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A.E.C. RESEARCH AND DEVELOPMENT REPORT

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**AMES
LABORATORY
IOWA STATE
COLLEGE**

PHYSICS. QUARTERLY SUMMARY RESEARCH REPORT
APRIL, MAY, JUNE, — 1955.

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U N I T E D S T A T E S A T O M I C E N E R G Y C O M M I S S I O N

QUARTERLY SUMMARY RESEARCH REPORT IN PHYSICS

For April, May, June, 1955

by

Ames Laboratory Staff

October 4, 1955

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U N C L A S S I F I E D

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QUARTERLY SUMMARY RESEARCH REPORT IN PHYSICS

For the Period April, May, and June, 1955

This report is prepared from material
submitted by the group leaders of
the Laboratory

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PHYSICS

Under the direction of F. H. Spedding, G. W. Fox, G. C. Danielson, D. E. Hudson, E. N. Jensen, J. M. Keller, J. K. Knipp, S. Legvold, and D. J. Zaffarano
G. H. Miller

Theoretical Physics1. Range Straggling in Nuclear Track Emulsion (J. K. Knipp)*

A recent paper by Barkas, Smith, and Birnbaum (Phys. Rev. 98, 605 (1955)) gave an account of range straggling by positive mu-mesons which resulted in a value of the straggling parameter which is not consistent with the value determined with great care by Fry and White (Phys. Rev. 90, 207 (1953)). The source of the inconsistency had been found and is the use of a biased estimator for the variance. The data of Barkas, Smith, and Birnbaum have been reanalyzed with the result that a value of the straggling parameter is determined which is in accord with that of Fry and White. Moreover, an estimate of the variation of the stopping power of the emulsion from plate to plate has been obtained.

2. Radiative Electron Decay of Pi Mesons (J. K. Knipp)

A very general analysis of the problem of the radiative decay of the pi meson with the emission in addition of an electron and a neutrino has been carried out. The relative probabilities of alternative modes of decay have been calculated.

3. Electron Scattering in Transition Metals (J. M. Keller)

For some time, we have been considering in some detail the thermal scattering of electrons between the s and d bands in transition metals, with special reference to nickel. This work is nearing conclusion, and the details will be described in a special report.

The calculation is based on the assumption of a deformable potential corrected for redistribution of charge in an inhomogeneously strained crystal. It has also been necessary to correct the expression for the deformed potential by the introduction of some shorter wave length terms than those used in the original formulation of Bloch.¹ Without these terms, the older forms of potential

*Names indicate group leaders.

¹F. Bloch, Z. Physik 52, 555 (1928). A Sommerfeld and H. A. Bethe, Handbuch der Physik (Julius Springer, Berlin) Vol. 24, part 2, Chapter 3.

were not entirely self-consistent. The additional terms have the effect of reducing the distinction between "normal" and "Umklapp" scattering processes. As the propagation vector of the scattering phonon increases toward the edge of the Brillouin zone, Umklapp type terms gradually appear, with increasing coefficients. Likewise, scattering that previously would have been considered as Umklapp appears to contain some normal parts.

4. Magnetic Properties of Dysprosium (J. M. Keller)

We have been continuing our efforts to understand the magnetic properties of dysprosium in the temperature region between 85°K and 176°K, where the material is assumed to be antiferromagnetic. The work is based on a molecular field approximation, which is surely not correct in detail, but which is relatively easy to handle, and is probably the only simple model that should give a fair description of magnetic behavior over such a temperature range. In order to allow the material to become ferromagnetic below 85°K, the molecular field coefficients are assumed slightly temperature dependent.

