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Pu-238 PRODUCTION AT THE SAVANNAH RIVER PLANT

by

Paul L. Roggenkamp
E. I. du Pont de Nemours and Company
Savannah River Laboratory
Aiken, SC 29808

SRL
RECORD COPY

A summary of a paper proposed for presentation at the
ANS 1987 Winter Meeting
Los Angeles, CA
November 15-19, 1987

and for publication in the transactions

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PRODUCTION OF Pu-238 AT THE SAVANNAH RIVER PLANT

Paul L. Roggenkamp, Senior Consultant
E. I. du Pont de Nemours and Company, Inc.

Capability exists at the Savannah River Plant (SRP) of the Department of Energy to produce about 50 kg of Pu-238 annually for use as the source of heat for radioisotope powered electric generators. The factor that limits the Pu-238 production is the availability of Np-237 which is the target nuclide in which neutrons are captured to produce Pu-238 by the subsequent decay of the Np-238 neutron capture product. Capacities of processing facilities at SRP match the 50 kg/yr with varying margins up to 50 percent.

Pu-238 is being considered as the heat source for electric power generation for the Boost Surveillance and Tracking System for the Strategic Defense Initiative. The Pu-238 heat source would be coupled with a dynamic energy conversion system.

The SRP reactors are ideal reactors for isotope production. The heavy water moderator provides excellent neutron economy. Reactor fuel is highly enriched uranium contained in tubular elements which are separate from the target elements whether the product be Pu-238, Pu-239, tritium or other nuclide species. The use of fuel and target elements that are separate generally simplifies the isotope recovery process. Over the years a great variety of isotopes have been produced.

For the production of Pu-238, the target nuclide is Np-237. To manufacture the neptunium targets, NpO_2 powder is compacted with aluminum powder to form a billet core which is assembled with aluminum components into a composite billet. The composite billet is extruded into a target tube having the NpO_2 -Al cermet core and aluminum cladding. The target tube is irradiated in the production reactor lattice where it displaces one of the depleted uranium target assemblies used for Pu-239 production. Up to one-fourth of the depleted uranium target assemblies may be replaced at any one time. During irradiation to produce specification plutonium at about 83% Pu-238, about 25% of the Np-237 is transmuted by neutron capture with about 16% remaining as Pu-238. The 9% difference is in higher mass plutonium isotopes and fission products.

The Pu-238 product is recovered from the Np-237 targets chemically (Ref. 1). After cooling, the targets are dissolved in nitric acid in a special section of the chemical reprocessing canyon. The plutonium, neptunium, and fission products and aluminum are partitioned by ion exchange techniques. In a facility with manipulator handling capability, the plutonium and neptunium nitrates are converted to oxides. The neptunium is recycled to target assemblies and the plutonium is sent to the heat source fabrication facility where it is formed into spheres each containing a nominal 112 grams of Pu-238, the spheres are then enclosed within an iridium shell.

The Np-237 feed material is produced gratuitously in the course of making the Pu-239 and tritium major products of SRP. The primary source of Np-237 is the enriched uranium fuel which is recycled for economic reasons. About 16% of neutron absorptions in U-235 result in the formation of U-236, which upon uranium recycle accompanies the U-235 back into the reactor. The U-237 that results from neutron capture in U-236 decays to Np-237. A secondary source results from an (n,2n) reaction on the U-238 target material for Pu-239 production. The Np-237 is recovered during reprocessing of both the enriched uranium fuel and the depleted uranium targets.

The current inventory of Np-237 is about 400 kg, which with the annual production rate of Np-237 of about 80 kg, will sustain an annual Pu-238 production rate of about 50 kg. The unit cost of the Pu-238 is about \$1200 per gram for manufacture and about \$400 per gram for heat source fabrication exclusive of the cost of the iridium shell material.

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1. G. A. Burney, Pu-238 Processing at Savannah River Plant, ANS Transactions 45, 247 (1983).

