pipe, and will even cauſe it to come out at K, if the elaſticity of the steam is ſufficiently great. In order to enſure this, the boiler has another pipe in its top, covered with a safety-valve V, which is kept down by a weight W ſuſpended on a steelyard L Μ. This weight is ſo adjusted that its preſſure on the ſafety-valve is ſome- what greater than the preſſure of a column of water *N k* as high as the point of diſcharge K. The fire is ſo regulated that the ſteam is always issuing a little by the loaded valve V. The workman keeps the ſteam- valve open till he hears the valve I rattle. This tells him that the water is all forced out of the receiver, and that the ſteam is now following it. He immediately turns the regulator which ſhuts the ſteam-cock, and now, for the first time, opens the injection-cock. The cold water trickles at first through the holes of the noz­zle *f,* and falling down through the ſteam, begins to condenſe it ; and then its elaſticity being leſs than the preſſure of the water in the pipe KEDf, the cold wa­ter ſpouts in all directions through the nozzle, and, quick as thought, produces a complete condenſation. The valve G now opens again by the preſſure of the atmoſphere on the water of the pit, and the receiver is ſoon filled with cold water. The injection-cock is now ſhut, and the ſteam-cock opened, and the whole opera­tion is now repeated ; and ſo on continually.

This is the ſimple account of the proceſs, and will ſerve to give the reader an introductory notion of the operation ; but a more minute attention muſt be paid to many particulars before we can ſee the properties and defects of this ingenious machine.

The water is driven along the riſing pipe by the elaſticity of the ſteam. This muſt in the boiler, and every part of the machine, exert a preſſure on every ſquare inch of the veſſels equal to that of the upright column of water. Suppoſe the water to be raiſed 100 feet, about 25 of this may be done in the ſuction-pipe ; that is, the upper part of the receiver may be about 25 feet above the ſurface of the pit-water. The re­maining 75 muſt be done by forcing, and every ſquare inch of the boiler will be ſqueezed out by a preſſure of more than 30 pounds. This very moderate height therefore requires very ſtrong veſſels ; and the Marquis of Worceſter was well aware of the danger of their burſting. A copper boiler of six feet diameter muſt be 9/10ths of an inch thick to be juſt in equilibrio with this preſ­ſure : and the ſoldered joint will not be able to withstand it, eſpecially in the high temperature to which the water muſt be heated in order to produce ſteam of ſufficient elaſticity. By conſulting the table of the elaſticity of ſteam deduced from our experiments men­tioned in the preceding article, we ſee that this tem­perature muſt be at leaſt 280⁰ of Fahrenheit’s thermo­meter. In this heat ſoft ſolder is juſt ready to melt, and has no tenacity ; even ſpelter ſolder is conſiderably weakened by it. Accordingly, in a machine erected by Captain Savary at York Buildings in London, the workman having loaded the ſafety-valve a little more than uſual to make the engine work more briſkly, the boiler burſt with a dreadful exploſion, and blew up the furnace and adjoining parts of the building as if it had been gunpowder. Mr Savary ſucceeded pretty well in raising moderate quantities of water to ſmall heights, but could make nothing of deep mines. Many attempts were made, on the Marquis’s principle, to

ſtrengthen the veſſels from within by radiated bars and by hoops, but in vain. Very ſmall boilers or evapora­tors were then tried, kept red-hot, or nearly ſo, and ſupplied with a ſlender ſtream of water trickling into them ; but this afforded no opportunity of making a collection of ſteam during the refrigeration of the re­ceiver, ſo as to have a magazine of ſteam in readiness for the next forcing operation ; and the working of ſuch machines was always an employment of great danger and anxiety.

The only ſituation in which this machine could be employed with perfect ſafety, and with ſome effect, was where the whole lift did not exceed 30 or 35 feet. In this caſe the greateſt part of it was performed by the ſuction-pipe, and a very manageable preſſure was ſufficient for the rest. Several machines of this kind were erected in England about the beginning of this cen­tury. A very large one was erected at a ſalt-work in the ſouth of France. Here the water was to be raiſed no more than 18 feet. The receiver was capacious, and it was occaſionally ſupplied with ſteam from a ſmall ſalt-pan conſtructed on purpoſe with a cover. The entry of the ſteam into the receiver merely allowed the water to run out of it by a large valve, which was open­ed by the hand, and the condenſation was produced by the help of a ſmall forcing pump alſo worked by the hand. In ſo particular a ſituation as this ( and many ſuch may occur in the endleſs variety of human wants), this is a very powerful engine ; and having few moving and rub­bing parts, it muſt be of great durability. This circum­ſtance has occaſioned much attention to be given to this first form of the engine, even long after it was ſupplanted by thoſe of a much better conſtruction. A very in­genious attempt was made very lately to adapt this con­ſtruction to the uſes of the miners. The whole depth of the pit was divided into lifts of 15 feet, in the ſame manner as is frequently done in pump-machines. In each of theſe was a ſuction-pipe 14 feet long, having above it a ſmall receiver like R, about a foot high, and its capacity ſomewhat greater than that of the pipe. This receiver had a valve at the head of the ſuction- pipe, and another opening outwards into the little cistern, into which the next ſuction-pipe above dipped to take in water. Each of theſe receivers ſent up a pipe from its top, which all met in the cover oſ a large veſſel above ground, which was of double the capacity of all the receivers and pipes. This veſſel was cloſe on all ſides. Another veſſel of equal capacity was placed im­mediately above it, with a pipe from its bottom paſſing through the cover of the lower veſſel and reaching near to its bottom This upper veſſel communicates with the boiler, and conſtitutes the receiver of the ſteam-engine. The operation is as follows : The lower veſſel is full of water. Steam is admitted into the upper veſ­ſel, which expels the air by a valve, and fills the veſſel. It is then condenſed by cold water. The preſſure of the atmoſphere would cauſe it to enter by all the ſuction-pipes of the different lifts, and press on the ſurface of the water in the lower receiver, and force it into the upper one. But becauſe each ſuction-pipe dips in a ciſtern of water, the air preſſes this water before it, raiſes it into each of the little receivers which it fills, and allows the spring of the air (which was formerly in them, but which now passes up into the lower recei­ver) to force the water out of the lower receiver into the