NUCLEAR POWER FOR THE FUTURE

Alfred Mamo

It has taken our Universe billions of years to evolve to its present organised state. And yet, in the span of only half a century, Man has discovered the fundamental nuclear particles — the proton in 1919 by Lord Rutherford and the neutron in 1932 by James Chadwick — and built nuclear power plants of such immense power that make the Industrial Revolution pale into insignificance.

Moreover, industrialised nations like the United States, Britain, Western Europe, Japan, Canada and Russia are consuming so much oil and coal that the prospects of future fuel supplies are indeed dismal; not to mention the facts, equally degrading, of the political and socio-economic repercussions resulting from underhand bartering for this 'Black Gold'. In fact, without nuclear power, these industrialised nations — and to a lesser extent the developing countries, too — will face ever-increasing imports of costlier and ever-dwindling supplies of oil and coal to burn in conventional power plants.

There are however, apart from oil/coal and Hydro-electric plants, other feasible, large-scale sources of energy: the sun, the sea and the wind. Science seems to have all the knowledge about solar, sea and wind power but Technology has, so far, failed to produce the Ultimate Machine that could transform the natural elements to useful efficient electrical power cheaper than the conventional and nuclear ones. It is true, for example, that in the French Pyrennees a large solar furnace has been constructed, its temperature being about 3500 degrees C.; new alloys have been fused there as part of the Space research programme. But very high temperatures on small masses do not constitute a large source of heat! And whatever is said about the Wind Machine at Filfla it is still a far cry from the desired industrial plant: "For which of you, intending to build a tower, sitteth not down first, and counteth the cost, whether he have sufficient to finish it?"

The future source of energy therefore seems to be nuclear energy. Indeed we already have it on a fairly large scale; there are at present 162 nuclear power plants in the world, 60 of them in the U.S.A. alone. It is also cheaper *to produce* electricity from nuclear energy now than air or coal (though not cheaper than hydro-electricity); compare:

Type of Fuel	Oil	Coal	Nuclear	Hydro
Cost (%)	£100	£70	£40	£5

Nuclear energy is of a much higher order than chemical combustion of

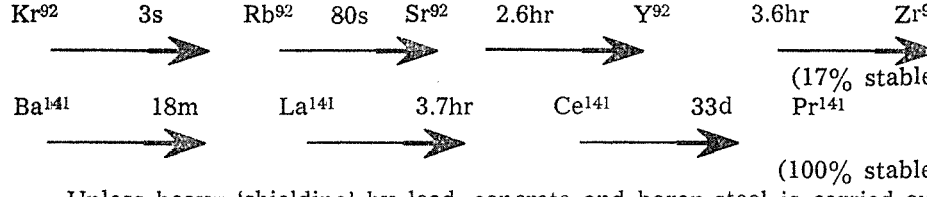
oil or coal; for example when ONE nuclide of Uranium-235 fissions in a nuclear reactor, it produces about 200 MeV of energy while the corresponding combustion of oil only produces about 4eV of energy, making nuclear energy about 50 million times more powerful than ordinary combustion! No wonder then that the nucleus is still a relatively untapped source of energy even.

The whole controversy over the expansion of the Nuclear Programme for peaceful means is built on ignorance of the fundamental facts. The man-in the street is misinformed by the mass media. Yet he wields great political power through his representatives that the nuclear programme may be halted or slowed down. This would indeed be detrimental to the whole human race, for, as William Blake (1757-1827) has written: "I must create a System, or be enslaved by another Man's; I will not reason and compare; my business is to create."

As every Science student should know, a fission reactor produces highly-excited by-products whenever a 'fast' or 'slow' neutron is captured by Uranium-238 or U-235 respectively. Consequently, extremely dangerous radiations, called alpha, beta and gamma rays, are released. A typical reaction would be as follows:

$n^1(\text{slow}) + U^{235} = Ba^{141} + Kr^{92} + 3\ n^1 +$ Energy of about 200-MeV

