IMPROVED DRILLING AND SLOTTING MACHINE.

In the accompanying engraving we illustrate a drilling machine made by Messrs. Lowry, of Cross Street Works, Salford, England, which embodies certain improvements introduced recently into this type of drill. These may be briefly described as consisting principally in carrying down the framing at the

swept by the piston at each stroke being known, the quantity passing is recorded on a dial by simple means easily understood. These meters, however, possess the disadvantage of liability to wear and tear in their operation, besides demanding considerable pressure in order to render them effective, which pressure in certain localities is not available.

The inferential meter consists of a small vessel containing

LOWERY & CO'S DRILLING AND SLOTTING MACHINE.

back of the jib-post to the bed-plate, so that it can be properly secured, and every trace of vibration is removed. The machine has also been so modified that it constitutes a very satisfactory key-way slotting machine. Our engraving, which is from *The Engineer*, will explain itself without further description.

NEW WATER METER.

THERE are two kinds of water meter, namely, the positive or actual measurer—and the inferential meter. This first is generally formed of a piston and cylinder with the correspond-

ing vane or screw fixed on its axle and revolving with freedom in suitable bearings. By the action of the passing water the vane acquires a rotary motion corresponding in speed with the velocity of the passage of the water. The action is similar to that of the patent log, gear work indicating on a dial the quantity of water inferred to have passed. The Deacon water-meter is another example of the inferential system. The rotating instruments are tolerably accurate when the full stream of the pipe supplying them is allowed to flow, but any material departure from this renders the indication erroneous, and by the accumulation of dirt they are sometimes rendered useless.

FIG. 1

FIG. 2

FIG. 4

FIG. 5

THE RICHARDS WATER METER.

ing valve or tap. When in operation the water enters the cylinder at both sides of the piston alternately, and at the same time is expelled by the action of the piston, actuated by the pressure of a head of water. Thus the cylinder is filled and emptied successively and continuously, and the volume

The meter represented in the engravings is of the positive description—that is, it is an absolute measurer, intended for either high or low pressure, and is the invention of and patented by Mr. William Richards, the inventor of the dry gas-meter. In this, as in the dry gas-meter, the fluid being

measured is separated by one or more flexible divisions or diaphragms, answering the purpose of a piston within the cylinder, and separating the measured from the unmeasured water. Within the cylindrical vessel, a portion of which is made of glass for the purpose of showing the action of the meter, Fig. 1, which is closed by a plate at each end, are hermetically attached two flexible diaphragms, each in form resembling the circular forge bellows, which divide the outer case into three distinct compartments or chambers, Nos. 1, 2, and 3, as represented in Fig. 2. To each diaphragm is affixed a disc, which moves freely within the case, and has three or four apertures on its periphery to permit of the water passing with facility into and from the chambers 1 and 2. The diaphragms are of considerably less diameter than the outer case, in order to prevent any rubbing or friction at those parts, and are guided by their discs. A shaft *c* is provided with two cranks placed at an angle of about 120 degrees to each other, and works in a suitable bearing at one end, the other end protruding through a stuffing-box and through the seat of a rotary valve with its cover. To this end of the shaft is attached the carrier *k*, Fig. 5, which gears with the lugs of the cover of the valve. Thus by the rotation of the shaft the cover permits of the ingress and egress of the water into and from the various chambers in succession.