An adequate theory should explain at least qualitatively the gradual rise in susceptibility observed¹ as the temperature is reduced below about 160°K. Our previous attempts to understand this as some sort of competition between the stable antiferromagnetic arrangement and the slightly unstable ferromagnetic arrangement failed. However, the transverse susceptibility--the susceptibility appropriate when the external field is applied perpendicular to the directions of spin orientation--turns out to have essentially the property observed. The transverse susceptibility per atom is given by the relation

$$\chi_{\perp} = \text{constant}/(T_A - T_F)$$

where T_A and T_F are temperatures at which the antiferromagnetic and ferromagnetic orientations respectively become stable compared to a random magnetic orientation. But in a theory in which the molecular field coefficients are temperature dependent, the denominator in the expression for $\chi_{\perp}$ is replaced by a temperature dependent term that slowly approaches zero as the temperature is lowered toward the ferro antiferromagnetic transition temperature.

The interpretation of the increase in susceptibility as being due to transverse susceptibility should be fairly simple to test experimentally when single crystals of dysprosium become available.

¹F. Trombe, Compt. rend. 236, 591 (1953). J. F. Elliott, S. Legvold and F. H. Spedding, Phys. Rev. 94, 1143 (1954).

Experimental Physics

1. Nuclear Studies

1.1 The Decay Scheme of Sc^{47} (E. N. Jensen)

The radiations from Sc^{47} have been examined with a scintillation spectrometer and an intermediate image spectrometer¹ operated in conjunction with a scintillation spectrometer for beta-gamma coincidence data.

The Sc^{47} was produced by irradiating titanium chloride in the x-ray beam of the Iowa State College synchrotron. The scandium was chemically separated from the titanium chloride. A charge discriminating baffle was used in the intermediate image spectrometer to eliminate the positrons from the 58-hr $\text{Sc}^{44\text{m}}$ activity. The sources were relatively thick, having a surface density of about 58 mg/cm².

One gamma ray was observed with a scintillation spectrometer and was found to have an energy of 167 ± 2 kev. Two beta groups were observed having allowed shapes and with maximum energies of 596 ± 10 kev and 430 ± 5 kev. The maximum energy of the low energy beta-group was obtained from the beta spectrum in coincidence with the gamma ray. The intensities of the beta groups were found to be 36 per cent and 64 per cent respectively, giving log ft values of 6.0 and 5.3 respectively.

The proposed decay scheme of Sc^{47} is shown in Fig. 1. The orbital assignments of the energy levels were determined from nuclear shell theory and the log ft values of the beta transitions. The gamma ray is presumed to be a magnetic dipole transition.

1.2 The Decay Scheme of Cl^{34} and $\text{Cl}^{34\text{m}}$ (E. N. Jensen)

A scintillation spectrometer and an intermediate image spectrometer¹ operated in conjunction with a scintillation spectrometer were used to examine the radiations from Cl^{34} and $\text{Cl}^{34\text{m}}$.

The Cl^{34} and $\text{Cl}^{34\text{m}}$ were obtained by irradiating carbon tetrachloride in the x-ray beam of the 70 Mev Iowa State College synchrotron. The Szilard-Chalmers process was employed to separate the radioactive chlorine fraction. Several sources were used to obtain the data.

The half-life of $\text{Cl}^{34\text{m}}$ was found to be 32.30 ± 0.14 min. One internal conversion line was observed, corresponding to a gamma-ray energy of 139 ± 1 kev. Three other gamma rays were observed. The highest energy gamma-ray was not evaluated because

¹Nichols, Pohm, Talboy, and Jensen, Rev. Sci. Instr. 26, 580 (1955).

Fig. 1 - The Decay Scheme of Sc^{47} .

of saturation in the amplifiers. Ticho¹ has determined the energy of this gamma ray as 3.22 ± 0.03 Mev. The energies of the other two gamma rays were found to be 2.08 ± 0.04 Mev and 1.17 ± 0.03 Mev.

Using subtraction techniques, the total positron spectrum was found to consist of three groups all having allowed shapes. The maximum energy of the highest energy positron groups was found to be 4.47 ± 0.02 Mev. The positron spectrum in coincidence with the gamma rays having energies above 200 kev was also obtained. This positron spectrum consisted of two groups having maximum energies of 2.57 ± 0.04 Mev and 1.33 ± 0.02 Mev. The positron spectrum in coincidence with the 3.22 Mev gamma ray was also observed. The statistics were too poor for an accurate energy determination, but the maximum energy of the positron group was about 1.2 Mev. No coincidences with the 139 kev gamma ray were observed.

