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HW 21511

AEC RESEARCH AND DEVELOPMENT REPORT HW-21511

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HEALTH INSTRUMENT DIVISIONS

QUARTERLY PROGRESS REPORT

RESEARCH AND DEVELOPMENT ACTIVITIES FOR APRIL - JUNE, 1951

JULY 6, 1951

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Health and Biology

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QUARTERLY PROGRESS REPORT
RESEARCH AND DEVELOPMENT ACTIVITIES
FOR APRIL - JUNE, 1951

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By

H.M. Parker, Manager
HEALTH INSTRUMENT DIVISIONS

July 6, 1951

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1. INTRODUCTION

This seventh quarterly report of the research and development activities of the Health Instrument Divisions, Hanford Works, as before, includes some items charged to control, but included for general interest. Such are identified as "not (060)".

The sixth report of the series was numbered HW-20866, April 18, 1951. (The cover sheet inadvertently referred to the period January - March, 1950).

2. PERSONNEL

	Biology Division			Development Division		
	3/31/51	6/30/51	Net Increase	3/31/51	6/30/51	Net Increase
Supervisors	7	6	-1	5	5	0
Scientific & Technical	39	41	2	24	27	3
Non-Technical	27	28	1	5	6	1
Clerical	3	4	1	2	2	0
Total	76	79	3	36	40	4

3. LABORATORY FACILITIES

The isotope storage addition was completed. Design of the train shed addition was completed. Bids on the aquatic biology laboratory were too high, and the unit was redesigned with some sacrifice of operating convenience, but little reduction in capacity to handle the problems envisaged.

The meteorological field stations were installed. Approved were the addition of an apparatus elevator in the 400 foot meteorological tower, and the construction of a portable mast for field studies of particle pick-up and associated micrometeorological conditions.

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Construction of the control and development laboratory was 22% complete.

4. PROBLEM ASSIGNMENTS PROGRESS - BIOLOGY DIVISION
(H.A. Kornberg, Division Head)

A. Analyses (A.C. Case, Acting Group Head)

Problem 677.10 - Radioactivity in Carcasses (R.F. Palmer, W.H. Brayman)

The determination of Ra in cadaver ashes by chemical separation and counting, and by Rn separation and counting continued.

Problem 677.11 - Alpha and Beta Analyses of Organic Materials
(A.C. Case, W.H. Brayman, R.F. Palmer, R.C. Thorburn)

Electrodeposition of radiocopper from samples of aquatic organisms was performed to verify previously reported percentage composition.

The method developed for I^{131} analysis of large organic samples was modified to include precipitation as PdI_2 instead of AgI.

Existing methods for tritium analyses were modified to reduce the size of sample needed for analysis, and to increase precision.

Problem 677.12 - Radioelements in Organisms in Pile Effluent (A.C. Case)

One algae sample, 2 Hydrophyche Cockerelli, several shiners, several chinook salmon fry, one crayfish, and carp bones and scales, were analyzed for beta emitters. The principal isotopes were Cu and As, as previously reported.

Problem 677.13 - Physical Processes Affecting Methods for Isotope Use
(R.F. Palmer, W.H. Brayman, A.C. Case, R.C. Thorburn)

Samples of CaC_2 were analyzed for radium content to determine if the varying amounts of Rn released during C_2H_2 generation could account for the observed background on the vibrating reed electrometer. Approximately 1 d/m of Ra/gm of CaC_2 was found, a value high enough to explain the background reading.

Over 100 calibrated samples containing tritium oxide were used to determine a graph of counting rate vs. sample activity for the Tracerlab windowless flow counter. A straight line with slope of 450 $\pm$ 40 c/m per μc/cc was found.

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Problem 677.14 - Waste Disposal Methods for Biological Specimens - Inactive

Problem 677.15 - Physical Chemical Methods for Dosimetry due to Deposited Isotopes - Inactive

B. Aquatic Biology (R.F. Foster, Group Head)

Problem 689.01 - Effect of Pile Effluent Water on Aquatic Organisms (not 260) (R.F. Foster, P.A. Olson)

