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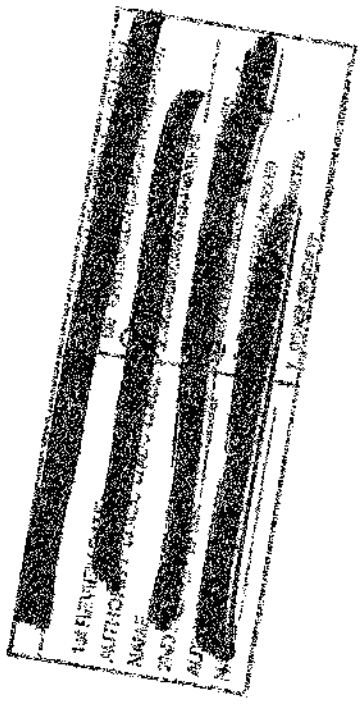

Report No. M 4002

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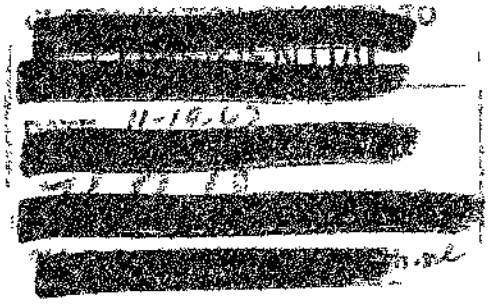

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RESEARCH AND DEVELOPMENT REPORTS

CHEMISTRY - GENERAL

A-2940 The Determination of Traces of Uranium in Leaf Ash and Soil, by G. W. Imirie *Jr.* 10 p. (NBS) 1946

The sample is dissolved in nitric acid, digested, and evaporated to dryness. The sample is again taken up in nitric acid, filtered, and the filtrate evaporated to dryness. The residue is taken up in ferric nitrate and extracted with ether, and the ether is washed with ammonium nitrate. Water is added to the other extract, which is allowed to evaporate and the water solution is made up to the desired volume. An aliquot is transferred to a gold dish, evaporated to dryness, fused with sodium fluoride, and fluorescence read on a fluorimeter.

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RESEARCH AND DEVELOPMENT REPORTS

CHEMISTRY - SEPARATIONS PROCESSES FOR PLUTONIUM

CN-3811 Brief Summary of Redox Solvent Extraction Process as of April 1, 1947, by *H. H. Hyman*. 10 p. (Argonne National Laboratory) 1947

This is a brief review of the status of the Redox Solvent Extraction Process. Two alternative flowsheets are included. Planned and current operations are indicated

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Mon-N-319 Variables Affecting Solvent Extraction and a Summary of Two Cycle Hexone Extractions Employing Irradiated U-235, by *F. R. Bruce, A. DeHaan, W. B. Howerton.* 43 p. (Clinton Laboratories) 1947

This report indicates that the optimum condition for maximum decontamination in continuous extraction, employs as low an extraction factor (D.C. x ratio of flow rates, *organic / aqueous*) as possible. The salting agent concentration in first-cycle extraction may be varied within wide limits without affecting decontamination adversely, providing the extraction factor is held constant. In second-cycle extraction there is an advantage to be gained in employing a higher salting agent concentration and varying the flow rates to maintain a low extraction factor.

The following variables which may be encountered in a continuous solvent extraction process have been found to influence the distribution coefficients (organic/aqueous) of fission products and (or) uranium:

(1) Uranium Concentration - In both hexone and dibutyl cellosolve extraction the uranium distribution coefficient appears to increase at uranium concentrations below 1.5 grams per liter.

(2) Temperature - Uranium and gamma emitting fission species distribution coefficients vary inversely, and at the same rate, with temperature in hexone extraction.

(3) First Cycle Salting Agent Concentration - In hexone extraction, uranium and fission product distribution coefficients vary directly, and at about the same rate, with salting agent in the concentration range, of 0.75M $Al(NO_3)_3$ to 1.75M $Al(NO_3)_3$. In extractions employing dibutyl cellosolve, the uranium distribution coefficient exhibits the same behavior as in hexone but the fission product distribution coefficient is independent of salting agent strength at concentrations above 1M $Al(NO_3)_3$.

(4) HNO_3 Concentration - In hexone extraction, HNO_3 functions much more effectively as a salting agent for fission products than it does for uranium, both distribution coefficients increasing with the free acid concentration. The same effect is observed in dibutyl cellosolve extractions except that the fission product distribution coefficient remains constant to a higher acid concentration. The desirability of maintaining a low free acid concentration in a separations process is apparent.

(5) Second Cycle Salting Agent Concentration - In second-cycle hexone extraction (system reduced by boiling with hydrazine) both the uranium and fission product distribution coefficients increase with $Al(NO_3)_3$ concentration; however, the uranium distribution coefficient increases more rapidly than that for fission products, suggesting operation at a higher salting agent concentration to enhance decontamination. (con't on next page)

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CHEMISTRY - SEPARATIONS PROCESSES FOR URANIUM

MonN-319 Variables Affecting Solvent Extraction and a Summary of Two Cycle Hexone Extraction Employing Irradiated U-235, by *F. R. Bruce, A. DeHaan, W. B. Howerton.* 43 p. (Clinton Laboratories) 1947 (con't from page 3)

Uranium distribution coefficients, in first and second cycle extraction and scrubbing systems containing low free acid, were found to increase at about the same rate with salt concentration as those in higher acid solutions.

In extractions employing irradiated U^{235} as starting material, the adverse effect of high salting agent and free HNO_3 was substantiated. In a run made with low free acid, and $Al(NO_3)_3$ to give a U distribution coefficient of 2, an overall gamma decontamination factor of 8×10^5 was obtained. The principle contaminant in the product from two cycle extractions proved to be ruthenium, which contributed from 49 - 85% of the gross beta contamination.

