# ATOMS AT WORK

# WHAT ARE ATOMS?

# YOU

## are made of ATOMS and so is everything around you

Over a hundred different types of atoms are known. Ninety of these are found naturally on the earth, the other dozen are made artificially in reactors and accelerators.

Each of these hundred species of atoms has a different name—for instance hydrogen, helium, iron, sulphur, etc. They differ from each other in chemical properties and are called the Chemical Elements.

They are the elementary units of MATTER which are usually joined together, in various arrangements, to give the more complex materials we meet in everyday life—for example:

WATER

WOOD

SUGAR

SALT

# ATOMS

**ARE**

VERY

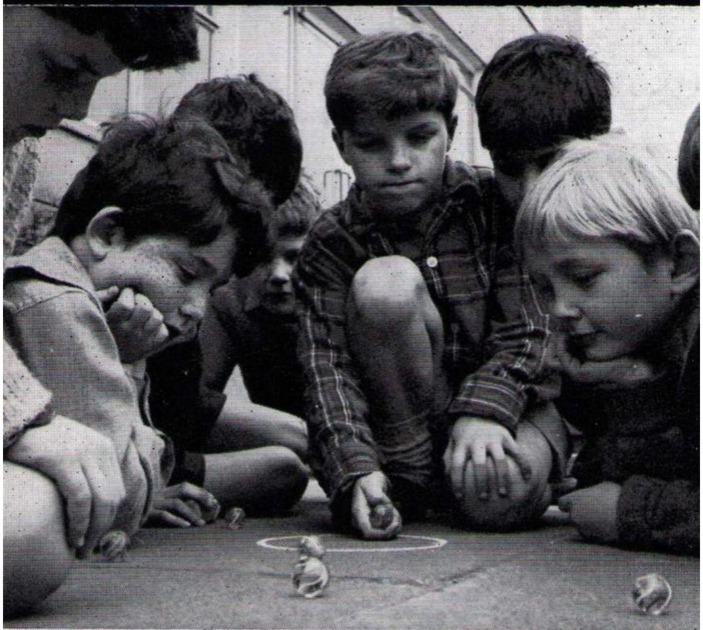
Small

The air inside an empty matchbox contains one thousand million million million atoms of oxygen and nitrogen.


Consider the number of ATOMS in a dot of printer's ink. They number more than the population of the world.

# WHAT ARE ATOMS MADE OF?

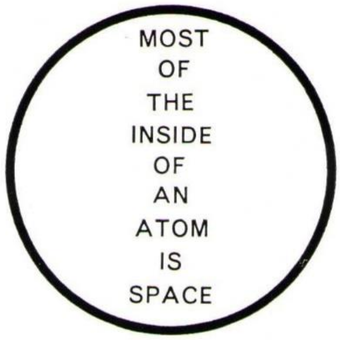
## ATOMS were once thought to be hard solid balls, like marbles



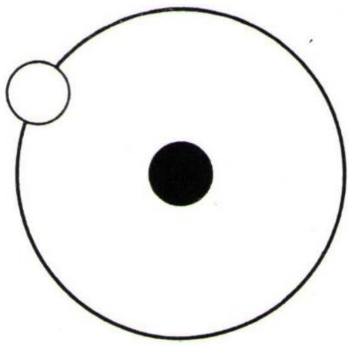
Nowadays an atom is thought of as a solar system—a "sun" in the centre with "planets" revolving round it.

The "sun" is called a NUCLEUS and the "planets" are called ELECTRONS.

The NUCLEUS and the ELECTRON are about the same size. Each of them is about a millionth of a millionth of an inch across.




If a hydrogen atom were magnified until it was 100 feet across, then the ELECTRON would be a pin's head revolving round another pin's head 50 feet away.



But the **NUCLEUS** is much heavier than the ELECTRON.

