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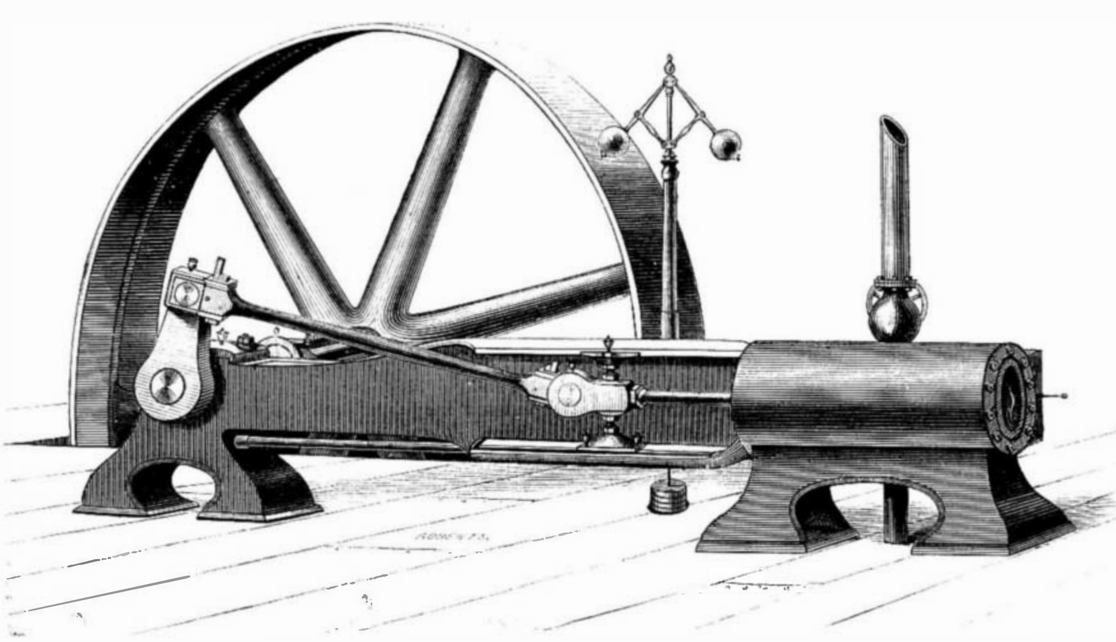
### Improved Cut-off in Engines.

Most of the features of modern steam engineering originated in the fertile brain of James Watt. He found the steam engine in a very crude state and left it in quite as perfect a condition (excepting only mechanical construction) as that of the ordinary engines at the present time. He invented separate condensation, expansion, steam jacketing, superheating, and the governor. The combination of the governor with a cut-off valve gear was reserved to a later period, having first been published in the "Repertory of Patent Inventions" for 1826, as the invention of James Whitelaw. Since then the steam engine has advanced by improvement in details and construction rather than by the development of new principles.

The inventors of the engine herewith presented to the public make no pretension to the introduction of radical improvements in the principle of using steam expansively, but they have devised and perfected a new and simple method of operating and controlling the action of the valves for admitting and cutting off the steam, by means of which better results are obtained than by the devices heretofore in use.

There is no necessity at the present day to argue the superiority of an engine regulated by the cut-off to one regulated by the throttle, so far as economy of fuel or regularity of speed are concerned. Practical business men have settled that question for themselves by experience, and no shrewd business man will purchase a throttle valve engine when he can procure one which automatically adjusts the supply of steam to the exact amount required for the work in hand. There are occasional situations, where the load is constant and the engine and pressure of steam are exactly adapted to the circumstances, when a fixed cut-off will give nearly or quite as good results as an automatic cut-off, but a change in the load or pressure of steam will disturb the conditions so as to destroy the equality. With a perfect automatic valve gear and regulator the variation of load or pressure within reasonable limits will not materially affect the economy; while there is no other possible means of regulating the speed and power of an engine with the perfection which is attained by a governor attached directly to a sensitive cut-off valve gear.



THE BABCOCK & WILCOX STEAM ENGINE.

This engine has a novel construction of the governor, by which the variation due to the pendulum action of the ordinary governor is overcome, and a regulator produced which will give the same speed whether the engine be light or heavily loaded, or the pressure of steam in the boiler be greater or less. The governor as invented by Watt, and adopted by modern engineers with rare exceptions, gives only an approximation to equal speed, requiring a variation of from five to thirty per cent between the extremes of motion.