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E. I. DU PONT DE NEMOURS & COMPANY
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AIKEN, SOUTH CAROLINA 29808-0001

(TWX: 810-771-2670, TEL: 803-725-6211, WU: AUGUSTA, GA.)

June 2, 1987

Mr. M. R. Grant, Tech Program Chairman
Attn: Transactions Office
American Nuclear Society
555 North Kensington Avenue
La Grange Park, IL 60525

Dear Mr. Grant:

Four copies of the summary of the paper "Pu-238 Production at the Savannah River Plant" (DP-MS-87-54X) by P. L. Roggenkamp are enclosed. This is an invited paper for the ANS 1987 Winter Meeting in Los Angeles in November. The Summary Cover and Filing and Mailing Information Sheets (pages 2 and 3) are also enclosed.

If we can be of further assistance, please let me know.

Very truly yours,

A handwritten signature in cursive script, appearing to read "L. W. Ice".

L. W. Ice
Publications Division

LWI:tww

Enclosures

BCC: P. L. Roggenkamp, 773-41A
T. C. Sutherland, 773-A

SRL File: (DP-MS-87-54X), 773-A ←

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June 12, 1987

Ms. Joann Hollensteiner
ANS Transactions Coordinator
American Nuclear Society
555 North Kensington Avenue
La Grange Park, IL 60525

Dear Ms. Hollensteiner:

Attached are the original and three copies of a revised version of the Summary, Pu-238 Production at the Savannah River Plant (DP-MS-87-54X, revised) by P. L. Roggenkamp, your Log #27. Please replace the initial version of the summary with the revised version.

If we can be of further assistance, please let me know.

Yours very truly,

L. W. Ice
Publications Division

LWI:tww

Enclosures

BCC: P. L. Roggenkamp, 773-41A
T. C. Sutherland, 773-A
SRL File: (DP-MS-87-54X), 773-A ←

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TYPE OF PUBLICATION (Check one)
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AUTHOR(S) Paul L. Roggenkamp

TITLE Pu-238 Production at the Savannah River Plant

DIVISION Operational Planning

MANUSCRIPT APPROVAL

Route in turn to

	Initials	Date	Initials	Date
1. AUTHOR	<u>DLR</u>	<u>4/30/87</u>		
2. SUPERVISOR	<u>-</u>	<u>-</u>		
3. DIVISION HEAD/DEPARTMENT SUPERINTENDENT	<u>DLR</u>	<u>4/30/87</u>		
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Circle one for each

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ABSTRACT S C

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SR-1C-50

Topic 292-11

PATENT CONSIDERATIONS

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CC:

- W. F. Perrin, DOE-SR (2)
- M. F. Sujka, 703-A
- J. F. Ortaldo, 703-A
- L. W. Ice, 703-43A
- J. M. Boswell-P. L. Roggenkamp, 773-41A
- File (DP-MS-87-54X)

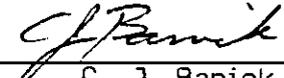
May 6, 1987

Mr. J. R. Powell, Technical Information Officer
U. S. Department of Energy
Savannah River Operations Office
Aiken, SC 29801

Dear Mr. Powell:

REQUEST FOR APPROVAL TO RELEASE SCIENTIFIC/TECHNICAL INFORMATION

The attached document is submitted for your approval for external release. Please complete Part II of this letter and return the letter to the undersigned, by: ASAP 6/19/87 Patent clearance is requested and received via direct communication between DOE Patent Counsel and AED Patent Reviewer. The document has ~~not~~ been reviewed for classification and UCNI. The document is ~~classified~~/unclassified and contains no UCNI. (Strike words that do not apply.)


