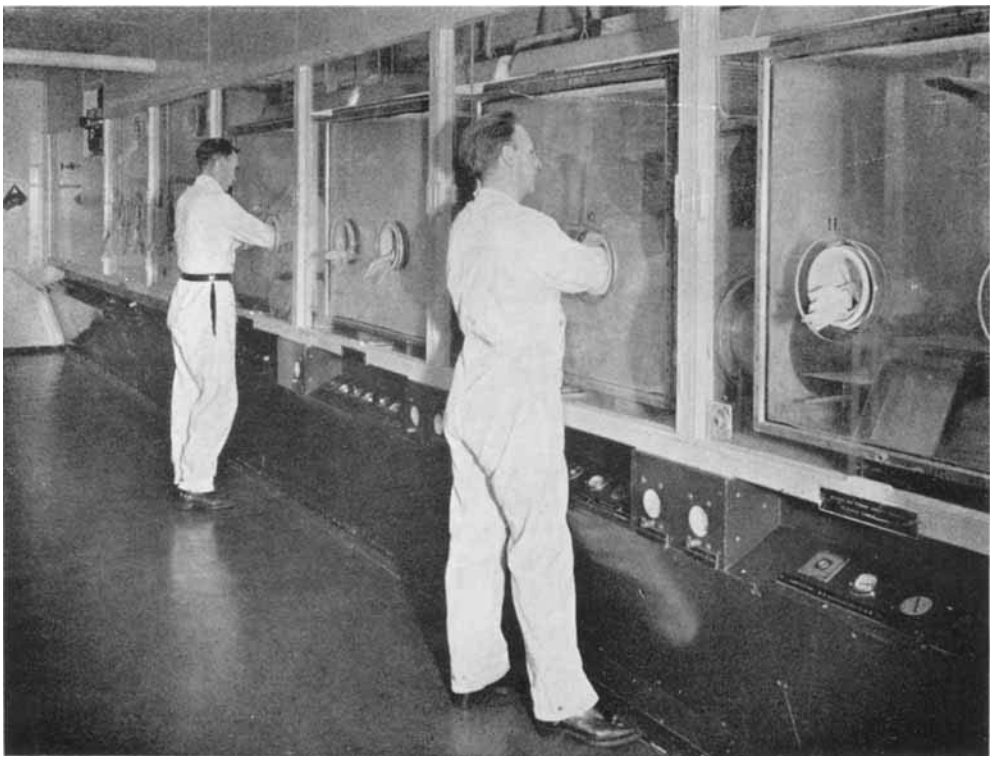
Extraction and Purification of Plutonium Metal

PLATINUM EQUIPMENT IN THE FINISHING PLANT AT THE WINDSCALE WORKS

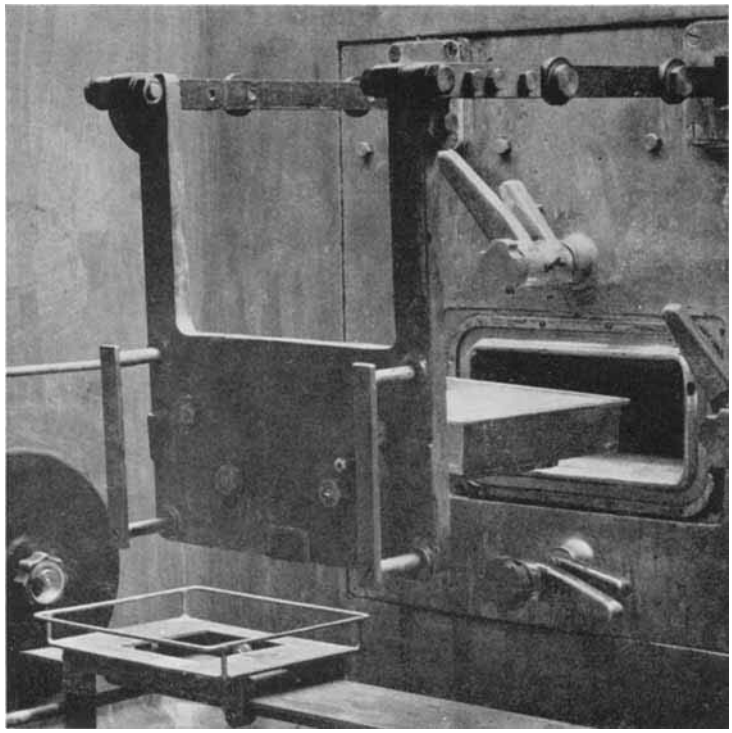
The extraction of plutonium from irradiated uranium and its subsequent purification constitute the primary task of the Windscale Works of the United Kingdom Atomic Energy Authority.

Plutonium is present in the irradiated rods to the extent of only about 300 parts per million, but the process developed gives a very high recovery efficiency and yields plutonium metal of 99.9 per cent purity.

After removal from the piles the uranium rods are first stored under water for several weeks to allow decay of the shorter-lived fission products and then dissolved in nitric acid in a continuous dissolver. Separation of uranium, plutonium and fission products is effected by a solvent extraction process, using dibutyl carbitol as the solvent. In the first stage uranium and plutonium nitrates are extracted together, leaving most of the fission products in the aqueous phase. In order to separate the plutonium from the uranium, the former is selectively reduced to the trivalent state, in which it is practically



The plutonium finishing line at the Windscale Works



One of the platinum lined electric furnaces in the plutonium purification plant at Windscale. Plutonium oxide, contained in a platinum tray, is converted to fluoride in these furnaces by high temperature treatment with anhydrous hydrofluoric acid

insoluble in the organic phase. The plutonium nitrate solution thus extracted is given a further purification cycle, first being re-oxidised to the tetravalent state, and is finally concentrated in batch evaporators.

Concentration and Reduction

At this point the plutonium is transferred to a separate plant designed to handle only a small throughput and to achieve high purity in the eventual product. Further purification and concentration are carried out here by a solvent extraction process, which yields a very pure aqueous solution ready for concentration.

Plutonium metal is prepared from this concentrate by precipitation, followed by conversion to oxide, thence to the tetrafluoride, using anhydrous hydrofluoric acid, and the reduction of this compound to metal with calcium in a small reaction vessel.

In these latter stages of the process the plutonium slurry from the wet process is handled in platinum trays. In the fluorination stage of the process a tray and its contents of plutonium oxide are placed in one of a battery of high temperature electric muffle furnaces into which anhydrous HF gas is passed for several hours. These furnaces, built by the Electric Resistance Furnace Co. Ltd., are lined with platinum in order to withstand attack by hydrogen fluoride, while the doors are kept as cool as possible by means of polished platinum heat reflecting shields mounted on their inner sides.

Precautions in Handling

Throughout the process it is naturally necessary to handle plutonium and its compounds in very small batches in order to avoid the accumulation of a critical assembly. It is also essential to eliminate any possibility of plutonium escaping from the plant, either in solution or as fine particles of dust. The equipment is therefore enclosed in stainless steel boxes with Perspex windows maintained at sub-atmospheric pressure.