The connecting rods, Fig. 2, are attached to the discs by means of the hinges *H H*, the stroke of each disc being controlled by the throw of the cranks. Fig. 3 represents a plan of the rotary valve, through the centre orifice of which passes the shaft *c*. The outer ring of the openings communicates with the chambers corresponding with their numbers. The two central spaces are in communication with the outlet. Fig. 4 is the face of the cover of the valve, the opening *i* being the passage of ingress and *o* the outlet; this corresponds with its seat in such a manner, that as the water enters one of the chambers it is also expelled from another. Fig. 5 represents the interior of the square box with the index removed, and shows the carrier *K* attached to the shaft and gearing with the lugs on the cover of the valve, on the top of which the water to be measured always enters. The action of the meter is as follows: The water enters the small box, Fig. 5, and passes through the valve into one of the chambers, and as represented is passing into that numbered 3, and has depressed the lower disc to the utmost limits, its crank being on the centre and inoperative; but in depressing the disc a quantity of water has been expelled from chamber No. 1 equal to that entering No. 3. The upper disc is rising by the action of the water and expelling a like quantity from chamber No. 2. In the meantime the changed position of the valve and crank permits the water to enter chamber 1 and expel a like volume from that marked 3, until the diaphragms collapse, when the action is reversed. In this manner the diaphragms are distended and collapsed alternately, and the action being continuous, a uniform flow of water is always being received and ejected, therefore, according to the capacity of the diaphragms and the distance they pass through, so will be the quantity delivered at each revolution of the crank, and this determines the necessary wheelwork for the index, and it is claimed that every drop of water passing through the meter is recorded with the most rigid accuracy.

As a precaution against any strain on the diaphragms the valve always has a lead, so that the inlet and outlet of any chamber are closed just before the crank gets on the centre.

The advantages claimed by the inventors are simplicity of construction, and the comparatively low price at which the meters can be manufactured. The friction is so slight that with a column of water only 3 inches in height the instrument is set in action, hence water measured by it will be delivered almost at the same elevation as it is supplied from.—*The Engineer*.

SHAPING MACHINES.

THE "SLOW ADVANCE AND QUICK RETURN" MOTION.

By PROF. C. W. MACCORD.

AN important and interesting practical purpose for which elliptical wheels may be used is the production of the "slow advance and quick return" movement, such as is required in a shaping-machine. Having determined how much more rapid the return is to be than the advance, the next thing is to construct a mechanical movement which will make it so, and there does not seem to be much readily accessible information as to the methods of accomplishing it. We give below three different movements, with explanations of the mode of proportioning the advance to the return in any desired ratio, and also velocity curves for comparing their action, accompanied

by a description of their construction. The varying velocity required is obtained in the first movement by a pair of elliptical wheels; in the second by a crank-pin acting upon a slotted lever, and in the third by a crank and connecting-rod actuating a vibrating lever, as in a Monitor engine.

For the purpose of illustration, let us suppose that the advance motion is to occupy three times as long as the return. Then, first, to determine the forms of the ellipses: in Fig. 1 let *AC* be the line of centres, and *C* the fixed centre, and therefore one focus, of the driver, which is to revolve with uniform speed. Assume any distance, as *CF*, between the foci, with which as radius, describe a circle about *C*. Divide the semi-circumference *PFO* into two parts, which are to each other as the time of the advance is to that of the return; in the case supposed, then, the angle *ACF* is to be one-third of its supplement, that is, 45° draw *FP* perpendicular to *CF*, cutting *AC* in *P*, which will be a point in the ellipse, whose major axis will therefore be equal to *PF + PC*.

For, making $PA=PF$, thus determining A the fixed centre of the follower, and constructing the two ellipses from the above data, in the positions shown in full lines, it will be apparent on inspection that while the driver moves as shown by the arrow through the angle FCL , or 90° , the follower will move through 180° , bringing the ellipses into the positions shown in the dotted lines, and the driver must make three-fourths of its revolutions after that in order to carry the follower through the other 180° . Any point in the line of the major axis of the follower, then, describes a circle round D, which circle is divided by the vertical line KH into halves, in such a manner that the point takes three times as long to describe one half as it does to describe the other. Such point may therefore be connected as usual by a link to the tool-holder, which has a reciprocating motion in the line KH , the stroke in one direction being quicker than in the other in the required proportion. The nature of the motion depending

wholly on the forms, not at all upon the dimensions of the ellipses, the diagram may be made on any convenient scale for determining the relative lengths of the axes, if the distance CD , or in other words, the major axis, is given.