Exposures of young chinook salmon to various dilutions of plant water were continued without unusual incident. This test terminated at the end of the quarter, since the salmon were ready to migrate to the ocean. The results are summarized in Table 1. Uncooled area effluent in strengths of 1% and 2% seemingly did not adversely affect the fish, and the resulting slight increase in temperature encouraged growth. At 5%, a distinct increase in mortality was evident although the growth rate was further accelerated. Excessive mortality occurred in the 10% area effluent, with the surviving fish of large average size, but showing considerable size variation. Where the area effluent was cooled to river water temperature, similar mortalities occurred at the 2% and 5% levels, with retardation of growth indicated at the higher concentration. Further retardation of growth was evident at the 10% level, but mortality was less than half that experienced with the uncooled effluent, indicating a significant temperature factor. Factors other than temperature per se may be operating, however, since 10% strength pile influent and effluent at only 0.5°C. higher temperature produced mortalities almost identical with that of the 10% uncooled area effluent. The striking similarity of the results at comparable levels is ample evidence that the observed effects are produced by chemical toxicity, and not by the radioactivity present in the pile effluent.

The activity density of the fish held in the effluent water increased appreciably during the quarter, mainly due to increased metabolic rate with rising temperatures.

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TABLE 1

EFFECT OF PROCESS WATERS ON CHINOOK FERTILIZATION

Condition	Strength	Average Temp. °C	Water Activity (μc/cc)x10^6	Activity (μc/g)x10^6 Fingerlings	Av. Wt. (g)	Percent Mortality from Hatching
River water control	100%	9.5	2.8	38.	1.89	7.5
Uncooled Area Effluent	1%	10.0	15	190	2.02	6.7
	2%	10.5	25	250	2.36	7.8
	5%	11.5	61	830	2.94	10.4
	10%	13.0	112	1,500	3.07	70.6
Cooled Area Effluent	2%	9.5	22	330	2.11	6.9
	5%	9.5	55	680	1.62	11.0
	10%	9.5	111	1,200	1.10	30.3
Pile influent carbon-filtered	2%	9.5	2.8*	38*	1.88	7.3
	5%	9.5	2.8*	38*	1.34	17.5
	10%	10.0	2.8*	38*	0.97	69.8
Cooled Pile effluent carbon-filtered	2%	9.5	17	370	1.68	10.2
	5%	9.5	36	860	1.40	16.8
	10%	10.0	73	1,300	1.04	66.9

* Estimated same as river water.

Problem 689.16 - Biological Chains (P.A. Olson, R.F. Foster)

Spawning of adult rainbow trout held in 5% pile effluent was completed during May. Since only 11 females (about 10%) matured and spawned, additional data on the potency of the males were obtained by utilizing the eggs from 8 large control females (3 years of age). A part of the eggs from each female was fertilized by sperm from a male selected from each of the four experimental ponds. The radioactive algae fed to one group of these fish originally was obtained from a retention basin, and had an average activity density of 0.3 μc/gm; but for the

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past 8 months, this source has not been of value due to algae control operations. Substitute algae held in laboratory ponds has not been as satisfactory since accumulated activity amounts to only a fraction of that of the algae which flourished in the retention basin. As a result, the activity density of the fish held in 5% effluent and fed the active algae diet has exceeded that of the fish held in the 5% effluent and fed a normal diet by only about 20% to 30%, whereas differences on the order of 500% were observed last year at this time. Table 2 summarizes the current data.

TABLE 2

GROWTH OF TROUT - EFFECTS OF EFFLUENT WATER AND OF RADIOACTIVE FOOD

Water Condition	Food	Activity Density* (μc/g) x 10^5	
		Fish Scale	Water
River water	Normal diet	12	0.3
River water	10% control algae	23	0.3
5% effluent	Normal diet	108	7.9
5% effluent	10% active algae*	124	8.7

*Average activity of algae when fed was 0.014 μc/g.

With warmer water temperatures, the activity of the fish increased by a factor of 3 over last quarter. These fish were not weighed for size determination during the quarter to avoid further handling following spawning.

Problem 689.17 - Radiobiological-Ecological Survey of the Columbia River
(J.J. Davis, R.W. Cooper, D.G. Watson, O.D. Palmiter)

The annual freshet occurred throughout the quarter with the peak during the

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second half of May. This inhibited the sampling of bottom organisms, but both large and small fish were readily obtained. Juvenile chinook salmon disappeared from inshore areas after June 6. Erratic fluctuations in water level hindered the growth of algae which normally flourishes at the water's edge at this time. Reduced invertebrate collection permitted extensive analysis of stomach contents of large fish for feeding habit studies. Routine plankton samples are now being taken on river cross-sections above and below the reactor areas, and at Richland.

