[For the Scientific American.]

THE FRICTION OF PLAIN SLIDE VALVES.

Mr. John Hill's method of calculating the power necessary to operate a slide valve, as published in the SCIENTIFIC AMERICAN SUPPLEMENT of March 10, would be intelligible providing he will tell us his reason for assuming the co-efficient of friction of a slide valve to its seat to be 0·75, and also for assuming that it is possible, or practicable, to make all valves of an equally good fit to their seats, and to prevent that fit from varying, by reason of the expansion and contraction due to variations of temperature, and by further reason of the spring of the valve from the pressure upon it.

Mr. Bourne, in his "Handbook of the Steam Engine," says: "Clean and smooth iron drawn over clean and smooth iron, without the interposition of a film of oil or other lubricating material, requires about one tenth of the force to move it that is employed to force the surfaces together. In other words, a piece of iron 10 lbs. in weight would require a weight of 1 lb. acting on a string passing over a pulley to draw the 10 lb. weight along an iron table. But if the surfaces are amply lubricated, the friction will only be from $\frac{1}{40}$ to $\frac{1}{60}$ of the weight." The experiments of General Morin on the friction of various bodies without an interposed film of lubricating liquid, but with the surfaces wiped clean by a greasy cloth, have been summarized by Professor Rankine in the following table:

	Angle of repose.	Friction in terms of the weight.
Metals on metals, dry	$8\frac{1}{2}$° to $11\frac{1}{2}$°	0·15 to 0·2
Metals on metals, wet.......	$16\frac{1}{2}$°	0·3
Smooth surfaces, greased...	4° to $4\frac{1}{2}$°	0·07 to 0·08
Smooth surfaces, best results.	$1\frac{3}{4}$° to 2°	0·03 to 0·36

In a paper, of which an abstract has appeared in the *Comptus Rendus* of the French Academy of Sciences, for April 26, 1858, M. H. Bochet describes a series of experiments which have led him to the conclusion that the friction between a pair of surfaces of iron is not, as it has hitherto been believed, absolutely independent of the velocity of sliding, but that it diminishes slowly as that velocity increases.

If we class the conditions under which a slide valve operates under the head of "metals on metals, dry," we are confronted at once with the question: For what reason shall we select the co-efficient as 0·15 in preference to the 0·2, or *vice versa?* If we class those conditions under any other of the headings in the table, where are we to get a co-efficient of 0·15? And if, as M. H. Bochet concludes, the co-efficient varies with the velocity of sliding, how can we assume a fixed co-efficient for a slide valve when its velocity of sliding varies with every variation in the speed of the engine, as well as at every inch of its movement? In the case of slide valves, however, the weight upon the valve is not a dead weight, but live steam; and hence, before we can make a calculation to determine the friction, we have to determine the pressure of the valve to its seat, and this, as may very easily be demonstrated, depends upon the fit of the valve to its seat.

In Appleton's "Cyclopædia" occurs the following: "Two glass or metal plates with well ground surfaces, when pressed together, will adhere with such force that the upper one will not only support the lower, but an additional weight will be required to separate them. The amount of this adhesive force has been measured by recording the weights necessary for their separation. The records of the old experimenters on this subject are worthless, because they placed a lubricating fluid (oil or fat) between the plates; they found thus the cohesion of the oil or fat, and not the adhesion of the plates. In later times, Prechtl, in Germany, has made the most careful experiments in this line; he took polished metal plates of $1\frac{1}{2}$ inches diameter, suspended the upper one to a balance, brought it to an equilibrium in a horizontal position, and attached the lower plate to a support beneath it. Both plates were then brought into contact, so that the flat polished surfaces covered one another perfectly, and the weights required in the scale, at the other end of the balance beam, to separate the plates were the measures of adhesion. He found thus the following remarkable law: The adhesion between two plates of the same material is the same as that between one of the plates and any material which possesses a less adhesive force. Prechtl found also that an attraction of the plates manifested itself at an appreciable distance before actual contact, and he even measured the amount of this attraction at the distance of $\frac{1}{24}$ of an inch by means of weights in fractions of grains. The suspended plate, when brought within this distance, was attracted with an accelerated motion till the contact took place with a slight concussion. The idea that the pressure of the air was the chief cause of the adhesion of two such plates, as it is in the case of the well known experiment with the Madgeburg hemispheres, was set at rest by Boyle, who suspended the adhesive plates charged with weight in the vacuum of an air pump; the plates were not separated, while the hemispheres, held together by the vacuum alone, fell apart."