The second movement was employed for the purpose named by Sir Joseph Whitworth, though the details actually used were quite different from those indicated in the diagram, Fig. 2, which, however, clearly shows the action of the device, C being the fixed centre of the driving-crank CA , whose pin A moves freely in a slot in a second crank BD , which turns on the fixed centre D. As before, describing a circle round C with the radius CA , the semi-circumference is divided in the ratio of the times occupied by the advance and return. Thus we make $FCA = \frac{1}{3} AC$, that is 45° ; then draw through A

the line BD perpendicular to FG , the line of centres, which will determine D, and as before, mere inspection suffices to show that the motion of A through the angle ACH , or 90° , will drive BD through 180° . The link which moves the tool-holder in the line BE , perpendicular to FG , may therefore be jointed to any point in the line of the second crank.

The remaining combination is shown in Fig. 3; C is the fixed centre of the driving-crank CA , which is connected by the link AB with a lever BD , which vibrates through a definite arc on the fixed centre D, instead of rotating continuously as in the preceding case. In constructing the diagram, the angle ACF is made equal to 90° , as before (the whole circumference of a circle round the centre of the driver in any

case representing the whole time occupied by both advance and return, is to be divided into parts having the given ratio of the times occupied by each respectively). Assuming the length AB of the link, set it off from A to B in the direction CA ; also from F to E, in the direction FC ; this determines EB , the chord of the arc described by the free end of the vibrating lever, of which the length is arbitrary; but the fixed centre must lie as shown upon the perpendicular bisecting the cord BE . Taking D as this centre, it will be seen that the driving-crank in moving through ACF , or 90° , causes the lever to swing through the whole angle BDE , and the other three-fourths of the revolution are required to bring it back to its original position. The circular reciprocation may be changed into rectilinear by the intervention of another link; taking the prolongation of BC as the line of motion, this link, GE , is jointed to a point G of BD , so chosen that the

angular vibration of GE shall be equally divided by the line BE , as shown, so that the tool-holder traverses back and forth in the path KLM .

Now, it is not to be supposed that the speed of the tool-holder is uniform in either direction in any one of these arrangements; and disregarding any other peculiarities which might make either preferable to the other, it is of interest to compare their actions in respect to the variations in this speed. One method of making such a comparison, and on many accounts the best, is by means of graphic representations of the motions. Admitting that calculated tables are useful, and in respect of minute accuracy superior, they do not and can not convey at a glance an idea of comparative velocities at different instants, which is precisely what is wanted, and precisely what can be done by diagrams, which are to tables and formulae what drawings are to specifications and verbal descriptions. In the construction of such a diagram, we may proceed either analytically or graphically. That is to say, we may investigate a formula for a combination in hand, and from it calculate the velocities, or we may ascertain them by means of diagrams only. The first method is unquestionably the more precise, but the second is more expeditious, and with reasonably careful manipulation gives results sufficiently accurate for ordinary purposes. Now, the process of finding graphically the velocity of any moving point in a given arrangement,

though simple, seems to have been much neglected by writers upon such subjects. We therefore give here the steps by which the velocities were determined for the purpose of comparing the three movements above described, which depend primarily each upon a different one of the three modes of transmitting motion between rigid parts, namely, rolling contact, as in the pitch ellipsis, sliding contact, as in the crank-pin and slotted arm, and linkwork as in the last of the three; while the constructions used involve all the leading principles necessary to making such determinations in any case.

