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THE INTERNATIONAL CONFERENCE ON THE PEACEFUL USES OF ATOMIC ENERGY

Geneva, Switzerland

August 8-20, 1955

Vol. I

Report of the United States Delegation to the International Conference on the Peaceful Uses of Atomic Energy held by the United Nations; with Appendices and Selected Documents

1035194

LETTER OF TRANSMITTAL

DELEGATION OF THE UNITED STATES OF AMERICA

INTERNATIONAL CONFERENCE

ON PEACEFUL USES OF ATOMIC ENERGY

The Honorable
THE SECRETARY OF STATE
Washington, D.C.

SIR: I refer to the letters to me dated February 14, 1955, and July 28, 1955, the first requesting me as Chairman of the Atomic Energy Commission to assume responsibility for the technical preparations for United States participation in the International Conference on the Peaceful Uses of Atomic Energy, and suggesting that I serve as Chairman of the United States Delegation; the second conveying instructions and setting forth for the guidance of the Delegation the Department's views concerning the Conference and United States participation. In conformity with those instructions, I submit the attached report.

I take pleasure in complimenting, and in expressing my sincere appreciation of, the spirit and the manner in which all members of the United States Delegation fulfilled their responsibilities. In the fullest sense, the United States presentation at the conference was the product of unstinting effort on the part of every segment of the United States atomic energy program—of industry, of academic institutions, and of the Government. The scientists and engineers of all these organizations produced the technical papers which formed so large a part of the United States contribution to world progress in the peaceful uses of atomic energy. Industry contributed not only notable papers but helped to build a large and broadly representative technical exhibit. The cooperation of other agencies of the Government was wholehearted.

I have written to express our thanks to the hundreds of individuals and organizations that helped to make the United States participation, and the conference itself, a worthy contribution of promoting the peaceful and beneficial uses of atomic energy throughout the world. I take this opportunity to bring to your attention a few among the many who made contributions. The idea for an international conference occurred to a number of leaders of science: it was broached informally by me in December, 1953, during the President's Bermuda meeting with the prime ministers of the United Kingdom and France. Subsequently,

1035195

Dr. Alan Waterman, Director, National Science Foundation, independently proposed such a conference and offered the services of his agency to help organize it. Dr. Isidor I. Rabi, Chairman of the General Advisory Committee, Atomic Energy Commission, made a similar suggestion. Dr. Rabi, with Dr. Robert A. Charpie, of Oak Ridge National Laboratory, as his deputy, was the United States architect of the conference, and of United States participation. Dr. George L. Weil left his private business as a consultant for some months to prepare and organize all technical aspects of the United States participation. Harry S. Traynor, of AEC, ably served as Executive Officer for the Delegation. Gerard Smith, Assistant to the Secretary of State for Atomic Energy Affairs; Consul General Franklin Gowen and his staff of Geneva; John McKnight, of the United States Information Agency, and the Office of International Conferences, Department of State, gave invaluable assistance.

Respectfully yours,

Lewis L. Strauss
Chairman

1035196

LETTER FROM DEPARTMENT OF STATE

February 14, 1955

Dear Mr. Chairman:

The President's proposal to have convened an international scientific conference, announced by you on April 19, 1954, has moved several steps nearer to fruition. It was, at United States initiative, the subject of a resolution of the General Assembly. Pursuant to this resolution, the Advisory Committee to the Secretary General of the United Nations met and advised concerning a topical agenda for the Conference and the Rules of Procedure that should govern it. I am enclosing a copy of despatch 605 of February 4 from our Delegation to the United Nations which encloses, in turn, a copy of the Secretary General's invitation to the United States Government to participate in the Conference and also the topical agenda and Rules of Procedure.

Since the Conference will be convened on August 8 at Geneva, the Rules provide for the submission of titles and abstracts of Conference papers, if possible, not later than May 15. In view of this tight time schedule, every effort will have to be made to take immediate steps to plan for this Government's presentations at the Conference, to organize the United States Delegation to the Conference, and to plan for exhibits by the United States at the Conference.

In view of the initiative taken by you in the matter of the Conference and the technical and scientific character of the Conference. I feel that the Atomic Energy Commission should take the primary responsibility in the technical planning for United States participation, although the over-all political responsibility for United States participation in the Conference, of course, resides in the Department of State. Specifically it would seem appropriate for the Commission to solicit appropriate technical papers, screen all papers (solicited and unsolicited), insure that only the best United States papers are presented to the Conference, make recommendations to the Department on the composition of the United States Delegation, and plan for significant exhibits by the United States at the site of the Conference.

I understand that Dr. George L. Weil, formerly Assistant Director of the Commission's Division of Reactor Development and now a Consultant to the Commission, is agreeable to serving in the capacity of Technical Director for United States participation in the Conference.

1035197

The Department of State will inform all interested agencies of the United States Government about the Conference and at the same time furnish copies of the pertinent documents. It is assumed that Dr. Weil, in his capacity of Technical Director, will undertake to secure the views of these other agencies as to the possible contributions of a technical and scientific nature they are prepared to make to the Conference. In order that these agencies may be informed of the important role that Dr. Weil will play in connection with United States participation in the Conference, copies of this letter are being sent along with the other documents referred to above.

It will be noted that this Government is obligated to provide the Secretary General of the United Nations at an early date with the name of an American citizen for designation as one of the Vice Presidents of the Conference. Also, suggestions should be offered the Secretary General as to individuals who may be designated to act as Chairman and Rapporteurs of Sections of the Conference. Your views on nominees for these positions would be appreciated.

Under Rule 2 of the Rules of Procedure, each participating State may designate five Representatives to the Conference. The Representatives may be accompanied by such number of Advisers as may be required to insure adequate presentation and discussion of technical papers. I should like to suggest that you consider accepting the position of Chairman of the United States Delegation to the Conference. In addition, your comments as to the other members of the group, both governmental and non-governmental, would be most helpful.

With respect to United States representation, it should be remembered that the United States nominee for the position of Vice President of the Conference and any suggested Chairmen and Rapporteurs of Sections accepted by the Secretary General, should be members of the United States Delegation as the expenses of their attendance will be a charge against this Government and not the United Nations. Formal nominations of delegation members should be accompanied by a statement attesting to their loyalty and security.

Rule 4 of the Rules of Procedure provides that credentials shall be presented to the Conference Secretary General not less than 14 days before the opening of the Conference. After receipt of your recommendations, the Department will determine the composition of the Delegation to meet this deadline. Any commitments concerning participation will, of course, be contingent upon such approval.

There is one other point that I would like to bring to your attention, namely the issuance of an initial press release on United States participation in the Conference. I believe that such a release should be issued jointly by the Department and the Atomic Energy Commission. It should include information on the agenda, Rules of Procedure, and point up the Commission's responsibility within the United States Government for the scientific and technical planning for United States participation in the Conference.

1035198

The Office of the Special Assistant for Atomic Energy and the Bureau of International Organization Affairs will continue to be responsible in the Department for all phases of the planning and preparation for the Conference and will be in constant touch with Dr. Weil and his staff.

Sincerely yours,

(Signed) Herbert C. Hoover, Jr.

Under Secretary

1035199

TABLE OF CONTENTS

		page
Letter of Transmittal		iii
Letter from Department of State		v
Report on the Conference		xv
The International Conference on Peaceful Uses of Atomic Energy—A Summary		xx
United States Participation in Conference—A Summary		xxix
APPENDIX I	- Plenary Sessions of Conference	1
APPENDIX II	- Scientific Secretaries' Reports on Technical Sections of Conference	34
	Attachment 1 - Listing of Technical Papers Review Committees	191
	Attachment 2 - Listing of United States Papers Submitted to United Nations	193
	Attachment 3 - Listing of Organizations which Submitted Abstracts	240
APPENDIX III	- Evening Lectures	245
APPENDIX IV	- United States Technical Exhibit at Geneva	254
	Attachment 1 - Contributors to Technical Exhibit	309
	Attachment 2 - Exhibit Brochure Distributed at Geneva	312
APPENDIX V	- United States Research Reactor Exhibit at Geneva	313
	Attachment 1 - Daily Attendance	335
	Attachment 2 - Memorandum of Transfer	336
	Attachment 3 - Reactor Brochures	338

1035200

APPENDIX VI - United States Technical Library Exhibit at Geneva 339

Attachment 1 - List of United States Technical Books and Monographs 344

Attachment 2 - List of Journals 358

Attachment 3 - Commercial Exhibit Literature 360

Attachment 4 - AEC Depository Libraries 368

Attachment 5 - Record of Daily Attendance 370

Attachment 6 - Press Releases 371

Attachment 7 - Photographs of United States Technical Library Exhibit 378

APPENDIX VII - Films Program at Geneva 386

APPENDIX VIII - Selected Reference Material 390

Attachment 1 - Letter from Chairman Strauss to Chiefs of Delegations 393

Attachment 2 - Price List for Selected Reference Material on Atomic Energy 394

Attachment 3 - Tables of Contents of Selected Reference Material 395

APPENDIX IX - United States Exhibit of Mobile Health and and Safety Laboratory 408

APPENDIX X - Educational and Commercial Exposition 410

Attachment 1 - US Contributors to Palais des Expositions Exhibits 411

APPENDIX XI - Address by President Dwight D. Eisenhower, December 8, 1953 412

APPENDIX XII - Address by Chairman Lewis L. Strauss, April 19, 1954 421

APPENDIX XIII - Speeches of United States Representatives before United Nations 430

1035201

APPENDIX XIV	- United Nations Notification to the United States on Conference: Invitation; General Assembly Resolution; Topical Agenda; Rules of Procedure; Notification from USSR	454
APPENDIX XV	- Conference Program as Issued by United Nations	484
APPENDIX XVI	- United Nations List of Delegations	564
	Attachment 1 - United States Delegation	670
APPENDIX XVII	- United States Press Releases Before and During Conference	674
APPENDIX XVIII	- Press Conference of US Officials	751
APPENDIX XIX	- Summaries of Press Coverage Abroad	840
APPENDIX XX	- Schedule of Special Events of the United States Delegation	863
APPENDIX XXI	- United Nations Schedule of Conference Publications	865

1035202

REPORT ON THE CONFERENCE

As Chairman of the United States Delegation, and on behalf of myself and the other Official Representatives--Dr. Willard F. Libby, Dr. Detlev Bronk, Dr. I. I. Rabi, and Dr. Shields Warren--I tender this report on the International Conference on the Peaceful Uses of Atomic Energy, held by the United Nations in Geneva, Switzerland, between August 8 and August 20, 1955.

Every indication points to the conclusion that the Conference must be regarded as an unqualified success. The statements of delegates of the 73 nations represented, the messages conveyed from the heads of states to the Conference, the interest of the public, and the comments of the news agencies throughout the world, all support this judgment. It is equally the considered consensus of the Official Representatives of the United States and their advisers.

The volume of the scientific and technical information exchanged is evidenced by the fact that the United Nations will require 16 volumes to publish the Conference proceedings.* In the judgment of the United States Delegation's Technical Advisers, the quality of the papers submitted, and the discussions of these papers, matched the best scientific forums. The discussions among delegates were deemed generally free and frank. The spirit of cooperation and friendliness among delegates of all the Nations represented at the Conference was entirely in harmony with that engendered a few weeks previously in Geneva during the Conference of President Eisenhower with the Prime Ministers of France, the Union of Soviet Socialist Republics, and the United Kingdom.

The measure of the Conference's success in all these particulars was the unanimity of the response to President Eisenhower's expressed hope, which I was privileged to voice in Geneva, that another international conference on peaceful uses of atomic energy could be held within two or three years. Prime Minister Bulganin of the USSR later made a similar suggestion in a formal message sent to the Conference's closing session. Secretary-General Dag Hammarskjold in his report on the Conference to the United Nations General Assembly on September 14, 1955, stated that the President of the Conference, Dr. Homi J. Bhabha, of India, had found that there was "universal sentiment. . .for another scientific conference . . .to carry forward the work so well begun."

It is gratifying to be able to report the conviction of the United States Official Representatives that this Conference has made a genuine contribution toward opening the way for world-wide cooperation

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* See Appendix XXI

1035203

to place atomic energy at the peaceful service of all nations. President Eisenhower's leadership in this broad effort was generously praised. Speakers at the Conference referred repeatedly to the President's address before the United Nations General Assembly on December 8, 1953,* in which he declared:

> ". . .the United States pledges before you—and therefore before the world—its determination to help solve the fearful atomic dilemma. . . to devote its entire heart and mind to find the way by which the miraculous inventiveness of man shall not be dedicated to his death, but consecrated to his life."

At the Conference, Official Representatives of the United States called attention to the positive steps which this country was taking in cooperation with other nations, and would continue to take, to fulfill this pledge:

> the United States commitment to allocate 200 kilograms of fissionable uranium for use by other nations in research reactors;
>
> the offer to contribute to the cost of building research reactors in other countries;
>
> the opening of reactor training courses to students from abroad;
>
> the invitations to medical and surgical experts from abroad to share in the work of cancer hospitals where atomic energy products are used in research and therapy;
>
> the gifts of technical libraries of US Atomic Energy Commission publications to 29 nations;
>
> the bilateral agreements of cooperation initialed or signed with 27 nations to share with the United States in development of peaceful uses of atomic energy, the discussions looking toward further agreements; and
>
> the new approach to speedier development accomplished by amending United States atomic energy law so as to promote wider participation by United States industry, and wider dissemination of information through international cooperation.

The international pool of atomic energy materials and knowledge, and the forming of an international agency to promote the peaceful uses

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* Text of President Eisenhower's address in Appendix XI

1035204

of atomic energy, which President Eisenhower proposed, could not be discussed in a nonpolitical conference, dedicated as this one was to scientific and technical information and problems. Several speakers nevertheless referred to the formation of an international agency as being highly desirable.

It will not be possible for some time to appraise fully the results of the Conference. Certain results can be cited with confidence, and others can be inferred as probable. In the opinion of the United States Official Representatives, the Conference accomplished these things:

1. The exchange of information, and the friendly intercourse among delegates to the Conference, began the reestablishment of world-wide communication among atomic scientists and engineers. The stimulation of these contacts, the access to new and broader information, provides an opportunity for the inventive imagination of the world of science to explore, to discover, and to develop new knowledge for the benefit of all nations.

2. Great quantities of scientific and technical information, some of which never before had been made generally available, were freely exchanged among the delegates of all nations. All nations learned new facts. Countries on the brink of wide atomic development will consequently be able to plan ahead with greater confidence. Nations still without atomic programs have acquired a workable basis for determining what they can best undertake and how to go about it.

3. Through the full reports on the Conference which were widely carried by the news services of the world, people everywhere have had the opportunity to learn of the many useful and constructive purposes to which atomic energy can be applied for their betterment and welfare. As a consequence of this and of further cooperation among nations, it is reasonable to hope that the blind dread of atomic energy, which many may have felt if they knew atomic energy only as a destructive force, may be abated. This is particularly true since the Conference emphasized the highly significant fact that the scientific and industrial development changes being brought about by atomic energy, which can profoundly alter the economies and patterns of life of peoples throughout the world, is being guided by considerations for the biological requirements of man, and directed toward advancing human welfare.

1035205

In the opinion of the United States Official Representatives, these accomplishments must be regarded not only as gains for the world, but equally as progress in the fulfillment of fundamental United States policies. It seems to us further that, from the standpoint of national self-interest, certain additional results should be listed:

4. The volume and quality of work reported by the United States to harness atomic energy for the welfare and betterment of man, and this nation's willingness to share its knowledge and to learn from others, could not have helped but convince delegates from other nations of the sincerity of United States efforts to "strip the atom of its military casing and to adapt it to the arts of peace." The reports these delegates make to their nations, and the news of the Conference which has preceded them, should convey a new understanding of the peaceful policies and intentions of the United States.

5. If we are correct in this estimate, it must follow as a result of the Conference that people in other nations will have a greater understanding of the United States desire and efforts to achieve a decent and enduring peace.

The Official Representatives would urge that this hopeful progress toward bettering world conditions and toward achieving world peace be considered no more than tentative at this point. They believe that the gains can be consolidated by continuing and expanding, as rapidly as may be feasible, the positive actions this country has taken under the President's Atoms for Peace program. We submit that the Conference has fully justified the money, the effort, and time invested in it, as the President recognized in urging that this conference should be followed by another to continue "this great beginning of international cooperation."

To assure that the United States in future conferences will continue to measure up to the obligations placed upon this nation by its position of world leadership in the development of peaceful uses of atomic energy, and to enable the United States to promote by this means its determined policy of international cooperation for peace and human welfare, the United States Official Representatives recommend:

1. <u>That the United States Government begin to plan now for participation in a second international conference on the peaceful uses of atomic energy; and</u>

1035206

2. That the Department of State promptly initiate joint action among the appropriate departments and agencies of Government with a view to assigning specific responsibility to each and starting now to take all necessary steps to prepare for United States participation.

Respectfully submitted,

Lewis L. Strauss, Chairman

Willard F. Libby, Vice-Chairman

I. I. Rabi

Detlev W. Bronk

Shields Warren

1035207

THE INTERNATIONAL CONFERENCE ON THE PEACEFUL USES OF ATOMIC ENERGY

A Summary

Sixty member states of the United Nations and 24 other states represented on 10 specialized agencies of the United Nations, as well as representatives of the 10 specialized UN agencies themselves, were invited by the Secretary-General of the United Nations on February 1, 1955, to participate in the International Conference on the Peaceful Uses of Atomic Energy, held in the United Nations' Geneva, Switzerland, headquarters, the Palais des Nations, between August 8 and August 20, 1955.

Secretary of State John Foster Dulles had proposed consideration of the Conference as an agenda item in an address* before the United Nations General Assembly on September 23, 1954. The General Assembly's Resolution 810 (IX),** approved unanimously on December 4, 1954, was jointly sponsored before the General Assembly's Committee I by seven nations: Australia, Belgium, Canada, France, the Netherlands, the United Kingdom and the United States. The invitations issued by Secretary-General Dag Hammarskjold incorporated a topical agenda and a statement of rules and procedures.** These were promulgated by Mr. Hammarskjold after consultation with the Conference Advisory Committee established by Resolution 810 (IX) and comprising members from Brazil, Canada, France, India, the Union of Soviet Socialist Republics, the United Kingdom, and the United States.

The members of the Conference Advisory Committee were:

Brazil - Mr. Jayme de Barros Gomes.
Alternate: Prof. Joaquim da Costa Ribeiro.

Canada - Dr. W. B. Lewis.

France - Dr. Bertrand Goldschmidt.

India - Dr. Homi J. Bhabha.

USSR - Academician Dimitri Skobeltzin.

UK - Sir John Cockcroft.
Alternate: Dr. J. V. Dunworth

US - Dr. I. I. Rabi.

The rules of procedures as accepted by the Conference Advisory Committee, and promulgated by Mr. Hammarskjold, were designed to keep the

* Text of addresses by Secretary of State Dulles and by Ambassador Henry Cabot Lodge are in Appendix XIII.

** Text of Resolution, Rules and Procedures and Topical Agenda are in Appendix XIV.

1035208

Conference focused strictly on technical and scientific discussions, to prevent the intrusion of political issues, and to facilitate organization of the Conference, and to define simple and precise procedures so as to make it possible to handle the great volume of information presented at the Conference by a large number of participants. Ample powers were given to the Secretary General of the Conference, and to the presiding officers. Officers were appointed by the UN Secretary General on recommendations of the Conference Advisory Committee, and affirmed by acclamation at the Conference's opening session.

The officers of the Conference were:

President:	Dr. Homi J. Bhabha (India).
Vice-President:	General Bernardino C. de Mattos (Brazil), Dr. W. B. Lewis (Canada), Professor Francis Perrin (France), Academician D. V. Skobeltzin (USSR), Sir John Cockcroft (UK), Dr. I. I. Rabi (US).
Conference Secretary General:	Professor Walter G. Whitman (US).
Conference Deputy Secretary General:	Dr. Viktor S. Vavilov (USSR).

Chairmen and Vice-Chairmen of the 52 technical sessions were appointed by the United Nations on th basis of nominations by the various countries, and with the advice of the representative of each country on the UN Secretary General's staff.

Seventy-three nations and eight specialized agencies of the United Nations were represented at Geneva: a total of 1,428 delegates. In addition to 902 representatives of the news services and media of the world, there were 1,334 official observers, principally from nongovernmental organizations, academic institutions and industrial concerns. A total of 1,067 technical and scientific papers was submitted to the Conference from 23 Nations and from four UN agencies: the World Health Organization, the Food and Agriculture Organization, the United Nations Economic, Social, and Cultural Organization, and the United Nations Organization.

The agenda of the Conference was balanced between plenary sessions on general subjects, and sections on technical subjects. There were plenary sessions on August 8, 9, 10, and morning of August 11, and the afternoon of August 20—eight half-day sessions in all. On the afternoon of August 10 and the morning of August 11, there were two concurrent technical sections,

1035209

Dr. I. I. Rabi (left), United States, shaking hands with Academician Dmitri V. Skobeltzin, Soviet Union, before meeting of Advisory Committee for Conference at U. N. Headquarters. Standing between them is Dr. J. V. Dunworth, United Kingdom.

1035210

1035211

and during the rest of the Conference, there were three technical sections each morning and afternoon (except Sunday) through the morning of August 20, a total of 52. Plenary sessions dealt with such broad topics as future world needs for energy, the economics of atomic energy, programs of international cooperation, and scientific education. The technical sections discussed research and power reactors; reactor theory; reactor physics; fuel elements; fissionable products and their extraction; raw materials exploration and processing; waste disposal and health protection; radioactive materials in diagnosis and therapy, in industry, and in agriculture; and production, handling, and use of radioisotopes.*

In addition to the general and technical sessions of the Conference, a series of 10 evening lectures was scheduled in which leading men of science from seven nations discussed matters of general scientific or public interest.* Nine nations presented technical exhibits which were placed in and about the Palais des Nations: Belgium, Canada, Denmark, France, Norway, Sweden, the Union of Soviet Socialist Republics, the United Kingdom and the United States. An educational and commercial exposition was held simultaneously at the Palais des Expositions in downtown Geneva. This was not an official part of the Conference, but was under the auspices of the Swiss Federal Council, the United Nations, the State Council of the Republic and Canton of Geneva, and the Administrative Council of the City of Geneva. Industries from eight nations took part in the commercial exhibit: Belgium, France, Lichtenstein, Netherlands, Switzerland, United Kingdom, United States, and West Germany. The governments of France and the United Kingdom presented educational exhibitions; the United States sponsored an educational "Atoms for Peace" show, and US commercial and industrial organizations made independent arrangements to take part in the trade fair.**

A program of documentary and technical motion pictures was presented daily in a small theater at the Palais des Nations, rotating 21 films prepared in the four official languages of the Conference: English, French, Russian and Spanish. Canada presented two films, France two, Norway one, the USSR three, the United Kingdom five, and the United States eight for this program.

The Conference was unique among international scientific conferences in that it was the first to be held in which all phases of a broad field were covered, from fundamental physics and biology, to their application in medicine, engineering, and industry.

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* Full agenda and the full program of the Conference are given in Appendix XV

** See Appendix X.

1035212

General view of the opening session of the International Conference on the Peaceful Uses of Atomic Energy in the Assembly Hall of the Palais des Nations, taken from near the rostrum.

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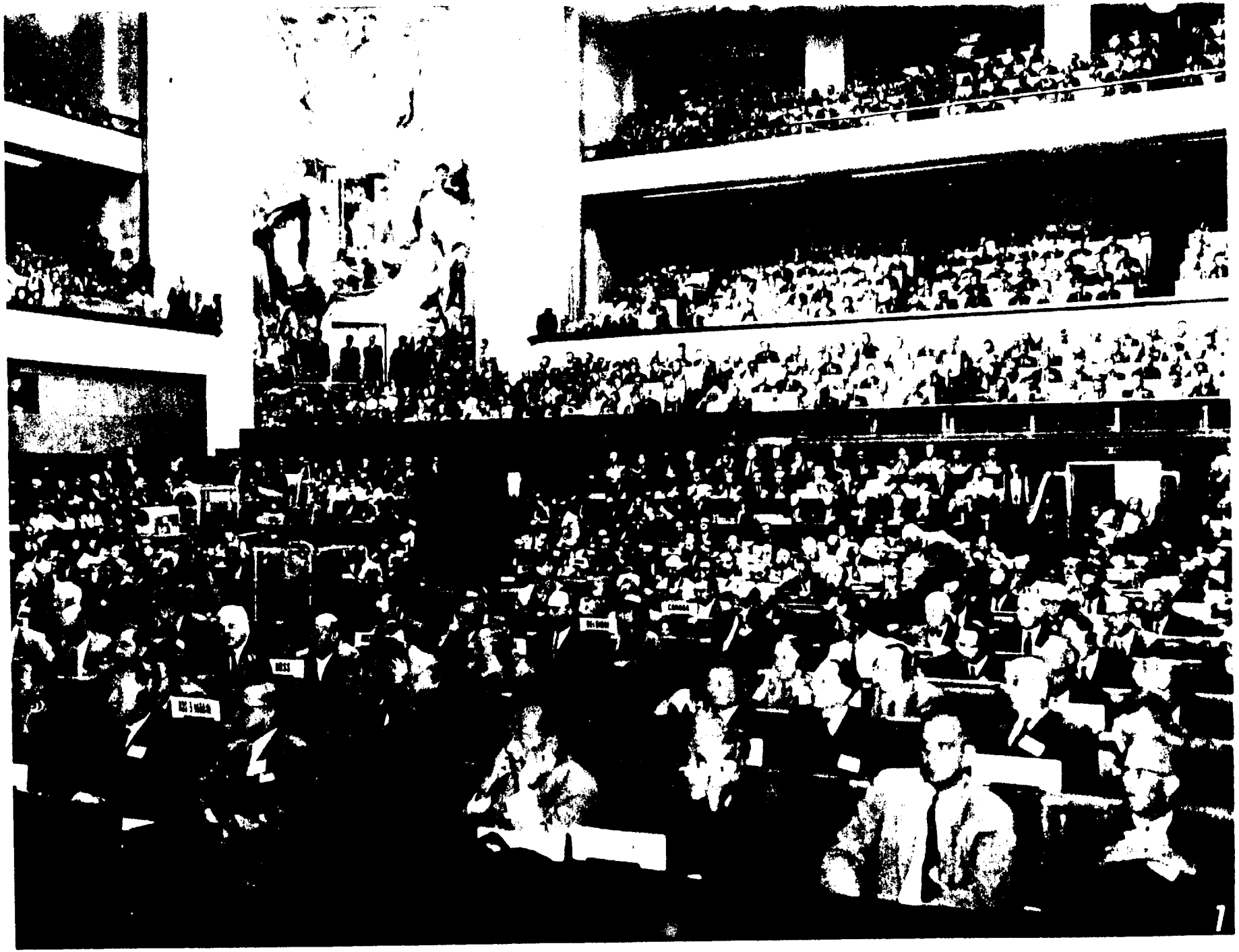

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US PARTICIPATION IN THE CONFERENCE

A Summary

The United Nations Conference evolved from earlier United States plans to hold a similar conference on the peaceful uses of atomic energy. The first public suggestion for such a conference was made by Chairman Lewis L. Strauss, of the Atomic Energy Commission in an address on April 19, 1954, when he stated on authority of President Eisenhower:

> "...the President's intention to arrange. . .an international conference of scientists. . .devoted to the exploration of the benign and peaceful uses of atomic energy."*

A few days later, Chairman Strauss requested Dr. I. I. Rabi, Chairman, General Advisory Committee to the Atomic Energy Commission, to undertake preliminary planning. Out of his work with officials of the AEC and the Department of State, and his consultations with British, Canadian and French scientists, grew the plan which ultimately resulted in the International Conference of the United Nations.

The Atomic Energy Commission began active planning for United States participation in the Conference in October, 1954, still under the guidance of Dr. Rabi. On December 14, 1954, Dr. Rabi was appointed US Representative on the UN Conference Advisory Committee. In February, 1955, after the State Department formally requested AEC to undertake preparations, Chairman Strauss appointed Dr. George L. Weil, private consultant and former AEC official, to take charge of technical preparations for US participation, to assemble the technical papers, plan and arrange exhibits, and take such other steps as were necessary to assure that the US presentation was representative of atomic energy enterprise in the United States.

Under the rules of procedures of the United Nations Conference, each participating nation was entitled to appoint five official representatives,** to be accompanied by technical advisers and other staff as required. The Official Representatives of the United States were:

Mr. Lewis L. Strauss, Chairman, Atomic Energy Commission, Chairman of the Delegation.

Dr. Willard F. Libby, Atomic Energy Commissioner, Vice-Chairman of the Delegation.

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*Text of address by Chairman Lewis L. Strauss is given in Appendix XII

**Official representatives of other 72 participating nations, with their advisers are listed in Appendix XVI

1035215

The bench of the Official Representatives of the United States in the Assembly Hall of the Conference: Right to left, Chairman Lewis L. Strauss; Conference historian, Mrs. Laura Fermi; Commissioner Willard F. Libby, Delegation vice-chairman, and Dr. John A. Hall, Director AEC Division of International Affairs.

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1035217

Dr. Isidor I. Rabi, Chairman, General Advisory Committee, AEC; Higgins Professor of Physics, Columbia University.

Dr. Detlev W. Bronk, President, National Academy of Sciences; President, Rockefeller Institute for Medical Research.

Dr. Shields Warren, Scientific Director, Cancer Research Institute, New England Deaconess Hospital.

The Official Representatives had eight Congressional advisers, 192 technical and other advisers, and a secretariat and staff comprising 84 principals (including 9 of the advisers) and 118 others--a total of 398 persons,* of whom 327 were accredited to the Conference. The Congressional advisers, all from the Joint Congressional Committee on Atomic Energy, were: Senator Clinton P. Anderson, Chairman; Senator John O. Pastore, Senator Bourke B. Hickenlooper, Senator John W. Bricker, and Representative Carl T. Durham, Representative Chet Holifield, Representative W. Sterling Cole, and Representative Carl Hinshaw.

Members of the US Delegation named as Chairmen of Conference Technical Sections were: Dr. J. C. Bugher, Dr. J. P. Howe, Dr. D. J. Hughes, Dr. W. F. Libby, Dr. Glenn Seaborg, Dr. F. H. Spedding, Dr. V. F. Weisskopf and Dr. E. P. Wigner.

The technical and scientific direction and administration of the US Delegation was under the leadership of Dr. Weil who headed the Office of Technical Programs and Exhibits, with Mr. Thomas O. Jones as his administrative officer. He was assisted by Dr. Paul W. McDaniel (AEC), Technical Papers Officer; Dr. George Manov (AEC), Reactor Officer; and Dr. Alberto Thompson (AEC), Technical Exhibits Officer. The Delegation's Information Office was under the direction of John P. McKnight (USIA) with Mr. Morse Salisbury (AEC), Mr. Joseph Hanson (USIA), and Mr. Richard Friedman (State) as deputies. The Office of Liaison and Protocol was under Mr. John A. Hall (AEC), and the Classification Office under Dr. Charles D. Luke (AEC), with Mr. C. L. Marshall (AEC) as deputy. The Special Services Office had Mr. Daniel H. Clare, Jr. (State) and Mr. Bryan F. LaPlante (AEC) as co-directors, with Mr. K. O. Lynch (State) and Mr. R. G. Cavanaugh (AEC) as deputies. The Administrative Office was headed by Mr. Albert J. Ciaffone (State) with Mr. H. D. Anamosa (AEC) and G. R. Koontz (State) as deputies.

The Executive Officer of the US Delegation was Mr. Harry S. [illegible] (AEC); Deputy Executive Officer, Mr. George M. Fenneman (State).

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* Complete list of advisers and staff is given in Appendix XVI

1035218

Congressional advisers to the United States delegation at the Conference, seated behind the United Kingdom delegation (Royaume-Uni), left to right, Senator Clinton P. Anderson, Chairman, Joint Congressional Committee on Atomic Energy, Representative Carl T. Durham, Senator Bourke B. Hickenlooper, Representative Sterling Cole, Senator John W. Bricker, Senator John A. Pastore.

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The United States submitted 512 technical papers for the Conference, nearly 48% of the total contributed by all Nations. It presented 176 of the 450 papers given orally at the Conference--39% of the total. US Scientific Secretaries were appointed for each plenary session or technical section of the Conference. They provided brief records of discussions for the convenience of the US Delegates, and in addition called pre-section meetings of US Delegates in order to assure the best possible presentation of material and to promote good discussions. The US Scientific Secretaries were: Dr. Walter D. Claus, Dr. R. Carson Dalzell, Dr. Edward Epremian, Dr. L. E. Glendenin, Dr. George A. Kolstad, Dr. Karl M. Mayer, Dr. Robert D. Nininger, Dr. Paul B. Pearson, Dr. Alvin Radkowsky, and Dr. Ulysses M. Staebler.*

Delegates from the US delivered four of the ten evening lectures. On August 11, Professor Ernest O. Lawrence spoke on "High Current Accelerators"; on August 15, Professor Hans A. Bethe discussed "Elementary Particles: Light Mesons", and in another parallel lecture, Professor Willard F. Libby spoke on "Radiocarbon Dating"; on August 17, Dr. Alexander Hollaender lectured on "Modification of Radiation Response".**

The US technical exhibit was in five parts: the US Research Reactor Exhibit, an operating pool-type research reactor, installed in a specially constructed building on the grounds of the Palais des Nations which was visited by approximately 63,400 persons during the two weeks of the Conference:*** the US Technical Exhibit, in Room XV of the Library Wing of the Palais des Nations, to which 105 academic, non-profit, and commercial organizations contributed and which drew about 36,200 visitors;*** the Mobile Health Unit set up in a truck semi-trailer on the Palais Grounds, which was visited by some 25,000 persons:*** the US Technical Library Exhibit, also in the Library Wing of the Palais des Nations, which served as a reference library for delegates, and which had about 19,500 visitors:*** and the 8-film contribution to the UN Conference program of technical and documentary motion pictures.***

In the educational and commercial exhibit held at the Palais des Expositions in downtown Geneva under Swiss and United Nations auspices, the United States Government presented the United States Information Agency's educational display. * * * This included an "Atoms for Peace" show from West Germany and exhibits from 18 US organizations. Adjoining it were exhibits by 20 US industrial and commercial organizations which had made independent arrangements with the Swiss sponsors. Altogether, in these exhibits, and including the 105 contributors to the Technical Exhibit at the Palais des Nations, 143 separate institutions and organizations participated. In addition, 50 associations and publishing houses assisted in the Technical Library Exhibit.

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* Summaries of Conference Sections, papers and discussions, are given in Appendices I and II

** Appendix III gives a report on the evening lectures.

*** Appendices IV, V, VI, VII, IX, and X give details and descriptions of these five exhibits

1035221

The US Delegation's Information Office was organized for three main purposes: (1) to provide service to news media, particularly in interpreting technical material; (2) through Conference coverage to keep the Official Representatives closely in touch with all Conference activities; and (3) to advise on the needs of news media as they developed.

Before and during the Conference, a number of news releases was issued.* News conferences were held by Dr. Rabi at New York and Pairs in May and by Chairman Strauss and Dr. Weil at New York and Washington in June, and by Dr. Weil at Geneva in August. During the Conference, two press conferences were held by Chairman Strauss and Commissioner Libby.* In the first, Chairman Strauss paid tribute to the Conference for "reopening lines of communication between men who have not been in communication for many years", and announced establishment by the Ford Motor Company of a $1 million fund to provide world-wide atoms-for-peace awards. In the second, Chairman Strauss discussed the prospects for thermonuclear power. He confirmed that the US had a program in this field but counseled that "there has been nothing in the nature of break-throughs that would warrant anyone assuming that this was anything except a very long range--and I would accent the word 'very'--prospect."

The US took the occasion of the Conference to announce on August 8, 1955, its prices for lease of enriched uranium and for sale of normal uranium and heavy water.

A major news release was a showing in Geneva of a motion picture on production of electricity by the AEC's experimental boiling water reactor, Borax II. The film pictured the town of Arco, Idaho, normally supplied with electricity by a conventional system, being lighted and powered experimentally for one hour with electricity generated by heat from the reactor on July 17, 1955--the first American community to receive its entire supply of electricity from a nuclear reactor.

Early in the planning stages of US participation in the Conference, AEC undertook to prepare an 8-volume set of selected reference material, a collection of technical unclassified information on various peaceful uses of atomic energy, together with a special introductory volume which was printed in the four official languages of the Conference: English, French, Russian, and Spanish.** An initial presentation of the introductory volume was made at a luncheon August 9 to officers of the Conference; other copies were made available through the US Technical Library at the Palais des Nations to all official representatives of all nations.

On the final day of the Conference, the US presented to the UN a reference and depository library, which formed the core of the US Technical Library Exhibit at the Conference. This was similar to 34 libraries that have been presented by the US to other countries. On that day also, Chairman Strauss, on behalf of the US government, signed over to Prof. Paul Scherrer, acting on behalf of the Swiss government, the research reactor

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* Text of press releases and transcripts of press conferences are given in Appendices XVII and XVIII. An analyses of press coverage abroad on the Conference is in Appendix XIX

** See Appendix VIII for details and description.

1035222

exhibited at Geneva which they had arranged to purchase under an agreement of cooperation signed July 18, 1955.*

In the planning stages of the Conference, Dr. Rabi pledged to other nations that the US would throw its "full weight" behind preparations for the Conference, and would gather "the best work of the best brains" for its participation. The Official Representatives of the US believe that this promise was fulfilled in the US presentations at the Conference, and that the US contribution to world knowledge through the Conference was entirely representative of US progress in developing, in all its many aspects, the peaceful uses of atomic energy.

* Appendix XX lists other special activities of US Delegation in Geneva

1035223

APPENDIX I — PLENARY SESSIONS OF CONFERENCE

Opening Session of Conference — 1

The Conference, which President Eisenhower characterized as incomparable in "scope, importance (and) widespread interest" to the world, convened August 8 in the Assembly Hall of the Palais des Nations. All 2000 seats at the first plenary session were occupied by delegates, advisers, observers, and the news correspondents. Presided over by Dr. Homi J. Bhabha (India) President, the Conference heard greetings and good wishes from the chiefs of state of France, India, the Union of Soviet Socialist Republics, the United Kingdom, and the United States, read by members of the respective delegations. Chairman Strauss read the message from President Eisenhower.

The Conference began with a welcome from M. Max Petitpierre, President of the Swiss Confederation, delivered in French.

"Solidarity," he said, "has been forced upon us by events. We must at last understand that unless we all go forward together, we shall all go back together." He forecast that the Conference would enable scientists of all the participating countries to share discoveries in the use of atomic energy for the ultimate benefit of mankind.

Dr. Bhabha then introduced Mr. Dag Hammarskjold, Secretary General of the United Nations who recalled that the Conference had its origins in President Eisenhower's address to the General Assembly of the United Nations in December, 1953, Mr. Hammarskjold declared he was sure that the exchange of scientific data at the Conference would "turn men's thoughts away from war to peace" by the removal "of barriers to understanding and friendship" of the postwar decade.

Messages were then read from chiefs of those states which played, in Dr. Bhabha's words, "a prominent role in organizing this Conference." M. Guillaumat, head of the French delegation, read a message from Edgar Faure, Chairman of the Council of Ministers of France; Dr. Bhabha read the message from Jawaharlal Nehru, Prime Minister of India; Academician D. V. Skobeltzin, head of the USSR delegation, read a message from Nicholai Bulganin, Chairman of the Council of Ministers of the Union of Soviet Socialist Republics; and Sir Edwin Plowden, Chairman of the British Atomic Energy Authority, read a message from Prime Minister Sir Anthony Eden.

1035224

M. Faure, Mr. Nehru, and Sir Anthony expressed a common hope that the Conference would show ways to develop peaceful uses of atomic energy so that its development could help in time to raise the standard of living throughout the world. Mr. Bulganin stressed particularly a hope that the Conference would be an important step toward international cooperation among nuclear scientists.

Mr. Strauss then read President Eisenhower's message in which he reaffirmed the pledge given in his address to the United Nations General Assembly, nearly two years before, that the United States was determined to employ atomic energy for the general use, and not abuse, of all mankind. In his message to the Conference, the President said:

> "Please accept my warmest greetings and sincere good wishes -- on behalf of the people of the United States -- for the success of this first International Conference on the Peaceful Uses of Atomic Energy, held under the auspices of the United Nations.
>
> "You -- the world's foremost nuclear scientists and engineers, who are penetrating the mysteries of atomic energy -- most surely know how the atom stands ready to become man's obedient and tireless servant, if man will only allow it.
>
> "The knowledge and vision which you possess carries with it a great opportunity -- and a great challenge. Your lives are dedicated to the search for knowledge and truth. You hold the respect of your peoples because they look to you for words of calm, unadorned scientific fact.
>
> "You can best unfold to the peoples of the world the bright promise of the benign atom.
>
> "You meet in Geneva under conditions favorable to this great purpose.
>
> "No other scientific gathering of such scope and importance, or of such widespread interest, has ever taken place. The peoples of the world are represented. At hand is a rich opportunity to restore old lines of free scientific communication which have been disrupted for so many years. The knowledge and skills which each of you has acquired in his own country to put the atom to work for peaceful purposes will be circulated and shared in the friendly atmosphere of hospitable Switzerland with its age-old tradition of freedom.

1035225

"This atmosphere is encouraged also by the fact that the United Nations Resolution of last December 4th, which created your Conference, limited its concern to scientific and technical matters. It is expressly non-political.

"You meet, therefore, as free men of science, interested only in enriching man's store of knowledge about this wonderful discovery.

"Science speaks in many tongues. The advancement of the nuclear arts has been the work of men of many nations. That is so because the atom itself is non-political. It wears no nationality and recognizes no frontiers. It is neither moral nor immoral. Only man's choice can make it good or evil. The phenomenon of nuclear fission having been revealed to man, it is still left to him to determine the use to which it shall be put.

"On December 8, 1953, I had the privilege of addressing the General Assembly of the United Nations on the subject which occupies this Conference — world cooperation for the Peaceful Uses of Atomic Energy.

"I stated then, and I reaffirm now, that the United States pledges its determination to help find ways by which the miraculous inventiveness of man shall not be dedicated to his death, but consecrated to his life.

"This pledge which we gave 20 months ago has become the law of our land, written into our statutes by the American Congress in the new Atomic Energy Act of 1954. The new act states in forthright language that we recognize our responsibilities to share with others, in a spirit of cooperation, what we know of the peaceful atomic art. To further encourage such cooperation with other nations, the new act relaxes the previously existing restrictions on independent atomic research and development by private industry, thereby further clearing the way for cooperation with others.

"Since our new Atomic Energy Act became law a year ago, we have striven in many ways and ever in a spirit of good will to translate its words and its purpose into concrete action.

1035226

"That is the way we interpret our responsibility and the responsibility of all nations of good will.

"We appeal not alone to Governments to join with us in this cooperative endeavor. We are hopeful also that business and professional groups throughout the world will become interested and will provide incentives in finding new ways that this science can be used.

"All of the enlightened nations of the world are spending large sums every year on programs of health, education and economic development. They do so because they know that disease, ignorance and the lack of economic opportunity are the dark breeding places of disorders and wars.

"Every scientific tool available has been brought to bear in this effort.

"Atomic science is the newest and the most promising tool of all.

"In your capable hands, I am confident it can be made to perform greatly for the betterment of human living."

Dr. Bhabha, as Conference President, delivered the major address of the opening session. He declared that atomic power had become "an absolute necessity."

He spoke of three epochs in human history, each of which was marked by a revolutionary change in the energy pattern of society.

In the first epoch, he said, man existed on earth for about 250,000 years although the earliest recorded civilizations only date back some 8,000 years. These early civilizations had a common foundation: all energy for doing work was supplied by muscle, either animal or human.

In the second epoch, Dr. Bhabha said, men turned to the widespread use of chemical energy, especially that obtained by burning coal and oil, and this leads to the industrial evolution. As a result, total consumption of energy rose enormously, is still going up, and will continue to rise, together with the world's population. This would mean, Dr. Bhabha believed, that world reserves of coal, oil, gas shale and oil shale would be exhausted in under a century. Presently known reserves of coal and oil were insufficient, he said, to enable under-developed countries, containing a major part of the world's population, to attain and maintain a standard of living

1035227

comparable to that of industrially advanced countries. This meant, Dr. Bhabha said, that atomic energy will be not merely an aid; it will be "an absolute necessity."

The third epoch was atomic, relatively near at hand. This would, Dr. Bhabha said, bring quantities of fissionable material into the hands of many nations. Such a responsibility would demand, therefore, "an international society in which major states have agreed to maintain peace."

"The historical period we are just entering in which atomic energy released by the fission process will supply some of the power requirements of the world, may well be regarded one day as the primitive period of the atomic age", Dr. Bhabha said. "It is well known that atomic energy can also be obtained by a fusion process, as in the H-bomb, and there is no basic scientific knowledge in our possession today to show that it is impossible for us to obtain this energy from the fusion process in a controlled manner. The technical problems are formidable, but one should remember that it is not yet fifteen years since atomic energy was released in an atomic pile for the first time by Fermi. I venture to predict that a method will be found for liberating fusion energy in a controlled manner within the next two decades. When that happens, the energy problems of the world will truly have been solved forever, for the fuel will be as plentiful as the heavy hydrogen in the oceans."

Dr. Bhabha concluded his address with these words:

"All the basic discoveries upon which atomic energy is based were made before the Second World War by scientists of many nations working in free and full collaboration. The war put an end to this free exchange of knowledge, and most of the technical developments concerning atomic energy were made subsequently by a few nations, each working in isolation behind a wall of secrecy. This Conference, arising out of the bold initiative of President Eisenhower, has already broken down many of these barriers and we have come to know of the remarkable advances in atomic energy achieved in several countries of which we were totally ignorant hitherto. It is to be hoped that through the remarkable improvement in the political climate which has taken place recently, and which we hope will continue, the barriers which remain will gradually disappear altogether. If so much has been achieved through the individual and isolated efforts of a few countries, how much more could be achieved by the combined effort of all. Those who have the good fortune to participate in this Conference are privileged to be in the vanguard of the march of history. . ."

In closing the first session, the Conference confirmed by acclamation the list of officers of the Conference, and the chairmen

1035228

and vice chairmen of the various sessions who had been previously appointed by Secretary-General Hammarskjold. This concluded the first session.

PLENARY SESSION 2 - WORLD ENERGY NEEDS

by Karl M. Mayer

Nathaniel B. Guyol, of the United Nations Secretariat, presented paper No. 902, "World Energy Requirements in 1975 and 2000" which described in detail the world's energy consumption pattern as of 1952, the sources of supply, and the use of energy. Use of energy was analyzed by types of consumers and geographic regions. Mr. Guyol concluded that by 1975 about three times as much energy would be used in the world as in 1952, and that by 2000, consumption would be 8 times 1952 totals.

A second paper, by Pierre Ailleret (France) was No. 326 "An Estimate of Energy Requirements" which stressed that energy requirements should not be lumped under a single unit of measure - for example, in terms of kilowatt-hours,but should be stated in terms of heat, power, etc., requirements. Ailleret pointed also to the difference in the elasticity of demand of "big" as opposed to "small" users of energy. The demands of the large user in most cases are more elastic, and the impact of price on consumption is far greater.

The third paper, No. 757, "The World's Need for a New Source of Energy" was given by E. A. G. Robinson (UK) who stated that Guyol gave what might be termed an "upper limit" of the amount of energy to be used in 2000 AD. Robinson estimated that the "lower limit" is about half Guyol's figure.

The fourth paper, No. 802, "Energy Requirements and Economic Growth" was given by E. S. Mason (US) who stressed that although large investments are needed to generate power, still larger investments are necessary to use power. This is particularly important in the development of less advanced countries, in which slow capital formation and lack of foreign exchange might constitute serious barriers.

The general papers were followed by a series on the needs of individual countries, and the possibilities for power and heat. In addition to a UN paper, others were presented by delegates of Brazil, Yugoslavia, Australia, Belgium, Czechoslovakia, Japan, Argentina and

1035229

India, and additional remarks were made by delegates of Egypt, Pakistan, Israel and Ceylon.

Paper No. 1116, "Contribution of Nuclear Energy to Future World Power Needs" by P. Sevette stressed that the needs for energy, and the ability to satisfy those needs in individual countries, must be subjected to thorough analyses within each nation. The Brazilian paper, No. 125, "The Brazilian Plan of Electrification and the Possibilities of Nuclear Power" by E. Motte Rezende, stressed the importance of fuel transport costs in the vast territory of Brazil. The Yugoslav paper No. 962, "Requirements and Possibilities of Production of Energy in Yugoslavia" by A. Blazek, et al., indicated that country would develop atomic power even if conventional sources were adequate because of the qualitative differences inherent in nuclear energy. The Australian paper, No. 987, "Electric Power in Australia - 1955-2004" stated the country has 60 power networks essentially not inter-connected; nuclear power, therefore, would go into those places or networks where transport costs were being incurred.

It was pointed out in the Belgian paper, No. 949, "Probable Evolution of Energy Needs in Belgium and the Possible Role of Nuclear Energy" by R. Van Mele, that the power industry of Belgium was almost completely dependent on coal and that a fuel crisis could be expected within a few decades - certainly from 1980 onward. The Czech paper, No. 799, "Prospects of Power Development in Czechoslovakia and the Part to be Played by Nuclear Energy for Peaceful Purposes" by A. Sevcik noted that the current trends in Czechoslovakia were such that the use of electricity was increasing at a far faster rate than the use of energy as a whole. The Japanese paper, No. 1060, "Japan's Energy Utilization, the Present and the Future", gave projections showing an increasing dependence on foreign sources of energy in the coming decades. The Argentine paper, No. 998, "Energy Needs and Resources of the Argentine Republic" by G. Mendivelzua, pointed out that the energy sources of Argentina were generally far removed from energy consumption centers and great transport costs were consequently incurred.

The Egyptian delegation statement by A. Rahman indicated that Egypt had given detailed consideration to questions involving national energy economics. The Pakistan representative, N. Ahmad, stated that Pakistan is looking to atomic energy to speed up economic development. E. D. Bergmann stated that Israel's use of power, especially for irrigation, was growing so fast that it cannot rely on conventional sources alone—it must look to atomic energy. The Ceylon statement—by C. J. Eliezer—was that the island has no oil, no coal and only a very small amount of hydro potential; Ceylon therefore was looking to atomic power to help eliminate poverty.

1035230

The final paper, No. 868, "The Role of Atomic Energy in India and Its Immediate Possibilities" by H. J. Bhabha of India, reviewed the energy resources of the country and discussed the possible role of atomic energy in the years immediately ahead and in a highly industrial economy in the more distant future.

PLENARY SESSION 3 - THE BUILDING OF A NUCLEAR ENERGY ENTERPRISE

by Karl M. Mayer

The first part of Plenary Session 3 considered "Experience with Nuclear Power Plants" and consisted of one USSR paper and one from the United States.

Paper No. 615, "The First Atomic Power Station in the USSR and the Prospects of Atomic Power Production" by D. I. Blokhintsev and N. A. Nikolaev, presented by Blokhintsev, contained a description of the flow sheet, physical peculiarities, materials, reactor design, and operating characteristics of the first Russian power reactor. Blokhintsev stated the atomic station was competitive in costs with coal stations and prospects for atomic power development were summarized. The USSR paper contained a number of conclusions regarding the operation of the first USSR power station for a period equivalent to the production of 10 million kilowatt hours. Among these statements were that (1) No fuel element failures occurred; (2) The reactor operation was very stable; (3) Radioactive contamination in the plant was kept considerably below tolerance, and (4) The operation of the atomic power station proved to be simpler than the operation of a conventional coal station.

Paper No. 851, "Design and Operating Experience of a Prototype Boiling Water Power Reactor" by J. R. Dietrich et al. was given by Walter Zinn (US) and contained a detailed description of the design of the Argonne National Laboratory boiling water power reactor. The US paper discussed the operating characteristics of the reactor and gave a cost analysis. The US paper stated that the power reactor described had a rating in the 5 to 10 MW range. The facility was built in order to acquire operating experience and, in particular, to test the stability of the boiling water reactor. The effect of feed water temperature, throttling of the steam exit, and of power production as a function of reactivity added by the control rods, were studied. The reactor was found to be remarkably stable under operating conditions. Cost data for the construction and operation of the plant were given in detail and the calculated cost of nuclear power from the facility was shown.

1035231

Question: Lewis (Canada) asked whether there were any instrumentation problems in the operation of the USSR reactor. Answer: Blokhintsev replied they had some instrumentation problems during the first few months of operation; however, they had no problems at this time.

Question: Libby (US) commented that in the United States the tendency in working toward economic nuclear power was in the direction of attaining high conversion ratios, but that the USSR reactor had a low conversion ratio and burned U 235. He asked whether the USSR had conversion ratios approaching unity in its large reactors and, if so, how did the USSR plan to change its fuel element for this purpose. Answer: Blokhintsev said the USSR reactor program planned to move in the direction of zirconium, to change the lattice and the reactor structure so that the conversion ratio would move toward unity and settle perhaps at about 0.5.

Question: Went (Netherlands) asked what was the alloy composition of the USSR fuel element and did they use a uranium-molybdenum alloy, for example. Answer: Blokhintsev said such an alloy would be possible.

Question: Dunworth (UK) asked whether the USSR would build many 5000 MW reactors. Answer: Blokhintsev said the USSR would build larger reactors.

Question: Dunworth (UK) recalled that Malenkov had said that a 100,000 kw reactor would be built in the USSR. Answer: Blokhintsev said that a 100,000 kw reactor would be constructed within one year.

Question: Shankar (India) asked whether there was much decomposition of water in the primary circuit and how was this taken care of. Answer: Blokhintsev said there was some decomposition at low pressures, but at the pressure the USSR used no detonating mixture was formed, and the decomposition was not substantial.

Question: Gamba (Argentina) asked for further information on the reactor fuel element fabrications. Answer: Blokhintsev said a detailed USSR report was available on fuel elements and on the influence of radiation on uranium and uranium alloys.

Question: Weinberg (US) asked how, if the fuel element had a jacket and was cooled only internally, the stability of the element was controlled. Answer: Blokhintsev said the USSR used a plastic material to keep the fission products from the graphite.

Question: Weinberg asked whether the USSR jacket was bonded to the fuel. Answer: Blokhintsev said there was a molecular liaison between jacket and fuel element.

1035232

Question: Weinberg then asked Blokhintsev about the neutron spectrum and breeding coefficient regarding their work on fast reactors. Answer: Blokhintsev answered that a conversion ratio of more than 2.0 had never been observed. He gave the number of neutrons per fission at 2.72 (hard); for 900 KV spectrums got 2.9 neutrons per fission; and for a 300 KV spectrum got 2.6 neutrons per fission.

Question: Kruzhilin (USSR) stated that Professor Zinn's report on the heterogeneous boiling-water reactor was of great technical interest. On the basis of industrial-scale experiments, the report gave a clear account of the most difficult problem of the reactor's stability. Direct experiments had shown that the use of a boiling-water reactor to generate power was feasible. As a result, the prospect of using a reactor in which steam is raised in the reactor vessel itself would become a reality. For a high load, natural circulation was unstable. He then asked what was the maximum amount of power a water boiler could make? Answer: Zinn answered that they thought they could make 1000 MW of heat. They expected to make pressure vessels over two meters and up to 4 meters in diameter. The reactor was fueled with enriched uranium thereby lessening the problem of size. The removal of heat from the core was more important than the heat transfer in the fuel element. Since they could not rely on natural circulation, forced circulation was necessary for large power outputs. Water channels were wide and the head on pump was low.

General Electric had suggested it is possible to withdraw heat from the core, flash the steam and increase the power of the reactor without lessening the safety.

Question: Goodlet (UK) stated that he had a certain agnosticism about boiling reactors because there was a fundamental contradiction which had never yet been resolved. If one wished to obtain a large amount of power from a boiling reactor it was necessary to produce a large amount of steam. In producing a large amount of steam there was a large amount of voidance in the core and oscillation difficulties which were described in Dr. Zinn's paper. He stated that if a steam main of a boiling reactor fractures it was necessary to let pressures down to something like atmospheric with the result that a large amount of flash steam would form. The flash operation would also cool what water remains in the reactor, and one would be left with a reactor full of water at about 100°C. That would also happen in pressurized water reactors and from that point of view as regards ultimate safety, and fractures resulting from water and steam, he could see very little difference between these two reactors. Answer: Zinn answered that they had actually opened a steam line in the primary and let the reactor depressurize itself. One had 30 to 40 seconds in which to insert the rods. It was therefore not hazardous because of the time lag.

1035233

Question: Dunworth (UK) asked if the aluminum reacted with the water. Answer: Zinn answered that no chemical reaction between the aluminum fuel elements and water in the reactor had been observed. There was no substantial aluminum - water reaction unless the metal was finely subdivided.

In the second part of the Session, two papers on capital costs of nuclear energy were presented, one by the United Kingdom, one by the United States.

In the UK paper No. 391, "Capital Investment Required for Nuclear Energy" by J. M. Hill and S. W. Joslin, Hill gave estimates of the construction cost of nuclear power stations and gaseous diffusion plants. He concluded that a country that wished to produce nuclear electricity with a minimum capital investment could purchase a reactor of proved design at about 50% above conventional costs; that independent development programs would require the diversion of substantial economic resources.

The paper from the United Kingdom gave a description of the facilities and staff at Harwell and the approximate cost. In addition the cost of nuclear power facilities was indicated. A discussion was given of the cost of the projected UK nuclear power programs and in terms of the probable drain on Britain's resources. The paper concluded with an assessment of the capital investment required for the UK program and pointed out specifically the difficulties encountered in trying to fix a "correct" rate of investment in the case of the United Kingdom.

In presenting paper No. 477, "Capital Investment Required for Nuclear Energy," W. K. Davis gave analyses of fixed charges associated with reactor investment under a number of circumstances. The size of the investment required was given for various portions of a nuclear power industry all the way from exploration to nuclear power plant construction, to irradiated fuel processing.

It was stressed in the US paper that much of the investment required by a nuclear power industry would be for conventional equipment used in conjunction with a reactor. The effect of radiation on the design and cost of nuclear facilities was discussed.

It was assumed that most nuclear power systems would be first operated on uranium cycles. However, since it might be desirable to switch to thorium at some time in the future, the cost of converting from uranium to thorium-using facilities in terms of new capital investment required, was discussed.

The US paper concluded that nuclear capital investments would probably be high to begin with; however, as technological progress

1035234

was made, the investment required by atomic and conventional power units would be the same for equivalent capacities.

PLENARY SESSION 4 - FACTORS IN THE USE OF NUCLEAR ENERGY

by Karl M. Mayer and Walter D. Claus

The first part of Session 4 — "Economics of Nuclear Power" — consisted of two papers. Paper No. 476 "Economics of Nuclear Power" by J. A. Lane (US) outlined present reactor development programs planned or under way in the United States, and gave estimated costs for capital and fuel.

Lane considered the operating and fuel costs associated with (1) highly enriched U 235 reactors; (2) natural or slightly enriched uranium reactors; (3) thorium breeders; and (4) plutonium fast breeders.

In addition the fuel inventory costs of various reactors were considered in detail. The fuel burn-up costs were shown to be affected by such factors as the system's neutron economy, length of fuel cycles, and the costs of reprocessing spent fuel elements. The various fuel element costs were combined with fixed and operating cost elements to yield specifications for reducing nuclear power generating cost to 6.7 mills per kwh. He concluded that the outlook for competitive, large-scale nuclear power in the United States was very promising.

UK paper No. 390, "The Cost of Power and the Value of Plutonium from Early Nuclear Power Stations" by J. A. Jukes, analyzed the gross costs of a 150 MW gas-cooled, graphite-moderated nuclear power station.

He stated that expected costs of nuclear power from early reactors should be equal to or below the cost of electricity from coal fired stations. It was stated, however, that it was difficult to give firm operating costs at this time. The importance of fixing plutonium credits at the correct economic level was stressed and various methods considered for deriving plutonium credits. The interplay of projected demands for plutonium and plutonium prices was treated in detail.

Question: Wigner (US) asked what the specific power of the first UK reactor was. Answer: Jukes answered that there was about 100 to 150 tons of fuel per reactor. There were two reactors per station; therefore, there would be about 1/2 MW output per ton of fuel. An enrichment of 0.75% had been provided for flexibility.

1035235

The limit of power output was the temperature of the fuel elements (400°C at the fuel element surface) near the center of the reactor. With enrichment one could flatten the reactor neutron flux and run more elements at the maximum (400°C) temperature.

Question: Davis (Canada) asked if the price of new uranium metal at this time was stable at around $28 per pound, what would happen to the price of plutonium in the UK if the price of uranium were cut in half. Answer: Jukes answered that in the UK reactor a large portion of the fuel cost resided in the cost of enrichment and fabrication. A drop in the price of new uranium metal would reduce the gross cost of electricity in the UK and also the net cost. However, a change in the price of uranium would lower the price of plutonium thereby encouraging the construction of natural uranium reactors and discouraging enriched, thorium, and plutonium reactors.

Question: Lawson (Canada) asked if waste disposal was included in the cost figures shown in the UK paper. Answer: Jukes answered that the figures did include the cost of waste disposal from present plants; however, the cost of processing was just a few pounds per gram.

A short paper, No. 867, entitled "The Possible Role of Thorium in Nuclear Energy" by J. V. Dunworth (UK) followed the discussion on power costs. Dunworth summarized the nuclear data available, the material available, the material needed and the manner in which it might be employed. He concluded that thorium could possibly become a more valuable power fuel than uranium.

The UK paper noted that present nuclear data indicated that a thermal homogeneous reactor system fuelled with thorium and U 233 was self-maintaining, and that it might be possible to make a system with a small gain factor. The exact gain factor would be determined by economic considerations but would probably not be higher than 10%. Systems with either negative or positive gain factors were studied. The achievement of a positive gain factor, however, was not considered to be of crucial importance.

Question: Lewis (Canada) asked if he increased his exposure level from 3000 to 5000 MWD/tons, how could his conclusions be changed. Answer: Dunworth answered that the 3000 MWD/ton applied only to the uranium.

Yoshio Fujioka presented paper No. 1063 by K. Suzue. The paper discussed in three parts the attempts of Japan to cope with "Administrative and Legal Problems on the Use of Radioisotopes in Japan." Part I described training of isotope users and technical administrators abroad and at home. Part 2 outlined 12 points being studied by the Scientific and Technical Administration Committee of

1035236

the Prime Minister's Office in preparation for setting up a National Research Institute for Radiation, in 1956. Part 3 dealt with problems of applying to radiation cases Japan's existing workmen's compensation laws.

Paper No. 400 "Administrative and Legal Problems of Widespread Use of High Level Radiation Sources - Industrial Health and Safety, Radiological Health Safety Codes," was presented by W. Binks (UK) who reported that, in the past, those responsible for protective measures depended on "self-regulation" by radiation workers and supervisors, based on recommended codes of protection. He said that violations were forcing the Ministry of Health to draw up specific codes for radiation protection of workers and populations.

The statutes were being drawn to be as simple and restricted as possible, while granting heads of radiological departments a reasonable measure of freedom in devising laboratories, techniques and protective measures. He said that, in general, the statute specified that International Committee on Radiation Protection codes be complied with. Binks stated a complete legislative code could not be enforced and some calculated risk to workers and populations must be allowed.

Under the statutes, licensing for use of radioisotopes would require setting up four classes of laboratories, depending on the nature of work and levels of activity handled. In addition, the Ministry of Health was setting up a special service to assist many small laboratories which could not afford well-trained health physicists, rather than attempting to control them through rigid regulation.

Question: Taylor (US) asked whether it was planned to require inspection before granting permission to use radiation sources. Answer: Binks said inspection for licensing was difficult, and licenses might be based on assurance that the laboratory and personnel knew the regulations and would comply. The Ministry would have to feel its way for awhile.

Question: Taylor then asked whether the UK would have a code to give detailed guidance as to definition of class of laboratory. Answer: Binks said various codes were under preparation and would be released shortly.

Paper No. 778 "The General Problems of Protection Against Radiation from the Public Health Point of View," was presented by Dr. Pierre Dorolle, Deputy Director-General for the UN World Health Organization. In it, he reviewed what he believed to be the responsibilities of WHO in protecting world health against harmful effects of radiation, particularly in studying genetic effects. Responsibility for the location of nuclear energy plants would eventually

1035237

fall on public health officials, he said. In the disposal of solid, liquid and gaseous wastes, international agreement should certainly be reached on criteria and locations for disposal. The paper outlined a suggested public health program, including training, dissemination of pertinent information, and a world-wide scientific study of somatic and genetic effects of background radiation.

Question: Cambel (Turkey) asked whether WHO would attempt to specify control of radioactive water and mud baths for therapeutic purposes. Answer: Dorolle said that regulations to date had been designed only for artificial sources, but certainly WHO would consider the desirability of controlling radioactive baths where such might be producing adverse effects, but this had not been thought of as a matter of radiation protection.

Question: Bolanos (Salvador) asked how could protection be assured against health hazards of reactor wastes which might be buried in the ground or in the sea. Answer: Dorolle answered that this question required much further study. International agreement on waste disposal was needed—there should not be indiscriminate dumping in the sea.

Paper No. 319, "The Achievement of Radiation Protection by Legislation and Other Means" by L. S. Taylor (US), treated control methods as they appeared to be developing in the United States. Trends were much as in England — voluntary compliance with the codes of the National Committee on Radiation Protection was insufficient, and both state and Federal regulations were being, or had been, drafted. NCRP started in 1953 to draw up a model law which suggested that states adopt only such regulations as they could enforce, and attempt to write laws only to cover cases which actually occurred in a given state rather than attempt to cover every possible situation. The NCRP model suggested certain small quantities of radioisotopes be exempt from regulation, and also covered licensing, permissible levels of exposure, monitoring methods, reporting, and waste disposal.

PLENARY SESSION 5 - THE ROLE OF NUCLEAR POWER IN THE NEXT 50 YEARS

by Karl M. Mayer

UN paper No. 893, "Some Economic Implications of Nuclear Power for Under-Developed Countries" by R. P. de Breuvery (United Nations) pertained to the correlation of present world-wide power supply with

1035238

general economic development area by area. In the second part, the cost of nuclear power for undeveloped countries was outlined and such aspects as the use of small reactors, the load factor, the cases of transmission and distribution, the investment in supplementary facilities, and the dependence on imported fuel or equipment were considered. The UN paper concluded that nuclear power in such countries could accelerate development, diversify the economy and facilitate the exploitation of mineral resources.

Paper No. 11, "An Economic Forecast of the Role of Nuclear Power in Canada" by J. Davis and W. B. Lewis (Canada), looked toward the construction of an increasing number of nuclear plants between 1960 and 1970.

Paper No. 327, "Integration of Nuclear Energy Among the Means of Energy Production" by P. Ailleret and P. Taranger (France), looked toward the gradual integration of nuclear energy into the power system of France.

Paper No. 758, "The Role of Nuclear Energy in Relation to Other Methods of Electricity Generation" by J. M. Kay (UK) was given in five parts. First a comparison between the economics of nuclear and conventional thermal stations was given. Second, an outline of hydro characteristics was presented. In the third part, the economics of joint nuclear-thermal plants was examined. In the fourth part the exclusion problem was discussed, and, in the final section, several examples of interconnected systems with thermal-hydro-nuclear facilities were given.

Paper No. 145, "Economic Significance of Nuclear Power for Brazil" by B. C. de Mattos and J. da Costa Rebeiro (Brazil) contained a general survey of the electric power installed in Brazil. Statistics on past electric power consumption were given and projections into the future were made. Selling prices of thermal and hydro power in Brazil were compared. Estimates of hydro, coal, oil uranium and thorium reserves were made. Tentative conclusions were reached with respect to the use of nuclear power in various regions of Brazil.

Paper No. 1002, "Role of Atomic Energy in the Argentine Republic" by P. E. Iraolagoitid (Argentina) stressed the lack of energy resources at or near the energy consuming regions in the country.

For example, it was stated that nuclear power development in the central and eastern part of the country are essential since those regions are undergoing considerable industrial development at this time. Nuclear power development in Argentina will be based on the use of domestically mined uranium and thorium. However, personnel will probably have to be trained overseas.

1035239

Paper No. 475 "The Economic Potential of Nuclear Energy" by K. M. Mayer (US) gave a detailed analysis of the economic potential of nuclear energy in the US and made projections on a world-wide basis.

It was stated, for example, that the quantities of energy marketable in the US power economy at corresponding costs of generation and at a near future date such as 1965 were calculated to be 1.3, 9.6, 12.9 and 34.1 thousand million kilowatt hours per year for bus-bar generating costs of 9, 8, 7 and 6 mills per kwh respectively.

Paper No. 389, "The Contribution of Nuclear Power to United Kingdom and World Energy Up to 1975" by J. D. Cockcroft (UK) outlined the United Kingdom nuclear power program. He gave some estimates of his country's electrical power requirements up to the year 2000 A.D. in terms of coal equivalent and discussed the ability of nuclear fuel to carry some of the burden. The effect of uranium utilization on requirements and its relation to reactor development were considered. The paper concluded that Great Britain will place ever greater reliance on nuclear energy for power production in the coming decades.

Question: Skobeltzin (USSR) asked if the UK expected to substitute water reactors for graphite reactors, could he explain the provisional trend to graphite, gas-cooled reactors. Answer: Cockcroft answered that the UK expected to begin with graphite and then go on to more advanced designs such as water if it proved to be economic. It now appeared that UK would go to water reactors by about 1965.

Question: Blokhinstev (USSR) asked what the cost of power at Calder Hall was. Answer: Cockcroft replied that the cost of power given by Mr. Jukes was 0.6d for power with a plutonium credit and 0.76d without a plutonium credit. The credit for plutonium included plutonium processing; however, fuel elements were considered once through and fabrication was not included.

Question: Libby (US) asked if uranium ore supplies were sufficient to support the projected UK program. Answer: Cockcroft answered that the UK has relied on projections made by Jesse Johnson of the United States who maintained that there was plenty of uranium ore available. Better utilization in the coming decades would improve the position.

Question: Davis (US) asked de Breuvery if he would comment, in connection with small reactor plant location, on the difficulties of transportation and the importance of cooling water. Answer: de Breuvery (UN) answered that in order ot exploit minerals located in remote areas it would be necessary to transport fuel by air and cooling water must be available.

1035240

Question: Davis (US) asked if he considered a nuclear plant in competition with a conventional plant, should he consider each at the same load factor. Answer: de Breuvery answered that in the case of under-developed areas, one should consider the load factor somewhat differently. There were numerous places which had no power so a comparison was very hard to make.

Question: Davis (US) asked if it would be possible to undertake economic studies involving the costs of conventional and nuclear power in underdeveloped countries such as Pakistan. Answer: de Breuvery replied yes; that such studies could be supported through some form of international assistance, or the cost of the study could be borne by the country itself.

Question: Davis (US) asked how he would use a small reactor where oil was cheap and the market dispersed. Answer: de Breuvery replied that oil might be cheap at the production point but not at the point of consumption. Since the markets were dispersed, transport costs were involved, and nuclear power might be the answer.

Question: Davis (US) asked if there was a market for power at 30 mills kwh at a 50% load factor. Answer: de Breuvery answered yes, that in fact there was a market for power at costs as high as 155 mills kwh.

Comment: Cats (Israel) commented on the fact that the rate of interest in a particular country such as Iraq was very important; capital charges must be offset by low fuel charges. At 15% returns and 60% load factor the capital charge was already 4.3 mills kwh. The solution was in lowering nuclear capital charges through international public finance.

Question: Skobeltzin (USSR) asked Davis (Canada) if the low temperature operation of a nuclear plant wasn't a great disadvantage. Answer: Davis replied that nuclear fuel as a heat source was very interesting - it had a low temperature advantage and could be used in such industries as pulp and paper in Canada. Electricity might be the by-product. It might be possible to use heat from the turbine for space heating.

Question: Skolbeltzin (USSR) asked if it were possible that the conclusions presented in the UK paper would be upset by technological advance. Answer: Kay (UK) answered that his paper was concerned with developments foreseeable in the next 10 years. He could not foresee any startling technological developments during the next ten years.

Question: Skobeltzin (USSR) commented that nuclear plants must have a high plant factor in order to be economic. He asked Mayer

1035241

how this affected the market for nuclear power. Answer: Mayer (US) answered that most calculations of nuclear power cost were based on high plant factors. However, in assessing the economic position of nuclear energy one must look first to the current and projected power market. In the final analysis, the market would determine the pattern of energy consumption. In studying the potential market for nuclear energy power in the United States the plant factors were taken into account automatically. In order to use the potentials shown, one must calculate the cost of nuclear power with the correct plant factor, size, etc. and then one can read the share of the market which nuclear power should capture directly from the data given in the study.

Question: Skobeltzin (USSR) asked how a reduction in transmission costs might affect the market potential of nuclear energy. Answer: Mayer (US) replied that advances in the technology of power transmission and distribution would benefit both nuclear and conventional power. Reduced costs at the point of delivery would stimulate the consumption of power. After corrections had been made for the cost of exclusion or containment, it would still be necessary to compare the costs of nuclear and conventional power generation at the bus bar.

PLENARY SESSION 6 — HEALTH AND SAFETY ASPECTS OF NUCLEAR ENERGY

by Robert J. Hasterlik and U. M. Staebler

Under the chairmanship of W. B. Lewis (Canada), Section 6 of the United Nations International Conference on the Peaceful Uses of Atomic Energy was divided into two parts, the first dealing with "Biological Effects of Radiation", the second with "Reactor Safety and Location of Power Reactors."

The first speaker was J. F. Loutit (UK) who delivered paper No. 392 on "The Experimental Animal for Study of the Biological Effects of Radiation". Loutit stated that it was to be expected the higher animals, including man, would be more sensitive to ionizing radiations than would lower forms. In order to collect data and set reasonable levels for radiation exposure to man, the International Commission on Radiation Protection had been organized. It was necessary to collect all available data concerning deleterious effects in the human which fall, in general, into four categories.

1. Superficial injury, such as the radiation burns suffered by the early radiologists.

1035242

2. General effects, such as the production of aplastic anemias following prolonged exposure to radiation.

3. Induction of tumors, such as have appeared on the skin after a latent period of 20 to 30 years following irradiation of the skin in a child at levels of 1500 roentgens. (Studies on skin carcinogenesis in the hairless mouse were presented.)

4. Other deleterious effects such as the production of cataracts, genetic effects, etc.

Future progress was to be expected on the basis of study using the experimental animal.

Certain studies of great importance have been going on in several countries concerning factors affecting recovery of the hemotopoietic systems from irradiation. These include studies on parabiosis; shielding of tissue such as spleen, liver, head; and the injection of bone marrow.

Loutit believed that periodic blood counts were not a sufficiently sensitive indicator of the occurrence of irradiation damage and recommended that the periodic blood count be replaced by physical methods of monitoring. During the course of his presentation, Loutit suggested that natural levels of radiation probably play little part in the natural mutation rate except in long-lived animals such as man.

The second paper, No. 616, "The Influence of the Ionizing Radiations on Animal Organisms," was presented by Prof. A. V. Lebedinsky (USSR) who stressed the importance of the therapeutic use of ionizing radiation but pointed out the limitations imposed by the development of "radiation sickness". USSR studies have for the most part been directed toward the effects of radiation on the nervous system.

A first approach has been by means of histological study of nervous tissue after irradiation. Nemenov has studied the effects of 2,500-3,500 r on conditioned reflexes in dogs. Nemenov's data demonstrated that, after radiation, there was a marked decrease in the latent period between the stimulus and appearance of the conditioned reflex, salivation, which was in larger volume than normal. After a lapse of time, a reverse effect was noted.

Gorizontov has irradiated rats with 600 r. He has found a fall in "internal inhibition" of the central nervous system, followed by a "depression of cortical activity", followed by a disappearance of reflexes, followed by their return.

1035243

Livanov and Anyanev have studied the changes in electroencephalographic changes in rabbits following 500-1000 r. They found a general depression of wave activity following irradiation up to 18 hours.

Lebedinsky reported studies on electroencephalographic studies done on six human beings irradiated for therapeutic purposes. He stated that caffeine administered before irradiation yielded an increase or no change in cerebral cortical electrical activity. After irradiation caffeine plus stimulation resulted in a decrease in cortical activity. He postulated that "overstrained" cortical cells respond to stimulation by inhibition. He also had no doubt that these effects occurred immediately following irradiation.

As a further example of the nervous system effects, Lebedinsky stated that the injection of acetyl choline causes a rise in blood pressure. Two days following irradiation the rise does not occur on injection of the drug, at three days there occurs a heightened blood pressure response, followed at four days with a normal response.

The third paper, No. 478, by R. J. Hasterlik and L. D. Marinelli (US) on "Physical Dosimetry and Clinical Observances on Four Human Beings Involved in an Accidental Critical Assembly Excursion", was presented by Hasterlik.

On June 2, 1952, three men and one woman were exposed to gamma rays and slow neutrons in an accident at the Argonne National Laboratory. The doses were respectively 190 rem, 160 rem, 70 rem, and 12 rem. The fast neutron energy component was approximately 2% of the total rads and the slow neutron component, approximately 0.5%. Detailed studies on the dosimetry, including a rerun of the reconstructed assembly at known power levels established the validity of the radiation doses.

Marked amino-acidura was a prominent finding in all individuals. One patient excreted as much as 5500 mg. in one day. An increased level of urinary amino acids persisted in one individual until four months following exposure.

Complete data on the hematologic findings were presented. Studies indicated that the sperm counts had returned to normal levels in the male patients at 20 months.

The last paper of the session, No. 617, "Two Cases of Acute Radiation Sickness in Man", by A. K. Guskova and G. D. Baisogolov (USSR) was presented by M. D. Domshlak.

Two individuals were exposed in an "experimental reactor" accident to 450 r and 300 r. No details were given concerning the

1035244

type of reactor or the details of dosimetry. It was reported that the individuals have been studied for 18 months following the exposure.

The authors stressed the changes occurring in "cortical activity" on the central nervous system and described the marked changes in chronaxie which they observed during the course of the radiation sickness and recovery.

Both individuals appeared clinically "well" until the 24th day, at which time their clinical condition deteriorated. Marked bleeding tendencies were seen and the patient exposed to 450 r developed a severe ulcerative pharyngitis and tonsollitis. The patients were treated with penicillin, neucleotides, frequent 200 cc blood transfusions, caffeine, cardiazol, oxygen, and bromides.

Question: Tatsuke (Japan) asked Domshlak (1) what he believed to be the effect of neutrons on the bone marrow, and (2) would he estimate the importance of the therapeutic effect of blood transfusions? Answer: Domshlak stated (1) the authors did not deal with the question of neutrons and the bone marrow, and, in answering (2) stressed the importance of early prophylactic effect of blood transfusion.

Question: Farr (US) asked what specific therapy could be used for the reported effects of radiation on the central nervous system? Answer: Domshlak (USSR) said bromides could be used in the stage of excitation and caffeine in the stage of nervous activity depression.

Question: Pearson (US) asked what were the relative proportion of neutrons and gamma rays in the exposures. Answer: Domshlak said the authors did not give the exact figures but believed the greatest amount was gamma rays, not much neutrons.

Question: Loutit (UK) asked whether Domshlak believed the effect on the central nervous system was primary or secondary? Answer: Domshlak (USSR) said this has been clarified by Lebedinsky in his paper, since alterations in the nervous system arise immediately.

Question: Mitchell (UK) asked (1) was there any evidence for the distribution of the radiation dosage to the body of the two patients, and was it uniform; and (2) what was the evidence for the value of pentoneucleotides or other nucleic acids in the treatment of the patients? Answer: Domshlak replied that the authors did not state the distribution of radiation, and (2) that the drugs mentioned had not been administered and studies were not made.

Question: Cambel (Turkey) asked Loutit whether he believed the mechanism of carcinogenesis in the hairless mouse to be the same

1035245

as in other mice? Answer: Loutit (UK) said the hairless mouse differed from the normal mouse only in having a hereditary absence of hair follicles, that sebaceous glands were present, and he believed the mechanism to be the same.

Question: Cipriani (Canada) commented that animal data were not always applicable to man and asked how could these difficulties be obviated? Answer: Loutit said it was necessary to study effects in several species and pointed out that data on humans could be obtained from radiotherapeutic irradiations, and accidental human exposures. He stressed the extreme value of a "world clearing-house" for the assembly of all human data.

Question: Roche (Venezuela) asked whether a nitrogen balance study was carried out and, if so, what were roughly the data? Answer: Hasterlik (US) said nitrogen balance studies were not carried out.

The first speaker in the second part of Section 6 was C. R. McCullough (US) who summarized paper No. 853, "The Safety of Nuclear Reactors", reviewing briefly the history, organization and responsibilities of the Advisory Committee on Reactor Safeguards. It was emphasized that this Committee was anxious to see rapid and fruitful development of reactor technology but insisted on prudent precautions against dangers. Reactor hazards are off-site as well as on-site and must be guarded against by careful design for intrinsic reactor stability, plus careful administrative controls. The nature of reactor hazards was described, and McCullough made it clear that a bomb-type explosion was not to be expected but that radioactive contamination over rather wide areas could occur. Since large land areas often could not be provided, design for containment of radioactivity in case of an incident was believed desirable. Development of reactor fuses was cited as a promising means for increasing reactor safety.

It was stated that if an accident occurred, the spread of contamination,even though no one were killed, might make it necessary to evacuate an area near the reactor for some years.

The second talk was a review of paper No. 481, "Experimental Determinations of the Self-Regulation and Safety of Operating Water-Moderated Reactors", presented by J. R. Dietrich (US). This talk summarized results of experiments on the transient behavior of homogeneous reactors at Los Alamos and Oak Ridge National Laboratory, and on heterogeneous water-moderated reactors by Argonne National Laboratory at the National Reactor Test Station in Idaho. Most of the talk was devoted to the latter experiments. Results were presented covering the effects of lattice geometry, pressures, initial temperature and excess reactivity added. The final destructive experiment of the boiling water reactor,which was planned

1035246

to melt fuel plates, was described and a short movie was shown on the effects of this experiment. It was emphasized that the extreme conditions imposed for this experiment were difficult to achieve and that they would be virtually impossible in a well designed nuclear power plant.

The final presentation, by W. G. Marley (UK) reporting on paper No. 394, "Radiological Hazards from an Escape of Fission Products and the Implications in Power Reactor Locations", expressed a philosophy similar to that of McCullough. Noting that McCullough had described the nature of reactor behavior which made reactors potentially hazardous, the speaker concentrated on suggested tolerance levels, and actions which should be taken in the event of radioactive contamination. It was pointed out that some radioactive elements which are long-lived or which seek sensitive areas of the body on ingestion, such as Sr 90 or Pu 239, could not be tolerated to nearly the same extent as other short-lived and easily removed contaminants. Possible concentration of activity in food from plants and milk from cows was estimated. The effects of rain or dry weather conditions in deposition from a radioactive cloud were noted. A release under conditions of turbulence in dry weather, of fission products restricted to 0.1 MW of reactor power, should not necessitate lengthy evacuation of population outside a narrow sector extending 1.7 km downwind. Temporary evacuation or restriction on living habits may extend to 5.7 km, while seriously contaminated milk might be expected, temporarily, from pastures up to 20 km. Marley concluded that satisfactory locating of high power reactors which incorporate suitable engineering safeguards could not present an insuperable problem in the development of nuclear power.

Question: Cockcroft (UK) asked what kind of reactor fuses were being developed? Answer: (McCullough) said there were many varieties which mainly consist of a reactor poison, such as boron, under pressure which will be released by heating of some mechanism under high neutron exposure.

Question: Morgan (US) asked whether Marley had considered the advantage which might come from short fuel cycles which might be achieved in a homogeneous type reactor. Answer: Marley said it had been considered but that the cycle would have to be reduced drastically to have any important effect. If very short cycles could be achieved it would reduce potential contamination from a reactor accident.

Question: Lavigne (Canada) asked whether there was any evidence of chemical reactions in the water boiler reactor experiments which Dietrich described. Answer: Dietrich said there was no conclusive evidence. The destructive effects were consistent with the nuclear energy released, thus it was not necessary to assume that a chemical reaction took place. Most of the fuel was

1035247

left in the immediate vicinity of the reactor, according to radiological surveys, so no large fraction could have reacted. Some aluminum oxide was found but was believed to be due to burning in air.

Question: Mummery (UK) noted that large scale reactor designs differed from the reactor described in which the transient experiments were performed and asked for a comment on the application of these experimental results to large reactors and to reactors using heavy water. Answer: Dietrich said results were not sufficient for a complete analysis, but that results of experiments with different lattices suggested that a given amount of energy must be supplied per unit of volume; but the steam void coefficient of reactivity also would be less in this particular comparison. Heavy water would have a longer neutron lifetime which would reduce the reactor period for a given reactivity increase.

Question: Went (Netherlands) asked what was the policy of the United States regarding degree of isolation required for a reactor. Answer: McCullough said that when feasible, reactors have been located in remote areas. When this was not feasible for power reactors, the U. S. was working on a policy which would consider (a) design, (b) administrative control, (c) containment, and (d) location. In response to a further question from Went about gas-tight buildings, Dietrich stated that they were not explosion-proof, but that it was believed possible to design buildings which would prevent release of dangerous amounts of fission products in case of a reactor accident.

PLENARY SESSION 7 — THE USE OF RADIOACTIVE ISOTOPES

by Paul C. Aebersold, H. B. Tukey, and Walter D. Claus

Section 7, dealing in three parts with "Isotopes in Technology and Industry", "Isotopes in Medicine, Biology, and Agriculture," and "Waste Disposal Problems," was chaired by General Bernardino C. de Mattos (Brazil).

The opening paper of part one (No. 308, "Importance of Isotopes in Technology and Industry") by P. C. Aebersold (US), the first in the Conference devoted entirely to isotope utilization, was introductory and broad. It outlined the power and versatility of the isotope tracer technique and the basic principles of all applications: (1) radiation used to affect materials, (2) radiation used to study or measure materials, (3) radiation used to trace material. Industrial applications were enumerated for each principle. In the United

1035248

States alone radioisotope utilization results in savings of $100 million a year and uses are growing rapidly, Aebersold said.

Seligman (UK) gave a paper (No. 395, "Recent Developments of Radioisotopes Used in Industry") on isotopes in technology and industry and covered some recent specific uses in England. The illustrated uses demonstrated application to problems of special importance in the United Kingdom. Since piping in water systems and industrial concerns in the United Kingdom may often be quite old, corrosion and leaks are a serious problem. A gamma-ray reflection gauge was described which can measure thickness of pipe by access to the outside alone. The device is more sensitive to lower-energy backscattered rays than to the direct rays from the source. The unit is quite portable, uses only a small Co 60 source and measures wall thickness to $\pm$ 4% for up to 2 cms of steel. Local irregularities, due to corrosion, larger than 1 cm in diameter, can be located.

A procedure was described for locating leaks in underground water mains. Short-lived Na 24 was used so that the water or pipes would not be long contaminated and the procedure could be used with safety.

To find leaks far underground a deep probing system was described. Leakage of fuel in planes was tested by radiotracer methods. An interesting large scale tracer study was the use of activated scandium oxide sand to study movement of silt in the Thames over a distance of more than 20 km. The results indicated tidal effects calling for revision of dredging procedures. General industrial tracer research uses were also noted.

In the discussion period, Dr. Seligman was asked a few details on the limits of accuracy of gauges and methods described. The Chairman gave Jules Gueron (France) a special opportunity, after commenting on the papers, to add experience on uses in France. Gueron indicated that the Aebersold paper had covered the broad principles of use and had given good arguments for the economic and training value of isotope usage, noted that the Seligman paper had given interesting specific examples, then offered statistics on isotope utilization in France and expected future growth.

Shields Warren (US), presenting the first paper in the second part of the section (No. 309, "Radioisotopes in Medicine") pointed out that the uses of isotopes may be placed in two general categories, namely, (1) tracer techniques and labeling, and (2) radiation effects, involving therapy, sterilization, food preservation and gene changes. He gave several examples of how isotope tracer techniques may be used to advantage. Thus, (1) from tracer studies it has been learned that there is much greater mobility and change of substances in the organism than has previously been

1035249

appreciated; (2) by assaying with isotopes, many tedious chemical methods of analysis have been greatly lightened, and frequently without disturbing the organism itself; (3) the ability of an organism to form a substance can be measured directly by the isotope technique, without calculating the total net gain from adding and subtracting materials of both constructive and destructive metabolism; (4) enzyme patterns can be followed in both plants and animals. Standards of operation have been established for work with tracers. The technique is of greatest importance and extremely promising.

Warren described therapeutic use of radioisotopes as both (1) external, and (2) internal. The ability to concentrate isotopes in certain tissues makes interior treatment far superior to external treatment. The advantages of low-cost, low-level reactors close to the source of use are many, and should receive careful consideration.

Question: Cambel (Turkey) asked whether cesium-teletherapy could be cheaper and superior to cobalt-teletherapy? Answer: Warren said that the chief saving for cesium would be that its softer radiation required less shielding, but since its rays are less penetrating, its use would be limited.

Question: Milcou (Romania) asked whether synthesized radioactive hormones been used in therapy? Answer: Warren said their radioactivity was so slight as not to be helpful in therapy, but that as tracers they helped understanding of metabolism.

A. L. Kursanov (Paper No. 618, "The Utilization of Radioactive Isotopes in Biology and Agriculture in the USSR") said Russian scientists have used tagged atoms rather extensively in research. They have done considerable work on roots where activity is fairly easily followed. P 32 is being used by field stations in dozens of locations in the USSR.

Among reported findings was that a much higher percentage of applied fertilizer was used by the plant than had been previously supposed. For example, 40 to 60 percent of the phosphorus used by a plant might come from applied fertilizer instead of the 10 to 12 percent as frequently suggested.

By the isotope technique, a more rational distribution of fertilizer could be made in the soil. For example, it had been found that the "efficiency" of a root could be greatly increased by being in contact with the fertilizer. Thus, using P 32 it had been shown that as little as 4 to 5 percent of the root system of some plants could take up the phosphorus requirements of the entire plant, meaning an increase in "efficiency" of 20 times.

Kursanov said it had been possible to follow the production of materials by micro-organisms and to ascertain the uptake and

1035250

utilization of these materials by the plant. A study of the disintegration of humus had shown that CO_2 might be picked up by the roots from the soil, transported to the leaves, and there used in photosynthesis fully as effectively as CO_2 from the air.

He said that the discovery of some steps in photosynthesis in vitro had been made simultaneously with a similar discovery made by US investigators.

It had been shown that both proteins and carbohydrates might be synthesized in the leaf in the presence of light. Further, the red-green portions of the spectrum was used in carbohydrate synthesis, and the blue portion in protein synthesis.

It had been found that the speed of movement of materials, and the buildup and breakdown of materials in the plant was very great. He pictured a dynamic system of great change and mobility.

The USSR scientists had studied the "non-root" intake (foliage intake) of plants. Following these studies many thousands of acres of plants had been given foliar feeding, mostly sugar beets, in cool areas, and under conditions where nutrients were not readily available at critical times.

It had been shown that sucrose was manufactured in the leaves of beets, and then moved to the roots. Because of this, greater attention was now being paid to leaves. In studies with fruits (poppy) it had been found that CO_2 might be evolved in the center of the fruit, and that the CO_2 might then diffuse to the periphery where it might be used in photo synthetic processes. There was a mechanism for maintaining the O_2 and the CO_2 levels at proper concentrations in different parts of the seed and the fruit.

Studies of latex synthesis had revealed some processes involved, notably that latex appeared very suddenly in some plants.

Questions: Mitsui (Japan) asked about isotopes in soil erosion studies. Spinks (Canada) asked whether universities participated in the program and was assured that they did. Reifer (Poland) asked for more information on synthesis of alkaloids.