Now whether Mr. Hill, in assuming the co-efficient of friction for slide valves to be 0·15, has assumed the valve to fit so closely to its seat as to induce the adhesion here referred to, I know not; but it is self-evident from the foregoing that, if the valves do not fit sufficiently closely to induce adhesion, the co-efficient will be less than if, from closeness of fit, such adhesion was induced. And furthermore, a self-feeding oil cup affixed to the steam chest or steam pipe will, according to Rankine, vary the co-efficient of friction according to the amount of lubricant it supplied to the valve; for all the above authorities vary the co-efficient with the conditions. And I now propose to demonstrate that those conditions, as existent in a slide valve, cannot be known, and certainly are never constant. First, then, beginning with scraped surfaces, is it not a fact that only a part of such surfaces are in contact, and what are we to presume fills or occupies the hollows of the scraping marks? According to Mr. Hill, they are under a vacuum; for he assumes the pressure on the back of the valve to be the area multiplied by the steam pressure. But what, in the conditions under which a slide valve operates, is to exclude the steam from filling the hollows?

In your own office, Mr. Editor, are a pair of surface plates used to surface valves and valve seats with. They are of cast iron, smoothly surfaced to a good fit; and beside them lies another similar plate, surfaced about as true as an ordinary slide valve. When newly fitted, either of these plates, weighing about 22 lbs., will, from the vacuum between the two surfaces, lift a plate of its own size and weight. The sizes of the two finely fitted plates is 12 x 18 respectively. Their weight is about 20 lbs. each, their shapes being shown in Fig. 1.

Fig. 1.

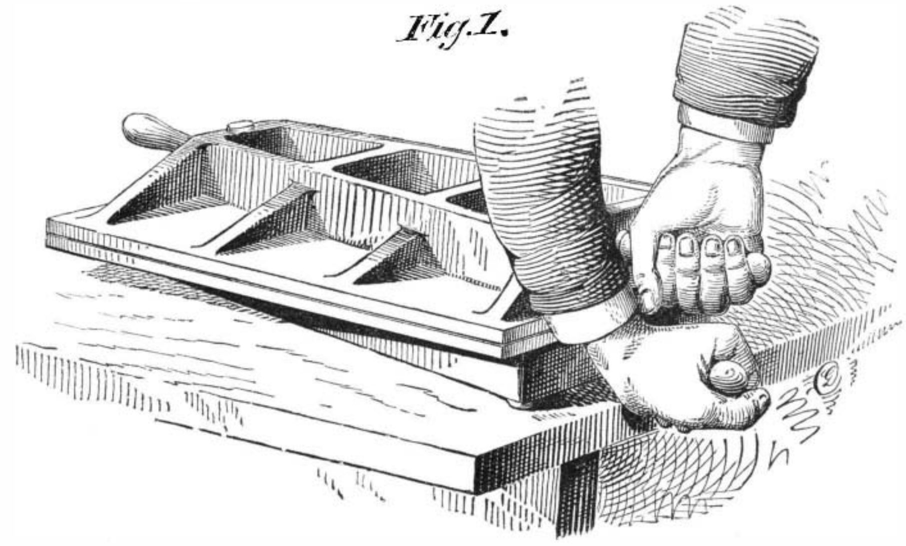
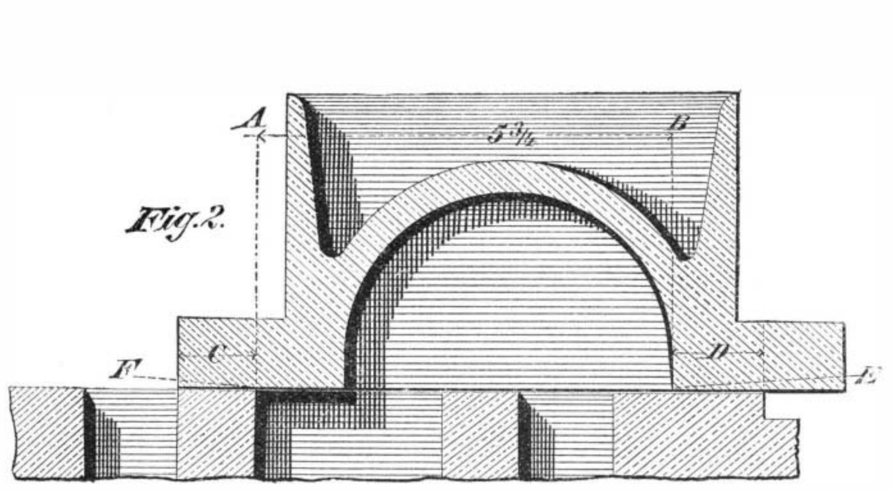


