interesting and curious as regards results. The engine was a double cylinder traction engine, built by Messrs. Howard, of Bedford. The cylinders are 8 inches diameter and 12¾ inches stroke. The engine shaft can be disconnected from all the rest of the machinery, so that the whole work done by the steam consists in turning the crank shaft and overcoming the friction of the bearings, pistons, etc. With 60 lbs. of steam in the boiler, the engine, making 190 revolutions, indicated unloaded 2·64-horse power. The engine was then set to drive a brake loaded to 16-horse power, the link being put in full gear; under these conditions the engine indicated 22·55-horse power. The frictional resistance was therefore increased, by the fact that the engine was now doing work, to 6·55-horse power, or to nearly three times that of the unloaded engine. This is all plain sailing, but now comes a most remarkable fact. The throttle valve was thrown full open, or nearly so, and the engines linked up—that is, worked expansively at the same velocity, 190 revolutions per minute. The load on the brake, etc., remaining absolutely unaltered; any engineer would predict that, under these circumstances, the result would be the same; far from this being the case, however, it was now found that the effective work or duty of the engine being unaltered, the indicated power *was only* 19·86-*horse power*, so that the friction of the engine when linked up was only 3·86-horse power, or little more than one-half that of the engine working in full gear. Lest there should be any mistake about this, the brake was then loaded with 504 lbs. With the link in full gear the engine indicated 44·88-horse power; the link was then put in the first notch, and the throttle valve fully opened, everything else remaining unchanged, when the power fell to 40·92-horse, the frictional or internal resistance of the engine in the latter case thus being 3·86-horse power less than in the immediately preceding experiment. How are these facts to be accounted for? Is it that the varying strain on moving surfaces in contact, due to the action of expanding steam, is attended with less frictional resistance than is present when the metals are under the steadier strain of non-expanding steam? We shall not pretend to answer these questions. There are the facts for the consideration of those interested.

Is it too much to hope that engineers who have the opportunity, will take up this subject, and endeavor to throw light into what is at present a very dark and unexplored region of mechanical engineering? We are convinced that the results would, when time and perseverance had multiplied data, be found of very great value to those who desire to see the steam engine undergo the real improvement of which it is still capable. We venture to suggest that the general practice of indicating the engines tested by the Royal Agricultural Society while running against the brake, and the publication of those diagrams, would be productive of much good. Suppose the Society begin at Oxford?

A Curious Exhibition.

A singular idea is that of a public exhibition of fans; yet such an exhibition has been held at the South Kensington Museum in London. The object of the exhibition was to promote the employment of women in a branch of industry peculiarly adapted to them, though how such an exhibition could further this good object one fails at this distance to perceive clearly. Nevertheless the exhibition brought out some wonders of mechanism and art, according to the *Building News*, which gives a column and a half to its description.

That journal says the present collection opens with a number of Chinese and Japanese fans, just brought over by one Mr. Mitford. They are, as a rule, very tasteful and curiously inexpensive. There are also some excellent specimens of Indian fans, lent by the Indian Museum, but the object of this exhibition is not so much to show us the different materials out of which a fan may be manufactured—such as carved in sandal wood, made from palm leaves, scented grasses, pheasants' feathers, or even beetlewings—as to set before us the fan as a work of art; and works of art most of the painted fans unquestionably are. Their subjects vary in an infinite number of ways. In this collection can be seen a geographical fan from Japan, with the route between Yeddo and Kiöto marked out upon it; a Spanish fan, containing an almanac and a globe; French fans, with revolutionary subjects; Italian fans, ornamented with paintings of Scriptural stories; and historical fans of all periods, from Rebekah and Eleazer down to the fan painted by Tjichy, a Hungarian artist, and presented to the Prince of Wales on the marriage of the Princess Dagmar with the heir of all the Russias. Here, too, are fans interesting to the public as relics—Nos. 262 and 272 were once used by the ill-fated Marie Antoinette; the Queen exhibits one which belonged to the Princess Charlotte; and a very curious fan, with imitation lace cut in paper and medallions in water color, was once possessed by Madame de Pompadour. It is not possible in this journal to devote much space to an object so apparently remote from its usual province as an exhibition of fans—nevertheless, there are points of common interest which claim our attention. Many of the French fans of the highest character, many Spanish fans, and some of the Italian ones, are of the class we will call pictorial. Thus the mounts of such fans are composed principally of pictures, no doubt designed to fill the peculiar space, but still pictures such as Gay describes as subjects for decoration:

> Paint Dido there, amidst her last distress,
> Pale cheeks and bloodshot eyes her grief express.

or—

> Here draw Œnone in the lonely grove,
> Where Paris first betrayed her into love.

Such fans have, at various times, been the work of the best artists of the day. Thus No. 224 is by Peter Oliver, the celebrated miniaturist of the time of Charles I. The subject of this fan, which has been painted out square and framed, is "The Triumph of Bacchus." Again, No. 348, a French fan, was painted about 1666, by Philippe de Champagne. It has a landscape on the reverse side, by PP. Valori. There are also one or two by Lancret, and No. 126 is a beautiful work by Boucher, while among those fans whose painters are unknown, we must call especial attention to "The Queen's Fan," No. 278, the subject of which is a highly-finished copy of Guido's Aurora. Some of the Italian fans of the pictorial class are enriched at the borders and near the sticks with delicate treatments of flowers and fruits so artfully arranged as to carry the color of the picture into the setting of the fan. No. 320 is a good specimen of such fans, while No. 82 is an excellent example of the same treatment of the mount, though the stick, which is of a subsequent date and quite plain, has been added to the fan without due regard to this artistic effect. Another class of fans may be described as a combination of ornament with pictures. A beautiful example of this is found in a modern fan belonging to the Empress of the French. In the center of the reverse side is a medallion, painted in grisaille by Moreau; while on each side some beautifully executed amorini, with arabesque ornaments, are supporting the imperial crown and her Majesty's initials. Of earlier examples Nos. 336 and 339, wherein vignettes are alternated with Pompeiian ornament, are very characteristic, and deserve study, because of the classic taste displayed in them. Many of the English fans of the last century belong to this class of treatment, sometimes consisting in vignettes and ornament, and sometimes in medallion portraits and ornaments. Of this character also is the fine French specimen by Boucher, to which we have already alluded. We cannot close without drawing attention to the fans decorated by Vernis Martin, that celebrated Frenchman, mentioned by Voltaire, who combined coach painting, when it still required the skill of an artist, with the decoration of furniture, snuff-boxes, and fans. He invented a varnish which has stuck to his name, and given character to the works of his hands. The labors of fan painting may be esteemed lightly by some, but we opine that when we find such French living artists as Eugene Lami, Moreau, and Hamon, not disdaining to devote their skill and time to such works, our countrywomen may well be proud to enter into the competition.

The first attempts to establish fire insurance were made during the reign of Charles II.