In Fig. 4, let CD be the fixed centres of the two ellipses whose point of contact is P , and E the link by which the tool-holder is made to traverse in the path ON , the end E describing a circle about D with radius ED . About C describe a circle with radius $AC=ED$; then the point A is supposed to travel with uniform velocity in this circle; and as the direction of a curve at any point is that of its largest at that point, we may assume AB , of any length, perpendicular to CD , as representing the linear velocity of A . EF , perpendicular to CD , will then be the linear velocity of E in its circle, the length being found by the proportion $\frac{EF}{AB} = \frac{PC}{BD}$ for the angular velocities are inversely proportional to the radii of contact, and so are the linear velocities in this case, because $ED=AC$. But E is a point in the link, and since in the position shown it is moving in a direction parallel to the path of I , another point of the link, and this direction is not perpendicular to EI , the velocities of the two points must be equal:

EF , then, is the representation of the linear velocity of I in the direction IN .

The crank-arm which moves the link is here shown as coinciding with the line of centres; but in any position, it is clear that the motion of the link consists of a bodily reciprocation, combined with a rotation about the end I , which is jointed to the tool-holder. The velocity of this rotation, at any point of the link, may be represented by a line perpendicular to EI , that is, tangent to a circle of which I is the centre, the velocity of the translation by a line parallel to the traverse of the point I . Considering the circular motion of E , then, we have the directions of the two components into which it is to be resolved, which is done by making the given line representing its velocity and direction the diagonal of a parallelogram whose sides are respectively parallel to ON and perpendicular to EI : the former will be the velocity component of E in the direction ON , and also, since the link is rigid, the velocity of I at the given time. This is illustrated in Fig. 5, EF , perpendicular to ED , being the actual motion of E , and EB , EA , the two components above mentioned, of which the latter is the required velocity of I , in the direction DI . This may also be found otherwise, thus: prolong ED (which is perpendicular to the path of E at the given instant) to cut at K the line IK , perpendicular to the path of I at the same instant; then K is the instantaneous axis, about which E , I , and all points of the line joining them, are at that instant

turning with, of course, the same angular velocity. Describe about K a circle with radius IK cutting EK in G , draw FK , and finally GH tangent to the circle at G , that is, parallel to EF : then GH will be the velocity of I in the direction IO ; as indeed will be evident if we draw the triangle IKO similar to EKF . When, therefore, the velocity of the circular motion of the crank or lever to which the link is jointed is known, either of these constructions may be used to find that of the tool-holder.

Fig. 6 shows the method of finding that circular velocity in the Whitworth movement. AC is the driving-crank, whose pin A moves in the circle round C , with a velocity represented by AE . This may be resolved into the components AF ,

in the line of BD , the slotted lever, and AG perpendicular to that line. Evidently AF is the velocity of sliding of the crank-pin in the slot, and AG the velocity with which the point A of BD rotates about D . If, then, the link BI is connected at B , as shown, we find the velocity of that point by drawing DG , producing it to cut BH parallel to AG in H . Then BH is the required velocity, to be resolved as above explained.

The third movement is represented in Fig. 7, AC being the driving crank, whose velocity is AE ; BD is the vibrating lever, AB the connecting-rod. The angular velocities of the crank and lever are to each other inversely as the segments PC , PD , into which the line of centres is divided by the con-

necting rod, or by similar triangles, inversely as the effective lever-arms CN , DM , perpendicular to AB .

Describe a circle round D , with radius $DF=AC$; then FH is the velocity of rotation of F round D , its value being found by the proportion $\frac{FH}{AE} = \frac{NC}{DM} = \frac{PC}{PD}$. G is the point of attachment of the link moving the tool-holder, which is omitted in this figure; having found the velocity of F , that of G is ascertained by drawing the triangle DGL similar to DFH , as shown; from which that of the other end of the link is determined as in Fig. 5. We may simplify the construction a little; since $GL = AE \times \frac{NC}{DM} \times \frac{DG}{DF}$, we may first find the value of $AE \times \frac{DG}{DT}$, and thus leave but one

construction to be made for the value of GL in any position of the parts, by the introduction of the variable factor $\frac{NC}{DM}$. All these determinations, it is hardly necessary to say, may be effected by the usual graphic means of finding the fourth proportional to three given lines; whereby the whole problem is reduced to a series of operations to be performed with the instruments always in the draughtsman's hands.

