full blaze of light which is thrown upon this subject by the illumination of modern science. Of so large a sub ject, one part only can be studied at a time, and that succession of parts by which they enter into the mind in easiest transition is the very succession in which history presents them to us.

We shall therefore divide this subject into two parts; the first containing a description of the steam-engine, and the elucidation of its principles, in historical order ; the second forming a description of the functions and parts of the modern steam-engine.

Part I—Historical Description of the Steam-Engine. 1. The Era of the Ancients. 2. The Era of Worcester. 3. The Era of Watt.

1. *The Era of the Ancients.*

The knowledge which some of the ancients possessed of the constitution of steam is remarkably in accordance with the most recent modern conclusions on this species of matter. Steam is now known to be only one of the common airs or gases whose particles at one degree of heat and of pressure assume a liquid form, and at another temperature and pressure become solid ice.

The modern doctrine concerning matter may be thus stated ; that matter is known to exist in four conditions— solid, liquid, aerial, and etherial. Earth and stone are exemplars of solid matter; water and mercury of liquid matter ; the atmosphere, and smoke, and steam, of aerial substances ; caloric, light, and electricity, of etherial matter. It is further the doctrine of modern physics that no kind of matter exclusively possesses one of these conditions as its distinguishing property, hut that all may, in certain circumstances assume different conditions. Stone is not essentially solid, for, by the action of heat, it may be melted under pressure ; and iron or lead, though usually solid, may be presented in the liquid form ; and the earths have likewise assumed the form of liquids when the contrivance of the chemist has succeeded in placing them in appropriate circumstances. Neither is water essentially a liquid, for, when frozen, it becomes a solid, with which we may construct houses, bridges, utensils, and even floating structures capable of navigating the ocean ; and, on the other hand, it is sometimes reduced into the vaporous or aerial form, as when the wa ter of a vessel, acted on by heat, is wholly dissipated and dispersed in an invisible form in air.

lt is also to be observed, that the condition of a body may be changed by the agency of heat. Solid ice, solid mercury, or solid lead, by the addition of heat, are converted into liquids, or are melted ; and form liquid ice, (called wa ter,) liquid mercury, (called quicksilver,) and liquid lead, (which has no separate name.) If to the liquid thus produced from the solid we add a certain other portion of heat, that will separate its particles still further from each other, and the matter thus diffused over more ex tended space becomes reduced to the aerial condition of steam, of mercurial or lithargical gas, or transparent va pour. But still the matter has undergone no constitutional change. It is only necessary to remove the heat, and the particles will again come together and resume their primitive form. By cooling down the aerial gas into which the matters had been dissipated, or even by corn pressing them, so as to contract them into their original bulk and bring them together into their original prox imity, the particles will once more resume their pristine form, the vapour will respectively appear as drops of li quid water, mercury, or lead, and those liquids being more condensed, will congeal into the original solid masses of solid ice, solid mercury, and solid lead. The most refractory gases have actually been found to obey this law, and we have no doubt that every substance in nature might

successively be presented to the senses in every one of these forms.

The following passages, taken from the *Timæus* of Plato, present a remarkable accordance with these enlarged views of the constitution of steam and other gases :—“ Let us therefore speculate concerning the nature and properties of fire and water, air and earth. This is the more arduous, because it is necessary to call into question, concerning each and all of them, whether they should be denominated liquid rather than etherial, or aerial rather than solid; or why any th ng should have one of these appellations rather than all. For, in the first place, that which we now call ‘ water,’ being congealed, becomes (hard) as a stone or earth, but being melted and diffused becomes gas or air, and this inflamed becomes fire, and fire extinct becomes again congregated into air, and air collected and condensed forms mist and cloud, and these again, more compressed, form water, and from the water earth and stone are reproduced. And thus they, in an endless circuit, produce each other. Since, then, these now appear to be the same, who will assert that one of them is of the one kind rather than the other ? It is most safe, therefore, to speak thus; that the thing we see is not absolute liquid, but something in the liquid state. That air is not necessarily a gas, but something in the gaseous slate ; not as being a particular thing of this or that specific nature, but that it is in such and such a condition.”

“ Let us then distribute the four modifications of matter into fire, earth, water, and air; and to earth let us assign an entical form, for it is the most immovable of all these kinds—to water that which is less movable than the other three—to fire the most easily movable form— and to air that which is intermediate.”

It appears to us highly probable that the ancients knew more of the phenomena of steam than has been generally admitted. One evident cause of this mistake is the cir­cumstance that no specific term equivalent to the word steam was generally used by them ; and water, when heated, was said to be converted into an air. It is now almost perfectly established by the progress of modern science, that steam is an air, (or gas,) invisible and perfectly transparent, differing in none of its mechanical properties from common air or gas, and in no respect differing in its constitution from carbonic and other gases or airs which, at certain temperatures and pressures, do, like steam, leave the elastic aerial form and become condensed into steam. Many of the phenomena, therefore, for which the ancients use the word air, are effects of steam, or of steam mixed with air ; and although they have not always carefully distinguished these sepa rate effects, yet they have frequently made judicious use of them. While, therefore, it would be wrong to draw any parallel between the want of individualization mani­fested in their writings, and the high generalization of modern science, it would be equally wide of truth to deprive them, as has sometimes been attempted, of the merit of having discovered and used some of the proper ties of water in the aerial state, simply because they supposed it rarefied into an air, and confounded its pheno meιιa with those of other gases, which, mixing with it, also contributed to the effect—as when we find that air rarefied by heat, and water rarefied into air, are men tioned.

Hero of Alexandria in his *Pneumatics,* has collected the science and inventions of the ancients, along with some of his own, into a systematic treatise, written in Greek, more than 120 years before the Christian era, some passages of which are identical with portions of modern treatises on pneumatics : and many portions of his apparatus may be found transformed into modern experimental models in cabinets of the physical schools. Now,