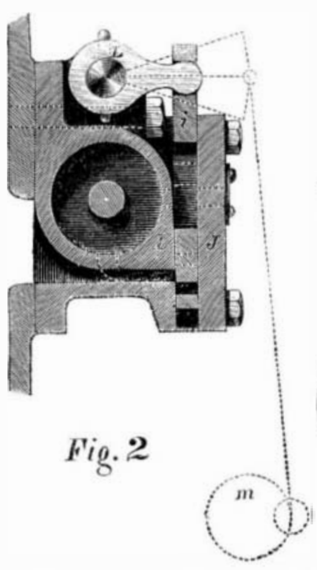
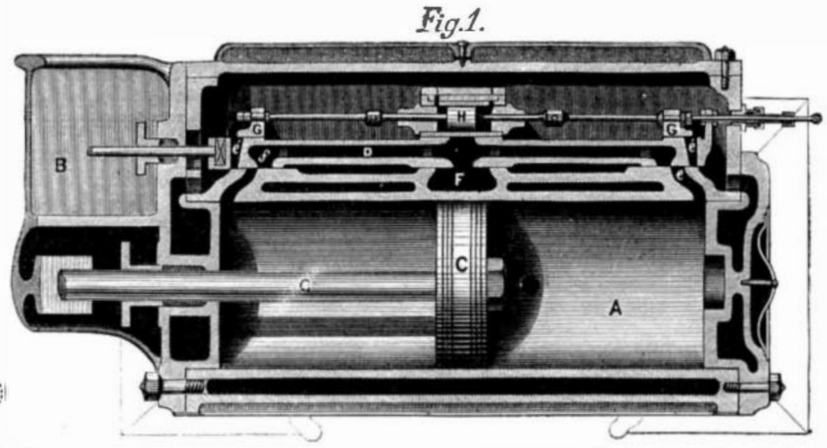


Fig. 2

In designing this engine it has been the object of the inventors not only to introduce their own peculiar ideas and improvements, but to combine therewith all those features which long practice has proved to be most conducive to economy of fuel, and the durability of all the working parts. The steam jacket has been much neglected in this country, though in almost universal use by the best engine makers of Europe; and so little is its theory and advantages understood here, that in most cases where it has been introduced in this country it is filled with the exhaust steam, thus defeating the very object for which it was designed. This engine is jacketed with live steam from the boiler in both heads as well as around the cylinders, thereby keeping the metal of the cylinders, as hot as the hottest steam which enters it.

The valves which effect the distribution of the steam in the steam engine are the most important part of the machine, as upon their properly performing their functions depends the efficiency of the working mediums. They must not only admit, exhaust, shut off, and close, at the proper periods, but they must be perfectly tight when closed, and when open admit the steam with the least possible resistance. They should also permit of such a relation to the cylinder as to give the least practicable lost space or clearance. There are four distinct varieties of valves used for this purpose, viz.: the plug or cock, the piston, the seat valve or poppet, and the slide. The first variety is never used now by competent engineers, having but one good quality, viz.: the equal pressure of steam on its sides, to balance its many bad features, such as leakages, sticking from expansion, and unequal wear. The piston valve is also nearly out of use owing to the excessive lost space inherent in its construction. The same objection applies to the poppet valve with the additional ones of great liability to leakage, and inability to open and close quickly from the fact that it opens immediately on starting, and is not closed until brought to rest. It is impossible to start or stop the valve instantaneously, therefore the opening and closing must be correspondingly so slow as to be objectionable except on slowly moving engines.

Fig.1.



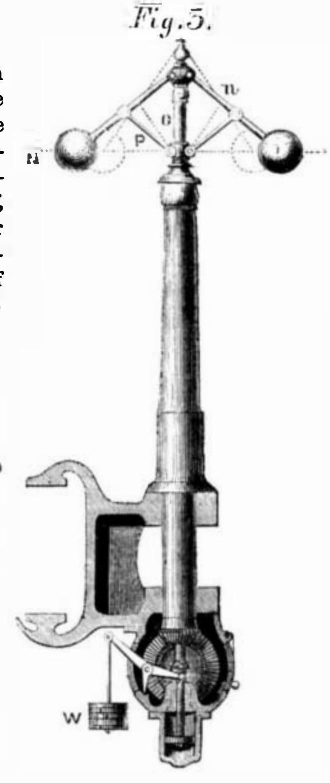

The universal experience in this country and Europe is in favor of the slide valve for opening and closing the ports of all quick moving engines. It is simple and easily fitted, admits of the least lost space, opens and closes the ports with the quickest possible motion, and is the least liable to become leaky from use of any form of valve. Of the two forms of slide valve the flat is much preferable to the curved, from the greater facility of accurate fitting, and the more equal wear of two planes as compared to inner and outer cylindrical surfaces.