Fig. 2.



If these two plates are carefully cleaned, and one is lowered upon the other, it does not take an ounce to slide one upon the other; indeed, unless the lower one is made to stand level, the top one will glide off. At the same time, it will lift the lower plate and suspend it (from a partial vacuum) for an indefinite length of time. It can scarcely then be said that such a surface would not be steamtight when under a steam pressure. Now accepting, for the sake of illustration, a co-efficient of friction of 0·15, and the weight of the plate as 20 lbs., it should take 3 lbs. to slide the top plate, even allowing that it was entirely free from any atmospheric pressure. What it actually does take I have never determined; but I should judge certainly not more than three ounces, and I doubt if it takes an ounce. If, however, one drop of oil is distributed by the hand over the two surfaces (having 96 inches of area each), it requires from 50 to 100 lbs. to slide the top one, according to the cleanliness from the particles of dust which fill the atmosphere (and these fall upon the surfaces even when the utmost care is taken and the greatest practicable despatch is employed in putting them together) which the surfaces may have, and on how much the plates are rubbed together.

An experiment, however, which is much more to the point, is as follows: If the surfaces of these plates are wiped as clean as it is practicable to get them by rubbing them well with dry and clean old rags, and if then we place them in contact at one corner only, and slide the top one over the other, it has taken $341\frac{1}{2}$ lbs. to slide one over the other (allowance being made for the weight of the top plate), as a certificate given by the Fairbanks Scale Company at the Centennial (which certificate now lays beside the plates) attests. From this we may proceed to test Mr. Hill's co-efficient of friction. According to his theory, every 15 lbs. required to slide the plate will represent 100 lbs. pressing them together; then the $341\frac{1}{2}$ lbs. it takes to slide the top one divided by 15 will represent the number of hundred pounds with which the plates are pressed together: hence $341\frac{1}{2} \div 15 = 22{\cdot}76 \times 100 = 2{,}276$ lbs. Now let us suppose that these plates have a perfect vacuum, of say 15 lbs. per inch, between them, and hence have the full atmospheric pressure of say 15 lbs. per inch upon them. Then the area of the plate (96 inches) multiplied by the atmospheric pressure (15) equals 1,440 lbs., and the difference between 1,440 and 2,276 is the actual equivalent of friction, and that assumed by Mr. Hill. It may be said that there is about 1,440 lbs. of atmospheric pressure upon the plates, and that the other 836 lbs. necessary to make up the 2,276 lbs. (that a co-efficient of 0·15 assumes there to be upon the plates, holding them together) is to be found in the adhesion above referred to. But the equivalent of friction of 0·15 is given by Rankine as in *terms of the weight,* and not in terms of the combined weight and whatever adhesion the smoothness of the surfaces may induce. Nor is it possible to give a definite co-efficient of friction, if the friction due to the weight or pressure is to be supplemented by an amount of adhesion induced by and varying with the smoothness and perfection of the fit. If we disregard the element of adhesion, and use, as Mr. Rankine does, a co-efficient in terms of the weight (*vide* Bourne); and if we then allow that co-efficient to be 0·237 instead of Mr. Hill's 0·15 (and 0·237 will be about the co-efficient allowed by General Morin, the excess of the last two figures being accounted for in the fact that 0·2 is for an angle of repose, whereas my plates lay level), then we have as follows: Every 23·7 it requires to slide these plates represents 100 lbs. pressing them together; hence the 341·5 lbs. required to slide the plate, divided by 23·7, equals 1,440 (nearly), and this equals the allowed atmospheric pressure of 1,440 lbs. resting upon the plates. It is not to be presumed, however, that these plates are in perfect contact, and hence there is presumably air to some extent, between them; and it is only reasonable to assume that, if they had, instead of about 15 lbs. per inch upon them, the 130 lbs. per inch under which many slide valves operate, they would be in more perfect contact, and would require more power to slide them. In other words, the co-efficient of friction would be increased in proportion as the air was more perfectly excluded from between the surfaces: providing, however, that there were no elements tending to warp the plates out of truth, and therefore to impair the contact of the surfaces and thus admit the pressing element, be it air or steam, between them. In a slide valve, however, there are several elements which preclude the possibility of the surfaces of the valve and the seat being of a perfect fit, and these I will now separately discuss.