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I. DETAILS OF REQUEST FOR RELEASE

DP-MS-87-54X, "PU-238 PRODUCTION AT THE SAVANNAH RIVER PLANT", By P. L. Roggenkamp

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Technical questions pertaining to the contents of this document should be addressed to the author(s) or

P. L. Roggenkamp, Senior Consultant
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_____, Date _____
J. R. Powell, Technical Information Officer, DOE-SR

May 6, 1987

TO: J. F. SABINO

FROM: C. J. BANICK *CJB*

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Document(s): DP-MS-87-54X

Title(s): "PU-238 PRODUCTION AT THE SAVANNAH RIVER PLANT"

Author(s): P. L. Roggenkamp

Contractual Origin: DE-AC09-76SR00001

Present Classification: Unclassified Paper

References:

No items were noted that, in my opinion, should be called to the attention of the DOE for patent consideration.



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J. R. Powell, Technical Information Officer, DOE-SR, Date 5/27/87

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TITLE

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AUTHOR(S)

P. L. Roggenkamp

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Authority for Classification Determination SR-1C-50, Topic 292.11
GUIDE NO. AND TOPIC NO.(S)

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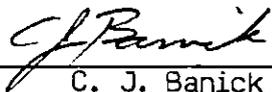
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P. L. Roggenkamp, 773-41A
File: (DP-MS-87-54)



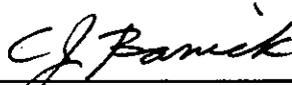
September 30, 1987

Mr. J. R. Powell, Technical Information Officer
U. S. Department of Energy
Savannah River Operations Office
Aiken, SC 29801

Dear Mr. Powell:

REQUEST FOR APPROVAL TO RELEASE SCIENTIFIC/TECHNICAL INFORMATION

The attached document is submitted for approval for external release. Please complete Part II of this letter and return the letter to the undersigned, by: 10/14/87 Patent clearance is requested and received via direct communication between DOE Patent Counsel and AED Patent Reviewer. The document has ~~not~~ been reviewed for classification and UCNI. The document is ~~classified~~ unclassified and contains no UCNI. (Strike words that do not apply.)



C. J. Banick AED Classification Officer

I. DETAILS OF REQUEST FOR RELEASE

DP-MS-87-54, "PU-238 PRODUCTION AT THE SAVANNAH RIVER PLANT", By P. L. Roggenkamp.

A paper proposed for presentation at the ANS 1987 Winter Meeting in Los Angeles, CA., on November 15-19, 1987.

Technical questions pertaining to the contents of the document should be addressed to the author(s) or

P. L. Roggenkamp, Senior Consultant
Operational Planning
Savannah River Laboratory

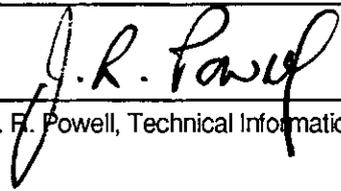
Questions concerning processing of this document should be addressed to the AED Classification Officer & Patent Reviewer at Extension 5-2606.

II. DOE-SR ACTION

DATE RECEIVED BY TIO 10-5-87

Approved as written
 Remarks

Not approved as written, revise and resubmit to DOE
 Approved upon completion of changes marked on document



J. R. Powell, Technical Information Officer, DOE-SR

Date 10/14/87

SAVANNAH RIVER DOCUMENT APPROVAL SHEET

(See SRP Procedures Manual Item 101)

Document Number DP-MS-8754
UC or C Number _____

1. DESCRIPTION OF DOCUMENT (to be completed by author)

TITLE Pu-238 Production at the Savannah River Plant

AUTHOR(S) Paul L. Roggenkamp PHONE NO. 5-5320

TYPE: INTERNAL DOCUMENT EXTERNAL DOCUMENT
 DP Report
 Paper (see below)
 Other _____

Additional Information for External Papers

PAPER FOR: Presentation Only * Publication Only _____ Both _____

MEETING NAME ANS Winter Meeting

CITY Los Angeles, CA DATES Nov. 15-19, 1987

CHAIRMAN & ADDRESS Norbert R. Grant, ANS, 555 N. Kensington Ave., LaGrange Park, IL 60525

JOURNAL NAME ---

DEADLINES FOR PUBLICATION: Abstract (already accepted) No. of Copies _____
Paper Nov. 13, 1987 No. of Copies 25

I understand that for the information in this paper for external distribution: *Copies are to be available at
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B. Distribution verbally, or by publication, must be in accordance with policies set forth in DOE-SR orders.
C. Content of the external distribution must be limited to that actually approved by DOE-SR.

