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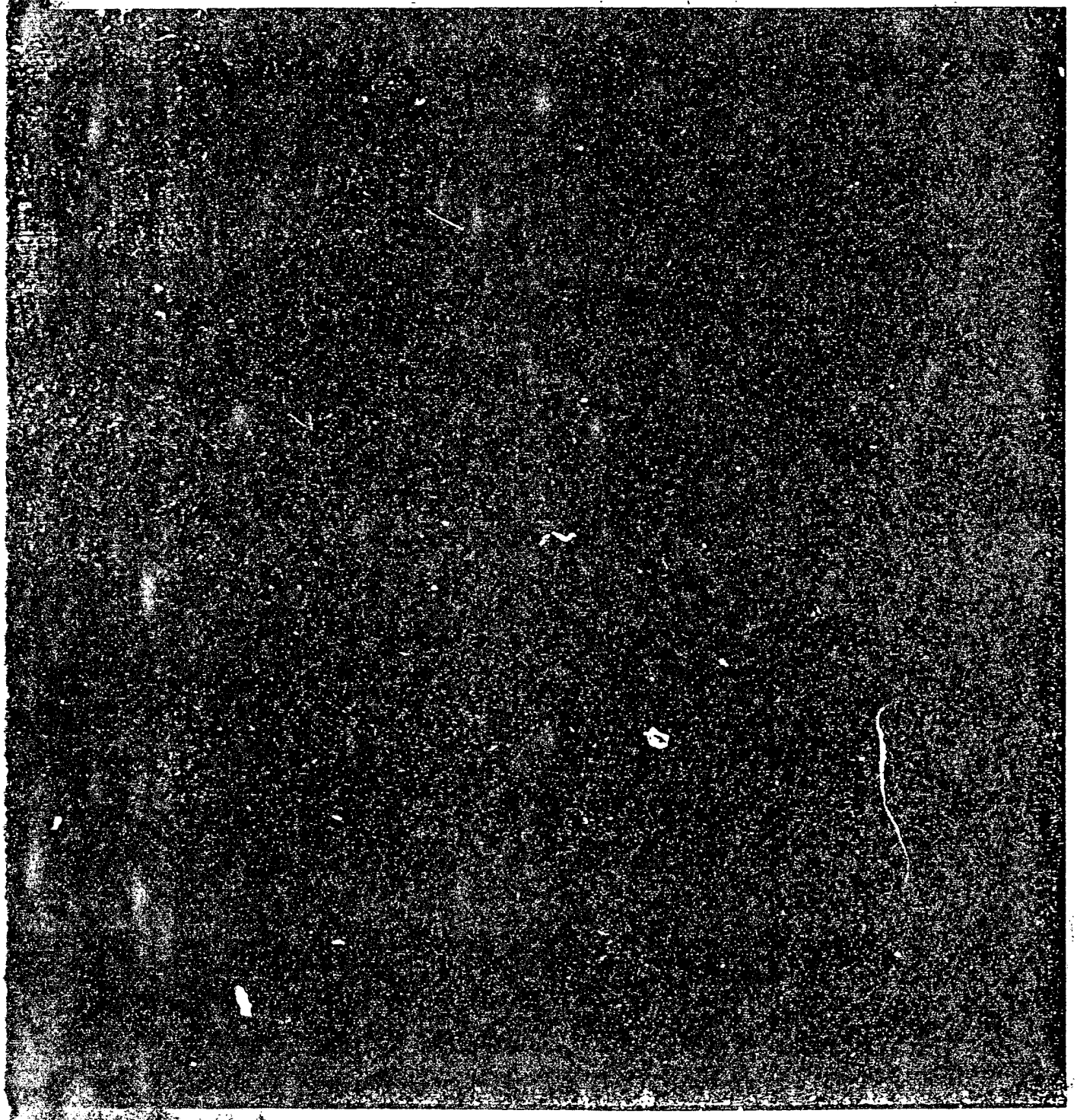

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PREFACE

This study examines the facilities at the Bhabha Atomic Research Center near Bombay, the organizational structure and key personnel of the Center, and the research being conducted there. The purpose is to attempt to identify the facilities in which the Indians developed and fabricated the components for the May 1974 nuclear device and the scientists at the Center who were involved in the test.

