Chapter 13.

On the special properties of coarse and subtle matter.

98. A body can only be placed into a smaller space if its pores are compressed; also only the apparent size of a body can be altered, not its true size, provided no coarse matter is taken away or added.

Since the subtle matter contained in the pores of bodies is so very tenuous, it is of no concern if it is counted into the proper matter of a body; but nevertheless we want to understand only the proper matter by this name, and ascribe to a body the same amount of matter as long as the amount of coarse matter it contains remains the same. It is known of many bodies that they can be compressed into a smaller space, thus decreasing their apparent size; but it can not be concluded that in this way the true size can also be decreased. In some cases it can even be seen that only the pores are being pressed together; but it will be shown below that the weight of a body must behave like a true quantity; since the weight of a body always remains the same, however much it may be compressed into a smaller space, such as air or other bodies that can be greatly compressed, it follows that its true size always remains the same, and the change affects only the apparent size. Since the density of coarse matter is everywhere the same, it seems that this definite degree of density is so characteristic of it that no force is able to compress it into a smaller space, or expand it into a larger one without the appearance of pores; in the former case the density would be increased, in the second it would be diminished. If changing the true density were possible, experiments on the weight of bodies would not always indicate the same density, since many bodies are in a very compressed state, where consequently the density would have to be greater. But from those bodies that cannot be compressed at all one can with confidence conclude that the density of coarse matter can not be changed.

99. Coarse matter is therefore not capable of any change other than in the appearance of its shape, which, if appropriate forces are available, can be changed in arbitrary ways.

We consider here a body that consists exclusively of coarse matter, and that in its entire extent has no pores. On its outside it may well be surrounded by subtle matter, since one could otherwise not conceive of its boundary. This body will therefore have the same density through and through, and all parts of equal size will contain the same amount of matter; its density will be so characteristic of it that no force is able to compress it into a smaller space. The entire body will resemble a lump of the same type of matter, in which no difference between parts can be perceived; since all parts that we can conceive in it are equally dense and also pores can not indicate a demarcation or difference between parts, there can at least in this piece be no place for differences. We do not intend to examine here whether in regard to hardness or other properties a differentiation is possible, because through that no internal difference would arise, such as is being considered here. The body is however divisible, and one can imagine that it is divided into as many parts as desired, and actually separated into them; if one reassembles these parts in a different manner, the body assumes a different shape; it is therefore capable to assume all possible shapes, provided the necessary forces are available. It is therefore possible that such a body, that now is spherical, assumes at another time a rectangular shape. It can also happen, if its parts are not all moved similarly, that its shape changes all the time, which happens when the body is light and flexible. Such a body can also be liquid, in which case the slightest cause can change its shape, but its volume must remain constant and its density always remain the same. But it is not very probable that such bodies exist in the world, rather it seems that all are filled with pores throughout, and consequently to be mixed with subtle matter.

100. It does not appear to be true that subtle matter also has always and everywhere the same density, such that it could through no force be driven into a smaller space. Instead an important difference between coarse and subtle matter seems to be that the latter can be compressed.

There is no reason to be found in the essence of matter generally why a certain amount of matter should be bound to a certain extension; and since we have already discovered two types of matter that are so different with regard to density, it is certain that the essence of matter does not stipulate a certain and definite density. Therefore the cause of coarse matter having an invariable density must lie not in the general essence of bodies, but in the particular essence of this matter. Because the subtle matter is so substantially different from the coarse matter, one has no sufficient reason to conclude that the subtle matter is also endowed with an unchangeable density. From the arguments so far we can not conclude the opposite, but it is sufficient for us to say that these arguments do not decide anything. Since from general experience alone we have determined the existence of two types of matter in the world, and also the unchangeable density of coarse matter, we must also rely on experience in examining the particular properties of subtle matter. But we shall see below, in the course of explaining many natural phenomena, that the subtle matter is indeed capable of changing its density; and if we only examine more closely the spring force of bodies, one finds easily that this is impossible to explain without ascribing to subtle matter itself such a force. But such a force can not be understood if there is no compression; for if the subtle matter, like the coarse matter, allowed no compression at all, one can conclude from the investigations that have been made that the spring force would be impossible to explain.

101. We must ascribe to subtle matter a certain density that is most appropriate to its nature, but it must be possible to compress it into a smaller space; but this requires forces, and it is easily seen that the more it is to be compressed, the greater the force required.

It cannot be a matter of no consequence how large a space a certain amount of subtle matter occupies; for if one considers a certain amount all on its own, having no connection with other matter, then it must occupy a certain amount of space in which, due to its persistence, it would remain forever. This implies a certain density, which must be regarded as appropriate to the nature of subtle matter. Nevertheless we must maintain that a higher density would not be totally at variance with its nature, since otherwise its density could not be variable, as we have shown to be the case. On its own, and without the assistance of an external cause, such matter would no more change its density than its state; but when it is pressed by forces from all directions, so that it cannot escape anywhere, then the already demonstrated effect must take place, namely that it is compressed into a smaller space, giving it a higher density. This one must of necessity concede, since otherwise one would have to deny the possibility of compression. One sees from this further that the compression due to certain forces must also be a certain one; for when the same forces could compress the subtle matter further and further, it would eventually be compressed into a point, which is absurd. A certain force is therefore only able to increase the density of subtle matter by a certain amount, and is then, so to speak, in equilibrium with it; if it were to be compressed further, one would have to apply a greater force. From this follows quite clearly that the more subtle matter is to be compressed, the greater a force must be applied; but the true ratio cannot be determined, i.e. whether for a doubling of the density just double the force is required; however such a determination is not needed for our present purposes.