S. A. Silow (FAO) in Paper No. 780, "The Uses of Atomic Energy in Food and Agriculture", stated that the world supply of food could be increased by (1) reducing the heavy losses that now occur in storage, transport and handling; (2) increasing the productive areas of the world; and (3) opening up new areas to production. Atomic energy could help eventually through producing cheaper power so as to remove salinity from water and provide better drainage, and through the use of isotopes.

1035251

Isotope studies might not stimulate production directly, so far as was known, but atomic energy radiations could induce mutations, sterilize foodstuffs, provide better knowledge of insect and disease control, show how fertilizers could be most economically applied, discover fishery sources and hence promote better production of fish and help determine adequate balance of diet.

Silow made a statement that only 1% of sunlight was used by plants. Wassink (Netherlands) pointed out that this might be so for an entire year but was not true for certain short phases of plant development and in low light intensities.

Opening the discussion of waste disposal, F. Glueckauf (UK) made estimates in his paper (No. 398, "Long-Term Aspects of Fission Product Disposal") on the product-by-product problem of reactor wastes. Krypton 85 released into the air would be less than that produced by cosmic rays, and hence negligible. He calculated that after one year of aging, the other radioactive residues would consist of only 12 isotopes, and after 20 years only 7 isotopes, including strontium and cesium. If these two (Sr and Cs) were removed from the wastes for other purposes, the biologically weighted relative activity of the remainder of the wastes would drop in 5 years to one-hundredth of the one-year total activity and in 20 years to about 5×10^{-5} of the one-year activity.

Storage of wastes for 13 years would generate a number of stable isotopes (such as rubidium, ruthenium, palladium and xenon, and the rare element technetium), all highly valuable, which perhaps would justify the costs of prolonged storage. There was a possibility that americium might eventually become so large a proportion of wastes through radioactive decay of other isotopes as to cause a bias against disposal to ground or sea, even though strontium and cesium were removed for other purposes.

The paper proposed storage and utilization of "wastes" for 13 to 50 years before disposal to ground or sea. It assumed that not more than 1000 tons of fissionable material would be consumed annually in the foreseeable future.

Dr. A. Wolman (US) in his paper (No. 310, "Management and Disposal of Radioactive Wastes") declared that actually disposing of 41 tons of fission products annually by the year 2000 would challenge the ingenuity and imagination of scientists and industrialists.

Present methods of control are adequate, but expensive, and these would not constitute "disposal" in the way the word is applied to industrial wastes. Low and middle-level wastes are returned in a controlled and safe concentration to nature, but high-

1035252

level wastes are stored expensively. The AEC is conducting a large number of studies on the fixation of radioactivity in prepared soils, looking toward ultimate storage in the earth or sea, Wolman said, pointing out that indiscriminate disposal to air or sea might have objectionable environmental results and cause international complications. For the present, the AEC continues to store its high-level wastes under close supervision.

Dr. R. Revelle, Director of Scripps Oceanographic Institute, made a brief statement on the work which oceanographers are doing to understand the resources of the ocean to receive industrial wastes: the rates of diffusion and current flow of deep waters; the vertical "turn-over" of deep water which would carry deep deposits into the surface waters where marine life abounds; sedimentation; and interactions between ocean, atmosphere and lithosphere.

Question: Taylor (US) said he understood Glueckauf to state that, because public opinion was so sensitive, ocean disposal could be considered only under conditions which guaranteed absolute safeguards against fission products entering human food or water supplies, and accidental exposure of the public to radiation levels above tolerance. He asked Glueckauf and Wolman to discuss the possibility that public opinion would become less sensitive in time, and that controlled release of radioactivity into the environment might in time become entirely acceptable? Answer: Glueckauf said that controlled release of low-level activity to the environment might be acceptable, but high levels never would. Wolman said he felt Glueckauf's statement was proper with respect to the release of material of very high activities, but that waters are capable of absorbing tremendous quantities of wastes of all kinds when properly managed. He said it should be possible to release large quantities of radioactivity to the hydrosphere without hazard to life.

Question: Dahl (Norway) asked whether Wolman would depend on a container to prevent dilution of waste disposed to the ocean, or on currents to produce dilution. Answer: Wolman said that, for certain lower levels of activity, many would prefer dilution. With very concentrated wastes, fixing would perhaps be better, and studies were under way to learn how to confine them. Answer: Wolman said AEC interim policy was to store, meanwhile seeking better disposal knowledge.

Question: Parker (US) said that, according to Hanford calculations, storage cost of high-level waste would be less than 1% of sales price of the power and asked Wolman to comment? Answer: Wolman said storage was "expensive" as related to cost per unit volume on an absolute basis, whereas Parker referred to cost as a portion of total cost of production. Wolman said $1 per gallon to store would be expensive for ordinary industrial waste disposal, but as 1% of total cost it might not be prohibitive.

1035253

Question: Libby (US) asked Glueckauf what would be the ultimate cost of fission product disposal? Answer: Glueckauf said estimates of cost were speculative, and were as well treated in his report as was now possible.

Question: Lawroski (US) asked Glueckauf whether it was likely that recovery of rare stable elements from wastes after long storage might lead to an undesirably high level of contamination of materials in industrial channels. Answer: Glueckauf said ruthenium was the most likely contaminant because of the difficulty of its chemical removal, but since it has a half life of only one year, its contamination would be eliminated in a few years.

CLOSING PLENARY SESSION NO. 24

by Karl M. Mayer

The closing general session of the Conference considered "International Cooperation in the Peaceful Uses of Atomic Energy," and "Education and Training of Personnel in Nuclear Energy." It was closed by the presidential address of Dr. Bhabha (India) who was also session chairman.

In presenting paper No. 619, "Assistance of the Soviet Union to other Countries in Peaceful Application of Atomic Energy," M. Lavrishchev (USSR) stated that cooperation, previously confined to neighboring countries, would be extended to other nations. The USSR wanted extensive international cooperation.

He stated that experimental piles and elementary particle accelerators are being designed by the USSR for the development of nuclear physics in China, Poland, Czechoslovakia, Rumania, Bulgaria, Hungary, and East Germany. Physicists and radiochemists from various countries were being trained in nuclear science in the Soviet Union. He closed his presentation with the hope that many more such conferences would be held.

Paper No. 805, "The United States Program of International Cooperation for Peaceful Uses of Atomic Energy," by Willard F. Libby* (US) referred to the address of President Eisenhower to the United Nations General Assembly on December 8, 1953, and the proposal that an international atomic energy agency be established under the aegis of the U. N. He stated that the U. S. had already taken steps toward international cooperation in advance of the formation of the agency.

*The text of Dr. Libby's paper is in Appendix XVII.

1035254

Dr. Libby stressed that the development of conventional sources of energy should not be neglected. Atomic energy would not make immediate large-scale contributions, but there might be a significant start of nuclear power generation in 10 years. He stated that announced prices for heavy water and fuel were so fixed that the United States neither gained nor lost through the sale of materials.

Sir John Cockcroft (UK) made an informal report on UK cooperation. He stated that the United Kingdom was grateful for the help received from Canada and the United States, and that the United Kingdom would help others through reactor instruction, and university post graduate training. The United Kingdom helped found a European technical society and would welcome visiting engineers to study reactor operation and experience costs, he said. The United Kingdom looked forward to seeing visitors at Harwell and would welcome another such conference as the present one in 3 to 4 years.

Nabor Carillo (Mexico) stated that Mexico left the Conference with profound satisfaction. The most important development was the fact that the Conference took place. Scientists had demonstrated that they were men of good will and that they had mutual respect for one another; they have impressed the whole world.

Pawel Szulkin (Poland) declared the two papers presented in the session were very important in the future development of atomic energy. Further cooperation would take place, it was predicted. Poland planned to help in whatever way it could. The Polish program included exchange of information, mutual visits, and training of young scientists.

The fourth statement was made by Keiichi Tatsuke (Japan). He stated that the Conference was a success and that other conferences should be held. A hope was expressed that an International Atomic Energy Authority would be set up.

Pavle Savic (Yugoslavia) stated that the most noteworthy aspect of the Conference was the daily cooperation of men of science. Savic said Yugoslavia would cooperate in any way it could in order to lead to a solution of the discrepancies in the development among different countries. A statement of good wishes and congratulations by President Tito was read.

Gunnar Randers (Norway) then commented about scientific cooperation between Norway and Holland. He stated that Norway and Holland had a joint reactor program and plan to build reactors for power and research. The golden rule of cooperation, Randers stated had the following elements: (1) There must be mutual need and desire; there cannot be a donor-receiver relationship; (2) There must be full cooperation with no "keep out" signs, and (3) Scientific cooperation and progress thrives in laboratories and not in offices or even in public meetings.

1035255

Paper No. 983, "Training of Research Staff in the Field of Peaceful Uses of Atomic Energy" was presented by Pierre Auger (UNESCO). He stressed the need for balance in education of the young. The general training should not be neglected and specialization in science should be encouraged. UNESCO would help nations meet the new needs of education in the atomic age.

Pierre Dorolle (WHO) stated that training of radiation protection personnel was an essential part of any public health program. WHO would help countries in organizing such training programs.

Dr. Nazir Ahmad (Pakistan) stated Pakistan was in agreement with the sentiments expressed by Mexico earlier. Pakistan would develop rapidly if it were helped by more advanced countries. Pakistan suggested the establishment of regional centers of research under the guidance of people from more advanced countries.

Henri Medi (Holy See) stated that the world must have a search for truth based on the love of man. Any discovery belongs to all men. The world should try to distribute its wealth to the less fortunate, he said, and correct the unequal distribution of wealth all over the world.

In the closing presidential address, Dr. Bhabha stated that the Conference had been a great success. He stated that speakers of the Conference held to time schedules because they had something concrete to say. He gave the highlights of the Conference as follows:

1.) The feasibility of atomic power generation is no longer doubted.

2.) The economics of atomic power have been greatly clarified.

3.) The Conference will lead to many serious studies of the utilization of atomic energy.

4.) Progress has been made in the field of biology and medicine but more knowledge is needed in the field of genetics.

5.) Knowledge once given cannot be withdrawn—the free flow of knowledge has been established.

6.) Another meeting should be held.

President Bhabha read a note of good wishes and congratulations from President Bulganin of the USSR, and ended by saying that President Eisenhower had also sent a congratulatory message.

1035256

APPENDIX II — U.S. SCIENTIFIC SECRETARIES' REPORTS ON TECHNICAL SECTIONS OF THE CONFERENCE

"A" SECTIONS OF CONFERENCE — PHYSICS AND REACTORS

Section 6A - Special Topics in Nuclear Physics

By George A. Kolstad and
V. Weisskopf

A. Bohr (Denmark) was chairman.

The first paper, No. 714, was delivered by H. V. Pasechnik (Ukr. SSR) on the "Inelastic Scattering of Fast Neutrons by Atomic Nuclei". The neutron energies were 2.5, 3.3, 4.1 and 14 mev, and threshold detectors were used.

Discussion: Walt (US) pointed out that Pasechnik got a different value for Pb and Bi, whereas US values are equal. Kazatchovsky (USSR) reported on photographic work on inelastic scatterings.

The next two talks were by R. B. Day and M. Walt (US). Day in No. 581, reported on "Gamma Rays from Neutron Inelastic Scattering" as studied at Los Alamos. In No. 588 "Angular Distribution and Non-Elastic Neutron Scattering" by Walt et al., Walt reported on the angular distribution of elastically scattered neutrons and on non-elastic cross-sections.

Pasechnik (Ukr. SSR) asked about the resolution of Day's gamma detector.

The following talk, No. 830, "The Theoretical Prediction of Neutron Cross Sections of Non-Fissionable Elements for Energies up to 10 Mev," was by V. Weisskopf (US) who gave a resume of the status of the theoretical predictions of neutron cross sections. In the discussion, Blokhintsev asked about the connection between the optical model and the Bohr theory of nuclear deformation.

The next talk, No. 650, "Investigation of the Neutron B-Decay", was given by M. S. Kozodaev (USSR) who reported on work by P. E. Spivak

1035257

et al. on neutron decay. He measured the lifetime of the neutron by a method similar to that of Robson in Canada. Kozodaev gave some preliminary results on the angular correlation of the decay electrons. Discussion focused on the accuracy of the measurement. Snell (US) asked how it was possible to determine the lifetime as accurately as given (12 ± 1 minute).

The next talk, No. 651, was given by B. P. Adiaseviech (USSR) on the work of L. V. Groshev et al. on "Thermal Neutron Capture Gamma Rays". Groshev used a Compton electron magnetic analyzer and covered the range from 0.3 mev to 10 mev.

In the discussion which followed Weisskopf (US) complimented the study and asked whether the measurements had been extended to heavier elements. Adiaseviech then showed new results with heavy elements.

The next paper, No. 941, "Investigation of the Structure of Molecules and the Structure of Liquids by Scattering of Thermal Neutrons" was given by M. H. Niewodnietzanski (Poland). The work done by J. Janik was on neutron scattering by organic molecules and the determination of their structure, using a small radium-beryllium neutron source.

The last paper, No. 870, "Thermal Inelastic Scattering of Cold Neutrons in Polycrystalline Solids" by K. S. Singur and Kothari, was given by L. S. Kothari (India.) Corrections to Placzek's theory were calculated on the basis of the Debye Model.

SECTION 7A - FISSION PHYSICS

by George A. Kolstad

V. F. Weisskopf (US) was chairman.

A. Bohr (Denmark) presented Paper No. 911, "Collective Motion in Atomic Nuclei", which described the properties of fission which result from the fact that there are a very small number of levels of non-collective nuclear motion which can come into play near threshold and said that the angular momentum of these states could have important consequence. Bohr gave a qualitative discussion of the influence of conservation laws on this process.

J. A. Wheeler (US) in Paper No. 593, "Fission Physics and Nuclear Theory", discussed the fission process.

1035258

Paper No. 993, "The Time Involved in the Fission Process" was given by D. Popovik (Yugoslavia) who was the first scientist to publish the width of a fission resonance. He referred to "this unfortunate period (of secrecy) which we hope is disappearing".

J. S. Auslander (Rumania) gave Paper No. 1089, "Statistics of Photographic Fission Tracks and Range Estimates of Fragments", on work by himself and T. Visky, a theoretical analysis of an experimental procedure.

Discussion: Wigner (US) said he felt that the ideas of Bohr were quite new and therefore difficult to understand without further thought. In the discussion of the papers of Bohr and Wheeler, it was brought out that the whole fission process is not adiabatic since the correct state for going over the potential barrier must be arrived at by a non-adiabatic process. However, while the barrier is actually being surmounted, the process may be considered as adiabatic.

Blokhintsev (USSR) in discussing questions on Wheeler's paper, said that he questioned adiabatic approximation. He said also that heavy nuclei were formed in excited states. Since the fission width increased with excitation energy, these states would fission rather than decay by gamma emission to the ground state. Thus one would not expect to form appreciable quantities of heavy nuclei in the ground state. He stated further that heavy nuclei did not exist because of the difficulties with the Dirac equation.

Peierls (UK) made the comment that for higher excitations, as in slow neutron fission, the adiabatic approximation may be questionable, for with the high number of degrees of freedom, there might not be a high density of nucleonic levels, so that the situation might be more nearly analagous to that occurring in the theory of solids.

V. V. Vladimirsky (USSR) commented that the liquid drop theory gave too high a threshold for fission. Changing the Weissacker formula by putting in an additional surface tension term, which depends on the neutron excess, gave better results.

Mostovoy (USSR) quoted a theory, erroneously attributed to Wigner, to the effect that the number of alpha particles from spontaneous fission was greater than that from induced fission by 60% in the mode of decay where alphas are also emitted.

M. D. de Souza Santos (Brazil), gave Paper No. 897, "Studies of the Nuclear Photoeffect", by himself and associates, describing the first work done in Brazil with a machine purchased from the United States. He said he hoped to do fission threshold measurements.

A. Lundby (Norway) gave Papers No. 884, "Angular Correlation

1035259

of Fission Neutrons" by K. Skarsvag, and No. 891, "High Energy Gamma Rays from Short-Lived Fission Products" by Lundby et al.

R. B. Leachman (US) in Paper No. 592, "Determination of Fission Quantities of Importance to Reactors" discussed the measurement of nu and nu average for U-233, U-235, Pu-239, Pu-240, etc., and the energy spectrum of fission neutrons.

Discussion: Kozodaev (USSR) complimented Leachman for a good paper and reported on the work of Spivak and coworkers on the relative determination of nu (thermal) for U-233, U-235, Pu-239, and spontaneous fission nu for Pu-240 and Pu-241, as follows:

nu (U-233)	= 2.6
nu (U-235)	= 2.5
nu (Pu-239)	= 3.0
nu (Pu-240)	= 2.2
nu (Pu-241)	= 3.1

Kozodaev said that the proceedings of the Moscow Conference were available to all delegations.

Egglestaff (UK) made some additional comment and showed some UK data on fast fission cross sections.

Question: Sanders (UK) asked Leachman about what difficulties were experienced with gamma rays in Diven's big scintillation chamber. Divens answered the question by describing discrimination techniques.

SECTION 8A - RESEARCH REACTORS

by Ulysses M. Staebler

Dr. C. N. Watson-Munro (Australia) was chairman of Section 8A.

L. Kowarski (UNESCO) gave paper No. 946 "Report on Research Reactors" in which he described 10 different types of organizations or institutions which might find a research reactor valuable. These ranged from facilities doing basic research to hospitals using radiation therapy. The speaker provided a background to help organizations to decide whether or not to acquire a reactor and to select one suited to particular needs.

Kowarski listed as activities which could be carried out with

1035260

research reactors (a) studies of the behavior of the reactor (b) physical research, (c) chemical research, (d) biology and medicine, (e) reactor engineering, and (f) other branches of applied research.

Technological factors affecting the choice of a research reactor were discussed including (a) performance rating, (b) nature of the fuel required, (c) moderator and reflector design and utilization, (d) cooling problems for high neutron flux, (e) shielding design, and (f) equipment for control and experimentation. Kowarski also discussed costs as affected by reactor choice and building requirements. Fluxes of 10^{12} n/cm^2/sec should be possible for an initial investment of about $400,000, and annual operations expenses of about $100,000, he said. Reactors giving a flux of many times 10^{13} n/cm^2/sec might cost $4 to 5 million and $1 million a year to operate.

The second speaker, A. H. Snell (US), in paper No. 484 "The Nuclear Reactor in Basic Science," described many specific basic research activities involving a reactor. These included studies of new materials such as technetium, radiation chemistry, and "hot atom" chemistry. Snell said gamma radiation from sources such as Co 60 was more desirable for many jobs than reactor radiation, which includes neutrons that cause secondary effects. He believed that many basic absolute nuclear measurements, such as the neutron-neutron interaction, would bear repetition. It was emphasized that already the impact of reactors on basic science is very broad though we have just begun the many investigations they make possible.

The third presentation (paper No. 401, "Research Reactors") by E. Bretscher (UK) included similar material. He noted certain conflicts which could develop between physicists and engineers in the design of a research reactor. He gave costs for construction of a high flux reactor that were higher than those stated by Kowarski.

In opening the discussion period the chairman stated there were many questions on costs of research reactors, but he would permit only limited discussion on this point because of lack of comparability among cost figures from different countries.

Question: Doan (US) commented on Kowarski's statement about relative costs of MTR and ORR, and pointed out that the lower cost of the ORR was largely due to experience. He stated that an MTR type reactor probably could be built now with its neutron fluxes in much larger volume for less money.

Question: Zinn (US) noted that costs of the E443 given by Bretscher were much higher than the actual cost of the US CP-5 reactor by almost a factor of two, and asked if this represented additional facilities or high cost of building research reactors in Great Britain.
Answer: Bretscher said research facilities were included. He believed

1035261

the flux to be slightly higher than in CP-5.

Question: Gomberg (US) commented on a statement by Kowarski regarding confusing prices for the Geneva research reactor ($180,000) and a similar one for Michigan State University, and stated that the Swiss would have to spend additional money for such things as experimental facilities and cooling, if they wanted high flux and that there was no great inconsistency in actual costs of a similar reactor.

Question: Buras (Poland) asked for a statement regarding the formula on exclusion distance in Kowarski's paper in relation to the experiments described by Dietrich. Answer: Kowarski said the formula was copied.

Question: The Chairman asked whether Zinn could amplify? Answer: Zinn said that exclusion considerations normally involved an assumption that the core had many fission products built up in it, whereas the reactor core used in the transient experiments did not have them built up to any appreciable level. The formulae would have provided adequate isolation.

Question: Billington (US) supplemented Snell's paper with a brief description of apparatus for, and results from, experiments at 20° K inside a reactor.

Question: Dunworth (UK) expressed concern over statements in Kowarski's paper regarding short-term interest in zero-energy systems and cited interesting and important work being done in such systems.

Question: Weinberg (US) commented on the future of the present generation of research reactors being designed and built on the basis of using natural uranium fuel. He noted that there was always a strong incentive to increase the power level and this usually could be done if adequate provision was made for shielding, reflector cooling, and similar items. He cited that the Oak Ridge reactor (X-10) had increased from 400 kw to 4000 kw and that ORR had gone from 5000 kw to 20,000 kw while under design. In addition to higher powers, increased thermal neutron flux density in limited areas could be provided without increasing power by using enriched fuel as was done in the CP-3 reactor.

Question: Went (Netherlands) said that Bretscher stressed the evident importance of installing new types of hot loops in a reactor instead of building a prototype reactor. If it were possible to reduce considerably the dimensions of such a reactor, he asked, would it be worthwhile building a small prototype reactor immediately instead of a hot loop? Answer: Watson-Munro said he knew of some experiments costing on the order of $250,000, and in some cases it would be better to build a separate high flux reactor running with the fuel element in

1035262

question, rather than to carry out the separate test in a high flux reactor that existed. He said it depended upon the test being carried out.

Question: Wirtz (West-Germany) wanted to know whether, if enriched uranium and heavy water were not available and a research reactor with a flux around 10^{13} was wanted, it would be better to build a separation plant for enriched uranium or a heavy water plant to get heavy water. Answer: Dunworth (UK) said he thought it should be possible in future to purchase either one or the other from some source, and that there was no straight answer, because neither a diffusion plant nor a heavy water plant would be built solely to enable construction of a research reactor.

The second part of Section 8A, "General Principles and Practical Experience", was opened with paper No. 888 ("Practical Experience with the JEEP Reactor" by T. J. Barendregt), presented by N. Hidle, Norway. This reactor operates at 350 kw producing a flux of 10^{12} n/cm^2/sec using heavy water moderator at less than 100°C. The speaker described the reactor and operational experience during an experimental program.

Question: Doan (US) asked was there a period meter operating a scram circuit on the reactor. Answer: Hidle replied there was not and the Chairman added that this seemed reasonable for a reactor of this size.

The next speaker, (R. F. Jackson, UK, No. 762 "Experience with BEPO"), described a reactor similar in many respects to X-10 at Oak Ridge.

Question: Huffman (US) asked about techniques for measuring flux in this reactor. Answer: Jackson described in some detail a thermocouple arrangement using boron coating on the hot junction and said this gave nearly linear responses as long as the temperature difference between hot and cold junctions was less than 5°C. He also mentioned activation of silica rods which worked satisfactorily since the activation cross section and half-life were about right for convenience.

The final presentation of the section (No. 485, "Materials Testing Reactor Experimental Program and Reactor Operation" by R. L. Doan and J. R. Huffman, US) gave the first complete public description of the core of this reactor, which produces the highest neutron fluxes of any known reactor. The fuel elements and operating cycle were described in detail as well as control rods. After describing the reactor's construction and operating specifications, the speaker reviewed research programs. It was emphasized that this reactor was particularly useful for studying radiation damage since it provided

1035263

high intensities of both fast and thermal neutrons in a number of experimental facilities. Mention was made of the Reactivity Measurement Facility recently added in the water canal in the MTR building to help accurate measurements of reactivity effects on materials irradiated in the MTR. Other research programs described were isotope studies, neutron cross section studies, isotope production, and gamma irradiation studies.

Question: Mummery (UK) asked for a breakdown of the reactivity in the reactor. Answer: He was given, as an approximation, 4.9% in xenon, 4.7% for xenon override, 5 to 5% for experiments, and 5 to 7% for fuel depletion.

Question: Grout (UK) asked (1) whether the beryllium reflector was essential, (2) what was the area or volume of maximum flux, and (3) was H_2O or D_2O better as a moderator for a high-flux materials testing reactor. Answer: Huffman said (1) that in current operation, portions of the beryllium reflector had been removed and the space used for experimental purposes, (2) the maximum flux of 3.5×10^{14} n/cm^2 sec was an unperturbed flux and decreased in the presence of experimental material, and its volume was about 2 to 3 inches by about 12 inches. Huffman and Weinberg gave the opinion that H_2O gave a higher fast neutron flux at a sacrifice in space, and that it might be somewhat easier to run an ordinary water reactor at very high neutron flux, but that H_2O and D_2O each had advantages and disadvantages.

SECTION 9A - RESEARCH REACTORS AND DESCRIPTIONS

by U. M. Staebler

Dr. J. J. Went was chairman.

The first talk, by V. V. Vladimirsky (No. 623, USSR, "A Heavy Water Research Reactor"), described a reactor that started operation in April 1949. Vladiminsky said it operated at 500 kw and utilized 5 tons of heavy water plus 2.5 to 3.0 tons of uranium. He also described exponential experiments on varying rods and lattices during the planning of this reactor. The uranium rods were hung vertically from an aluminum plate which could rotate. The reactor had a graphite reflector about one meter thick. Control was by four cadmium rods which could operate either manually or automatically.

Experimental facilities included three good channels for columnating neutron beams and a 9 cm diameter aluminum tank down the center of the core. A platinum catalyzer was used to recombine the mixture of hydrogen and oxygen gas formed during operation. The speaker indicated

1035264

plans to reconstruct the reactor for a tenfold increase in neutron flux.

In the second presentation, (No. 387, "The Saclay Pile, Two Years' Experience in Heat Transfer of Pressurized Gases" by J. Yvon, France) the Saclay reactor was emphasized as a heat transfer experiment. Yvon said the reactor contained 6 tons of uranium in 136 rods, 3 tons of heavy water, and was cooled with gas. The gas originally was nitrogen but argon in air contamination caused radioactivity which limited operative time more than was considered acceptable. The French switched to carbonic gas— the blowers were not designed for helium. Yvon said the gas left the reactor at 120°C and the hottest fuel element jacket was 320°C.

Paper No. 915 "Description of the Swiss Research Reactor" prepared by F. Alder et al. and read by W. Zunti (Switzerland), described a reactor and shop and laboratory facilities to be built 30 km from Zurich. It was conceived as a low temperature reactor moderated and cooled by heavy water with natural uranium fuel. The design power was 10 MW, the maximum thermal flux 2.5×10^{13} n/cm^{2}sec.

Question: Lichtenberger, (US) asked Vladimirsky what was done to keep the heavy water in the USSR reactor clean? Answer: Vladimirsky said that corrosion was very low and the water needed to be cleaned very infrequently.

Question: Zinn (US) asked about a footnote of the USSR paper that mentioned the tank had been replaced. Answer: Vladimirsky explained that a fuel rupture occurred in 1953 and that, in the process of removing the rod through the top of the tank, the rod broke, dropped, and damaged the bottom of the tank. Spare tanks were on hand so the top and fuel were removed and the tank replaced. They met the greatest difficulty in disjointing the tank because radiation reached an intensity of 700 r/hr.

Question: Hurst (Canada) asked for more information on planned modification to the USSR reactor. Answer: Vladimirsky said about 250 kg of uranium containing 2% U 235 would be used in fuel elements that would be cooled inside and outside. The power would be raised to over 3 MW, using forced flow rather than gravity circulation. A 10-fold net increase in neutron flux was expected.

Question: Spinrad (US) asked what was the rate of motion of control rods or rate of possible increase in reactivity? Answer: Vladimirsky said the rods held 1 to 1-1/2% k and could be withdrawn in about one-half minute.

Question: Spinrad (US) asked what was the mean lifetime of thermal neutrons in the core, and what was the effect of filling the central pit with uranium? Answer: Vladimirsky said no measurements

1035265

had been made, but calculations were made by the Pontecorvo method. With uranium in the center, the lifetime would be shorter.

Question: Beck (US) asked whether the French reactor gave any difficulty due to activity of gas impurities other than argon, i.e., dust, or products of fuel ruptures. Answer: Yvon said no fuel ruptures had been experienced; that dust had been found but the activity was not disturbing.

Question: Liljeblad (Sweden) asked whether the large gas leakage reported by Yvon could be stopped by welding joints. Answer: Yvon agreed welding would help, but claimed advantages also for ease of disassembling an unwelded system.

The second part of the section was opened with paper No. 860, "The Brookhaven Reactor" by M . Fox, presented by D. Gurinsky (US), which Gurinsky illustrated profusely with slides showing construction stages, design features such as fuel elements, and experimental equipment arrangements. It was noted that the graphite-moderated and air cooled construction provided large volumes of reactor space for experimental purposes at a sacrifice in neutron flux for a given power level. Operating experience with the reactor, including effects of operation on graphite, was mentioned briefly. The speaker also told of plans to use enriched fuel to increase the maximum available flux from 5×10^{12} n/cm^2/sec to 3×10^{13} n/cm^2 sec.

The next paper (No. 488, "Design and Description of Water Boiler Reactors", by L.D.P. King, US), surveyed the origin, design, and operating characteristics of small enriched homogeneous reactors which have become known as "water boilers", with emphasis on the Los Alamos versions, particularly one known as SUPO. It was pointed out that two similar reactors had been built by North American Aviation, Inc., one by North Carolina State College, and others were being planned. Advantages of this type reactor were cited as (a) inherent safety, (b) small size and material requirements, (c) absence of fuel elements needing to be replaced, (d) ease of operation, and (e) automatic removal of fission gases. The chief disadvantage was low neutron flux, limited to about 10^{13} n/cm^2 sec even in advanced designs.

Question: Jackson (UK) inquired about ruptures of finned fuel cans at Brookhaven and whether this influenced the decision to modify the design. Answer: Gurinsky reported there had been three ruptures leaking fission products into the exhaust air, and other less severe leaks, but said that the primary incentive for changing design was to get a higher neutron flux. He stated ruptures occurred more frequently in the center of the reactor due to higher flux and higher gas velocity which caused "fluttering" of fuel elements, over 50% of the original fuel was still in the reactor.

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The next portion of the section opened with papers No. 621, "The Experimental Nuclear Reactor with Ordinary Water and Enriched Uranium" and No. 622, "A 2000 kw Thermal Power Nuclear Reactor for Research Purposes", both read by Y. G. Nikolaev (USSR). He described a reactor fueled with uranium containing 10% U-235 (3.5 kg U-235), water moderated and cooled, and designed to operate at 300 kw with flux of 2×10^{12} n/cm/^{2}/sec.

In addition to a brief physical description of the reactor with the aid of slides, Nikolaev gave results of certain physics experiments on critical mass, lattice spacing, and thermal neutron distribution through the reactor. The second part of the talk gave some information on modifications planned, mentioning an increase of power to 2000 kw. The coolant flow would be increased to 900 cubic meters per hour in the primary system and 250 cubic meters per hour in the secondary system. The maximum heat transfer rate would be 3.8×10^5 cal/m^2/hr.

The final talk, by A. Weinberg (US), was based principally on paper No. 490, "The Materials Testing Reactor and Related Research Reactors". Weinberg observed that the Soviet design of a graphite-moderated reactor sacrificed fast neutron flux to get volume. He said ordinary water reactors could provide high thermal and fast neutron flux but generally in small volume. Basic philosophy and problems in the design of the MTR type reactors were discussed. A comparison was made of various reactors in the MTR family including the MTR, the Oak Ridge Research Reactor, the low intensity testing reactor, and the pool reactor. He reported also on the status of measurements and tests on MTR type fuel elements made with uranium containing 20% U-235 such as the US will make available to other countries under Bilateral Agreements for Cooperation. It was noted that U-Al alloy becomes brittle and difficult to fabricate at U concentrations which would be required for this material. A technique had been developed using a uranium oxide and aluminum oxide compact. Measurements on critical mass showed the difference between fully enriched U-235 and 20% U-235 material to be less than one percent. Sample fuel elements made by this technique had been tested in the LITR and the MTR without failures up to a maximum exposure of 30×10^{19} NVT at a maximum flux of 2×10^{14} n/cm^2 sec. This corresponded to 20% burnup of U-235, Weinberg said.

Question: Mummery (UK) asked whether the shape of the curve shown by Nikolaev for the effect of temperature on reactivity neglected the change in slowing down area in the reactor. Answer: Nikolaev replied that the effect was a "non-monotonous" development which depended upon the coefficient of thermal utilization of neutrons and the delay or tau function. At the time of measurements one percent in reactivity was in control rods.

Question: Spinrad (US) observed that the plot of neutron flux through a lattice cell did not continue through the fuel element.

1035267

Answer: Nikolaev said no measurements had been made in the region, only theoretical calculations using diffusion theory with necessary adjustments.

Question: Mummery (UK) asked whether, in the 2000 kw reactor, the uranium would be combined with an alloy? Answer: Nikolaev stated that unlike fuel in the US the USSR uses U and UO_2 with Mg.

Question: Kalitzine (Bulgaria) asked what radioactive content of air was observed? Answer: Nikolaev said it was not great or dangerous, being several hundredths of a curie per hour, and was projected for the future as about a tenth of a curie per hour.

Question: Schmid, (Switzerland) asked what kind of slowing down theory was suited for criticality calculations of beryllium-reflected MTR-type reactors. Answer: Weinberg said designers had very good results in MTR calculations using simple one- or two-group diffusion theory. He states this probably was due to the fact that most of the neutrons leaking to the reflector were fast neutrons.

SECTION 10A - RESEARCH REACTORS, DESCRIPTIONS AND FUEL CYCLES

by U. M. Staebler

Prof. M. Oliphant (Australia) chaired Conference Section 10A.

First, G. N. Kruzhilin (USSR) reviewed Paper No. 620 "Reactor for Physical and Technical Investigations", a USSR equivalent of the United States MTR. It "went into operation" on April 15, 1952, compared to criticality of MTR on March 31, 1952, and full power on May 22, 1952. Water was first considered as a moderator Kruzhilin said, but since loops were needed for fuel element tests it was decided to use graphite as moderator, and water as coolant. He mentioned the Brookhaven reactor as the most powerful graphite research reactor but said the USSR design used enriched material and a more compact lattice in which water provided about 50 percent of the moderation. The USSR reactor had five loops, two cooled by water at 100 to 200 atmospheres pressure, one cooled by molten metal, and one cooled by gas. Kruzhilin reported that a fuel element chosen for the large USSR power reactor had been operating in this test reactor for over a year. The reactor was described as one of the first in the USSR with a closed circulating system, operating at 10 MW with maximum flux of 8×10^{13} n/cm^2 sec.

Next, F. W. Fenning (UK) reviewed paper No. 402 ("The Experimental Facilities of E 443") which emphasized the need for high neutron flux as a reason for building the E 443 heavy-water moderated and cooled research

1035268

reactor. He gave present flux limits at Harwell as 1.5×10^{13} n/cm^2 sec. Fenning said the planned reactor would be fueled with about 2.5 kg of U 235 in MTR type fuel elements. Experimental facilities would include (a) neutron beam columnators, (b) irradiation facilities with no environmental control, and (c) irradiation facilities designed for careful control of temperature, pressure and other environmental factors. The cost of the reactor and certain laboratory facilities was expected to be under 2 million pounds (about $5.6 million).

Question: Brooks (US) asked what was the actual thermal neutron flux. Answer: Kruzhilin said the thermal flux of the USSR reactor with experimental equipment in place was about 4.5×10^{13} n/cm^2 sec; no figure was available for fast neutron flux.

Question: Weinberg (US) asked whether any provision had been made for gas-tight containment of the USSR reactor? Answer: He was told the helium atmosphere of the reactor was hermetically contained, but that experimental reactors in the Soviet were built without containment.

Question: Mummery (UK) asked whether loop experiments were located in the reflector of the reactor because the flux was adequate in this region and experiments so located would have less effect on reactivity? Answer: Kruzhilin said that was the reason.

Question: Kronberger (UK) asked about wear noticed on fuel elements in the USSR reactor. Answer: Kruzhilin stated USSR workers believed local vibrations of fuel elements were caused by water flow. Thicker ribs and cantering sprockets were provided on the fuel elements and have eliminated the trouble.

Question: Harrer (US) asked about the specifications and tests planned on the gas-tight building around the E 443 reactor. Answer: Fenning said the vessel was being built in accordance with British standard code 1500 and would be tested at full pressure.

The second part of the section consisted of three talks on the general subject of fuel cycles, the first by J. V. Dunworth (UK) on paper No. 403, "Fuel Cycles and Types of Reactors". The basic philosophy expressed was that a fuel cycle based on burning U-235 and making plutonium from U-238 was likely to have a negative gain and that to utilize a satisfactory fraction of the uranium resources, it would be necessary to recycle plutonium in these reactors. He referred to remarks he made in section 4.2 on the likely role of thorium in thermal reactors and predicted that eventually uranium would be used in fast reactors and thorium in thermal reactors.

The next talk was delivered by W. B. Lewis (Canada) reviewing paper No. 41, "Some Economic Aspects of Nuclear Fuel Cycles." He noted

1035269

Dunworth's remarks about fuel cycles with a negative gain and emphasized that the important consideration on fuel cycles was which one would provide cheapest power. He stated the case for thermal converter reactors which he believed would be the first to make economically competitive nuclear power and might maintain this position for many years. He compared the unused uranium in such systems with the uranium content of water used to make hydroelectric power and noted that the loss of power resource per unit of power generated was greater in this case than in converter reactors.

A. M. Weinberg (US) presented the final paper, No. 862 "Survey of Fuel Cycles and Reactor Types". He cited the similarity between the development of fossil hydrocarbon fuel and nuclear fuel in that each had different forms and a variety of devices in which they could be used. He predicted that as in the case of fossil fuels the variations in nuclear power would find application in specific locations in accordance with specific merits. He then reviewed nuclear considerations of fuel cycles such as values of nu (neutrons produced per fission), and eta (neutrons produced per atom of fissionable material destroyed). He said that relatively high capture cross sections in the intermediate energy regions for both U-235 and Pu-239 made reactors designed to operate on such neutrons of little interest for central power reactors. In comparing breeding of various cycles, Weinberg noted that both "thermal efficiency" and "material efficiency" should be considered. The higher specific power (or material efficiency) which might be possible in the thermal neutron system could offset high breeding gain and high thermal efficiency in fast reactors. Weinberg concluded that all thermal reactor systems were likely to be operated ultimately on the Th, U-233 cycle but that acceptable fast reactors on the Pu-239, U-238 cycle also would be developed in the long run.

Question: Gast (US) asked what method was proposed for maintaining reactivity over the long fuel cycle proposed by Lewis? Answer: Lewis said the use of D_2O in large reactors with periodic relocation of fuel seemed to make this practical, but there was not enough data to be sure.

Question: Wigner (US) brought out that the values of eta in the neutron energy resonance region were for thin slabs and that in actual reactors the resonance capture would be somewhat less because of self-shielding.

Question: Taranger (France). Taranger observed that Weinberg seemed to condemn gas-cooled reactors because of low "material efficiency" and asked if this attitude extended to "good gas at high temperatures." Answer: Weinberg replied that figures in his paper probably were too pessimistic and that Dunworth had pointed out the Calder Hall reactors expected to achieve 4000 kw/kg. He stated, however, that he believed there was a factor of five between a good gas system and a good liquid-cooled system.

1035270

Discussion among the three speakers (Dunworth, Lewis and Weinberg) brought out differences in local situations. Lewis agreed that very large supplies of uranium would be required to move ahead on schedules for expansion of nuclear power being considered. Dunworth noted that there was plenty of uranium in Canada compared with Great Britain and stated that in the fuel cycle proposed by Lewis, Great Britain would soon have a very large uranium import bill. Weinberg emphasized that his comments did not intend to discredit the cycle proposed by Lewis but were a prediction of what might happen to the reactors in, say, 30 years. Lewis stated that his own predictions for 50 years did include use of thorium in the reactors. Davis (US) stated that the breeding gain was not the only important thing in a breeder reactor. The time for doubling the fuel investment depended upon the product of breeding gain and specific power.

Question: Geoghegan (UK) asked about whether the cycle described by Dunworth would limit the rate of expansion. Answer: Dunworth confirmed that the cycle would limit the rate of expansion to 5% per year unless additional fissionable material was supplied from outside.

SECTION 11A - DESIGN OF REACTORS FOR POWER PRODUCTION

by U. M. Staebler

Section 11A was the first of two Conference sections to take up design of reactors for power production. Under the chairmanship of O. Dahl (Norway), the section discussion began with a talk by P. Chambadal (France), based on paper No. 333, "Utilization of the Energy Released in the Graphite-Moderated, Air Cooled G 1." The reactor construction was described briefly and special attention was given to the operating conditions of the gas system, noting that at the time G1 was built (1952) technology would not permit building a power reactor. The reactor produced 40 MW of thermal energy using a charge of 100 tons of natural uranium. Conditions were described which permitted recovery of 5750 kw of electrical power from this system using an outlet coolant temperature of 220°C in an air heat exchanger.

The second talk, presented by P. Taranger (France) based on paper No. 337 "Design of the Dual Purpose Pile, G 2" by P. Alleret et al., described design of a future reactor. The fuel in this second production reactor for France was described as cylindrical uranium alloyed with a small amount of aluminum and sheathed in magnesium tubes mechanically bonded to the uranium. The reactor was designed for replacement of fuel without a shut down. Fuel temperatures were expected to be 550°C at the center and 400° C at the sheath. Two reactors were being built, G 2 and G 3, Taranger said and each would produce 30,000 kw of electricity,

1035271

giving France 60,000 kw of nuclear electricity capacity in 1959. The speaker predicted a doubling of capacity every 3 to 4 years after that.

The third talk on designs of graphite-moderated power reactor designs was presented by P. F. Gast (US), based on paper No. 492 "A Graphite Moderated Nuclear Power Plant Design" by A. B. Carson. The speaker presented drawings of a preliminary design for a water-cooled, graphite-moderated power plant designed to produce several hundred thousand kw of electricity--a basic design similar to that of a 5,000 kw power plant in operation in the USSR.

A further variation in graphite moderated power reactors was described by C. Starr (US) reviewing paper No. 493 "A Sodium-Graphite Reactor 75,000 Electrical kw Power Plant." After describing the concept with the aid of slides including fuel element designs, the speaker discussed the probable economics of such plants. He provided breakdowns of cost factors based on current technology and expected improvements to show how unit costs could drop from the order of 11 mills per kwh to something like 6 or 7 mills.

Discussion: Discussion of the Taranger paper brought out that the total power of G2 and G3 would be 150,000 kw each, thermal dynamic efficiency would be 25% with a net conversion efficiency, after allowing for electrical requirements of the plant, of about 20%. Loading and unloading of the reactor would be accomplished through hermetically sealed vessels fitted against the reactor walls. Any moisture in the gas system would have "appalling" effects on the Mg cladding, Taranger said, so the pressure of this system would be maintained greater than that of the water in the heat exchangers. Gas flow would be by axial compressors.

Question: Blokhintsev (USSR) said he had many questions for Gast which he would like to discuss privately. For the general discussion, he asked only of the state of this reactor project. Answer: Gast said it was only a paper design, and answered other detailed design and operating questions about support of water walls, charge-discharge techniques, conversion ratio, effect of loss of water, and instrumentation against serious consequence of fuel failure.

Question: Blokhintsev (USSR) asked why steel was used in Starr's design when Zr was very stable in sodium, and also what was the temperature of the graphite? Answer: Starr said steel was used only on fuel jackets which must support entire weight of the fuel elements, and that zirconium strength at operating temperatures was not great enough. The graphite temperature was stated to be more than the sodium temperature but not exactly known. Starr answered other questions, saying sodium was primarily an engineering choice, that no means were provided for specific detection of a leak in the graphite can or fuel jacket, and that a secondary coolant system might be desirable for cost reasons in spite of safety considerations.

1035272

Question: Fenning (UK) said British results for eta of U-233 were lower than assumed in Starr's economic analysis. Answer: Starr acknowledged that a lowering of the neutron economy would increase power costs.

The second group of talks in Section 11A was initiated by J. J. Went (Netherlands) summarizing paper No. 936 "The Design of a Small Scale Prototype of a Homogeneous Power Reactor Fueled With a Uranium Oxide Suspension." Went pointed out that because the Netherlands lacked uranium and thorium it was interested in power reactors with very high specific power and low fuel inventory. His very preliminary design proposed the use of UO_2 or U_3O_8 as a fuel in suspension in heavy water, with later plans looking toward ThO_2 and U-233 oxides in a breeder cycle. The advantage of homogeneous liquid reactors were discussed and some results were given on characteristics of the particles or grains of fuel produced by various methods.

A companion paper, No. 938 "Power Reactors Fueled with 'Dry' Suspensions of Uranium Oxide," summarized by H. deBruyn (Netherlands), considered reactors fueled with gaseous rather than liquid suspensions of small uranium oxide grains. Three types were considered: (1) a homogeneous reactor in which the reactor vessel was filled with compound grains of UO_2 and BeO fluidized in a helium gas stream, (2) a quasi-heterogeneous reactor in which the reactor vessel contained larger grains of UO_2-BeO in a fixed bed, and (3) a heterogeneous reactor in which heavy water was used as moderator and UO_2 suspension was passed through graphite fuel tubes. The paper concluded that the heterogeneous reactor offered the best possibility, but deBruyn reported that revised calculations on a quasi-heterogeneous reactor made it likely that this reactor would give lowest cost, although the conversion ratio was lower.

The final presentation was by C. Williams (US) based on paper No. 494 "Liquid Metal Fuel Reactor." He described a graphite moderated reactor fueled with a solution of enriched uranium (eventually U-233) in bismuth, with a blanket of thorium in which to generate fuel. The technological basis for this concept was summarized and slides shown of a conceptual design and flow system, including fuel processing. This design would provide 210,000 kw of electricity at a thermal efficiency of 42%.

Estimated capital and operating costs were given leading to a conclusion that power might be made from such a plant for about 8 mills/kwh.

Question: W. Riezler (West Germany) asked if there would not be dangerous changes in concentration of fuel in a suspension-type reactor which would cause serious reactivity changes. Answer: Went believed the reactors would be stable.

1035273

Question: Vladimirsky (USSR) said he believed suspension designs were quite promising for nuclear power. He asked for the maximum concentration of UO_2 in D_2O, and the gasket material to be used in the pumps for the wet suspension reactor. Answer: He was told a 4% volume would be used in a large reactor, and enriched material would be used in small reactors to give the same concentration of uranium. The pump was described as a gas-lift pump combined with heat exchangers which would not require gasketing.

Question: Benedict (US) asked deBruyn to discuss pressure and possible leakage conditions in a D_2O moderated dry suspension? Answer: deBruyn put the pressure inside the tubes at about 40 atmospheres at 250° C, and said there would be no pressure drop across the graphite as it was expected to be sufficiently tight to prevent leakage.

Question: Swartout (US) asked Went whether he had considered the problem of material balance in the homogeneous system? Answer: Went said the UO_2 would be more uniformly distributed in the primary circuit; they would measure the overall concentration in the reactor vessel and the pressure difference in the system related to the specific weight of the fuel suspension.

Question: Spinrad (US) asked what would be the density of the fuel in the flowing grain channels of the dry suspension reactors? Answer: He was told the channels were 70% filled with UO_2 - BeO with density of individual grains about 3.2.

Questions: Hawthorne (UK) and others commented that delayed neutrons would be lost in the Williams' design due to circulating fuel. Answer: They were told the losses had been calculated for some designs and it was believed that they would not reduce the conversion ratio to less than 1.0. In response to a question from Fry (UK), Williams stated that there was evidence that the graphite components would stand up against corrosion under temperatures somewhat less than those planned. Answering a question from Rollier (Italy), Williams stated that the Po activity at equilibrium would be of the same order of magnitude as that from fission products.

SECTION 12A - DESIGN OF REACTORS FOR POWER PRODUCTION

by U. M. Staebler

D. I. Blokhintsev (USSR) was chairman of Section 12A. Since W. H. Zinn (US) was scheduled to present two talks, the agenda was rearranged to make his presentations first and last.

1035274

In the first talk on paper No. 495, "Heavy Water Reactors for Industrial Power Including Boiling Reactors," by H. P. Iakenderian et al. Zinn noted that heavy water has long been considered a nearly ideal moderator but that high cost has been a disadvantage. The recently announced US price of $28 a pound for heavy water gave cause for increased attention to its use in power reactors, since its cost might be reduced to less than one mill per kwh. Direct cycle boiling reactor plants are particularly well suited to use of D_2O as moderator and coolant. Preliminary designs for three boiling reactors were reviewed and compared. These were (a) a 1000 MW D_2O, (b) 250 MW D_2O, and (c) 250 MW H_2O. Zinn concluded that for a very small output plants H_2O was superior but for large output plants D_2O was superior, that they were about equal in the range of 200 MW of heat output.

L. Y. Suvorov (USSR) then presented paper No. 624, "Homogeneous Power Producing Water Boiler," by A. I. Alichanow et al. Suvorov pointed out that the chief advantages cited for the boiling homogeneous reactor were elimination of the large hold-up of fuel outside the reactor, and simplification of the pumping and circulation problem. He reviewed parameter studies of this general type of reactor and concluded that, for each 1000 kw of electrical capacity in small capacity plants, such a reactor would require 0.3 to 0.7 kg of fissionable material, and 200 to 300 kg of D_2O. These unit requirements would decrease for large plants.

He was followed by J. A. Swartout (US) whose paper No. 496, "Aqueous Homogeneous Power Reactors," summarized operating experience with the HRE No. 1 as a background for larger power reactors of this type. Reactor core design details were presented with flow sheets that included fuel processing and gas handling. Designs for pumps, valves and heat exchangers were described with slides. The status of technology for such nuclear power plants was analyzed with the conclusion that a main problem remaining to be solved was the stability and long-term reliability of a ThO_2 slurry for the breeder blanket.

Question: Kruzhilin (USSR) questioned the need for containment around reactors. Answer: Zinn and McCullough pointed out there was always a small possibility that an accident could occur and that the cost of protection seemed small in comparison with the possible consequence of an accident at this stage of reactor development.

Question: Hahn (Austria) asked whether it was possible to shut down and start up a heavy water boiling reactor frequently. Answer: Zinn replied this could be done but was not desirable, particularly if temperature and pressure were not maintained since thermal cycling could damage fuel elements. Zinn answered a question by Goodlet, (UK) saying that there was a factor of about two between design heat transfer rates and burn-out conditions, and that the steam from boiling reactors would not be very wet. Steam separators would be provided and competent steam engineers found the level is acceptable.

1035275

Question: Vendryes (France) asked what procedure would be used to detect failures in fuel cladding and whether they could be detected before becoming dangerous in view of the normal activity of the heavy water. Answer: He was told that vigorous tests would be performed on fuel before charging, and that the steam would be monitored for gaseous fission products. If found, leaks could be traced by detectors to specific channels since the only important activity in D_2O was very short lived (7 sec). Zinn told other questioners that exponential and critical experiments had been done.

Question: Kay (UK) asked what method was used to produce D_2O at $28 a pound? Answer: Zinn stated this was the price announced by the United States and disqualified himself as an expert. With regard to fuel elements for achieving 10,000 MD/ ton exposure he stated that other papers showed alloys which reduced distortion and that one of these might be used.

Question: Goodlet (UK) asked what method the USSR used for steam clean-up by 10^{10}. Answer: Souvorov said a column had been used in laboratory tests and achieved this performance.

Next, J. Weill (France) reported on paper No. 335, "Complete Automatic Control of Nuclear Reactors," describing experiments on the Saclay reactor. Automatic power adjustments were described in which a change of 500 kw was made with an accuracy of $\pm$ 1 kw.

Question: Harrer (US) emphasized the limitation in range in asking about power control by temperature coefficients within a band of about 5% with rods used beyond this. Answer: The Saclay reactor did not cover a wide power range for control experiments.

The final two papers concerned fast reactors. T. M. Fry (UK) summarized No. 405, "The Dounreay Fast Reactor Project", and said that, since they could not plan accurately for a fast reactor core, they were designing the reactor for maximum flexibility in the core region. It would consist of a pot equipped with a system capable of removing 60 MW of heat to make about 20 MW of electricity. The coolant would be NaK initially, but Na later. Since the core coolant had to be guaranteed at all times there would be no valves or dump tanks in the primary system. The arrangement of the reactor was discussed generally; the hazards of the project in somewhat greater detail. The speaker closed with a remark that he was glad to give way to Zinn who was leading the way on the difficult path of fast reactor development with EBR.

Zinn presented his second talk on paper No. 814, "Review of Fast Power Reactors." He took exception to previous remarks by Lewis (Canada) comparing the uranium discarded from a thermal neutron converter reactor with that contained in water used to make hydroelectric power. He agreed however that the first economically competitive nuclear

1035276

power plants would be thermal neutron converters. Zinn then presented an analysis of the physics of fast reactors, noting the physical constants which determine actors, noting the physical constants which determine their performance. The importance of heat transfer to achieve high specific power and reasonable doubling time was mentioned. Other factors, such as control and reprocessing of fuel were discussed briefly. No specific reactor design was described.

Question: Kazatchkovsky (USSR) asked whether the assumed burn up of 2% was not very conservative? Wouldn't 5% or 10% be possible? Answer: Zinn noted that 2% burn up of all atoms in the fuel alloy amounted to 20% burn up of fissionable material, but agreed that higher burn ups were desirable and that the US hoped to achieve them. He emphasized that he had tried to be conservative in his calculations.

Question: Shepherd (UK) asked whether the value of nu for U 238 was a measured value? Use of one plus alpha in the expression for breeding ratio in the paper was not strictly correct since some atoms formed by successive neutron captures (Pu 240) also were fissionable. He observed also that the number used for U 238 fissions per primary fission was lower than measured in ZEPHYR. Answer: Zinn stated there was no measurement for nu of U 238 for fast fissions and pointed out that ZEPHYR was not a dilute assembly as would be the case in a practical power reactor.

SECTION 13A - POWER REACTORS, PROTOTYPES

by U. M. Staebler

Section 13A was the first of two sections devoted to prototype power reactors. All reactors described were under construction or definitely scheduled for construction and had power technology as a primary objective.

E. P. Wigner (US) was chairman and J. W. Simpson (US) presented the first paper, No. 815 "Description of the Pressurized Water Reactor (PWR) Power Plant at Shippingport, Pa.", describing the reactor, with slides showing fuel elements, core arrangements (including seed and blanket), plant layout, heat exchangers, pumps and valves. Operating specifications were given, but were expected to be exceeded. Mention was made of financial participation in the project by the Duquesne Light Company. Simpson reviewed many considerations and reasons for specific decisions on design.

Questions: Lewis (Canada) and Goodlet (UK) said they doubted

1035277

the need for operation at 2000 psi. Goodlet cited what he called an inconsistency between papers on boiling water reactors and a statement in Simpson's paper that local and bulk boiling caused pit-type corrosion. Answer: Simpson emphasized that the PWR design was very conservative, and that local boiling was not really expected to cause serious pitting. The rather large overpressure provided an added margin of safety against transient loads which might cause boiling and produce instability by altering the $U:H_2O$ ratio in a reactor not designed for boiling.

Question: Ward (Canada) asked what was expected to limit the life of a blanket element and what was known about fission product effects in the blanket? Answer: Simpson said the design specification for these elements was 3000 megawatt days but that this was expected to be surpassed eventually. Calculations indicated that fission products would not cause any difficulties.

Question: Dalton (Australia) asked about different cooling arrangements for seed and blanket elements and about the density of UO_2 fuel elements. Answer: Simpson said the orificing arrangement allowed greater water flow through the higher powered seed elements. Greater than 90 per cent of theoretical density was achieved for individual UO_2 pellets but Simpson did not recall the density as assembled. He told Descans (France) that the pressure vessel was being made according to the American Society of Mechanical Engineers code and would have a cold hydrostatic test at 3750 psi. No devices were being built in for remote maintenance since these were not believed necessary.

Question: Dalton asked for unit capital cost and power cost figures for the plant. Answer: Simpson said a main reason for building the plant was to learn definite unit costs, but that initial costs would be higher than comparable steam plants today. They expected to learn enough so that an extrapolated plant might be competitive.

Question: Bowden (UK) asked whether consideration had been given to the economics of a superheater? Answer: This was considered in early planning and judged to be of marginal economic value.

Question: Cockcroft (UK) asked what arrangements had been made for inspection of the pressure vessel after operation? Answer: A considerable body of information held that stainless steel would not corrode under planned operating conditions, but inspection could be carried out by a rather difficult procedure.

The second presentation was based on paper No. 879, "Preliminary Study of an Experimental Pressurized Heavy Water Reactor", by O. Dahl (Norway), who stressed Norway's interest in ship propulsion. He noted that economic competition was less important for ship reactors since, in this application, reactors had other potential advantages. He reviewed Norway's reactor project and stated a program was under way to

1035278

design a boiling heavy water reactor. The reactor would have 10 MW thermal output, might increase to 15 MW, and would begin operation in about two years.

Question: Draley (US) was told that the basic idea had been to establish the project, and that no decision had been made on how the aluminum cladding or heavy water moderator would be treated to limit corrosion.

The third paper was No. 497, and "The Engineering Design of a Prototype Boiling Water Reactor Power Plant" which J. M. Harrer (US) described in considerable detail. In addition to fuel elements, core structure, and flow diagrams, Harrer discussed the control problem between the reactor and generating plant. He noted the containment feature in the building, and analyzed the economics of power generation. EBWR would make electricity for about 34 mills per kwh as being built, but if the reactor could produce twice its design rating, unit costs would drop to about 24 m/kwh. If containment and experimental facilities were eliminated, cost would drop to 14 to 16 m/kwh— a figure of considerable interest for power plants of 5 to 20 MW electrical capacity.

Question: Schmid (Switzerland) questioned the type of control rods and asked if there were anything else for control. Answer: No additional absorber or control element was planned since those designed were considered satisfactory.

Question: Bogaardt (Netherlands) asked whether boric acid would mix rapidly enough to be effective as a control? Answer: Injections actually would be at the bottom, as close to the core as possible, and other effects in the reactor were such that injections would not have to be made against over-short time intervals.

Question: Moore (UK) asked about instrumentation and experience in connection with fuel bursts. Answer: He was told no bursts had occurred in boiling water reactors, but it was considered an important problem. Bulk monitoring was used and a serious burst probably would make it necessary to remove and inspect fuel elements. Harrer said the stability question was largely answered for smaller reactors by field experience, but that only actual experience with larger reactors would reveal their exact behavior.

The final paper was No. 498, "The Homogeneous Reactor Test", by J. A. Swartout (US), who pointed out that the present homogeneous reactor is the second of this type. HRE No. 1 was termed a successful engineering and physics test. The objectives of HRE No. 2 were enumerated and the design specifications summarized; the flow sheet and various major components were reviewed with slides. It was noted that the reator was being built without control rods. Design features for blast

1035279

protection around the core and containment of gases in case of accident also were mentioned. Present state of construction was shown on photographic slides.

Question: Baxter (Australia) asked what was the behavior of Zircalloy under reactor conditions, including radiation, for long periods? Answer: There was much corrosion data on stainless steel, zirconium, and titanium, but it did not include radiation conditions.

Question: Lewis (Canada) noted that leakage of volatile fission products might be an important problem in large homogeneous reactors. Answer: The entire primary system was designed to be gas tight.

Question: Spence (UK) asked about techniques for dealing with leaks. Answer: This would depend upon the location of a leak. The most serious would be in the heat exchanger and various designs were being developed. Some troublesome leaks could be isolated by freeze plugs but the reactor would have to shut down.

SECTION 14A - POWER REACTORS, PROTOTYPES

by U. M. Staebler

The second session on power reactor prototypes was chaired by Gunnar Randers (UN, Norway). The first presentation was a summary of paper No. 499, "The Sodium Reactor Experiment" by W. E. Parkins (US), accompanied by many slides. Experimental work in support of the design and building activities was included, as were drawings and photographs of the plant. Toluene cooling of sodium seals on mechanical pumps was indicated. Design for clusters of stainless steel-clad fuel elements and for zirconium-canned graphite components was described. The primary purpose of the program was declared to be finding ways to reduce the cost of nuclear power from such plants.

Question: Preece (UK) asked why mechanical rather than electromagnetic pumps were used and could a gas turbine be used with the reactor? Answer: The primary reason for using mechanical pumps was cost, although problems must be solved to adapt the mechanical pumps. To run a gas turbine the temperature would have to be raised but the design called for certain parts to withstand 1200°F, a temperature that might begin to be adequate for gas turbines.

Question: Shepherd (UK) asked about experience with toluene under irradiation? Answer: Its decomposition rate would be quite satisfactory under conditions where it was being used, but another

1035280

organic material might actually be used because of the high vapor pressure of toluene.

Question: Moore (UK) asked why the reactor was being placed underground, and what was the fuel enrichment, and the conversion ratio at start-up. Answer: Parkins said underground construction had important safety features in preventing loss of sodium as well as in making shielding easier. The fuel enrichment was given as 2.8% U 235, the initial conversion ratio about 0.7.

Questions were answered regarding the use of sodium-potassium bonding in the fuel element: that it was not affected by thermal cycling; that a helium atmosphere was maintained on the surface of the NaK; and that gaseous fission products could collect without excessive pressure.

The second talk, on paper No. 406, "The Graphite-Moderated, Gas-Cooled Pile and Its Place in Power Production", presented by Sir Christopher Hinton (UK) was based primarily on slides showing the construction of the Calder Hall reactors. Hinton pointed out that the UK program of graphite-moderated, gas-cooled power reactors required neither exotic materials nor new technology. He projected a spectrum power of designs with this type reactor on one end, and on the other end, the fast breeder reactor. He noted that the UK was making extensive efforts at both extremes. Historical reductions in cost of conventional steam plants were cited as evidence that the same trend could be expected for reactors if the types built embodied sound engineering principles.

Question: Horowitz (France) asked about the form of the fuel elements, and the maximum kilowatts per kilogram expected. Answer: Hinton said the fuel was finned and enclosed in light metal cans, then added that there were some things which "one just does not reveal to his competitors". The specific power was given as from 2.5 megawatts per ton upward.

Question: Swartout (US) noted that the 0.6 pence/kwh in the paper appeared to apply to Calder Hall reactors based on known technology. Answer: This figure did not apply to Calder Hall reactors but to stations built with production of electricity as the primary objective. Calder Hall reactors were dual purpose and not optimized for power production.

Question: Taranger (France) asked about pressures in various parts of the systems, the quality of the CO_2, and the reasons for vertical fuel orientation. Answer: Gas pressure was given as 100 psi., primary steam 200 psi, and secondary 50 psi. The gas was commercial grade CO_2. The principal reason given for vertical fuel orientation was to support fuel channels.

1035281

Question: Doan (US) asked whether shielding was needed around the heat exchangers. Answer: They were not shielded.

Question: Hering (France) asked about outlet gas temperature, and of possible danger from CO. Answer: Outlet temperature would be of the order of 300 to 350°C. CO was not expected to present a serious problem.

Question: Bruni (Italy) asked about the possibility of producing power with gas turbines attached to this type reactor. Answer: The necessary temperatures could not be achieved now, and the steam cycle appears best.

Two papers on fast breeder reactors followed. The first, presented by H. V. Lichtenberger (US), summarized paper No. 813, "Operating Experience and Experimental Results Obtained from a NaK-Cooled Fast Reactor", and described briefly the design of the experimental breeder reactor. Major attention was given to measurements made on the reactor, especially the breeding gain.

The second paper, No. 501 ("The Engineering Design of EBR II, a Prototype Fast Neutron Reactor Power Plant" by A. H. Barnes et al) was presented by L. Koch (US). He said this fifth US experimental power reactor described at the conference was ready for detailed engineering design. The concept of the plant was described in detail, including operation of pumps and charge-discharge-storage in a pool of sodium. The importance of its fuel processing was stressed and plans were given for an integrated pyrochemical processing plant. Brief analysis of the possible economics of its power indicated a cost of 8 to 9 mills per kwh, using an estimated cost of $300 per kw for the plant itself. A major objective of the EBR II program was to learn ways of reducing these costs.

Question: Kazatchkovsky (USSR) asked whether or not fuel elements had burst in EBR, and, if so, how were they detected and had there been any leakage of gas. Answer: He was told no fuel elements had stuck so that they could not be removed from the reactor, and no gas leakage problem had occurred. There was no monitoring system to detect ruptures, because high Na activity made this difficult.

Question: Cockcroft (UK) asked whether, if a core melted down, it led to a serious criticality condition. Answer: In the design, special precautions were taken to avoid coolant loss and core melting.

Question: Hering (France) asked what safety measures were taken to avoid leaks of Na and water in the heat exchanger. Answer: Design was not completely established, but several industrial firms were offering double-walled tubing to prevent leaks.

1035282

Question: Dalton (Australia) asked what effect the inner blanket had on neutron-energy spectra and breeding ratio. Answer: He was told that no critical experiments had been done but that calculations indicated the effect would be less than the percentage of error of neutron cross sections. The effect on breeding was not yet known.

Question: Jackson (UK) expressed surprise that there was only one type of shut off mechanism in the EBR II design. Answer: Koch said there were 12 identical rods, but each was independently operated.

Question: Shepherd (UK) asked for the contemplated burnup. Answer: He was told that 2% of total atoms was the design basis in a 120-day cycle. This might not be achieved initially but the target was an even higher burnup.

SECTION 15A - EQUIPMENT AND TECHNIQUES USED IN MEASURING CROSS SECTIONS IMPORTANT TO REACTOR DESIGN

by W. W. Havens and George A. Kolstad

The Chairman, Eduardo Amaldi (Italy), opened the session promptly by reading by title some papers submitted to Section 15A which would not be presented orally because of lack of time, but which would appear in the published proceedings.

The papers read in this session included:

No. 576 - D. J. Hughes (US) - Neutron Velocity Selectors Used at Reactors.

No. 640 - V. I. Mostovoy (USSR) - Mechanical Neutron Velocity Selector.

No. 641 - V. V. Vladimirsky (USSR) - A Neutron Spectrometer with the Mechanical Interrupter.

No. 421 - E. R. Wiblin (UK) - Neutron Spectrometers Based on Pulsed Sources.

No. 577 - L. Cranberg (US) - Time-of-Flight Techniques Applied to Fast Neutron Measurements.

No. 580 - L. M. Bollinger (US) - Recent Advances in Neutron Detection.

1035283

No. 806 - W. A. Higginbotham (US) - Time-of-Flight Instrumentation for Neutron Spectrometers.

No. 573 - R. F. Taschek (US) - Techniques for Measuring Elastic, Non-Elastic and Transport Neutron Cross Sections.

Hughes' paper described fast choppers, slow choppers and crystal spectrometers used for cross section measurements at all United States research reactors. He emphasized that the different instruments complemented each other in a measurement program required to cover the whole spectrum from about 10^{-4} ev to 10^{4} ev. Above 10^{4} ev, time-of-flight instruments could not compete with other techniques because of the rapid decrease in resolution with increasing energy. Hughes felt that neutron choppers had almost reached their limit of resolution and that improved resolution would be obtained with pulsed machines.

Mostovoy then presented a paper describing a chopper, used at USSR's RFT reactor, with a rotor run by an air turbine at 20,000 r.p.m. to obtain neutron bursts as fast as 6 microseconds. The best resolution obtained was 0.8 microsec/m. Mostovoy described the time analyzer for this velocity selector, and a new system which incorporates electrostatic storage and display. A cathode ray tube with independent beams was used for reading and writing.

Mostovoy also described an ionization chamber used to measure plutonium fission cross section. This chamber contained 22 milligrams Pu^{239}, placed on thin nylon films and ionization from both fission fragments was collected. This gave a uniform fission output pulse since the total energy released in fission is always approximately constant. The fission pulse would thus be larger and more uniform than that usually obtained in fission chambers. These characteristics enabled Mostovoy to put much more plutonium than usual in the chamber and still discriminate better against the alpha-background than he would otherwise have been able to do. More information was brought out about this chamber in the question period.

V. V. Vladimirsky (USSR) in paper No. 641, "A Neutron Spectrometer with the Mechanical Interrupter", reported next on two choppers built for use with the heavy water reactor at his laboratory. The second chopper, which he discussed most, had a considerably better resolution. The resolution of the old chopper was given as 0.4 microsec/m, that of the new chopper as 0.08 microsec/m. The maximum speed of rotation was 30,000 r.p.m., to give neutron bursts as fast as 1.0 microsecond.

Vladimirsky presented curves on various elements, including tantalum. He also presented data on natural uranium and thorium and described the time analyzer system.

1035284

Question: As a comment on Hughes' paper, Shapiro (USSR) presented another method of utilizing a reactor to measure cross sections. In this method, a beam of ions would be sent through the center of the reactor to be bombarded by the neutrons in the center of the reactor. The beam would be collected and the nuclei that had been made radioactive could be counted with ordinary techniques. By this method it might be possible to get a large increase in resolution because of the accurate control of the ion energy compared to the energy control of fast neutrons. Answer: Hughes said that any experiment that could place the apparatus inside the reactor and thus take advantage of the large flux would have a great advantage since the number of neutrons which could be used in beams outside the reactor was much smaller than the number inside. There were, however, serious technical difficulties involved in placing equipment in the reactor.

Egglestaff (UK) then reported on the first chopper work done at Harwell. The Harwell chopper had the limited objective of measuring the cross sections of extremely small samples, particularly for radioactive materials, with a resolution of 0.001 microsec. Egglestaff presented plans for a Harwell "Super-chopper" which would have a 100-meter flight path with neutron bursts of 1 microsecond.

Question: Havens (US) asked Vladimirsky about (1) the dimensions of the BF_3 counters and how many were used with the new chopper? (2) the pressure of the BF_3 in the counters (3) and the counting rate with this detector. Answer: Vladimirsky said a maximum of 25 counters of length 200 mm, diameter 30 mm filled to a pressure of 500 mm of BF_3 was used as detectors. With this detector bank at 15 meters, the counting rate was 500 counts/hour, per microsecond channel.

Question: Harvey (US) asked if the flight time in the counters was included in the resolution width. Answer: Vladimirsky said the resolution quoted was that obtained near the high energy limit of the machine where this was unimportant.

Question: Sanders (UK) asked Mostovoy for some details of the fission chamber where 22 mgm of Pu 239 was used, since the people in the United Kingdom were not able to put more than 13 mgm in a chamber without having the alpha pile-up ruin the operating characteristics. Answer: Mostovoy replied that the Pu was deposited on a very thin nylon film which was coated with Ag to make a conducting surface. The fission fragments went into both halves of the chamber, and the pulses from both halves went to a preamplifier to give a much larger pulse than obtained with one fission fragment. The spacing of the chamber was such that only the initial part of the path length was used so as to maximize the ionization due to fission.

Question: Taschek (US) asked what was the rise time of the amplifier used with this chamber. Answer: Mostovoy replied 0.1 microseconds.

1035285

Chairman Amaldi then called for paper No. 421 by E. R. Wiblin (UK) and Wiblin summarized all pulsed accelerator velocity spectrometers both in the United States and the United Kingdom, taking some information from the paper of Havens (US) which was not read. In a brief history of the field, he mentioned that Alvares started this type of work in 1938 using the Berkeley cyclotron, listed the General Electric betatron, the ORNL Van de Graaff, the Columbia pulse transformer and the Columbia synchrocyclotron. He presented a table comparing the resolution width of all the pulsed machines. In this slide he compared existing facilities in the United States with proposed facilities in the United Kingdom.

His paper dealt mainly with the Harwell linear accelerator which has four experimental stations with four time-analyzers. He said the Harwell group was using n, gamma fast detectors to improve resolution and counting rates.

Of particular interest was the development of an electron accelerator in the United Kingdom which would have an output energy of 25 mev and a pulse current of 1 ampere. This would also use a subcritical assembly to obtain a neutron amplification of about 30. The machine was designed to operate with a pulse repetition rate of 500 per second. Pulses of 0.1 microsecond or less would be used on the electron gun.

Cranberg (US) gave his paper, No. 577, summarizing US work in "Time-of-Flight Techniques Applied to Fast Neutron Measurements", mentioned the initial work using the small Cornell University cyclotron, the work now in progress with the Brookhaven National Laboratory 18-inch cyclotron, some work done with the University of Michigan cyclotron and particularly stressing the work Cranberg did at Los Alamos Scientific Laboratory. He described the pulsing and analyzing system used with the Los Alamos Van de Graaff and gave some results on inelastic scattering which well illustrated the capabilities of the apparatus.

Bollinger (US) in his paper No. 580, "Recent Advances in Neutron Detection", then summarized developments in scintillation counters and described the B^{10} loaded liquid scintillators, the large banks of rapid-rise-time BF_3 proportional counters and the $ZnS.B_2O_3$ mixtures used for slow neutron detection. For fast neutron detection he described the small sphere plastic liquid scintillators and the delayed coincidence boron and Cd loaded large liquid scintillators which have been used to measure the quantity, average nu, which is important to reactor design. He closed by describing the newly developed gas scintillator for fission cross section measurements.

The chairman then called for paper No. 806 ("Time-of-Flight Instrumentation for Neutron Spectrometers") by W. A. Higginbotham (US)

1035286

which described techniques used in pulse height analyzers and time analyzers. He limited himself to block diagrams because there was not enough time to discuss the circuits in detail. He described all US systems now in operation and one planned for an Argonne National Laboratory chopper -- the pulse height-analyzer using magnetic core storage. He stated he had circuit diagrams available for detailed discussion after adjournment.

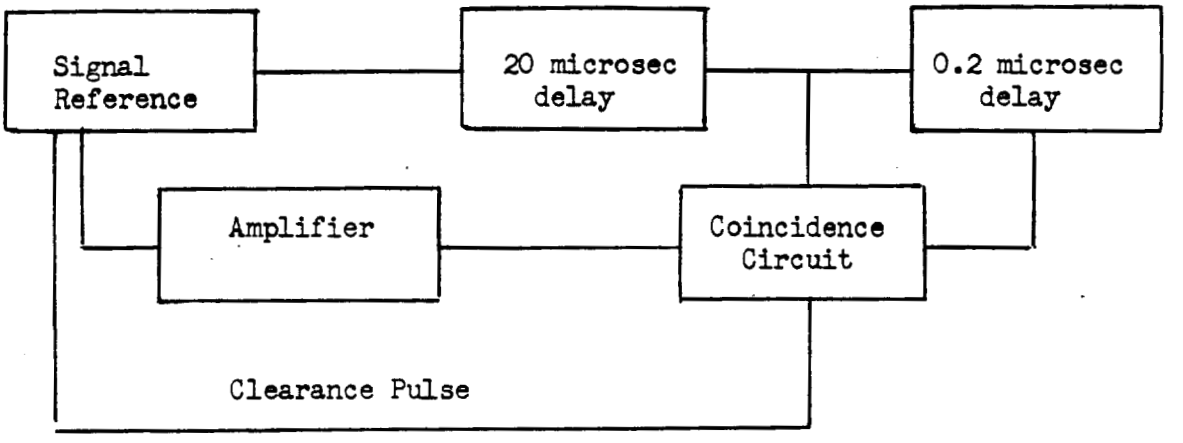
Discussion: Havens (US) presented recent results with a 400-mev synchro-cyclotron slow neutron velocity spectrometer with the best resolution of any time-of-flight spectrometers. He also presented a system for pulsing a 2 mev Van de Graaff which produces neutrons by p,n reaction. He said thick targets were used to increase neutron production and the neutrons then were timed over a measured path. Because no slow neutrons were produced, a high repetition rate could be used, and because neutrons were produced only in the forward direction just above threshold, the background was small. This technique gave good results in the 1-50 kev region.

Discussion: Egglestaff (UK) referred to Cranberg's paper and compared the equipment described with a spectrometer recently developed at Harwell with a resolution of 3% which used the pulse height spectrum in a He^3 counter. This spectrometer was used to measure the spectrum of delayed neutrons where time-of-flight techniques could not be used. Egglestaff's quoted resolution was considerably better than that reported by Cranberg. He showed neutron spectra from inelastic scattering in U 238 for two neutron energies below 1 mev.
Answer: Cranberg answered that the main advantage of the LASL system was its versatility, which can also measure angular distributions. He said he did not see how Egglestaff's resolution could be obtained. He acknowledged the limitation of his counter to energies less than 1 mev because of elastic scattering of the He atoms.

Adiaseviech (USSR) described a system using a 14 mev cyclotron very similar to the Brookhaven 2 mev cyclotron. USSR scientists studied DT and DD reactions and found large groups of neutrons at low energies formed by deuteron disintegration. The cyclotron had a 5×10^{-9} sec pulse, with a repetition rate of 8.9 megacycles and a 3 meter path length.

Wiblin (UK) described the time-expander system used to produce the 0.2 microsecond gate in the Harwell analyzer presented in this block diagram:

1035287



Question: Romanofsky (USSR) asked Higginbotham which method he considered the best for the future. Answer: Higginbotham felt the magnetic core and electrostatic memory units could be built up almost without limit. He said economics also was a factor since everyone did not need such an elaborate system. A quartz delay line was the most economical and could be used where the delay line could trigger the accelerator.

The chairman called for paper No. 573 by R. F. Taschek (US) on "Techniques for Measuring Neutron Cross Sections , Elastic, Non-elastic, and Transport", which summarized the sphere technique using counters and proportional counters. Taschek described results obtained with small crystal spheres and the work on angular distributions of elastic scattering.

Discussion: Kazatchkovsky (USSR), commenting on Taschek's paper, pointed to the equivalence of the direct and inverse geometry by spheres of any thickness. The distribution of neutrons within the sphere should be cosinusoidal. The detector should be no less than the scattering length. The mean length of time of issue from the measuring device would be

$$\frac{\bar{L}}{R} = 0.71 + 0.50\, R/\lambda + 0.29\, e^{-0.46\, R/\lambda}$$

$$\sigma = \frac{-1}{Ne} \ln T$$

where T = ratio of counts in detector with and without the sphere. Kazatchkovsky said that he would submit his calculations. Answer: Taschek replied that the effective path length L has been used by Barschall.

1035288

SECTION 16A - EQUIPMENT AND TECHNIQUES; CROSS SECTIONS OF NON-FISSIONABLE MATERIALS; DELAYED NEUTRONS

by D. J. Hughes and George A. Kolstad

L. Janossi (Hungary) was chairman.

D. Breton (France) gave paper No. 356 "Testing of Materials Using the Chatillon Pile-Oscillator," and emphasized the mathematical details of pile transients with the possibility of measuring scattering separately from absorption.

Question: Harvey (US) asked if it were possible to measure absolute cross section, or cross sections relative to boron, for materials which have small absorption cross sections? If so, did Breton have any values for graphite, bismuth or beryllium? Answer: Breton said he could not measure absolute values of capture when they were small.

F. L. Shapiro (USSR) presented paper No. 642 by A. A. Bergman et al., "A Neutron Spectrometer Based on Measuring Slowing Down Time of Neutrons in Lead." Bergman had high counting rates.

Question: Bollinger (US) asked if it were possible to obtain absolute cross sections and resonance parameters by this method. Answer: Shapiro answered that only combinations of parameters could be obtained. He told Wigner (US) there was no experimental evidence that gamma rays were different from level to level. He told Brooks it might be possible to measure alpha with an anti-coincidence arrangement.

J. A. Harvey (US) gave paper No. 832 "The Determination and Evaluation of Fundamental Thermal Neutron Cross Sections," dealing with Au, B, U 238, and U 235.

Question: Egglestaff (UK) commented by summarizing the UK situation and Harvey pointed out that isotopic difference in samples should always be taken into account in such comparisons. Sanders (UK) asked about the measurement of U 234 capture. Harvey replied that using a pile oscillator probably was best.

S. Bernstein (US) gave paper No. 591 "Summary of Cross Section of Measurements of the Fission Product Poison Xe 135," by Bernstein and E. C. Smith. He discussed the difficult problem of sample preparation and the techniques of measurement. The following discussion ensued:

1035289

Question: Wigner (US) asked whether there were any resonances found in Xe 135 at higher energies in addition to the one at 0.08 ev. Answer: Bernstein said none was observed up to about one kilovolt. A Resonance was observed in stable Xe 136.

Question: Okrent (US) asked whether it would be possible to choose between the two possible values of g (the statistical weight factor) by using measured values of the capture cross section in addition to the measurements of the total cross section? Answer: Bernstein thought existing measurements of the capture cross section were sufficiently accurate to make a definite choice. Warde, (Canada) reported on a measurement recently made in Chalk River of the capture cross section of Xe 135 for pile neutrons by mass spectrographic measurement of Cs 136. The value 3.25 megabarns was obtained. The value 3.25×10^{-18} cm^2 for the capture cross section was higher than the total cross section for a Maxwell spectrum calculated from the total cross section vs. energy measurements reported by Bernstein.

G. R. Keepin (US) gave his paper No. 831 "Delayed Neutrons" summarizing the present status of the data concerning delayed neutrons from fission.

Saunders (UK) discussed measurements of the energies of the 55 sec. and 22 sec. periods by a He^3 ion chamber which seemed to indicate structure in the energy distribution.

Question: Krasik (US) asked Keepin how he determined prompt critical for the in-hour equation comparison with delayed neutron data. Answer: Keepin said the definition of prompt critical was that reactivity at which an assembly would be self-sustaining for prompt neutrons alone, and therefore the point at which the period for prompt neutrons (defined as $alpha^{-1}$) was infinite. A method existed for measurement of alpha in the vicinity of prompt critical, he said. Extrapolation to zero of a plot of alpha versus R, defined as any arbitrary reactivity parameter, established prompt critical in terms of R. A rough determination of prompt critical could also be given by the point of inflection in an experimental period-vs-reactivity plot.

Question: R. Cohen (US) asked whether Keepin had tried several period groups in his decay curve analysis using the 701 computer (e.g., 5 or 7 period groups). Answer: Keepin reported trying 5 periods and finding that the IBM-701 computer did not converge readily, indicating the inadequacy of 5 periods. However, for 6 periods, convergence was readily obtained. He had not tried a 7-group analysis because of the apparent adequacy of the 6-group treatment, but when computer time permitted, a 7-group analysis would be made.

1035290

Question: Sanders (UK) asked whether it was true that the delayed neutron periods need not necessarily agree with radiochemical determinations of Beta-decay periods because of multiple Beta-decay to the final delayed neutron precursor. Answer: Keepin said that was correct, and this effect of cascade Beta-decay could only lengthen the particular delayed neutron period in question. Therefore, he did not necessarily expect a one-to-one correspondence between measured delayed neutron periods and precursor Beta-decay periods as determined radiochemically.

SECTION 17A - CROSS SECTIONS OF FISSIONABLE MATERIALS

by Hans A. Bethe and George A. Kolstad

Under the chairmanship of D. J. Hughes (US) 21 papers were presented in Section 17A, plus 4 questions and remarks in the discussion, in the allotted time of 3 hours.

B. T. Price (UK) gave the main talk on slow neutrons in plutonium, based on paper No. 422, "Cross Sections of the Plutonium Isotopes," prepared by J. F. Raffle and Price, which gave recent resonances for Pu 239, 240, and 241.

Price said the UK analyzed data for resonance parameters up to 22 ev energy and hoped to extend this analysis up to 100 ev. For one resonance, the British found a value of alpha as high as 7.

In Pu^{240}, the British found only one resonance up to 24 ev, the one at 1.05 ev. Their parameters are σ = 135 kilobarns, $\sqrt{\gamma}$ = 29 millivolts. The UK sample contained 7% Pu^{240}.

In the case of Pu^{241}, the British showed data up to 8 ev, using a sample containing about 1/3 of this isotope.

V. F. Gerasimov (USSR) reported in paper No. 645, "Fission and Total Cross Sections of Some Heavy Nuclides for Monochromatic Neutrons as Measured by a Mechanical Neutron Velocity Selector", by Y. V. Adamchuk et al., on the work of one of 3 Russian projects. Above 1/2 ev. energy, there was a systematic and increasing shift in the energies at which various Pu^{239} resonances occurred. On Pu^{240}, the USSR measured an 8% sample.

S. I. Sukhorutchkin (USSR) in paper No. 646, "Time-of-Flight Measurement of the Total Neutron Cross Section of Uranium 233,

1035291

Uranium 235, and Plutonium 239", by S. J. Kikitin et al., reported on work done with a cyclotron source, with a time resolution of about 0.25 microseconds/meter. He gave total cross sections from .01 to 100 ev, and fission cross-sections for lower energies. For the first resonance, he obtained alpha = 0.64. He also obtained resonance parameters.

Francis Netter (France) in paper No. 354, "Measurement of Cross Sections of Fissile Materials for Slow Neutrons", by A. Berthelot and G. Vendryes, presented total and fission cross sections up to about 10 ev, normalized to US values.

Paul F. Gast, speaking for B. R. Leonard (US) in paper no. 589, "The Total and Fission Cross Sections of Plutonium", reported the total cross section at 2200 m.sec as 1050 barns. He also gave results from the Argonne National Laboratory fast chopper work, and the work by Hanford Atomic Products Operations on the fission cross section at low energy, with accurate parameters for the 0.3 ev resonance.

V. V. Vladimirsky (USSR) reported very recent results on a new USSR chopper with high resolution (0.08 microsec/m), covering particularly the range from 7 to 25 ev. He also used a thick sample measured up to 3000 ev.

Paper No. 586, "The Low-Energy Cross Sections of U 235", by V. L. Sailor (US), opened the second part of the section. Sailor gave a relatively brief account of US data on U 235. He discussed the evaluation of resonance parameters from the experiments, including those for negative resonances. The evidence for interference between resonances was presented.

Gerasimov (USSR) in paper No. 645, presented earlier in this section, had obtained lower cross sections below 40 ev than other laboratories, apart from the shift in the energy scale already reported for Pu. He measured fission up to 1 kev.

The Berthelot-Vendryes (France) paper No. 354, presented earlier in this section, gave crystal spectrometer curves for sigma total from 0.03 to 3 ev, obtained with a sample containing only 6% U-235. For the fission cross section, their resolution was 6 microsec/m below 1 ev, and 1.5 microsec/m above 1 ev, and they reported difficulties with their boron monitor.

P. A. Egglestaff (UK), presenting paper No. 423, "Slow Neutron Cross Sections of the Uranium Isotopes", by J. E. Lynn and N. J. Pattenden, stated that the UK project had obtained the same general results on sigma vs. energy as other countries. He stressed some disagreement on the absolute fission cross section at 2200m/sec between the UK and other countries; given were:

1035292

	TOTAL	FISSION	RESULTING ALPHA
UK	716 ± 15	638 ± 20	0.12
USSR	697 ± 20	570 ± 15	0.22
USA	687 ± 4 or 7	580 ± 8	0.186

The British measured sigma F directly, by comparison with Au and B as standards. Their combination of sigma T and sigma F led to a very low value of alpha, in definite contradiction with accurate US mass spectrographic determinations of alpha.

V. V. Vladimirsky (USSR) in paper No. 644, "Determination of the Absorption Cross Section and of the Radiation Capture Cross Section of Uranium 233 for Pile Neutrons", gave the main report on U 233, opening part three of the section. He first discussed the measurement of alpha by mass spectrographic determination of the build-up U 234 and the destruction of U 233 in a sample exposed in the pile, the same method US uses. The value obtained was alpha equals 0.095. This alpha was the basis of their fission cross section standard.

The total cross section was compared with Li as a standard and found to be 615 30 barns. The spectrum showed many levels and was complex. Vladimirsky reported fission data up to 800 ev.

Gerasimov (USSR) in paper No. 645, presented earlier, reported fission cross sections, normalized to 510 barns at 2200 m/sec. He gave resonance parameters for 4 levels:

E_o	Gamma	Sigma-sub zero
0.38	0.42	57
1.42	0.44	116
1.82	0.33	667
2.31	0.22	358

Sukhorutchkin (USSR) in paper No. 646, presented earlier, remarked that 233 was the only fissile nucleus whose cross section was nearly 1/v near thermal. He gave results similar to Gerasimov's.

Wiblin (UK) in paper No. 423, presented earlier, pointed out that the U 233 cross section was 1/v up to about 1 ev, and showed a spectrum with good resolution up to about 22 ev. He again discussed absolute values at 2200 m/sec and gave the following:

1035293

	Total	Fission	Alpha Deduced
UK	605 ± 10	515 ± 15	0.175
USSR	615 ± 30	510	

The Berthelot and Vendryes (France) paper No. 354, presented earlier, gave $\frac{\sigma F(23)}{\sigma F(49)} = 0.626 \pm 0.010$, which would yield 450 barns using the present value for Pu.

Chairman Hughes, giving a summary, showed composite curves of the data of all nations prepared by the United States and emphasized the agreement. He pointed out that the resonance structure has become more complex with improving resolution. He said one resonance, in U 233 at 0.3 ev, appearing as a slight bump in each country's data, had been attributed by each to experimental error until a comparison of data from various countries showed its reality.

Hughes thanked all scientists from other countries for their cooperation in supplying data for the US cross section compilation, and expressed a hope that during the conference best values for absolute cross sections could be agreed upon.

Question: Harvey (US) asked why Gerasimov had used 625 barns for sigma F (Pu) at 2200 m/sec. Answer: Gerasimov replied that 625 had been obtained by another group in his laboratory, but that they now used 720.

Question: Palevsky (US) asked why UK had used 4 barns for the scattering cross section of Pu when $4\pi R^2 = 11$ barns. Answer: Egglestaff said 4 barns gave the best fit, but that the scattering should be measured.

Question: Havens (US) asked Sukhorutchkin about the energy and current of his cyclotron. Answer: Sukhorutchkin gave 12 mev for the energy.

Opening the fourth part of Section 17A, Berthelot (France) gave paper No. 355, "Study of the Variation with Energy of the Fission Cross Sections of U 233, U 235, Pu 239 for Fast Neutrons." Berthelot talked about measurements which were normalized to US measurements on U 238 as reported in AEC unclassified report No. [illegible]. The French get the value for sigma F of Pu, namely 2.04 ± 0.12 barns at 1600 kev.

B. C. Diven (US) next gave paper No. 5[illegible], "Techniques for Measurement of Fast Neutron Flux," the main report on this subject. US cross sections were based on comparison with proton recoil counters whose response to monochromatic neutrons was tested. Diven presented curves of US cross sections.

1035294

Egglestaff reported UK data, using the hydrogen cross section for fission cross section comparison. The British made absolute measurements at 0.6 and 1.1 mev, relative measurements at various energies, and independent measurements of the energy dependence. Egglestaff regarded the agreement for Pu and U 235 as satisfactory.

SECTION 18A - PROPERTIES OF FISSIONABLE MATERIALS - NU, ETA, ALPHA; RESONANCE ANALYSIS

by George A. Kolstad, H. Palevsky and H. Hurwitz

The Chairman was Paul Scherrer (Switzerland).

The first paper, No. 657, by P. E. Spivak and B. G. Yerosolimsky (USSR) on "Measuring the Neutron Multiplication Factor Effective Number of Secondary Neutrons for Thermal Fission of Uranium and Plutonium", presented by M. S. Kozodaev, reported measurement of eta, which Russians call nu effective, in a graphite geometry 1.8 x 1.8 x 2 meters high on top of pile. The experiment was performed by measuring the effect of boron and fissile samples on an ionization chamber near the top of the graphite geometry. The speaker said they determined experimentally the ratio of these two cross sections and calculated the ratio of the effect of slow to fission spectrum neutrons. The values reported of eta for U 233, U 235, Pu 239 were within 1% of US values.

V. V. Vladimirsky (USSR) in paper No. 658, "Number of Fission Neutrons Per One Captured Thermal Neutron in U 233, U 235 and Pu 239" by himself, A. I. Alichanow and S. J. Nikitin, reported measurements on nu effective (eta) by introducing a sample of fissionable material into a thermal pit (obtained by removing U rods from reactor) and balancing the increase in reactivity by the addition of boron, so as to compensate for the increase of reactivity. The sample used was a heavy water solution of B_2O_3 and U 233 oxalate, U 235 oxalate and Pu $(SO_4)_2$. From the ratio of boron to fissile material cross sections obtained from other experiments, USSR obtained nu effective, or alpha, in good agreement with values given in paper No. 657 which Kozodaev had just presented.