Suppose that all slide valves were made of an equally good fit to their seats (and this is supposing a good deal when we remember that some engine builders put in the valves just as they were planed, making no attempt to fit them to their seats on the cylinder port faces, while others file them to a fit, and others again scrape both valve and seat true to a surface plate). Suppose that the co-efficient of friction, whether due to the pressure only of the valve to its seat or to the combined pressure and induced adhesion from perfect contact, was in all cases alike, when the valves were put in new. Let us see how long they would remain so. First, then, an iron or brass casting, heated after having the surface removed by planing or filing, warps, and its fit is impaired. With the loss of the fit goes a loss of the adhesion, and an admission of steam beneath that part of the surface of the valve which does not fit. How much it will warp depends upon the temperature to which it is heated, on how much was cut off the planed face, on how unevenly the valve casting cooled after being taken out of the mould, on the shape and thickness of the valve, and on several other elements. Let us presume, however, that a casting could be made so that it would not warp from having its surface skin removed, and that, by heating the valve after it had been once surfaced, the reset had taken place, and the valve, being refaced true, would not again warp from being reheated (as experience demonstrates that it always does), and that, being heated to a given temperature, it would remain as close a fit to its seat as it was when cold. Then, just so soon as the temperature varied, the expansion and shape of the valve would vary. Cast iron expands by heat, in proportion to the temperature. The valve has, acting on the inside area of its exhaust port, the cooling effects of the atmosphere, which finds ingress through the exhaust pipe. The exhaust steam itself lowers in temperature as its pressure decreases, and the live steam on the back of the valve is comparatively constant in temperature: as a result, then, the valve is continually changing in form from the expansion due to the high temperature of the exhaust steam during the early part, and the lower temperature during the latter part, of the exhaust. Now comes another and more important question, and that is: How far will the spring of the valve, from the pressure of the steam upon its back, affect the fit to its seat, and will it so spring as to permit of a fine film of steam finding its way beneath the wings of the valve, thus relieving, to a certain extent, the amount of its pressure to its seat?

If we take a pair of the plates shown in Fig. 1, and get them so closely together that it requires, say, 340 lbs., to slide one upon the other, and then take hold of the plates by the handles, as shown in our engraving, we can pull them apart by exerting a force of about 130 lbs.; in other words, it will require but little more than one third as much power to pull them apart, in this manner, as it requires to slide one upon the other. In thus pulling them apart, we have, upon the back, whatever weight of the atmosphere the fineness of the fit leaves unbalanced, and, in addition, whatever amount of adhesion the perfect contact of the surfaces may induce. Hence, allowing a co-efficient of friction of 0·15, we should have 2,276 lbs. holding the plates together; and while allowing a co-efficient of 23·7, we should have 1,440 lbs. resisting the effort to pull the plates apart. The fact, therefore, that 130 lbs. will actually, under the conditions shown, pull the plates apart, appears at first sight not a little singular. The solution, however, is simple enough. The plates spring from the pressure placed by the hands upon them, and hence they unlap and come apart just as if we took two sheets of paper, placed together and soaked with water, and then took hold of two corresponding corners and pulled them apart. The plates are ½ inch thick in the body, and the ribs are each $\frac{7}{16}$ inch thick and 2⅜ inches high; and yet 130 lbs. applied as shown will spring them sufficiently to let the air get in between them. Let us in the light of this fact examine the shape and pressure upon a slide valve (assuming for the nonce that the pressure is the unbalanced area in contact multiplied by the steam pressure), and ascertain whether it is reasonable to suppose that the pressure of the steam upon the valve springs the wings, and permits the steam to find its way beneath them.

