Uranium, Radium, and Thorium

By Jack W. Clark and H. D. Keiser

GENERAL SUMMARY

URGENCY was the keynote of the atomic energy program in 1950. Definite knowledge prevailed that the U. S. S. R. possessed the atomic bomb; moreover, the confession of Dr. Klaus Fuchs and the defection of Prof. Bruno Pontecorvo provided reason for believing that the Soviet Union possessed sufficient information for further rapid development of atomic weapons. Communist aggressors in Korea drove back United Nations forces the latter part of the year, and on December 16, 1950, President Truman proclaimed a state of national emergency. Congress soon thereafter approved appropriations for the atomic energy program, bringing the total to over $2,000,000,000 for the fiscal year ending June 30, 1951.

Construction of the so-called hydrogen or superbomb was authorized early in 1950, and on November 28 the Atomic Energy Commission announced plans for a $260,000,000 Savannah River Project in Aiken and Barnwell Counties, S. C. As further needs developed for the atomic energy program as a whole, this project was increased in scope before the close of the year. In addition, the AEC announced on December 15 plans for constructing a new $500,000,000 facility at the Kentucky Ordnance Works, near Paducah, Ky., to produce uranium-235 by the gaseous diffusion process, thereby increasing markedly the future availability of that atomic bomb material.

This same rapid expansion featured all phases of the atomic energy program in 1950. Production of domestic uranium ore was the highest on record, placing the United States ahead of Canada in rank and second only to the Belgian Congo. Outputs of the fissionable isotope uranium-235 and plutonium were at new record rates and at new low unit costs. Shipments of radioisotopes were substantially larger in number than in any previous year.

MINE AND MILL PRODUCTION

Most of the production of domestic uranium ore in 1950 resulted from greatly increased activity in the Colorado Plateau region in southwestern Colorado, southeastern Utah, and northeastern Arizona. More than 200 separate mining operations employing an aggregate of at least 1,600 men were reported.¹ Plants for processing the ores were operated by the Vanadium Corp. of America at Naturita and Durango,

Colo.; the United States Vanadium Corp. at Rifle and Uravan, Colo.; and the Galigher Co. (for the AEC) at Monticello, Utah. A pilot plant for treating copper-uranium ores was operated at Hite, Utah, by the Vanadium Corp. of America. Two additional plants were nearing completion as the year closed—that of the Climax Uranium Co. at Grand Junction, Colo., and the plant taken over for remodeling at Salt Lake City, Utah, by the Vitro Manufacturing Co. Uranium ore processing operations were described.

Exploratory diamond drilling on the Colorado Plateau in 1950 by the AEC and by the Geological Survey on behalf of the AEC was at a combined rate of 300,000 to 400,000 feet a year and effected an increase in ore reserves. Development operations in the Marysvale, Utah, area during 1950 were so encouraging that the AEC opened an ore-buying station at Marysvale on March 15 and on August 30 announced the accumulation of a stockpile of 1,000 tons of ore at the station, with some receipts of ore assaying 0.8 percent \( U_3O_8 \). Similar results were achieved during the year in the Lukachukai Mountains area, in the northern part of the Navajo Indian Reservation, Ariz., where 50,000 feet of diamond drilling was completed by the AEC in 1950. Probably the most significant uranium discovery in 1950 was that made almost at the year end near Grants, N. Mex., along the main line of the Atchison, Topeka & Santa Fe Railway Co., where carnottite was found in limestone. The discovery extended the known limits of the sedimentary uranium deposits in the region.

Other significant developments in 1950 included further exploration of the primary uranium occurrence discovered during 1949 in the Sunshine mine, Coeur d'Alene district, Idaho; prospecting by the Jones & Laughlin Ore Co. of the pitchblende deposit discovered late in 1949 on the upper peninsula of Michigan; and exploration at the Caribou mine, in the Colorado Front Range. Additional promising prospects were reported to have been found during 1950 in Arizona, Colorado, Idaho, Michigan, Montana, Nevada, New Mexico, Utah, and Wyoming, with an increasing number of mining companies investigating uranium deposits.

The possibility of recovering uranium from low-grade uraniferous sediments continued to have the consideration of the AEC in 1950. These sediments comprise principally the black shales, particularly the Chattanooga shale of the east-central United States and its equivalent in the midcontinent area; the land-pebble phosphate deposits in Florida; and the Phosphoria formation in Idaho, Montana, Utah, and Wyoming. International Minerals & Chemical Corp. announced plans to recover uranium as a byproduct in the processing of its Florida phosphate ores.

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9 Work cited in footnote 4.
10 Work cited in footnote 7.
In a survey of domestic thorium resources, the investigation of the monazite content of placer deposits, principally in Idaho and California, was continued in 1950 by the Bureau of Mines under contract to the AEC. Domestic production of monazite as a coproduct of the Florida titanium-mining industry was on an increasing scale in 1950; production of monazite on a small scale was begun in Idaho during the year.

New types of radiation-detection instruments, particularly the scintillometer, were developed and applied in 1950. Numerous publications were issued in 1950 relative to uranium and thorium raw materials.

**REFINERY AND REACTOR PRODUCTION**

**Uranium.**—Production in 1950 of the fissionable isotope uranium–235 was achieved at a new record rate and at new low unit costs. Construction of the K–29 and K–31 additions to the Oak Ridge, Tenn., gaseous diffusion plant proceeded throughout the year. On December 15, 1950, the AEC announced plans for constructing a new facility to produce uranium–235 by the gaseous diffusion process on a 5,000-acre site at the Kentucky Ordnance Works, 16 miles west of Paducah, Ky. Union Carbide & Carbon Corp. will operate the new plant, the cost of which was estimated at $500,000,000. Construction of a chemical processing plant for recovering nuclear fuel from used reactor fuel elements at the reactor testing station, Arco, Idaho, was announced by the AEC; estimated cost of the plant was $8,000,000. The American Cyanamid Co. will operate the plant.