MonT-320 Preliminary Report on the Recovery of Uranium from Spent Graphite-Uranium Fuel Material, by *H. K. Jackson.* 28 p. (Clinton Laboratories) 1947

Processes have been investigated for the recovery of uranium from carbon and graphite parts. No study on the recovery of uranium from carbon parts containing fission products has been reported.

The only process utilized on a large scale has been the operation at Y-12 in which carbon parts are burned in oxygen, the ash leached with hot nitric acid, and the residue fused with sodium hydroxide, and then leached with nitric acid. If complete combustion is obtained, the uranium content of the residue after the first nitric acid leach is of the order of 1,000 ppm, and the uranium content of the insoluble residue after leaching of the fusion product is of the order of 50-100 ppm. If this recovery data is extrapolated to a power pile graphite fuel unit containing .04% ash and 2% uranium the losses after the first and second leach would be of the order of .001% and 0.0001% respectively.

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CHEMISTRY - SEPARATIONS PROCESSES FOR URANIUM

MonT-320 Preliminary Report on the Recovery of Uranium from Spent Graphite-Uranium Fuel Material, by *H. K. Jackson*. 28 p. (Clinton Laboratories) 1947

(con't from page 4)

It has been demonstrated that a residue completely soluble in nitric acid can be obtained by mixing ground carbon parts containing uranium with five parts by weight of sodium carbonate, and heating to 750°C for 17 hours. The residue has a sodium/uranium atom ratio of about 1000 to 1, and nullifies one of the major advantages of the graphite fuel unit, i.e., the small amount of solution required for fission product separation compared to that necessary when the Be-U and BeO-UO_2 type fuel units are used.

The other methods of recovery reported in the literature appear to be less attractive than the process outlined above, either because of incomplete recovery or excessive corrosion effects on materials of construction.

It is recommended that an experimental program be undertaken to determine the recovery which can be obtained by the burning-acid leach process, using a graphite containing fission products and .04% ash. If it is found that the recovery is sufficiently high, as can be expected, then recovery equipment should be designed, and the adequacy of the process and equipment demonstrated. An outline of a design which appears to be feasible on the basis of present data is given in the report.

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HEALTH AND BIOLOGY - GENERAL

CH-3719 Studies of Porphyrin Metabolism IV. The Effect of Irradiation on Coproporphyrin Excretion, by *S. Schwartz et al.* (Argonne) 24 p. 1947

The effect of irradiation exposure on coproporphyrin in excretion has been studied in 38 dogs A diminished excretion of this porphyrin in urine and feces was found to follow the administration of lethal or nearly lethal doses of total body X ray strontium^{89}, and plutonium In most instances a sharp increase in porphyrin excretion occurred during the terminal period.

Preliminary studies showed no significant change in the ratio of the two coproporphyrin isomers (I and III) following irradiation.

CH-3720 Studies of Porphyrin Metabolism. III The Relation of Erythropoiesis to the Excretion of Corproporphyrin by Dogs and Rabbits, and to the Concentration of Coproporphyrin and Protoporphyrin in Rabbit Erythrocytes, by *S. Schwartz et al.* 22 p. (Chicago) 1947

Coproporphyrin has been demonstrated, apparently for the first time in the red blood cells of rabbits An average concentration of 3.3 micrograms per 100 ml of red blood cells was found in 13 control rabbits Values as high as 40 micrograms per 100 ml of cells were found in 3 rabbits subjected to repeated bleeding Reticulocyte counts and red cell protoporphyrin concentrations in these latter rabbits were also appreciably elevated Studies in which the red blood cells were fractionated to yield an increased percentage of reticulocytes indicated that both coproporphyrin and protoporphyrin are concentrated in the fractions that are richest in reticulocytes

The isomer type of this coproporphyrin has not yet been determined

An increase in the excretion of coproporphyrin I was found in both urine and feces of 2 dogs injected subcutaneously with 40 mg of phenylhydrazine per kg body weight Two rabbits injected subcutaneously with 15 mg of phenylhydrazine per kg body weight showed an apparent increase in the excretion of total fecal coproporphyrin but only one of them had a significant increase in urinary coproporphyrin output Incomplete studies showed no evidence of increased excretion of the type I isomer in the urine of the rabbits. Isomer data on the faces of the rabbits are not available.

In all 4 animals, the phenylhydrazine produced an acute hemolytic reaction as indicated by a rapid fall in blood hemoglobin concentration and by an increased excretion of fecal urobilinogen. The reticulocyte count and coproporphyrin excretion reached peak values about one week after administration of the phenylhydrazine.

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HEALTH AND BIOLOGY - GENERAL

CH-3760 Studies of the Hemolytic Effect of Radiation, by *S. Schwartz E. J. Katz L. M. Porter L. E Jacobson and C J Watson.* 51 p. (Argonne) 1946

Evidence is presented indicating that both acute and chronic radiation anemia are due in part to a hemolytic reaction, and not solely to an inhibition of erythropoietic activity as has been assumed by most investigators

The hemolytic concept is based on the following evidence taken from a survey of the literature as well as from experimental studies (1) The red cell count in human and animal subjects may fall at a rate that is faster than can be accounted for by assuming even 100 per cent inhibition of erythropoiesis (2) The red cell count may decline at a time when the reticulocyte count is actually elevated (3) Histological evidence of increased red cell destruction has been demonstrated repeatedly (4) The bone marrow of humans that have anemia due to chronic radium poisoning is typically hyperplastic not aplastic (5) Increased bile pigment excretion has been shown to occur following administration of large doses of P^{32} or total body X-ray

Excessive irradiation appears to destroy both mature and immature cells in increased amounts More studies of human subjects are required to evaluate the importance of this hemolytic factor Special attention in these studies should be given to bile pigment excretion and reticulocyte measurements