Vladimirsky then gave N. A. Burgov's paper No. 660, "Number of Fission Neutrons Per One Captured Thermal Neutron for Natural Uranium." By the same method described in paper 658 Burgov obtained Nu(eff) for natural uranium equal to 1.33 $\pm$ 0.006 in good agreement with US values.

1035295

J. E. Saunders (UK) next gave paper No. 245, by P. A. Egglestaff and himself, on "Neutron Yields from Fissile Nuclei." Part I of the paper reported a measured nu average by means of a fission chamber surrounded by BF_3 counters in a paraffin geometry. The neutron counters were gated on after the fission pulse occurred in the calibrated neutron counters using spontaneous fissions in a natural U sample. They measured U 235, U 233, Pu 239, Pu 241 relative to U 235 and obtain the following values:

nu average (233) = 2.46 plus or minus 0.15

nu average (235) = 2.45 " " " 0.15

nu average (239) = 2.86 " " " 0.18

nu avergae (241) = 2.98 " " " 0.21

In Part II of the paper they calculated the variation in alpha from the cross section data of Lynn and Pattenden given in the report in Section 17A (Paper No. 423) and found alpha to be constant from 0.005 to 2.1 ev in U 233. They obtained:

$$\frac{(\text{alpha } 0.3)}{(\text{alpha } 0.025)}\ \text{U } 235 = 2.7 \text{ plus or minus } 1.0$$

$$\frac{(\text{alpha } 0.3)}{(\text{alpha } 0.025)}\ \text{Pu } 239 = 1.6 \text{ plus or minus } 0.2$$

In Part III, the variation of eta with energy was reported as measured with a crystal spectrometer. The experimental arrangement involved the use of a thick fissile sample surrounded by BF_2 counters in a paraffin geometry. They found eta to be constant from 0.025 to 1.8 ev for U 233, consistent with fact that nu is also constant over this energy interval. Measurements on Pu 239 gave:

$$\frac{\text{eta } 0.3}{\text{eta } 0.025} = 0.77 \pm 0.04$$

compared to 0.84 ± 0.05 variations for eta/1 + alpha. They concluded that the most likely result gave the mean value of nu to be constant.

In Part IV, the UK experimenters estimated alpha for 7 positive levels up to 17.7 ev in Pu 239 from the cross section measurements of Raffle and Price (paper No. 422) and concluded that the fission widths varied much more than radiation widths.

H. Palevsky (US) in paper No. 587, "Measurement of Capture to Fission Ratio of U 235, U 233, and Pu 239 by a New Method" described a method of obtaining eta by counting fission neutrons from a black

1035296

sample of fissile material by means of a scintillation counter. The number of neutrons in the incident beam was determined by a thin BF_3 counter. From the variation of the ratio of the two counting rates Palevsky obtained the variation in eta. The method was capable of high precision because corrections were small and easily made. For U 233, eta was found to be constant between 0.01 to 0.1 ev. For U 235, eta rose by about 1% from 0.01 to 0.1 and then dropped about 6% from 0.1 to 0.3 ev, the position of the resonance, and then rose and passed through resonance to 0.5 ev. The results agreed well with variation of sigma F/sigma A calculated from U 235 data. For Pu 239, this gave:

$$\frac{\text{eta } 0.3}{\text{eta } 0.025} = 0.75 \text{ plus or minus } .02$$

W. R. Kanne (US), in paper No. 595, "Capture to Fission Ratio of Pu 239 and U 235 for Intermediate Energy Neutrons", described work on alpha in the intermediate energy region which included both irradiations of U 235 and Pu 249 at Hanford Atomic Products Operations and reactivity coefficient measurements.

Discussion: Mostovoy (USSR) presented data on the variation of eta calculated from his measurement of the fission and absorption cross section, assuming nu to be constant. For U 235, after making corrections for resonance scattering, he obtained a variation similar to that presented by Palevsky but with a slightly greater discrepancy (about 10%) at 0.3 ev compared to thermal. He showed a prepared slide giving the scattering correction to data taken at Brookhaven National Laboratory. For Pu 239, the results were in good agreement with those calculated by Palevsky.

Kozodaev (USSR) presented results of measurement of nu effective (or alpha) using photo neutrons from SbBe as the 30 kev source and from NaBe as the 900 kev source. The experiments were performed in a graphite prism. He did not give details of measurement but offered the following results for nu effective:

Isotope	30 kev	900 kev
U 233	2.23 ± 0.07	2.60 ± 0.13
U 235	1.86 ± 0.07	2.28 ± 0.08
Pu 239	2.01 ± 0.05	2.52 ± 0.13

Question: Taschek (US) asked what was the efficiency and sensitivity of the neutron detector used in the UK for measuring average nu. Answer: Sanders said that 16 BF_3 counters in paraffin were used and gave an efficiency of 1.03% for thermal neutrons. An error of ± 5% on calibration of source accounted for most of the uncertainty

1035297

in the results. Farley (New Zealand) discussed a method used at the Harwell linear accelerator to measure the variation of eta with energy. Their detector for fission neutrons had an efficiency of 1%. The experiments were not complete, but the data suggested that eta did not vary much from level to level.

Sukhorutchkin (USSR) measured nu effective with a cyclotron using thick samples and detecting fission neutrons with a scintillation detector, and made measurements up to 11 ev on U 233, U 235, U 239. Sukhorutchkin concluded that Pu 239 might show a variation in gamma radiation level widths at 8 and 12 ev one-and-a-half times narrower than other levels. Eta seemed constant from level to level.

Callihan (US) told Sanders that by method of critical spheres he had compared eta for U 235 to eta for U 233. Assuming eta (235) = 2.08, he got eta (233) = 2.32, in good agreement with other US values but not with data presented by Sanders.

Question: Higgersberger (Austria) asked concerning data in paper No. 595 by Kanne what statistical fluctuations had been observed with full sensitivity and how had they been eliminated? Answer: Data were taken using electron multiplier detectors and exhibited small fluctuations.

H. A. Bethe (US) then gave paper No. 585, "Analysis of the Velocity Selector Results on Fissile Materials" on properties of resonance in fissionable material.

H. H. Hurwitz, Jr. (US) in paper No. 590 on "Status of Information on Reactor Material Cross Section", discussed the resonances in the intermediate energy region and fission product poisoning. He quoted results of the Knolls Atomic Power Laboratory danger coefficient measurements. Hurwitz gave smaller estimates for intermediate energy fission product poisoning than had Weinberg.

Question: Mostovoy (USSR) asked Bethe (1) about the distribution of level spacings in terms of the mean values, and (2) how did UK and US results compare with USSR findings in studying Sigma F, which showed first resonance levels of U 238 and Pu 239 about the same (0.3 ev). Answer: Bethe replied (1) that the distribution of levels was being measured at Brookhaven National Laboratory but the analysis was not yet complete. At one time it appeared that very close spacings were less likely than expected on the basis of random spacing. Much more analysis was required than had been given so far. (2) the occurrence of 3 or 4 levels at 0.3 ev was in Bethe's opinion, purely accidental. There was no reason to expect that the neutron energy should have any more significance than any other value. However, US opinion was not unanimous that the 0.3 levels had no significance.

1035298

Wiblin (UK) discussed procedures for evaluating resonance parameters (for details, see paper No. 42 , UK, which UN will print as part of the record of Section 15A). [illegible] pointed out a need for using data of many different kinds; i.e., scattering and capture as well as transmission.

Question: Shapiro (USSR) asked a series of questions of Bethe on the statistics of level spacings and the reasons that neutron widths fluctuate. Answer: Bethe explained that fluctuations were to be expected because only one final state existed and the character of the wave functions for the various individual levels were different. Neutron emission constituted only one of the same. This was consistent with present ideas on the relation between individual and giant resonances.

Question: Raievski (France) presented a question for Hurwitz as to where Hurwitz got a figure for the capture cross section of carbon which he quoted in his paper. Answer: Hurwitz said he did not know in detail how it was measured, but thought several samples had been used.

Question: Weinberg (US) commented that the observations by the Harwell group indicated a constancy of Sigma C and Sigma F. He asked Bethe to comment on the fact that alpha appeared to be constant up to 20 ev. Answer: Bethe replied that alpha was very small and $\sqrt{F}$ very large in U 233. The measurements would have to be made much more accurately (better than 5%) in order really to see the constancy. He commented that it was a remarkable thing that $\sqrt{F}$ was so much bigger than anything else.

SECTION 19A - INTEGRAL MEASUREMENTS

by Alvin Radkowsky

A. de Shalit (Israel) was Chairman.

Paper No. 661 (USSR) "A Study of Neutron Diffusion in Beryllium, Graphite, and Water by the Impulse Method," by A. V. Antonov, et al, developed a theory of neutron beam methods, first giving credit to the pioneer work of von Dardel. The basic idea was to shoot a neutron pulse -- obtained from an accelerator -- into a medium, the nuclear properties of which are being tested. Measurements were made of neutron intensity in the material as a function of time following the burst. It was shown that by comparing measurements in samples of different geometric buckling it was possible to obtain both the thermal diffusion constant and neutron lifetime. Data were obtained for the

1035299

three media listed in the title, including measurements in water at high temperature. In the last case, the authors expressed surprise at the amount of increase in diffusion length obtained. It was shown that the neutron age could be obtained by using a sample of the medium, infinite in one direction, and comparing measurements at two adjacent points.

Radkowsky (US) pointed out that a theory had been developed for the variation with temperature of the diffusion length in water and that the work was outlined in Conference paper 603 by J. Chernick.

Paper No. 662 (USSR) "A Study of Beryllium as a Neutron Moderator," by L. A. Geraseva et al, described the experimental determination of nuclear reactor physics constants for Be, specifically capture cross section, age, and thermal diffusion length. The capture cross section was measured in a graphite pile by danger coefficient methods. Great care was exercised in the measurement; the method involved comparison with substances such as D_2O of known capture and moderating power. The measurements of age and diffusion length were conventional.

A value of 6 mb was obtained for the capture cross section for pure Be, which was much less than that reported by other experimenters, the discrepancy being attributed to the fact that the Be used by others contained impurities.

Paper No. 359 (France) "Measurement of Diffusion Length of Thermal Neutrons in Beryllium Oxide," by J. C. Koechlin et al, reported on the measurement of the thermal diffusion length in BeO, using conventional means, i.e., a large block of material irradiated by neutrons from the thermal column of the Saclay reactor. The value of the diffusion length was larger than computed by transport theory. This discrepancy was attributed to the fact that the source neutrons were not truly thermal.

Paper No. 872 (India) "On the Determination of Diffusion and Slowing Down Constants of Ordinary Water and Beryllium Oxide Using a Pulsed Neutron Source," by R. Ramanna et al, described a method similar in principle to that in USSR paper No. 661. He described a new method of time analysis to correlate thermal neutron decay with the time at which the source of fast neutrons was fed in. The principle used was to make the ion pulse at the accelerator target initiate the time base of an oscilloscope, and allow thermal neutron pulses to intensify the oscilloscope spot.

Paper No. 360 (France) "Measurement of a Complex Diffusion Length in a Solid or Liquid to Determine the Transport Mean Free Path for Thermal Neutrons," by J. Horowitz et al, was primarily a development of the theory of the experiment. Some experimental

1035300

results were given. The source of neutrons incident on the specimen to be studied was modulated by a periodic variation, and the amplitude of oscillation as a function of time measured at various points in the medium, as well as the phase angle of the neutron level relative to the source. The theory developed a means of deducing the desired quantity from the data. A substantial number of corrections had to be made to the data.

Paper No. 789 (Sweden) "Measurements on a Subcritical Reactor with A Pulsed Neutron Source," by N. G. Sjostrand et al, gave an interesting method of determining the amount of subcriticality of a reactor without using a calibrated control rod. A pulsed neutron source was used and the time behavior of the neutron flux in the reactor could be studied to determine its subcriticality. The method required knowing the slowing down time of the delayed neutrons and the effective geometric buckling of the reactor. The method would not work for subcriticality of more than about 1% in k, since then flux harmonics become important.

Paper No. 933 (Netherlands) "Determination of Neutron Capture to Fission Ratio in Different Uranium Samples," by T. J. Barendrecht and M. Bustraan, described work carried out with natural uranium, UO_2, and U_3O_8 rods of various diameters irradiated in the JEEP reactor. Capture of neutrons was determined by determining the beta activity of the U 239 formed. Fissions were estimated by measuring the activity of Ba 139, the fission yield of which is well known. The thermal absorption of U 238 was calculated in preference to the usual method of inserting the rods in cadmium. The results showed clearly the difference between uranium and uranium oxide rods. In uranium rods the resonance capture occurred primarily at the surface, while in oxide, due to the oxygen scattering, the resonance capture remained substantial inside the rod.

Paper No. 597 (US) "Status of Experimental and Theoretical Information on Neutron Slowing Down Distribution in Hydrogenous Media," by J. E. Wilkins et al., considered discrepancies between measured and calculated ages of neutrons in H_2O. Experimental measurement of the age presented great difficulties.

Paper No. 357 (France) "Time-of-Flight Spectrometer Equipment Used at the Saclay Pile of Inelastic Scattering of Slow Neutrons," by B. Jacrot et al., described an apparatus consisting of a mechanical shutter and crystal spectrometer capable of good resolution up to energies of 1000 ev. The apparatus was used to study thermal neutron spectra and variations of fission cross section as functions of neutron energy. The experiments described in the paper concerned diffusion of very low energy neutrons, (about 3×10^{-3} ev) in monocrystals, D_2O, and H_2O.

1035301

SECTION 20A - RESONANCE INTEGRALS FISSION POISONING, CRITICALITY OF SOLUTION

by Alvin Radkowsky

The Chairman was G. von Dardel (Sweden).

Paper No. 659 (USSR) "Measurements of Resonance Absorption Integrals for Various Materials and the Multiplication Co-efficient Effective Secondary of Resonance Neutrons for Fissionable Isotopes", by P. E. Spivak et al, reported on measurement of resonance integrals by the transmission method, using thin films of material. The neutron beam was obtained from the RFT reactor, the desired energy being obtained by filtering the beam through boron of various thicknesses. Eta measurements involved the use of a thermal neutron converter, utilizing a spherical paraffin boron filter. No results for eta were reported.

Question: Wigner (US) pointed out that the thicknesses of samples used in some of the resonance absorption measurements were so great as to make it almost impossible to obtain the statistical accuracy claimed. Answer: The experiment was a very difficult one.

Paper No. 833 (US), "Resonance Capture Integrals", by R. L. Macklin and H. S. Pomerance, was presented by Wigner, who reviewed the experimental situation in the United States. He discussed ways of accounting for the cut-off energy for Maxwellian neutrons, and of the effect of absorbing resonance at energies in the unresolved region.

Wigner pointed out that the US definition of the resonance capture integral in U 238 took into account the depression of resonance flux in the rod, while most other measurements gave the resonance integral directly, thus introducing a seeming discrepancy with US results.

Paper No. 948 (Netherlands), "Computation of the Effective Resonance Integral", by E. F. M. van der Held was in two parts. The first part included a means for deducing the Breit-Wigner parameters, taking Doppler broadening into account by means similar to the area method used by Hughes, Havens, et al. In the second part, the author evaluated the volume portion of the U 238 resonance integral from the resonance parameters and concluded that most of the effect came from the lowest three levels.

Paper No. 427 (UK), "Studies on the Neutron Resonance Absorption of U 238", by V. S. Crocker was a study by the self-indication

1035302

technique of the resonance absorption of U 238. Layers of various thicknesses were studied and the effects of temperature variation were included. The results agree with US values of resonance absorption for small rods in which the disadvantage factors, described earlier by Wigner, were not significant.

Paper No. 883 (Norway), "Measurements of the Effective Resonance Integral of Uranium with the Pile Oscillator", by V. O. Eriksen, et al., described measuring the resonance integral of lumped U 238 by the pile oscillator method. The surface and mass terms were separated by using a thin-walled uranium box as container and successively filling the box with discs of uranium. The method was similar to that reported by Wigner in paper No. 833.

Paper No. 5 (Canada), "Experiments on Some Characteristics of the NRX Reactor, Part I", by D. G. Hurst described the NRX reactor. The methods used in making accurate reactivity measurements were given and the work applied to measurements of reactivity changes as a function of megawatt days per ton up to 3000 MWD/ton. He said the difficulties of making unambiguous reactivity measurements were very great in a reactor of this type, the photo neutron effect from D_2O being an additional complicating factor. The main conclusion was that, in a reactor of this type, irradiation up to 3000 MWD/ton did not produce catastrophic reactivity losses.

Paper No. 6 (Canada), "Experiments on Some Characteristics of the NRX Reactor, Part II", by A. G. Ward reported measurements at Chalk River of temperature co-efficients of reactivity and xenon reactivity effects. By making measurements on the equilibrium xenon buildup it was possible to determine both xenon yield and absorption cross section. The xenon yield seemed to be 5.7% rather than 6.4% as determined by the radiochemists.

Paper No. 835 (US), "Reactivity Changes and Reactivity Lifetime of Fixed Fuel Elements in Thermal Reactors", by B. I. Spinrad, et al, discussed long-term reactivity changes in both uranium and thorium. It was shown that considerable gains in MWD/ton could be obtained by rearranging and recycling fuel and by removal of fission product poisons.

Paper No. 432 (UK), "Long Term Reactivity Changes in Natural Uranium Reactors", by D. J. Littler analyzed long-term reactivity changes by a method which linearized all effects except Xe and Sm buildups. The method was good up to about 1000 MWD/ton. The author concluded that the Sm fission yield was 1% instead of the commonly used 1.3%.

Paper No. 834 (US), "Small Thermal Homogeneous Critical Assemblies", by A. D. Callihan, et al, was a study of critical

1035303

dimensions and loadings for U 233 and Pu 239 fuel in homogeneous solutions in light water. The author concluded that the criticality was explained by the Selengut-Goertzel theory. The effect of varying fuel distribution to obtain a flat flux also was presented.

Question: There were some questions about the range of the water-to-fuel ratios used. Hurwitz (US) pointed out that a careful calculation on the basis of transport theory for a slab reactor with a reflector having the same slowing down properties as the core, except for fuel, showed that the Selengut-Goertzel assumption gave results considerably at variance with experiment and that a more exact method, using the Weiner-Hopf integral method, would check with the criticality result found experimentally.

Paper No. 428 (UK), "Plutonium - Water Critical Assemblies", by C. C. Horton and J. D. McCullen measured criticality for three H to Pu ratios. By fitting criticality to a two-group solution, it was found that eta of Pu was 2.22.

SECTION 21A - ZERO ENERGY AND EXPONENTIAL EXPERIMENTS

by Alvin Radkowsky

The Section was chaired by O. Gamba (Argentina).

Paper No. 600 (US), "Exponential Experiments with Slightly Enriched Uranium Rods in Ordinary Water" by H. Kouts, et al, covered a comprehensive series of experiments including measurements of reactivity, age, fast effect, thermal utilization and resonance escape probability in subcritical lattices consisting of slightly enriched uranium. The lattices were measured in exponential experiments, utilizing a beam from the Brookhaven reactor. The methods used in performing the measurements and of analyzing them are given. One surprising result was that the migration areas in the lattices as deduced from the bucklings was almost independent of the water-to-uranium ratio.

Discussion: Barkov (USSR) reported on a series of direct measurements of the neutron age in uranium-water lattices, the uranium being enclosed in cadmium sleeves to prevent multiplication. It was found that, at low uranium ratios, the results agreed with those of Kouts, but that at very high uranium ratios, corresponding to closely packed lattices, the migration area rose very sharply. Shapiro (USSR) reported on the gains of reactivity in natural uranium-water lattices if air gaps were used around the uranium rods. It was found that the magnitude of the gains was only half that anticipated.

1035304

Paper No. 601 (US), "Pressurized Water Reactor (PWR) Critical and Exponential Experiments" by S. Krasik and A. Radkowsky discussed the physics experimental program for PWR. In one phase the slightly enriched rods studied at Brookhaven National Laboratory in exponential experiments were utilized in critical assemblies with a light water moderator. A second phase consisted of mock-up experiments of the actual PWR reactor. The motivation for the seed and blanket design was presented briefly.

Blokhintsev (USSR) stated he thought the seed core was "a very good idea".

Paper No. 790 (Sweden), "Some Experience from Measurements on an Exponential Pile of Uranium and Heavy Water" by R. Persson, et al, described some experiments yielding bucklings for two diameters of uranium rods vs heavy water-to-metal volume ratio. An arrangement of the top plate gave great flexibility in adjusting rod distances. The rods were held by rollers which could be moved along a slotted beam.

Paper No. 791 (Sweden), "Characteristics of the Swedish Heavy Water Reactor", by E. Hellstrand et al, summarized a series of experiments on the reactor including a study of the transfer functions, response of the reactor to a step change in reactivity, reactivity changes due to the heavy water level, flux distributions, power level calibrations, and a theoretical and experimental treatment of the effect of channels on reactivity.

Paper No. 361 (France), "Neutron Study on Two Heavy Water Piles" by J. Horowitz, outlined a very thorough study of the nuclear characteristics of the two French heavy water piles. The pile spectrum was measured directly by a neutron spectrometer and time-of-flight method. He compared the two piles, one of which uses channels for gas cooling.

Paper No. 605 (US), "Exponential Experiments on Uranium D_2O Lattices" by E. R. Cohen, reported on United States U - D_2O lattice work, particularly that at North American Aviation and at Argonne National Laboratory, and a comparison with Chalk River data. The bucklings found at Chalk River were lower by approximately 3½%.

Persson (Sweden) pointed out that his measurements of buckling were lower than those of Chalk River, but thought that he might have been making a systematic error.

Paper No. 623 (USSR), "Heavy Water Research Reactor (Results of Critical Experiments)" by A. I. Alichanov, et al, described a USSR reactor. A novel feature was a "pit" — a region 60 to 70 cm in diameter in the center which is free of uranium rods and which

1035305

has a very high flux of purely thermal neutrons. Fast flux in this region can be obtained by use of a "neutron transformer" (a water cooled U-cylinder).

It was noted that the age in heavy water used by the USSR was 20 cm^2 greater than the American value. Spinrad (US) was told by Rudik that the USSR value was a calculation based on a harder fission spectrum than used in the US.

Paper No. 429 (UK), "The Experimental Basis of Lattice Calculations", by P. W. Mummery, presented an approach to accurate reactor design based upon a correlation of theoretical and experimental work. The methods were especially applicable to graphite moderation. The two-group theory was used as a basis, with deviations adjusted by correlation with exponential experiments. The value of eta found in this manner was less than that deduced in other ways.

Paper No. 607 (US) "Normal Uranium Graphite Moderated Reactors—A Comparison of Theory and Experiment. Water-Cooled Lattices" by P. F. Gast, described an experimental and theoretical program for studying uranium/graphite water-cooled lattices. Difficulties have been encountered in explaining experimental bucklings. The advances made by Hanford Atomic Products Operations included introducing the concepts of rod "blackness" and the successive generation method. A description was given of an experimental pile which permitted measurement of the reactivity factors with a high degree of precision.

Paper No. 606 (US), "Uranium Graphite Lattices. Part II. The Brookhaven Reactor" by I. Kaplan and J. Chernik, gave the history of the physics design of the Brookhaven National Laboratory reactor in a manner which would assist anyone designing a reactor of this type. A comparison of theory and experiments was given for the effect on reactivity of the air cooling gap.

SECTION 22A - ZERO ENERGY EXPERIMENTS ON FAST REACTORS AND REACTOR KINETICS

by Alvin Radkowsky

S. Eklund (Sweden) was chairman of Section 22A.

Paper No. 404 (UK), "Experimental Studies on Fast Neutron Reactors at AERE" by L. R. Shepherd, described the British fast neutron zero power reactors and experiments with them. The danger coefficients of a large number of elements were measured and the

1035306

values fell on regular curves as a function of atomic numbers, Shepherd said, thus permitting use of interpolation for predicting danger coefficients for elements not measured. Flux measurements were facilitated because the Pu fission cross section was constant as a function of energy in the fast region. The piles were too small to permit inserting sufficient material to simulate the effects of the coolant.

Paper No. 598 (US), "The Fast Exponential Experiment" by F. C. Beyer, et al, presented by Spinrad, outlined fast exponential experimental work performed at Argonne National Laboratory. The fast subcritical assembly was irradiated by a beam from a low power source reactor. Experimental values were determined for buckling, reflector savings, and for U 235 to U 238 fission ratios. The effect on bucklings of variation of parameters, has been studied. The ratio of U 235 to U 238 fissions in a block of solid natural uranium was found to be higher than previously measured. The discrepancy might be due to the fact that the block was too small for the flux spectrum to reach equilibrium value.

Paper No. 609 (US), "A Survey of the Theoretical and Experimental Aspects of Fast Reactor Physics" by R. Avery, et al, presented by D. Okrent, discussed various problems encountered in fast reactor design, including comparison of theory with reactivity and with power distributions in previous fast assemblies such as Godiva and EBR-1. A chief point of concern was lack of knowledge of the ratios of parasitic-to-fission cross section (alpha) for U 235 and Pu 239. The authors felt little doubt that with Pu 239 as a fuel there would be ample margin of neutron output for breeding. There was some doubt about U 235, since the neutron spectrum might be significantly lowered by inelastic collisions. A very recent and preliminary measurement of alpha for U 235 in EBR 1, for a spectrum similar to that of a power reactor, gave a value of only 0.2 which is still low enough to permit breeding.

Paper No. 775 (Israel), "Stability Conditions in the Non-Linear Dynamics of Heterogeneous Reactors" by H. J. Lipkin and R. Thieberger, extended the results of Ergen and Weinberg of US on reactor stability to a heterogeneous reactor consisting of two media, such as uranium and heavy water, where heat is produced in one medium and extracted from the second. It was found that the system would be extremely stable.

Paper No. 934 (Netherlands), "The Influence of Temperature on the Transfer Function of a D_2O Reactor " by J. Pelser, presented calculations of the transfer function of a simplified JEEP-type reactor in which the external system was represented by a simple time constant.

Paper No. 334 (France), "Kinetic Problems of a Power Reactor and Analogue Machines" by P. Braffort, outlined the use of analogue computers in predicting reactor transient behavior.

1035307

Paper No. 610 (US), "Kinetics of Stationary Reactor Systems" by T. A. Welton, generalized on previous work on reactor stability, such as that of Weinberg, Ergen, and Fleckner. The linear stability conditions were given and the effects of compressibility outlined. A treatment was also given on non-linear stability. Approximately 26 slides full of mathematical symbols were flashed on the screen.

Questioning was limited to clarification of the data presented.

SECTION 23A - REACTOR THEORY

by Alvin Radkowsky

The Chairman was C. Salvetti (Italy).

Paper No. 611 (US), "Survey of Neutron Thermalization Theories" by E. R. Cohen, summarized the various methods used to calculate the neutron spectrum in the thermal region, taking into account the preferential absorption of slow neutrons. Cohen showed that there should be an additional effect in reducing the value of the age to thermal energy.

Paper No. 433 (UK), "Calculation of the Fine Structure of the Thermal Neutron Flux in a Pile by the Spherical Harmonics Method" by J. H. Tait, extended the methods of spherical harmonics to rods surrounded by air gaps. The difference in thermal utilization as computed by diffusion theory, P_3 approximation, and P_5, were compared. The diffusion theory gave too large a value.

Paper No. 608 (US), "Comparison of Theory and Experiment for Intermediate Assemblies" by H. Hurwitz and R. Ehrlich, outlined many refinements in the application of multigroup theory developed at Knolls Atomic Power Laboratory. The availibility of high speed digital computers, the speaker said, had made it possible to extend the method to two-dimensional studies. Considerable question as to the validity of the results still existed because of uncertainties in cross sections and neglect of the Be (n.2n) reaction.

Paper No. 430 (UK), "Method for Calculating the Critical Mass of an Intermediate Reactor" by M. E. Mandl and J. Howlett, was withdrawn because the material was almost completely covered by the preceding paper.

Paper No. 664 (USSR), "Application of the Method of Effective Boundary Conditions for Calculating the Critical Dimensions of Reactors" by A. D. Galanin, pointed out that in large reactors with reflectors

1035308

one-group theory was satisfactory except within a distance from the boundary equal to the square root of age. In this region two-group theory was applied to calculate boundary effects and results then could be used with one-group theory to obtain correct criticality conditions and power distributions.

Hurwitz (US) stated extensive work of this type had been carried out, particularly by Volkoff (Canada). Expecially accurate results had been obtained when the reflector had the same slowing down properties as the core, except for fuel, in which case the reflector savings might be expressed as an integral involving the Fousier transform of the slowing down density.

Paper No. 669 (USSR), "Heterogeneous Methods of Reactor Calculations: Survey of Results and Comparison with Experiments" by S. M. Feinberg, compared the usual homogeneous theory for reactor calculations with results obtained by treating each fuel element as a line source or sink—a method that would not be valid for closely packed lattices, in which the dimensions of fuel must be considered. It was found that the homogeneous theory was valid except for very small assemblies, or near the edge of the reactor.

P. Gast (US) pointed out that the work of the paper was similar to a small source theory developed at Hanford.

Paper No. 649 (USSR), "Theory of Resonance Absorption in Heterogeneous Systems" by I. I. Gurevich and I. Y. Pomeranchouk, outlined the work on resonance absorption for U 238 performed in the USSR. Extensive calculations were made; the result still involved two constants which had to be determined by experiment. The formula used the 3/2 power of the radius.

In the ensuing discussion Wigner (US) pointed out that the chief difference between the US and USSR viewpoints was that the USSR did not consider the effect on neutron energy of scattering by uranium. Wigner was told by Shapiro (USSR) about an experiment in which Bi was placed at the center of a uranium rod without any resultant increase in resonance absorption.

Paper No. 666 (USSR), "The Thermal Utilization Factor in a Heterogeneous Reactor" by A. D. Galanin, examined the assumption in a lattice - type reactor that each cell might be replaced by an equivalent cylinder. Various cell shapes were examined and it was found that cylinderization usually introduced only small errors. The small source theory was used.

Paper No. 1003 (Argentina), "Lattice Calculations on Natural Uranium-Beryllium Oxide and Natural Uranium-Beryllium Metal in a Cylindrical Reactor" by O. Gamba, et al, examined the critical dimensions

1035309

of reactors that used natural uranium and were gas - cooled, and Be - or BeO - moderated. Conventional formulas were used, various cases were considered, and it was found that Be requirements would be 50 to 150 tons.

Paper No. 656 (USSR), "Equation for the Importance of Neutrons, Reactor Kinetics, and the Theory of Perturbation" by L. N. Ussachoff, developed perturbation theory and developed equations taking into account the relative importance of fast and slow neutrons as a function of positions in the reactor.

Question: Hurwitz (US) pointed out that the paper computed the power change resulting from introduction of a neutron into the assembly whereas in the United States the corresponding quantity used was the fissions per generation. Answer: The speaker stated he thought either formulation could be used.

Paper No. 796 (Czechoslovakia), "Remarks about the Milne Problem with Cylindrical Symmetry" by L. Trlifaj, was an extension of Davison's work in England to a case of cylindrical symmetry.

Paper No. 667 (USSR), "Effective Boundary Conditions for 'Grey' Bodies" by D. F. Zaretsky, was of practical importance for computing the effectiveness of control rods which are not completely black. Starting from the Peierels equation, a match was obtained with the solution at asymptatic distances. An approximate formula was obtained and compared with results from the variational method. Results were given for both spheres and cylinders.

1035310

"B" SECTIONS - CHEMISTRY, METALLURGY, AND TECHNOLOGY

Section 6B - The Natural Occurrence of Uranium and Thorium

by Robert D. Nininger

Section 6B, chaired by Joaquim da Costa Ribeiro (Brazil), consisted of one 30-minute paper by Paul F. Kerr (UN), summarizing all papers submitted to the Conference for this section, and a 20-minute paper by Jesse C. Johnson (US) on fuel supplies for power reactors. After these two papers there was a 1 3/4 hour panel discussion by delegates from 12 countries on uranium and thorium occurrence.

Kerr's paper (No. 1114, "The Natural Occurrence of Uranium and Thorium") represented the consensus of participating delegations' views on the geology of uranium and thorium as represented by their papers, two thirds of which were submitted by the US. Kerr briefly discussed the geology of the Shinkolobwe mine in Belgian Congo, and Canadian, Australian, Portuguese and other deposits.

Johnson's paper, (No. 470, "Nuclear Fuel for the World Power Program") had as a thesis that there were adequate resources of uranium and thorium for a long-range expanded world power program. Johnson listed major uranium operations in the Belgian Congo, Canada, South Africa, and the United States, and said that Australia, France, and Portugal were mining uranium with good prospects for increased production. On the basis of present evidence, Johnson estimated the producing nations of the West had resources of between 1 and 2 million tons of uranium available at an average cost of about $10 a pound of U_3O_8 in high grade concentrates. In addition to this, the resources in low grade higher cost uranium-bearing materials such as phosphates and shales were virtually unlimited, with the United States alone estimated to have 600,000 tons of uranium in phosphates and 5 to 6 million tons in shales. The cost of extracting uranium from such materials might be $30 to $50 a pound.

Participants in the panel discussion, moderated by Kerr, were: V. Angelelli, Argentina; J. P. Baxter, Australia; Jean Van Der Spek, Belgium; E. Tavora, Brazil; A. H. Lang, Canada; M. Roubault, France; D. N. Wadia, India; F. Ippolito, Italy; K. Aki, Japan; C. P. Lobato, Portugal; S. H. U. Bowie, United Kingdom; and L. R. Page, United States.

1035311

Only 10 minutes was allotted to each speaker, and statements consequently were chiefly brief descriptions of deposits in the respective countries, as follows:

Angelelli (Argentina): Small nickel-cobalt-uranium veins in northern Argentina; copper and carnotite deposits of limited extent in Mendoz province; pegmatites and low grade shale deposits.

Baxter (Australia): Deposits in Northern Territory, northern Queensland; occurrences of unknown importance in western Australia, New South Wales, and Tasmania.

Van Der Spek (Belgium): Description of the geology of the Shinkolobwe mine of the Belgian Congo.

Tavora (Brazil): Occurrences of uranium with zircon at Poco de Caldas; newly discovered occurrences of uranium in the gold-bearing conglomerate at Serra de Jacobina in Bahia; numerous pegmatites of Minas Gerais; monazite deposits of the coastal regions.

Lang (Canada): Descriptions of the important deposits at Great Bear Lake, Lake Athabasca, and Blind River.

Roubault (France): Small but very significant pitchblends vein deposits of Central France; minor occurrences of uranium in Madasgascar; uranothorite deposits in Southern Madagascar.

Wadia (India): Beach deposits of monazite in southern India; two uranium occurrences under investigation—one pegmatite, the other with copper deposits.

Ippolito (Italy): Uranium occurrences in the Italian Maritime Alps now under development.

Aki (Japan): Occurrences of uranium and thorium in pegmatite and alluvial deposits derived from them; extensive exploration under way.

Lobato (Portugal): Deposits at Urgeirica, Guarda, and Belmonte; described the recently organized Portuguese exploration program.

Bowie (UK) and Page (US): A general discussion of uranium and thorium geology, summarizing current theories of conditions and methods of deposition in economic mineral deposits.

1035312

SECTION 7B - PROSPECTING FOR URANIUM AND THORIUM

by Robert D. Nininger

Section 7B on "Prospecting for Uranium and Thorium", chaired by D. N. Wadia (India), consisted of 9 papers by 7 countries, UK and USSR each presenting two. The papers dealt with specific, single techniques for prospecting, except that the Canadian, US, and one UK paper summarized a large number of methods. Construction or use of counters, was emphasized. The US paper dealt with geological, geochemical, geophysical, and engineering techniques which the authors felt were significant for the future.

The first paper, No. 764, "Methods of Prospecting for Uranium and Thorium" prepared by C. F. Davidson and S. H. U. Bowie (UK) and presented by Bowie, was a summary of prospecting techniques as developed by the Geological Survey of Great Britain. They included, primarily, the use of geology in determining favorable areas, the field use of portable geiger and scintillation counters by geologists, and the use of field geochemical techniques for sampling soils, vegetation and water. The speaker did not consider use of radiation detection equipment in aircraft to be very effective.

The second paper, No. 1, "Uranium Prospecting in Canada—Ground and Aerial Surveys" by A. H. Lang, was primarily a historical description of Canadian prospecting since 1946. It concerned the work of prospectors and the problems concerned with their support in remote regions of Canada. Because of the vast unexplored areas in Canada their problems were somewhat unique. Brief attention was given to geologic evaluation including the use of diamond drilling and portable radiation detection equipment. The history of Canadian experiments with aerial surveys was described with a statement that it had limited use in Canada because of the type of terrain and geology encountered.

The third paper, No. 763 (UK) "Instrumental Developments in the Prospecting, Mining and Chemical Processing of Nuclear Materials" by H. Bisby et al., was a technical discussion of the design of counters for field prospecting and mill monitoring. For prospecting, Bisby reported use of halogen-quenched geiger counters in preference to other types and in preference to scintillation counters. He told of developing geiger counter equipment for monitoring a continuous flow of concentrates and liquors in process plants.

The fourth paper, No. 994 (Yugoslavia) "Radiation Detectors with Halogen Counters for Use in Prospecting" by A. Milojevic et al., presented by M. Petrovic, discussed the design of halogen-quenched hand-prospecting counters.

1035313

The fifth paper, No. 132 (Brazil) "Air Survey Applied to the Search for Radioactive Minerals in Brazil" by D. A. MacFadyen and S. V. Guedes, presented by Guedes, gave a detailed description of the organization and execution of an aerial prospecting program carried out in Brazil to evaluate resources of uranium and thorium.

The sixth paper, No. 625 (USSR) "Aeroradiometric Prospecting for Uranium and Thorium Deposits and the Interpretation of Gamma Anomalies" by V. I. Baranov, presented by V. G. Melkov, was a technical discussion of physical principles involved, and techniques used, in aerial radiometric prospecting. A description was given of a completely self-supporting prospecting unit for carrying out exploration in a remote area. A unit consisted of aircraft and crew, geologists for ground investigation, portable drilling equipment and analytical facilities.

The seventh paper, No. 503 (US) "Techniques for Prospecting for Uranium and Thorium" by R. D. Nininger, summarized papers on prospecting techniques submitted by the AEC and the U.S. Geological Survey, emphasizing geologic, geophysical, and geochemical methods.

The eighth paper, No. 626 (USSR) "Radiohydrogeological Method in Prospecting for Uranium Deposits" by A. A. Saukoff, presented by A. P. Vinogradov, described in detail a water-sampling method of evaluating the uranium possibilities of an area, a method which the USSR called radiohydrogeological prospecting, and which the Western countries refer to as hydrogeochemical prospecting.

The ninth paper, No. 869 (India) "Remote Location of Uranium and Thorium Deposits" by K. G. Vohra, described a method of evaluating uranium deposits in large areas through air monitoring at a central station. An analysis of radioactive particles in air blown over long distances was assumed to show whether the terrain over which the air passed contained rocks of sufficiently greater than average radioactivity to indicate commercial uranium or thorium deposits.

Question: Lecoq (France) asked Bowie whether aerial prospecting might not be effective under certain conditions. Answer: Bowie replied that he thought it undoubtedly was in such areas as the Colorado Plateau in the United States and other areas of exposed outcrops, but that in many places within the British Commonwealth thick soil or forest mantle made this method ineffective.

Question: Page (US) inquired (1) what intensity of radiation detected in aerial prospecting represented an anomaly of sufficient interest to investigate on the ground, and (2) what means were used to check anomalies on the ground. Answer: Malkov (USSR) replied that (1) it was not possible to give specific figures because this depended upon many variables, including the instrument used, the elevation of flight, the type of terrain, the type of geology, etc. and (2) that the usual ground survey methods were used.

1035314

Question: Lecoq (France) asked Nininger (1) whether resistivity studies had been made in exploration for vein deposits, (2) whether a drill-hole scintillation counter developed by the United States could determine the grade of uranium ore penetrated and distinguish between small high grade ore bodies and large low grade ore bodies. Answer: Nininger (US) replied (1) that since the most important deposits in the United States were of the sedimentary type, the US concentrated on physical studies on that type of deposit and had not investigated the use of geophysical techniques in connection with exploration for vein deposits, and that (2) with proper calibration the approximate grade of material penetrated could be determined if ore extended for several inches in all directions from the hole and was of appreciable thickness. However, if the drill hole penetrated only the edge of an ore body or a very thin body, the interpretation of the counter reading would be in error. He stated that some work had been done on a directional counter which would permit better interpretation.

Question: Harrison Brown (US) asked under what circumstances USSR geochemical methods were used and whether they were combined with other methods. Answer: Vinogradov replied that all possible prospecting techniques were used in combination in all areas and a final evaluation made upon analysis of all information collected. Radiohydrogeological methods normally were used first, followed by soil and vegetation sampling, aerial radiometric prospecting, and surface geologic investigation.

Nininger (US) commented that in view of the apparent difference of opinion, about the effectiveness of aerial prospecting between the Brazilian and the USSR delegations on the one hand, and the British and Canadian delegations on the other, he would evaluate briefly the US experience which was more in line with that of the Brazilian and the USSR. In the US aerial prospecting had discovered many productive deposits. Bowie (UK) then commented that he felt there was no real difference in opinion but rather a difference in experience due to the types of geology and other conditions in the respective countries.

SECTION 8B - THE FISSION PROCESS: FACILITIES FOR HANDLING HIGHLY RADIOACTIVE MATERIALS

by L. E. Glendenin and E. P. Steinberg

The Chairman, Otto Hahn (West Germany) opened the session by recalling his 1938-39 investigations in collaboration with F. Strassmann which led to the discovery of uranium fission. In particular, he mentioned the very weak sources he used, but emphasized the ease of handling such sources chemically since the radiation hazard was essentially nil.

1035315

E. P. Steinberg (US) presented the first paper of the session (No. 614 "Survey of Radiochemical Studies of the Fission Process") by L. E. Glendenin and himself, which reviewed data on yields for reactor neutron fission of Th 232, U 233, U 235, U 238, and Pu 239, and emphasized the changes that take place in mass distributions as the fissile nuclide changes. Data on division and distribution of nuclear charges in fission were presented showing the satisfactory application of the equal charge displacement hypothesis. An analysis of the fine structure effects observed in mass spectrometric investigation of fission yields was given in terms of the influence of nuclear closed shells of 50 and 82 neutrons.

A. Ghiorso (US) presented paper (No. 718, "Spontaneous Fission Correlations"), which mentioned the discovery of elements 99 and 100 (einsteinium and fermium), and the forthcoming joint publication on the work by Argonne National Laboratory, Radiation Laboratory at Berkeley and Los Alamos Scientific Laboratory. Preparation of these elements was described as resulting from 17 successive neutron captures in bomb tests. Ghiorso traced the history of the correlation of data on spontaneous fission half-lives and illustrated the results as functions of Z^2/A.

The paper suggested that a shell of 152 neutrons had an important effect on spontaneous fission half-life, just as it had on alpha half-life. The subshell could account for the very rapid decrease in spontaneous fission half-life observed for even-numbered neutron isotopes of elements 98 and 100 with neutron numbers greater than 152.

Such a hypothesis allowed predictions of unknown half-lives. Its usefulness would depend on additional empirical data, particularly for the fermium isotopes, Fm 250 and Fm 252. The data indicated that the half-lives for spontaneous fission would probably not become competitive with alpha half-lives even for elements as high as 102 or 103 except for isotopes having greater than 152 neutrons. With 156 neutrons, spontaneous fission apparently was the chief mode of decay.

Question: The chairman read a prepared question from an unnamed delegate regarding the shortest half-life radioisotope that could be detected by mass spectrometry. Answer: Steinberg (US) pointed out the dependence of mass spectrometer sensitivity on the element involved. He indicated that isotopes with half-lives as short as a few hours had been studied by mass spectrometry.

Question: Adiasoviech (USSR), commenting on the spontaneous fission half-life of Th 232, pointed out that instead of Segre's value of 1.4×10^{18} years the USSR obtained a value of 10^{20} years when action of cosmic rays was excluded. Answer: Ghiroso (US) said the discrepancy was perhaps not unreasonable but that the Th 232 half-life had also been measured by determining the number of neutrons

1035316

emitted. A value of 2 neutrons per fission corresponded to Segre's half-life. If the USSR half-life were correct, 10 or more neutrons would have to be emitted per fission.

The next paper No. 881 was by A. C. Pappas (Norway) on "The Distribution of Nuclear Charge in Low Energy Fission", reviewed the development of the equal charge displacement hypothesis and his contribution regarding the influence of discontinuities in the stability valley Z_A on the charge distribution picture. Using the discontinuous Z_A values, and applying the equal charge displacement hypothesis to fragments (before neutron emission), Pappas redefined the postulate and illustrated the fit of the data with this new approach.

Pappas pointed out that the theoretical treatment of Present on charge division, if modified to include compressibility (as suggested by Swiatecki) and a more up-to-date mass formula, might give good agreement with the general trend in the Z_p function but would not give the periodicities and discontinuities ascribed to closed shell effects.

The chairman introduced the next set of papers on "Facilities for Handling Highly Radioactive Materials" and again referred to the vast development in intensity of sources and the new techniques necessary for handling them.

R. Spence (UK), in paper No. 438 ("An Atomic Energy Radiochemical Laboratory Design and Operating Experience") pointed out that the laboratory at Harwell was built before much experience had been accumulated. The important points he made were with on using sealed plastic bags to remove contaminated materials from glove boxes, and hard-gloss enamel paint rather than expensive strippable lacquer for walls, ceilings, etc., except in immediate vicinity of activity (as in hoods and gloves boxes). Chlorinated rubber paint also has been used as a second coat over strippable lacquer. Chemical operations were better served by small concrete cells with good vision and good manipulation rather than by large areas of concrete. Spence illustrated the use of pressurized suits and the design of removable walls on alpha boxes. Recently, mobile alpha boxes had been introduced for ease in servicing. Experience indicated the need for keeping ventilation high so that fumes hoods could be used in addition to the glove boxes. Exhaust activity from stack was limited to 75 millicuries of beta and 75 microcuries of alpha activity per day. The ventilation ductwork was large and this helped to keep down contamination and to lower noise levels. A system of segregating liquid effluent into contaminated and uncontaminated categories had worked well.

Accident experience indicated need for careful control against ingestion, for neutralization of waste solutions containing HNO_3 and

1035317

organic solvents, and for reliable fire control and alarm. Cotton shoe bags, as used for visitors, were considered easier to use and more comfortable than rubber boots.

W. M. Manning (US) presented a paper (No. 725, "Hot Laboratory Facilities for a Wide Variety of Radiochemical Problems," by P. R. Fields and C. H. Youngquist) describing the various facilities for radiochemical studies at Argonne National Laboratory. In particular techniques for study of transuranic elements were illustrated.

Three types of "hot" caves were described: (1) large caves for handling up to 10,000 curies of gamma activity, (2) intermediate caves for levels up to 100 curies, and (3) low-level, or junior caves for levels up to 1 curie of gamma activity. The main portion of the presentation consisted of slides showing various installations. The chemical processing of an irradiated Pu 239 sample (200-300 milligrams) was described in detail with decontamination from an initial level of 300,000 roentgens per hour to 1r per hour, which was low enough so that only minor shielding was required for further operations. Also described was the use of lucite boxes around each piece of equipment in a large cave for containing radon gas produced in working up a sample of 30 grams of radium. Air passed through each box and the radon was trapped by freezing on activated charcoal. The air continued through a regular filter system and out a 30-meter stack. The use of horizontal resin columns to prevent clogging by bubble formation (from action of radiation on solutions) was illustrated.

Manning also described accident experience at Argonne, pointing out that only minor contamination has resulted outside the caves. He also mentioned an accident involving a worker's hand being pierced by a contaminated forcep. The forcep fortunately had only rather pure Th ^{227} activity which rapidly decayed; no serious consequences resulted.

The last paper (No. 673, "Metal Research Hot Laboratory" by N. V. Pravdjuk, USSR), was presented by G. S. Zhdanov and described facilities for studying changes in physical properties of irradiated materials. The Laboratory was designed so that several hot cells were linked in a large unit with different properties investigated in separate cells. Transport of material and storage, was handled remotely. The first cells could handle up to 50,000 curies, the rest up to 20,000 curies.

Slides illustrated equipment in the various cells. A milling-machine was described which did both transverse and longitudinal cutting and had a support enclosed in plexiglass to protect the mechanism. Cutting was done in a stream of distilled water. The walls and floor of this cell were lined with polished stainless steel and could be washed with water or acids by a remote controlled hose arrangement. Special mirror systems and contamination detectors were located in the cell.

1035318

The next cell in line was the "distribution cell" used for storage and as a supply center for various technological cells. Connection was by means of a trolley-transporter, and light signals in operator's room showed the exact location of the trolley. One research cell was used for metallographic studies and contained a grinding machine, electrolytic etching and polishing equipment, and metallographic microscope. Two cells were used for physical measurements. Various equipment could be introduced and fixed in place as needed. A final cell was used for mechanical tests and for preparation of castmolds of irradiated materials.

A brief survey of the methods in use included a description of the use of reflected X-ray diffraction patterns. Automatic recording was employed for first order reflection settings of the monochromator. The use of photographic techniques employing the metallomicroscope was mentioned, as was the use of an aluminum varnish replica for electron microscope examination. The use of the microhardness tester and the measurements of modulus of elasticity and internal friction were also described. A plexiglass split-moulding box was described for the casting of replicas of the irradiated specimens using a gypsum form and a Wood's metal casting.

Question: Jenssen, (Norway) asked Spence if the UK had continuous health physics inspection and what was the ratio of health physicists to other laboratory personnel. Answer: Spence said health physicists performed constant monitoring of the building with a staff of 3 or 4, or more for special tests. A ratio of about 1 health physicist to 25 scientists existed.

Question: Manning, (US) asked how Spence would change the design of his laboratory if he were to build another. Answer: Spence said he would prefer a more open structure consisting of a large, cheap open hall with a strong floor, and then would put in equipment as needed. Chemical Engineering at Harwell has built such a structure.

Question: Walton (UK) pointed out the difficulty of constructing a manipulator operating in a completely sealed cave and asked whether it had been necessary to do this at Argonne. Answer: Manning said Argonne relied on air flow, always having an inward flow of 60-70 centimeters per second. Geortz (US) mentioned that in another paper he would describe a completely covered manipulator, fitted with plastic boot for contamination control.

Question: Spence (UK) asked about experience with ventilation equipment at Argonne. Answer: Manning said the original design was not fulfilled because of economy cutbacks. Difficulties were encountered due to suck-backs during high winds since there was a lag in motors turning on. To offset this, all motors were run continuously but blowers drew air only from the attic, until a damper

1035319

operated on demand for conditioned air from inside. Changes now being made would fulfill the original design level of the ventilating system which then should be quite satisfactory.

Question: The chairman read a question about operations using master-slave manipulators in junior caves, asking whether the distance the operator had to stand from the cell interfered with small scale manipulations? Answer: Manning said the arms were believed flexible enough to approach as close as desired. Goertz said there was a fixed distance, but this was not objectionable because cave was shallow and walls thin. In larger caves, the manipulators were flexible enough so the operator could stand closer to the work.

Question: The chairman read another question asking about the life of zinc bromide solutions under irradiation. Answer: Manning said that with hydroxylamine as a stabilizer the lifetime in lower level caves was indefinite. Goertz said hydroxylamine, as a reducing agent, acted to absorb the free bromine liberated on irradiation. He did not know precisely the irradiation which the solutions could stand, but estimated 10^{10} roentgens or more.

Question: Kosiskov (USSR) asked whether any chemical agent was employed to decrease bubble formation in resin columns. Answer: Manning said no catalysts had been employed to inhibit gas formation and the possibility of doing so was uncertain.

Question: Goertz (US) asked whether USSR cells were designed to handle high level alpha as well as gamma activity. If so, what methods were used to control contamination? Answer: Zhdanov said only gamma radiation was handled.

Question: Spence (UK) asked whether USSR used glass objectives in the microscopes or was special glass or plastic used in the high gamma fluxes present? Answer: Zhdanov said plain glass was used.

Question: Goertz (US) asked what was the physical size of the USSR facility and did the lead glass used have any radiation stability material added to it. Answer: Zhdanov said the area of one facility was 1,000 square meters. Cells were 3 meters by 1.5 meters. Ordinary lead glass was used.

Question: Baxter (Australia) asked if the US had any experience in using stereoscopic television for remote control observation. Answer: Goertz said the US had not had much experience in using television in operating conditions, but had experimented with it in preparation for emergency. Evidence indicated windows were considerably better than television as presently developed.

1035320

SECTION 9B - CHEMISTRY OF FISSION PRODUCTS: SOLUTION CHEMISTRY OF GROSS FISSION PRODUCTS

by L. E. Glendenin and E. P. Steinberg

The Chairman, A. P. Vinogradov (USSR), in opening the session, commented on the important role radio chemists have played in nuclear science. R. D. Hammond (US) in the first paper, (No. 724, "Chemical Processing in Intense Radiation Fields"), gave the following examples: (1) preparing radiolanthanum sources of 500,000 curies per cm^3, (2) separating high level alpha isotopes, and (3) recovering uranium from homogeneous reactor solutions by solvent extraction.

Each illustrated a chemical effect of intense radiation. In (1) the difficulties were overcome by avoiding oxidizing or reducing media, by using large excesses of inorganic reagents and by using platinum-lined equipment. The self-heating encountered helped the process by preventing bumping during boiling. In (2) dilution of solutions, the use of excess reagents, and recycling were employed. In (3) dilution of reagents and use of purified solvents was necessary.

Hammond pointed out the importance of recombination of the hydrogen and oxygen produced in homogeneous reactor solutions. Studies resulted in these conclusions: (1) the gas was produced mainly by the action of the fission fragments: (2) recombination was assisted by the gamma-ray flux; (3) specific ions might either catalyze or inhibit the recombination (negative uranium ion included) and (4) recombination was strongly dependent on temperature, pressure, and presence of excess hydrogen or oxygen.

F. R. Bruce (US) in paper No. 719 ("The Solvent Extraction Chemistry of Fission Products") surveyed present knowledge about extracting cerium, niobium, zirconium and ruthenium from aqueous nitrate solutions. In all cases, extraction into organic solvents was enhanced by increasing nitrate ion concentration, especially by nitric acid. The dependence of extraction on oxidation state was illustrated by Ce and Ru which extract more readily in higher valence states. The effect of complex formation was illustrated by increased extraction of ruthenium in the presence of nitrite ions which formed a nitroso complex. Extraction decreased with increasing temperature. Anions which formed aqueous soluble complexes (such as citrate with zirconium and niobium) also decreased extractibility.

The effects of pH were illustrated by extraction coefficients for zirconium and niobium into methyl isobutyl ketone. At high acidities, extraction was good; at low acidities, they were not extracted. The difficulties encountered with ruthenium extraction were mentioned.

1035321

Extraction of ruthenium and rare earths by application of tributyl phosphate indicated extraction took place by complex formation. Tributyl phosphate might complex with uranium or thorium and not extract fission products. Zirconium was extracted by forming a soluble complex with monobutyl phosphate impurity. Trivalent cerium would not extract, while tetravalent cerium extracted quantitatively.

The speaker pointed out the general applicability of thenoyl trifluoroacetone to extraction of almost all fission products under proper conditions.

K. A. Kraus (US) presented paper No. 837 ("Anion Exchange Studies of the Fission Products"), which surveyed the field of anion exchange and illustrated the method's advantages for separating nearly all metallic elements. Studies on chloride solution were presented in some detail and copies of a periodic chart of the elements with their elution curves were distributed.

Anion exchange could be applied to problems of the aqueous solution chemistry of metals, particularly in concentrated solutions. Data showed that the position of the adsorption maximum was related to the stability of the complex. The effect of concentration of ligand on the rate of change of the distribution coefficients gave information on the types and stability of intermediates, and on the activity coefficient quotients involved in equilibrium constants. Kraus pointed out that the use of radioactive tracers practically eliminated the time-consuming analyses previously required.

Question: Nicholls (UK) asked Hammond about the use of fluorinated plastics such as teflon in equipment under intense radiation. Answer: Hammond said data on radiation stability of plastics was in the literature. Teflon was easily attacked and gave off corrosive hydrofluoric acid, hence was not a good choice of material.

Question: Timoshev (USSR) asked whether the nature of the solvent had an essential influence on the distribution of fission products. Answer: Bruce said it was not easy to generalize on fission product extractions into various solvent classes, but in general extraction increased with increasing water solubility in the solvent. Data given in the table showed large differences in extraction into hexane and tributylphosphate.

Question: Fletcher (UK) discussed the valency state of ruthenium in extraction. He found it only extracted when nitrosyl form was present, and that the reduction in extractibility on heating with ferrous sulfamate was connected with conversion of nitrosyl form back to normal 3- or 4-valent ruthenium. He mentioned that the time factor was important in ruthenium extraction, and asked Bruce about times in his experiments. Answer: Bruce answered that times were

1035322

all about 5 minutes. He found the effect of ferrous sulfamate greater than that of sulfamic acid and believed a valency effect was involved in ruthenium extraction. He acknowledged the importance of the time factor and pointed out experiments which indicated 10-fold higher extraction of ruthenium could be achieved by allowing it to stand several days before extracting.

Question: Shankar (India) asked Kraus to comment on temperature co-efficients in his experiments. Answer: Kraus said much was done on this but that the temperature coefficient was quite large for anion complex equilibrium, and small for ion exchange equilibrium.

Question: Glueckauf (UK) asked about separating neptunium from fission products in nitrate solution. Answer: Kraus said they had done no work on neptunium in nitrate solution but that neptunium behaved much like uranium in fluoride or chloride. He referred Glueckauf to Hyde's paper (P/728 in Session 10B) for data on neptunium.

Question: Riabtchikov (USSR) said it appeared possible to separate any element from all others by anion exchange, using built-in groups for special anion development. Answer: Kraus agreed but excepted the three heavy alkali metals as difficult to separate. He did not think there was need for built-in groups since simple resins seemed adequate.

Fletcher (UK) then presented paper No. 437 ("The Chemistry of Ruthenium"), pointing out the importance of ruthenium in process chemistry. He stressed that little was known of the chemistry of ruthenium nitric acid solution and compared the structure of nitrate complexes of nitrosyl ruthenium to amino, halogeno and yano complexes of nitrosyl ruthenium. He cited the similarity to trivalent cobalt and tetravalent platinum, and gave a number of examples of possible structures for various complexes. Absorption spectra were not easily applied, Fletcher said, but reactions and behavior on anion and cation exchange resins led to certain choices of structure. He pointed out how presence of the nitrosyl group profoundly affected the nature of ruthenium complexes.

For Ru 4 the pattern was much like other tetravalent ions. Rates of nitration and denitration was fast for uronyl, plutonyl and Pu 4 + and Th 4+ , but slow for ruthenium.

Fletcher concluded that study of ruthenium should help lower cost of processing fuel and of disposing of waste which today were complicated by the difficulties of separating ruthenium from uranium and plutonium.

Question: Fayed (Egypt) asked Fletcher what was the most stable compound with respect to aging effects. Separation problem might

1035323

be solved by anodic oxidation to volatile RuO_4. Answer: Fletcher did not want to give a definite answer to the question, but pointed out that he mentioned the nitro complexes were most stable in nitric acid.

Question: Ripan (Romania) asked whether there was a relation between size of molecule and anion exchange adsorption even for the same charge? Rollier (Italy) asked had the crystal structure of the solid ruthenium compound Fletcher mentioned been investigated? Answer: Fletcher said crystal studies had not been done since the materials were very hygroscopic, but that they had made infra-red absorption spectra studies. He answered the Romanian delegate by saying they had noted different behaviors in going from one complex to another and on different resins.

The next paper, No. 671 ("Some Chemical Properties of Technetium" by J. B. Gerlit, USSR), was presented by Chairman Vinogradov. The paper reviewed some studies using Te 99 tracer and stated that coprecipitation of technetium sulfide on rhenium, copper and bismuth sulfide decreased with increasing concentration of Hcl, because of reduction of technetium to tetravalent state by the chlorine ion. Gerlit also found the pertechnetrate ion coprecipitated well with slightly soluble chlorates and the rate of precipitation increased as solubility of the corresponding compound of the carrier decreased. Extraction of rhenium and technetium was found to be dependent on presence of amines or oxygen-containing solvents.

Some data were given on conditions for preparing sexavalent technetium and for reducing heptavalent technetium to the +4 state. When reduced by zinc in HCl, technetium was found in its lowest valent state in which it differed from rhenium.

Gerlit's paper also reviewed rapid solvent extraction methods for separating technetium from molybdenum and rhenium.

W. Seelman-Eggebert (Argentina) presented 2 papers, No. 1023, "Determination of Half-Life of Tc^{102}" and No. 1026, "Determination of Half-Life of Tc^{105}". They were brief reports covering the separation and standard half-life and energy determination by decay and absorption, respectively. The results were a half-life of 5 ± 1 sec and an energy of 4.2 mev for Tc 102 and a half-life of 10.5 minutes for Tc 105.

Walton (UK) gave paper No. 436 ("The Condition of Fission Product Iodine in Irradiated Uranium Metal"), describing experiments in which irradiated uranium was ground and mixed with such solvents as hexane, H_2O, and HNO_3 and the iodine extracted. Results indicated iodine formed as neutral atoms.

1035324

Walton told of studying metal during irradiation to determine the conditions which governed release of fission products with special reference to xenon and krypton. This technique had not yet been applied to determining independent fission yields, but Walton hoped to do so soon.

Question: Steinberg (US) asked whether the difficulties encountered in radioactive interchange with carrier iodine were a result of the action of the solvent on the neutral iodine formed. Answer: Walton said this was possible, particularly since more difficulties were noted in nitric than in hydrochloric acid solutions.

Question: Yaffe (Canada) asked whether the solvent would not affect the valence state of the iodine. Answer: Walton said precautions had been taken and studies by other workers showed hexane was not attacked by iodine atoms.

SECTION 10B - HEAVY ELEMENT CHEMISTRY: SURVEYS OF CHEMISTRY OF TRANSURANCIES

by L. E. Glendenin

The chairman, G. T. Seaborg (US) opened the session on heavy element chemistry with introductory remarks on the considerable extension of the periodic table including the recent discoveries of elements 99 (einsteinium), 100 (fermium), and 101 (mendelevium).

The first paper, No. 726, "Thermodynamics of the Heavy Elements" by B. B. Cunningham (US) reported on studies including entropy, heat capacity, heat of formation, etc., for various heavy element compounds. He pointed out the importance of purity in the studies and the difficulties of selfheating caused by the radioactivity of these elements. Trends in free energy of formation of aqueous ions of different valence states with atomic number were illustrated in slides.

Question: Riabchikov (USSR) said a number of investigations had been made in the USSR on equilibrium diagrams of plutonium with beryllium, tungsten, iron, manganese, nickel, and other elements, and the results published this year in a symposium. He asked Cunningham to comment on US studies. Answer: Cunningham knew of numerous studies of intermetallic systems involving plutonium but he did not feel qualified to outline the work.

1035325

The second paper, No. 440, ("Electronic Configuration of the Actinide Elements") by J. K. Dawson (UK) summarized studies of magnetic properties of heavy element compounds. In general, the magnetic studies verified the filling of the 5f-shell in agreement with the "actinide hypothesis" of Seaborg, although there were some peculiarities not yet explained.

Discussion: Kletchkovsky (USSR) gave a rule for the filling in of electrons in the successive orbits of the periodic table, based on the following equation:

$Z = 1/6\ (2L + 1)^3 + 1/6\ (5-2L)$, where Z is the number of electrons in the orbit of spin 1. Cunningham (US) commented that the excellent work of Dawson contributed to the interpretation of electron configuration of ions in heavy element compounds. He remarked further that magnetic susceptibility measurements at Radiation Laboratory, Berkeley, on americium trifluoride were in agreement with the actinide concept of Seaborg.

Question: Racah (Israel) asked if Dawson's computations on electronic configurations of the actinide elements were made by the method of Hartree and Fock. Answer: Calculations made by Eisenstein and Pryce had been published and Dawson's written paper (No. 440) contained references to this. Racah commented there was competition between the d-shell and f-shell filling which depended on the degree of ionization. The chairman, Seaborg, said he had read Racah's excellent papers on this subject and agreed.

Zhdanov (USSR) said considerable work had been done in the USSR on intermetallic compounds of plutonium. He presented some slides on phase diagrams.

E. K. Hyde (US) presented paper, No. 728 ("Separation Methods for Actinide Elements"), covering solvent extraction separations with thenoyl trifluoroacetone (TTA), tributyl phosphate (TBP), and other organic solvents. TTA was called particularly advantageous because of its stability in acid solutions, low cost, and its enormous variability in equilibrium constant for complex formation with various elements. The paper also covered the excellent separations afforded by cation (Dowex-50) and anion (Dowex-1) exchange resins using glycolic, lactic, and hydrochloric acids for elution.

Next, V. N. Kosiakov made remarks on two Russian papers, No. 674 and No. 677, to be included in the published proceeding of the section and described a method of separating neptunium from plutonium by sublimation of neptunium tetrachloride, and studies of the relative rate of oxidation of neptunium and plutonium by potassium bromate. Kosiakov reported also the quantitative coprecipitation of tracer amounts of Am (V) with the double carbonates of U (VI) or Pu (VI) and potassium.

1035326

J. Kooi (Netherlands) reported briefly on studies of the extraction of neptunium in its various oxidation states by the organic solvents, dibutyl carbitol, diethyl ether, and methyl isobutyl ketone.

Question: Katz (US) stated that US scientists separate protactinium from thorium by a volatilization procedure similar to that described in USSR paper No. 674, and the US paper No. 823, scheduled in 22B would describe volatility procedures. Answer: (Kosiakov): Such procedures undoubtedly are of great value, important economically and industrially, and therefore must be under study in all countries.

Question: Hyde (US) and McKay (UK) commented that Kooi's data for extraction of neptunium (V) seemed too high, the possibility being that he had not allowed for the rapid disproportionation of Np(V) in strong nitric acid solution. Answer: Kooi said he had checked the oxidation state by coprecipitation experiments, carried out the measurements as fast as possible, and varied the time of shaking, so that he believed the data were good.

Question: Penneman (US) commented that the USSR had given the stoichiometry of the orthorhombic $K_5AmO_2(CO_3)_3$. He said the US had identified $K_5AmO_2CO_3$ as hexagonal, but that there were still one or more unidentified phases. Had the USSR studied them? Answer: Kosiakov said the USSR had not studied them.

The section then took up the chemistry of neptunium, americium, and curium, starting with paper No. 736, "Some Recent Developments in the Chemistry of Neptunium" by J. C. Hindman (US). Hindman covered in considerable detail the isolation of gram quantities of pure neptunium from irradiated uranium, and studies of the thermodynamic properties had electrochemical behavior of the various oxidation states of neptunium.

R. A. Penneman (US) presented paper No. 838, "A Review of Americium and Curium Chemistry", reporting the availability and separation of gram amounts of americium and milligram amounts of curium. Data were presented on preparation and properties of americium and curium metal, oxidation states in solution and in compounds, absorption spectra for americium in solution and self-reduction of Am (V) in solution by alpha radiation.

The final paper, No. 676, was a brief report by Kosiakov (USSR) on "Spectrophotometric Studies of the Behavior of Americium Ions in Solutions". The important absorption bands for Am (III), Am (V), and Am (VI) were determined. The complex ions of Am (III) were studied in perchloric, hydrochloric, sulfuric, and nitric acids. The reaction constant for the self-reduction of Am (VI) by alpha radiation was determined.

1035327

Question: Penneman (US) asked whether Kosiakov had any actual constants for formation of complex ions of americium? Answer: Kosiakov said the work was mostly qualitative.

SECTION 11B - EFFECTS OF RADIATION ON REACTOR MATERIALS

by E. Epremian

The chairman, J. H. de Boer (Netherlands), opened Section 11B with remarks on the scientific interest and the practical importance of irradiation effects. He commented that this was a united session: there were participants from the United Kingdom, the United States, the United Republics of the Soviet holding a meeting under United Nations auspices.

The first speaker, D. S. Billington (US) gave a survey paper, No. 744, "Radiation Damage in Reactor Materials". In dealing with irradiation effects in non-fissionable materials, he discussed a wide variety of materials and phenomena, including the change in shear stress, damping, and elastic modulus of copper single crystals; the mechanical strength of carbon-silicon steel typical of those which might be used in a reactor. He showed the effect of irradiation on precipitation from super-saturated solid solution by presenting experimental data on a nickel-beryllium alloy. Also discussed were irradiation effects on ceramics (e.g., quartz) and plastics (vinyl chloride acetate).

In discussing irradiation effects in fissionable materials, Billington presented considerable data on uranium alloys containing 5 and 15 per cent aluminum. He indicated the change in properties upon irradiation and their recovery upon annealing.

The second paper, No. 681, USSR ("Effect of Irradiation on Structure and Properties of Fissionable Materials") by S. T. Konobeevsky and co-workers, was presented by G. S. Zhdanov. The paper made the point that uranium had a high amount of plasticity under irradiation, its creep rate being increased by a factor of 1.5 to 2. Plasticity after exposure was much reduced as demonstrated by a decrease in impact strength.

Photomicrographs were presented to show the the "wavy twins" produced in uranium when irradiated, and also the destruction of uranium carbide inclusions in an irradiated uranium sample.

Resistivity data for uranium under pile conditions resulted in no simple law for the changes. From annealing experiments and

1035328

measurements of changes in resistivity, the investigators found the activation energy for recovery increased with increasing temperature and approached values for the self-diffusion activation energy in heavy metals.

Zhdanov cited other results of irradiation effects in uranium and its alloys, in particular, the dimensional changes. He stated that a uranium alloy containing 9 per cent of molybdenum, which has a high cross section for neutron absorption, showed no change in dimensions under extensive irradiation. The USSR found that this uranium molybdenum alloy, if cooled fairly rapidly from high temperatures, retained the high temperature gamma phase at room temperature. If the alloy then was heated at temperatures below 600°C, the structure became heterogeneous, consisting of alpha uranium and the intermetallic compound. The USSR scientists observed that, if the alloy were irradiated in the heterogeneous state to an integrated flux of the order of 10^{19} nvt, it reverted to a homogeneous structure of the gamma phase. This observation was supported by metallagraphic and X-ray diffraction evidence.

Question: US and UK delegations asked further information or clarification of the following items: the details of the polishing, etching, and replication techniques used in the optical and electron microscopy; had the USSR made self-diffusion measurements on uranium and could they state the activation energy for uranium self-diffusion; further details on the experimental technique and the precision of the in-pile creep experiments on uranium. Answer: In reply to each question, Zhdanov repeated a related phrase from the text of his manuscript.

S. F. Pugh (UK) presented paper No. 443, "Damage Occurring in Uranium During Burn-up", discussing the factors governing growth of uranium under irradiation. He outlined two current theories for this mechanism: plastic deformation and diffusion. Pugh believed it was practically impossible to design a critical experiment to choose between the two theories.

He discussed the measures for avoiding or minimizing dimensional instability in uranium under irradiation.

Another phenomenon Pugh discussed was the swelling of uranium—an increase in volume without change in shape—when irradiated at higher temperatures. Inert gases and volatile fission products might be responsible for this behavior, particularly at higher temperatures where uranium's creep resistance was reduced. But to explain quantitatively effect observed at 500°C, irradiation would have to increase the creep rate by a factor of 100, which Pugh considered unlikely.

1035329

Another observation reported by Pugh was the effect of short irradiation (about 10^{17} nvt) on the stress-strain curve of uranium. After a brief irradiation, uranium had a large increase in Young's modulus and jerky flow in tension. This behavior was explained semi-quantitatively by the number of defects induced by irradiation.

Question: Brooks (US) pointed out that Pugh's computation on duration of a thermal spike was probably too brief by a factor of 10. Answer: Pugh felt a factor of 10 was not sufficient to help him since he is concerned with a factor of about 10^6.

Question: Weber (US) made the point that cracks developed in uranium around inclusions during thermal cycling and said this might contribute to the swelling and cracking reported by Pugh. Answer: Pugh had considered this possibility but did not believe it explained the effects.

Next, W. K. Woods (US) gave paper No. 746, "Irradiation Damage to Artificial Graphite". Data on the following were included: changes in strength, elastic modulus, thermal and electrical resistivity and lattice parameters after irradiation up to 15 or 20×10^{20} nvt at 30°C; data for the changes in various properties as a function of the temperature of irradiation; and stored energy measurements obtained by annealing samples which had been irradiated at 30°C.

The paper of G. H. Kinchin (UK), No. 442, ("The Effects of Irradiation on Graphite") offered a model for irradiation-damaged graphite which postulated three types of defects: vacancies, single interstitial atoms, and groups of interstitials. Single interstitials were mobile at relatively low temperatures. Vacancies were effective in the recovery process only at temperatures in the neighborhood of 1100°C. Recovery which occurred at temperatures between 400°C and 1000°C was attributed to the formation and breaking up of groups of interstitial atoms.

The Woods and Kinchin papers were discussed together and most of the allotted time was taken up by Hering (France) with questions such as: were the graphites studied by Woods laboratory or industrial grade; what was the future of graphite as a moderator; was there a valid relationship between thermal and irradiation expansion; what was the influence of graphitizing temperature on the expansion characteristics for low and high exposure, the influence of density on the growth rate, etc.

The last paper (No. 680, "The Effect of Irradiation on the Structure and Properties of Structural Materials"), was presented by Zhdanov (USSR) for Konobeevsky and co-workers. The first portion of the paper contained some results: changes in mechanical and physical

1035330

properties of annealed copper, nickel, iron, and aluminum upon irradiation. One observation was that, microstructurally, the grain size of the copper and nickel samples increased upon irradiation. This was interpreted as a recrystallization phenomenon accompanied, contrary to usual metallurgical behavior, by an increase rather than a decrease in hardness.

Zhdanov also showed photomicrographs to demonstrate that deformation twins and recrystallization had occurred in zirconium due to irradiation.

Extensive data were presented on the mechanical properties of a variety of carbon and alloy steels, taken both before and after irradiation, showing the usual and expected behavior. Investigators found that neutron irradiation did not induce decomposition of austenite in stainless steel.

Question: Finniston (UK) stated he found the USSR results very puzzling and asked for a theoretical explanation or a model to explain the observations. Answer: Zhdanov said USSR scientists were working on theories and people should not be disturbed if experimental results were different from those which others might predict from usual experience.

SECTION 12B - EFFECTS OF RADIATION ON LIQUIDS

by C. J. Hochanadel

In this section, chaired by I. Dostrovsky (Israel), seven papers were presented, five concerned with radiation chemistry of aqueous solutions, two with effects of radiation on liquid organic systems.

The first paper, No. 738, "A Survey of Recent American Research in the Radiation Chemistry of Aqueous Solutions", by A. O. Allen (US) outlined the basic theory of the radiation decomposition of water and aqueous solutions in the light of recent research. Results obtained on irradiating many different solutions could be correlated, assuming a primary decomposition of water into H, OH, H_2, and H_2O_2.

The second paper, No. 739, "The Radiation Induced Reaction of Hydrogen and Oxygen in Water at 25°C to 250°C", by C. J. Hochanadel (US) discussed the kinetics of radiation-induced reactions of hydrogen, oxygen, and hydrogen peroxide in aqueous solution. Mechanisms

1035331

were presented to explain the reaction of hydrogen with oxygen to form peroxide at low temperatures and to form water at high temperatures.

E. Saeland (Norway) presented some yields for oxidation of ferrous sulfate by heavy particles, which had been printed in JENER, Publication 8.

Question: Haissinsky (France) asked Allen about the effect of solutes on free radical and "molecular" yields in water decomposition, and whether Allen thought results on aqueous solutions could be explained satisfactorily in terms of reactions of the solutes with the free radicals produced by water decomposition. These questions had been answered by the paper.

Question: De Bruyn (Netherlands) asked Allen about the pH dependence of the reaction of H atoms with O_2. Hammond (US) asked Hochanadel whether the wall of the silica vessel catalyzed the thermal reaction of H_2 with O_2 in the gas phase. Kondriatiev (USSR) asked Hochanadel why, in the mechanism for the reaction of H_2 with O_2 at high temperatures, the reaction of H_2O_2 with H and with OH were not considered important.

The second group of two papers dealt with the radiation chemistry of organic systems. Paper No. 363, "Chemical Reactions Induced by Ionizing Radiations in Various Organic Substances", by L. Bouby et al. (France) presented by M. Magat, covered two main topics: (1) the measurement of yields of free radicals produced in the radiolysis of various organic liquids by means of DPPH scavenger, and (2) the kinetics of radiation-induced polymerization reactions.

Paper No. 683, "Radiolytic Oxidation of Organic Compounds", by Nathalie Back (USSR), presented by V. H. Kondratiev, discussed the radiolysis of hydrocarbons: alcohols, acids, polymers, aqueous organic solutions, and mixtures of organics.

The last group of papers again dealt with radiolysis of aqueous systems. Paper No. 679, "Radiolysis of Water in the Presence of H_2 and O_2 under the Action of Reactor Irradiations, Fission Fragments, and X-Rays", by P. I. Dolin and B. W. Ershler, presented by G. V. Suvorov (USSR), discussed decomposition of water by pile radiations and by X-rays. Some new and interesting results were reported for hydrogen formation at high oxygen pressures. During the discussion period, Allen (US) suggested that these results could be explained as resulting from a lowering of the "molecular" hydrogen yield by oxygen.

Paper No. 7, "Experience with Heavy Water Systems in the NRX Reactor", by R. F. S. Robertson (Canada) dealt with "loop" experiments conducted in the NRX reactor. The radiolysis results confirmed present theories of water decomposition.

1035332

Question: Roth (France) asked at what minimum temperature mass transfer occurred. Answer: Robertson was also asked whether aluminum was as effective as stainless steel in catalyzing hydrogen and oxygen. Robertson said experiments were at 250°C and the lower limit was not known. He thought reduced steel surfaces were more effective.

Paper No. 445, "Effect of Radiation on Heterogeneous Systems of Air on Nitrogen and Water" by J. Wright et al. (UK) discussed formation of H_3O^+, NO_3^-, and NH_4^+ in radiolysis of water in the presence of air or nitrogen.

SECTION 13B - EFFECTS OF RADIATION IN SOLIDS

by E. Epremian

Chairman V. N. Kondratiev (USSR) opened this extremely well attended section with a discussion of irradiation effects in solids and a brief summary of the mechanisms involved. He stated this subject had not been extensively studied and commented that theory and experiment must coincide more closely than in the past.

F. Seitz (US) gave a lecture on the theory and basis of irradiation effects, including the types and energies of incident radiation, the defects they produced, and the mechanisms involved (paper No. 749, "The Theory of Lattice Displacements Produced During Irradiation"). He demonstrated how the theory and experimental results compared by showing data for changes in electrical resistivity and the annealing kinetics.

Questions: Perriot (France) raised numerous questions: the discrepancy between theory and experiment for electrical resistivity, in particular the difference between deuterons and electrons and the temperature effect; the relative merits of the two foremost theories on electrical resistivity; the possibility of thermal diffusion during irradiation, etc. Owing to the complexity of the questions, the chairman suggested these questions be discussed by the individuals after the session.

Question: Hoffman (Hungary) discussed the idea that all metals were alloys of the pure metal and vacancies. He estimated free energy as a function of the concentration of vacancies and temperature. Upon irradiation, the concentration of vacancies was increased above the equilibrium concentration. In referring to Figure 7 of Seitz's paper he raised a question as to whether flux

1035333

intensity influenced annealing. Answer: Seitz expressed a belief that there was no influence. His work, and that at Oak Ridge National Laboratory with neutron irradiation, gave similar annealing effects over the temperature range.

The second paper No. 750 "Theoretical Aspects of Radiation Damage in Metals" was presented by G. J. Dienes (US) who emphasized research on the transmission scattering of long wave length neutrons in graphite. Dienes and his colleagues have succeeded in obtaining an absolute number for the concentration of defects in graphite, which value compared well with that predicted from Seitz's theory. Dienes also presented data for annealing experiments.

H. M. Finniston (UK) presented J. H. O. Varley's paper (No. 444, "Radiation Damage in Non-Fissile Materials"). He brought out that Makin's work at Harwell disagreed with that of Blewitt at Oak Ridge National Laboratory on the critical shear stress for irradiated single crystals of copper. Makin reported values which were about half those obtained by Blewitt. The British assumed that Blewitt's specimens were imperfect or impure.

Another observation reported was the effect of neutron irradiation on the yield stress of nickel over the temperature range from minus 200°C to plus 300°C. The values for unirradiated material changed very little with temperature, whereas irradiated samples showed a significant increase in yield stress which rose with decreasing temperature. At 300 degrees and above the irradiation effect was lost.

In-pile creep experiments on aluminum had shown no effect, Finniston reported, and alpha irradiation up to 5×10^8 had no effect on the creep of cadmium. The British planned to test cadmium again at lower temperatures. The effect of irradiation to 10^{19} had no effect on the modulus of austenitic steel; similar experiments were now in progress on uranium.

Lomer had made a theoretical calculation on the effect of irradiation on diffusion, Finniston reported. At low temperatures the diffusion coefficient could be affected appreciably but at high temperatures an effect could be seen because of rapid annealing. Experimentally it would be difficult to detect the effect at low temperatures because of the slow diffusion rates involved, but Lomer estimated the effect should be seen without difficulty at 450°K for copper.

Finniston then reviewed the irradiation effects on the lattice parameter of boron nitride which has a structure similar to graphite. He also discussed very briefly Varley's work on alkali halides and his mechanism for ionic crystals.

1035334

Discussion: Lintner (Austria) presented the results of his work with Schmidt which showed that zinc crystals irradiated with alpha particles underwent a slower rate of creep. Kurdiumov (USSR) took the opportunity to discuss a question unanswered by his colleague, Zhdanov, during Section 11-B concerning the decomposition of austenite during irradiation. Kurdiumov presented experimental data which showed that the M_s temperature and the total per cent austenite transformed could be decreased appreciably by neutron irradiation; with another steel, however, the exact opposite could be obtained.

Question: Pugh (UK) stated the method used by Dienes had been considered at Harwell for use on metals but discarded because it was thought that neutron scattering from other sources would be too great. Answer: Dienes saw no reason why the method would not work for a low cross-section material such as aluminum.

Question: Finniston (UK) made the observation that in attacking the problem of distinguishing between vacancies and interstitials it was useful to conduct quenching experiments which give vacancies without interstitials, as well as irradiation experiments.

Question: Perriot (France) inquired whether there were many clusters of defects at the temperatures involved in Dienes' experiments. Answer: Dienes said the concentration of clusters was very low for his experiments.

Kinchin (UK) inquired about the effect of lattice distortion on the cross-section which apparently was not a problem in the experiments.

G. Mayer (France), in paper No. 362, "Modification Produced in Non-Metallic Materials by Radiation and the Thermal Healing of Those Effects", by Mayer et al., devoted most of his presentation to the problem of irradiation effects in graphite. In addition to the usual data on electrical resistivity, the speaker presented results for the effect of irradiation on the velocity of sound transmission.

After annealing at temperatures up to about 220° C the electrical resistivity of graphite fell off rapidly whereas the sound velocity was unaffected; above this temperature the sound velocity decreased rapidly but the electrical resistivity underwent little further change. Some experiments had also been made on the stored energy release upon annealing to compare with the sonic data. As yet no theory had been developed for the sound velocity effect.

Mayer also gave information on irradiation effects in lithium fluoride. He showed that two divergent American investigations were in agreement, each within the appropriate range of irradiation. Heavy

1035335

exposures produced an agglomoration of defects (Keating) whereas low exposures produced isolated defects (Sturm and Binder). From differential thermal analysis it was shown that one calorie per gram is stored per 10^{17} nvt. Mayer also gave some results on the effect of irradiation on the piezoelectric properties of quartz.

The next paper, No. 753, "A Review of Investigations of Radiation Effects in Ionic and Covalent Crystals" by J. H. Crawford, Jr., and M. C. Wittels (US) presented by Crawford. The presentation consisted of two parts: (a) the structural changes produced by fast neutrons as detected by X-ray methods; and (b) optical, magnetic and electrical effects produced by fast and thermal neutrons. Included were: changes in the c/a ratio of quartz as a function of flux and recovery of these changes upon annealing; warping of the lattice of a zircon single crystal; the decrease in density of diamond under irradiation, small angle X-ray scattering, etc.

In the second part of the talk, Crawford reviewed the optical behavior of quartz as well as its paramagnetic resonance absorption and similar research on silica. Question: Magat indicated that the French had conducted a great deal of work on the optical properties of irradiated quartz; five absorption bands were reported and discussed.

The last paper on the program was No. 751, "Interpretation of Radiation Damage to Graphite", by G. R. Hennig and J. C. Hove, (US). Following a review of the displacement process and the defects produced, Hennig described the paramagnetic resonance work whereby displaced atoms which have trapped an electron produce an effect. By this technique the investigators have detected the clustering of defects and their dispersal as well as the dependence of these phenomena on temperature and amount of irradiation. Other properties considered in developing a picture of radiation damage in graphite included X-ray diffraction, thermal conductivity, selective leaching, electrical resistivity, Hall coefficient, etc. Remarkable agreement was shown for the rate of interstitial production between theory and experiments on susceptibility, X-ray diffraction and electrical resistivity.

Question: Kinchin (UK) observed that there was a persistence of paramagnetic resonance at 1000° C and therefore the measurement should be associated with single vacancy defects rather than with clusters. Answer: Hennig pointed out that all effects are annealed out for weak irradiation at a temperature of 400°C. The responsible defects cannot be vacancies because it is observed that these defects are mobile below room temperature where vacancies cannot move.

Discussion: Humberto Fernandez Moran (Venezuela) presented some information on a microtone which has a diamond knife capable of cutting slices of aluminum 200Å thick for electron diffraction and microscopy.

1035336

Kurdiumov (USSR) commented that irradiation and plastic deformation had many similar effects, e.g. changes in hardness, solubility, etc. It was important to carry out both types of experiments for a clear understanding of the processes. Kurdiumov raised and discussed the question as to whether irradiation could affect the binding forces in metals. He suggested that experiments be conducted on the thermal diffuse X-ray scattering of metals after irradiation. He has already conducted and published (in Russian) similar work for plastically deformed metals. He found that plastic deformation did not change the X-ray Debye Θ of pure iron, but in the case of an iron alloy containing chromium or tungsten there was a marked effect.

In closing the section, Chairman Kondratiev said the lively discussion was not as extensive as might be desired due to lack of time, and proposed that after adjournment an informal discussion take place. All USSR delegates remained as did most of the US scientists.

SECTION 14.B - TREATMENT OF URANIUM AND THORIUM ORES AND ORE CONCENTRATES

by George Marvin

The Chairman, Bertrand Goldschmidt (France), opened the meeting with a comment that free exchange of information on treating ores, previously under severe security restriction, was overdue as evidenced by the many common denominators in the work reported by the various delegations. He welcomed a statement made by the US delegation that, in keeping with the spirit of this United Nations Conference, they were prepared to discuss freely US practice, research, and development, of methods for the extraction of uranium from its ores.

The keynote paper was No. 519, "Recovery of Uranium from Its Ores", covering US methods of handling and processing primary and secondary ores presented by G. G. Marvin (US). Marvin summarized all US experience in the beneficiation of uranium ores, pointing out unique contributions to milling practice — particularly the addition of ion exchange and solvent extraction techniques to conventional hydrometallurgical processes. Brief mention was made of current developments ranging from research to pilot plant operations.

Panel papers then were summarized briefly by their authors, or alternates, as follows:

1035337

No. 2	(Canada)	"Canadian Practice in Ore Dressing and Extractive Metallurgy of Uranium", A. Thunaes
No. 399	(France)	"Method for Chemical Processing of Low-Grade Uranium Ores", P. Mouret and P. Pagny, presented by Mouret
No. 521	(US)	"Some Unusual Problems Met in the Recovery of Uranium from a Very Low-Grade Ore", M. D. Hassialis and R. Musa; presented by Hassialis
No. 524	(US)	"Recovery of Uranium from Phosphates by Solvent Extraction", R. S. Long et al; presented by Marvin
No. 784	(Sweden)	"Recovery of Uranium from Uranium Bearing Alum Shale", E. Svenke
No. 871	(India)	"An Ion Exchange Process for the Recovery of Uranium from Carbonate Leach Solutions", J. Shankar et al; presented by Shankar
No. 977	(Portugal)	"Some Aspects of the Chemical Treatment of Portuguese Uranium Ores", F. Videira et al; presented by Videira
No. 986	(Australia)	"Acid Pressure Leaching of Uranium Ores", P. M. J. Gray; presented by R. G. Thomas
No. 997	(South Africa)	"The South African Uranium Industry", C. S. McLean and T. K. Prentice

After the panel papers, the Chairman opened the meeting for discussion.

Question: Modia (India) asked Marvin whether classical beneficiation techniques would play a secondary role in the dressing of uranium and thorium ores. The Chairman referred Modia to Marvin's paper and quoted the following excerpt: "In summary, only a few ores being processed for uranium have been found amenable to physical beneficiation techniques. However, we have no reason to believe that physical beneficiation is not an economic possibility and we are continuing our efforts to develop commercially attractive techniques."

Question: Videiro (Portugal) asked the amount of uranium contained in a precipitate obtained by direct magnesia precipitation. Answer: Thunaes (Canada) replied this varied considerably with the type of ore, ranging from as high as 10 to 15% for a rich ore to as low as 2 to 3% for a lean ore.

1035338

Question: The Chairman asked the ratio of thorium to uranium in the Bancroft ores containing uranous chloride. Answer: Thunaes said the question was difficult to answer because the ores contain uraninite as well. The Chairman commented the French were treating a Madagascar urano-thorite ore containing seven parts thorium to one of uranium.

Question: Lecoq (France) asked whether quantity concentration of Port Radium ore had been discontinued and why. Answer: Thunaes replied that gravity concentration of this ore were still maintained on a small scale, the ore being treated by jets followed by jigging. The jig concentrate went to an acid leaching plant where it was joined by tailings from previous operations. He said that in the early days flotation had been tried unsuccessfully on this ore.

Question: Mabile (France) asked about the general application of the La Pointe belt picker in Canada. Answer: Thunaes said it was not being used on a commercial scale but in some pilot plant work it was used to upgrade jig concentration. The assay of rejects increased inversely to particle size. Either scintillometers or geiger counters could be used.

Asked to compare this process economically with classical processes, Thunaes pointed out the La Pointe separator had not been used on a commercial scale but said the electronic belt picker could only reject some 30% of the ore mined whereas a heavy density separator could give a higher concentration.

Question: Videira (Portugal) asked whether precipitation of uranous phosphate was applicable to ores as rich as 4 to 5%. Answer: The Chairman pointed out that, since it had been used on ores as lean as 0.1%, it certainly would be applicable to richer ores. The Chairman undertook another answer to the question by saying that aluminum entrained with uranous phosphates. Mouret (France) asserted that no aluminum was entrained.

Question: Mouret (France) asked a detailed question concerning the operational variable of the resin-in-pulp process. Answer: Marvin said a detailed answer was contained in paper No. 526, a US paper not presented orally, but to be included in the printed record. Marvin, answering another question on whether any process had been applied to pyrochlor minerals, responded that an African ore of very low grade had been investigated on a small scale but that work had been discontinued because of lack of apparent feasibility. He commented that the British at Teddington had done considerably more work.

