ANIMAL MECHANICS.

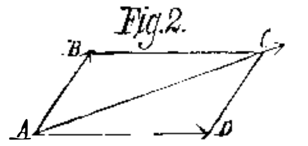
A highly interesting and suggestive paper on some unsettled points in animal mechanics was read before the New York Academy of Sciences, at their regular meeting, November 4, by Prof. W. P. Trowbridge, of the Columbia College School of Mines.

The subject of animal mechanics is an important one; the very existence of animals depends on their power of locomotion, by which they are enabled to escape danger and to search for food. In recent times this subject has been studied by Marey, who instituted a number of ingenious experiments to determine the exact curve described by the wing of a bird while flying, and of a horse's hoof while in motion. Houghton studied the matter in a much more philosophical manner, and with the view to determine the laws of fatigue and rest. One of the most recent books on the subject, by Pettigrew, is so full of absurd and ridiculous positions, that its admission in the international series is a matter of astonishment. Huxley, in his physiology, briefly refers to the elementary machines as exemplified in the bodies of animals, and classes them as levers of the first, second, and third orders, while Marey assigns them all to the third order, and remarks that man has greatly improved on the model provided by his own body, as regards the transmission of power. A little consideration will soon teach us, however, that we are very far indeed from even approaching the perfection of our own structure in our best mechanical contrivances. Imagine a skeleton before us, all the bones of which may be provided with cords and pulleys, and then realize how far such a machine would be from uniting the infinite variety of motions executed by a lády while playing the piano; and yet all her motions are produced by the action of cords on rigid bones. Foucault compares the motions of a fish's tail with that of a propeller, but in reality there is no comparison between them. Man the fact that forces do not exist except in the action of one body upon another.

Only two geometrical theories are required to discuss the effect of forces on the animal mechanism. The first is that of the "moment of forces." The moment of a force is the product of that force, measured in pounds, etc., by the lever arm or perpendicular distance of its line of action from the fulcrum. Thus, in a common lever in equilibrium (Fig. 1), the power multiplied by its lever arm is equal to the weight multiplied by its lever arm, and the pressure on the fulcrum represents a third force, which maintains the equilibrium of the other two. The other theory involved is that of the parallelogram of forces. (See Fig. 2.) If one force, sufficient to move a body from A to B, acts simultaneously with another force tending to move the same body to D, the body will reach C by moving along the diagonal, A C, of the parallelogram constructed upon the lines representing the two forces.

Fig. 1.

Fig. 2.



All elementary machines, or simplest devices, by which force is applied to overcome resistance, either in mechanisms or the animal frame, may be classed under four heads:

1. Lever.
2. Inclined plane.
3. Jointed links.
4. Hydrostatic press.

The elementary machines have been discussed for many years, and authors differ greatly in their classifications; but and of springing with its hind feet. A powerful muscle was seen attached to the backbone and to the forearm, and another to the shoulder blade and the projection of the elbow, thus forming a combination of levers producing the greatest economy of force. In the hind leg the muscles are similarly attached to a jointed link, having a great range of motion by reason of the ability of the animal to draw its hind legs close up to its body. Whenever the body of an animal is raised from the ground, it is done by means of jointed links, the ground furnishing the resistance.