CH-3820 Biochemical Studies Relating to the Effects of Radiation and Metals, by *S. Schwartz.* 72 p. (Argonne) 1947

Various biochemical effects of radiation have been studied in 10 patients given total body x ray in total doses of 75 to 310 r (skin) in 5 patients given 20 to 36 mc. P^{32} and in 5 project personnel accidentally exposed to excessive doses of external radiations Similar studies have also been made on several hundred Plutonium Project personnel exposed in most instances to relatively small amounts of uranium, lead and other metals and to chemicals and radioactive sources These studies included the investigation of liver function, of white blood cell chemistry, and of various urinary constituents such as coproporphyrin urorosein and other pigments urobilinogen corticosteroid like substances catalase, and uranium

Definitely excessive exposures resulted in various abnormalities in the above tests With the exception of urinary uranium analysis none of them are specific in indicating overexposure to either radiation metals, or chemicals When interpreted in the light of the exposure and medical history however, it is felt that they may aid in the clinical interpretation of relatively marked overexposure at least. In addition, they may afford further insight into the nature of radiation effects.

The literature on the biochemical effects of radiation is reviewed briefly, and certain suggestions are offered regarding future investigations in this field

CH-3824 Acute Radiotoxicity of Injected Cerium^{144} in the Rat, by *D. S. Anthony, and K. A. Lathrop.* 22 p. (Argonne) 1947

Groups of 10 or more rats were given doses of 10 7 5, 3, and 2 μc of (CE-Pr)^{144} per gram of body weight by intravenous injection. The metabolism of the Ce was studied and the effect of this radioactive material on the general clinical condition, survival, and weight was observed.

At no time was the excretion of cerium rapid; in fact, it required approximately 35 days for the rats to excrete half of the injected dose. The rate of excretion of Ce^{144} in the urine fell continuously with time while the rate of excretion in the feces rose to a maximum at about one week and then dropped with time. The ratio of the amount excreted in the urine to that in the feces fell continuously with time.

The early retention of Ce^{144} was largely in the liver but this dropped rapidly with time. Apparently, some of the radiocerium released by the liver was taken up by the skeleton since the activity of the bones rose to a maximum during the period when the liver was rapidly losing its cerium. As the liver became exhusted of Ce, the activity of the skeleton dropped with time.

The rats that died within the first 30 to 40 days showed an almostcomplete lack of gross lesions which are usually noted in radiotoxicity studies. In 4 of the 6 animals that died between 70 and 120 days after injection there was abundant visible evidence of radiation injury to the liver. In a few animals dying at still later times, osteogenic sarcomas were found.

The 30 day LD_{50} for intravenously injected Ce^{144} in the rat was found to be about 3 μc/g of body weight. By 120 days the LD_{50} was down to between 2 and 3 μc/g.

At all dose levels there was a diminution of the growth rate as measured by increase in body weight.

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CH-3825 Acute Radiotoxicity of $(Ba\text{-}La)^{140}$ in Rats and Mice Part IV, Lethal Action and Clinical Symptoms, by *R. D. Finkle, R. H. Snyder, and W. E. Kisieleski.* 6 p. (Argonne) 1947

In the $(Ba\text{-}La)^{140}$ experiments, rats and mice were injected intraperitoneally with toxic doses of radiobarium. The dose of $(Ba\text{-}La)^{140}$ necessary to kill 50 per cent of the injected mice in one month was about 3 to 5 $\mu c/g$. The dose required to kill half of the injected rats in 90 days was about 4 $\mu c/g$.

CH-3826 Acute Radiotoxicity of $(Ba\text{-}La)^{140}$ in Rats and Mice. Part II, Metabolism of $(Ba\text{-}La)^{140}$, by *R. H. Snyder, D. S. Anthony, W. E. Kisieleski, and R. D. Finkle.* 17 p (Argonne) 1947

In these experiments mice and rats were injected intraperitoneally with toxic doses of $(Ba\text{-}La)^{140}$. Absorption was relatively rapid and excretion was considerable during the first day. Mice usually excreted 25 per cent of the injected dose by 12 hours, and rats excreted a comparable amount by 50 hours. This excretion rate was comparable to that reported by Hamilton who found for rats a total excretion, in 4 days, of about 46 per cent Ba^{133} and 25 per cent Ba^{140}. Excretion declined rapidly so that after 6 days, mice excreted 0.4 per cent and rats excreted 0.5 per cent of the injected dose per day. In rats, a little more than twice as much Ba^{140} was excreted in the feces as in the urine.

In mice, about 45 per cent of the injected dose of Ba^{140} was deposited in bone, and in rats, about 60 per cent of the dose was deposited there. In both species, these values represent practically all of the retained Ba^{140}. Absorption and decay curves on soft tissues, however, show that most of the injected La^{140} was present in the spleen, liver, and kidney immediately after injection. Limited data indicated that practically none of the La^{140} formed in bone by Ba^{140} decay left the bone for the soft tissues.

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CH-3826 Acute Radiotoxicity of $(Ba\text{-}La)^{140}$ in Rats and Mice Part II, Metabolism of $(Ba\text{-}La)^{140}$, by *R. H. Snyder, D. S. Anthony, W. E. Kisieleski, and R.D. Finkle*. 17 p. (Argonne) 1947 (con't from page 9)

It can be concluded that the excretion and distribution of radiobarium, and the distribution of radiolanthanum at the toxic levels are comparable to those at the tracer levels. No significant variations of barium metabolism with the size of dose was noted in mice. With rats, however, large (lethal) doses were retained more completely by the skeleton than were the lower doses. It is likely that this effect of dose represents a "flooding" of the excretion apparatus and, therefore, is dependent on the amount of inactive barium injected with the Ba^{140}. The authors did not have the opportunity to confirm both the observation and explanation with a larger number of animals.