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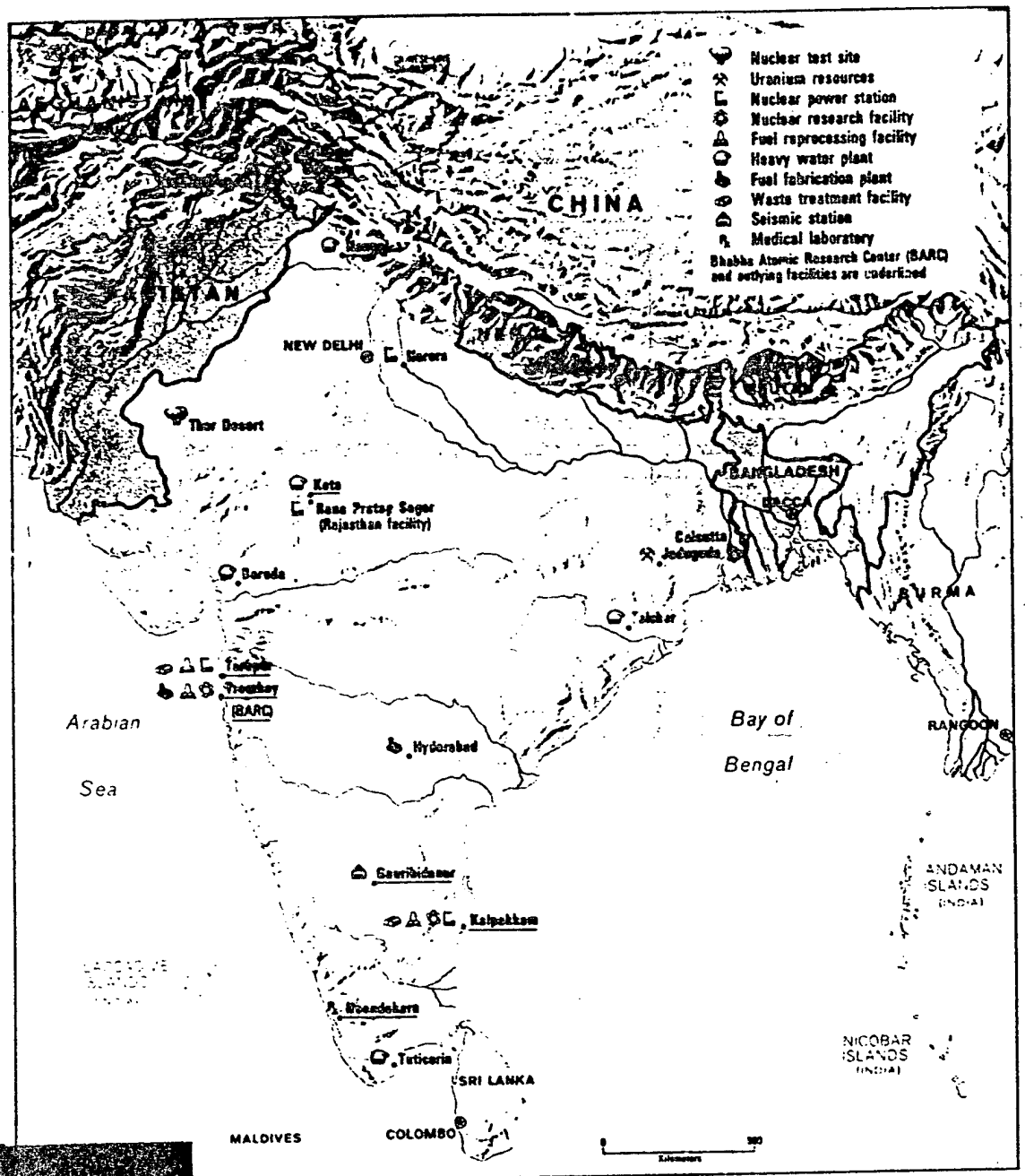

Principal Indian Nuclear Facilities

[redacted]

The Bhabha Atomic Research Center Near Bombay, India

Central Intelligence Agency
National Foreign Assessment Center

November 1978

Key Judgments

- The Bhabha Atomic Research Center (BARC) on Trombay Island near Bombay is India's largest nuclear research installation. [redacted] most of its laboratories and facilities, including three of the four operating research reactors, were built without foreign assistance.
- The bulk of the nuclear research carried out at BARC has direct peaceful applications, and some of the primary activities involve research with plutonium. [redacted] The plutonium research concentrates on the use of plutonium in mixed-oxide fuel fabrication for experimental breeder reactor fuels. [redacted]
- Some of the scientists now in charge of facilities at BARC were directly involved in the 1974 test of a nuclear explosive. [redacted]

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SUMMARY

The Bhabha Atomic Research Center (BARC) near Bombay is India's principal center for nuclear research and development. It has four operating research reactors, and a fifth—designated the R-5—is under construction. The R-5, like the CIRUS reactor obtained from Canada in the late 1950s, will be capable of producing plutonium that could be used in nuclear weapons. [redacted] Facilities are also present for fabricating uranium metal and uranium dioxide into reactor fuel. A laboratory at BARC is developing, and is capable of fabricating, mixed (plutonium-uranium) oxide fuel pins for a fast breeder test reactor at a research center being constructed at Kalpakkam.

The Fuel Reprocessing Division of the Center operates a reprocessing plant that has separated plutonium from the spent fuel of the CIRUS reactor. The plant is currently shut down, however, for modifications and expansion to enable it to reprocess spent fuel from the R-5 after that reactor becomes operational. [redacted] The research is administered under 10 major groups, mostly in scientific and engineering fields: physics, metallurgy, chemistry, reactor operations and engineering, radioisotope production, electronics, chemical engineering, radioactive waste management, nuclear medicine, and biology.