Now, in order to construct the curve representing the varying velocity of the tool-holder, we proceed thus. If the curve is to represent the advance, divide the three-fourths of the circumference of the circle about the centre of the driver, in the movement diagram of the combination selected, into any convenient number of equal parts, and determine the position and velocity of the tool-holder, corresponding to each

point of division, assuming any velocity at which the machine may be supposed to run. Divide a right line representing the time occupied by the stroke, into the same number of equal parts, and perpendicular to it set up at the points of division ordinates equal in length to the velocities at the corresponding points in the division of the circle. A precisely similar construction is to be made for the return, except that as the motion is in the opposite direction, the ordinates are to be set off on the opposite side of the line. Since we have assumed that the advance takes three times as long as the return-stroke, and the lengths are the same, the average velocity in one direction is three times as great as that in the other; and since the product of the time by the velocity is the space passed over, and by this construction each time is represented by the same line, it follows that the area of one curve should be three times that of the other, the one representing the return motion being the greater because the velocity is greater.

For the purpose of comparison, the same line should be assumed as representing the time in each diagram, and the velocity of the driver should be the same in each case, under which conditions the areas of the three advanced curves should be equal, and also those of the three return curves; and the comparative actions of the several devices will be very clearly illustrated by the differences in the lengths of corresponding ordinates.

In Fig. 8 we give the curves, obtained by the processes above described, from each of the combinations, numbered 1, 2, 3, in the order in which they have been considered. The horizontal line A B represents the time, the advance-curves being below, the return-curves above. A comparison of these diagrams would seem to indicate the superiority of the first, since during the greater portion of the advance there is less deviation from uniformity of speed; and on the return, the maximum velocity is less, which is an advantage, as the return-motion may be made much more rapid than the advance without an objectionable amount of momentum being acquired.

Mathematical worshippers at the shrine of analysis are prone to sneer at the results of what they style "mere graphics," as crude and unworthy of the serene confidence to be reposed in well-managed symbols, as if the positive sign were the true cross; and many of them would no doubt feel a holy horror at the numerous "chances of error" involved in making such determinations, as these were made, entirely by instrumental construction. Now, we have a good test of the accuracy of the work, and of the reliability of the diagrams, by the comparison of areas which ought to be equal, and of others which ought to have a known ratio to each other. Assuming that the mean area is more nearly exact than either, we find by computation that in the case of the advance-curves the greatest discrepancy is less than $\frac{1}{15}$, the mean error less than $\frac{1}{34}$; in comparing the return curves the maximum is $\frac{1}{35}$, the mean $\frac{1}{37}$. There is, as might be expected, a greater deviation in comparing the advance-curves with the return, because the ordinates of the former are shorter, so that an error in determination would be greater in proportion to the whole; but here even the greatest discrepancy is $\frac{1}{35}$, the mean $\frac{1}{158}$.

But these constructions were made on a small scale, the cut being half the size of the original diagram; in actual practice that scale would be at least doubled, thus at once diminishing the probabilities of making an error, reducing its proportion to the ordinate one half, and quadrupling the area to be affected by it; so that it is safe to assert that a draughtsman who recollects that "a chance to make an error" means, being interpreted, an opportunity to be careful, will be able to make the areas correspond within $\frac{1}{300}$. This, as claimed, would be an approximation abundantly close for all practical purposes; and the graphic method, in addition to its obvious directness and expedition, may be intelligently employed by those who are unable to use the algebraic formulae, and keeps a constant check upon the successive determinations, since the results of the preceding ones are always under the eye.

