and then condensing that steam so as to form the liquid. Different substances take the liquid form at various temperatures ; and, therefore, the heat may he so regulated that only one substance of a mixture shall take the form of vapour, and being conveyed by a pipe through a vessel of cold water, or otherwise exposed to the cooling process, the vapour being condensed will give the pure liquid. A great improvement upon the process of separating liquids has been successfully introduced by Mr. Howard. It consists of *distillation or evaporation in vacuo,* and has been most usefully employed in the refining process of sugar. When sugar is dissolved in water, it requires a much higher temperature than 212° to boil the mixture, or to convert the water into steam and separate it from the solid ; and as the process goes on, and the solution comes to hold less and less water, the requisite degree of heat is further augmented, until the temperature he comes so high as to injure the colour and otherwise deteriorate the article of merchandise in its crystallized state. Instead of this increased temperature, Mr Howard places the syrup in vacuo, and thus boils it at a low and innoxious heat. This he accomplishes by pumping out the air and vaporized water from the close boiler, by means of a large air-pump driven by machinery. The process has produced a great improvement on this article of commerce, and has remunerated its inventor with an ample fortune.

Distillation in vacuo is peculiarly adapted to obtaining those delicate extracts and essential oils from vegetable substances, which are apt to suffer deterioration from the usual high temperatures.

19. \* The pulse glass, an invention attributed to Dr Franklin, is an apparatus illustrating beautifully the process of ebullition in vacuo at low temperatures. If two glass balls, A and B (fig. 5), be connected by a slender tube, and one of them, A, be filled with water, a small opening or pipe *b* being left at the top of the other, and this be made to boil, the vapour produced by it will drive all the air out of the other, and will at last come out itself, producing steam at the mouth of the pipe. When the ball B is observed to be occupied by transparent vapour, we may conclude that the air is completely expelled. Now, shut the pipe by sticking it into a piece of tallow or wax, the vapour in B will soon condense, and there will be a vacuum. The flame of a lamp and blow-pipe being directed to the little pipe *b,* will immediately cause it to close and seal her metically. We have now a pulse glass. Grasp the ball A in the holIow of the hand ; the heat of the hand will immediately expand the bubble of vapour which may be in it, and this vapour will drive the water into B, and then will blow up through it for a Iong while, keeping it in a state of violent ebullition, as long as there remains a drop or film of water in A. But care must be taken that B is all the while kept cold, that it may condense the vapour as fast as it rises through the water. Touching B with the hand, or breathing warm on it, will immediately stop the ebullition. When the water in A has thus been dissipated, grasp B in the hand ; the water will be driven into A, and the ebullition will take place there as it did in B. Putting one of the balls into the mouth will make the ebullition more violent in the other, and the one in the mouth will feel very cold. This is a pretty iliustration of the rapid absorption of the heat by the particles of water which are thus converted into elastic vapour. We have seen this little toy suspended by the middle of the tube like a balance, and thus placed in the inside of a window, having two holes, *a, b,* cut in the pane, in such a situation, that, when A is full of water and prepon­

derates, B is opposite to the hole *b.* Whenever the room became sufficiently warm, the vapour was formed in A and immediately brought the water into B, which was kept cool by the air coming into the room through the hole *b.* By this means B was made to preponderate in its turn, and A was then opposite to the hole *a*, and the process was now repeated in the opposite direction. This amusement continued as long as the room was warm enough. Instead of water, alcohol or ether may be substituted, and will act more readily.

20. The follow­ing experiment, where ebullition is produced by the application of cold, is instructive. A Florence flask F, is about 1/3 full of water, and is placed over a lamp E until the water boils ; and when the steam has been rising for a short time violently from the neck of the vessel, the cork S is to be applied as a stopper, and must fit with great accuracy. The flask thus closed is to be set aside for a few minutes till it have cooled considerably, and is then to be suddenly placed on a stand in the cold water W, contained in the glass reservoir R. The ebullition in the flask will rccommence with a degree of violence proportioned to the cold ness of the water W.

The theory of this action is simple. When the flask is plunged in the cold water, 2/3 of its contents are steam: the chill water condenses it into water, it shrinks up into l1728th part of its bulk, and would leave 1727 parts out of 1728 vacuous; but the warm water being now in vacuo, throws up in rapid ebullition (according to Art. 14) copious volumes of vapour of its own temperature, which is again, by coming into contact with the sides of the vessel, and by directly giving off its heat to the water, chilled into water, and so in succession all the vapour thus sent up is in turn reconverted into water, and the vacuum sustained, until at last, the equilibrium between the temperature of the water, within and around the flask, having been es­tablished, the interchange of caloric ceases ; and even now, if the flask were plunged into freezing water, the ebullition would recommence as violently as before.

21. We have already noticed (Art. 11.) the fact that, when water is confined in a close vessel, and heat is applied to it, the water will not boil even at a temperature of 212°. If heat be continually thrown into the water in this state, the particles will acquire a very high temperature ; and, at the same time, the tendency of the enclosed fluid to burst the vessel will become very great. The following experiment upon this subject is one of the most interesting and the earliest of which we are in possession. It was published in 1663 by the Marquis of Worcester, and we give it in his own words. “ I have taken a piece of a whole cannon, whereof the end was burst, and filled it three quarters full, stopping and screwing up the broken end, as also the touch-hole, and making a constant fire under it ; within twenty-four hours it burst, and made a great crack.”

It is in virtue of the great elastic force by which water, when heated, tends to expand into 1728 times its bulk, in the form of steam, that this element has become a mechanical mover, subject to the control of man. There are two great principles upon which such machines are con­