quantity of water raiſed by it. Iſ this were all that is to be attended to, we know that the weight of the column of water ſhould be nearly 2/5ths of the preſſure of the atmoſphere, this being the proportion which gives the maximum in the common pulley. But the time of the returning ſtroke is a neceſſary part of the whole time elapſed, and therefore the velocity of the return­ing ſtroke equally merits attention. This is regulated by the counter weight. The number of ſtrokes *per* minute does not give an immediate proof of the goodneſs of the engine. A ſmall load of water and a great counter weight will enſure this, becauſe theſe condi­tions will produce a briſk motion in both directions.— The proper adjuſtment of the preſſure of the atmoſphere on the piſton, the column of water to be raiſed, and the counter weight, is a problem of very great difficulty ; and mathematicians have not turned much of their at­tention to the subject, although it is certainly the moſt intereſting queſtion that practical mechanics affords them.

Mr Boſſut has ſolved it very ſhortly and simply, upon this ſuppoſition, that the working and return­ing ſtroke ſhould be made in equal times. This, in­deed, is generally aimed at in the erection of theſe ma­chines, and they are not reckoned to be well arranged if it be otherwise. We doubt oſ the propriety of the maxim. Supposing, however, this condition for the preſent, we may compute the loadings of the two ends of the beam as follows. Let *a* be the length of the inner arm of the working beam, or that by which the great piſton is ſupported. Let *b* be the outer arm car­rying the pump rods, and let W be a weight equivalent to all the load which is laid on the machine. Let *c2* be the area of the piſton ; let H be the height of a column of water having c2 for its baſe, and being equal in weight to the preſſure exerted by the ſteam on the under side of the piſton ; and let *h* be the preſſure of the atmoſphere on the ſame area, or the height oſ a column of water of equal weight. It is evident that both ſtrokes will be performed in equal times, if *h c2 a* — W *b* be equal to (h — H) *c2 a +* W *b.* The first of theſe quantities is the energy of the machine during the working ſtroke, and the second expreſſes the ſimilar energy during the returning ſtroke. This equation gives us W = 2 *h c2 a —* H *c2 a (2h —* H) c2 a

2 *b 2 b*

the arms of the lever equal and H ≡ *h,* we have W *h*

*= c2—* ; that is, the whole weight of the outer end

of the beam ſhould be half the preſſure of the air on the great piſton. This is nearly the uſual practice ; and the engineers expreſs it by ſaying, that the engine is loaded with ſeven or eight pounds on the ſquare inch. This has been found to be nearly the moſt advantage­ous load. This way of expreſſing the matter would do well enough, if the maxim were not founded on er­roneous notions, which hinder us from ſeeing the ſtate of the machine, and the circumſtances on which its im­provement depends. The piſton bears a preſſure of 15 pounds, it is ſaid, on the ſquare inch, if the vacuum below it be perfect ; but as this is far from being the caſe, we muſt not load it above the power of its vacuum, which very little exceeds eight pounds. But this is very far from the truth. When the cylinder is tight, the vacuum is not more than 1/20th deficient, when the cylinder is cooled by the injection to the degree that is every day practicable, and the piſton really bears during its deſcent a preſſure very near to 14 pounds on the inch. The load muſt be diminiſhed, not on account of the im­perfect vacuum, but to give the machine a reaſonable motion. We muſt conſider not only the moving force, but alſo the quantity of matter to be put in motion. This is ſo great in the ſteam engine, that even if it were balan­ced, that is, if there were ſuſpended on the piſton arm a weight equal to the whole column of water and the coun­ter weight, the full preſſure of the atmoſphere on the ſteam piſton would not make it move twice as faſt as it does.

This equation by Mr Boſſut is moreover eſſentially faulty in another reſpect. The W in the first member is not the ſame with the W in the second. In the first it is the column of water to be raiſed, together with the counter weight. In the second it is the counter weight only. Nor is the quantity H the ſame in both cases, as is moſt evident. The proper equation for enſuring the equal duration of the two ſtrokes may be had in the following manner. Let it be determined by ex­periment what portion of the atmoſpheric preſſure is exerted on the great piſton during its deſcent. This depends on the remaining elaſticity of the ſteam. Suppose it 9/10ths: this we may expreſs by ah, *a* being =9/10ths. Let it alſo be determined by experiment what portion of the atmoſpheric preſſure on the piſton remains un­balanced by the ſteam below it during its aſcent. Suppoſe this 1/10th, we may expreſs this by *b h.* Then let W be the weight of the column of water to be raiſed, and *c* the counter weight. Then, if the arms of the beam are equal, we have the energy during the work­ing ſtroke =ah *—* W — c, and during the returning ſtroke it is = *c — b h.* Therefore *c — b h zz a h —* W — *c* ; and *c h(a + b) - W* ; which, on the above ſuppoſition of the values of *a* and *b,* gives us *c = h-W/2.* We ſhall make ſome uſe of this equation af­terwards ; but it affords us no information concerning the moſt advantageous proportion of *h* and W, which is the material point.

We muſt conſider this matter in another way : And that we may not involve ourſelves in unneceſſary diffi­culties, let us make the caſe as simple as poſſible, and ſuppoſe the arms of the working-beam to be of equal length.

We ſhall first conſider the adjuſtment of things at the outer end of the beam.

Since the ſole uſe of the ſteam is to give room for the action of the atmoſpheric preſſure by its rapid condensibility, it is admitted into the cylinder only to allow the piſton to riſe again, but without giving it any impulſe. The pump-rods muſt therefore be returned to the bottom of the working barrels by means of a preponderancy at the outer end of the beam. It may be the weight of the pump, rods themſelves, or may be conſidered as making part of this weight. A weight at the end of the beam will not operate on the rods which are ſuſpended there by chains, and it muſt therefore be attached to the rods themſelves, but above their reſpective pump-barrels, ſo that it may not loſe part of its efficacy by immerſion in the water. We may conſider the whole under the notion of the pump-gear, and call it p. Its office is to depreſs the-pump-rods with ſuffi-