# Chapter 17.

## Explanation of the strength of bodies.

*126. An agglomeration of coarse matter is compressed by the surrounding aether in such a manner that its parts can not be separated from each other except by forces which are greater than the pressure of the aether.*

We recognize only two basic types of matter in the universe, the subtle and the coarse. That which is called aether is completely liquid and many thousand times more rarefied than coarse matter, and allows itself to be compressed into a smaller space, since it exercises a force so as to expand again; and in such a forced state it really fills all space that is free of coarse matter. On the other hand the coarse matter, which is many thousand times more dense, in accordance with its nature always retains the same density, and does not allow itself to be compressed into a smaller space by any force, however great it might be. But we consider it such that, if it alone were present, there would be no attachment between its parts, and the smallest force would be able to separate each particle from the others. But if a body, consisting solely of coarse matter, is in the aether, then it will be pressed by the latter from all directions, and all its parts be pressed together from all sides. This force is the elasticity of the aether, and the greater it is, the more strongly are the particles of the body pressed together. Therefore if one wants to tear a piece from this body, a greater force is needed than the spring force of the aether; and no part can be separated from the others by a smaller force. For this reason we must associate with such a body a strength which will be the greater, the more the aether has been compressed, and through that has its spring force augmented; and since this strength is an effect due to the aether, it can not be regarded as an internal characteristic of coarse matter.

*127. The cause of all strength and hardness of bodies is therefore to be sought solely in the coarse matter that is compressed from all sides by the aether. But for the force of the aether no parts of the body would hang together, and the smallest force would be able to scatter them from each other.*

It has been much debated whether the smallest particles of all bodies must be regarded as liquid or solid, that means whether a liquid body could be composed of solid particles or a solid body of liquid particles. If we do not straight away accept such particles, which one could regard as ultimate and not further divisible, the problem is readily discussed in connection with the assertion of the two types of matter, the coarse and the subtle. For the subtle matter is by its very nature liquid such that no solid body could be formed from it alone. To the coarse matter itself we can also not assign strength, since even the smallest force would be able to scatter all particles we could imagine like a dust. A solid body is only formed when coarse matter is compressed from all sides by the aether; and since the particles can not be separated from each other by anything other than a sufficiently strong force, such a body has all the properties of strength and hardness. This explanation can not be doubted particularly because one can not show in the whole world hard bodies

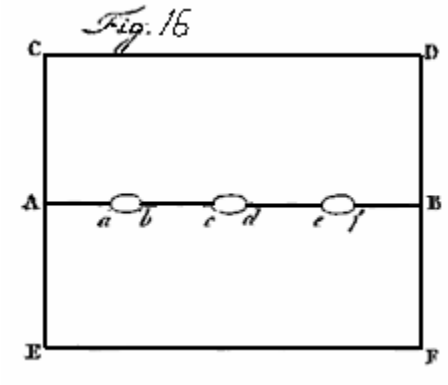
whose hardness is greater than that due to the pressure of the aether, and since moreover it is certain from other considerations that the aether really has an extraordinarily strong spring force, and even the hardest bodies can be broken up. It would therefore be illogical to postulate a special reason for hardness in the nature of bodies.

*128. If two bodies, each of which consists only of coarse matter, are fitted together such that there is not left even the smallest space between them in which there could be aether, then these two bodies are held together as strongly as if they were one piece, and their strength will be so great that it could not be greater.*

If two bodies are in contact such that not even the smallest space remains between them, then they are pressed together by the surrounding aether as if they had never been separated from each other, and if one wanted to tear them apart, one would have to use a force greater than the one that presses them together. Because the strength and hardness of bodies is solely due to the pressure of the aether, no greater strength and hardness can occur in the world, than that caused by the total pressure of the aether. Since this is so in the case under discussion, it would not be possible to be more firmly attached to each other than they are pressed together by the pressure of the aether. But if this degree of hardness is to be obtained by placing them together, then the surfaces of the two bodies that are to be joined must match so that between them there remains not the smallest space; this can be achieved if one polishes them to the highest degree. For if they had the slightest unevenness, such joining would hardly be possible. We shall consider the two matching surfaces to be flat and we call their area $ff$ and the pressure of the aether shall be given by the height $k$; it is then clear that the total pressure that presses these two bodies together varies as $ffk$. If the force of the aether were not greater than that of air, and one wanted to express the pressure in terms of the weight of a quantity of water, then $k$ would amount to approximately 32 feet. If we assume $k$ for aether to be only 100 times greater, then the compressing force would be equal to the weight of a mass of water of $3200ff$ cubic feet. If we put the area of contact $ff = 1$ square foot and take the weight of one cubic foot of water to be 70 pounds, then the compressing force amounts to 224000 pounds, and the strength would be ten times greater if we had assumed the height $k$ to be one thousand times greater that 32 feet.

*129. If in joining the above two bodies their surfaces do not make contact at all points, but if instead minute spaces remain between them that are filled by the subtle matter of the aether, then the strength must be estimated from the parts that actually make contact.*