CH-3835 Effect of Total Body X-Ray on Weights of Organs in the Rat, by *A. M. Brues, G. A. Sacher, and H. O. France* 12 p. (Metallurgical Laboratory) 1947

Weights and water content of organs were investigated in a group of growing male rats that had received 1498 r at 13.82 r/day average. The weights of the majority of the visceral organs were affected less than body weight as a whole; weights of muscle and femur were affected in the same ratio as body weight; and spleen, thymus, gonads, and gonadal fat were reduced out of proportion to body weight. Adrenal weights were normal. Water content per gram of tissue in muscle and bone of irradiated animals was 4.3 per cent greater than in the control animals. Thus the retardation in growth is similar to that seen in inanition except for the relatively greater effect on organs known to be radiosensitive.

Organ weights and total body weights of rats that had received single doses of X-ray up to 100 r several months previously, showed no deviations from the normal.

M-1974 Summary of Progress in the Pharmacology Division for the Month of May 1947, *H. C. Hodge.* 60 p. (University of Rochester) 1947

URANIUM TOXICITY

The animals being exposed to an atmosphere containing approximately 2 mg U/m^3, as uranyl nitrate, have exhibited no changes in the past month. This is the 23rd month of a 2-year study. During the month, 1 dog died of causes unknown; grossly the kidneys were normal. A few rats also have died, presumably of old age. The NPN of the dogs' blood samples, which was somewhat elevated last month, has returned to normal concentrations this month.

LUNG RETENTION

Thirty-five rabbits have been studied in the lung retention apparatus. Two size-graded samples of uranium dioxide have been used--one about 1.0 micron and the other about 0.5 micron. The amount retained is directly proportional to the concentration for either particle size.

BERYLLIUM TOXICITY

Beryllium Fume

Rats exposed to beryllium fume died promptly or if they survived the exposure, showed little lasting effect. The fume exposures were high-grade, concentrations of the order of 160 mg/m^3 were achieved. Thirty-minute exposures were carried out. It appeared to make no difference in the growth curves of the rats whether the total 30-minute exposure was on one day or in 4 or in 30 equal exposures on succeeding days. The most prominent response to the exposures was an increase in neutrophils of the blood.

The hematological observations appeared to be the most useful criteria of beryllium poisoning at present especially the increase in relative and absolute polymorphonuclear leucocytes. The increases are greater when the poisoning is sufficiently severe to produce a loss of weight and is marked in the period immediately preceeding death.

Beryllium Feeding

Beryllium sulfate fed to rats for 40 days produced a severe growth depression. These rats were then put for 100 days on the stock diet containing no added beryllium. The growth, although markedly restored and the rickets healed has failed to reach the control weight of the rats. Feeding 10% of beryllium metal was without effect.

Intravenous Beryllium

The intravenous administration of repeated doses of beryllium sulfate has produced an extraordinary calcification of the marrow of the long bone.

A single intravenous dose of beryllium is followed by polyuria and an increase in the amino-acid nitrogen to creatinine ratio.

Radioberyllium

The administration of Be^7 into the stomach of rats is followed by the excretion of most of the beryllium in the feces. Sixty percent or more is excreted, mostly in the first 48 hours. At the end of five days, some is found in the bone and some in the liver.

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M-1974 Summary of Progress in the Pharmacology Division for the Month of May 1947, by *H. C. Hodge*. 60 p. (University of Rochester) 1947 (Con't from page 11)

Beryllium Color Method

A histidine buffer has been found useful in the colorimetric determination of beryllium.

Plant Survey

Beryllium dust analyses have been made in a beryllium manufacturing plant. Several dust-collecting devices were tried and compared. In certain operations as much as 4 mg of beryllium/m^3 have been found in the air. At other places in the plant, dust concentrations of lesser magnitude, viz., 0.5 to 0.05 and even as low as 0.01, were found. In this same survey, fluorides were found in amounts of from 0.7 to 1.6 mg/m^3; in some samples as much as 60 mg F/m^3 were reported. The particle sizes of the dusts obtained in this factory were small, of the order of 0.8 micron near the furnace. Farther away larger particles, averaging in size from 1 to 6 microns, were obtained. The most hazardous locations seemed to be near the beryllium metal furnace and near the BeF_2 furnace.

THORIUM TOXICITY

Including 10% thorium nitrate in the diet of rats precluded growth. In a paired feeding experiment, a group of control rats, averaging 61 g, were compared to a group of rats fed thorium nitrate, which weighed initially 69 g. At the end of the experiment the control rats weighed 96 g, and the thorium-fed rats 59 g. These data are interpreted as showing that thorium exerts a toxic effect beyond the reduction in food intake.

Radio Thorium

Forty-eight hours after thorium marked with UX_1 is injected intravenously into rats, the liver contains roughly 3/4 of the original dose. The intestine contains 4-7%, perhaps as a result of biliary excretion; the spleen has about 4%; the remainder of the carcass, 6-9%. When a similar experiment is carried out on rabbits, the blood retains 30-60% of the dose for 6 hours. At this time the liver contains roughly 30% of the dose. This tends to increase to values as high as roughly 2/3 of the dose in the liver in 48 hours. The spleen contains about 1%; little is found in urine, feces, kidney, or lungs.

HALOGENATED HYDROCARBONS

The preliminary studies on the halogenated hydrocarbons have been completed. Hexachloropropylene (HCP) produces a delayed poisoning following 30-minute exposures. The peak of mortality did not occur until 1-4 days. The rabbit is the most susceptible animal; mice are intermediate; and rats are the most resistant of the three species. HCP has a low vapor pressure and has an easily identifiable odor at a few ppm, which becomes unbearable at higher concentrations. The LD50 for a 30-minute exposure is less than 400 ppm for rabbits and of the order of 300-500 ppm for rats and mice.