The Chairman stated that two delegates had requested permission to make comments, and called first upon F. Forward (Canada) who pointed out that precipitation of uranium by hydrogen had been successfully

1035339

carried out on a small pilot plant scale (1000 lbs. per 24 hours) at 120°C and 10 atmospheres pressure, using a nickel catalyst. The solution was completely stripped of uranium. Forward said papers by Thomas (Australia) and Grey (South Africa) could be misinterpreted as implying that a very high oxygen pressure (500 psi) was required to oxidize sulfide minerals in ores in a pressure leach method. These results could be obtained at a temperature of 140°C to 150°C using one atmosphere of oxygen or 10 atmospheres of air. He noted that the agitation in the rocking autoclave was the probable source of misinterpretation.

The Chairman then called on Bozo Tezak (Yugoslavia) who noted that there were other factors involved in the effectiveness of the chemical precipitation of uranium from alkaline leach liquors. Concentration of the precipitating reagent, as well as of neutral salts, was important.

SECTION 15B - PRODUCTION OF METALLIC URANIUM AND THORIUM: ANALYTICAL METHODS IN RAW MATERIAL PRODUCTION

by R. Carson Dalzell and C. J. Rodden

This section, chaired by H. Brynielsson (Sweden), was divided into two parts, the first dealing with production, the second with analyses.

P. Danckwertz (UK), in paper No. 407, ("Production of Uranium Metals" by L. Grainger), gave a complete description of UK uranium metal production process, and pointed out that UK essentially skipped the pilot plant stage to get into production. The process was practically the same as used in the US. Although the quality of the metal has been entirely satisfactory, a new plant would show many changes, including probably the use of magnesium instead of calcium as a reductant.

Wilhelm (US) drew attention to his paper No. 817, which explains a method using magnesium.

Questions: Maly (Czechoslovakia) asked several detailed questions which were answered fully. Danckwerts told Kay (UK) about the advantages hoped for in the fluidized bed technique for the steps in converting from uranyl nitrate to uranium tetrafluoride, but pointed out that many technical problems remained to be solved.

1035340

Paper No. 341 ("Preparation of Pure Uranium Metal") by B. Goldschmidt (France) described the French process and remarked they had the advantage of a late start (1950), and were able to devote more time to process development, which uses TBP solvent extraction.

Paper No. 636 ("Metallurgy of Thorium", by G. E. Kaplan) and paper No. 635 ("Powder Metallurgy of Thorium", by G. A. Meierson), presented by Meierson (USSR), discussed the metallurgy and the powder metallurgy of thorium. Meierson referred to both electrolytic and calcium reduction methods to provide powder.

Question: Wilhelm (US) asked what was the oxygen content of the finished thorium product, and was told the thorium content was 99.8% and that the balance probably was oxygen in the form of oxide.

Foote (US) asked about melted thorium and was told that USSR was not interested in large bodies, so powder metallurgy products were all they had. Laboratory melts indicated no quality gain.

In the second part of the section, the methods of analysis used at all stages of processing were discussed by C. J. Rodden (US) in paper No. 952, "Analysis of Uranium and Thorium Raw Materials". This paper was followed by No. 627, "Physico-Chemical Methods of Uranium Production Control", by A. P. Vinogradov (USSR), who stressed analysis of the final product. He described spectographic methods which could detect impurities of small amounts, and do it directly. Another method, apparently not suggested before, added isotopes of uranium to the material for internal standards, or used radioactive tracers. USSR polarographic equipment of the oscilloscope type was in production for use in geochemical work.

Paper No. 942 was read by A. Soltan (Poland) "On the Method of Measuring Concentrations of Uranium and Thorium in Ores and in Photographic Emulsions", Paper No. 964 "Polarographic Determination of Uranium in Ores Without Preliminary Chemical Separation" was read by M. W. Susic (Yugoslavia), followed by a USSR paper, No. 630, by G. R. Golbek et al., "The Physical Method of Determining Uranium, Radium and Thorium in Radioactive Ores", and paper No. 1008 by I. G. de Fraenz and W. Seelmann-Eggebert (Argentina) on the determination of U-235. USSR paper No. 630 described methods that could be of value in analyzing radioactive ores.

1035341

SECTION 16B - PRODUCTION TECHNOLOGY OF SPECIAL MATERIALS: HEAVY WATER AND GRAPHITE

by R. Carson Dalzell

F. Giordani (Italy) presided as chairman.

Paper No. 819, "Survey of Heavy Water Production Processes", by M. Benedict (US) described and analyzed eight processes for producing heavy water, and identified the process used by the United States (a three-step process: dual temperature H_2S-water exchange process, followed by fractional distillation and electrolytic separation). Benedict advocated this method for a dependable low-cost output of quantities greater than 20 to 40 tons a years. He speculated that, if a suitable catalyst were developed, the dual temperature steam-hydrogen exchange process might become the best way of making cheap and abundant heavy water.

Ritchie (New Zealand) reported that a plant for 400,000 kw electricity with by-product heavy water, using geothermal heat, was being designed for New Zealand.

Question: Roth (France) sought Benedict's opinion on a choice of two possible processes for a heavy water plant built in conjunction with an ammonia plant. Answer: Benedict expressed a general opinion that both processes would be quite costly but cautioned that detailed study was necessary.

Question: Ronitsch (Switzerland) asked the ratio of capital to operating costs in the $28 per pound selling price announced by the US. Answer: Benedict replied that he could say only that conventional US government accounting procedures were used, and that the price represented neither a loss nor a profit.

Question: Liljeblad (Sweden) asked about how far enrichment should be carried by the H_2S method before changing to another process. Answer: Benedict said that, in general, the larger the H_2S plant the higher the concentration should be carried. Answering another question about the life of the plant, Benedict replied that a 5% capital charge covered interest, amortization, etc., a rate typical of long-life government-financed plants.

In Paper No. 774, "Design of Isotope Separation Plants: Some Basic Design Equations for the Distillation Process", I. Dostrovsky (Israel) developed equations, tables, and curves on a theoretical basis to provide design engineers with tools to appraise various processes.

1035342

Paper No. 958 was "Efficiency of Some Catalysts in the Exchange Reaction Between Heavy Water and Hydrogen", by P. Savic et al, presented by Slobodan Ribnikar (Yugoslavia).

Question: Roth (France) asked about the amount of water absorbed on the catalyzers and whether or not this affected their activity. Answer: Ribnikar replied this effect had not been measured, but that after many uses, the activity did not change more than 30%.

Paper No. 927, "Final Concentration of Heavy Water by Rectification" by P. Baertschi and W. Kuhn, presented by Baertschi (Switzerland) described a rectifying process for which high efficiency was claimed. He declared that the secret of obtaining high-efficiency, high-capacity, large diameter, packed fractionating towers was to use multiple small tubes with individual reflux instead of one large tube.

Question: Benedict (US) inquired and was given data on equipment size in the pilot plant.

Paper No. 410, "Infra-Red Methods for the Analysis of Heavy Water", by J. Gaunt (UK) described the infra-red spectrometers developed for determining the D content of heavy water. Gaunt said they had been used for 2 years at Harwell as standard technique, and proved both rapid and reliable, but needed additional work to extend monitoring to the lower ranges.

Question: Rodden (US) asked about cell windows. Answer: Gaunt said that fused silica was best for high concentrations, and that glass could be used for the 50% range, but calcium chloride was best for other ranges.

Paper No. 631, on "Methods of Isotopic Analysis of Heavy Water" was read by K. V. Vladimirsky (USSR).

Questions: Roth (France) asked about the ion source, and Vladimirsky replied in full. Rodden (US) asked about memory effect in the mass spectrometer and Vladimirsky said the memory effect was the reason this method was so time-consuming. Vladimirsky also said that density was the most precise method but slow. He felt the Gaunt method was excellent.

Paper No. 534 was "The Production and Properties of Graphite for Reactors" by L. M. Currie (US).

Question: Wirtz (Germany) asked how cross sections were measured. Answer: Hennig (US) described in-pile measurements of C12 and C13 content, and pile oscillator check. Wirtz remarked that he had pressed blocks from natural graphite with a cross section of 4.6 millibarns and a density of 2.1.

1035343

Question: Hering (France) asked a number of detailed questions, and was particularly interested in high density material made with furnace black.

In presenting paper No. 343, "Production of Nuclear Graphite in France" by P. Legendre et al. Jules Gueron (France) remarked that much of his paper duplicated Currie's. The French were producing low cross section graphite of better than 1.60 density.

Question: Howe (US) asked what halogens were used for purification and what temperatures, etc. Answer: Gueron pleaded "industrial secrecy" and did not answer. In response to Wood's question, Gueron said that radiation damage studies had not been made in graphites of various densities.

In paper No. 943, "Some Experiments Concerning Pile Materials", Bronislaw Buras (Poland) touched on reduction of boron content by graphitizing at very high temperatures. He said they had also found sublimed napthalene a good raw material for low boron graphite. Buras told Currie, in response to a question, that they have made rods about 10 cm. diameter.

SECTION 17B - PRODUCTION TECHNOLOGY OF SPECIAL MATERIALS: ZIRCONIUM AND BERYLLIUM

by R. Carson Dalzell

The Section Chairman was C. Eichner (France).

Paper No. 533, "Zirconium Metal Production", by S. M. Shelton (US) described publicly for the first time the US process for making hafnium-free zirconium.

Question: Smales (UK) asked about nitrogen determination and was told the Kjeldahl method was reliable.

Eichner (France) asked if the complete process was used by Carbide and Carbon Chemical Corp., to which Shelton replied that Carborundum Metals Co. was now apparently supplying US needs, and that he thought they had metal for sale commercially.

Eichner asked about alloying zirconium for improved corrosion resistance and was told that, in general, certain alloys were superior, but that the field had not been thoroughly explored.

1035344

Paper No. 347, "Separation of Zirconium from Hafnium" by J. Hure and R. Saint-James, presented by Hure (France) described the French hafnium separation process, in which tributyl phosphate was used with petroleum ether of 0.74 density and a boiling point of 140° to 190°C.

Paper No. 876, "Separation of Hafnium from Zirconium by Vapour Phase De-chlorination" by B. Prakash and C. V. Sundaram, presented by Prakash (India) said the process products were (1) a volatile chloride high in hafnium, and (2) a zirconium oxide relatively low in hafnium. Under optimum conditions in a laboratory set-up, one treatment lowered the hafnium content about 50%.

Question: Meierson (USSR) remarked that the process described in paper No. 644 (USSR) was a crystallization method which in about 18 steps reduced hafnium from 2.5% to less than 0.01%; the yield was given as 80%.

Shelton (US) expressed interest in the Indian process. Kaufmann (US) asked if this process would reduce hafnium to 0.01%. Reply was that India regularly got no better than 0.3% and that probably they needed to work toward avoiding segregation of gases. Benedict was told the thermodynamic data had not been confirmed experimentally, but were theoretical.

After Paper No. 633, "Techniques for Manufacturing Items of Pure Beryllium and Beryllium Oxide for Use in Nuclear Reactors", was presented by G. A. Meierson (USSR), Kaufmann (US) requested more details on methods used for decomposing the beryllium acetate, which Meierson described fully.

Question: Bagnall (UK) asked about barium content of the beryllium, and the beryllium content of the barium fluoride flux. Meierson said that the flux was originally used to improve the yield; later work made this unnecessary, so they had no data.

Alder (Australia) asked what process was used to get 5 to 10% ductility and also if a process was known for producing ductile tube.

Kaufmann asked about alloys to improve corrosion resistance. The answer gave only generalities.

Paper No. 820, "Status of Beryllium Technology in the USA", by A. R. Kaufmann (US) covered the production of beryllium metal and fabrication into shapes, and also of beryllium oxide refractories. Kaufmann also discussed directional ductility in beryllium and how it could be controlled.

1035345

Question: Darwin (UK) asked about the pickling operation, the effect of iron on beryllium corrosion resistance, and welding.

Answer: Kaufmann replied that pickling was not critical, but that adding a little sulphuric acid to the 50% nitric acid accelerated the removal of the iron can. He said there was no hydrogen pickup; a little iron seemed to improve corrosion resistance to water but not to air; welding extruded cast metal was unsuccessful, but he thought it might work with powder-metallurgy metal.

Hilton (UK) asked about changes in thermal conductivity under irradiation. Kaufmann said that, at low temperatures, about 50% reduction occurred.

Finniston (UK) asked if anyone had plans for using beryllium as a canning material in a reactor. Kaufmann replied that he thought the technology probably was not sufficiently advanced. Paper No. 345, "Sintering of Beryllium Oxide" by R. Caillat and R. Pointud, presented by Caillat (France) described studies made on aluminum oxide which were believed hopeful as a theoretical guide to BeO sintering.

Paper No. 1015, "Purification of Beryllium Oxide" by A. E. Cairo and M. B. Crespi, presented by Cairo (Argentina) discussed a process of preferential solution of the basic acetate in chloroform.

Kaufmann (US) asked if Cairo considered this process commercially competitive. Cairo replied that, not being an engineer, he did not know, but thought this had not been calculated.

SECTION 18B - METALLURGY OF THORIUM, URANIUM AND THEIR ALLOYS, AND FABRICATION OF FUEL ELEMENTS

by E. Epremian and R. Carson Dalzell

H. M. Finniston (UK), the Chairman, in opening the section, emphasized the importance of the metallurgy of uranium and thorium (the first part of the section), and the fabrication of fuel elements (the second part).

The first paper by F. G. Foote (US) No. 555, "Physical Metallurgy of Uranium", as written was a comprehensive treatment, but Foote confined his oral presentation to the following topics: deformation mechanisms (slip and twinning in alpha uranium); preferred orientation (pole figures for uranium fabricated by rolling, extruding,

1035346

and swaging); and the peculiar thermal expansion characteristics and the thermal cycling effects, as well as the factors governing these phenomena.

A. Kiessling (Sweden) in paper No. 786, "The Solid State Reaction Between Uranium and Aluminum", reported the development of porosity on the aluminum side of the samples and noted the compounds which formed at various temperatures up to 600°C. These compounds included $U\ Al_2$, $U\ Al_3$, and $U\ Al_4$ which formed in varying amounts depending upon the temperature.

Discussion: Gurinsky (US) described means of inhibiting the interaction of uranium and aluminum as a practical problem in developing fuel elements, and sketched the anodizing method used for the Brookhaven National Laboratory reactor.

Questions: Carlsen (Norway) brought out a statement by Gurinsky that the oxide layer on aluminum produced by anodizing set up a 15°C differential in the heat flow characteristics of the fuel element. Gurinsky used a sulfuric acid solution; Kiessling favored chromic acid. Perriot (France) inquired whether there were other means of inhibiting diffusion between uranium and aluminum. The Chairman stated that other means were possible but that the reactor physicist might not be willing to accept the effect on the fuel element.

In reply to Finniston, Kiessling stated he had not established why the interface nuclei formed where they did. Lavigne (Canada) brought out that Kiessling electropolished the surface of the metal samples with phosphoric acid, which could produce a fine oxide and explain the high temperatures which proved necessary.

Replying to Lavigne, Foote stated that thermal cycling experiments were not a satisfactory basis for predicting behavior under irradiation. Aass (Norway) inquired why powder metallurgy fuel elements had not been used in a reactor to which Foote replied that this depended on further research and development as well as promotion.

The next paper, No. 556, a survey on "The Metallurgy of Thorium and Its Alloys" by O. N. Carlson et al, was presented by H. A. Wilhelm (US). He described the zinc process of extracting thorium and techniques for subsequent melting and casting. Wilhelm briefly outlined mechanical and physical properties, recrystallization behavior, and fabricability, as well as the role of impurities. Finally, he discussed the alloying characteristics of thorium according to several typical diagrams.

1035347

J. P. Howe (US) gave a review paper (No. 825, "The Metallurgy of Reactor Fuels") covering (1) fuel elements and systems, their uses and limitations, (2) materials and processes used to prepare them, and (3) physical and chemical phenomena important in their preparation and use.

Questions: Darwin (UK) asked about the effect of allowing central temperature in a solid uranium rod to go above the transformation temperature. Howe replied that cracking occurred, and that after sufficient reversals a central void was apt to develop.

Finniston (UK) asked what burn-up might be reported or expected. Howe said that MTR elements show relatively small changes at about 1% burn-up; that the fission product gases seemed to occupy no more than "solid volume", and that only at high temperatures did segregation into gas bubbles occur. The implication of this where matrix type elements was concerned, Howe speculated, was that they could be used to perhaps 75% of their melting point (absolute temperature).

C. E. Weber (US), in paper No. 561 by himself and H. H. Hirsch, described the manufacture and properties of "Dispersion-Type Fuel Elements"—those in which fuel particles were dispersed in a non-fissile diluent, rather than alloyed. He discussed theoretical aspects, and illustrated fabrication with discussion of an iron-clad iron/UO_2 element. He also described the fuel element of aluminum-clad Al/UO_2 of the US exhibit research reactor in Geneva.

Questions: Walton (UK) asked for information on fission products carrying other atoms into the matrix. Weber replied there was no experimental evidence but that he thought the effect was inconsequential from a practical viewpoint.

Weber told Carlsen (Norway) that uranium-magnesium dispersions had been mentioned only as an example of two insoluble compounds, that a little general laboratory work had been done but he knew of no fuel element development.

J. E. Cunningham (US) in paper No. 953, by E. J. Boyle and Cunningham, "MTR-Type Fuel Elements" described fabrication of the MTR-type fuel element, both alloy and powder metallurgy types, including UO_2 fuel.

Question: Replying to a question, Cunningham explained the theory of the flux-annealing treatment to prevent bubbles, and said that 80% of the plates would be lost unless some such precaution were taken.

1035348

F. Boeschoten (Netherlands) gave a paper No. 947, "On the Possibility to Improve the Heat Transfer of Uranium and Aluminum Surfaces in Contact", describing studies of various bonds such as gas and liquid metals. It was a preliminary study and several US delegates made suggestions for more advanced work.

SECTION 19B - LIQUID METAL TECHNOLOGY

by R. Carson Dalzell

The Chairman was L. Rotherham (UK).

Paper No. 123, "Sodium and Sodium Potassium Alloy for Reactor Cooling and Steam Generation" by T. Trocki et al (US) described many investigations of liquid metals for cooling reactors. Trocki listed factors affecting design of power plants (EBR and SGR), and emphasized their feasibility.

Questions about the percentage by-pass to cold traps for purification, the effect of cavitation, and of entrainment of gases were answered.

Paper No. 866, "Liquid Metal Handling" as presented by S. G. Bauer (UK) included a set of efficiency curves not in the original paper. The paper complemented Trocki's work, being more detailed on liquid metal handling.

Questions: U.S. delegates asked questions dealing with materials, construction, corrosion experience, the use of NH_3 for cleaning, and clean-up of area after a bad leak, all of which were answered.

Kronberger (UK) remarked that the large size of the Risley plant precluded use of NH_3 for cleaning, but low pressure steam worked well in vaccuum systems; otherwise buffered steam was used. They considered handling liquid metals a minor problem in plant design.

Trocki asked about hot spots, and was told it was necessary to admit steam slowly and to monitor the reaction with charcoal Pirami gauges.

Paper No. 639, "Heat Transfer of Molten Metals" by M. A. Mikheyev et al, presented by K. D. Voskresensky (USSR) gave a long theoretical discussion of heat transfer of molten metals, covering much material not in the paper. In 1939 the USSR experimenters

1035349

discovered that molten metals did not follow the generally recognized heat exchange laws and the prevailing concepts about heat transfer of "usual" turbulent liquids of low heat conductivity.

Questions: Hull (UK) asked several questions about experiment details and then asked if he could get original data. He was given detailed answers and told he could get the data from the author.

Lyon (US) complimented the quality of the work and expressed his hope that it would be continued.

Paper No. 119, "Corrosion by Liquid Metals" by L. F. Epstein (US) presented a survey of U. S. work and included descriptions of experimental techniques.

Questions: Several questions were asked, including one about the relation of sodium attack on graphite to Siegel's upcoming paper on a sodium-graphite reactor. The answer was that Siegel planned to clad the graphite.

Gurinsky added a comment that the build-up of zirconium nitride on steel surfaces apparently accounted for the beneficial effect of adding zirconium to molten bismuth. He suggested that titanium nitride might likewise account for the value of adding titanium to mercury.

The oral presentation of paper No. 787 ("Observations on the Corrosion of Uranium in Liquid Sodium" by H. Mogard) by A. Kiessling (Sweden) gave much more detail than the original paper.

Paper No. 829, "Basic Technology of Sodium Graphite Reactor" by S. Siegel et al. (US) gave a good discussion of the materials problems of the SGR, which are essentially the interaction of sodium, graphite, zirconium, and stainless steel.

Questions: Hall (UK) asked about temperature variation, mechanical restraint to prevent uranium growth, and evaporated coatings. Siegel replied in detail.

LaVigne (Canada) asked about the uranium content of the thorium-uranium alloy referred to, and was told "3½ to 4%". In response to another question Siegel described the effect on surface of cycling uranium through the alpha-beta range.

1035350

SECTION 20B - CHEMICAL ASPECTS OF NUCLEAR REACTORS

by L. E. Glendenin

The Chairman, P. Savic (Yugoslavia) made no introductory remarks.

The first paper (No. 900, "Chemical Problems of Power Reactors" R. Hurst and J. Wright, UK), surveyed deleterious reactions of carbon, air, and water under radiation. Hurst said that corrosion of steel and other materials had to be considered as well as removal of corrosion products and fission products. He pointed out that the problems, and the establishment of correct design, became increasingly complex and difficult in going from low-temperature, air- or water-cooled piles, to high temperature and homogeneous reactors.

C. H. Secoy (US) presented the next paper (No. 821, "Survey of Homogeneous Reactor Chemical Problems"), which surveyed the chemical factors involved in selecting a fuel-bearing solute in an aqueous homogeneous reactor, and of the chemical phenomena encountered in operating such a reactor, in particular for a fuel system of uranium salts in true solution in either H_2O (light water) or D_2O (heavy water). The requirements were that the uranium retain homogeneity and that the salts not decompose or hydrolyze under reactor conditions. Of various salts studied uranyl sulfate was the most attractive. The release of hydrogen and oxygen from radiation decomposition of water was another problem, but recombination by a catalyst bed had proved feasible. The paper provided data on phase diagrams for uranium salt and water systems.

The third paper (No. 348, "Behavior of Heavy Water in Piles of the C.E.A.") was given by J. Chenouard et al., (France) on the Chatillon reactor (P 1) and the Saclay reactor (P 2). The chief problems with the heavy water system were decomposition into hydrogen and oxygen, and contamination of the water by corrosion products and induced radioactivity. Centrifugation had been used to remove insoluble contamination, and plans were being made to use ion exchange.

<u>Questions</u>: Wright (UK) asked Secoy (US) whether the nitrogen evolution from radiolytic decomposition of uranyl nitrate was reversible. The answer was the decomposition was small, and no steady state was reached.

Swartout (US) asked Hurst whether he had any data on the solubility of fission products or corrosion products in water or uranyl sulfate solutions at high temperature. Hurst said the solubilities of rare earth sulfates were being studied using autoclaves. Swartout asked Chenouard to comment on the chloride content of the platinum-alumina catalyst (used in recombination of hydrogen and oxygen). Chenouard said a palladium catalyst was used and purified from chloride before use.

1035351

The chair was turned over to the Vice-Chairman, J. Shankar (India) for the remainder of the session.

The first paper (No. 535, "Aqueous Corrosion of Aluminum Alloys at Elevated Temperatures") by J. E. Draley and W. E. Ruther (US), reported very severe corrosion and blistering (apparently due to hydrogen production) occurred with aluminum in water at temperatures above 200 degrees centigrade. The method for controlling the aqueous corrosion was to use a reducible metal such as nickel either as a salt in low concentration in the water or alloyed with the aluminum. Another successful method consisted of plating the aluminum surface with nickel.

K. Carlsen (Norway) presented paper (No. 880, "Corrosion of Aluminum and Aluminum Alloys in Aqueous Solutions at High Temperatures") which described severe corrosion of various aluminum alloys at 230°C. Several preventive methods tried showed little promise.

The last paper (No. 537, Aqueous Corrosion of Zirconium and Its Alloys at Elevated Temperatures,") given by D. E. Thomas (US) reported the corrosion rate initially was low for a protracted period, but was followed by a period of rapid corrosion. The situation was greatly improved by suitable alloying. Tin was shown to be an important alloying element; also iron, nickel, and chromium in conjunction with tin.

Arnet (Switzerland) commented on aluminum corrosion tests at 200°C. The addition of 0.5% silicon, iron, or copper to the aluminum was found to be helpful.

Questions: Draley (US) asked Carlsen if he had attempted to determine whether the barrier layer film formed on aluminum in the silicate-chromate inhibiting solution was different from that formed in the absence of inhibitors, and would this inhibition be permanent. Carlsen replied that more experiments would be necessary to answer this problem.

Levine (Canada) remarked that the metallurgical condition and heat treatment of material was important in corrosion. He mentioned the difficulty of reproducing the metallurgical condition of aluminum and said that he found corrosion to be highly dependent on the nature of the previous cold working and annealing; he felt that speakers had overlooked this point. Draley stated that the metallurgical condition of importance in corrosion inhibition was a well distributed fine precipitate of the alloying element. Carlsen commented that different heat treatments were used and no great differences observed.

1035352

The final paper (No. 811, "Aqueous Uranium and Thorium Slurries") by A. S. Kitzes and R. N. Lyon (US), presented by Lyon, described various slurries for homogeneous reactors and discussed problems of corrosion, caking and flow viscosity. Successful operating conditions were found.

Questions: Dawson (UK) remarked that the rod form of UO_3 particles was unstable and went over to the platelet form above 200 degrees centigrade. How would this affect pumping and flow? He also asked about continuous removal of fission product poisons. Answer: Lyon said that no difficulty was observed because of change of form. On fission product removal, he replied that if the slurry particle size was small, fission products should go into the water and be removable, but he had no information on this point.

In a discussion regarding choice of slurry compounds and gaseous environment in homogeneous reactors, de Bruyn (Netherlands) preferred a UO_2 slurry and a hydrogen atmosphere while Lyon and Secoy (both US) expressed preference for UO_3 in an oxygen environment.

SECTION 21B - CHEMICAL PROCESSING OF IRRADIATED FUEL ELEMENTS

by F. L. Culler

R. Spence (UK), chairman, stressed the importance of chemical reprocessing saying cheap reprocessing was vitally necessary; that solvent extraction was highly developed and might possibly be the reprocessing technique used until metallurgical fabrication developed in the remote future.

The first paper (No. 414, "Criteria for the Selection of Separation Processes") given by C. M. Nicholls (UK) outlined requirements for a chemical reprocessing plant.

A review paper, No. 882, "Reprocessing of Reactor Fuel and Blanket Materials by Solvent Extraction" by F. L. Culler (US) was combined with paper No. 540, "The Solvent Extraction Separation of U 233 and Thorium from Fission Products by Means of Tributyl Phosphate" by A. T. Gresky, on the Thorax process. Culler stressed use of the solvents tributyl phosphate (TBP), and hexane, and presented a general discussion of the mechanism of extraction and separation peculiar to these solvents, along with schematic flowsheets of the Purex, Redox, and Thorex processes.

Paper No. 349, "Solvent Extraction of Plutonium from Uranium Irradiated in Atomic Piles" by B. Goldschmidt (France) presented, in almost complete detail, a chemical flowsheet of the

1035353

Purex process. For Pu isolation, the French propose use of anion exchange resin, taking advantage of a $Pu(NO_3)_6^{-2}$ anion formed in nitric solution.

The French are building a Purex plant at Barcoul, with a capacity for producing 15 kg of Pu initially and, possibly within two years, 100 kg per year. The plant should be completed by the last of 1956 or early 1957.

Paper No. 785, "Extraction of Uranium and Plutonium with Tetrabutylammonium Nitrate, Cupferron and Neocupferron as Complexing Agents," by F. Haeffner et al. (Sweden) presented an analytical method for Pu determination, using reagents listed in the paper.

Paper No. 824, "Practical Limitations of Solvent Extraction Processes" by R. F. Tomlinson (US) was a very good general discussion of the limits of solvent extraction processes, among which it listed solids and emulsion difficulties; and the problem of the anomalous behavior of fission products such as ruthenium in the Redox process.

Question: McKay (UK) said the British thought that the TBP complex with thorium coordinated with 2 molecules of TBP rather than with 4 as reported in US paper, and added that, in TBP system, extraction of uranium and plutonium into the organic phase was competitive, whereas in the hexane systems such as Redox, the transfer of U and Pu into the organic phase was rather mutually beneficial. Answer: Culler said the use of 4 TBP molecules in the organic soluble complex of thorium had been determined experimentally and had been used successfully as a basis for an operating process for the separation of Th and U 233. However, there was reason to doubt the 4-complex as being absolutely valid from other data and the British work done in dilute concentrations could be correct.

Question: Fletcher, (UK) asked what cost was assigned to separations in determination of power costs? Answer: Culler said costs were difficult to state without reference to capacity, location, type of element and other factors. For homogeneous reactor system, such as that described by Ferguson, the costs could be estimated to be between 2 and 3 mills per kwh, which included amortization, inventory charges, heavy water losses, and normal operating expense. For natural U and Pu separation, with metal fuel elements as feed, the costs probably were not much less than $2 to $3 per pound of uranium, assuming that Pu cost was included in this. No good numbers could be given without estimating each particular case.

Question: Benedict (US) asked how was Pu valance stabilized to the IV state in the TBP Purex process? Answer: Culler said stabilization was achieved by addition of nitrous acid or $NaNO_2$ to the feed solution followed by a heating period to allow the reaction to proceed. Reactions:

1035354

$Pu\ (III) + HNO_2 + H$ $\qquad$ $PU\ (IV) + NO + H_2O$

$Pu\ (VI) + HNO_2 + H_2O$ $\qquad$ $PU\ (IV) + NO_3^- + 3H +$

Question: What was the reductant used to reduce Pu (IV) to Pu (III) in the hexone and TBP processes? Answer: Several reductants could be used: hydroxylamine, hydrazine, hydroquinone, ferrous ion and sulfamic acid.

Question: Fletcher (UK) asked how could solvent extraction procedures be modified to accommodate high temperature fuel elements such as those described for the PWR? Answer: Culler said this could be done by modifying dissolution and feed preparation procedures. For stainless steel, dissolution was possible in H_2SO_4. For zirconium, it was possible to use HF. After dissolution, sufficient nitrate salts such as $Al(NO_3)_3$ or HNO_3 could be added to make it possible to use the same solvent processes. These processes might be expensive.

Question: Regnaut (France) asked what was the material used for corrosion resistance in thorium dissolution with HNO_3 - HF mixtures? Answer: Culler answered type 309 SCb stainless steel. The fluoride ion was complexed by Th and Al. Most serious corrosion occurred during the boil-down step following dissolution. Question: In using TBP had a two-phase formation been experienced in the organic phase? Answer: The answer was negative. The hydrocarbon diluent was pretreated by contacting with oleum to remove unsaturates. There had been no third phase difficulty in the Thorex process. Question: What diluent was used for TBP in the Thorex process? Answer: Oleum pretreated Amisco 125-90W.

Question: Tomlinson (US) asked Goldschmidt if he could provide information about the mechanical dejacketing of fuel mentioned in his paper? Answer: Stating that it was a hard question for a chemist, Goldschmidt replied that it was done routinely and that about 4 kg of metal was dejacketed at one pass because of the nature of the fuel elements.

Question: Seaborg (US) asked whether the French intended to recover Np. Answer: The answer was that they would like to do so when they had time to determine how it could be done.

Question: Bruce (US) asked why anion rather than cation exchange was being used for Pu isolation? Answer: He was told anion exchange was more selective.

Question: Haeffner (Sweden) asked what method of Pu recovery was used. Answer: Oxalate precipitation. Question: Why was $NaNO_2$ used. Answer: To stabilize Pu to Pu(IV).

1035355

Question: Bruce (US) asked why was a mixture of hydrazine and ferrous sulphamate used as the reducing agent for Pu. Answer: Hydrazine was used first, the ferrous sulphamate later. They continued to use hydrazine.

Question: Timoshev (USSR) asked what were the limits of HNO_3 concentration and radiation exposure for TBP. Answer: He was told pure TBP was stable to HNO_3 up to 12 molar. The kerosene diluent was affected by HNO_3 concentrations in the range of 6 - 8 molar. TBP, diluted with kerosene, had been exposed to solutions containing several hundreds of curies per liter without any effect. Culler added that TBP limits on radiation under conditions encountered in processing was between 0.2 and 2 mwh per liter of solvent, as reported in paper 743 by G. I. Cathers.

The last paper No. 551, "The Chemical Processing of Aqueous Homogeneous Reactor Fuel" by D. E. Ferguson (US) described several potential techniques for removing high cross section fission products, corrosion products, and other fission products from a circulating UO_2SO_4 - heavy water fuel. Ferguson's analysis was that ion exchange was not too useful; that a promising method was liquid-solid separation, taking advantage of the fact that insolubility of fission and corrosion products increased with temperature in dilute uranyl sulphate solution, and removing precipitates by means of hydroclone separation; that plating out of insoluble fission products on hot surfaces might be used in conjunction with solids removal.

Methods for processing a ThO_2 slurry blanket were discussed and a flow-sheet for a combined plant for core and blanket processing was given.

Question: Glueckauf (UK) asked what percent of fission products appeared in the gas fraction of a homogeneous reactor? Answer: Ferguson said they had not made quantitative measurements during operation of the HRE.

SECTION 22B - CHEMICAL PROCESSING OF IRRADIATED FUEL ELEMENTS: SEPARATION AND STORAGE OF FISSION PRODUCTS

by L. E. Glendenin

J. P. Baxter (Australia) was chairman.

S. Lawroski (US) gave paper No. 823, "Survey of Separation Processes", on various separation processes including (1) precipitation ($BiPO_4$) process, (2) ion exchange, (3) fractional distillation,

1035356

and (4) pyrometallurgical or high temperature processes. Solvent extraction had been covered in paper No. 822 by Culler.

In paper No. 350, "Method for Extraction of Uranium 233 from Thorium Irradiated in Atomic Piles", by A. Chesne and R. Regnaut (France), Regnaut described a process based on selective elution of thorium, protactinium, and uranium from anion exchange resins with hydrochloric acid. The method was good, the main difficulty was corrosion of equipment by hydrochloric acid.

H. M. Feder (US) presented paper No. 544, "Pyrometallurgical Processing of Nuclear Materials", describing the method's advantages as the avoidance of the many chemical steps (dissolution in acids, chemical separation of fission products, recovery of fissile and fertile materials, disposal of liquid wastes, etc.) inherent in other methods; and immediate refabrication of the metallic fuel element. He said the pyrometallurgical processes had speed and simplicity, but all operations had to be handled by remote control.

The last paper, No. 545, "Purification of Uranium Reactor Fuel by Liquid Metal Extraction" by A. F. Voigt, presented by F. Spedding (US), Vice Chairman of the Section, dealt with extracting plutonium and certain fission products from molten uranium by immiscible liquid metals such as silver, lanthanum, cerium and magnesium.

Question: Glueckauf (UK) remarked that several ion exchange resins were available in Europe which Lawroski had not mentioned, and asked Lawroski to enlarge on ion exchange methods. Answer: Lawroski (US) replied he had no intention of slighting the resin manufacturers of Europe, the studies described were 10 years old, and precipitation and solvent extraction processes looked more attractive from a decontamination standpoint. Recently, the possibilities of continuous ion exchange processing, and availability of better resins, made the outlook for this process seem more favorable.

Question: Darwin (UK) asked about useful lives for crucibles in high temperature work. Answer: Feder (US) said there was no experience for large scale operations, but that corrosion with molten uranium was small in laboratory studies.

Question: Miles (Australia) commented on a procedure for dissolving uranium in fused lead chloride, and recovering the uranium by addition of magnesium. He asked Lawroski to comment, (1) on corrosion by compounds like bromine trifluoride, and (2) on relative volatility of plutonium and uranium. Answer: Lawroski answered, (1) that corrosion problems with chlorine and bromine trifluoride were not serious, and (2) that the volatility of uranium was several hundredfold less than that of plutonium in vacuum distillation.

1035357

Question: Miles said results at Harwell were largely in agreement with Feder's but differed on the reaction of fission products with impurities in the uranium rather than with the wall of the crucible. Answer: Feder suggested that the uranium used in UK studies contained more impurities than US uranium and that this affected results. McKenzie (Canada) said his results using US uranium agreed with Feder's. He concluded the United States apparently had purer uranium than the United Kingdom.

Question: Nicholls (UK) asked Feder to comment, (1) on preferred mode of heating, and (2) on reproducibility of artificial alloys (mixed uranium and fission elements simulating burned fuel elements). Answer: Feder replied (1) that resistance heating was preferred to high frequency heating because of the agitation caused by the latter, and (2) that it was difficult to incorporate volatile elements into artificial alloys, but recent experience with powder metallurgy gave results similar to actual fuel elements.

Question: Maly (Czechoslovakia) asked for data on extraction of molten uranium with fused salts such as magnesium chloride. Answer: Lawroski (US) stated that molten magnesium fluoride extracted plutonium, and referred to a conference paper by E. Motta (US). Feder (US) added that extractions of uranium with molten salts accorded with thermodynamic calculations.

Question: Fletcher (UK) asked what separation process was preferable economically. Answer: Lawroski said cost estimating was very difficult because of diversity of fuel elements for various reactors.

The first paper in the second part of the section, No. 415, "Chemical Processing of Fission Product Solutions" by E. Glueckauf and T. V. Healy (UK), outlined procedures for recovering fission products (including cesium 137 and strontium 90) from the highly radioactive waste streams of solvent extraction plants. Glueckauf listed evaporation; separation by drying, roasting and leaching; precipitation; electrolytic precipitation with anionic exchanger membranes; and precipitation on anionic resins.

The next paper, No. 552, "Design and Operation of High-Level Waste Storage Facilities" by C. R. Anderson and C. A. Rohrmann, was presented by Parker (US) who discussed the problems of storing tremendous quantities (millions of gallons) of highly radioactive aqueous wastes. The storage vessels were shielded by earth barriers. The heat released by radioactive decay led to boiling, and decontamination of vapors leaving the storage tank was important.

1035358

The final paper, No. 553, "Processes for High-Level Waste Disposal", by L. P. Hatch and B. Manowitz (US) described two methods for high-level radiochemical waste disposal: fusion to a melt, and adsorption and fixing on clays. A movie was presented to illustrate the operation of a pilot plant which dehydrated and fused typical aqueous waste salt solutions to an anhydrous, free-flowing melt on a continuous basis. This plant had been operated successfully for several hundred hours.

Solid mountmorillonite clay was found to have advantages of good capacity for fixing fission wastes, low cost, ease of handling, and stability. A pilot plant for testing the clay process was in operation.

Question: Lawroski (US) asked for comment on reproducibility of results in deionization with exchange membranes in view of the fact that erratic results have been observed. Answer: Glueckauf said reproducibility depends on initial stages of the process; avoidance of reduction of uranium to the tetravalent state was important.

Nicholls (UK) made a brief comment on a convenient and continuous method for destroying nitric acid with formaldehyde.

Question: Baxter (UK) asked about the fate of volatile activities in the fusion disposal process. Answer: Manowitz said there were some volatile activities, but no definite information was available yet.

Glueckauf (UK) stated he had used sands for fixing waste products and found advantages in filterability and the lack of need for pretreatment. The capacity was about one-third that of clays.

Question: Manowitz (US) asked whether there were volatile products from fixing of clays at 1000°C. Answer: Glueckauf said apparently not.

Mawson (Canada) commented on the use of a nephaline cyanite, which formed a dry gel with acids at 2.5 normal concentration, fused below 1000°C, and did not release activity upon leaching.

SECTION 23B - WASTE TREATMENT AND DISPOSAL

by R. Carson Dalzell and Walter D. Claus

This section, chaired by A. J. Cipriani (Canada), was in three parts, dealing respectively with land, sea, and air disposal.

1035359

Opening the land section, Parker (US) presented R. E. Brown's paper, No. 565, "Disposal of Liquid Wastes to the Ground", describing the Hanford Atomic Products Operations method of disposal used for the last ten years. He discussed factors considered and the continuous test and control program and results. He emphasized that this was controlled ground storage, not uncontrolled disposal, and that the basic policy was to avoid ground water contamination.

Glueckauf (UK) remarked that the British now used large underground containers; they planned later to establish clay or green sand beds in concrete tanks.

C. A. Mawson (Canada), Paper No. 12, "Waste Disposal into the Ground", described the investigations made in conjunction with operation of experimental reactors and the waste disposal problem. He emphasized that it was important to keep detailed records to ensure that fixed material was not leached by subsequent disposals. The Chairman (Canada) remarked on the apparent difference in policy (Canada puts the waste into the water table), and said that it was really a large tracer experiment rather than a permanent practice.

The Chairman, opening the second part of Section 23B, stated the primary subject under discussion was disposal of large-volume, low-level radioactive wastes. Although the sea seemed an attractive depository, there was a problem that the activity might return to land, via the beaches or in food. Disposal at sea of large quantities of power wastes would require a great deal more study.

The first three papers comprised a series and were presented by H. Seligman, H. J. Dunster and D. R. R. Fair (UK) respectively. In No. 418, "The Discharge of Radioactive Waste Products in the Irish Sea - Part I", Seligman described a preliminary experiment eight years ago to determine how fluorescein dye would dilute when piped two miles out into the Irish Sea, in a solution having the density of sea water. Collections had to be made at night since sunlight destroyed the dye within 15 to 20 minutes of discharge. Three ships criss-crossed the discharge area, were positioned by radar, and sampled in eleven experiments. They could never account for more than 30% of the released dye. These experiments indicated that 100 curies per day could be released for 50 days and be adequately diluted.

In paper No. 419, "The Discharge of Radioactive Waste Products in the Irish Sea - Part II", Dunster described estimates of safe amounts of fission product activity which might be released from Windscale, 40 miles to the Isle of Man. Estimates were made of concentrations in the sea, of activity in fish, seaweed and sand on the beaches and suitable criteria were derived for safety, and safe limits of daily discharge. Pickup of activity by fish and seaweed

1035360

had been estimated in the laboratory. Results indicated that uptake by fish was approximately as estimated, but uptake by seaweed was much greater. There was no reasonable probability that anyone exposed on shore, or consuming fish or seaweed, would exceed 10% of maximum permissible dose. Discharges then were determined by including an additional safety factor of ten.

In paper No. 420, "The Discharge of Radioactive Waste Products in the Irish Sea - Part III", by Fair and A. S. McLean, Fair described observations made over several months on discharges of sizeable amounts of typical laboratory effluents. Main daily discharges were 0.05 curies of plutonium, 7 curies of strontium, 16 curies of ruthenium and 35 curies of all beta emitters other than ruthenium. The original estimates were found to be conservative by factors of 5 to 100. Were it not for an unusual problem connected with the fact that seaweed is harvested in that area, much larger amounts of beta-emitters could be discharged.

Paper No. 569 on the "Disposal of Radioactive Wastes at Sea" by C. E. Renn, presented by Walter Claus (US) was a survey which urged critical review of proposals to use the sea as a dumping area. Claus said health and safety features had to be established by oceanographers and ecologists. Acceptable concentrations of activity in the sea had to be established on the basis of food and chemicals taken from the sea. Use of the sea involved international relationships which had to be considered.

Discussion: Krotkov (USSR) said that when wastes were disposed to water, adsorption by organisms was of great importance. Accumulations by organisms could be greater than 10,000 times the concentration in the water. It was hence necessary to make radiometric determinations not only in the water, but also in fish, etc., and to make sure that limits on activity in open waters were not exceeded. This called for regulations on an international level.

Revelle (US) said there were areas, for example the Black Sea and parts of the Carribean, where concentration of hydrogen sulfide in bottom waters was so great, that the bottom and top waters probably had not mixed in many centuries. It would be perfectly safe to dispose of wastes to these bottoms. Also, there were 10 megatons of strontium in ocean waters, and 700 megatons of calcium, so that any conceivable amount of added strontium would be adequately diluted isotopically.

Mawson (Canada) declared that things loosed into the sea were of interest to all nations, and this applied also to international rivers. He felt that some kind of international regulations should be drawn up before this situation got out of hand.

1035361

Marley (UK) appealed for experimental work to produce useable data, with international cooperation. Claus (US) said discussions with oceanographers were under way with intent to design a suitable experiment and to develop necessary instrumentation for following a tracer deposition of activity in the sea, and that the United States would welcome international interest in such an experiment.

Question: Foster (US) asked whether in the Irish Sea studies, Dunster had considered seasonal changes and food cycles? Answer: Within the possibilities of the experiment, they were considered, although the actual experiment continued over only a few months. Question: Would not timing of discharge to make use of tidal currents be advantageous? Answer: Fair said turbulent diffusion at the point of discharge was found to be so great that complete vertical mixing occurred in the Irish Sea. Tides were not required.

The only paper on air disposal was No. 571, "Air and Gas Cleaning for Nuclear Energy Processes", by L. Silverman (US) who stated that cooling air used in reactors and chemical processing plants had to be cleaned before discharge. High efficiency, low resistance to air flow, and long life were necessary for filters in practical use. Great improvement in filters had been accomplished since the early days of the atomic energy industry such as: cellulose acetate filters protected by glass fiber prefilters; all-glass filter papers resistant to acids; and filters made of plastic fibers. Cleaning and removal of rare gases was very difficult. They could be dispersed through tall stacks into the atmosphere, or adsorbed on cold charcoal before removal for storage and decay. In some cases of low volumes, compression and storage for decay was possible. In some ways, meteorological and oceanographic disposal of activity was similar. Dilution must occur to levels which were harmless.

1035362

"C" SECTIONS - BIOLOGICAL AND MEDICAL

SECTION 8C - Radioactive Isotopes and Nuclear Radiations in Medicine: Therapy

by A. M. Brues

The Chairman, F. Leborgne (Uruguay), in opening the section, indicated that the powerful effectiveness of isotopes in medicine was limited by physiological and topographic considerations -- the location of lesions.

Dr. A. V. Kozlova's paper (No. 685, "Medical Application of Some Radioactive Isotopes") was presented by M. N. Fateieva (USSR). The chief isotopes used have been Co 60, Au 198, P 32 and I 131, and Fateieva stated that free medical service makes large-scale medical observations possible. Comparing Co 60 and radium, as external agents, she said the former caused slighter injury to normal tissues and so made repeated therapy easier. 160 oncological establishments have received tubes and needles of 0.5 to 35 mgms. radium equivalent. A few clinics have 400 curie packs, used at 35 or 60 cm. skin distance, and 20 curies used at 6 cm.

Various data presented were interpreted as showing that therapeutic results have been better since the use of cobalt. In one type (esophageal carcinoma) where greatest improvement appeared, teletherapy was combined with intracavitary treatment.

Fateieva also mentioned use of gold and chromic phosphate colloids locally in 11 melanomas with metastases, and said 8 showed no spread in 2 years. Cobalt was being used for cavernous angioma, and P 32 for angioma, neurodermatitis, precancerous skin conditions, eczema, psoriasis and red lichen. P 32 was injected for erythremia, preceded by venesection and introduction of plasma;4 mc. is the maximum given in course of treatment. Other modes of therapy were detailed in the paper. Some slides were shown of 7-year cures of several neoplasms.

In paper No. 446, J. S. Mitchell (UK) discussed "Some Problems of Radio-therapeutics", mentioning the possible usefulness of I 124 and P 33 as substitutes for I 131 and P 32 because physical characteristics were probably more favorable. He brought out the use of Cs 137

1035363

as a gamma source and Ce 144 as a hard-beta source. He also emphasized conservatism in the use of I 131 in nonmalignant states, pointing out that if the mortality from delayed carcinogenesis were as little as 2%, surgery still would be preferable.

Question: Brucer (US) asked what was the meaning of "recovery" and were all cases histologically proved? Answer: Fateieva said recovery meant the tumor was gone at the end of treatment; biopsy and histology were done in nearly all cases.

Question: Aebersold (US) asked whether cobalt was used in teletherapy or in needles; how many years' experience had they had with teletherapy? Answer: Fateieva said this depended on circumstances; needles and teletherapy were used in conjunction in bladder cases, for example; 160 institutions were supplied with cobalt and results from all of them summarized in the central organization.

Question: Schuffelen (Netherlands) asked about germanium dosimeters which he had not found useful. Answer: Eateieva stated USSR workers were not yet ready to draw conclusions.

In Paper No. 179, "Teletherapy Devices with Radioactive Isotopes", M. Brucer discussed teletherapy devices using cobalt 60 and cesium 137, and presented tables for calculating shielding. He appeared to favor using cesium when available, shielded with tungsten alloy. He believed the enthusiasm for sources over 1000 curies was decreasing.

Question: Lebedinsky, (USSR) asked whether hectocuries or kilocuries would eventually be used in packs. Answer: Brucer stated most people used 200 to 400 curies and of those using 1000, about half would use more the next time and the other half less.

Question: Bora (India) asked for the evidence that 5 roetgens/hour/meter was an inadequate dose rate. Answer: This was arbitrary but generally accepted.

Question: Khanolkar(India) asked how the tumor dose was determined. Answer: Brucer said the policy was, in general, similar to that used with 250 kv X-ray. With the larger machines some radiologists tended to give higher doses.

J. H. Muller (Switzerland) in presenting paper No. 925, "Internal Radioactive Isotope Therapy of Neoplastic Diseases by Means of Radioactive Suspensions", discussed intravenous colloidal suspensions, intracavitary, and tumor infiltration, and mentioned the escape of colloid into lymphatic drainage areas as an advantage of the latter.

A. Chevallier (France), paper No. 367, "Utilization of Colloidal Chromium Radiophosphate in Malignant Tumor Therapy" by Chevallier and C. Burg, discussed very fine (100-150Å) chromic phosphate colloid, implanted

1035364

in gelatin, which seemed to promote infiltration via the lymphatics. This was demonstrated by autoradiographs.

Question: Mitchell (UK) asked Muller about dosage in interstitial treatment; for example, 50,000 rps are often needed in the case of beta emitters. Answer: One mc/ml was about enough, but in large volumes this should be reduced.

Question: Siwarbessy (Indonesia) asked what was the effect of collodial gold, used locally, on the liver and spleen, and had Muller had any experience with cancer of liver. Answer: Muller replied that the dosage to liver and spleen was not high; perhaps the stimulation of the reticuloendothelial system from the lower doses might be protective. He had no wide experience with liver but thought gold would be only palliative.

Question: Ross (US) asked whether or not lymphatic drainage was blocked when there were metastases, and why gold was better than P 32. Answer: Muller said local injections might reach very early metastases before blockage of lymphatic drainage occurred; or after removal of metastatic masses. Many factors were involved, he said, in the preference for gold.

J. H. Lawrence (US), paper No. 183, "Radioactive Isotopes in Hematologic Therapy" gave a historical account of treatment with isotopes, primarily P 32. Best results were obtained in the case of polycythemia vera (erythremia), with relative success in the leukemias (particularly chronic forms) and some of the lymphoblastomas. Colloids also have been used (chromic phosphate, or some of the rare earths) but were not considered superior to the administration of soluble phosphate.

V. H. France (Portugal), paper No. 970, "An Accurate Method for Treatment of Hyperthroidism with I 131", described a method for outlining the thyroid gland by circuminjecdion of air and showed x-rays. In only three cases was this technique unsuccessful and two of these were post-operative. He also used small repeated doses of I 131 to avoid myxedema. In injecting air, the patient was placed on the left side and negative pressure was used as a test to avoid embolism; a 0.7 mm. needle was used; the size of the gland was calculated from radiographs as 2 ellipsoids with the axes as measured from pictures.

L. E. Farr (US), paper No. 177, "Use of the Nuclear Reactor for Neutron Capture Therapy of Cancer" reporting using a flux of 2×10^8 and 3×10^9 slow neutrons per cm^2/sec. with boron 10 injections, and gave data. For good results, 30 times the higher flux was necessary -- about 10^{11}. He described a special reactor for medical purposes only which would accomplish this, as well as provide for animal experiments and the production of very short-lived isotopes for immediate use.

1035365

The only elements other than boron 10 that might be injected would be lithium 6 and uranium 235. Boron 10 was used because of availability and the probability that its tissue distribution with time after injection is favorable. Treatment was now being given between 10 and 50 minutes after intravenous injection of borax. This was the time interval during which the difference in boron concentration between brain and tumor tissue was greatest.

Question: Ross asked Franco (1) what about varying the dose of I 131 along with the severity of the disease; (2) what about the hazards of interstitial air here, as in the case of adrenal radiography; (3) how did his size estimates agree with those made by scintillation scanning or palpation. Answer: Franco said (1) that it was known that different doses were required, but in this study all were given equivalent doses since it was experimental; in the care of 4 nodular goiters, function was only reduced somewhat and then surgery was done; (2) that he had had no accidents with 50 insufflations; (3) that comparison with other methods of measurement was not made.

SECTION 9C - RADIOACTIVE ISOTOPES AND NUCLEAR RADIATIONS IN MEDICINE: DIAGNOSIS AND STUDIES OF DISEASE

by Marshall Brucer

The Chairman, V. R. Khanolkar (India) opened the section, pointing out that radioactive isotopes were helping to reshape the diagnostic art.

W. V. Mayneord (UK) presented paper No. 768, "The Use of Radioactive Isotopes in Diagnostic Procedures", a general summary of material he had previously written up in the British Medical Bulletin (1952). Mayneord's work included use of various kinds of instrumentation for measuring beta and gamma emitters under clinical conditions, and the possible uses of many different isotopes. He described studies of total thyroid uptake, measurements of protein-bound iodine, using roughly collimated counters and methods of blood iodine measurement. Mayneord described some problems in Fe 59 and Cr 51 work and indicated their fundamental similarity to the I 131 problems.

Much of Mayneord's time was spent describing his radiographic devices. He concluded that there was a reasonable possibility that radiography might be successful with isotopes in the future.

M. N. Fateieva (USSR) in her paper No. 684, "Experience in Clinical and Diagnostic Application of Some Radioactive Isotopes in the USSR", reported using 2 microcurie doses for standard 2- to 24-hour uptake measurements. She reported mass-scale examinations of population in endemic goiter districts. Fateieva described simple uptake and dynamic studies with I 131 in rheumatic and hypertensive heart disease. Work was also presented on Na 24 measurements on hypertensive patients and blood flow studies in heart disease.

1035366

B. G. Ziedses des Plantes (Netherlands) showed 3 slides on his electrical stylus method of correlating the scanning image with a true body image on a scintiscan of the thyroid.

Marcel Roche (Venezuela) described a mass population study of thyroid uptake in the lowlands of Venezuela and high in the Andes, showing 2 slides. At very high altitudes there was a uniformly higher thyroid radioiodine uptake.

Questions: W. H. Sweet (US) asked about the ratios of activities of isotopes in normal and in brain tumor tissue. Bacq (Belgium) asked in what form the iodine circulates in the blood. Lawrence (US) asked how sensitive the scanning device was. Answer: Mayneord was not conversant on the first two questions. He stated that the average scanning dose was one millicurie and that theoretical studies had indicated it would be impossible to outline the shape of a mass with less than 10 to 20 microcuries.

Fateieva enlarged her description of the mass population surveys: one in the Urals, and two in the Ukraine. One Ukraine area was in an endemic area of hyperthyroid patients. The thyroid uptakes were high and the urine counts low in the hyperthyroid endemic area and the opposite was true in another area where euthyroidism was prevalent.

W. H. Sweet presented the work of G. L. Brownell and Sweet (US) in paper No. 181, "Scanning of Positron-emitting Isotopes in Diagnosis of Intracranial and Other Lesions" on the methods of visualization of isotope distribution in the body by automatic scanning with scintillation detection. He remarked that they had been able to detect verified tumors of the cerebral hemispheres outlined with radioarsenic in nearly 80% of patients. In meningiomas the results were over 95%. Mention was made of the extension of this work to other areas of the body.

J. F. Ross (US) emphasized work on dynamic studies of hematopoietic tissues and in erythropoiesis in paper No. 754, "The Dynamic Aspects of Erythropoiesis in Normal and Pathologic States as Indicated with the Radioactive Isotope Tracer Technique", by Ross and A. Miller. With isotopes, hemotologists were able to prepare a comprehensive outline of the entire red blood cell cycle. Ross described some of the mechanics of the measurement techniques and presented examples of the work done in Boston.

In the discussion, Kunkel (West Germany) described similar work using a simple coincidence counter system measuring gamma rays. He indicated that the use of positron-emitters was unnecessary.

Question: Bale (US) asked about the relative efficiency of single channel and coincidence systems. Answer: Brownell (US) said studies showed that the coincidence system demanded only one-tenth the activity of a single channel system.

1035367

E. E. Pochin (UK), presenting paper No. 769, "The Speed of Iodine Metabolism", described in some detail the advantages of the neck-thigh ratio and the equipment he used to make the measurements. Pochin used I 132, particularly in pregnant women where he indicated a six-microcurie dose. Pochin then outlined his work on metabolic pathways of iodine and described a linear scan of the vertical plane of the body to get an index of the discharge rate of iodine.

C. H. Jaimet (Canada) in presenting paper No. 9, "Further Clinical Studies of Thyroid and Salivary Gland Function with Radioiodine" by Jaimet and H. G. Thode, discussed the metabolism of I 131 in the salivary gland and his development of the salivary iodine test.

Michel Berger (France) presented a summary of paper No. 365, "The Role of Genetic Factors in the Development of Congenital Myxedema", the genetic history of 21 cases prepared by M. Bernheim, et al. (France). He stated that in most of the families of the patients, he found evidence of thyroid abnormality. In the cases of nine patients, both parents showed abnormal thyroids, there being usually a high thyroid iodine fixation in the male parent. Berger discussed the genetic possibilities of his studies and proposed a hypothesis of genetic transfer of the diseases.

Paper No. 1097 by Stefan Miledu et al. (Romania) "Influence of the Dynamics of the Central Nervous System on Iodine Fixation in the Thyroid" stated Romania had just begun to receive isotopes and hoped for more assistance in the near future. Romanian scientists have studied the effects of estrodiol on iodine metabolism in rats and have concluded that there was a thyroid block with high doses of estrodiol and a thyroid stimulation with low doses.

Opening the discussion, Joyet (Switzerland) presented a short extra paper which emphasized that the major movements of I 131 could not be explained mathematically unless the three factors of thyroid, blood, and urine, were taken into account. He described some complex mathematical formulations of what appeared to be averaged blood, urine, and thyroid counts on many patients in order to arrive at definitions of hyper, hypo, and euthyroidism.

Question: Pochin (UK) was asked a number of questions on handling of post surgery patients, carcinoma of the thyroid patients and the use of chromotography. His answers emphasized the necessity for iodine turnover or clearance studies.

Vetter (Austria) commenting on Jaimet's paper, said that they had tried the saliva tests in Vienna, and had attempted to work out a parotid clearance test. They found the clearance through saliva was independent of thyroid clearance rates. The conclusion was that the salivary tests were not better, and might be much less reliable, than other tests.

1035368

Berger was asked about living conditions of the families studied for genetic factors. Berger said there were no abnormal conditions apparent. He was asked about the possibility of hyperthyroid mothers, but thought that this could not explain the transmission through the male parent. He was asked his definition of the words "biochemical hyperactivity" and indicated that this meant a sub-clinical hyperthyroidism.

W. F. Bale (US) presented his and I. L. Spar's work in paper No. 199, "Tissue Specific Antibodies as Carriers of Radioactive Materials for the Treatment of Cancer."

SECTION 10C - RADIOACTIVE ISOTOPES AND NUCLEAR RADIATIONS IN MEDICINE: DIAGNOSIS AND STUDIES OF DISEASE

by Paul B. Pearson

M. Tsuzuki (Japan) presided as chairman.

A. Baird Hastings (US) discussed paper No. 178, "The Use of Isotopes in Biochemical and Medical Research" and then read the paper by DeWitt Stetten (US) No. 840 on "The Use of Isotopes in Analysis of Metabolic Disorders". These were general review papers with a historical background on isotopes as a research tool in biology and medicine. The following areas were covered: total body water, plasma and red blood cells, intracellular fluids, bones and teeth, proteins, nucleic acids, lipides and carbohydrate metabolism.

The paper by B. A. Burrows and J. F. Ross (US), No. 180, "The Use of Radiosodium and Radiopotassium Tracer Studies in Man", was concerned with the metabolism of sodium, potassium, and the sulfate distribution in body fluids in both pre- and post-operative patients. Using radioisotopes, studies were made on the distribution of sodium and potassium between extracellular and non-extracellular phases by serum sampling at appropriate intervals following intravenous administration of a tracer dose of the isotope. Simultaneously, isotope dilution measurements of the body potassium, chiefly intracellular, were made to determine changes in the ratio of body sodium to body potassium as well as changes in body potassium alone.

There were no questions or discussion of these three papers. "The Absorption of Vitamin B_{12} and the Pathogenesis of Vitamin B_{12} Deficiency", paper No. 447, by D. L. Mollin and E. Lester-Smith (UK), was presented by Lester-Smith. In these studies Vitamin B_{12} containing radioactive Co 58 was used. Co 58 has a half life of 270 days and had been used with safety in amounts up to 5 microcuries. The labeled vitamins were made biosynthetically by small scale fermentations in an almost cobalt-free medium. Patients suffering from various types of anemias were given labeled vitamin B_{12} and its adsorption and utilization studied.

1035369

Paper No. 711 by D. L. Ferdman (Ukr.SSR) presented by R. E. Kavetsky, discussed "The Application of Radioactive Isotopes to the Study of the Biochemistry of Muscles". Studies were made using rabbits as the chief experimental animal. Data were presented on the following: the biochemistry of muscles in the vitamin E renewal rate of proteins in hyperthreosis; the renewal rate of proteins and phosphoric compounds in otomised muscles; and the renewal rate of proteins in denervated muscles.

P. Saraiya presented paper No. 921 by Saraiya, V. R. Khanolkar and A. R. Gopal-Ayengar (India) on the "Synthesis of 4:4' - Diaminodiphenyl Sulphone - S 35 and Its Use in Leprosy Research". The procedure for synthesizing the compound labeled with sulfur 35 was given. The labeled drug was administered orally to leprosy patients. Radioautographic techniques were used to measure the uptake of the drug by the lepromatous tissue. The radioautographs did not suggest that there had been a preferential incorporation by particular tissue systems. There was indication of a more or less generalized distribution of the radioactive material throughout the tissues.

"Utilization of Nuclear Energy in Public Health Problems on the Epidemiology of Communicable Diseases", paper No. 224, was discussed by Dale W. Jenkins (US). This was a general review paper covering disease transmission by vectors; relation of animal hosts and parasites; insecticide and natural control of vectors; radiation control of vectors and diseases; and air-borne and water-borne diseases. Jenkins said that the use of nuclear energy in studying the epidemiology of communicable diseases offers an extremely promising and fertile field to epidemiologists and other investigators. Additional discoveries of major importance in the field of health were to be expected.

Question: Clark (US) asked Lester-Smith (No. 447) if he would define "loop syndromes". Answer: Lester-Smith replied that he was not the medical partner of the team, but he understood a loop syndrome to be a fluid intestinal diversion or loop.

Question: Cheoskul (Thailand) asked Lester-Smith whether or not they had measured concurrently the Co 58 and biological activity of B_{12} in the feces so as to determine whether or not the labeled B_{12} had undergone metabolic change. Answer: Lester-Smith pointed out that it was not easy to measure this, B_{12} being synthesized in the gastrointestinal tract. Using B_{12} labeled with both Co 58 and P 32, they found evidence that B_{12} was not degraded to any extent in the digestive tract.

Question: Ross (US) asked Lester-Smith if they had made any studies on the adsorption of vitamin B_{12} across the respiratory epithelium. Answer: Lester-Smith said they had not made such

1035370

experiments, but that it would not be unreasonable to expect the vitamin to be adsorbed by this pathway.

A paper by Marino B. Aragao et al., (No. 140), presented by J. da Costa Febeiro (Brazil), discussed "A New Radioactive Method for Marking Mosquitoes and Its Application". The methods used a nuclear emulsion and had a much higher sensitivity than other methods previously used. In this method long-lived radioactive elements like thorium and uranium had been used for marking mosquitoes.

Question: Bugher (US) asked Jenkins to comment on applying these methods to tsetse fly control against hypanosomiases, and anopheles control against malaria. Answer: Jenkins pointed out there were several ways of using radioisotopes for studying tsetse fly control.

Question: Troitsky (USSR) asked about the possibility of labeling bacteria and how such labeled bacteria could be used to solve epidemiological problems. Answer: Jenkins said bacteria had been labeled and pointed out a number of ways labeled bacteria have been used in epidemiological studies.

Question: Gopal-Ayengar (India) asked Jenkins if isotope work had been done, (1) on the spread of allergens, (2) on the metabolism of tubercle bacillus. Answer: Jenkins said some work has been done following the spread of pollen from plants that had been fed radioisotopes, and referred to some papers cited in his manuscript in reply to other questions.

Question: Jenkins asked Costa Ribeiro about plans for continuing the disposal of anopheles mosquitoes. Answer: Costa Ribeiro said he was not working on this problem, but did outline some work using thorium nitrate on Shaga's disease.

SECTION 11C - BIOLOGICAL EFFECTS OF RADIATION: MODES OF RADIATION INJURY AND RADIATION HAZARDS

by C. L. Comar

R. Latarjet (France) was Chairman.

A. M. Brues (US) presented paper No. 82, "Commentary on the Modes of Radiation Injury", in which he emphasized that information was needed to establish firm values of permissible dosage, and also to find means of protection against, and treatment for, radiation injury. He reviewed the various modes of radiation injury: bone marrow effect; lymphocyte and immunological function; gastrointestinal tract effects; sterility; loss of hair; secondary metabolic changes;

1035371

genetic effects; localized responses and others. He concluded that permissible levels now employed for total body irradiation were justified but values where only a part of the body was involved might be too conservative.

E. Rock-Carling (UK) next presented paper No. 450, "Modes of Radiation Injury -- Medical Aspects", giving a general description of information requirements and the philosophy of the physician who must treat patients exposed to radiation injury. Education and apparatus design could do much to minimize exposure, but accidents did occur. The safety record in nuclear establishments had been better than in comparable industrial establishments.

Rock-Carling said, "To the non-geneticists it appears that for the benefit of the race as a whole in the future, one mutation which results in an Aristotle, a Leonardo, a Newton, a Gauss, a Pasteur, an Einstein, might well out-weigh ninety-nine that led to mental defectives."

V. L. Troitsky (USSR) presented paper No. 692 by L. A. Pigalyev ("Some Aspects of the Immunity of the Organism Exposed to Action of Ionizing Radiation") saying that since radiation sickness was often complicated by infection, it was important to study the immunity of an organism exposed to radiation and infected with germs. In general, X-irradiation produced a decline in natural resistance to infections.

In a study of relationships between administered tetanus toxin and polonium it was demonstrated that the response to polonium was increased whereas the tetanus symptoms were decreased. Studies were reported on comparative effects of radiation on fully formed immunity and on immunogenesis. In general, immunogenesis was inhibited while there was little or no effect on fully formed immunity. Internal radiation from polonium or radio-thorium gave the same results as did external irradiation.

Discussion: Gustaffson (Sweden) objected to Rock-Carling's statement on genius vs. mental defectives. Detrimental results were easily brought about; to produce genius required much more: a summation of good effects. He stated there was great difference between these two. Russell (US) stated it was not necessarily beneficial to man to increase the mutation rate. Answer: Rock-Carling replied he had wanted and was glad to have on the record these statements by geneticists.

Question: Brues (US) asked whether combined treatment produced the pathology of the toxin or of the radioelement. Answer: Troitsky replied that there was radiation sickness due to polonium, but tetanus symptoms were observed later than in the control animal. Guinea pigs died earlier on account of the toxin; those with toxin alone survived, whereas those getting toxin plus polonium died.

1035372

Question: Cambel (Turkey) asked what enzymes besides sulfhydryl were affected by radiation and inquired about alkaline phosphatase. Answer: Brues replied that since radiation affected proteins, we should expect enzymes to be affected. Alkaline phosphatase appeared to be less sensitive to radiation than other enzymes.

Question: Costachel (Romania) stated that the nervous system was important in radiation response, and that narcosis would reduce biological effects. This might be a way of increasing doses used in radiotherapy.

W. F. Neumann (US) presented paper No. 847, "The Use of Isotopes in Study of Skeletal Physiology and Metabolism", which described the nature of bone with emphasis on the processes by which bone-seeking isotopes became deposited in the skeleton. The physical processes were exchange, diffusion and recrystallization, while the biological processes were bone growth, resorption, and remodeling of Haversian systems. Exchange and diffusion were reversible whereas the others were irreversible. The difficulties in removing skeletally deposited radioisotopes were caused by the irreversibility of these processes.

F. E. Hoecker (US) presented his paper No. 88, "The Deposition of Radioactive Substances in Bone". A new technique for dating radioactive deposits in bone by concurrent injections of radioactive substance and alizarin red was described; it was thereby shown that these substances were found only in bone being formed at the time of entry of these substances. In general, the higher the atomic number of the alkali earth, the smaller the placental transfer. Lactation studies indicated that a negative calcium balance induced before or shortly after deposition could reduce the retention of the bone-seeker.

D. E. Clark (US) presented paper No. 242, "The Association of Irradiation with Cancer of the Thyroid in Children and Adolescents". Fifteen cases of thyroid carcinoma in children up to 15 years of age were reported. Each case had received X-irradiation in infancy or early childhood. The total dose ranged from 200 to 725 r and the period between irradiation and diagnosis averaged 6 to 9 years. Statistics showed that thyroid carcinoma was increasing and this appeared to be correlated with prior X-ray treatment for such conditions as enlarged thymus, enlarged tonsils and adenoids, cervical adenitis and benign pulmonary conditions.

Question: Loutit (UK) asked if there were any hope of either preventing skeletally deposited radioactivity or causing removal. Answer: Neumann replied there might be hope if it were possible to stop the growth processes, but this seemed unlikely. To prevent deposition and to cause removal very quick action would be needed.

Question: Bacq (Belgium) asked if Neumann could explain chemical analyses of bone which showed a higher calcium to phosphate ratio than theoretically expected. Answer: Neumann replied that lattice was

1035373

capable of wide variations in composition due to defects and surface adsorption.

Question: Copp (Canada) stated that studies indicated that isotopes were deposited in bone as quickly as brought there and that work in which he was associated had not been able to bring about removal by a negative calcium balance. Answer: Hoecker agreed in regard to old deposits, but said that negative calcium balance, induced shortly after acquisition, could accomplish removal.

Question: Ara (Cuba) said that it was desirable to know more about the metabolism of calcium and other radioisotopes in humans and asked whether serial biopsies and autoradiograms would be useful. Answer: Hoecker said human data were from old specimens from Martland. There was always the problem of how to extrapolate from animal experiments to humans.

Question: Tubiana (France) asked about the relation between thyroid carcinoma in adults and previous irradiation. Answer: Clark answered that these studies were not yet complete and that it was difficult to get early histories for adults.

Question: Stanley (Australia) asked if he had any figures for uptake of I 131 by the carcinoma. Answer: Clark replied that they used a biopsy technique and if there were good localization, they treated with I 131.

Liane B. Russell (US) presented her paper No. 77, "Hazards to the Embryo and Fetus from Ionizing Radiation". Experiments with mice indicated that the potential radiation hazard was greatest during the period of major organogenesis. In applying these findings to the human, it was recommended that pelvic irradiation of women of child-bearing age should be restricted to the 2 weeks following the menses, when there was little chance of an unsuspected pregnancy. The present permissible weekly dose did not appear to constitute a measurable hazard at any stage in pregnancy.

G. W. Casarett presented his paper, No. 257, "Effects of Daily Low Doses of X-rays on Spermatogenesis in Dogs". He found that in general 0.6 r-day of X-rays produced in dogs a progressive decline in absolute sperm count after the 20th to 30th weeks of exposure. Most of the dogs have proved infertile in test mating. No effects have been demonstrated as yet in the 0.3 r/week and 0.6 r/week dogs after radiation exposures of from 2 to 4 years.

H. Fritz-Niggli, Switzerland, presented her paper, No. 1070, "Dominant Lethal Factors and Embryonic Mortality After Irradiation at 180 Kev and 31 Mev." Drosophila were used to study the effect of 3000 r on spermatogenesis. Hatchability was definitely decreased, with 180 kev radiation more effective. The greatest decrease was observed in the second brood period (5-7 days). The maturing spermatids appeared to be the most sensitive.

1035374

Question: Cambel (Turkey) stated in general she had seen the same results as Russell, but in the same litters had had some normal and some abnormal offspring. She also had one patient in which no effect on offspring were observed, although the mother received radiation during pregnancy. Answer: Russell stated there was not always 100% incidence either within litters or between litters. This might be due to probability relations and also to slight differences in developmental age.

Question: Somerwil (Netherlands) asked whether studies on the recovery of fertility in dogs had been done. Answer: Casarett stated that in the reported experiment the dogs would be irradiated throughout life. Other experiments were under way for recovery data, but results were not yet available.

SECTION 12C - BIOLOGICAL EFFECTS OF RADIATION (continued) - MECHANISMS OF RADIATION INJURY; PROTECTION AND RECOVERY

by A. Hollaender

Z. Bacq (Belgium) was Chairman.

The first paper, No. 899, "Biological Damage Resulting from Exposure to Ionizing Radiations" by L. H. Gray (UK) discussed radiation damage mainly from the physical point of view.

Gray reviewed the mechanism of the use of isotopes in biological research and discussed the effect of density of ionization on the biological effectiveness of different types of radiation. He emphasized variation among the different biological mechanisms upset by radiation, with special emphasis on the different stages of mitosis, the function of respiration, and the synthesis of nucleic acids. He brought out that the actual step from the changes produced by radiation in water to the biological response was poorly understood, and finally he discussed certain of these aspects in relation to the oxygen effect.

Alexander Haddow (UK), paper No. 898, "Comparative Studies of the Biological Effects of Radiation and of Radiomimetic Chemical Agents," compared the biological effects of ionizing radiation with the radiomimetic chemical agents. He related the structure of these compounds to their biological effectiveness and showed that certain groups were necessary for the effectiveness of these compounds. He illustrated the function of the compounds and the effect on hair pigmentation, inhibition of growth, carcinogenesis, mutation production, cytological changes and their action on natural and synthetic macromolecules. He discussed the cytological effects in greater detail on the basis of work done at the Chester Beatty Institute.

1035375

Paper No. 904, "Cytological and Cytochemical Effects of Radiation in Actively Proliferating Biological Systems" was presented by A. Gopal-Ayengar (India). He illustrated his talk with many slides showing differences in the chromosomes of ascites tumors, bean roots, and related materials.

N. M. Sissakian (USSR), presenting his paper No. 691, "On the Nature of Changes in Metabolism Under Irradiation Effects", discussed the nature of the basic changes of the biological materials and the effects of ionizing radiation. Whereas individual enzyme systems in vitro were very resistant to radiation, the mechanism of synthesizing the enzymes which were responsible for saccharose, proteins and nucleic acid production was much less resistant. The nucleic acid production was changed by 5000 r, proteins by 20,000 r and saccharose by 30,000 r. When plants grew older they became much more resistant to radiation. Sissakian believed that the alterations in nucleic acid synthesis were easily reversible. He emphasized the great importance of metabolism and the interaction among different synthesizing systems which could be easily upset by radiation.

Sissakian also read a paper, No. 690 by M. N. Meissel (USSR) on the "Biological Effects of Ionizing Radiation on Micro-Organisms".

R. Latarjet (France) discussed paper No. 371, "The Problem of the Biological Action of Low Doses of Ionizing Radiation" by H. Markovich, his co-worker, on various effects of low dosage of ionizing radiation on lysogenic bacteria. He found the lysogenic process extremely sensitive to radiation and one roentgen or possibly less would initiate the process. Since the process was so extremely sensitive, he thought he might be able to detect the different levels of cosmic radiation at sea level and at high altitude; for this reason he had carried several flasks of lysogenic bacteria to the top of Mont Blanc which he would collect next summer.

Question: Caldecott (US) asked Sissakian why the concentration of S-H_2 groups was so high after exposure to radiation. Answer: Sissakian pointed out that insects were extremely resistant to radiation. If the same mechanism of radiation damage were involved in all the different kinds of organisms, why did such tremendous variation exist in sensitivity?

The next paper, No. 78, "Studies on Protection by Treatment Before and After Exposure to X- and Gamma Radiation", by A. Hollaender and G. E. Stapleton, was given by Hollaender (US), based on work on the mechanism of protection against radiation damage. After a review of protection of bacteria by chemical compounds and the support of the recovery of nutrilites, the action of the four compounds was compared: cysteine, B-Mercaptoethylamine, S-B Aminoethylisothiuronium, and Tyramine.

1035376

It was typical for all these four compounds that they had the NH_2 group. The most successful ones were cysteamine and thiuronium. The latter seemed to be of considerable promise, since it was quite stable in air and had relatively low toxicity. The last part of the paper reported the observation that in bacteria the mutation rates produced by radiation were not necessarily proportional to the amount of radiation absorbed, but rather inverse in proportion to the survival ratio. The possible implication of this finding was discussed.

J. Maisin (Belgium) discussed protective action of cysteamine on mammals in his paper, No. 940, "Tissue and Cell Damage Due to Radiation; Their Consequences and Their Repair". He reviewed the work of his group and the protection produced by shielding the liver against radiation in his more clinical approaches to this problem.

Several questions were asked about why the oxidized as well as the unoxidized form of cysteamine protected under certain circumstances. Gray explained that the cysteamine could be reduced in the animal body and did become protective. Since bacteria were not able to reduce this compound, cysteamine gave them little protection.

Fritz-Niggli (Switzerland), in commenting on Sissakian's paper, reported the detection of changes in enzymes by direct observation of the oxygen consumption in tissues. She believed she was able to recognize changes in the citric acid cycle.

A scheduled paper, No. 932, "The Scope of Chemical Protection Against Ionizing Radiation in Mammals" by D. W. Van Bekkum and J. A. Cohen (Netherlands) was not presented.

SECTION 13C - BIOLOGICAL EFFECTS OF RADIATION: GENETIC EFFECTS; HUMAN IMPLICATIONS RADIOACTIVE ISOTOPES AND IONIZING RADIATIONS IN AGRICULTURE -- RADIATION-INDUCED GENETIC CHANGES AND CROP IMPROVEMENT

by B. Wallace and R. Caldecott

Section 13 of the Conference was divided into two parts, the first dealing with human genetics, chaired by T. Kemp (Denmark), the second with crop improvements through radiation-induced genetic changes chaired by A. Gustafsson (Sweden).

In presenting paper No. 238, "The Genetic Structure of Mendelian Populations and its Bearing on Radiation Problems", B. Wallace (US) emphasized the importance of heterosis and polymorphism, rather than the highly uniform genetic structure generally ascribed to species, and

1035377

the large proportion of homozygous individuals resulting from such a structure. Starting with the idea that a species could be equated with the museum type specimen, Wallace followed the breakdown of "typical" thinking to the term "allele" itself. Supposedly identical "wild-type" alleles have upon closer analysis been shown to be different (iso-alleles). Polymorphism has been found to be extremely common in many groups. Wallace summarized the evidence that supported the thesis that polymorphism was the rule -- not the exception -- and that wild type individuals were largely heterozygous. The implication of this concept for radiation problems was that genes were acted upon by selection in heterozygous individuals to a greater extent than was generally recognized. If a gene were deleterious in the heterozygous condition, it would be eliminated from a population rather rapidly; if it were beneficial, no matter how rare, it would be favored by selection.

This concept was not contrary to the humanitarian view that needless irradiation should be kept to an absolute minimum, Wallace said. In the process of elimination of deleterious genes, harm occurred to some individuals. In fairness to these individuals, the numbers of deleterious genes must be kept as low as possible.

In paper No. 235, "Genetics Effects of Radiation in Mice and Their Bearing on Estimation of Human Hazards", W. L. Russell (US) discussed investigations into mutation rates in mice and the harm resulting from these mutations. Russell reported a lower mutation rate of irradiated spermatogonial cells as compared to the mature sperm. From this observation it was recommended that males exposed accidentally to high doses of irradiation should refrain from procreation for five weeks after exposure so that exposed sperm would become eliminated and new sperm would have formed from spermatogonia. Not all mutations could be eliminated by this technique; Russell emphasized that further elimination through intercellular selection seemed to be absent.

Russell pointed out that mice irradiated with 300 r produced, on the average, 3% to 4% fewer offspring than unirradiated males. This might indicate the effect of slightly deleterious genes and, hence, reflected a not inconsiderable drop in overall viability of first generation individuals.

In paper No. 449, "The Genetic Problem of Irradiated Human Populations", T. C. Carter (UK) introduced the concept that human societies accepted harm to a few or a slight harm to many, if these resulted from some activity that conferred good to the multitude. He pointed out that the great concern over radiation effects stemmed from our inability to predict the amount of harm and, hence, to weigh the harm against the good. He pointed out that more research was needed in population genetics to test the models developed on theoretical grounds. He stated that more research on mutations was necessary -- especially research dealing with low levels of irradiation. He believed that the populations of areas

1035378

rich in granite-bearing rock which had higher radioactivity could be contrasted with those of areas deficient in this type of material to discover differences in mutation rates.

Question: Ehrenberg (Sweden) stated that barley had been exposed to chronic irradiation in Sweden and certain mutation rates found. Were these data comparable to the information in mice? Answer: Russell said that in general they were, but that he did not really have comparable treatments.

Question: Wallace (US) stated that Russell had mentioned a lack of elimination of mutations as irradiated males aged. He asked for the rate of elimination still consistent with the data. Answer: Russell said that the analyses were not yet far enough along to say.

Question: Bacq (Belgium) asked if there were evidence of a genetic recovery. Answer: Russell replied that there was not.

Gustafsson, as Chairman, opened the second part of the section with a statement emphasizing that 99% of all mutations obtained by irradiating plant material were deleterious. With plant populations this was no particular problem because there was no remorse over "mass-killing" of an experimental field to obtain one beneficial mutant.

The first paper was No.110, "The Contribution of Radiation Genetics to Crop Improvement" by W. R. Singleton et al. (US). The significant researches of Swedish scientists were referred to and it was mentioned that they had been able to increase yields of agricultural crops in addition to obtaining stiffer straw and earlier ripening of cereals. Gregory (North Carolina) had been able to induce disease resistance in peanuts. At Brookhaven Laboratory, Konzak had induced resistance to stem rust and Helminthosporium in some of his oat material.

Singleton showed that proper utilization of a Co 60 source could augment the production of mutations in Zea mays. This could be a very significant contribution if the beneficial mutations occurred often enough to be worked with by practical breeders. There was every reason to think this would be the case.

In the second paper, No. 890, "Studies on Genetic Effects in Plants of Chronic Gamma-Radiation", Mikaelson (Norway) mentioned that Ir 192 and Co 60 had been installed in a field for irradiating plant material. He conducted some important studies on the frequency of chromosome aberrations resulting from chronic irradiation of Tradescantia and showed that, per r unit, chronic radiation was more effective at breaking chromosomes than acute irradiation. Relatively small doses of chronic radiation produced a high frequency of chronic radiation and produced a high frequency of chlorophyll mutations in barley. A rather high frequency of variability in flower characters and abnormal development of flower parts was another manifestation of chronic

1035379

radiation of Tradescantia. There was every reason to believe that promising new horticultural species might be developed using this method.

In presenting paper No. 793, "The Production of Beneficial New Hereditary Traits by Means of Ionizing Radiation", by L. Ehrenberg et al., (Sweden) Ehrenberg stated that recent studies in Sweden had again emphasized that induced mutations were an important tool in plant breeding. It was shown that mutations of a beneficial nature might accompany chromosome anomalies, and Ehrenberg expressed a view that a complete modification of species, as to type, would be possible. Some mutants produced had greater ecological ranges than conventionally derived varieties, and it was noteworthy that mutants of the "bright-green" barley required less nitrogen fertilizer than did normal colored varieties. In addition, the bright green mutations evidenced a greater resistance toward certain fungi than did the mother strain. The variety of sweet lupine now cultivated in Sweden arose from a radiation- induced mutation.

A radiation-induced mutant of white mustard, released in Sweden had a higher grain and oil yield than the original strain, and was now the principal commercial strain grown in Sweden. In addition to those mentioned, numerous other mutants in barley, wheat, peas, and lupine were being tested in large scale experiments.

In one institute in Sweden, techniques had been worked out to help increase the frequency in which bud sports were induced in fruit trees.

In the fourth paper, No. 101, "Ionizing Radiations as a Tool for Plant Breeders", R. S. Caldecott (US) placed some emphasis on the need for increasing our knowledge of the action of ionizing radiations in seeds and other plant organs. He discussed a number of studies in which an attempt was made to modify their radiosensitivity. The sensitivity of seeds to X-rays could be strikingly modified by hydration and oxygenation but this had not been demonstrated with neutrons.

The studies showed that more mutations and chromosomal aberrations per unit survival could be induced with densely ionizing radiations than with sparsely ionizing radiations. In addition, plants from seeds subjected to neutrons were more uniformly injured. Caldecott particularly emphasized the need for strong support of basic research programs in agricultural institutions to provide the plant breeder with maximum numbers of induced beneficial mutations.

Question: Savalescu (Romania) asked whether or not the disease resistant plants reported by Singleton had been examined morphologically for characteristics of biological significance which were modified by the radiation. Answer: Singleton said that such studies had not been undertaken but that they were anticipated.

1035380

Question: Bonet-Maury (France) was particularly interested in ion density and the mutations induced from densely ionizing radiations. He asked Ehrenberg about the mechanism of such radiation. Answer: Ehrenberg replied that it was a most important question but not too much could be said about it at this time.

Question: Lester-Smith (UK) asked how useful isotopes might be in a plant breeding program. Answer: Singleton indicated that the only studies he was familiar with were in neurospora but that the subject should be further investigated.

Question: Roche (Venezuela) asked whether or not there was information on the electrolytic content of hydrated seeds. Answer: Caldecott said he had no data.

SECTION 14C - RADIOACTIVE ISOTOPES AND IONIZING RADIATIONS IN AGRICULTURE - TRACER STUDIES IN AGRICULTURE

by E. Epstein

The Chairman, V. F. Kuprevich, (Bye. USSR) spoke briefly on the utility of the tracer technique for elucidating many kinds of problems in agriculture and biology.

Paper No. 10, "Studies of Special Problems in Agriculture and Silviculture by the Use of Radioisotopes", by J. W. T. Spinks (Canada) surveyed Canadian experience. After briefly reviewing general principles and questions of methodology, Spinks described typical results of tracer fertilizer experiments. The stage of growth of the crop, its type and variety, the type of soil, placement of the fertilizer, the type of fertilizer and its rate of application, were factors which influenced the uptake of the fertilizer by the crop. He said radiation damage seemed slight at the levels of radioactivity commonly applied.

The available soil phosphorus (A) could be measured by comparing the percentage of P from the soil with that from (tagged) fertilizer, using the Fried and Dean equation

$$A = \frac{(\text{rate of application of fertilizer} \times \%\ \text{P from soil})}{(\%\ \text{P from fertilizer})}$$

Spinks next discussed diffusion of ions in the soil, saying that tagging provided the only means of determining the path of fertilizer phosphorus. Measurement of soil moisture by means of a neutron flux provided an alternative to conventional methods.

Spinks concluded by discussing radioactive tagging of insects and pests, and the gross movement of nutrients in trees.

1035381

S. Mitsui (Japan) presented paper No. 1049, "Studies on Plant Nutrition, Fertilizers and Soil by Use of Radioactive Isotopes". He found little loss of P 32 from rice plants under normal conditions, but hydrogen sulfide severely interfered with normal phosphorus movement and retention. Foliar absorption of P 32 by rice and other crops was demonstrated. Field studies on a moderate scale, using P 32, have been conducted, demonstrating very limited movement of the applied P 32 in the soil. Mitsui concluded with a consideration of various technical and methodological problems.

E. Epstein (US) presented paper No. 112 by Epstein and S. B. Hendricks, "Uptake and Transport of Mineral Nutrients in Plant Roots". Using excised barley roots and various radioactively tagged inorganic ions, they demonstrated three modes of uptake; ion exchange, diffusion, and active transport. Of these, the first two were passive, and reversible, whereas the third involved metabolic activity on the part of the tissue. A hypothesis was advanced, and evidence presented, that this active transport involved the attachment of the ions to metabolically generated "carriers". Active transport was shown to be specific in regard to the ions taken up and their mutual interference.

R. Scott-Russell (UK) presented paper No. 460 by Scott-Russell et al., on "Factors Affecting the Availability to Plants of Soil Phosphates". He described two methods for estimating labile soil phosphate by means of P 32: isotopically exchangeable soil phosphate referred to as the "E" value, and the "A" value already described by Spinks. He took issue with the interpretation of the latter value as the "available" soil phosphorus, and referred to this value as the "L" (Larsen) value. For each soil used, absorption of phosphorus by plants increased approximately linearly with both the "E" and "L" values, when aliguots of a soil to which different quantities of phosphate had been added were compared. This relationship did not, however, hold when different soils were compared.

Because of the greater ease of determining the "E" as compared with the "L" value, Scott-Russell expressed a preference for the former.

V. M. Kletchkovsky (USSR) presented paper No. 694 on "The Use of Tracer Atoms in Studying the Application of Fertilizers". Kletchkovsky stressed the possibility of distinguishing by labeling between applied and soil fertilizer elements. He stated that densely spaced grains of superphosphate resulted in optimal utilization of the applied phosphate by young plants whose root systems were as yet poorly developed. At later stages, better results were obtained from larger, more widely spaced granules because under those conditions, fixation of the added phosphate by the soil was minimized.

Depth of application in the soil was an important factor. Best results were obtained by a combination of two types of placement: one at slight depth before sowing to give the young seedlings a source of

1035382

nutrients at an early stage of development; another more massive application plowed under, to supply the plant during the remainder of its growth.

Kletchkovsky concluded with a brief consideration of experiments on foliar application of fertilizers.

A. V. Sokolov (USSR) in paper No. 695, "Determination of the Assimilation Capacity of Soil Phosphates and Fertilizers with the Aid of Radioactive Isotopes of Phosphorus", stated phosphatic fertilizers might give different results depending on the type of soil, and that addition of phosphatic fertilizer might substantially reduce the relative uptake of native soil phosphate.

Sokolov discussed the use and limitations of the value described earlier in the session as the "A" (Spinks) or "L" (Scott-Russell) value. He also considered the equilibrium between solid phase and liquid phase phosphorus, which could be studied by adding amounts of P 32 so small as not to disturb the ratio between the two quantities.

O. K. Kedrov-Zikhman (Bye. USSR) presented a paper (No. 716) on "Co 60 in the Study of the Role of Cobalt as a Micro-Element in Plant Nutrition". He stated that there was an erroneous opinion in the world literature that cobalt fertilizers had no significance for agriculture, but that this opinion had been refuted in the Bye. SSR. He reported various agricultural crops were observed. The effects depended on the quantity of lime applied, cobalt being positive in the presence of lime, and negative in its absence. He also claimed positive effects due to the radiation from Co 60.

H. B. Tukey (US) in presenting paper No. 106, "Utilization of Radioactive Isotopes in Resolving the Effectiveness of Foliar Absorption of Plant Nutrients", described studies which he and several collaborators made by means of radioactive isotopes. Radioactive mineral nutrients were readily absorbed where applied to leaf, stem, and fruit surfaces, and even through the bark of dormant trees. The leaf, however, was the most important organ for entry of nutrients. Movement of mobile elements, such as nitrogen, phosphorus, potassium, and rubidium, after the application of their radioisotopes to the leaves, was comparable in rate to the movement of the same elements absorbed through the roots. Calcium, on the other hand, did not move in the direction of the root (basipetally).

Not only trees, but herbaceous plants as well, could absorb and translocate nutrients in this manner.

Tukey discussed a number of factors which affected foliar absorption of nutrients: temperature, light, pH, and carrier of the solutions used, as well as various characteristics of the plant treated. Tukey finally discussed foliar applications of C 14 urea and the loss of nutrients from the leaves through leaching.