The activity density of the plankton diminished markedly during the quarter with increased river flow, but was increasing again at the end of the period. Observed activities were over twice as high as one year ago, and five times the level recorded in 1949. The activity density of bottom algae during June was 1.3×10^{-3} $\mu c/gm$, approximately the same as observed last quarter. Caddis fly larvae dredged from the center of the river had an activity density of 4.3×10^{-4} $\mu c/gm$. Small fish activity density amounted to 3×10^{-4} $\mu c/gm$, in June, a 5-fold increase over last quarter. For large fish, a maximum value of 1.6×10^{-3} $\mu c/gm$ was found in the liver of a sucker. The flesh of the same fish indicated 2.0×10^{-4} $\mu c/gm$. The abundance of plankton increased steadily from 11,000 organisms/liter in March to 60,000 organisms/liter in June.

Problem 689.04 - Control of Algae in Retention Basins (not 060)
(R.J. Foster)

No progress.

C. Biochemistry (J. Katz, Group Head)

Problem 687.10 - Relative Biological Effects via Biochemical Systems
(M.E. Getzendaner, R.A. Kornberg)

The sensitivity of L. Casei inhibitory response to tritium oxide present in culture media was increased 3.3 times when a suboptimal medium was used for

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growing the cells. It is believed that this is due to an additive effect of tritium beta particles on scarce nutrilites and on the micro-organisms. An exponential relationship between the time required for half maximum growth of L. Casei and the concentration of the tritium-containing medium was observed and can be described by the equation:

$$\ln t_{\frac{1}{2}} = 0.0063 \text{ mc T/ml of medium}$$

Problem 687.19 - Absorption of Pu from the G.I. Tract (J. Katz)

In order to shorten the duration of this experiment, all rats received 3 feedings per day. As of this date, each experimental rat has received 180 doses of Pu. With the exception of 2 rats which died, all animals appeared to be in good health.

Problem 687.20 - Tritium Biological Investigations

Retention and Distribution of Tritium (R.C. Thompson)

A summation of the more important biological parameters in tritium metabolism obtained to date following IP injection of tritium oxide solutions appears in Table 3.

TABLE 3

BIOLOGICAL HALF-LIVES OF BOUND TRITIUM IN TOTAL CARCASSES

Animal	Days after injection	$T_{\frac{1}{2}}$	Most active Tissue
Mouse	160	~100 days	-----
Hat	130	[illegible] days	Skin ($T_{\frac{1}{2}}$, 90 days)
Rat	130	*53 days	Hair

*All tissues except viscera, pelt, skeleton, and blood.

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Percutaneous Absorption of Tritium (C.W. DeLong)

Rates at which water vapor is transmitted through skin exposed for 1 hour to air saturated with tritium-labeled water vapor are given in Table 4. Results are shown in terms of quantities of water absorbed by a unit area of skin per unit time, assuming that tritium oxide and water are absorbed at equal rates.

TABLE 4

PERCUTANEOUS TRANSMISSION OF TRITIUM-LABELED WATER VAPOR (SATURATED)

Animal	Specific Activity Curie/gm H_2O	Sample	Absorption Rate $\mu g\ H_2O/cm^2/min.$
Rats *	0.15	Blood	2.5 ± 1.3
		Body water	3.0 ± 1.5
Rats (F)	0.14	Blood	5.6 ± 2.4
		Body water	6.5 ± 2.7
Rats (M)	0.14	Blood	5.7 ± 3.7
		Body water	7.1 ± 3.6
Mice	0.14	Body water	21.0 ± 10.0
10 Humans (M)	0.2	Urine	8.7 ± 2.3

* A static method was used in earlier experiments. All other exposures were made under a constant flow of the gas prepared by passing dry air at 30°C through a sintered-glass rod immersed in the tritium oxide solution, thence over the skin.

Problem 687.21 - Possible Therapeutic Agents for Radiation Damage (P.L. Hackett, J. Katz)

No progress.

Problem 687.22 - Percutaneous Absorption of Radioelements (J. Katz)

No progress.

D. Botany Group (J.W. Porter, Group Head)

Problem 688.23 - Agricultural Field Station (J.F. Cline)

The average activity density of 10 soil samples taken from the experimental plots during April was 2×10^{-5} μc/gm; with a range from 5.6×10^{-6} to 3.1×10^{-5} μc/gm.

