Here U denotes the energy of the system. Let A be the area of one face of the cube; then

$$A(\Delta x + \Delta y + \Delta z) = \Delta V \ , \tag{23}$$

if all increments ΔV and $\Delta x = \Delta y = \Delta z$ are taken as positive in the compression. The work done in the compression is

$$\Delta U = p_s A(\Delta x + \Delta y + \Delta z) = p_s \Delta V \ , \tag{24}$$

so that, on comparison with (22),

$$p_s = -d\varepsilon_s/dV \tag{25}$$

is the pressure on a system in the state s.

We average (25) over all states of the ensemble to obtain the average pressure $\langle p \rangle$, usually written as p:

$$\boxed{p = -\left(\frac{\partial U}{\partial V}\right)_\sigma \ ,} \tag{26}$$

where $U \equiv \langle \varepsilon \rangle$. The entropy σ is held constant in the derivative because the number of states in the ensemble is unchanged in the reversible compression we have described. We have a collection of systems, each in some state, and each remains in this state in the compression.

The result (26) corresponds to our mechanical picture of the pressure on a system that is maintained in some specific state. Appendix D discusses the result more deeply. For applications we shall need also the later result (50) for the pressure on a system maintained at constant temperature.

We look for other expressions for the pressure. The number of states and thus the entropy depend only on U and on V, for a fixed number of particles, so that only the two variables U and V describe the system. The differential of the entropy is

$$d\sigma(U,V) = \left(\frac{\partial \sigma}{\partial U}\right)_V dU + \left(\frac{\partial \sigma}{\partial V}\right)_U dV. \tag{27}$$

This gives the differential change of the entropy for arbitrary independent differential changes dU and dV. Assume now that we select dU and dV interdependently, in such a way that the two terms on the right-hand side of (27)