1035383

A. J. Riker (US) presented paper No. 105, "The Use of Radioactive Isotopes to Ascertain the Role of Root-Grafting in the Translocation of Water, Nutrients and Disease-Inducing Organisms Among Forest Trees", embodying work by J. E. Kuntz, Riker and others. Radioactive isotopes were used to trace the movement of materials in the sap streams within and among trees. The experiments and observations indicated, for some species, a widespread occurrence of root grafts by which the vascular systems of many trees were connected. These findings have interesting implications for the study of disease susceptibility, mineral nutrition, and other aspects of tree growth. Movement of substances within individual trees was studied also, and marked differences were observed between species.

Question: Tukey (US) asked about the scope of foliar nutrient studies. Answer: Kletchkovsky (USSR) said foliar application of nutrients was being used on thousands of hectares. It was particularly valuable for plants on poorer types of soil. Kletchkovsky, answering a question by Schuffelen (Netherlands), said the amounts and distribution of rainfall were important considerations in the placement of fertilizers.

Question: Epstein (US) asked whether positive effects on crops from the application of cobalt to the soil were considered adequate evidence for classifying cobalt as an essential plant nutrient. Answer: Kedrov-Zikhman (Bye. SSR) answered in the affirmative for those cases where the responses were specific to cobalt.

SECTION 15C - RADIOACTIVE ISOTOPES IN PHYSIOLOGY AND BIOCHEMISTRY: ANIMAL PHYSIOLOGY AND PLANT BIOCHEMISTRY

by C. L. Comar and M. Calvin

Section 15C of the Conference was divided into two parts, the first dealing with animal studies, chaired by A. V. Palledin (Ukr. SSR); the second dealing with plants, presided over by the Vice-Chairman, E. C. Wassink (Netherlands).

C. L. Comar opened the first part with his paper, No. 90, "Radioisotopes in Animal Physiology and Nutrition-Mineral Metabolism", in which an overall mechanism for calcium ion movement in the body was presented. The data explained the rapid deposition of such bone-seekers as calcium, radium and strontium in the skeleton and the difficulties in their subsequent removal. The importance of the endogenous fecal loss was presented both from the viewpoint of removal of bone-seekers and utilization in nutritional studies. As an example of nutritional application it was shown that cattle could adapt to a sub-optimum calcium diet by a reduction in the fecal endogenous loss. Also, it was demonstrated that milk was greatly superior to hay and grain as a source of calcium for calves.

1035384

Methods were described for the simultaneous estimation of fecal endogenous calcium and phosphorous as well as total digestive juice calcium and phosphorus.

H. H. Ussing (Denmark) presented paper No. 908, "Use of Isotopes in Permeability Studies". Methods were described for measuring the transport of radioisotopes such as Na 22 and Na 24 through frog skin and, at the same time, measuring potential differences and electric currents. There was an identity between active Na transport and electric current output which indicated that the active Na transport was the sole source of electric asymmetry. It was concluded that the operating force was of chemical nature. In studying the effects of neurohypophyseal it was shown that (a) osmosis through a living membrane could be of the type of bulk flow, (b) the layer acted upon by the hormone was provided with pores, (c) the hormone acted by increasing the pore size.

Question: Pora (Romania) asked if Comar had taken into account such variables as Vitamin D and parathormone, and had radioisotopes been used to study the effects of these substances on mineral metabolism. Answer: Comar replied that all the studies described were carried out with animals on normal diets with respect to Vitamin D and hormones. Radioisotopes had been widely used to study these substances. For example, the effects of parathormone in removing calcium and phosphorus from bone, in causing increased urinary phosphorus excretion, and in causing accumulation of calcium in the kidney had been clearly demonstrated by use of the isotope.

Question: Hastings (US) asked what the effect was of pH, K and Ca on the drag force. Answer: Ussing remarked that these had not been studied in detail. However, the hormone was optimally effective between pH 7 and 9.

Question: Bergmann (Israel) asked if the influence of glyceric acid on ion transport had been studied. Answer: Ussing replied in the negative, but that it was a good idea.

C. Blincoe (US) then presented paper No. 275, "Use of I 131 in Study of the Influence of Climatic Factors on Thyroid Activity and Productivity of Livestock", prepared by Blincoe and S. Brody. Methods were described for measuring thyroid activity as follows: (a) maximum thyroidal uptake of I 131, (b) rate of thyroidal uptake of I 131, (c) rate of thyroidal release of I 131, and (d) time changes in thyroxine I 131 in plasma.

The larger the animal and the higher the production level, the greater was the decrease with rising temperature in thyroid activity, heat production, and milk production. India-evolved cows showed less thyroid changes at high temperature than did Europe-evolved cows.

1035385

A. Jentzer (Switzerland) then presented an unscheduled paper No. 119, "Problems Related to the Posterior Hypophysis Studied by Radioactivity". It was demonstrated that the posterior hypophysis would accumulate thyroxine I 131 and that this accumulation was markedly affected by induction of hibernation or anesthesia.

G. Mitsui (Japan) presented paper No. 1047 by R. Sasaki, "Studies on the Metabolism of Calcium and Phosphorus in the Laying Hen", describing detailed experiments in which Ca 45 or P 32 were administered to hens or eggs and the movement followed into the various compartments. Most of the calcium required for egg formation was derived from the feed. The calcium required for the developing embryo came from the yolk but to a greater extent from the shell.

Paper No. 697, "Tracer Atoms Used to Study the Products of Photosynthesis Depending on the Conditions Under Which the Process Takes Place", by A. A. Nichiporovich (USSR), presented by A. M. Kuniz, consisted of an empirical extension of the observation that amino acids and proteins were products of the transformation of the very earliest primary products of photosynthesis. Kunuz reported that blue light promoted amino acid and protein synthesis, as contrasted to red light which was supposed to favor carbohydrate formation. The explanation offered was based upon the photosynthetic cycle which was described in the next paper No. 259, "The Photosynthetic Cycle", by M. Calvin and J. A. Bassham, published in its entirety in 1953 (UCRL) and in JACS 76 - 1760 (1954).

Question: Calvin, (US) asked if the suggestion were made that there might exist a major port of entry of carbon (in substantial non-catalytic amounts) into the reduced material of the plant other than the carboxylation of RuDP to PGA, as was suggested in the text; if so, what was it and under what conditions did it function. Answer: Kuzin answered that no port of entry was proposed other than that given in the "photosynthetic cycle".

Question: Calvin (US) remarked that in view of the known dependence of the nature of the secondary products formed (protein, fat, carbohydrate) upon the overall light intensity, had the comparison between the effects of blue light (filtered Hg arc) and red light (incandescent lamp) been made at the same incident quantum rate? Answer: Kuzin replied that it had.

Paper No. 715, "C 14 in the Study of the Biosynthesis of Chlorophyll" by T. I. Godnev and A. A. Shlyk (Bye. SSR) reported a set of experiments in which plants were fed both $C^{14}O_2$ and C^{14} acetate.

Question: G. Burr (US) questioned the quantitative significance of the 19-day life of the chlorophyll molecule reported by Godnev in view of the known and expected dependence of the turnover rates of

103538b

such molecules upon environmental conditions such as light, which were not reported. Answer: Godnev stated that he recognized such control by environmental conditions and indicated some observations of different turnover rates under different field conditions. Details were not given.

Paper No. 459, "Some Aspects of Sucrose Metabolism in Plants" by H. K. Porter and J. Edelman (UK) reported using sucrose labeled selectively in either half (glucose or fructose) of the molecule, the relationship between this disaccharride and the free hexoses, oligosaccharrides and starch had been studied, as they were interconverted by various enzymes. He reported that sucrose acted by a transfructosidation mechanism and not through the free hexoses.

SECTION 16C - RADIOACTIVE ISOTOPES IN PHYSIOLOGY AND BIOCHEMISTRY: GENERAL BIOCHEMISTRY

by D. E. Koshland, Jr.

The section was called to order by Chairman Hans Ussing (Denmark).

Paper No. 456, "Some Recent Applications of Tritium in Biological Research", by R. F. Glascock (UK), described a new method of tritium analysis in which the tritiated water was reacted with butyl magnesium bromide to produce butane. The method, particularly valuable for multiple labeling experiments, was applied to studies of fatty acid synthesis. It was shown that, in agreement with theory, the isotopic ratio, tritium to deuterium, was different at a site of net synthesis than at a site at which only turnover was occurring. Double labeling experiments were also used to show that insulin and glycerol stimulate fatty acid synthesis by independent mechanisms.

The next paper, No. 710, presented by A. V. Palladin (Ukr. SSR) and titled "Use of Radioactive Isotopes in the Study of the Functional Biochemistry of the Brain" by Palladin and G. E. Vladimirov, reviewed the work of many institutes on turnover studies in brain tissue. Using radioactive carbon and phosphorus, experimenters found that turnover of protein proceeded more rapidly in the functionally complex and phytogenetically young sections of the central nervous system than in the older and simpler parts. Another conclusion was that excitation increased incorporation of P 32 into ribonucleic acid, phospholipides, etc., whereas narcosis caused a decrease in this incorporation.

Next, D. E. Koshland, Jr. (US) presented paper No. 262, "Use of Isotopes in the Study of Enzyme Mechanisms", which described two general types of isotopic use in this field: (a) the use of a labeled atom to delineate the type of enzyme-substrate intermediate in a complex enzymatic reaction and (b) the use of isotopes to substantiate a theory on the nature of enzyme catalysis. The first application was to the problem of peptide-bond formation and established that in the synthesis

1035387

of glutamine a phosphorylated intermediate must be involved. The second application was to a theoretical prediction of bond-splitting which was supported by isotopic experiments with invertase and beta glucosidase. The theory thus supported was that the orientation of the catalytic groups was a major factor in enzyme catalysis.

A paper by F. J. Dixon (US), "The Role of Radioactive Isotopes in Immunological Investigation", described the application of S 35 and I 131 to studies on immunity. The tracer studies showed that antibody synthesis in the primary response was maximum near the end of the period when antigens could be detected in the host, and this rate decreased precipitously to negligible levels shortly after the antigen could no longer be detected. In contrast, during the secondary response, antibody synthesis was demonstrable for long after the elimination of the antigen.

E. D. Bergman (Israel) presented the next paper, No. 776, for B. Shapiro and G. Rose, "Application of C^{14}-Labeled Substances in the Study of Adipose Tissue Metabolism". Bergman described the use of radioactive substrates which showed that lower fatty acids were activated at a considerably slower rate than the higher fatty acids. Starved rats increased glycogen synthesis due to a block in the catabolism of glucose beyond the glucose phosphate stage,and a diversion to glycogen synthesis.

P. Fromageot (France) presented paper No. 377, "Utilization of Sulphites by Higher Animals", by Fromageot and F. Chapeville. Reactions paralleling the carbon dioxide fixation and transamination reactions were observed for SO_2 and sulphur compounds. In accordance with deductions by analogy it was possible to isolate cysteinesulfinic acid formed by transamination from sulfinylpyruvic acid.

Paper No. 686, "Investigation of the Incorporation of Amino Acids into Proteins In Vivo and In Vitro", by V. N. Orekhovich, presented by A. M. Kuzin (USSR), described the incorporation of labeled amino acids into proteins. In chicken eggs the tracer studies showed that the proteins of the yolk and the white of the egg did not incorporate radioactive carbon, whereas the embryo proteins did. In guinea pigs it was shown that healthy pigs incorporated the C 14 of labeled glycine into their collagen and procollagen, whereas scorbutic animals did not. The authors concluded that incorporation of amino acids occurred only in the course of synthesis of the proteins and not as a result of renewal.

Paper No. 260, presented by G. B. Brown, "Pathways of Biosynthesis of Nucleic Acids", described using two or three isotopes and determining that the purine ring remained intact during certain metabolic transformations. Likewise the pyrimidine-riboside moiety was transferred intact, but the phosphate was metabolized independently.

1035388

Direct conversion of ribosyl to deoxyriboxyl derivatives was indicated by comparison of isotopic ratios.

The final paper, No. 457, "Studies on the Incorporation of Radioactive Precursors Into the Nucleic Acids and Related Compounds of Living Cells" by R. M. S. Smellie and J. N. Davidson, was presented by Smellie (UK). The paper described improved analytic procedures for analyzing the isotopic contents of nucleotides. Applying these to the problems of nucleic acid systhesis in living systems, the author found that nuclear RNA turnover was greater than that of DNA or cytoplasmic RNA, while DNA exceeded cytoplasmic RNA only in the appendix and bone marrow.

SECTION 17C - RADIATION SAFETY RECOMMENDATIONS AND CONTROL; HAZARDS RELATED TO URANIUM MINING

by Walter D. Claus

W. V. Mayneord (UK) presided over the first part of Section 17, dealing with radiation controls, the vice-chairman, J. C. Coursaget (France) over the second part, dealing with uranium mining protection.

Paper No. 451, "Radiation Injury and Protection - Maximum Permissible Exposure Standards", presented by W. Binks (UK) reviewed recommendations by the International Committee on Radiation Protection, and called for greater research. In view of possible genetic influences which could result from radiation, including radiological exposures in medicine, he called for a careful recording of exposures to total populations. He noted that a 30-year average for medical exposures, spread over the whole population, amounted only to 0.1 r per generation.

Question: Bale (US) asked Binks to speculate on what might reasonably be described as an "over-exposure" which should receive special attention. Answer: Binks stated that if a 13-week total were less than about 4 r, no action was taken. If 4 r were exceeded, he suggested medical supervision and a reduction of the average exposure to 0.3 r/week.

Question: Parker (US) commented that, for genetic effects, the effective exposure was that received before the conception of each child. Did Binks have data on how this would modify maximum permissible exposure for whole populations? Answer: Binks said the suggested total exposure limit of 50 r per person applied through the child-bearing period, but even this limit needed a great deal more experiment and thought.

Question: Parker (US) cited that maximum dose to the eye was set at 0.3 rem per week, and asked if neutron irradiation were involved would conversion from RADS to rems in the eye be different than in the surrounding tissue. He asked whether it could be assumed that rbe factors were liberal enough to take care of this. Answer: Binks said this again was a weakness in knowledge -- practically, he said special effort is made to prevent irradiation of the eyes with neutrons.

1035389

R. S. Stone (US), in presenting paper No. 89, "Maximum Permissible Exposure Standards", gave a history of the development of the concept of permissible radiation dosage. It considered various effects anticipated, including genetic, and closed with an appeal that, in view of the unsatisfactory nature of the data on which permissible levels were based, exposures should be kept to the lowest possible level.

Question: Morgan (US) asked if Stone felt that blood-counts were not a logical part of personnel monitoring. Answer: Stone remarked that it was difficult to distinguish changes due to radiation from changes due to general health conditions. Changes that might be due to small doses were extremely difficult to prove of importance. Long-range studies of hospital patients receiving high doses of radiation have shown that they recovered normal blood counts. There was no evidence that small changes, such as increase in bi-lobed lymphocytes, were of any consequence to health. Blood counts were a valid part, however, of examination following a supposed over-exposure.

Paper No. 79, "Maximum Permissible Concentration of Radioactive Isotopes in Air and Water for Short Period Exposure" by K . Z. Morgan et al. (US), reported on a complex study of considerations in fixing the maximum amounts of various radioactive substances which could find their way into the body in a single emergency incident without exceeding permissible levels. . Permissible amounts were based on succeeding doses to the body of 0.3 rem per week, 15.7 rem in the next year, or 150 rem in 70 years, depending on the radioactive material.

Question: Claus (US) asked why, if the gastrointestinal tract were now considered the critical organ affected by many isotopes, this was not included in Handbook No. 52. If a revision of Handbook No. 52 were contemplated, how would present maximum permissible concentration (MPC) be affected? Answer: Morgan said the fact was not used in Handbook No. 52 because only recently have data, particularly UK data, indicated that the gastrointestinal tract received the most radiation from many ingested isotopes. The MPC's would presumably be revised downward for a large proportion of the radioisotopes.

Question: Tarasov (USSR) asked what were the basic criteria for calculating permissible internal and external exposure. Answer: Morgan remarked that bone exposure was based on an assumption that 0.1 microcurie of radium in the skeleton was safe. Other bone seekers were assumed to have a "non-uniformity distribution factor of five", compared with radium and calculations were based on energy relationships. Exposure to the whole body must not exceed 0.3 rem per week, average.

Paper No. 689, "Health Protection of Workers Exposed to Ionizing Radiations" by A. A. Letavet, was presented by F. G. Krotkov (USSR). The USSR Ministry of Health code included a six-hour working day (in certain cases, 5 hours), and 24-day to 30-day paid vacations for radiation workers. Rest homes, 70% paid for by the State, also were available for them. 0.05 r/day was the maximum permissible dose (rather than 0.3 per week or

1035390

3.0 r per quarter), the rates having been computed on the basis of studies on animals. He further stated that the USSR paid great attention to neurological effects.

Question: Taylor (US) asked what evidence he had that a permissible exposure rate of 0.3 r per week was more harmful than a rate of 0.05 r per day. Secondly, how had he measured 0.05 r per day on a mass basis? Answer: Krotkov answered that it was a basic assumption that the limit of 0.05 r/day was less hazardous since large fluctuations were eliminated. The large number of required observations daily was made by many operators with a variety of instruments.

Question: Morgan asked (1) if Krotkov reduced the values listed in Table 3 by a factor of about 10 for residential sections; (2) whether his reference to a "committee of physicians and physicists" implied that there was a group of professional Health Physicists in the USSR. Answer: (1) Yes. (2) USSR did not have special medical physicists. Both physicians and physicists were consulted by the Division of Labor Hygiene.

Question: Morgan (US) and Jammet (France) asked about neurological symptoms. Answer: These were extremely difficult to discuss. Krotkov invited Jammet, Morgan and others interested to a round-table discussion.

Question: Cambel (Turkey) asked if higher salaries were paid to radiation workers and scientists, and did the Ministry of Health have control of all radiation hazards. Answer: (1) Higher salary rates, paid vacations and improved dietary norms -- also rest homes and sanataria at reduced rates were provided. (2) In answer to the second question, Krotkov stated that the Ministry of Health had full control.

Paper No. 907, "The Protection of Workers Against Ionizing Radiations" by K. L. Goodall (UK), presented the ideas of the International Labor Organization for a program to make possible the safe use of radiation isotopes and devices, especially in under-developed areas which did not have good protection organizations. ILO was drawing up a model code of regulations on the assumption that its effort should be devoted primarily to the protection of workers in radiation industries. The ILO program suggested (1) a 40-hour week with 4-5 weeks' consecutive vacation; (2) education of workers to obtain their complete cooperation; (3) a standard form for world-wide recording of exposures, blood examinations and medical records; (4) continued concentrated study of radium workers, many of whom were still working in the industry; (5) more studies on radon exposures in uranium mines; (6) safety precautions in labeling and shipping.

Paper No. 792, "Measurements of Low-Level Radioactivity, Particularly the Gamma Radiation from Living Subjects", presented by

1035391

R. M. Sievert (Sweden), described an attempt to ascertain whether any correlation existed between natural radiation observed and health conditions of a population, or the incidence of dominant mutations. A mobile laboratory was built to make measurements close to the source, and radon concentrations in various types of houses were measured. Doses were found to lie in the range of 1 to 10 mr per week with very few greater than 5 mr/week, so that project was dropped.

The Swedish group studied natural gamma radiation from persons not occupationally exposed, and found that males showed more gamma radiation than females, and young people more than older people — probably due to K 40 gamma being absorbed in fat layers. Because of genetic potentialities, Sievert stated, exposures should be kept to lowest possible amount; an international protective organization was needed to carry out broad research on genetic effects.

Question: Taylor (US) remarked that Sweden had developed one of the world's most complete sets of data on the exposure of all kinds of persons to radiation. He asked if there were any long-range plans for analyzing these data, particularly from the genetic point of view. Answer: Sievert said they had discussed the possibility but did not have suitable facilities available. Such studies should be made on an international basis.

Vice-Chairman Coursaget, presiding over the second part of the section, called for paper No. 370 by H. Jammet and J. Pradel (France) on "The Problem of Radon in Uranium Mines". Jammet said the standards set by ICRP were necessary but difficult to provide. The paper was limited to measuring radon exposures but recognized potential hazards of other air contaminants. Measurements were made near individual miners with a charcoal absorber. Concentrations found often exceeded the MPC of 10^{-10} curies per litre of air. Various methods such as ventilation, eliminating drainage waters, and spraying ore walls have been tried, but to meet protection standards, mining techniques should be improved and severe discipline maintained. Those responsible for production were not inclined to attempt to reach safer levels than specified.

Question: Eisenbud (US) stated that in the United States, non-uranium mines often contained radon in excess of 10^{-10} curies/litre. He asked if Sievert had made observations in other than uranium workings. Answer: Sievert answered in the negative, but stated that he had noticed that in certain areas, normal air sometimes exceeds 10^{-10}. Radon concentration in the air was a function of climatic and geological conditions.

In presenting paper No. 85 by M. Eisenbud and J. A. Quigley (US), "Industrial Hygiene of Uranium Processing", Eisenbud reported that when soluble uranium compounds were inhaled, the hazard was a possible chemical effect on the kidneys, rather than radiological. In discussing exposure to insoluble radioactive dusts, Eisenbud reported

1035392

that autopsy examination of lungs of two miners who had been exposed over a period of 13 years showed low accumulations of insoluble dusts and no pathology, and thus suggested that the present MPC might be lower than necessary.

Question: Bale (US) asked if he had an explanation for the difference between predicted and observed content of uranium in the lungs of the two autopsied miners. Answer: The basis of MPC was experiments performed on dogs with dusts of lower density and higher concentrations than usually encountered, with the results extrapolated to predictions for man. There was a possibility that our estimates of the exposure of the miners might have been excessive.

Question: Cambel (Turkey) asked what was the effect of uranium on the kidneys of animals and what were the effects on other organs. Answer: Farr (US) answered that soluble uranium salts administered to dogs caused destruction of the tubules of the kidneys. These were replaced by a new type of cell which functioned adequately and which was much more resistant to uranium damage than the original cells. Later, tests of some human patients showed no evidence of progressive renal damage from soluble uranium ingestion.

SECTION 18C - HAZARDS RELATED TO REACTOR AND CHEMICAL PROCESSING; ECOLOGICAL PROBLEMS RELATED TO REACTOR OPERATION

by Walter D. Claus

Chairman J. Bugher (US) opened the section.

Paper No. 8, "Health and Safety Activities in Reactor Operations and Chemical Processing Plants", by A. J. Cipriani (Canada), stated that to afford radiation protection, Chalk River found it necessary to keep the organization of control separate from that of operation groups. Constant surveillance and strict control had prevented any sizeable exposure of personnel despite a reactor incident in 1953. It was the practice to consider radiation hazards in early planning of operations, thus doing much to avoid hazards.

In checking on internal exposures of workers through urinary assays, Cipriani reported they had depended on the fact that daily creatinine excretion was relatively constant and related to body weight. Thus, instead of requiring a full 24-hour collection of urine for precise measurements, the excretion of creatinine in a urine sample could be used in estimating the 24-hour excretion of radioactive material as compared with that measured in a sample.

Question: Krotkov (USSR) asked if specific treatment was given to workers who became contaminated internally at Chalk River. Answer:

1035393

Cipriani remarked that they were simply removed from the work until the excretion level had dropped sufficiently.

Paper No. 240, "Radiation Exposure Experience in a Major Atomic Energy Facility" by H. M. Parker (US) gave a 10-year summary of numbers of exposure cases of various kinds at Hanford, showing the low incidence of exposure with operating reactors, and the fact that radiation hazards could be controlled economically. Studies strongly indicated that the additional cost of operating to high standards was a relatively small increment to the necessary cost for marginal protection, which cost could be decreased by engineering advances.

Paper No. 452, "Control of Radiation Hazards in the Operation of Medium Powered Experimental Reactors" by W. G. Marley and B. S. Smith (UK) pointed out that protection problems around research reactors were greater than with power reactors, although the potential risk of a major accident would be greater with a large power reactor. He reported the criteria and protective methods in effect at the 6 MW BEPO at Harwell, and emphasized the principle that all staff working in the area should be trained both in elementary health physics and in the use of monitoring instruments, so that they could avoid hazards in normal operations.

Paper No. 845, "Approaches to Treatment of Poisoning by Both Radioactive and Non-Radioactive Elements Encountered in Atomic Energy Operations", by J. Schubert (US), reported on the use of chelating agents which combined with ingested radioactive poison to make them soluble and more easily excreted. EDTA is the most useful chelating agent for removing heavy elements such as radium, plutonium, americium; it was of no use in removing lighter elements such as strontium. BAL (British anti-Lewisite) assisted in the excretion of elements which reacted strongly with sulfhydryl groupings, such as polonium. Citrates were effective and experiments were under way to find means for slowing up their decomposition in the body. Zirconium salts, sometimes in conjunction with EDTA, was under study.

Paper No. 278, "The Absorption of Fission Products by Plants", by J. H. Rediske and F. P. Hungate (US), was presented by H. M. Parker. He reported that vegetation could become contaminated by external deposition of activity, or by uptake from the soil through the roots. Hanford experience indicated that deposition of I 131 on vegetation might be the limiting factor for air discharges from an atomic energy installation. As to absorption through the root systems, addition of stable isotopes to dilute radioactive isotopes might, in fact, significantly increase the absorption. This increase was quite large for iodine, somewhat less for strontium and cesium. He suggested that if Sr 90 should enter the biotic cycle through animals eating contaminated vegetation, in quantities sufficient to be of concern for human consumers, one possible mechanism of removal would be to shunt it into the bones of the animals where it could be stored.

1035394

Question: Wassink (Netherlands) asked if the concentration factors were due to an isotopic effect or to chemical selectivity. Answer: There was no evidence of an isotopic selectivity, hence chemical selectivity was believed to be the explanation.

Question: Kletchkovsky (USSR) stated that activity affected plant roots by radiation, and the effects were greater when plants were raised in soil than when raised in water. Activity in soil might be increased by cultivation, which would spread the activity and permit greater uptake. Answer: Parker said his observations were preliminary and he reported only orders of magnitude of uptake.

Paper No. 280, "The Accumulation of Radioactive Substances in Aquatic Forms", by R. F. Foster and J. J. Davis (US), presented by Foster, was a summary of the uptake of various isotopes by different organisms and their deposition in various parts of fish in the vicinity of Hanford. Concentrations of short-lived isotopes were found to be of little consequence in higher organisms such as fish. Radio-phosphorous, however, might be concentrated 100,000 times. The power of some aquatic forms to concentrate some radioisotopes indicated a need for careful consideration of potential hazards prior to disposal of wastes to public waters. Foster believed that fish would be unsafe for human food if raised in water containing a maximum permissible level for drinking purposes of phosphorous 32.

Question: Gopal-Ayengar (India) asked if Foster had any information about preferential uptake of fission products into different parts of cells. Answer: Foster indicated that he had no information on actual distribution in plant cells. They would like to know as a first approximation how much was on the exterior and how much in the protoplasm.

Question: Pora (Rumania) asked if there was possibly an accumulation of isotopes in aquatic animals through osmotic phenomena. Answer: No tests were made on osmosis since all studies were in fresh water environment. Observations on transfer across gill membranes of fish showed very rapid transfer of sodium but very slow transfer with phosphorous.

Question: Cambel (Turkey) asked if studies had been made on migrating fish and on the migration of plankton, and on the migration of fish during spawning period. Answer: Foster replied that contamination in fish served as a tracer for migration of fish to other areas. There was migration of planton in Columbia River, but it was due to the strong river currents which swept them and radioactivity down the river. The vertical rise and fall of plankton between day and night could be observed through radioactivity was observed in salmon eggs, but the fish matured in the ocean, carrying little trace of the original radioactivity that had been in the eggs.

1035395

Question: Odum (US) remarked that he had had the impression that the concentration of activity in streams was less than in ponds, such as White Oak Lake at Oak Ridge. Answer: Foster replied that in ponds, elimination of activity was necessarily due mostly to adsorption into food chains and bottom mud, and to natural decay. In rivers, some activity was swept away, although some was also accumulated in bottom muds and organisms.

Paper No. 281, "Radioactivity in Terrestrial Animals Near an Atomic Energy Site", by W. C. Hanson and H. A. Kornberg (US), presented by Parker, completed the Hanford series. The researchers found a P 32 concentration was 1,500,000 times greater in the yolk of water fowl eggs than in the water; but no deleterious effect was observed on egg hatchability, or on the fertility of adults developed from the eggs. P 32 deposits in water fowl around Hanford generated doses or about one RAD per day. In coots, the principal accumulation was cesium in the muscle and strontium in the bone (concentration factor about 1,500). Iodine 131 concentration in the area could be monitored biologically by capture of jack-rabbits, provided other seasonal factors were considered. Radioactive particles found in lungs of rabbits supported an expectation that inhalation of like particles constituted an insignificant hazard to man

Question: Mawson (Canada) asked if rapid uptake of phosphorous by bacteria had been considered as part of the mechanism of concentration. Answer: Parker stated that bacteria as such had not been considered, although incidental observations, such as adsorption on glassware, supported the idea that bacteria might play a significant part in chain of concentration.

Paper No. 393, "The Behavior of I 131 and Sr 89 and 90 in Certain Agricultural Food Chains", by R. Scott-Russell et al. (UK), was presented by Scott-Russell. He reported that when grazing animals such as cattle must get all their food from local vegetation, and thus ingest radioactive material which deposits out from large amounts in air, the concentration of activity permitted in air for human breathing purposes was far too high for safety. Iodine and strontium found their way into milk. After a period for equilibrium with calcium to be established, 3×10^{-4} microcuries of strontium per square meter per day was calculated as the maximum permissible dose for vegetation. The problem was of special importance in England where reactors must be located near agricultural areas. Permissible concentration of I 131 was over 100 times less when grazing was considered than for human breathing purposes. Since monitoring of stock effluents was very difficult, monitoring of vegetatation was proper.

Question: Parker (US) stated that experimental work on sheep had shown damage at 5 microcuries of I 131 per day intake, and no damage at 0.15 microcuries per day. These were respectively 150 and 4 rad per

1035396

week. The lower level corresponded to 2×10^{-5} microcuries of I 131 per gram of vegetation. It was believed that the accepted limit should not exceed this. He asked would Scott-Russell care to comment on this figure compared with his value of 3×10^{-4} microcurie per gram. Answer: Scott-Russell answered that herbage intake by animals under Hanford conditions was several times greater than in UK studies, hence the two figures might not be so far apart.

Question: Parker (US) observed that Scott-Russell emphasized both I 131 and Sr 90 as important contaminants of grazing land. Hanford experience showed radiostrontium contamination was insignificant. Scott-Russell was asked if he knew of any data results to the contrary from industrial and similar installations. Answer: He replied that because strontium concentrated in milk, it was considered as part of the general case. Chamberlain remarked that since it was not always possible to identify fission products in low concentrations, at times they must be considered as if they were all strontium.

Question: Parker commented that Scott-Russell assumed that plants derived their calcium from the upper 25 cm. of soil. Such deep-rooted plants as alfalfa and Russian thistle could recover strontium from much greater depths and could be used as underground leak detectors. He asked whether this uptake might not also be true for calcium. Answer: Scott-Russell said that 25 cm. was only a figure for discussion. Most roots did not tap the soil below 20 cm., although absorption from greater depths might be possible.

1035397

"C" SECTIONS — RADIOACTIVE ISOTOPES

SECTION 19C - GENERAL USES OF RADIOACTIVE ISOTOPES; GENERAL ASPECTS; PRODUCTION AND HANDLING OF RADIOACTIVE ISOTOPES

by Paul C. Aebersold and A. Rupp

Chairman W. F. Libby, in opening the section, emphasized the broad and growing usefulness of isotopes in all fields, and said that in some aspects their applications have only begun to be realized. He pointed out the wide availability of radioisotopes from many countries, and mentioned the U. S. intention to continue to assist other nations in obtaining their isotope needs and in utilization. He said the United States was simplifying procedures and reducing costs to assist international distribution.

Paper No. 985, "The Use of Radioisotopes in Australia" by C. E. Eddy (Australia), emphasized that although the uses were meager compared with countries with reactors, they were representative of a country far removed from a reactor supply. Since Sydney was 12,000 miles from London, the supply problem was a major difficulty. Usage had been confined almost entirely to isotopes with half-lives of more than several days. Eddy outlined Australian organization and procedures for distribution and control of radioisotopes: a central office with advisory scientific committees. Importation and control arrangements were similar to those used by nations with extensive programs.

Question: Aebersold (US) asked Eddy how much a research reactor in Australia would help in satisfying isotope needs and assisting users. Answer: Eddy said Australia would probably continue for some time to import long-lived isotopes from Canadian, U.S. and UK sources, but that a reactor would permit use of short-lived isotopes, studies of radiation effects on materials, and activation analyses. A country far distant from a reactor could still do a great deal to realize benefits from isotopes, but eventually a local reactor would be helpful.

Paper No. 801, "Report on the Use of Radioisotopes in the Czechoslovakian Republic", by C. Simane, explained that studies have not yet extended over many years and that the first uses were mainly in scientific and medical institutions. The USSR had been supplying their isotope needs. Medical use had developed most rapidly; treatment with P 32 and I 131 had been beneficial to several hundred patients and diagnostic studies exceed 2,000. Czechoslovakia was using

1035398

a wide variety of isotopes in metabolic studies, including Fe 59, Ca 45, S 35, and C 14, and a number in such agricultural studies as physiology of plants, uptake of fertilizers, nutrition through foliage, and animal husbandry.

Simane said industry had been slower to develop uses, but was now making research in metallurgy and wear, and using radiography and thickness gaging. He concluded that usage would grow rapidly when Czechoslovakia had its own reactor with USSR aid.

The closing paper, No. 146, of the first part of the section was by S.E. Eaton (US) on "Radioisotopes in Industrial Research". Omitting applications in control and gaging, Eaton gave examples: activation analysis; completeness of mixing; mode of action of a silver-plating brightener; efficiency of cattle food additives; catalytic cracking problems; fate of sulfur in coal and coke for coking ovens; flow pattern of molten glass; and metallic corrosion and loss of ore dust in blast furnaces.

Opening the second part of the section, A. F. Rupp (US) in paper No. 314 reported on "Large Scale Production of Radioisotopes", describing the program at Oak Ridge National Laboratory and the main processes for producing I 131, C 14, and separating fission products radioisotopes. The role of U. S. private business in secondary processing of radioisotopes was pointed out. The successful separation of kilocurie quantities of fission products, notably Cs 137, from reactor waste and its fabrication into useful radiation sources was reported and illustrated.

Question: Fisher (France) asked what requirements were there for a business concern to handle radioisotopes and were they subsidized by the AEC. Answer: Aebersold answered that the only requirement was that the firm be competent to handle radioisotopes, particularly as regards health and safety. They were not subsidized.

Paper No. 461, "The Production of Beta-Ray Sources for Industrial and Clinical Uses" by P. E. Carter and L. C. Myerscough (UK), described the techniques used at Amersham for producing industrial beta-ray sources. Carter said the principal method was to incorporate the radioisotope with powdered silver, gold or platinum and press it into a billet securely sealed between two covering sheets of precious metal. The billet was then rolled to produce a thin source.

Question: Rupp (US) asked how much carrier-free Sr 90, as the oxide, could be incorporated in the powdered silver matrix, per unit volume? Answer: Carter stated that about 15% by weight could be incorporated.

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Paper No. 886, "Separation of Carrier-Free Isotopes by Diffusion Methods" by K. Samsahl and K. Taugbol was given by E. Saeland (Norway). Saeland described two separation processes (for I 131 and P 32) by diffusion out of the parent target material crystals. (Te O_2 and elemental sulfur, respectively). These methods were said to be simpler than usual US processes and to require simpler equipment. High yields (of the order of 90%) were claimed for these processes.

Paper No. 13, "Current Techniques of Handling and Distributing Cobalt 60 Radiation Sources" was presented by A. B. Lillie (Canada) who described the techniques of loading cobalt into the Canadian reactors and the methods of sealing the finished sources.

Question: Muller (Switzerland) asked what Lillie's opinion was of international standardization of the size Co 60 pellets and sources? Answer: Lillie responded that he did not think standardization of the pellets was necessary, but the external source holder should be standard to allow interchangeability.

Paper No. 69, "Mechanical Arms Incorporating a Sense of Feel for Conducting Experiments with Radioactive Materials" by J. Burnett et al, was presented by R. Goertz (US). Several "master-slave" devices for remote handling were described with the aid of slides.

Chairman Libby, closing the section, again emphasized the great value which use of isotopes could be to nations before atomic power reactors were ready for routine use, and said that everything possible should be done to develop a more widespread and effective use of these peaceful applications.

SECTION 20C - RADIOACTIVE ISOTOPES IN RESEARCH

by R. L. Butenhoff and W. D. Claus

E. Saeland (Norway), opening the section as chairman, pointed to the importance of dosimetry and instrumentation to the nuclear program.

In paper No. 150 "Low-Level Counting and the Future of Isotopic Tracers" W. H. Johnston (US) surveyed various methods and techniques of low-level counting which included the Libby counter and modifications, and liquid scintillation methods. The counter used at Purdue University, employing low-activity shielding and appropriate anti-coincidence circuits, reduced the background counting rate from 450 counts per minute to 2 counts per minute. He pointed out the importance of low-level counting for safely tagging such materials as oil.

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A table recommended the type of low level counter most useful for various samples. Discussion: R. M. Chaudhair (Pakistan) described development of photosensitive geiger tubes for use as high-gain phototubes in scintillation counters. The tubes' nickle cathodes were oxidized, then made photosensitive by discharging the tube in an atmosphere of alcohol and argon gas. The tubes had maximum response between 3300 and 4000 Angstroms. With a radioactive sample attached to the tube, the counting rate was about 20% higher than with the geiger counter alone.

Paper No. 386, "The Dosimetry of Cobalt 60 Gamma Rays and Thermal Neutrons in Heavy Water Piles," by J. Sutton et al., was presented by J. Gueron (France). Silica ampoules of ferrous ammonium sulfate were used to measure doses of mixed radiations as great as 10^6 rep. An aerated system of ferrous ammonium sulfate with lithium sulfate in 0.8 normal sulfuric acid had been used extensively in studying pile reflector radiations. The effects of gamma rays and of neutrons were strictly additive. Oxalic acid-water systems were useful to measure doses of gamma rays as high as 7×10^7 reps, and were independent of neutron flux.

Paper No. 70 by J. S. Laughlin, et al., (US), "Absolute Dosimetry of Cobalt 60 Gamma Rays," demonstrated that it was technically feasible to determine precisely the quantity of energy in a gamma ray beam by means of a calorimeter, sensitive to a temperature change of 10^{-5} degrees centigrade. Such a calorimetric method was suggested as a primary standard for measurement of hard gamma rays.

Discussion: Sevcheuko (Bye.SSR) mentioned work published in the July 1955 "Journal of the Academy of Sciences" (USSR) dealing with a new method of dosimetry for beta-gamma and thermal neutron radiation. It consisted of a 1.6 x 1.5 cm radiation-sensitive glass in a container. After exposure to radiation, fluorescence under infrared gave a measure of doses, 0.005 to 1000 roentgens.

Paper No. 154 "Dosimetry of Reactor Radiations by Calorimetric Measurements," by D. M. Richardson, et al., was presented by C. J. Hochanadel (US). He stated that since the spectrum of radiation from a nuclear reactor was not well-defined, the determination of total energy absorbed in a material required calorimetric measurement. A calorimeter was developed which could distinguish between heat produced within the sample material and that produced in the rest of the apparatus. It was developed primarily for studies on reactor engineering aspects rather than for measurement of dosages of biological interest.

Paper No. 63 "Methods of Measurements of Neutron Flux at Low Levels," by F. P. Cowan and J. O'Brien (US), was presented by Cowan. Threshold detectors, coupled with scintillation techniques, were used to measure low neutron fluxes over energy ranges from 1 to 50 mev. This method would measure fluxes as low as 6.6 neutrons per square centimeter per second at 1.1 mev, and 2.3 n/cm^2 at 20 mev.

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Since fast neutrons were more hazardous than slow neutrons, special emphasis was placed on their detection and measurement. The "phoswich," or phosphor and scintillator sandwich, had been devised for this purpose, consisting of alternate layers of clear crystal or plastic scintillator and the material used for detecting the nuetrons. For example, sulfur interleaved between layers of scintillator plastic, and observed end-on with a photomultiplier tube, formed a sensitive device for measuring neutrons of energy 2.0 mev.

Paper No. 60 "A Gamma-Insensitive Semi-Conductor Fast-Neutron Dosimeter Using Single Crystal Germanium," was presented by B. Cassen (US). It was sometimes desirable to measure doses of fast neutrons differentially in a mixture containing also slow neutrons and gamma rays. A practical dosimeter which had been developed was a germanium wafer 0.16 inch x 0.08 inch. Electrical conductivity of the wafer increased linearly with fast neutron dose between 200 and 4800 rep. Anomalies in the region of 100 rep were being studied with a view to eliminating them, possibly by preirradiation.

The final portion of Section 20C comprised five papers on counting and electronics.

Paper No. 71 "Dosimetry of Ionizing Particles," by G. Failla (US) described the principles and practical problems involved in measuring a dose of ionizing radiation in tissue. The author described various modifications of his "extrapolation chamber," and particularly his "wall-less ionization chamber" to measure the dose received by various amounts of tissue with radioactive material at their centers.

Paper No. 61 "Recent Developments in the Scintillation Counter Field" was presented as a review by G. A. Morton (US). The scintillation counter consisted of a clear phosphor which emitted a flash of light when ionizing energy was absorbed by it. The flash released photoelectrons in a multiplier tube which, with suitable circuits, presented a quantity of electric current proportional to the energy of the ionization. Scintillator-counter systems had been evolved which were invaluable in countless applications requiring ruggedness, speed, high resolution and high electivity for various kinds of radiation.

Paper No. 66 by G. G. Kelley and P. R. Bell (US), presented by Arthur Snell (US) discussed "Methods of Pulse Analysis" in the study of nuclear processes. Ion chambers, proportional counters and scintillation counters were used to obtain electrical pulses, one for each incident particle, whose amplitudes were nearly proportional to the energy lost in the detecting medium. Earlier devices were used to measure the number of incidents in an entire spectrum spread over 120 channels registering concurrently; a more recent 20-channel version had proved less expensive and more versatile. No one type of equipment was most suited to all applications in the field of amplitude or time analysis, and all types were likely to continue in use.

1035402

Paper No. 159, by H. J. Gomberg and M. J. Schlesinger, Jr. (US), described "High Resolution Radiation Detectors in Research" as a means of locating radioactive tracers with high accuracy. Gomberg said present localization techniques provided resolution of only one micron under best conditions, indicating the amount of improvement possible. Present methods included stripping film and liquid emulsions, and the wet collodion process wherein a specimen containing a tracer was coated with a metallic bromide solution of collodion and exposed in a solution of silver nitrate, to precipitate silver at the points of radiation. Newer methods included a thin photographic film suitable for use with the electron microscope, systems utilizing polymerization reactions, and a beta-ray microscope which observed directly the scintillations produced in a crystal scintillator 75-micron field of view.

Paper No. 930 "New Geiger Tube Design-Hollow Anode and Parallel Plate Counters" by J. Hersen et al., (Netherlands), was presented by K. Van Duuren, who stated that halogen counters had been constructed with cathode/anode diameter of 2-4, with low working potential. Flat plate electrodes also showed favorable characteristics. Modifications of these for special purposes were made, such as a 4-pi gamma counter, a wide-angle mica window beta counter, and a thin-wall flow counter.

SECTION 21C - RADIOACTIVE ISOTOPES IN RESEARCH

by E. Epremian

A. H. W. Aten, Jr. (Netherlands) opened the session by commenting that the use of isotopes was older than atomic energy and was a most appropriate subject of discussion at this Conference.

The first paper No. 708, "Application of Tracer Atoms in the Study of the Mechanism of Chemical Reactions" by V. N. Kondratyev (USSR), surveyed problems and techniques in the field, and included such items as combustion of butane; thermal oxidation of methane; accelerators in the vulcanization of rubber; and exchange reactions in iodine compounds.

John Turkevich (US) presented paper No. 163, "Stable and Unstable Isotopes in Heterogeneous Catalytic Reactions." He discussed several basic questions, such as the number of reactants activated and the nature of the activation process. Radioactive tracer research was presented on (1) the use of tritium containing materials to study both the migration of the double bond in butane-1 - butane-2 system, and the tritium exchange between the catalyst and the hydrocarbons; (2) the mechanism of the reduction of radioactive carbon dioxide by charcoal;

1035403

and the reaction between carbon monoxide and hydrogen on an iron catalyst at one atmosphere using radiocarbon. Research with stable isotopes included: study of the products and kinetics of the ethylene-deuterium reaction and that for propylene-deuterium; cyclopropane-deuterium; and others.

J. J. Katz (US), presenting paper No. 149, "Tritium as a Research Tool in Chemistry and Industry" on behalf of W. G. Brown and coworkers, outlined the characteristics and advantages of this isotope and discussed its use. Topics considered were: analytical procedures, synthetic methods, uses in reaction rate and mechanism studies.

Question: Daniels (US) asked Kondratyev to expand on the types of problems and systems to which he and his colleagues had applied the methods described. Answer: Kondratyev stated that considerable data had been obtained on the structure of molecules and their mobilities, particularly the bromides; much of this had been published or would be soon.

Question: Kondratyev asked Turkevich's opinion on the USSR theory of hydrolysis and catalysis. Answer: Turkevich replied there was a similarity between the USSR theory and the ideas expressed in his own paper. He had received inspiration from USSR work, but their theory had certain limitations and the US work had gone beyond it.

Paper No. 632, "Quantitative Determination of Impurities in High-Purity Metals by Radioactivation Analysis" by V. V. Jakovlev, was presented by A. P. Vinogradov (USSR). Particular attention was given to: determination of rare earth impurities in graphite, beryllium oxide, bismuth, and lead; also copper, antimony, molybdenum, and zinc in germanium.

Paper No. 706, "Application of Radioactive Isotopes in Chemical Analysis", prepared by I. P. Alimarin and presented by A. P. Vinogradov (USSR) covered a range of basic and applied investigations.

Paper No. 770, "Recent Advances in Radioactivation Analysis", by A. A. Smales (UK) gave emphasis to geochemical applications and to semi-conductor silicon.

Question: H. Brown (US) questioned Vinogradov concerning the use of charged particles to activate elements difficult to activate by neutrons. Answer: Vinogradov indicated that the USSR had not carried out this work but planned to do so, using deuterons for Nb, V, W, and Cr.

Question: Saeland (Norway) asked whether Smales had used zinc in aluminum or in aluminum oxide. Answer: Smales replied in the negative.

1035404

Question: Rodden (US) asked Smales what the best neutron source would be if a reactor were not available. Answer: Smales replied that without a reactor it would be impossible to obtain the desirable degree of sensitivity.

Question: Answering a query from Kaufmann (US), Vinogradov stated that low amounts of oxygen in metals could easily be determined. Both Leveque (France) and Smales said they could determine oxygen in metals with a sensitivity of one part per thousand.

The last part of the section, devoted to using tracers in metallurgical research, contained one paper, No. 702, "Investigation of Diffusion and Atomic Interaction in Alloys with the Aid of Radioactive Isotopes", by G. V. Kurdyumov (USSR).

Question: Walton (UK) asked if the USSR had studied the diffusion of sulfur, phosphorus, and other non-metals in metals, and also whether they had investigated the influence of irradiation on diffusion. Answer: Kurdyumov replied that the former had not been done; he did not know about the latter.

Question: Epremian (US) emphasized the importance of determining the diffusion coefficient and activation energy for both elements in a binary alloy; he also gave a brief review of US tracer research on diffusion and asked if the USSR had measured diffusion in a uranium single crystal. C. S. Smith (US) asked about the effect of the martensite transformation on diffusion and the influence of grain size and subgrain size. Answer: Kurdyumov stated the grain size was large and therefore should not have affected the results. The subgrain size as determined by X-ray diffraction was on the order of 10^{-5} cm in diameter. This subgrain size tended to increase with increase in temperature but did not alter significantly up to 1000°C. It was also stated that the USSR had not measured the self-diffusion of uranium.

SECTION 22C - RADIOACTIVE ISOTOPES IN CONTROL AND TECHNOLOGY

by E. Epremian

In his opening remarks, Chairman G. V. Kurdyumov (USSR) placed emphasis on the use of isotopes in the improvement and control of processes in the metallurgical industry.

J. L. Putnan (UK), the first speaker, in paper No. 463, described the "Development in Thickness Gauges and Allied Instruments". He discussed devices for measuring the thickness of pipes as well as coatings, the use of a portable neutron source to distinguish between crude oil and brine in a borehole, and the use of gamma rays for sorting coal and shale.

1035405

Paper No. 164, "Versatility of Radiation Applications Involving Penetration or Reflection" was presented by P. C. Aebersold (US) for C. E. Crompton. Many applications were reviewed, including sulfur analysis (absorption of X-rays), measurement of the density of silt at the bottom of large bodies of water (beta rays from strontium 90), and measurement of the H/c ratio in hydrocarbons (also strontium 90).

S. T. Nazarov (USSR) gave paper No. 704, by G. G. Iordan et al., on "Application of Radioactive Isotopes in Technological Process Control Instruments." Nazarov gave emphasis to the gaging of continuous rolled steel strip, measurement of thickness of coatings, recording the level of liquids in sealed vessels, and the marking of steel strip as described in the proceedings of the Moscow USSR conference on atomic energy in July 1955.

Question: Gianella (Switzerland) asked Putnam about testing the steel linings of pen stocks by reflection techniques. Answer: Putnam said it would be possible provided the detector could be placed against the surface.

Question: Putnam (UK) asked Aebersold about the possible effect of soil contaminants which could absorb neutrons. Answer: This would be a problem in salty soils, Aebersold said; concerning the accuracy of the measurements, Aebersold said the device he had described was intended for ordinary highway and airport construction.

Question: Eaton (US) inquired whether the Russians saw any particular advantages in the low pressure manometer described by Nazarov and whether it was being used. Answer: Nazarov said it had certain advantages and was used for research purposes.

Question: Gomberg (US) questioned Nazarov about a pipe-seam detection device, in particular about the size and density of a defect which could be picked up and also how close the scintillometer should be to the sample. Answer: The reply was that the method was less sensitive but more rapid than X-rays.

P. Leveque (France) presented paper No. 383, "Studies and Industrial Applications of Bremsstrahlung from the Beta Rays of Yttrium 90", which discussed possible uses.

In paper No. 462, "Application of Radioisotopes to Leakage and Hydraulic Problems", prepared by J. L. Putnam and S. Jefferson (UK), Putnam emphasized the detection of water main leaks and the study of silt movements in the Thames River.

A. M. Samarin (USSR) gave a comprehensive summary of USSR work on the "Use of Radioactive Isotopes in the Study of Steel and Pig Iron Production", paper No. 707. The subjects included: thermodynamic

1035406

functions and kinetics of reactions; sources of inclusions in steels; solidification in cast ingots; blast furnace reactions; ore benefication; and production control.

A second paper, No. 713, given by Samarin for D. B. Grozin (USSR) on the "Use of Isotopes in the Study of the Wear of Machine Parts", stated the work had led to the optimum conditions and duration for breaking in a new aircraft, tractor or automotive engines,and also improved lubricants.

Question: Saeland (Norway) asked Leveque about the size of his source. Answer: If the source were too large, one encountered self-absorption. Leveque favored a 1 curie or 5 milligram strontium source.

Question: Aebersold observed that the USSR used phosphorus and sulfur isotopes in production, and since these entered steels used for general purposes, he wished to know what tolerances had been placed on this in consideration of the health hazard. Answer: Samarin replied that these isotopes were so dilute they presented no problem; they had not set any tolerances.

Question: Gombert (US) inquired about the use of autoradiography on inclusions in steel and asked for the practical limit of resolution. Answer: Samarin's reply was that they had learned to change the refractory used for linings to minimize inclusions; the details were in a report of the Moscow Steel Institute.

Question: Leveque (France) brought out from Samarin the fact that the USSR work on wear had a precision of 5 to 10%. Gomberg asked Leveque if he had made any tests on a tungsten target; the investigator had not, and had used lead as an absorber.

M. Kato (Japan) gave paper No. 1054, "Brief Review of the Applications of Isotopes in Process and Quality Control". These included: a gamma-ray liquid level meter, the behavior of silver as an impurity in the electrolytic refining of copper, the kinetics of the slag-metal transfer of sulfur, the absorption of certain agents on silver bromide photographic and emulsion, etc.

U. Been (Norway) in paper No. 882, "Some Industrial Uses of Radioisotopes in Norway", by Been and F.Saeland, cited five instances, namely: (1) flow control on rotary cement kilns, (2) loss of catalyst in nitric acid production, (3) wear of turbines due to cavitation, (4) efficiency of mixing in the production of carbon electrodes and, (5) monitoring of fluorine compounds from stock gases.

Question: Aebersold (US) asked Kato about the use of isotopes for determining transit times and distribution of materials through the steaming pipe where starch was saccharified and whether this was used industrially. Answer: Kato discussed the application.

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Question: Gomberg (US) asked Been why isotopes were added over a 2-hour period rather than in one batch in the rotating kiln experiment. Answer: Been said he preferred this procedure so as to obtain an average.

SECTION 23C - FISSION PRODUCTS AND THEIR APPLICATIONS

by B. Manowitz, B. E. Proctor and E. Epremian

The closing "C" Section was divided into three parts, each of which considered a particular peaceful application of fission products, essentially the wastes from atomic reactors. In the first, radiation-induced polymerization was discussed; in the second, the use of radiation to sterilize food; in the third, conversion of radiation directly into electricity. J. Gueron (France) chaired all three parts of the section.

Paper No. 168, presented by J. J. Martin (US), "The Effect of Gamma Radiation on Some Chemical Reactions of Possible Industrial Importance", by B. G. Bray et al, reported on radiation-induced polymerizations and halogenations. Data were given on polymerization of ethylene in a radiation field, including yield data and physical properties.

Of chlorination of benzene and other hydrocarbons, Martin said additional compounds seemed to be favored with the production of different products than by the standard method. Cost estimates were given for benzene hexachloride production.

Paper No. 465, by A. Charlesby (US) "Recent Developments in the Irradiation of Long-Chain Polymers" discussed the mechanism of cross-linking and chain-cleavage. Gel formation in dilute solutions provided a technique for the study of the direct and indirect effects of ionization.

Question: Magat (France) commented that to achieve rapid utilization of fission products it would be necessary to experiment with appreciable quantities so that the effect of intensity on reaction rate and on reaction products could be determined. He pointed out that weak sources would spread out evenly so that there were homogeneous fields and this might turn out to be more useful than very intense sources. The answer was required soon. As an example, in the polymerization of methyl methacrylate 100 curies at one intensity could produce 20 to 25 tons a year. By increasing the intensity fourfold, the yield was increased by a factor of less than two. G values should be given as a function of dose rate. The yield of primary radicals was a better way of describing radiation processes.

1035408

Answer: Martin remarked that the comments were well made on intensity effect. The University of Michigan's calculations assumed a linear effect because it gave a conservative cost estimate. Experiments in the benzene hexachloride system indicated that the yield was independent of dose rate.

Question: Leveque (France) asked for an explanation for the differences in polyethylene yield. Tests at the same temperature and pressure, according to the data given, gave different results by a factor of 3. Answer: Martin replied that a variation in polyethylene yield was found. Inhibitor studies (O_2) were carried out to find the reason for the variation, and very pure ethylene was used. The yield for pure ethylene was four times greater. The variation probably was due to an inhibitor and very pure chemicals would give higher yields. The same effect was observed in hydrocarbon halogenation. A new purification technique was being worked out involving a short radiation exposure, then a distillation. The distillate was used in the experiments and gave a higher yield.

Question: Drimus (Romania) reported exploring several methods for making benzene hexachloride including UV, free radicals (without light), liquid Cl_2 (without light). All methods gave the same yield. Drimus believed that gamma radiation would be superior because it would give a greater output. Answer: Martin said the problem of increasing the per cent of gamma isomer was being worked on and results indicated that the yield depended on temperature rather than intensity. Temperatures of 0^oC and lower were now being investigated with a hope of increasing gamma isomer yield.

Question: J. Gueron (France) asked if Martin could compare the polyethylene prepared or modified through radiation with the German polyethylene polymer recently produced. Answer: Martin replied that Ziegler process material was not available so no direct comparison could be made, but probably the radiation polymer was more highly cross-linked. Charlesby (UK) remarked that densities could be compared. Both Ziegler and radiation polymers were more crystalline than the standard polyethylene.

Magat (France) stated that Charlesby mentioned an O_2 effect. Magat noted that O_2 played an important part in this work. The Russians and the French had shown through infra-red spectroscopy that O_2 created intramolecular bridges. Some of these broke at 80^oC to 150^oC — possibly the peroxide groups. Magat said that in France they added acrylonitrile to air irradiated polyethylene heated at 120^oC. The polyethylene was swelled and prompt polymerization occurred. The polyacrylonitrile was fixed in P. E. chains to form a grafted copolymer. This offered a new way of making a material difficult to prepare by other techniques. In the graft operation, moreover, the form of the material was retained.

1035409

Graft copolymers offered a rapid application of radiation since techniques were simple and the dose requirements were low.

In presenting paper No. 172, "Progress and Problems in the Development of Cold Sterilization in Foods" by B. E. Proctor and S. A. Goldblith (US), Proctor gave a concise review of 11 years' endeavor in the field of radiation sterilization at Massachusetts Institute of Technology.

He reported that their data related to various types of micro-organisms and their sensitivity to radiation, the considerations necessary when determining the magnitude of the sterilizing dose, the effect of radiation changes on food components and the factors which influenced such change. He further reported the protective action which may have resulted from combining one radio-sensitive chemical compound with another which changed the sensitivity of the two components. This phenomenon might be used to advantage in some food radiation sterilization processes by using some compounds to protect others.

He emphasized that some food enzymes required 10 to 20 times the normal food sterilization dose, which was approximately 2 million rep, for their inactivation. This indicated that some other means of enzyme inactivation might be required. One suggested possibility was high-frequency heating by electricity.

The problems in food sterilization by radiation today related primarily to changes in flavor, color and texture which might and frequently did occur at sterilization levels. These changes might be alleviated by irradiation of food in the frozen state, irradiation in inert atmospheres, or addition of free radical acceptors such as ascorbic acid. Much study was being given to these and alternate means of controlling changes.

Complete answers for permanent preservation with no detectable changes were being sought by many scientists. Speculation had been raised concerning whether any compounds of toxic nature might be formed by irradiating foods and numerous tests were currently under way to determine these facts. Limited published reports indicated no toxic factors, but some loss of nutritive values, such as also occurred in commercial thermal food processing.

That foods, pharmaceuticals and tissues might be adequately sterilized by ionizing radiation was now an established fact, and the levels and types of radiation that might accomplish this sterilization were known, in any type of container currently used for processed foods.

<u>Question</u>: Comar (US) wanted to know what time and effort were necessary to determine by laboratory tests whether foods subjected to

1035410

radiation sterilization might not produce changes undesirable from a health standpoint, when the food was ingested. Answer: Proctor answered that the type and extent of tests outlined by the U. S. Food and Drug Administration required the feeding of large numbers of laboratory animals through several generations for growth and reproduction evaluation, and the feeding of a larger animal type, such as dogs, for a period of a year. Tests might require two years for the consideration of any specific food.

Paper No. 225, "Health Protection Against Food-Borne Parasitic Diseases with Particular Reference to Control of Trichinosis" by H. J. Gomberg and S. E. Gould was presented by Gomberg, who told of several years' study of the destruction by radiation of larvae encysted in meat. He said the results suggested that ionizing radiation might also be used to control such food-borne parasites as beef or pork tapeworm, pork cysticercosis, and hydatid; fish tapeworm infection, Chinese liver fluke, intestinal fluke, and ascariasis.

Gomberg described the typical cycle of trichina larvae in man and animals, and said the larvae could be killed in meat by exposures of about 1 million rep of 250 kv X-rays or Co 60 gamma rays which, however, made the flavor of the pork rancid and sour. About 18,000 rep of Co 60 or Cs 137 gamma rays, or 15,000 rep of 250 kv X-rays would inhibit development of the larvae, and produced no detectable changes in flavor, texture, or appearance of the pork. Sterilization of female larvae could be accomplished by 15,000 rep of Co 60, or Cs 137 Gammas, or 5,000 rep of 250 kv X-rays. These results indicated that 30,000 rep of Co 60 or Cs 137 Gammas, or its equivalent, delivered to pork would prevent and eradicate trichinosis. There was no indication of deleterious side effects which would contraindicate on medical or biological grounds the use of radiation as a means of trichinosis control. Gomberg gave detailed data on methods of using radiation, testing the dosage, and the analysis of results when laboratory animals were fed with irradiated and non-irradiated infested meat.

Gomberg showed a slide of a designed plant which could handle 2,000 hogs a day, and said smaller mobile units could be built, that semi-skilled personnel could handle the operation, and that only routine materials were needed for the structures. He reported that initial contacts with the World Health Organization indicated WHO was willing to act as a coordinating agency for bringing together research workers in various parts of the world to study the problem of constructing pilot plants.

Question: Comar (US) asked if there were any specific tests being made on diseases other than trichinosis at this time? Answer: Gomberg answered that tests on ascariasis lumbar cortis had just started and tests on tapeworm were planned. Gomberg showed some slides on ascariasis eggs, and described their cycle. His tests currently

1035411

were directed at determining the sensitive points in the cycle. To a question from Leborgne (Uruguay) about hydatid, Gomberg urged that this problem be studied in South America where hydatid was most prevalent.

In presenting paper No. 175, "Sterilization of Medical Supplies with Gamma Radiation", by L. E. Brownell and J. J. Blumer, Brownell indicated medical dressings, cotton gauze, instruments and special items such as human bone might be sterilized by the use of gamma radiation, as might pharmaceuticals and antibiotics.

Bulk medical supplies could be sterilized in the final packages with possible savings in packaging costs. He advocated gamma radiation because of its great depth of penetrations, and found the dosage for complete sterilization was 2 million rep.

Tentative specifications for an installation were given, together with calculations for a preliminary design which could be used to irradiate bulk medical supplies in packages (4'x4'x4') using cooling reactor fuel elements as a source of radiation.

The third part of the section, concerned with conversion of radiation directly into electricity, was opened by E. Haeffner (Sweden) who gave paper No. 794, "Study on the Properties of an Electrolytic Cell Consisting of an Electrode System in a Chloroform Alcohol Solution Under Gamma Irradiation", by C. G. Osterlundh and Haeffner. Haeffner described a cell consisting of graphite and lead electrodes with a chloroform-alcohol electrolyte. Details were given for the behavior with various compositions of electrolyte, various irradiation exposures, etc. The efficiency of the cell in converting gamma radiation to electricity was 0.9 %.

E. G. Linder (US) presented paper No. 169, "The Direct Conversion of Radiation into Electricity" for himself and his co-workers. Linder discussed the present role, limitations, and potentialities of the direct conversion: (1) direct charging methods utilizing charged radiation and involving the simple collection of charged particles by an electrode to create a voltage; (2) contact potential methods which might utilize both types of radiation and use contact potential fields to separate charges and produce currents; (3) thermo-couple methods whereby irradiation was used to create heat by absorption which was converted to electricity; and (4) semi-conductor junction methods in which carriers were formed within the semi-conductor by either type of radiation and separated by the internal junction field.

The last method now had an efficiency of 3%. At higher power levels it was estimated this could reach 7%. Other problems yet to be solved in the use of these devices were radiation damage, radiation shielding, and the high cost of radioactive material.

1035412

Question: Turkevich (US) asked whether there was any hope of improving the efficiency of the cell described by Haeffner and, if so, by what means. Answer: Haeffner said that exclusion of oxygen from the solution gave a five-fold increase in current; other means might come from further research.

Question: Gueron (France) asked what part of the output came from absorption of radiation and what from chemical reaction. Answer: Haeffner was unable to say but welcomed a suggestion by Gueron that tracers be used to investigate this point.

Question: Haeffner asked about the probability of low-cost isotopes in the future so that an atomic battery could be operated at higher power and hence higher efficiency. Answer: Rupp (US) mentioned the new facilities for isotope production and expressed a hope that the cost of isotopes would be greatly reduced in the near future.

Question: Epremian (US) noted that there were certain similarities between the semi-conductor atomic battery and the device for conversion of solar energy to electricity and asked Linder to discuss the similarities and differences between these devices. Answer: Linder pointed out that both the atomic and solar batteries use Si and p-n junctions, but, of course, the radiation used differed, and the atomic device would work with charged particles. Another difference was that visible radiation affected only the surface of the component in the solar device while penetration occurred with the other; thus, there was a difference in geometry. With regard to efficiencies, the solar battery had a value of 6 to 10%, and the atomic battery now had a 3% value. This difference was largely due to the difference in input energies.

1035413

ATTACHMENT 1 - TECHNICAL PAPERS REVIEW COMMITTEES

Biology & Medicine

Paul G. LeFevre, Chairman
Roy E. Albert
George V. LeRoy
Marshall H. Brucer
P. K. Smith
Henry S. Kaplan
Earl Green
Willis R. Boss
Nathan J. Hall
Sterling Hendricks
Walter Claus
Hanson Blatz
Lauriston Taylor
Forrest Western
James G. Terrill
Robert Butenhoff
H. O. Wycoff
J. B. H. Kuper

Isotopes

T. R. Jones, Chairman
S. E. Eaton
J. E. Christian
H. E. Skipper
J. E. Willard
Paul Aebersold
George Manov

Raw Materials

Thomas B. Upchurch, Chairman
Alan T. Morphew
Hobart Stocking
Lincoln Page

Reactor

U. M. Staebler, Chairman
J. A. Swartout
Gale Young
Norman Hilberry
Sidney Siegel
Manson Benedict
Henry Hurwitz
C. Rogers McCullough
W. K. Woods
Harvey Brooks
Irving Kaplan
Thoma Snyder
H. Etherington
Titus LeClair
Clarke Williams

Chemistry

George M. Kavanagh, Chairman
Stephen Lawroski
O. C. Simpson
James R. Gilbreath
B. B. Cunningham
I. Perlman
Floyd L. Culler
Charles D. Coryell
A. O. Allen
Daniel R. Miller

Physics

George A. Kolstad, Chairman
William W. Havens
Richard F. Taschek
Donald J. Hughes
Hans A. Bethe

1035414

Metallurgy

Edward Epremian, Chairman
D. W. Lillie
E. C. Creutz
J. P. Howe
R. C. Dalzell
J. F. White

Economics and Law

Dr. Charles Thornton, Office of General Manager, helped to organize an informal group on economics papers, and Mr. William Mitchell, AEC General Counsel, reviewed papers dealing with legal aspects.

1035415

ATTACHMENT 2 - LIST OF US PAPERS SUBMITTED TO UNITED NATIONS FOR GENEVA CONFERENCE

(* Indicates papers presented orally)

SESSION 2 - WORLD ENERGY NEEDS

UN NO. 467	Alternate Energy Sources (Unconventional Types)	Daniels, Farrington
469	A Century of Growth of Electric Power Requirements in the United States	Hughes, E. T.
802*	Energy Requirements and Economic Growth	Mason, E. S.

SESSION 3 - THE BUILDING OF A NUCLEAR ENERGY ENTERPRISE

(Session 3.2 - Capital Investment Required for Nuclear Energy)		
UN NO. 477*	Capital Investment Required for Nuclear Energy	Davis, W. K.
(Session 3.1 - Experience with Nuclear Power Plants)		
UN NO. 851	Design and Operating Experience of a Prototype Boiling Water Power Reactor	Dickson, J.J., et al

SESSION 4 - FACTORS IN THE USE OF NUCLEAR ENERGY

(Session 4.3 - Legal and Administrative Problems)		
UN NO. 319*	The Achievement of Radiation Protection by Legislation and Other Means	Taylor, L. S.
(Session 4.3 - Legal and Administrative Problems)		
UN NO. 320	Insurance for Reactors	Williams, Charles R.
321	Administrative Problems in Radiation Protection in New York State	Tabershaw, Irving R.
322	Industrial Training Aspects of the Peaceful Uses of Atomic Energy	Erhard, Fred W.
323	Workmen's Compensation Aspects of the Peaceful Uses of Atomic Energy	Greene, Bruce A.

1035416

SESSION 4 - FACTORS IN THE USE OF NUCLEAR ENERGY (CONTINUED)

(Session 4.1 - Economics of Nuclear Power)

UN NO. 476*	Economics of Nuclear Power	Lane, J. A.

(Session 4.3 - Legal and Administrative Problems)

UN NO. 854	Some Administrative and Legal Problems Related to the Widespread Use of High Level Radiation Sources	Mitchell, William
855	Problems in the Legal and Administrative Control of a Program for Distribution of Radioisotopes	Cobb, S. P., Jr.

(Session 4.3 - Legal and Administrative Problems)

UN NO. 856	Boiler Safety Codes for Power Reactors	Miller, E. C.
857	Administrative Problems in the Industrial Utilization of Atomic Energy	Manov, George G.

SESSION 5 - THE ROLE OF NUCLEAR POWER IN THE NEXT 50 YEARS

UN NO. 468	The Role of Energy and the Role of Nuclear Energy in the United States	Sporn, Philip
475*	A Study of the Economic Potential of Nuclear Energy	Mayer, K. M.
810	The Outlook for Nuclear Power in Puerto Rico	Mullenbach, Philip
849	Need in the United States for Small Power Reactors	Morris, Samuel B.
863	The Role Which Nuclear Energy Can Play as an Energy Source in the Next 25 to 50 Years	Cisler, Walker L.

SESSION 6 - HEALTH AND SAFETY ASPECTS OF NUCLEAR ENERGY

(Session 6.1 - Biological Effects of Radiation)

UN NO. 478*	Physical Dosimetry and Clinical Observances on Four Human Beings Involved in an Accidental Critical Assembly Excursion	Hasterlik, R. J. Marinelli, L. D.

1035417

SESSION 6 - HEALTH AND SAFETY ASPECTS OF NUCLEAR ENERGY (CONTINUED)

UN NO. 479	A Summary of Radium and Thorium Excretion in Humans	Looney, William B.
(Session 6.2 - Reactor Safety and Location of Power Reactors)		
UN NO. 481*	Experimental Determinations of the Self-Regulation and Safety of Operating Water-Moderated Reactors - Results and Motion-picture Records	Dickson, J. J.
482	Environmental Effects of a Major Reactor Disaster	Parker, H. M.
483	Radiological Monitoring of a Nuclear Release	Griffiths, Percy
572	Radiation from Clouds of Reactor Debris	Holland, J. Z.
(Session 6.1 - Biological Effects of Radiation)		
UN NO. 803	Biological Effects of Radiation	Bugher, John C.
852	Studies on the Radium Content of Humans Arising from the Natural Radium of their Environment	Stehney, A. F.
(Session 6.2 - Reactor Safety and Location of Power Reactors)		
UN NO. 853*	The Essentials of the Evaluation of Reactor Hazards	Teller, E., et al

SESSION 7 - THE USE OF RADIOACTIVE ISOTOPES

(Session 7.1 - Isotopes in Technology and Industry)		
UN NO. 308*	Importance of Isotopes in Technology and Industry	Aebersold, P. C.
(Session 7.2 - Isotopes in Medicine, Biology and Agriculture)		
UN NO. 309*	Radioisotopes in Medicine	Warren, S.
(Session 7.3 - Waste Disposal Problems)		
UN NO. 310*	The Management and Disposal of Radioactive Wastes	Wolman, A.
311	Methods for Decontamination of Low-Level Radioactive Liquid Wastes	Straub, Conrad P.

1035418

SESSION 7 - THE USE OF RADIOACTIVE ISOTOPES (CONTINUED)

UN NO. 312	Low-Level Radioactive Waste Disposal	Geyer, John C.
848	Fundamental Considerations in the Release of Large Quantities of Radioactive Wastes to Land and Sea	Claus, Walter D.

SESSION 24 - CLOSING GENERAL SESSION

(Session 24.2 - Education and Training of Personnel in Nuclear Energy)

UN NO. 755	Education and Training in Nuclear Science and Engineering in the United States	Overman, R. T., et al

(Session 24.1 - International Cooperation in the Peaceful Uses of Atomic Energy)

UN NO. 805*	International Cooperation in Atomic Energy Developments	Libby, W. F.

SESSION 6A - SPECIAL TOPICS IN NUCLEAR PHYSICS

UN NO. 579	Neutron Diffraction Research in the United States	Wollan, E.O., et al
581*	Gamma Rays from Neutron Inelastic Scattering	Day, R. B.
588*	Angular Distributions and Non-Elastic Neutron Scattering	Walt, M., et al
807	Physics Research with Reactors	McReynolds, A.W., et al
830*	The Theoretical Prediction of Neutron Cross Sections of Non-Fissionable Elements for Energies up to 10 mev.	Weisskopf, V. F.

SESSION 7A - FISSION PHYSICS

UN NO. 592*	Determination of Fission Quantities of Importance to Reactors	Leachman, R.B., et al
593*	Theory of the Fission Process	Wheeler, J. A.
836	The Nuclear Fission Process	Huizenga, J. R.

1035419

SESSION 8A - RESEARCH REACTORS

(Session 8A.1 - Survey Papers on Types)

UN NO. 484*	The Nuclear Reactor in Basic Science	Snell, A. H.

(Session 8A.2 - General Principles and Practical Experience)

UN NO. 485*	Materials Testing Reactor Experimental Program and Reactor Operation	Doan, R. L. Huffman, J. R.
486	Research Program and Operating Experience on ORNL Reactors	Ramsey, M.E., et al
487	Observations on Operation, Training and Research Experiences with the Raleigh Research Reactor	Beck, Clifford
804	The Need for Basic Research in an Atomic Energy Program	Johnson, Thomas H.
859	Research Program and Operating Experience on ANL Reactors	Zinn, W.H., et al

SESSION 9A - RESEARCH REACTORS AND DESCRIPTIONS

UN NO. 488*	Design and Description of Water Boiler Reactors	King, L. D. P.
489	The Swimming Pool Reactor and its Modifications	Breazeale, Wm.M. et al
490*	The Materials Testing Reactor and Related Research Reactors	Weinberg, A.M., et al
860*	The Brookhaven Reactor	Fox, M.

SESSION 10A - RESEARCH REACTORS, DESCRIPTIONS: FUEL CYCLES

(Session 10A.1 - Research Reactors, Descriptions)

UN NO. 861	Design and Description of ANL Reactors (CP-3, CP-3' and CP-5)	Zinn, W.H., et al

(Session 10A.2 - Fuel Cycles)

UN NO. 862*	Survey of Fuel Cycles and Reactor Types	Weinberg, A. M.

SESSION 11A - DESIGN OF REACTORS FOR POWER PRODUCTION

UN NO. 492*	A Graphite-Moderated Nuclear Power Plant Design	Carson, A. B.
493*	A Sodium Graphite Reactor 75,000 Electrical Kilowatt Power Plant	Starr, C.

1035420

SESSION 11A - DESIGN OF REACTORS FOR POWER PRODUCTION (CONTINUED)

UN NO. 494*	Liquid Metal Fuel Reactor	Miles, F. T. Williams, C.

SESSION 12A - DESIGN OF REACTORS FOR POWER PRODUCTION (CONCLUDED)

UN NO. 491	A Developmental Fast Neutron Breeder Reactor	Wagner, H. A.
495*	Heavy Water Reactors for Industrial Power Including Boiling Reactors	Iskenderian, H. P., et al
496*	Aqueous Homogeneous Power Reactors	Briggs, R. B. Swartout, J. A.
814*	Review of Fast Power Reactors	Zinn, W. H.

SESSION 13A - POWER REACTORS, PROTOTYPES

UN NO. 497*	The Engineering Design of a Prototype Boiling Water Reactor Power Plant	Harrer, J.M., et al
498*	The Homogeneous Reactor Test	Beall, J. E. Swartout, J. A.
500	Los Alamos Power Reactor Experiments	Froman, Darol
815*	Description of the Pressurized Water Reactor (PWR) Power Plant at Shippingport, Pa.	Simpson, J.W., et al
816	Objectives and Summary of US AEC Civilian Power Reactor Program	Staebler, U. M.

SESSION 14A - POWER REACTORS, PROTOTYPES (CONCLUDED)

UN NO. 499*	The Sodium Reactor Experiment	Parkins, W. E.
501*	The Engineering Design of ERB II, a Prototype Fast Neutron Reactor Power Plant	Barnes, A.H., et al

1035421

SESSION 14A - POWER REACTORS, PROTOTYPES (CONCLUDED)
(CONTINUED)

UN NO. 813*	Operating Experience and Experimental Results Obtained from a NaK Cooled Fast Reactor	Lichtenberger, H. V., et al

SESSION 15A - EQUIPMENT AND TECHNIQUES USED IN MEASURING CROSS-SECTIONS IMPORTANT TO REACTOR DESIGN

UN NO. 573*	Techniques for Measuring Elastic, Non-Elastic, and Transport Neutron Cross-Sections	Taschek, R. F.
574	Pulsed Accelerator Slow Neutron Velocity Spectrometers	Havens, W. W., Jr., et al
576*	Neutron Velocity Selectors Used at Reactors	Hughes, D. J.
577	Time-of-Flight Techniques Applied to Fast Neutron Measurements	Cranberg, L.
580*	Recent Advances in Neutron Detection	Bollinger, L. M.
582	Techniques for Measurement of Neutron Cross-Sections and Energy Spectra for Sources which are Continuous in Energy and Time	Rosen, Louis, et al
584	Cyclotrons Designed for Precision Fast-Neutron Cross-Section Measurements	Thornton, R.L., et al
806*	Time-of-Flight Instrumentation for Neutron Spectrometers	Higinbotham, W. A.

1035422

SESSION 16A - EQUIPMENT AND TECHNIQUES (CONCLUDED):
CROSS-SECTIONS OF NON-FISSIONABLE MATERIALS: DELAYED NEUTRONS

(Session 16A.1 - Equipment and Techniques)

UN NO. 578	Van de Graaff and Cockcroft-Walton Accelerators for Fast Neutron Cross-Section Measurements	Bonner, T. W.

(Session 16A.2 - Cross-Sections of Non-Fissionable Materials)

UN NO. 591*	Summary of Cross-Section Measurements of the Fission Product Poison Xe-135	Bernstein, S.

(Session 16A.1 - Equipment and Techniques)

UN NO. 596	Mass Spectrometric Methods for the Determination of Nuclear Constants	Inghram, M.G. et al

(Session 16A.3 - Delayed Neutrons)

UN NO. 831*	Delayed Neutrons	Keepin, G.R., et al

(Session 16A.2 - Cross Sections of Non-Fissionable Materials)

UN NO. 832*	The Determination and Evaluation of Fundamental Thermal Neutron Cross-Sections	Harvey, J. A.

SESSION 17A - CROSS-SECTIONS OF FISSIONABLE MATERIALS

(Session 17A.2 - Low-Energy U-235 Cross Sections)

UN NO. 586*	The Low-Energy Cross Sections of U-235	Sailor, V.L., et al

(Session 17A.1 - Low-Energy Pu Cross-Sections)

UN NO. 589*	The Total and Fission Cross-Sections of Plutonium	Leonard, B. R.

(Session 17A.4 - High-Energy Cross Sections)

UN NO. 594*	Techniques for Measurement of Fast Neutron Flux	Diven, B. C.

SESSION 18A - PROPERTIES OF FISSIONABLE MATERIALS...:
RESONANCE ANALYSIS

UN NO. 583	Analysis of Low-Energy Neutron Resonances	Melkonian, E., et al

1035423

SESSION 18A - PROPERTIES OF FISSIONABLE MATERIALS...: RESONANCE ANALYSIS (CONTINUED)

UN NO. 585*	Analysis of the Velocity Selector Results on Fissile Materials	Bethe, H. A.
587*	Measurement of Capture to Fission Ratio of U-235, U-233 and Pu-239 by a New Method	Palevsky, H.
590*	Status of Information on Reactor Material Cross Sections	Hurwitz, R., Jr.
595*	Capture to Fission Ratio of Pu-239 and U-235 for Intermediate Energy Neutrons	Kanne, W.R., et al

SESSION 19A - INTEGRAL MEASUREMENTS

UN NO. 597*	Status of Experimental and Theoretical Information on Neutron Slowing Down Distribution in Hydrogeneous Media	Wilkins, J.E., et al

SESSION 20A - RESONANCE INTEGRALS: FISSION PRODUCT POISONING: CRITICALITY OF SOLUTIONS

(Session 20A.1 - Resonance Integrals)

UN NO. 833*	Resonance Capture Integrals	Macklin, R. L. Pomerance, H. S.

(Session 20A.3 - Criticality in Solutions)

UN NO. 834*	Small Thermal Homogeneous Critical Assemblies	Callihan, A.D., et al

(Session 20A.2 - Fission Product Poisoning)

UN NO. 835*	Reactivity Changes and Reactivity Lifetime of Fixed Fuel Elements in Thermal Reactors	Spinrad, B.I., et al

SESSION 21A - ZERO ENERGY AND EXPONENTIAL EXPERIMENTS

UN NO. 599	Exponential Experiments in Graphite Systems	Davenport, D. E.
600*	Exponential Experiments with Slightly Enriched Uranium Rods in Ordinary Water	Kouts, H., et al
601*	Pressurized Water Reactor (PWR) Critical and Exponential Experiments	Krasik, S. Radkowsky, A.

1035424

SESSION 21A - ZERO ENERGY AND EXPONENTIAL EXPERIMENTS
(CONTINUED)

UN NO. 602	The Critical Assembly - A Nuclear Design Tool	Snyder, T.M., et al
603	The Theory of Uranium Water Lattices	Chernick, Jack
604	Physics Aspects of the Pressurized Water Reactor (PWR)	Radkowsky, A., et al
605*	Exponential Experiments on Uranium D_2O Lattices	Cohen, E. R.
606*	Uranium Graphite Lattices. Part I - The Brookhaven Reactor	Kaplan, I. Chernik, J.
607*	Normal Uranium Graphite Moderated Reactors - A Comparison of Theory and Experiment. Water-Cooled Lattices	Gast, P. F.

SESSION 22A - ZERO ENERGY EXPERIMENTS ON FAST REACTORS AND REACTOR KINETICS

(Session 22A.1 - Zero Energy Experiments)

UN NO. 598*	The Fast Exponential Experiment	Beyer, F.C., et al
609*	A Survey of the Theoretical and Experimental Aspects of Fast Reactor Physics	Avery, R., et al

(Session 22A.2 - Reactor Kinetics)

UN NO. 610*	Kinetics of Stationary Reactor Systems	Welton, T. A.
612	Experimental Checks of Control Rod Theory	Gast, P.F., et al

SESSION 23A - REACTOR THEORY

UN NO. 608*	Comparison of Theory and Experiment for Intermediate Assemblies	Hurwitz, H. Erlich, R.
611*	Survey of Neutron Thermalization Theories	Cohen, E. R.

1035425

SESSION 23A - REACTOR THEORY (CONTINUED)

UN NO. 613	An Estimation of Doppler Effect in Intermediate and Fast Neutron Reactors	Goertzel, G., et al

SESSION 6B - OCCURRENCE OF URANIUM AND THORIUM

UN NO. 14	Uranium Provinces	Klepper, M.R., et al
15	Distribution of Uranium Occurences in the U.S.	Butler, A. P., Jr., et al
16	Uranium in Igneous Rocks of the USA	Neuerburg, Geo. J.
17	Uranium in Magmatic Differentiation	Larsen, E.S., et al
18	Distribution of Uranium and Certain Other Trace Elements in Felsic Volcanic Rocks of Cenozoic Age of the Western U.S.	Coats, Robt. R.
19	Uranium Deposits in Volcanic Rocks of the Basin and Range Province	Sharp, Byron J.
20	Uranium-Bearing Vein Deposits in the U.S.	Everhart, D. L.
21	Pitchblende Deposits in the Central City District and Adjoining Areas, Gilpin and Clear Creek Counties, Colorado	Sims, P.K., et al
22	Uranium Deposits of the Boulder Batholith, Montana	Becraft, Geo. E.
23	Uranium in the Fluorspar Deposits of the Thomas Range, Utah	Staatz, M.H., et al
24	Wall-Rock Control of Certain Pitchblende Deposits in Golden Gate Canyon, Jefferson County, Colorado	Adams, John W., et al
25	Relation of Secondary Uranium Minerals to Pitchblende-Bearing Veins at Marysvale, Piute County Utah	Walker, G.W., et al

1035426

SESSION 6B - OCCURRENCE OF URANIUM AND THORIUM (CONTINUED)

UN NO. 27	Uranium Deposits at the Contact of Meta-Sediments and Granitic Intrusives in the Western United States	Thurlow, Ernest E.
28	Relation of Tectonic Elements in Pre-Cambrian Rocks to Uranium Deposits in the Cordilleran Foreland of the Western United States	Osterwald, F. W.
29	Influence of Regional Structure upon the Origin and Distribution of Uranium in the Colorado Plateau	Kelley, Vincent C.
30	Age, Environment and Production of Uranium Host Rocks on the Colorado Plateau	Wood, Hiram B.
32	Regional Transmissivity of the Exposed Sediments of the Colorado Plateau as Related to Distribution of Uranium Deposits	Jobin, D. A.
33	Relation of Carnotite Deposits to Permeable Rocks in the Morrison Formation, Mesa County, Colorado	Phoenix, David A.
34	Direction of Transportation of the Sediment Constituting the Triassic and Associated Formations of the Colorado Plateau	Poole, F.G., et al
35	Sedimentary Features of Upper Sandstone Lenses of the Salt Wash Sandstone Member and Their Relation to Uranium-Vanadium Deposits in the Uravan District, Montrose County, Colorado	Boardman, R. L., et al
36	Significance of Roll Ore Bodies in Genesis of Uranium-Vanadium Deposits on the Colorado Plateau	Shawe, Daniel R.
37	Uranium Deposits in Limestone	Gabelman, John W.

1035427

SESSION 6B - OCCURRENCE OF URANIUM AND THORIUM (CONTINUED)

UN NO. 38	Guides to Uranium Deposits in the Gallup-Laguna Area, New Mexico	Hilpwert, L. S., et al
39	Geology of Uranium Deposits of the Shinarump and Chinle Formations on the Colorado Plateau	Isachsen, Y. W.
40	Channels and Related Swales at the Base of the Shinarump Conglomerate, Monument Valley, Arizona	Witkind, I. J.
41	Deep Drilling in the Temple Mountain Collapse San Rafael Swell, Utah	Keys, W. Scott
42	Uranium Deposits in the White Canyon Area San Juan County, Utah	Trites, A. F., Jr., et al
43	Uranium in Shoreline Sandstones of Terrestrial and Marine Origin Colorado Plateau	Carithers, L. W., et al
44	Uranium in Clastic Rocks of the Basin and Range Province	Davis, Dudley L., et al
45	Uranium Deposits in Tertiary Clastics in Wyoming and Northern Colorado	Grutt, E. W., Jr.
46	Geology and Uranium Deposits of the Pumpkin Buttes Area, Powder River Basin, Wyoming	Sharp, W.N., et al
47	Lithologic, Structural and Geochemical Controls of Uranium Deposition in the Southern Black Hills, South Dakota	Bell, H., III, et al
48	Occurrence of Uranium in Diatremes on the Navajo and Hopi Reservations, Arizona, New Mexico and Utah	Shoemaker, E.M.
49	The Organic Geochemistry of Uranium	Breger, I.A., et al

1035428

SESSION 6B - OCCURRENCE OF URANIUM AND THORIUM (CONTINUED)

UN NO. 50	Uranium Deposits in Paludal Black Shales of the Dalpta Formation, San Juan Basin, New Mexico	Gabelman, John W.
51	Uranium in Marine Black Shales of the U.S.	Swanson, Vernon E.
52	Environment of Accumulation of the Chattanooga Shale	Conant, Louis C.
53	Uranium in the Chattanooga Shale of Eastern Tennessee	Brown, A., et al
54	Uraniferous Black Shales in the Northern Rocky Mountains and Great Plains Regions	Mapel, W. J.
55	Uranium-Bearing Coal in the United States	Vine, James D.
56	Trace Elements in Coal in the Red Desert, Wyoming	Masursky, Harold
57	Uranium-Bearing Lignite and its Relation to Volcanic Tuffs in Eastern Montana and the Dakotas	Denson, N.M., et al
285	The Los Ochos Uranium Deposit	Derzay, Raymond C.
286	High-Grade Uraniferous Lignites in Harding County, South Dakota	King, John W.
287	Uranium-Bearing Coal in the Central Part of the Great Divide Basin, Sweetwater County, Wyoming	Pipiringos, Geo. N.
288	Uranium in Asphalt-Bearing Rocks	Hail, W. J., Jr., et al
289	Radioactive Elements and their Daughter Products in the Texas Panhandle and Other Oil and Gas Fields in the U.S.	Pierce, A.P., et al
290	Uranium in Phosphate Rock	McKelvey, V. E.

1035429

SESSION 6B - OCCURRENCE OF URANIUM AND THORIUM
(CONTINUED)

UN NO. 291	Uranium in the Phosphoria Formation	McKelvey, V. E., et al
292	The Aluminum Phosphate Zone of the Bone Valley Formation and its Uranium Deposits	Altschuler, Z. S., et al
293	Distribution and Occurrence of Uranium in the Calcium Phosphate Zone of the Land-Pebble Phosphate District of Florida	Cathcart, James B.
294	Uranium in Precipitates and Evaporites	Bell, Kenneth G.
295	Mineralogy and Oxidation of the Colorado Plateau Uranium Ores	Weeks, Alice D.
296	A Comparison of Black Uranium Ores in Utah, New Mexico and Wyoming	Gruner, John W.
297	Paragenetic Studies of Uranium Deposits of the Colorado Plateau	Laverty, R.A., et al
298	The Interpretation of the Pb-206/U-238 $<$ Pb-207/U-235 $<<$ Pb-207/Pb-206 Age Sequence of Uranium Ores	Stieff, L.R., et al
299	The Isotope Geology of Some Uranium Minerals	Hoekstra, H. R., et al
300	Summary of Hypotheses of Genesis of Uranium Deposits	McKelvey, V. E., et al
301	The Geology of Thorium Deposits in the U.S.	Twenhofel, W. S., et al
302	The Mineralogy of Thorium	Frondel, Clifford
303	Thorium Deposits in the Wet Mountains, Colorado	Singewald, Q.D., et al

1035430

SESSION 6B - OCCURRENCE OF URANIUM AND THORIUM (CONTINUED)

UN NO. 304	Thorium in the Powderhorn District, Gunnison County, Colorado	Wallace, S.R., et al
305	Uranium- and Thorium-Bearing Minerals in Placer Deposits in Idaho	Mackin, J. Hoover
306	Monazite in Southeastern United States	Overstreet, W. C., et al
307	Geology and Monazite Content of the Goodrich Quartzite Palmer Area, Marquette County, Michigan	Vickers, R. C.
470*	Nuclear Fuel for the World Power Program	Johnson, J. C.
471	Natural Occurrence of Uranium in the U.S.	Staffs of US Geological Survey and US AEC
472	Uranium in Terrestrial Sedimentary Rocks in the U.S. Exclusive of the Colorado Plateau	Finch, W. I.
473	Uranium-Vanadium-Copper Deposits of the Colorado Plateau Region	Fischer, R. P.
474	Some Examples of Uranium Deposits in the Upper Jurassic Morrison Formation on the Colorado Plateau	Dodd, Philip H.