In Fig. 2 is shown an ordinary locomotive slide valve, the ports being 1¼ x 17 inches, the bridges between ports 1 inch wide, the cylinder exhaust port 2½ inches wide, and the valve having 1 inch of steam lap, covering the ends of the cylinder ports 1 inch at each end. When the valve is in the position shown, it will be noted that there is a very large proportion of the area of the valve unsupported by the seat; the area of this portion will be in this case 5¾ inches, as marked in the engraving, one way, and 17 inches the other =97·75 inches. Now supposing the steam pressure to be 130 lbs. per inch: then 97·75 × 130 = 12,707 lbs., the assumed pressure of the valve to its seat, tending to spring the flanges or wings in the direction denoted by the dotted lines, E and F, respectively. What have we to offset this amount? The area of one bridge equals 17, the area covered under the valve flange at D equals 11 inches, and the amount of the valve flange overlapping the ends of the steam ports equals 15·5; total 43·5 square inches, which, multiplied by the steam pressure, would give 5,855 lbs. as the pressure tending to spring the valve wings in the direction marked. There will, it is true, be a pressure placed on the underneath side of the valve by the exhausting steam, the area thus acted on being, in the position shown, 97·79 square inches; but it can scarcely be advanced that this pressure can be sufficient to relieve the valve from its liability to spring from the 5,855 lbs. on the other side.

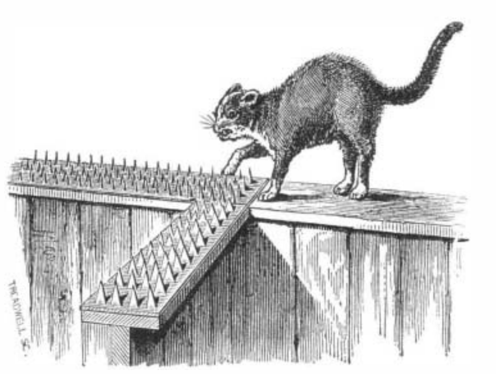
Theoretically, a valve will spring of its own weight; and that it will spring from the pressure which a man can put upon it with his hands, I have often found in facing valves up. For example, if, in trying the valve on the surface plate, the former is pressed in the middle by the hands to make the plate mark the face plainly, and the valve is fitted under these conditions to a practically perfect fit, the surface plate marks showing equally all over, we may then let the valve lie upon the plate of its own weight only, and the marks will show (after of course moving the valve back and forth) at and near the edges of the valve only, showing that the pressure of the hands sprung it. There are plenty of instances of metal in the most solid of forms springing of its own weight: witness the Morton Poole rolls, which, though of chilled cast iron and 12 inches in diameter, spring and bend by the insertion between them of a piece of gold leaf $\frac{1}{5000}$ inch thick. There is yet another part of this question, however, which is found in practice to be of the utmost importance, and that is (as a visit to any locomotive repair shop will demonstrate, by the engines that come in to be repaired), that the valve wears out of truth, and so does the seat. In my experience, I have chipped a full $\frac{1}{16}$ inch off valve seat faces without cutting the worn grooves out. I have examined, or had come under my observation, at least 400 slide valves, and I never saw one that was, after working three months, of a sufficient fit to its seat to require 1 lb. more than its own weight to lift it from its seat; whereas, if such a valve as is shown in Fig. 2 were of a practically perfect fit, it would require, when in mid-position, some 800 lbs. to lift it vertically, taking hold of the ribs outside the arch. The fact is that the bridges wear hollow lengthways, and hollow, as denoted by a straight edge, over the seat and across the bridges. Then there usually wears in the seat face a groove at right angles to, and close to, the edges of the ports. To remedy this, a practice sprung up in in England, in about the year 1865, of drilling, in the face of the valve and in a line with the exhaust port edge, a hole in each wing; and this hole may be found mentioned in recent engine specifications published in this city. Now just so soon as a valve face loses its smoothness, though the grooves may be only the one hundredth of an inch deep, or like coarse file marks, it becomes impracticable to exclude the surrounding air at atmospheric pressure, let alone steam at a high pressure, from between the surfaces.

