

EUROPEAN-AMERICAN NUCLEAR DATA COMMITTEE

TECHNICAL MINUTES OF THE SECOND
MEETING (15 - 18 November 1960)
Oak Ridge, Tennessee

EANDC - 10(T)

compiled by

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Aided by

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Atomic Energy of Canada Ltd.,
Chalk River, Ontario, Canada.

March, 1961.

(For additional copies, apply to R. Perret, ENEA,
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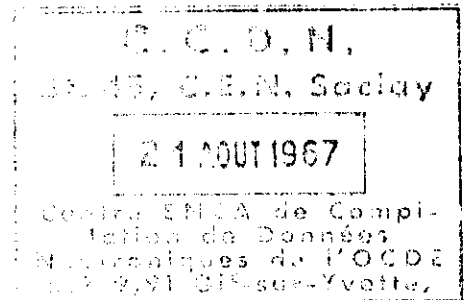


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NOTE

This version of the minutes of the meeting of the European-American Nuclear Data Committee is produced for general distribution to those concerned with measurement programmes in the nuclear data field. The conclusions are, however, of an interim nature in many cases, and the document is therefore marked "Not for Publication" and should neither be quoted in publications nor listed by abstract journals.

^{*} Pages 17-22, 23, and 24-26 of this document are identical with pages in the complete minutes and therefore carry the numbers 37-42, 45, and 48-50 respectively; the alternative numbers are given only on pages 23 and 24. It is hoped that this will not cause confusion.

EANDC-8: Final Agenda for the Second Meeting

Oak Ridge, Tennessee, November 15 - 18, 1960

1. (a) Minutes of First Meeting: EANDC-5
(b) Changes of sizes of delegations - approval?
(c) Adoption of final form of agenda for this meeting
2. Matters arising from EANDC-5 (action numbers quoted from App. XIV):
 - (a) Document circulation - EANDC-6 and Corrigenda 1 and 2
 - (b) Stable isotope pool (Action 10)
 - (c) Documents
 - (i) on Standards etc. (Actions 11, 24) EANDC(E)-8,
 - (ii) on mass separators (53)
 - (d) Exchange of personnel (23, 25, 46)
 - (e) Miscellaneous administrative (2, 12, 16-17, 22, 37, 38, 39, 45) including relations with IAEA and ISO.
 - (f) Discrepancies and requests (27-36, 40-44)
 - (g) Miscellaneous technical (18, 20-21, 26, 47-52, 54)
3. General problems:
 - (a) Nomenclature, symbolism, definitions, and compilations
 - (i) General (EANDC(Can)-3, -(Can)-4)
 - (ii) Resonance integrals: nomenclature and definitions - EANDC(Can)-8, EANDC(E)-14, EANDC(UK)-9, EANDC(US)-17
 - (b) Possible exchanges or mutual use of equipment
 - (c) Exchange of personnel
 - (i) reciprocal
 - (ii) unilateral, but for specific reasons
 - (d) Possible exchanges and transfers - Educative - Kowarski
4. Information on facilities and programs (EANDC(US)-14 and -15)
 - (a) Subcommittee on list of facilities (EANDC-7: EANDC(US)-16)
 - (b) Receipt (without comment) of other documents (EANDC(Can)-3, 5 and 6, EANDC(E)-10, 11, 16 and 17, EANDC(US)-14, 15 and 16)
5. Extension of area of work of committee or alternative proposals for work in the integral field EANDC(OR)-8
 - (a) Diffusion length in D₂O

- (b) Neutron spectrum measurements
 - (i) chopper method; (ii) pulsed source method
- 6. Consideration of discrepancies EANDC-9 - EANDC(E)-9; EANDC(E)-12
 - (a) Non-cross-section discrepancies
- 7. Consideration of request lists (principal items only) EANDC(Can)-7; (E)-9,-15; (OR)-10; (UK)-6; (US)-8,-18:
 - (a) Elements ($Z < 92$) E: MeV region
 - (i) $\sigma_{n,n}(E)$ (ii) $\sigma_{n,n'}(E, E')$
 - (iii) $\sigma_{n,n'}(E; E_\gamma)$ or $\sigma_{nG}(E; E_\gamma)$
 - (b) $Z < 92$, keV region, $\sigma_{n,\gamma}$
 - (c) $Z < 92$, $E < 1$ keV, $\sigma_{n,\gamma}(E)$ or $\sigma_{act}(E)$ or resonance parameters
 - (d) Uranium isotopes (EANDC(UK)-7)
 - (i) U-233 (ii) U-235 (iii) U-238
 - (e) Plutonium isotopes
 - (i) Pu-239 (ii) Pu-240 (iii) Pu-241 (iv) Pu-242
 - (f) Neptunium, Americium and higher Z isotopes
 - (g) Other requests
 - (i) thermal inelastic scattering (ii) fission products
 - (h) Documentation of requests
- 8. Particular actions required in connection with the foregoing:
 - (a) Personnel exchange
 - (b) Exchange of samples
 - (c) Exchange of standards
- 9. Production of special isotopes
 - (a) UK, US, Canadian plutonium program - Taschek. EANDC(US)-12
 - (b) Seibersdorf - Kowarski
 - (c) Euratom - Spaepen
 - (d) Pure Pu-239 - Kolstad or Taschek
 - (e) Sample of irradiated Pu from Saclay - Joly
 - (f) Other (EANDC(E)-13)
- 10. (a) Fission foil exchange scheme
 - (b) Foil and target fabrication

11. Nuclear Standardization Laboratories
 - (a) Euratom - Spaepen
 - (b) National Standards Laboratories (NPL and NBS)
12. Symposia - UK working party (EANDC(UK)-8)
13. Any other business
14. Date and place of next meeting
15. Adjournment

SUBJECT INDEX

References are to page numbers, and part of page
(α , β , γ , λ , μ , i.e. γ = about middle of page.)

