3.12. It does not seem that confinement of a plasma by an electrostatic field will be possible for several reasons. Suppose that an electrostatic "cage" is established by means of a set of charged electrodes and that the field is able to prevent the plasma from making contact with the material of the electrodes. If such a system is capable of confining electrically charged particles of one sign, e.g., ions, then clearly those of the opposite sign, i.e., electrons, present in the plasma cannot be confined, since the electric field has oppositely directed

effects on the positive and negative particles. Furthermore, according to Earnshaw's theorem of classical electrostatics, there is no position of stable equilibrium for a charged particle in an electrostatic field, no matter how complex its structure [1]. A consequence of this theorem is that no configuration of charges, such as a plasma, can exist in stable equilibrium under the influence of purely electrostatic forces [4].

3.13. In addition to the foregoing qualitative arguments, there is a quantitative reason why confinement of a plasma by means of an electrostatic field is not likely to be practical. An essentially static electric field can exert an effective pressure on a system of charged particles which is limited to the energy density of the field, given by $E^2/8\pi$.* If E is the field strength in statvolts/cm, then the energy density (or pressure) will be obtained in ergs/cm^3 (or dynes/cm^2). The pressure of the plasma, treated as an ideal gas, is nkT, where n is the total number of particles per cubic centimeter, i.e., the total particle density of the plasma. If the number densities of ions and electrons are each 10^{15} particles/cm^3, then n is 2×10^{15} particles/cm^3; and suppose T (or rather kT) is 100 kev. The minimum value of E required to contain the plasma is found by equating $E^2/8\pi$ to nkT; thus,

$$\frac{E^2}{8\pi} \geqslant 2 \times 10^{15} \times 100 \times 1.6 \times 10^{-9} = 3.2 \times 10^8 \text{ ergs/cm}^3,$$

where 1.6×10^{-9} is the factor for converting kilo-electron volts into ergs. It is seen that E must be nearly 9×10^4 statvolts/cm or about 2.7×10^7 volts/cm. Thus, a stationary electrostatic field of impossibly large magnitude would be required to confine a plasma of reasonable particle density such as might be used in a thermonuclear reactor.