An important condition of equal wear in a slide valve, however, is a constant travel. Where the induction valve is made also to act as a cut-off valve, as in a link motion, and in detachable valve gear, this condition cannot obtain, and as a consequence we find that such valves are always wearing leaky.

The adaptation of a cut-off mechanism to act in conjunction with a plain slide valve. the latter to admit and exhaust the steam, and the former to close the port at any desired point in the stroke, has been a favorite pursuit of engineers for the past half century, but in all arrangements previous to the invention of Babcock & Wilcox, the motion of the main valve had more or less effect upon the action of the cut-off, and the latter would not work with the desired rapidity at all points, nor would it admit of a range of motion throughout the stroke of the piston. Nine-tenths of all the expansion engines now built in Europe have some modification of this form of valve gear, and the engine of Messrs. Farcot & Sons, which received the Grand Prize at the late Paris Exposition, was of this class.

One of the points in which the Babcock & Wilcox engine differs from the best engines which have preceded it is the manner in which the cut-off valves are operated, viz.: by the action of the steam itself, independent entirely of the action of the main valve; thus insuring an instantaneous, positive, and easily controlled cut off, at any desired point in the stroke of the piston. The distribution of the steam to the alternate sides of the piston, and its release from the cylinder when the stroke is completed, are performed in the manner most approved by experienced engineers, by means of a plane slide valve operated by the ordinary eccentric. But from the fact that the induction valve has in no case to effect the suppression of the stream—or, in American phrase, act as a cut-off valve—and from the further fact that the cut-off is actuated independently of the motion of the main valve, the functions of "lead" and "cushion" can be adjusted to any desired degree, without in any manner affecting the action of the cut-off valve. This is an important distinction between the operation of the main valve of this engine and those which have preceded it. In the ordinary three-ported slide valve, or in any other arrangement where the several functions of *lead, out-off, release*, and *compression*, or closing the exhaust, are dependent on the motion of one eccentric, the "exhaust" functions—*i. e.*, the release and compression— must always be subservient to the "steam" functions—*i. e.*, the lead and suppression, or cut-off.

Fig.3.




In the Babcock & Wilcox engine, however, the cut-off being actuated by a separate and entirely independent mechanism, a single valve is capable of giving any degree of lead and compression which may be desired, as perfectly as with the most complicated valve gear.

Another important difference between this engine and all previous adjustable slide or rolling valve cut-offs, lies in the fact that the valves have a constant travel under all circumstances, thereby insuring an equal wear. A valve which varies its throw to effect the cut-off, as in all detachable valve gear, cannot wear equally, and has a continual tendency to grow leaky. Again, this constant throw insures a wide, open port, and the least loss through throttling the steam by the action of the valve—or, in other words, enables us to obtain a pressure in the cylinder more nearly approaching that in the boiler, than can be realized with other valve motions.

Another peculiarity of this engine is its extreme simplicity and the fewness of parts exposed to wear. At first sight, it has the appearance of one of the simplest styles of non-expansive engines, having none of the catches, cams, dash-pots, springs, tappets, etc., which are common to other expansion engines. With the exception of the cut off gear, the engine is a simple slide-valve engine, and can be used as such, should any accident occur to the cut-off. The cut-off mechanism itself is also of the simplest possible description, having the least possible number of parts, consistent with a proper performance of its functions. It consists of two cut-off slides, a miniature steam cylinder, and a valve for controlling the admission of steam to the same. This small cylinder, being enveloped in the steam, requiring no packing, and having only the weight of its piston to produce wear, is, for all practical purposes, indestructible. The cut-off slides are always balanced when they move, consequently they are not exposed to injurious wear.

Another advantage of the Babcock & Wilcox engine is that it is easily comprehended by ordinary mechanics. The motions and adjustments are similar to those familiar to any one who understands a plain slide-valve engine; and any man who can adjust such an engine properly, can readily adjust this.