102. If the subtle matter has been brought into a space narrower than associated with its natural state, then it exercises a force to expand, and this force is the stronger, the more the subtle matter has been compressed.

A force is needed to compress the subtle matter into a smaller space than that associated with its natural state, and nevertheless it contains a force to resist the compression. If a quantity of subtle matter, that normally occupies one cubic foot has been compressed to half a cubic foot by the necessary force, and if this force has now ceased to act, then the matter can not remain in this compressed state; for since in this state it exerts an equal force resisting the external force, and is in equilibrium with it, then as soon as the external force ceases to act, the internal force must act so that the matter expands again and resumes its natural space of one cubic foot. If this did not happen, it would follow that the compressed state were the natural one. Such a compressed state can thus appropriately be called a forced state, since the matter cannot be maintained in it other than through an external force, and in such a state the matter exerts a force to expand, which is called the spring force or elasticity of the subtle matter. The spring force of subtle matter is therefore the force it exerts when it is in a forced state, and it is equal to the force that is needed to bring it into the forced state and to maintain it there. The more the subtle matter is compressed, the larger becomes the spring force. Let d be the natural density of subtle matter, and assume it is compressed to a density $2d$; then it will in this forced state exercise a force K, which is its spring force. Should it be compressed to an even smaller space, so that its density becomes $3d$, then the spring force would also be greater than K, because a greater force would be needed to bring it into that state; but how this force compares to the other can not yet be determined. But we do know that if the density D is related to the spring force K, then K depends on D in such a manner that if $D = d$ we have $K = 0$, but if $D = nd$, then K gets progressively larger the more units the number n represents.

103. The compression of subtle matter is in no contradiction to what was taught above about impenetrability; and if these concepts are properly analyzed, one will find that the spring force has the same origin as the forces which in the above were ascribed to impenetrability.

If one imagines a body composed of certain parts, each of which occupies a certain space, then it is impossible to understand how a body could be compressed into a smaller space without its parts interpenetrating each other, provided one excludes all empty space between its parts. But this concept is incorrect in that one seriously imagines such parts to exist which, due to their essence have a certain size, since there is nothing in the essence that could connect a certain amount of matter with a certain size. One then regards these parts as real entities of which the body is to be composed, which is in conflict with the divisibility of bodies. In one's imagination one can think of a body composed of 100, 1000 and as many parts as one wishes, and regard these parts as so many units; but these are only arbitrary units in the imagination, in nature itself there are no units. A body can thus be compressed when these imagined parts become smaller and move closer together; and this can happen without an actual penetration taking place. Let us imagine a body whose matter is to occupy one cubic foot; one imagine further a force that tries to compress it into a smaller space. Depending on the particular characteristics of the body, this force will either really compress the body into a smaller space or it will not. If the body can not be compressed into a smaller space, then in its state it resists the force acting on it with the same force, and from this case we have actually derived the forces of impenetrability. But if the body is capable of being compressed, then the imagined force will compress it to a certain degree, but subsequently it will, in order to resist further compression, exert a similar force as in the first case, which force we now call the spring force, and which as regards its origin cannot be distinguished from the forces of impenetrability. Both are based on the fact that a body will oppose with equal force a force that has been able to bring it into a certain state, in order to resist its further action.

104. From the fact that subtle matter is compressible, and always can be compressed by a greater force into a smaller space, it does not follow that it can finally be brought into a point and effectively be annihilated.

We have not determined the rules according to which a larger force compresses subtle matter to a higher degree of density, but it is easy to understand that if a certain quantity of matter were to be brought into an infinitely small space, since then the density would be infinite, a force not smaller than an infinitely great one would be required, which is equivalent to denying that such a compression would be possible. But it can be that an infinite force is already needed to compress subtle matter only to a certain degree; one can imagine infinitely many such relations between any degree of density and the force required for it; let for example the natural density be d, with which there is no spring force associated, and let a force p act on the subtle matter, which compresses it such that the density becomes s, so that a spring force p corresponds to the density s. If a relation

$$s = \frac{np+k}{p+k}d$$

were to hold, where n is an arbitrary number greater than 1, then it would follow that when the force $p = 0$, the density $s = d$ would result, as required by the nature of the matter. Subsequently any larger force p would produce a larger density; for when $p = k$ one would have

$$s = \frac{n+1}{2}d;$$

if $p = 2k$ one would have

$$s = \frac{2n+1}{3}d\ ;$$

If $p = 3k$ one would have

$$s = \frac{3n+1}{4}d$$

and thus becoming ever larger, the larger the force p is assumed to be. But even if the force p is taken to be infinite one would only obtain $s = nd$, or it would be impossible to compress the subtle matter to this degree of density. Whether this relation or some other relation applies in Nature, the compression into an infinitely small space remains impossible.