Trichloracrylylchloride (TCAC) has quite different characteristics: Following 30-minute exposures the animals which die do so promptly, that is, within one day. TCAC is most toxic for the rat; the rabbit is intermediate; the the mouse the most resistant of these three species. TCAC has a high toxicity--approximately of the same order as phosgene. There is less warning than with HCP, and it is possible that a dangerous concentration might be established without a warning due to irradiation. The LD50 for a 30-minute exposure is of the order of 100-200 ppm for the species studied.

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HEALTH AND BIOLOGY - GENERAL

M-1974 Summary of Progress in the Pharmacology Division for the Month of May 1947, by *H. C. Hodge*. 60 p. (University of Rochester) 1947 (Con't from page 12)

BONE SURFACE

Samples of fresh bone and ashed bone powders were subjected to measurements of specific surface using ethane adsorption. Powdered bone is found to have relatively huge specific adsorbing surface. Fresh bone values between 1.5 and 4.5 sq m/g were obtained; and for ashed bone values of 102 to 244 sq m/g. Such particles show an extreme degree of porosity. It is believed that the adsorption surfaces are the submicroscopic crystals of hydroxyapatite.

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MonH-285 The Response of High Leukemia Strain Mice to Radiation, by *P. S. Henshaw, E. F. Riley, G. E. Stapleton and M. B. Cupp.* 18 p. (Clinton Labs) 1947

The studies with C58 mice have revealed the following:

(1) That on the basis of survival, the r/n ratio is approximately 17 to 1.

(2) That the effects obtained with 8.6 r per day and 51.6 r per week (i.e., the same weekly dose in each case) indicate that the single weekly treatment is slightly more effective.

(3) That the time of occurrence of leukemia in C58 animals is not set ahead by the treatments with gamma rays and fast neutrons as given.

(4) That a high spontaneous rate of leukemia does not assure a high leukemogenic response to radiation, as originally presumed.

MonH-288 The General Picture of Irradiation Lamage to Tissues, by *P. S. Henshaw & R. S. Snider.* Parts I and II 29 p. (Clinton Laboratories) 1947
I Superficial Radiation (Beta rays)

The pertinent facts associated with induction of skin tumors with superficial radiations may be listed as follows:

1. It is important to remember that skin consists of layers of cells with the germinal layer at the base, and the germinal layer proliferates other germinal cells and cells which become differentiated first to form an intermediate layer and finally the dead, corneal layer.

2. In the skin there must continually be a residuum of active germinal cells and a process of maturation to death of cells in order to have normal skin function.

3. Skin abnormalities consist of three types: (1) failures manifested as drying, scaling, fissuring, lessened resiliency, and reduced regenerative capacity; (2) anomalies such as badly formed nails, poor quality of hair, and poorly developed teeth; and (3) excesses involving overgrowth and overfunction as in neoplasia.

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MonH-288 The General Picture of Irradiation Damage to Tissues, by *P. S. Henshaw & R. S. Snider.* Parts I and II 29 p. (Clinton Laboratories) 1947
(Con't from page 13)

4. Radiation absorbed in the skin causes damage primarily in the germinal layer. When the damage to this layer is partial, the effect is a skin failure; the germinal layer is unable to proliferate enough cells to maintain the integument with the result that there is drying, scaling, fissuring, possible loss of hair, etc. Repair takes place from the floor of the damaged area, however, from living germinal cells that remain. When damage of the germinal layer is complete the effect is skin sterilization; not only is there drying and scaling, but also there is exudation, sloughing and ulcer formation. In this case healing must be from the edges as no germinal elements remain.

5. Skin tumors often arise out of such wounds that have become refractory.

6. In the case of superficial radiations skin tumors (of practically every type) have been observed to appear in animals that display little or no gross evidence of skin break-down.

7. Single applications of beta rays have been observed to be carcinogenic, as many as 50 to 100 loci of tumor growth being produced on rats that ordinarily show no skin lesions.

II Penetrating Radiations (Neutron, Gamma rays)

1. The most radiosensitive tissues are of the generative type--that is, those which in life are continually proliferating new cells which undergo maturation, serve a useful function for a limited period and then die.

2. The skin, testis hemopoietic organs gastro-intestinal epithelium, and perhaps other tissue series show a parallel type of differentiation with these features in common.

3. In all cases (with the possible exception of lymphocytes), certain parent cells (but not necessarily the most primitive types), were found to be the most susceptible to radiation.

4. Partial damage to a particular tissue series results in a limited period during which mature cells are being formed whereas complete damage results in sterilization.

5. Recovery to an apparently normal condition takes place even when the acute histologic destruction has been almost complete.

6. Subliminal damage in the case of daily exposure may hold an animal nearer to a state of exhaustion so that he is less able to cope with a crisis.

7. Animals receiving large doses of radiation (either single or repeat treatments) die prematurely usually either a state of atrophy or neoplasia.

8. When penetrating radiations are applied generally to the whole body, leukemia is the predominant tumor type obtained; when only slightly penetrating radiations are applied to the body surface, skin tumors are obtained; and when internal emitters that are bone seekers are applied, bone tumors are obtained.

H-10.430.6 Study of Heater Wires Subjected to UF_4 Vapor, by *C. E. Larson.* 15 p. (C&CCC-Y-12) April 1947

One of the problems encountered in the use of UF_4 as a charge material for the calutron is that of finding a corrosion-resistant heater wire which may be operated at 1000°C. in contact with UF_4 vapor for at least 48 hours without burning out.

The equipment consisted briefly of an externally heated quartz tube furnace, a conventional vacuum system, and a container within which four test wires could be subjected simultaneously to corrosion by UF_4 vapor. Each wire was electrically heated to 1000°C. with the tube furnace adjusted to operate at 800°C. An optical pyrometer was used to observe the temperature of the wires, estimating a drop of approximately 30 degrees as due to the loss through two observation windows. The actual temperature of the test wires with the furnace operating at 800°C was estimated to be 1080°C.