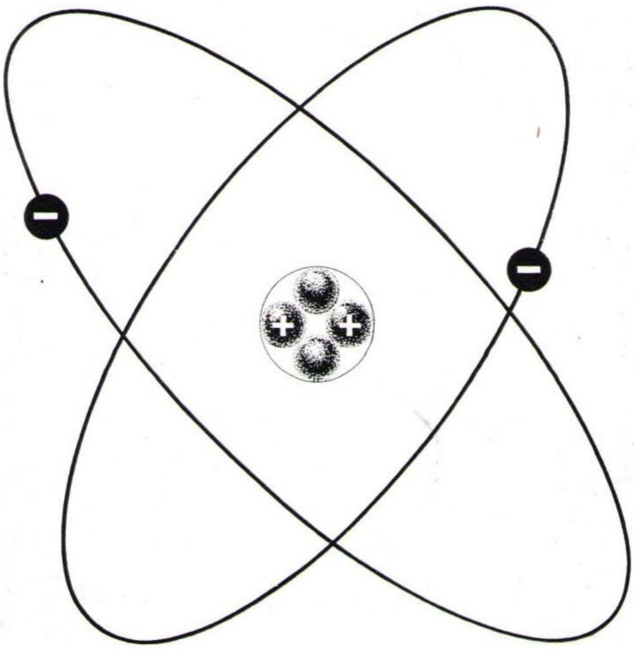
In our atom magnified to 100 feet.

one pin's head (ELECTRON) would weigh 10 tons

the other pin's head (NUCLEUS) would weigh 18,400 tons.

For more complicated atoms the nucleus would weigh much more, up to 238 times as much in the case of Uranium. Also there would be up to 90 or more electrons.

# WHAT HOLDS AN ATOM TOGETHER?



The NUCLEUS is not a single unit. It is made up of two different kinds of particle—PROTONS AND NEUTRONS.

Each PROTON carries a POSITIVE electric charge.

The NEUTRONS are electrically neutral.

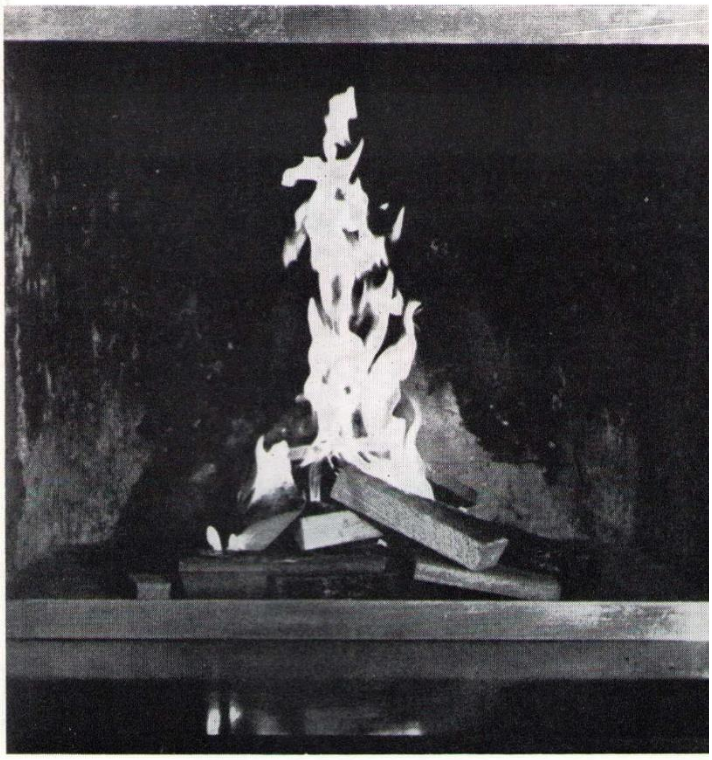
Each ELECTRON carries a NEGATIVE electric charge.

For every PROTON (+) there is an ELECTRON (—).

Thus electrostatic forces hold the ATOM together just as the force of gravity holds planets in their paths around the sun.

No one yet knows what exactly are the forces that hold a NUCLEUS together. (That is why nuclear physicists continue to work on this subject).

But it is clear that they are a MILLION TIMES AS STRONG as the chemical forces holding atoms together.