Wherever a cavity exists between the two bodies that contains aether, the later will tend to expand because of its spring force, and presses on the two bodies with the same strength as if they were in contact with the open aether, in consequence of which the compressing force is diminished by the same amount. To show this more clearly, let the




two bodies (Figure 16) *ABCD* and *ABEF* be joined at the plane surface *AB* = *ff* such that between them the cavities *ab, cd, ef* still remain filled with the subtle matter of the aether, the total width of which is called *gg*. We want to regard the two bodies as cylindrical, so that their outer surfaces *CD* and *EF* are also equal to *ff*, and let *k* be the height that determines the pressure of the subtle matter. The body ABCD will then be forced against the other body by the aether that presses on the plane CD with a force = *ffk*; on the other hand it will be pushed back by the aether in the cavities *ab, cd, ef* with a force = *ggk*. Therefore the force with which the body ABCD is pressed against the other body ABEF is only $ffk - ggk = (ff - gg)k$, which means the two bodies are pressed against each other only as if their area of contact were not *ff* but only *ff – gg*. One must therefore deduct the width of all the cavities present between the bodies from the total area *ff* over which they are joined and calculate the strength on the basis of the remainder. This remainder is in fact the true area of contact, since the strength only arises from the pressure of the aether to the extent that the coarse particles are in immediate contact, and therefore the true contact must be carefully distinguished from the apparent one, which also includes the contact of the subtle matter. The apparent contact can therefore be very large, and nevertheless only very few coarse particles be in contact, leading to a very low degree of strength. It can also happen that no coarse particles at all are in contact, and the apparent contact only involves subtle matter, in which case the bodies are not pushed together at all and can be separated by the smallest imaginable force.

*130. A body is therefore by so much stronger as more coarse particles within it are in immediate contact .Since this contact occurs throughout the body and in all directions, it becomes understandable how some bodies are hard, others soft and flexible or brittle.*

There is in the world no body that consists solely of coarse matter. The many pores and cavities that are seen in all bodies indicate sufficiently that subtle matter fills a considerable part of the space occupied by each body. Therefore every body must be regarded as a mixture of coarse and subtle matter, and since these two kinds of matter can be mixed in infinitely many ways as regards quantity, size and distribution of particles of both kinds, it is easy to understand how from these two kinds of matter all different kinds of bodies can originate, and why it is extremely improbable that even only two bodies should be identical and similar (sic.) in all respects. Here it must firstly be noted that, where coarse particles are separated from each other, they do not hang together in the slightest; but where coarse particles are in immediate contact with each other, they are pressed together by the spring force the more, the larger the area of contact. Because in this there is an infinite variety, it is easily understood why some bodies can be more or less hard, soft, flexible or brittle. The hardest and strongest body that can exist in the

world is one that consists entirely of coarse matter and contains absolutely no cavities filled with subtle matter. But the strength of such a body can always be overcome by a force sufficient to exceed the spring force of the aether, so that no bodies are possible in the world, whose strength and hardness can not be overcome. But all bodies that actually exist in the world must have a far lower degree of strength and hardness, and therefore one can explain how these can be bent, torn or otherwise be changed in their shape. For whatever change in this occurs, it must always involve particles, that previously were in contact, being separated from each other, and from the force by which they were previously pressed together one can conclude how large a force is needed for their separation.

*131. From this follows that the stronger a body is, the more coarse particles within it are in immediate contact. However in a liquid body there can be no such contact, but all coarse particles must be at a distance from each others, separated by subtle matter.*

Because therefore a body is solid if its particles hang together so strongly that they can only be torn apart by a sufficiently strong force, but this cohesion is caused by the pressure of the aether, when coarse particles are in immediate contact, we can conclude in reverse that in a very strong body many coarse particles are in immediate contact. For if there were between them the minutest amount of subtle matter, then each particle would be pressed with equal force from all directions and consequently nowhere would two be pressed together. But where in a body the particles can be easily separated from each other, there must also be very little contact between the coarse particles, and in liquid matter such contact does not occur at all. Liquid matter is thus suffused by the aether to such an extent that the coarse particles achieve nowhere immediate contact. To see how this could happen, one need merely imagine that every particle of coarse matter is surrounded by subtle matter, and the particles can consequently never approach each other so closely that there would not remain some subtle matter between them. If everything were at rest, such a degree of mixing would be hard to understand; but if we imagine the subtle matter to be in such motion that it continuously flows between the coarse particles, then in this way immediate contact can be impeded. In the following it will be shown that heat consists in the movement of the subtle matter, and from this one can easily explain how solid bodies are transformed by a high degree of heat into liquid ones, and on the other hand how, when the heat has been reduced to a certain degree, water is transformed into ice. At least one already sees at this stage that a number of natural phenomena can without difficulty be explained using the principles so far established.

*132.Here we also find the reason why two pieces of marble, when they are smoothly polished and then pressed together, hang together so strongly that they can be torn apart by nothing but a very strong force ;and quite generally this is the cause of the cohesion of bodies when they are in contact.*

That two smoothly polished marble plates are not merely pressed together by the air, is shown by the fact that they also stick firmly together in a vacuum, an effect that must be ascribed to the pressure of the aether. In addition it is necessary that many coarse parti-

cles are in immediate contact, and to this end the marble plates must be well polished and be ground together for some time, so that all subtle matter between them is driven away. For this it is also customary to moisten the marble plates or to smear them with grease, through which the aim is reached much more readily. Other bodies can also be put together in this way so as to stick to each other fairly firmly; for this nothing other is required than that coarse particles are in immediate contact. This has caused some Natural Scientists to ascribe to bodies in contact a force of attraction, and to regard this as an essential property; they have also endeavored to determine the laws of this force of attraction, or rather of attachment, and they maintain that under the same conditions this force is the greater, the more dense the bodies are. The matter itself is therefore quite correct if one discounts the opinion that this is the manifestation of a special property of bodies; for if two bodies can be placed together such that coarse particles can make immediate contact, then cohesion ensues of necessity because of the pressure of the aether. One also understands that density can make a contribution here, since under the same conditions in the case of denser bodies more coarse particles can make contact. The main factors however are the number and size of the coarse particles that make immediate contact. Because this force is located only in the immediate region of contact, one can not regard it as an attractive agency that depends on the distance such that, as long as the bodies are still separated from each other, it is indiscernible, but on actual contact it becomes considerable.