an explosive chain reaction. If, indeed, we introduce in a system of this type one initial neutron, this will give rise to a fission in which two neutrons will be produced. In their turn they will give rise to a second fission and produce two neutrons each and so on. The number of neutrons will then double at each step or "generation" so that their number will rapidly multiply until the reaction reaches extreme violence and great amounts of heat are developed. This sudden release of energy produces the atomic explosion. The system as just discussed is said to have a "reproduction factor" of 2 because at each generation one neutron gives rise to 2 new neutrons.

FAST NEUTRON AND SLOW NEUTRON REACTIONS

In designing a bomb one tries to achieve conditions in which the fission energy is released as fast as possible. This requires that the "generation" time be as short as possible and that at each generation the number of neutrons should increase by the largest possible factor. In order to make the generation time short one will use fast neutrons and in order to make the reproduction factor as large as possible one will try to adjust things in such a way that a large percentage of the neutrons end up by producing a new fission and thereby the largest possible number of new neutrons.

If we want, instead, to produce a controllable chain reaction, the reproduction factor will have to be very close to 1 and there will be no need to have a short generation time. Indeed it would be, if anything, more desirable that the generation time be rather long because this would make control more easy. It is possible therefore to use slow neutrons in a controlled chain reaction. There is one more fundamental difference between the bomb and a controlled chain reaction. The fast reaction on which the bomb is working is operated using "valuable" fissionable materials like U^{235} which is separated from uranium at Oak Ridge, Tennessee, or plutonium which is a new element which is actually fabricated at Hanford, Washington.

Controllable chain reactions can instead be obtained using natural uranium. Indeed this material was used in producing the first chain reaction for the simple reason that at that time the "valuable" fissionable materials were not available. It also is used in all the industrial piles that have been constructed so far. Natural uranium consists primarily of a mixture of U^{238} representing about 99.3 per cent of the total and U^{235} representing about .7 per cent. It is well known that it is this small amount of U^{235} that makes the reaction possible since U^{238} does not react giving rise to fission when bombarded by slow neutrons. Actually a chain reaction can be obtained quite easily using pure U^{235} since thereby one avoids the parasitic absorption due to the U^{238}. When ordinary unseparated uranium is used the problem is appreciably more difficult since the positive excess in the neutron balance in each generation is in this case very small and all unavoidable losses must be kept to a minimum so as to end up with a reproduction factor larger than unity. From this point of view, therefore, the presence of U^{238} is very undesirable. On the other hand U^{238} plays a very essential role in the plutonium production. Indeed U^{238} is transformed during the reaction into plutonium by the mechanism represented in the following nuclear process:

$$U^{238} + n \longrightarrow U^{239}$$
$$U^{239} \longrightarrow N_p^{239} + 0^-$$
$$N_p^{239} \longrightarrow Pu^{239} + 0^-$$

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The first of these reactions represents the absorption of a neutron by the nucleus 238 which is thereby transformed into the isotope U^{239}. U^{239} is an unstable isotope of uranium which spontaneously disintegrates by emitting an electron and transforming into the new element neptunium of atomic charge 93