metal, etc. No. 13 is a quadrangular double-faced drill point for drilling stone, etc. No. 14 is a quadrangular pyramid used for reaming stone or metal. No. 15 is similar to No. 5, and is used for the same purpose. No. 16 is a quadrangular cube with graver edge for cutting metal, etc. No. 17 is a flat octahedron for drilling stone, glass, etc. No. 18 is a flat ovoid; with double drill point, for drilling or countersinking stone, metal, etc. No. 19 is a tetrahedron, used the same as No. 18. No. 20 is a pyramidical drill point, used the same as Nos. 18 and 19. No. 21 is a truncated prism, used the same as Nos. 1 and 10. No. 22 is a drill-pointed prism reamer. No. 23 is similar to No. 22, and used the same. No. 24 the same as No. 7, with angular edges, and used for the same purpose. No. 25 is a double-inclined plano wedge for cutting stone or metal. No 26 is a quadrangular wedge for turning stone or metal. No. 27 is an acute conical-turned diamond point, used for engraving, etching steel by bank-note engravers, etc. No. 28 is a diamond in its natural crystallized state, as found in the mines. Crystallized carbon, of which the above points are made, is of a black or gray color, opaque and irregular in shape and devoid of angles. The above illustrated points or cutters range in size from one-sixteenth of a carat to ten carats each (a carat is equal to four grains). Their perfectness of finish depends upon the purpose and material to which they are to be applied. For metal they require to be sharper than for stone. The prices are fixed in accordance to their shape and finish. A patent for this important improvement in the preparation of diamond carbon was obtained by Mr. John Dickinson, 64 Nassau street, New York, June 1, 1869.

The superior accuracy of work done by the diamond point is owing to the fact that it does not wear away and become blunted like a steel tool. It therefore has come largely into use for fine steel engraving, engraving on stone, etc. We shall probably give, on a future occasion, an illustrated description of some of the various cutting machines and tools employing diamonds for the above purposes.

The operation of these tools was witnessed by us as we have already said on a recent occasion, and the speed and certainty with which the hardest known substances can be drilled, turned, and cut by them, is really astonishing. A drill with a carbon point like that seen at No. 2 in the engraving was made to pass through a block of Arkansas stone in less time than the same thickness of cast iron could have been penetrated by a well-tempered steel drill. Vulcanized emery wheels, so hard that they could not be clipped with the cold chisel, were drilled and turned with seemingly still greater facility. But the most interesting experiment to us was the performance of the patent millstone-dressing machine, which, by means of a diamond point, enables a boy to work with his eyes shut and do more accurate work, and a much larger quantity of it, than can by any possibility be done in any other method ever before employed. A description of this machine, for which there is a large and growing demand, is deferred for the present.

The uses to which this form of carbon can be put, in the form of saws, drills, and other cutting tools are daily found to be more and more numerous, and though their first cost is greater, the large saving of labor they effect, renders them the cheapest tools which can be employed for such purposes.

ON THE FLOW OF ELASTIC FLUIDS THROUGH ORIFICES OR PIPES.

We condense from *The Engineer* the following on the above subject. It being one upon which we are very frequently asked to give information, it will be of interest to many of our readers :

" In order to determine the number of cubic feet of steam or air, or other gas, which will be discharged through a given orifice in a given time, it is necessary to ascertain the velocity of issue. In no other way can the problem be solved, except by experiments with vessels of known capacity, from one of which the air, steam, or gas, flows to the other. Such a solution is, for reasons on which it is not necessary to enter, practically beyond the reach of most men ; and it has already been tried by many, with results which have enabled a general law to be laid down, to which law we shall come presently. If the velocity is known all the rest follows easily enough. Let us suppose the orifice in the side of a boiler to be one inch square. A cubic foot of steam contains 1,728 cubic inches. We may suppose this cubic foot of steam all contained in a column or bar 1,728 inches long and 1 inch square. Let one end of this bar be brought opposite the orifice and the work of expulsion begun ; then it is obvious, that before the whole cubic foot of steam is discharged, a column of steam 1,728 inches long must be passed through the hole. Now, if the velocity of efflux is 1,728 inches per minute, then one minute of time will be required for the escape of one foot of steam. If it have a velocity of efflux of 1,728 feet per second, then the orifice will discharge one cubic foot per second, and so on. And this law is totally independent of the pressure or weight of the steam. As the pressure increases the *velocity* of discharge will increase in a certain ratio to be presently explained ; but the pressure will not affect the fact that the *velocity of discharge in inches per second*, multiplied by the area of the orifice in square inches, and divided by 1,728, will give the discharge in cubic feet per second.

" When a discharge of water, steam, gas, or other liquid or fluid takes place through an orifice in a thin plate, a certain contraction takes place in the issuing column which reduces the amount of discharge below that proper to the actual area of the orifice, but it is needless to do more than mention the fact here. It is quite unnecessary to complicate a statement which we wish to make as simple as possible, by further reference to the *Vena Contracta*.