**Plutonium.**—Plutonium was also produced in 1950 at a new record rate and new low unit costs. Construction continued throughout the year on the expansion program underway at the Hanford, Wash., plutonium works.

**TABLE 1.**—Radioisotopes shipped by the U. S. Atomic Energy Commission, by kinds, 1946–50, in number of shipments

<table>
<thead>
<tr>
<th>Radioisotope</th>
<th>1946 1</th>
<th>1947</th>
<th>1948</th>
<th>1949</th>
<th>1950</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iodine–131</td>
<td>68</td>
<td>405</td>
<td>978</td>
<td>1,237</td>
<td>2,333</td>
<td>5,431</td>
</tr>
<tr>
<td>Phosphorus–32</td>
<td>48</td>
<td>537</td>
<td>901</td>
<td>1,430</td>
<td>2,736</td>
<td>4,642</td>
</tr>
<tr>
<td>Carbon–14</td>
<td>47</td>
<td>108</td>
<td>124</td>
<td>192</td>
<td>259</td>
<td>730</td>
</tr>
<tr>
<td>Sodium–24</td>
<td>1</td>
<td>80</td>
<td>119</td>
<td>229</td>
<td>286</td>
<td>715</td>
</tr>
<tr>
<td>Sulfur–35</td>
<td>12</td>
<td>39</td>
<td>41</td>
<td>108</td>
<td>125</td>
<td>325</td>
</tr>
<tr>
<td>Gold–198 and gold–199</td>
<td>17</td>
<td>52</td>
<td>29</td>
<td>36</td>
<td>164</td>
<td>298</td>
</tr>
<tr>
<td>Cobalt–60</td>
<td>4</td>
<td>32</td>
<td>30</td>
<td>64</td>
<td>137</td>
<td>267</td>
</tr>
<tr>
<td>Potassium–42</td>
<td>6</td>
<td>31</td>
<td>24</td>
<td>75</td>
<td>123</td>
<td>259</td>
</tr>
<tr>
<td>Calcium–45</td>
<td>5</td>
<td>42</td>
<td>33</td>
<td>68</td>
<td>89</td>
<td>237</td>
</tr>
<tr>
<td>Iron–55 and iron–90</td>
<td>5</td>
<td>41</td>
<td>33</td>
<td>54</td>
<td>68</td>
<td>201</td>
</tr>
<tr>
<td>Strontium–89 and strontium–90</td>
<td>3</td>
<td>9</td>
<td>18</td>
<td>19</td>
<td>46</td>
<td>95</td>
</tr>
<tr>
<td>Others</td>
<td>30</td>
<td>186</td>
<td>314</td>
<td>568</td>
<td>848</td>
<td>1,946</td>
</tr>
<tr>
<td>Total</td>
<td>246</td>
<td>1,652</td>
<td>2,644</td>
<td>4,370</td>
<td>6,234</td>
<td>15,146</td>
</tr>
</tbody>
</table>

1 Shipped by Manhattan District, Corps of Engineers, U. S. Army Service Forces.

**Isotopes.**—Production, processing, and distribution of radioisotopes by the AEC in 1950 were centered at the Oak Ridge, Tenn., National

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1 Work cited in footnote 7.


4 See selected bibliography at the end of this chapter listing publications not mentioned in footnotes.
Laboratory. Over 100 different kinds of radioisotopes were produced, with half lives ranging from a few hours to thousands of years. A new facility for handling and shipping isotopes, costing $2,400,000, was placed in operation at Oak Ridge in February 1950.

Radium.—Production of radium in the United States was practically at a standstill in 1950, except for a small amount salvaged from consumers’ wastes. Processes employed by plants extracting uranium from domestic ores made no provision for radium recovery; hence, no radium-rich residues were available for further refinement. Radium and its derivatives were produced by the Canadian Radium & Uranium Corp. at its Mount Kisco, N. Y., refinery.

Thorium.—A few tens of thousands of pounds of thorium compounds were produced in 1950 in the United States in conjunction with the production of rare earths. Output of thorium metal was virtually negligible. Principal producers of thorium compounds (chiefly nitrate and oxide) were Lindsay Light & Chemical Co., West Chicago, Ill., and Maywood Chemical Works, Maywood, N. J.

<table>
<thead>
<tr>
<th>Year</th>
<th>From domestic ores</th>
<th>From Canadian ores</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Milligrams</td>
<td>Estimated value</td>
<td>Milligrams</td>
</tr>
<tr>
<td>1941–43</td>
<td>2,042</td>
<td>$51,600</td>
<td>21,800</td>
</tr>
<tr>
<td>1944</td>
<td>200</td>
<td>3,700</td>
<td>200</td>
</tr>
<tr>
<td>1945</td>
<td>200</td>
<td>3,700</td>
<td>200</td>
</tr>
<tr>
<td>1946</td>
<td>200</td>
<td>3,700</td>
<td>200</td>
</tr>
<tr>
<td>1947</td>
<td>16,400</td>
<td>303,400</td>
<td>16,400</td>
</tr>
<tr>
<td>1948</td>
<td>4,219</td>
<td>77,880</td>
<td>3,610</td>
</tr>
</tbody>
</table>

1 Excludes confidential figures representing certain shipments in October 1943 to May 1944. Data for 1949–50 withheld to avoid disclosure of individual company operations.

CONSUMPTION AND USES

Weapons.—On January 31, 1950, President Truman announced that he had directed the AEC “to continue its work on all forms of weapons, including the so-called hydrogen or superbomb.” Atomic weapons were produced in 1950 at the rate authorized by the President, and uranium–235 and plutonium were produced at a new record rate, exceeding that of 1949. Pursuant to the Presidential directive of January 31, the AEC announced on November 28, 1950, plans for the Savannah River Project, which involved construction of new facilities, on a 200,000-acre tract in Aiken and Barnwell Counties, S. C., to be designed, built, and operated by E. I. du Pont de Nemours & Co., wartime builders and operators of the Hanford, Wash., Engineer Works. Total cost of the new facilities was estimated at $260,000,000.