The bulk of the nuclear research being conducted is strictly peaceful in nature, and the rest at least has peaceful applications. The research reactors are used for nuclear experiments in the basic sciences, for engineering studies of future power and research reactors, and for training of personnel. A large number of radiopharmaceuticals, biochemicals, and labeled compounds are produced from radioisotopes that are obtained from the reactors. Studies are being conducted on the use of radiation for food preservation, and a variety of nuclear instruments and other specialized equipment and apparatus for India's atomic energy program are developed and manufactured in laboratories and workshops at Trombay.

Not all of the research done at the Center is nuclear related. Nonnuclear research includes desalination studies and a pilot project to develop an electrothermal process for producing fertilizer from phosphates.

[redacted]

A number of BARC elements are located elsewhere in India. These include such activities as a seismic station for detecting earthquakes and nuclear explosions, a research facility for conducting high-altitude physics research, and those parts of the organization that oversee the construction and operation of BARC-designed and -engineered installations.

[redacted]

Several separate organizations also have been established as a result of BARC activities or projects. These spinoff organizations are the Reactor Research Center near Kalpakkam, the Variable Energy Cyclotron Facility near Calcutta, the Electronics Corporation of India Ltd. plant at Hyderabad, and the Nuclear Fuel Complex at Hyderabad.

[redacted]

Current research in plutonium metallurgy and chemistry appears to be directed toward improving Indian fuel fabrication and reprocessing technology. The main effort in radiometallurgy is centered on the development of mixed-oxide reactor fuel.

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The Bhabha Atomic Research Center Near Bombay, India

Development of Facilities

History and Early Facilities

The Bhabha Atomic Research Center (BARC) is located on Trombay Island, about 10 kilometers northeast of Bombay. It was set up in 1954 by the Indian Atomic Energy Commission (IAEC) to conduct research and development on the peaceful uses of atomic energy. Initially named the Atomic Energy Establishment, Trombay, the Center was given its present name in honor of Dr. Homi J. Bhabha, who was the leading proponent of a nuclear program in India and the Center's first director. Dr. Bhabha died in an airplane accident in 1966.

Dr. Bhabha was the first chairman of the IAEC, which has been in existence since 1948 as an advisory group to the Indian Government in nuclear matters. In order to supervise the entire nuclear effort and to provide a link between the IAEC and Parliament, the government of India established a separate department in August 1954—the Department of Atomic Energy (DAE)—under the direct supervision of the Prime Minister. BARC, therefore, had its beginning as the major research body under the DAE; its director automatically serves as the member in the IAEC for research and development.

The initial activities undertaken by BARC for the IAEC were putting a thorium plant into production and forming an electronics group. [3] These facilities are still in operation in the southern end of the Center, referred to as the industrial area (figures 1 and 2). The thorium plant was built to process thorium and small quantities of uranium from monazite sands mined along the southwestern coast in Kerala. This activity formed the nucleus for a DAE support organization, Indian Rare Earths Ltd., which is responsible for this activity. The Electronics Group, still an integral part of BARC, was set up to develop and fabricate control systems and peripheral health and safety equipment for reactors. An outgrowth of this group has been the Electronics Corporation of India Ltd., located in Hyderabad, which now supplies instrumentation for nuclear power projects and digital computers for the DAE as well as various equipment unrelated to nuclear activities.

In 1955 the IAEC decided, as its first major research project, to construct a 1-megawatt-thermal (MWt) reactor of the swimming-pool type at BARC. This indigenous reactor, called APSARA, uses enriched uranium fuel elements that were supplied by the United Kingdom (table 1). It was built in the industrial area and went into operation in August 1956.

About the time that the decision to build APSARA was made, India was considering another reactor for engineering research and for radioisotope production. In 1955 Canada offered to supply a natural uranium-fueled, heavy-water-moderated research reactor for this purpose, and a formal agreement for a joint project was signed between the two countries in April 1956. Construction began later in 1956, and the costs and responsibilities were shared until the reactor, the Canada India Reactor (CIR—later CIRUS), was completed. Upon completion in July 1960, full title and control passed to the government of India.