Problem 688.24 - Translocation of Radioelements in Plants (J.H. Rediske, A.A. Selders)

In the range of 0.0001 to 50 ppm of Y in the nutrient solution, the uptake of this element by excised barley roots was directly proportional to its concentration. At 100 ppm of Y, the uptake by excised roots was less than that at 50 ppm; thus indicating a toxicity of the element at the higher concentration level. These results were in agreement with those obtained with intact red kidney bean plants.

The absorption of Sr by red kidney bean plants, during a 4-day period, from a nutrient solution containing 1.0 ppm of Sr and 0.099 μc Sr^{90}/liter was greatest when the nutrient medium was held at pH 6.0. At pH 5.0, the uptake of Sr was approximately 10% less; and at pH 4.0 or 7.0, it was 20% less than at pH 6.0. The absorption of Sr by Russian Thistle plants was only 30% of that by red kidney bean plants. Tomato and wheat plants were intermediate to bean and thistle plants in their ability to absorb Sr.

The uptake of Cs from a nutrient solution of pH 6.0 by red kidney bean plants was directly proportional to the concentration of Cs in the solution, over a range of 1 to 100 ppm. Under these experimental conditions, the bean plants concentrated Cs in their leaves to the extent of 2 to 3 times that of the nutrient solution.

The rare earth Ce and the related element La, competitively inhibited the uptake of Y by excised barley roots. These results indicated that plants grown

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in soil containing the rare earths would take up less Y than those grown in soil in which the rare earths were absent.

Problem 698.29 - Tritium Botanical Investigations
(J.W. Porter, O.E. Smith, H.O. Marshall, J.F. Cline, D. Weinberger)

The concentrations of tritium in plant water and organic matter, of tops of 6 inch red kidney bean plants whose roots were exposed to tritium oxide and whose tops were exposed to light or darkness under standard environmental conditions for varying periods of time, were determined. After 24-hours in light or in darkness, the concentrations of tritium in plant water were 70% and 23%, respectively, of that in the nutrient solution. The contents of tritium in organic matter under the same conditions were 5% and 1%, respectively, of that in the nutrient solutions.

Red kidney bean plants were grown for 24-hours in light and in nutrient solution containing tritium oxide and adjusted to pH 4.0, 6.0, and 8.0. No significant difference was noted in the uptake of tritium oxide by these plants over the 24-hour growth period.

Further work on the metabolism of tritium gas by bacteria containing the enzyme hydrogenase indicated that 10% to 20% of the gas can be converted to the oxide, and 0.01% to 0.06% can be incorporated into cellular constituents under the given exposure conditions.

Studies on the absorption of tritium oxide by several micro-organisms showed the following rates of fixation:

Azotobacter vinelandii	130 μc/100 mg. cellular H/24 hrs.
Escherichia coli	410 μc/100 mg. cellular H/24 hrs.
Proteus vulgaris	130 μc/100 mg. cellular H/24 hrs.

In these experiments, suspensions of cells were held in saline at pH 6.5 and at a temperature of 23.5°C in the presence of 5 mc of tritium oxide/ml. In

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other experiments in which the suspensions were held in Burks-glucose medium, the rate of uptake was approximately 4 times greater. In each of the above experiments, a straight-line function was obtained over the period of 8 to 24 hours, but in the latter experiment a lag phase was noted during the first 8 hours.

In the studies on tritium oxide metabolism, it was found that maximum incorporation of tritium into cells occurred at pH 6.5 when the cells were respiring and at pH 8.0 when they were being autolyzed.

Experiments showed that tritium may be incorporated into cells by exchange reactions with the nutrient medium (glucose) and subsequent metabolism of constituents of the medium. It may also be incorporated directly from the oxide through reactions such as the transformation of fumaric acid to malic acid. Finally, it may be incorporated through exchange reactions with cellular components.

Problem 688.26 - Effects of Radiation on Plant Life
(J.H. Rediske, A.A. Selders, J.W. Porter)

An experiment on the effects of several levels of P^{32} on the growth rate of Chlorella pyrenoidosa yielded inconclusive results.