The following wires were subjected to the corrosion tests:

1. 20 mil Tungsten (M.P. 3370 degrees C.)
2. 10 mil "TaW" (Tungsten-Tantalum Alloy) (M.P. not determined)
3. 20 mil Tantalum (M.P. 2850 degrees C.)
4. 20 mil Molybdenum (M.P. 2620 degrees C.)
5. 20 mil Nichrome (M.P. 1400 degrees C.)
6. 20 mil Inconel (M.P. approx. 1350 degrees C.)
7. 10 mil Monel (M.P. 1300 degrees C.)
8. 20 mil Nickel (M.P. 1450 degrees C.)

After assembling four of the wires to be tested within the inner container the tube furnace was evacuated overnight; then the wires were adjusted 1000°C. and the tube furnace turned on. The tube furnace was maintained at 800°C. for 48 hours without changing the adjustment on the wire heater supplies; later, after the furnace was cooled to room temperature, each wire was studied visually and by means of photomicrographs for signs of corrosion, embrittlement, etc.

The results of these tests indicate that molybdenum and tantalum apparently are little affected by UF_4 vapor. The molybdenum appeared to be as resistant as the tantalum wire, so its use is recommended over tantalum from an economical standpoint. The balance of the wires tested either burned out during the run or were otherwise unsuitable for use in UF_4 vapor.

Nichrome, Inconel, Monel, and nickel wires will not operate at 1000°C. in UF_4 vapor for any appreciable length of time.

It is questionable whether tungsten wire would be suitable for a heater wire which would be subjected directly to UF_4 vapor.

These experiments indicate that tantalum and molybdenum wires of 20 mil diameter or larger may be operated at 1000°C. directly in contact with UF_4 vapor for a period of 48 hours or less. The corrosive action of UF_4 vapors on hot filament wires for periods longer than 48 hours have not been investigated. The corrosive effect of additional gases such as oxygen, etc., together with UF_4 vapor have not been considered, and in these tests a major proportion of foreign gases was removed by evacuating the tube furnace system overnight before turning on the filament and heater supplies.

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M-3443 Report on Visit to the Beryllium Corporation, Reading, Pa., to Investigate Facilities for Production of Pure Beryllium Metal, by *H. G. Rickover*. 25 p. (U. S. Navy, Clinton Labs.). 1947

On March 4, 1947, Captain H. G. Rickover and Lt. (j.g.) R. H. Dick, Naval Group, Oak Ridge, Tennessee, visited the Beryllium Corporation to inspect their facilities for production of pure beryllium metal. Arrangements for the visit were made by the Area Engineer, Madison Square Area.

This report presents the observations made during the visit, together with information obtained largely from discussions with Mr. H. C. Kawecki, Director of Research, The Beryllium Corporation.

The Corporation has its factory at Reading, Pa., and a business office in New York City. The firm is headed by Mr. Julian S. Gravely.

The Corporation's primary product is beryllium-copper. Beryllium-aluminum and a few zirconium alloys are also produced. Pure beryllium metal has not yet been made on an industrial scale.

The Corporation is presently developing processes and equipment to produce pure beryllium at a rate of 45 pounds per day; this production rate should be attained by June, 1947, but unforseen difficulties may delay this somewhat.

Beryl ore is used as the raw material for the production of beryllium and its alloys. The Corporation has sufficient beryl ore on hand to permit about two years full production of all beryllium products at present production rates.

It was stated that the first production of the Clinton Laboratories' order would be available by April 10, 1947. Preliminary spectro-chemical analysis has been made on laboratory test lots of this beryllium and the results show the metal to be pure enough for nuclear reactor requirements.

Technical descriptions of the processes used at the Beryllium Corporation are given in appendices to this report. Also, a cost breakdown and some analytical results are included in appendices.

Mon-P-321 Solution of a Two Dimensional Neutron Diffusion Problem, by *L. Noderer and G. Goertzel.* 5 p. (Clinton Labs.) June 1947

The neutron flux distribution is desired for a repeating cell latice, infinite in the Z direction and consisting of square prisms of material A surrounded by material B.

Let D = diffusion coefficient

σ = macroscopic cross-section

q = source strength

φ = neutron flux

Then the one group simple diffusion theory yields

$$\text{Div D grad } \varphi - \sigma \varphi + q = 0 \qquad (1)$$

to be satisfied everywhere.

For a square lattice spacing of dimension h, equation (1) may be approximated by the following finite difference equation

$$D/h^2 \left[\varphi (x_o + h, y_o) + \varphi (x_o - h, y_o) + \varphi (x_o, y_o + h) + \varphi (x_o, y_o - h) - 4 \varphi (x_o, y_o)\right] - \sigma \varphi (x_o, y_o) + q = 0.$$

At the boundaries appropriate averages of D, σ and q are taken. The boundary conditions are given by noting that the current must vanish at lines of symmetry. Neutron flux distribution plotted.

BC-59 Table of Isotopes, by *G. T. Seaborg and I. Perlman.* 47 p. (UCRL) 1947

The included table represents a complete list of all the artificial and natural radioactive isotopes and stable isotopes known to date (covering publications, restricted distribution reports, and private communications received prior to March 1, 1947) together with a number of important features associated with them. With very few exceptions the criterion for listing a radioactive isotope has been the actual observation of its radiation.