SESSION 7B - PROSPECTING FOR URANIUM AND THORIUM

UN NO. 502	Rock Alteration Criteria in the Search for Uranium	Kerr, Paul F.
503*	Techniques for Prospecting for Uranium and Thorium	Staffs of US AEC and Geological Survey
504	Geologic Prospecting for Uranium and Thorium	Page, Lincoln R.
505	Heavy-Mineral Prospecting	Overstreet, W. C., et al

1035431

SESSION 7B - PROSPECTING FOR URANIUM AND THORIUM
(CONTINUED)

UN NO.	506	Geochemical Prospecting for Uranium by Sampling Ground and Surface Waters	Fix, Philip F.
	507	Water Sampling as a Guide in the Search for Uranium Deposits and its Use in Evaluating Widespread Volcanic Units as Potential Source Beds for Uranium	Denson, N.M., et al
	508	The Use of Geochemical Techniques and Methods in Prospecting for Uranium	Lovering, T.S., et al
	509	Botanical Methods of Prospecting for Uranium	Cannon, H.L., et al
	510	Airborne Radiometric Surveying	Boyle, Thomas L.
	511	Instruments and Techniques for Measuring Radioactivity in the Field	Stead, Frank W.
	512	Scintillation Drill-Hole Logging	Comstock, Sherman S.
	513	Drilling Techniques in Search of Uranium	Chester, John W.
	514	Geophysical Exploration for Uranium on the Colorado Plateau	Black, R. A.
	515	Geophysical-Geochemical Prospecting for Uranium	Denson, M.E., Jr.
	516	Subsurface Techniques for Outlining Favorable Zones Using Widely Spaced Core Drilling	Pitman, R.K., et al
	517	Techniques and Guides for Exploration of Shinarump Channels on the Colorado Plateau	Wood, H.B., et al
	518	Air Scattering of Gamma Rays from Thick Uranium Sources	Sakakura, A. Y.

1035432

SESSION 8B - THE FISSION PROCESS: FACILITIES FOR HANDLING HIGHLY RADIOACTIVE MATERIALS

(Session 8B.1 - The Fission Process)

UN NO. 614*	Survey of Radiochemical Studies of the Fission Process	Glendenin, L.E. Steinberg, E.P.
718*	Spontaneous Fission Correlation	Ghiorso, A.
721	Determination of Nuclear Constants by Chemical Methods	Crouthamel, C. E., et al

(Session 8B.2 - Facilities for Handling Highly Radioactive Materials.)

UN NO. 722	Laboratory Handling of Radioactive Material	Garden, Nelson
723	Hot Laboratory Facilities and Techniques for Handling Radioactive Materials	Dismuke, S. E., et al
725*	Hot Laboratory Facilities for a Wide Variety of Radiochemical Problems	Fields, P. R. Youngquist, G. H.

SESSION 9B - CHEMISTRY OF FISSION PRODUCTS

(Session 9B.1 - Solution Chemistry of Gross Fission Products)

UN NO. 719*	Solvent Extraction Chemistry of Fission Products	Bruce, F. R.
724*	Chemical Processing in Intense Radiation Fields	Hammond, R. P.
837*	Anion Exchange Studies of the Fission Products	Kraus, K. A. Nelson, F.

SESSION 10B - HEAVY ELEMENT CHEMISTRY

(Session 10B.1 - Surveys of Chemistry of Transuranics)

UN NO. 726*	Thermodynamics of the Heavy Elements	Cunningham, B.B.

(Session 10B.2 - Methods of Separating Heavy Elements)

UN NO. 728*	Radiochemical Separation Methods for the Actinide Elements	Hyde, E. K.

1035433

SESSION 10B - HEAVY ELEMENT CHEMISTRY (CONTINUED)

UN NO. 729	Rare Earth and Transplutonium Element Separations by Ion Exchange Methods	Stewart, D. C.
730	The Chemistry and Crystal Chemistry of Heavy Element Compounds	Fried, S., et al
731	Hydrolytic Behavior of the Heavy Elements	Kraus, K. A.
732	Effective Capture Cross-Sections of Pa-233 and Np-239 for Thermal Reactor Neutrons	Halperin, J., et al
(Session 10B.3 - Chemistry of Specific Heavy Elements)		
UN NO. 733	The Properties of Plutonium Hexafluoride	Weinstock, B., et al
734	Recent Developments in the Chemistry of Thorium	Katzin, Leonard I.
735	Vapor Pressure of Liquid Plutonium	Simpson, O. C., et al
736*	Some Recent Developments in the Chemistry of Neptunium	Hindman, J. C., et al
737	Recent Developments in the Chemistry of the Uranium-Oxygen System	Hoekstra, H. R., et al
(Session 10B.1 - Surveys of Chemistry of Transuranics)		
UN NO. 809	The Formation of Higher Isotopes and Higher Elements by Reactor Irradiation of Pu-239; Some Nuclear Properties of the Heavier Isotopes	Bentley, W. C., et al
(Session 10B.3 - Chemistry of Specific Heavy Elements)		
UN NO. 838*	A Review of Americium and Curium Chemistry	Penneman, R. A. Asprey, L. B.

1035434

SESSION 11B - EFFECTS OF RADIATION ON REACTOR MATERIALS

UN NO. 743	Radiation Damage to Radiochemical Processing Reagents	Cathers, G. I., et al
744*	Radiation Damage in Reactor Materials	Billington, D.S.
745	Irradiation Effects in Uranium and its Alloys	Paine, S. H., et al
746*	Irradiation Damage to Artificial Graphite	Woods, W. K., et al
747	The Effects of Irradiation on Structural Materials	Faris, F. E.

SESSION 12B - EFFECTS OF RADIATION ON LIQUIDS

UN NO. 738*	A Survey of Recent American Research in the Radiation Chemistry of Aqueous Solutions	Allen, A. O.
739*	The Radiation Induced Reaction of Hydrogen and Oxygen in Water at 25°C to 250°C	Hochanadel, C. J.
740	The Effects of Reactor Radiation Upon High Temperature Static Water Systems	Humphreys, J. R., et al
741	The Decomposition of Water by Fission Recoil Particles	Boyle, J. W., et al
742	Organics as Reactor Moderator-Coolants: Some Aspects of Their Thermal and Radiation Stabilities	Bolt, R. O., et al
839	The Decomposition of Light and Heavy Water Boric Acid Solutions by Nuclear Reactor Radiations	Hart, E. J., et al

1035435

SESSION 13B - EFFECTS OF RADIATION ON SOLIDS

UN NO. 748	Effect of Nuclear Irradiation on Ionic Crystals	Smoluchowski, R., et al
749*	The Theory of Lattice Displacements Produced During Irradiation	Seitz, F. Koehler, J. S.
750*	Theoretical Aspects of Radiation Damage in Metals	Dienes, G. J.
751*	Interpretation of Radiation Damage to Graphite	Hennig, G. R. Hove, J. G.
753*	A Review of Investigations of Radiation Effects in Ionic and Covalent Crystals	Crawford, J.H., Jr. Wittels, M.C.

SESSION 14B - TREATMENT OF URANIUM AND THORIUM ORES AND ORE CONCENTRATES

UN NO. 519*	Recovery of Uranium from its Ores	Marvin, G. G., et al
520	Alkaline Leaching of Uranium Ores	Stephens, F. M., Jr., et al
521*	Some Unusual Problems Met in the Recovery of Uranium from a Very Low-Grade Ore	Hassialis, M.D. Musa, R.
522	Recovery of Uranium from Sulfuric Acid and Carbonate Leach Liquors by Anion Exchange	Grinstead, R. R., et al
523	Solvent Extraction of Uranium from Acid Leach Slurries and Solutions	Grinstead, R. R., et al
524*	Recovery of Uranium from Phosphates by Solvent Extraction	Long, R. S., et al
525	The Carbonate Chemistry of Uranium: Theory and Applications	McClaine, L. A., et al

1035436

SESSION 14B - TREATMENT OF URANIUM AND THORIUM ORES AND ORE CONCENTRATES (CONTINUED)

UN NO. 526	The Resin-in-Pulp Process for Recovery of Uranium	Hollis, R.F., et al
527	A General Survey of Types and Characteristics of Ion Exchange Resins Used in Uranium Recovery	Kunin, R., et al
528	Accelerated Thickening and Filtering of Uranium Leach Pulps	Clemmer, J. B., et al
529	Principles and New Developments in Uranium Leaching	Gaudin, A. M.
850	The Possibilities of Securing Long-Range Supplies of Uranium, Thorium and Other Substances from Igneous Rocks	Brown, H., et al

SESSION 15B - PRODUCTION OF METALLIC URANIUM AND THORIUM: ANALYTICAL METHODS IN RAW MATERIAL PRODUCTION

(Session 15B.2 - Analytical Methods in Raw Material Production)

UN NO. 116	The Analysis of Low-Grade Uranium Ores and Their Products	Hassialis, M. D., et al
117	Determination of Microgram and Submicrogram Quantities of Thorium by Neutron Activation Analysis	Leddicotte, G. W., et al

(Session 15B.1 - Production of Metallic Uranium and Thorium)

UN NO. 531	Fundamental Considerations in the Reduction Processes of Thorium and Uranium	Kopelman, B.

(Session 15B.2 - Analytical Methods in Raw Material Production)

UN NO. 532	Spectrophotometric Determination of Uranium with Thiocyanate in Acetone-Ethyl Acetate-Water Medium	DeSesa, M.A., et al

1035437

SESSION 15B - PRODUCTION OF METALLIC URANIUM AND THORIUM: ANALYTICAL METHODS IN RAW MATERIAL PRODUCTION (CONTINUED)

(Session 15B.1 - Production of Metallic Uranium and Thorium)

UN NO. 817	The Preparation of Uranium Metal by the Reduction of Uranium Tetrafluoride with Magnesium	Wilhelm, H. A.

(Session 15B.2 - Analytical Methods in Raw Material Production)

UN NO. 818	The Use of Ion Exchange Resins for the Determination of Uranium in Ores and Solutions	Kunin, R., et al
952*	Analysis of Uranium and Thorium Raw Materials	Rodden, C. J.

SESSION 16B - PRODUCTION TECHNOLOGY OF SPECIAL MATERIALS

(Session 16B.2 - Graphite)

UN NO. 534*	The Production and Properties of Graphite for Reactors	Currie, L.M., et al

(Session 16B.1 - Heavy Water)

UN NO. 819*	Survey of Heavy Water Production Processes	Benedict, M.

SESSION 17B - PRODUCTION TECHNOLOGY OF SPECIAL MATERIALS (CONCLUDED)

(Session 17B.1 - Zirconium)

UN NO. 533*	Zirconium Metal Production	Shelton, S. M., et al

(Session 17B.2 - Beryllium)

UN NO. 820*	Status of Beryllium Technology in the USA	Kaufmann, A. R. Kjellgren, B.R.F.

SESSION 18B - METALLURGY OF THORIUM, URANIUM AND THEIR ALLOYS: FABRICATION OF FUEL ELEMENTS

(Session 18B.1 - Metallurgy of Thorium, Uranium and Their Alloys)

UN NO. 555*	Physical Metallurgy of Uranium	Foote, F. G.
556*	The Metallurgy of Thorium and Its Alloys	Carlson, O. N., et al

1035438

SESSION 18B - METALLURGY OF THORIUM, URANIUM AND THEIR ALLOYS: FABRICATION OF FUEL ELEMENTS (CONTINUED)

UN NO. 557	Thermal Cycling Effects in Uranium	Chiswik, H.H., et al
558	The Alloys of Uranium	Saller, H.A., et al
(Session 18B.2 - Fabrication of Fuel Elements)		
559	The Technology of UO_2 and ThO_2	Johnson, J.R., et al
561*	Dispersion Type Fuel Elements	Weber, C. E. Hirsch, H. H.
562	Preparation, Properties and Cladding of Aluminum-Uranium Alloys	Saller, H. A.
825*	The Metallurgy of Reactor Fuels	Howe, J. P.
826	The Intermetallic Compounds of Plutonium	Coffinberry, A. S., et al
827	Fabrication of Uranium Alloys	Kaufmann, A. R.
828	The Fabrication of Fuel Elements for the BNL Reactor	Gurinsky, David H.
953*	MTR-Type Fuel Elements	Boyle, E. J. Cunningham, J.E.

SESSION 19B - LIQUID METAL TECHNOLOGY

(Session 19B.3 - Corrosion in Liquid Metal Systems)		
UN NO. 118	Corrosion Problems with Bismuth Uranium Fuels	Weeks, J. R., et al
119*	Corrosion by Liquid Metals	Epstein, L. F.
(Session 19B.2 - Liquid Metal Heat Transfer)		
UN NO. 120	Liquid Metal Heat Transfer Predictions	Lyon, R. N.
(Session 19B.1 - Handling Liquid Metals)		
UN NO. 121	Pumping of Liquid Metals	Barnes, A. H.

1035439

SESSION 19B - LIQUID METAL TECHNOLOGY (CONTINUED)

(Session 19B.3 - Corrosion in Liquid Metal Systems)

UN NO. 122	Mass Transfer in Molten Metal and Molten Salt Systems	Bonilla, C.F., et al

(Session 19B.1 - Handling Liquid Metals)

UN NO. 123*	Sodium and Sodium Potassium Alloy for Reactor Cooling and Steam Generation	Trocki, T., et al

(Session 19B.3 - Corrosion in Liquid Metal Systems)

UN NO. 124	The Solubility of Structural Materials in Sodium	Miller, R.R., et al

(Session 19B.1 - Handling Liquid Metals)

UN NO. 812	The Use of High Temperature Sodium in Manufacture of NaK Alloy	Jackson, C.B., et al

(Session 19B.3 - Corrosion in Liquid Metal Systems)

UN NO. 829*	Basic Technology of Sodium Graphite Reactor	Siegel, S., et al

SESSION 20B - CHEMICAL ASPECTS OF NUCLEAR REACTORS

UN NO. 535*	Aqueous Corrosion of Aluminum Alloys at Elevated Temperatures	Draley, J. E. Ruther, W. E.
536	Pressurized Water Reactor (PWR) Water Chemistry	Rockwell, T., III, et al
537*	Aqueous Corrosion of Zirconium and its Alloys at Elevated Temperatures	Thomas, D. E. Mandil, I. H.
811*	Aqueous Uranium and Thorium Slurries	Kitzes, A. S. Lyon, R. N.
821*	Survey of Homogeneous Reactor Chemical Problems	Secoy, C. H.

SESSION 21B - CHEMICAL PROCESSING OF IRRADIATED FUEL ELEMENTS

UN NO. 539	Solvent Extraction Separation of Uranium and Plutonium from Fission Products by Means of Tributyl Phosphate	Flanary, J. R., et al

1035440

SESSION 21B - CHEMICAL PROCESSING OF IRRADIATED FUEL ELEMENTS (CONTINUED)

UN NO. 540*	The Solvent Extraction Separation of U-233 and Thorium from Fission Products by Means of Tributyl Phosphate	Gresky, A. T.
541	The Processing of Uranium-Aluminum Reactor Fuel Elements	Culler, F. L. Bruce, F. R.
543	Experience with a Direct Maintenance Radiochemical Processing Plant	Reid, D. G., et al
547	Nuclear Reactor Fuel Dissolution	Foster, D. L., et al
548	Removal of Fission Products from Stainless Steel	Campbell, D. O.
549	High-Level Sampling Devices for Radiochemical Plants	Landry, J. W.
551*	The Chemical Processing of Aqueous Homogeneous Reactor Fuel	Ferguson, D. E.
822*	Reprocessing of Reactor Fuel and Blanket Materials by Solvent Extraction (This may also include reference to No. 541 this session)	Culler, F. L.
824*	Practical Limitations of Solvent Extraction Processes	Tomlinson, R. E.

SESSION 22B - CHEMICAL PROCESSING OF IRRADIATED FUEL ELEMENTS (CONCLUDED): SEPARATION AND STORAGE OF FISSION PRODUCTS

(Session 22B.1 - Chemical Processing of Irradiated Fuel Elements)

UN NO. 542	High Temperature Fuel Processing Methods	Motta, E. E.

(Session 22B.1 - Chemical Processing of Irradiated Fuel Elements)

UN NO. 544*	Pyrometallurgical Processing of Nuclear Materials	Feder, H.M.

1035441

SESSION 22B - CHEMICAL PROCESSING OF IRRADIATED FUEL ELEMENTS (CONCLUDED): SEPARATION AND STORAGE OF FISSION PRODUCTS (CONTINUED)

UN NO. 545*	The Purification of Uranium Reactor Fuel by Liquid Metal Extraction	Voigt, A. F.
546	Decontamination of Irradiated Reactor Fuels by Fractional Distillation Processes using Uranium Hexafluoride	Katz, J.J., et al
550	High-Temperature Processing Systems for Liquid-Metal Fuels and Breeder Blankets	Dwyer, O.E., et al
(Session 22B.2 - Separation and Storage of Fission Products)		
UN NO. 552*	The Design and Operation of High-Level Waste Storage Facilities	Anderson, C. R. Rohrmann, C. A.
553*	Processes for High-Level Waste Disposal	Hatch, L. P. Manowitz, B.
(Session 22B.1 - Chemical Processing of Irradiated Fuel Elements)		
UN NO. 823*	Survey of Separation Processes	Lawroski, S.

SESSION 23B - WASTE TREATMENT AND DISPOSAL

(Session 23B.1 - Disposal in the Ground)		
UN NO. 554	Disposal of High-Level Radioactive Liquid Wastes in Terrestrial Pits	Struxness, E. G., et al
564	Problems of Ground Disposal of Nuclear Wastes	Theis, C. V.
565*	Disposal of Liquid Wastes to the Ground	Brown, R.E., et al
(Session 23B.3 - Airborne Problems)		
UN NO. 567	The Variation of Effluent Concentrations from an Elevated Point Source	Smith, M. E.
(Session 23B.2 - Disposal in the Sea)		
UN NO. 569*	Disposal of Radioactive Wastes at Sea	Renn, C. E.
571*	Air and Gas Cleaning for Nuclear Energy Processes	Silverman, L.

1035442

SESSION 8C - RADIOACTIVE ISOTOPES AND NUCLEAR RADIATIONS IN MEDICINE - THERAPY

UN NO. 177*	Use of the Nuclear Reactor for Neutron Capture Therapy of Cancer	Farr, L.E., et al
179*	Teletherapy Devices with Radioactive Isotopes	Brucer, M.
183*	Radioactive Isotopes in Hematologic Therapy	Lawrence, J. H.
184	Therapeutic Usefulness of Radioactive Colloids: Comparative Value of Gold-198, Chromic Phosphate (P-32), Yttrium-90 and Lutecium-177	Andrews, G. A., et al
185	Hypothyroidism Induced by I-131 in the Treatment of Euthyroid Patients with Intractable Angina Pectoris and Congestive Failure	Blumgart, H. L., et al
194	The Role of Radioactive Iodine in the Treatment of Thyrotoxicosis and Carcinoma of the Thyroid	Clark, D.E., et al
197	Pre-Therapeutic Considerations for 70 mev X-Rays	Adams, G.D., et al
200	Isotope Therapy for Intra-Abdominal Tumors	Harper, P.V., et al
201	Irradiation Hypophysectomy and Related Studies using 340 mev Protons and 190 mev Deuterons	Lawrence, J. H., et al
202	Versatility of Radioactive Gold in Treatment of Malignant Disease	Hahn, P. F.
203	An SR-90 Surface Applicator Designed for Treatment of Corneal Lesions and Evaluation of Biological Effects	Friedell, H. L., et al

1035443

SESSION 8C - RADIOACTIVE ISOTOPES AND NUCLEAR RADIATIONS IN MEDICINE: THERAPY (CONTINUED)

UN NO. 206	Physiological and Biochemical Studies of Astatine-211 (EKA-IODINE)	Hamilton, J. G., et al
208	Destruction of the Hypophysis with Radioactive Yttrium Pellets in Metastatic Cancer	Harper, P.V., et al
209	Artificial Radioisotopes in Nylon Ribbons for Implantation in Neoplasms	Henschke, U.K.,
210	Kilocurie Revolving Cobalt-60 Therapy Unit	Lanzl, L.H., et al
211	Cobalt-60 Teletherapy Isodose Patterns for Combined and Non-Uniform Longitudinal and Transverse Source Motions	Braestrup, C. B., et al
212	Biological Studies on Calcium, Strontium, Lanthanum and Yttrium	Laszlo, D., et al
213	The Distribution and Excretion of Hexavalent Uranium in Man	Struxness, E. G., et al

SESSION 9C - RADIOACTIVE ISOTOPES AND NUCLEAR RADIATIONS IN MEDICINE (CONTINUED) - DIAGNOSIS AND STUDIES OF DISEASE

UN NO. 181*	Scanning of Positron-Emitting Isotopes in Diagnosis of Intra-Cranial and Other Lesions	Brownell, G. L. Sweet, W. H.
187	Integration of a Radioactive Isotope Program into Medical School Research and Teaching	Solomon, A. K.
189	The Measurement of Thyroid Gland Uptake and Turnover of I-131 in Man by External Counting: Its Use in Diagnosis and Treatment of Thyroid Disorders	Freedberg, A. S., et al

1035444

SESSION 9C - RADIOACTIVE ISOTOPES AND NUCLEAR RADIATIONS IN MEDICINE (CONTINUED) - DIAGNOSIS AND STUDIES OF DISEASE (CONTINUED)

UN NO. 190	The Radioactive (I-131-Labeled) Rose Bengal Liver Uptake-Excretion Test. Its Use in the Evaluation of Hepatic Function.	Taplin, G.V., et al
191	The Use of P-32 in the Identification of Intra-Ocular Tumors	Krohmer, J.S., et al
193	The Use of I-131-Labeled Serum Albumin in the Study of Cardiac Output and Peripheral Vascular Flow	MacIntyre, W. J., et al
196	Thyroid Radioiodine Uptake Calibration	Brucer, M., et al
198	Possibilities and Limitations of In Vivo External Counting Techniques in Biology and Medicine	Cassen, B., et al
199*	Tissue Specific Anti-Bodies as Carriers of Radioactive Materials for the Treatment of Cancer	Bale, W. F. Spar, I. L.
207	Tritium (H-3) Measurements of Lung Ventilation Volumes and Kinetics	Huff, R.L., et al
216	The Use of Radioactive Tagged Red Cells and Platelets to Study the Phenomenon of Sequestration	Crosby, W.H., et al
227	The Absorption of Radioiron Labeled Foods and Inorganic Iron by Normal, Iron-Deficient, and Hemochromatotic Subjects	Chodos, R.B., et al
754*	The Dynamic Aspects of Erythropoiesis in Normal and Pathologic States as Indicated with the Radioactive Isotope Tracer Technique	Ross, J. R. Miller, A.
841	Recent Advances in Methods for the Study of Red Cell Mass and Red Cell Production and Destruction	Lawrence, J. H., et al

1035445

SESSION 10C - RADIOACTIVE ISOTOPES AND NUCLEAR RADIATIONS IN MEDICINE (CONCLUDED) - DIAGNOSIS AND STUDIES OF DISEASE

UN NO. 178*	The Use of Isotopes in Biochemical and Medical Research	Hastings, A. Baird
180*	The Use of Radiosodium and Radiopotassium Tracer Studies in Man	Burrows, B. A. Ross, J. F.
188	Dental Uses of Radioisotopes	Wainwright, W. W.
192	Biosynthesis of Abnormal Proteins in Multiple Myeloma	Putnam, F.W., et al
214	Studies on the Metabolism of Tubercle Bacilli, and Their Fate after Phagocytosis	Karnovsky, M. L., et al
215	Use of Radioactive Metabolites in Studying Modes of Action of Anti-Cancer Agents and Searches for Exploitable Bio-Chemical Differences between Normal and Cancer Cells	Skipper, H. E.
217	Radioisotopic Studies of Human Serum Lipoproteins	Morton, M.E., et al
219	Biochemical Changes of Experimental Pre-Cancer. Amino Acid Metabolism in the Isolated Perfused Rat Liver Studies with the Aid of Lysine-6-C-14 and Histidine-2-C-14	Miller, L.L., et al
220	The Application of Radioisotopes to the Study of Cancer Induction	Heidelberger, Chas.
224*	Utilization of Nuclear Energy in Public Health Problems on the Epidemiology of Communicable Diseases	Jenkins, D.W.
228	The Use of Radioactively Labeled Compounds in Study of Metabolic Inter-Relationships of Host and Parasitic Helminths	Stoner, R.D., et al

1035446

SESSION 10C - RADIOACTIVE ISOTOPES AND NUCLEAR RADIATIONS IN MEDICINE (CONCLUDED) - DIAGNOSIS AND STUDIES OF DISEASE (CONTINUED)

UN NO. 229	The Use of C-14 Labeled Compounds in Tuberculosis Research	Koch-Weser, D., et al
840*	The Use of Isotopes in Analysis of Metabolic Disorders	Stetten, DeWitt, Jr.
844	Studies of the Use of RB-86 as a Tracer of Potassium in Man	Burch, G.E., et al

SESSION 11C - BIOLOGICAL EFFECTS OF RADIATION: MODES OF RADIATION INJURY AND RADIATION HAZARDS

UN NO. 72	Irreversibility of Damage Produced by Alpha Emitters	Stannard, J.N., et al
75	The Potentiated Lethal Action of Radioisotopes Used in Combination	Friedell, H.L., et al

(Effects on Reproductive System and on Fetus)

UN NO. 77*	Hazards to the Embryo and Fetus from Ionizing Radiation	Russell, Liane B., Russell, W.L.
UN NO. 80	Internal Emitters and Tumor Induction	Finkel, Miriam P.
81	Biological Effects of Fast Neutrons and Gamma Rays	Clark, J.W., et al

(Modes of Radiation Injury)

UN NO. 82*	Commentary on the Modes of Radiation Injury	Brues, A. M.

(Carcinogenesis and Metabolism of Bone-Seeking Isotopes)

UN NO. 88*	The Deposition of Radioactive Substance in Bone	Hoecker, F.E.

1035447

SESSION 11C - BIOLOGICAL EFFECTS OF RADIATION: MODES OF RADIATION INJURY AND RADIATION HAZARDS (CONTINUED)

UN NO. 236	Genetic Differences in Longevity and Disease Resistance in Animals under Irradiation	Gowen, John W.
(Carcinogenesis and Metabolism of Bone-Seeking Isotopes)		
UN NO. 242*	The Association of Irradiation with Cancer of the Thyroid in Children and Adolescents	Clark, D.E.
UN NO. 243	The Delayed Toxicity of Radium Deposited in the Skeleton of Human Beings	Hasterlik, R.J., et al
244	A Formulation of the Relation Between Radiation Dose and Shortening of Life Span	Blair, H.A.
251	Early Radiation Death	Brace, K.C., et al
254	Modes of Acute Radiation Death	Quastler, Henry
UN NO. 256	Effects of Whole Body Exposure to Nuclear or X-Ray Energy on Life Span and Life Efficiency	Gowen, John W.
(Effects on Reproductive System and on Fetus)		
UN NO. 257*	The Effects of Daily Low Doses of X-Rays on Spermatogenesis in Dogs	Casarett, G.W. Hursh, J.B.
(Carcinogenesis and Metabolism of Bone-Seeking Isotopes)		
UN NO. 847*	The Use of Isotopes in Study of Skeletal Physiology and Metabolism	Neumann, W.F.

SESSION 12C - BIOLOGICAL EFFECTS OF RADIATION (CONTINUED) - MECHANISMS OF RADIATION INJURY: PROTECTION AND RECOVERY

(Protection and Recovery)		
UN NO. 78*	Studies on Protection by Treatment Before and After Exposure to X- and Gamma Radiation	Hollaender, A. Stapleton, G.E.

1035448

SESSION 12C - BIOLOGICAL EFFECTS OF RADIATION (CONTINUED) - MECHANISMS OF RADIATION INJURY: PROTECTION AND RECOVERY

UN NO. 83	Studies of the Biological Basis of Radiosensitivity	Tahmisian, Theo. N.
84	Medical Care of Wounds Contaminated with Radioactive Materials	Hathaway, E.A., et al
87	Relative Biological Effectiveness	Adams, G.D., et al
94	Use of Partial-Cell Irradiation in Studies of Cell Division	Zirkle, R.E., et al
97	Studies on the Mechanism of Phytohormone Damage by Ionizing Radiation	Gordon, Solon A.
239	Radiation Effects on Cells: Genetics or Physiology?	Powers, E. L., et al
249	The Effect of Non-Cellular Preparations on Survival after Lethal Doses of X-Radiation	Goldwasser, E., et al
252	The Effect of X-Irradiation Fat Metabolism	Coniglio, J.G., et al
253	Relationship between Electrolytes and Radiation Effects on Cell Metabolism	Bair, W.J., et al
255	Studies on Hyperferremia Following Acute Whole Body X-Irradiation	Haley, T.J., et al

SESSION 13C - BIOLOGICAL EFFECTS OF RADIATION (CONCLUDED) - GENETIC EFFECTS: HUMAN IMPLICATIONS - RADIOACTIVE ISOTOPES AND IONIZING RADIATIONS IN AGRICULTURE - RADIATION-INDUCED GENETIC CHANGES AND CROP IMPROVEMENT

(Session 13C.2 -- Radiation-Induced Genetic Changes and Crop Improvement)

1035449

SESSION 13C - BIOLOGICAL EFFECTS OF RADIATION (CONCLUDED) - GENETIC EFFECTS: HUMAN IMPLICATIONS-RADIOACTIVE ISOTOPES AND IONIZING RADIATIONS IN AGRICULTURE - RADIATION-INDUCED GENETIC CHANGES AND CROP IMPROVEMENT

UN NO. 101*	Ionizing Radiations as a Tool for Plant Breeders	Caldecott, R. S.
103	Resistance to Rust Induced by Ionizing Radiations in Wheat and Oats	Myers, W.M., et al
107	The Comparative Effects of Radiation and Hybridization in Plant Breeding	Gregory, Walton C.
UN NO. 110*	The Contribution of Radiation Genetics to Crop Improvement	Singleton, W.R., et al

(Session 13C.1 - Genetic Effects: Human Implications)

UN NO. 234	How Radiation Changes the Genetic Constitution	Muller, H.J.
UN NO. 235*	Genetic Effects of Radiation in Mice and Their Bearing on the Estimation of Human Hazards	Russell, W.L.
238*	The Genetic Structure of Mendelian Populations and its Bearing on Radiation Problems	Wallace, B.

(Session 13C.2 - Radiation-Induced Genetic Changes and Crop Improvement)

UN NO. 266	The Effects on Plants of Chronic Exposure to Gamma Radiation from Radio-Cobalt	Sparrow, A.H., et al

SESSION 14C - RADIOACTIVE ISOTOPES AND IONIZING RADIATIONS IN AGRICULTURE (CONCLUDED) - TRACER STUDIES IN AGRICULTURE

UN NO. 100	Use of Radioisotopes in Tracing Fungicidal Action	Miller, L.P., et al

1035450

SESSION 14C - RADIOACTIVE ISOTOPES AND IONIZING RADIATIONS IN AGRICULTURE (CONCLUDED) - TRACER STUDIES IN AGRICULTURE

UN NO. 104*	Applications of Radioactive Isotopes to the Study of Soils and Fertilizers	Dean, L.A.
105*	The Use of Radioactive Isotopes to Ascertain the Role of Root-Grafting in the Translocation of Water, Nutrients and Disease-Inducing Organisms Among Forest Trees	Kuntz, J.E. Riker, A.J.
106*	Utilization of Radioactive Isotopes in Resolving the Effectiveness of Foliar Absorption of Plant Nutrients	Tukey, H.B., et al
108	Absorption of Radioactive Sulfur by the Fruit System in Comparison to the Roots of Peanuts	Harris, Henry C.
109	Use of Isotopes for Determining the Availability of Chelated Metals to Growing Plants	Stewart, I., et al
111	Use of Labeled Compounds in Weed Research	Crafts, A.S., et al
112*	Uptake and Transport of Mineral Nutrients in Plant Roots	Epstein, E. Hendricks, S.B.
113	In Situ Measurement of Soil Bulk Density	Vomocil, James A.
114	Eradication of the Screw-Worm Fly by Releasing Gamma-Ray-Sterilized Males among the Natural Population	Bushland, R.C., et al
115	Uses of Radioisotopes by the Hawaiian Sugar Plantations	Burr, G.O., et al

1035451

SESSION 15C - RADIOACTIVE ISOTOPES IN PHYSIOLOGY AND BIOCHEMISTRY

(Session 15C.1 - Animal Physiology)

UN NO. 90*	Radioactive Isotopes in Animal Physiology and Nutrition -- Mineral Metabolism	Comar, C.L.
91	The Mechanism of Gastric Acid Secretion as Revealed by Radioisotopes	Hogben, C.A.M.
92	Time Relations between Potassium K-42 Outflux. Action Potential and Contraction Phase of Heart Muscle as Revealed by the Effluogram	Wilde, W.S., et al
93	Isotopes in Research on Animal Nutrition and Metabolism	Kleiber, M., et al
95	Use of Radioactive Iodine (I-131) and Thyroxine to Determine the Thyroid Hormone Secretion Rate of Intact Animals	Reineke, E.P., et al
96	Respiratory Carbon-14 Patterns and Physiological State	Tolbert, B.M., et al
99	Studies of Brain Potassium in Relation to the Adrenal Cortex	Bergen, J.R., et al

(Session 15C.2 - Plant Biochemistry)

UN NO.259*	The Photosynthetic Cycle	Calvin, M. Bassham, J.A.
269	The Application of Carbon-14 to Studies on Bacterial Photosynthesis	Siegel, Jack M.
271	The Metabolism of Mucopolysaccharides	Dorfman, A., et al
274	Biosynthesis in C-14-Labeled Plants; Their Use in Agricultural and Biological Research	Scully, N.J., et al

1035452

SESSION 15C - RADIOACTIVE ISOTOPES IN PHYSIOLOGY AND BIOCHEMISTRY
(Session 15C.1 - Animal Physiology)

UN NO. 275*	Use of I-131 in Study of the Influence of Climatic Factors on Thyroid Activity and Productivity of Livestock	Blincoe, C. Brody, S.

SESSION 16C - RADIOACTIVE ISOTOPES IN PHYSIOLOGY AND BIOCHEMISTRY (CONCLUDED) - GENERAL BIOCHEMISTRY

UN NO. 98	Metabolism of Radioisotope-Labeled Drugs	Smith, P.K., et al
182*	Role of Radioactive Isotopes in Immunologic Investigation Including Recent Studies on the Rate of Antibody Synthesis	Dixon, F.J.
221	Absence of Amino Acid Incorporation into Antibody During the Induction Period	Taliaferro, W.H., et al
222	The Metabolic Fate of "Internally" and "Externally" Labeled Protein Antigens	Haurowitz, F., et al
260*	Pathways of Biosynthesis of Nucleic Acids	Brown, G. B.
261	Dietary Factors in the Oxidation and Synthesis of Fatty Acid by Tissue Preparations	Artom, Camillo
262*	Isotope Tracers in the Study of Enzyme Mechanisms	Koshland, D.E., Jr. Gibbs, M.
263	Nucleotide and Nucleic Acid Metabolism Studied with Adenine-C-14	Bennett, E.L., et al
264	Nature of the I-131 Compounds Appearing in the Thyroid Vein after Injection of Iodine I-131	Chaikoff, I.L., et al

1035453

SESSION 16C - RADIOACTIVE ISOTOPES IN PHYSIOLOGY AND BIOCHEMISTRY (CONCLUDED) - GENERAL BIOCHEMISTRY

UN NO. 265	Mechanism of Incorporation of Labeled Amino Acids into Protein	Zamecnik, P.C., et al
267	Some Biochemical Functions of the Cell Surface as Deduced by Isotope Studies	Rothstein, Aser
268	Distribution of Radioactive Carbon Dioxide Incorporated into Rat Liver Glycogen	Marks, P.A., et al
270	The Study of Certain Phases of Cell Dynamic States with Short-Lived Isotopes as Exemplified by Mn-56 Partition Studies in Organs and Intra-Cellular Organelles	Cotzias, G.C., et al
272	Isotopic Studies in Cholesterol Metabolism	Biggs, M.W.
273	Radioactive Oxytetracycline (Terramycin[a]). I. Mode of Synthesis and Properties of the Radioactive Compound	Snell, J.F., et al
842	Isotopic Studies of Steroid Metabolism in Man	Hellman, L., et al
843	Steroid Metabolism Studies with the Aid of C-14-Labeled Compounds	Dorfman, R.I., et al
846	The Biosynthesis of Porphyrins	Shemin, David

SESSION 17C - SAFETY STANDARDS AND HEALTH ASPECTS OF LARGE-SCALE USE OF ATOMIC ENERGY

(Session 17C.2 - Hazards Related to Uranium Mining)

UN NO. 73	Mechanism of Uranium Poisoning	Hodge, H.C., et al

(Session 17C.1 - Radiation Safety Recommendations and Control)

UN NO. 74	Experimental Data Useful in Establishing Maximum Permissible Single and Multiple Exposures to Polonium	Anthony, D.S., et al

1035454

SESSION 17C - SAFETY STANDARDS AND HEALTH ASPECTS OF LARGE-SCALE USE OF ATOMIC ENERGY

(Session 17C.2 - Hazards Related to Uranium Mining)

UN NO. 76	Radiation Dosage to Lungs from Radon and its Daughter Products	Bale, W.F., et al

(Session 17C.1 - Radiation Safety Recommendations and Control)

UN NO. 79*	Maximum Permissible Concentration of Radioactive Isotopes in Air and Water for Short Period Exposure	Morgan, K.Z., et al

(Session 17C.2 - Hazards Related to Uranium Mining)

UN NO. 85*	Industrial Hygiene of Uranium Processing	Eisenbud, M. Quigley, J.A.

(Session 17C.1 - Radiation Safety Recommendations and Control)

UN NO. 89*	Maximum Permissible Exposure Standards	Stone, R.S.

(Session 17C.2 - Hazards Related to Uranium Mining)

UN NO. 230	Use of Radioisotopes in Studies of Health Hazards in the Uranium Mining Industry	Tsivoglou, E.C.

(Session 17C.1 - Radiation Safety Recommendations and Control)

UN NO. 241	Lymphocytes with Bilobed Nuclei as Indicators of Radiation Exposures in the Tolerance Range	Ingram, M.
245	Validity of Maximum Permissible Standards for Internal Exposure	Thompson, R.C., et al
247	Permissible Exposure to Ionization Radiation	Taylor, L.S.
250	Is the Concept of "Critical Organ" Valid in Determining the Maximum Permissible Level for Exposure to Radioactive Materials?	Stannard, J.N.

(Session 17C.2 - Hazards Related to Uranium Mining)

UN NO. 258	Health Protection of Uranium Miners and Millers	Miller, S.E., et al

1035455

SESSION 18C - SAFETY STANDARDS AND HEALTH ASPECTS OF LARGE-SCALE USE OF ATOMIC ENERGY (CONCLUDED)

(Session 18C.1 - Hazards Related to Reactor and Chemical Processing)

UN NO. 240*	Radiation Exposure Experience in a Major Atomic Energy Facility	Parker, H.M.
248	Health Protection in Chemical Processing Plants	Parker, H.M., et al

(Session 18C.2 - Ecological Problems Related to Reactor Operation)

UN NO. 276	Atomic Energy and Meteorology	Wexler, H., et al
277	...Nuclear Science and Oceanography	Revelle, R., et al
278*	The Absorption of Fission Products by Plants	Rediske, J.H. Hungate, F.P.
279	Radiation Exposure from Environmental Hazards	Parker, H.M.
280*	The Accumulation of Radioactive Substances in Aquatic Forms	Foster, R.F. Davis, J.J.
281	Radioactivity in Terrestrial Animals Near an Atomic Energy Site	Hanson, W.C. Kornberg, H.A.
283	Environmental Aspects of the Atomic Energy Industry	Gorman, Arthur E.
480	Assaying the Function of Total Biotic Communities in Relation to the New Field of Radiation Ecology	Odum, E.P., et al

(Session 18C.1 - Hazards Related to Reactor and Chemical Processing)

UN NO. 845*	Approaches to Treatment of Poisoning by both Radioactive and Non-Radioactive Elements Encountered in Atomic Energy Operations	Schubert, J.

1035456

SESSION 19C - GENERAL USES, PRODUCTION AND HANDLING OF RADIOACTIVE ISOTOPES

(Session 19C.3 - Handling of Radioactive Isotopes)

UN NO. 69*	Mechanical Arms Incorporating a Sense of Feel for Conducting Experiments with Radioactive Materials	Burnett, J.R., et al
86	Transportation of Large Quantities of Radioactive Materials	Blatz, Hanson

(Session 19C.1 - General Aspects)

UN NO. 146*	Radioisotopes in Industrial Research	Eaton, S. E.

(Session 19C.2 - Production of Radioactive Isotopes)

UN NO. 313	Preparation of Kilocurie Quantities of Xenon-135	Creek, G.E., et al

(Session 19C.3 - Handling of Radioactive Isotopes)

UN NO. 314*	Large-Scale Production of Radioisotopes	Rupp, A. F.
315	Methods of Handling Multikilocurie Quantities of Radioactive Materials	Rupp, A. F.
316	Design of Radiation Analytical Facilities at Oak Ridge National Laboratory	Goeller, H.E., et al

(Session 19C.2 - Production of Radioactive Isotopes)

UN NO. 317	Design and Operation of a Pilot Plant to Produce Kilocurie Fission Product Sources	Consiglio, J. A., et al
318	The Preparation of Kilocurie LA-140 Sources	Hammond, R.P., et al

1035457

SESSION 20C - DOSIMETRY

(Session 20C.1 - General Aspects)

UN NO. 58	Portable Instruments for Beta-Ray Dosimetry	Roesch, W.C., et al
59	Measurement of Tissue Dose as a Function of Specific Ionization	Rossi, H.H., et al

(Session 20C.3 - Neutron Dosimetry)

UN NO. 60*	A Gamma Insensitive Semi-Conductor Fast Neutron Dosimeter Using Single Crystal Germanium	Cassen, B.

(Session 20C.4 - Counting and Electronics)

UN NO. 61*	Recent Developments in the Scintillation Counter Field in the U.S.	Morton, G.A.

(Session 20C.1 - General Aspects)

UN NO. 62	The Theory of Cavity Ionization	Spencer, L.V., et al

(Session 20C.3 - Neutron Dosimetry)

UN NO. 63*	Methods of Measurements of Neutron Flux at Low Levels	Cowan, F. P. O'Brien, J.

(Session 20C.1 - General Aspects)

UN NO. 64	Neutron and Gamma-Ray Dosimetry of a Thermal Neutron Irradiation Facility	Cowan, F.P., et al

(Session 20C.3 - Neutron Dosimetry)

UN NO. 65	Fast Neutron Dosimetry	Hurst, G.S., et al

(Session 20C.4 - Counting and Electronics)

UN NO. 66*	Methods of Pulse Analysis	Kelley, G.G. Bell, P.R.
67	The Role of Liquid Scintillators in Nuclear Medicine	Hayes, F.N., et al

(Session 20C.1 - General Aspects)

UN NO. 68	Liquid Scintillation Counting of Natural Radiocarbon	Hayes, F.N., et al

1035458

SESSION 20C - DOSIMETRY

(Session 20C.2 - Dosimetry of Gamma-Rays)

UN NO. 70*	Absolute Dosimetry of Cobalt-60 Gamma-Rays	Laughlin, J.S., et al

(Session 20C.4 - Counting and Electronics)

UN NO. 71*	Dosimetry of Ionizing Particles	Failla, G.

(Session 20C.1 - General Aspects)

UN NO. 150*	Low-Level Counting and the Future of Isotopic Tracers	Johnston, W. H.
151	A High Level Dosimeter for the Detection of Beta and Gamma Radiation and Thermal Neutrons	Dondes, S.

(Session 20C.4 - Counting and Electronics)

UN NO. 152	The Development and Design of a Series of Precision Radioactive Airborne Particle Detectors for Health Monitoring and Control Systems	Anton, Nicholas

(Session 20C.2 - Dosimetry of Gamma-Rays)

UN NO. 153	Development of Direct-Reading Chemical Dosimeters for Measurement of X, Gamma, and Fast Neutron Radiation	Taplin, Geo. V.

(Session 20C.3 - Neutron Dosimetry)

UN NO. 154*	Dosimetry of Reactor Radiations by Calorimetric Measurements	Richardson, D.M., et al

(Session 20C.2 - Dosimetry of Gamma-Rays)

UN NO. 155	Use of the Fricke Ferrous Sulfate Dosimeter for Gamma-Ray Doses in the Range 4 to 40 KR	Weiss, J., et al

(Session 20C.4 - Counting and Electronics)

UN NO. 157	Medical Scintillation Spectrometer	Francis, J. E., et al

(Session 20C.2 - Dosimetry of Gamma-Rays)

UN NO. 158	Visualization of Gamma-Ray-Emitting Isotopes in the Human Body	Anger, H.O., et al

1035459

SESSION 20C - DOSIMETRY
(Session 20C.4 - Counting and Electronics)

UN NO. 159*	High Resolution Radiation Detectors in Research	Gomberg, H. J. Schlesinger, M.J., Jr.

SESSION 21C - RADIOACTIVE ISOTOPES IN RESEARCH
(Session 21C.2 - Activation Analysis)

UN NO. 147	Applications of Radioisotopes in Chemical Research and Analysis	Willard, John E.

(Session 21C.1 - Reaction Mechanisms)

UN NO. 149*	Tritium as a Research Tool in Chemistry and Industry	Brown, W.G., et al
160	The Use of Radioactive Tracers for Studying Absorption from Solution by Fibrous Materials	White, H.J., Jr., et al
161	Radioactive Isotopes in Petroleum-Production Research	Dunning, H.N., et al
163*	Stable and Unstable Isotopes in Heterogeneous Catalytic Reactions	Turkevich, J.
226	Radioactive Isotopes as Tools in Sanitary Engineering Research	Thomas, H. A., Jr.
232	Use of Carbon-14 to Study Organic Adsorption Properties of Activated Carbon	Ettinger, M.B., et al
233	Radiometric Methods for Drinking Water Analysis	Moeller, D.W., et al

1035460

SESSION 22C - RADIOACTIVE ISOTOPES IN CONTROL AND TECHNOLOGY

UN NO. 148	Radioisotopes in the Study of Fluid Dynamics	Beatty, K.O., et al
162	Industrial Inspection with Reactor Isotopes	Clarke, Eric T.
164*	Versatility of Radiation Applications Involving Penetration or Reflection	Crompton, C.E.
165	Portable Isotopic X-Ray Units	Daggs, R.G., et al
166	Radioisotopes in Petroleum Refining, Research and Analysis	Hull, D.W., et al

SESSION 23C - FISSION PRODUCTS AND THEIR APPLICATIONS

(Session 23C.3 - Conversion of Radiation into Electricity)

UN NO. 156	Beta-Ray Excited X-Ray Sources	Reiffel, L., et al

(Session 23C.2 - Food Sterilization)

UN NO. 167	Technology and Economics of High-Intensity Ionizing Radiations	Michaelis, Michael

(Session 23C.1 - Polymerisation Induced by Radiation)

UN NO. 168*	The Effect of Gamma Radiation on Some Chemical Reactions of Possible Industrial Importance	Bray, B.G., et al

(Session 23C.3 - Conversion of Radiation into Electricity)

UN NO. 169*	The Direct Conversion of Radiation into Electricity	Linder, E.G., et al

(Session 23C.1 - Polymerisation Induced by Radiation)

UN NO. 170	Use of Radioisotopes in the Production of Self-Luminous Compounds	Wallhausen, C.W.

(Session 23C.3 - Conversion of Radiation into Electricity)

UN NO. 171	Nuclear Batteries - A Survey	Shorr, William

1035461

SESSION 23C - FISSION PRODUCTS AND THEIR APPLICATIONS
(Session 23C.2 - Food Sterilization)

UN NO. 172*	Progress and Problems in the Development of Cold Sterilization of Foods	Proctor, B.E. Goldblith, S. A.
173	Ionizing Radiations for Meat Processing	Doty, D.M., et al
174	Research in the U.S. on the Radiation Sterilization of Foods	Siu, R.G.H., et al
175*	Sterilization of Medical Supplies with Gamma-Radiations	Brownell, L. E. Blumer, J.J.
176	Feeding Studies in the Appraisal of the Wholesomeness of Radiation Sterilized Foods	Huber, T.E., et al
225*	Health Protection Against Food-Borne Parasitic Diseases with Particular Reference to Control of Trichinosis	Lomberg, H.J. Gould, S.E.

1035462

ATTACHMENT 3 - ORGANIZATIONS WHICH SUBMITTED ABSTRACTS

Aerojet-General Corporation, Azusa, California
American Gas & Electric Services Corporation, New York City
American Institute of Architects, Washington, D. C.
American Machine & Foundry Company, New York City
American Meat Institute Foundation, Chicago
American Public Power Association, Washington, D. C.
Anton Electronic Laboratories, Brooklyn, N. Y.
Argonne National Laboratory, Lemont, Illinois
Armour Research Foundation of Ill. Institute of Tech., Chicago
Army Medical Research Laboratory, Fort Knox, Kentucky

Battelle Memorial Institute, Columbus, Ohio
Baylor University, Houston, Texas
Beth Israel Hospital, New York City
Boyce Thompson Institute for Plant Research, Yonkers, N. Y.
Bozell & Jacobs, Washington, D. C.
Brookhaven National Laboratory, Upton, N. Y.
Brush Beryllium Company, Cleveland, Ohio

California Institute of Technology, Pasadena, California
California Research Corporation, San Francisco, California
Carbide and Carbon Chemicals Company, Oak Ridge, Tennessee
Camp Detrick, Frederick, Maryland
Carnegie Institute of Technology, Pittsburgh, Pa.
Clark, Hitchcock and Associates, Washington, D. C.
Columbia University, New York City
College of Texas, Agricultural & Mechanical, College Station, Texas
Combustion Engineering, Inc., New York City
Crane Company, Chicago
Curtiss-Wright Corporation, Wood-Ridge, New Jersey

David Sarnoff Research Laboratories, Princeton, N. J.
Day & Zimmermann, Inc., Philadelphia, Pa.
Department of Agriculture, Washington, D. C.
Department of the Army, Washington, D. C.
Department of Commerce, Washington, D. C.
Department of Health, Education and Welfare, Washington, D. C.
Department of the Interior, Washington, D. C.
Department of Labor, Washington, D. C.
Department of the Navy, Washington, D. C.
Department of State, Washington, D. C.
Detroit Edison Company, Detroit, Michigan
Dow Chemical Company, Pittsburgh, California
Duke University, Durham, N. C.
DuMont Laboratories, Clifton, N. J.

1035463

Elliseva Sayers and Associates, New York City
Esso Research & Engineering Co., New York City

Federal Power Commission, Washington, D. C.
Firth Sterling, Inc., Pittsburgh, Pa.
Florida State University, Tallahassee, Florida
Francis Delafield Hospital, New York City
Frankford Arsenal, Philadelphia, Pa.
Franklin Institute, Philadelphia, Pa.

General Electric Company, Cincinnati, Ohio, Richland, Washington, and Schenectady, New York
George Washington University, Washington, D. C.
Great Lakes Carbon Corporation, Chicago

Harvard University, Boston, Mass.
Hawaiian Sugar Planters' Association, Honolulu, Hawaii
Hanford Atomic Products Operation, Richland, Washington
High Voltage Engineering Corporation, Cambridge, Mass.
Horizons Incorporated, Cleveland, Ohio

Idaho Operations Office, AEC, Idaho Falls, Idaho
Indiana University, Bloomington, Indiana
Institute for Cancer Research, Philadelphia, Pa.
Iowa State College, Ames, Iowa
Iowa State College of Agriculture and Mechanic Arts, Ames, Iowa

Johns Hopkins University, Chevy Chase, Md.
Johns Manville Sales Corporation, New York City

Kettering-Meyer Laboratory, Birmingham, Alabama
Kidde Nuclear Laboratories, Inc., Garden City, New York
Knolls Atomic Power Laboratory, Schenectady, N. Y.

Liberty Mutual, Boston, Mass.
Little, Arthur D., Inc., Cambridge, Mass. and San Francisco, Calif.
Long Island Biological Laboratory, Cold Spring Harbor, N. Y.
Los Alamos Scientific Laboratory, Los Alamos, New Mexico
Los Angeles, City of, Dept. of Water and Power, Los Angeles, Calif.
Lovelace Foundation, Albuquerque, New Mexico

Mallinckrodt Chemical Works, St. Louis, Missouri
Massachusetts General Hospital, Boston, Mass.
Massachusetts Institute of Technology, Cambridge, Mass.
Meharry Medical College, Nashville, Tennessee
Michigan State College, East Lansing, Michigan
Mine Safety Appliances Company, Pittsburgh, Pa.
Minneapolis-Honeywell Regulator Co., Philadelphia, Pa.

1035464

Monsanto Chemical Company, St. Louis, Missouri
Montefiore Hospital, New York City
Mound Laboratory, Miamisburg, Ohio

National Advisory Committee for Aeronautics, Washington, D. C.
National Board of Fire Underwriters, New York City
National Bureau of Standards, Washington, D. C.
National Carbon Company, New York City, and Cleveland, Ohio
National Industrial Conference Board, New York City
National Lead Company, New York City and Winchester, Mass.
National Planning Association, Washington, D. C.
Naval Medical Research Institute, Bethesda, Md.
Naval Research Laboratory, Washington, D. C.
New England Deaconess Hospital, Boston, Mass.
New Brunswick Laboratory, AEC, New Brunswick, N. J.
New York Operations Office, AEC, New York City
N. Y. State Department of Labor, New York City
New York University, New York City
Norden Laboratories, White Plains, New York
North American Aviation, Inc., Downey, California
North Carolina State College, Raleigh, N. C.
Northwestern University, Evanston, Ill.
Norton Company, Worcester, Massachusetts
Nuclear Development Associates, Inc., White Plains, N. Y.
Nuclear Energy Research Bureau, New York City
Nuclear Metals, Inc., Cambridge, Mass.
Nucleonics, New York City

Oak Ridge Institute of Nuclear Studies, Oak Ridge, Tennessee
Oak Ridge National Laboratory, Oak Ridge, Tennessee
Ohio State University, Columbus, Ohio

Panellit, Inc., Skokie, Illinois
Pennsylvania State University, University Park, Pa.
Charles Pfizer & Co., Inc., Brooklyn, N. Y.
Phillips Petroleum Company, Idaho Falls, Idaho
Princeton University, Princeton, N. J.
Phychiatric Institute, New York City
Purdue University, Lafayette, Indiana

RCA Corporation, Princeton, New Jersey
Rand Corporation, Santa Monica, California
Rensselaer Polytechnic Institute, Troy, N. Y.
Rice Institute, Houston, Texas
Rohm & Haas Company, Philadelphia, Pa.
Rutgers University, New Brunswick, New York

1035465

Scripps Institute of Oceanography, LaJolla, California
Sheffield Corporation, Dayton, Ohio
Shell Development Company, Houston, Texas
Silas Mason Company, Las Vegas, Nevada
Sloan-Kettering Institute for Cancer Research, New York City
Southwest Foundation for Research & Education, San Antonio, Texas
Standard Oil Company, Chicago, Illinois
Stanford Research Institute, Stanford, California
Sylvania Electric Products, Inc., Bayside, N. Y.
Syracuse University, Syracuse, N. Y.

Technical Operations, Arlington, Mass.
Textile Research Institute, Princeton, N. J.
Tracerlab, Inc., Richmond, California
Tulane University, New Orleans, Louisiana

University of Arkansas, Fayetteville, Arkansas and Little Rock, Ark.
University of California, Berkeley, Davis, Los Angeles, San Francisco, California
University of Chicago, Chicago, Illinois
University of Florida, Gainesville, Florida
University of Georgia, Athens, Georgia
University of Kansas, Lawrence, Kansas
University of Illinois, Urbana, Illinois
University of Michigan, Ann Arbor, Michigan
University of Minnesota, Minneapolis, Minn.
University of Missouri, Columbia, Mo.
University of North Carolina, Raleigh, N. C.
University of Pittsburgh, Pittsburgh, Pa.
University of Rochester, Rochester, N. Y.
University of Southern California, Los Angeles, California
University of Texas, Austin, Texas
University of Tennessee, Memphis, Tenn.
University of Utah, Salt Lake City, Utah
University of Washington, Seattle, Wash.
University of Wisconsin, Madison, Wis.
United Carbon Products Company, Inc., Bay City, Michigan
U. S. Geological Survey, Albuquerque, New Mexico
U. S. Naval Hospital, Bethesda, Md.
U. S. Radium Corporation, New York City

Vanderbilt University, Nashville, Tennessee
Veterans Administration Hospital, Boston, Mass., Hines, Ill. Long Beach, Calif.
Vitro Corporation of America, New York City

1035466

Wake Forest College, Winston-Salem, N. C.
Washington University, St. Louis, Mo.
Western Reserve University, Cleveland, Ohio
Westinghouse Air Brake Company, Pittsburgh, Pa.
Westinghouse Electric Corporation, Pittsburgh, Pa.
Woods Hole Institute, Woods Hole, Mass.
Worcester Foundation for Experimental Biology, Shrewsbury, Mass.

Yale University, New Haven, Connecticut

1035467

APPENDIX III — EVENING LECTURES

Ten evening lectures were given at the Palais des Nations during the Geneva Conference with the intention of covering in more general terms certain broad aspects of nuclear science which might otherwise be neglected in the more detailed work of the Technical Sections. They were directed not alone to participants in the Conference but to the world of science in general. One lecture dealing on a popular level with the general significance of atomic energy was given by Sir John Cockcroft in a summation lecture, interpreting the meaning of the Conference for the future.

The following is the list of speakers, dates and titles of lectures:

9 August	Prof. Niels Bohr (Denmark) - "Physical Science and Man's Position"
11 August	Dr. Ernest O. Lawrence (US) - "High Current Accelerators"
11 August	Prof. Vladimir I. Veksler (USSR) - "Principles of the Acceleration of Charged Particles"
15 August	Dr. Hans A. Bethe (US) - "Elementary Particles. Light Mesons"
15 August	Prof. Louis Leprince-Ringuet (France) - "The 'Strange Particles'- Mesons and Hyperons"
15 August	Dr. George de Hevesy (Sweden) - "Radioactive Tracers and Their Application"
15 August	Dr. Willard F. Libby (US) - "Radiocarbon Dating"
17 August	Dr. Alexander Hollaender (US) - "Modification of Radiation Response"
17 August	Prof. Andrei L. Kursanov (USSR) - "Radioactive Elements in the Study of Plant Life"
19 August	Sir John D. Cockcroft (UK) - "The Future of Atomic Energy"

1035468

Prof. Niels Bohr

The lectures commenced on the evening of August 9, 1955, with Prof. Niels Bohr (Denmark) as the speaker. Prof. Bohr made a plea for re-establishment of international freedom of information — such as was then taking place at the Conference. He began by stating that with man's expansion of knowledge in the 20th century, "our whole civilization is confronted with a most serious challenge" which demands an adjustment between nations. "We are," Prof. Bohr said, "dealing with consequences of endeavors which know no national borders." He reminded his audience how "the development of modern science is the outcome of a most intense international cooperation."

Prof. Bohr retraced the exploratory steps of Einstein, Planck, Mendelejef among many famous nuclear pioneers, explaining that the knowledge of how to utilize the forces within the atom could never have been gained without "freedom of experimentation." The fruits of scientific research, he continued, are "a common human inheritance."

Prof. Bohr hoped he had conveyed "an impression of the seriousness of . . . our human position, which the exploration of the atom world has given us" and he went on to express his conviction that science will play an even more decisive part in the cause of humanity in the future. He expressed the belief that "the co-operation in scientific research offers perhaps more than anything else opportunities for the furthering of close contacts and common understanding. Indeed, he said, establishment of co-operation among all peoples, "now so urgently needed, depends essentially on the free access to all information, and unhampered discussions of all problems of human interest." Dr. Bohr closed by stating his conviction that the Geneva Conference "will come to stand as a landmark for scientific and technological co-operation."

Dr. E. O. Lawrence

Dr. Ernest O. Lawrence (US), Director of the Radiation Laboratory of the University of California, gave the second lecture, on the evening of August 11, 1955. His subject was high current accelerators. He began by paying tribute to several men whose work was essential to the development of these machines which open up "the richness of the domain of the nucleus." Dr. Lawrence singled out Cockcroft and Walton of England, and Professor Veksler of the Soviet Union for particular praise. He showed slides of California's bevatron which, he said, "is being utilized by scientists of many laboratories in America and abroad." About 25 per cent of the bevatron's operating time, Dr. Lawrence reported, has been devoted to furthering work outside the United States.

1035469

Dr. Lawrence then reviewed the history and development of the new A-48 high current-linear accelerator. This idea began, he believed, with a paper published by L. H. Thomas in 1938, whose significance was overlooked for 10 years. After the war Thomas's proposals were paralleled by McMillan. Dr. Lawrence gave a technical explanation of the linear accelerator, discussing in detail also the cloverleaf cyclotron whose construction had been considered but was abandoned at California in favor of the linear accelerator, which would not require as high capital expenditure and would allow, also, extension almost indefinitely to higher voltages as desired.

Emphasizing his enthusiasm for "this great machine", Dr. Lawrence said: "those of us who have had the good fortune of participating in these developments during the past quarter of a century have indeed a vivid impression that each new door to a hitherto inaccessible region of nature opened by the development of an accelerator of new capabilities always leads to unexpected advances in knowledge of both scientific and technological importance." He expressed the hope that many of the delegates "will give us the pleasure of a visit some day soon in California."

Prof. Vladimir I. Veksler (USSR) followed Dr. Lawrence on the evening of August 11, 1955, giving the third lecture of the series. He discussed the various techniques employed by different types of accelerators. He described the use of accelerators, producing by artificial means particles possessing high energy (previously observed only in cosmic rays in small quantity), as "a new branch of contemporary nuclear physics." Discovery after discovery has been made in this field during the last few years, making possible study of the "deep fission of atomic nuclei" and revealing "far-reaching prospects of developing the artificial synthesis of substances." The main hopes of physicists centered at first, for these purposes, on the cyclotron, but this machine was unable, Prof. Veksler stated, to accelerate particles to the maximum desired. "It seemed that the gateway to substantially higher energies was hermetically sealed."

Prof. Veksler then described how both in the U. S., at Berkeley, Calif., and in the USSR, approaches had been made toward solving the problem at least to some extent. Noting that the cyclotron accelerates particles on the order of 10-20 mev, Prof. Veksler described in some detail the process of auto-phasing, raising the upper energy limit obtainable in the cyclotron "a thousandfold." He described also the synchrotron, designed to produce an energy beam of 5-10 thousand Mev, the phasotron or synchrocyclotron, with beam energies (in the Soviet machine) of 680 mev, and the synchrophasotron. These machines, however, "are still far from the limiting energies possessed by cosmic-ray particles," Prof. Veksler observed. He spoke of energies from 50,000 to 100,000 mev. "My personal opinion," he concluded, "is that

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we must seek out completely new approaches," he said, "but it would be premature to discuss the problem here, as it still needs very thorough examination."

Dr. Hans A. Bethe

On the evening of August 15, 1955, the fourth, fifth, sixth, and seventh lectures of the series were given, two in each of two simultaneous sessions. Dr. Hans A. Bethe (US) presented the fourth, a paper on light mesons. He began by explaining that interest in mesons originated from a desire to explain intra-nuclear forces. In substance, Dr. Bethe spoke as follows:

By means of high energy accelerators, mesons have been produced in large quantities. It has been found that these elementary particles exist with unit positive charge, with unit negative charge and in a neutral form. All three forms have about 270 electron masses. Both charged mesons decay into mesons and neutrinos. The neutral meson decays into two gamma rays. Dr. Bethe discussed meson scattering studies and their relation to nuclear forces in some detail. He said that it now seems likely that a satisfactory theory of nuclear forces can be constructed with mesons alone.

Dr. Bethe discussed the properties of the meson. He said that mesons decay into electrons and two neutrons, and that this process was responsible for most of the electrons found in cosmic radiation. There is no evidence for any nuclear interaction of the meson. In fact, he declared, there is no understanding of the role which the meson plays in the structure of the universe.

Dr. Bethe predicted that the search by the Berkeley Group for the anti-proton would be successful.

Prof. Louis Leprince-Ringuet

In a paper complementary to Dr. Bethe's, Prof. Louis Leprince-Ringuet (France), in the same session on the evening of August 15, 1955, gave the fifth lecture, discussing heavy mesons and hyperons, those particles which are studied in the principal cosmic ray laboratories and with the particle accelerators of Brookhaven National Laboratory and of the University of California's Radiation Laboratory, Berkeley.

Dr. Leprince-Ringuet discussed these particles entirely from the experimental standpoint, explaining that theoretical treatment of the problems is quite fragmentary. He said that heavy mesons all have a mass of about 1000 times that of the electron and may be positively charged, negatively charged, or neutral. Information about heavy mesons is not as complete as for mesons because of the difficulty of producing them in large quantities.

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Hyperons, he continued, appear to be particles composed of a nucleon and a light meson. There are hyperons with charges of both signs and at least one neutral type. Upon disintegration they usually produce a nucleon and a meson. The hyperon family, the speaker implied, must be rather complicated.

Prof. Leprince-Ringuet predicted that the impending experimental results will stimulate the attempts to evolve theory.

Dr. George de Hevesy

Dr. George de Hevesy (Sweden) introduced the topic of radioactivity for the lecture in opening the second simultaneous session on the evening of August 15, 1955, and gave the sixth lecture of the session. He began by recalling the earliest days of the development of the method of using radioactive tracers. He recalled his work at the University of Manchester, in 1911, and his unsuccessful attempt, at the instigation of Prof. Ernest Rutherford, to separate radium D from lead chloride. In this early period, Dr. Hevesy recalled, the Imperial Austrian Government owned the only uranium mine in the world, that of Joachimsthal in Bohemia. "The Austrian Government," he said, "showed great generosity towards scientists engaged in the study of radioactivity. It presented Pierre and Marie Curie with a railway carload of pitchblende, enabling them to isolate radium shortly after their discovery of this element. All work carried out with radium by Rutherford and his school had to be done with a radium sample lent by the Austrian Government which presented Rutherford also with many hundreds of kilograms of lead chloride prepared from pitchblende containing precious radium D." This, however, was useless because it could not be separated from the lead chloride. In 1912, Dr. Hevesy went to the Vienna Institute of Radium Research to meet Dr. Paneth, who had also sought this separation without success. Years later the discovery by Frederic and Irene Joliot-Curie of artificial radioactivity "opened up a fairyland," Dr. Hevesy recalled which subsequently was "immensely enlarged by Ernest Lawrence's construction of the cyclotron." This machine produced radioactive substances of "prodigious activities" which Dr. Lawrence, "with the greatest generosity" put at the disposal of others working with these new tracers. The next great advance was the construction of the pile at Stagg Field as a result of which radioactive isotopes of almost every element and of prodigious activity became available. Among these was Carbon 14 which, from all radioactive tracers, "has found the most extended application", Dr. Hevesy reported. From this tracer alone "results of greatest importance for biochemistry and physiology were obtained."

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Dr. Willard F. Libby

The science of radiocarbon dating was described by its originator, Dr. W. F. Libby (US) in the seventh lecture of the series, following Dr. de Hevesy on August 15, 1955. Dr. Libby began by giving his audience a thorough technical explanation of the system. He then told how the system was applied for precise dating of the earth's history, one of the principal goals throughout the history of research. The American Anthropological Association and the Geological Society of America appointed a committee on Carbon-14 to organize a comprehensive test of the method while the Wenner Gren Foundation for Anthropological Research gave "generous" support to the research. In addition, part of the development was conducted under contract with the U. S. Air Force. As Dr. Libby told the story, "the advisory committee decided that it would be possible to test the method against samples of known age back to about 5,000 years." With one or two exceptions, there was full agreement between radiocarbon dating and the items of known age.

"It is interesting that, according to radiocarbon evidence," Dr. Libby said, "the earliest men in North America, Britain, and Denmark appeared contemporaneously some ten thousand years ago." Dr. Libby said there was fear that by the radiocarbon dating method "we should find men older than the last ice age, and had agreed that this would constitute sufficiently conclusive evidence to discredit the whole method." Men were not found in those parts of the world covered by the great glaciers. "We learn," Dr. Libby said, "of the correlation of the calendars of the ancient Babylonians and Mayans with our Christian calendar. We see that the oceans of the world probably have risen in water level at a leisurely and stately pace as the glaciers melted. Further measurement of the depths of the ancient sea shores should help us to further understand this rate of rise. This should lead to new conclusions as to the geography of the earth in ancient times and it seems that most interesting historical results may follow this study."

Dr. Alexander Hollaender

"Modification of Radiation Response" was the subject of a lecture on protection and recovery from radiation damage, the eighth lecture of the series, by Dr. Alexander Hollaender of the biology division of the Oak Ridge National Laboratory, on August 17, 1955. Dr. Hollaender observed, in his opening remarks, that "studies conducted in many laboratories all over the world have brought out many interesting ways to modify radiation response. The efforts in this direction have shown that international co-operation in the atomic field can be obtained even without any elaborate organization." Dr. Hollaender discussed the "tremendous variation in radiation sensitivity of living

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organisms." He reviewed different attempts to increase radiation resistance, such as reduction of temperature, or the reduction of moisture content in mammals. Both, he said, are effective in increasing radiation resistance but these are techniques which cannot be readily used with mammals. Reduction of oxygen tension is another technique, again not effective for mammals.

In the field of chemical protection, Dr. Hollaender discussed in detail three compounds, cysteine, B-mercaptoethylamine (csteamine), and S. B-aminoethylisothiuronium (AET). Dr. Hollaender then reviewed such radiation protection measures as transplanting of spleen from a non-irradiated body, the use of antibiotics, and nutritional support. "The entire field of radiation recovery," Dr. Hollaender noted, "is still in its infancy. There are many possibilities, especially in regard to combined treatments which have not yet been explored."

In essence, Dr. Hollaender's lecture, dwelling on problems connected with the action of ionizing radiation on organisms, revealed the profound metabolic changes that can be brought about in living creatures by the use of radiation. In closing, Dr. Hollaender spoke of the necessity that "the basic mechanism of radiation damage to living cells" be better understood in order that means of protection can be found to meet any circumstances which might arise.

Prof. Andrei L. Kursanov

Use of radioactive elements to procure high and sustained harvest, leading to a "secure and quiet life for man" was described by Prof. Andrei L. Kursanov of the USSR on August 17, 1955, in the ninth lecture of the series. "We are," the speaker began," still on the threshold of that new era which will rightly be called the age of the peaceful use of atomic energy." Use of radioactive elements, as research tools, Professor Kursanov said, already has carried man far toward understanding the metabolism of organisms. He discussed the use of "labelled atoms" in the study of plant nutrition, as it appears now after several years' use. Citing the work of many U. S. as well as USSR scientists, Prof. Kursanov surveyed innumerable experiments in the world which have led to the proved conclusion that the root systems of plants and trees feed the organism, just as carbon dioxide is absorbed by the leaves from the air. Before the use of radioactive tracers it had been widely accepted that the roots of plants provided mainly for securing the plant (or tree) to the earth, and providing the organism with moisture, while the food was absorbed from the air. Use of labelled atoms has proved, Prof. Kursanov explained, "that there is a rapid circulation of organic substance covering the entire body of the plant from its uppermost leaves to the tips of its roots...Thus we can no longer accept

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the earlier idea that ascribed to the roots a humble role . . .On the contrary, we may ascribe to the roots a leading part in those complex transformations. . ."

This means, Professor Kursanov went on, that agriculturalists will be able to learn far more about the needs of plant nourishment and fertilization and will be able to increase crops and harvests substantially. Moreover, the speaker went on, the success achieved so far in radioactive tracer work "give grounds for hoping that. . .in the not too distant future, the possibility may arise of the practical application of photosynthesis outside the plant." Thus, Prof. Kursanov concluded, "we can see that the rational use of atomic energy is already paving the way to the mastery of the energy of light." As peoples of the world realize the mighty benefits to come from the peaceful uses of atomic energy, such as these discussed, they may look "with respect and trust on the work now being carried on."

Sir John D. Cockcroft

The tenth and final lecture of the series was delivered by Sir John Cockcroft (U.K.) on the evening of August 19, 1955. Sir John summarized the present relations of the peaceful uses of atomic energy to the affairs of mankind, forecasting that for the next decade nuclear engineers will be occupied in laying a sound basis from which nuclear power can expand rapidly to become "the major power source of the world." Nuclear power stations of 1970, Sir John said, "will look as different from those of 1957 as the modern motor car differs from the Model T Ford." While the papers at the Conference had shown that nuclear power cheaper than power from coal could not be expected for a decade, he said, this was not the point. The important point is that an additional source of energy is becoming available to the world. Two requirements must be met, he said: lower capital costs for nuclear plants, and an increase in the amount of energy to be extracted from each ton of uranium or thorium.

Sir John traced his expectations of nuclear power development country by country, and identified some industries which would be among the first to need this power: mines, pulp and paper, cement, and aluminum. Sir John said he was not greatly worried about the problem of disposal of radioactive wastes in the future and he thought such waste products would have more important uses than are foreseen now. He discussed uses of radiation and mentioned particularly that in its use for insect control men had not begun to appreciate the benefits to come.

Speaking of radiation in connection with human safety, Sir John noted that codes of practice are now being drawn up by experts and that the next step is for the nations of the world to agree on International Codes of Practice. "The United Nations Organization,"

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he said, "is in the process of giving birth to a much more ambitious offspring, the International Atomic Energy Agency. We must all hope that its birth will not be too painful or too long delayed. The Agency, wisely guided, could do a great deal to ensure that the inherent dangers in our development are prevented."

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APPENDIX IV — U. S. TECHNICAL EXHIBIT AT GENEVA

The United States was one of 9 nations to present technical exhibits at the Palais des Nations during the two weeks the Conference was held there. The other nations exhibiting were: Belgium, Canada, Denmark, France, Norway, Sweden, Union of Soviet Socialist Republics, and the United Kingdom.

The US exhibit in the Library Wing of the Palais des Nations, where the USSR and United Kingdom exhibits also were placed, filled a room about 40 to 100 feet in size (room XV). The room was laid out with exhibits against the walls, and also around a central island. Between its opening to the public at 5 p.m., Aug. 7, and its closing at 10 p.m., Aug. 20, a total of 36,222 visitors was counted.

The USSR exhibit was the only one in the Palais which occupied space equivalent to that of the United States. The USSR displayed models of three reactors, many mineralogical samples, and some experimental equipment. Intermittently, they showed a film on constructing and operating their power reactor. The United Kingdom placed its main emphasis on an educational and commercial exposition held simultaneously with the Conference under Swiss auspices at the Palais des Expositions in downtown Geneva. At the Palais des Nations, the UK emphasized power generation, showed a model of a Calder Hall reactor, and gave information on 7 reactors in all. Canada displayed a model of its NRX reactor, but placed main emphasis on a full-size teletherapy unit. The Danish-Norwegian-Swedish area featured a model of the Swedish Kjeller reactor, and Sweden, in addition, showed a mobile radiological survey unit. Belgium displayed a reactor simulator, some instruments, and its wall panels pictured research projects and the famous Congo Shinkolobwe mines. The French exhibit gave considerable emphasis to ore mining and processing, and included a simplified full-scale reactor control panel, operating in conjunction with a model of a vertical section of a reactor.

The US exhibit included 101 reactor models, two of them small, and four drawings and diagrams for wall panels on additional reactors. There were samples of rare earths, with flow charts on their separation, actual samples of transuranic elements, a large continuously operating cloud chamber, a master-slave "hot" laboratory, a model of a chemical separating plant, a model of an Argonne National Laboratory (see photograph "A", model of entire US Technical Exhibit) greenhouse where plant experiments are carried out, growing samples of irradiation mutated plants from Brookhaven National Laboratory, a lavish display of

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radiation-detection instruments, including a hand-and-foot counter used to protect workers in atomic plants, a 100-channel analyzer — a so-called electronic "brain" used in scientific computations — from Los Alamos Scientific Laboratory, and medical exhibit from Sloan-Kettering Institute. All of these bore explanatory labels, printed in the four offical languages of the Conference. (Detailed descriptions and photographs of the exhibit, designed and arranged by Design and Production, Inc., Alexandria, Va., are given later). The exhibitors in the US Technical Exhibit totaled 105 and included industrial and commercial firms, academic, professional, and private educational and research organizations (full list of participants in Attachment 1).

Distinguished men of science who visited the Technical Exhibit included Sir John Cockcroft, (UK) and Professors Niels Bohr, (Denmark) Otto Hahn, (West Germany) and Paul Scherrer (Switzerland). Also among the prominent visitors were Dr. Homi J. Bhabha (India), Conference President; Dr. Walter Whitman, Conference Secretary General; Academician D. V. Skobeltzin, Chief, USSR Delegation; Sir Christopher Hinton (UK); also President Max Petit-Pierre, of Switzerland, Secretary General Dag Hammarskjold, of the United Nations, Miss Frances Willis and Mr. V. Alexis Johnson, American ambassadors to Switzerland and Czechoslovakia respectively, and U. S. Senators and Representatives (See photograph "B", Dr. George L. Weil, Technical Director, escorting Secretary General Dag Hammarskjold of the United Nations (on Dr. Weil's right), and Gunnar Randers, special assistant to Mr. Hammarskjold (on Dr. Weil's left) through U. S. Technical Exhibit).

The U. S. Exhibit was opened officially on Sunday, August 7 with a press preview at 2 p.m., followed by a tour of all national exhibits at Palais des Nations by Mr. Hammarskjold and officials of the Conference. At 5 p.m., the doors were opened to the public.

During the next two weeks the U. S. Technical Exhibit and the exhibits of the other nations at the Palais were opened on week days from 10 a.m. to 9 p.m. except for the first Monday and Tuesday, August 8 and 9, when they were opened from 9 a.m. to 10 p.m. The public was admitted after 5 p.m. On two Sundays, August 14 and 21, the public came during the entire open period which was from 10 a.m. to noon and from 2 to 7 p.m.

Attendance at the U. S. Exhibit increased daily. During the first week 12,808 visits were counted. Attendance the second week was 23,414, nearly double that of the first week. The heaviest day was [illegible], August 19, when 4,648 people were counted. Twenty-five thousand copies of a four-language brochure describing the exhibit were shipped to Geneva for distribution. The last were handed out on request several days before the exhibit closed.

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Description of the Exhibit

As one entered the U. S. Technical Exhibit he found on his left the following passage from President Eisenhower's message in four languages, (as was practically all text in the Exhibit):

Photo No. 1: "The atom cannot be limited by national boundaries. Men of science from many countries, often working together, help to harness its great energy for the good of mankind. The Geneva Conference on Peaceful Uses of Atomic Energy is a tribute to the inventive genius of these men. At the same time, it demonstrates to people everywhere that continued international cooperation is essential if we are to realize man's capacity to create for himself an increasingly productive world, living at peace.

"The great strides already made in putting atomic energy to work in industry, agriculture, medicine and research, will become evident during the course of this Conference. We hope that the free exchange of technical information and ideas among leading scientists and engineers of many nations will stimulate ever greater progress in the months and years ahead.

"In this cause, the United States is firmly dedicated to promote international cooperation and to contribute its share of scientific knowledge and resources."

Then straight ahead on the wall was the United States emblem for the Conference, on its left the reception desk and on its right the first display covering the production of uranium and thorium.

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Photo No. 2: The Production of Uranium and Thorium Metals panel contained two parallel flow diagrams, each extending the full 15-foot length of the panel, with 32 samples of uranium materials and 17 samples of thorium materials furnished by the Lindsay Chemical Company. On a table in front of the panel were 27 samples of uranium minerals and the same number of uranium-thorium minerals, brilliantly lighted under transparent plastic.

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Photo No. Behind the uranium and thorium panel one could see past four other reactor materials panels to the fuel element display.

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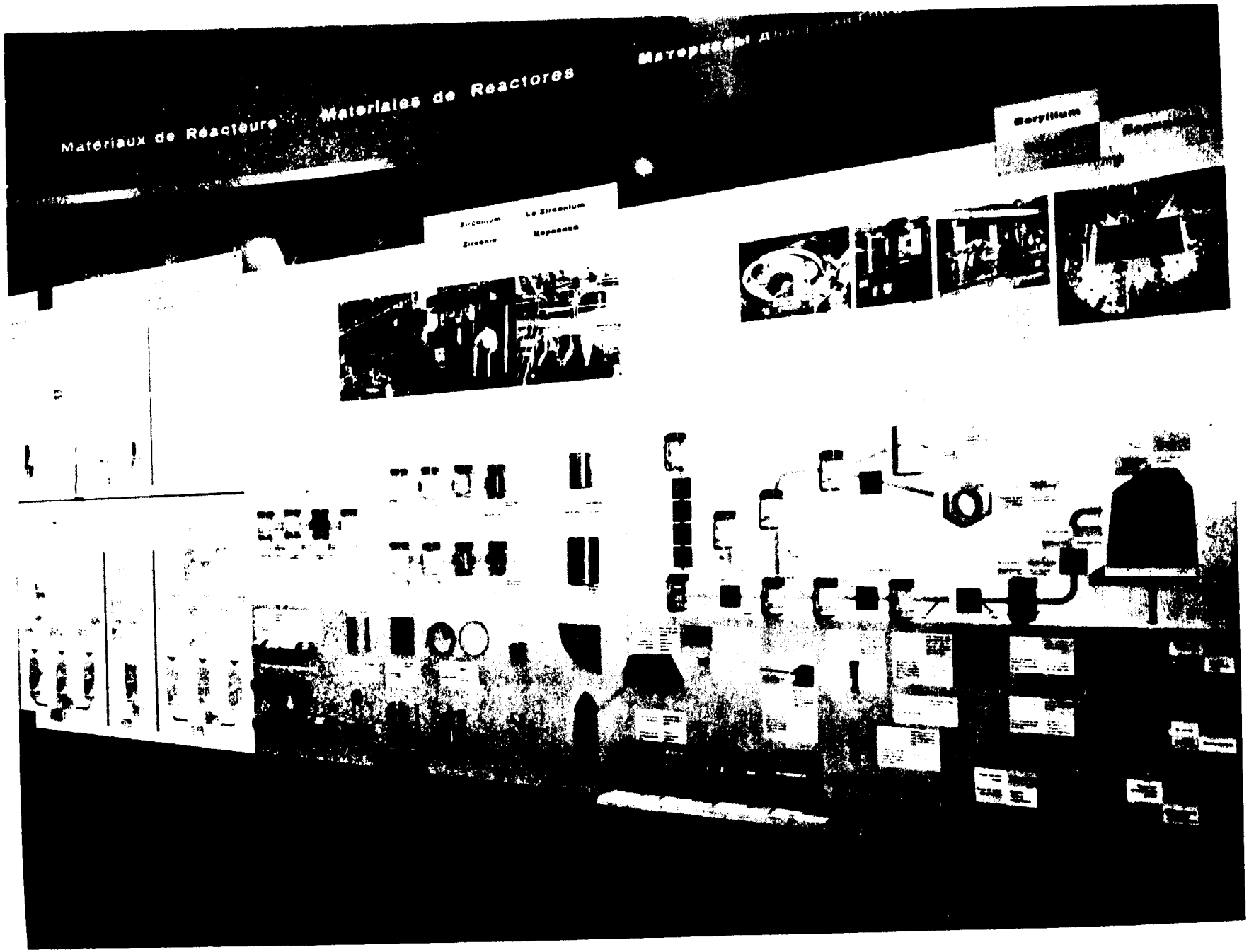
Materiaux de Réacteurs
Materiales de Reactores
Beryllium
Le Zirconium
Zirconio

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Photo No. 4: The first of the four reactor materials panels described the production of beryllium with four photographs and a flow diagram, contained 12 samples and illustrated the fabrication of the metal with 25 items across the bottom of the panel. A large machined piece of beryllium produced by powder metallurgy supplemented the panel. These materials came from Brush Beryllium Co. and Nuclear Metals, Inc.

Next, there was a similar panel on zirconium with three photographs, 14 samples in a flow diagram and 29 on fabrication from the United States Bureau of Mines Electrometallurgical Station at Albany, Oregon, and Nuclear Metals, Inc.

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Photo No. 5: Then, under the head, "Thermal Cycling of Uranium", distortion of the metal caused by repeated heating and cooling was illustrated with pure uranium samples which had actually been subjected to various degrees of cycling. For comparison, the panel included heat-treated and alloyed samples which exhibited less damage. This display, containing 15 samples sealed in glass, was prepared by Argonne National Laboratory.

The final reactor materials display, also by Argonne, illustrated the corrosive effect of hot water on aluminum and improvement achieved by alloying with nickel. The panel contained six samples.

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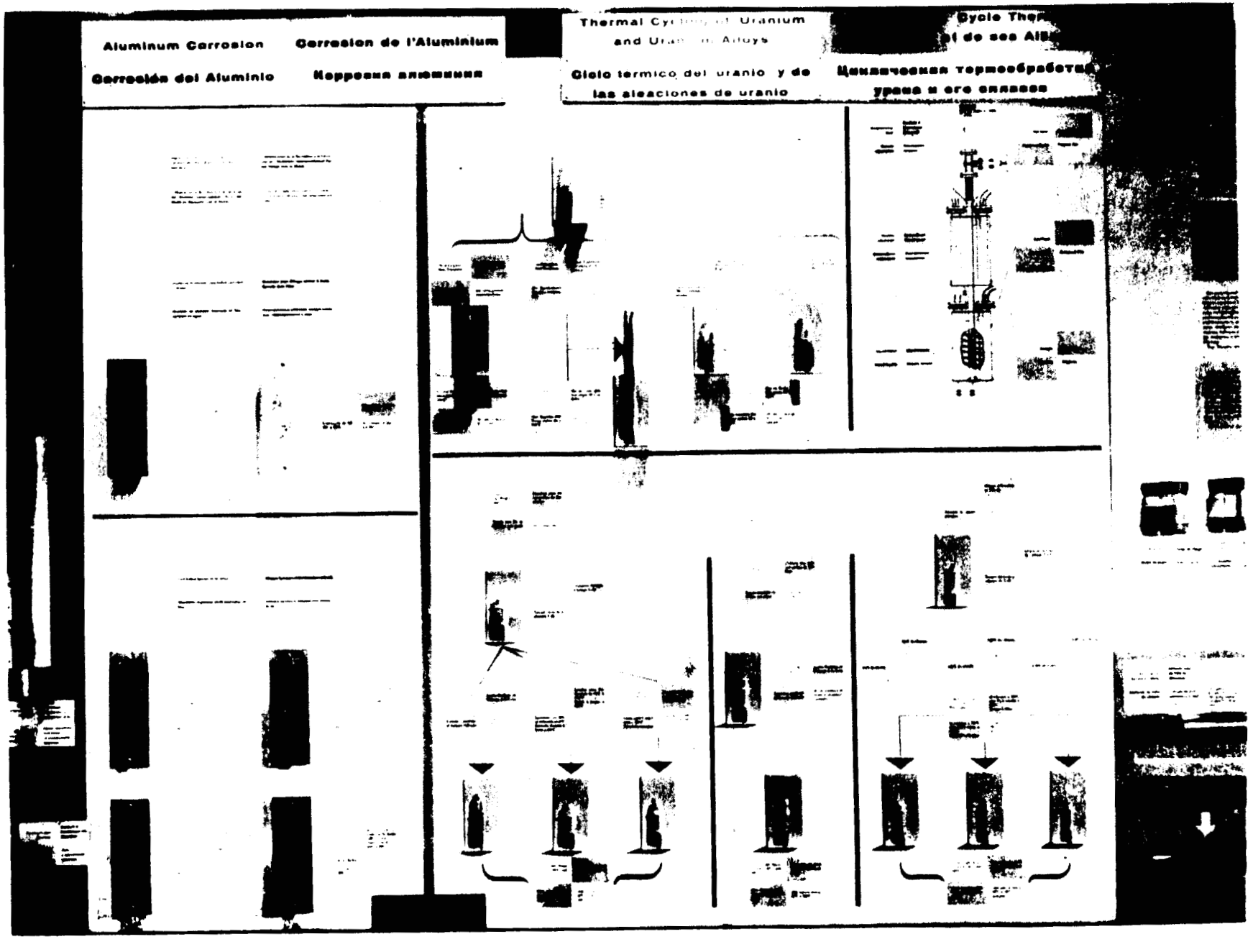
Aluminum Corrosion
Corrosion de l'Aluminium
Corrosión del Aluminio
Коррозия алюминия
Thermal Cy
and Ura
Ciclo termico del uranio y de
las aleaciones de uranio
Cycle Ther
el de ses Al
Циклическая термообработ
урана и его сплавов

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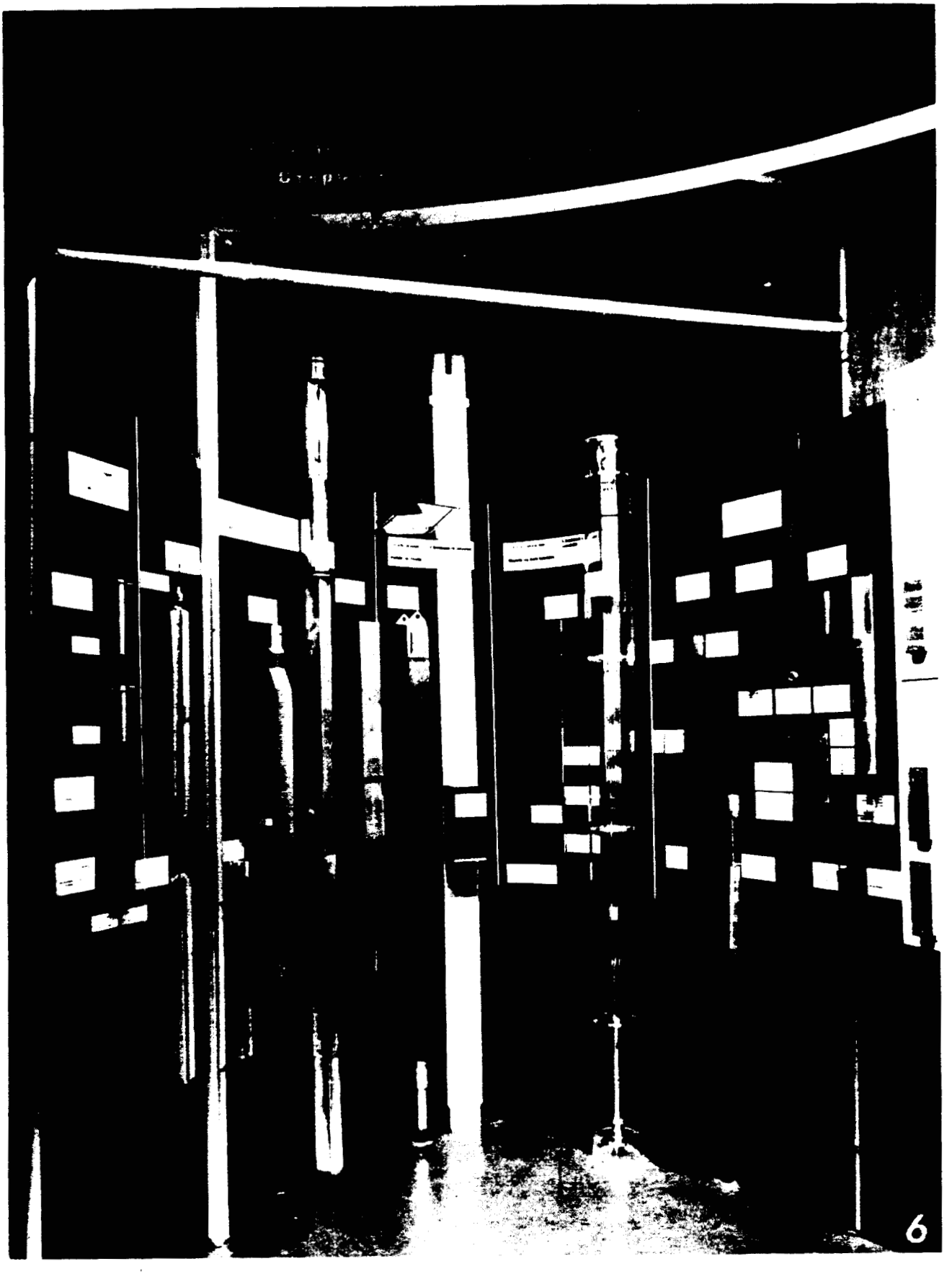


1035491

Photo No. 6: Upon a concave black background, the fuel element section displayed elements used in or developed for eight reactors. They were grouped according to the cladding material — aluminum, zirconium and stainless steel.