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Documents	5 γ , 12 λ
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Fission Foils	13, 24-26
Fission Products	12 β
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Resonance integrals	3 γ -5 β
Standards Laboratories	15-16
Spectrum in D ₂ O reactors	5 μ -6 β
Thermal inelastic scattering	11 μ
Various cross sections	7 γ

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Au	6 μ	Pu-239	11 α
B-10	23	Pu-240	8 γ , 11 β
Be	8 β	Pu-241, 242	11 γ - λ
C-12	6 γ	S(n,p)P	7 α
Co-59	8 μ , 15 λ	Th-232	8 λ
Fe-56	7 λ , 8 α - β	U-233	9 α - λ
Li	8 α	U-235	9 μ -10 β
Mo	8 μ	U-238	7 γ - μ , 10 γ - μ
N, Na	8 γ	W-184	8 β - γ
Ni-58	6 λ , 8 α , 15 λ	Xe-135	9 α , 12 β
Oxygen	7 λ , 8 α	Zr	8 β

Minutes of the Second Meeting of EANDC

Held at
Holiday Inn and Oak Ridge National Laboratory
Oak Ridge, Tennessee, U.S.A.
November 15 - 18, 1960, inclusive

There were present:

R.F. Taschek, LASL, USA (Chairman)
C.H. Westcott, AECL, Canada (Executive Secretary)
K.H. Beckurts, Karlsruhe, Germany
A. Bracci, Ispra, Italy
E. Bretscher, AERE, UK
H. Goldstein, NDA, USA (November 15 - 17 noon only)
J. Harvey, ORNL, USA
G.A. Kolstad, USAEC, Washington, USA
L. Kowarski, ENEA, Paris
R. Meier, EIR, Wurenlingen, Switzerland
E.B. Paul, AERE, UK
N.G. Sjöstrand, A.B. Atomenergi, Sweden
J. Spaepen, Euratom, Mol
J.S. Story, AERE, UK
R.P. Perret, ENEA, Paris (Observer and Acting Corresponding
Secretary for the Meeting)
W.E. Kunz, USAEC, Oak Ridge, USA (Observer)
F.C. Maienschein, ORNL, USA (Observer and Local Secretary)
A. Snell (for part of the November 16 morning meeting only, i.e.
agenda item 3 (d))

A tape-recording technician was also present. The corresponding secretary (R. Joly) was not present, for the reasons explained below.

INTRODUCTION

The Chairman called the meeting to order by introducing Mr. F.C. Maienschein, who was acting as local secretary, and announcing that he had received a cable from R. Joly regretting his inability to be present, for family reasons. By correspondence it had been agreed to accept as an observer at this one meeting Mr. R.P. Perret of ENEA and Perret volunteered to perform the functions of corresponding secretary for this meeting, due to be performed by Joly. This offer was gratefully accepted. Messrs. W.E. Kunz and A. Snell were also invited to be present as observers during portions of the meeting.

1. MINUTES OF THE FIRST MEETING

1(a) Acceptance of minutes (EANDC-5 and -5(T))

Meier had notified amendments desired in EANDC-5(T) and these were accepted, as follows: (references are to pages in EANDC-5(T))

p.11 (middle), "work done at Zurich", add reference M. Brullmann, H.J. Gerber, D. Meier, P. Scherrer: "Streuung and Polarisations-effekte von 3.27-MeV-Neutronen und Deutronen", Helvetica Physica Acta, 32, 511-48, (1959).

p.12 (last paragraph, $\sigma_{n,n}(E,E')$), add after "of ion source" the words "to the 1 MeV accelerator".

p.13, 4th paragraph, substitute " $109 \pm 3 \text{ cm}^2$ " for "is known to better than 3 per cent" and add after "lethargy" the words " 6.8 cm^2 per unit of lethargy, accurate".

The executive secretary admitted that all references to "Silbersdorf" should read "Seibersdorf", also p.24, third title, should be "Off-site....."

With these changes EANDC-5 and -5(T) were accepted.

3. GENERAL PROBLEMS

3(a) Nomenclature, symbolism, definitions, and compilations

(1) General: EANDC(Can)-3, -(Can)-4

Taschek outlined the U.S. situation, mentioning the Ajzenberg and K. Way operations, two groups at Brookhaven (BNL-325 group and cross section evaluation group) and the Argonne Constants Centre. He also cited some informal discussions on the occasion of the recent Kingston (ICNS) conference aimed at eliminating overlapping compilations and streamlining arrangements; as a result of this discussion

the IAEA is to call a meeting. Kolstad felt that the IAEA was tending to reorientation away from microscopic or fundamental data for reactor purposes. Paul, Taschek, Goldstein and Kolstad all regretted this trend. The Chairman agreed to draft a letter recommending that fundamental microscopic data be not excluded and send it to the IAEA with members' comments.

Beckurts mentioned that a compilation of data for fast reactors was being proposed at Karlsruhe and said it would be made available to EANDC if it was desired; it was agreed that this would be done.

Goldstein spoke of the Brookhaven Nuclear Cross Section Evaluation Group set up under the U.S.A.E.C. Reactor Division. Requests to be included in the mailing list for their news-letters should be sent direct to BNL (R. Sher).

(ii) Resonance Integrals: nomenclature and definitions
(EANDC(Can)-8, -(E)-14, -(UK)-9 and -(US)-17)

Beckurts said that the Horowitz (-(E)-14) document was only indirectly connected with resonance integrals.

Westcott introduced the subject by reference to -(Can)-8, saying that he had abandoned the attempt to produce an all-inclusive symbolism. Measurements by integral methods were complicated by the "bump" in the cutoff function (Swedish work cited in -(Can)-4) and the failure of the $1/E$ flux-distribution law in special lattice arrangements (e.g. vacant fuel sites) often used in measurements. He explained the confusion of using both total and $1/v$ subtracted integrals, and recommended a fixed energy cutoff (say 0.45 eV)^{*} rather than a stated Cd thickness as a lower limit of the integral. By contrast -(US)-17 stated a preference for a directly-measured quantity, such as that obtained with an 0.040-inch thick filter (geometry unspecified^{**}); the authors also preferred using the Maxwellian component of the neutron density as a basis for σ_{eff} and thereby introduced a convention similar to, but unfortunately slightly different from, that of EANDC(Can)-4.

Westcott then said that, to reduce the number of alternative forms

* chosen for EANDC(Can)-4 as a compromise between 0.4 and 0.5 eV.