The intensities of the positron groups were found to be 39 per cent, 31 per cent, and 30 per cent for the highest-energy, intermediate-energy, and lowest-energy positron groups respectively.

The decay scheme shown in Fig. 2 for Cl^{34} and Cl^{34m} is consistent with the data obtained in this investigation. Kline and Zaffarano² have measured the half-life of Cl^{34} as 1.53 ± 0.02 sec.

1.3 Excitation of Isomers by High-Energy X-Rays (D. J. Zaffarano)

Considerable progress in the understanding of the systematics which may exist in nuclear energy levels has been made by the application of selection rules arising from the shell and collective models of nuclei. The spins and parities of the lowest energy states, in particular, are most easily predicted by theories based on these models. These states can be most conveniently studied when they have long life times (metastable states). The observation of such states has been limited by the number of known radioactive nuclei (isomers) which decay via long-lived gamma-ray emission.

Although it has been previously demonstrated that isomers can be excited by high-energy x-ray bombardment of nuclei, apparently no systematic search for microsecond activities has been previously reported. To date, the elements, Pb, Cu, Pt, Au, Ag, Fe, Zn, Sn, and W have been examined here. Of these elements,

¹H. K. Ticho, Phys. Rev. 84, 745 (1951).

²R. M. Kline and D. J. Zaffarano, Phys. Rev. 96, 1620 (1954).

Fig. 2 - The Decay Scheme of Cl^{34} and Cl^{34m} .

Au, W, and Zn have been found to have long-lived (microsecond) states. The results of preliminary measurements are shown in Table 1.

Table 1

Element	Energy (kev)	Half-life (μ sec)
W	340 ± 17	12 ± 3
Au	61 ± 3 67 ± 3	12 ± 3
Zn ^{67m}	90 ± 5	9

The results for W and Au are new, while the Zn has been previously reported.

1.4 Examination of Synchrotron-Induced Radioactivities (D. J. Zaffarano)

The low energy gamma-ray spectrum of Te¹²⁹ was investigated and a new strong gamma transition at approximately 35 kev was detected. Beta-gamma coincidence measurements showed the 35 kev gamma-ray to be in coincidence with the 1460 kev beta group previously found, and gamma-gamma coincidences showed the 450 kev and 35 kev gamma-rays to be in coincidence. The decay scheme of Te¹²⁹ and the probable level assignments of the excited I¹²⁹ nucleus have been determined to be as shown in Fig. 3.

1.5 Beta-Spectra of Some Short-Lived Nuclides (D. J. Zaffarano)

A report entitled "Beta-Spectra of Some Short Lived Nuclides" by L. S. Ring, Jr. and D. J. Zaffarano was distributed as ISC-648.

Abstract

The determination of the energy endpoints of the beta radiation spectra from the parent nuclides of 'mirror' pairs was undertaken utilizing an improved scintillation spectrometer as the means of detection. The Iowa State College 67 Mev synchrotron was used to create the short-lived parent nuclei, and a short pneumatic tube was used to transport the samples rapidly to the counting position.

Fig. 3 - Decay Scheme of Te^{129} .

The scintillation spectrometer was an improved version of the one reported in ISC-359¹ and subsequently by Hunt.² The detector consisted of two photomultiplier tubes and anthracene crystals arranged to give nearly complete solid angle response to the particles from the thin (40 mg/cm²) samples used.

The Cs¹³⁷ internal conversion electron peak was analyzed. The resolution of the peak was 15.9% with a valley to peak ratio of 0.29. The P³², Y⁹⁰, and Cl³⁴ spectra, which have reported endpoint energies of 1.70, 2.24, and 4.47 Mev respectively, were examined to test the accuracy of the scintillation spectrometer and recording equipment. A calibration pulse height versus energy ratio was established by adjusting the Kurie plot from the recorded P³² negatron spectrum to have an endpoint energy of 1.70 Mev. The calibration ratio was then applied to the Y⁹⁰ negatron spectrum and the Cl³⁴ positron spectrum to determine their endpoint energies. The endpoint energies agreed with magnetic spectrometer values. This and additional spectral calibrations established that positron endpoints could be determined accurately with this equipment.