AUTHOR'S SIGNATURE Paul L Roggenkamp

2. APPROVAL BY AUTHOR'S ORGANIZATION (required for all technical documents)

SRP/SRL ORGANIZATION AED Planning

DERIVATIVE CLASSIFIER P.L. Roggenkamp

Classification Unclassified Topic _____

DISTRIBUTION _____ Limit to List Attached. Reason: _____
_____ Limit to SRP & SRL. Reason: _____
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_____ Site-Specific Procedure Data Sheet, TA, etc.
_____ Unlimited To General Public

APPROVED BY RESEARCH MANAGER/SUPERINTENDENT P L Roggenkamp DATE 9/29/87

3. CLASSIFICATION & PATENT INFORMATION (to be completed by Patent & Classification Reviewer)

CLASSIFICATION (circle one for each)
Overall S C UCNI
Abstract S C UCNI
Title S C UCNI
Cover Letter S C UCNI

CLASSIFICATION GUIDE TOPICS
SR-1C-50
Topic 292.11.1
292.12.5

PATENT CONSIDERATIONS
Possible Novel Features _____
Closest Prior Art _____

APPROVED BY AED PATENT & CLASSIFICATION OFFICER C J Parikh DATE 9/30/87

4. PUBLICATIONS DIVISION PROCESSING

DATE RECEIVED _____ PUBLICATIONS SUPERVISOR _____

EDITOR _____ DATE ASSIGNED _____

DATE COPIES SUBMITTED FOR RELEASE _____

DOE-SR RELEASE DATES: Patent Branch _____ Tech. Info. Office _____

DATE COMPLETED _____ DATE SUBMITTED TO OSTI _____

SAVANNAH RIVER
PUBLICATION APPROVAL SHEET
SHADED AREAS FOR PUBLICATIONS DIVISION USE ONLY

DOCUMENT NO. DP-MS-87-54
TYPE OF PUBLICATION (Check one)
DP REPORT PAPER

DP CATEGORY _____

AUTHOR(S) Paul L. Roggenkamp 773-41A

TITLE Pu-238 Production at the Savannah River Plant

DIVISION Operational Planning

MANUSCRIPT APPROVAL

Route in turn to	Initials	Date	Initials	Date
1. AUTHOR	<u>DLR</u>	<u>9/25</u>	_____	_____
2. SUPERVISOR	_____	_____	_____	_____
3. DIVISION HEAD/DEPARTMENT SUPERINTENDENT	<u>DLR</u>	<u>9/25</u>	_____	_____
4. PD EDITOR	<u>lwi</u>	<u>9-29</u>	_____	_____
5. PUBLICATIONS REVIEWER	_____	_____	_____	_____

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CLASSIFICATION
Circle one for each

OVERALL S C U

ABSTRACT S C U

TITLE S C U

TRANSMITTAL LETTER S C U

APPROVAL: CJB 9/28/87
Division Head/ PD
Department Superintendent

CLASSIFICATION GUIDE TOPICS

SRAC-50

292.11.1

292.12.5

PATENT CONSIDERATIONS

POSSIBLE NOVEL FEATURES None

CLOSEST PRIOR ART _____

APPROVAL: CJB 9/28/87
Author PD

BUDGET SUBCODE

of Work Described 8333 - 2L

FILL IN FOR PAPERS ONLY

PAPER FOR: PRESENTATION ONLY PUBLICATION ONLY PRESENTATION AND PUBLICATION

JOURNAL None, but copies of paper will be available.