In a fire the electro-static forces which hold together the atoms in wood or petrol are rearranged and energy is released.

But if the much stronger forces which hold the nucleus together can be rearranged, a correspondingly greater amount of energy will be released.

Burning gives you **Chemical Energy**.

Breaking a nucleus ("splitting the atom" as it used to be called) gives you **Nuclear Energy.**

This **Nuclear Energy** is mostly released in the form of *Heat*.

For the same weight of fuel, **Nuclear Energy** releases more than a *million times* as much heat as **Chemical Energy**.

# USING THE ATOM'S ENERGY

HOW can one put to practical use the enormous energy which holds the nucleus together?

Scientists found that some atoms (including certain types of uranium) break into fragments when a single neutron is added to the central nucleus.

When this happens:

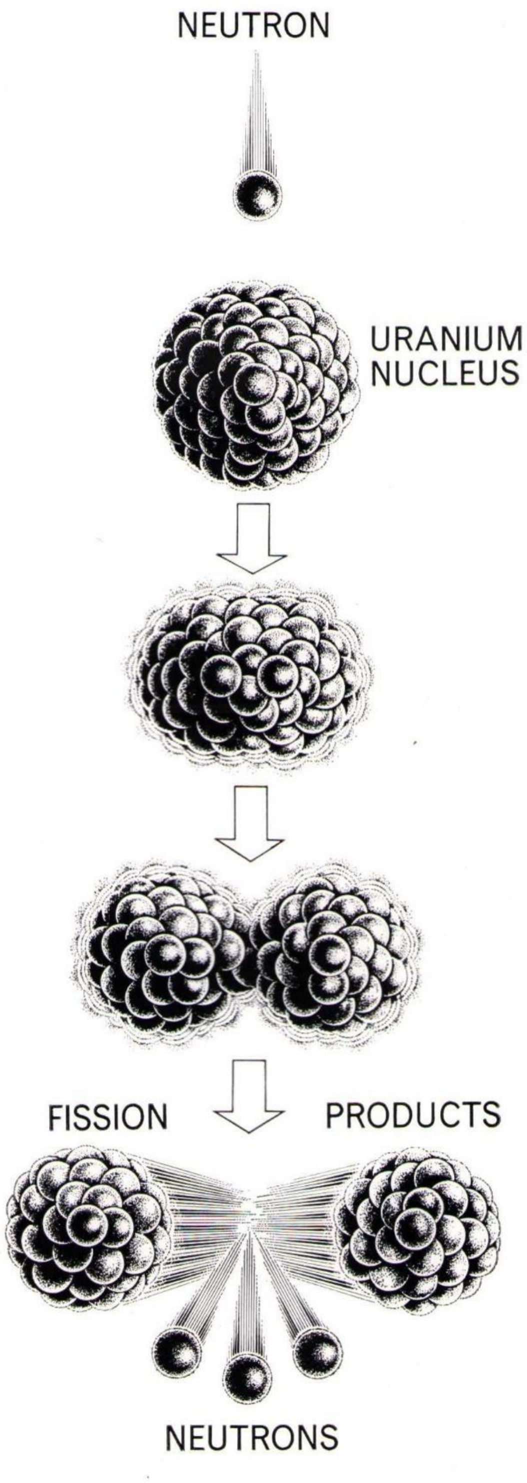
The uranium atom splits into two smaller atoms

energy is released, mostly as heat

Two or three neutrons are given off.

These can be used to split further nuclei and continue the process.

This is called a CHAIN REACTION. The uranium acts as fuel, and gets hot.