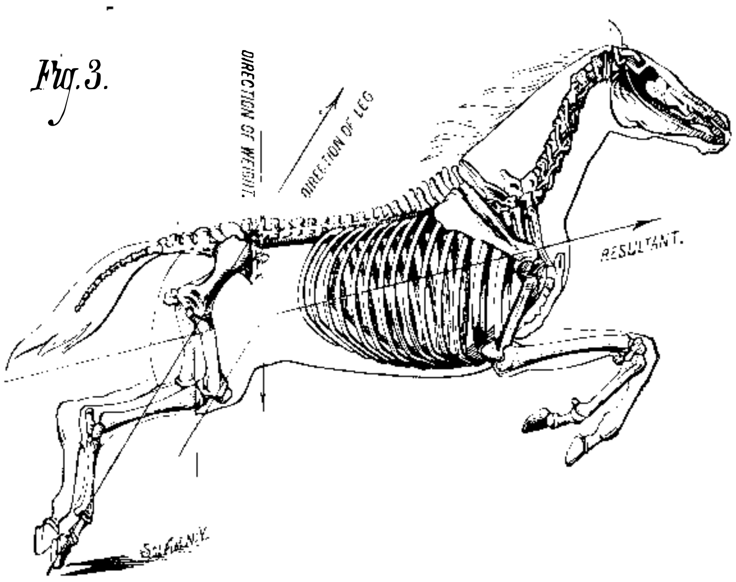
This point was illustrated by a diagram of a horse in the act of leaping (Fig. 3). Here we have a thousand pounds leaping easily and readily into the air, and an examination of the hind leg of a horse will reveal the fact that it consists of a combination of jointed links. By the parallelogram of forces we then combine the force of propulsion with the weight of the animal, and we find the direction of the spring. When the momentary force of propulsion has ceased, gravity acts alone, and the horse reaches the ground by a curve. To resist the shock, the muscles of the foreleg are well developed.

It is generally supposed that horses draw loads by their shoulders, but this is an error. They do it chiefly by their hind legs, the trunk acting only as a beam, to which the traces are attached (Fig. 4). The resultant is here seen to pass through the trunk, and this explains why a horse pulling a load may at the same time carry a load on its back, the effect being to increase its own weight.

The force exerted in leaping was excellently illustrated by means of a jointed hat rack, where it was evident that very little force applied at one end propelled the other through a considerable distance.

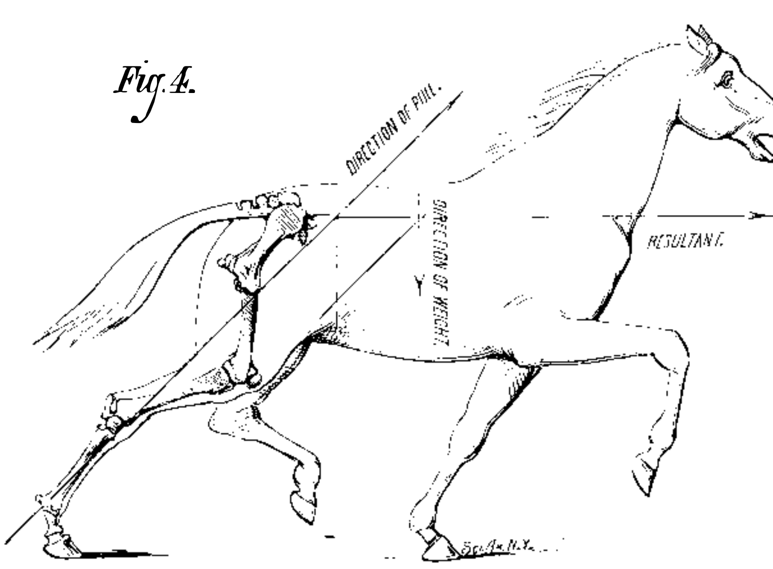
The octopus uses the hydrostatic press alone to propel itself in the water. At first sight it would seem as though its long arms (30 to 40 feet), extending in all directions,

Fig. 3.



LEAPING.

Fig. 4.



PULLING.

cannot approach the perfection of this animated instrument of propulsion.

To begin at the very foundation of our subject, in order to obtain a clear and connected view, the following forces may be considered as the only ones involved in animal locomotion:

External forces: 1. Gravitation; 2, inertia; 3, friction.

Molecular forces.

Muscular contraction.

Of the nature of the force of gravitation we know nothing; but we all know its effects and the law according to which it acts, namely, "Every body attracts every other body directly as its mass and inversely as the square of the distance." With inertia we are all familiar. It is the resistance a body opposes to a force tending to move it. With friction we are acquainted chiefly as an obstruction to motion; but we are also continually availing ourselves of it to produce useful work. The difficulty of walking on ice will give us a faint idea of the predicament we should be in without the existence of this force. But for friction the mountains would run down and fill the plains.

