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# TECHNICAL MINUTES OF THE USNDC MEETING 24-26 OCTOBER 1972

## NATIONAL BUREAU OF STANDARDS GAITHERSBURG, MARYLAND





H. E. Jackson, Secretary, USNDC

Argonne National Laboratory

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Held at

National Bureau of Standards
Gaithersburg, Maryland

H. E. Jackson
Secretary, USNDC



ARGONNE NATIONAL LABORATORY
9700 South Cass Avenue
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FOREWORD:

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SUMMARY:

The broadened scope and expanding responsibilities of the USNDC toward the application of nuclear data to science and technology was a major topic of the October, 1972 meeting. Discussion began with a review of changes in the subcommittee structure proposed in response to these developments. In addition to the customary disciplinary groups, subcommittees oriented toward specific technologies were formally approved in the areas of controlled thermonuclear research, materials and environmental analysis, and biomedical applications. Nuclear data needs in these areas and for nuclear safeguards were considered in subsequent presentations by committee members. The NDC agreed to sponsor a proposal for a symposium on nuclear data in medicine to be held in connection with the meeting of the Society of Nuclear Medicine in June 12-15, 1973. The recommendations of the NAS/NRC Ad-hoc Panel on Nuclear Data Compilations were reviewed in detail. NDC members concurred with the panel's concern over the lack of coordination of U.S. nuclear data compilation and evaluation efforts and were receptive to the suggestion that the USNDC is the appropriate executive group to establish a coherent policy. The NDC considered its present character and possible modifications in procedures, organization, and membership which would be appropriate in light of the panel's recommendations.

The progress of the ORNL Isotopes Separation Program in automating calutron operation was reviewed. Reports covering the status of the request compilation were received from each of the disciplinary subcommittees. The current list will go to press about December 1. R. Dannels gave an extensive review of current NNCSC activities, plans for the third edition of BNL-325, and a status report on ENDF/B - III. D. Horen reported on the status of current non-neutron nuclear data compilation efforts of the Nuclear Data Project. A comprehensive technical presentation on research activities at NBS included reviews of the Neutron Standards Program, The National Standard Reference Data System, nuclear data needs for cancer therapy, NBS reactor research, photonuclear data compilation activities, and electron scattering measurements.

Attendance was as follows:

1. R. E. Chrien, BNL, Chairman
2. H. E. Jackson, ANL, Secretary
3. H. Alter, AI
4. R. C. Block, RPI
5. C. D. Bowman, NBS
6. R. S. Caswell, NBS
7. L. Gevantman,† NBS
8. H. Goldstein, Columbia
9. P. B. Hemmig, * AEC/DRDT
10. D. J. Horen, ORNL
11. M. H. Kalos, NYU
12. D. C. Kaul,† USAF
13. G. A. Kolstad, * AEC/DPR
14. D. R. Lide, * NBS/ORSD
15. M. S. Moore, LASL
16. H. W. Newson, Duke
17. F. G. J. Perey, ORNL
18. G. C. Phillips, Rice
19. J. S. Robertson, BNL
20. C. L. Rogosa, AEC/DPR
21. A. B. Smith, * ANL
22. E. M. Smith, Miami
23. D. Steiner, ORNL
24. R. Taschek, * LASL
25. R. Wood, * AEC/DBM

Consultant Subcommittee Members

1. A. D. Carlson, NBS
2. E. G. Fuller, NBS

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†Alternate

*Ex-officio members

Invited Guests and Speakers

1. W. Hannum, AEC/DRDT
2. R. Dannels, NNCSC
3. J. Grundl, NBS
4. J. Leiss, NBS
5. S. Penner, NBS
6. I. Schroder, NBS

AGENDA

## I. Administrative Items

### 1. Introductions

The Chairman, opened the meeting by reviewing briefly the recent history of the U.S. Nuclear Data Committee. In the recent reorganization a number of new members had been added to the committee. At the chair's request each member introduced himself giving his affiliation.

Dr. Ernest Ambler, Director of the Institute for Basic Standards, welcomed the committee to NBS and outlined briefly the activities and organization of the Bureau. Of particular interest to the USNDC was an increase in funding for the program of Neutron Standards Measurements, at the Center for Radiation Research of $415,000 to a level of $815,000.

### 2. Agenda

The chairman introduced an additional agenda item, I-7, entitled User/Compiler Meetings. He also requested the addition of topics under the titles: Activities of the UK Nuclear Data Committee, and Charged Particle Compilation Efforts, as agenda items III-5, and III-6 respectively. Under Agenda heading VI additional subjects were proposed: VI-5, Panel on Neutron Standard Reference Data to be held November 4 in Vienna; VI-9, International conference on Nuclear and Microanalysis of Thin Films to be held May 21-23, 1973; VI-13, Texas Symposim on the Technology of CTR to be held in Austin, 20-22 Nov., 1972; VI-14, National Soviet Conference on Neutron Physics to be held in Kiev, May 28, 1973; and VI-15, Reactor Shielding Conference, Paris October, 1972 Moore suggested a status report of the Los Alamos WNR project under agenda item VIII-3. Smith requested the addition of an agenda item entitled Philosopy of Evaluation of Nuclear Data as agenda item V-4. The above mentioned topics were adopted together with an agenda-item V-5, CINDA

### 3. Committee and Subcommittee Reorganization

The chairman observed that the USNDC had expanded its horizions to include non-neutron nuclear data and applications. He asked for a brief review of the broadened subcommittee structure formed in response to these new demands and proposed that he issue formal invitations to individual

members of the subcommittee as the chairman of the USNDC. Kolstad suggested that subcommittees be appointed by the Chairman on the basis of membership proposed by the subcommittee chairmen, but with the prior approval of the full committee. He suggested that the terms of reference of the USNDC be reworked in this regard. The Chairman noted that in fact he merely affirms the choices of the chairmen and that the USNDC could in the interim adopt a temporary operating mode until new terms of reference are formulated. Kolstad presented a formal motion for an interim guideline for appointment of subcommittee members by the Chairman of the USNDC based upon nominations of the appropriate subcommittee chairman with the advice and consent of the full committee. The procedure would consist of prior circulation to all full committee members 30 days in advance of appointment of a proposed choice. It would be left to the discretion of the NDC chairman as to whether committee consensus this for the appointment was received. Bowman seconded the motion. In subsequent discussion it was observed that the procedure would avoid embarrassment at later date and lead to a more effective subcommittee structure. It was emphasised that the chairman would be responsible for circulation of the proposed membership to the USNDC, but that he would look to the subcommittee chairmen for nominations. The motion would apply to all future appointments. Steiner inquired about policy with regard to membership on a more than one subcommittee and the chairman indicated that there is no restriction. The motion was carried unamimously.

A rapid review of the proposed subcommittee structure followed. Kolstad proposed that the Isotope Committee be renamed Committee on Stable or Separated Isotopes. Taschek suggested the addition of G. Cowan of Los Alamos to maintain contact with the ICONS program at LASL and the Mound program. No change was proposed in the membership of the Standards Subcommittee. In discussing the membership of the Scattering Committee A. Smith noted that at present time there were only 3 active programs in the United States, two of which involved non-AEC contractors; the latter are under R. Lane at Ohio University, and M. Mc Ellistrem at the University

of Kentucky. Because the University of Kentucky program is supported in part by the NSF, Mc Ellistrem's membership should be cleared through the NSF representative to the USNDC who, unfortunately, was not present. However this discussion raised the question of travel support for non-AEC contractors and Kolstad noted that the AEC had no plans for special consulting contracts. Kalos inquired about Aberdeen Research Center representation of the committee and A. Smith indicated that it would be desirable. A. Smith agreed to review the reorganization of the Scattering Committee in light of the current understanding with regard to travel support, in consultation with the chairman and to check with the National Science Foundation concerning the possible membership of R. Lane. No changes were made in the membership of either the $\gamma$-ray Production or the Total Capture Subcommittees. Moore announced that membership on the fission subcommittee would be reformulated and that in addition in the future measurements of $\bar{\nu}$ would be included among its responsibilities. In the view of the expanded committee responsibility of the Resonance Parameter Subcommittee Block agreed to reformulate a new membership list. In view of the extensive effort current at Argonne, Alter proposed the addition of D. L. Smith of ANL to the fast Neutron Reaction sub-committee. He also tentively proposed George Butler of LASL. Chrien proposed the addition of G. C. Phillips to the Medium Energy Cross-Section Committee. Steiner noted that the correct title for the CTR Subcommittee was Controlled Thermonuclear Research Subcommittee. No changes in the membership were proposed.

Various committee members expressed concern over the title of the Subcommittee for Nuclear Data for Material and Environmental Analysis. Newson inquired as to whether x-rays were involved in the area of responsibility of the subcommittee or whether the committee should be limited to consideration of Nuclear Data. In many cases the methods are nuclear, the data are usually atomic. Phillips observed that there is a great deal of real Atomic Physics and that it is a relatively new area. The subcommittee chairman, Horen, pointed out that some members may have the problems with funding for travel but proposed no changes in the current membership. No changes were proposed in the Bio-Medical Application Subcommittee. However, it was observed that

the Nuclear Data Centers were not represented. Horen was thereupon appointed to the subcommittee. In response to a question about the subcommittees attitude toward Cancer Research E. M. Smith replied that the subcommittees response would be an evolving thing and in the area of nuclear data people would define their needs in time. In subsequent discussion the issue was raised on inclusion of need of Biological research in the committee charge. No conclusions were reached and further discussion was deferred.

Bowman noted that the response to earlier activities of the Nuclear Safeguards Subcommittee had not been encouraging. An earlier subcommittee review and report had been received by the safeguards community without comment. The representative of the DSMM, Bartels, was not present to comment on this observation. Taschek suggested that it would be appropriate to contact Keepin at LASL and inform him of the subcommittee situation and also be worth while to contact Bartels. Bowman replied that in the past Bartels appeared to have been embarassed by the Safeguards subcommittee reports and regarded them as a possible motivation for seeking research funds from DSMM. Gevantman noted that the U. K. Committee on Chemical Data was working in this area.

Bowman noted further that the photonuclear committee had met in September and found all safeguards requests for photonuclear data unchanged. He proposed the addition of B. Berman of LLL as a member of the Photonuclear Subcommittee. Newson inquired as to whether the committee still wished to have a charged particle subcommittee. Steiner observed that CTR charged particle requests are covered in the CTR committee but that the area of responsibility is limited, that is requests are considered over a limited energy range. There are other areas of need, i.e., materials analysis and it appeared that a disciplinary subcommittee was appropriate. Kolstad suggested that the formation of a nuclear data for basic science committee to replace both the safeguards and the photonuclear subcommittees. He observed that discussion could be deferred till agenda item I ,6. Taschek added that safeguards more logically should go into the area of nuclear data for material and environmental analysis. The chairman then requested that Bowman, Horen, Taschek, and Newson meet and develop a proposed scheme for subcommittee reorganization in the area of photonuclear

physics, safeguards, charged particle physics, and nuclear data for basic science. The subsequent proposal was accepted by the committee: namely that the nuclear safeguards committee be absorbed by the committee on Material and Enviromental Analysis, and that a charged particle subcommittee be established under the chairmanship of Newson. In response to the consensus of the NDC the subcommittee on Photonuclear Reactions was continued under the chairmanship of C. Bowman. A new action 1 was established on all subcommittee chairmen, to forward to R. E. Chrien within 30 days final subcommittee membership lists for circulation among the NDC membership for final approval. The proposed subcommittee structure as adopted at the time of the NDC meeting is included as Appendix A in the minutes.

ACTION 1
Subcommittee Chairmen

4. Minutes of Previous Meeting

Goldstein noted one correction to the minutes of the previous meeting, USNDC-2, on page 41. In the discussion regarding CINDA'72 the first complete sentence on page 41 should read "each volume will total 800 pages". The minutes as amended were approved without further reading.

5. Past Actions of USNDC (USNDC-2, p. 68)

A review of outstanding actions followed;

Action 1

Issue in addition to the draft minutes a technical version to consulting subcommittee members. The secretary noted that this had been done, but at the time of issuance a number had not been assigned to the technical version. The technical minutes of the previous meeting would be assigned the number USNDC—2a and in the future a similar convention would be followed in indexing the technical minutes.

Action 3—Goldstein, All Committee Members.

Maintain a compilation of cross-section discrepancies listed in order of importance to the nuclear-energy program with the assistance of committee members and direct the attention of concerned parties to the list and solicit their comments. Goldstein reported that there had been negligible input since the previous meeting and that although modifications of priority had been made there were no substantive changes in the discrepancy list. Goldstein noted that questions concerning $\bar{E}_n$ of the

$^{252}Cf$ fission spectrum had been raised in recent age measurements at NBS. Spiegel had carried out integral measurements in a pure $^{252}Cf$ fission spectrum. Experimental corrections for finite geometry may explain the discrepancies observed. However if they are substantiated the age result will suggest that the $\bar{E}_n$ is lower than the accepted value by about 10%. An alternative explanation is that californium may have a soft neutron component. Goldstein noted that the relationship between age and $\bar{E}_n$ is an old one. The age of any source is a linear function of $\bar{E}_n$. This relationship is valid as long as the effect of the neutron absorption is relatively small and it is independent of source shape. This conclusion was drawn in a paper dated 1958 and there is a need to re-examine the problem. Before this discrepancy is accepted, this relationship should be re-examined, and in addition all experimental uncertainties in the corrections in the data analysis should be reconsidered.

ACTION 2
Goldstein, all members

The continuing action, Action 3 was carried forward as new Action 2.

Action 4—All Members

Submit to the chairman suggestions for the next NDC meeting and on technical symposia and enlarged responsibilities of the nuclear data committee in application of nuclear data to any fields not related to reactor technology. This action was completed.

Action 5—Isotope Subcommittee

Write a one-paragraph warning to be incorporated into the standard Isotope Request Form with regard to activation and forward to George Rogosa. Perey indicated because of the confusion during the subcommittee re-organizations, this action has not been completed. Jackson indicated that according to the discussion of previous meetings the NDC was satisfied with the method in which the Isotopes Division was handling problems of sample activation. The intent of Action 5 was to insure that all users would be aware of the potential hazards of sample activation. This

ACTION 3
Perey

action was carried forward as New Action 3 on Perey.

Action 6—Chairman

In a letter to the Division of Physical Research express the concern of the NDC over the dramatic drop in calutron effort in the

period FY 69 to FY 72. This action had been completed with a letter dated June 1, 1972 to the Director, DPR. There had been no response to date.

Action 7—A. Smith

Contact B. Leonard At Pacific Northwest about obtaining and maintaining the elemental sample inventory presently at Pacific Northwest. This action had been completed. The material in question is presently at Wright-Patterson AFB and is being inventoried and prepared for transfer to ANL.

Action 8—Secretary

Include a list of elemental sample inventories and their location in the technical minutes of NDC meetings. This action had not been completed because of uncertainty in the content and location of the Pacific Northwest inventory. An interim sample inventory list including only those materials at ANL and RPI had been distributed to committee and subcommittee members. This list had not included materials specified in the elemental sample inventory of the isotope subcommittee. A New Action 4 on Perey was adopted, to forward to the secretary the elemental sample inventory list presently held by the isotope subcommittee. Old action 8 was carried forward as new Action 5 on the secretary.

ACTION 4
Perey

ACTION 5
Secretary

Action 9—Chairman

Express the recommendation of the committee in an appropriate letter that all elemental separations of RMC materials be classified as special fabrications and be retained in the pool in special form until a specific request for further conversion is received. This action had been completed with the letter of June 1, 1972 to the Director, DPR. A New Action 6 on Perey was adopted, investigate the response of the Isotopes Division to NDC action 9 of May 1972.

ACTION 6
Perey

Action 10—All Members

Submit comments to the chairman on the LASL proposal to measure delayed neutron production by June 10. This action had expired and in a letter of

June 19 to Dr. McDaniel, the chairman had expressed the consensus of the committee on the delayed neutron proposal. Moore stated that he had not received a copy of this letter and had been unable to respond to the inquiries of the LASL staff regarding the committee opinion on the issues outlined in the proposal. He requested that in the future such letters be circulated to the whole committee.

Action 11 -- Caswell

Circulate the revised standard committee report among NDC members. This action had been completed.

Action 12--Chairman

Draft a letter of recommendation to the Division of Physical Research that $\bar{\nu}$ be measured for $^{252}$Cf and that J. R. Smith of Aerojet Nuclear be chosen as the appropriate experimenter. The letter of June 20, 1972 to Dr. McDaniel, Director, DPR, from the chairman completed this action.

Action 13—All Members

Comment on the proposed list of reordering of priorities for outstanding discrepancies by June 15. This action had expired.

Action 14—All Members

Contribute comments on the proposed format of the request compilation to be forwarded to the Chairman and in turn to the NNCSC. Chairman had completed this action. Little comment had been received.

Action 15—Subcommittee Chairmen

Review by September 1 the status of each request in the current compilation and for all requests of questionable justification contact the requestor and confirm need or obtain consent to eliminate the request. This action was under execution and extended discussion was deferred until agenda item II—2. Perey indicated that there are new DRDT needs which are not in the compilation. Hemmig replied that these requests will not be reviewed by ACRP until December. Alter raised the question of listing the large number of requests which have been withdrawn from the compilation. He noted that many people do not list needs which coincide with requests already included. A listing of requests withdrawn would make it possible for these people to be aware of the changing situation. Moore replied that such a list is not practical at this time and would be difficult to implement. The

Chairman stated that the issue will be solved in the future when the compilation is maintained at NNCSC in a RENDA format. The problem is recognized.

Action 16—All Members

Submit to the the Chairman by June 5 comments on the Attree-Schmidt letter outlining procedures for publishing a RENDA. This action had expired and the Chairman had forwarded the comments of committee members to Kolstad in the letter of June 13, 1972. Kolstad in turn had included the committee sentiment in his letter of June 16, 1972 to Attree and Schmidt. Moore again observed that the Chairman's letter, a consensus document, might have been circulated among committee members before mailing. However, in this case the time deadline had precluded this procedure. In such circumstances committee members must rely on the judgement of the Chairman.

Action 17—Chairman

Bring to the attention of the Division of Physical Research in a formal letter the difficulty that NNCSC is experiencing in obtaining data from experimenters. The letter of June 2, 1972 to Dr. McDaniel from the Chairman of USNDC completed this action. Kolstad announced that a letter had been sent to all AEC contractors requesting their cooperation in this regard. Pearlstein indicated that there had been difficulty in obtaining a specific body of data from Livermore and that the LLL representative, Bowman, had interceded on behalf of the Cross Section Center.

Action 18—Chairman

Write a letter to the American Nuclear Society bringing to their attention that the recent comments by Dessauer regarding an information gap are unfounded. Subsequent discussions with Dessauer indicated that the need for this action had disappeared. Subsequently the Action 18 was dropped.

Action 19—Chairman

Forward Dessauer's letter to Hemmig in response to his letter of April 16 and ask DRDT be represented at USNDC meetings either through its ex officio member or a designated observer. This action had been completed with a letter of May 31, 1972 to Mr. Hemmig. Kolstad indicated that the committee had over-emphasized the seriousness of the

situation and the absence of the DRDT representative had been brought about by pressing prior commitment.

Action 20—Chairman

Advice L. Cranberg of the Las Vegas panel on fast neutron sources to be held on 17 June 1972. Action on this point had proved unnecessary. The Action was dropped.

Action 21—Chairman

Write a letter reflecting the consensus of the committee to the Division of Physical Research specifically endorsing the ORELA heavy element proposal and the need for measurement. The letter of June 20, 1972 to the Director, DPR, completed this action.

Action 22—Chairman

Write a letter of support to the Division of Physical Research on the technical merit of the University of Colorado program. The letter of June 20, 1972 to the Director, DPR, completed this action.

6. Recommendations of NAS/NRC Ad-Hoc Committee on Nuclear Data Compilations (Aug. 10, 1972).

The chairman reviewed briefly the background material which had been distributed to USNDC members in anticipation of an open discussion. The purpose of the Aug. meeting of the NAS/NRC Panel had been to review the needs for nuclear data, the present nature, history and funding of nuclear data projects both here and abroad and to propose measures aimed at strengthing the U.S. Nuclear Data Program. The final recommendations of the Ad-Hoc Panel are contained in appendix C. Jackson added that the Panel members had felt that the present resources were not adequate to meet the needs for nuclear data compilation and that it was important

to determine the most efficient use of the limited resources available. The purpose of the panel was to discuss these points and to attempt to develop a more coherent approach. Panel discussion focused on the Nuclear Data Project. Because of inadequate resources the Nuclear Data Project found it difficult both to meet its responsibilities in compilation area and at the same time service the needs of applied programs. For this reason the panel concluded that the only way to insure the future usefulness of the Nuclear Data Compilation Program was to orient its activities primarily toward fulfilling the needs of basic science and providing a comprehensive summary of nuclear physics. More generally, there, was concern that communication and coordination among the many groups engaged in compilation efforts is lacking.

Although the panel recommended that the USNDC assume the responsibility of an executive committee in regard to coordination of the efforts of non-neutron compilation groups in the United States, the members were concerned that the present restriction on membership prevented representation of University scientists and workers in basic as opposed to applied nuclear physics. In addition they were concerned that the present orientation of the USNDC was too strongly towards applied as opposed to basic nuclear data with a heavy emphasis on neutron nuclear data. These concerns are reflected in their recommendations. (See Appendix C).