** This document (-(US)-17) has now been issued in a revised form in which this question has been treated at greater length.

of resonance integral to be quoted, he would agree to drop the $1/v$ -term subtraction for cases^{*} (like Pu-239) where $\sigma(E)$ was very different from a $1/v$ variation; for all other cases he preferred the $1/v$ term to be subtracted. For cases like Pa-233 (σ -law unknown below 0.5 eV) one had to "assume" a $1/v$ -law to interpret measurements but keeping the $1/v$ -term subtracted gave the most direct transition from the measured quantity to what was needed in reactor calculations. Story said that -(UK)-9 merely suggested a few clearly-defined quantities which might be chosen to clarify the situation. Goldstein said that as more was learned about reactors the need for more corrections to integrally-measured resonance integrals became apparent; in fact there was a tendency towards wanting to use only detailed resonance parameters. Westcott pointed out that EANDC(Can)-8 asked for a new review of numerical values for resonance integrals (often old measurements) and for a clear statement of the basis in which results should (and how well the old ones could) be stated, to help to clarify the situation. Harvey, referring to § 4 of EANDC(Can)-8, pointed out that the resonance parameters, as normally quoted, gave directly the contributions to the total resonance integral, while for the capture resonance integral it was only when Γ_n/Γ_γ was of order unity that much information was lost by quoting Γ 's separately; Westcott agreed his difficulties had been for elements like Zr and Co and agreed that his criticisms needed modification.

After further discussion Taschek said he felt the difference between -(US)-17 and Westcott was in fact smaller than had been suggested. Goldstein mentioned the Argonne resonance integral compilation, due to be completed December 1st, 1960, and later to appear in a revision of ANL-5800; he also said that resonance integrals were of interest to several different groups of people and that much of the confusion arises from their different view points. He suggested that EANDC should properly limit its recommendations only to consideration of how resonance integrals should be reported. In -(Can)-8 the conclusion was drawn that it would be very useful to combine with a new compilation an introductory

*The subtraction of $\sigma_0 v_0/v$ then differs appreciably from $\hat{\sigma} v_0/v$ or $\bar{\sigma} v/v$. Therefore, in this case, there would be several different $1/v$ -subtracted integrals; for the other cases, only one.

article pointing out the pitfalls and reasons why old values might be inaccurate. After discussion Taschek appointed Harvey, Goldstein, Story and Westcott a subcommittee to produce, within about one month, a report to EANDC on an agreed system for resonance integrals.

The subcommittee reported two days later that it had agreed to try to produce an agreed document (to be EANDC-12) within a month or two. The subcommittee proposed that later (after EANDC-12 had been written) Story, with assistance, particularly in documenting U.S. measurements, and probably with co-authors, would prepare a publication on the nature of the difficulties in measuring resonance integrals, followed by an assessment and compilation of the values available; a suitable place for publication (if dates fitted) would be the Pergamon Press "Progress in Nuclear Energy, Series I".

4. INFORMATION ON FACILITIES AND PROGRAMMES

In connection with the progress reports EANDC(US)-14 and -(US)-15, Kolstad said this series had long been compiled in the U.S. and had been found to be very useful. They consisted of informal reports from the national laboratories issued before each NCSAG meeting, and "off-site" programmes (cf EANDC(US)-3) were also issued once a year. He suggested that other groups produce similar reports for each EANDC meeting and after discussion this proposal was adopted. (Canada might use excerpts from quarterly reports and the UK appendices from NRDC minutes, supplemented as necessary.) For "E" and "OR" groups, preparation three months before EANDC meetings would be attempted. Perret said he could handle re-production of these additional documents if requested.

5. EXTENSION OF WORK OF THE COMMITTEE IN THE INTEGRAL MEASUREMENTS FIELD

5(b) Neutron spectrum by time-of-flight methods.

Interest has been expressed informally by Sweden, Switzerland, and Canada and discussions had been held with France and UK physicists concerning further measurements of spectra in typical D_2O lattices. A pulsed source method or a chopper were the alternatives. Westcott said that he felt there was some uncertainty as to how good the former method would be for D_2O and the resolution would be greatly diminished by thermalization and diffusion times. He felt further studies of the

feasibility of this method for D_2O spectra were required. Beckurts drew attention also to the perturbation corrections due to a probe-hole within the lattice and said the whole problem should be studied carefully before a programme was set up. The chopper technique would be subject to some of the same limitations, but neutron life-time was unimportant; on the other hand, the fuel used would get appreciably radioactive after some months' use. Taschek said he felt that a neutron spectrum cooperative measurement might be within the scope of the EANDC but detailed lattice interpretations were beyond our field.

The decision was to continue feasibility studies, especially (i) a study of the limitations of the pulsed method for this work, and related calculations of lattice problems and (ii) enquiries concerning possible locales for chopper work, including a study of the problems of fuel handling. A typical maximum-buckling nat-U + D_2O lattice is envisaged, in either case, but no detailed plans will be made at present.

6. CONSIDERATION OF DISCREPANCIES - (EANDC-9, also EANDC(E)-9 and -(E)-12 insofar as they include discrepancies).

Goldstein presented EANDC-9, and detailed discussion followed; e.g., for C^{12} $\sigma_n(\theta)$ Taschek and Goldstein appeared to differ on the relative reliability of ANL and ORNL data. For $\sigma_{n,n}(U-238)$, very careful measurements of Smith (ANL) and Cranberg (LASL) now agreed and it is concluded that all other measurements are incorrect. For Ni-58 (new discrepancy) Taschek felt new measurements by Passell and Heath removed the discrepancy; Paul mentioned AWRE measurements also, but Spaepen said that Co-58 may have a very large thermal cross section and this may spoil the use of Ni-58 for measuring fast neutron fluxes - Harvey substantiated this cross section as being about 1500 barns (- (US)-15, p.68). Beckurts asked if the $\sigma_A(C-12)$ included the effects of nitrogen in the graphite pores, and Goldstein said this was a good question; he would check this. For Au-197, Taschek wondered if the trouble was the loss of γ -rays in scintillation tanks; Goldstein said a paper could probably be written on the various methods of measuring $\sigma_\gamma(Au-197)$ and their possible deficiencies, including the discrepancies quoted, but no action was taken to request this (other than the appearance of the item in EANDC-9). Beckurts asked about a discrepancy for $\sigma_\gamma(E)$ of U-238 between the recent Diven data and those plotted in BNL-325; Paul thought he remembered that there had been a (~30%) misplot of Harwell data in this compilation.

However, it still seemed that fast integral measurements disagreed (by ~15%) with Rose's and other fundamental data, although Taschek seemed to remember reasonable agreement with the Harwell data as supplied direct from AERE.