Of the molecular forces, the only one we need consider is that which resists rupture from strains to which the animal frame is constantly subjected.

Muscular contraction is a vital force whose cause is not known; all we can say of it in this connection is that it pulls the tendons by which the muscles are attached to the animal frame.

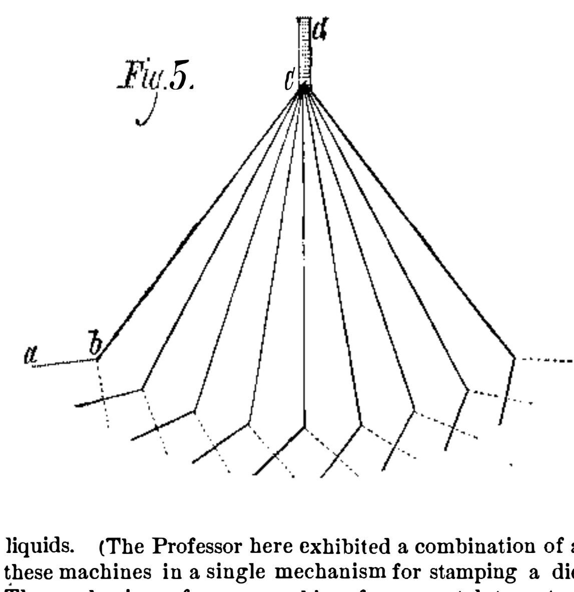
All these forces are susceptible of being measured in pounds, and of being represented by right lines, the length of each line being in proportion to the amount of the corresponding force.

The dynamical laws involved in the motions produced in the animal mechanism by these forces are represented by the following axioms of Newton:

1. Inertness.
2. Motion is proportional to the impressed forces.
3. Action and reaction are equal.

By inertness Newton designates the force of continuance residing in matter by virtue of which it retains any force imparted to it. That the motion produced is proportional to the impressed force is an axiom to which we readily assent. The axiom that action and reaction are equal is involved in the above may be the simplest for present purposes. The principle of the lever has already been stated, and it includes the wheel and axle and the movable pulley. The inclined plane and the jointed links (also known as the toggle joint) depend on the parallelogram of forces. A force applied at the joint of two rigid bars, one of which is fixed and the other free to move outward in such a way as to increase the angle between them, will be greatly multiplied at the free end. This machine is employed in hand printing presses, in Blake's stone crusher, in cutting iron, etc. The hydrostatic press depends on the distribution of pressure by

Fig. 5.



liquids. (The Professor here exhibited a combination of all these machines in a single mechanism for stamping a die.) The mechanism of every machine, from a watch to a steam engine, and the frame of every animal, is made up of a combination of some of these elementary machines.

In the following remarks on locomotion, microscopic animals, which propel themselves by the vibration of cilia, or by simple contraction like the earthworm, are not considered.

A diagram was then shown, representing the skeleton of a tiger, to explain its great power of striking with its forefeet, would be extremely unfavorable to motion, but a little closer examination will show that it arranges them in the position of least resistance and swims backwards in the following manner: A powerful hollow muscle passing all around the animal's body is filled with water and confined by a valve, it is then forced through a narrow exit pipe, and the octopus moves by the force of the recoil.

The swimming of a fish is usually explained in the cyclopedias by means of a time-honored diagram representing a parallelogram of forces constructed on the resistance of the water and the motion of the fish's tail. It is very easy to understand how the tail moves the fish forward when it turns one way; but why the fish is not drawn back again by the contrary motion of the tail is not so plain. In fact, Sir John Lubbock at one time gave up the problem and confessed he did not see how a fish managed to swim.