Kolstad stated that the terms of reference of the USNDC should be revised and broadened. In response to the panel request that restriction on membership be lifted so that any individual with the necessary competence and interest is eligible, Kolstad noted that the presence of a representative from the NSF is an appropriate response and that in addition the only restriction on membership is that the individuals are responsible for their travel support. "A broading of the agencies to which USNDC is responsible was also suggested." Kolstad noted that the main purpose in organizing the USNDC with primary responsibility to the AEC and the OSRD was on the one hand to give the Committee a focus with the government and on the otherhand to insure that the deliberations, and conclusions of the Committee would not be reported in a broadcast fashion.

With regard to the proposal for liaison with professional groups active in nuclear science, Kolstad suggested that this would be reasonable only in an informal way. To establish such a formal relationship would greatly enlarge the membership and change the character of the Committee so as effectively to prevent the selection of people on the basis of their technical competence. In summary the USNDC is changing to meet broadened needs and the preponderance of neutron physics is changing slowly in an evoluntionary way so that the committee character will be appropriate to the applied needs of the moment. It was pointed out that 1/3 of the committee is University associated. A method for meeting the spirit of the suggestions of the NRC Ad hoc panel would be to appoint a basic research scientist to the committee membership bearing in mind that the primary function of the committee, is to advise on meeting applied needs for nuclear data. The NDC is expanding its sub-committee structure to reflect the expanded scope of its responsibilities. Newson added that it would be appropriate to invite University people to serve on the charged particle sub-committee as a move in this direction.

The chairman stated that the committee should draft a response to the NAS/NRC memorandum and Kolstad indicated that he would like to have a draft letter within a week in preparation for a meeting within the AEC of the Committee on Nuclear Science. A New Action 7 was placed on the Chairman to draft a consensus letter reflecting the response of the committee to the NAS-NRC recommendation by November 10.

ACTION 7
Chairman

In the closing discussion Bowman expressed the fear that the responsibilities of the Committee, if organized along the lines proposed in the memorandum, would be too broad. In the interest of effectiveness the Committee should limit itself to applied nuclear data. Chrien expressed agreement with the observation of the NRC memorandum that "Great advantages would accrue to the U.S. Nuclear program if nuclear data efforts were such as to satisfy the needs of all nuclear science basic as well as applied." Horen suggested that in view of the importance of this discussion that the committee should give more thought before responding to the memorandum. Newson observed

that some panel members may feel that the USNDC is not the appropriate advisory committee within the AEC for nuclear physics. Kolstad observed that the USNDC is already too large and that he would not wish to appoint more than one additional member, but that Feshbach would be a good appointment. Further discussion was deferred.

7. User Compiler Meetings - Discussion was deferred.

II. Program Reviews - Neutron Related Data

1. Isotope Separation Activities.

A report on the status of the calutron automation program, included as appendix D, was distributed by Perey to the committee members. The PDP-8/L computer system installed on an $180^{o}$ sector isotope separator demonstrated that high quality separation of stable isotopes is possible at greater production rates. In an excellent run on this system during the previous summer a separation of $^{156}Dy$ had been carried out and the results were encouraging. After a three week shutdown a new run had been planned on Sn, however, some problems had been encountered and this separation has been rescheduled. The status report included a complete schedule of plans for computerizing control of the calutrons. Perey believes that Love is proceeding slowly in order to avoid impairing the effciency of the current separation program. He is doing this in response to the concern of the NDC over the decrease in the number of tank hours of effort per year and partly as a result of the increasing competition from the Soviet separation program. Perey announced that J. Ratledge at ORNL had received an unsolicited offer from the U.S.S.R. for delivery of the separated isotope of $^{57}Fe$ in $>100$ gram quantities and purities in excess of 87% at a price of 2.09 per mg. This material was evidently in stock. In response to the question of violent fluctuations in production costs Taschek suggested that accountants should be able to iron out the fluctuations and feed the isotope inventories in a manner that takes normal fluctuations into account. The important point was to institute accounting procedures which give full cost recovery.

Perey replied that Love is upset about fluctuations in production

costs and was concerned that difficulties with $^{120}Sn$ separations could lead to sky-rocketing costs. However Perey emphasized that the automation proposal could triple the number of tank hours of operation costs per tank hour by permiting round the clock operation. Kolstad noted that the committee needed a reassessment of unit costs under computerization. A new action 8 was levied on Perey, to complete with L. Love a reassessment of calutron unit costs under full computer operation and report the results at the next committee meeting.

ACTION 8
Perey

With regard to planned operations Perey announced that track 5 involving 14 operational calutrons would be devoted to separations of $^{98}Mo$ and Tc for sales devoted to medical purposes. In addition during the next year the pilot plant facility will be operated on an 8 hour per day basis for separation of isotopes of Iridium. The Os separation have been deferred because of chemical problems with the Os source. To date the following quantities of Pu isotopes had been obtained from the Pu separation:

| | |
|---|---|
| 55g of $^{239}_{240}Pu$ at 90% purity | 30g of $^{242}_{244}Pu$ at 80% purity |
| 115g of $^{240}Pu$ at 97% purity | 25g of $^{244}Pu$ at 25% purity |
| 35g of $^{241}Pu$ at 92% purity | 2g of $^{244}Pu$ at 99% purity |
| 35g of $^{241}Pu$ at 97% purity | |

Smith noted that in addition to ORNL request for $Pu^{241}$ ANL requested a sample to be used for in-pile spectral irradiation as part of the EBR II program.

Perey stated the activity in the isotope program during FY-72 was sales level of 1.1 million dollars per year. 50% of the sales were directed to medical applications and 2/3 of the sales involved foreign buyers. The loan activity during the fiscal year in terms of inventory costs involved a level of 5 million dollars. In response to an inquiry by Block concerning a loan dated Aug. 11 for 62 grams of $^{92}Mo$ and 3 grams of Hf nominally to Mitsubishi Corp., A. Smith noted that the samples were needed for measurments at JERI.

Perey informed the committee that approximately 1 kg of $^{28}Si$ and 32 kg of $^{40}Ca$ on inventory at a price of .005 dollars per milligram are currently stored at ORNL but are not being used or placed in inventory. This material is a by-product of separations in which other isotopes of Si and Ca are desired. The costs of such separations are charged against the isotope needed and the by-product isotopes are written off. The committee was concerned as to why the material could not be entered into sales inventory at cost and why a discrepancy existed between the present catalog price of $^{40}Ca$ and the price at which the "basement" material is carried on inventory. Kolstad suggested that the list of by-product isotopes be circulated among the NDC before any publication. It appeared that the full inventory could not be listed at cost without accountants approval. Perey offered to report to the full committee at the next meeting on the accounting problem. Caswell added that the committee should attempt to get the material on the market at a reasonable cost. Steiner affirmed Perey's suggestion as a desirable one and suggested that Perey discuss the problem with Gillette and, if necessary, with Culler. Several committee members suggested that the problem be discussed at highest authority level within the laboratory. A New Action 9 was placed on Perey to circulate to the NDC members a complete list of the by-product isotopes in storage with a recommendation on how to make this inventory available and also to circulate a copy of the Soviet $^{57}Fe$ offer. New action 10 was placed on the Isotopes Subcommittee to form a recommendation for the disposition of unprocessed calutron material so that this national resource can be made available to U. S. Scientific programs.

ACTION 9
Perey

ACTION 10
Isotopes Subcommittee

II. Request Compilation—Reviews

In response to the request of the chairman for a status report from each of the disciplinary sub-committees covering the status of the request compilation, the sub-committee chairmen had distributed to committee members prior to the NDC meeting draft the versions of the committee reports. The chairman called for comments on the individual reports.

a. Standards

Caswell reiterated the position of Standards Subcommittee on the question of inclusion of requests for total cross section measurements in connection with the need for precise data on associated standard cross sections. Although the subcommittee opinion is unanimous to this point, they will defer to the judgment of the full NDC membership. A second point of importance is a request for a 2% measurement of the angular distribution for n, p scattering up to 20 Mev neutron energy. Motivation of this request is accurate calibration of recoil telescopes. Although the committee is aware that this is a very difficult measurement they feel that the request should be retained because of its importance.

A. Smith did concur that in the case of the 6 Li (n, α) problem there had been too many measurements of the total cross section. However, in his opinion in any light nucleus, all of the cross sections must be understood in total. A narrow view denies the real road to the answer. Moore replied that the intent of the subcommittee was to discourage people from attacking only the easiest aspect of the problem. No one will object to measurements of the total cross section if such measurements are related and necessary, but people should not be divered from direct measurements of the n,$\alpha$ reactions in the case of $^{6}$Li. Chrien suggested that it might be acceptable to include in the comment on $^{6}$Li (n, $\alpha$,) a remark to encourage any useful basic measurement. Caswell agreed to the inclusion of such a statment.

Hemmig observed that a similar situation existed with regard to discrepancy in the $^{10}$B(n, $\alpha$) cross section. He also raised a point not discussed in the standards report, namely an INDC recommendation for the measurement of the $^{239}$Pu/$^{197}$Au fission capture ratio. These data appear to be a most important standard and Hemmig inquired as to why the NDC was not requesting its measurement. In an INDC report authored by Havens, et. al. it had been recommended that this ratio be measured in the region 10 keV to 1 Mev.

Taschek indicated that the request for this ratio was motivated by a study of the data loop consisting of the cross section ratios U/Au, Pu/Au, and U/Pu. The present information on these cross sections does not close the loop and it appears that the error in the Pu/Au ratio is a missing link. In response to the question by Block, Chrien noted that the gold is a priority one request.

Block expressed the confusion at the receipt of letters from Poenitz dated September 8, and from Stewart dated September 18, each asking for recent data which would be relevant to the second International Panel on Neutron Standard Reference Data to be held November 4 in Vienna. In response it was noted that Poenitz was to be the offical U.S. Representative at this panel and that L. Stewart would attend as an observer. Kolstad emphasised that more generally outside measurers should funnel all new standards data to the NNCSC through Dannels. In addition outstanding discrepancies and comments on such descrepancies should continue to be directed to Goldstein as part of the continuing NDC action on all members.

b. Scattering

Smith observed that experimenters in the neutron scattering field are not active and that the response of the sub-committee had been negligible. At present there appeared to be only two active programs. The second point which he raised was the redundancy of measurements for $\bar{\nu}$ in the request list of the Scattering and Fission Subcommittees.

In reply Perey noted that the scattering program at ORELA is not dead and stated that he would prepare a paragraph on the status and plans in this area. He noted that measurements on the Van de Graaff at ORNL had been closed out and that a new program was planned on ORELA. Rogosa noted that the NSF will terminate support

of the program at Kentucky and that R. Lane at Ohio is currently preparing a proposal to the AEC for support. Unfortunately the NSF representative, W. Rodney was not present and therefore no clarification of the attitude of NSF toward such programs could be obtained.

Kolstad inquired as to the possibility of a program of basic measurements, such as suggested in the Shaw-Miller memo (see agenda item VIII-3) which would increase our understanding of the scattering process. Smith replied that such a program was a very real possibility. In particular reaction studies of direct excitation 2+ and 4+ states of $^{184}W$ and polarization studies of inelastically scattered neutrons would be very useful in confirming model calculations of the scattering process. Smith noted that the same techniques could be applied to p, n studies furnishing similarly basic information. The chairman then requested Smith to incorporate Perey's contribution into scattering report and to include remarks on possible basic measurements which would imporove our understanding of the scattering process.

c. Fission

Moore announced that the report of fission subcommittee had been based on the questionnaire prepared by Bowman. Source material for this report had included EANDC documents and the previous status reports that were available. He emphasised that the report is preliminary and had not received subcommittee review. He added that a internal report had been issued on the status of the $^{252}Cf$ production chain and on what cross section data are presently available. This report will be distributed to the NDC when available.

d. Capture

The chairman pointed out that the chairman of the capture subcommittee, Macklin, was not a full NDC member, and that Block was the committee representative on the Capture Subcommittee.

e. γ-ray Production

Jackson summarized the two principle points of gamma ray production report, namely that progress since the last review of the request compilation has not been substantial and the number of requests for gamma ray production data had increased to 36 to 76 with no requests satisfied. The national capability for meeting cross section needs in this area appears at best to have remained constant and most likely has diminished. This point was confirmed by the remarks in later discussion of the DNA representative, Kaul, who observed that support of the two principal active programs, ORELA and GRT would be cut back in about 18 months. Perey reiterated this support problem and noted in addition that support had been limited to measurements covering about a dozen light nuclei. If present

progress continued data for these targets would be satisfied. However, a broad range of nuclear data needs for targets in the range A=50-150 will not be touched because of restrictions in the support of the present programs. He noted that recent progress both at GRT and ORELA indicated that experimenters were on the threshold of developing a reliable technique which could satisfy a major portion of the needs for gamma-ray production data.

Kaul added that very little information is available for photons below 1 MeV and that information in this region is needed for radiation transport calculations. It is possible that weapons effects program may generate uses for such data. Bowman added that at LLL an effort in the area of gamma-ray production is planned on the electron linac. There is a very strong interest there in this type of measurement and measurement activity will probably grow. Kolstad inquired as to what compilation efforts were currently in progress in this area and suggested that the subcommittee address itself to the question of data compilation as well as problems in funding. In response Perey noted that gamma-ray production data is presently tabulated in the CSISR file for neutrons in the MeV range. Block noted that there is no compilation of gamma-ray production data for neutrons in the thermal and resonance region. Jackson observed that compilation of gamma-ray production is most difficult for the low energy region but the compilation of all gamma-ray production data in the format and under the restrictions specified by requestors presented no problems of compilation.

f. Resonance Parameters

Block emphasized that the Resonance Parameter Report should be regarded as a preliminary report and he forwarded a corrected page 9 to the secretary. Alter pointed out that some confusion existed

on the question of whether requests had been withdrawn and raised the question of whether withdrawn requests should be listed. After some discussion it was decided to adopt the policy of listing the status comment—this request is withdrawn and will not appear in the next list.

g. Fast Reactions

Alter reported that only DRDT is presently funding measurements in this area, in spite of the fact that DCTR and DMA are the major requestors. The only programmatic effort in progress is at the FNG at ANL. Some measurements by Barr who is on the subcommittee are in progress at LASL but they do not involve a systematic effort. Hemmig added that earlier work at Lockheed had been phased out because of inadequacy of the facility. He emphasized that A. Smith was working in this area because of the power of his facility.

Kolstad remarked that the subcommittee reports contain much information of great utility. Distribution as a USNDC document particularly to the international committee members would be appropriate, perhaps with a warning to use the information at their own risk. Moore observed that in many cases the comments are rather frank and Kolstad replied that two weeks could be allowed to get revisions to the chairman. Moore also noted that the request numbers refer only to the earlier handout and would not be useful to the general reader. Kolstad noted that both the general remarks and the status remarks were of interest and for this reason the request numbers should be normalized either to RENDA or to NCSAC-35. A New Action 11 was adopted on the subcommittee chairmen to review and normalize status comments in the subcommittee reports to NCSAC-35 and to forward the revised document within three weeks, by November 15, to the chairman. The resulting document will be given INDC and EANDC distribution. The chairman agreed to write an introduction and then forward the document to Kolstad.

ACTION 11
Subcommittee Chairmen

Moore indicated that the request compilation would go to press approximately December 1. Kolstad commented that perhaps list in view of the needs of CTR, biomedical applications, etc. it would be appropriate to organize the requests in chapters on various needs and with listing in the chapters according to atomic number. If such a reorganization was not feasible at the present time it could be deferred. The chairman reported that the Four Centers compilation will include application flags. And for this reason retrievals can be organized as desired. The format of RENDA is not clear as yet and was under discussion at the Four Center Meeting held the previous week, but it is clear that the system will permit whatever retrievals are desired. Kolstad observed that the Dunford memo (see agenda item V-3) did not discuss the RENDA format in this context. Block observed that in such a format the overlap of request compilations in different areas would be lost. Kolstad requested an expression of opinion from the committee on the form of publication, particularly if there is a fair amount of unanimity. Moore proposed that in lieu of reorganization of the compilation, appendices be added giving an index of retrievals by application. After some discussion this view was adopted as the committee consensus and a New Action 12 was adopted on the chairman to transmit a formal letter to NNCSC expressing the consensus of the NDC on the possible publication formats for the request compilation.

ACTION 12
Chairman

III. Nuclear Data Applications—Status Reports

1. CTR-D. Steiner, ORNL

Steiner described briefly the present nuclear data needs of the CTR program and the present philosophy toward nuclear data problems. He cited a paper entitled "Neutron Cross Section Requirements for Fusion Reactor Design" presented at the Knoxville Conference on Neutron Cross Section Technology in March of 1971. At present, the primary emphasis is on fusion reactors based on d, t reactions leading to 14 MeV neutron production. For this reason neutron as well as charged-particle cross sections are of importance. Other fusion reactions of

interest include the (d, d) and (d, $^{3}$He) reactions. In addition, people have speculated on fusion reactors based on reactions such as (p, Be) and (p, Li). However, such systems have not been emphasized because of the high energies necessary to sustain the appropriate reactions. In addition to nuclear data needs the CTR program has data needs in the area of atomic and molecular physics.

The four basic areas of need relative to neutron-induced reactions are cross sections for the breeding of tritium, i.e. (n, Li) reactions leading to T; information on energy deposition within the system by reaction products and $\gamma$-ray production; neutron-induced radiation problems; and activation problems. In general, available cross sections are adequate to meet the present programmatic needs in the area of transport calculations and Monte Carlo calculations. Nuclear data and models in the higher energy ranges are generally adequate for calculations of atomic displacement rates, transmutation rates, and helium and hydrogen production rates.

For the present, the CTR program will draw heavily on the experience of defense programs in meeting needs for 14 MeV cross sections while attempting to define in a more precise way their future cross section needs. As the design stage is approached the program would expect to pay for meeting specific nuclear data needs. A modest program of cross section sensitivity tests is currently in progress and a bench mark neutronic calculation is underway for a reference reactor configuration. One present area of concern is discrepancies between existing data processing codes. Steiner noted that at a meeting in June of 1971 a list of cross needs had been formulated and that DCTR had fed this list into the request compilation both in the U.S. and at IAEA. However, in his opinion, the signifigance of this list must be viewed with caution since the priorities of the program are yet to be defined.

Kaul stated that military programs will not be a source of nuclear data production much longer. In approximately one year he

expects output to be cut back by about 50%. The relevant programs include studies of γ-ray production for a dozen materials at ORELA and GRT, a scattering program at ORNL, scattering measurements at BNP, and a study of epithermal γ-ray spectra. He estimated that by the end of FY—74 measurements would be completed for all the needs which have been specified by the military agencies. Beyond that there is no reason evident for further work. However, he expressed concern that the facilities on which these programs have been conducted will be dismantled. His office will attempt some sort of residual effort to maintain capability in these areas. However, he noted that the CTR effort faces the possibility of losing a substantial portion of the capability on which it was relying. In further discussion Hemmig indicated that the sensitivity studies mentioned by Steiner are of interest to DRDT and that general activity in this area is increasing. In reply to another question Steiner indicated that photonuclear needs had not yet been considered in CTR deliberations.

2. Nuclear Data in Materials and Environmental Analysis—D. J. Horen, ORNL.

Horen's presentation began with the observation that the material analysis is a very broad area and that the bulk of the relevant nuclear data is concerned with radioactivity. The nuclear data project has met many of the needs for this type of application but clearly more compilation and evaluation is needed. A question of importance at the present time is whether or not compilation efforts should be directed toward neutron activation data.

At this point in the discussion the issue of the lack of evaluated non-neutron nuclear data raised in Aten's letter of July 28 to INDC members was cited. Horen noted that many of the specific questions raised in Aten's communication had already been answered and that the information he alluded to could have been obtained by contacting the Nuclear Data Project at ORNL. But it is true that users do not have the means frequently to find the answers they need. In an effort to remedy this situation CODATA is preparing a compilation of all current compilation projects. Steiner inquired as to whether NDC should take the initiative

of informing people of the available nuclear data centers perhaps by issuing the appropriate information to all individuals on the membership lists of the appropriate professional societies. Bowman added that every issue of Nuclear Data might have a page with the addresses of the nuclear data centers. It is very unlikely that a single-shot distribution would solve the problem.

Kolstad inquired of Horen whether the Nuclear Data Project could act as a clearing house for nuclear data requests from other files. That is, operate as a referral service. In such a case people would have to go to only two addresses, NDP and NNCSC for neutron data to fulfill their needs. Horen replied that the NDP could not meet this responsibility without fully interfering with the normal compilation activities. Lide noted that the OSRD already serves as a referral service to some extent. Hemmig noted that Aten is actually asking for evaluated nuclear data. Horen elaborated that the NDP did not want to stop its current efforts to meet specific requests for evaluated data.

3. Nuclear Safeguards — C. D. Bowman, NBS

The earlier activities of the Ad-hoc Subcommittee on Nuclear Safeguards had been discussed under agenda item I-3. In view of the elimination of the proposed safeguards subcommittee in the reorganization adopted at that point, discussion of this topic was terminated.

4. Nuclear Data in Medicine — J. S. Robertson, BNL.

Robertson began with a review of the members and the qualifications of the subcommittee on biomedical applications. He then observed that in 1966 there 1.7 million adminstrations of radioactive pharmaceuticals and that at the present time this number has grown to about 10 million administrations. Although the nuclear data requirements in this area are limited, because of the extensive use of such techniques and the human involvement, these needs take on added importance. The users must have numbers they can use with assurance. He then outlined areas where nuclear data play an important

role in the following contribution:

The medical uses of radioactive materials require nuclear data for applications in radiation detection, activation analysis, and the biological effects of radiation.