The aluminum-clad elements were those for the Brookhaven Reactor (from Brookhaven National Laboratory), the Materials Testing Reactor (from Oak Ridge National Laboratory), the Argonne Research Reactor and the Boiling Reactor Power Plant (from Argonne National Laboratory). Both an old natural uranium Brookhaven element and a proposed enriched element were displayed.

The zirconium-clad elements were of the Experimental Boiling Water Reactor (from Argonne National Laboratory) and the Shippingport Pressurized Water Reactor (from Westinghouse Electric Corporation).

The elements clad in stainless steel were for Experimental Breeder Reactors Nos. 1 and 2 (from Argonne National Laboratory).

In addition, on the left side of the display there were samples of uranium and thorium slugs produced by rolling and machining, by extrusion and by power metallurgy. On the other side were a number of forms of interest to reactor designers, some cast, some extruded, and others produced by power metallurgy. These supplementary materials were furnished by the duPont Company, Sylvania Electric Products, Inc., and Nuclear Metals, Inc.

1035492

Photo No. 7: As one left the fuel element display and looked across the end of the 40 by 100-foot room, the five models of the Government's Experimental Power Reactor Program lay before him. Each model contained supplementary information in text and illustration on the wall behind it.

1035493

1035494

Shippingport Pressurized Water Reactor
Reactor de agua a presión en Shippingport

1035495

Photo No. 8: The Shippingport Pressurized Water Reactor Model, from Westinghouse Electric Corporation, had operating control rods and a pressure vessel, piping, heat exchanger, turbine and generator that lighted up in sequence to illustrate the flow of energy.

1035496

Photo No. 9: The model of the Experimental Boiling Water Reactor, from the Argonne National Laboratory, contained a core which simulated boiling by the effective use of lighting.

1035497

Experimental Boiling Water Reactor — Réacteur Expérimental à Eau Bouillante

Reactor experimental de agua en ebullición — Quadrant stainless steel reactor

1035498

Experimental Boiling Water Reactor
Reactor Generator Experimental No 2

1035499

Photo No. 10: The core of Experimental Breeder Reactor No. 2, represented by this model from the Argonne Laboratory, is to the left and underground in the model. The top of the turbo-generator is visible on the right.

1035500

Photo No. 11: The model of Homogeneous Reactor Experiment No. 2, from Oak Ridge National Laboratory, contained two colored liquids circulating with bubbles to simulate the flow of the fuel and blanket solutions.

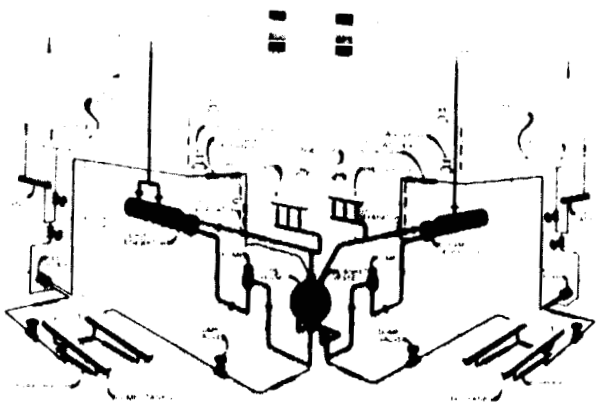
1035501

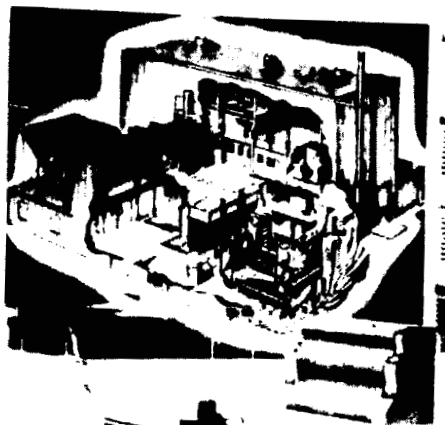
Homogeneous Reactor Experiment No. 2

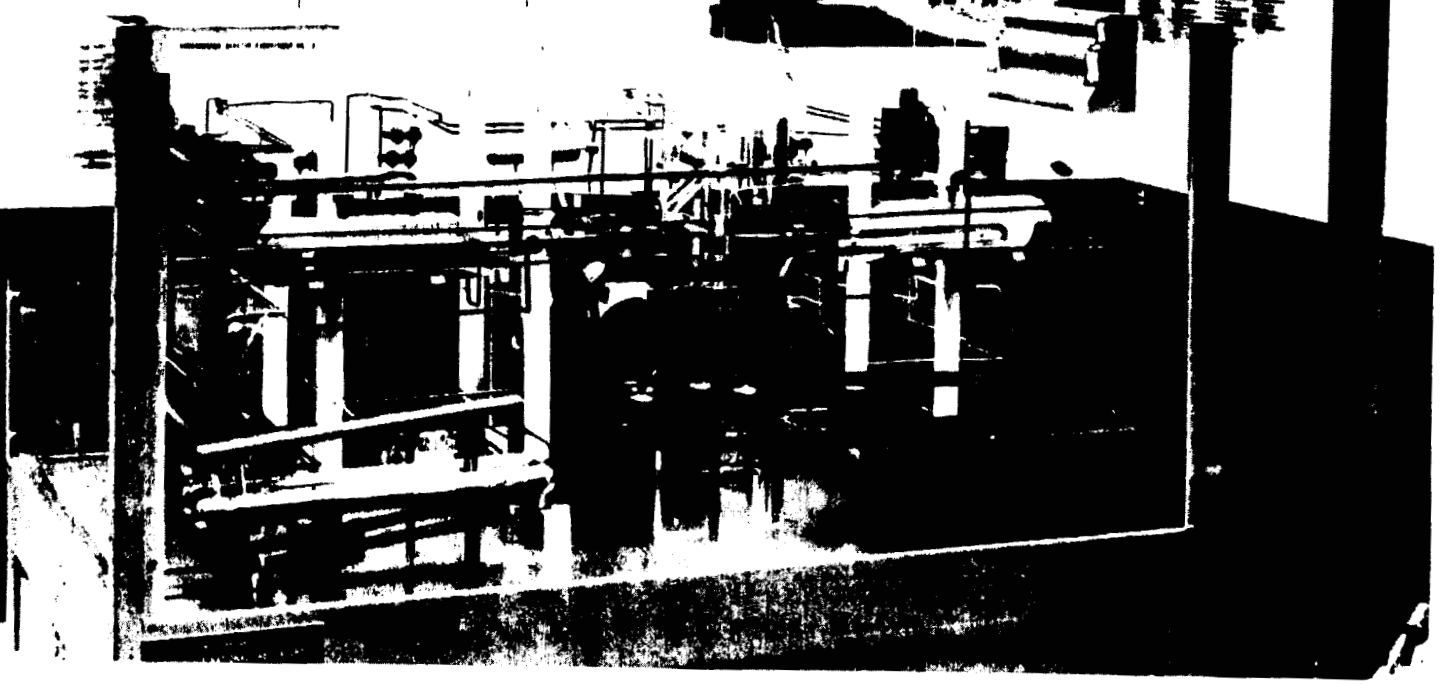
L'Experience de Reacteur Homogene No. 2

El reactor experimental homogeneo No. 2

Гомогенный реактор, опытный образец № 2







1035502

1035503

Photo No. 12: In the Sodium Reactor Experiment model, from North American Aviation, Inc., colored liquid containing bubbles was circulated to simulate the flow of reactor liquids, in this case the primary and secondary liquid metal coolants.

1035504

Photo No. 13: Following the Government program, which consists chiefly of small pilot plants, there were displays of four full-scale plants proposed by industry.

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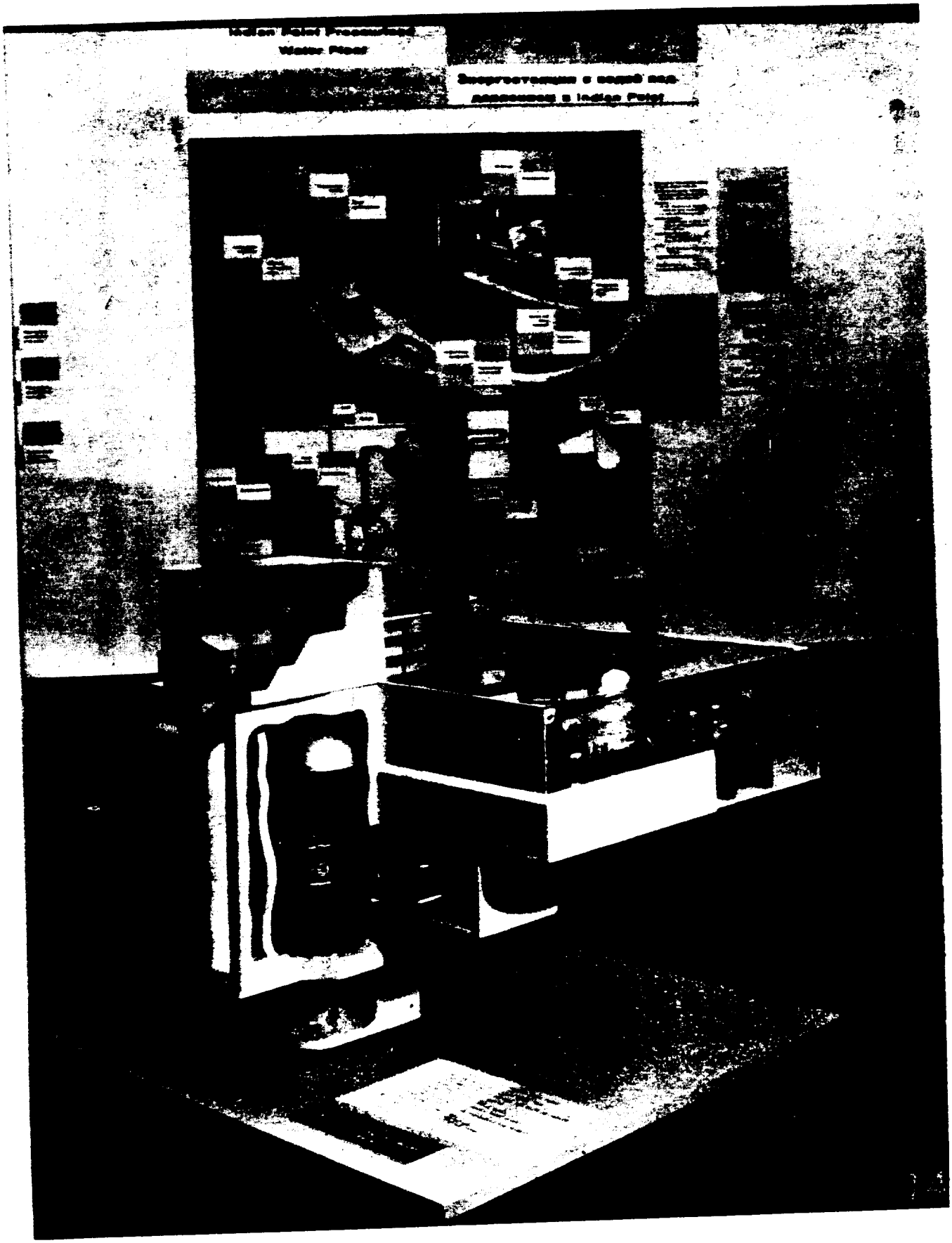
1035506



1035507

Photo No. 14: The 240,000-kilowatt Indian Point Pressurized Water Plant, proposed by the Consolidated Edison Co., of New York City, was illustrated by an artist's perspective drawing of the installation, a flow diagram and a small model, all furnished by Babcock and Wilcox Co., the contractor.

1035508

Photo No. 15: The 180,000-kilowatt Dual-Cycle Boiling Water Plant, proposed by the Nuclear Power Group, was explained by four drawings, including cut-away perspectives of the special type of boiling reactor with its flash drums. The contractor, the General Electric Company, furnished this material.

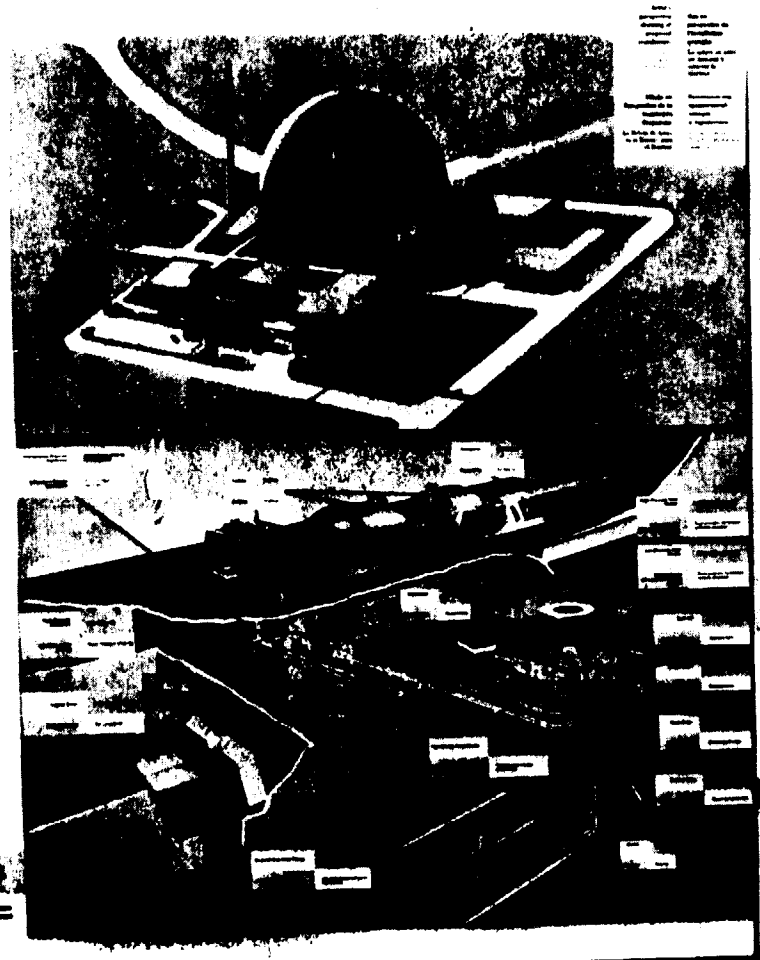
1035509

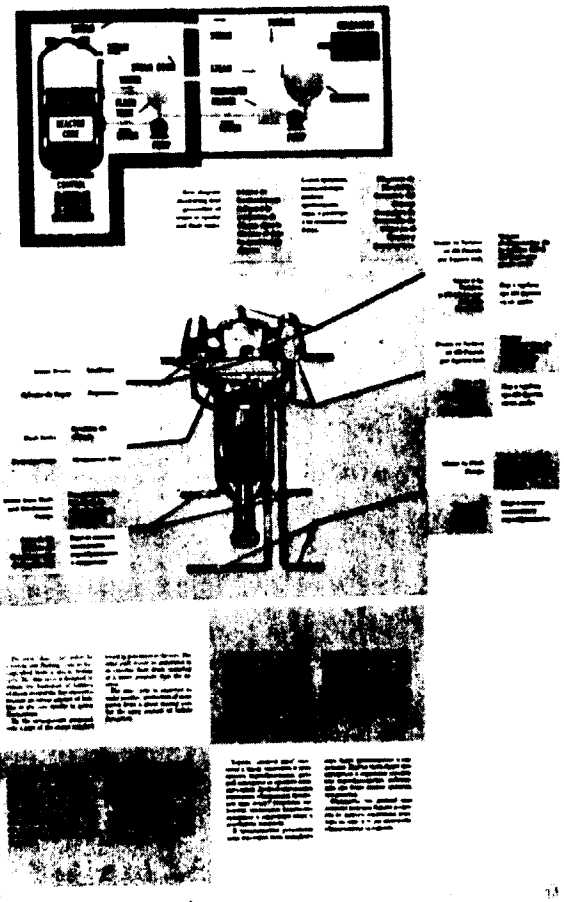
Dual-Cycle Boiling Reactor Plant

Réacteur à eau bouillante à deux étages

Planta con Reactor Hirviente de Ciclo Compuesto

Энергостанция на атомном паровотле с двойным циклом

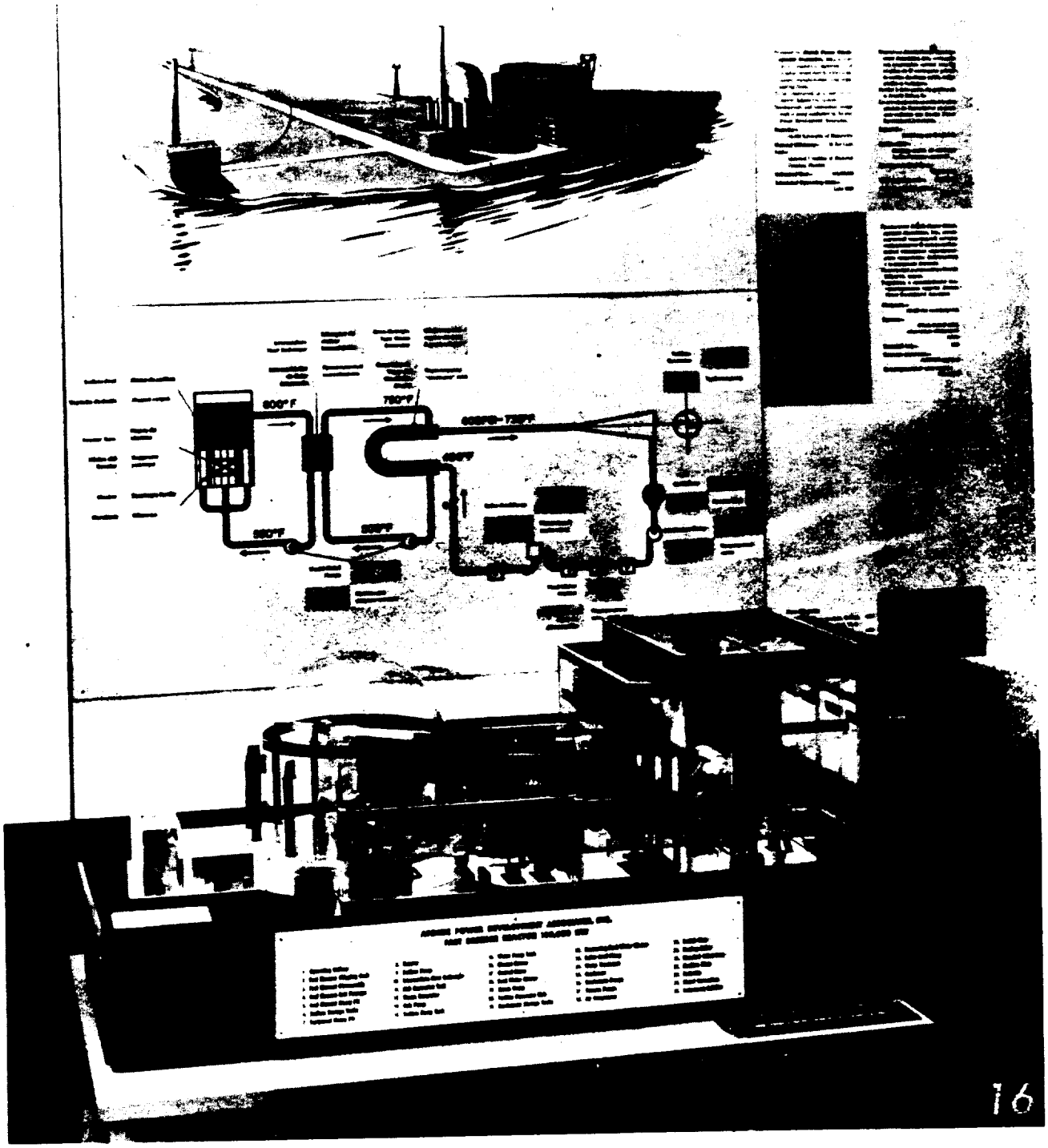




1035510

Fast Breeder Power Plant **Réacteur Générateur de N**

Planta con Reactor Generador de Flujo Rápido **Энергостанция с быстрым разм**



1035511

Photo No. 16: The 100,000-kilowatt Fast Breeder Power Plant, proposed by Atomic Power Development Associates, was described by a perspective drawing of the installation, a flow diagram and a small model, all furnished by Nuclear Power Development Associates.

1035512

Photo No. 17: The 75,000-kilowatt Sodium Graphite Plant, proposed by Consumers Public Power District, of Columbus, Nebraska, was pictured by two cut-away perspective drawings from North American Aviation, Inc., developer of this type of reactor.

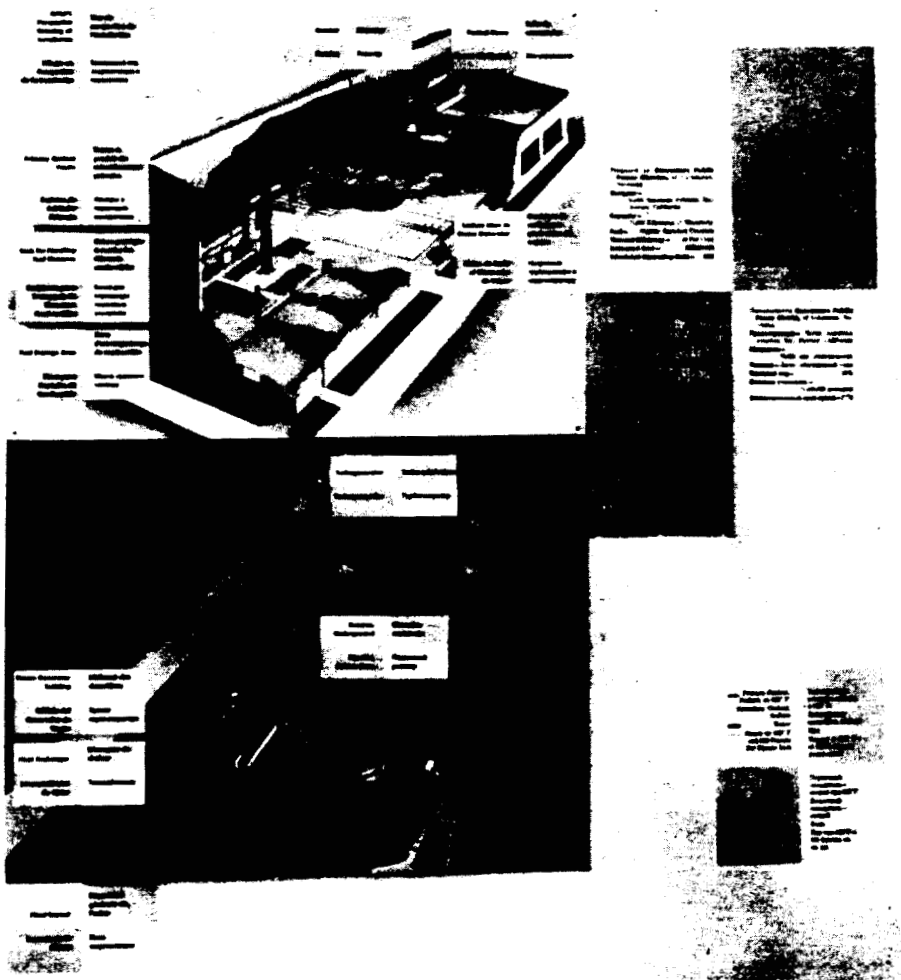
1035513

Sodium Graphite Plant

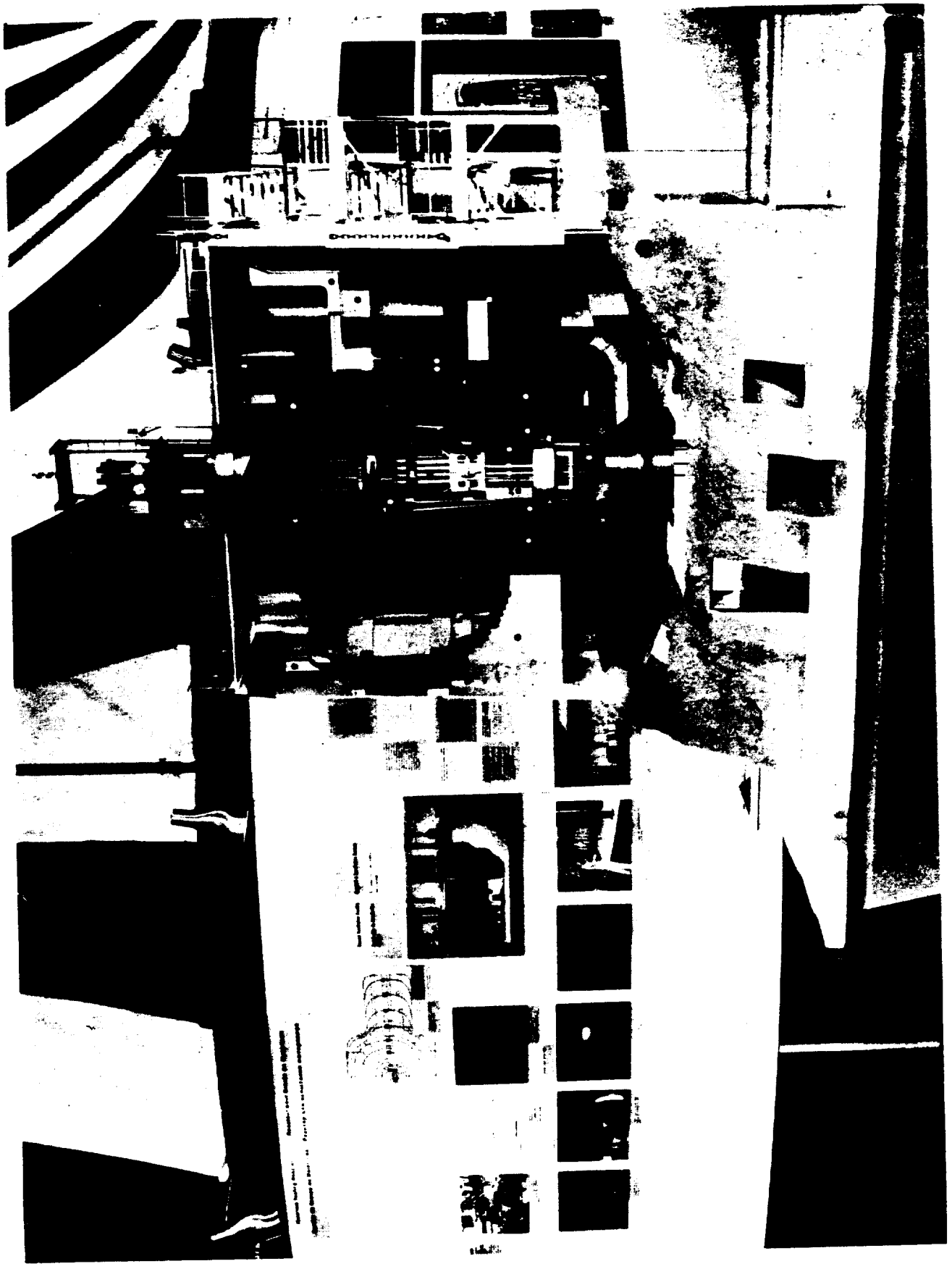
Centrale à Réacteur au Sodium Graphite

Planta con Reactor de Sodio Grafito

Натри-графитовый завод



1035514



1035515

Photo No. 18: On the other side of the aisle, opposite the Industrial Power Program exhibits, were the last three reactor models. There was a large and detailed model of the 30,000-kilowatt Materials Testing Reactor. Its accompanying wall panel illustrated the new Irradiation Facility at the MTR. (These materials came from the Phillips Petroleum Co.)

1035516

Photo No. 19: Exploration of the boiling reactor principle was covered by a model of the Boiling Reactor Power Plant in Idaho, which in an experiment for a short time on July 17, 1955, was the exclusive source of electricity for the nearby town of Arco. The Argonne Laboratory furnished the model.

1035517

1035518

Argonne Research Reactor
Reactor de Investigación en Argonne

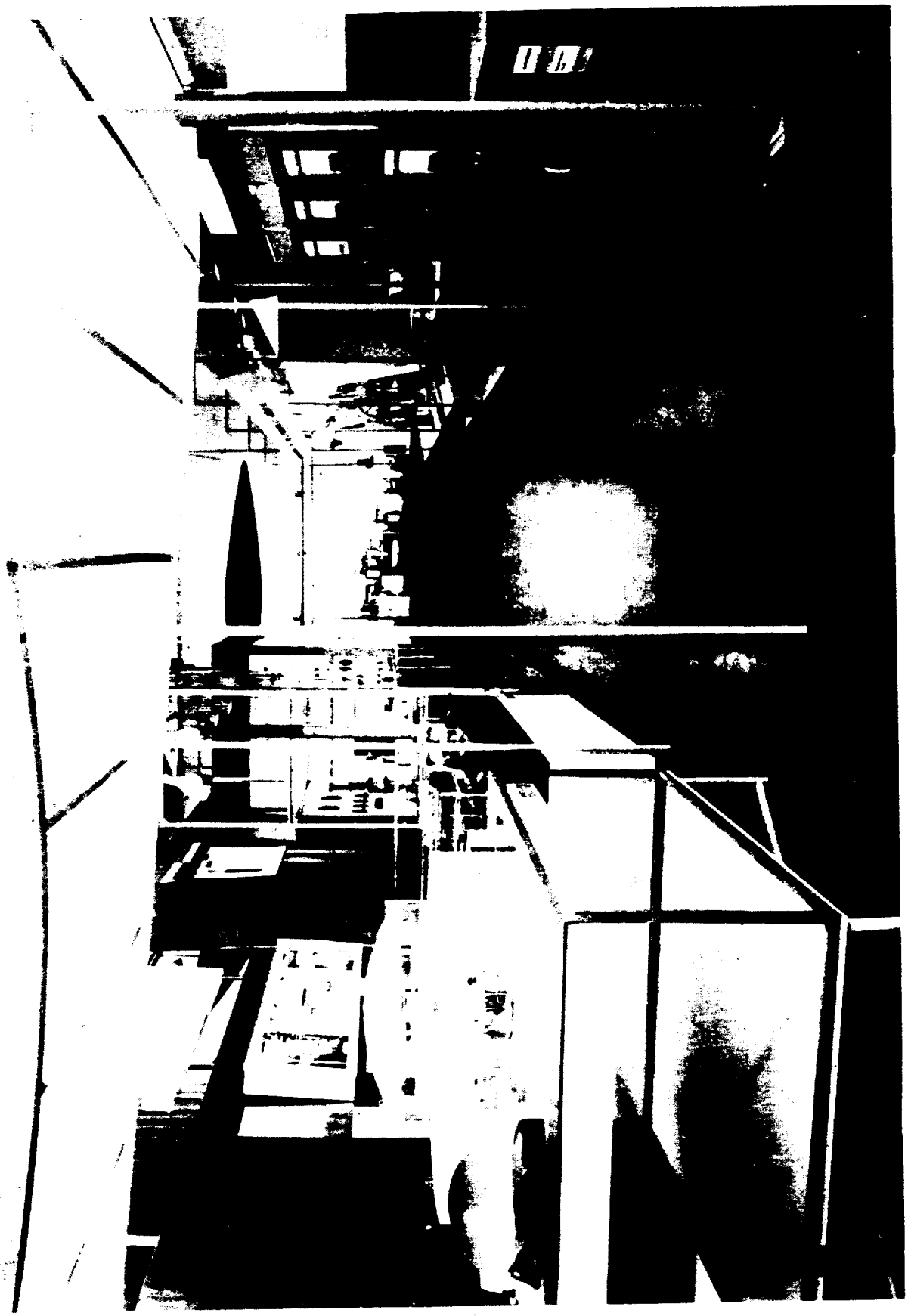
1035519

Photo No. 20: The New Argonne Research Reactor was represented by a model from the laboratory after which the reactor is named.

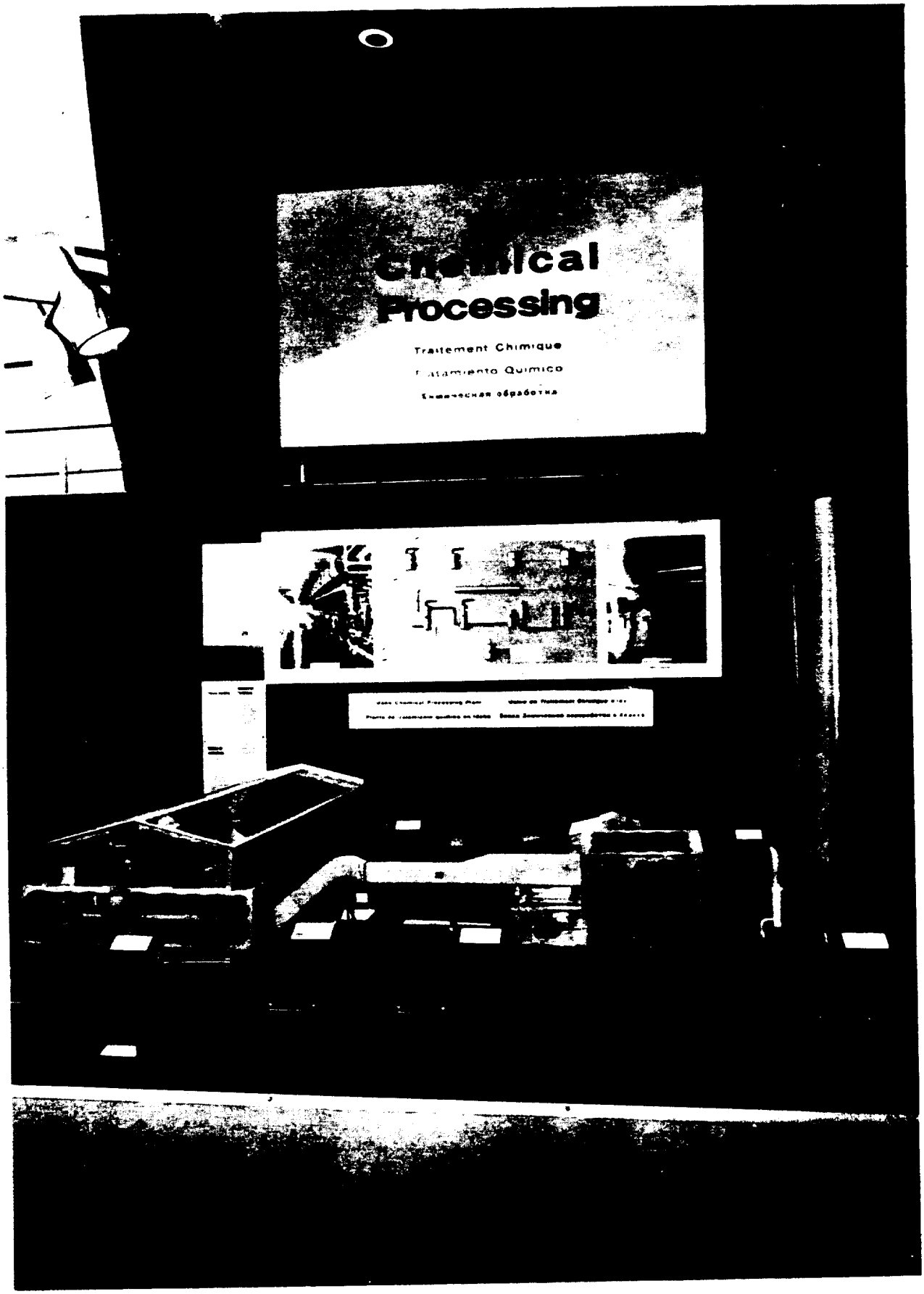
1035520

Photo No. 21: Looking past the Argonne Research Reactor model and toward the Instrumentation section, one could see on the left a model of the Idaho Chemical Processing Plant and a pilot plant chemical separations operation and, on the right, a reactor control panel, a welding demonstration and a section of Reactor Components and Auxiliaries.

1035521



1035522


Chemical
Processing
Traitement Chimique
Tratamiento Quimico

1035523

Idaho Chemical Processing Plant
Usine de Traitement Chimique d'Idaho
Planta de reprocesamiento químico de Idaho
Zona Suministrada Especialmente a Expertos

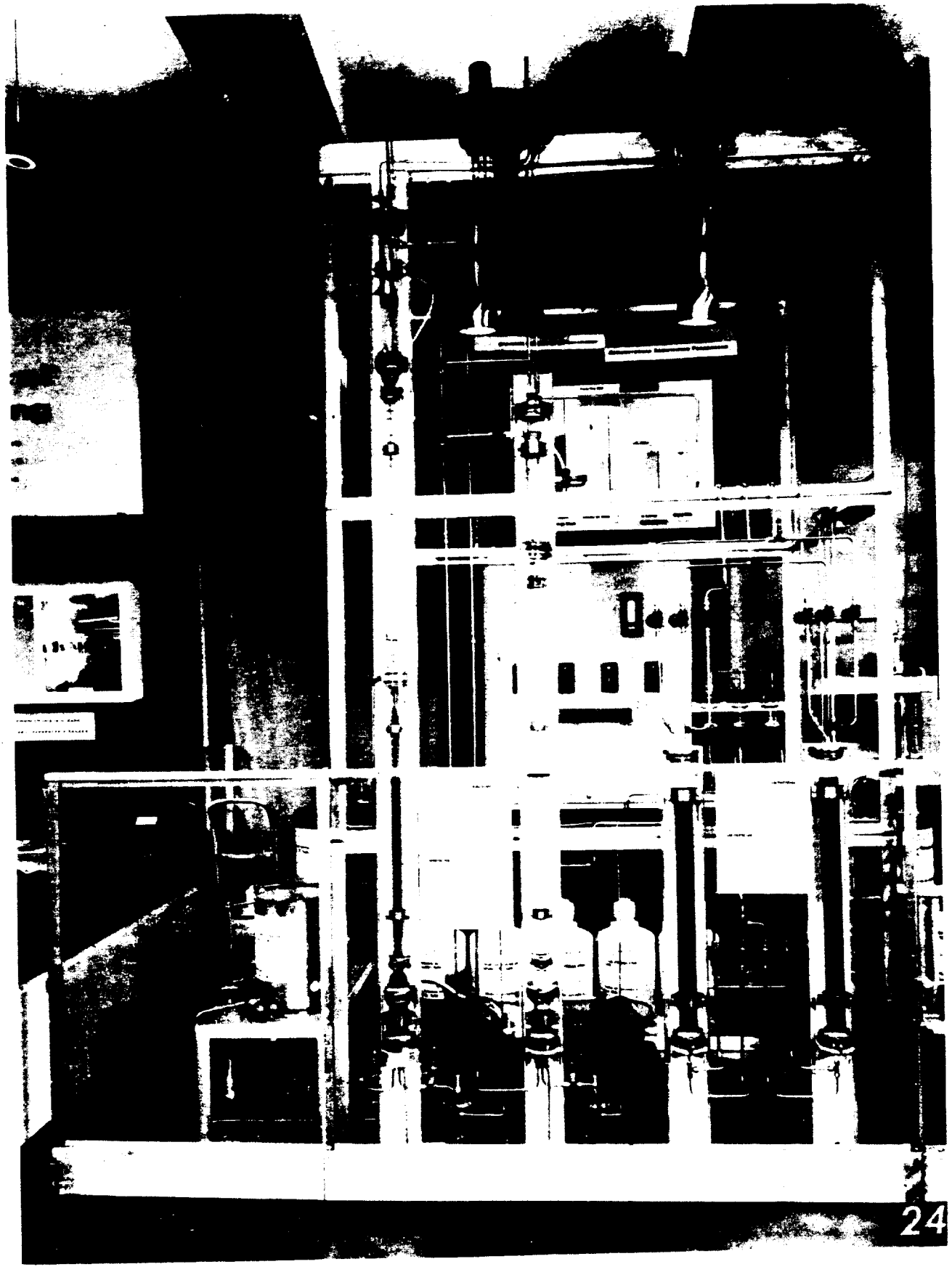
1035524

Photos Nos. 22 and 23: The model of the Idaho Chemical Processing Plant included the waste treatment building and the two large storage tanks. Several typical cells contain equipment. There was a simplified flow diagram on the wall above the model. This portion of the Exhibit came from the Phillips Petroleum Company.

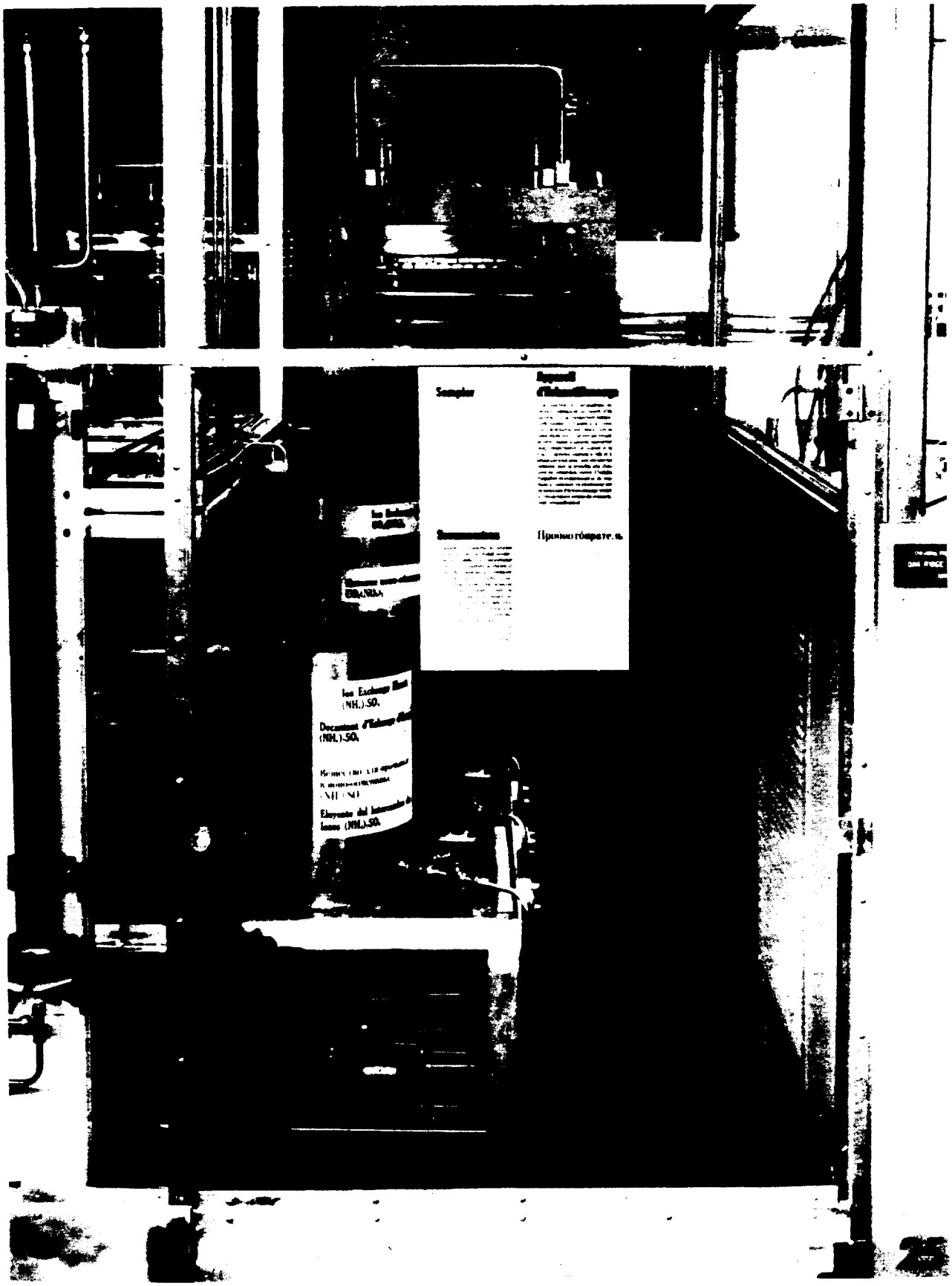
1035525

Photo No. 24: The pilot plant demonstrated separation of uranium from fission products by ion extraction with subsequent concentration by ion exchange. Copper was used to simulate radioactive fission products. Its green color in solution, contrasting with the yellow of the uranium solution, added to the effectiveness of the demonstration. The plant included a pair of one-inch diameter transparent pulse-type columns and three-inch diameter transparent ion exchange columns. The process was described by a flow sheet on the wall.

1035526



1035527


Sampler
Ion Exchange
(NH4)2SO4
Document d'Echange
(NH4)2SO4
Elemento del Intercambio de Iones (NH4)2SO4

1035528

Photo No. 25: Operating as a part of the pilot plant was a sampler, pictured here in the background, and hot cell on the right. This was a full-scale unit capable of sampling ten sources simultaneously.

1035529

Photo No. 26: The hot cell, used for determining nitrate ion and uranium concentration of radioactive solutions, included two Argonne Model 8 manipulators, a three-foot thick viewing window and analytical equipment. Most of the equipment of the three units was furnished by the Oak Ridge National Laboratory. It was operated by a team from the Laboratory.

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Photo No. 27: The reactor control panel, containing instruments essential for operating a reactor, was used to move an actual reactor control rod. The control rod and its equipment was furnished by American Machine and Foundry Company, and the instrument panel by Minneapolis-Honeywell Regulator Company. Both were operated by three men from the latter organization, one being a Geneva representative of the firm.

1035533

Photo No. 28: The welding equipment demonstrated the new consumable insert method of welding. Advantages of this method for reactor and chemical plant circulating systems include less susceptibility to corrosion and flaws and less friction for the circulating liquids. The equipment was furnished by General Dynamics Corporation, who developed the method, and was operated by the Arcos Company.

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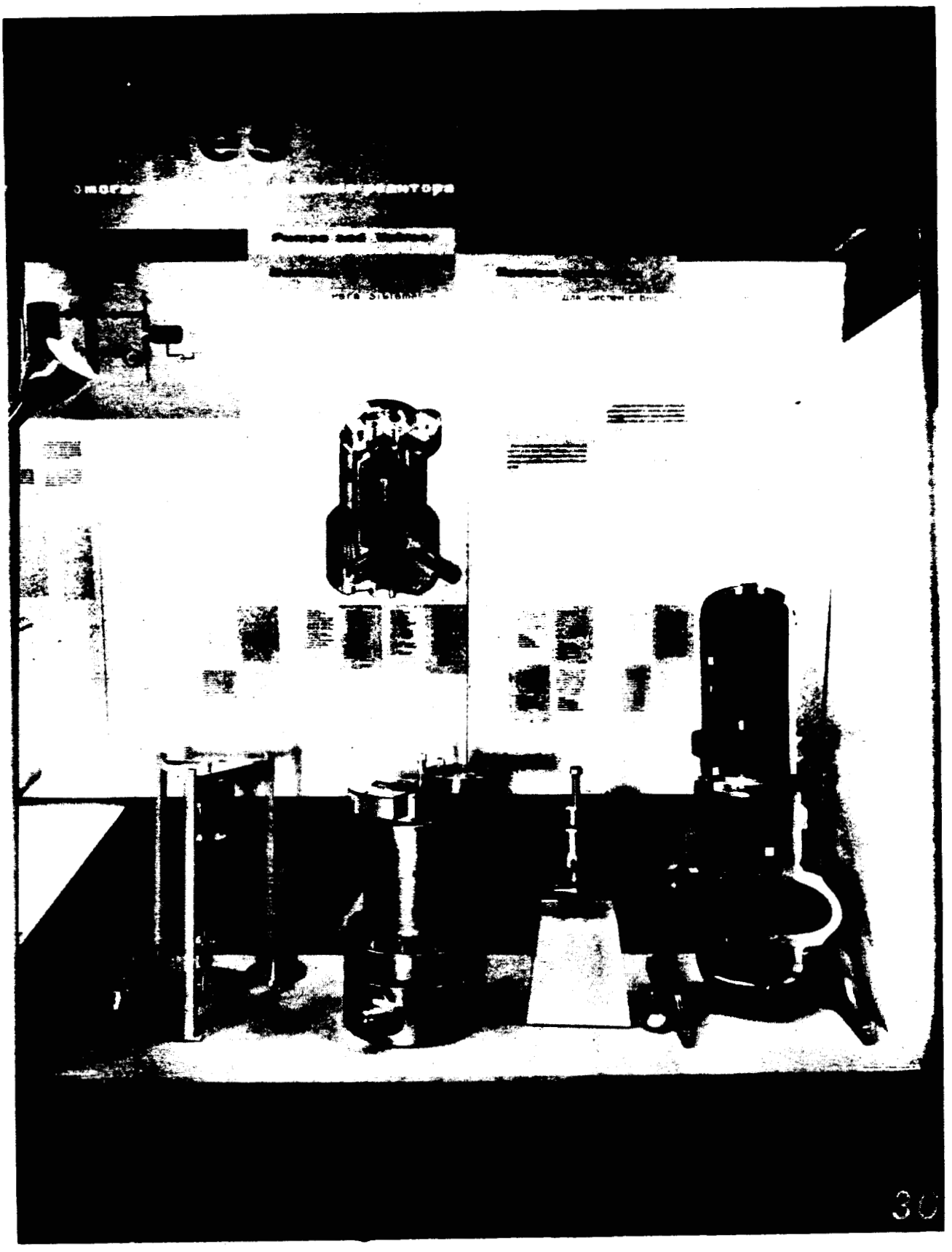
Photo No. 29: A portion of the Exhibit entitled Reactor Components and Auxiliaries was made up of a section on Pumps and Valves, on the right, and a section on Protection of Environment, on the left.

1035537

Photo No. 30: The Pump and Valve section contained, equipment for high-pressure systems, illustrated here: From right to left, a large cut-away gate valve from the Chapman Valve and Manufacturing Company, a small cut-away valve from the Crane Company, and a small Westinghouse canned motor pump, partly disassembled, with a cut-away drawing. All are of stainless steel. The large valve, which had been used in test, was left uncleaned so that it would illustrate the corrosive effect of reactor coolants even on corrosion-resistant stainless steel. These valves and the canned pump are for the primary coolant systems of pressurized water reactors and the fuel systems of homogeneous reactors.

1035538



30

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Photo No. 31: For low-pressure liquid metal systems, the display contained two bellows-sealed valves from the Crane Company, an illustration of a frozen liquid metal seal from North American Aviation, Inc., a cut-away drawing of an alternating current induction electromagnetic pump from the General Electric Company and a model, with accompanying cut-away drawing, of a direct current electromagnetic pump from Argonne National Laboratory.

1035541

Photo No. 32: The Protection of Environment from Radioactivity section covered, from left to right:

(1) Development at Brookhaven National Laboratory of a pilot plant for absorbing the radioactivity of high-level liquid wastes on montmorillonite clay;

(2) Weather factors considered in atomic energy operations, with illustrations from the United States Weather Bureau and New York University;

(3) Study of the radioactive contamination of water supplies, with a photograph and data from investigations at Massachusetts Institute of Technology and a photograph of a laboratory barge on the Mohawk River in New York;

(4) Two types of filters for air cleaning with photographs of installations, one from the Monsanto Chemical Company and the other from the General Electric Company;

(5) A model of an incinerator developed by the United States Bureau of Mines for reducing the bulk of low-level combustible wastes;

(6) A study at Johns Hopkins University of biologic slimes for removing radioactivity from sewage, a pilot plant at New York University, and the first full-scale installation at the National Reactor Testing Station in Idaho.

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Photo No. 33: A survey of the major portion of the instruments section revealed from right to left: prospecting equipment, radiation monitors, an anti-coincidence counter, radiation spectrometers and medical instruments. Components of instruments were displayed on the table in the center of the open space. Beneath the table was a large unpolished casting of scintillating plastic illuminated with ultra-violet light.

1035545

Photo No. 34: In the prospecting equipment area, at the extreme right was a drill hole logging instrument with photographs illustrating its use from a station wagon. The probe, the vertical cylinder beneath the table, is lowered into a drill hole by 2,000 feet of cable from the reel. As it moves at 10 to 20 feet per minute, it detects uranium mineralization. The radiation levels are automatically plotted on the Esterline Angus recorder on the left. This equipment was supplied by the Instrument Branch of AEC's New York Health and Safety Laboratory by whom it was designed.

At the left on the raised shelf along the back wall was scintillation counter equipment used for airborne uranium exploration. The shiny cylindrical object is the detector probe containing an eight-inch diameter plastic scintillator viewed by a five-inch diameter photomultiplier tube. In the exhibit it detected radiation from two minerals on the turntable below. The signals were recorded or observed by instruments on the shelf. This equipment was lent by the Sherwin Instrument Company.

On the extreme left were several types of portable instruments for surface exploration.

1035546

Processing Equipment Equipment to Processing
Gauge gas Exploration Pressures temperature

1035547

1035548

Photo No. 35: Thirteen representative types of portable instruments used for surface exploration were exhibited. All could be operated by attendants and visitors. Most of them were Geiger counters, three were scintillation counters and two were multiple bismuth-lined geiger counter tube instruments. Three unique instruments were the portable drill hole logging instrument near the center, a portable scaler in the far left bottom compartment, and a transistorized geiger counter with a loud speaker output in the lower left compartment. These instruments were loaned by the following companies:

1. Atomic Research Corporation
2. Berkeley Scientific Division of Beckman Instruments, Inc.
3. The Detectron Corporation
4. El-Tronics, Inc.
5. Engineers Syndicate, Ltd.
6. La Roe Instruments, Inc.
7. Nuclear Instruments and Chemical Corp.
8. Nucleonic Company of America
9. Precision Radiation Instruments
10. Victoreen Instrument Company

1035549

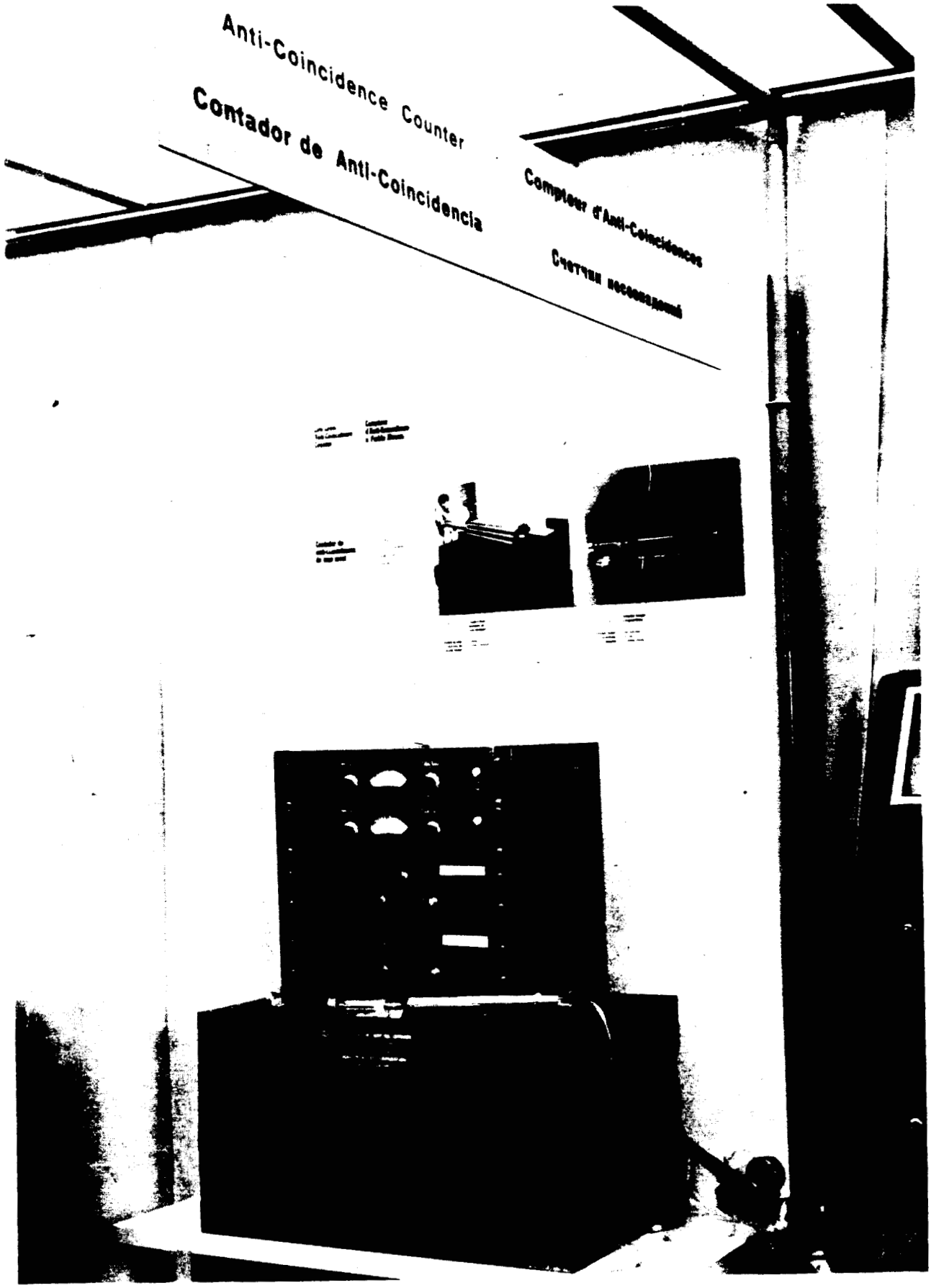
Photo No. 36: Visitors often stood in line in the Radiation Monitors section to test themselves on the hand-and-foot contamination monitor, loaned by Technical Associates Company. Far back on the table was an air collector, loaned by Anton Electronic Laboratories. The remaining instruments on the right, all portable, consisted of types for measuring various kinds of radiation -- alpha, beta, gamma and neutrons. On the panel is a display of picket-ionization chambers and film badges.

These instruments were made by the following companies or organizations:

1. Atomic Instruments Company
2. A. O. Beckman, Incorporated
3. Bendix Aviation Corporation
4. Cambridge Instrument Company
5. Consolidated Engineering Corporation
6. General Electric Company
7. Keleket X-Ray Division of Tracerlab, Incorporated
8. Landsverk Electrometer Company
9. Nuclear Instrument and Chemical Corporation
10. Nuclear Research and Development, Incorporated
11. Nuclear Research Corporation
12. Radiation Counter Laboratories, Incorporated
13. Radiation Industries Company
14. Radioactive Products, Incorporated
15. Victoreen Instrument Company
16. Argonne National Laboratory

1035550

1035551


Anti-Coincidence Counter
Contador de Anti-Coincidencia
Compteur d'Anti-Coincidences

1035552

Photo No. 37: An anti-coincidence counter is the instrument used for measuring the radioactivity of extremely low-level materials. For example, it is employed in carbon dating. Such an instrument was furnished by Nuclear Science and Engineering Corporation through the courtesy of Norden-Ketay Corporation. The iron shielding blocks, upon which the cabinet is resting, help to keep cosmic and other external radiation from the counter tube within. Radiation that does get through the shield must pass through one of a number of geiger tubes in an anti-coincidence cylinder to reach the counter tube, and when this happens the signals from the two tubes cancel each other. Thus only radiation originating within the cylinder itself registers. This arrangement reduces the background from 30 or 40 counts per minute to only a few counts per hour.

1035553

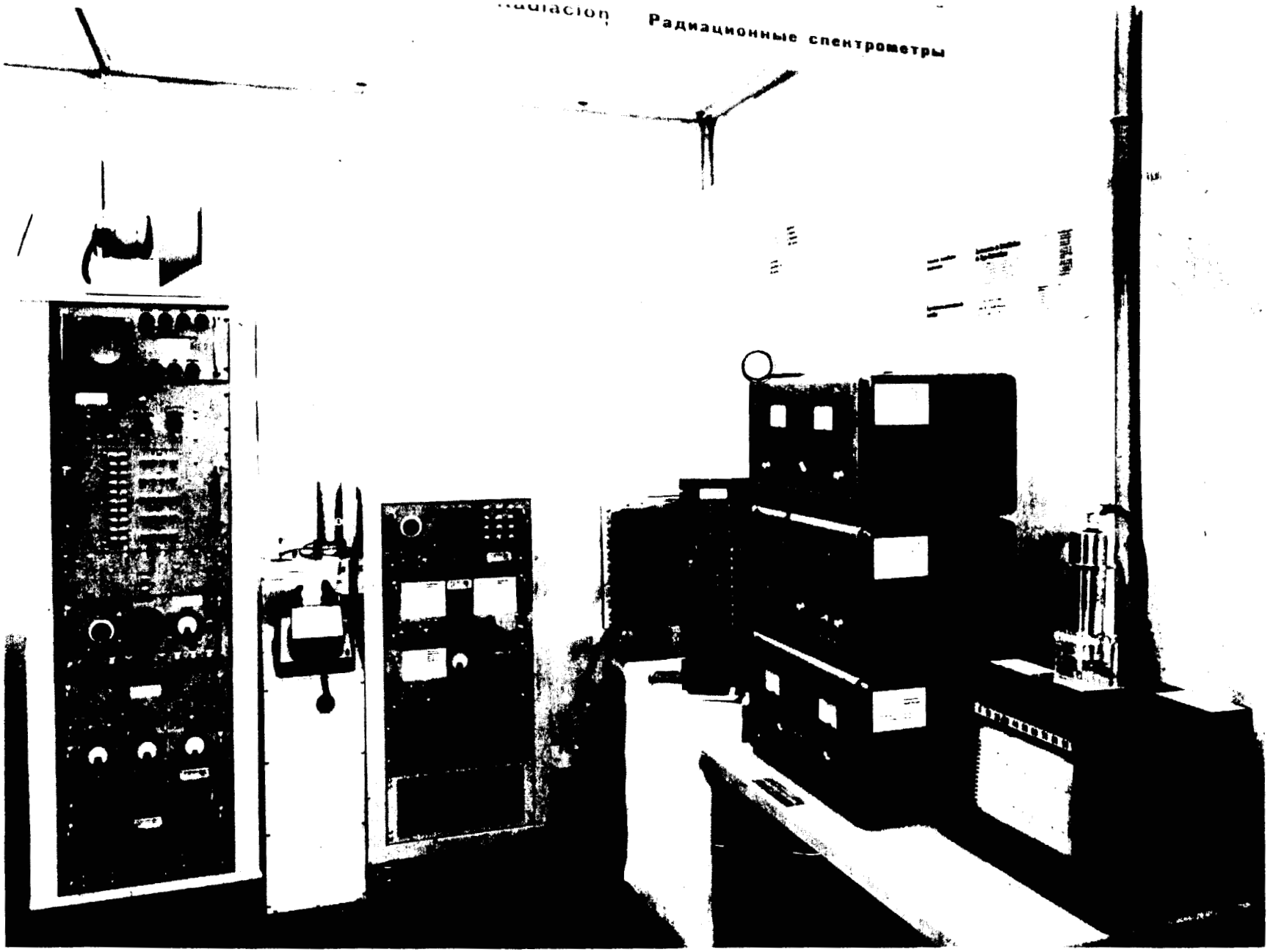
Photo No. 38: There were three radiation spectrometers in the exhibit: the automatic scintillation spectrometer on the table at the right, the 100-channel analyzer on the floor at the left, and a radiation spectrometer demonstrator in the next picture. The demonstrator is described first because it is the simplest of the three.

The demonstrator, the large, low cabinet on the right, was supplied by the United States Bureau of Standards to illustrate the basic principle of these instruments. In it, gamma radiation from cesium 137 or mercury 203 is absorbed by a scintillating crystal. The absorption gives off visible light with intensity proportional to the energy of the absorbed radiation, and the light, viewed by a photomultiplier tube, produces an electrical output proportional to its intensity. This output, displayed on a cathode ray oscilloscope, takes the form of pulses whose maximum height is determined by the energy of the absorbed radiation. Cesium 137, with gamma radiation of 661,000 electron volts energy, produces pulses more than twice as high as mercury 203, whose gamma radiation has only 279,000 electron volts energy. Pulses of all heights between zero and that corresponding to the energy of the gamma radiation are pictured on the scope.

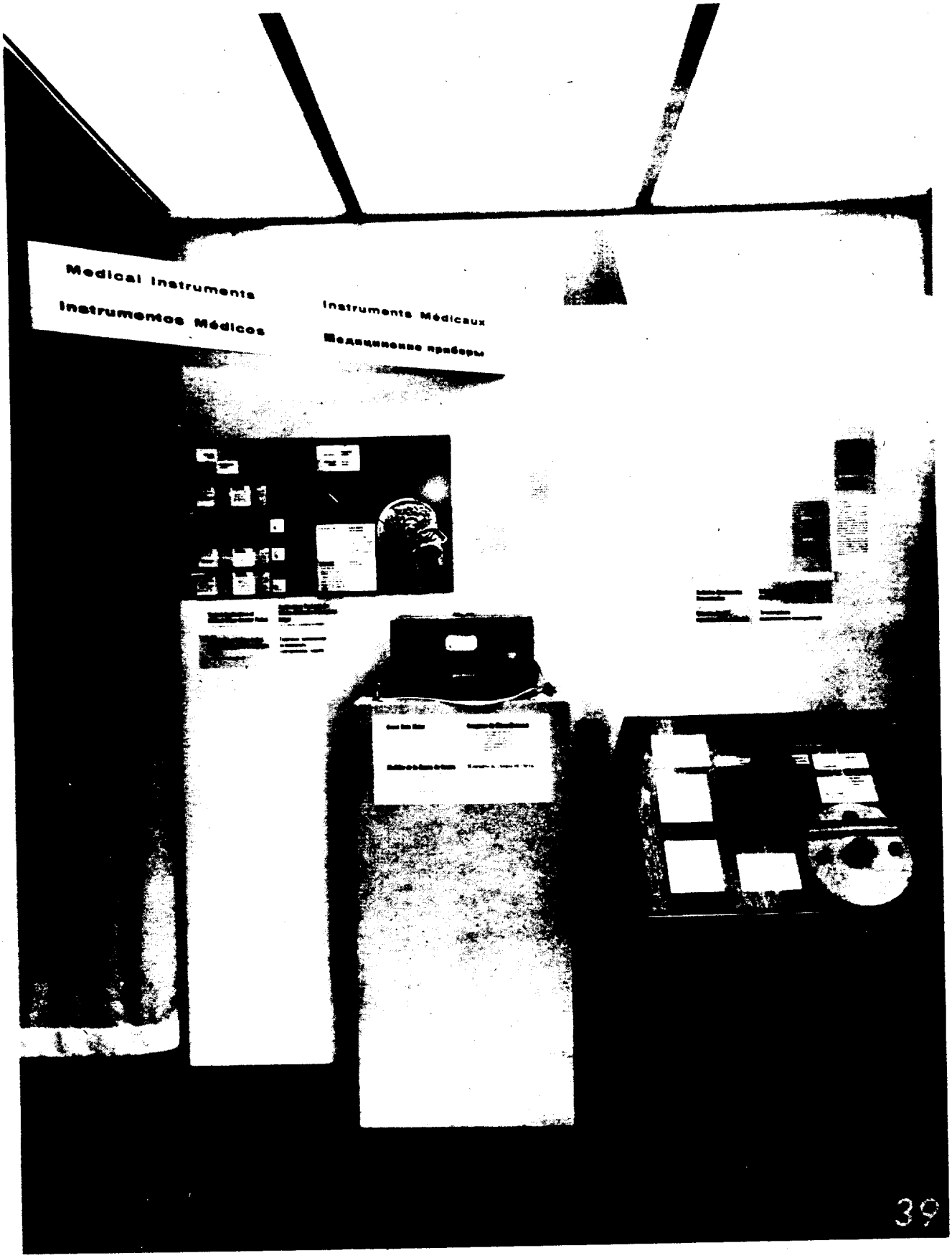
The counter detector head of the automatic scintillation spectrometer is seen on top of the Honeywell-Brown recorder on the right. It is a single channel spectrometer, which permits the observation at any one time of pulses of a certain predetermined energy level. However, the entire energy range can be scanned sequentially in small energy increments either manually or automatically. Scanning is done automatically and the instrument automatically records the number of pulses falling within each energy increment. The three cabinets immediately to the left of the detector head contained, from top to bottom, the electronic sweep and count rate computer circuit, the pulse height analyzer, and the high voltage power supply. This instrument was loaned by the Radiation Instrument Development Laboratory.

Instead of sequentially scanning the entire energy range, the 100-channel analyzer breaks down the full range into 100 equal intervals and simultaneously counts the pulses in each. The detector head of this analyzer is the cylindrical object resting on the small stand between the two cabinets. The instrument stores this data in a magnetic memory unit which is scanned to reproduce the energy spectrum on an oscilloscope. The actual number of pulses in each channel can be printed automatically by the printer on the small central stand. This equipment contains about 300 vacuum tubes. It was provided by the Los Alamos Scientific Laboratory and was set up and operated by a Los Alamos electronics expert.

1035554



10355555


Medical Instruments
Instrumentos Médicos
Instruments Médicaux
Медицинские приборы
39

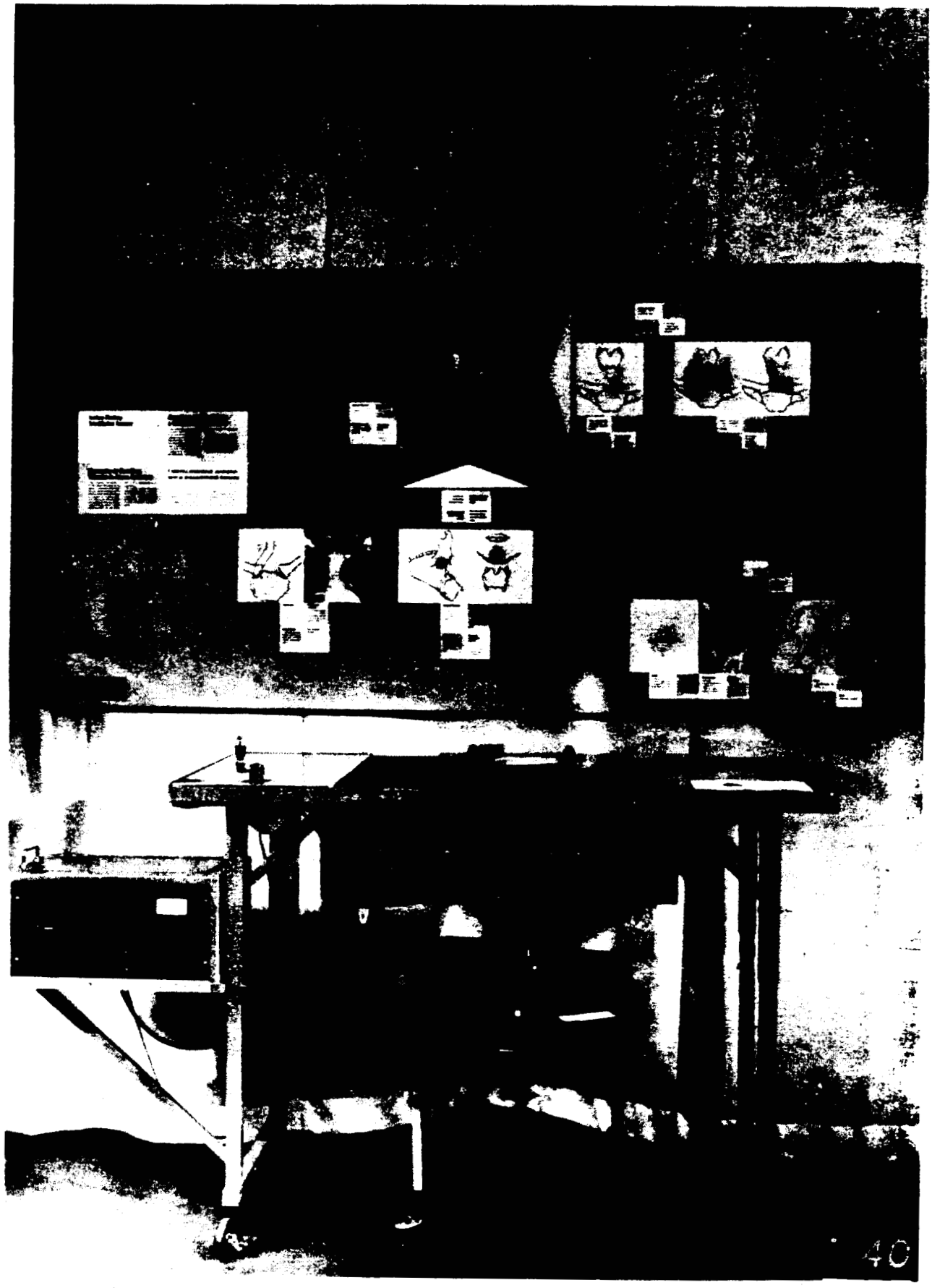
1035556

Photo No. 39: The first of two medical instrument displays was of various types of geiger counter probes used for tumor diagnosis and localization. Fastened to the plaque were three different thin-window eye probes and a brain tumor probe. The cabinet on the stand contained a count rate meter circuit and on its left was a preamplifier and on its right a geiger counter brain probe similar to that seen on the plaque. These exhibits were furnished by the Anton Electronic Laboratories and the H. W. Leighton Laboratories.

1035557

Photo No. 40: The second medical instrument exhibit showed one of the first commercial scintillation scanning instruments. It automatically plots the radiation contour of organs and tissues which have taken up radioisotopes. The instrument is used primarily to locate and estimate the size and shape of functioning thyroid tissue and carcinoma. A mark is formed on recording paper after a predetermined number of counts have accumulated in the scaling circuit in the cabinet to the left of the instrument. A density pattern results from which the organ or tissue can be distinguished. In use, the patient would lie on a cot beneath the instrument and the scanning head would move back and forth across a part of his body. In the exhibit, the patient was replaced by a radioactive source in the shape of the thyroid glands. Actual records from patients were displayed above the instrument. This exhibit was furnished by the R. C. Scientific Instrument Company.

1035558



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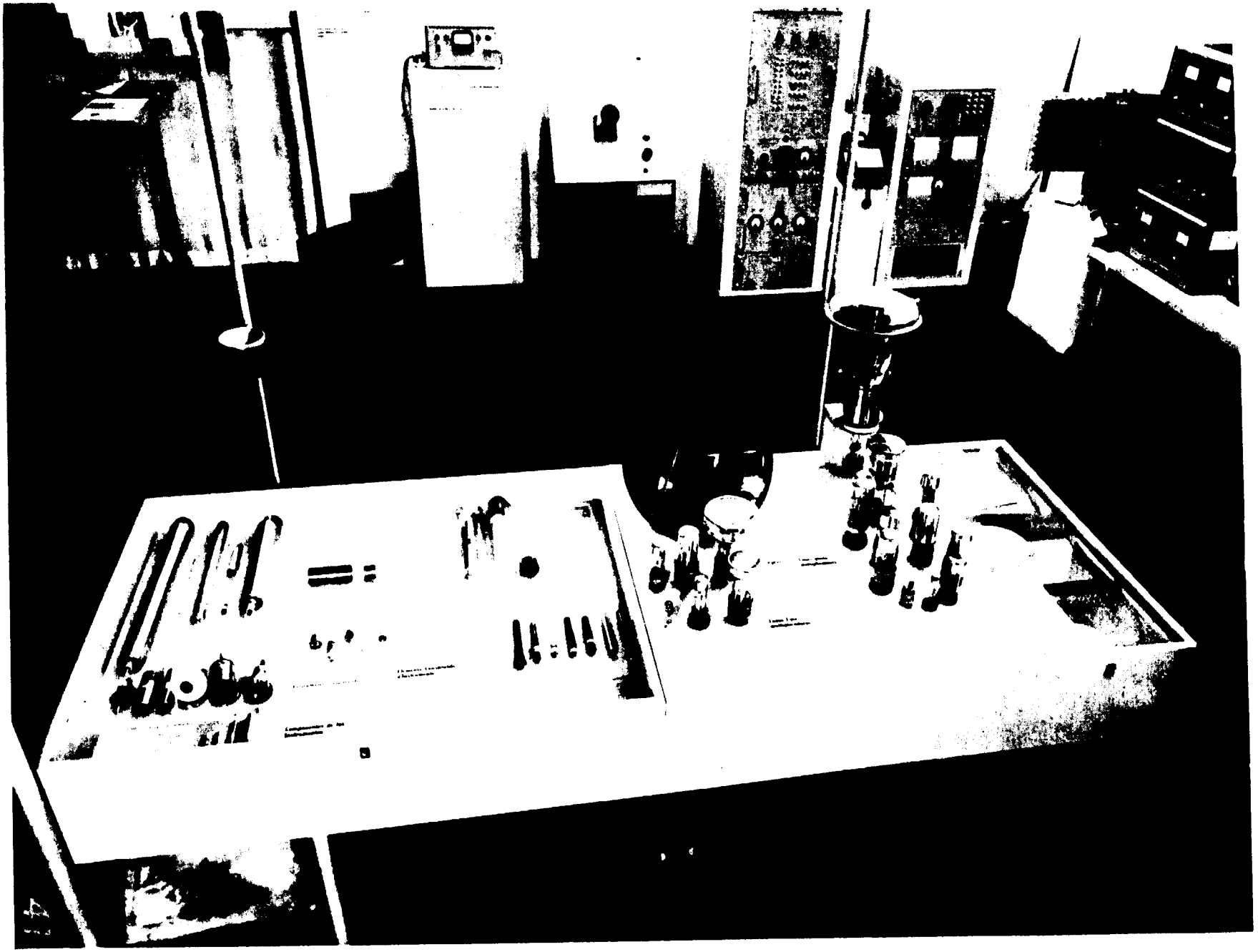

1035560

Photo No. 41: The last item of the instruments section was a display of various special electronic components used in radiation-detecting instruments. The glass-covered part of the display table, on the left, contained various types of special geiger and proportinnal counters; on the table to the right, commercially and experimental photomultiplier tubes developed largely for atomic energy applications; and ranging from three-fourth inch to 16 inches in diameter; and under glass on the right, samples of scintillating materials including a six-inch diameter clear plastic scintillator, a large diameter canned sodium iodide (thallium activated) scintillator, and smaller canned sodium iodide crystals.

1035561

Photo No. 42: Looking down the aisle from the instrument section to the entrance opposite the red and white striped canopy: most of the biology and medicine exhibits were grouped on the left while exhibits of applications of radioisotopes were on the right.

In the left foreground was a display of techniques used in administering radioactivity from small sources directly on or in tissue. Sources of different sizes and shapes used in this therapy, and instruments for implanting and removing them, were mounted above and below a row of back-lighted transparencies. Pressing a button brought additional rows into view one at a time from a drum containing six rows. Materials for this exhibit were furnished by Oak Ridge Institute for Nuclear Studies, Argonne Memorial Cancer Research Hospital, and Ohio State Medical School.

There was one medical isotopes application exhibit on the right, where the mannequin's head is visible.

1035562

1035563

Thyroid Uptake Calibration
L'Etalonnage de l'Absorption Thyroïdale
Calibración del poder colmitativo de la tiroides
Измерение резорбции щитовидной железы

1035564

Photo No. 43: In this exhibit, titled "Thyroid Uptake Calibration", the Oak Ridge Institute of Nuclear Studies demonstrated the characteristics of three types of measuring instruments, called attention to discrepancies and to the need for standardization. The turn-table on the left placed radioactive calibration sources, and phantom "patients" representing patients whose thyroids had absorbed some radioiodine, before the detection heads of the three instruments. The electronic circuits of these instruments were in the cabinets on the right. The automatic slide projector gave more information on methods and problems.

1035565

Photo No. 44: Two other radiation therapy exhibits were grouped with the brachy-therapy display: one on teletherapy in the center; one on slow neutron capture therapy to the left.

Seven models of teletherapy units being constructed or used in the United States were shown. Such units shield cobalt 60, cesium 137, iridium 192, europium 152, cerium 144 and cadmium 109 with openings through which their radiation can be released when it is desired for patients. More than 50 teletherapy units have replaced and supplemented high-voltage X-ray equipment at hospitals in this country.

Research in slow neutron capture therapy at the Brookhaven National Laboratory was reported by a number of photographs and drawings. In this therapy, thus far used only for cases otherwise incurable, a patient with a brain tumor is given an intravenous injection of a boron-10 compound which is taken up preferentially by the tumor. The patient's head is then placed above a hole in the Brookhaven reactor. The slow neutrons streaming through this hole interact with the boron to cause the emission of alpha particles, which, in turn, produce extremely dense ionization in the region of the tumor which is intended to destroy it or retard its growth.

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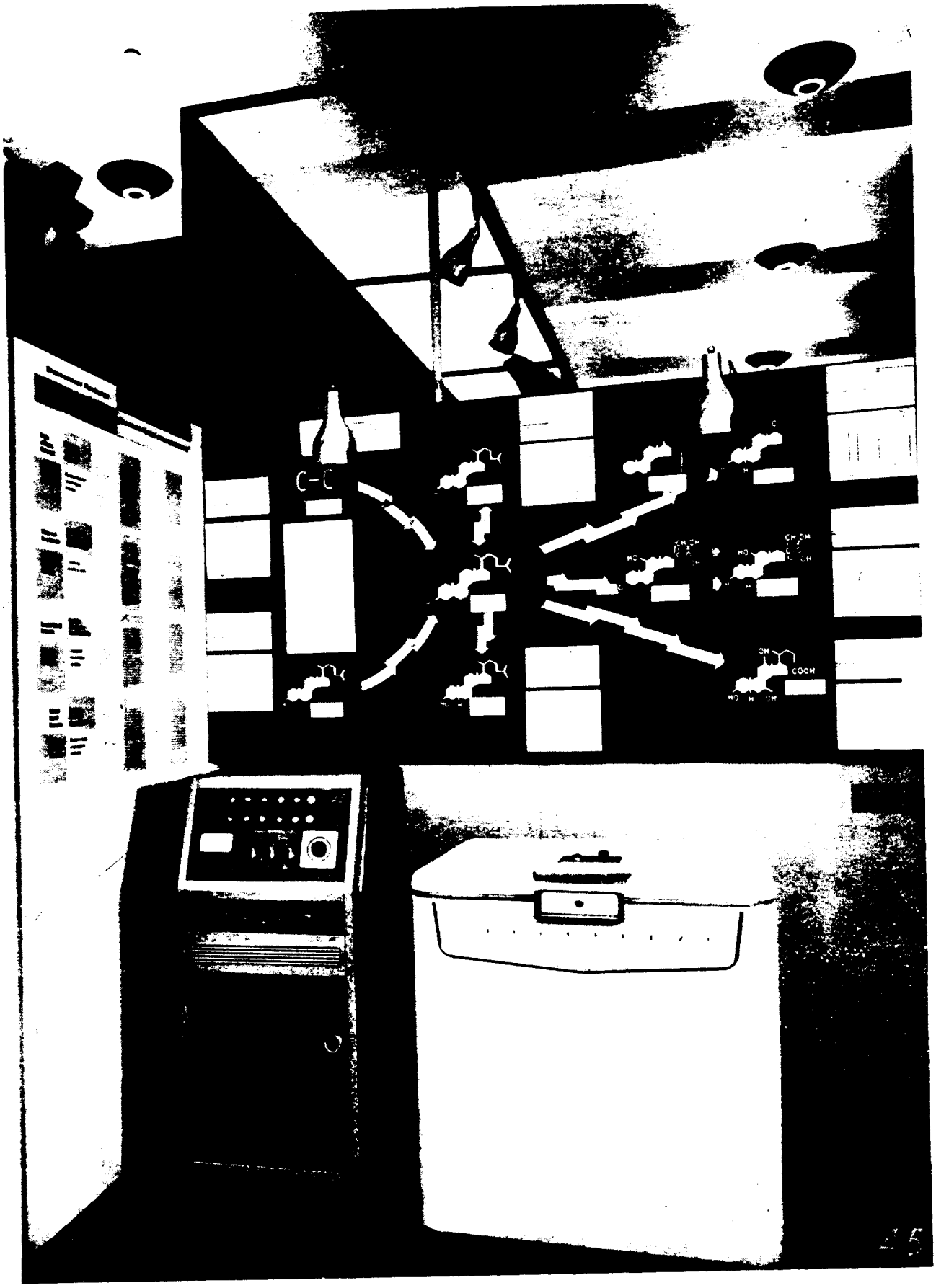

1035568

Photo No. 45: Results of studies at the Sloan-Kettering Institute on the origin and metabolism of steroids in man were presented on an exhibit panel. The studies, which are of importance in cancer research, were accomplished by use of carbon 14 and tritium tracers. The instrument below the panel, furnished by the Packard Instrument Company, was a liquid scintillation spectrometer for the precise low-level counting of these beta-emitting radioisotopes. The sample is added to the liquid scintillating materials and placed in a light-tight counting chamber kept at sub-zero temperatures in a refrigerator to reduce background due to thermionic noise pulses in the scintillation counter's photomultiplier tubes.

1035569

Photo No. 46: Progress in autoradiography -- the technique by which a thin slice of plant or animal tissue containing radioisotopes takes a picture of itself -- was reported in two panels containing back-lighted transparencies. Autoradiography provides a method for studying the biological fates of radioisotopes in much greater detail than is possible with counting methods. The top panel, describing a modified liquid emulsion technique for microautoradiography, was contributed by the New England Deaconness Hospital. The lower panel, describing the opposition method of gross autoradiography, was from the Oak Ridge Institute of Nuclear Studies.

1035570

Autoradiography | Auto-radiographie

Autoradiografia | Авторадиография (авторентгеноскимки)

1035571

1035572

Photo No. 47: Brookhaven National Laboratory prepared an exhibit on Radiation and Plant Genetics. The center of attention was a model of a segment of Brookhaven's gamma radiation field. The model contained living plants showing the effects of radiation, a real but very low energy gamma source, and a geiger counter and amplifier that detected the radiation when the source was raised from its storage shield into the irradiating position. Above the model was an aerial photograph of the field and an illustration of the Brookhaven reactor showing the thermal column facility for the irradiation of biological materials.

A panel to the left of the model of the field showed how radiation increases the number of mutations over that which occurs naturally. Mutations for color and starch content in corn kernels were used to illustrate this point. The lower part of this panel showed the uniform growth one obtains when seeds are irradiated with thermal neutrons as contrasted with the nonuniform growth of seedlings when the seeds are treated with X-rays. Living barley seedlings were used.

To the right of the model three color transparencies were used to illustrate how oat seedlings are screened for disease resistant mutations after irradiation. Such methods have produced mutations resistant to Victoria blight, stem rust and wheat rust in oats, leaf spot in peanuts and stem rust in flax. These mutations are being tested and studied prior to release of seed to farmers.

Still further to the right, there were exhibited living carnation plants which showed flower form and color mutations. By mutating a single branch, experimenters produced a plant which bears both red and white flowers and single and double flowers. These mutations were produced in the gamma radiation field.

1035573

Photo No. 48: An exhibit titled, "Use of C 14 Tracers in Biosynthesis", featured a model of the small greenhouse at the Argonne National Laboratory in which drug-producing plants are grown in an atmosphere containing radioactive carbon 14 in carbon dioxide. The model greenhouse contained growing plants. Samples of 20 biochemicals and pharmaceuticals from plants produced in the Argonne radioactive greenhouse were displayed. Above them, a book-type display described their production and use.

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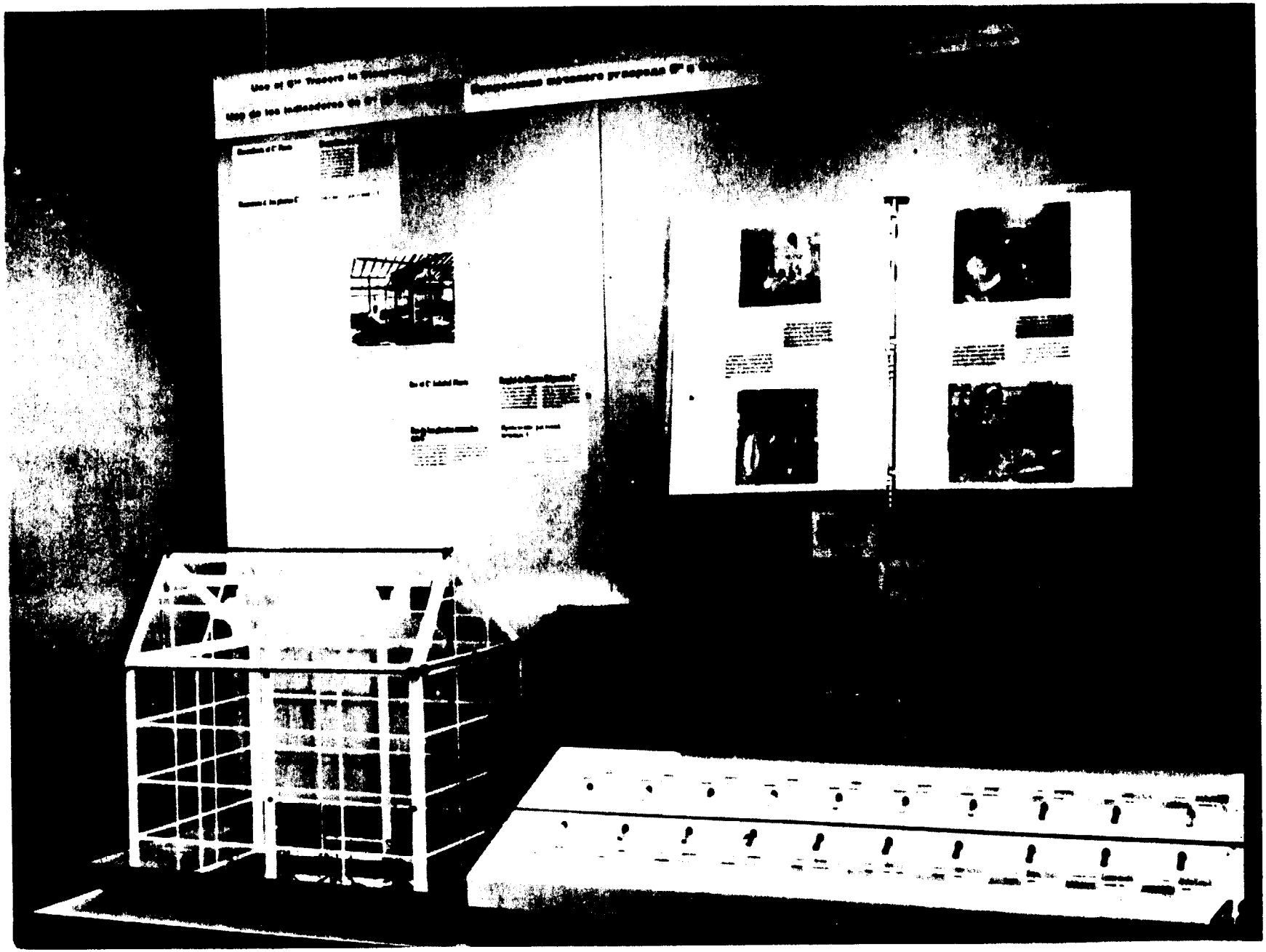

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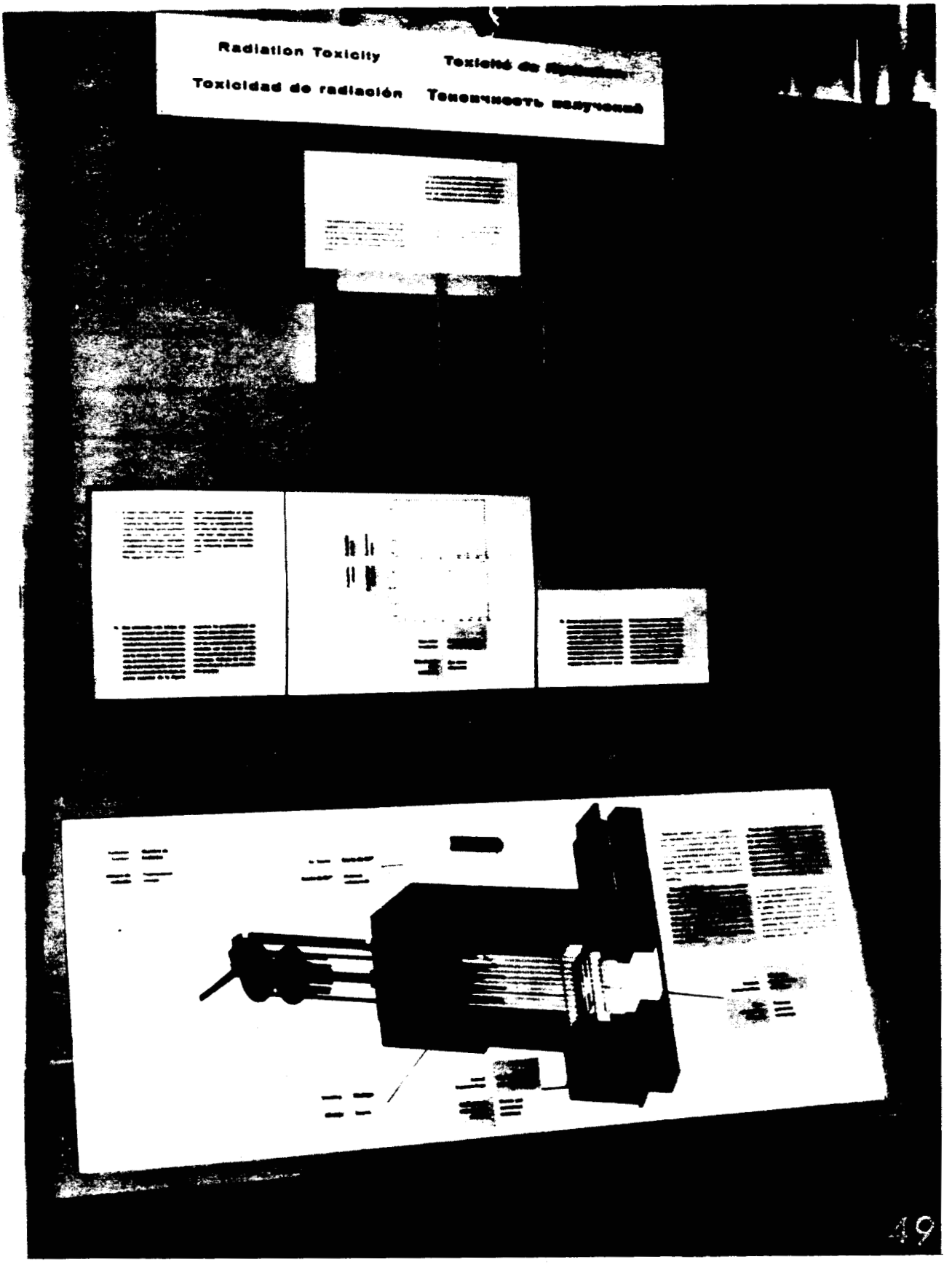


103557b

Photo No. 49: In an exhibit headed "Radiation Toxicity", Argonne National Laboratory reported results of a research project on the biological effects of neutrons and gamma rays. Text and graphs were mounted on a continuous belt so that section after section was brought into view by an automatic timing circuit. The bottom part of the panel illustrated the way in which mixed neutron and gamma radiations are produced by a reactor. Improved understanding of the effects of mixed neutron-gamma radiation is important to establishing permissible radiation levels for reactor operators and hence to the shielding design and operation of the reactors themselves.