I have a plate of the same size as those shown in Fig. 1, which has been planed and not fitted in any way. The planer marks are all intact. By placing a finished true plate upon it, the partial vacuum between the two will lift the planed one; but in about ten seconds it will fall, because the weight of the plate causes it to sag, and the air travels along the fine planer marks until there is not sufficient vacuum to sustain the weight of the plate, which is about 20 lbs. Now since the planed plate can be lifted by the vacuum, it is at least as good a fit as an ordinary slide valve, and under a steam pressure would undoubtedly be steam-tight, although the steam, like the air, would find its way along the planer marks, and thus counterbalance a large proportion of the pressure placed by the steam on the back of the valve. How much the elements of warping from expansion, changing form from irregular temperature, and counterbalancing from steam finding its way beneath the valve, will affect the pressure of a valve to its seat whether these causes act either in concert or partly counteract each the other, will depend upon the shape, size, strength, etc., of the valve. Isaac Walton said, in giving instructions how to cook a trout, "first catch your trout;" so it may be justly said, in calculating the friction of a slide valve, first find your pressure.

New York city. JOSHUA ROSE.

THE CAT TEASER.

No one who in the chill midnight air has hurled improper language and miscellaneous toilet articles at feline vocalists chanting on the back fence can afford to remain in ignorance of the merits of the ingenious little device represented in our engraving. It prevents cat concerts, simply by preventing the cats from prowling on the top of fences; and it compels them to take refuge on the fences of one's neighbors. Distance then lends enchantment to their howls, and the thoughtful man who has provided himself with the cat teaser "may wrap the drapery of his couch about him and lie down to pleasant dreams," lulled by the distant wauls, mingled with the profanity of some one several doors away, both reduced to gentle murmurs ere they reach his ear.



The cat teaser consists of a strip of sheet metal in which V-shaped cuts are made. The pointed pieces of the metal are then bent upward so as to stand perpendicularly; and the strips are tacked on the top of the fence. It is not necessary to surround an entire back fence with the device, because, if the fence at the rear end of the yard, and for a short distance adjoining on each side, is covered, cats cannot jump into the yard from the adjoining fences. It is impossible for a cat to walk on the points, nor can she insert her paws between them. Not only fences but roofs may thus be protected, while the device may also be used for keeping cats away from flower beds.

Practical tests of the invention have shown that it is discouraging to cats in a high degree. Tom cats of exceptional intelligence, who have long treated with contempt such trivial obstacles as spikes and broken glass, have retreated baffled before the teaser. As a means of preventing chickens roosting on unauthorized fences, the device has also proved very useful, and carries far deeper conviction to the mind of the average hen than does throwing stones at her after she is comfortably settled for the night.

Persons who value slumbers unbroken by feline melodies should address the inventor, Mr. C. L. Topliff, P. O. box 773, New York city.

A Silk-Spinning Fish.

There is a mollusk—the *pinna* of the Mediterranean—which has the curious power of spinning a viscid silk which is made in Sicily into a textile fabric. The operation of the mollusk is rather like the work of a wire-drawer, the substance being first cast in a mould formed by a sort of slit in the tongue, and then drawn out as may be required. The mechanism is exceedingly curious. A considerable number of the bivalves possess what is called a *byssus*, that is, a bundle of more or less delicate filaments, issuing from the base of the foot, and by means of which the animal fixes itself to foreign bodies. It employs the foot to guide the filaments to the proper place and to glue them there; and it can reproduce them when cut away. The extremity of the thread is attached by means of its adhesive quality to some stone; and this done, the *pinna*, receding, draws out the thread through the perforation of the extensile member. The material when gathered is washed in soap and water, dried, straightened, and carded—1 lb. of coarse filament yielding about 3 ozs. of fine thread, which, when made into a web, is of burnished golden brown color. A large manufactory for this material exists in Palermo.