Preparations were continued for additional full-scale weapons tests, and the Eniwetok Proving Ground in the Marshall Islands was maintained. The AEC was authorized to use part of the 5,000-square-
mile Las Vegas, Nev., bombing and gunnery range for experiments necessary to the atomic weapons development program. Construction proceeded on new facilities for the Los Alamos, N. Mex., scientific laboratory and for the Sandia Corp. at Albuquerque, N. Mex.\footnote{Work cited in footnote 17, pp. 6-7.}

**Industrial Power.**—Nuclear energy as a possible source of industrial power continued to be the subject of much discussion in 1950,\footnote{Ayres, Eugene, and Thomas, Charles A., What Are the Prospects for Industrial Nuclear Power: Nucleonics, vol. 7, No. 2, August 1950, pp. 72-78.} with the general outlook for such a development in the relatively near future somewhat more encouraging than it had been in 1949. Completion of the AEC experimental breeder reactor, under construction in 1950 at the Commission’s reactor-testing station near Arco, Idaho, was awaited with much interest (see Minerals Yearbook 1949, p. 1251). This reactor will test the feasibility of creating new nuclear fuel faster than it is consumed and will produce a small amount of power for experimental purposes.\footnote{Cockcroft, J. D., The Development of Power from Nuclear Energy: 4th World Power Conference, London, 1950, Section J, Paper 1, 8 pp.}

At the reactor station in Idaho the AEC began construction in 1950 of a materials-testing reactor and a land-based prototype submarine thermal reactor. The materials-testing reactor was designed to operate in the thermal, or slow, neutron energy range and will supply scientists with a much-needed tool to test materials under intense neutron bombardment. Although construction of the submarine thermal reactor was for the Navy, it was said to be giving impetus to the ultimate use of nuclear energy for industrial power production. At the Knolls (Schenectady, N. Y.) atomic power laboratory, development of a submarine intermediate-reactor power plant was undertaken for the Navy that will operate in a neutron-energy-range intermediate between thermal, or slow, neutrons and high-energy neutrons. The Oak Ridge, Tenn., national laboratory of AEC began construction of a pilot model of a fluidized reactor. All AEC reactors, except the Los Alamos, N. Mex., water boiler, are heterogeneous; that is, the fuel and moderator are separate, and in most reactors both are solids. In a fluidized reactor, fuel and moderator are mixed in a liquid.\footnote{Hoff, Lawrence B., Power from Atomic Reactors: Metal Prog., vol. 55, No. 6, December 1950, pp. 889-873; Reactor Program of the Atomic Energy Commission: Remarks before Am. Petrol. Inst., Los Angeles, Calif., Nov. 15, 1950; The Outlook for Atomic Energy: Min. Cong. Jour., vol. 36, No. 10, October 1950, pp. 83-83.}

During 1950 the AEC received several inquiries looking toward the designing and constructing of nuclear reactors with private capital and their operation and use by industry. The proposals were welcomed by the Commission, which stated that it was studying the problems involved.\footnote{Lillicolad, Ragnar, Some Economic and Technical Aspects of the Use of Nuclear Fuel for Power Production: 4th World Power Conference, London, 1950, Section J, Paper 5, 4 pp.}

