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ON THE FEASIBILITY OF COAL-DRIVEN POWER STATIONS

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Editor's note: Dr. Frisch obtained his Ph.D. at the University of Vienna in 1926. He taught in Berlin and Hamburg, and later worked in Bohr's laboratory in Copenhagen. When his aunt, Lise Meitner, fled Germany and evolved the suggestion that uranium was undergoing fission under neutron bombardment, he collaborated in the paper that resulted. Dr. Frisch has since earned a reputation as a popular science writer. Along with his permission to reprint this imaginative and humorous article, Professor Frisch wrote, "I hope Iowans are so proud of their coal that they remember it is a valuable chemical, too valuable for burning!"

INTRODUCTION

The recent discovery of coal (black, fossilized plant remains) in a number of places offers an interesting alternative to the production of power from fission. Some of the places where coal has been found show indeed signs of previous exploitation by prehistoric men, who, however, probably used it for jewels and to blacken their faces at religious ceremonies.

The power potentials depend on the fact that coal can be readily oxidized, with the production of a high temperature and an energy of about 0.0000001 megawatt days per gram. That is, of course, very little, but large amounts of coal (perhaps millions of tons) appear to be available.

The chief advantage is that the critical amount is very much smaller for coal than for any fissile material. Fission plants become, as is well known, uneconomical below 50 megawatts, and a coal driven plant may be competitive for small communities (such as small islands) with small power requirements.

DESIGN OF A COAL REACTOR

The main problem is to achieve free, yet controlled, access of oxygen to the fuel elements. The kinetics of the coal-oxygen reaction are much more complicated than fission kinetics, and not yet completely understood. A differential equation which approximates the behavior of the reaction has been set up, but its solution is possible only in the simplest cases.

It is therefore proposed to make the reaction vessel in the form of a cylinder, with perforated walls to allow the combustion gases to escape. A concentric inner cylinder, also perforated, serves to introduce the oxygen while the fuel elements are placed between the two cylinders. The necessary presence of end plates poses a difficult but not insoluble mathematical problem.

FUEL ELEMENTS

It is likely that these will be easier to manufacture than in the case of fission reactors. Canning is unnecessary and indeed undesirable since it would make it impossible for the oxygen to gain access to the fuel. Various lattices have been calculated and it appears that the simplest of all—a close packing of equal spheres—is likely to be satisfactory. Computations are in progress to determine the optimum size of the spheres and the required tolerances. Coal is soft and easy to machine, so the manufacture of the spheres should present no major problem.

OXYDANT

Pure oxygen is, of course, ideal but costly; it is therefore proposed to use air in the first place. However, it must be remembered that air contains 78 percent nitrogen. If even a fraction of that combined with the carbon of the coal to form the highly toxic gas cyanogen, this would constitute a grave health hazard (see below).

OPERATION AND CONTROL

To start the reaction, one requires a fairly high temperature of about 988° F. This is most conveniently achieved by passing an electrical current between the inner and outer cylinder (the end plates being made of insulating ceramic). A current of several thousand amperes is needed, at some thirty volts, and the required large storage battery will add substantially to the cost of the installation.

There is the possibility of starting the reaction by some auxiliary self-starting reaction, such as that between phosphine and hydrogen peroxide; this is being looked into. Once the reaction is started, its rate can be controlled by adjusting the rate at which oxygen is admitted. This is almost as simple as the use of control rods in a conventional fission reactor.

CORROSION

The walls of the reactor must withstand a temperature of well over

1000°F in the presence of oxygen, nitrogen, carbon monoxide and dioxide as well as small amounts of sulphur dioxide and other impurities, some still unknown. Few metals and ceramics can withstand such gruelling conditions. Niobium with a thin lining of nickel might be an attractive possibility, but probably solid nickel will have to be used. For the ceramic, fused thoria appears to be the best bet.

HEALTH HAZARDS

The main health hazard is attached to the gaseous waste products. They contain not only carbon monoxide and sulphur dioxide (both highly toxic) but also a number of carcinogenic compounds such as phenanthrene and others. To discharge these into the air is impossible; it would cause the tolerance level to be exceeded for several miles around the reactor.

It is therefore necessary to collect the gaseous waste in suitable containers, pending chemical detoxification. Alternatively, the waste might be mixed with hydrogen and filled into large balloons which are subsequently released.

The solid waste products will have to be removed at frequent intervals (perhaps as often as daily), but the health hazards involved in that operation can easily be minimized by the use of conventional remote-handling equipment. The waste could then be taken out to sea and dumped.

There is a possibility—though it may seem remote—that the oxygen supply may get out of control. This would lead to melting of the entire reactor and the liberation of vast amounts of toxic gases. Here is a grave argument against the use of coal in favor of fission reactors which have proved their complete safety over a period of several thousand years. It will probably take decades before a control system of sufficient reliability can be evolved to allay the fears of those to whom the safety of our people is entrusted.