ANNEXES

ANNEX I

FIELDS OF RESEARCH CONCERNING NUCLEAR ENERGY REFERRED TO IN ARTICLE 4 OF THIS TREATY

I. **Raw materials**

1. Methods for the prospecting and mining of base materials (uranium, thorium and other products of particular importance in the field of nuclear energy).

2. Methods of concentrating these materials and converting them into technically pure compounds.

3. Methods of converting these technically pure compounds into nuclear grade compounds and metals.

4. Methods for the conversion and processing of these compounds and metals as well as plutonium, uranium 235 or uranium 233, either pure or combined with such compounds or metals into fuel elements by the chemical, ceramic or metallurgical industries.

5. Methods of protecting such fuel elements against corrosion or erosion by external agents.

6. Methods of producing, refining, processing and preserving other special materials used in the field of nuclear energy, in particular:

(a) moderators, such as heavy water, nuclear grade graphite, beryllium and beryllium oxide;

(b) structural materials such as zirconium (hafnium-free), niobium, lanthanum, titanium, beryllium and their oxides, carbides and other compounds capable of being used in the field of nuclear energy;

(c) coolants, such as helium, organic liquids, sodium, sodium potassium alloys, bismuth, lead bismuth alloys.

7. Methods of isotope separation:

(a) of uranium;

(b) of materials in ponderable quantities which can be used in the production of nuclear energy, such as lithium 6, lithium 7, nitrogen 15 and boron 10;

(c) of isotopes used in small quantities for research.

II. **Physics applied to nuclear energy**

1. Applied theoretical physics:

(a) low energy nuclear reactions, in particular neutron induced reactions;

(b) fission;

(c) interaction of ionizing radiation and photons with matter;

(d) solid state theory;

(e) study of fusion, with particular reference to the behaviour of an ionized plasma under the action of electromagnetic forces and to the thermodynamics of extremely high temperatures.

2. Applied experimental physics:

(a) the same subjects as those specified in 1 above;

(b) study of the properties of transuranic elements of importance in the field of nuclear energy.

3. Reactor calculations:

(a) theoretical macroscopic neutron physics;

(b) experimental neutron measurements; exponential and critical experiments;

(c) thermodynamic calculations and calculations of strength of materials;

(d) corresponding experimental measurements;

(e) reactor kinetics, reactor control problems and relevant experiments;

(f) radiation protection calculations and relevant experiments.

III. **Physical chemistry of reactors**

1. Study of changes in the physical and chemical structure and of alterations in the technical properties of various materials in reactors brought about by:

(a) heat;

(b) the nature of the agents with which they are in contact;

(c) mechanical factors.

2. Study of degradation and other phenomena produced by irradiation in:

(a) fuel elements;

(b) structural materials and coolants;

(c) moderators.

3. Application of analytical chemistry and analytical physical chemistry to reactor components.

4. Physical chemistry of homogeneous reactors: radiochemistry, corrosion.

IV. **Processing of radioactive material**

1. Methods of extracting plutonium and uranium 233 from irradiated fuels, and possible recovery of uranium or thorium.

2. Chemistry and metallurgy of plutonium.

3. Methods of extracting and chemistry of other transuranic elements.

4. Methods of extracting and chemistry of useful radioisotopes:

(a) fission products;

(b) radioisotopes obtained by irradiation.

5. Concentration and storage of useless radioactive waste.

V. **Applications of radioisotopes**

Application of radioisotopes as active elements or tracers in:

(a) industry and science;

(b) medicine and biology;

(c) agriculture.

VI. **Study of the harmful affects of radiation on living organisms**

1. Study of the detection and measurement of harmful radiations.

2. Study of adequate preventive and protective measures and the appropriate safety standards.

3. Study of the treatment of radiation effects.

VII. **Equipment**

Studies relating to the construction and improvement of equipment specially intended not only for reactors but also for any of the industrial and research installations required for the research activities listed above. As examples may be mentioned:

1. The following types of mechanical equipment:

   (a) pumps for special fluids;

   (b) heat exchangers;

   (c) apparatus for nuclear physics research, such as neutron velocity selectors;

   (d) remote handling equipment.

2. The following types of electrical equipment:

   (a) instruments for radiation detection and measurement, used particularly in:
   — prospecting for minerals,
   — scientific and technical research,
   — reactor control,
   — health and safety,

   (b) reactor control equipment;

   (c) low energy particle accelerators (up to 10 MeV).

VIII. **Economic aspects of energy production**

1. Comparative studies, both theoretical and experimental, of the various reactor types.

2. Technical and economic study of fuel cycles.