The cut-off valve of this engine presents a convenient means of stopping at any desired point, simply by opening or closing the cut-off valve by hand, as the case may require. The engine may be warmed up, also, without danger of starting, by closing the cut-off valve by hand. In cases where it is desirable to back the engine, a starting bar may be readily shipped and the engine handled with the same ease as the plain slide.

The bed or framing which has been adopted for horizontal engines is of the form first introduced by Horatio Allen, Esq., of the Novelty Iron Works. It is bolted to the end of the cylinder, and extends to the pillow-block, and the metal is so disposed as to give the greatest rigidity with the least weight. The cross-head is upright, and is supported on flat slides, a drip cut cast on the bed serving to catch all drippings, not only from the slides, but from all the stuffing boxes.

The regulator or governor is driven by gearing, thus avoiding all danger of breakage or slipping of belts, and the consequent damage to the engine and machinery from the "running away" of the engine.

In addition to the steam jacket for preserving the temperature of the cylinder, a covering of felt is employed around all the exposed parts, and this in turn is covered by a casing of polished metal. The latter is the best possible protection against loss by radiation.

In the construction of these engines, no pains or expense is spared to procure the best material and workmanship, and the proportions and relative strength of all the parts are calculated with the utmost care, from formulas based on long experience, as well as a thorough knowledge of the qualities and peculiarities of the materials. Great attention is also paid to giving artistic forms to the various parts, every piece being designed with reference to rigid simplicity and a cultivated taste.

The largest engraving gives a perspective view of the engine.

Fig. 1 represents a horizontal section of the cylinder and valves, showing the peculiarities of the cut-off motion. A, is the cylinder which is steam jacketed as are also the heads. B, is a portion of the bed piece, which forms also the front head of the cylinder. C is the piston and C' the piston rod. D, is the main valve, e e' the induction ports, and F, is the exhaust port. The body of the valve is hollow and conveys the exhaust steam from either end of the cylinder alternately to the exhaust port, F, whence it goes into the exhaust pipe. The steam passes through ports e' in each end of the valve, into the induction ports of the cylinder, alternately as they are opened by the motion of the valve derived from an eccentric in the usual manner. On the back of the valve at either end is a slide, G, which can be made to cover the port at that end, and these slides are each attached to one end of a piston, H, fitting in a small steam cylinder bolted to the back of the valve, and so adjusted that when the port in one end of the valve is closed the other is open. Upon steam being admitted to either end of the piston, H, the piston is shot over and the corresponding side closed to cut off steam from that end of the main cylinder; while the port at the other end of the main valve is opened ready to admit steam to the other side of the main piston when the valve shall arrive at the proper position.

It will be observed that the cut-off slides, G, are always balanced when moved. The one about to close having steam of equal pressure upon each side, while the other one has been balanced by the main valve riding past the end of the valve face on the cylinder, thus admitting steam behind the slide, G. This condition obtains during the whole stroke of the piston until the steam is cut off, after which the cut-off slides, G, remain stationary relatively to the main valve until ready to cut off steam on the return stroke, previously to which time they have been balanced by the over-riding of the valve at the other end. These slides, have, therefore, literally no wear, and once fitted tight, they will remain so indefinitely. The piston, H, in the small cylinder, is turned to fit, and has no packing, neither have the rods stuffing boxes, as the pressure is equal on both sides except during the inappreciable time which intervenes between the exhausting of the cylinder, I, and the movement of the piston. The only tendency to wear in these parts is due to the weight of the piston and rods, which is supported on large surfaces. In fact, after twenty months constant use, none of these parts have worn sufficiently to obliterate the tool marks upon the surfaces.

Steam is admitted alternately to each end of the piston, H, at every revolution of the engine, causing the cut-off slides to move at every stroke, cutting off the steam at the point determined by the governor.

Fig. 2 shows a cross section of the cylinder, I, and its valve. This valve is balanced by the plate, J, upon its back and is operated by a toe upon the rock shaft, L, carried upon the main valve, and extending through the end of the steam chest where it receives motion from a crank, M, which is adjusted in its position by the governor. The exhaust ports of the cylinder, I, are made upon the bottom and are at a little distance from the end, while the steam ports are upon the side and at the extreme end of the cylinder. By this arrangement the piston closes its own exhaust port and cushions on the remaining distance, thus dispensing with all dash pots or air cushions, and causing the valve to work without any noise.