Ross Winans.

Mr. Ross Winans, one of the many inventors who have amassed colossal fortunes, recently died in Baltimore, Md., at the age of 81 years. Mr. Winans began life as a merchant's clerk, but laid the foundation of his fortune by rearing horses. His first invention was a plow, that had a large sale. In 1830, he became interested in the building of rolling stock for the Baltimore and Ohio Railroad Company; and for the succeeding thirty years of his life he devoted himself to the designing of railroad cars and locomotives. The heavy freight engine known as the camel-back is his invention; and he also claimed to have originated the modern eight-wheeled passenger car. His shop became famous, and he built a large number of locomotives, and in this way accumulated the greater part of his wealth. During the war, he devised a steam gun for the Southern army, but it was captured by the Federal forces almost immediately, and thus never used. It was not a formidable weapon. Since his withdrawal from locomotive building, Mr. Winans has tested plans for improved working men's dwellings with much success. Thirty years ago he was offered the management of the Russian railways by the Czar, but this he declined in favor of his sons, who brought much ability to the work. Recently, Mr. Winans has resided on his model farm near Baltimore.

Blocking the Straits of Belle Isle.

In this city a kind of mild war is chronic between the Harbor Commissioners on one hand and the police authorities on the other, the subject being the disposition of ashes and solid refuse of all kinds, not susceptible of utilization, which if thrown into the bay tends to fill up channels and otherwise to obstruct navigation. At present, this material is carried out to sea in large scows, and there dumped. A new engineering scheme, rather startling in its magnitude, has recently been advocated, which, as a daily contemporary suggests, if ever seriously regarded, will afford an outlet for all the ashes, etc., New York and all other Atlantic coast cities can furnish. The project is to block up the Straits of Belle Isle, the object being to divert the ice which comes down every year from Baffin's Bay, through the Straits, and which makes the shores past which the icebergs float many degrees colder than those to the eastward, which face the ocean and get the benefit of the Gulf Stream. It is believed that, if this project could be accomplished, the climate of Anticosta and of the Gulf of St. Lawrence would be greatly modified, and navigation through the neighboring waters could be kept open during the whole year. In the narrowest portion, the width of the Straits is 8½ miles.

Whole Ox Soup.

In Australia, where the horned stock has increased of late in a more rapid ratio than the population, the supply of meat is much greater than the demand; and at the present time the price of cattle is commonly quoted "at boiling rate;" that is, the animals will fetch no more from the butchers than can be realized for their hides, horns, hoofs, tallow, etc., for exportation. In large establishments devoted to preparing these utilizable portions of the bullock, there was of course an immense waste when the ox went into the melting pot; but this loss is now in a great measure avoided by boiling the animal at once into soup, or concentrated extract of beef. After the head, horns, hoofs, etc., are removed, the meat is cut into convenient sized pieces and conveyed to immense steam-tight double cylinders capable of holding upwards of fifty bullocks at a time. In seven hours, during which they are subjected to a pressure of steam of 15 lbs. per square inch, the bones and meat are reduced to a pulp. The steam is then condensed, and the tallow, which floats on the surface, drawn off. The pulp is removed and placed in a powerful press, which squeezes out the soup. The latter is, however, not yet sufficiently concentrated; and to render it so, it is placed in a peculiarly constructed boiler, there reduced by evaporation, and finally run off into bladders. When cold, the essence is semi-transparent, of a rich reddish brown color, and sweet to the smell and taste, almost like confectionery. A whole bullock, after being thus treated, yields but 20 lbs. of soup.

Telephonic Music.

At a recent telephonic concert in Washington, it was stated by the lecturer that the electric waves of sound sent through a single wire are frequently conveyed, indirectly, by other wires running parallel with it on the same poles, although entirely disconnected from it. This statement was verified in the Washington office of the Associated Press, where a number of the tunes played in Philadelphia, and conveyed electrically to Lincoln Hall in Washington, were distinctly heard on the relay used in the Press office, which had no connection with the wire that was attached to the telephone. The tones thus conveyed, although not loud, were stated to be audible at a distance of several yards from the instrument.