Radiation Detection

Radioactive materials are administered to patients for diagnostic, therapeutic and research reasons. In all of these it is important to be able to measure quantitatively the radioactivity in a given location of the body or in samples of tissue or fluids from the body.

Since many aspects of radiation detection such as attenuation in tissue are dependent on radiation type and energy, an accurate knowledge of the decay schemes of the nuclides in use is essential. In particular, it is necessary to know the absolute fraction of disintegrations that involve a particular gamma ray. This is mentioned because often the abundance of gamma rays is given relative to each other rather than to the disintegration rate. Of course many other features of the decay scheme such as the energies and half lives are important but in general these do not involve a problem of the user not being abl e to find the information.

Activation Analysis

Activation analysis is applied in medicine both for in vit ro and in vivo measurements. In the in vitro applications it is used principally for the determination of the amounts and location of tracer elements. The in vivo applications also include studies of substances such as calcium, which are present in the body in relatively large quantities but which are difficult to determine quantitatively by other methods because they are in locations such as bone which are inaccessible and do not turn over rapidly enough to be studies by exchange methods for example.

Here, of course, the essential nuclear data are the neutron capture cross sections as functions of neutron energy.

Biological effects of radiation

In therapy, but also in all uses of radioactive materials, it

is necessary to be able to measure or compute the radiation dose associated with the procedure. In some situations dose calculations may become quite complex because a variety of factors in addition to the physical decay characteristics such as biological localization and turnover are also involved.

For internally distributed nuclides, again a knowledge of the decays scheme is essential. In addition to the gamma ray components, for dose calculations it is also necessary to have full information on beta-ray energies, Auger electrons, x-rays and any other component that can contribute to the dose. One difficulty in the use of available data that may be singled out as being most important (or at least annoying) is the specification of $\beta$ energies. In general only the $E_0$ is given, whereas what is needed for dose calculations is the $E_{AVE}$. In some cases, where $E_{AVE}$ has been determined experimentally, as by calorimetry, it is given but otherwise it is omitted. It is recognized that $E_{AVE}$ can always be computed from $E_0$, but the computation is a not-so-simple function of Z as well as $E_0$, is different for $\beta^-$ and $\beta^+$, and is dependent on whether the transition is allowed or forbidden. In the case of some of the forbidden spectra (for example Ra E, or $^{210}_{83}$Bi) the experimentally determined spectrum is substantially different from the hypothetical allowed spectrum. It would therefore be more reliable if an expert in the field would make the necessary calculations and make the $E_{AVE}$ available along with $E_0$ in the nuclear data compilations.

It may be mentioned that there is a committee of the Society of Nuclear Medicine, known as MIRD (Medical Internal Radiation Dose Committee) that evaluates decays schemes and presents the data in a form useable for internal radiation dose calculations.

Future applications in medicine may involve neutron, proton and $\pi$ meson beams directly, and all of the nuclear data pertinent to these

particles and their reactions with tissue and other target materials will become of interest in this field.

It should be emphasized that for users in the Medical area the nuclear data requirements are usually incidental to other principal problems and these users cannot keep up to date by the method of referring to the physics literature. Compilations are necessary for these users to have ready access to the required information. At present the principal references in use are the Lederer, Hollander, and Perlman Table of Isotopes, the K. Way et al, Frequent Use Tables, and the MIRD publications.

In response to a question of Phillips, Robertson stated that approximately 500 millirads of dose are necessary to determine a whole body calcium content. Bowman asked for a clarification on cross section requirements for 14 MeV neutron treatments, particularly in light of variations of expected dose with individual physical characteristics. Moore asked specifically if cross sections known with a 10% accuracy would be sufficient to do the neutron transport calculation. E. Smith stated that it was a question of cost vs. precision. Block noted that the objective should be to optimize all the accuracies but that the various sources of error are not clear. Wood inquired as to what is the variation in the calcium content in the normal people. Robertson replied that the calculations of calcium content depends upon the body build and there is no simple answer. The normal variation after normalization for such factors is roughly 5-10%. Furthermore, both absolute and relative determinations of calcium content are important.

In regard to the remarks in Robertson's contribution on $E_{AVE}$ vs. $E_0$ the variations between these numbers can be as great as 50%. However, both Smith and Horen felt that a substantial amount of data of this specific type is available to the medical worker and in particular a large number of absorbed dose calculations have been completed by Martin Berger of the NBS. A request for beta-ray absorbed

dose calculations to be forwarded to Berger of NBS was proposed but E. Smith questioned whether there was sufficient new data to justify such an effort.

E. Smith continued that it would be appropriate to summarize what medical researchers do with the dose data and how they obtain such data. Robertson replied that the dose is the limiting factor in the use of beta-ray radiation in biomedical applications.

In such applications the complete beta spectrum can be important.

It appeared clear to the Committee that Robertson was asking Committee aid, in funding dose calculations. However, Wood observed that the present needs of the biomedical research are not clearly spelled out. In his view, initially NDC should address itself to the question of availability of nuclear data and communication of information to the appropriate parties and only then consider further data compilation. Taschek suggested that it would be appropriate for an expanded subcommittee to prepare an extensive paper identifying the nuclear data problems and clarifying the present organizational funding structure problems. The problems are not clearly defined at the present time. Lide seconded Taschek's remark noting that the committee should have a more formal document to present to OSRD and DPR.

E. Smith began his presentation by announcing that he would send a set of MIRD supplements to the Journal of Nuclear Medicine, specifically concerned with the evaluation of nuclear decay schemes for internal radiation dose calculations. In addition, he would send supplements to the Journal which were concerned with calculations on dose rates. His subsequent remarks were concerned with the problem of radio isotope production. The major factor at the present time was cyclotron

radiation, and for such isotope production only minimal data was available for optimizing production. In a handout (presented as appendix E) he outlined potentially useful reactions for which cross section data was needed. He indicated that it would be desireable if the Nuclear Data Committee could stimulate the acquisition of this data thereby encouraging work in their own or other laboratories as well as bringing the data deficiency to the attention of granting and funding agencies. Newson noted that these cross section needs could go into the request compilation. The chairman stated that the committee has the authority to enter this kind of a request.

E. Smith reiterated earlier remarks that most decay scheme nuclear data, particularly the Hollander compilation, is not useful for biomedical purposes. His organization has carried out an appropriate compilation themselves directed toward their need for a radionuclide data. The principle deficiency in the Table of Isotopes compilation appears to be its failure to give absoulte intensities in place of the branching ratios.

Smith expressed a fear of future dependence on a national agency such as BNL in the case of BLIP production for obtaining radio isotopes. He observed that commercial companies have invested in the radioisotope business to provide a radio nuclide in useful and reliable form. He doubted that national agencies responded to such motivation. Taschek replied that commercial companies would acquire the material needed from BLIP and LAMPF and in fact would be the commercial sources. Furthermore, short lived times would not be a severe limitation on such an approach since heavy overproduction of sources could be used to compensate for the decay loss. Isotopes produced in this way should be available in about one year.

In response to an inquiry on the current status of efforts to meet cross section needs, Horen replied that Munsel in Germany is currently completing a compilation of charged particle reaction data. Wood indicated that about six cyclotrons in various hospital installations would address some of these measurements in the near future but that no organized effort was planned. Perey stated that E. Smith would be requested to serve

on the Isotope Subcommittee in view of the large use of stable isotopes for medical use. A New Action 13 was levied on Robertson requesting that he provide for the next NDC meeting a summary paper identifying the data problems in the biomedical area and outlining the current structure for funding the appropriate research.

ACTION 13
Robertson

Bob Wood declared that a symposium is needed to bring together users and compilers of nuclear data in the area of biomedical applications. He had raised this possibility earlier and felt that now was the time to begin planning for such a meeting. The Society of Nuclear Medicine is currently planning a meeting in Miami, on June 12—15, 1973. The organization of this meeting is under the direction of Gerry Freeman. If a symposium on nuclear data is to be held in connection with this meeting it is important to communciate the plans to him as soon as possible. One objective of such a symposium would be to outline specifically what data are now available to workers. The NDC would be asked to furnish speakers. Wood continued that it would be important to prepare a document to be published in the Journal of Nuclear Medicine after distribution at the meeting. In addition there should be a list of speakers who can talk in simple terms.

Wood suggested that the Symposium last approximately two hours with four speakers or two from each side followed by a summary panel. It would be appropriate to have representatives from possibly the Nuclear Data Project, NBS, and the Hollander Compilation Group. A New Action 14 was adopted on E. Smith and R. Chrien, to prepare a proposal for a Nuclear Data in Medicine Symposium to be held in connection with the meeting of the Society for Nuclear Medicine, June 12-15, 1973 in Miami. This proposal is to be forwarded to the Chairman for transmittal to the Society for Nuclear Medicine.

ACTION 14
E. Smith
R. Chrien

Taschek pointed out that at the Symposium on Applications of Nuclear Data to be held in Paris in March of 1973 speakers were needed

on the complementary side of the question. Papers for this meeting can be contributed quite late. The Chairman noted that the USNDC is represented on the program committee by W. Havens and that an abstract had been submitted by the USNDC on its responsibilities and expansion into non-neutron areas. It would be appropriate at such a meeting to develop the possibility of generating a request compilation directed specifically toward biomedical needs.

5. Activities of the U. K. Chemical Nuclear Data Committee

The Chairman reviewed the account of the work of the U. K, CNDC presented in the letter of 21 June 1972 to members of the INDC (see appendix F ). The present issue is whether the NDC should set up a request list of a similar character. Hemmig noted that there are many similar programs in DRDT of similar character . The efforts in these areas are not as yet coordinated, and the needs for data are not currently included in the request compilation. Programs exist at Aerojet General, General Electric and NBS, which are specifically directed at measurements of nuclear data by chemical means. Kolstad inquired whether it was relevant to be concerned with the method by which cross sections are measured. Chrien responded that the committee is concerned that techniques are not too far afield, in spite of the fact that the request list is not organized on this basis. A. Smith emphasized that we do not want another request list and that in fact much of the information included under the responsibility of the UKCNDC was already included in the U. S. request compilation. Alter added that a review of delayed neutron problems had been completed and would be available soon. Kolstad pointed out that where committee members know of appropriate reviews distribution can be arranged as an EANDC document. It would be appropriate to suggest to subcommittee chairmen that they consider for such distribution review papers in critical areas.

Gevantman observed that some of the activities of the UKCNDC are within the area of interest in the USNDC. It would be

appropriate to establish a contact with the UKCNDC. He suggested that if an EANDC representative is a member of the USNDC, that he act as a liaison making the Chemical Nuclear Data Committee aware of USNDC responsibilities and interest in this area. Kolstad suggested that in a similar vein it would be appropriate to establish contact with the Transplutonium Committee. He raised the question of whether nuclear data needs that bear on their interests should be entered in the request compilation. Moore replied that committee was interested only in the mass region above $^{242}$Pu and mainly in the chemical properties of those nuclides.

The final committee consensus was that the aims of the UK Chemical Data Nuclear Committee in promoting reviews should be investigated but that the USNDC should not break up a separate request list of the chemical nuclear data.

6. Charged Particle Compilation Efforts

Chrien read the letter of June 27, 1972 which he had written to E. Ritter of the DPR. The purpose of this letter was to correct the impression of the previous NDC meeting that there was not a serious need for a charged particle reaction compilation. Since that meeting he had become aware of a major need for a comprehensive charged particle compilation effort. Presently one-man year of effort is directed at this area at ORNL. Chrien cited the use of charged particle beams from small Van de Graffs for material analysis and impurity concentration profiles as evidence for the need for evaluated nuclear data and quoted a review paper by Nicolet et. al, on back scattering techniques as well as a letter from Zeigler (IBM) and J. W. Mayer (Cal Tech) which touched briefly on the needs for nuclear data. Horen suggested that one man, McGowan be designated to handle all charge particle questions. This would be the most efficient way to handle the problem and the data needs represent a very small area.

Taschek observed that the Biomedical Subcommittee would probably generate its own request for nuclear data needs and that the appropriate compilation should take place in McGowan's group. Horen observed that no one is currently doing biomedical compilations.

Taschek replied that it would be the purpose of the NDC to find ways to encourage the measurements needed, perhaps through the subcommittees. Caswell observed that the members of the Biomedical Subcommittee are competent to present requests for cross sections. Perey observed that the cross sections measurers on the subcommittee should have the necessary expertise. However, Bowman suggested that it would not be possible to cover all the concerns with the limited membership. Taschek proposed that the subcommittee structure of disipline area and program oriented subcommittees could meet this responsibility as the situation warrants. A charged particle subcommittee for example might review whether adequate contact between measurers, compilers and users exists. Kolstad proposed that the medium energy subcommittee be combined with the charged particle subcommittee. However, Newson stated that he sees needs for charged particle measurements at low energy, e.g. CTR requests and that such a subcommittee would be easy to consitute. Taschek noted that LASL is doing some limited evaluations of charged particle data and Perey added that CSEWEG is considering such data and has a subcommittee responsible for such data. A New Action 15 was adopted on Newson to proceed with formation of a charged particle subcommittee and where possible to draw upon University researchers for membership.

ACTION 15
Newson

IV. Review of NBS Programs

1. Role of the Center for Radiation Research-J. Leiss

Leiss pointed out that NBS has legislative authority for developing methods and standards of measurement including the investigation of radiation, radioactive substances, and x rays-their uses, and means of protection of persons from their harmful effects. Two of the objectives of CRR which stem from this responsibility are to provide the national quantitative basis for measurement of ionizing radiation and to develop and operate major radiation facilities for use by NBS, other agencies and appropriate non-government groups. The activities of the center are divided into four areas-theoretical radiation physics, health physics, applied radiation studies, and a radiation

physics section which includes programs on the 100 MeV linac, 3 MeV Van de Graaff, as well as other research installations. The research budget for CRR was in excess of $4 million per year with direct RTS funds at slightly less than $3 million per year. These numbers do not include new money for the neutron standards program. The total work force of the CRR is about 120 people.

Areas of national interest to which CRR programs are related include among others radiation environment and safety, medical applications of radiation, and environmental pollution. The radiation safety program on ionizing radiation includes maintenance of radioactivity standards, maintenance of absorbed dose standards for cancer therapy, studies of patient exposure and diagnostic radiology, and emphasis on measurement assurance in the field. On this last point, Leiss indicated that aid to laboratories in the field is a major and unique responsibility of the Bureau. NBS is able to obtain responses from institutions public and private, and to inform them of their performance, technologically. It is important that private institutions have this avenue to assess their performance without penalty for poor results. In this regard, NBS does evaluate instruments for insitutions as well as other agencies, but only on an individual basis. Commercial systems as such are not evaluated. The objective of the radioactivity standards program is to increase NBS production of radioactivity standards, provide tests of measurement systems, elaborate procedures for self evaluation, and conduct

As part of the environmental radioactivity program the center has conducted a round-robin in which mixed samples were distributed for evaluation in inter-laboratory comparisons. This typifies the tendency to go to the users problem and provide a means of testing the user himself. An objective of this effort was to get everyone on the same measurement base. The center is currently establishing regional calibration centers for x ray instruments.

A major effort is devoted to the development of new monoenergetic x ray sources for applied technology. Back angle production of x rays from electron bombardment is the primary source of monoenergetic x rays. This program has been quite successful in providing low intensity sources which are useful in detector calibrations, diagnostic radiology, materials studies, and explosives detection. The programs in intense pulse sources have not yet bridged the gap to the level of practicality. Here intense means a few thousands of amperes of elctron currents. Such sources are of interest in underground testing of weapons, weapons simulation, fusion research, high speed x ray diffraction, and explosion studies. In closing Leiss noted that the programs on the NBS linac are probably of particular interest to the committee. The linac program is a very broad one involving studies in the areas from medical dosimetry research to photonuclear physics and electron scattering.

2. Neutron Standards Program-C. D. Bowman

Bowman outlined a major expansion in the Neutrons Standard Program at NBS. The budget for this program which has been increased from $400,000 to $815,000 will permit the addition of 8 people to the measurement program. The major research facilities are a 3-MeV Van de Graaff recently transferred from Argonne National Laboratory, the 100-MeV electron Linac, and the NBS 10-megawatt reactor. The NDC had been instrumental in bringing about a $1 million appropriation for an above-the-ground neutron facility for the electron Linac. This facility will be fully operational perhaps late next summer. Construction will be finished late this year. Currently, the Linac is capable of only 1 ampere of peak current. A high-priority future addition will be a new injector which should increase this peak current capability by an order of magnitude. Development of the new injector, flight tubes for the neutron facility and computer data-reduction components will come in part from operating funds. The $415,000 increase in operating funds will be used in part

for these problems until the additional staff is hired.

Activities in various research areas, supervising scientist, and the staffing were as follows:

1. Neutron dosimetry—Caswell—one man year.
2. Integral measurements— Grundl—3.5 man years.
3. Basic reactor physics— Schroeder— 3.0 man years.
4. Linac research— Schwartz—6 man years.
5. Van de Graaff—Carlson—4.0 man years.

The total operating funding for these activities is currently at a level of $935,000 and the professional staff is approximately 11 Ph. D. scientists.

In the future the center hopes to carry out a program of differential measurements backed up by integral measurements. The NBS situation is unique inasmuch as a Linac, a Van de Graaff, and a reactor are available under one program. It is the intention to develop programs which capitalizeon this capability, and to attempt projects whcih require at least two facilities in the same laboratory. Taschek observed that Hannum's request in the area of neutron standards is finding its home in the program at NBS. In response to another question Bowman stated 40% of the Linac operating time would be devoted to neutron standards and that with a new data-acquisition system this should be completely adequate.

3. National Standard Reference Data System—D. Lide

Lide outlined briefly the essential features of the National Standard Reference Data System which is part of the NBS Information Program and is under the direction of the Office of Standard Reference Data. Over the year the Bureau of Standards had been given a mandate to support projects, coordinate efforts, and to encourage other agencies in the area of basic reference data. This mandate was formalized in 1968 when congress authorized the Secretary of Commerce to undertake this responsibility. The basic task of this program is to furnish basic reference data. A good example of hard scientific data is physical and chemical property data. This is a well characterized data area and the basic reference data needs are clear. At present the reference

data project is expanding to include more poorly defined data. In these areas the emphasis will be on critical evaluation of data and an indication of data uncertainties. This will be a decentralized program including efforts both at NBS and outside efforts at universitites and private laboratories. Objective of these cooperative efforts will be critical data compilations, bibliographies, one-shot data compilations and critical reviews. The Bureau is responsible for publication of the output and also for maintaining liaison with overseas groups active in data evaluation and compilation. The objective of this coordination will be to avoid duplication of effort. The primary output will be critical reviews and compilations. Already an NBS series under the key word, NSRDS-NBS, contains 40 titles. Publication of a refereed journal on reference data, the Journal of Physical and Chemical Reference Data, began this year and to date two issues have been published.

The NSRDS is divided into seven basic areas— thermodynamic and transport properties, colloidal and surface properties, solid state data, chemical kinetic data, nuclear data, atomic and molecular data, and mechanical properties. In addition to work in these areas the project has supporting services which include information programs and data systems design. Several projects of interest to the NDC are in the nuclear data division under L. Gevantman. They include: 1) photonuclear data center, 2) compilations of attenuation coefficients for x rays and $\gamma$ rays, 3) efforts in support of the Berkeley Particle Data Center, 4) support of the Berkeley Table of Isotopes Project, and 5) a compilation of nuclear moments. Lide added that a journal of reference data will periodically issue abstracts on new data compilations. Horen has suggested that it would be appropriate in this journal to also publish the index to the Nuclear Data Sheets now published regularly in Nuclear Data.

4. Intermediate Energy Neutrons Standards— J. Grundl

Grundl observed that energy-distributed neutron fields provide nuclear data test capabilities for critical assembles, and for this reason NBS supported an effort in this area. He began with a very brief discription of a new metal critical assembly for neutron energies

less than one MeV which was to be used in the LMFBR Program as an energy spectrum standard. He noted that the source driven systems have been over shadowed by critical assemblies, but that such systems have a special appeal as neutron spectrum standards. He described the new Standard Neutron Spectrum Facility, a spherically symmetric driven system whose source spectrum is the fission neutron spectrum of $^{235}U$. Various laboratories have used this system both in the United States and Europe. European users have obtained reproductable results with a 5% precision, and have proposed that this system be adopted as an international standard. This particular design uses natural uranium to transform a fission spectrum to the standard spectrum. In spite of the success of this design, Grundl expressed the views that only H, C, and $^{10}B$, should be used to modify a fission spectrum.

Measurements with the new NBS low mass, low volume $^{252}Cf$ source were described. In these measurements fission foils in a fission chamber are used as a detector and energy averaged fission cross sections are obtained. Corrections for scattering in the typical experimental configuration have been determined to be less than 3%. The particular appeal of this experimental technique is the ability to determine corrections such as neutron wall return by measurements in which the source geometry is changed. A major goal of the program is to develop a intermediate standard neutron field (ISNF). The effort is motivated by 1) the need for well characterized and permanently established neutron fields 2) the fact that at NBS existing facilities are appropriate and reduce the effort required to develop an ISNF.and 3) an ISNF is an appropriate complement to sources and fields already at NBS. The goals of the program are to develop a permanent ISNF system for the NBS Reactor Thermal Column, to characterize the field accuracy sufficient for validation experiments, to design the features that match requirements of reactor technology. It is expected that in addition to use as a basic neutron spectrum standard such a

facility will be used for measurements of energy averaged fission and capture cross sections. The ISNF will consist of a spherical cavity in an extended graphite moderator. With in the cavity will be a concentric spherical shell of $^{10}B$. Four fission foils placed symmetrically, at the outer edges of the cavity, will provide source neutrons. The central region will be the ISNF and a nv field of $\geq 10$ n/sec is expected with a gradient $\leq 2\%$. This arrangement will be installed in the NBS reactor thermal column.