The valve, i, being balanced, and the rod, L, carried through its stuffing box by the main valve, there is the least possible power required by the regulator to adjust the crank, m, thereby ensuring a more sensitive action than can be attained where the governor has labor to perform.

The governor is peculiar and is shown at Fig. 3. The balls, N, are hung upon arms in the usual manner, which arms are jointed at their upper ends to a head attached to the rod, o, which slides within the hollow shaft that drives the balls; the motion being communicated through the radius rods, p, which are jointed at their lower ends to the gearing shaft, and at their upper ends to the center of the arms, n. The rods, p, are half the length of the arms, n, measuring from the center of the ball, and it will be readily seen that in consequence of this arrangement the arms, n, and rods, p, form a parallel motion and compel the balls to move outward in a horizontal plane.

In the ordinary pendulum governor the balls move in the arc of a circle and rise as they extend. It therefore requires an increased speed to maintain them in their advanced position. The engine must consequently run faster when the load is light than when it is heavy, and such is the case with all ordinary governors. In this improved governor it will be seen that the gravity of the balls has no tendency to move them in either direction, and exerts no influence whatever upon the speed of the engine. The centrifugal force causes them to diverge, and a weight, W, tends to bring them towards the shaft. When therefore these two forces are in equilibrium the balls will remain in the same position, but as either preponderates they are moved in a corresponding manner, thus affecting the speed of the engine by varying the amount of cut-off. The weight, W, is supported upon a bent lever which is so proportioned, that the centrifugal force at any given speed will just balance the weight in all positions. The speed of the engine, will, therefore, remain at that fixed point with all variations of load or pressure of steam; for any increase or diminution will cause either the balls or weight to preponderate and the point of cut-off to be changed until the speed is again brought to the standard where the two forces are in equilibrium.

Any desired speed can be obtained by altering the weight, W, and the action of the governor will be as perfect in one case as in any other. A spiral on the rod, o, serves to advance or retire the crank, m, relatively to the main crank, so as to cause the cut-off to occur earlier or later in the stroke, as the balls diverge or converge; and the amount of this adjustment is such that the cut-off may be varied from nothing to seven-eighth stroke. [See Advertisements on page 270.]

## Correspondence.

*The Editors are not responsible for the opinions expressed by their correspondents.*

### The Late Explosion in New York City.

Messrs. Editors:—After a careful and reflective examination, I have come to the conclusion that the steam boiler disaster in Twenty-eighth street was not an explosion, but that the boiler gave out and was carried to the place where we found it by the ordinary pressure of steam. I find the rupture was in the strongest part of the boiler—the tube cylinder—which was 52 inches in diameter and 7 feet long, made of 5-16 iron, which was of good quality. The outside shell was 96 inches in diameter and but 4-16 thick. Now, taking the diameters of the two into consideration, and the extra thickness of the iron of the tube cylinder, I find it capable of sustaining fully double the pressure per inch that the outside shell could; yet the outside remained entire.

There is nothing to indicate a lack of water in the boiler, but the most conclusive evidence that there was a full supply. Had there been a lack of water, the boiler would undoubtedly have been destroyed, but its subsequent flight, the destruction of two lives and a dwelling house 150 yards distant would in all probability not have been the result.

This seems perhaps paradoxical, but if we examine the construction of the boiler which our readers will see illustrated on the first page of this journal dated July 9th, 1867, we will see that it is of that type of boilers having a large fire surface with a very small water space, particularly in the tube cylinder, which is on one side exposed to intense heat outwardly, while the heat returns through the tubes internally. In the upper half of this cylinder, probably, the major part of the steam was generated, which of course must find its way to the steam reservoir in the top—the water spaces being small around the tubes—the water was necessarily forced out by the steam, the iron heated—the water returns on the heated iron—thus alternately expanding and contracting the plate of the cylinder most exposed to the intense heat of the furnace, while its attachment to the main part of the boiler being less exposed to heat, was expanded less. This alternating continually weakens, disintegrates, finally destroys the strength of the iron, and it gives out in the strongest part!

I have said that there was no evidence of a lack of water. This is proved by the fact that the crown is one foot or more above the top flue sheet of the inner tube cylinder, showing no marks of overheating. This crown sheet is flat, sustained by suspension stays from the top. It was intact—no depression in any part, nor any marks of overheating, while the tube sheet of the cylinder showed most unmistakable evidence that when the rupture took place, that and one half the length of the tubes and one half of the shell of this cylinder were *red hot!*

With regard to the elevation and flight of the boiler, if we assume the boiler had 60 pounds of steam to the square inch, this multiplied by the area of 96 inches (the diameter of the outer shell of the boiler), gives us an ascensive power of nearly 218 tuns, while the parts of the boiler that ascended weighed but about four tuns.