At this point Spaepen referred to EANDC(E)-12, and in particular to the unpublished values of the S-32(n,p) and Al-27(n, α) cross sections of Depuydt and Nève given in the table at the end of this document. Discussion centred on the S(n,p) cross section, Taschek citing Allen, Biggars, Prestwood, and Smith, Phys. Rev. 107, p. 1363, 1957, as a good absolute calibration for this cross section, but Goldstein expressed some reservations.

In connection with activation cross sections for other elements, Taschek stated that for the last four years R.T. Prestwood and B.P. Bayhurst at Los Alamos had been studying (n,2n) reactions (at 7 to 8 and 12 to 19.8 MeV) in Sc-45, Ti-46, Ni-58, Cu-65, Ge-70, As-75, Rb-85, Rb-87, Sr-84, Y-89, Zr-90, Nb-93, Ag-107, In-115, Sn-112, Sb-121, Sb-123, Ta-181, Au-197, Tl-203, and Th-232, (n,p) reactions in Sc-45, As-75, Sr-86, Y-89, Zr-90, Ag-109, Cd-111 and Au-197, and (n, α) reactions in Al-27, Sc-45, As-75, Y-89, Zr-92, Zr-94, Nb-93, Cd-112, Sn-118 and Au-197. Prestwood and Bayhurst's (Phys. Rev.^{*}) preprint is entitled, "(n,2n) Excitation Functions of Several Nuclei from 12.0 to 19.8 MeV"; papers on the other work will be submitted shortly to Physical Review or Journ. Inorganic & Nuclear Chem. for publication; see also Phys. Rev. 109, 2031, 1958. Taschek also cited Livermore (Tewes et al., UCRL-6028-T) for various (n,p) and (n, α) cross sections, as well as Passell and Heath (forthcoming Nucl. Sc. and Eng.).

Goldstein said that the BNL evaluation group's second news-letter (BNL-634) indicates a serious discrepancy in O-16(n,p) between $\sigma(E)$ and integral cross section measurements. Taschek quoted the Fe-56 data of Terrell as reliable, and wondered if it were not well known, as he frequently saw requests for this measurement.

6(a) The Chairman also asked if anyone had non-cross-section discrepancies, but none were forthcoming. The field covered was fission product yields and half-lives, fission anisotropies, etc., but questions like fission anisotropies were quoted as typical of problems not dealt with by EANDC.

* Now issued in Vol. 121, p. 1438 (1961).

7. CONSIDERATION OF REQUEST LISTS EANDC(US)-8 and -18, EANDC(UK)-6, EANDC(Can)-7, EANDC(E)-9, -12 and -15, EANDC(OR)-10

Only priority I items were discussed in general.

7(a) Elements $Z < 92$; $E > 1$ MeV.

(i) Elastic scattering: Li, O^{16} (ex US list) and Fe, Ni (ex UK); Goldstein said the priority on O^{16} may be reduced, if Philips and the Swiss measurements agree.

(ii) Inelastic scattering: requests were Be (incl. Be (n,2n)0, Zr, W-184 (ex US), Fe (? US), Na (ex UK); concerning Na Goldstein said the U.S. used Joan Freeman's results and Paul that AWRE had started new measurements.

(iii) $\sigma_{n,n'}(E;E_\gamma)$ or $\sigma_{n,G}(E;E_\gamma)$: requests were for N, Fe, Pb. Paul said AWRE would work on the γ -spectrum when they measured neutron inelastic scattering - Harwell will also use their new pulsed Van de Graaff for this type of work.

(iv) σ_T : Beckurts asked for values for Na-23 from 1 to 2 MeV and 4 to 14 MeV; work in this field is in progress at Livermore.

7(b) $Z < 92$, $1 \text{ MeV} > E > 1 \text{ keV}$. Only the σ_γ (Pu-240) U.S. request (10% for 0.5 to 150 keV) was cited.

7(c) $Z < 92$, $E < 1 \text{ keV}$.

The U.K. request was for a mean value of Γ_γ to $\pm 10\%$ for Th-232 which AERE is measuring, also Havens (EANDC(US)-15, p.27), whose measurements should be continued. U.S. requests were for $\sigma(E)$ for W-184, Th-232, and Pa-233, the latter being also a Canadian and U.K. (priority II) request. The MTR programme will not yield a result on Pa-233 for at least a year; ORNL could perhaps do it also if Floyd Culler and the Chem. Tech. Division obtain approval to establish a chemical separation process for U-232 - the same separation techniques and Harvey's chopper (with extra shielding) could be used. Kolstad thought Culler's programme was approved. Bretscher asked whether effort to design a chopper for a specially small sample would not be a preferable approach in such a case. It was decided that Harvey should prepare a report for the next EANDC meeting on what could be done.

Other requests were for $\sigma_{act}(E)$ for Co, and $\sigma_T(\text{Mo})$ from 0.7 to 10 keV; Chalk River or ANL (Bollinger) might be able to do this, and

Good et al. (ORNL) could measure in the higher energy region. Sjöstrand, referring to EANDC(OR)-10, asked for $\sigma_T(\text{Xe-135})$ and $\sigma_\gamma(2200 \text{ m/s})$ for D_2O to $\pm 5\%$.

7(d) Uranium Isotopes

(i) U-233: The discrepancy in η -measurements was discussed; EANDC(UK)-7 (not yet received by all committee members) reported on the Harwell reactivity measurements which appeared to give a systematic difference in the reactivities observed with U-233 samples from U.K. and U.S. sources, the U.S. samples appearing $(3.4 \pm 0.9)\%$ more reactive (several samples were measured). This appeared to be the only discrepancy remaining and its cause remains unexplained, since chemical and isotopic analyses were made both at Harwell and at Oak Ridge and showed excellent agreement. Story had suggested to the TNCC that it might indicate the existence of some long-lived isomeric state. It was noted that the U.K. request for a measurements extends down to 0.005eV and U.S. had requests for $\alpha(E)$, $\sigma_f(E)$ and $\sigma_\gamma(E)$. In reply to Taschek, Story stated that the U.K. request was in connection with a specific reactor programme, also adding that a mass-spectrographic α measurement was planned at Aldermaston. Westcott quoted EANDC-5(T) (p.16) as stating that Saclay was already measuring $\sigma_f(\text{U-233})$. In Joly's absence no information on this was available; Spaepen would enquire what the position was.