One virtue of the system is the possibility of determining the fission spectrum and return spectrum by measurements with and without the $^{10}B$ shell. The goal is a FTR spectrum, however at present the spectrum is much harder. The system spectrum is a fair approximation up to 1MeV. In response to an inquiry about driving the system with $^{252}Cf$ or a different number of sources Grundl replied that an ISNF mock up on the NBS linac also will be attempted with the objective of determining the scalar neutron spectrum in time of flight measurements.

5. Nuclear Data need for Cancer Therapy—R. Caswell

Caswell pointed out that a recent interest in Cancer Therapy is neutrons with energies in the range $8 \leq E_n \leq 40$ MeV. This interest stems from experience at the Hammersmith Hospital in England where such radiation therapy is yielding encouraging results. In addition studies of radiation therapy with high energy protons are in progress in U.S., Sweden, and the USSR and planned at LASL with $\pi$ mesons. These new developments raise critical demands for theoretical dosimetry. The primary functions of the theoretical dosimetry are the interpretation of measurement, the predication of spatial distribution of dose, and determination of radiation quality, i.e. prediction of effect of different radiations. In this area generally calculation is easier then experiments with phantoms. One carries out major radiation transport calculations with the objective of developing interpretation codes which can be used at local centers with minicomputer installations. The weakness of such an approach is that calulations are limited in the complexites of the systems

that can be handled. Much data, e.g. stopping powers, are not adequately known. In addition characteristics of the incident spectrum are not always well defined. The objective of such calculations is to determine dosage with a precision of 5%.

The factors which must be known in the interpretation of measurements are the relations between detector reading and absorbed dose in the instrument itself, and the subsequent conversion to tissue dose. For example, typically a comparison of a calorimeter with an ionization chamber produces an agreement to 1%. By contrast conversion of instrument reading to dose on a single measurement at 10 rads/min. is in the range of 1-3%. This is the current state of the art in calorimetry. Other factors which must be known in interpretation of measurements are degree of perturbation of radiation fields by the detector and possible mixed field effects due to the presence of more than one type of radiation, ($\pi$, u, e, $\gamma$).

In establishing the spatial distribution of the absorbed dose characteristics of the radiation source, specification of the medium, and input interaction data are the critical factors. One of the major cross section problems at present is the inadequacy of neutron cross sections for higher energies. A recent experiment by Harder and Schultz is a measure of the state of the art for electrons. In this experiment they were able to obtain agreement within 5% between experiment and calulation of a dose rate in lucite as a function of depth. Caswell than reviewed the dose depth relationship for (d, d) neutrons; 2.5 MeV neutrons; and pion beams. He noted that calculations of the particle spectrum from stopped pions disagreed by as much as the factor of 5 in certain regions. In attempting to predict the affects of heavy recoils, $3 < Z < 7$, the situation is even worse. In these areas more nuclear data are definitely needed.

In commenting on the depth dose curves for a $\pi$ beam

Phillips noted that nuclear data are badly needed in this area. There is some indication that the star production curve may even rise at low depth. Fast pion cross sections are desperately needed, and the rising shoulder observed for small depths may be due to the 3, 3 resonance at higher energy.

The failure of theoretical approaches to describe radiation effectiveness can be attributed to the lack of a good general theory. Several models of energy dosimetry are currently in use, each suited to particular conditions but no general theory exists. 14-MeV neutrons are of much interest and for these conditions the most data are available. In this instance the energy distribution of recoiling charged particles is of importance as well as characteristics of the n, d and n, α reactions. In this area the critical need is for data on the stopping powers at low energies for heavy particles. Caswell closed with a curve showing the fractional dose from 14-MeV neutrons for a medium consisting of 3.14 micron diameter spheres. This choice of medium was related to the objective of determining the probability of destroying cells, and was chosen to illustrate the fact that energy absorbed is only the first approximation and that the ultimate objective is to understand the relative biological effectiveness of the various radiations.

6. Nuclear Physics Research at the NBS Reactor-I. Schroder

The 10 megawatt $D_2O$ moderated NBS reactor was described by Schroder. In addition to the radial beam tubes, two tangential beam holes traverse the $^{235}U$ core. One thermal column, one radial beam hole, and one tangential beam hole are devoted to nuclear physics experiments. The beam from the radial beam tube is split for utilization in the two experimental programs. The Harvard-NBS colloboration utilized the beam from the tangential facility. Recent experimental studies include a search for two photon emission in the n, p, capture process. In this measurement it was possible to place an upper limit for the cross section for this process of less than 1 mb compared to an expected value of 30 mb.

A major portion of the experimental effort is devoted to studies of fission. Because the ratio of symmetric to asymmetric fission is known to be spin dependent it is possible that the frequency of ternary fission might also be dependent on I. Schroder described a search for such effects in an NBS study of ternary fission. He noted that while in an old experimental study of fission the ternary, binary ratio was

not found to change in U, the ratio was observed to very strongly in Pu over the first resonance. In the measurement described at NBS energy selection of neutrons is accomplished by use of filters with a crude velocity selector. Fission in the $^{239}$Pu target is observed in a surface barrier detector which is shielded by an Al foil which absorbs fission fragments. From runs with and without the Al foil it is possible to determine the ternary/binary ratio. Runs at 3 energy conditions, subthermal, thermal, and resonance energy yield ratios between 500 and 515 indicating little change. In addition the ratio of α particles with energies less than 7.5 MeV to those with energies greater than 12.5 MeV does not change. All values of the ternary/binary ratio for $^{239}$Pu are consistent with the thermal fission value of 500.

The NBS group has also studied the angular distribution of alpha particles with respect to the fission fragments. Although the alpha particles tend to emerge at 90° with respect to the fragments directions, for higher alpha particles energies the angular distribution becomes more nearly isotropic. In studies of the correlation between the alpha particle energy and light fragment energy, a strong correlation was found in the alpha particle energy and the energy of the fission fragments for alpha particles emitted along the fission fragment axes. In particular the highest energy alpha particles appeared to be associated with fission fragments corresponding to symmetric fission. Phillips inquired whether the observed correlation could be attributed to phase space limitations. He emphasised that it is important to know the ratio $d\sigma(\perp) / d\sigma(11)$ for alpha particle emission since this quantity is strongly influenced by volume available in phase space. Moore pointed out that an experiment at Geel Deruytter claimed to make spin assignments by measuring ternary fission in $^{235}$U.

In closing Schroder. described one additional experiment carried out in collaboration with Stein and Hanson of LASL, a study of the average fission cross section of the $^{238}$U for neutrons emitted in

fission in $^{235}U$. This is the old Leachman Schmitt experiment.

7. Photonuclear Data Compilation and Evaluation — E. Fuller

Fuller updated an earlier description of the activities of the photonuclear data center at NBS presented at the NCSAC meeting of May 1971 (see NCSAC—37). He noted that as a result of the NCSAC recommendation support in the area of photonuclear cross section compilation had increased with the National Standard Reference Data System assuming responsibility for supporting the NBS compilation effort. In addition a NIRA associate has been assigned to the project for the next two years. One of the major outputs of the center is the Photonuclear Data Index and, to date, two supplements. The objective of this project is to formulate and maintain a current photonuclear data file which can be used as source material. The original index, NBS Miscellaneous Publication 277 covers data from data from January 1955 to January 1965. The two supplements cover data from 1965 to February 1970. A new data index has been prepared in draft form and covers all publications with a cutoff data of August, 1972. It is hoped to have a final version of this document in time for the Asilomar Conference which will cover all publications from 1955 to 1973. The intention is to publish this index in Nuclear Data A. All of the published data contained in the photoneutron index has been stored in the centers files and can be retrieved according to specific entries in the NBS photonuclear index.

The center does have plans for a compilation program. He noted that already a group at Lund had published a compilation of photonuclear data directed toward activation analysis under the title, Photonuclear Cross Sections. The authors are Bulow and Forkman. At present this compilation is available as a Nuclear Physics report No. LUNP—7208 and it will be published as a 55-page chapter in the book on activation analysis. In the center's survey of published measurements 311 targets were identified and 207 data sets. 256 isotopes are included in this body of data. The Lund group has compiled results for 55 of these cases. The NBS effort will attempt a complete description

of this data body. An atlas is planned which will present 5 types of data for each target—first curves of all pertinent cross sections in a 16 X 22 cm format, second resonance parameters which give gross fits for the cross sections for photons of less than 30 MeV energy, 3) sum rule values for the total absorption cross section weighted with various powers of the photon energy, 4) tabular cross section data over energy intervals of .5 MeV, and finally 5) tables of yield data for all important or useful reactions. The yield data will include bremsstrahlung weighted cross sections at energy points of 10, 15, 20, 25, and 30 MeV for total neutron yield and measurable activities. A total of 5 man years of effort is planned for completion of this compilation.

Goldstein noted that Abramov of the Institute of Physics and Power, Obninsk, USSR had circulated a report on a CINDA type compilation of threshold photoneutron data. A translation of this report would be of value as would a response to the proposal on the part of USNDC. Fuller indicated that the NBS Photonuclear Center is planning a response to the Soviet effort. He noted that this was a limited photoneutron index covering only cross sections in the region of threshold. The index included the same article as many as 10 times. He did not believe that a need for such an expanded nuclear data index existed. Kolstad indicated that this was the first case in which the Russians have asked for our comments and cooperation and an NDC response would be desirable. Jackson stated that the character of the compilation proposed was extremely detailed including entries for every piece of data, graph, table, etc. individually. Horen noted that the material is in the CINDA Index format and questioned why this choice. It also appeared to him that the detail of the compilation was excessive. A New Action 16 was adopted on Jackson, to obtain a translation of the Abramov document to circulate it together with a letter of comment.

ACTION 16
Jackson

8. Nuclear Physics with Electron Scattering — S. Penner

Penner began with a summary of the advantages of the electron scattering measurements. Electron scattering is a probe of the charge distribution of the ground state of the target nucleus. Because the electromagnetic interaction is a relatively weak and well understood the interaction can be calculated accurately. The major advantage of electron scattering is that the wavelength of the photon transfered can be changed at will by changing the angle of scatter of the incident electron.

Electro excitation of collective states in heavy nuclei is of strong current interest because the recently developed dynamic collective model makes a detailed predictions of the relevant cross sections. These experiments are quite difficult compared to the earlier work carried out on the light nuclei because very high resolution is necessary in the heavy nuclei to overcome effects of a strong radiative tail for elastic scattering and to resolve the narrowly spaced scattered electron groups.

The essential experimental information derived from these measurements are three form factors — a charge form factor, a transverse electric form factor, and a magnetic form factor, for each final state group. These form factors are related to specific matrix elements which can be calulated from the collective model. In excitation of vibrational and rotational degrees of freedom the L=2 exitation is easiest to excite. For spherical nuclei whose level sequence is given by the usual quadrapole spectrum the first excited state is strongly excited by electron scattering and in the case of $^{64}$Zn it was found that the second 2+ state also can be observed. This was not expected and has theoretical ramifications. The first experiments involved studies of four Zn isotopes and the results were interpreted by J. Lightbody who modified the current theory by allowing mixing of the phonon excitations, i.e., he introduced one additional parameter, a mixing parameter for 2+ states. With this change he was able to obtain agreement with the observed data and develop a technique for determining the quadrupole movement for excited states from the electron scattering data.

Nuclei with a rotator spectrum, e.g. $^{152}Sm$ have also been studied. In this case excitation of the first 2 + and 4+ states were observed. Form factors were determined for the first three levels by adjusting the skin thickness and the Hexadecapole moment to fit the data. The agreement between theory and experiment indicate that the rigid rotator model is quite satisfactory for the Sm targets and also for Tb. Experimental studies in progress are currently focused on $^{238}U$ and $^{232}Th$. In response to a question concerning monopole transitions as observed in a Japanese study of electron scattering by $^{90}Zr$ Penner replied that monopole transitions do occur but not at zero momentum transfer. He agreed with the Japanese conclusion that at low energies one can not distinguish between $E_o$ and $E_2$ excitations.

V. Compilation and Evaluation Activities

1. NNCSC—R. Dannels, Acting Director

Dannels, who is acting director in the absence of S. Pearlstein, on leave at Harwell, reported on the current activities at the National Neutron Cross Section Center. Dannels has been acting director for the last four months. Recently he has alternated one week at BNL and one week at his permanent position with Westinghouse Corporation in Pittsburgh. In his absence R. Chrien assumes the responsibility of Acting Director. Dannels announced that in an attempt to give an overview of the content of the ENDF files, all ENDF/ III data will be published in graphic form in a book of curves. As examples he passed out plots of data for $^{197}Au$ and $^{238}U$. Such global plots had already proved useful in making obvious discrepancies in the data. In particular for Au discontinuities in the total cross sections curves at 10 eV and $10^4$ eV make clear the discrepancies in the evaluated data. Dannels pointed out that previous to these plots the evaluator may have been unaware of the discrepancies. An additional discontinuity in the Au data at 1 KeV was attributed to a change in analysis from a resolved parameter involving discrete resonance values to an average cross section analysis. On subsequent plots the resolved region was explained in very much expanded detail. This book of ENDF /III curves will have limited

distribution in keeping with the present general restriction on distribution of evaluated data. The document is intended as a working paper for CSWEG.

The third edition of BNL-325 is in preparation. It will appear in two volumes, the first to contain resonance and thermal parameters. This volume will be 8-1/2 by 11 and will contain only recommended values.

As an example Dannels distributed material for resonance parameters of $_{44}Ru$. A complete bibliography will be presented at the end of the data tables and will contain all known data sources. The values for the neutron binding energies will be taken from published data. It was noted that the abbreviation for millielectron volts should be meV, not mV.

This type of desk-top aid is believed to be what most people want, however the center will be in a position to provide, upon request, all the data used in determining the recommended values. A typical readout of original data on all measured parameters for Os was distributed to the committee. Such distributions will be available upon request. Newson asked why the chemical symbol had not been used in the data retrieval in place of the atomic number, Z. Dannels agreed, after discussion, to correct this point (the committee unanimously backed Newson's position). In these retrievals, no evaluation judgement is made on the data presented. Such kits will be available both for resonance parameters and thermal parameters. When recommended values are known they will be included. All data will be in the data file, only redundant data will be eliminated. The computer version of BNL-325 will be a continuing file kept up to date as new data is received. Resonance and thermal parameter kits will contain all of the data currently in the file and a cutoff time will be given for evaluation.

BNL-325, volume II, will be a desk-top reference work patterned after the ENDF/III curves distributed to the committee. Depending upon the isotope and the character of the cross section the curves will include expansions of the initial plot. Data points may be included in these

plots but no attempt will be made to key data points to indvidual experiments.

Several comments were made by various committee members. Alter suggested that $\bar{\nu}$ plots should be linear in energy. Kolstad indicated his approval of the first-page overview plot and suggested that dotted average curve might be desirable. Newson elaborated that the user cannot obtain the average from the plots but the center has the data with which to calculate such an average. Perey replied that preprocessed average cross sections are available and that the dotted plots on the overview would be of doubtful utility because of difficulty in reading such plots with sufficient precision. Dannels stated that the ENDF/III files are being worked to obtain average cross sections but that the data must be synthesized correctly. Block noted that in general the ENDF/III file does not deal with actual data points.

Hemmig emphasized that unlike a volume II of BNL-325 which dealt with curves and experimental data, the volume of ENDF/III overview curves would have the limited distribution and would be issued as a BNL internal document for ENDF/B workers and ACRP. The curves are intended for use with the ENDF file and their possession will be based on direct and active involvement in CSEWG. The NDC should have no difficult in obtaining access to this information.

A. Smith, noting the dearth of information in the CSISRS files inquired as to whether the new edition of the BNL-325 would be based on the CSISR file contents. Dannels replied that the CSISRS file is now in much better shape than last May at the time of the previous NDC criticism. The new volumes of the BNL-325 will be based on the data file. A. Smith, then inquired about European data exchanges. Dannels replied specifically that the contents of the Helsinki Conference will be entered directly and will not be contingent upon four center exchanges. He added further that many of the format problems had been ironed out. A. Smith then inquired about the inclusion of the contents of CSISRS I in the data base. Dannel's reply that CSSRS I had first been

coverted into CSISRSII and then checked for consistency. The conversion had been completed and the corrections were still in progress. Forty tapes of data had been converted and of these forty, twelve had been checked for consistency. He indicated that in view of the concern and criticism expressed by the NDC at its previous meeting, efforts had been made with success to correct the deficiencies in the CSISRS file. The file was not as yet 100% complete and correct but is approaching it.

In commenting on the four centers meeting, Dannels noted that the question of evaluated data exchanges had been raised and in response seven sets of evaluated standards files had been sent to the Soviet and in response a file of evaluated data on $^{238}U$ has been received. Prince, of the NNCSC was currently reviewing the $^{238}U$ data file. The Chairman indicated that individual members should communicate their comments on the format of BNL-325 to NNCSC. Such comments would be gratefully received. In response to a final question by Dannels the committee indicated that the expanded plots of cross section data be very useful and should be included in any desk top compilation.

2. Nuclear Data Project

Horen reported that the nuclear data project in co-operation with NIRA planned to complete 40 mass chain compilations in the next year. A great deal of effort was being devoted to developing proceedures for checking the internal consistency of the compilation and pressure was being exerted on NIRA sponers to check the work of associates. By the end of 72 five compilations by NIRA associates will be published. A status report on the Nuclear Data project is presented in appendix G.

The project is attempting to develop interaction with applied users. Reactor designers are reexamining the data files for fission product and radioactive decay information and are making comparisions with the previous versions in their data file. Hemmig noted that CSWEG will enter the new NDP data into ENDF files for use in decay neat calculations. Horen requested that this fact be publicized. He also noted that the NDP is working with an effort to develop a revised biomedical tablulation through Wayne Snyder at ORNL. Where possible the project continues to answer other applications

inquiries. Horen agreed to furnish a tabulation of compilation efforts in the U.S. and throughout the world, (included as appendix H).

Kolstad inquired about the result of the meeting of the National Compilation groups at BNL. Horen noted that the NDP is working with the Berkley Compilation group and that up-to-date compilation of decay data is needed. The Berkley workers could handle this task if they ignored reaction data, but unfortunately they plan to include such data in their compilation. Horen stated that R. Heath of Aerojet Nuclear tabulates $\gamma$-spectra for applied areas. However, very few people are involved in that specific task and to his knowledge only one other European group is carrying out such a compilation for thermal neutron data. There are many compilations of $E_\gamma$ vs $I_\gamma$ for different specific areas, for example the need of geological survey projects. Heath is geared to meet the need of activation analysis, and at present there is no duplication between NDP and his effort. However, overlap with the Berkley project may exist.

Taschek pointed out that extensive files such as Heath's and others should be generally available. However, it was observed that the detectors involved in the Heath compilations are not standard and for this reason the data must be used with discretion. Kolstad stressed the need for a continuing series of meetings to cordinate compilation activities and the Chai rman affirmed that it is the function of the NDC to watch for duplication and to encourage co-operation.

3. WRENDA—Recommendations of Attree and Dunford. (26 Sept. 1972)

The Chairman agreed to circulate the minutes and recommendations of the Four Centers meeting to be held in Vienna, October 16-20, 1972. The proceedure of publication of WRENDA proposed by Attree and Dunford in the memo 4C-3/62 raised again the issue of national reviews of the request list. Chrien noted that the previous Committee consensus had been to not indulge in WRENDA reviews. He requested further comment on this point. Moore noted that information

on European and Soviet efforts is not generally available for NDC reviews. The advantage of getting complete world coverage would occur from NDC participation in the WRENDA review. Jackson commented that information on non-U. S. programs should be available through international data committees. Kolstad stated that our policy was to encourage the IAEA to put the request list together with a minimum amount of information. However, he noted that the IAEA had taken the position that they will conduct the reviews exclusive of the U. S. Some difference of opinion was evident in the following discussion about the availability of information.

Kolstad noted that the NDC routinely obtains status reports from all the INDC and EANDC member countries. He summarized the U. S. position as: publication of WRENDA should not be held up for review, and that U. S. Scientists should not be requested to review a compilation which is of marginal value. Furthermore, individual participation in such reviews should be discouraged. The Committee consensus was that the question of reviews should not be reopened at this time. In response to the request for increased exchange of information on non U. S. programs, Kolstad proposed that we give INDC—"G" distribution to "sanitized" USNDC subcommittee reports and request a similiar response on the part of the INDC. A New Action 17 was adopted on NDC members of the INDC and EANDC to provide to the USNDC full background information and when possible insure adequate information exchange between the USNDC and the international data committees.

ACTION 17
INDC and EANDC Members

In reference to the Dunford memo 4C-3/62 concerning the IAEA proposal for compilation of the World Request List for Nuclear Data, the NDC felt strongly that the proposed mode of information acquisition, storage and retrieval is hopelessly complex. The techniques outlined involved 9 types of card format for each type of request. Goldstein proposed that the NDC make a serious appeal for simplification of the proposal.