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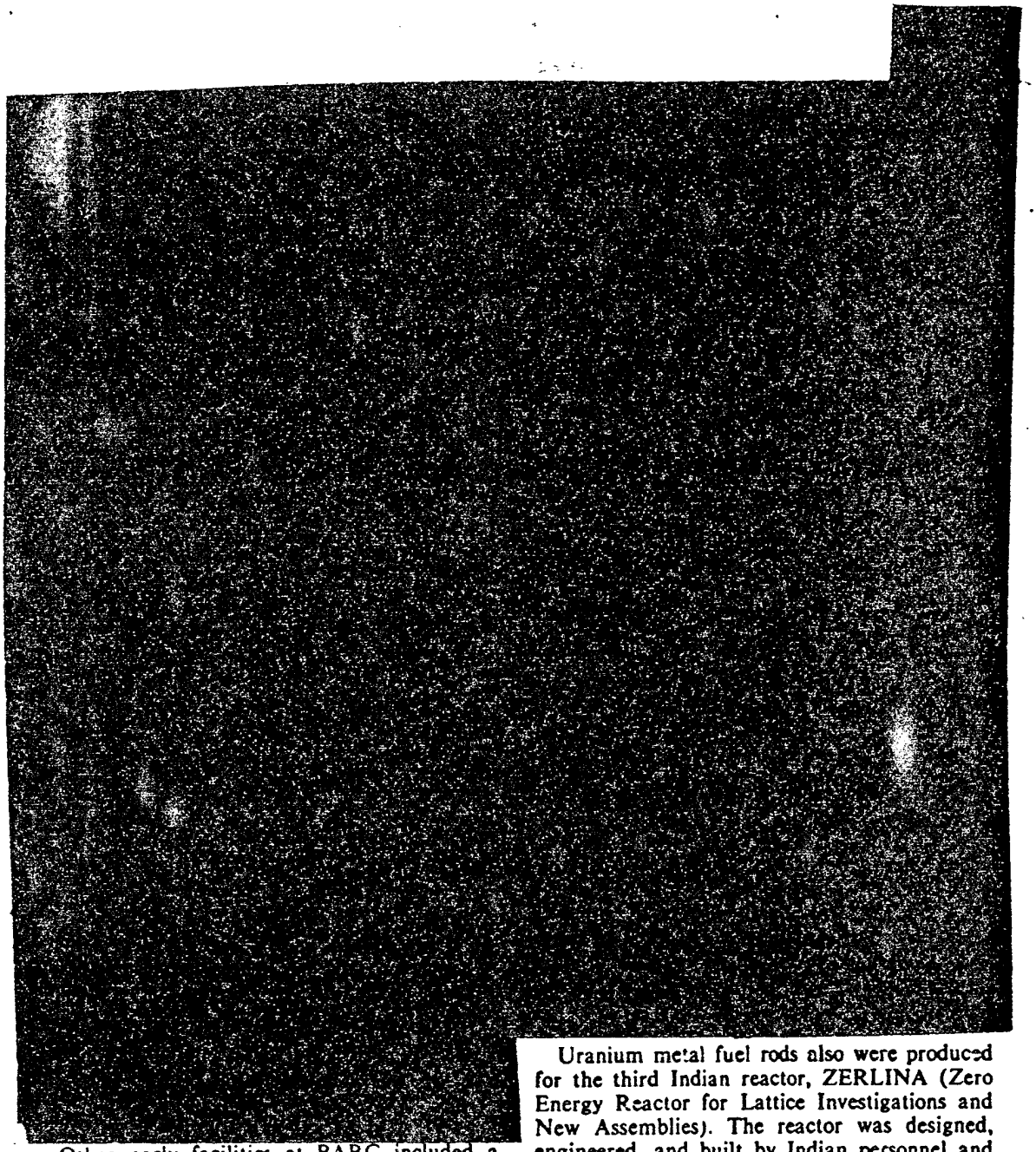

Other early facilities at BARC included a uranium metal plant and a fuel element fabrication plant.

Uranium metal fuel rods also were produced for the third Indian reactor, ZERLINA (Zero Energy Reactor for Lattice Investigations and New Assemblies). The reactor was designed, engineered, and built by Indian personnel and began operating in January 1961 for research into the physics of CIRUS-type cores. By 1967 it had been converted to operate with uranium dioxide (UO_2) fuel elements in a heavy-water

Table 1

Research Reactors at Trombay and Kalpakkam

Name	Reactor Type	Criticality Date	Maximum Power (thermal)	Fuel	Coolant & Moderator	Peak Core Flux (n/cm²/sec)	Uses
APSARA	Swimming pool	Aug 1956	1 MW	Enriched uranium (80% uranium-235)	Light water	10^{13}	Radioisotope production; solid state and nuclear physics research; training
CIRUS	High-flux research	Jul 1960	40 MW	Natural uranium	Light water (C); heavy water (M)	6×10^{13}	Radioisotope production; nuclear chemistry, and engineering loop experiments; materials testing; solid state and nuclear physics research; plutonium and uranium-233 production
ZERLINA	Zero energy	Jan 1961	100W	Natural uranium	Air (C); heavy water (M)	10^{7}	Fuel element configuration studies; control loop experiments; fundamental research of nuclear properties
PURNIMA	Fast neutron	May 1972	10W	Plutonium dioxide (I) uranium-233 (II)	Not required	10^{9}	Study of fast reactor systems and as a critical assembly fueled with uranium-233
R-5	High-flux research	1981	100 MW	Natural uranium	Heavy water	3×10^{14}	Radioisotope production; power reactor engineering studies; nuclear and solid state physics research; plutonium production
FBTR (Kalpakkam)	Fast breeder test	1981	42.5 MW	Uranium dioxide (70%); plutonium dioxide (30%)	Liquid sodium (C); not moderated	8×10^{15}	Development of fast breeder technology; sodium coolant research

moderator for researching the core physics of the CANDU-type[1] power reactor that India is building.