Taschek queried the U.K. request for σ_f from 200 eV to 1 MeV to $\pm 13\%$ and suggested that at 1 MeV the available data are good to better than 13%. Story said this request was based on estimates of the accuracy needed for criticality calculations for the Dragon project. Although Allen and Henkel claimed only about 5% uncertainty for σ_f above 1 MeV the data are much less reliable in the region below 100 keV.

(ii) U-235: Taschek asked Harvey about the last item on p.32 of -(US)-18, (column 8), i.e., whether Diven was still planning to measure \bar{v} for thermal neutrons and Harvey confirmed that the remark had been checked with Diven. Paul reported on the U.K. work; the AERE value was 2.43 and the AWRE 2.39 would probably rise to 2.43 also after correction for the effects of Cf and for the neutron spectra; the measurements were relative to Cf. Bretscher asked about low-energy measurements of η and Harvey said Slaughter was measuring it to about 10 eV. Concerning the (OR)-10 request for η to $\pm 0.5\%$ from 0.001 to 1 eV, Harvey suggested this accuracy was not needed above 0.2 eV and Westcott said it

was more necessary near the resonances (below 0.4 eV and above 1 eV) than elsewhere. (The previous item, 6 of -(OR)-10 asked for 0.05% accuracy for natural Uranium, but it was confirmed that this was a misprint for 0.5%). Paul suggested that anyone requesting an accuracy greater than 1% should provide a document justifying the accuracy needed in detail.

It was suggested that Saclay might attempt σ_f and σ_T measurements for U-235 - Spaepen to discuss with Joly. Taschek said the $\alpha(E)$ (10 eV to 10 keV) request was already partially satisfied (cf -(US)-18, where on p.33, 2nd item, column 4 should read "+3% desired, +5% acceptable") and Kolstad asked that all groups' request lists in future include columns corresponding to cols. 6 and 7 of the U.S. lists; it was agreed that it was useful to have names to contact (even if only committee secretaries) added to requests. The U.K. also said they would improve the intelligibility of their list.

(iii) U-238: Concerning the U.K. request for $\sigma_{n,n'}$ from threshold to 1 MeV to $\pm 10\%$, and from 1 to 10 MeV to $\pm 2\%$, Taschek said that 2% was very difficult to attain, and pointed out the complications involved in these requests, which was made in connection with calculations for blankets for fast reactors; Bretscher agreed that it was total yield from all processes that was involved. Paul said extensive documentation is in preparation to justify these requests. Goldstein surmised that the presence of structural and coolant materials would lower the importance of the >1 MeV region, but Paul countered that this request was for blankets. Beckurts discussed -(E)-9, in particular the σ_T (2 to 10 keV) request, important for prompt (Doppler) temperature coefficients for fast reactors. The data given in BNL-325 as Harwell "unpublished" were probably from an AERE report (< 2 keV). AERE might measure this quantity further but the problem was inadequate energy resolution; Beckurts also said that Germany was setting up equipment to measure this quantity also. Harvey remarked that the proposed ORNL Linac is aiming for an energy resolution as good as 1.5×10^{-10} s/m, and Bretscher said the AERE resolution would also be improved.

The German requests, for σ_γ (10-250 keV) and $\sigma_{n,n'}$ (threshold to 1 MeV) for U-238 were deleted; Newson results covered the first and -(US)-15 the second, but Harvey said he would check this one with Dresner. Taschek also said D.B. Thomson at LASL had data at two energies which should help fill this request.

7(e) Plutonium

(i) Pu-239: Spaepen said he was preparing to measure σ_f (2200 m/sec) and was surprised to note in -(US)-18 that the request may be withdrawn (after review by Kouts). Westcott said the feeling in Canada was that they were not happy with the Pu-239/U-235 σ_f ratios in BNL-325, and it seemed likely that the U.S. request will remain. Spaepen said his measurement would use a 4π gaseous fission chamber and be relative to boron; they had started two months ago. On the -(UK)-6 list, item xiv for Pu-239, the upper limit was changed from "fission" to "1 MeV".

(ii) Pu-240: Re $\bar{\nu}$, Taschek said he felt that extrapolation to 14 MeV on a constant $\partial\bar{\nu}/\partial E$ basis was unsafe, citing recent USSR data. Concerning Beckurts' request for $\sigma_T(E)$, Taschek said there was not enough material available; for $\sigma_{n,n'}(E;E_\gamma)$ the lower limit ("threshold") was specified as 200 keV. Beckurts also cited his request for σ_f (Pu-240) below 40 keV.

(iii) Pu-241: Taschek cited p.34 of -(US)-14 for measurements of $\sigma_f(E)$ between 120 keV and 21 MeV (with a reasonably interpolatable gap from 8.6 to 12 MeV) for this isotope, and Harvey that Butler at ANL had measurements from 100 keV to 1.5 MeV. Westcott said σ_T measurements with the Chalk River fast chopper would begin very soon - the sample had been received recently from MTR. Paul said the UK item viii (of -(UK)-6 for this isotope), which looked like i, should be a request for α .

(iv) Pu-242: There were no priority I requests for Pu-242 (all those in -(E)-9 were downgraded to II). On the other hand, the opinion was expressed that the reactor specialists might suddenly find they needed Pu-242 data at some future time.

7(f) Neptunium, Americium and higher Z elements

No discussion; only priority II requests listed.

7(g) Other requests (i) Thermal inelastic scattering

The U.K. is requesting this item and joint measurements at Chalk River are already under way; Beckurts said Karlsruhe is preparing experiments in this field but the reactor will not be ready for about 18 months; a rotating crystal will be used, and hydrogenous and organic moderators will be studied, probably for higher incident neutron energies

to supplement the Can-UK results. Euratom also expressed an interest in this problem; Spaepen said this was in connection with a heavy water reactor project and data were needed for organic moderators, in particular for terphenyl (santowax).