\begin{thebibliography}{10}
\bibitem{1} Work cited in footnote 17, pp. 6-7.
\end{thebibliography}
<table>
<thead>
<tr>
<th>Country</th>
<th>Date of beginning operation</th>
<th>Fuel</th>
<th>moderator</th>
<th>coolant</th>
<th>Neutron velocity</th>
<th>Capacity (kw.)</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arco, Idaho:</td>
<td>Under construction</td>
<td>Enriched uranium metal</td>
<td>(?)</td>
<td>Liquid metal</td>
<td>Fast</td>
<td>Very much higher than Los Alamos fast reactor, Research in breeding fissionable material, heat transfer, and power production.</td>
<td></td>
</tr>
<tr>
<td>Do</td>
<td>do</td>
<td>Enriched uranium metal</td>
<td>(?)</td>
<td>do (?)</td>
<td>Slow</td>
<td>Large</td>
<td>Research in testing reactor construction materials.</td>
</tr>
<tr>
<td>Do</td>
<td>do</td>
<td>Enriched uranium metal</td>
<td>(?)</td>
<td>do (?)</td>
<td>do</td>
<td>do</td>
<td>Research in power generation for submarine propulsion and industrial use.</td>
</tr>
<tr>
<td>Brookhaven, N. Y</td>
<td>Aug. 22, 1960</td>
<td>Uranium metal</td>
<td>Graphite</td>
<td>Air</td>
<td>do</td>
<td>30,000</td>
<td>Research and radioisotope and experimental power production.</td>
</tr>
<tr>
<td>Chicago, Ill.</td>
<td>Dec. 2, 1942 (subsequently dismantled and rebuilt at a different site)</td>
<td>Uranium metal and oxide</td>
<td>do</td>
<td>None</td>
<td>do</td>
<td>Few kilowatts</td>
<td>Do.</td>
</tr>
<tr>
<td>Hanford, Wash</td>
<td>May 15, 1944</td>
<td>Uranium metal</td>
<td>Heavy water</td>
<td>Heavy water</td>
<td>do</td>
<td>300</td>
<td>Research.</td>
</tr>
<tr>
<td>Do</td>
<td>February 1944</td>
<td>do</td>
<td>Graphite</td>
<td>(?)</td>
<td>do</td>
<td>Small</td>
<td>Research in plutonium production.</td>
</tr>
<tr>
<td>Oak Ridge, Tenn.</td>
<td>Under construction</td>
<td>Uranium metal</td>
<td>Graphite</td>
<td>Air</td>
<td>Slow</td>
<td>Possibly 500,000 to 1,500,000</td>
<td>Weapons research.</td>
</tr>
<tr>
<td>Do</td>
<td>do</td>
<td>Uranium salts (?)</td>
<td>(?)</td>
<td>(?)</td>
<td>(?)</td>
<td>(?), (?), (?)</td>
<td>Research and radioisotope production.</td>
</tr>
<tr>
<td>Raleigh, N. C.</td>
<td>do</td>
<td>Enriched uranium salts.</td>
<td>Water</td>
<td>Water</td>
<td>(variable)</td>
<td>10</td>
<td>Research and radioisotope production.</td>
</tr>
<tr>
<td>Ellenton, S. C.</td>
<td>November 1946</td>
<td>Uranium metal</td>
<td>Heavy water</td>
<td>Liquid metal</td>
<td>Fast</td>
<td>Possibly 500,000 to 1,500,000</td>
<td>Research and radioisotope production.</td>
</tr>
<tr>
<td>Schenectady, N. Y</td>
<td>1948 (?)</td>
<td>Enriched uranium metal</td>
<td>(?)</td>
<td>(variable)</td>
<td>Intermediate</td>
<td>Small</td>
<td>Experiments in reactor assembly.</td>
</tr>
<tr>
<td>West Milton, N. Y</td>
<td>Under construction</td>
<td>do</td>
<td>(?)</td>
<td>Liquid metal</td>
<td>Intermediate</td>
<td>Large</td>
<td>Research in power generation for submarine propulsion and industrial use.</td>
</tr>
<tr>
<td>Country</td>
<td>Location</td>
<td>Date</td>
<td>Fuel Form</td>
<td>Moderator</td>
<td>Moderator</td>
<td>Power</td>
<td>Reactor Type</td>
</tr>
<tr>
<td>--------------</td>
<td>----------</td>
<td>-----------</td>
<td>-----------</td>
<td>-----------</td>
<td>-----------</td>
<td>-------</td>
<td>-------------------------------</td>
</tr>
<tr>
<td>Canada:</td>
<td>Chalk River, Ont.</td>
<td>Sept. 5, 1945</td>
<td>Uranium metal</td>
<td>Heavy water</td>
<td>None</td>
<td>Slow</td>
<td>3.5 watts, Research, Research and plutonium and radioisotope production.</td>
</tr>
<tr>
<td></td>
<td>Do</td>
<td></td>
<td>do</td>
<td>do</td>
<td></td>
<td>do</td>
<td>10,000 Watts, Reactor.</td>
</tr>
<tr>
<td>France:</td>
<td>Chatillon</td>
<td>Dec. 15, 1948</td>
<td>Uranium oxide</td>
<td>do</td>
<td>None</td>
<td>Slow</td>
<td>Narrow, Reactor.</td>
</tr>
<tr>
<td></td>
<td>Saclay</td>
<td>Construction begun in August 1949</td>
<td>Uranium metal</td>
<td>do</td>
<td>Nitrogen gas</td>
<td>Slow</td>
<td>Small, Reactor.</td>
</tr>
<tr>
<td></td>
<td>Do</td>
<td>Under construction</td>
<td>(?)</td>
<td>do</td>
<td>(?)</td>
<td>(?)</td>
<td>Very large, Reactor.</td>
</tr>
<tr>
<td>Netherlands 1</td>
<td></td>
<td>Planned for construction</td>
<td>(?)</td>
<td>do</td>
<td>(?)</td>
<td>do</td>
<td>Few watts, Reactor.</td>
</tr>
<tr>
<td>Norway:</td>
<td>Kjeller</td>
<td>Under construction</td>
<td>Uranium metal</td>
<td>Heavy water</td>
<td>(?)</td>
<td>Slow</td>
<td>100 Watts, Reactor.</td>
</tr>
<tr>
<td>Sweden:</td>
<td></td>
<td>do</td>
<td>Uranium metal (?)</td>
<td>(?)</td>
<td>(?)</td>
<td>(?)</td>
<td>Large, Reactor.</td>
</tr>
<tr>
<td>U. S. S. R.</td>
<td></td>
<td>Later than 1945 (?)</td>
<td>do</td>
<td>Graphite (?)</td>
<td>Water (?)</td>
<td>Slow (?)</td>
<td>Probably similar to Hanford, Wash., reactors.</td>
</tr>
<tr>
<td>United Kingdom:</td>
<td>Harwell</td>
<td>August 1947</td>
<td>Uranium metal</td>
<td>Graphite</td>
<td>Air</td>
<td>Slow</td>
<td>100 Watts, Research and radioisotope production, Reactor.</td>
</tr>
<tr>
<td></td>
<td>Do</td>
<td>July 3, 1948</td>
<td>do</td>
<td>do</td>
<td>do</td>
<td>do</td>
<td>6,000 Watts (being increased to 10,000), Reactor.</td>
</tr>
<tr>
<td></td>
<td>Sellafield</td>
<td>1949-50</td>
<td>do</td>
<td>do</td>
<td>Water</td>
<td>do</td>
<td>Probably similar to Hanford, Wash., reactors.</td>
</tr>
</tbody>
</table>

1 In addition, India, Belgium, Denmark, Switzerland, Union of South Africa, and Argentina have declared their intention to build research reactors, and scientists in Western Germany have requested permission to build a reactor for fundamental research.

2 Building reactor in cooperation with Norway. (See Norway)
Radiography.—As of December 1950, AEC-supplied isotopes were in use in 939 departments of 485 institutions in 47 States and Territories of the United States, compared with use in 549 departments of 305 institutions in 1949 and use in 241 departments of 160 institutions in 1947. Growth in isotope distribution was said to stem mainly from an increase in the number of scientists and technical personnel experienced in using radioactive materials, plus the construction and operation of a new AEC radioisotope-processing facility at the Oak Ridge, Tenn., national laboratory that made it possible to offer a wider range of radiomaterials at reduced costs.  