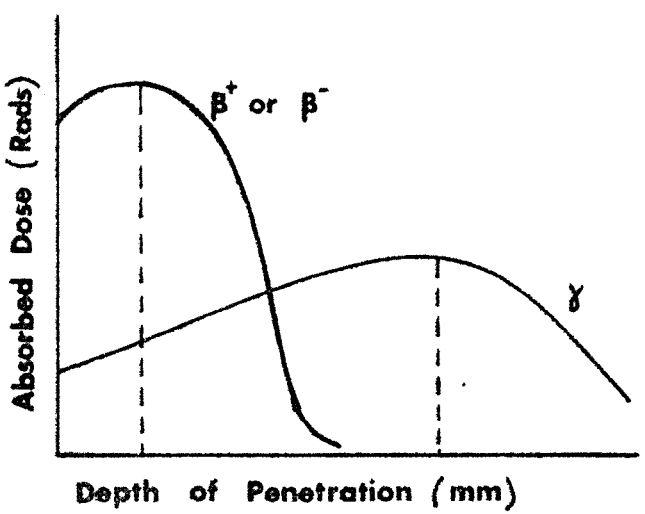
The three neutrons so produced are eventually moderated to thermal or 'slow' energies, hopefully to carry on the 'chain-reaction'. The energy inside the reactor core is then extracted by passing, say, carbon dioxide gas through the core and heating steam with it to drive electrical turbines. The binary heavy products are themselves highly-excited and would, over a period ranging from a few seconds to a few days, decay by beta-minus emissions to stable states:



Unless heavy 'shielding' by lead, concrete and boron-steel is carried out at these nuclear power plants, the harmful radiations escaping from the reactor core to the surroundings would cause great alarm among conservationists, ecologists, politicians AND scientists alike — a kind of 'fall-out' like that following the explosion of the atom bomb on Hiroshima and Nagasaki would result! But this is NOT the case! So far the safety record of the nuclear industry has been remarkable. Although, worldwide, about 25,000 people are employed at such sites as scientists, engineers, technicians, guards and ancillary staff, there hasn't been a single *radiation* fatality in any of these plants, a safety record which no other large industry can boast of. This is due mainly to the stringent safety measures laid down by the Nuclear Regulatory Commission of the U.S.A., the United Kingdom Atomic Energy Com-

are as many as twelve safety systems at work simultaneously in a nuclear-power plant. When for example, on March 22, 1975, a careless technician started a major fire which knocked out seven of the twelve safety systems at the Browns Ferry reactor in Alabama, the remaining five proved more than sufficient to prevent a catastrophic meltdown of the reactor plant. The chances of a major mishap are estimated to be 5,000 million-to-one, whereas the chances of being killed in a car accident are only 5,000-to-one. One is a million times safer working in a nuclear power plant than driving to it in any given year.

The 'shielding' and the safety systems make nuclear energy safer and more hygienic for people inside and outside the plant than oil or coal combustion in which such harmful pollutants as sulphur dioxide are produced. In fact, medical experts blame these pollutants for as much as 10,000 deaths yearly per million population through such causes as heart disease, asthma and lung infections. It is very true that exposure to nuclear radiations, especially gamma-rays and neutrons (we are on the verge of producing the dreaded 'Neutron Bomb') will cause cancer. Here medical physics comes into play by defining and standardising accepted dose levels and applying various dosimetry methods for preventive reasons. In such big hospitals as St. Bartholomeo's Hospital, London, there are nuclear physicists onsite as part of the medical team to assess, and prevent, the amount of radiation present during radiotherapy treatment of cervical cancer, ironically enough. It has consequently been found out that a short-time full-body exposure to 300R of gamma-radiation is fatal in 55% of the cases. (1R = 1 Roentgen = 2.58×10^{-4} Ckg^{-1} = unit of exposure.)



Although beta-rays have a lower penetration than gamma rays, nevertheless they cause epidermal cancer if the body is exposed to them. For example, the Beta-peak corresponds to the basal layers of the epidermis while the Gamma-peak of the graph corresponds to depths of the bone marrow and the testes.

Finally, there is still the unsolved problem of what to do with nuc-

lear 'waste', namely, Plutonium-239. A typical heavy-water reactor that generates enough power to supply the needs of one million people per year also produces enough plutonium that could destroy more than 20 million people at one go! The possibility of 'nuclear blackmail' by extremist groups is a real possibility since producing such plutonium-bombs is a relatively easy, though dangerous, process. Besides, dumping this 'waste' underground or on the sea-bed might increase pollution while breakage of the 'waste' container during transportation would be disastrous. This is the worst problem of the nuclear-power plant. However with the onset of the BREEDER reactor and the strong possibility of a controlled thermo-nuclear fusion process, the 'waste' disposal problem would be eliminated or, at least, reduced to good safety levels.

In any case, the abuse of the harmful drug 'Mandrex', should not stop its production. Similarly because the car causes so much pollution and has such a high accident rate, no one in his right senses advocates its abolition. Rather Science and Technology are researching into the 'Electrically-driven' car. The nuclear-power plant is here to stay in the foreseeable future, until perhaps superceded by solar, wind or thermonuclear fusion. We have now reached the point of no return!

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