(ii) Fission Products: Meier asked for data on yield of Xe-135 from U-235 fission (priority I, to $\pm 5\%$). Westcott asked whether the Petrushka et al., Can. J. Phys. 33, p.640, 1955 paper gave good enough data, (Canada was still using this value, cf EANDC(Can)-3) and Story remarked that the result from this measurement might need amendment in the light of Bigham's re-assessment of the neutron spectrum, quoted by Fickel and Tomlinson, Can. J. Phys. 37, 531 (1959).^{*} Finally Meier said he would review the situation and would write to Taschek and Westcott if he wished to pursue the matter further.

Westcott pointed out that -(Can)-7 contained only priority II items but that -(Can)-3 showed the thinking on what fission product data were needed for thermal reactors, and it also cited the need for measurements for Ce-144, Ru-106, Pd-107, Xe-131, Rh-103, Rh-105, Pm-147, and Nd-143.

7(h) Documentation of requests

Kolstad and Paul said they felt more background information (perhaps presented as EANDC(UK)-5) on why requests were made was desirable - the U.S. and Canada had agreed at a recent TNCC meeting to do something of this kind. Paul suggested two aspects of the problem: first, a critical survey of the literature and the second, a list of what was wanted and why. It was agreed in principle that this was a desirable aim.

8. PARTICULAR ACTIONS REQUIRED IN CONNECTION WITH THE FOREGOING

8(b) Exchange of samples:

Westcott also reported that Mr. G.W. Fletcher was now the Canadian isotope coordinator, replacing Mr. W.A. Prosser whose name appears in EANDC(Can)-1, (p.7).

^{*} Examination of the method of Petrushka et al. has since shown that only the cross-section of Xe-135 is seriously affected by the neutron spectra, the yield value being quite insensitive to this.

8(c) Exchange of standards: See separate item 10(a) below.

Kolstad asked about neutron standards in Europe; Spaepen quoted the list (EANDC(E)-8, just issued). He said that some intercomparisons of neutron sources had been made and the Bureau International des Poids et Mesures (Sèvres, Paris) were now entering the nuclear field. It was also agreed that Spaepen would act coordinator for standards of boron glass and standard gold foils.

10. SPECIAL PROBLEMS: FOILS AND TARGETS

10(a) Fission foil exchange scheme.

Taschek outlined the fission foil exchange scheme started some years ago by TNCC (with the $\sigma_f(U-235)$ discrepancy as one incentive) and said it was now rather inactive - he suggested that EANDC discuss the situation. W. Kunz of the Oak Ridge Operations Office of the USAEC, who now organizes the scheme, described the platinum foils which had been prepared at Harwell. He quoted some of the specifications and procedures (cf. Appendix XI below, which includes Egelstaff's original document), saying also that the programme was 2-3/4 years old but little had yet come of it. Some comments had been that the Pt was too thick or that Al would be preferred, or that other shapes, sizes, or thicknesses would have been more convenient.

Paul presented remarks from Egelstaff saying that the foil could have two uses - study of properties of fissile materials and use as standard flux monitors (in beams, etc.). Perhaps some of the confusion was due to those two approaches; others added that the Pt backing was unsuitable for γ -ray measurements in the isotopes concerned, but this was not part of the original intention.

Taschek referred to the promises to participate at three "levels"; (see Appendix). Kunz said the promises carried no commitments as to time-scale, but mentioned that Livermore had prepared foils with a few nanogram/cm² deposits; Taschek said Los Alamos had chemists preparing foils and a physicist who (part-time) had built a special counter for foils.

Spaepen said that he was awaiting replies to his questionnaire on fission foils, but he agreed that he could act as a central agency for Europe for the foil exchange scheme.

10(b) Foil and target preparation: proposed central facility.

In the discussion which started when agenda item 3(b) was being discussed (v. p.13 above), Taschek started by saying that an area of possible initial help would be in target and foil fabrication. Although ORNL produced (and had a "pool" stock of) isotopes, the experimenter usually has either to make his own foils or targets or find a friendly expert within his laboratory. Bretscher asked whether commercial interests could be induced to provide such common service facilities. Taschek and Kolstad felt not; a measure of research into methods would be involved in finding the best methods and Taschek quoted Sjöstrand's Pu-240 foil as a good example of a request which could not be fulfilled because of a lack of facilities for fabricating the foil. Further discussion followed in the course of which Taschek said he realized that a central fabricating facility at ORNL or in Europe was a possibility but had not specifically intended to propose this, rather emphasizing the importance of using the existing knowledge which had been accumulated in foil preparation.

Spaepen discussed the situation at the Euratom Bureau Central de Mesures Nucléaires (cf. § 11(a) below), where they were interested in Lu and Dy foils. Also, Saclay (in the Euratom data committee) had asked whether this Bureau could evaporate plutonium foils for them, although this one request did not justify the budgetary provision needed, and the matter is still under study.

Kolstad said that he felt that a service group of professional foil and target preparers should be located at or near enough to use the general facilities of a large laboratory. For the experimenter himself to do this kind of work on scarce materials was not generally desirable and often impracticable - asking colleagues in other specialties to do it was not uniformly satisfactory. Some research on improving methods should be included so that he felt it was not a job suitable for a commercial firm. Kolstad also said that an assured supply of feed materials would be essential - if the facility were set up in continental Europe, firm commitments from the U.K. and the U.S. to supply isotopes would be essential. It could be used to supply targets for both destructive and non-destructive uses.

11. NUCLEAR STANDARDIZATION LABORATORIES

11(a) Euratom: Bureau Central de Mesures Nucleaires

Spaepen reported on the progress and programme of this laboratory as follows. A High Voltage Eng. Corp. 3 MeV Van de Graaff with bunching magnet has been ordered (delivery in 20 months) and two offers have been received for a linear accelerator (energy 45 - 65 MeV, minimum burst time 10 nanoseconds, min. 3 amperes in the burst). The installation of an electromagnetic mass separator is being considered but this project will probably not be continued after the discussion at the present meeting.