Additional uranium also was beginning to be obtained from mining and milling operations carried out at Jaduguda by the Uranium Corporation of India Ltd. (UCIL), a public sector company set up by the DAE.

Construction commenced on the nuclear fuel reprocessing plant in the northern area of BARC in the early 1960s. This plant, referred to by the Indians as the Trombay Plutonium Plant, was designed and built by BARC personnel for the purpose of separating plutonium from fuel elements irradiated in CIRUS.

A heavy-water reconcentration plant was commissioned in September 1960. Other construction in the 1960s included research laboratories, engineering halls, and various administrative, service, and support facilities. Most of the construction was in the central area.

[1] CANDU is a Canadian power reactor that is fueled with natural uranium and moderated by heavy water.

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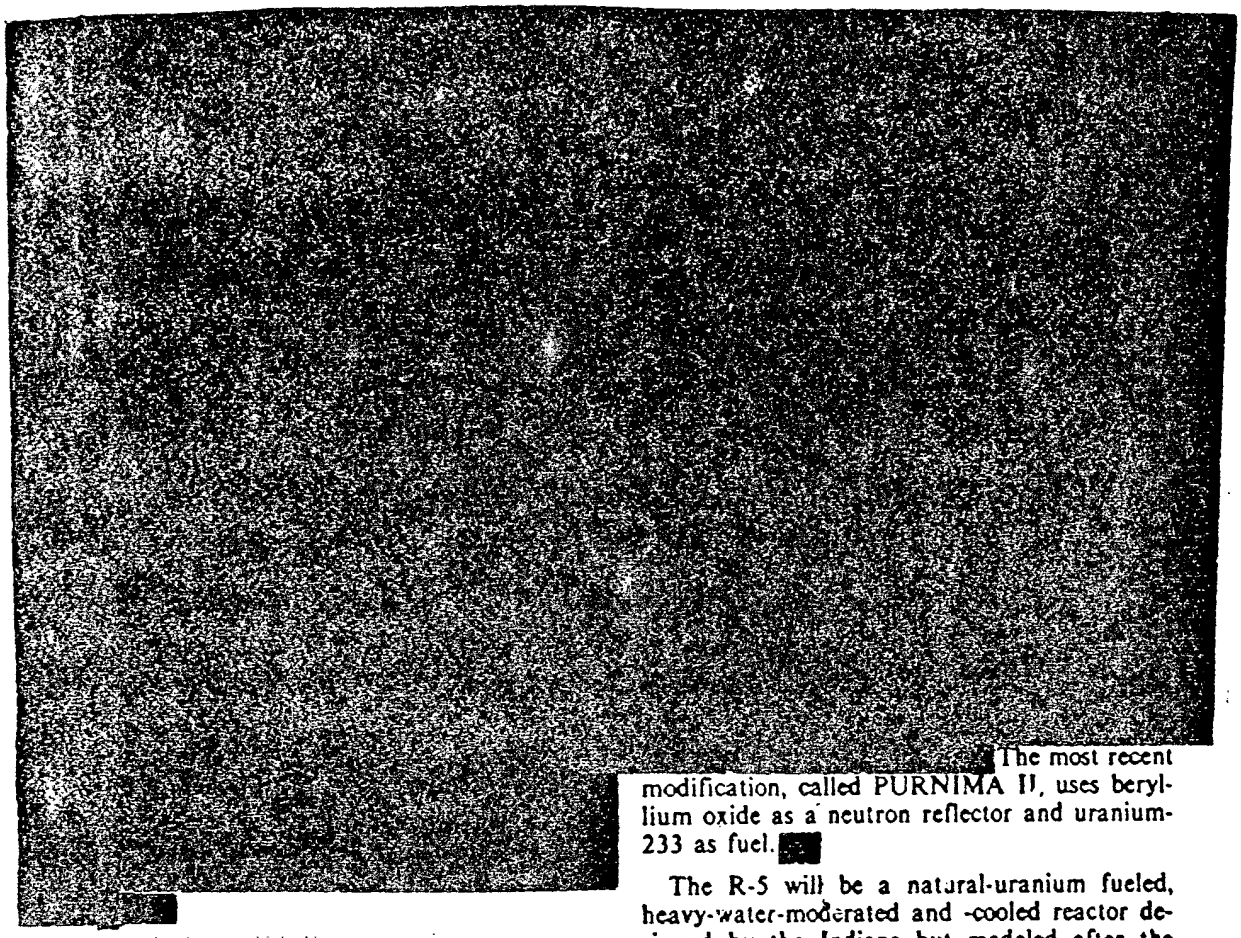