A greenhouse experiment, in which P^{32} levels of 0, 25, 100, and 250 μc/plant (and per liter in the nutrient medium) were used, yielded no significant difference in weights of plant parts or content of phosphorus after an 8-day growth period. However, the extremely large within-sample variation in this experiment may have obscured variations between samples.

The uptake of Y by excised barley roots was reduced below that of controls at levels of 50 μc/liter. At 1,000 μc/liter, the uptake of Y was only one-third that of controls. These results are somewhat similar to those obtained earlier for like experiments with P^{32}.

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Red kidney bean plants were grown for 7 days in nutrient solution containing 100 μc P^{32}/liter, and a range of total phosphorus of 5×10^{-6} to 5×10^{-3} mole/liter. Light intensity and quality were controlled. No significant effect of P^{32} on growth was noted, but the concentration of phosphorus, in $\mu g/gm$ of dry plant tissue at the end of an 8-day growth period, was significantly greater in the plants grown in the presence of 100 μc P^{32}/liter than in control plants exposed to 0.1 μc P^{32}/liter.

E. Physiology Group (M.H. Joffe, Group Head)

Problem 698.27 - Biological Effects of Active Particles (M.H. Joffe)

Strain A pulmonary tumor-sensitive mice were successfully bred, in preparation for this test.

Problem 698.28 - Bone Metabolism of Radioelements (M.H. Joffe)

Radiochemical analyses on the animal given 0.11 μg Pu^{239}/gm body weight, and autopsied 23 days later, showed a variation in Pu content from 1.0 $\mu g/gm$ liver to 0.0006 $\mu g/gm$ skeletal muscle; vertebrae showed 0.52 $\mu g/gm$, while other bones surprisingly had no more than 0.15 $\mu g/gm$. The activity density in spleen was 0.24 $\mu g/gm$, more than double that of any other soft tissue. A second animal, still surviving after 32-days of harboring 0.11 μg Pu^{239}/gm body weight appeared to be healthy with good appetite, although defecation frequency declined markedly, a phenomenon noticed also with the first animal.

Problem 698.29 - Techniques in Autoradiography (L.A. Temple)

This problem was reassigned recently, and facilities other than the service darkroom have been arranged.

Problem 698.30 - Inhalation of Tritium (M.H. Joffe, L.A. Temple)

Otherwise careful experiments on the assimilation of tritium gas and its conversion to oxides in the respiratory system of rats were vitiated by difficulties in the analyses for tritium oxides, leading to unreliable material balances.

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V. Zoology Group (K.E. Herde, Group Head)

Problem 600.03 - Biological Monitoring (not 260)
(W.C. Hanson, R.L. Browning, K.E. Herde)

Thyroid activity densities increased by a factor of 55 over the previous quarter, with a maximum value of 0.5 μc/gm detected in a rabbit.

All waterfowl and aquatic bird samples were below the chronic MPC of P^{32} in man. Maximum density found in bone samples was 5.0×10^{-4} μc/gm.

A total of 124 Canada geese was banded on the project by cooperative work with the Washington State Game Department.

An increase in the number of nesting waterfowl on the Columbia River within the plant boundaries was noted. A further increase is expected when the backwater of McNary Dam inundates some 20 islands used extensively for nesting. The birds are expected to move, at least in part, to suitable islands located within the Hanford Works boundaries.

Aerial census indicated the population of wild waterfowl within plant boundaries to be nearly stable during the quarter at approximately 700. This figure will probably remain stable through the remaining summer months, until fall migration occurs.

Problem 600.10 - Toxicology of I^{131} in Stock Animals
(L.Z. Duncan, K.E. Herde, D.E. Warner, N.G. Farnham)

Lambing operations were completed during this period. Eighty-seven ewes gave birth to 141 lambs. Fifty-one ewes were involved in multiple births; 3 of which were triplets, the remainder being twins. One hundred and thirteen lambs survived. Eleven ewes receiving 240 μc I^{131}/day dropped 15 lambs. One of these ewes was involved in a monotriparity, which is considered only as an interesting coincidence. Of the 15 lambs dropped by this high level group, none survived beyond 3-1/2 days. The wool coat on these lambs varied from normal to almost complete alopecia. The thyroid glandular tissue present

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varied from moderate amounts in some lambs to an almost complete athyroidal condition in others. In those animals whose thyroids were most severely affected, there was an involvement of the trachea adjacent to the gland. The involvement, which appeared to be agenesis of the tracheal cartilage, varied from almost complete stenosis to no apparent reduction in luminal diameter.