"We have said that the velocity is regulated by the pressure, but this fact only holds good for each particular fluid. Speaking comprehensively, the velocity of discharge depends on the density as well as the pressure of the fluid ; the lighter the fluid the greater will be the discharge. Thus, hydrogen will issue more rapidly under a given pressure through a given orifice, than will atmospheric air under the same conditions of pressure and orifice. If our readers have followed us thus far, they will be able to comprehend the nature of the law determining the velocity of discharge under given conditions of orifice and pressure. But before giving this law it may be as well to explain that any body falling freely under the influence of gravity has a progressively accelerated rate ; the velocity being in England, and similar latitudes, such that 16 feet 1 inch will be traversed the first second, 48 feet 3 inches in the next second, 80 feet 5 inches in the third second, and so on. The velocity of a falling body at any distance from the point where it started, may be found by multiplying the square root of the hight passed through in feet by $8\frac{1}{24}$, the product being the velocity in feet per second. Thus, a bullet has been suffered to drop from the top of a tower 100 feet high ; what is its velocity at the moment of touching the ground ? The square root of 100 is 10, and 10 multiplied by $8\frac{1}{24}$, gives 80·042 feet as the velocity. Our non-mathematical readers will now be in a position to understand the law regulating the velocity of efflux of elastic fluids, such as steam, under pressure, which may be thus stated : *Elastic fluids flow into a vacuum with a velocity the same as that which a body of the same density would acquire in falling through a space equal to the hight of a column of steam or gas of the given pressure.* Let us suppose that we are dealing with steam of 45 pounds on the square inch, and the orifice of discharge has one square inch of area. Let us further suppose that a column of steam stands on a valve temporarily closing the orifice. What hight must the column of steam one inch square be to weigh 45 pounds ? Avoiding fractions, nine cubic feet of such steam will weigh one pound ; therefore, our column of steam one inch square must contain 9 × 45, or 405 cubic feet of steam ; and multiplying 405 by 1,728, we get 699,840 as the hight in inches, or 58,320 as the hight in feet of our column of steam. (This is an approximation only. The true volume of one pound of steam at 45 pounds total pressure is 9·000216 cubic feet.) The square root of 58,320 is 241·5 nearly, and this multiplied by $8\frac{1}{24}$, or 8·042, gives 1942·14 feet per minute as the velocity with which steam of 45 pounds pressure would issue into a vacuum.

" It is here necessary to explain that to avoid the introduction of a multiplicity of figures, we have omitted several fractions, and, therefore, the velocity we have given above is too low, but this in no way affects the principle of the arithmetical process we have described. Any of our readers mastering it will be able to calculate for themselves the velocity with which elastic fluids flow into a vacuum. The calculation, as we have worked it out, is, however, laborious, and for the benefit of such of our readers as understand logarithms, we give the following comprehensive rule for finding the velocity of discharge : Add 4·29 to the pressure in pounds per square inch ; deduct the logarithm of this sum from the logarithm of the pressure; to one half the remainder add 3·3254, and the natural number of this sum will be the velocity in feet per second. The difference between the velocities due to any two pressures is the velocity with which steam or air will flow into the lower pressure. Thus, if the pressure in a cylinder is 20 pounds, while that in the condenser is 5 pounds, at what rate will the steam flow from the former to the latter ? The velocity proper to steam of 5 pound pressure, calculated by the last rule, is 1,552 feet per second, while that proper to 20 pounds is 1,919, and 1,919 — 1,552 gives 367 feet per second as the velocity of the exhaust.

" In the earlier portion of this article we stated that the actual area of the column of discharge was less than that of the orifice through which it flowed, and it is now time to say that this fact materially modifies the results of such calculations as the foregoing. Moreover, account must be taken of the frictional resistance due to the sides of pipes or tubes through which the fluid flows. On this latter subject there is considerable diversity of opinion ; the subject has been keenly discussed once in our correspondence columns, and we shall not be surprised if it be discussed again. Meanwhile we cannot better conclude this article than with the following rule, extracted from ' Bourne's Treatise on the Steam Engine,' and regarded by many engineers as one of the best yet made on the subject. It refers to the flow of steam through a straight pipe of uniform diameter, and its relation to the rules we have laid down will be readily traced : ' To the temperature of the steam in degrees Fah., add the constant 459, and multiply the square root of the sum by 60·2143 ; the product is the required velocity.' All enlargements and contractions, and all bends or elbows, will reduce the velocity, but there is no trustworthy formula in existence which will enable us to determine exactly how much in any of the particular cases which may suggest themselves to our readers."

OVERSHOT WHEELS.

BY JOSEPH GLYNN, F.R.S.

It is not difficult to imagine that if a small stream of water descending from a hill side were directed into the mouths of the earthern vessels or wooden buckets of wheels used for irrigation, the vessels so loaded would descend and the wheels revolve, so that rotary motion and mechanical power would be gained ; the buckets emptying themselves at the lowest point, as they were before emptied at the highest ; the wheel turning in the opposite direction, because the weight or gravity of the water was now the moving power of this overshot wheel.

