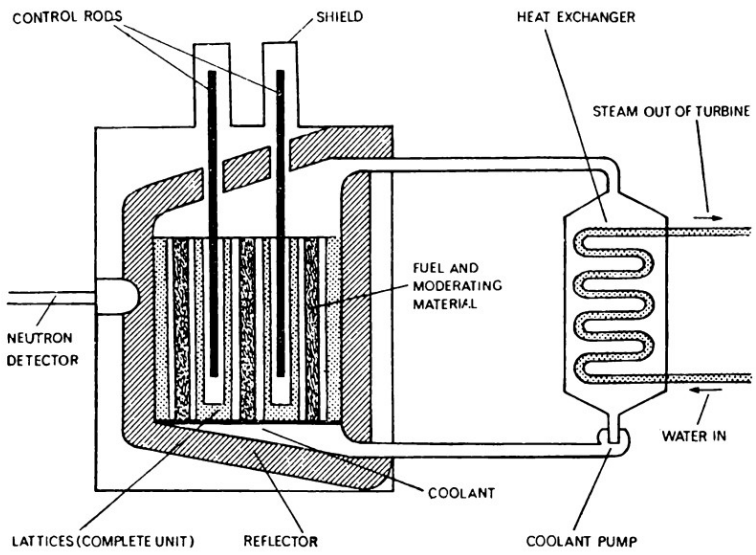
Chapter 2

Reading: Chain Reaction

When fission occurs, an average of 2.5 neutrons are emitted from the nucleus.
If the fission process can be ***so arranged*** that one of these liberated neutrons is captured by another U-235 nucleus to produce another fission, then the reaction will become self-sustaining.
When emitted, neutrons travel at a high velocity, and it is known that such fast neutrons have little chance of being captured by the fissile uranium.
However, **if slowed down** to thermal speeds, their probability of capture is greatly increased. In the normal thermal reactor, the uranium is surrounded by a large mass of moderating material. The liberated neutrons ***collide*** repeatedly with the light atoms of the moderator ***in such a way that*** they lose much of their energy and eventually become thermalised. The moderator may be either a liquid such as heavy water, or a solid such as graphite. Both these substances are of low atomic weight and have low neutron absorption cross-sections. With the graphite moderator, the uranium which is generally in the form of rods is inserted into channels cut out of the graphite. These channels ***are so arranged as to*** form a lattice structure, the object of which is to reduce neutron escape to a minimum. Provided that a sufficient mass of uranium is disposed in a number of rods through the moderator, a high enough proportion of the emitted neutrons will find their way to fissile nuclei to produce a chain reaction. The minimum quantity of uranium required to initiate the chain reaction is called the critical mass.

Once irradiated, the uranium fuel elements tend to lose strength and become wrinkled. It is therefore necessary to encase them in a can or cladding of some material such as aluminium or magnesium. These cans are ***designed so that*** they not only support the uranium inside, but also contain the highly radioactive fission products, and prevent reaction taking place between the fuel and the coolant.

A chain reaction can be initiated by inserting more and more fuel elements into the reactor core until the critical mass is attained. It can be terminated by withdrawing the rods. **Once started**, the chain reaction must be ***controlled in such a way that*** a steady neutron flux rate, and thus a steady production of heat energy, is maintained. The simplest method of control is by inserting control rods of cadmium, or some similar material with a very high neutron absorption cross-section, into the moderator. The purpose of the control rodsis to absorb the neutrons emanating from a fissioned nucleus. If therefore there is an increase in the neutron flux rate in the reactor, more control rods can be inserted until the reaction rate is stabilised again: that is, until the multiplication factor is exactly 1.



Cross-section of thermal reactor

Word study

Maintain

The aircraft ***maintained*** the same speed for several hours. (= keep up)
Steam tightness is ***maintained*** by means of asbestos packing.
The back pressure is ***maintained*** at a constant value by the condenser.
The flow of steam must be sufficient to ***maintain*** the pressure.
These nickel alloys ***maintain*** their strength at very high temperatures.

The machinery is very simple to ***maintain***. (= keep in good condition)
Maintenance should be carried out regularly. (= inspection and repair)

Sustain

The car driver ***sustained*** serious injuries in the crash. (= suffered)
The factory ***sustained*** heavy damage in the fire.

The shield must be capable of ***sustaining*** very high temperatures. (= withstand)
The metal ***sustained*** a lot of hammering, and needed normalising.

The lift from the wings must ***sustain*** the whole weight of the aircraft. (= support)
In order to ***sustain*** the chain reaction, the multiplication factor must be unity. (= keep going)

Contain

The tank ***contained*** ten gallons of petrol. (= hold)

The pressure vessel is designed to ***contain*** the effects of an explosion in the core. (= keep in)
All radioactivity must be ***contained*** within the biological shield.
The ***containment*** of radioactive particles is one of the chief concerns of the designerof a nuclear reactor.

Retain

Permanent magnets are capable of ***retaining*** their magnetism indefinitely. (= keep)
The exhaust steam ***retains*** a considerable amount of heat
The nut is ***retained*** by a cotter pin. (= hold in position)

Flux

A ***flux*** is a substance added to a metal to assist its melting.
A welding ***flux***, such as sand or borax, is applied to a weld to prevent oxidation ofthe metal.
The neutron ***flux*** in a reactor is the neutron density X the neutron velocity.
The luminous ***flux*** is the rate of flow of light from any source.
The magnetic ***flux*** is the number of lines of force passing through a medium.