1035577

Photo No. 50: Another display reported possible useful applications of gamma radiation. Called "Research on Effects of Radiation", it emphasized, with six color transparencies and samples of four different foods, investigations of radiation for food preservation. The foods pictured were liverwurst, bread, cheese, smoked salmon, ground beef, corn and sausage and the samples were of bread, smoked salmon, chicken and ground beef. These transparencies and food materials were furnished by the Quartermaster Corps of the United States Army.

By pictures and charts this exhibit also reported on:

Prevention of sprouting of onions (University of Michigan)

Prevention of sprouting of potatoes (Brookhaven National Laboratory)

Destruction of food-spoiling mold by radiation (University of Michigan)

Preservation of beans and grain from weevils (University of Michigan)

Destruction of trichinosis organism (University of Michigan)

Feeding tests on white rats (University of Michigan)

Measurement of radiation by darkening of glass (Naval Research Laboratory)

Radiation damage to organic liquids potentially useful as reactor coolants and methods of reducing this damage.

The large panel against the back wall consisted of flow charts, specimens and text illustrating the winning from the ores of pure rare earth compounds and metals. There were also samples of 15 oxides and 15 metals. The panel pointed out the significance of these materials for basic research and for commercial application as in the manufacture of glass, lighter flints, carbon arc lamps, incandescent gas mantles, metal alloys, radiation sources and analytical chemical reagents. The exhibit materials were furnished by the Ames Laboratory, Iowa State College.

1035578

1035579

Rare earths are becoming available in increasing quantity as a by-product of atomic energy activity. Ion exchange processes developed for separating highly radioactive fission products, many of which are rare earths, are now being applied to nonradioactive rare earths.

The large cases on the right contained 12 samples of compounds of three transuranic elements (heavier than uranium) and produced by artificial means, and the first bit of plutonium isolated and weighed as a pure compound. It contained in milligram quantities: plutonium trichloride, tetrafluoride, trifluoride and dioxide, neptunium dioxide, tetrachloride, tetrafluoride trichloride, and trifluoride; and americium dioxide, sesquioxide, and trifluoride.

The first plutonium sample, isolated as a pure compound at the University of California, could be seen on a screen magnified by a microscope. Neptunium, the first transuranium element discovered, also represented an achievement of the University of California. Americium, the fourth new element isolated, was identified at the Metallurgical Laboratory of the Manhattan Project. A total of nine transuranic elements has been identified.

The display case was prepared by the Radiation Laboratory of the University of California. The samples were sealed in special containers to eliminate any hazard of radioactivity.

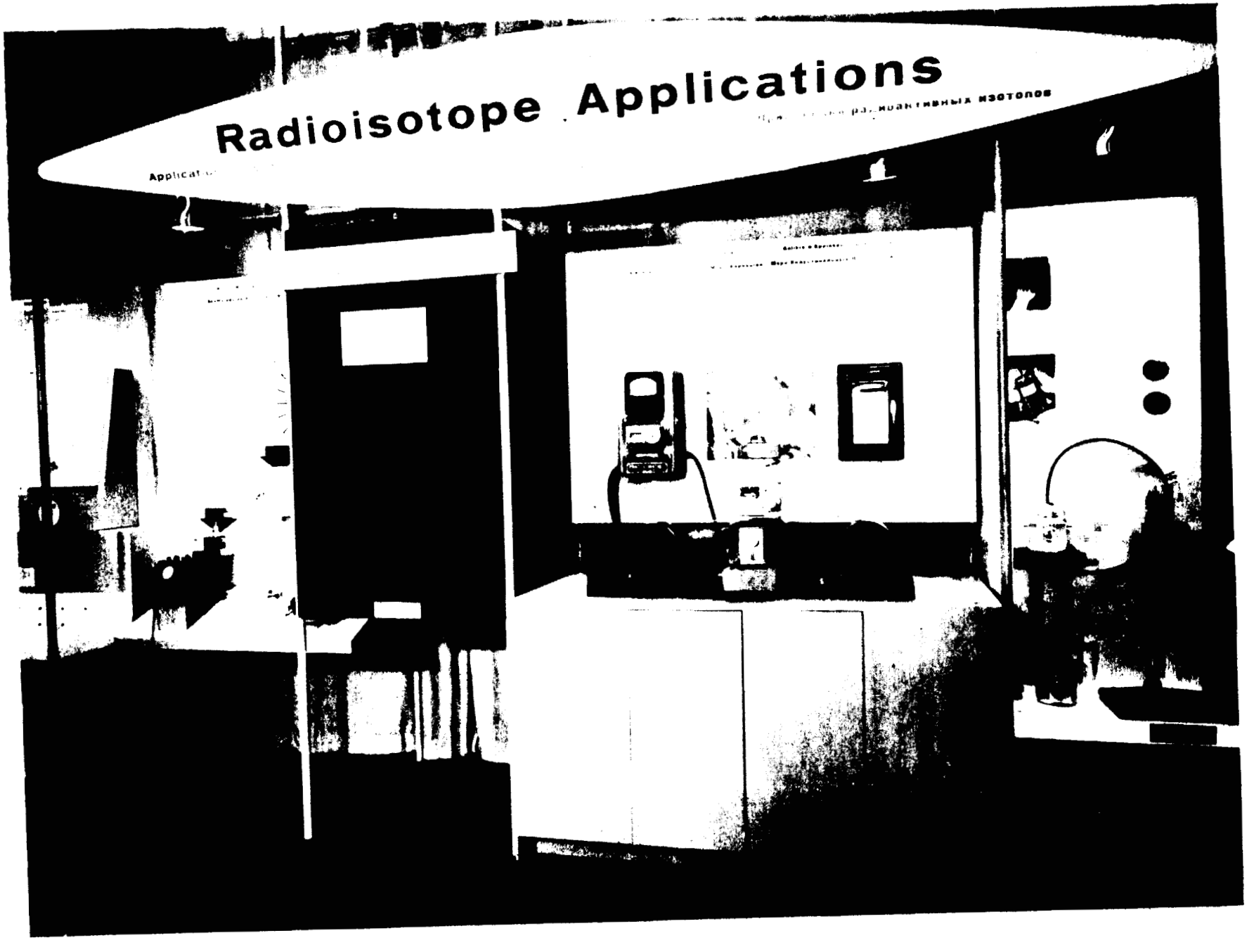
1035580

Photo No. 51: Exhibits on applications of radioisotopes were grouped together on the right of the aisle near the entrance. The central feature of this display was an operating industrial thickness gage loaned by the Niles-Bement-Pond Company, a division of Pratt and Whitney. An endless strip of metal containing a thick spot passed continuously through the gage. Every time the spot got in the path of radiations from the gage's strontium 90 source, a blip registered on the paper of a continuous recording instrument. Gages of this type are used in industry to measure and control the thickness of many materials such as paper, aluminum foil and plastic sheets.

On the right was a display on the development and application of a portable X-ray unit, using radioactive thulium and requiring no electric current for operation. It included an actual prototype developed by the Argonne National Laboratory, a transparent plastic model of this prototype and a unit now produced commercially by Litton Industries.

Three types of atomic batteries, in actual operating condition, were exhibited on the left, with diagrams illustrating construction and principles of operation.

1035581



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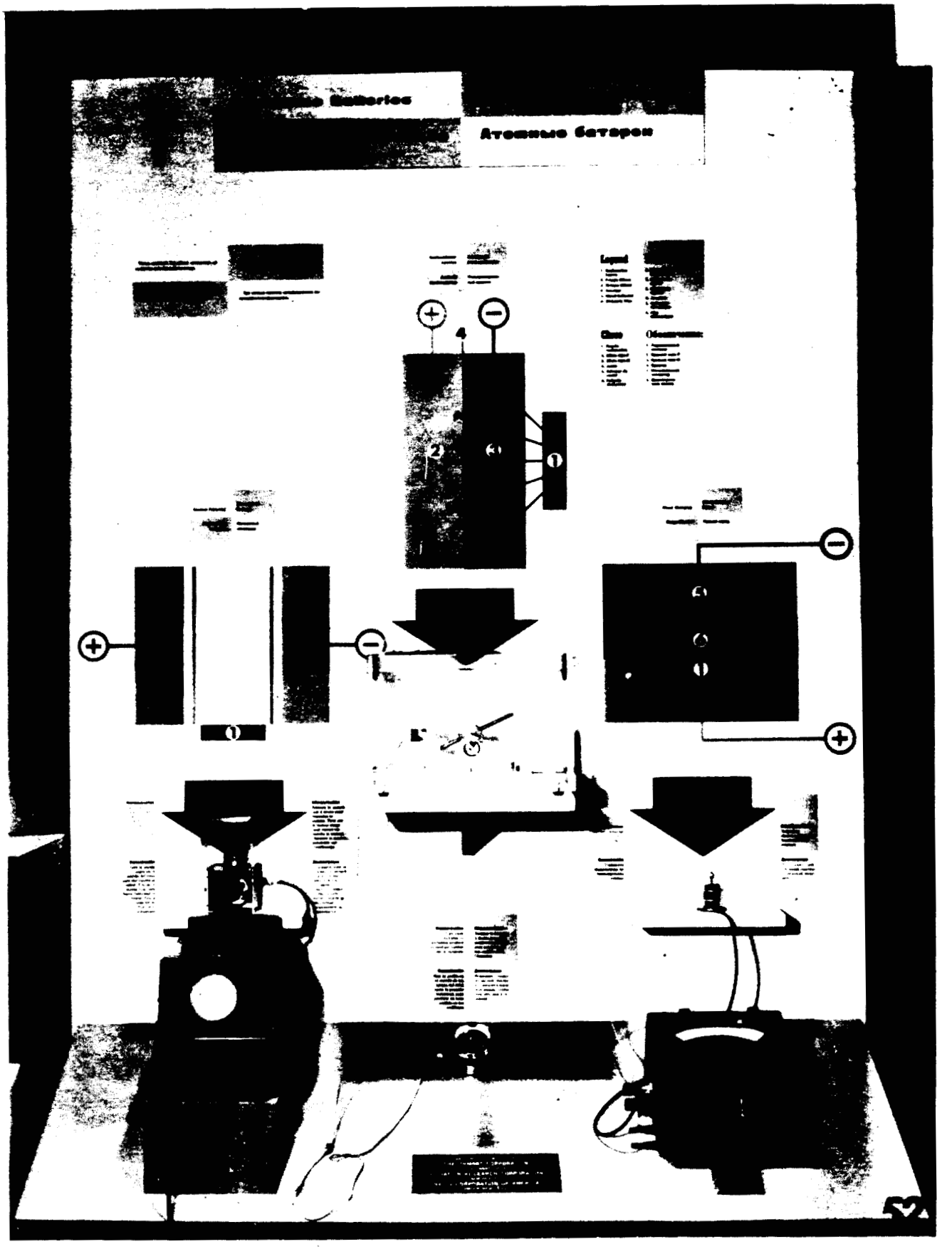

1035583

Photo No. 52: Near the center of the atomic battery exhibit and housed in a thick plastic container was a Radio Corporation of America semi-conductor battery and its strontium 90 source. The source was mounted on the end of a rod so that visitors could move it near the battery, and the battery was connected to a small audio-oscillator and earphone outside the box. Thus by use of the earphone visitors could "hear" the energy generated when they brought the source near the battery.

On a shelf to the right was a strontium 90 beta radiation battery from Radiation Research Corporation. Beta rays, originating at a central electrode, pass through a very thin membrane to an outer electrode wall thereby transferring charge from the central electrode to the outer wall. It is theoretically possible to produce potentials as high as the energy of the beta rays passing through the membrane; in practice several thousand volts are obtained. The potential was measured by an electrostatic voltmeter below the battery. The current from these batteries is extremely small, of the order of 1/100 billionth of an ampere.

On the left, mounted under a small plastic cover, was an Ohmart contact potential type battery in which ionizing radiation produces a current used to charge a condenser which, when discharged intermittently, produced a pulse on the oscilloscope below the battery.

1035584

Photo No. 53: Just outside the entrance to Room XV was an interesting and important feature of the United States Technical Exhibit: a continuously operating cloud chamber designed and built for the exhibit by the Radiation Laboratory of the University of California and operated by a representative of the United States Bureau of Standards. Over an area five feet square and several inches deep visitors saw at any one time about 500 atomic particle tracks originating from cosmic ray disintegration products and from natural radioactivity sources. The cloud chamber demonstrated the naturally occurring radiation which constantly penetrates the human body.

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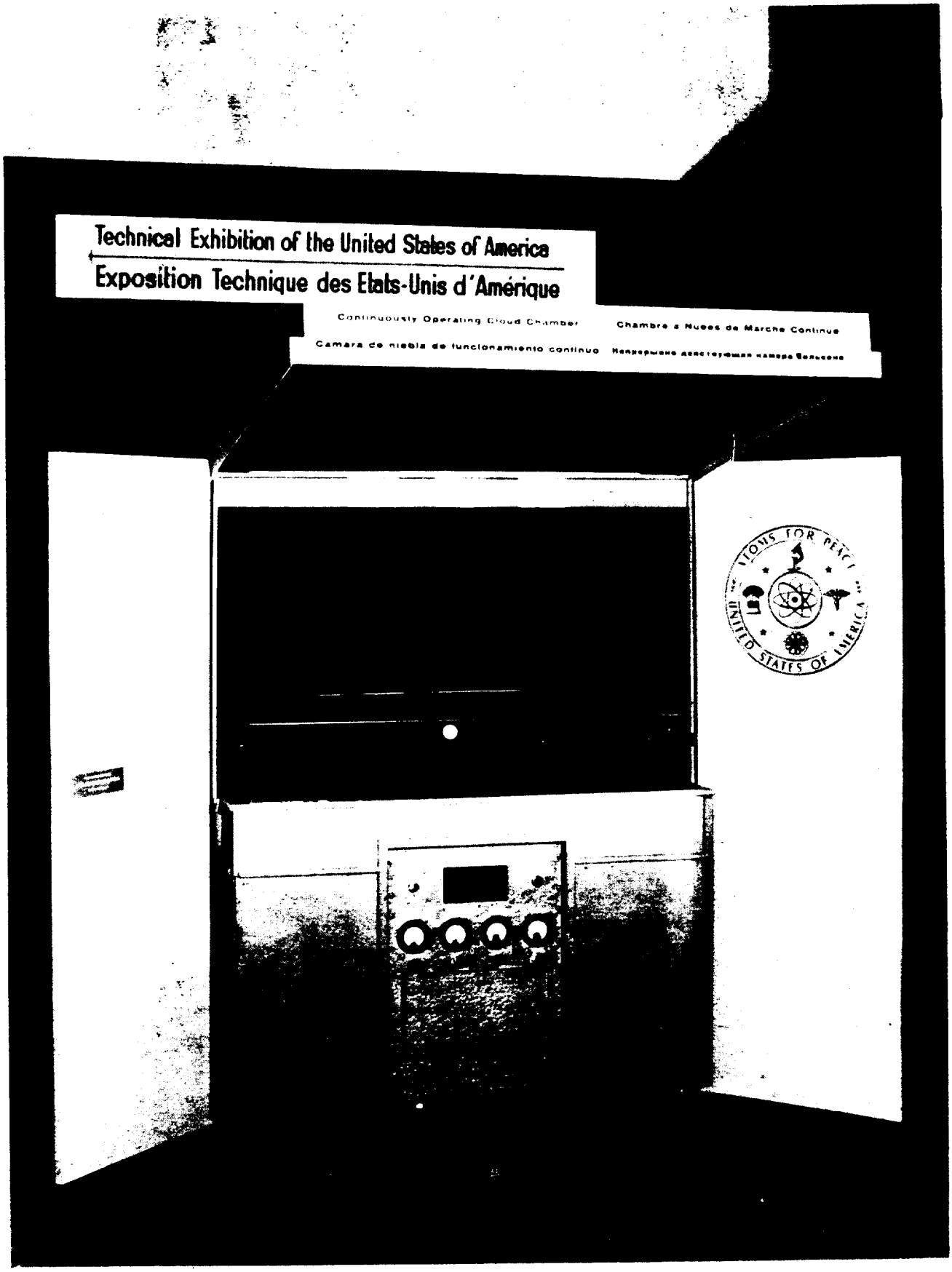

Technical Exhibition of the United States of America
Exposition Technique des Etats-Unis d'Amérique
Continuously Operating Cloud Chamber
Chambre à Nuées de Marche Continue
Camara de niebla de funcionamiento continuo
ATOMS FOR PEACE
UNITED STATES OF AMERICA

103558b

ATTACHMENT 1 - CONTRIBUTORS TO TECHNICAL EXHIBIT

American Machine and Foundry Company, New York, New York
Anton Electronic Laboratory, Brooklyn, New York
Argonne Memorial Cancer Research Hospital, University of Chicago, Chicago, Illinois
Argonne National Laboratory, Chicago, Illinois
Atomic Instrument Company, Cambridge, Massachusetts
Atomic Power Development Associates, Inc., Detroit, Michigan
Atomic Research Corporation, Colorado Springs, Colorado
The Babcock & Wilcox Company, New York, New York
A.O. Beckman, Inc., South Pasadena, California
Beckman Instruments, Inc., Fullerton, California
Bendix Aviation Corporation, Cincinnati, Ohio
Brookhaven National Laboratory, Upton, New York
The Brush Beryllium Company, Cleveland, Ohio
Burton-Rogers Company, Cincinnati, Ohio
Cambridge Instrument Company, Inc., New York, New York
Chapman Valve Manufacturing Company, Indian Orchard, Massachusetts
Cincinnati Ventilating Company, Covington, Kentucky
Commonwealth Edison Company, Chicago, Illinois
Consolidated Edison Company, New York, New York
Consolidated Engineering Corporation, Pasadena, California
Consumers Public Power District of Nebraska, Columbus, Nebraska
Craftweld Equipment Company, Long Island, New York
Crane Company, Chicago, Illinois
Daystrom Instrument Company, Archbald, Pennsylvania
Design and Production, Inc., Alexandria, Virginia
Detectron Corporation, North Hollywood, California
Detroit Edison Company, Detroit, Michigan
Allen B. DuMont Laboratories, Inc., Clifton, New Jersey
Electric Machinery Company, Minneapolis, Minnesota
El-Tronics Inc., Philadelphia, Pennsylvania
Engineers Syndicate Ltd., Hollywood, California
Fisher and Porter Manufacturing Company, Hatboro, Pennsylvania
General Dynamics Corporation, Groton, Connecticut
General Electric Company, Schenectady, New York
Harig Manufacturing Company, Chicago, Illinois
The Harshaw Chemical Company, Cleveland, Ohio
Illinois Water Treatment Company, Rockford, Illinois
International Instrument, Inc., New Haven, Connecticut
Iowa State College, Ames Laboratory, Ames, Iowa
Johns Hopkins University, Baltimore, Maryland
Keleket X-Ray Corporation, Covington, Kentucky
King Typographic Service Corporation, New York, New York
Labour Company, Elkhart, Indiana

1035587

Landsverk Electrometer Company, Glendale, California
LaRoe Instruments, Inc., Bethesda, Maryland
Leeds and Northrup Company, Philadelphia, Pennsylvania
H. W. Leighton Laboratories, Hatboro, Pennsylvania
Lindsay Chemical Company, West Chicago, Illinois
Litton Industries, Beverley Hills, California
Los Alamos Scientific Laboratory, Los Alamos, New Mexico
Massachusetts Institute of Technology, Cambridge, Massachusetts
Master Electric Company, Dayton, Ohio
McGraw-Hill Book Co., Inc.,New York, New York
Michigan State College, East Lansing, Michigan
Minneapolis-Honeywell Regulator Co., Philadelphia, Pennsylvania
National Bureau of Standards, United States Department of Commerce
National Radiac, Inc., Newark, New Jersey
New England Deaconess Hospital, Boston, Massachusetts
New York University, New York, New York
Norden-Ketay Corporation, New York, New York
North American Aviation, Inc., Downey, California
Nuclear Instrument and Chemical Corporation, Chicago, Illinois
Nuclear Metals, Inc., Cambridge, Massachusetts
Nuclear Power Group, Chicago, Illinois
Nuclear Research Corporation, Philadelphia, Pennsylvania
Nuclear Research and Development, Inc., St. Louis, Missouri
Nuclear Science and Engineering, Inc., Pittsburgh, Pennsylvania
Nucleonic Company of America, Brooklyn, New York
Oak Ridge Institute of Nuclear Studies, Oak Ridge, Tennessee
Ohio State University, Department of Medicine, Columbus, Ohio
The Ohmart Corporation, Cincinnati, Ohio
Packard Instrument Company, LaGrange, Illinois
Panellit, Inc., Skokie, Illinois
Phillips Petroleum Company, Idaho Falls, Idaho
Pratt and Whitney, Division Niles-Bement-Pond Co., Hartford, Connecticut
Precision Radiation Instruments, Los Angeles, California
Publication Services, Inc., Washington, District of Columbia
Radiation Counter Laboratories, Skokie, Illinois
Radiation Industries Company, Brookhaven, New York
Radiation Instrument Development Laboratory, Chicago, Illinois
Radiation Research Corporation, West Palm Beach, Florida
Radio Corporation of America, Camden, New Jersey
Radioactive Products, Inc., Detroit, Michigan
Raytheon Manufacturing Company, Waltham, Massachusetts
R-C Scientific Instruments Company, Inc., Playa Del Rey, California
L. Schreiber and Sons, Company, Covington, Kentucky
Sherwin Instrument Company, New York, New York
Sloan Kettering Institute for Cancer Research, New York, New York
Structural Display Company, Inc., Long Island, New York
Sylvania Electric Products, Inc., Bayside, Long Island, New York
Technical Associates, Burbank, California
Tracerlab, Inc., Boston, Massachusetts
Union Carbide and Carbon Corporation, New York, New York

1035588

United States Atomic Energy Commission
United States Bureau of Mines
United States Geological Survey
United States Radium Corporation, New York, New York
United States Weather Bureau
University of California, Radiation Laboratory, Berkeley, California
University of Michigan, Ann Arbor, Michigan
Victoreen Instrument Company, Cleveland, Ohio
The Vitro Corporation of America, New York, New York
Westinghouse Electric Corporation, Pittsburgh, Pennsylvania
N. Wood Counter Laboratory, Chicago, Illinois

1035589

ATTACHMENT 2 - EXHIBIT BROCHURE DISTRIBUTED AT GENEVA

1035590

Technical Exhibition of the United States of America

Exposition Technique des Etats-Unis d'Amérique

Техническая Выставка Соединенных Штатов Америки

Exhibición Técnica de los Estados Unidos

INTERNATIONAL CONFERENCE ON THE PEACEFUL USES OF ATOMIC ENERGY

PALAIS DES NATIONS GENEVA

AUGUST 8 TO 20, 1955

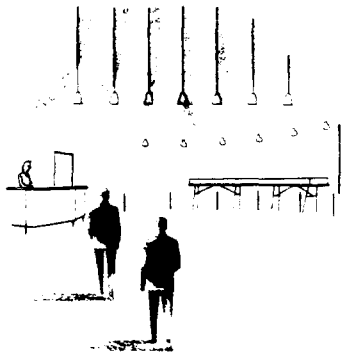
1035591

■ The great strides already made in putting atomic energy to work in industry, agriculture, medicine and research, will become evident during the course of this Conference. We hope that the free exchange of technical information and ideas among leading scientists and engineers of many nations will stimulate even greater progress in the months and years ahead.

In this cause, the United States is firmly dedicated to promote international cooperation and to contribute its share of scientific knowledge and resources.

■ Les énormes progrès déjà réalisés dans la mise en œuvre de l'énergie atomique dans les domaines de l'industrie, de l'agriculture, de la médecine et de la recherche scientifique seront mis en lumière au cours de la Conférence. Nous espérons que l'échange libre d'idées et de documentation technique parmi l'élite des savants et des ingénieurs de nombreuses nations engendrera des progrès plus grands encore au cours des mois et des années à venir.

Les Etats-Unis se vouent sans réserve à cette cause en vue de favoriser la coopération internationale et contribueront à ces fins leur part de ressources et de connaissances scientifiques.



■ В ходе работ Конференции выявятся крупные шаги, уже сделанные для использования атомной энергии в промышленности, в сельском хозяйстве, в медицине и в исследованиях. Мы надеемся, что свободный обмен технической информацией и идеями среди ведущих ученых и инженеров многих стран будет способствовать еще большему прогрессу в течение будущих месяцев и лет.

Ради этого дела Соединенные Штаты твердо намерены развивать международное сотрудничество и вносить свою долю научного знания и ресурсов.

■ Los notables adelantos alcanzados en la utilización de la energía atómica en la industria, la agricultura, la medicina y la ciencia de investigación, serán puestos de relieve en el transcurso de esta Conferencia. Nuestra esperanza sincera es que ese libre intercambio de información técnica e ideas por parte de los más destacados ingenieros y científicos de tantas naciones, contribuya a crear un progreso aún mayor en los meses venideros.

En esta causa común, los Estados Unidos ponen su mas decidido empeño en fomentar una cooperación internacional y en contribuir su parte correspondiente de recursos y conocimientos técnicos.

Dwight D. Eisenhower

1035592

Introduction

In March, 1955, the United Nations invited all countries planning to participate in the International Conference on the Peaceful Uses of Atomic Energy to present technical exhibits at the Palais des Nations in Geneva during the sessions.

The United States Exhibit, especially prepared for the occasion, consists of three parts: an operating Research Reactor, housed in its own building adjacent to the Library wing of the Palais; a comprehensive display, covering selected peaceful applications of atomic energy in Salle XV of the Library; and a Technical Reference Library, located near Salle XV. The United States is also showing a number of special technical films during the Conference.

The various parts of the U. S. Exhibit serve as a visual supplement to the technical papers presented to the Conference by the United States.

Detailed data on individual elements of the reactor and Salle XV displays is available, upon request, in the Technical Library.

The Exhibit, including the Reactor and Technical Library, was assembled by the U. S. Atomic Energy Commission in cooperation with other U. S. Government agencies and private American companies and organizations.

The U. S. Information Agency is presenting a popular, nontechnical "Atoms For Peace" exhibit in the Palais des Expositions in Geneva.

Introduction

Au mois de mars 1955, les Nations Unies invitèrent tous les pays se proposant de participer à la Conférence Internationale sur l'Utilisation de l'Energie Atomique à des Fins Pacifiques à organiser une exposition scientifique au Palais des Nations à Genève.

L'exposition des Etats-Unis, spécialement préparée pour l'occasion, comprend trois parties: un réacteur à recherches scientifiques en état de fonctionnement, logé dans son propre bâtiment, lequel est contigu à l'aile du Palais abritant la Bibliothèque; une exposition d'ensemble sur des utilisations sélectionnées de l'énergie atomique à des fins pacifiques, dans la Salle XV de la Bibliothèque; et une Bibliothèque d'Ouvrages Techniques de Référence, situéé près de la Salle XV. Les Etats-Unis montreront un certain nombre de films techniques pendant la Conférence.

Les différentes parties de l'exposition américaine servent de compléments visuels aux communications scientifiques présentés à la Conférence par les Etats-Unis.

Des renseignements détaillés portant sur les différents éléments du réacteur et sur l'exhibition de la Salle XV pourront être obtenus, sur demande, à la Bibliothèque Technique.

L'exposition, y compris le Réacteur et la Bibliothèque Technique, a été montée par la Commission de l'Energie Atomique des Etats-Unis en collaboration avec d'autres organismes gouvernementaux et des sociétés et organisations privées.

De son côte, le Service d'Information des Etats-Unis (United States Information Agency) présente une exposition de vulgarisation de caractère non technique, ayant pour sujet "l'Atome au Service de la Paix," dans le Palais des Expositions à Genève.

1035593

Введение

В марте 1955 г. Объединенные Нации предложили всем странам, имевшим в виду участвовать в Международной конференции по мирному использованию атомной энергии, представить их технические экспонаты во Дворце наций (Palais des Nations), в Женеве, во время заседаний.

Выставка США, специально подготовленная для этого случая, состоит из трех частей: 1) Действующий исследовательский реактор, помещенный в отдельном здании рядом с библиотечным крылом Дворца; 2) Обширная выставка, иллюстрирующая избранные мирные применения атомной энергии — в Зале XV Библиотеки и 3) Техническая справочная библиотека — около Залы XV. США покажут также несколько специальных технических фильмов во время Конференции.

Различные экспонаты США служат наглядными дополнениями к техническим докладам, представляемым Соединенными Штатами на Конференции. Подробные данные об отдельных частях реактора и экспонатов Залы XV можно получить в Технической библиотеке по запросу.

Экспонаты, вместе с реактором и с технической библиотекой, были скомплектованы Комиссией по атомной энергии США при содействии других американских госучреждений, частных фирм и организаций.

Информационное агентство США представляет популярную нетехническую выставку "Атомы для дела мира" во Дворце выставок (Palais des Expositions) в Женеве.

Introducción

En el mes de marzo de 1955, las Naciones Unidas extendieron una invitación a todos los países que planeaban participar en la Conferencia Internacional sobre la Utilización de la Energía Atómica con Fines Pacíficos, para que presentaran exhibiciones técnicas en el Palais de Nations en Ginebra durante las sesiones.

La Exhibición de los Estados Unidos, preparada especialmente para esta ocasión, está dividida en tres partes: un Reactor de Investigación en operación, alojado en su propio edificio adyacente al ala de la Biblioteca del Palais; una exhibición completa, incluyendo aplicaciones seleccionadas de la energía atómica para usos pacíficos, en la Salle XV de la Biblioteca; y una Biblioteca Técnica de Referencia, cerca de la Salle XV. Durante la Conferencia, los Estados Unidos proyectarán también varias películas técnicas especiales.

Las diferentes partes de la Exhibición de los Estados Unidos sirven de suplementos visuales a los trabajos técnicos presentados en la Conferencia. Información detallada sobre los elementos individuales del reactor y las exhibiciones en la Salle XV, puede ser solicitada en la Biblioteca Técnica.

La Exhibición, incluyendo el Reactor y la Biblioteca Técnica, fué preparada por la Comisión de la Energía Atómica de los Estados Unidos, en colaboración con otras agencias del Gobierno de los Estados Unidos, y con organizaciones y compañías privadas norteamericanas.

La Agencia de Información de los Estados Unidos está presentando una exhibición popular, no técnica, de "Atomos para la Paz", en el Palais des Expositions en Ginebra.

1035594

Research Reactor

The United States Research Reactor is in a specially constructed building slightly to the northwest of the Library and opposite the north end of the Assembly building.

The reactor is of the type popularly known as a "pool reactor" because the fuel elements operate while immersed in a tank of water. The core, completely visible, consists of 23 compactly arranged fuel elements containing approximately 3.6 kg. of enriched uranium-235. When operating, the core gives off the familiar blue glow known as the Cerenkov effect.

Supplementing the reactor itself are a number of displays explaining its construction and operation, and showing its varied uses both as a research tool and for the production of radioisotopes.

Demonstrations of the reactor have been scheduled at announced intervals and attendants will be present to provide additional information or to answer questions.

The Swiss Government has arranged to purchase the reactor at the conclusion of the Conference, and will move it to the Federal Institute of Technology in Zurich.

On June 11, President Eisenhower announced that the United States Government was prepared to help provide research reactors for other free nations and to contribute half their cost as well as furnish the nuclear fuel required.

Réacteur à Recherches Scientifiques

Le Réacteur à Recherches Scientifiques exposé par les Etats-Unis est installé dans un bâtiment qui a été spécialement construit pour le loger. Il est situé légèrement au nord-ouest de la Bibliothèque et vis-à-vis de l'extrémité nord de l'immeuble réservé aux séances.

Ce réacteur appartient au type généralement connu sous le nom de réacteur "à réservoir" en raison du fait que les éléments combustibles produisent leurs effets alors qu'ils sont immergés dans un réservoir à eau. Le noyau entièrement visible, consiste en 23 éléments combustibles disposés d'une manière compacte et contenant approximativement 3,6 kg d'uranium-235 enrichi. Lorsque le réacteur fonctionne, ce noyau émet une lueur bleue bien connue sous le nom de radiation de Cerenkov.

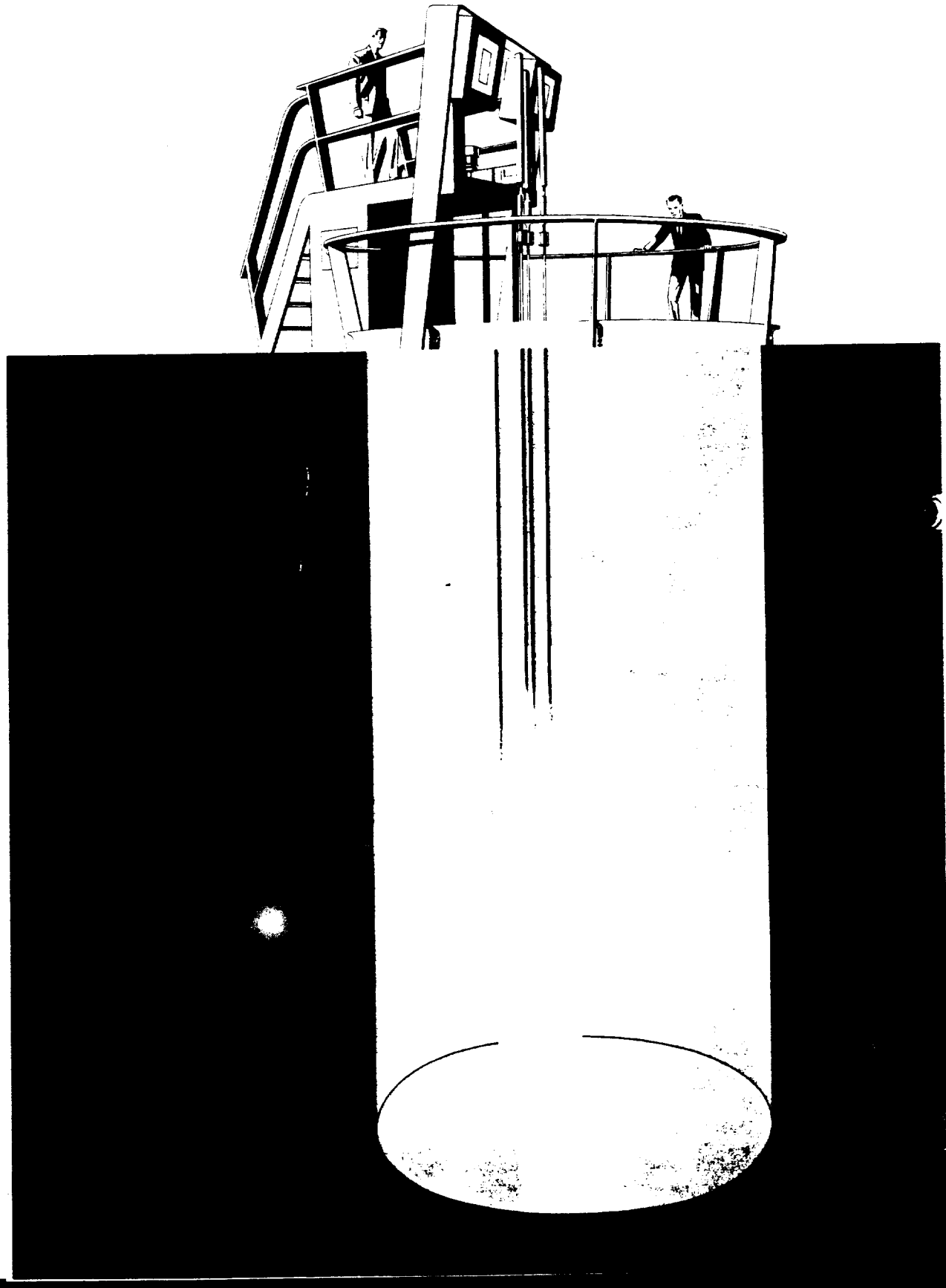
La présentation du réacteur même est complétée par une exposition d'objets ayant pour but d'expliquer sa construction et son fonctionnement et de mettre en lumière ses différents usages tant pour la recherche scientifique que pour la production de radio-isotopes.

Des démonstrations du réacteur auront lieu à des heures qui seront portées à la connaissance du public, et un personnel compétent sera présent pour fournir des renseignements complémentaires aux personnes intéressées et répondre à leurs questions.

A la clôture de la Conférence, le Gouvernement Suisse se rendra acquéreur du réacteur et le transportera à l'Institut Fédéral de Technologie à Zurich.

Le 11 juin, le Président Eisenhower a annoncé que le Gouvernement des Etats-Unis était prêt à aider les pays libres à se procurer des réacteurs à recherches scientifiques et à prendre à leur charge la moitié de leur prix d'achat, ainsi qu'à fournir les combustibles nucléaires nécessaires.

1035595



1035596

Исследовательский Реактор

Исследовательский реактор США помещен в специально построенном здании слегка к северо-западу от Библиотеки, против северного конца здания Ассамблеи.

Реактор этот хорошо известен под названием "бассейного", так как его топливные элементы работают в бассейне с водой. Его хорошо видный сердечник состоит из 23 компактно собранных топливных элементов, содержащих около 3,6 кг обогащенного урана-235. При работе сердечник излучает голубое, так называемое черенковское, свечение.

Сам реактор дополнен несколькими экспонатами, которые разъясняют его конструкцию и работу и иллюстрируют его различные применения для исследований и для производства радиоактивных изотопов.

Демонстрации работы реактора будут происходить по объявленному расписанию; дежурные будут на месте для дачи дополнительных сведений и для ответа на вопросы.

Швейцарское правительство договорилось о покупке этого реактора после закрытия Конференции; реактор будет перенесен в Федеральный технологический институт, в Цюрихе.

Одиннадцатого июня Президент Айзенхауэр объявил, что Правительство США готово помочь другим свободным странам в приобретении исследовательских реакторов и готово оплатить половину их стоимости, а также предоставить потребное ядерное горючее.

Reactor de Investigación

El Reactor de Investigación de los Estados Unidos está en un edificio especialmente construído para él, al noroeste de la Biblioteca y frente al lado norte del edificio de Asambleas.

Este reactor es del tipo conocido popularmente como "reactor de tanque." porque los elementos combustibles funcionan sumergidos en un tanque de agua. El núcleo, completamente visible, consiste de 23 elementos combustibles dispuestos en forma compacta, y conteniendo aproximadamente 3.6 kilogramos de uranio-235 enriquecido. Cuando está funcionando, el núcleo emite un brillo azul, conocido con el nombre de efecto Cerenkov.

Además del reactor mismo, hay una serie de exhibiciones que explican su construcción y funcionamiento, y que muestran sus distintos usos como equipo de investigación y para la producción de radioisótopos.

El programa incluye demostraciones del reactor anunciadas periódicamente, en las que participarán ayudantes para dar información adicional o para contestar cualquier pregunta.

El Gobierno Suizo ha hecho arreglos para comprar el reactor cuando se termine la Conferencia, y lo trasladará al Instituto Tecnológico Federal en Zurich.

El 11 de junio, el Presidente Eisenhower anunció que el Gobierno de los Estados Unidos estaba preparado para ayudar a suministrar reactores de investigación a otras naciones del mundo libre, y a contribuir la mitad de su costo, así como el combustible nuclear necesario.

1035597

1 PRODUCTION OF URANIUM AND THORIUM METALS

Specimens of primary and secondary uranium-bearing and thorium-bearing minerals.

Steps in the processing of uranium and thorium ores from mine to metal.

2 REACTOR MATERIALS

Beryllium and zirconium production, fabrication and utilization.

Improving corrosion resistance of aluminum, at elevated temperatures, by alloying with nickel.

Improving the dimensional stability of uranium, under thermal cycling, by alloying with zirconium, niobium and chromium.

3 REACTOR FUEL ELEMENTS

Examples of fuel elements developed for research and experimental power reactors.

4 REACTORS

Models and data on various power and research reactors in operation, under construction, and planned in the United States:

U. S. Experimental Power Reactor Program

Shippingport Pressurized Water Reactor
Experimental Boiling Water Reactor
Experimental Breeder Reactor No. 2
Homogeneous Reactor Experiment No. 2
Sodium Reactor Experiment

Materials Testing Reactor
Argonne Research Reactor
Boiling Reactor Power Plant
Industrial Atomic Power Projects

Demonstration of reactor control panel with simulator and control rod drive mechanism.

5 REACTOR COMPONENTS AND AUXILIARIES

Demonstration of new consumable insert weld for reactor circulating systems.

Reactor pumps and valves, with representative equipment for high- and low-pressure systems.

Protection of environment from radioactivity, including weather and stream studies, air cleaning, incineration to concentrate combustible wastes, absorption of radioactivity on clay, and investigations of removal of radioactivity from water supplies and sewage.

6 CHEMICAL PROCESSING

Model of Idaho Chemical processing plant.

Uranium processing demonstration showing techniques applicable to the chemical separation of radioactive materials. Demonstration includes the separation of uranium from copper by solvent extraction, concentration of uranium by ion exchange, and remote sampling and analysis of uranium and sodium nitrate solutions in the manipulator-equipped remote analytical cell.

1035598

7 INSTRUMENTATION

Prospecting Equipment
Operating examples of airborne scintillation counters, drill hole logging instruments and portable prospecting instruments used for locating uranium ore deposits.

Radiation Monitoring Instruments
Examples of dosimeters, air particle monitors, hand and foot contamination monitors and portable radiation survey instruments used to safeguard persons working with radioactive materials.

Instrument Components
Geiger and proportional counter tubes, photomultiplier tubes, scintillation phosphors and crystals used as nuclear radiation detectors.

Low-Level Anti-Coincidence Counter
Demonstration of low-level counting techniques.

Radiation Spectrometers and Pulse-Height Analyzers
Demonstration of gamma radiation spectroscopy, 100-channel pulse-height analyzer and sliding single channel automatic spectrometer.

Medical Instruments
Demonstration of automatic scintillation scanner and special Geiger counter eye and brain probes.

8 BIOLOGY AND MEDICINE

Biochemical Research in Connection with Steroid Metabolism Studies
The first uses of carbon-14 and tritium for the *in vivo* study of steroid synthesis and degradation in human subjects. A liquid scintillation spectrometer of a type used for the above study is included.

Slow Neutron Capture Therapy in Treatment of Brain Tumors
Techniques and results of brain tumor treatment using boron-10 and reactor-produced thermal neutrons.

Teletherapy and Brachy-Therapy with Radioisotopes
Models demonstrating various possibilities for radiation teletherapy, including both fixed-beam and rotational-therapy types; and new methods of interstitial radiation therapy, with other techniques in brachy-therapy.

Autoradiography Techniques in Pathology
Microscopic and gross autoradiography techniques together with selected autoradiograms illustrating results.

Radiation Toxicity Studies
Results of research on the effects of gamma and mixed gamma and neutron radiation exposure on biological and plant life.

Radiation and Plant Genetics
The role of radiation in plant genetics and crop improvement, including methods used to obtain beneficial mutations, and examples of the resulting mutations.

Research on Effects of Radiation
Examples of food preservation, deterioration of organic chemicals, and bone sterilization.

9 APPLICATIONS OF RADIOISOTOPES

Demonstration of methods for thyroid uptake calibration.

Portable thulium X-ray unit.

Industrial radiation thickness gage demonstration.

Isotope-activated light sources – used for signs and markers.

Atomic batteries – illustrating three methods for the direct conversion of radiation into electrical energy.

Use of carbon-14 tracers in biosynthesis.

10 RARE EARTHS AND TRANSURANIUM ELEMENTS

Separation and preparation of rare earths and transuranium elements.

CLOUD CHAMBER (Near Salle XV)

A continuously operating four-by-eight-foot cloud chamber, showing the paths of cosmic rays, 500 at any one instant.

1035599

Exposition d'Ensemble de la Salle XV

1

PRODUCTION DE METAUX D'URANIUM ET DE THORIUM

Spécimens de minéraux primaires et secondaires contenant de l'uranium et du thorium.
Gamme d'opérations pour transformer des minerais d'uranium et de thorium en métal à partir de leur extraction de la mine.

2

MATERIAUX DE REACTEURS

Production, fabrication et utilisation du béryllium et du zirconium.

Amélioration de la résistance de l'aluminium à la corrosion à des températures élevées par alliage avec du nickel.

Amélioration de la stabilité dimensionnelle de l'uranium par traitement par cycle thermique, par alliage avec du zirconium, du niobium et du chrome.

3

ELEMENTS COMBUSTIBLES DE REACTEUR

Spécimens d'éléments combustibles produits pour alimenter les réacteurs générateurs d'énergie expérimentaux et à recherches scientifiques.

4

REACTEURS

Modèles et caractéristiques de fonctionnement de différents réacteurs générateurs d'énergie et à recherches scientifiques en service, en voie de construction et dont la construction est prévue aux Etats-Unis:

Programme de Réacteurs Générateurs d'Energie Expérimentaux aux Etats-Unis

Réacteur à Eau sous Pression de Shippingport

Réacteur Expérimental à Eau bouillante

Réacteur Générateur Expérimental No. 2

Réacteur Homogène Expérimental No. 2

Réacteur Expérimental au Sodium

Réacteur d'Essais de Matériaux

Réacteur à Recherches Scientifiques d'Argonne

Centrale d'Energie à Réacteur Bouillant

Centrales Industrielles d'Energie Atomique

Démonstration du fonctionnement d'un tableau de commande de réacteur muni d'un simulateur et d'un mécanisme de barres de commande.

5

ELEMENTS CONSTITUTIFS ET AUXILIAIRES DE REACTEUR

Démonstration du nouveau procédé de soudure rapportée consumable pour les systèmes de circulation des réacteurs. Pompes et vannes de réacteur, avec appareillage type pour les systèmes à haute et à basse pressions.

Protection du milieu ambiant contre les effets de la radioactivité, y compris l'évaluation des facteurs météorologiques et des facteurs de dilution dans les cours d'eau, la décontamination de l'air, l'incinération en vue de la concentration des résidus combustibles, l'absorption de radioactivité sur argile, et certaines études portant sur la décontamination des approvisionnements d'eau et des eaux d'égouts.

6

TRAITEMENT CHIMIQUE

Maquette de l'usine de traitement chimique de l'Idaho.

Démonstration du traitement de l'uranium mettant en lumière les techniques applicables à la séparation chimique des matières radioactives. Cette démonstration comprend la séparation de l'uranium du cuivre par extraction dissolvante, la concentration de l'uranium par l'échange d'ions, et l'échantillonnage ainsi que l'analyse à distance de solutions d'uranium et de nitrate de soude à l'intérieur de la cellule analytique dotée d'un manipulateur de commande à distance.

1035600

7

INSTRUMENTS

Equipement de Prospection

Exemples de compteurs à scintillation aéroportés, d'équipement d'enregistrement de trous de sondage et d'instruments portatifs de prospection utilisés pour la détection des gisements de minerai d'uranium.

Instruments de Contrôle de Radiations

Exemples de dosimètres, d'instruments de détection et de mesure de radiations des particules dans l'air, de contrôleurs de contamination des mains et des pieds, et d'instruments portatifs de détection utilisés pour la protection des personnes manipulant des substances radioactives.

Eléments constitutifs des Instruments

Tubes de compteurs Geiger et de compteurs proportionnels, tubes de photomultiplicateurs, phosphores et cristaux de scintillations utilisés comme détecteurs de radiations nucléaires.

Compteur d'Anti-Coincidence à bas Niveau

Démonstration des techniques de détection à bas niveau.

Spectromètres de Radiations et Analyseurs de Hauteur de Pulsations

Démonstration de l'identification de radiation gamma par spectroscopie, d'un analyseur de hauteur de pulsations à 100 circuits et d'un spectromètre de circuit unique à curseur automatique.

Instruments médicaux

Démonstration d'une sonde automatique à scintillation et d'ausculteurs à compteur Geiger spécial pour les yeux et le cerveau.

8

BIOLOGIE ET MEDECINE

La Recherche biochimique dans l'Etude du Métabolisme stéroïde

Premières utilisations de carbone-14 et de tritérium dans l'étude *in vivo* de la synthèse stéroïde et de la dégénération chez l'homme. Cette exhibition comprend un spectromètre liquide à scintillation du type utilisé dans l'étude mentionnée ci-dessus.

Thérapeutique par Captage de Neutrons lents dans le Traitement de Tumeurs au Cerveau

Méthodes de traitement d'une tumeur au cerveau à l'aide de bore-10 et de neutrons thermiques produits par réacteur, et résultats obtenus.

Téléthérapeutique et Brachy-thérapeutique à l'aide de Radio-isotopes

Modèles d'appareils de types à faisceau fixe et à traitement rotatif démontrant les diverses possibilités d'application de la téléthérapeutique par radiation; et nouvelles méthodes thérapeutiques par radiation interstitielle et autres techniques employées en brachy-thérapeutique.

Techniques autoradiographiques en Pathologie

Techniques d'autoradiographie microscopique et macroscopique avec autoradiogrammes sélectionnés représentant les résultats obtenus.

Etudes sur la Toxicité de Radiation

Résultats des recherches effectuées sur les effets produits par des radiations gamma, et des radiations gamma mélangées avec des neutrons, sur la vie animale et végétale.

La Radiation et la Génétique des Plantes

Rôle de la radiation dans la génétique des plantes et l'amélioration des récoltes, y compris les méthodes employées afin d'obtenir des mutations utiles, et exemples de mutations en résultant.

Recherches sur les Effets de la Radiation

Exemples de préservation d'aliments, de détérioration de produits chimiques organiques et de stérilisation des os.

9

UTILISATIONS DES RADIO-ISOTOPES

Démonstration des méthodes pour mesurer le taux d'ingestion de la thyroïde.
Appareil radiographique portatif à thulium.
Démonstration sur l'évaluation des épaisseurs par radiation dans l'industrie.
Sources lumineuses activées avec des isotopes utilisés dans les enseignes et les signaux lumineux. Batteries atomiques—montrant trois méthodes pour convertir directement la radiation en énergie électrique. Utilisation d'éléments traceurs de carbone-14 en biosynthèse.

10

TERRES RARES ET ELEMENTS TRANSURANIUM

Séparation et préparation des terres rares et des éléments transuranium.

CHAMBRE A DETENTE
(Près de la Salle XV)

Chambre à détente mesurant quatre pieds sur huit et fonctionnant de façon continue, dans laquelle il est possible d'observer le passage de 500 rayons cosmiques à la fois.

11

1035601

1 ПРОИЗВОДСТВО МЕТАЛЛИЧЕСКОГО УРАНА И ТОРИЯ

Образцы первичных и вторичных минералов, содержащих уран и торий.

Ступени в переработке урановых и ториевых руд, от шахты до металла.

2 МАТЕРИАЛЫ ДЛЯ РЕАКТОРОВ

Производство, обработка и использование бериллия и циркония.

Повышение коррозийностойкости алюминия при высоких температурах путем сплавления его с никелем.

Повышение габаритной стойкости урана при циклической термообработке посредством сплавления его с цирконием, ниобием и хромом.

3 ТОПЛИВНЫЕ ЭЛЕМЕНТЫ РЕАКТОРА

Примеры топливных элементов, разработанных для исследовательских реакторов и для опытных энергореакторов.

4 РЕАКТОРЫ

Модели и данные по различным энергетическим и исследовательским реакторам, работающим, строящимся и проектируемым в США:

План США по строительству опытных энергореакторов

Реактор с водой под давлением в Шиппингпорте

Опытный реактор-парокотел

Опытный реакторразмножитель №2

Опытный гомогенный реактор №2

Опытный натриевый реактор

Реактор для испытания материалов

Аргоннский исследовательский реактор

Энергостанция с реактором-парокотлом

Применение атомной энергии в промышленности

Демонстрация панели управления реактора с симулятором и приводным механизмом регулирующего стержня.

5 ДЕТАЛИ И ВСПОМОГАТЕЛЬНЫЕ УСТРОЙСТВА РЕАКТОРОВ

Демонстрация новой сварки с потребляемой вставкой, применяемой в циркуляционных устройствах реактора.

Насосы и вентили реактора с типичным оборудованием для устройств высокого и низкого давления.

Защита окружающей среды от радиоактивности: метеорологические изыскания, исследования течений, очистка воздуха, сжигание горючих отходов с целью их концентрации, поглощение радиоактивности глиной, исследования удаления радиоактивности из водоснабжающих и канализационных устройств.

6 ХИМИЧЕСКАЯ ПЕРЕРАБОТКА

Модель химико-технологического завода в Айдахо.

Демонстрация переработки урана, показывающая методику химического разделения радиоактивных материалов.

Демонстрируется следующее: отделение урана от меди посредством экстракции растворителем, концентрация урана путем ионного обмена, дистанционный отбор проб и анализ растворов нитрата урана и натрия в аналитической ячейке с манипулятором.

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7 ПРИБОРЫ

Разведочная аппаратура

Эксплуатационные образцы самолетных сцинтилляционных счетчиков, приборов для буровых записей и переносных разведочных приборов, применяемых для обнаружения залежей урановой руды.

Приборы для контроля излучений

Образцы дозиметров, контролеров частиц в воздухе, контролёров загрязнения рук и ног, а также переносных приборов для обследования излучений, которые применяются для защиты здоровья лиц, работающих с радиоактивными материалами.

Детали приборов

Трубки для гайгеровских и пропорциональных счетчиков, фотоумножительные лампы, сцинтилляционные люминофоры и кристаллы, применяемые для обнаружения ядерных излучений.

Счетчик несовпадений для низких уровней

Демонстрация техники счета при низких уровнях.

Радиационный спектрометр и анализатор высоты импульсов

Демонстрация спектроскопии гамма-излучений, 100-канального анализатора высоты импульсов и автоматического спектрометра с одним скользящим каналом.

Медицинские приборы

Демонстрация автоматического сцинтилляционного развертывателя и специальных зондов для глаза и мозга на гайгеровских счетчиках.

8 БИОЛОГИЯ И МЕДИЦИНА

Биохимические исследования в связи с изучением стероидного метаболизма

Первые применения углерода-14 и трития для исследования стероидного синтеза и деградации в живом человеке. Представлен жидкостный сцинтилляционный спектрометр того типа, который применялся в этом исследовании.

Лечение захватом медленных нейтронов в случаях мозговых опухолей

Приемы и результаты лечения мозговых опухолей посредством бора-10 и тепловых нейтронов из реактора.

"Телетерапия" и "Брахи" терапия радиоактивными изотопами

Модели, показывающие различные возможности радиационной "телетерапии" с фиксированным и с поворотным лучом; новые методы терапии промежуточными облучениями и другие приемы "брахи" терапии.

Техника авторадиографии в патологии

Техника микроскопической и макроскопической авторадиографии с иллюстрацией результатов на подобранных авторадиоснимках.

Изучение токсичности излучений

Результат исследований влияния гамма-излучений и смешанных гамма-нейтронных излучений на животную и растительную жизнь.

Излучения и генетика растений

Роль излучений в генетике растений и в улучшении культур; методы получения благотворных мутаций и примеры мутаций.

Исследования влияния облучений

Примеры консервации пищепродуктов, разложения органических химикатов и стерилизации костей.

9 ПРИМЕНЕНИЯ РАДИОАКТИВНЫХ ИЗОТОПОВ

Демонстрация методов калибровки всасывания щитовидной железой.

Переносный рентгеновский прибор, работающий на тулии.

Демонстрация промышленного радиационного толщиномера.

Источники света, активированные изотопами, применяемые для знаков и меток.

Атомные батареи, иллюстрирующие три метода прямого преобразования излучений в электроэнергию.

Применение меток углеродом-14 в биосинтезе.

10 РЕДКИЕ ЗЕМЛИ И ТРАНСУРАНОВЫЕ ЭЛЕМЕНТЫ

Выделение и получение редких земель и трансурановых элементов.

КАМЕРА ВИЛЬСОНА (ОКОЛО ЗАЛЫ XV)

Камера Вильсона 4x8 футов действует непрерывно и показывает 500 траекторий космических лучей в любой момент времени.

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5

Chemical Processing

Traitement Chimique
Химическая обработка
Tratamiento Químico

Instrumentation

Appareillage
Измерительные приборы и аппаратура
Instrumentos

8

Radioisotope Applications

Applications des Isotopes Radioa
Применения радиоактивных изот
Aplicaciones de los Radioisótopos

This floor plan of Salle XV is keyed by numbers to the booklet descriptions. Certain information not contained in this booklet will be found on the descriptive plates near each display. Additional details may be found in the nearby Technical Library.

Ce plan de la Salle XV emploie la même numérotation que la brochure descriptive. On trouvera certaines informations supplémentant celles contennes dans la brochure dans les légendes descriptives placées auprès de chaque stand, et des informations détaillées dans la Bibliothèque Technique ci-près.

Этот план расположения залы XV сочленен номерами с описаниями в брошюре.

Некоторые сведения не имеющиеся в этой брошюре могут быть найдены в описаниях вблизи экспонатов. Добавочные сведения имеются в Технической Библиотеке.

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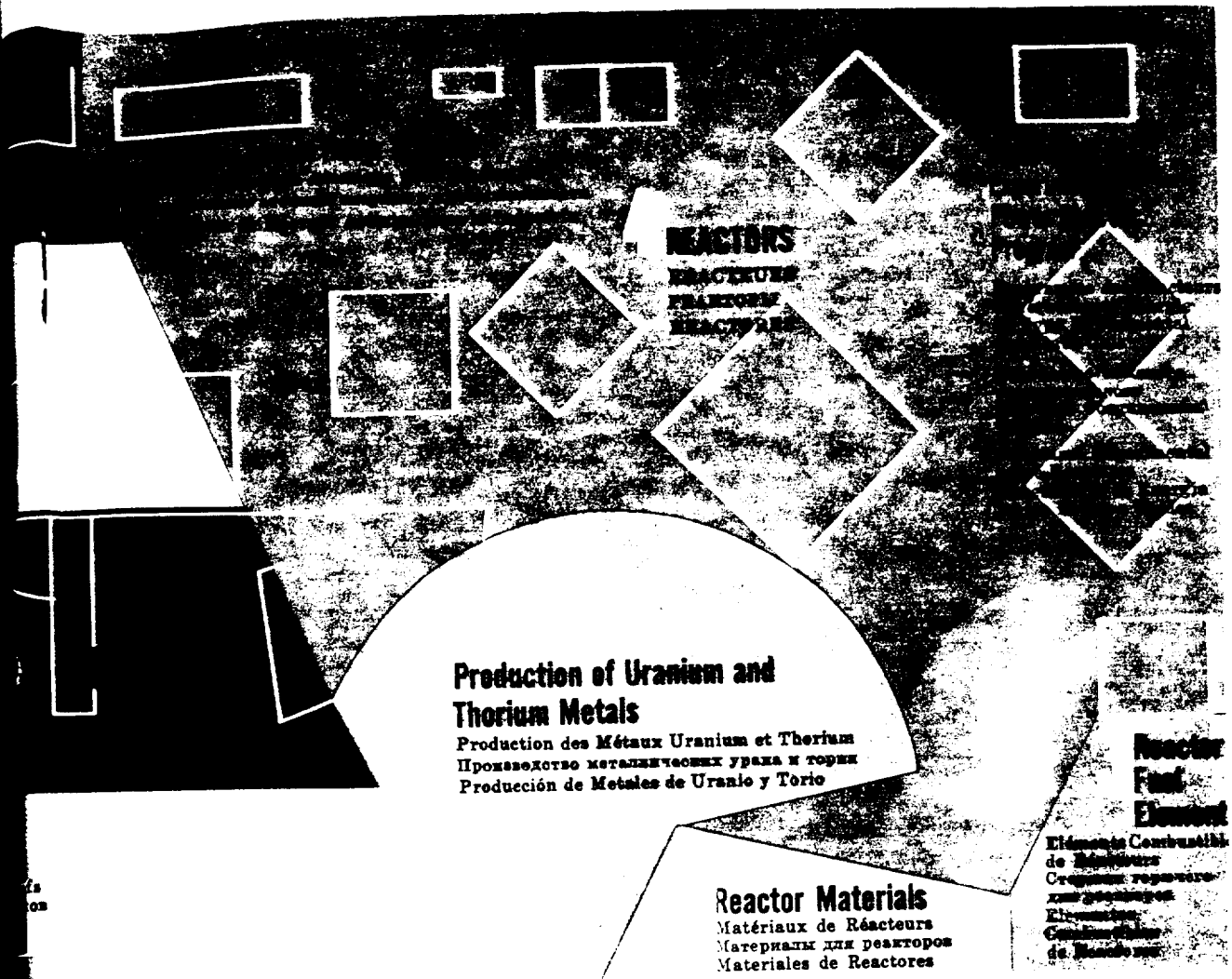

Este plano del piso de la Salle XV tiene la misma clave numérica usada en el folleto de descripciones. Cierta información que no está contenida en este folleto se encontrará en los carteles descriptivos cerca de cada cuadro de exhibición. Detalles adicionales pueden conseguirse en la Biblioteca Técnica contigua.

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Exhibiciones en la Salle XV

1 PRODUCCION DE METALES DE URANIO Y TORIO

Especímenes de minerales primarios y secundarios de uranio y de torio.

Pasos en el tratamiento de los minerales de uranio y torio, desde la mina hasta el estado de metal.

2 MATERIALES DEL REACTOR

Producción, fabricación y utilización de berilio y zirconio. Mejorando la resistencia a la corrosión del aluminio, a temperaturas elevadas, por medio de aleaciones con níckel.

Mejorando la estabilidad dimensional del uranio, en el ciclo térmico, mediante aleaciones con zirconio, niobio y cromio.

3 ELEMENTOS COMBUSTIBLES DEL REACTOR

Ejemplos de elementos combustibles desarrollados para los reactores experimentales de energía y de investigación.

4 REACTORES

Modelos e información sobre diversos reactores de energía y de investigación, actualmente en uso, en construcción o en proyecto en los Estados Unidos.

Programa de Reactores Experimentales de Energía de los Estados Unidos

Reactor de Agua a Presión de Shippingport
Reactor Experimental de Agua Hirviendo
Reactor Generador Experimental No. 2
Reactor Homogéneo Experimental No. 2
Reactor Experimental de Sodio

Reactor de Ensayo de Materiales

Reactor de Investigación de Argonne

Central de Energía de Reactor de Agua Hirviendo

Proyectos Industriales de Energía Atómica

Demostración del panel de control con simulador y mecanismo impulsador de la varilla de control.

5 COMPONENTES Y AUXILIARES DEL REACTOR

Demostración de la nueva soldadura de inserto consumible para los sistemas de circulación del reactor.

Bombas y válvulas del reactor, con el equipo típico para sistemas de alta y baja presión.

Protección del ambiente contra la radioactividad, incluyendo estudios del tiempo y las corrientes, limpieza del aire, incineración para concentrar los desechos consumibles, absorción de la radioactividad en arcilla, e investigación de la eliminación de la radioactividad de los sistemas de abastecimiento de agua y alcantarillados.

TRATAMIENTO QUIMICO

Modelo de la planta de tratamiento químico de Idaho.

Demostración del tratamiento del uranio mostrando las técnicas aplicables a la separación química de los materiales radioactivos. La demostración incluye el separar el uranio del cobre por extracción por solvente; la concentración del uranio por intercambio de iones; y la extracción de muestras y análisis a distancia de las soluciones de nitratos de uranio y de sodio, usando la celda analítica equipada con manipulador.

INSTRUMENTOS

Equipo Explorador

Ejemplos prácticos del uso aéreo de contadores de centelleo, instrumentos

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de registro para perforaciones, e instrumentos portátiles de exploración usados para localizar los depósitos de mineral de uranio.

Instrumentos Monitores de Radiación

Ejemplos de dosímetros, monitores de partículas en el aire, monitores de contaminación de manos y pies, e instrumentos portátiles para estudiar la radiación, usados para proteger a las personas que trabajan con materiales radioactivos.

Componentes de los Instrumentos

Tubos de contadores proporcionales y Geiger, tubos fotomultiplicadores, fosforescentes de centelleo y cristales usados como detectores de radiación nuclear.

Contador de Anticoincidencia de Bajo Nivel

Demostración de las técnicas de conteo de bajo nivel.

Analizadores de Pulsaciones y Espectrómetros de Radiación

Demostración de espectroscopia de radiación gamma, analizador de pulsaciones de 100 canales, y espectrómetro automático deslizante de un solo canal.

Instrumentos Médicos

Demostración de la sonda para ojos y cerebro, con contador Geiger especial, y explorador automático de centelleo.

8 BIOLOGIA Y MEDICINA

Investigación Bioquímica en Conexión con los Estudios de Metabolismo Esteroideo

Los primeros usos del carbono-14 y el tritio para los estudios *in vivo* de la síntesis esteroidea y su degradación en los sujetos humanos. Se incluye un espectrómetro para líquidos de centelleo del tipo usado para el estudio mencionado.

Terapia de Captura de Neutrones Lentos en el Tratamiento de Tumores en el Cerebro

Técnicas y resultados del tratamiento de tumores en el cerebro, usando boro-10 y neutrones térmicos producidos en el reactor.

Teleterapia y Braquiterapia con Radioisótopos

Modelos para demostrar las distintas posibilidades de la teleterapia de radiación, incluyendo los tipos de rayo fijo y rotatorio; así como los métodos nuevos de terapia de radiación intersticial, con otras técnicas de braquiterapia.

Técnicas de Autoradiografía en Patología

Técnicas de autoradiografía microscópica y corriente, junto con autoradiogramas seleccionados para mostrar los resultados.

Estudios de Toxicidad de la Radiación

Resultados de los estudios hechos sobre los efectos de la exposición de la vida animal y vegetal a radiaciones gamma o gamma mezclada con neutrones.

La radiación y la Genética de Plantas

La parte que juega la radiación en la genética de las plantas y en el mejoramiento de las cosechas, incluyendo los métodos usados para obtener mutaciones beneficiosas, y ejemplos de las mutaciones resultantes.

Estudios sobre los Efectos de la Radiación

Ejemplos de preservación de alimentos, deterioro de cuerpos químicos orgánicos, y esterilización de huesos.

9 APLICACIONES DE RADIOISOTOPOS

Demostración de los métodos para determinación de la absorción de la tiroides.

Unidad portátil de rayos X, de tulio. Demostración del calibrador industrial para medir espesores por medio de radiación.

Fuentes de luz activadas por isótopos —usadas para señales y marcadores.

Acumuladores atómicos — mostrando tres métodos para la conversión directa de radiación a energía eléctrica. Uso de indicadores de carbono-14 en la biosíntesis.

10 ELEMENTOS TRANSURANICOS Y METALES ALCALINOS RAROS

Separación y preparación de los metales alcalinos raros y los elementos transuránicos.

CAMARA DE NIEBLA (Cerca de la Salle XV)

Cámara de niebla de funcionamiento continuo, de cuatro por ocho pies, en la cual pueden verse 500 trayectorias de rayos cósmicos en cualquier momento dado.

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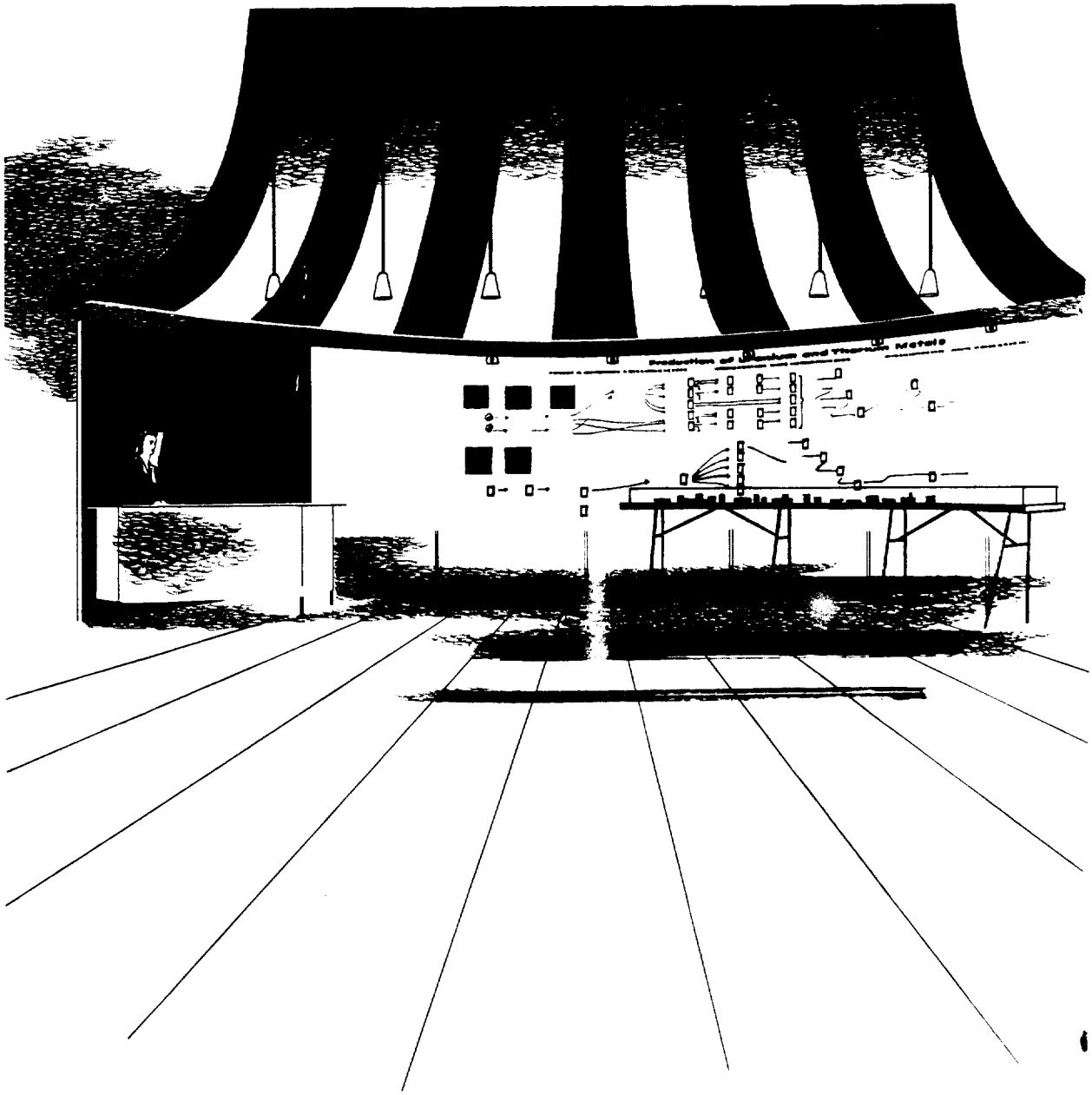

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U. S. Technical Library

The U. S. Technical Library exhibit is intended to show the types of scientific and technical information on atomic energy available in the United States. It includes representative examples of published accounts of both government and privately sponsored work. The U. S. Government policy of encouraging open publication of research results makes the conventional publications of the learned societies a basic reference tool in the United States for atomic energy information.

The Technical Library includes a depository collection similar to those which the United States is offering to other nations as part of its contribution to the "Atoms for Peace" program. These depository libraries, each including approximately 7,000 laboratory reports, some in full-size and some in microcopy form, provide the information that, coupled with published data and continually brought up to date, represents the total contribution of the United States to the scientific literature on atomic energy. Guides to the literature, journals of abstracts, and librarians' manuals are included to simplify reference.

Books sponsored by the U. S. Atomic Energy Commission form an important part of the depository collection. These include the National Nuclear Energy Series, textbooks, and training manuals, including several volumes completed within recent weeks.

The Technical Library exhibit also includes over 100 books on atomic energy subjects contributed by American publishers and a display of technical journals published in the United States.

Booklets, pamphlets and data sheets, prepared by private companies, which are exhibiting products, equipment and processes in Salle XV and the Reactor Building, are available in the Technical Library. For the convenience of Delegates and visitors, a card index of this material has been prepared.

Following the Conference, the depository collection will be presented to the United Nations Library in Geneva for its permanent collection.

The attendants at the Library exhibit, among whom are persons who speak the conference languages, are prepared to assist each visitor in finding the information and materials he desires.

Bibliothèque Technique des Etats-Unis

L'exposition de la Bibliothèque Technique des Etats-Unis a pour objet de mettre en lumière les divers renseignements d'ordre scientifique et technique sur l'energie atomique qu'il est possible d'obtenir aux Etats-Unis. Cette exposition comprend des exemplaires d'articles publiés sur les travaux effectués sous les auspices du Gouvernement et d'entreprises privées. La politique du Gouvernement des Etats-Unis qui consiste à encourager la publication des résultats des recherches, fait des publications émanant des sociétés savantes un instrument fondamental de référence pour l'obtention de renseignements sur l'énergie atomique.

La Bibliothèque Technique comprend une collection semblable à celle qu'offrent les Etats-Unis à d'autres pays dans le cadre de leur contribution au programme de "l'Atome au Service de la Paix." Ces bibliothèques, dont chacune comprend approximativement 7.000 rapports de laboratoire, les uns reproduits sur format normal, les autres sur microfilm, fournissent les renseignements qui, constamment tenus à jour et ajoutés aux données parues, représentent la contribution totale des Etats-Unis à la littérature scientifique sur l'énergie atomique. Ces bibliothèques comprennent également des répertoires d'ouvrages scientifiques, des recueils d'extraits et des manuels à l'usage des bibliothécaires en vue de simplifier l'obtention des ouvrages de référence.

Les ouvrages publiés sous le patronage de la Commission de l'Energie Atomique des Etats-Unis représentent une partie importante de la collection de référence. Ceux-ci comprennent des recueils et des manuels d'instruction de la "National Nuclear Energy Series" ainsi que des volumes complétés il y a quelques semaines.

L'exposition de la Bibliothèque Technique renferme également plus de 100 ouvrages présentés par des éditeurs américains et une collection de journaux techniques publiés aux Etats-Unis.

Les notices descriptives, brochures et feuilles de renseignements préparées par les sociétés privées qui exposent des produits, du matériel d'équipement et des procédés dans la Salle XV et dans le Bâtiment du Réacteur peuvent être obtenus à la Bibliothèque Technique. Un fichier indiquant les produits, le matériel et les procédés exposés a été préparé à l'intention des Délégués et des visiteurs.

Après la Conférence, la collection d'ouvrages sera présentée à la Bibliothèque des Nations Unies à Genève pour sa collection permanente.

Les membres du personnel attaché à l'exposition de la bibliothèque, dont certains parlent les langues employées à la Conférence, sont à la disposition des visiteurs pour les aider à obtenir les renseignements qu'ils pourraient désirer.

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Техническая Библиотека США

Экспонирование Технической библиотеки США имеет целью показать типы научно-технической информации по атомной энергии, имеющейся в США. В библиотеке имеются типичные образцы опубликованных отчетов о работах как по государственным, так и по частным заказам. Политика поощрения опубликования результатов исследований, проводимая Правительством США, делает издания ученых обществ основным справочным инструментом в США для информации об атомной энергии.

В Техническую библиотеку входит "дополняемая библиотека", сходная с теми, которые США предлагают другим странам как часть своего вклада в программу "Атомы для дела мира". Такая постоянно подновляемая библиотека, состоящая приблизительно из 7000 лабораторных отчетов (из них некоторые в виде микрокопий), дает информацию, которая в сочетании с опубликованными данными, представляет полный вклад США в научную литературу по атомной энергии. Чтобы упростить наведение справок, приложены указатели литературы, аннотационные журналы и пособия для библиотекарей.

Книги, изданные при поддержке Комиссии по атомной энергии США, составляют важную часть дополняемой библиотеки. Сюда входят "Выпуски по ядерной энергии" (National Nuclear Energy Series) и учебные руководства и пособия; из них некоторые закончены в течение последних недель.

В экспонаты Технической библиотеки входит также свыше 100 книг по вопросам атомной энергии, предоставленных американскими издательствами, и ряд технических журналов, издаваемых в США.

В Технической библиотеке можно также получить книжки, брошюры и спецификации, изданные теми частными фирмами, которые экспонируют свою продукцию, аппаратуру и процессы в Зале XV и в здании реактора. Для удобства делегатов и посетителей приготовлена указательная картотека по этим материалам.

После Конференции дополняемая библиотека будет передана в постоянную коллекцию Библиотеки Объединенных наций в Женеве.

Дежурные по библиотечным экспонатам, среди которых имеются лица говорящие на языках Конференции, готовы помочь каждому посетителю найти нужные ему сведения и материалы.

Biblioteca Técnica de los Estados Unidos

La exhibición de la Biblioteca Técnica de los Estados Unidos tiene como propósito mostrar los tipos de información técnica y científica que sobre energía atómica se tienen en los Estados Unidos. En ella se incluyen ejemplos representativos de los trabajos patrocinados tanto por el gobierno como por las compañías privadas. Gracias a la política del Gobierno de los Estados Unidos, que siempre favorece la publicación de los resultados de los estudios hechos, las publicaciones de las sociedades doctas constituyen un medio básico de referencia sobre información nacional relacionada con la energía atómica.

La Biblioteca Técnica incluye una colección similar a la ofrecida por los Estados Unidos a otros gobiernos como parte de su contribución al programa de Usos Pacíficos de la Energía Atómica. Estas colecciones, que incluyen cada una aproximadamente 7,000 informes de laboratorio (algunos en tamaño natural, otros en microcopias), suministran la información que, junto con los datos publicados y continuamente revisados, representan la contribución total de los Estados Unidos a las publicaciones científicas sobre la energía atómica. Para facilitar su uso se incluyen guías, manuales de bibliotecario, y revistas de artículos condensados.

Los libros patrocinados por la Comisión de la Energía Atómica de los Estados Unidos forman una parte importante de esta colección. Estos incluyen la Serie Nacional de Energía Nuclear, así como libros de texto y manuales de entrenamiento, entre los cuales hay varios volúmenes terminados hace unas pocas semanas.

La Biblioteca Técnica incluye también más de 100 libros sobre temas de la energía atómica que han sido donados por los publicistas americanos, y una variedad de revistas técnicas publicadas en los Estados Unidos.

En la Biblioteca Técnica se tienen disponibles varios folletos, informes y hojas de datos, preparados por las compañías privadas que exhiben sus productos, equipos o tratamientos en la Salle XV y en el edificio del Reactor. Se ha preparado índice en tarjetas de este material, para la conveniencia de los Delegados y los visitantes.

Al terminar la Conferencia, se obsequiará la colección depositaria a la Biblioteca de las Naciones Unidas en Ginebra, para añadirla a su colección permanente.

Los ayudantes presentes en la exhibición de la biblioteca (entre los cuales hay personas que hablan los idomas usados en la Conferencia) están preparados para ayudar a los visitantes a encontrar la información y los materiales que deseen.

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Films

Technical films on various peaceful aspects of atomic energy will be shown by the United States during the Conference. A list of the films that will be available, and a description of each, follows:

NUCLEAR REACTORS FOR RESEARCH. Explains the basic design of a small homogeneous "water boiler" reactor-type and describes components and various construction steps. Operation of the reactor is described and various research uses are illustrated.

CONSTRUCTION OF THE ARGONNE RESEARCH REACTOR. Shows some of the important stages in the construction and illustrates many design features of the Argonne Research Reactor.

DEVELOPING HOMOGENEOUS REACTORS. Depicts some of the most important stages in the development, construction, operation and dismantling of a homogeneous reactor designed to operate at 1,000 kilowatts.

SODIUM GRAPHITE REACTOR PROGRESS REPORT. Shows a number of experiments devoted to the development of the Sodium Reactor Experiment, with special emphasis on the fuel element. A number of sequences of the testing of components are shown.

SAFETY EXPERIMENTS ON A BOILING REACTOR. Records a series of safety experiments with a prototype boiling water reactor, consisting of a pressure vessel containing an assembly of uranium-bearing plates submerged in water, plus a control mechanism.

THE RADIOISOTOPE IN GENERAL SCIENCE. Shows the use of radioisotopes in a variety of scientific experiments, illustrating uses in different fields of scientific research and development, including metallurgy, chemistry, biochemistry, and plant physiology.

RADIOISOTOPES—THEIR APPLICATIONS TO HUMANS FOR TRACER STUDIES AND THERAPEUTIC USE. Illustrates diagnostic and therapeutic medical work with radioisotopes. The application of these techniques in a variety of medical situations is depicted.

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Films

Des films techniques relatifs à divers usages pacifiques de l'énergie atomique seront montrés par les Etats-Unis au cours de la Conférence. La liste et la description de ces films suivent:

NUCLEAR REACTORS FOR RESEARCH *(Réacteurs nucléaires à Recherches scientifiques)*. Ce film explique le plan fondamental d'un petit réacteur du type à "eau bouillante" et décrit ses éléments constitutifs et diverses opérations dans la gamme des travaux de construction. Le fonctionnement du réacteur est également décrit et différentes utilisations à des fins de recherche sont démontrées par des exemples.

CONSTRUCTION OF THE ARGONNE RESEARCH REACTOR *(Construction du Réacteur à Recherches scientifiques d'Argonne)*. Ce film montre certaines des opérations importantes effectuées au cours des travaux de construction et met en lumière maintes caractéristiques de la structure du Réacteur à Recherches scientifiques d'Argonne.

DEVELOPING HOMOGENEOUS REACTORS *(Création de Réacteurs homogènes)*. Ce film décrit quelques-unes des opérations les plus importantes dans la conception, la construction, le fonctionnement et le démontage d'un réacteur homogène, dont le fonctionnement est prévu pour un régime de 1000 kilowatts.

SODIUM GRAPHITE REACTOR PROGRESS REPORT *(Compte rendu des progrès réalisés dans la mise au point du Réacteur au sodium graphite)*. Ce film présente un certain nombre d'expériences consacrées à la mise au point du Réacteur expérimental au sodium mettant en relief l'élément combustible. Un certain nombre de scènes décrivant l'essai d'éléments constitutifs sont projetées.

SAFETY EXPERIMENTS ON A BOILING REACTOR *(Expériences de Sécurité effectuées sur un Réacteur bouillant)*. Ce film présente une série d'expériences pratiquées sur un prototype de réacteur à eau bouillante, composé d'un vase à pression contenant un ensemble de plaques à teneur d'uranium immergées dans de l'eau et d'un mécanisme de commande.

THE RADIO-ISOTOPE IN GENERAL SCIENCE *(Le Radio-isotope dans les domaines de la Science)*. Ce film décrit l'usage qui est fait de radio-isotopes au cours d'expériences scientifiques, mettant en lumière leur utilisation dans différents domaines de recherche et de développement scientifiques comprenant la métallurgie, la chimie, la biochimie et la phyto-physiologie.

RADIO-ISOTOPES—THEIR APPLICATIONS TO HUMANS FOR TRACER STUDIES AND THERAPEUTIC USE. *(Les radio-isotopes—Leur utilisation en thérapeutique et pour effecteur des études par la méthode des éléments marqués)*. Ce film montre l'emploi qui est fait des radio-isotopes en médecine pour l'identification et le traitement des maladies. Il décrit les méthodes employées dans diverses situations médicales.

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ФИЛЬМЫ

Во время работ Конференции, США покажут технические фильмы о различных мирных сторонах атомной энергии. Ниже дан перечень фильмов и содержание каждого из них:

ЯДЕРНЫЕ РЕАКТОРЫ ДЛЯ ИССЛЕДОВАНИЙ. Разъясняются основы конструкции малого гомогенного реактора-парокотла и описываются детали и различные ступени его постройки. Описывается действие реактора и иллюстрируются различные исследовательские его применения.

ПОСТРОЙКА АРГОННСКОГО ИССЛЕДОВАТЕЛЬСКОГО РЕАКТОРА. Показываются некоторые важные стадии постройки и иллюстрируются многие конструктивные черты Аргоннского исследовательского реактора.

РАЗРАБОТКА ГОМОГЕННЫХ РЕАКТОРОВ. Обрисованы некоторые наиболее важные стадии разработки, постройки, работы и демонтажа гомогенного реактора, рассчитанного на эксплуатацию при 1000 квт.

ДОКЛАД ОБ УСПЕХАХ НАТРО-ГРАФИТОВОГО РЕАКТОРА. Показывается несколько опытов, посвященных разработке опытного натриевого реактора, в особенности его топливного элемента. Показано несколько серий испытаний деталей.

ОПЫТЫ ПО БЕЗОПАСНОСТИ РЕАКТОРА-ПАРОКОТЛА. Отмечается серия опытов по безопасности реактора-парокотла (прототипа), состоящего из камеры давления, в которой имеется комплект ураносодержащих пластин, погруженных в воду, плюс механизм управления.

РАДИОАКТИВНЫЙ ИЗОТОП В ОБЩЕЙ НАУКЕ. Показывается применение радиоизотопов в разнообразных научных экспериментах; иллюстрируется их использование в различных областях научных исследований и разработок, включая металлургию, химию, биохимию и физиологию растений.

РАДИОАКТИВНЫЕ ИЗОТОПЫ, ИХ ПРИМЕНЕНИЯ К ЧЕЛОВЕКУ ДЛЯ ИССЛЕДОВАНИЙ С МЕЧЕНЫМИ ЭЛЕМЕНТАМИ И ДЛЯ ТЕРАПЕВТИЧЕСКИХ ЦЕЛЕЙ. Иллюстрируется диагностическая и терапевтическая медицинская работа с радиоизотопами. Обрисовываются применения этих методов в различных медицинских ситуациях.

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Películas

Durante la Conferencia, los Estados Unidos exhibirán películas técnicas sobre varios usos pacíficos de la energía atómica. A continuación damos una lista de las películas, con una descripción breve de cada una:

REACTORES NUCLEARES PARA INVESTIGACION. Explica el diseño básico de un reactor pequeño, homogéneo, del tipo de "caldera de agua," y describe sus componentes y los detalles de su construcción. Se describe el funcionamiento del reactor y los usos que pueden dársele en trabajos de investigación.

CONSTRUCCION DEL REACTOR DE INVESTIGACION DE ARGONNE. Muestra varios pasos importantes de la construcción, e ilustra numerosos detalles de diseño del reactor de investigación en Argonne.

DESARROLLO DE LOS REACTORES HOMOGENEOS. Incluye varios de los capítulos más importantes en el desarrollo, construcción, operación y desmontaje de un reactor homogéneo, diseñado para trabajar a 1000 kilovatios.

INFORME DEL ADELANTO DEL REACTOR DE SODIO GRAFITO. Muestra varios experimentos dedicados al perfeccionamiento del reactor experimental de sodio, poniendo énfais especial en el elemento combustible. Se ven varias escenas sobre el ensayo de los componentes.

ENSAYOS DE SEGURIDAD EN UN REACTOR DE AGUA HIRVIENDO. Enseña una serie de ensayos de seguridad en un reactor típico de agua hirviendo, que consiste en una vasija a presión en la que se tiene un conjunto de placas con uranio sumergidas en el agua, más un mecanismo de control.

LOS RADIOISOTOPOS EN LA CIENCIA EN GENERAL. Muestra el uso de los radioisótopos en una gran variedad de experimentos científicos, ilustrando sus aplicaciones en numerosos campos de la investigación científica, incluyendo la metalurgia, la química, la bioquímica y la fisiología de las plantas.

RADIOISOTOPOS—SUS APLICACIONES EN EL HOMBRE PARA LOS ESTUDIOS CON INDICADORES Y EN TERAPEUTICA. Muestra trabajos terapéuticos y de diagnosis con radioisótopos. Se enseña la aplicación de estas técnicas en una gran cantidad de casos médicos.

1035614

H. W. Leighton Laboratories, Hatboro, Pennsylvania
Lindsay Chemical Company, West Chicago, Illinois
Litton Industries, Beverley Hills, California
Los Alamos Scientific Laboratory, Los Alamos, New Mexico
Massachusetts Institute of Technology, Cambridge, Massachusetts
Master Electric Company, Dayton, Ohio
McGraw-Hill Book Co., Inc., New York, New York
Michigan State College, East Lansing, Michigan
Minneapolis-Honeywell Regulator Co., Philadelphia, Pennsylvania
National Bureau of Standards, United States Department of Commerce
National Radiac, Inc., Newark, New Jersey
New England Deaconess Hospital, Boston, Massachusetts
New York University, New York, New York
Norden-Ketay Corporation, New York, New York
North American Aviation, Inc., Downey, California
Nuclear Instrument and Chemical Corporation, Chicago, Illinois
Nuclear Metals Inc., Cambridge, Massachusetts
Nuclear Power Group, Chicago, Illinois
Nuclear Research Corporation, Philadelphia, Pennsylvania
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