A table of reported experimental half-lives and positron energy endpoints for parent 'mirror' nuclei with atomic numbers greater than ten is included.

The positron endpoint energies obtained by the author, and the respective 'ft' values for the transitions are listed in Table 1.

Table 1. Endpoint kinetic energies, half-lives, and 'ft' values for some 'mirror' transitions.

Nucleus	E _{max} (Mev)	t _{1/2} (sec)	ft (sec)
Si ²⁷	3.82±0.04	4.47±0.05	4520±310
P ²⁹	3.82±0.04	4.46±0.05	4350±310
S ³¹	4.42±0.03	2.55±0.02	4640±250
Ca ³⁹	5.58±0.04	0.97±0.02	4830±230

¹W. A. Hunt, W. Rhinehart, J. Weber, and D. J. Zaffarano, Ames Laboratory Report ISC-359 (1953); Rev. Sci. Instr. 25, 268 (1954).

²W. A. Hunt, Radioactive Disintegration Spectra of Some Short-Lived Nuclides, Unpublished Ph. D. Thesis, Ames, Iowa, Iowa State College Library. (1954).

1.6 Alternate Gradient Synchrotron Beam Extraction (D. J. Zaffarano)

The complete details of this work are given in ISC-547.

1.7 Pulse Height Analysis (D. J. Zaffarano)

A report (ISC-598) entitled "A Voltage Calibration System for Accurate Pulse Height Measurements" by W. A. Rhinehart and D. J. Zaffarano, was distributed.

Abstract

A system is described for accurately measuring the amplitudes of voltage pulses. The system is particularly suited for obtaining calibration and linearity data on amplifiers, pulse-height analyzers, pulse attenuators and other pulse equipment commonly found in the field of nuclear research. An accuracy of 0.3% is maintained for unknown voltage pulses of 0.1-v to 200-v magnitude and of either positive or negative polarity. A visual comparison method is used which enables any given point of a voltage waveform to be measured.

1.8 Secondary Electron Emission (G. H. Miller)

A report (ISC-562) entitled "Secondary Electron Emission Due to Positive Ion Bombardment" by G. H. Miller and J. W. Murdock, was distributed.

Abstract

Stray electrons were produced in the Ames Laboratory linear accelerator by the ion beam striking the target and various other parts of the accelerator. This experiment was done to determine if the stray electrons from parts of the accelerator other than the target could be reduced by using construction materials other than brass. Measurements of the number of electrons produced from several materials, however, indicated that there is no particular advantage in using other materials in place of brass.

The ratio of electrons produced per proton bombarding a copper target varied from 1.15 to 1.57 with a high at 1.64 as the ion beam energy was varied from 23 kilovolts to 130 kilovolts. In this same beam energy, the range varied more for diatomic and triatomic hydrogen. The ratio for triatomic hydrogen increased from 1.48 to 3.59.

Measurements showed that most of the electrons produced at the target had an energy less than thirty electron volts. The curves for the integral electron energy distribution were similar to the curves for diode for diode vacuum tubes. The energy measurement methods were

similar to those used to produce the space charge limited curve of a diode; thus, it was assumed that the electrons bombarded from the target produced a space charge at the target similar to the space charge formed at the cathode of a diode.

1.9 Ionization Yield in Gases (G. H. Miller)

A report (ISC-655) entitled "Measurement of the Ionization Yield of Low Energy Atomic Particles in Gases" by R. A. Lowry and G. H. Miller, was distributed.

Abstract

The purpose of this investigation was to study the total ionization yield of charged atomic particles in gases for energies in the range of a few to 250 kev. A large cylindrical ionization chamber was used for this study. The charged particles were selected from the kevatron beam by a magnetic and an electrostatic analyzer and entered the chamber by means of a 0.004 inch diameter open window. A differential pumping system permitted pressures up to 10 mm Hg to be maintained in the chamber. The chamber was alternately operated as a proportional counter and an ionization chamber to measure the rate with which the primary ions entered the chamber and the ionization produced by them, respectively. A detailed description of the apparatus and measuring technique are given.

