cient velocity, by overcoming the reſiſtances ariſing from the following cauſes.

1. From the inertia of the beams and all the parts of the apparatus which are in motion during the deſcent of the pump-rods.

2. From the loſs of weight ſuſtained by the immerſion oſ the pump-rods in water.

3. From the friction of all the piſtons and the weight oſ the plug-frame.

4. From the reſiſtance to the piſton’s motion, ariſing from the velocity which muſt be generated in the wa­ter in paſſing through the deſcending piſtons.

The ſum of all theſe reſiſtances is equal to the preſsure oſ ſome weight (as yet unknown), which we may call *m.*

When the pump-rods are brought up again, they bring along with them a column of water, whoſe weight we may call w*.*

It is evident that the load which muſt be overcome by the preſſure of the atmoſphere on the ſteam piſton conſiſts of *ιυ* and p*.* Let this load be called L, and the preſſure of the air be called P.

If p be = L, no water will be raiſed ; if *p* be = o, the rods will not deſcend : therefore there is ſome in­termediate value of p which will produce the greateſt effect.

In order to diſcover this, let *g* be the fall of a heavy body in a ſecond.

The deſcending maſs is *p :* but it does not deſcend with its full weight ; becauſe it is overcoming a set of reſiſtances which are equivalent to a weight m, and the moving force is p—*m.* In order to discover the ſpace through which the rods will deſcend in a ſecond, when urged by the force p*—m* (ſupposed conſtant, notwith­standing the increaſe of velocity, and consequently of *m),* we muſt inſtitute this proportion p : p - m = g: g(p-m)/p.

The fourth term of this analogy is the ſpace re­quired.

Let *t* be the whole time of the deſcent in ſeconds. g(p— *m) t2g(p—m)*

Then I2 : *t2 =* This laſt term is

*p*

the whole deſcent or length of the ſtroke accompliſhed in the time t.

The weight of the column of water, which has now got above the piſton, is w, == L —*p.* This muſt be lifted in the next working ſtroke through the ſpace

Therefore the performance of the engine

must be t2g(p-m)(L-p)

*p*

That this may be the greateſt poſſible, we muſt consider p as the variable quantity, and make the fluxion of the fraction

p.

This will be found to give us *p = Lm ;* that is, the counter weight or preppnderancy of the outer end of the beam is = Lm

This gives us a method of determining *m* experimen­tally. We can diſcover by actual meaſurement the quantity L in any engine, it being equal to the un­balanced weights on the beam and the weight of the water in the pumps. Then *m =* p2/L.

Alſo we have the weight of the column of water =L—*p,* =L—Lm.

When therefore we have determined the load which is to be on the outer end of the beam during the work­ing ſtroke, it muſt be diſtributed into two parts, which have the proportion of V L w to L— √Lm*.* The first is the counter weight, and the ſecond is the weight of the column of water.

If *m* is a fraction of L, ſuch as an aliquot part of it; that is, if

m = L/1, L /4, L/9, L/16, L/25, &c.

*p = L/1, L/2, L/3, L/4, L5, &c.*

The circumſtance which is commonly obtruded on us by local conſiderations is the quantity of water, and the depth ſrom which it is to be raiſed; that is, w: and it will be convenient to determine every thing in con­formity to this.

We ſaw that w = L—Lm. This gives us L =

√<m *m* +—+—+ τv, and the counter weight 4 2

*∕ m2 m*

*w ιn +-+*

4 2.

Having thus aſcertained that diſtribution of the load on the outer end of the beam which produces the great­eſt effect, we come now to conſider what proportion of moving force we muſt apply, ſo that it may be employ­ed to the beſt advantage, or ſo that any expence of power may produce the greateſt performance. It will be ſo much the greater as the work done is greater, and the power employed is leſs ; and will therefore be properly measured by the quotient of the work done di­vided by the power employed.

The work immediately done is the lifting up the weight L. In order to accompliſh this, we muſt em­ploy a preſſure P, which is greater than L. Let it be — L + *y ;* alſo let *s* be the length of the ſtroke.

If the maſs L were urged along the ſpace *s* by the force L+y, it would acquire a certain velocity, which we may expreſs by s ; but it is impelled only by the force *y,* the rest of P being employed in balancing L. The velocities which different forces generate by impel­ling a body along the ſame space are as the ſquare roots of the forces. Therefore √L + y : √ *y =*√s :√sy. The fourth term of this analogy expreſſes the

√L+y velocity of the piſton at the end of the ſtroke. The quantity of motion produced will be had by multiply­ing this velocity by the maſs L. This gives

L=y and this, divided by the power expended, or by L+y', gives us the meaſure of the performance ; namely, L (sy) That this may be a maximum, conſider *y* as the va-