The following measurements and research have been started:

- (i) absolute calibration of neutron sources (foil activation in water bath).
- (ii) preparation of boron standards. Remeasurement of the B-10 absorption cross section.
- (iii) fission cross section of Pu-239 at 2200 m/sec.
- (iv) neutron spectra with Li^6I at low temperatures, in collaboration with solid state laboratory of the University of Ghent which will prepare crystals of different isotopic concentrations and will study some of their solid state properties.
- (v) preparation of standardized foils for integrated flux and neutron temperature measurements (Lu and Dy).
- (vi) working group on flux and spectra measurements in high flux reactors. The working group will standardize methods for thermal and fast integrated flux measurements and for fast spectra measurements inside high flux reactors. Co-59 foils are considered as integrators for thermal fluxes and research may be undertaken to apply the methods proposed by Trice, Hartman and Uthe (expansion in orthonormal functions) for measurement of fast spectra. The Ni-58(np)Co-58 reaction has been considered for fast flux integration and small quartz crystals may be used as radiation damage monitors. In the latter case density changes, induced by neutron-radiation, are measured.
- (vii) systematical study of methods of preparation and properties of thin foils and thin sample deposits for absolute counting of radionuclides. A handbook will be issued on this subject.
- (viii) wall effects in gas counting.
- (ix) absolute counting of K-capture radionuclides.

(x) systematic study of Methane-filled proportional counters.

Kolstad congratulated Spaepen on the progress since the Stockholm meeting.

In answer to a question Spaepen said that the linac would have a pulse repetition rate of 1000 sec^{-1} , or possibly 1500 s^{-1} .

Plans call for a staff of 170 by 1962, divided into a neutron physics division, a radioisotopes division and a stable isotopes division, and the latter is equipped with four mass spectrometers. One other has been ordered while two more are considered for ordering. The building now occupied has area 3500 m^2 , and separate buildings will be added for the Van de Graaff, linac and mass spectrometry.

11(b) National Standards Laboratories

Paul reported on the situation at the U.K. National Physical Laboratory, which had only recently expanded its work in the nuclear area (to about 12 staff, with Campion from Chalk River). They are considering getting a research reactor - a report on their programme will be prepared for the next EANDC meeting but comments on what they might do would be appropriate now. Spaepen said his laboratory had decided against a Minerve-type reactor although funds were tentatively available for this (Paul said Spaepen had other reactors nearby).

Kolstad said the U.S. National Bureau of Standards now has a research reactor under way (due to NCSAG urging) under Muehlhause and Landon - also a 100-130 MeV energy linac under Koch. He admitted that the NBS neutron physics programme had developed slowly - the equipment is primarily for other than neutron work.

14. DATE AND PLACE OF NEXT MEETING

It was agreed to hold the next meeting in the U.K., probably at AERE, and the date eventually chosen was the 18th - 21st July, 1961.

15. ADJOURNMENT

On adjournment, votes of thanks to the Chairman and to all the local officers were moved and adopted.

APPENDIX I

LIST OF GENERAL DOCUMENTS SUBMITTEDAT THE SECOND MEETING, OAK RIDGE

<u>No.</u>	<u>Classification</u>	<u>Title</u>	<u>Author</u>
EANDC-6	L	Distribution of EANDC Documents	C.H. Westcott R.P. Perret
+ Corrigendum 1	L	Greece	
+ Corrigendum 2	L	United Kingdom	
EANDC-7	U(NfP)	Report of EANDC Working Group on Lists of Facilities	R.P. Perret
EANDC-8 (Prov.)	A	Provisional Agenda for Second Meeting	
EANDC-9	U	A List of Current Experimental Neutron Cross-Section Discrepancies	H. Goldstein

Intended future allocations of numbers (this document is EANDC-10)

EANDC-11	U	List of facilities	R.P. Perret
EANDC-12	L	Report of Subcommittee on Resonance Integrals	
EANDC-13	U	Collected Priority I requests	Corresponding Secretary.

APPENDIX II

LIST OF CANADIAN DOCUMENTS SUBMITTED
AT THE SECOND MEETING, OAK RIDGE

<u>No.</u>	<u>Classification</u>	<u>Title</u>	<u>Author</u>
EANDC (Can)-3 CRRP-913 AECL No. 1054	U	Yields and Effective Cross Sections of Fission Products and Pseudo-Fission-Products	W.H. Walker (S.A. Kushneriuk)
EANDC (Can)-4 CRRP-960 AECL No. 1101	U	Effective Cross Section Values for Well-Moderated Thermal Reactor Spectra	C.H. Westcott
EANDC (Can)-5 CRP-936 AECL No. 1056	U	A Survey of Published Values of ν in the Fast Fission of U-238	G.C. Hanna
EANDC (Can)-6 AECL No. 873	U	A Review of Measure- ments of the Fission Cross Section of U-235	G.C. Hanna
EANDC (Can)-7	L	Canadian Requests for Measurements	-
EANDC (Can)-8	L	Infinite Dilution Resonance Integrals	C.H. Westcott

APPENDIX III

LIST OF EURATOM DOCUMENTS SUBMITTEDAT THE SECOND MEETING, OAK RIDGE

<u>No.</u>	<u>Classification</u>	<u>Title</u>	<u>Author</u>
EANDC(E)-8	U	Standards for Neutron Measurements Available in the Countries Represented at the EANDC	-
EANDC(E)-9	L	Nuclear Data Needs for Fast and Intermediate Reactor Calculations	J.J. Schmidt
EANDC(E)-10	U	Measurement of Thermal Absorption and Scattering Cross Sections of Natural Neon	R. Genin H. Beil R. Joly M. Ribrag
EANDC(E)-11	U	The Absorption Cross Section of Neon for Slow Neutrons	W. Wiedemann T. Springer
EANDC(E)-12	U	Request for Precise Data on Activation Cross Section of Threshold Detectors	J. Spaepen
EANDC(E)-13	U	Request of U-238 Sample	
EANDC(E)-14	L	Effective Cross Sections for Thermal Reactors	Horowitz Tretiakoff
EANDC(E)-15	L	List of Some Nuclear Data Requirements in Euratom Countries	
EANDC(E)-16	A	Fission Cross Section of U-235 at 0.0253 eV, etc.	Deruytter
EANDC(E)-17	U	Neutron Cross Section and Fission Parameters of Pu-240, Pu-241, and Pu-242	Prosdoccini

APPENDIX IV

LIST OF DOCUMENTS OF OTHER OEEC COUNTRIES AND
ENEA SUBMITTED TO THE SECOND MEETING, OAK RIDGE

<u>No.</u>	<u>Classification</u>	<u>Title</u>	<u>Author</u>
EANDC(OR)-8	A	Note on Collaboration in the Field of Reactor Physics	-
EANDC(OR)-9	U	List of Facilities used or which can be used for the deter- mination of nuclear data in OR countries (not yet published, to be incorporated in EANDC-11)	R.P. Perret
EANDC(OR)-10	L	List of Nuclear Data Requirements in Denmark and Switzerland	-