Mon-P-303 The Rate of Decay of Fission Products, by *K. Way and E. P. Wigner.* 27 p. (Clinton Laboratories) 1947

By considering the fission products as a sort of statistical assembly, calculations have been made of the number of β - disintegrations per second and of the total energy emitted per second at any time after fission has taken place. The results are in good agreement with experiment. The theoretical work is based on the assumption that the mass of a nucleus of mass number A and charge Z is given by $a(Z_o(A)-Z)^2 + b$. Empirical values for a and b are used. Use is also made of an approximate empirical relationship between half-life and disintegration energy. A further basic hypothesis which is important for the results at very short times after fission has taken place is that, in the most probable way of splitting, the chain lengths of the light and heavy fragments are equal and that there is not much deviation from this most probable mode of fission. The average number of β - disintegrations per fission is found to be 6.3.

PHYSICS- INSTRUMENTATION

LAMS-573 A Ten Channel Pulse-Height Analyzer, by *E. W. Dexter.* 19 p. (Los Alamos) 1947

This report describes an electronic device for recording voltage pulses according to their various amplitudes. The pulses are sorted into ten amplitude intervals so that ten points of a differential bias curve are obtained simultaneously. Pulses can be handled at rates up to 12,000 per minute. Provision is made for examining a complete distribution curve in large intervals or for examining the fine structure of a distribution.

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A-4208 Survey of Atomic Power Plants for Naval Ship Propulsion, by *Navy Department, Bureau of Ships Under Contract W-37-109-Eng-52.* 168 p. 38 drawings, 11 photographs (General Electric Company Knolls Atomic Power Laboratory) 1947

The advantages to a naval vessel of a propulsion plant capable of thousands of hours of operation without refueling are obvious. It appears that such advantages can be realized with a propulsion plant utilizing an atomic energy reactor. The purpose of this survey was to investigate the possibility of applying atomic energy to ship propulsion in the immediate future.

Briefly stated, the basis for the design study was the selection of a pile whose weight and power output most nearly matched the capabilities and demand of a readily available standard ship. A goal of six months wartime operation without refueling was set, along with the requirement that adequate shielding would be used to allow normal shipboard activity without safety hazard.

Conclusions

(a) On the basis of available information it appears feasible to build a developmental atomic power plant for propulsion of a DE-51 class vessel. Additional experimental data are required for design of this type of power plant, and a development program of considerable extent is visualized before the power plant can be applied to a tactical vessel. It appears that a new hull design will be required to take full advantage of the atomic power plant because of its high concentration of weight.

(b) This survey indicates that the developmental atomic power plant would consist of a shielded reactor, shielded, liquid-metal, heat transfer system, and presently installed propulsion machinery. It is estimated that a pile and heat transfer system weighing about 650 tons, could develop 15,000 shaft horse-power. The biological shielding accounts for about 75 per cent of this weight.

(c) The results of this survey indicate that at this time a pile operating on thermal energy neutrons is the most feasible for naval application. This conclusion is based on consideration of the present state of knowledge of nuclear physics, initial fuel investment, total weight of power plant, and the rate of gain or depletion of fissionable material.

(d) An estimate of the amount of U-235 necessary for the reactor of the thermal pile studied is given.

(e) The heat transfer system may consist of a single steam generator through which the liquid-metal pile coolant passes, or a double heat exchanger system in which an intermediate exchanger is interposed between the reactor and the steam generator. The optimum arrangement has not yet been established; however, the heat exchanger design is dependent primarily upon the choice of metal coolant and the steam demand of the propulsion equipment, and is not greatly influenced by the choice of nuclear reactor.

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PILES - THERMAL

M-3550 Effect of Heat Transfer Requirements on Size & Output of Gas-Cooled Piles, by *Naval Group, Oak Ridge, Tennessee.* 13 p. May 1947

Gas-cooled nuclear reactors are of interest for a number of reasons, the two primary being:

(a) They can be used directly in the working cycle of gas turbine

PILES - THERMAL

M-3555 Abstracts from Information Meeting Papers, by *Naval Group, Oak Ridge, Tennessee* 36 p. (Argonne National Laboratory) 1947

This paper, prepared by the Naval Group at Oak Ridge, Tennessee, summarizes those papers presented in the fields of pile technology, chemistry, physics and biology which are of special interest to the pile designer. A total of thirty five of the technical papers presented at the Information Meeting of the United States Atomic Energy Commission, held at the Argonne National Laboratory, on April 21, 22, and 23, 1947 are summarized herein.

M-3796 Effects of Radiation on Materials, Chemical Compounds, by *A. O. Allen.* 10 p. (Clinton Laboratories) 1947

This paper describes the effects of radiation on chemical compounds held together by covalent bonds. All covalent bonds may be broken by ionizing radiations. Since all covalent compounds are affected by radiation their use as permanent members within pile structures is to be avoided. The only important exception is the use of heavy water as a moderator. Calculations are presented giving the decomposition of water molecules at Hanford. Gaseous corrosion and corrosion by organic liquids when irradiated are discussed.

M-3855 Pile Technology, Lecture 33, Effects of Radiation on Materials-Solids, by *S. Siegel*. 20 p. (Clinton Labs.) 1947

Fast neutron bombardment produces very marked changes in graphite, measurable changes in some properties (e.g. thermal conductivity) of pure BeO but has not produced important changes in metals. The changes produced depend in magnitude on the temperature of exposure, are generally smaller at higher temperatures, and can be partially annealed out.

Fission events within U, BeO-UO_2 mixtures, and graphite-UO_2 mixtures have produced marked effects much greater than are observed with fast neutron bombardment alone.

Apparently all fissionable solids will be damaged by the events occurring within them. Metals exposed to fast neutrons alone are much less sensitive to this radiation than graphite or BeO. The data, except for graphite, are relatively meager for both types of bombardment and much work remains before a well understood picture of the situation will be available. Effects of γ rays and β particles also briefly noted.