Referring to Figs. 1 and 2, a study of the movements will show that the increments and decrements of the velocity-ratio are symmetrical with respect to the central position of the driver on both the advance and return. In each case, also, the follower will have made just half the semi-revolution required for the stroke, when the driver reaches that central position. From this it would at first sight appear that the velocity curves of these movements should be symmetrically divided by the central ordinates; and so they would be were the link (E I, Figs. 4 and 5) infinitely long, so as to be always parallel to itself; its varying obliquity is the cause of the distortion, which may be reduced by increasing the length of the link; this has in the construction of these diagrams been taken equal to three times the stroke. In the third movement the obliquity of this last link (G K of Fig. 3) is so slight as to produce very little effect; but the angles made by the main connecting-rod (A B of Fig. 3), with both the crank and the vibrating lever, vary in such a manner as wholly to preclude any approach to symmetry.

The length of the line A B, Fig. 8, representing the time occupied in making a stroke, is wholly arbitrary. There is, however, an obvious appropriateness in making it equal to the length of the stroke, as we have in fact done. And this fitness is the more evident, from the consideration that it is desirable to compare the velocities at given points in the stroke as well as at given times. The latter only can be done directly by the curves shown in Fig. 8: for the former purpose those given in Fig. 9 must be constructed, in which A B is, of course, the actual length of the stroke, and the ordinate at any point represents the velocity when the tool-holder has reached that point. By assuming the same line, then, to represent the time in laying out the first curve, the second will not only have a more natural relation to it, but may be readily set up at the same time, since, in order to determine the direction of the link, which is necessary in finding the velocity, the position of the tool-holder on that line must be determined, thus at once locating the ordinate of the second curve. Inasmuch as the abscissas in this last one do not represent times, it is clear that there is no definite relation between the areas and the velocities, as in the first. Nevertheless this curve is of interest and value in the study of the action of the mechanism, which, by the aid of the two sets of diagrams, is very clearly illustrated.

It may be worth while to add in conclusion that it is not pretended that the proportions above assumed are at all such as would be used in practice; unless in a very small machine it would not answer to make the return three times as rapid as the advance, and the third movement would very clearly be much improved by using a longer link and a longer lever. But, leaving these points to be determined by the designer according to the dictates of his own judgment, we have selected the proportions shown for the purpose of presenting the peculiarities of the motions in as striking a light as possible, the principles and methods involved being equally applicable under all circumstances.

[The Engineer.]

SCREW PROPELLERS.

By N. D. SPARTALI.

I GIVE a front end view sketch of my improved propeller, showing the blades set diagonally across the centre boss, and also the ends of the blades as set end to end at the extreme point of angle, also diagonally to each other, and, if the centre be forged, the lower ends or base of the blades will serve as rudiments or sockets, wherein the blades could be socketed by riveting, bolting, or welding, or otherwise be made fast, and lighter and stronger. By the concentration of these blades on to the centre boss, and by the nature of their angles to each other, and also by their perceptible inclination to the back of the axis, they not only follow each other in rapid succession in their forward action, but displace and cut, or slice the water at a long angle from that part to the front of the boss, and each blade acts beneficially on the centre water, and also what is called by captains backwater, or the water sucked or carried by the ship's stern on her progress forward, and their return upwards is effected at the extreme curved sides of the blades offering the least resisting surface to the water. In the Griffith's, as well as in most of the ordinary propellers,

the blades are set on a long plain centre, and in large ocean steamers on very large square or circular planes at a distance from each other, the one blade at half angle or diameter of their breadth to each other; and the four blades so placed are made to revolve round the large centre, leaving a large void in the centre and in its immediate periphery, owing further to the space intervening between it and the pitch of the blades, at an angle of 45 degrees or thereabouts, from the axis. Independent of this large mass of dead water, and of the back stern water detracting from the effect of the propeller, and to which I attach a greater amount of importance than what is generally believed by so-called practical men, owing to the above great pitch, or angle of the blade, a great deal of water is pitched from one side to the other of this large centre, and a great deal of it is lifted on the upward travel of the blades, causing accumulated resistance and useless waste of engine power, and a great deal of friction of the metal to the water and spattering of the water between the blades, well known to engineers as centrifugal action.

