The second consideration, the tendency of Z to be equal to A/2, should be taken into account. Since A is the total number of nuclear particles (neutrons plus protons) this tendency means that there is a tendency for the number of protons to be the same as the number of neutrons. (While it is true that for heavy nuclei there are fewer protons than neutrons, we shall assume that this is due to the electrostatic repulsion between protons, which will be considered next. In other words, we are assuming that if it were not for Coulomb forces between protons, there would be equal numbers of protons and neutrons in nuclei.) There are at least three types of nuclear forces within a nucleus: neutron-proton, proton-proton, and neutron-neutron. In view of the equality of the number of protons and neutrons in nuclei, the last two types of forces must be of the same order of magnitude. For if the proton-proton forces were stronger, nuclei with more protons than neutrons would tend to be more strongly bound, hence more stable than those with equal numbers of each. If the energy of isobars (same A, different Z) were plotted against Z, we should get a curve symmetric about Z - A/2, as nuclei with Z protons and A-Z neutrons would have the same energy as those with Z neutrons and (A-Z protons, assuming equality of neutron-neutron and proton-proton forces. The isobar curve as shown in Figure 48 shows a minimum at Z = A/2 since nuclei for which Z = A/2 are the most stable. Thus E_2, the energy associated with the departure from equality in the number of protons and neutrons, must be proportional to some even power of Z–(A/2). For simplicity, consider that in the neighborhood of Z = A/2, the energy E_2 is proportional to the square of Z–(A/2). To see what the "dimensions" of the coefficient should be, consider two nuclei with the same value for Z/A, one having an A twice the other, so that both nuclei have

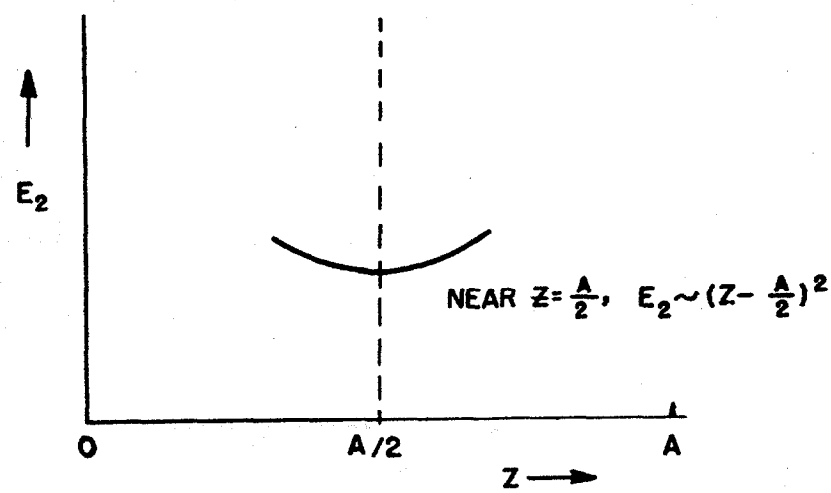

Figure 48. Quadratic shape of energy surface.

a-93-88