Facilities Built in the 1970s or Under Construction

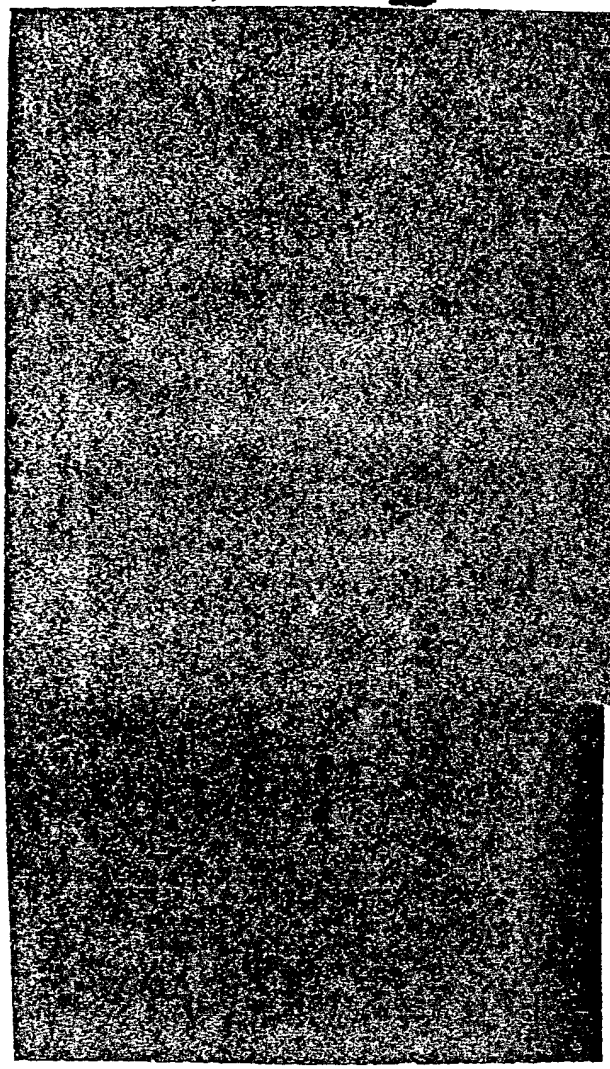
A zero-power experimental fast reactor, PURNIMA, and a 100-MWt research reactor called R-5 (which is still under construction) are among the newer facilities at BARC. PURNIMA (Plutonium Reactor for Neutronic Investigations in Multiplying Assemblies) was put into operation in May 1972. The most recent modification, called PURNIMA II, uses beryllium oxide as a neutron reflector and uranium-233 as fuel.

The R-5 will be a natural-uranium fueled, heavy-water-moderated and -cooled reactor designed by the Indians but modeled after the Canadian NRU reactor. The R-5's ostensible purposes are to provide a test bed for power reactor fuels and to produce radioisotopes. The R-5 is scheduled for completion in 1981.

The fuel reprocessing plant at BARC was shut down, probably in late 1976, for plant modification and eventual expansion.

A building for the High Intensity Radiation Utilization Project (HIRUP) was commissioned in 1972 for the Isotope Division of BARC. This facility is used for research into industrial applications of radiation sources. A radiation plant for the sterilization of medical products, called ISOMED, was also built in the industrial area and completed in 1974.

The Center's work is carried out administratively under groups, several subgroups, divisions, and sections. It is not within the scope of this study to describe the functions and responsibilities of all these units (much of which is available in unclassified annual reports of the DAE).



Facilities Under Control of BARC and Spinoff Organizations

Besides the units at Trombay and in the Bombay area, BARC controls or oversees elements located elsewhere in India. These include the High Altitude Research Laboratory in Gulmarg, the Nuclear Research Laboratory in Srinagar, the Gauribidanur Seismic Station north of Bangalore, the Waste Immobilization Project at Tarapur, the Centralized Waste Management Facility at Kalpakkam, a medical laboratory at

Neendekara, and a network of environmental survey laboratories and air monitoring stations. The Architecture Section at BARC is involved in various construction projects for the DAE, and the Engineering Group oversees the operation of the power reactor fuel reprocessing plant at Tarapur and the heavy-water plant at Nangal as well as ongoing construction of the Kota Heavy Water Plant.

A number of spinoff organizations have resulted from BARC activities or projects. The Reactor Research Center (RRC) near Kalpakkam was organized in 1971 for the development of fast reactor systems. Formerly, there had been a Fast Reactor Studies Section at BARC, headed by Dr. S. R. Paranjpe; this activity was transferred to the RRC when research laboratories there were completed. The first phase of RRC's development program is to operate a mixed (plutonium-uranium) oxide-fueled fast reactor, currently under construction, which will serve as a test bed for breeding uranium-233 from thorium-232. The project director of this program is N. Srinivasan, who had been head of the Fuel Reprocessing Division at BARC. Reprocessing of the spent fuel will be an important aspect of the fast reactor fuel cycle. A fuel reprocessing laboratory being built at the RRC will be used for detailed investigations of fuels of high fissile material content such as are used in fast reactors. These investigations will provide a base for a full-scale reprocessing plant that is planned for Kalpakkam. The ultimate objective of the RRC is to be able to design fast breeder power stations fueled with uranium-233.