4. Philosophy of Evaluation

A. Smith had proposed this discussion topic in order to highlight the issue of nuclear data in a useful form. He emphasised that one should realize that the ENDF file is a neutronics calculation system, and noted

that new areas will put a heavy reliance on this system. The status of the data base and evaluations should be considered in the light of their use in peripheral areas. As an example he cited Nb evaluations which are an order of magnitude off the measurement scale. These data are currently being used by the CTR program. There are many such deficient areas. A second example is the data file on C for which energy discrepencies of 10 keV have been observed. The cross section community must give attention to this matter or users will be returning a few years hence with justified criticism of the system. Reviews of the system should be directed to programs presently using its services. Alter affirmed the validity of this observation, but noted that it is not easy to shift ENDF into another direction. Chrien observed that the ENDF global curve distribution may pin point some of these areas of difficulties. The thrust of the distribution is to encourage user feedback. Hemmig observed that the comments on Nb indicate a communication gap at ANL and suggested that niobium be reevaluated for ENDF/IV.

Taschek suggested that interested projects should tune up to assess the utility of the file for their needs. Kaul noted that DNA and DMA found advantages in contributing to the ENDF effort. Such participation influenced the data formats toward meeting their needs. Such participation by CTR might be appropriate now. In this regard, he also noted that a substantial interlocking of the programs might be appropriate. Taschek stated that the framework had been setup, spadework had been done, and that each program must establish the adequacy for their purposes. Kolstad questioned whether this issue is sufficently important to call to the attention of the CTR program. Chrien replied that distribution of the ENDF III curves may go along way toward resolving this problem.

5. CINDA

Goldstein indicated that CINDA-72 had gone to press in June of 1972 and that 3 or 4 copies were available in the United States at the present time. There had been two reasons for delay. The IAEA had been 2 months behind in preparing CINDA-72, and further delay in the bulk shipment had occurred as a result of dispute over payment of shipping charges. He announced that CINDA-72, supplement I, has now gone to press.

VI. Meetings

1. INDC Meeting , Vienna, July 1972.

In response to the request of Kolstad the Committee reviewed and recommended responses to actions of the INDC on the U. S. members. The action list is included as Appendix T. The comments for recommended response to the individual actions are tabulated below.

Action 9—Havens had the appropriate data.

Action 17—Smith will request that Poenitz forward to Schmidt a pre-meeting copy of all data $^{235}U$ fission cross section area that has been assembled for presentation.

ACTION 18
Caswell
Standards
Subcommittee

Action 18—A New Action 18 on Caswell and the Standards Subcommittee was adopted: assist INDC members in implementation of INDC action 18 on non neutron standard reference data.

ACTION 19
Alter

Action 19— New Action 19 on Alter was adopted; assist INDC members in implementation of INDC action 19 on reaction data needs for flux measurements and include a list of the relevant reactions in the next subcommittee report.

Action 25—This subject, $\bar{\nu}$ , will be the review topic at the next EANDC meeting to be held November 27 and to be attended by Havens,Chrien, Kolstad, and Smith. Bowman stated that LLL and ORNL should be contacted and relevant data forwarded to Havens.

Action 28—Referred to Dannels, NNCSC

Action 31—Expired

Action 38— New NDC action 28 fulfills this obligation. The chairman noted in this regard that the McNally request list would be included in the new edition of RENDA and should be entered in our lists.

ACTION 20
Alter

Action 40— New Action 20 on Alter was adopted to assist INDC members in completing INDC action 40 by forwarding a report on the use of clean inegral measurements for evaluating nuclear data files.

Action 42— Moore noted that the Russians will not participate in a world wide evluation news letter, unless there is free

exchange of evaluated data. Such a letter persumably would be an expansion of the present Ribon letter. Moore moved that the U. S. take the position that there is no clear advantage to participation in a world wide newsletter at this time. The motion was adopted.

Action 48—Completed

Action 49—Completed

Action 50—This is a continuing obligation on the USNDC.

Action 51—Does not apply.

Action 52—Does not apply. Moore noted that a letter accompanying the McNally request list from the Fusion Research Council stated the IAEA plans to solicit requests from individuals. This countradicts the understanding that the IAEA is expected to work through government agencies. Kolstad noted that this raises the question of a proper U. S. Screening procedure. A New Action 21 was adopted on the CTR, Material Environmental and Safeguard Analysis, and the Nuclear Data in Medicine subcommittees, to recommend appropriate screening proceedures for data requests in these areas.

ACTION 21
CTR, Mesa NDM Sub-committees

Action 57—The Russians have proposed a symposium on high energy neutron sources, possibly to be held in Kiev. Chrien noted that no strong need was evident in the discussions at Budapest for such a meeting, and that no new ideas at this time appeared to justify such an event. However, possible topics for such a meeting might include WNR or the KING facility at LASL. Bowman mentioned a 2000 amp. accelerator that Leiss is constructing at NBS. This facility, similar in concept to the LLL Astron facility and generates an intense 1 MeV electron pulse which by addition of more modules can be extended to much higher energies. The New Action 22 was adopted on all members to submit to Kolstad comments on a proposal for a high intensity neutron source symposium.

ACTION 22
All Members

Action 58—No comment.

2. Nuclear Structure Study with Neutrons, Budapest, July 31, 1972

The Chairman stated that although representation from the United Kingdom was very disappointing East West interaction had been effective. The proceedings for the conference will be published probably early next year. Bowman inquired about recent developments in isomeric fission. Moore replied that the conversion electron spectrum of the shape

isomer of $^{240}$Pu was presented formally at the conference as part of a review. Details were discussed in the hallway afterward.

3. Conference on Particle Accelerator and Radiation Therapy, LASL, October 2-4.

The intent of the conference had been to bring together three type of people, radio-therapists, radio-biologists, and physicists. In this respect the conference had been sucessful. Kolstad noted that a lecture by Mills on "reinventing the wheel" had broken the ice and led to a much more sucessful discussion. He pointed out that the sucess of the meeting had demonstrated the need for such events in other areas to focus on the nuclear data aspects of appropriate problems.

4. Four Center Meeting, Vienna, October 16-20, 1972.

The Chairman agreed to distribute a summary of the proceedings of this conference to the NDC members.

5. Panel on neutron Standard Reference Data, Vienna 4 Nov. 1972

This meeting had been discussed briefly under Agenda Item VI-1 in connection with INDC Action 17.

6. EANDC Meeting, Paris, Nov. 27-Dec. 1, 1972.

No Discussion

7. International Conference on Photonuclear Reactions and Applications, As ilomar, 26-30 March 1973.

No Discussion

8. Symposium on Application of Nuclear Data in Science and Technology, Paris, March 12-16, 1973.

The Chairman announced that Havens, Kolstad, and Chrien, had submitted an abstract for this meeting in the name of the Nuclear Data Committee. This abstract entitled The Expanding Role of the United States Nuclear Data Committee is included as Appendix J and describes the recent organization and activities of the NDC.

9. International Conference on Nuclear Back Scattering and Microanalysis of Thin Films, 21-23 May.

Developments leading to the organization of this meeting had been discussed under Agenda Item III-6.

10. Internation al Conference on Nuclear Physics, Munich, Germany, 27 August-1 September, 1973.

No Discussion

11. Specialist Meeting on Fission Product Nuclear Data, 1973.

ACTION 23
All Members

The chairman requested a New Action 23 on all members to forward comments on the proposed 1973 IAEA specialist meeting on fission product nuclear data by November 5.

12. Third IAEA Conference on Nuclear Data for Reactors, 1974.

The phrase "for reactors" had been dropped from the title for this conference. NDC member, Havens, has been appointed to serve on the program committee for this meeting and will attend its first meeting to be held before EANDC meeting in Paris at the end of November. A New Action 24 was adopted on all members to forward comments on the agenda for the proposed third IAEA conference on nuclear data to the chairman as soon as possible.

ACTION 24
All Members

13. Texas Symposium on the Technology of CTR, Austin, 20-22 Nov., 1972.

No Discussion

14. Fourth International Conference on Shielding, Paris, October 1972.

Goldstein indicated that the discussion and agenda of this conference had been dominated by questions of cross sections. For the first time it had become possible to make large scale calculations with some hope of representing the real world. As a result of the discussion at this meeting Schmidt had agreed to set up an IAEA panel meeting in July 1974, the objective of which is to produce a position paper on the needs for neutron shielding. Conference comments indicated the existence of sensitivity experiments and calculations in the United States,

Europe and Russia. These efforts appear to be directed toward completion for the 1974 IAEA Conference on Nuclear Data.

15. National Soviet Conference on Neutron Physics, Kiev, 28 May-3 June, 1973.

The chairman then requested any information on additional meetings of interest. Block indicated receipt of an announcement of the National Soviet Conference on Neutron Physics to be held in Kiev, from May 28 to June 3, 1973. He forwarded to the secretary for distribution to committee members an announcement of the meeting and the topics of the conference. Kolstad suggested that an American representative should attend to keep the U.S. aware of current Soviet efforts. Smith indicated that three Argonne workers had received invitations but that their attendance was still uncertain. In response to an inquiry a New Action 25 was adopted on Rogosa to furnish USNDC members with announcement for the 1973 Rochester Fission Conference.

ACTION 25
Rogosa

VII. USNDC Status Reports.

1. Comments

Moore cited new measurements of the Fission Neutron spectra of $^{238}U$, $^{235}U$, $^{239}Pu$ reported in the LASL status report. This work was motivated by recent reports of discrepancies in the observed Fission Neutron Spectra as reported in the report UKNDC (72) P.37, page 16. Such affects are not observed in the new data reported by the LASL group. In particular the nuclear temperatures observed for the Fission Spectra $^{238}U$ and $^{239}Pu$ are in good agreement with earlier accepted values.

Chrien announced that the Nuclear Cryogenics Group at BNL using the transmission of polorized neutrons had been able to determine definitively spin assignments for 11 resonances in $^{235}U$. The results are contained in the BNL status report. A comparison with a large body of earlier experiments attempting assignments of J values indicate that the only reliable assignments appear to be those obtained by Coceva using a technique involving the observation of low

energy capture $\gamma$ rays. He also announced that a new 25 keV filtered neutron beam had been installed at the HFBR reactor and that at the current time a flux of $10^5$ n/sec was available with an energy spread of 2.5 keV. The hot chemists at BNL are interested in using this facility.

2. Scope of Status Reports

Kolstad began by proposing that the status reports be organized along a disciplinary line and that reports be included from data compilation groups. Block suggested that an alternative to reorganization of the reports would be indexing of the contributions according to dicipline. This would facilitate the preparation of the final document by the secretary. Bowman suggested that an application oriented reorganization would be a possible alternative. After considerable discussion it was decided to continue with the present indexing for the next edition of the status reports, defer format changes, but expand the list of institutions solicited for contributions and expand the request to include nuclear data for applications in non-neutron and non-fission reactor areas. A New Action 26 was placed on the secretary to expand the request for contributions to the status reports to reflect non-neutron nuclear data applications and activities of data compilation centers. New Action 27 was adopted on the Secretary to investigate the feasibility of a general indexing of the status reports according to discipline and application.

ACTION 26 Secretary

ACTION 27 Secretary

3. LAMPF: Weapons Neutron Research Facility(WNR)

At present, Title I design for WNR is roughly 75% complete; Title I Review is scheduled to begin during the week of November 6, 1972, and will last about 1 month. Completion of the facility is still estimated as September 1974. The present design configuration is shown in Figs. 1 and 2.

Figure 1 shows the switchyard area; the bending magnets have a maximum field of 3.85 kG, which will permit either $H^+$ or $H^-$ beams to be piped south of the road to WNR. (The $H^+$ beam piping will be done on a timesharing basis; $H^-$ piping involves sole use of the accelerator under the present configuration.)

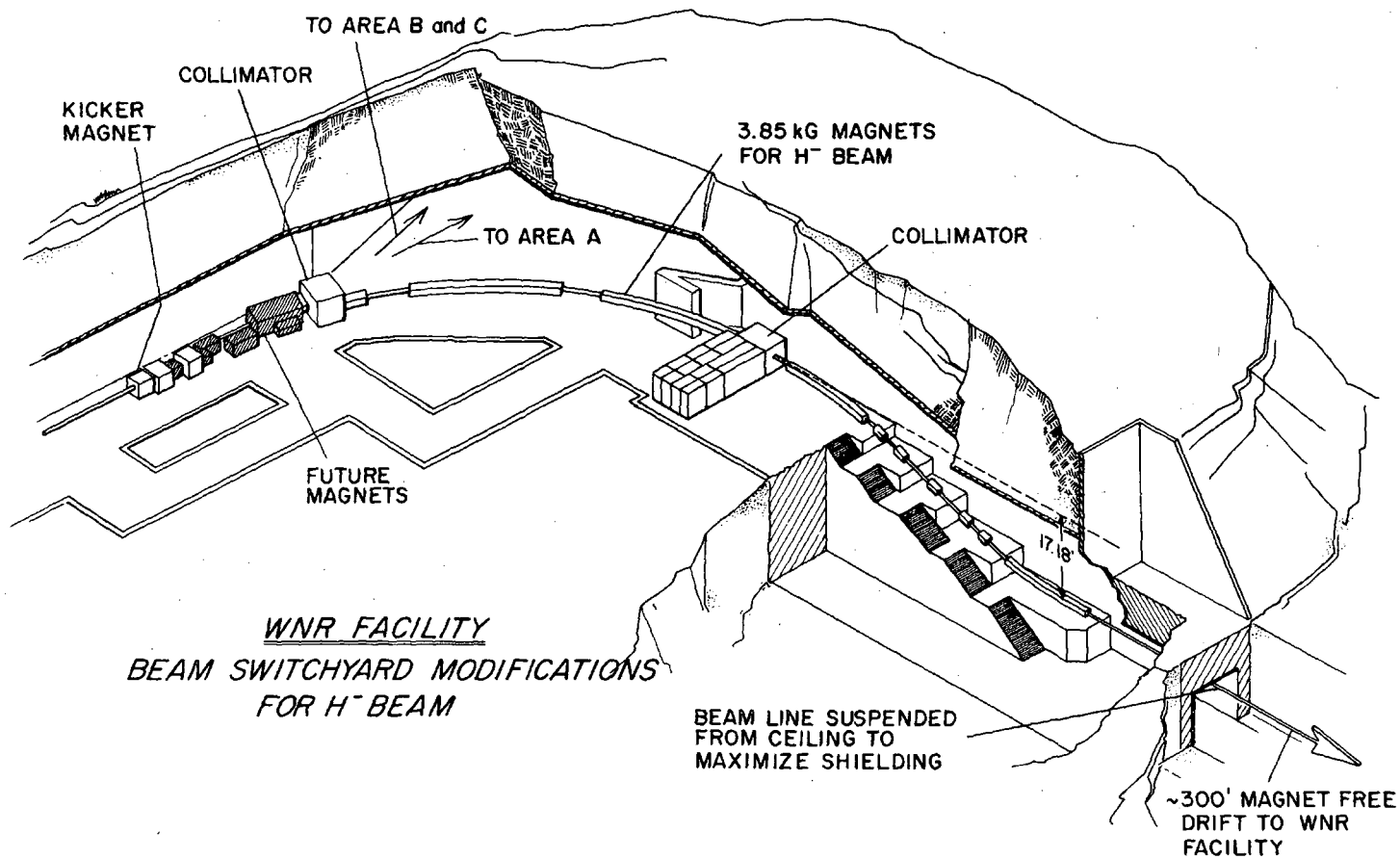
TO AREA B and C
COLLIMATOR
KICKER MAGNET
3.85 kG MAGNETS FOR H⁻ BEAM
TO AREA A
COLLIMATOR
FUTURE MAGNETS
17.18°
WNR FACILITY
BEAM SWITCHYARD MODIFICATIONS FOR H⁻ BEAM
BEAM LINE SUSPENDED FROM CEILING TO MAXIMIZE SHIELDING
~300' MAGNET FREE DRIFT TO WNR FACILITY

Fig. 1

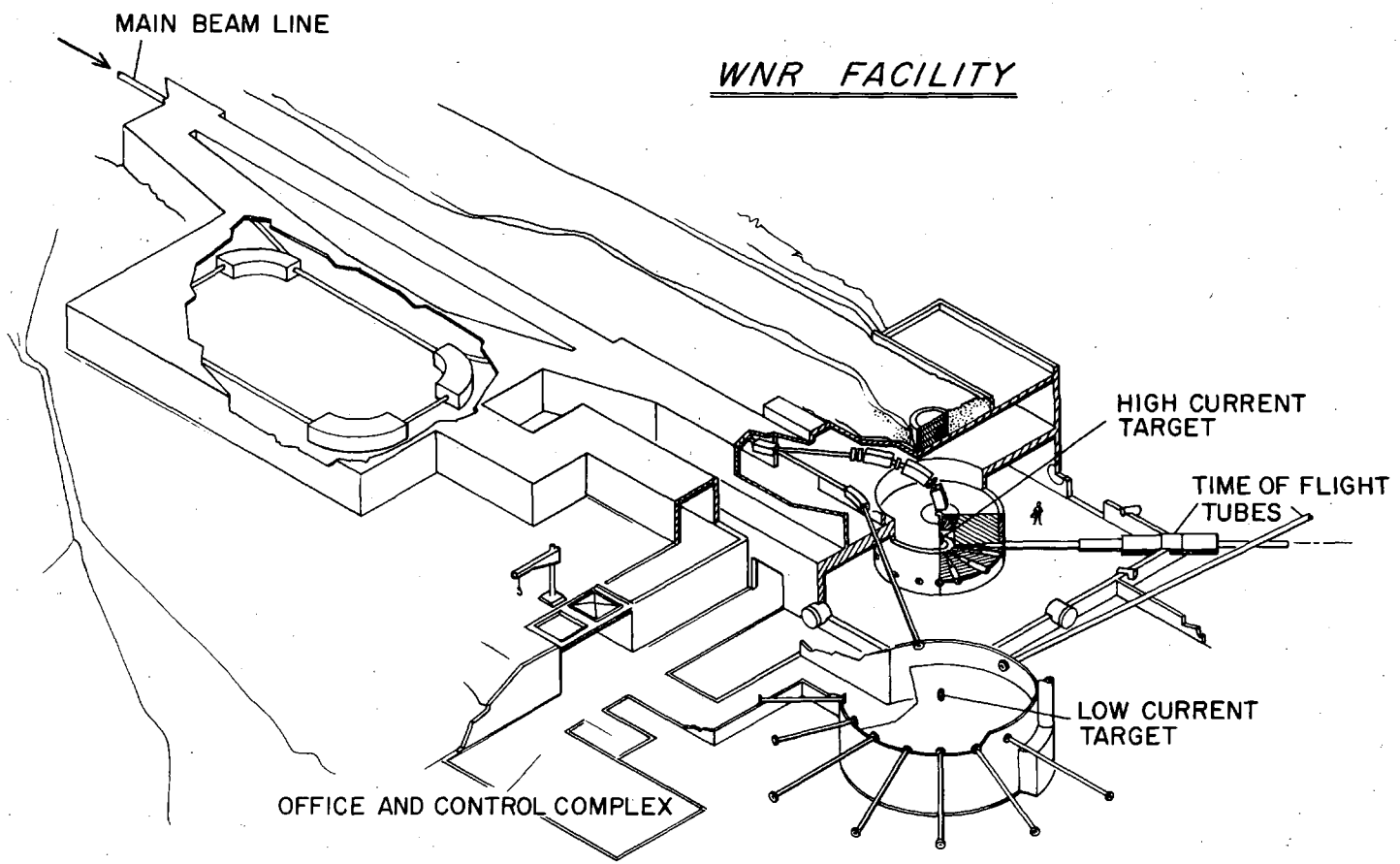
MAIN BEAM LINE
WNR FACILITY
HIGH CURRENT TARGET
TIME OF FLIGHT TUBES
LOW CURRENT TARGET
OFFICE AND CONTROL COMPLEX

Fig. 2

Figure 2 shows the WNR facility. Two target areas are shown. Target 1 is designed for one percent of the full $H^+$ accelerator beam, and has a 12-ft-thick shield (mostly iron) to permit experimentalists to be in the area while the beam is on. Twelve flight tubes will be available, ranging from 4 to 200 m in length. Target 2 is designed for lower intensity work, for example for high resolution: a single micropulse and a thin neutron-producing target. With the 100-m flight path shown, the highest resolution will be about 2.5 psec/m. Target 2 is provided with flight tubes through the earth , so that one can take advantage of the enhanced high-energy neutron spectrum at forward angles, if desired.

VIII. Reviews and Recommendations

1. IFRC Priority Criteria for Fusion Requests

Kolstad had requested USNDC comments on a response to Action 38 of the INDC on Kolstad to inquire regarding the adoption of the priority criteria approved by the IFRC and the possible resubmission of an official U. S. fusion request list using these priority criteria before the end of 1972. It was recommended that the USNDC not adopt the criteria at the present time but refer the question to the CTR subcommittee for discussion. It would be appropriate to hold both the request list and the assigned priorities in abeyance until sensitivity tests are completed (sometime off). Taschek noted that in the meantime execution of the experiments could be a local question. Moore observed that the present priority assignments are not compatible with the standards used other areas. Taschek noted that because of the long lead time, it was important not to defer measurements of potentially usful data. Steiner reiterated that the CTR subcommittee should consider the priorities, particularly since needs are not clear at the present time. Steiner recommended further that if possible priorities be deleted from the present CTR request list. In the event that this was not possible he would be happy to see priority 3 assigned to all requests. However, various committee members expressed concern over the implications of downgrading priorities. Such a development would weaken the case for beginning new measurements in this area. Smith noted that the data base for sensitivity studies in the CTR program bugets only $60,000

for neutron research and that they must do what is realistic within this limitation.