MEETING ANS Winter Meeting
Give complete official title and attach copy of instructions to contributors.

CITY Los Angeles, CA DATES November 15 - 19, 1987

DEADLINE FOR SUBMISSION November 13, 1987 CHAIRMAN Norbert R. Grant

ABSTRACT _____ NO. COPIES _____ ADDRESS Amer. Nucl. Soc.

Summary - completed; paper accepted. 555 N. Kensington Ave.

PAPER _____ NO. COPIES _____ LaGrange Park, IL 60525

FOR ORAL PRESENTATION, THE AUTHOR MUST SIGN THE FOLLOWING STATEMENT AFTER THE CLASSIFICATION REVIEW IS COMPLETE:

I UNDERSTAND THE SIGNIFICANCE OF, AND THE LIMITATIONS IMPOSED BY, THE PERTINENT SROO CLASSIFICATION GUIDE TOPICS COVERING CLASSIFIED INFORMATION RELATED TO THE SUBJECT OF THIS PAPER. THE PERTINENT TOPICS INCLUDE: _____

Author

cc: W.F. Perrin, DOE-SR(2)
M. F. Sijka, SRP 703-A
J. F. Ortaldo 703-A
L. W. Ice 703-43A
P. L. Roggenkamp, SR 773-41A
File (DP-MS-87-54)

~~To Ortaldo~~
To Powell:

P. L. Roggenkamp, Senior Consultant
Operational Planning
Sandia Laboratory

OSR 14 357 is on the way

no others needed



E. I. DU PONT DE NEMOURS & COMPANY
INCORPORATED

ATOMIC ENERGY DIVISION

SAVANNAH RIVER PLANT
AIKEN, SOUTH CAROLINA 29808-0001
(TWX: 810-771-2670, TEL: 803-725-6211, WU: AUGUSTA, GA.)

July 20, 1987

Mr. A. F. Westerdahl, Chief
Patent Branch
U. S. Department of Energy
Aiken, South Carolina 29808

Dear Mr. Westerdahl:

REQUEST FOR PATENT REVIEW

Please review for patent matters:

DP-MS-87-54, "AGENCY UPDATE", By B. J. Eberhard.

A paper proposed for publication only from the IMOG Joining Committee Meeting held at Rocky Flats on March 10-12, 1987.

Please telephone your comments to the Records Management Office (Ext. 52606) and notify me by signing and returning to C. J. Banick the original of this letter. A copy is provided for your file.

If you decide to pursue a patent on any development covered, I shall be happy to supply additional information required such as appropriate reference and the names of persons responsible for the development.

Very truly yours,

C. J. Banick,
AED Patent Reviewer

The above item is approved for release

A. F. Westerdahl
Chief Patent Branch
DOE-SR

7/27/87
Date

SAVANNAH RIVER
PUBLICATION APPROVAL SHEET
SHADED AREAS FOR PUBLICATIONS DIVISION USE ONLY

DOCUMENT NO. DP-MS-86-54

TYPE OF PUBLICATION (Check one)

DP REPORT

- PAPER

DP CATEGORY _____

AUTHOR(S) B. J. EBERNARD

TITLE AGENCY UPDATE

DIVISION EED

MANUSCRIPT APPROVAL

Routes in turn to

	Initials	Date	Initials	Date
1. AUTHOR	*			
2. SUPERVISOR	*			
3. DIVISION HEAD/DEPARTMENT SUPERINTENDENT	*			
4. PD EDITOR				
5. PUBLICATIONS REVIEWER				
6. AUTHOR				
7. DIVISION HEAD/DEPARTMENT SUPERINTENDENT	*			
8. SECTION DIRECTOR/ GENERAL SUPERINTENDENT	*			
9. PD				