The 11 ewes that lambed in the group receiving 5 μc/day dropped 19 lambs. Only one of these expired, thus exhibiting the best lamb survival rate of any group.

All of the 9 ram lambs previously placed (February 1951) on a feeding regimen containing 480 μc I^{131}/ram/day have been sacrificed. The thyroids of the 3 lambs sacrificed when the thyroid evidenced loss of ability to concentrate I^{131} still appeared to possess functional tissue. Three rams in this group removed from the I^{131} regimen at the time of the thyroid "break" were given a tracer feeding 2 months after daily I^{131} feeding ceased. All 3 of these rams exhibited less than 7% thyroidal uptake.

Analyses of hematological and blood chemical results revealed significant changes that are limited to those animals in groups receiving 240 μc or more of I^{131} daily. These changes were limited to a distinct depression in leucocyte count and an increase in creatinine in the old ewes. The ewe lambs, however, exhibited more changes, which included a significant depression in calcium with a complementary increase in phosphorus, indications of a decrease in glucose and cholesterol, a definite increase in NPN, decrease in hemoglobin, red blood cells, in lymphocytes and eosinophiles.

There were seasonal variations noted in all groups in calcium, creatinine, cholesterol, glucose, NPN, total protein, red blood cell count, hemoglobin. The off-project controls displayed higher hemoglobin levels during some periods.

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Excellent collaboration of the Hanford Works Technical Divisions in analysis of the statistical significance of the blood chemistry results is acknowledged.

C. PROBLEM ASSIGNMENTS PROGRESS - H.I. DEVELOPMENT DIVISION
(C.C. Gamertsfelder, Division Head)

A. Physics (W.C. Roesch is Chief Physicist)

Problem 678.10 - Moderated Slow Neutron Detectors (D.W. Glasgow)

An examination of the calibration used with moderated BF_3 counters indicated that large corrections (~ factor 2) were required for scattering from walls and floors. It was also found that an asymmetry in emission of at least one of the Po-B sources existed; the measured emission through the ends was about one-third less than that through the sides.

A "Long Counter" such as developed by Hansen was built to provide a comparison instrument of fairly good and known energy sensitivity.

Problem 678.11 - Recoil Proton Coincidence Analyzer (J.S. Reddie, W.C. Roesch)

Samples of each type of neutron detector were prepared for intercomparison with the various neutron sources. A Hurst dose-counter gave 0.67 counts per minute/neutron/cm^2 per sec over a background of 0.1 count per minute, in this program.

A neutron detector consisting of ZnS-loaded polystyrene placed before a photomultiplier was made. The recoil protons from the polystyrene are much more efficient in exciting scintillations from the ZnS than are recoil electrons due to gamma radiation. The sensitivity was about 0.3 counts per minute/neutron/cm^2 per sec.

Problem 678.12 - Beta Dose-rate from a Distant Source (W.C. Roesch)

Inactive.

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Problem 678.13 - Tritium Measurements (W.C. Roesch)

The counting of tritium as hydrogen in an argon-methane proportional counter was applied to: (1) identification of tritium in recirculating water in a reactor; (2) estimation of the concentration efficiency of tritium by electrolysis; and (3) checking of the equality of the rates of evaporation of ordinary and tritiated water.

A brief theoretical investigation of the D(n, gamma) T reaction was made to see if a fast neutron flux might be responsible for the presence of tritium in recirculated water. The calculations indicated it was not.

Theoretical analysis of some results of the Health Instrument Divisions Control laboratory obtained from glassware heavily contaminated with tritium indicated that they were detecting bremstrahlung from the tritium beta rays. This method of detection had been tried earlier, - but abandoned as being too insensitive for samples of ordinary interest.

Problem 678.14 - Neutron Energy Spectra by Nuclear Emulsion Techniques (E.C. Watson)

Careful checking of a range-energy relation was done prior to a final analysis of spectrum data.

Problem 678.15 - Gamma Energy Dependence of Ionization Chambers (I.T. Myers, W.C. Roesch, E.C. Watson)

Several more ion chambers were constructed so as to extend investigations of the effect of wall thickness to very small thicknesses and another set made to investigate the effect of chamber volume for constant wall thickness. The method of interpolating between the readings of graphite and aluminum-walled chambers to obtain a standard measurement of gamma dose was applied to a nitrogen-16 gamma-ray source, and a series of survey instruments calibrated accordingly.