The committee consensus was that all CTR requests should be submitted to the U. S. request compilation as they stand but with priorities left blank in the local request list. The CTR request list should also be transmitted as it stands to the IAEA but with the understanding that the proposed priority criteria of the IFRC will not be accepted at the present time. A New Action 28 was adopted on the Chairman to advise DPR of the USNDC recommendation on disposition of CTR requests for RENDA and deferral of a decision of the IFRC criteria for CTR priorities.

ACTION 28
Chairman

VII.

# APPENDIX A

## USNDC SUBCOMMITTEES
October 1972

**Separated Isotopes**
F. Perey, ORNL, Chrm.
W. M. Good, ORNL
H. W. Newson, TUNL
R. C. Block, RPI
G. L. Rogosa, USAEC
G. A. Cowan, LASL
E. M. Smith, U Miami

**Charged Particles**
H. W. Newson, TUNL, Chrm.

**Standards**
R. S. Caswell, NBS, Chrm.
W. W. Havens, Col.
W. Poenitz, ANL
L. Stewart, LASL
B. Leonard, PNL

**Elastic and Inelastic Scattering**
A. B. Smith, ANL, Chrm.

**Gamma-ray Production**
H. E. Jackson, ANL, Chrm.
H. Motz, LASL
R. E. Chrien, BNL
J. K. Dickens, ORNL
V. J. Orphan, GRT

**Total Capture Cross Sections**
R. L. Macklin, ORNL, Chrm.
R. C. Block, RPI
M. P. Fricke, GRT
W. Poenitz, ANL
J. B. Czirr, LLL

**Fission**
M. S. Moore, LASL, Chrm.
C. D. Bowman, NBS
G. de Saussure, ORNL
J. C. Brown, LLL
W. G. Davey, ANL

**Photonuclear Reactions**
C. D. Bowman, NBS, Chrm.
E. G. Fuller, NBS
T. Godlove, NRL
W. Miller, U Notre Dame
R. L. Bramblett, GRT
B. L. Berman, LLL

**Resonance Parameters, Resonance Integrals, and Total Cross Sections**
R. Block, RPI, Chrm.

**Fast Neutron Reactions**
H. Alter, AI, Chrm.
D. Barr, LASL
D. Gardner, LLL
J. L. Brownlee, LLL
G. Butler, LASL
D. L. Smith, ANL

**Medium Energy Cross Sections**
R. E. Chrien, BNL, Chrm.
D. Cochran, LASL
G. C. Phillips, Rice U

**Controlled Thermonuclear Research**
D. Steiner, ORNL, Chrm.
H. Goldstein, Col.
D. Dudziak, LASL
C. F. Barnett, ORNL
V. Orphan, GRT
L. Stewart, LASL

**Nuclear Data for Materials and Environmental Analyses**
D. J. Horen, ORNL, Chrm.
F. McGowan, ORNL
G. Gordon, U Maryland
J. Mayer, Cal. Tech.
T. Cahill, U Cal., Davis

**Biomedical Applications**
J. S. Robertson, BNL, Chrm.
E. M. Smith, U Miami
G. L. Brownell, Mass. Gen. Hosp.
J. S. Laughlin, Memorial Hosp. NY
R. J. Shalek, M. D. Anderson Hosp., Houston
R. S. Caswell, NBS
D. J. Horen, ORNL

APPENDIX B

## ACTION ITEMS

| | |
|---|---|
| Action 1<br>Subcommittee Chairmen | Forward to R. E. Chrien within 30 days final subcommittee membership lists for circulation among the NDC membership for final approval. |
| Action 2<br>Goldstein, all members | Maintain a compilation of cross section discrepancies listed in order of importance to the Nuclear Energy Program with the assistance of committee members and direct the attention of concerned parties to the list and solicit their comments. |
| Action 3<br>Perey | Write a one-Paragraph warning to be incorporated into the standard isotope request form with regard to activation and forward to George Rogosa. |
| Action 4<br>Perey | Forward to the secretary the elemental sample inventory list presently held by the isotope subcommittee. |
| Action 5 | Include a list of elemental inventories and their location in the technical minutes of NDC meetings. |
| Action 6<br>Perey | Investigate the response of the Isotopes Division to NDC Action 9 of May 1972. |
| Action 7<br>Chairman | Draft a consensus letter reflecting the response of the committee to the NAS-NRC recommendation by November 10. |
| Action 8<br>Perey | Complete with L. Love a reassessment of calutron unit costs under full computer operation and report the results at the next committee meeting. |

APPENDIX B

ACTION ITEMS
(Continued)

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|---|---|
| Action 9<br>Perey | Circulate among the NDC members a complete list of the by-product isotopes in storage with a recommendation on how to make this inventory available and also circulate a copy of the Soviet offer to sell $^{57}Fe$ to ORNL. |
| Action 10<br>Isotopes Subcommittee | Form a recommendation for the disposition of unprocessed calutron material so that this national resource can be made available to U.S. Scientific programs. |
| Action 11 | Review and normalize status comments in the subcommittee reports to NCSAC-35 and to forward the revised document within three weeks, by November 15, to the chairman. |
| Action 12<br>Chairman | Transmit a formal letter to NNCSC expressing the consensus of the NDC on the possible publication formats for the request compilation. |
| Action 13 | Provide for the NDC meeting a summary paper identifying the data problems in the biomedical area and outlining the current structure for funding the appropriate reasearch. |
| Action 14<br>E. Smith<br>R. Chrien | Prepare a proposal for a Nuclear Data in Medicine Symposium to be held in connection with the meeting on the Society for Nuclear Medicine, June 12-15, 1973 in Miami. This proposal is to be forwarded to the chairman for transmittal to the Society for Nuclear Medicine. |
| Action 15<br>Newson | Proceed with formation of a charged particle subcommittee and where possible to draw upon University researchers for membership. |

APPENDIX B

ACTION ITEMS
(Continued)

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| Action 16<br>Jackson | Obtain a translation of the Abramov document circulate it together with a letter of comment. |
| Action 17<br>INDC and EANDC Members | Provide to NDC members full background information and when possible insure adequate information exchange USNDC and the international data committees. |
| Action 18<br>Caswell<br>Standards Subcommittee | Assist INDC members in implementation of INDC action 18 on non-neutron standard reference data. |
| Action 19<br>Alter | Assist INDC members in implementation of INDC action 19 on reaction data needs for flux measurements and include a list of the relevant reactions in the next subcommittee report. |
| Action 20<br>Alter | Assist INDC members in completing INDC action 40 by forwarding a report on the use of clean integral measurements for evaluating nuclear data files. |
| Action 21<br>CTR, MESA NDM Subcommittees | Recommend appropriate screening procedures for data requests in these areas of CTR, materials analysis, and biomedical applications. |
| Action 22<br>All Members | Submit to Kolstad comments on a proposal for a high intensity neutron source symposium. |
| Action 23<br>All Members | Forward comments on the proposed 1973 IAEA specialist meeting on fission product nuclear data by November 5. |
| Action 24<br>All Members | Forward comments on the agenda for the proposed third IAEA conference on nuclear data to the Chairman as soon as possible. |

APPENDIX B

ACTION ITEMS

(continued)

| | |
|---|---|
| Action 25 | Furnish USNDC members with announcement for the 1973 Rochester Fission Conference. |
| Action 26<br>Secretary | Expand the request for contributions to the status reports to reflect non-neutron nuclear data applications and activities of data compilation centers. |
| Action 27<br>Secretary | Investigate the feasibility of a general indexing of the status reports according to discipline and application. |
| Action 28<br>Chairman | Advise DPR of the USNDC recommendation on disposition of CTR request for RENDA and deferral of a decision of the IFRC criteria for CTR priorities. |

APPENDIX C

# NATIONAL RESEARCH COUNCIL

NATIONAL ACADEMY OF SCIENCES NATIONAL ACADEMY OF ENGINEERING

2101 CONSTITUTION AVENUE WASHINGTON, D.C. 20418

DIVISION OF PHYSICAL SCIENCES

COMMITTEE ON NUCLEAR SCIENCE

MEMORANDUM

TO : D. Allan Bromley

FROM: Herman Feshbach and Gertrude S. Goldhaber

RE : August 10th Meeting on Nuclear Data Compilations

A meeting on Nuclear Data Compilations was convened by the NAS-NRC Committee on Nuclear Science, D. Allan Bromley, Chairman, on August 10, 1972, at the Joseph Henry Building, Washington, D.C. The participants and their affiliations are listed in the attached Appendix B.

The participants reviewed the needs for nuclear data, the present nature, history and funding of nuclear data projects both here and abroad, and proposed measures aimed at strengthening the U.S. Nuclear Data Program. It was generally agreed that:

(1) there is an essential need for evaluated nuclear data for nuclear science and basic nuclear physics. The study of nuclei generally required a systematic study of nuclear properties using many types of probes and reactions. Data compilation is essential for the extraction and verification of fundamental laws and for developing models governing nuclear behavior. Because of their predictive power these results are significant not only for basic nuclear science but for many applications as well;

(2) there is an important need for evaluated nuclear data for use in a wide variety of technical areas including reactors, biomedicine, industry and environmental management, as well as in scientific fields ranging from basic nuclear physics, astro- and space-physics, biology, chemistry, oceanography, etc., to archaeology. The special and urgent nature of the needs for nuclear safeguards, defense, space and reactor application was recognized. The sophistication of the data required may not be known for some of these applications;

(3) there is an important need for improved communication and interaction among the producers, compilers and users of nuclear data. For this reason great advantages would accrue to the U.S. nuclear program if nuclear data efforts were such as to satisfy the needs of all of nuclear science, basic as well as applied. Some decentralization of data compilation

# APPENDIX C

Research, in consultation with the NBS, appoints the members of the USNDC from AEC contractors and federal agencies having a major interest in nuclear science. The effectiveness of the USNDC would be improved if its national character were more explicit. At the very least the restrictions on the membership of the Committee should be lifted so that any individual having the necessary competence and interest is eligible. A broadening of the agencies to which the USNDC is responsible is similarly suggested. In particular, the NSF should be given a more explicit role since it plays an important part in the funding of nuclear science and thus in the production, compilation and exploitation of nuclear data.

(3) That liaison be established with professional groups active in nuclear science such as the Division of Nuclear Physics of the APS and similar units in the ACS, as well as with user-oriented societies. This is of importance for the improvement of communication and interaction among producers, compilers and users of nuclear data.

(4) A broader participation of university based nuclear scientists directly involved in the production and application of nuclear data. With regard to points (3) and (4) it should be noted that the present Committee because of historical reasons reflects applied needs and neutron physics. Its membership is taken for the most part from national laboratories and other user organizations. The participants agreed that inclusion of the data required by the basic science community would necessitate some changes in both the structure and membership of the USNDC. It is therefore recommended that

(5) The Committee be reconstituted and/or appropriate subcommittees be appointed in order to reflect the expanded scope of the Committee's operations and its expanded constituency. The Committee should encourage the participation of all interested agencies to help insure that the various channels for funding data compilations efforts remain available and are exploited.

These specific suggestions demonstrate the conclusion of the ad-hoc group that a single committee to oversee both the basic and applied aspects of nuclear data production and use would be desirable. This may require some changes in the "Operational Guidelines" for the USNDC, the details of which the ad-hoc group did not explicitly discuss.

## APPENDIX C

involving the producers of data in the process of compilation was considered beneficial in spite of some resulting inefficiency;

(4) the future may bring new needs for evaluated nuclear data. Immediate examples which come to mind are the field of biomedicine and the CTR program. The development of data not immediately needed in applied programs but which may be of importance later require the inclusion of basic nuclear information in the data compilation effort.

Considerable discussion was devoted to a mechanism through which these general needs could be met. It was felt that the data compilation effort should be a national effort. It should therefore involve participation of all the concerned government agencies, of all concerned nuclear science groups, the chemists, the biomedical people, the reactor physicists, the university research teams as well as those based at national laboratories. It was recognized that it will not be possible to treat certain governmental needs, for example those of the reactor division of the AEC and the Defense Department which together now finance a major fraction of the data compilation effort, on the same footing as the requirements of other sectors.

The group felt that the newly created U.S. Nuclear Data Committee could be the appropriate vehicle for achieving the desired goals. This committee is an outgrowth of the AEC's Nuclear Cross-Sections Advisory Group which was primarily devoted to advising on the acquisition and evaluation of neutron cross-sections and other nuclear data for reactors, weapons, and nuclear safeguards. In its present form the committee undertakes to "assure maximum acquisition, expansion and dissemination of nuclear data of general relevance to the U.S. nuclear program".[1] This statement of purpose is broad enough to encompass all the goals described above. There has been a significant change in the Committee's personnel from that of the original AEC group and a broadening of its activities is envisaged. After a reivew of the present operations of the USNDC (the "Operational Guidelines" were examined by the undersigned) the ad-hoc group made the following recommendations:

(1) The USNDC include among its programmatic responsibilities the data needs of the basic science community. The present membership of the Committee and the attitudes implicit in its "Operational Guidelines" indicate a present concentration on needs of applied science. As far as the "Operational Guidelines" are concerned a definition which included "basic science" in the term "U.S. nuclear program" would make this expansion explicit.

(2) The national nature of the USNDC should be made more visible. At the present moment the "Operational Guidelines" states that USNDC is an AEC committee acting in cooperation with the National Standard Reference Data System of the National Bureau of Standards but reporting and responsible only to the AEC Director of Physical Research. The Director of Physical

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[1] Operational Guidelines for the U.S. Nuclear Data Committee, January 18, 1972.

# APPENDIX C

## PARTICIPANTS

| | |
|---|---|
| Professor D. Allan Bromley | Yale University |
| Dr. Robert Dannels | Brookhaven National Laboratory |
| Dr. Gene Eichler | Oak Ridge National Laboratory |
| Professor Herman Feshbach | M.I.T. |
| Dr. Lewis Gevantman | National Bureau of Standards |
| Dr. Gertrude Goldhaber | Brookhaven National Laboratory |
| Dr. David Goldman | National Bureau of Standards |
| Professor William Havens | Columbia University |
| Dr. William Heenan | National Science Foundation |
| Dr. Daniel Horen | ORNL Nuclear Data Group |
| Dr. Harold Jackson | Argonne National Laboratory |
| Dr. James Joy | National Science Foundation |
| Dr. George Kolstad | Atomic Energy Commission |
| Dr. Michael Lederer | Lawrence Berkeley Laboratory |
| Dr. Enloe Ritter | Atomic Energy Commission |
| Dr. James Robertson | Brookhaven National Laboratory |
| Dr. William Rodney | National Science Foundation |
| Dr. John Schiffer | Argonne National Laboratory |
| Professor Fay Ajzenberg-Selove | University of Pennsylvania |
| Dr. Hendrik Van Olphen | Staff Officer, NRC |
| Mr. Charles Reed | Staff Officer, NRC |

# APPENDIX D

## STATUS OF THE CALUTRON COMPUTERIZATION PROGRAM

(October 17, 1972)

The 180° Oak Ridge Sector Isotope Separator PDP-8/I computer system has demonstrated that control of most of the isotope separator functions is within its capability. Several of the more significant variables have been controlled during an ultra-high purity collection ($E_{156}$ = 400,000*) and while the operation was under surveillance, the run was regarded as a significant accomplishment because the operator was freed from making constant adjustments. For such runs, only intermittent operator attention is now considered necessary, the most significant problem being that of making the ionization-arc adjustments. The use of solid charges will result in sparking due to dirty ion sources and cause electrical discharges which make optimizing the operations considerably more difficult. It is anticipated that this problem will be brought under acceptable control for most elements during the next year.

Funds have been requested to expand the sector computer system to include the operation of both the sector separator and at least one experimental calutron. They will be operated simultaneously. The sector operation will have two objectives: (1) performing useful separations with computer assistance, and (2) upgrading its performance under computer control. The calutron will be undergoing the necessary modifications for computer-assisted operation in Track 5.

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* $E = \frac{c_e}{c_o}\left(\frac{100 - c_o}{100 - c_e}\right)$

$c_e$ = abundance of $^{156}Dy$ in enriched sample

$c_o$ = natural abundance of $^{156}Dy$

# APPENDIX D

A proposal for the purchase of a computer system to collect and process data from the Track 5 calutron operation is now nearing completion. The system, which will eventually be expanded for computer-assisted control, will be installed in steps consistent with available funds, manpower, and proven developments in the experimental calutron and sector separator system.

The first step in computerizing the calutrons would be the acquisition of a basic computer system that could be added to the present ORSIS system and allow the computerization of an experimental calutron in Track 6, adjacent to the sector. Following this, the second step would involve the purchase of equipment sufficient to provide data-taking and data-processing for 16 operational calutrons in Track 5. To prevent duplication of purchases and excessive costs, this second step would also include some of the software and interface equipment necessary in the third step. It is estimated that this second step would be completed by December 1974. The third step would involve the purchase and installation of control hardware that would permit computer-assisted operation of 16 calutrons in Track 5 (December 1975). Early approval of the purchases and addition of one electrical mechanic could shorten this time by approximately 6 months. The fourth step in the sequence would be the purchase and installation of sufficient equipment to provide computer-assisted operation of the remaining 14 calutrons in Track 5. Hopefully, the advantage of this arrangement would be the ability to operate the full track with approximately the same personnel currently employed.

# APPENDIX D

In summary, the program of computerizing the calutrons in Track 5 would approximate the following schedule:

STEP ONE

Purchase and install a computer system on ORSIS to develop control techniques for at least one calutron. In conjunction with this will be the operation of ORSIS for useful separations and the improvement of its computer operation. $48,000 -- October 1973

STEP TWO

Purchase and install equipment for collecting and processing the data from 16 calutrons in Track 5. $100,000 -- December 1974

STEP THREE

Purchase and install equipment for computer-assisted operations for 16 separators. ~$150,000 -- December 1975

STEP FOUR

Purchase and install equipment for computer-assisted operations in the remainder of the Track 5 calutrons. $150,000 -- after December 1975

APPENDIX E

October 19, 1972

M E M O R A N D U M

TO: Members and Ex-offico Members
U. S. Nuclear Data Committee

FROM: Edward M. Smith, Sc.D.
Division of Nuclear Medicine
University of Miami School of Medicine

SUBJECT: Nuclear data required for medical applications.

1. Listed below are some potentially useful cyclotron produced radionuclides, along with some selected reaction modes for their information. In order to properly evaluate optimum production techniques for various existing medical cyclotrons, it would be desirable to have excitation functions for these reactions at energies up to 15 MeV for deutrons, 27 MeV for protons, 30 MeV for alpha particles and 39 MeV for helium three particles.

Excitation Functions Needed

Fluorine-18

1. a. $^{16}O(^{3}He,n)^{18}Ne$ $\beta^+$ $^{18}F$
   b. $^{16}O(^{3}He,p)^{18}F$
2. a. $^{16}O(\alpha,2n)^{18}Ne$ $\beta^+$ $^{18}F$
   b. $^{16}O(\alpha,pn)^{18}F$
3. $^{20}Ne(d,\alpha)\ ^{18}F$
4. $^{22}Ne(p,\alpha n)^{18}F$
5. $^{18}O(p,n)^{18}F$
6. a. $^{19}F(p,2n)^{18}Ne$ $\beta^+$ $^{18}F$
   b. $^{19}F(p,pn)^{18}F$

Potassium-43

1. $^{40}Ar(\alpha,p)^{43}K$
2. a. $^{44}Ca(d,^{3}He)^{43}K$
   b. $^{44}Ca(d,\alpha)^{42}K$

Gallium-67

1. $^{66}Zn(d,n)^{67}Ga$
2. $^{67}Zn(d,2n)^{67}Ga$
3. $^{65}Cu(^{3}He,n)^{67}Ga$
4. $^{65}Cu(\alpha,2n)^{67}Ga$
5. $^{67}Zn(p,n)^{67}Ga$
6. $^{67}Zn(p,2n)^{67}Ga$

Strontium-82

1. $^{82}Kr(^{3}He,3n)^{82}Sr$
2. $^{80}Kr(\alpha,2n)^{82}Sr$
3. $^{84}Sr(p,3n)^{82}Y$ $\beta^+$ $^{82}Sr$

Iron -52

1. $^{50}Cr(\alpha,2n)^{52}Fe$
2. $^{52}Cr(^{3}He,3n)^{52}Fe$

Yttrium-87 $\beta^+$ Strontium-87m

1. $^{87}Rb(^{3}He,3n)^{87}Y$
2. $^{87}Sr(p,n)^{87}Y$
3. $^{88}Sr(p,2n)^{87}Y$

Indium-111

1. $^{109}Ag(\alpha,2n)^{111}In$
2. $^{109}Ag(^{3}He,n)^{111}In$
3. $^{111}Cd(p,n)^{111}In$
4. $^{112}Cd(p,2n)^{111}In$
5. $^{110}Cd(d,n)^{111}In$
6. $^{111}Cd(d,2n)^{111}In$

APPENDIX E

Smith/U.S.N.D.C.
October 19, 1972

Iodine-123

1. $^{122}Te(d,n)^{123}I$
2. $^{122}Te(^{3}He,2n)^{123}Xe \xleftrightarrow{\beta+} {}^{123}I$
3. $^{123}Te(p,n)^{123}I$
4. $^{123}Te(d,2n)^{123}I$
5. $^{123}Te(^{3}He,3n)^{123}Xe \quad {}^{123}I$
6. $^{124}Te(p,2n)^{123}I$

Dysprosium-147

1. $^{159}Tb(p,3n)^{157}Dy$
2. $^{156}Gd(^{3}He,2n)^{157}Dy$
3. $^{155}Gd(\alpha,2n)^{157}Dy$

Cesium-129

1.a. $^{130}Ba(p,2n)^{129}La \quad {}^{129}Cs$
b. $^{130}Ba(p,2p)^{129}Cs$
2. $^{132}Ba(p,\alpha)^{129}Cs$
3. $^{127}I(\alpha,2n)^{129}Cs$
4. $^{127}I(^{3}He,n)^{129}Cs$

It would be desireable if the Nuclear Data Committe could stimulate the acquisition of this data by encouraging this work in their own or other laboratories as well as bringing this data deficiency to the attention of granting and funding agencies.