The results I obtained in my models, driven by steam at a great speed, are an increase of speed of from 10 to 15 per cent on the other propellers, and, what is most important, a considerable saving in the quantity of steam supplied to the engines, as much as that required to drive the Griffith's and other propellers, which I have been able to ascertain by the relative fall of pressure indicated by my most accurate little pressure gauge fitted on to the copper boiler supplying the engines, the loss in pressure with my propeller being of 3 lbs. to 4 lbs. to 5 lbs. to 6 lbs. per square inch with the others on a run of 100 ft. each time.

My experiments with little steam models have been various and extensive, and conducted with a great deal of accuracy and observation, and no little care and trouble. My object was principally to ascertain the highest possible speed that such could be driven by carefully and skillfully constructed engines and the best constructed propellers, as also as compared to the best engines and paddles for paddle steamers. My models are all of one length, say 5 ft. 6 in., 8 in. beam, and one model same length by 10 in. beam.

My first experiment was with a model with a rather bluff entrance to the water, not very fine lines aft, but what only a few years ago would have been considered a fair specimen of an ocean going steamship; her engines were two vertical oscillating cylinders of the ordinary construction. Drawing 6 in. of water and driven by a 5 in. Griffith's propeller, I have run her the measured distance in the canal in 28 seconds, and with my propeller, same distance, same everything, in 25 seconds.

My second experiment consisted of a model specially constructed on my own lines, same length, 5 ft. 6 in. by 8 in., beam very flat, and very gently rounded bottom, centre with fine entrance, and long lines under her water line, with a clear run to the poop aft, but not extra fine lines gradually tapering—a hull of comparatively large cubic capacity on a light draft—such a vessel as would be suitable for the New-Orleans trade. Drawing 4½ in. aft, with about 15 lbs. of ballast (lead), besides her boiler weighing 9 lbs. to 10 lbs., and its content of water another 4 lbs. to 5 lbs., say total dead weight about 30 lbs., besides her keel being partially weighted with lead for stiffness on the water when used as a paddle boat. I have also had specially constructed a pair of compact inverted cylinder-engines most faithfully and most correctly put together, very light material, but very true and strong in all their

working parts, slide valve, spindles, cranks, and bearings—sufficiently strong, in fact, to stand the shock and friction of a terrific speed of piston. The revolutions I have obtained from these engines (pigmy engines) is no less than from 1500 to 2000 per minute; with ordinary Griffith's propeller she ran the measured distance in the canal of 100 ft. with full boiler power at a pressure of 40 lbs. to 45 lbs. of steam per square inch in 17½ to 18½ seconds, and with my propeller in 16 to 17 seconds, but the falling off in the pressure of the steam was 6 lbs. to 8 lbs., with the ordinary propellers, and only of 3 lbs. to 4 lbs. with my propeller, the heating surface and the quantity of heat supplied (spirit wick burners) being the same in all trials.

My third experiment as follows: The said model being well suited to carry paddle-wheels, I had a pair of the most perfect and modern set made, fitted with feathering gear such as are, in fact, fitted with the Isle of Man fast passenger boats sailing daily from Liverpool, their diameter being 9 in., with number of floats in proportion, three catching the water at every revolution, perhaps 3½ inches each side, I also had constructed further a pair of the best type of side-lever two-cylinder long stroke engines, working at a great speed, and worked admirably with the same boiler as for the screw engines, with the same amount of heat, etc. The speed of this little paddle yacht model was so good that she attracted general attention when she was run in the lake in Newsham Park, yet in the measured distance of 100 ft. in the canal the time she made was no less than 25 seconds, as against 16 to 18 with the screw; a clear gain in favor of the screw propeller of no less than 40 per cent.