The ionization yields of protons in nitrogen were measured as a preliminary test of the feasibility of the experimental method and to check the performance of the apparatus. The results of these measurements were subject to large uncertainties but indicated a straight line relation between ionization yield and energy for energies above 75 kev. The slope of the line corresponded to 36.6 ev/ip.

More precise measurements were made of the ionization yield of protons in argon. The results indicated that any deviation from a linear relation between ionization yield and energy was small for energies above 25 kev. The slope of a least squares plot of the data corresponded to 26.5 ev/ip. The straight line representing the least squares plot intercepted the energy axis at 1.4 kev indicating a slight ionization defect for protons in argon.

It was concluded that the apparatus and measuring technique had proven to be relatively successful and perhaps adequate to continue with an investigation of more interesting combinations of ions and gases.

1.10 Automatic Pressure Regulator (G. H. Miller)

A report (ISC-599) entitled "A Pressure Regulator for a Low-Pressure Continuous-Flow Ionization Chamber" by R. A. Lowry, J. E. Osher, and G. H. Miller, was distributed.

Abstract

A description is given of an automatic pressure-regulating device for a continuous-flow ionization chamber operated in the pressure range of 1 to 10 mm Hg. The pressure monitor consisted of an oil manometer, a light source, and two phototubes arranged whereby any small change in pressure gave rise to a corresponding electrical signal. This signal was used to control the power to a thermal gas flow valve. The regulator was capable of maintaining the pressure constant to within 0.03 mm Hg for a period of at least 24 hours.

2. Solid State Studies

2.1 Semi-conducting Metallic Compounds (G. C. Danielson)

2.10 Electrical Properties of Magnesium Germanide (Mg_2Ge)

A single crystal of magnesium germanide (Mg_2Ge) has been grown. The dimensions of the crystal were 14 mm by 1.7 mm by 0.6 mm. The room temperature resistivity varied between 0.072 and 0.085 ohm-cm along the length of the sample but was uniform, within 5 per cent, in the region between potential probes. The crucible cracked during the preparation of the crystal and the crystal was contaminated with several impurities. Spectrographic analysis showed weak lines due to iron; very weak lines due to manganese; traces due to copper, silver, chromium and nickel; faint traces due to silicon; and very faint traces due to aluminum.

At room temperature and for magnetic fields as high as 10 kilogauss, no magnetoresistance effect was detected and the Hall voltage was negative and varied linearly with magnetic field (see Figure 4). The logarithm of the resistivity as a function of the reciprocal of the absolute temperature is plotted in Figure 5 and the logarithm of the absolute value of the Hall coefficient as a function of $1/T$ is plotted in Figure 6. The absolute value of the Hall mobility, defined as the absolute value of the Hall coefficient divided by the resistivity, is plotted in Figure 7 on a log-log plot.

Fig. 4 - Dependence of V_H/I_s on H for Mg₂Ge 3A.

Fig. 5 - Resistivity of Mg_2Ge 3A.

Fig. 6 - Hall Coefficient of Mg_2Ge 3A.

Fig. 7 - Hall Mobility of Mg_2Ge 3A.

Since the Hall coefficient was negative at all temperatures, the dominating charge carriers were electrons rather than holes. Above 500°K the sample behaved as an intrinsic semiconductor. Since the Hall coefficient remained negative, the mobility of the electrons must be greater than the mobility of the holes.