2. The medical Internal Radiation Dose (MIRD) Committee of the Society of Nuclear Medicine is publishing an enlarged and updated revision of MIRD Pamphlets 4 and 6. The followind radionuclides will be tentatively included in the publication

Radionuclides to be included in revision of Dillman pamphlet

| | | | |
|---|---|---|---|
| H-3 | Al-28 | Sc-49 | Co-60 |
| Be-7 | P-32 | Cr-51 | Cu-64 |
| C-11 | S-35 | Mn-52 | Cu-67 |
| C-14 | K-40 | Mn-52m | Zn-62 |
| N-13 | K-42 | Mn-54 | Zn-65 |
| O-15 | K-43 | Fe-52 | Ga-66 |
| F-18 | Ca-45 | Fe-55 | Ga-67 |
| Na-22 | Ca-47 | Fe-59 | Ga-68 |
| Na-24 | Ca-49 | Co-57 | Ga-72 |
| Mg-28 | Sc-47 | Co-58 | Ge-68 |

APPENDIX E

Smith/U.S.N.D.C.
October 19, 1972

Radionuclides to be included in revision of Dillman pamphlet (con't.)

| | | | |
|---|---|---|---|
| As-73 | Kr-85m | Y-90 | I-123 |
| As-74 | Rb-81 | Mo-99 | I-124 |
| Se-73 | Rb-82 | Tc-99m | I-125 |
| Se-75 | Rb-84 | Ru-97 | I-126 |
| Se-77m | Rb-86 | Pd-103 | I-130 |
| Br-77 | Sr-82 | Ag-109m | I-131 |
| Br-82 | Sr-85 | Cd-109 | I-132 |
| Kr-81 | Sr-87m | In-111 | Xe-127 |
| Kr-81m | Sr-90 | In-113m | Xe-133 |
| Kr-85 | Y-87 | Sn-113 | Cs-129 |
| Cs-131 | Dy-157 | Ir-190m | Hg-197 |
| Cs-137 | Er-171 | Au-195 | Hg-203 |
| Ba-133 | Yb-169 | Au-195m | Bi-206 |
| Ba-135m | W-188 | Au-198 | Ra-224 |
| Ba-137m | Re-188 | Au-199 | Am-241 |
| Ce-139 | Os-190m | | |

Total number of radionuclides 102 8/28/72

Radionuclides added to above list resulting from memo dated 8/28/72

A-37
In-115m
I-129
I-133
Cs-127
Tl-201

Total number of Radionuclides 108 10/2/72

Cs-134

Total number of Radionuclides 109 10/20/72

# APPENDIX F

## The U.K. Chemical Nuclear Data Committee

### INTRODUCTION

For many years the U.K. Atomic Energy Authority has had a Working Party dealing with that part of nuclear data which is not fully covered by the various physics committees and which has come to be called "chemical" nuclear data, largely because, although it is frequently physical in nature, its examination usually involves the use of radiochemical techniques and so has been traditionally carried out by radiochemists.

In 1971 the old Working Party was re-convened as the U.K. Chemical Nuclear Data Committee with more widely defined objectives. This note seeks to explain these with the purpose of trying to further the cause of international collaboration in the subjects covered by the Committee.

### DEFINITION OF CHEMICAL NUCLEAR DATA

Chemical nuclear data is defined as nuclear data which is obtained by nuclear or radio-chemical means. This definition broadly covers the following:-

1. Assessment and measurement of fission yields for all reactor systems, for design and operation of reactors, fuel processing and shielding.
2. Assessment and measurement of yields of other radioactive materials produced in reactors, including actinides and corrosion products.
3. Cross-section decay-scheme and other nuclear data measurements made by nuclear-chemical and radio-chemical means.
4. Delayed neutron assessment and measurements.
5. Fission fragment kinetic energy measurements.
6. Certain calculations involving fission products and actinides.
7. Techniques used in the above measurements.

### OBJECTIVES OF THE COMMITTEE

The main objectives of the Committee are as follows:-

1. To maintain a categorised request list of chemical nuclear data required for design and operation of reactors and processing plant. This list is re-issued every six months and is similar in format to the physics list.
2. To discuss requests, decide how they can best be carried out, and make recommendations.

APPENDIX F

3. To discuss critically work in progress or completed and to provide the most expert possible advice on any chemical nuclear data problem.

4. To generate ideas for basic research in the chemical nuclear data field and suggest how they might be carried out.

5. To issue and maintain certain compilations and evaluations of chemical nuclear data. So far these are as follows:-

Already issued

(a) A compilation and evaluation of delayed neutrons from fission.

(b) First edition of chemical nuclear data request list, Jan. 1972.

To be issued shortly

(c) Second edition of chemical nuclear data request list, July 1972.

(d) A critical assessment of all thermal neutron fission fields.

(e) A critical assessment of all fast neutron fission yields.
(Both of the above eventually to be published in Nuclear Data Tables)

(f) Compilation of $\gamma$-rays ordered by A and Z.

(g) Compilation of $\gamma$-rays ordered by $E\gamma$.

(h) Bibliography of $\gamma$-ray energy literature.

(i) Compilation of $\alpha$ particle emitters.

(j) List of sources of data on cross-sections for fission product and corrosion products and for their decay schemes, half-lives, branching ratios, etc.

CONSTITUTION OF THE COMMITTEE

The Committee is made up of both users and measurers of chemical nuclear data, all of whom are expert in their field. The members are drawn from most of the research establishments of the U.K.A.E.A., from the British Nuclear Fuel Co. and from the Central Electricity Generating Board.

At the present time (May 1972) the chairman is

J.G. Cuninghame,
Chemistry Division,
A.E.R.E., Harwell,
Didcot,
Berkshire, England.

and the secretary

E.A.C. Crouch (at the same address)

APPENDIX G

OAK RIDGE NATIONAL LABORATORY
OPERATED BY
UNION CARBIDE CORPORATION
NUCLEAR DIVISION

POST OFFICE BOX X
OAK RIDGE, TENNESSEE 37830

November 6, 1972

To: H.E. Jackson From: D.J. Horen

Subject: Status Report of Nuclear Data Project (January-October 1972)

## Mass Chain Compilations

The following mass chain compilations have been compiled and published (see publications list).

A = 70, 92, 95, 107, 108, 112, 122, 123, 125, 127, 129, 194, 196, 197, 206, 212

The following mass chains are in various stages of preparation (*signifies NIRA compiler).

A = 62, 71,* 77,* 91, 93,* 96,* 101,* 114, 124, 126, 128, 153,* 157,* 169, 174,* 181, 183, 191, 192, 193, 195, 225*

## References

Recent References which contains keywords and references to the published literature (predominantly nuclear structure oriented) in low-to-medium energy nuclear physics has covered the periods September-December (1971), January-April (1972), and May-August (1972).

The Data Project maintains a computerized reference list of published papers in low-medium energy nuclear physics. The Project also maintains a file of unpublished work (i.e., BAPS, laboratory reports, preprints, etc., which are received by the Project) for internal usage. Specialized reference lists are periodically provided to the following.

Table of Isotopes (Hollander, LBL); magnetic tapes
Mass Tables (Wapstra, Holland)
Nuclear Moments (G.H. Fuller, NBS)
NIRA's
Non-Project mass chain compilers [A. Artna-Cohen (USA), H. Verheul (Holland), S.C. Pancholi (India), B.S. Dzhelepov (Russia)]
Photonuclear Cross-Section Center (E.G. Fuller, NBS); just commencing
National Neutron Cross-Section Center (BNL); exploring usefulness
Numerous selected reference lists have been provided on request.

# APPENDIX G

H.E. Jackson November 6, 1972

## Response to Requests

Decay data for $^{83}Kr$, $^{85}Kr$, $^{87}Kr$, $^{88}Kr$, $^{88}Rb$, $^{131m}Xe$, $^{133}Xe$, $^{135}Xe$, $^{137}Xe$, $^{137}Cs$ were prepared by M.J. Martin in a format similar to that used in Radioactive Atoms, Nuclear Data Tables A8, 1 (1970), by M.J. Martin and P.H. Blichert-Toft, at the request of Dr. J. Kastener of the Division of Radiological and Environmental Protection of the USAEC. The same data was later provided to Dr. J.E. Cline at Idaho Falls for use by the Division of Compliance and Regulations of the USAEC.

In addition, more than thirty requests for information ranging from references to specific data have been answered thus far in 1972. These requests have come from a variety of establishments including other divisions at ORNL, private industry, the U.S. Geological Survey, foreign scientists, university researchers, national laboratories, etc.

## Other Research

Most members of the Project are actively engaged in research other than preparation of mass chain compilations. This work is not cited here.

## Partial Listing of Nuclear Data Compilation Groups

See attached listing of compilation groups.

## Contents of Nuclear Data Sheets (*denotes NIRA)

Volume B7-1 (January 1972)
Revised A-Chains

| | |
|---|---|
| A = 107 | F.E. Bertrand and D.J. Horen |
| A = 108 | F.E. Bertrand |
| A = 112 | S. Raman and H.J. Kim |

Volume B7-2 (February 1972)
Revised A-Chains

| | |
|---|---|
| A = 194 | R.L. Auble |
| A = 197 | M.B. Lewis |
| A = 206 | K.K. Seth |

Volume B7-3 (March 1972)
Recent References (September-December 1971)
D.C. West, F.W. Hurley, S.H. Dockery, and S.J. Ball

Volume B7-4 (April 1972)
Revised A-Chains

| | |
|---|---|
| A = 92 | D.C. Kocher* and D.J. Horen |
| A = 123 | R.L. Auble |
| A = 196 | M.R. Schmorak |

Contents of Nuclear Data Sheets (continued)

Volume B7-5 (May 1972)
Revised A-Chains

| | |
|---|---|
| A = 122 | F.E. Bertrand |
| A = 125 | R.L. Auble |

Volume B7-6 (June 1972)
Recent References (January-April 1972)
D.C. West, F.W. Hurley, S.H. Dockery, and S.J. Ball

Volume B8-1 (July 1972)
Revised A-Chains

| | |
|---|---|
| A = 70 | K.R. Alvar* and S. Raman |
| A = 95 | L.R. Medsker* and D.J. Horen |

Volume B8-2 (August 1972)
Revised A-Chains

| | |
|---|---|
| A = 127 | R.L. Auble |
| A = 129 | D.J. Horen |
| A = 212 | S.C. Pancholi and M.J. Martin |

Volume B8-3 (September 1972)
Recent References (May-August 1972)
D.C. West, W.B. Ewbank, F.W. Hurley, and M.R. McGinnis

DJH:sjb

Enclosure

Distribution

H. Alter, Atomics International
W. Bartels, USAEC
R.C. Block, RPI
C.D. Bowman, NBS
R.S. Caswell, NBS
R.E. Chrien, BNL
H. Goldstein, Columbia University
W.W. Havens, Jr., Columbia University
P.B. Hemming, USAEC
M.H. Kalos, New York University
G.A. Kolstad, USAEC
D.R. Lide, NBS
M.S. Moore, LASL
H.W. Newson, Duke University
F.G. Perey, ORNL
G.C. Phillips, Rice University
J.S. Robertson, BNL
W.S. Rodney, NSF
G.L. Rogosa, USAEC
A.B. Smith, ANL
E.M. Smith, University of Miami
D. Steiner, ORNL
R.F. Taschek, LASL

# APPENDIX H

## Partial Listing of Nuclear Data Compilation Groups in USA

| Group | MY (PhD) | Topics | Support Agency | $ |
|---|---|---|---|---|
| Table of Isotopes* | 6 | $A \leq 260$ | AEC (+ NBS) | ~130k |
| Selove-Lauritsen | 1 | A = 5-20 | NSF | 40k |
| Nuclear Data Project | 10+ | $A \geq 45$<br>Radioactive Atoms (Auger electrons, $\alpha$-, $\beta$-, $\gamma$-, and X-ray data) | AEC | 500k |
| NIRA's* | 16 | A | NSF | 300k |
| Wapstra-Gove* | ~1/5 | Nuclear masses, Q-values | AEC | k |
| Fuller-Cohen* | | Nuclear spins and moments | | |
| V. Shirley* | | Nuclear spins and moments | | |
| Chart of Nuclides* | ~1 | $A \leq 260$ ($\sigma_n$, $T_{1/2}$, atomic weights) | GE | ~50k |
| Charged-Particle Cross-Section Center | 1-1/2 | Reaction lists | AEC | 65k |
| Photonuclear Data Center | 2 | Index to cross sections for photon interactions, data | NBS | 50k |
| National Neutron Cross-Section Center* | ~16 | Neutron cross-section data, EANDF File | AEC | 800k |
| ASDG (Howerton, LLL)* | ~8 | Neutronic-photonic evaluated cross sections | AEC | ~250k |

*Indicates group partially uses Nuclear Data Project output (e.g., Recent References, Data Sheets, specific requests, etc.)

APPENDIX H

| Group | MY (PhD) | Topics | Support Agency | $ |
|---|---|---|---|---|
| Perey (ORNL)* | 3 | $\sigma(n,x)$ for specific nuclei (8 nuclei); $E_n < 20$ MeV, evaluated SNAP | AEC + DNA | 120k |
| Harris (LASL) | | Neutron and charged-particle $\sigma(p,x)$, etc. | | |
| Information Center for Internal Exposure (ORNL) | ~1 | Radioisotopes used in medicine or health physics (~350 radioisotopes), MIRD pamphlets, etc. | AEC | 40k |
| Scintillation Spectrum $\gamma$-Catalogue* | 1 | $\gamma$-catalogue of radioactive nuclides, fission product data | AEC | ~50k |
| Meek and Rider* | | $\gamma$ and $\beta$ energy and intensity data of radionuclides observed in fissioning reactors | GE( ) | |
| U.S. Geological Survey | ~1/3 | $E_\gamma$, $I_\gamma$ for $(n,\gamma)$ used in geological survey. Activation vs capture sensitivity | U.S. Geological Survey | |
| Dyer and Bate (ORNL) | 1/20 | Computer file for over 500 radionuclides, $E_\gamma$, $I_\gamma$, $T_{1/2}$. Available RSIC | AEC | MSRE |
| Wakat (Savannah River) | | Computer file of $\gamma$-ray catalogue | du Pont | |
| Gunnink et al. (LLL) | | $E_\gamma$, $I_\gamma$ computer file | | |
| Filby et al. (Washington State Univ.) | | $E_\gamma$, $I_\gamma$ | | |
| Dooley et al. (NBS) | | $E_\gamma$, $I_\gamma$, $T_{1/2}$, etc., for identification of reactor produced isotopes | | |
| Perey (ORNL) | ~1/3 | Optical model parameters | AEC | |

($E_\gamma$, $I_\gamma$, etc.) — Many at different locations

(Neutron $\sigma$ evaluation) — Many at different locations

# APPENDIX H

Partial Listing of Nuclear Data Compilation Groups Outside USA

| Group | MY | Topics | Country |
|---|---|---|---|
| Endt and Van der Leun* | 1/2 - 1 | $21 \leq A \leq 44$ | The Netherlands |
| Dzhelepov* | ? | $A \leq 260$ | Russia |
| Nuclidkarte* | | $\sigma_n$, $T_{1/2}$, etc. | West Germany |
| Munzel et al. | | Cross sections for charged-particle induced reactions | West Germany |
| Wapstra and Gove* | | Nuclear masses, etc. | The Netherlands |
| Neutron Four-Centers | | Vienna<br>Obninsk<br>Saclay | |
| U.K. Chemical Nuclear Data Committee | | Fission product yields | United Kingdom |
| Allen et al. | | (10 - 150) keV n-capture $\gamma$'s<br>A = 40 - 70 | Australia |
| Karlsruhe | | $\gamma$-ray spectra from neutron activation analysis with 14-MeV n | West Germany |
| Sakai | | Bands in even-even nuclei | Japan |
| UKAEA | | U.K. Nuclear Data Library mainly for fission and fusion reactors<br>Delayed n from fission. $E_\gamma$, $E_\alpha$, $I_\alpha$, etc. [$E_n$(therm, fast), f] yields | United Kindgom |

*Indicates group partially uses Nuclear Data Project output (e.g., Recent References, Data Sheets, specific requests, etc.)

APPENDIX H

| Group | MY | Topics | Country |
|---|---|---|---|
| Baranov | | Alpha spectra of heavy nuclei | Russia |
| Groshev | | Compilation of thermal n, γ | Russia |
| Russia | | Much more data, not yet clearly defined | |
| Euratom Group | | Standardized evaluation of decay properties of 100 radionuclides | Belgium, France The Netherlands |
| Pagden et al. | | $E_\gamma$, $I_\gamma$ computer file | Canada |
| Sanguist et al [sic] (also recent literature, non-evaluated) | | $E_\gamma$, $I_\gamma$ for fission products and nuclides produced by n, γ | [illegible] |

APPENDIX I

UNITED STATES
ATOMIC ENERGY COMMISSION
WASHINGTON, D.C. 20545

AUG 2 2 1972

USNDC Members

INDC "ACTIONS"

The following "actions" (see attached list) placed on all members of the INDC are referred to you for consideration by the USNDC at its next meeting.

George A. Kolstad
U.S. Member of INDC

Attachment:
List of "Actions"

# APPENDIX I

## LIST OF "ACTIONS"

| Number | Action on | Action |
|---|---|---|
| 9 | Havens | Review the $\langle \Gamma_\gamma \rangle$ for $^{238}U$ from the different USA measurements and inform INDC members. |
| 17 | All members | Send new experimental fast fission cross section data on $^{235}U$ to NDS in time for the "Panel on Neutron Standard Reference Data". |
| 18 | All members | Inquire into standard reference data to be considered in future by the standards sub-committee including non-neutron nuclear standards and report to the next meeting (e.g. standards for fission yields, decay schemes, level energies, half lives, radiation standards). |
| 19 | All members | Inform RENDA requestors in their respective countries about the list of reactions needed for neutron flux measurements and investigation of radiation damage as recommended by the International Working Group on Radiation Measurements (IWGRRM). |
| 25 | All members | Inform NDS (Manero), as soon as possible, of the most recent data obtained in their respective countries on $\bar{\nu}(E)$ and $\bar{\nu}$ in the resonance region, in order to permit timely publication of INDC(NDS)-34/G in the "Atomic Energy Review". |
| 28 | Neutron Data Centres | Consider in their next meeting the problem of compiling the data on fission neutron spectra. |
| 31 | All members | Inform NDS before 31 August 1972 about organizations, journals and other public media to be contacted by NDS for advertising the Nuclear Data Symposium, Paris, March 1973. |

APPENDIX I

| | | |
|---|---|---|
| 38 | Kolstad | Inquire with the USNDC regarding the adoption of the priority criteria for CTR nuclear data requests as approved by IFRC and the possible resubmission of an official US fusion request list before the end of 1972. |
| 39 | Kolstad | Inquire with the CTR Division of USAEC about the inclusion into the international fusion request list of the unofficial data requests by McNally from ORNL. |
| 40 | All members | Consider in local data committees the problem of taking into account simple (clean) integral experiments in establishing evaluated data files. |
| 42 | All members | Define for the next INDC meeting their positions about the edition of a "World-wide Evaluation Newsletter" by NDS. |
| 48 | All members | Urge nuclear physicists in their respective countries to send experimental neutron data to the neutron data centre in their area (NNCSC Brookhaven, CCDN Saclay, CJD Obninsk, and NDS/IAEA). |
| 49 | All members | Urge nuclear physicists in their respective countries to send nuclear data on nuclear levels, decay schemes and related subjects to the ORNL Nuclear Data Project.<br>Address: Dr. Daniel Horen<br>Director, Nuclear Data Project<br>Oak Ridge National Laboratory<br>Oak Ridge, Tennessee 37831<br>P.O. Box X - U.S.A. |
| 50 | All members | Urge that more reports on specific researches (related to INDC interest) are submitted to INDC and provide sufficient number of copies (G - 45, L - 280, U - 450). |
| 51 | All members | Send information to INDC members on the status and the programme of all non-neutron nuclear data centres in their respective countries (cf. Action 18 of fourth meeting fulfilled by Kolstad only). |
| 52 | All members | Ensure that appropriate screening procedures are established in respective member states for neutron nuclear data requests. |

# APPENDIX I

| | | |
|---|---|---|
| 57 | All members | Send to NDS comments about their interest for holding a "Symposium on high intensity neutron sources", after having documented their opinion, in particular from the Budapest Conference. |
| 58 | All members | Arrange that physicists concerned in their respective countries send finalized data on fission spectrum measurements to the "Neutron Data Centre" in their area and to NDS. (Recommendation No. 10 of the consultant meeting on the status of prompt fission neutron spectra in August/September 1971). |

# APPENDIX J

## The Expanding Role of the United States Nuclear Data Committee

W.W. Havens, Jr., Columbia University; G.A. Kolstad, United States Atomic Energy Commission; R. Chrien, Brookhaven National Laboratory

The need for exchange of information between measurers, compilers, evaluators, and users of nuclear data has long been recognized in the reactor physics field. Both National and International Advisory Committees have encouraged active cooperation. In the United States, the U.S. Nuclear Data Committee plays an advisory role to the Division of Physical Research of the Atomic Energy Commission and the Advisory Committee on Reactor Physics plays an analagous role to the Division of Reactor Development and Technology. On the international level, the European-American Nuclear Data Committee, the European-American Committee on Reactor Physics, and the International Nuclear Data Committee occupy similar advisory roles. On the local level, the USNDC assists in establishing a feedback from users to measurers by compiling a request list for measurements needed in reactor, safeguards, fission and other neutron physics applications. The Committee also makes available to users, status reports on measurements currently planned or underway.