It must be remembered that the tail of a fish is flexible, and that its flexure is in contrary directions during the two halves of its stroke. The diagrams (Fig. 5) will then make its action plain. Suppose the bent bar, *a b c*, to be articulated at *c* to a fixed piece, *c d*, and to move through a resisting medium from left to right. It is evident that it will exert a forward pressure at the point of articulation. Now, when it arrives at the extreme right, let the flexure of the bent bar be reversed, as shown in the dotted lines; we will have the same conditions as before, and a forward pressure will again be exerted upon the point of articulation during the whole of the return stroke.

In the case of a fish's tail we have no bar, but a yielding material which will describe curves. An idea of this motion is easily acquired by waving a feather rapidly through the air. If the mainsail of a common schooner could by any mechanism be made to oscillate rapidly to and fro like the tail of a fish, it would propel the schooner. In the case of a snake wriggling through the water, the whole body may be viewed as a series of planes, each of which exerts the same forward pressure as does the tail of a fish. Some species of sharks propel themselves by a kind of sculling motion of the tail, which is so powerful that they have been known to jump clear over the decks of schooners.

Professor Trowbridge exhibited a small boat which he had constructed, and which was propelled in a trough by means of the fin of a fish oscillated by clockwork.

A great advantage of animal over artificial mechanism is that the animal frame adapts itself to the kind of work required of it; the muscles that come into play grow more and more capable of performing it. This point is well observed by comparing those whose labors affect one set of muscles chiefly with those accustomed to a great variety of motion—the hod carrier and the gymnast, for example.

The force of inertia is constantly experienced in every motion we make. We cannot even rise from a chair without leaning forward first, *i. e.*, placing our bodies in a position favorable for overcoming their inertia. In leaping, flying, etc., the initial effort is always the greatest, much less force being afterward required to keep up the motion. All these efforts result in fatigue proportional to their intensity. Thus, in walking on a level plane, the body is raised on an average 1·2 inch from the ground at every step. In walking up stairs the force expended is much greater. By the time a lady has ascended three flights of stairs, she experiences more fatigue than after walking around two blocks in New York. The study of animal mechanics may be productive of great advantage to us, by leading us to a better understanding of the laws of fatigue and rest.

Professor Trowbridge's paper was followed by a discussion in which Messrs. Newberry, Warner, and Martin took part. Attention was drawn to the wonderful instinct by which birds so adjust the resisting surfaces of their bodies as to be able to sail across and even against powerful currents of air with apparent ease, and to another cause of superiority of animal over artificial mechanism, namely, the mysterious nerve communication by means of which the different organs transmit their sensations to the brain of the animal, and in return receive instantaneous commands, enabling them to adapt themselves to every emergency. C. F. K.

Correspondence.

Alum in Baking Powders.

To the Editor of the Scientific American:

SIR: In your issue of the 7th inst. I noticed an article on the above subject by Henry Pemberton, Jr., as also some editorial remarks by yourself. With respect to Mr. Pemberton's remarks, I would state that it is evident he formed his opinion on entirely a theoretical basis. His opinion is one which would very probably be expressed by any number of persons who rely on theories instead of on facts. Mr. Pemberton states that when an alum baking powder is used in baking, the alumina of the alum is precipitated and becomes insoluble by heating. A very distinguished scientific man writes to me, and says: "This is a matter of experiment, and facts thus obtained are undoubtedly worth far more than conclusions derived from theoretical considerations." This last paragraph has embodied in it my views on this subject, and it strikes me it would have been proper for Mr. Pemberton to have made a few experiments with bread or biscuits made with an alum powder, to see if the alumina was really in an insoluble or in a soluble condition, before expressing so decided an opinion. I am perfectly well aware that when an alum baking powder is used in baking, the alum is transformed into another alumina salt, provided the constituents of the powder are combined in exact chemical equivalents. If, however, the constituents are not in exact equivalent proportion (which is more probable than otherwise, as chemical weights are seldom, if ever, adopted by manufacturers), there will be a certain per cent of alum left unaltered. There would, therefore, be present in the baked product in either case an alumina salt; and in the last, or more probable case, in addition to the alumina salt, some unaltered alum. So that, supposing a portion of the alum was transformed into an insoluble alumina salt (which has not been proved as yet in the baked product), it is evident persons eating the baked product would run the risk of taking into their stomachs the unaltered alum. It is true the per cent of this would probably be small, but by its continued use would certainly bring about serious disorders in the system. As regards the alumina salt, let us stop a minute. Wagner states: "The active principle of alum is evidently the sulphate of alumina, not the sulphate of potassa and ammonia." That alumina is the poisonous element of alum, I think the following provings clearly demonstrate, which I take from my Encyclopædia of Materia Medica: "It destroys the appetite, produces sour eructations, heartburn, pain in the abdominal ring, the rectum is rendered inactive, constipation or loose bloody discharges are produced." From these provings it will be seen that the effects of alumina on the system are substantially the same as alum. That is to say, that alumina bears the same relation to alum (being its active principle) as morphine does to opium or nicotine does to tobacco. Supposing, again, that the alumina salt formed in baking was in an insoluble condition (which I have already stated has not been demonstrated), and not considering the amount of alum left unaltered, I doubt if the public would be willing to run the risk of eating the baked product, for fear that the heat of the oven was not in the proper condition to render it all insoluble. Supposing, on high scientific authority, I should state that a salt of antimony (take for example tartar emetic) if added to a cup of tea would be completely neutralized by the tannin or rendered "insoluble" for instance. How many persons would I find willing to drink the tea? Not many, I am quite positive; and this is the view I think the public will take about alum baking powders. When they can obtain a number of powders on the market composed of wholesome constituents, I think they will not care to run the risk with alum powders. As to the alumina salt being in an insoluble condition, I shall, in a future article, have something more to say, to satisfy the scientific men; but I think the public will have received, after carefully reading the above, sufficient satisfaction or explanation to convince them that alum baking powders are most dangerous to use.

In answer to "Pro Bono Publico," I would state that my intention was in the beginning to expose injurious baking powders: not to advertise baking powders. It was necessary for me to select a good baking powder for comparison, which might have been any of the other powders other than the one selected, if I found it composed of wholesome elements. For me to publish the whole list and have my name on every baking powder can in the country, as I have been asked to do by a large number of manufacturers already, is more than I am willing to do, and also, I think, more than the public would think of asking of me. Respectfully,

HENRY A. MOTT, JR., Ph.D., E. M.

New York, November 28, 1878.

P. S.—Mr. Dooley insinuated to you that my analysis of his powder was not correct. Now, in justice to me and the public who wish only the truth, I suggest that Dooley publish in your paper a correct analysis of its composition. I found over 26 per cent of burnt alum in one sample.

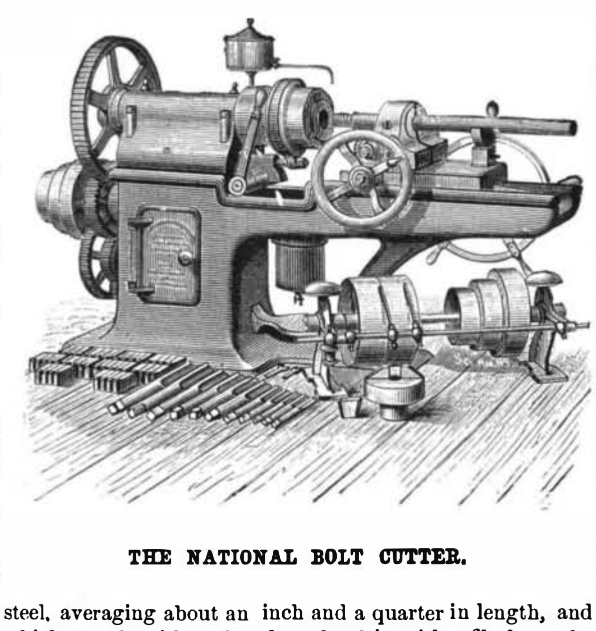
H. A. MOTT, Jr.