Fourth experiment: This was effected with a specially arranged model for testing the accuracy of Mr. Griffith's theory of the advantage of bow and stern propeller and efficiency. The gain in speed he makes on the collective propellers over the single stern propeller is 40 per cent by doubling his power. This model is much finer fore and aft than the previous one, and the bottom centre gently barreled, shape a good type of an ocean-going steamer. Two finely cut and smoothly finished longitudinal arches with hollow roofs were cut under the ship's bottom, protruding at a height from the floor of the hull internally, and right across the keel, under the bottom aforesaid, the one arch about one sixth from the foreake, and the other about equal distance from the stern post; into each of these arched vaults a propeller of 4½ in. diameter was fitted and connected to one main shaft and to the engine, and worked by the same boiler as used in the former model and in a line with a shaft as nearly as possible all but touching the hull's floor, to obtain the requisite rectilinear level with the axis of the respective propellers outside. This model so fitted has run the distance of the measured line of 100 ft. in 18 to 19 seconds. The same model, fitted with two separate shafts and two distinct pairs of engines to each screw, gave precisely the same result without any increase of speed whatsoever, and with half speed of the stern engine,

and full speed of the forward engine, the loss in speed was 5 seconds in the distance of 100 ft., namely, 100 ft. in 24 to 25 seconds, pressure of steam and all conditions always the same. Similar result with full speed to stern engine, half speed to forward engine. The forward engine and propeller worked at full speed alone gave 2 seconds less speed in 8 to 10 per cent loss on the stern propeller worked alone with full power.

My sixth experiment consisted of a peculiarly-constructed model, a fine gently tapered V-shaped hull, all lines from stem to stern a little fuller in the centre broadside under the water line, but gently barreled upwards, and in proportion for the whole length from the point of the water or load line upwards above the water line, with a great breadth of beam—10 in.—the wide deck covering the ship from end to end like a floating bridge, the length being always the same, namely, 5 ft. 6 in. This model of half as much capacity as the flat-bottomed one mentioned in my second experiment, and drawing 5½ in. to 6 in. of water, or 1 in. to 1½ in. more than that driven with same boiler and engine, has given with a 4½ in. propeller nearly the same speed as the above-mentioned, but as regards stability and steadiness in the water she is a perfect specimen; she appears as firm in the water at full speed as a locomotive on the rails, and is admirably fit as a type for a Channel passenger steamer, and equally, if not better, for a heavy turret man-of-war carrying heavy guns.

The inevitable conclusion of these experiments is: (1) That skillfully and accurately constructed engines for high pressure, made light but strong, can be made to work at an incredibly high speed, although relative to the size and work to be done. In these small engines the speed of 1500 to 2000 revolutions is wonderful, and beats even the small electric engines by far. (2) That a fine model, with perfect engines and perfect propellers, or as perfect as can be made by man, will run 40 per cent faster than a full model with ordinary engines and propeller. (3) That such a fine model, fitted with perfect engines and propeller, will run 40 per cent faster than the best modeled, the best engined paddle-boat steamer fitted with the best made and most improved set of paddle-wheels, with feathering gear the most approved, and furthermore, with one-third of the engine power. (4) That a single propeller, and in preference a stern propeller, will drive such a model as fast as two propellers—bow and stern—whether these latter be driven by the same or by separate engines; consequently, that vessels fitted with two sets of propellers, or two sets of paddle-wheels and, I may also observe, twin vessels are the greatest engineering errors of our time. The models driven by these propellers keep a wonderfully straight course on the water as if steered to her course, and a clear stream without commotion in the immediate back of the ship's stern is the result.

EVAPORATION AND PERCOLATION.

BEFORE the Institution of Civil Engineers, Mr. George Robert Stephenson, President, in the chair, a paper on "Evaporation and Percolation" was read by Mr. Charles Greaves, M. Inst. C.E.

This paper treated only of evaporation due to natural in-