Another spinoff organization is the Variable Energy Cyclotron (VEC) Facility near Calcutta. The VEC will be used as a national facility for advanced work in nuclear physics, for production of charged-particle-induced radioisotopes in biological and agricultural products, and for radiation damage studies having applications in power and fast reactor technology. The 262-ton magnet of this particle accelerator was fabricated in the Central Workshops at BARC. The magnet and many of the instruments and electronic components were designed, developed, and subsequently assembled in Calcutta by BARC scientists and engineers. This facility became partially operational in June 1977, and a number of scientists formerly stationed at BARC were transferred to Calcutta. The manager is Dr. A. S. Divatia, who earlier had been in charge of the Van de Graaff accelerator at BARC.

Other organizations also had their beginnings at BARC. As previously mentioned, the Electronics Corporation of India Ltd. (ECIL) at Hyderabad was formed from the electronics production unit of BARC. ECIL produces on a commercial scale a variety of nuclear and nonnuclear instruments, components, and control instruments. A. S. Rao, once director of the Electronics Group at BARC, is the managing director of ECIL. The Nuclear Fuel Complex (NFC), also at Hyderabad, is a public-sector company producing fuel elements for power reactors. NFC was designed, built, and staffed by the Chemical Engineering and Atomic Fuels Divisions of BARC. The director of the Atomic Fuels Division, N. Kondal Rao, is also the chief executive of the NFC.

The DAE has direct authority over several units that are sometimes mistakenly thought to belong to the BARC organization. One such unit is the Power Projects Engineering Division, which is responsible for the design, construction, and commissioning of nuclear power plants. Commercial management of operating power plants is done by the Atomic Power Authority. The Atomic Minerals Division of DAE is also separate from BARC. This division, headquartered in Hyderabad, is responsible for locating uranium, thorium, and other minerals for the Indian nuclear program. The Uranium Corporation of India Ltd. (UCIL) was formed from the Atomic Minerals Division. Other DAE units which have personnel stationed at BARC include the Directorate of Purchase and Stores and the Civil Engineering Division. BARC, however, has its own Civil Engineering Division for looking after construction activities at the Center and in outlying facilities under its control.

Possible Weapon-Related Research

Introduction

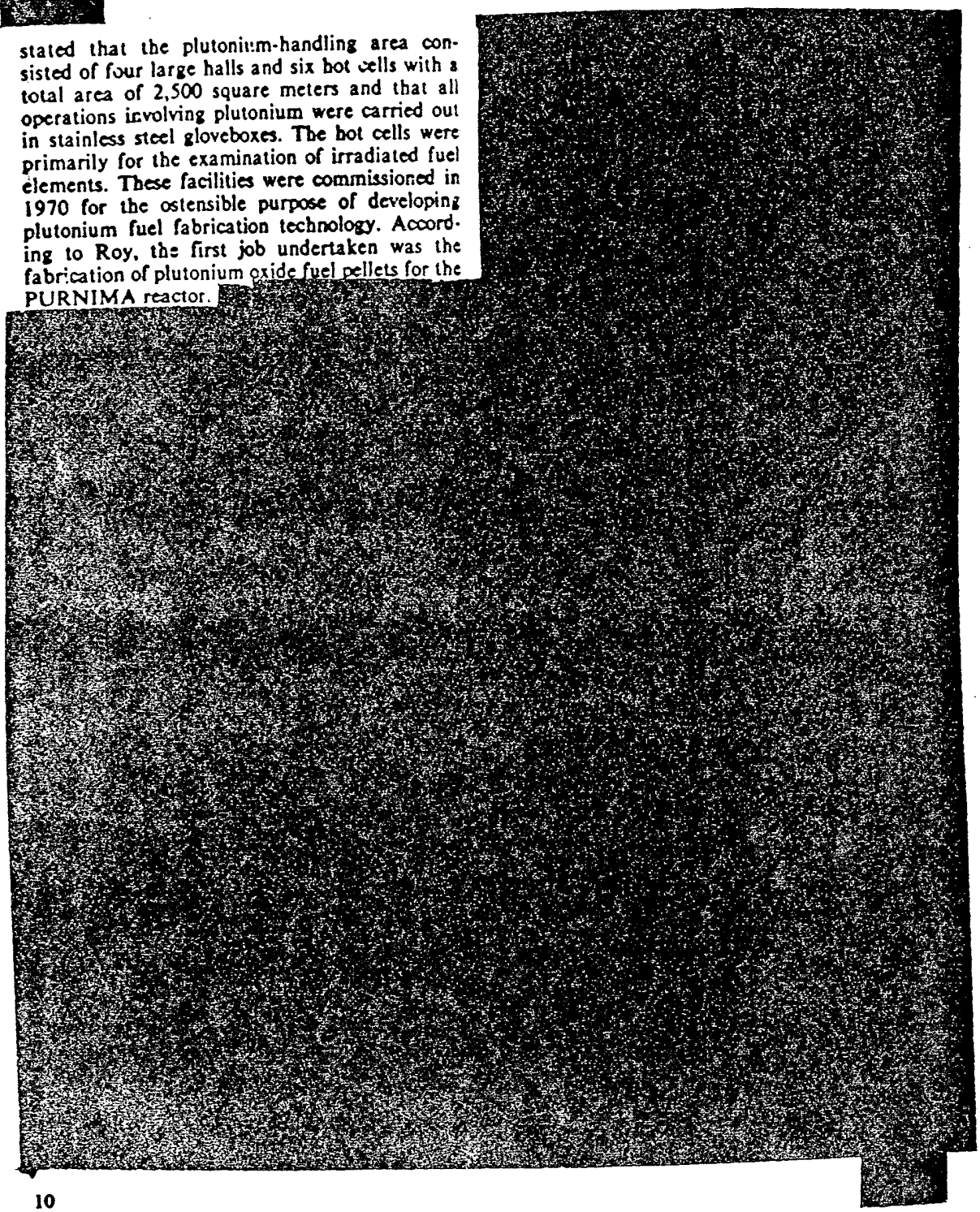
Several facilities at BARC were instrumental in providing the fissile material for the 1974 Indian nuclear test. Certain individuals who then had and still have responsible positions at BARC were associated with that test.