At low temperature Figure 7 suggests that the mobility may have increased as $T^{3/2}$, which is characteristic of electron scattering by ionized impurities. After passing through a maximum at 100°K the mobility decreased as $T^{-3/2}$, which is characteristic of electron scattering by the acoustical modes of the thermal vibrations. Above room temperature the mobility decreased more nearly as T^{-1} and this suggests strong scattering by optical modes having a characteristic temperature near room temperature. In the temperature region just above 500°K the intrinsic carrier density was apparently overtaking the impurity carrier density and the strong decline of the mobility as T^{-2} may be attributed to the increasing influence of holes. At the highest temperatures, those above 700°K, the mobility decreased as $T^{-3/2}$ and scattering by the acoustical modes must have predominated once more.

From the data below 100°K, calculations gave an energy for the donor levels of 0.006 ev below the conduction band. At 100°K the number of donor impurities was computed to be $2(10^{16})$ per cm^3 or less than one part per million. Hence most of the impurities shown by spectrographic analysis did not act as donors.

From the high temperature data above 700°K the energy band separation was calculated to be about 0.63 ev.

2.11 Electrical Properties of Magnesium Plumbide (Mg_2Pb) (G. C. Danielson)

Single crystals of magnesium plumbide have been grown. It has now been shown that single crystals can be grown for each of the four fluorspar compounds Mg_2X where X represents Si, Ge, Sn, or Pb.

Polycrystalline samples of Mg_2Pb have been investigated by Robertson and Uhlig¹ and by Busch and Winkler.² The former measured the resistivity only between 20°C and 150°C and concluded that Mg_2Pb is a metal; the latter, without presenting data, conclude that Mg_2Pb is a degenerate semiconductor at room temperature. This question can be resolved by measurements of resistivity at low temperatures.

Our preliminary measurements at low temperatures indicate that Mg_2Pb does not become an insulator at absolute zero and is therefore a metal rather than a degenerate semiconductor. The resistivity of single crystals, in agreement with Uhlig and Busch's resistivity of polycrystalline material, was about $2(10^{-4})$ ohm-cm at 300°K. The resistivity at 70°C was about

¹W. D. Robertson and H. H. Uhlig, Metals Tech. 15, publication number 2468 (1948).

²G. Busch and U. Winkler, Physica 20, 1067 (1954).

$1(10^{-4})$ ohm-cm. The resistivity increased more slowly than linearly with temperature in the range 70°K to 300°K and, therefore, Mg_2Pb does not behave as a normal metal.

The Hall coefficient had a value of $-0.055 \text{ cm}^3/\text{coulomb}$ and was constant from 70°K to 300°K. This value corresponds to $1.1(10^{20})$ electron charge carriers per cm^3 . If we assume that free electron theory is valid (which is certainly not the case) and that the effective mass of the charge carriers is equal to the free electron mass, the Fermi level for Mg_2Pb would be about 0.08 electron-volts. This value is very low compared to most metals but high enough to suggest that the compound remains a metallic conductor even at absolute zero.

The Hall mobility is about $280 \text{ cm}^2/\text{volt-sec}$ at room temperature and $550 \text{ cm}^2/\text{volt-sec}$ at 70°K. These mobilities are much higher than the mobilities of the Mg or Pb constituents or, in fact, of any ordinary metals. (Even the best metal conductors, such as silver or copper, have mobilities less than $60 \text{ cm}^2/\text{volt-sec}$ at 300°K.) The mobilities of the electrons in the metal Mg_2Pb are comparable to those in the semiconductors Mg_2Si , Mg_2Ge (see Figure 7), and Mg_2Sn . The fluor spar structure appears to give mobilities between 100 and $1000 \text{ cm}^2/\text{volt-sec}$.

2.2 Specific Heat of Nickel by a Pulse Method (G. C. Danielson)

The specific heat of nickel from 20°C to 600°C has been measured by a pulse method (see Figure 8). The data, in general, agree with calorimetric determinations to within five per cent. The abrupt drop from $0.19 \text{ cal/gm } ^\circ\text{C}$ to $0.12 \text{ cal/gm } ^\circ\text{C}$ at the Curie temperature (360°C) appeared to be sharper than that reported by previous investigators who used calorimetric methods. This result suggests that the pulse method may be superior to calorimetric methods for investigating certain types of phase transitions.