The AEC made 6,234 shipments of radioisotopes in 1950, or over 40 percent of the total 15,000 shipments made since the isotopes program was initiated in 1946. The major part of the radioisotope shipments in 1950 was for use in the field of medical therapy; but important new uses were developed in industry, particularly for cobalt—60, and were discussed in the scientific and technical press. Radium was used principally in medical therapy, as an energy source in luminous paints, and for industrial radiography. New graphs were published for the exposure time required for radium radiography of steel.

### TABLE 4.—Radioisotopes shipped by the U. S. Atomic Energy Commission, by uses, 1946–50, in number of shipments

<table>
<thead>
<tr>
<th>Use</th>
<th>1946</th>
<th>1947</th>
<th>1948</th>
<th>1949</th>
<th>1950</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medical therapy</td>
<td>88</td>
<td>716</td>
<td>1,142</td>
<td>2,037</td>
<td>3,037</td>
<td>7,020</td>
</tr>
<tr>
<td>Animal physiology</td>
<td>78</td>
<td>508</td>
<td>777</td>
<td>1,058</td>
<td>1,230</td>
<td>3,621</td>
</tr>
<tr>
<td>Physical research</td>
<td>17</td>
<td>134</td>
<td>202</td>
<td>315</td>
<td>445</td>
<td>1,116</td>
</tr>
<tr>
<td>Chemistry</td>
<td>27</td>
<td>138</td>
<td>225</td>
<td>238</td>
<td>274</td>
<td>892</td>
</tr>
<tr>
<td>Plant physiology</td>
<td>16</td>
<td>62</td>
<td>116</td>
<td>241</td>
<td>319</td>
<td>754</td>
</tr>
<tr>
<td>Industrial research</td>
<td>14</td>
<td>51</td>
<td>83</td>
<td>170</td>
<td>270</td>
<td>586</td>
</tr>
<tr>
<td>Bacteriology</td>
<td>4</td>
<td>33</td>
<td>53</td>
<td>83</td>
<td>87</td>
<td>260</td>
</tr>
<tr>
<td>Metallurgy</td>
<td>2</td>
<td>10</td>
<td>11</td>
<td>(?)</td>
<td>(?)</td>
<td>23</td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td>33</td>
<td>262</td>
<td>589</td>
<td>804</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>246</td>
<td>1,652</td>
<td>2,644</td>
<td>4,370</td>
<td>6,234</td>
<td>15,146</td>
</tr>
</tbody>
</table>

1 Shipped by Manhattan District, Corps of Engineers, U. S. Army Service Forces.  
2 Included in "Industrial research.”  
3 Specific field of utilization unknown (issuance of general authorizations permits approved applicant to use radioisotopes at a specified location for any research and development activity and permits him to obtain from any supplier any available form and quantity of any radioisotope distributed on authorization or approval of the U. S. Atomic Energy Commission.

### PRICES

Uranium Ore.—Prices paid by the AEC in 1950 for uranium were the same as in 1949 (see Minerals Yearbook 1949, pp. 1253–1255), except that new pricing applied to ores from the Marysvale, Utah, area. On March 12, 1950, the AEC announced that an ore-purchase depot would be established at Marysvale and that the ores would

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17 Work cited in footnote 17, pp. 56-37.  
23 Metal Industry, Tracers in Metallurgy: Vol. 77, No. 6, Aug. 11, 1959, p. 81.  
be purchased under contractual agreements negotiated with individual producers. On October 23, 1950, the Commission announced that lower-grade development ore would be accepted from the area. Under the new policy development ore containing as little as 0.10 percent U₃O₈ was acceptable, provided deliveries averaged about 0.15 percent. Previously, the minimum acceptable grade was 0.20 percent, with an average grade of 0.30 percent. The development allowance, under the new policy, was set so that payment, including the allowance, for ores containing 0.10 to 0.20 percent U₃O₈ amounted to $2.50 per pound of contained U₃O₈. The new pricing schedule for the Marysvale ores applied only to ores extracted during the prospecting and development stages of operations.

**TABLE 5.—Consumption of uranium and thorium compounds for nonenergy purposes in the United States, 1945-50, in pounds of contained U₃O₈ and ThO₂**

[U.S. Atomic Energy Commission]

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>URANIUM (U₃O₈ EQUIVALENT)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chemical (including catalytic)</td>
<td>3,800</td>
<td>2,500</td>
<td>2,400</td>
<td>1,993</td>
<td>2,426</td>
<td>2,835</td>
</tr>
<tr>
<td>Ceramic (including glass)</td>
<td>150</td>
<td>1,000</td>
<td>825</td>
<td>385</td>
<td>270</td>
<td>938</td>
</tr>
<tr>
<td>Photographic</td>
<td>300</td>
<td>220</td>
<td>285</td>
<td>170</td>
<td>113</td>
<td>33</td>
</tr>
<tr>
<td>Electrical</td>
<td>1,000</td>
<td>300</td>
<td>150</td>
<td>200</td>
<td>153</td>
<td>33</td>
</tr>
<tr>
<td>Total U₃O₈</td>
<td>4,960</td>
<td>4,160</td>
<td>3,375</td>
<td>2,803</td>
<td>2,799</td>
<td>3,806</td>
</tr>
<tr>
<td><strong>THORIUM (THO₂ EQUIVALENT)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gas-mantle manufacture</td>
<td>26,658</td>
<td>28,947</td>
<td>44,621</td>
<td>48,471</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Refractories and polishing compounds</td>
<td>2,176</td>
<td>1,767</td>
<td>585</td>
<td>2,097</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chemical and medical</td>
<td>522</td>
<td>427</td>
<td>237</td>
<td>314</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total ThO₂</td>
<td>32,227</td>
<td>40,325</td>
<td>47,301</td>
<td>52,777</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

¹ Photographic included with chemical.
² Figure not available.

**Uranium.**—High-purity uranium metal was available throughout 1950 to AEC licensees at about $50 a pound. The metal, in the form of pencil-size rods about 4 inches long, was produced by Mallinckrodt Chemical Co., St. Louis, Mo., and distributed to all the major chemical companies, from whom the metal was available to the licensees in its original rod form, as rolled sheets, or as foil.