Now there is ample evidence that the water and steam (and the water contained in the boiler would become steam when liberated) was still being discharged from the lower end of the boiler until it landed, acting precisely like the force of gunpowder being discharged by a rocket in its ascent.

Now taking this view of it, the escaping steam had to impinge on the atmosphere, which we will assume as 15 pounds per square inch, this multiplied by the area of 96 inches, gives us a propelling power of more than 54 tuns, against 4 tuns to propel.

Need we look after a *gas theory* to give these results? Is it necessary to invent any "mysterious" causes? I found the iron of which the boiler was constructed good, the workmanship unexceptional, but the principle on which the boiler is constructed wrong.

F. W. B.

### Artesian Wells in Illinois.

Messrs. Editors:—I crave a short space in your scientific journal for the purpose of asking a few questions that would perhaps interest some of your 100,000 readers, and may benefit the inhabitants of this section. Onargo, the point whence this comes, is located in central Illinois, 85 miles south of Chicago. It is in the center of what is known as the Artesian Well region. These overflowing wells can be produced within a radius of 20 miles at the depth of 70 feet, variations in surface allowed. Water is procured by boring with a six-inch auger through about 5 feet of soil, 10 to 20 feet of sand, 15 to 20 feet of blue clay, 20 to 30 feet of hard pan, a composition of blue clay and coarse sand or gravel, and as hard as baked pottery, and into a bed of white sand called "water vein." In this bed of sand the water is found, it will in many places fill the discharge pipe several feet above the surface, which may be conducted to any part of the farm by pipes. Onargo is 92 feet above Lake Michigan and higher than the surrounding country, and these wells are found on every farm, flowing a constant stream at an even temperature. The question is, where does this water come from? Some of these wells throw 20 gallons per minute, others 120. A gentleman well acquainted with this country and the numerous wells, estimates the amount of water brought to the surface in this district at 53,400,000 gallons per day; this is allowing but 50 gallons to a well per minute. Where does this water come from? It cannot come from the lake, as we are so much higher than that body of water. It cannot collect in reservoirs from the surface, because it is impossible for water to penetrate the stratum known as hardpan, that overlays the sand or water vein. In this vein, where the water is found, there are no vacuums, or lakes, or veins of water, or currents, but a hard and compact bed of sand, almost pure white. Now if this water does not come from the lake or surface in this vicinity, but its source is a body of water some distance away, would it not be necessary for it to be at a great hight to overcome the resistance it meets in traveling through this bed of sand? Say this old theory is correct, say that the source is 200 miles away and 200 feet higher than the discharge, would not the resistance it meets in traveling through this compact bed of sand so overcome the power it receives from the fountain head that it would fail to reach the surface? Or do you consider that this water is conducted through this sand on the capillary principle? and if this is true why is it that beyond a certain radius they bore to the bed rock and fail to procure water?

A great many other things I would like to ask, but I know I must be brief. We find peculiarities in every section of this great artesian well country, most of them worthy of note, which if collected would fill your paper a dozen times. If you want a map of this section, with number of wells and location, size of streams, etc, I will forward the same.

Ed. Rumley.

[We would be glad to receive from our correspondent any further information he may deem interesting.—Eds.

### Turbines and Water Power.

Messrs. Editors.—For some time I have watched with peculiar interest for items relating to Hydraulics, especially in reference to the most economical use of water power, as I am about fitting up a mill where I have a fair water power. In your issue dated October 5th, I notice two statements purporting to be made by parties using the "Leffell wheel," which seem to me to be extremely improbable, viz., in one case where a turbine wheel of only 6 inches diameter had replaced two 20 feet overshot wheels and was doing more work on less water than they had been able to, and the other where a 10-inch wheel was running 3 pairs of large flouring burrs. Now I am pretty well acquainted with the amount of power required to do the work therein stated and that acquaintance leads me to believe that this is impossible, that it is impracticable for any such wheels to accomplish these results, especially with the small amount of water said to have been used.

Now if the Leffell or any other wheel can do what is there claimed, it is certainly important for all millers and manufac-