2.3 Magnetic Properties of Holmium (F. H. Spëdding and H. S. Legvold)

The magnetic properties of holmium metal were measured over the temperature range from 23°K to 300°K. The sample was 1 mm by 1 mm by 10 mm and the magnetic moment was determined in applied fields from 3 to 18 kilogauss.

The magnetization isotherms for holmium as shown in Figure 9 are not unlike those for dysprosium. There is a magnetic transition or Neel point at about 136°K with the sample paramagnetic above this temperature and perhaps ferromagnetic or antiferromagnetic below. This transition can best be observed in Figure 10 where the magnetic moment observed in a constant magnetic field is plotted against temperature. When the applied field is held constant, the rapid rise of the magnetic moment with decreasing temperature below 100°K suggests that a second transition may take place somewhat below 20°K, the sample being ferromagnetic below this temperature.

Fig. 8 - Specific Heat of Nickel.

Fig. 9 - Isotherm Data for Holmium σ_c with Increasing H.

Fig. 10 - Isofield Data on Holmium.

The transitions indicated are in reasonably close agreement with observations made on the specific heat of holmium by others at this Laboratory.

APPENDIX: LIST OF REPORTS FROM THE AMES LABORATORY

1. Reports for Cooperating Laboratories

- ISC-531 Ames Laboratory Staff. Metallurgy. Quarterly Summary Research Report. July, August, September, 1954.
- ISC-574 Ames Laboratory Staff. Chemistry. Quarterly Summary Research Report. October, November, December, 1954.
- ISC-576 Compiled by P. Chiotti and O. N. Carlson. Hanford Slug Program. Quarterly Summary Research Report. October, November, December, 1954.
- ISC-577 Ames Laboratory Staff. Physics. Quarterly Summary Research Report. October, November, December, 1954.
- ISC-598 W. A. Rhinehart and D. J. Zaffarano. A Voltage Calibration System for Accurate Pulse Height Measurements.
- ISC-599 R. A. Lowry, J. E. Osher and G. H. Miller. A Pressure Regulator for a Low Pressure Continuous Flow Ionization Chamber.
- ISC-601 R. W. Fisher. Comprehensive Report on Production of Thorium. IA. Thorium Fluoride Preparation.
- ISC-602 R. N. Kniseley and V. A. Fassel. A Rotating Step Sector for Use with AC or Other Intermittent Spectrographic Light Sources.

2. Papers Published in Scientific Journals

- Banks, C. V. and R. J. Davis
Analytical Applications of the Reaction of Thorium with Benzenephosphoric Acid. Anal. Chem. Acta 12, 418-431 (May, 1955).
- Banks, C. V. and R. E. Edwards. Separation and Determination of Thorium and Aluminum. Anal. Chem. 27, 947-49 (June, 1955).
- Duke, F. R. and R. W. Laity
The Measurement of Transport Numbers in Pure Fused Salts. J. Phys. Chem. 59, 549-52 (June, 1955).
- Fassel, V. A., B. Quinney, L. C. Kretz and C. F. Lentz
Quantitative Spectrographic Analysis of the Rare Earth Elements. Anal. Chem. 27, 1010-14 (June, 1955).

- Grantham, LeRoy F., T. S. Elleman and D. S. Martin, Jr.
Exchange of Chlorine in Aqueous Systems Containing
Chloride and Tetrachloroplatinate. II. J. Am. Chem.
Soc. 77, 2965-71 (June, 1955).
- Hammer, C. L. and A. J. Bureau
A Method for the Prompt Destruction of the Electron Beam
in a Conventional Synchrotron. Rev. Sci. Instr. 26,
594-98 (June, 1955).
- Hammer, C. L. and A. J. Bureau
A Method for the Prompt Destruction of the Electron Beam
in a Conventional Synchrotron. II. Rev. Sci. Instr.
26, 598-600 (June, 1955).
- Hansen, R. S. and R. D. Hansen
The Adsorption of Hydrocarbons for Menthanol and Ethanol
Solutions by Non-Porous Carbons. J. Phys. Chem. 59,
496-498 (June, 1955).
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