Mon-P-310 Distribution of Heat Input Along Cooling Streams, by *G. Young*. 10 p. (Clinton Labs.) June 1947

The ratio of maximum wall temperature rise to maximum stream temperature rise is considered for a number of types of heat influx distributions along a uniform stream. The best distribution is an exponential; a few numerical calculations are made to get some idea of how much poorer the results are with certain other distributions. Possible modifications introduced by thermal stress considerations are mentioned briefly.

PILES - THERMAL

Mon-P-313 Separation of Space and Energy Variables on a Bare Thermal or Semi-Thermal Pile, by *G. Goertzel*. 7 p. (Clinton Laboratories) 1947

An investigation is made of the conditions under which the Fermi Equation for a bare pile of variable density may be separated into space and energy equations, thus permitting solution of the problem by elementary methods. Formulae are given which apply to thermal piles, resonance piles, and mixed thermal-resonance piles.

MT-222 **Efficiency of Control Rods as a Function of Their Position in a Cylindrical Pile in the One Group Picture**, by *F. T. Adler*. 27 p. (Chalk River) 1947

The efficiency of a single eccentric control rod and of a ring of N rods is determined as a function of their distance d from the centre of the pile. The eigenvalue problem for the critical lateral Laplacian β^2 is solved by means of the superposition method (section2) and the eigenvalue condition for β^2 obtained in the form

$$\lambda_1(\alpha) = -\frac{1}{\beta\, Y_1(\beta\alpha)} \left\{ Y_o(\beta\alpha) + \sum_{n=2}^{N} Y_o(\beta r_{n1}) - N J_o^2(\beta d)\, \frac{Y_o(\beta R) - \beta \Delta_1 Y_1(\beta R)}{J_o(\beta R) - \beta \Delta_1 J_1(\beta R)} \right.$$

The neutron density in the pile is given in the report, as well as lateral outward leakage and the total leakage into the control rods

$$\frac{\text{Lateral outward leakage}}{\text{No. of neutrons absorbed in the core per unit time}} =$$

$$= D\tau\beta^2 \; \frac{J_o(\beta d)}{J_o(\beta d) - J_o(\beta R) + \beta \Delta_1 J_1(\beta R)}$$

$$\frac{\text{Total leakage into N rods}}{\text{No. of neutrons absorbed in the core per unit time}} =$$

$$= D\tau\beta^2 \; \frac{-J_o(\beta R) + \beta \Delta_1 J_1(\beta R)}{J_o(\beta d) - J_o(\beta R) + \beta \Delta_1 J_1(\beta R)}$$

The validity of the approximation method is investigated and the positive and negative interference (shadow) effect of 4 rods is discussed numerically as a function of the position of the rods.

CRX-332 Pilot Plant Purification of Uranium Oxide, by *G. E. Haddeland*. 16 p. (Chalk River) 1947

The construction and initial operation of a pilot plant to provide experimental quantities of high-purity uranium oxide and to yield process information, is described.

The process is based upon a selective ether extraction of uranyl nitrate from slightly acid, aqueous solutions, saturated with ammonium nitrate, the uranyl nitrate then being stripped from the ether by distilled water.

Efficiencies in excess of 99 per cent have been obtained for both extraction and stripping columns. The degree of purification effected has been small, but work is continuing towards a more complete evaluation of the merits of the scheme.

H-4.360.12 Tentative Procedures for Analysis of HCP Process Materials, by *H. J. Belknap, G. J. Nessle, W. R. Grimes.* 48 p. (C&CCC). 1947

The procedures recommended for analysis in Department 190 Laboratories, in the Limits Control Laboratory, and in the Analytical Development Laboratories, of all process materials from the HCP cycle are presented in a stepwise manner. A description of the characteristics of each sample type along with a brief discussion of factors involved in the Analytical Quality Control program is included.

H-4.360.14 Application of Ascorbic Acid Method to Uranium in Salvage Solutions, by *C. D. Rothenberger and W. R. Grimes.* 23 p. (C&CCC). 1947

The erroneously high values for uranium content of salvage solutions as determined by the ether extraction-ascorbic acid procedure have been demonstrated to be due to the presence of colored organic materials in these solutions. Evaporation of such solutions to fumes of $HClO_4$ before extraction has been shown to be completely successful in preventing such interference, while pretreatment with activated carbon is sufficiently successful for application in Control Laboratories. Complete procedures for application of either pretreatment and results of such application to composite salvage solutions received over a six-month period are included.

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RESEARCH AND DEVELOPMENT REPORTS

PROGRESS REPORTS

BC-55 Progress Report for April 1947, by *W. M. Latimer, Director.* 6 p. (UCRL) 1947

Work continued during April along the following lines: (1) Metals and high-temperature thermodynamics. A preliminary value for the heat of vaporization of graphite to form C_2 (gas) has been obtained. Thermal conductivity measurements have been started on various refractory materials. An unsuccessful attempt was made to prepare "lower" oxides of several elements. (2) Basic Chemistry including metal chelates. Work has been done on the following items: solvent extraction of zirconium by TTA, (thenoyl trifluoroacetone) hydrolysis of TTA, extraction of uranium by TTA, activity coefficients of $PuCl_4$, heat of solution of UCl_4, extraction of uranium by ether.

Mon-N-312 Report for Quarter Ending May 31, 1947, by *M. C. Leverett.* 47 p. (Clinton Laboratories) 1947

During the quarter ending May 31, 1947, the Technical Division put 78% of its technical effort on the high flux pile project, and 14% on radioisotope development. The pile area is under design by the Kellex Corporation, and the pile itself will soon be released to them for detailed design.

The design of the 1200 (25 Separation) area will start during the next quarter. Laboratory and semi-works investigations have gone forward with the result that the required decontamination factor has been obtained in a batch simulation of a continuous solvent extraction process.

Work on C^{14}, P^{32}, and I^{131} installations continued. Initial operation troubles have bothered the C^{14} and P^{32} processes, and installation of the I^{131} equipment is not yet complete.

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