APPENDIX V

LIST OF UNITED KINGDOM DOCUMENTS SUBMITTED
AT THE SECOND MEETING, OAK RIDGE

<u>No.</u>	<u>Classification</u>	<u>Title</u>	<u>Author</u>
EANDC(UK)-6	L	Interim List of UK Nuclear Cross-Section Data Requirements	J.S. Story
EANDC(UK)-7	L	Harwell Pile Oscil- lator Measurements on the Relative Neutron Yields of Uranium 233, Uranium 235, and Plutonium 239	M.J. Cabell H. Rose R.B. Tattersall
EANDC(UK)-8	A	Proposal to hold a Symposium on the Technique of the Time-of-Flight Methods Suitable for Neutron Physics Research	E. Bretscher
EANDC(UK)-9	L	On the Nomenclature for Resonance Integrals of Very Dilute Materials	J.S. Story

APPENDIX VI

LIST OF THE UNITED STATES DOCUMENTS
SUBMITTED AT THE SECOND MEETING, OAK RIDGE

<u>No.</u>	<u>Classification</u>	<u>Title</u>	<u>Author</u>
EANDC(US)-12	A	Status of Electromagnetically Separated Plutonium Isotope Production, Usage, and Allocation	R.F. Taschek
EANDC(US)-13	A	Preliminary Measurements of α of U 233, U 235, and Pu 239	B.C. Diven J.C. Hopkins
EANDC(US)-14	U	Report to the AEC Nuclear Cross Section Advisory Group (April 1960)	J.A. Harvey Secretary NCSAG
EANDC(US)-15 WASH-1029	U	Report to the AEC Nuclear Cross Section Advisory Group (September 1960)	J.A. Harvey Secretary NCSAG
EANDC(US)-16	L	Mass Separators and Special Mass Spectrometers in the USA	J.A. Harvey et al
EANDC(US)-17	A	Standardization of Infinite Dilution Resonance Integral	R.W. Stoughton J. Halperin
EANDC(US)-18	L	Compilation of Requests For Nuclear Cross Section Measurements	J.A. Harvey Secretary NCSAG

APPENDIX IX

BORON. σ_A (2200 m/sec).

The following values are drawn from a painstaking analysis of all available data, excepting the preliminary values reported in WASH 1028 (1960). All have been converted to the ANL basis for boron.

	σ_A , barns.
Average from spectrometer measurements at long wavelengths	752 \pm 4
Average from spectrometer measurements in the thermal region, 0.01 to 0.1 eV.	761 \pm 5
Weighted mean of all direct measurements including pulsed-source data.	756.0 \pm 2.5
From weighted means of direct measurements on σ_A (H) and ratios of B/H.	769.8 \pm 9.0
From weighted means of spectrometer measurements on σ_A (Au) at long wavelengths, and ratios of B/Au.	766.3 \pm 8.4

Preferred value, taking all the data into account	757.7 \pm 3.0

It can be argued that these results are consistent, within the errors, but the systematic trends are somewhat disturbing.

Dr. Sjöstrand and I used our own judgement in weighting the data to obtain the values given above. A χ^2 test of all the best data showed less than 0.1% probability that the uncertainties assigned by the experimenters are correct.

October 1960.

J.S. Story.

TRIPARTITE NUCLEAR CROSS SECTION COMMITTEE'S SCHEME
FOR STANDARDIZATION OF FISSILE FOILS

1. Object

To prepare standard foils of the fissile isotopes for fission counting, and whose thickness or mass is accurately known. It is believed that this will enable fission cross sections measured by counting fission fragments to be considerably improved in accuracy.

2. Method

It is assumed that the object can be achieved if foils are prepared by many different techniques, the thicknesses or masses measured by many different methods and all the foils intercompared.

3. Use of existing foils and knowledge

An important part of the scheme will be to bring all the foils which have been carefully prepared and tested in many laboratories on to a common standard. Such foils are designated "Laboratory Standard Foils". It is proposed that these foils remain at the laboratory of origin and fresh foils be made for circulation.

4. Levels of participation in the scheme

1A. To make foils for circulation, and

(a) to measure thickness or mass independently.

(b) to compare with own "Lab. Std. Foils".

1B. To make foils for circulation and to measure their thickness or mass.

1C. To make foils for circulation and to compare with own "Lab. Std. Foil".

2A. To intercompare all foils made for circulation and to check standardization against own "Lab. Std. Foil".

2B. To intercompare foils of a particular size or thickness only and to check standardization against own "Lab. Std. Foil".

3A.) As 2A and 2B but without check against.

3B.) "Lab. Std. Foil".

5. Administration

Backings, housed in plastic containers, to the accompanying drawing will be supplied by Harwell to all users. It is suggested that one backing per foil to be made, and one blank are supplied. Stocks of the proposed foil data sheet are also available from Harwell. Data sheets for the "Laboratory Standard Foils" are to be deposited at the administrative centre, and data sheets for the foils in circulation are to travel with the foils. The administrative centre is temporarily at Harwell, but the future centre* will be decided at the next meeting of the T.N.C.C. Copies of results of measurements to be sent to the administrative centre, which will circulate them to all participants at intervals.

(*Oak Ridge)

.....

Extract from circular letter from P.A. Egelstaff enclosing the above:

"Although the details of the scheme are not necessarily final, it is hoped that modifications suggested by those who participate will be kept to a minimum. This is because the practical details embodied in the present scheme result from a compromise of many points of view. For example Al, Ni and Pt, each of various thicknesses, were considered for the foil backing material. Platinum of 0.005" thickness was finally chosen as the best compromise between the requirements of mechanical strength, neutron absorption and scattering properties, and chemical inertness with respect to first baking and later chemical removal of the deposit.....

"If you decide to participate at level i, please would you let me know approximately what thickness ($\mu\text{gm}/\text{cm}^2$) and diameter of deposit you would lay down. Any further information such as which fissile materials you can deposit, methods of deposition to be used, of measuring thickness of deposit, comparing foils etc., would be welcome. A suggested set of information on each foil to be supplied by the originating laboratory is also enclosed."

Enclosure:
For enclosure (Data Sheet) see over.

P.A. Egelstaff