NEUTRON
URANIUM NUCLEUS
FISSION
PRODUCTS
NEUTRONS

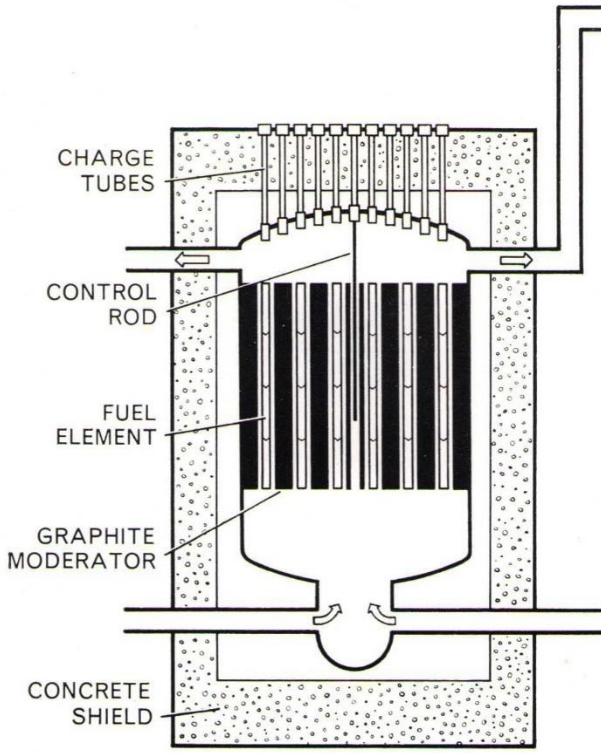
For the chain reaction to continue at a steady rate the number of neutrons which carry on the reaction must be controlled. This is generally done by absorbing excess neutrons in BORON, made up into CONTROL RODS.

Usually it is most convenient if the escaping neutrons are SLOWED DOWN so that they can more easily split the nuclei.

The neutrons are slowed down by surrounding URANIUM FUEL by a MODERATOR (so called because it moderates the speed of the neutrons). Most British reactors use GRAPHITE as the MODERATOR.

The whole assembly of FUEL, MODERATOR and CONTROL RODS is called a NUCLEAR REACTOR.

**REACTOR**



It is a new type of furnace in which HEAT is produced by splitting of URANIUM nuclei.

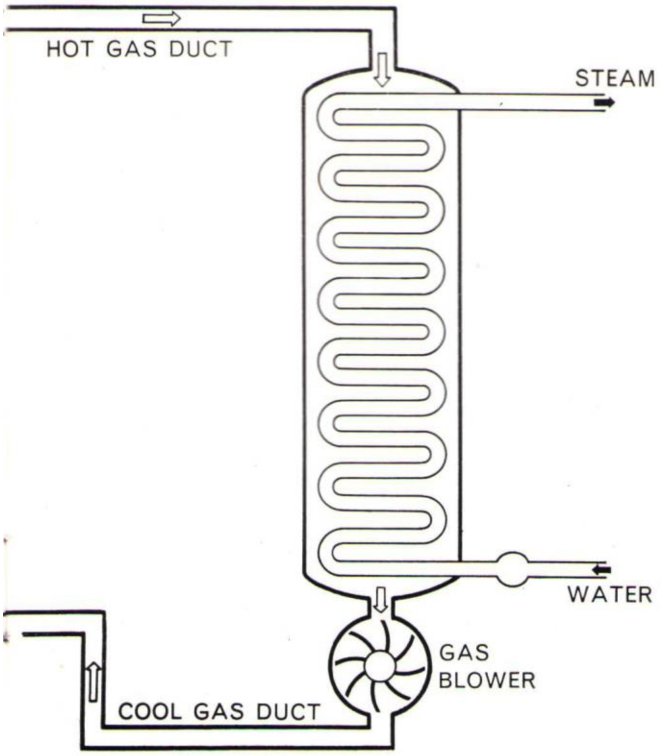
Two more items are needed:

1. A concrete shield to prevent the escape of dangerous RADIATION.
2. A means of transferring the HEAT. In British reactors such as CALDER HALL this is done by circulating CARBON DIOXIDE gas.

This HEAT is used to produce STEAM which will drive electricity generators.

So the power of the atom can be used to produce ELECTRICITY.