As nuclear data applications in other fields become important, it has become clear that it is necessary to promote such close ties between measurers and users in the non-neutron nuclear data field. The U.S. is meeting its obligations in these non-neutron areas by expanding the scope of operations of the USNDC. Recently, the USNDC has created a number of subcommittees to survey the needs and establish user-measurer relationships on applications of nuclear data to the controlled thermonuclear reactor program, to medical needs, to safeguards of nuclear material, and to nuclear data in industrial and environmental analyses. These subcommittees will seek to emulate the relationships which have been so successful in the reactor physics field. This effort should give a clearer total picture of nuclear data needs and compilation efforts. This attempt is being carried out with the assistance of the Office of Standard Reference Data of the National Bureau of Standards and the National Science Foundation.

ARGONNE NATIONAL LABORATORY

March 13, 1973

TO: Members, USNDC

FROM: H. E. Jackson, Secretary

SUBJECT: Elemental Sample Inventory

In response to Action 5 adopted at the October USNDC meeting, a current inventory of available elemental target samples is attached. This list includes material collected at Rensselaer Polytechnic Institute by R. C. Block and at Argonne National Laboratory by A. B. Smith. This list will be updated on a continuing basis to include new material as it becomes available. Inquiries concerning loan of currently listed materials should be directed to the institution in possession of the material in question.

9700 South Cass Avenue, Argonne, Illinois 60439 · Telephone 312-739-7711 · TWX 910-258-3285 · WUX LB, Argonne, Illinois

# RPI SAMPLE INVENTORY

June 1972

| Z | ELEMENT | FORM | SIZE | NO. OF SAMPLES |
|---|---|---|---|---|
| (9) | $CF_2$ | | 3 1/8" D. X 3/32" | 1 |
| | | | 3 1/8" D. X 3/4" | 1 |
| | | | 2½" D. X 1/8" | 4 |
| | | | 3 1/8" D. X ½" | 1 |
| 11 | Na | metal in thin wall aluminum container | 2½" D. X .030" | 1 |
| | | " " | 2½" D. X .060" | 1 |
| | | " " | 2½" D. X .100" | 1 |
| | | " " | 2½" D. X .150" | 1 |
| | | " " | 2½" D. X 1" | |
| | | " " | 2 15/16" D. X .160" | 1 |
| | | " " | 2 15/16" D. X .640" | 1 |
| | | " " | 2 15/16" D. X .136" | 1 |
| | | " " | 2 15/16" D. X .020" | 1 |
| | | " " | 2 15/16" D. X .080" | 1 |
| | | " " | 2 15/16" D. X .040" | 1 |
| 12 | Mg | metal | 3 1/3" D. X ½" | 1 |
| | | | 3 1/8" D. X ¼" | 1 |
| | | | 3 1/8" D. X 1/8" | 1 |
| | | | 3 1/8" D. X 1/16" | 1 |
| | | | 2 3/4" D. X ¼" | 2 |
| 12 | C | reactor grade | 213/16" D. X 1" | 8 |
| | | | 2½" D. X 1" | 1 |
| | | | 3" D. X 1" | 3 |
| 15 | P | powder in a 2 5/8" D. thin wall aluminum container | 21.4 gm | 1 |
| | | | 41.9 gm | 1 |
| | Ir | Powdered Metal | 62.72 gm | 1 |
| 16 | S | Pressed powder | 2¼" D. X 3/8" | 1 |
| | | | 2¼" D. X 5/16" | 1 |

| Z | ELEMENT | FORM | SIZE | NO. OF SAMPLES |
|---|---|---|---|---|
| 23 | V | metal | 2½" D. X .050" | 2 |
| | | " | 3" X 1" X .200" | 2 |
| (25) | 80% Mn-20% Cu | metal foil | 4" X 6" X .010" | 5 |
| | | " " | 6" X 6" X 1/32" | 5 |
| | | " " | 6" X 6" X 1/16" | 1 |
| | | " " | 4½" X 9 3/16" X .027 | 8 |
| 26 | Fe | metal | 3 1/8" D. X 1/¼" | 1 |
| | | " | 3 1/8" D. X 1/8" | 2 |
| | | " | 3 1/8" D. X 1/16" | 1 |
| | | " | 3 1/8" D. X 1/32" | 1 |
| 27 | Co | metal foil | 2" X 100" X .002" | 1 |
| 29 | Cu | metal | 3 1/8" D. X .053" | 6 |
| 40 | Zr | metal foil | 213/16" D. X 1/32" | 1 |
| | | " " | 2 13/16" D. X .016" | 1 |
| | | " " | 2 13/16" D. X .010" | 1 |
| | | " " | 2 13/16" D. X 005" | 1 |
| | | " " | 2 13/16" D. X .003" | 1 |
| | | " " | 2 13/16" D. X .001" | 1 |
| | | " " | 2½" D. X .136" | 1 |
| | | " " | 2½" D. X .219 | 1 |
| | | " " | 2 15/16" X 1 7/16" | 30 |
| 47 | Ag | metal foil | 3 1/8" D. X .010" | 1 |
| | | " " | 3 1/8" D. X .001" | 4 |
| | | " " | 5" X 6" X .001" | 1 |
| | | " " | 7½" X 20" X .0005" | 1 |
| | | " " | 3" X 3" X .005" | 6 |
| | | " " | 3" X 3" X .050" | 6 |

| Z | ELEMENT | FORM | SIZE | NO. OF SAMPLES |
|---|---|---|---|---|
| 47 | Ag | metal foil | 3" X 3" X .500" | 1 |
| | | " " | 2" X 2½" X .125" | 4 |
| | | " " | 2" X 2" X .020" | 36 |
| | | " " | 2" X 2" X .025" | 4 |
| | | " " | 3" X 3" X .004" | 1 |
| | | " " | 3" X 3" X .001 | 1 |
| 49 | In | metal foil | 3" X 6" X .005" | 3 |
| | | " " | 3" X 6" X .002" | 2 |
| 73 | Ta | metal foil | 2 5/8" D. X .010" | 1 |
| | | " " | 2 13/16" D. X .020" | 1 |
| | | " " | 3" D. X .020" | 1 |
| 74 | W | metal foil | 6" X 6" X .025" | 3 |
| | | " " | 6" X 6" X .002" | 2 |
| | | " " | 6" X 6" X .001" | 4 |
| | | " " | 3 1/8" D. X .002" | 8 |
| | | " " | 2 3/8" D. X .001" | 2 |
| 78 | Pt | metal foil | 6" X 6" X .020" | 1 |
| | | " " | 3" X 3" X .003" | 1 |
| | | " " | 3" X 3" X .006" | 1 |
| | | " " | 3¼" X 5" X .0006" | 1 |
| | | " " | 3" X 3" X .030" | 1 |
| | | " " | 3" X 3" X .001" | 1 |
| 79 | Au | metal foil | 2 13/16"D. X .020" | 1 |
| | | " " | 3½" X 3½" X .0002" | 8 |
| | | " " | 6" X 6" X .002" | 1 |
| | | " " | 3" X 3" X .003" | 1 |
| | | " " | 2" X 3" X .003" | 1 |
| | | " " | 3" X 3" X .010" | 1 |
| | | " " | 3" X 3" X .020" | 2 |
| | | " " | 6" X 6" X .005" | 2 |

| Z | ELEMENT | FORM | SIZE | NO. OF SAMPLES |
|---|---|---|---|---|
| 83 | Bi | metal | 2½" D. X ¼" | 2 |
| 90 | Th | metal foil | 2" X 2" X .005" | 2 |
| 92 | U(depleted) | metal foil | 2 13/16" D. X 1/32" | 1 |
| | | | 2 13/16" D. X .052" | 1 |

SPECIAL METALLIC SEPARATED ISOTOPES

| | |
|---|---|
| $^{7}Li$ | 2" D. metallic samples (vacuum distilled) inside .010" thick stainless steel cell: 14.4662 gm, 28.2632 gm , 82.4222 gm, and 120.9700 gm. (In addition, there are empty cans for each sample). |
| $^{182}W$ | 2.8" D. porous metal disks: 8 disks, total of 351.372 gm. |
| $^{183}W$ | " " " " : 6 disks, " " 251.294 gm. |
| $^{184}W$ | " " " " : 8 " , " " 333.827 " |
| $^{186}W$ | " " " " : 8 " , " " 326.362 " |

## NEUTRON SCATTERING SAMPLES -- MOSTLY ELEMENTAL

All Weights Listed in Grams

| Name | | Size | Weight | Atoms/cm$^3$ | Comments |
|---|---|---|---|---|---|
| Aluminum | Al | 1½" dia. x 1½" | 117.6 | 6.19 x $10^{22}$ | |
| | | .7" dia. x .7" | 11.954 | .06083 x $10^{24}$ | |
| Argentum | Ag | .7" dia. x .7" | 45.85 | 5.831 x $10^{22}$ | |
| Beryllium | Be | .7" x .7" dia. | 8.286 | .1262 x $10^{24}$ | |
| Bismuth | Bi | .803" x .801" dia. | 64.2628 | .0281076 x $10^{24}$ | |
| | | .5" x .5" dia. | 15.89 | | |
| | | .7" x .7" dia. | 42.94 | .0283 x $10^{24}$ | |
| | | 1" x 1" dia. | 125.5 | | |
| Cadmium | Cd | .7" x .7" dia. | 37.90 | .04626 x $10^{24}$ | |
| Calcium | Ca | 2.0005" x 1" dia. | 40.6791 | | In brass can |
| | | .8" x .8" dia. | 10.3067 (net) | | In S.S. can* |
| | | | | | *empty can available |
| Carbon | C | .801" ht x .802" dia | 9.6754 | .07338 x $10^{24}$ | Painted red |
| | | .799" x .800" | 3.6966 | | Has holes |
| | | .679" x .335" R | 6.1475 | .07865 x $10^{24}$ | Canned |
| | | .7" x .7" dia. | 6.70 | .07262 x $10^{24}$ | |
| | | 1" x 1" dia. | 21.3 | .0832 x $10^{24}$ | |
| | | 1½" x 1½" dia. | 47.1965 | .03545 x $10^{24}$ | Six holes |
| | | 2" x 1½" dia. | 63.0858 | .035534 x $10^{24}$ | Six holes |
| | | .8" x .8" dia. | 10.4654 | 7.97 x $10^{22}$ | Painted yellow |
| | | .782" x .819" d | 11.0152 | .08193 x $10^{24}$ | |

## NEUTRON SCATTERING SAMPLES -- MOSTLY ELEMENTAL

| Name | | Size | Weight | Atoms/cm$^3$ | Comments |
|---|---|---|---|---|---|
| Cerium | Ce | .7" x .7" dia. | *29.43 | .02883 x $10^{24}$ | |
| *Sample weight varies as it oxidizes & flakes off. As of July 23, 1965, weight ∿ 28.5 gms. | | | | | |
| Chromium | Cr | .7" x .7" dia. | 31.65 | .08352 x $10^{24}$ | |
| | Cr A | .7" x .7" | 31.6 | .0824 x $10^{24}$ | |
| Cobalt | Co | .8" x .8" dia. | 55.357 | .08597 x $10^{24}$ | |
| | | .7" x .7" dia. | 38.95 | .09067 x $10^{24}$ | |
| Cuprum (Copper) | Cu | .7" x .7" dia. | 39.17 | .08457 x $10^{24}$ | |
| | | .801" x .802$\phi$ | 58.9867 | | |
| Erbium | Er | .8" x .801 dia. | 60.1520 | | |
| Ferrum (Iron) | Fe | 3" dia. x 1" th. | | | |
| | | 1.982 cm x 1.040 cm dia. | | .08397 x $10^{24}$ | |
| | | .7" x .7" dia. | 34.5 | .0848 x $10^{24}$ | |
| | | 1" x 1" | 100.3 | .0839 x $10^{24}$ | "Armco" |
| | | .783" x .818"$\phi$ | 52.578 | | |
| Gadolinium | Gd | .802" x .803" dia. | 52.3234 | .03011 x $10^{24}$ | |
| | | .7" x .7" dia. | 34.53 | .0302 x $10^{24}$ | |
| Gallium | Ga | .8" x .8" dia. | 38.3004 | | |

## NEUTRON SCATTERING SAMPLES -- MOSTLY ELEMENTAL

| Name | | Size | Weight | Atoms/cm$^3$ | Comments |
|---|---|---|---|---|---|
| Germanium | Ge | .8" x .801" dia. | *34.6553 | .0436355 x $10^{24}$ | |
| | | .799" x .801" dia. | 34.6520 | | |
| | | .7" x .7" dia. | 23.2953 | .04378 x $10^{24}$ | |
| *New weight (due to chipping) = 34.6274 gm as of March 21, 1967. Atoms/cm$^3$ figured for weight of 34.652 gms. | | | | | |
| Hafnium | Hf | .8" x .799" dia. | 85.8258 | | |
| | | .8" x .8" dia. | 85.737 | .043907 x $10^{24}$ | |
| Holmium | Ho | .801" x .801" | 58.0258 | .03215 x $10^{24}$ | |
| | | *.701" d x .704" | 38.3613 | .031716 x $10^{24}$ | |
| *Volume taking into account hole thru center = 4.417 cm$^3$ | | | | | |
| Hydrargyrum (Mercury) | Hg | .7" x .7" | 61.6315 | .0408 x $10^{24}$ | In can.* *empty can available |
| Indium | In | .7" x .7" | 31.40 | .03753 x $10^{24}$ | |
| Lanthanum | La | .8" x .8" dia. | 27.361 | | In can.* *empty can available |
| Magnesium | Mg | 3" dia. x 1 3/8" th. | | | |
| | | .8" x .8" dia. | 11.5778 | .04354 x $10^{24}$ | |
| Molybdenum | Mo | 2.039 cm x 2.026 dia. | 66.438 | .06345 x $10^{24}$ | |
| | | .7" x .7" | 38.46 | .05501 x $10^{24}$ | |

## NEUTRON SCATTERING SAMPLES -- MOSTLY ELEMENTAL

| Name | | Size | Weight | Atoms/$cm^3$ | Comments |
|---|---|---|---|---|---|
| Neodymium | Nd | .701" x .701" | 30.9467 | | In can* |
| Can + Cover | | | 8.5186 | | |
| *empty can available | | | | | |
| Nickel | Ni | .7" x .7" dia. | 39.05 | .0913 x $10^{24}$ | |
| | | .802" x .801" dia. | 58.3655 | | |
| Niobium | Nb | .801" x .801" dia. | 56.7184 | .0556648 x $10^{24}$ | |
| | | .7" x .7" | 37.58 | .0554 x $10^{24}$ | |
| Palladium | Pd | .8" x .8" dia. | 78.83 | *A = 106.4; dens. = .67723 | |
| | | .7" x .7" | 53.3136 | .067742 x $10^{24}$ | |
| * .067723 x $10^{24}$ atoms/$cm^3$ | | | | | |
| Platinum | Pt | .802" x .802" | 140.8180 | .066011 x $10^{24}$ | |
| | | .7" x .7" | 94.27 | .06626 x $10^{24}$ | |
| Plumbum (Lead) | Pb | .7" x .7" | 50.2488 | .0326608 x $10^{24}$ | |
| | | .7" x .7" | 49.36 | .0327 x $10^{24}$ | |
| Plutonium | Pu-239 | .679" x .335 R | 56.3667 | .0362 x $10^{24}$ | In can*[a] |
| | | .814" x .795" dia. | 98.609 | .037714 x $10^{24}$ | In can*[b] |

* empty can available
a contains 1.27 wt/percent Al.
b contains 4.5 wt/percent $^{240}Pu$

## NEUTRON SCATTERING SAMPLES -- MOSTLY ELEMENTAL

| Name | | Size | Weight | Atoms/cm$^3$ | Comments |
|---|---|---|---|---|---|
| Praeseodymium | Pr | .7" x .7" | 29.8334 | | In can* |
| | | .8" x .8" | 44.7005 | | In can* |
| * empty can available | | | | | |
| Rhenium | Re | .727" x .806" dia. | 124.4095 | .0610749 x $10^{24}$ | |
| | | 2.037 cm x 1.016 cm R | 124.559 | .0638 x $10^{24}$ | |
| | | 1.772 cm x 1.68 cm | 86.865 | .06778 x $10^{24}$ | Solid Metal |
| | | .7" x .7" dia. | 26.1696 | .01913 x $10^{24}$ | In can (powder) |
| Rhodium | Rh | .8" x .8" | 81.88 | .07257 x $10^{24}$ | |
| Samarium | Sm | .8" x .8015" dia. | 49.1724 | .02975 x $10^{24}$ | |
| | | .7" x .7" | 32.95 | .03006 x $10^{24}$ | |
| Stannum (Tin) | Sn | 2.034 cm x 2.032 dia. | 47.567 | .0366 x $10^{24}$ | |
| | | .7" x .7" | 31.73 | .0367 x $10^{24}$ | |
| Stibium (Antimony) | Sb | 2.037 cm x 1.016 R | 43.715 | .03278 x $10^{24}$ | |
| | | .7" x .7" | 29.00 | .03271 x $10^{24}$ | |
| Strontium | Sr | .801" x .8" dia. | 17.7441 | | Slug in can* |
| * empty can available | | | | | |
| Sulfer | S | 3" dia. x 13/16" th. | | | |
| | | .8" x .8" dia. | 12.668 | | |
| Selenium | Se | .8" x .8" dia. | 28.2256 | | |

## NEUTRON SCATTERING SAMPLES -- MOSTLY ELEMENTAL

| Name | | Size | Weight | Atoms/cm$^3$ | Comments |
|---|---|---|---|---|---|
| Tantalum | Ta | .8" x .801" | 108.7292 | | |
| | | .7" x .7" dia. | 72.7 | .0553 x $10^{24}$ | |
| Teflon | | 2 1/2" x 3/8" th. | 67.74 | | |
| Fluorine Content Thereof | | 2 1/2" x 9/16 th. | 97.70 | | |
| | | .810" x .796" dia. | 14.2045 | | |
| | | .8" x .8" | 14.04689 | .05136 x $10^{24}$ | |
| Tellurium | $Te_{130}$ | .78" x .793 dia. | 34.9584 | | |
| | $Te_{128}$ | .782" x .782" dia. | 34.9262 | | |
| | Te | .8" x .8" dia. | 25.9616 | .018556 x $10^{24}$ | |
| Thorium | Th (A) | 1" x 1" | 150 | .030 x $10^{24}$ | |
| | Th (A) | .7" x .7" | 51.1 | .030 x $10^{24}$ | |
| | Th (B) | 1/2" x 1/2" | 19.06 | | |
| | Th | .8" x .801" dia. | 75.910 | | |
| Titanium | Ti | .802" x .801" dia. | 29.7312 | | |
| | | 1.001" x .999 dia. | 57.9453 | | |
| | | .7" x .7" | | .05667 x $10^{24}$ | |
| | | .7" x .7" | 51.99 | .0349 x $10^{24}$ | |
| Uranium | U | .5" x .5" | 30.3 | | |
| | U | .7" x .7" | 82.7 | .04772 x $10^{24}$ | |
| | U | 1" x 1" | 242.6 | .04772 x $10^{24}$ | |
| | U | .802" x .801" dia. | 123.983 | | |
| | $U_{235}$ | .7" x .7" | 89.0 | .0519 x $10^{24}$ | ~ 94% |

## NEUTRON SCATTERING SAMPLES -- MOSTLY ELEMENTAL

| Name | | Size | Weight | Atoms/cm$^3$ | Comments |
|---|---|---|---|---|---|
| Vanadium | V | 2" x 2" x 1/8" th.<br>.801" x .801" dia. | 40.126 | .0549413 x $10^{24}$ | 6 pieces |
| Wolfram<br>(Tungsten) | W | 1" x 1"<br>.7" x .7" | 243.1<br>80.67 | .06015 x $10^{24}$ | |
| Ytterbium | Yb | .797" x .797"<br>.7" x .7" | 45.4159<br>30.72 | .02437 x $10^{24}$ | |
| Yttrium | Y | .8" x .801" dia. | 29.5562 | | |
| Zinc | Zn | .7" x .7"<br>.802" x .802" | 31.15<br>46.9976 | .06536 x $10^{24}$ | |
| Zirconium | $Zr_{90}$ | .820" x .786" | 44.772 | | returned 4/5/68 |
| | Zr | .783" x .820" dia. | 43.6725 | .0437592 x $10^{24}$ | |
| | Zr | .7" x .7" | 28.58 | .04301 x $10^{24}$ | |
| | Zr | 1" x 1" | 84.0 | | |
| | Zr | 2.0828 cm dia. x<br>1.988 cm | 43.6748 | .0428 x $10^{24}$ | |