In the undershot wheel the impulse of the water striking the floats drives the wheels ; in the overshot wheel the weight of the water flowing into the buckets turns the wheel, and all impulse must be avoided ; the water must flow with the same velocity as the wheel, or just so much in excess as will prevent the buckets from striking the water as they present themselves to be filled. Experience soon showed that the earthern jar or the suspended bucket were cumbrous and inconvenient, and as larger and more powerful wheels were applied to more copious streams, a series of simple wooden troughs formed across the face of the wheel were found to answer the purpose better. When the supply of water was ample and the wheels large, it was found that to fill these troughs well and regularly the stream should be made nearly as broad as the wheel, and shallow in proportion to its width. The wheel was then formed by placing two sets of arms, at a sufficient distance apart, upon the axle, and fixing to their ends segments of wood to form the circle ; upon these segments across the face of the wheel, and equal to, or somewhat exceeding in length the width of the stream or sheet of water, were nailed the sole-boards ; on the end of these boards, and at right angles to them, so as to form a projecting rim or ledge on each side of the wheel's face, was fixed the shrouding, formed of stout plank generally from 12 to 18 inches broad ; and between these shroudings, across the face of the wheel, were placed the buckets, made of lighter planking, and having their ends let into the shrouding, by which the ends were closed. The edge of the bucket board meeting the sole plank formed two sides of a triangular trough, the third being open to receive the discharge of water. Subsequently the bucket was made in two boards, one called the front, and the other the bottom of the bucket, the latter taking off the angle and making the section of the bucket, or form of the trough, that of a trapezium, which form it long retained, until the buckets of water wheels were made of iron plate.

Since water wheels have been made wholly of iron, and chiefly of wrought iron, the form of the bucket has been either a part of a circle, a cycloid, an epicycloid, or an Archimedian spiral. These forms are noticed in a subsequent page in connection with breast wheels. Great pains are now taken by the best makers of water wheels to form and adapt the curve of the buckets so that they may readily fill with water, retain their load as long as possible, and discharge it with facility when it has ceased to be useful.

Mr. Smeaton had the merit of proving and demonstrating the advantage and the difference of effect resulting from employing the weight instead of the impulse of a volume of water descending from a given hight.

In reasoning without experiment, one might be led to imagine that, however different the mode of application is, yet that wherever the same quantity of water descends through the same perpendicular space the natural effective power would be equal; supposing the machinery free from friction, equally calculated to receive the full effect of the power, and to make the most of it : for if we suppose the hight of a column of water to be 30 inches and resting upon a base or aperture of 1 inch square, every cubic inch of water that departs therefrom will acquire the same velocity or momentum, from the uniform pressure of 30 inches above it, that 1 cubic inch let fall from the top will acquire in falling down to the level of the aperture ; one would therefore suppose that a cubic inch of water let fall through a space of 30 inches, and then impinging upon another body, would be capable of producing an equal effect by collision, as if the same cubic inch had descended through the same space with a slower motion, and produced its effects gradually ; for in both cases gravity acts upon an equal quantity of matter, through an equal space ; and, consequently, that whatever was the ratio, between power and effect in undershot wheels, the same would obtain in overshot, and indeed in all others ; yet, however conclusive this reasoning may seem, it appears upon trial, that the effect of the gravity of descending bodies is very different from the effect of the stroke of such as are non-elastic, though generated by an equal mechanical power.

Gravity, it is true, acts for a longer space of time upon the body that descends slowly, than upon one that falls quickly : but this cannot occasion the difference in the effect ; for an elastic body falling through the same space in the same time will, by collision upon another elastic body, rebound nearly to the hight from which it fell : or, by communicating its motion, cause an equal one to ascend to the same hight.

The observations and deductions which Mr. Smeaton made from his experiments were as follows :

First. As to the ratio between the power and effect of overshot wheels.

The effective power of water must be reckoned upon the whole descent ; because it must be raised to that hight, in order to be in a condition for producing the same effect a second time.

The ratio between the powers so estimated, and the effect at the maximum as deduced from the several sets of experiments, is shown to range from 10 to 7·6 to that of 10 to 5·2 ; that is nearly from 4 to 3, and from 4 to 2. In these experiments, where the heads of water and quantities expended are least, the proportion is nearly as 4 to 3 ; but where the heads and quantities are greatest, it approaches nearer to that of 4 to 2, and by a medium of the whole the ratio is that of 3 to 2 nearly. We have seen before, in our observations upon the effects of undershot wheels, that the general ratio of the power to the effect when greatest was 3 to 1; the effect, therefore, of overshot wheels, under the same circumstances of quantity and fall, is, at a medium, double to that of the undershot.

Second. As to the proper hight of the wheel in proportion to the whole descent.

It has been observed that the effect of the same quantity of