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* SEE ATTACHED OSR 14-300

CLASSIFICATION

Circle one for each

OVERALL	S	C	<u>U</u>
ABSTRACT	S	C	<u>U</u>
TITLE	S	C	<u>U</u>
TRANSMITTAL LETTER	S	C	U

APPROVAL: GJB 4/15/87
Division Head/ Department Superintendent PD

CLASSIFICATION GUIDE TOPICS

CG-DARY
Topic 1.1

PATENT CONSIDERATIONS

POSSIBLE NOVEL FEATURES NA

CLOSEST PRIOR ART _____

APPROVAL: _____

Author

PD

GJB 4/15/87

BUDGET SUBCODE

of Work Described _____

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JOURNAL * See attached

MEETING (encircled in red)

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DATES _____

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CHAIRMAN _____

ABSTRACT _____ NO. COPIES _____

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Author

REVIEW - APPROVAL ROUTING FOR TECHNICAL PAPER DRAFT

REFERENCE: SRP PROCEDURES MANUAL, PROCEDURE 513
WORKS TECHNICAL STANDARD
PRACTICE MANUAL, BULLETIN 7-2

DATE 3/10/87

2754

TITLE OF PAPER
AGENCY UPDATE

AUTHOR(S) B. J. FEISERHARD DEPARTMENT SR/L/REED

FOR JOURNAL ARTICLE
 YES NO
NAME AND ADDRESS OF JOURNAL
FOR INCLUSION IN THE MINUTES OF SPRING 1987 MEETING OF THE IMOG - JOINING SUBGROUP HELD AT ROCKY FLATS ON 3/10-12/87.

PAPER FOR ORAL PRESENTATION
 YES NO
DATE AND LOCATION OF MEETING
Rocky Flats 3/10-12/87
NAME OF MEETING
IMOG - JOINING COMMITTEE
SPONSORED BY
DOE

REQUIRED APPROVAL
DEPARTMENT SUPERINTENDENT H. Cook SIGNATURE
GENERAL SUPERINTENDENT J. DeLoach SIGNATURE

ROUTE TO: 1. ~~AUTHOR~~ 2. TECHNICAL SERVICES, 703A, B-219

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A minimum of six weeks is required by TS for editing and formal release of a paper after receipt of the approved draft.

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B. Request DOE-SR concurrence, then distribute per their instructions. DOE-SR's instructions usually call for sending document to TIC for distribution as specified on the form (DOE F 1332.15) attached to the document.

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III. APPROVALS FOR EXTERNAL DISTRIBUTION *To be completed only if item IIIA. has been completed.*

A. TECHNICAL CONTENT

Authorized by: _____ (RESEARCH MANAGER OR DEPARTMENT SUPERINTENDENT) DATE _____

B. CLASSIFICATION

Reviewed by: _____ (AUTHORIZED DERIVATIVE CLASSIFIER) DATE _____

C. J. Banick, _____ DATE _____
(AED CLASSIFICATION OFFICER)

Authority for Classification Determination CG-DAR-1, Topic 1.1 GUIDE NO. AND TOPIC NO(S) _____

TO BE COMPLETED BY RECORDS MANAGEMENT

IV. CATEGORY IF DP REPORT

Approved by: _____ (RECORDS MANAGEMENT SUPERVISION) DATE _____

V. DOE RELEASES *(date only)*

Patent Branch: (See Form Letter "Request for Patent Reviews") _____

Technical Information Office: (See Form signed by DOE-SR Technical Information Office) _____

July 20, 1987

TO: J. F. SABINO

FROM: *J. F. Sabino for*
C. J. BANICK

DOCUMENT REVIEW

Document(s): DP-MS-87-54

Title(s): "AGENCY UPDATE"

Author(s): B. J. Eberhard

Contractual Origin: DE-AC09-76SR00001

Present Classification: Unclassified Paper

References:

No items were noted that, in my opinion, should be called to the attention of the DOE for patent consideration.