Dispose of (= throw away, get rid of)

The government has a lot of surplus equipment it wants to ***dispose of***.
Radioactive waste must be carefully stored until it can safely be ***disposed of***.
These machines are obsolete, and will be ***disposed of*** as soon as possible

Emit, Emanate

1. *a.* A radar transmitter ***emits*** radio pulses, which are reflected back.
   b. A heated body ***emits*** radiations to its surroundings. (= throws out)
   c. An electron gun ***emits*** electrons.
   d. A nucleus ***emits*** neutrons when fission takes place.

   e. The biological shield reduces radioactive ***emissions*** from the reactor core to almost nothing

2. *a.* The heat rays which ***emanate*** from a body can be measured by a pyrometer.
   b. The hot gases which ***emanate*** from a jet-pipe travel at very high velocity. (= come from)
   c. The neutrons which ***emanate*** from a fissioned nucleus are fast.
   d. The biological shield reduces radioactive ***emanations*** from the reactor core to almost nothing.

Patterns

1. Manner (1)

Compare these two statements :

a) The bridge was ***so well built that*** it lasted for a hundred years.
b) The bridge was ***so designed that*** it would last for a hundred years.

Or this variation of the statements :

a) The bridge was strongly built, ***so that*** it lasted for a century.
b) The bridge was ***designed so that*** it would last for a century.

The patterns used are almost identical, but the emphasis is different.
The a) statements emphasise the ***result***, which is often ***unintentional***.
The b) statements emphasise the ***deliberate way*** or ***manner*** in which the results are brought about.

Here are the patterns for this type of statement:

1. The air drier can be ***modified in such a way that*** it fits inside the boiler.
   The air drier can be ***modified so that*** it fits inside the boiler.
   The air drier can be ***so modified that*** it fits inside the boiler.

2. The air drier can be ***modified in such a way as to*** allow it to fit inside the boiler.
   The air drier can be ***modified so as to*** allow it to fit inside the boiler.
   The air drier can be ***so modified as to*** allow it to fit inside the boiler.

2. When, Once, If, etc. + *Past Participle*

We can shorten a time clause or if-clause in two ways:

a)	***After*** ***On*** ***Before*** ***During***	separation …	=	***After*** ***When*** ***Before*** ***While***	it	is was has been	separated.
b)	***When*** ***While*** ***Once*** ***If***	separated …	=	***When*** ***While*** ***Once*** ***If***	it	is was has been	separated.

When, while, once and ***if*** must be followed by an ***-ed form of the verb*** in this construction, not by a noun.

c) Notice that these four words can also be used with an ***adjective.***
when necessary
if possible
once full
while still hot

3. Arrangements

a) = *Plans*

1.	The government will ***arrange to*** employ the redundant workers elsewhere. The government will ***arrange for*** redundant workers to be employed elsewhere.
2.	The employers must ***arrange to*** install safety devices on all machines. The employers must ***arrange for*** safety devices to be installed on all machines.
3.	***a. Arrangements*** have been ***made*** to employ the redundant workers elsewhere. ***Arrangements*** have been ***made*** to install safety devices on all machines ***b. Arrangements*** are ***made*** to pass the flue gases up both sides of the boiler.

b) = *Positioning*

1.	The boiler steam drums can be ***arranged*** in a variety of ways. The boiler steam drums can be ***disposed*** in a variety of ways.
2.	The fuel elements are ***arranged*** in a lattice in the moderator. The fuel elements are ***disposed*** in a lattice in the moderator.
3.	The orbiting electrons are ***arranged*** in shells at varying distances from the nucleus. The orbiting electrons are ***disposed*** in shells at varying distances from the nucleus.
4.	The engines can be ***arranged*** radially round the crankshaft. The engines can be ***disposed*** radially round the crankshaft.
5.	The ***arrangement*** of the heating surface varies with the type of boiler. The ***disposition*** of the heating surface varies with the type of boiler.
6.	The ***arrangement*** of the tubes at an angle over the furnace ensures good water circulation. The ***disposition*** of the tubes at an angle over the furnace ensures good water circulation.

c) = *System*

A ***system*** of gears connects the turbine shaft to the air-compressor.
An ***arrangement*** of gears connects the turbine shaft to the air-compressor.

The heating ***system*** in the factory **is** quite inadequate.
The heating ***arrangements*** in the factory **are** quite inadequate.

d) = The idea of ***arrangement*** is closely connected with ***Manner***

The cooling system of the reactor must be so ***disposed*** that the steam generators are not exposed to radiation.
The cooling system of the reactor must be so ***ordered*** that the steam generators are not exposed to radiation.
The cooling system of the reactor must be so ***planned*** that the steam generators are not exposed to radiation.
The cooling system of the reactor must be so ***rranged*** that the steam generators are not exposed to radiation.
The cooling system of the reactor must be so ***organised*** that the steam generators are not exposed to radiation.
The cooling system of the reactor must be so ***designed*** that the steam generators are not exposed to radiation.
The cooling system of the reactor must be so ***set out*** that the steam generators are not exposed to radiation.