**HEAT EXCHANGER**



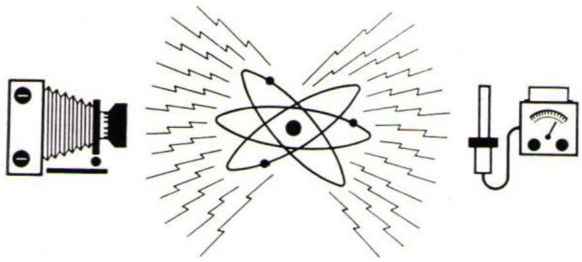
# AN INTRODUCTION TO RADIOISOTOPES

The useful applications of atomic energy fall into two main classes:—

The Production of Electricity

The Uses of RADIOISOTOPES

A RADIOISOTOPE (or radioactive isotope) is a material whose atoms are their own "radio station". Its presence can be detected by "signals" which register on photographic film or electronic instruments.



Because the RADIOISOTOPE has this quality of "detectability" it can (if you have the right instruments) be adapted to a variety of uses in

INDUSTRY
MEDICINE
AGRICULTURE
RESEARCH

It can for example be used

To take "X-RAY" PHOTOGRAPHS

To CHECK THE THICKNESS OF PAPER, METAL, etc.

To MEASURE THE FLOW OF LIQUIDS in pipelines

To CHECK THE CONTENTS OF PACKAGES in mass-production

By the use of isotope techniques BRITISH INDUSTRY is saving £4,000,000 A YEAR.

Radioisotopes are radioactive (or "unstable") versions of ordinary substances such as carbon, iodine, gold, etc.

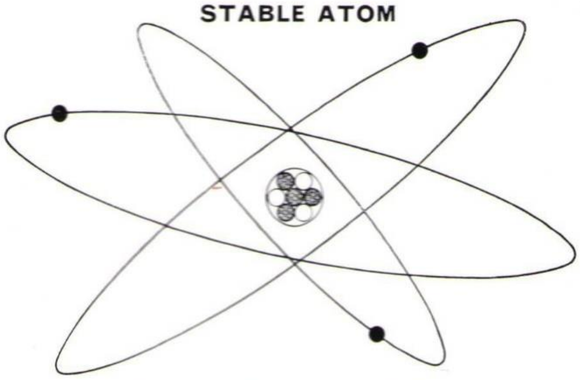
They are made artificially in reactors or other nuclear devices.

*Chemically* they are identical with the substances in their non-radioactive state.

The scientific explanation of this phenomenon is as follows:—

Usually in every atom there is one ELECTRON in orbit for each PROTON in the nucleus. In atoms other than ordinary hydrogen there are also NEUTRONS in the nucleus.

**STABLE ATOM**



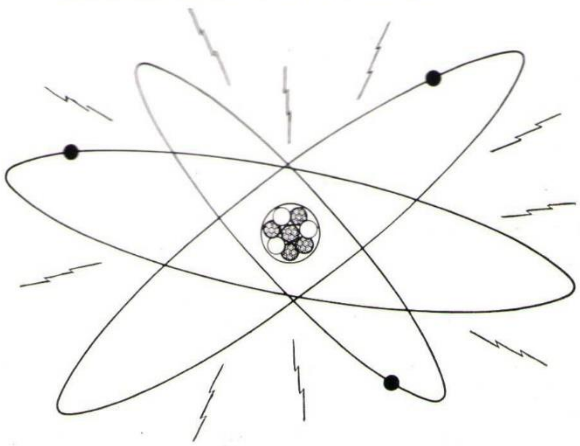
PROTONS ○○○ NEUTRONS
ELECTRONS ●●●

Atoms of any one element differing only in their number of neutrons are called ISOTOPES of that element.

An excess of neutrons in the nucleus can make an atom unstable, although it does not alter the chemical properties of the atom.

This instability results in the emission of radiation and such unstable isotopes are called radioactive isotopes, often shortened to radioisotopes.

**Radioactive UNSTABLE ATOM**



PROTONS ○○○ NEUTRONS
ELECTRONS ●●●

# SCIENCE FICTION PROPHESIED NUCLEAR ENERGY

In "The World Set Free" (1914) H. G. Wells prophesied atomic power stations would be operating in 1953.

Calder Hall, Britain's first atomic power station, began operation in 1956.