IMPROVED BOLT CUTTER.

The annexed engraving represents a machine for cutting screw threads on bolts, and is one of superior design. It is named the No. 5 National Bolt Cutter, and is adapted for cutting threads on bolts from one inch to two and a half inches in diameter. Among other good features claimed by the manufacturers the following may be mentioned as the most prominent ones.

The die head is constructed to receive blocks or cases, with inserted chasers, forming the dies, thus doing away with the labor of fitting each die or chaser to the head.

The chasers, four in number, are simply flat pieces of steel, averaging about an inch and a quarter in length, and which may be either planed or fitted in with a file from the rough stock. A small screw in the end of the case sets the chasers forward as it becomes necessary to dress over the dies. Another style of chasers is constructed upon the interchangeable system, with threads at each end, and are held in the cases by studs, thereby becoming as serviceable as two sets of dies. Broken or damaged chasers can be replaced by duplicates at little expense.



THE NATIONAL BOLT CUTTER.

The adjustment of dies to the proper size is accomplished by merely turning a screw in the front of the head. The die head can be quickly stripped without removing it from the machine. One set of case dies can be removed and another inserted in the head in less than one minute by changing a stop pin, projecting from the sleeve, from its position when the machine is working, to a point opposite a hole in the flange at the rear of the head, then, by means of the lever, pushing the sleeve back to the flange, uncovering the cases, and permitting their removal and replacement by hand. The machine can be quickly converted into a nut tapper by removing the case dies and putting in their place a steel block to which is secured a universal chuck for holding taps that is furnished with each machine. All the working parts of the die head are protected from chips or dirt. The locking device is positive and requires but one movement of the lever for unlocking and opening the dies or closing and locking.

The die blocks are held rigidly by the inclosing sleeve when locked, and consequently cut bolts of more uniform diameter than is the case when the chasers or cutters can spring away from the bolt when cutting.

Machines of this description are made of various sizes, and for special purposes with the necessary modifications in gearing and proportions. They are supplied with all necessary adjuncts and facilities for lubricating the parts, and are constructed with the care and extreme accuracy for which this company are so well known.

Further information may be obtained from the makers, the Pratt & Whitney Company, of Hartford, Conn.

ASTRONOMICAL NOTES.

BY BERLIN H. WRIGHT.

PENN YAN, N. Y., Saturday, December 28 1878.

The following calculations are adapted to the latitude of New York city, and are expressed in true or clock time, being for the date given in the caption when not otherwise stated:

PLANETS.

	H.M.		H.M.
Mars rises	4 51 mo.	Uranus rises	9 16 eve.
Jupiter sets	7 14 eve.	Neptune in meridian	7 52 eve.
Saturn sets	11 12 eve.		

FIRST MAGNITUDE STARS, ETC.

	H.M.		H.M.
Alpheratz in meridian	5 33 eve.	Procyon rises	6 45 eve.
Mira (var.) in meridian	7 44 eve.	Regulus rises	8 48 eve.
Algol (var.) in meridian	8 31 eve.	Spica rises	1 29 mo.
7 stars (Pleiades) in merid.	9 11 eve.	Arcturus rises	0 32 mo.
Aldebaran in meridian	9 59 eve.	Antares rises	5 35 mo.
Capella in meridian	10 38 eve.	Vega sets	8 57 eve.
Rigel in meridian	10 39 eve.	Altair sets	7 45 eve.
Betelgeuse in meridian	11 19 eve.	Deneb sets	0 07 mo
Sirius rises	7 10 eve.	Fomalhaut sets	8 21 eve.

MOON'S PLACE IN THE CONSTELLATIONS AT 7 P.M.

Saturday, *Aqua us*	9°	Wednesday, *Pisces*	27°
Sunday, *Aquarius*	21°	Thursday, *Aries*	9°
Monday, *Pisces*	3°	Friday, *Aries*	21°
Tuesday, *Pisces*	15°		

REMARKS.