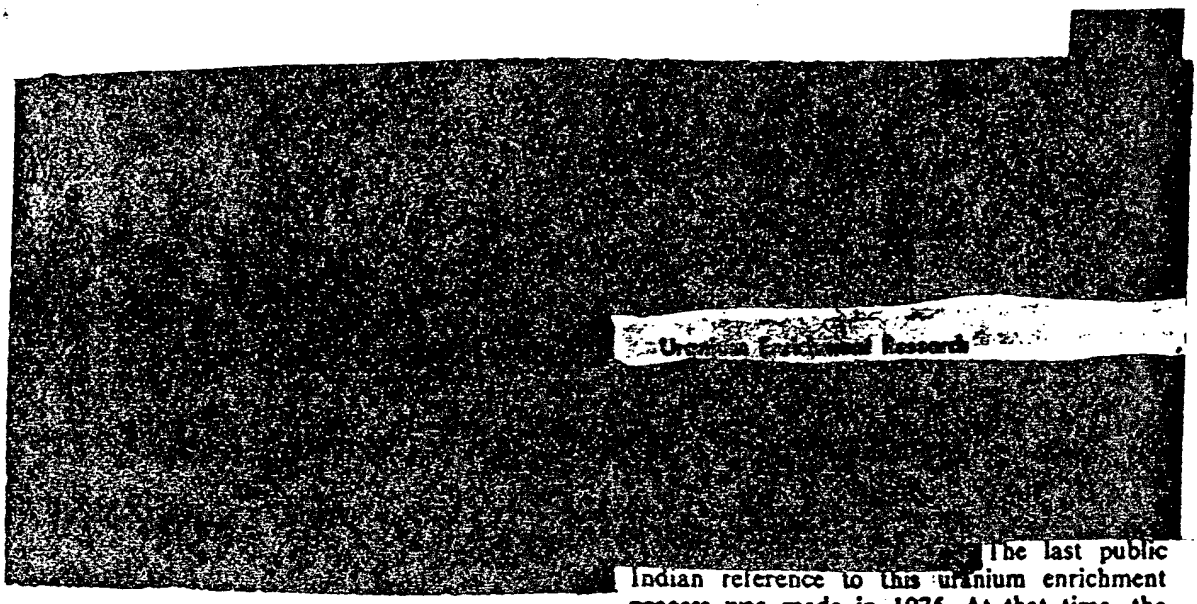
Facilities and Individuals Associated With the 1974 Test

As previously stated, the nuclear test in 1974 used plutonium produced in the CIRUS reactor and separated in the fuel reprocessing plant at BARC.

The facilities were described in detail in a professional paper written by Roy. He

stated that the plutonium-handling area consisted of four large halls and six hot cells with a total area of 2,500 square meters and that all operations involving plutonium were carried out in stainless steel gloveboxes. The hot cells were primarily for the examination of irradiated fuel elements. These facilities were commissioned in 1970 for the ostensible purpose of developing plutonium fuel fabrication technology. According to Roy, the first job undertaken was the fabrication of plutonium oxide fuel pellets for the PURNIMA reactor.





Uranium Enrichment Research

The last public Indian reference to this uranium enrichment process was made in 1975. At that time, the DAE annual report mentioned that the machining of the components and assembly of the motor test assembly for the centrifuge project was successfully carried out in the central workshops of BARC.

Other Research

Plutonium Research

Ongoing research with plutonium at BARC centers around improving Indian fuel fabrication and reprocessing technology.

The main effort of the Radiometallurgy Section is developing and fabricating mixed-oxide (plutonium-uranium) fuel pins for the fast breeder test reactor at Kalpakkam.

[1] UF_6 is the gaseous medium for the process, and the heavier molecules of the gas are separated from the lighter molecules by spinning the gas in ultra-high-speed centrifuges—each a vertical, hollow cylinder mounted on a rotor. Hundreds or even thousands of centrifuges are required to obtain significant quantities of enriched material.

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