fed steam, to deſcend by its own weight through the eduction-pipe *d e g h* to open the valve *h,* and to run out into the hot well. And we muſt easily ſee that this water is boiling hot ; for while lying in the bottom of the cylinder, it will condenſe ſteam till it acquires this temperature, and therefore cannot run down till it con­denses no more. There is ſtill a waſte of ſteam at its firſt admiſſion, in order to heat the inſide of the cylin­der and the injected water to the boiling temperature : but the ſpace being ſmall, and the whole being already very warm, this is very ſoon done ; and when things are properly conſtructed, little more ſteam is wanted than what will warm the cylinder ; for the eduction­-pipe receives the injection water even during the de­scent of the piſton, and it is therefore removed pretty much out of the way of the ſteam.

This firſt puff of the entering ſteam is of great ſervice : it drives out of the cylinder the vapour which it finds there. This is ſeldom pure watery vapour : all water contains a quantity of air in a ſtate of chemical union. The union is but feeble, and a boiling heat is sufficient for diſengaging the greateſt part oſ it by increaſing its elaſticity. It may alſo be diſengaged by ſimply removing the external pressure of the atmoſphere. This is clearly ſeen when we expoſe a glaſs of water in an exhauſted receiver. Therefore the ſmall ſpace below the piſton contains watery vapour mixed with all the air which had been diſengaged from the water in the boiler by ebullition, and all that was separated from the injection water by the diminution of ex­ternal pressures. All this is blown out of the cylinder by the firſt puff of ſteam. We may obſerve in this place, that waters differ exceedingly in the quantity of air which they hold in a ſtate of ſolution. All ſpring water contains much of it : and water newly brought up from deep mines contains a great deal more, becauſe the ſolution was aided in theſe ſituations by great preſſures. Such waters ſparkle when poured into a glaſs. It is therefore of great conſequence to the good per­formance of a ſteam-engine to uſe water containing little air, both in the boiler and in the injection-ciſtern. The water of running brooks is preferable to all others, and the freer it is from any ſaline impregnation it ge­nerally contains leſs air. Such engines as are ſo un­fortunately situated that they are obliged to employ the very water which they have brought up from great depths, are found greatly inferior in their performance to others. The air collected below the piſton great­ly diminiſhes the accelerating force, and the expulsion of ſuch a quantity requires a long continued blaſt of the beſt ſteam at the beginning of every ſtroke. It is adviſable to keep ſuch water in a large ſhallow pond for a long while before uſing it.

Let us now consider the state of the piſton. It is evident that it will ſtart or begin to riſe the moment the ſteam-cock is opened ; for at that inſtant the ex­cels of atmoſpherical pressure, by which it was kept down in opposition to the preponderancy of the outer end of the beam, is diminiſhed. The piſton is therefore *dragged* upwards, and it will riſe even although the ſteam which is admitted be not ſo elaſtic as common air. Suppoſe the mercury in the barometer to ſtand at 30 inches, and that the preponderancy at the outer end of the beam is 1/9th of the pressure of the air on the piſton, the piſton will not riſe if the elaſticity of the ſteam is not equal to 30—30/9, that is, to 26,7 inches nearly ; but if it is juſt this quantity, the piſton will riſe as Faſt as this ſteam can be ſupplied through the ſteam-pipe, and the velo­city of its aſcent depends entirely on the velocity of this ſupply. This obſervation is of great importance ; and it does not ſeem to have occurred to the mathema­ticians, who have paid moſt attention to the mcchaniſm of the motion of this engine. In the mean time, we may clearly ſee that the entry of the ſteam depends chiefly on the counter weight at E : for ſuppoſe there was none, ſteam no ſtronger than air would not enter the cylinder at all ; and if the ſteam be ſtronger, it will en­ter only by the exceſs of its ſtrengtſh. Writers on the ſteam-engine (and even ſome of great reputation) fami­liarly ſpeak of the ſteam giving the piſton a puſh : But this is ſcarcely poſſible. During the riſe of the piſton the ſhifting valve is never obſerved to blow; and we have not heard any well atteſted accounts of the piſton- chains. ever being ſlackened by the upward preſſure of the ſteam, even at the very beginning of the ſtroke. Du­ring the riling of the piſton the ſteam is (according to the common conception and manner of ſpeaking) s*ucked in,* in the ſame way that air is sucked into a com­mon ſyringe or pump when we draw up the piſton ; for in the ſteam-engine the piſton is really drawn up by the counter weight. But it is ſtill more sucked in, and requires a more copious ſupply, for another reaſon. As the piſton deſcended only in conſequence of the inſide of the cylinder’s being ſufficiently cooled to condenſe the ſteam, this cooled ſurface muſt again be preſented to the ſteam during the riſe of the piſton, and muſt condenſe ſteam a ſecond time. The piſton cannot rise an­other inch till the part of the cylinder which the piſton has already quitted has been warmed up to the boiling point, and ſteam muſt be expended in this warming. The inner ſurface of the cylinder is not only of the heat of boiling water while the piſton riſes, but is also perfectly dry ; for the film of water left on it by the aſcending piſton muſt be completely evaporated, otherwise it will be condenſing ſteam. That the quantity thus waſted is conſiderable, appears by the experiments of Mr Beighton. He found that five pints of water were boiled off in a minute, and produced 16 ſtrokes of an en­gine whoſe cylinder contained 113 gallons of 282 inches each ; and he thence concluded that ſteam was 2886 times rarer them water. But in no experiment made with ſcrupulous care on the expanſion of boiling water

does it appear that the denſity of ſteam exceeds 1/10,000th of the denſity of water. Deſaguliers ſays that it is above 14,000 times rarer than water. We have frequently attempted to meaſure the weight of ſteam which filled a very light vessel, which held 12,600 grains of water, and found it always leſs than one grain ; ſo that we have no doubt of its being much more than 10,000 times rarer than water. This being the caſe, we may ſafely ſup­poſe that the number of gallons of ſteam, inſtead of be­ing 16 times 113, were nearly five times as much ; and that only 1/5th were employed in allowing the piſton to riſe, and the remaining 4/5ths were employed to warm the cylinder.

The moving force during the aſcent of the piſton muſt be conſidered as reſulting chiefly, if not ſolely, from the preponderating weight of the pit piſton-rods. The office of this is to return the ſteam-piſton to the