**Radium.**—Radium was quoted throughout 1950 at $25 to $30 per milligram of radium content, depending on quantity.

**Isotopes.**—Isotopes were available in 1950 through the Isotopes Division of AEC in a wider range and at lower prices than in 1949. All isotopes used to study, diagnose, or treat cancer and allied diseases were made available free of production costs.

**Thorium.**—Average prices in 1950 for thorium nitrate and oxide were reported by a large producer in 100-pound lots, f. o. b. producer's plant, as follows: Thorium nitrate, mantle grade—domestic price $2.20 per pound, export $3.50 per pound; thorium oxide, 97 percent ThO₂—domestic price $5.00 per pound; thorium oxide, photographe lense grade, 99 percent ThO₂—domestic price $10.00 per pound. (See Minor Nonmetals chapter of this volume for monazite prices.)
FOREIGN TRADE

The AEC announced that in 1950 receipts of foreign ore continued at a satisfactory rate and that new foreign sources of supply had been developed. Uranium used by the AEC is obtained principally from the Belgian Congo and Canada. Data are not disclosed on imports and exports of uranium and thorium ores, concentrates, metal, alloys, and compounds. Cumulative exports of radioisotopes reported by the AEC as of November 30, 1950, reached 975 shipments distributed among 29 different nations.

TABLE 6.—Radium salts imported for consumption in the United States, 1946–50

[U. S. Department of Commerce]

<table>
<thead>
<tr>
<th>Year</th>
<th>Radium salts</th>
<th>Radioactive substitutes (value)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Milligrams</td>
<td>Total</td>
</tr>
<tr>
<td>1946</td>
<td>16,696</td>
<td>$325,922</td>
</tr>
<tr>
<td>1947</td>
<td>76,681</td>
<td>1,504,514</td>
</tr>
<tr>
<td>1948</td>
<td>77,018</td>
<td>1,355,337</td>
</tr>
<tr>
<td>1949</td>
<td>98,032</td>
<td>1,719,656</td>
</tr>
<tr>
<td>1950</td>
<td>80,969</td>
<td>1,235,511</td>
</tr>
</tbody>
</table>

WORLD REVIEW


At the Fifth General Assembly of United Nations, December 13 and 14, 1950, the Assembly adopted the following resolution, proposed by Australia, Canada, Ecuador, France, Netherlands, Turkey, United Kingdom, and the United States, that carried forward President Truman’s suggestion that conventional and atomic weapons be considered in a joint disarmament commission:

The General Assembly * * * decides to establish a committee of 12, consisting of representatives of the members of the Security Council as of 1 January 1951, together with Canada, to consider and report to the next regular session of the General Assembly on ways and means whereby the work of the Atomic Energy Commission and the Commission for Conventional Armaments may be coordinated and on the advisability of their functions being merged and placed under a new and consolidated disarmament commission.

Representatives of Canada, the United Kingdom, and the United States conferred in March 1950 at Chalk River, Ontario, on problems involved in the design and application of instruments for detecting and measuring radiations encountered in atomic energy work.
November 23, 1950, an announcement was issued that the Governments of Canada, the United Kingdom, and the United States had adopted a revised "Declassification Guide" that permitted publication of information necessary for the design, construction, and operation of low-power nuclear reactors used for research purposes.30

In December 1950 the Union of South Africa announced an agreement providing for the sale of uranium to the United States and the United Kingdom. (See Africa, below.)

A conference in Washington, D. C., on January 31, 1950, of representatives of Belgium, the United Kingdom, and the United States was reported by the Belgian foreign office.31 Indications were that the conference dealt mainly with the production of uranium ore in the Belgian Congo.

On March 1, 1950, Dr. Klaus Julius Emil Fuchs, German-born scientist and chief physicist at the British atomic research plant at Harwell, England, pleaded guilty of violating the Official Secrets Act and was sentenced to 14 years in prison. Evidence showed that he had communicated valuable atomic information to Russian agents in Britain and in the United States, where he had worked on the Los Alamos project.32 In September 1950 Prof. Bruno Pontecorvo, a nuclear scientist and the possessor of highly classified information obtained while engaged on atomic energy programs in England and the United States, defected to the U. S. S. R.33

WESTERN HEMISPHERE

Brazil.—Near the end of 1950 the Brazilian Chamber of Deputies approved a bill that provided for control by the National Security Council of the mining, beneficiation, and industrialization of certain minerals suitable for the development of atomic energy. Under the bill the export of uranium, thorium, and other atomic-energy minerals would be prohibited, except on a Government-to-Government basis.34

Discovery was reported of an extensive deposit of the uranium mineral djalmaite at São João d’el-Rey in Minas Gerais. The deposit was said to be about 4 miles long and ranging in width from 66 to 165 feet.35

Canada.—In 1950 the mine of the Crown company, Eldorado Mining & Refining (1944), Ltd., at Great Bear Lake, N. W. T., was again the source of virtually all the uranium ore produced in Canada. Operations of the company were at a new high level, with total tons of ore milled and sorted 29 percent higher than in 1949. Development footage and exploratory diamond drilling totaled 13,388 and 26,148 feet, respectively, compared with 10,600 and 14,590 feet in 1949. Estimates indicated that ore reserves were being maintained.36

Underground development continued in 1950 in the Goldfields area of Saskatchewan, on the north shore of Lake Athabaska, the so-called uranium "hot spot" in Canada. Principal operator in the area was Eldorado Mining & Refining (1944), Ltd., along the north shore of Beaverlodge Lake. Development by the company on its Ace and Eagle claims included the sinking of two shafts, 10,582 feet

of drifting and crosscutting, and 21,716 feet of diamond drilling. At the property of Nicholson Mines, Ltd., on Nicholson Bay, along the north shore of Lake Athabaska, development was also extensive, and the prediction was made that the property would probably be the first privately owned and financed uranium mine in Canada to become productive. Development and exploration were likewise actively in progress during 1950 in the Black Lake, Lac La Ronge, and Charlebois Lake areas in northern Saskatchewan. The Montreal River area, in the Algoma district, 50 miles north of Saulte Ste. Marie, was the main center of exploration for uranium in the Province of Ontario in 1950. The various deposits were described. Exploration continued at Hottah Lake and Contact Lake in the Great Bear Lake area of Northwest Territories, and in British Columbia activity was centered in the New Hazelton area.