Venus is still invisible, setting only 18 minutes after the sun. Saturn will be about 7° south of the moon December 30. The earth will be nearest the sun January 2, 1879.

Prof. James C. Watson, late of Ann Arbor, Mich., and Prof. Lewis Swift, of Rochester, N. Y., are, we believe, of the opinion that the planets discovered by them during the July eclipse are identical. Thus two planets were discovered within 2m. 52 seconds after the commencement of the search for them. Exclusive of comets, there are now 224 members of the solar system known.

There are now 190 asteroids known, unless others have been discovered since October 1. In 1875 there were 17 discovered, the greatest number in one year. Prof. C. H. F. Peters, of the Litchfield Observatory, Hamilton College, has discovered the greatest number—31. Professor Watson follows him in the list, having discovered 23. The following shows the number discovered in the different months, September being the lucky month:

January, 11; February, 15; March, 15; April, 24; May, 14; June, 8; July, 8; August, 21; September, 33; October, 16; November, 22; December, 3.

January 9 Neptune will be 10° 43m. 47 sec. south and 5° 10m. 48 sec. east of *a Arietis*. January 29 Neptune will be 10° 41m. 50 sec. south and 5° 12m. 45 sec. east of *a Arietis*.

A line from *Lambda* (91) *Ceti* through *Mu* (87) *Ceti* produced five degrees northwest, will pass very close to Neptune. *Lambda* and *Mu* form the northern side of a pentagonal figure (sides 3°–5°) in the Whale's head.

New Mechanical Inventions.

Mr. James Griffin, of Mendocino, Cal., has patented an improved Saw Guide, that may be adjusted by the operator when the saw is in the cut, which is of special advantage when sawing long timber, and by which the wear of the parts is taken up in easy manner, so as to keep the guide always in good working condition.

Mr. Charles Galigher, of Cairo, Ill., has patented an improved Millstone Curb and Chop Conveyer. In this contrivance the meal cannot choke up or become clogged, but falls freely from the vicinity of the stones as soon as it comes out from between them. Access of air is thus permitted to the stones, and the flour is not injured by detention between the grinding surfaces or by friction against the stone and curb.

Mr. Harrison W. Holley, of Hale's Ford, Va., has invented an improved Machine for Rolling and Cutting Tobacco, which consists, essentially, of three sets of pressure rolls, arranged successively close together, an endless feed belt passing through the first set of rolls, longitudinal knives on the second set, and transverse knives on the third set, all of said rolls being geared together, so as to press and cut the tobacco as it is carried through the machine by the endless belt.

Southern Factories.

According to a carefully prepared statement of Gen. L. P. Walker, of Alabama, that State has 2,118 factories, working 8,248 hands, with a capital invested of $5,714,032, paying annually in wages $2,227,968, and yielding annually in products $13,040,644. Florida has 630 factories, working 2,749 hands, with a capital invested of $1,679,930, paying annually in wages $989,592, and yielding annually in products $4,685,403. Georgia has 3,846 factories, working 17,871 hands, with a capital invested of $13,930,125, paying in wages $4,844,508, yielding annually in products $31,196,115. Louisiana has 2,557 factories, working 30,071 hands, with a capital invested of $18,313,974, paying in wages $4,593,470, yielding annually in products $24,161,905. Mississippi has 1,731 factories, working 5,941 hands, with a capital invested of $4,501,714, paying in wages $1,579,428, yielding annually in products $8,154,758. South Carolina has 1,584 factories, working 8,141 hands, with a capital invested of $5,400,418, paying in wages $1,543,715, yielding annually in products $9,858,981. Texas has 2,319 factories, working 7,927 hands, with a capital invested of $5,284,110, paying in wages $1,787,835, yielding annually in products $11,517,302. Aggregate number of factories, 14,884; aggregate number of hands employed, 80,948; aggregate capital invested, $54,824,303; aggregate wages paid annually, $17,514,516; aggregate annual value of products, $102,615,108.