On April 17, 1950, announcement was made that the period of guaranteed price for radioactive ores had been extended from March 31, 1955, to March 31, 1958, and on the following day a new pricing formula was announced, superseding that which had been in effect since April 1948. Under the new formula producers would be paid up to C$6 a pound for uranium oxide, as compared with a previous minimum price of C$2.75 a pound. Published details on the application of the new formula included the following:

The formula devised to determine the price to be paid for uranium oxide takes into consideration unusual operating conditions and is based upon: (1) A price of $2.75 per pound for the uranium oxide content of the ore or mill feed; (2) a milling allowance of $7.25 per ton of ore milled; (3) a maximum allowable price, which is based on a mill head of 0.25 percent uranium oxide; (4) a minimum extraction of 70 percent. Eldorado will purchase, f. o. b. rail, concentrates at a price per pound of uranium oxide determined by the following formula:

The price per pound to be paid for the U₃O₈ content (uranium oxide) of acceptable concentrates containing 10 percent or more by weight of U₃O₈ shall be the product obtained by multiplying the average number of pounds of U₃O₈ per ton of mill feed by $2.75 a pound, adding to this a milling allowance of $7.25 per ton of ore milled, and dividing the sum of the two by 70 percent of the average number of pounds of U₃O₈ per ton of mill feed.

The maximum price per pound of U₃O₈, which will be paid, is that based upon the formula applied to an ore, with an average grade of 0.25 percent or 5 pounds per ton. This works out to $6 per pound.

It will be necessary for each mine to make an individual contract with Eldorado specifying the price that is to be paid. Eldorado reserves the right to adjust the contract from time to time to bring it into conformity with actual operating results. In other words, if the grade of ore actually mined turned out to be different from that which was used in calculating the price for the uranium oxide, the price would be revised to conform with the grade of ore that was actually treated. At the panel discussion, Mr. Bennett indicated that the average grade would be calculated on a yearly basis.

The formula is designed to encourage efficiency in ore dressing. The greater the recovery that is obtained, the more pounds of uranium oxide there will be in the concentrates that are sold and, hence, the greater will be the value per ton of the ore that is mined and milled.

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39 The Precambrian, Development of Uranium Deposits Nears Stage of Plant Building for Production: Vol. 24, No. 1, January 1951, p. 33.
42 C. D. Howe, Minister of Trade and Commerce, speaking in the House of Commons, Ottawa, Ontario, Apr. 17, 1950.
43 W. J. Bennett, president, Eldorado Mining & Refining (1944), Ltd., addressing the annual meeting of the Canadian Institute of Mining and Metallurgy, held in Toronto, Ontario, Apr. 17-19, 1950.
The price paid for uranium oxide includes all radioactive elements in the concentrates. Reimbursement will be made for other valuable metals that may be contained in the concentrates.

**Mexico.**—The Mexican Government was reported in 1950 to be investigating uranium deposits in the States of Chihuahua, Guerrero, and Oaxaca and planning to erect a large plant for treating uranium ores.

**EUROPE**

**France.**—Three uranium-mining centers in France were particularly active in 1950—Grury, in Saône et Loire; Lachaux, in Puy de Dôme, 25 kilometers southwest of Vichy; and La Crouzille, in Haute Vienne, 20 kilometers north of Limoges. Mining operations reached a depth of 80 meters at Grury, and a fair tonnage of medium and low-grade ore was extracted. At Lachaux, a substantial tonnage of low-grade ore was mined, enough to warrant construction of mechanical-concentrating and chemical-processing plants. La Crouzille, where representatives of the Commissariat a l'Energie Atomique discovered a pitchblende deposit in 1948, was the main center of activity. On July 10, 1950, the first shaft at La Crouzille was placed in operation with appropriate ceremonies. Continuity of the deposit was said to be remarkable. The new mine is 100 meters deep and equipped with a surface plant of the most-modern type for the recovery of uranium.

**Italy.**—Prospecting for uranium was active in Sardinia in 1950. The Mining Department of the Ministry of Industry and Commerce was reported prospecting a property in Calabria, southern Italy. The Azienda Minerali Metallici Italiani was authorized by the Italian Government to start development of the uranium deposits in the Aosta Valley. In Arbatax, Sardinia, uranium deposits were discovered and were to be taken over by a new organization, Società Mineraria e Chemica per l'Uranio, of Milan. Deposits of uranium reported to have been found south of Turin were to be examined by Italian Government representatives.

**Spain.**—Discovery of radioactive ore was reported in 1950 at San Martin de Oscos in the Province of Oviedo, northwestern Spain, and uranium was said to have been found at the Santa Matilde mine in the Province of Lerida.

**U. S. S. R.**—A description of Soviet uranium mining in East Germany was issued on August 23, 1950, by the British Control Commission. It stated that 300,000 Germans had been drafted by the Russians and the East German Government to mine ore. Operations were said to be on a 24-hour intensified basis aimed at producing a maximum of uranium regardless of wastage in manpower and material. Wismuth A. G., the Soviet monopoly that controls all uranium production in the Russian zone, was reported to have its own staff of secret police, immunity before all German courts, power of life or death over the

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44 Roubaud, Marcel, [Uranium in the World]: Le Monde (Paris), Nov. 16, 17, and 18, 1950.
45 Echo des mines et de la metallurgie, No. 3,423, August 1950, p. 346.
48 Mining World, vol. 12, No. 12, November 1950, p. 49.
51 Mining World, vol. 12, No. 8, July 1950, p. 49.
miners, authority to take over any village or property, and unlimited access to East German funds.

New uranium operations by the Russians in East Germany reported in 1950 included exploitation in the Katchvete area, Province of Thüringia, and the opening of a new mine near Weringrode in the Harz Mountains. A concentrator was erected in 1950 at the Buhoyo mine, situated about 18 miles from Sofia, Bulgaria. The mine is said to be the largest uranium producer in the Balkans. A high-grade uranium deposit was reported to have been discovered about 35 miles southwest of Prague, Czechoslovakia, and a number of new mines were said to be in operation in the Bohutice area in Bohemia. Uranium deposits were discovered near the Polish border town of Goerlitz, southeast of Berlin.

**United Kingdom.**—The Department of Scientific and Industrial Research announced in 1950 discovery of about a million tons of uraniferous black shale in north Wales. The deposits, known as the Dolgelly black shales, are too low-grade to be economically important, containing 80 grams of U₃O₈ per ton, which is below the minimum content established by the Ministry of Supply.

**AFRICA**

**Belgian Congo.**—Early in 1950 the British Treasury sold 1,667,961 ordinary shares of Tanganyika Concessions, Ltd., to an Anglo-Belgian group; 600,000 of these shares were subsequently acquired by American interests. Tanganyika Concessions holds a 14.5-percent share interest, with 20 percent voting rights in Union Minière du Haut Katanga, operator of the Shinkolobwe mine in the Belgian Congo, the world’s largest producer of high-grade uranium and one of the main sources of uranium metal used by the United States.

**Mozambique.**—In 1947 a uranium-bearing titanium mineral, resembling davidite from Radium Hill, South Australia, was found at Mavuzi in the Tete district. Uranium mineralization is distributed scantily over an area of about 300 square miles north of the community of Tete. Exploration at Mavuzi was undertaken jointly by the British South Africa Co., New Consolidated Gold Fields, Ltd., and Gold Fields Rhodesian Development Co., Ltd. About 150 tons of ore assaying up to 8 percent U₃O₈ were produced, the largest part being sold in France.

**Nigeria.**—Monazite and thorite (thorium silicate containing 50–70 percent ThO₂) occur as minor constituents in the placer-tin deposits. In 1949 the United Kingdom Ministry of Supply announced a guaranteed price, effective for 10 years, at which it would buy thorium mineral concentrates: For concentrates sold as monazite a basic price of £50 per long ton, f. o. b. Jos or Dukura, bagged, combined monazite and thorite content not less than 95 percent, a £3 bonus to be added for each percent by which the thoria (ThO₂) content exceeds

54 Mining World, vol. 12, No. 8, July 1930, p. 49.
55 Mining World, vol. 12, No. 4, April 1930, p. 44.
56 Engineering and Mining Journal, vol. 151, No. 9, September 1960, p. 142.
57 Mining World, vol. 12, No. 1, January 1930, p. 52.
61 Mining Journal (London), May 1931, p. 177.
6 percent; for concentrates sold as thorite, payment of £6 10s. for each percent ThO₂, minimum of 15 percent ThO₂, additional consideration to be made for abnormally high uranium content.66 Despite the foregoing purchase guarantee, there was little resultant production of either thorite or monazite, the prices offered being too low to cover the cost of recovery.67

**Union of South Africa.**—In December 1950 an agreement was concluded by representatives of the United States, United Kingdom, and the Union of South Africa for the recovery of uranium as a byproduct in the processing of South African gold ores and for the sale of the uranium to the United States and the United Kingdom. The agreement marked successful completion of several years' intensive research and development by the three nations on the problem of recovering uranium economically from the gold ores. Although the uranium content of the ores is small, potential production of uranium is relatively large because of the great quantity of ore processed. Mining companies initially engaging in the project are West Rand Consolidated Mines, Ltd., Daggafontein Mines, Ltd., Blyvooruitzicht Gold Mining Co., Ltd., and Western Reefs Exploration & Development Co., Ltd. Design and construction of uranium-recovery plants will proceed on an expedited basis under the agreement. Negotiations leading to the agreement were a continuation of those held a year previously.68

**ASIA AND AUSTRALIA**

**Australia.**—Near the end of 1950, the Mines Department announced that a £50,000 program would soon be undertaken at the Radium Hill deposit near Olary, South Australia, said to be the most important uranium occurrence in the Commonwealth. Plans included thorough testing of the ore, installation of a sampling mill, development of concentrating processes, and erection of a pilot plant, to be followed by commercial exploitation of the deposit. During 1950 the Commonwealth Government explored and drilled a number of deposits discovered in several different regions of Australia, including those found in the Rum Jungle field near Darwin in Northern Territory.69 A lode deposit containing torbernite was discovered along the main north-south road at Fergusson River, 176 miles south of Darwin, and was judged to be one of the more significant discoveries made in the Territory.70

**India.**—The Government of India announced in April 1950 that rewards would be paid for the discovery of deposits of uranium ore in India. The new deposits would have to be at least 100 miles from already-known deposits. Such new deposits, if capable of producing 100 tons of uranium oxide in ore that assays not less than 0.4 percent U₃O₈, will command a reward up to Rs. 10,000. Grants-in-aid for mine development were made available to applicants who produce and deliver not less than 20 tons of uranium ore from a concession or mining lease not previously worked for uranium.

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On July 11, 1950, the Government of India announced its decision to purchase all stocks of uranium in India in the hands of dealers or mine owners. A minimum uranium content equivalent to 10 percent by weight of uranium oxide in the ores or concentrates will normally be required. Payment will be made at the minimum rate of Rs. 9 per pound of contained uranium oxide, f. o. b. station of despatch, and the rate will be guaranteed for 5 years. Consideration will be given to the commercially recoverable value of any associated mineral constituents of the ores. The announcement pointed out that under the Atomic Energy Act XXIX of 1948 uranium was a “prescribed” mineral and could be compulsorily acquired by the Government, and that it would therefore be advantageous for dealers and mine owners or persons possessing stocks of uranium to sell such stocks to the Government of India at an early date.

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