The Victoreen condenser R-Meter was not designed for use at ordinary gamma-

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ray energies, but at times has been so used. The properties of the chamber are being systematically checked with radium. It has been found that the position of the source relative to the chamber for a fixed radial distance has a pronounced effect on the reading. Nearby scattering materials also influence results considerably.

A calibration of several gamma survey and monitoring instruments was carried out at 17 Kev for use in a special exposure problem. An X-ray unit was used for a source, and measurements were standardized against a free air chamber.

Problem 678.16 - Thin Window Counter Investigations (J.S. Reddie)

Inactive.

Problem 678.17 - Water Tank for Neutron Calibrations

Inactive.

B. Instrument Development (P.L. Eisenacher, Group Head)

Problem 692.31 - Alpha Scintillation Counting (G.E. Driver)

A simplified "poppy" circuit was devised using the "starvation" principle of amplification. Laboratory tests indicated the amplifier to be suitable for both scintillation and air proportional counting. In the latter service, maintenance of instruments would be facilitated.

Problem 692.32 - Experimental Alpha Counting

Inactive.

Problem 692.33 - Sample Changer

Inactive.

Problem 692.34 - Portable Slow Neutron Equipment (H. Wilhelmi)

Completed.

Problem 692.35 - Fast Neutron Measurement

Inactive.

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Problem 692.36 - D.C. Amplifier (R.J. Dorwart, P.L. Eisenacher)

The applicability of "starved" pentode amplifiers for D.C. amplification of electrometer tube output voltages was studied. To date, progress has been encouraging, because of the high over-all current gains obtained. Stability troubles somewhat off-set this advantage.

Problem 692.37 - Beta Scintillation Counting (G.E. Driver)

Scintillation probes for monitoring I^{131} in human thyroids were placed in routine service. Better support for the probe and an improved electronic system are possible improvements. Redesign will not be undertaken until other suggestions are brought out by field use.

The matter of scintillation counter plateaus was investigated; certain crystal-counter combinations yielded plateaus for I^{131} counting. The plateaus were helpful in setting up a system, though not very rectangular in appearance. There is some indication that plateaus can be produced by adjusting the early dynode voltages but the practical value is still questionable.

It was found that, for a given counting arrangement, maximum background pulse heights were several times maximum I^{131} pulse heights. An anti-coincidence scheme for discriminating against background counts was therefore investigated.

Problem 692.38 - Atmospheric Monitoring (P.C. Althoff, R.J. Dorwart, P.L. Eisenacher)

The new system for continuous air monitoring was in service throughout the period and gave satisfactory service. A simplified scheme for performing the necessary operations has been devised using a telephone-type stepping relay.

Some work was done on a dust precipitator built some time ago with inadequate high voltage for present purposes. The current work has the objective of producing stable, adequate high voltage from an r.f. supply in a mobile instrument.

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A fluorescence method for monitoring the instantaneous concentration of oil fog in air was studied. Oil fog fluoresces under ultra-violet irradiation, which may provide a useful method for discriminating against dust interference, and minimizing the effect of droplet size. Preliminary laboratory tests were made with promising results.

Problem 692.39 - Soft Beta Counting (R.G. Clark)

No successful system for counting soft beta emitters in air has been found thus far. A review of the common counting-quench gas mixtures, relative to absorption and emission spectra under excitation, indicated that almost any combination theoretically useful would have properties undesirable from the industrial hygiene or safety standpoints. The rare gases are, therefore, being studied carefully to determine their reaction to limited air contamination.

Problem 692.40 - Hand Counter

Inactive.

Problem 692.41 - Tritium Instrumentation (R.G. Clark, R.J. Dorwart)

A small chamber for monitoring tritium absorption by enzymes was built and tested in the laboratory.

Some work was done toward "sensitizing" the current hydrogen-counting system used in the Biology division. Spurious counting of water samples obtained by azeotropic distillation was found due to residual benzene which is now eliminated by shaking with oil and separating the water.

Problem 692.42 - Pile Shield Monitoring

Inactive.

Problem 692.43 - Biological Instrumentation (G.E. Driver)

Some work was done toward developing a needle counter for radioactive materials imbedded in organisms or deposited in organs. Background information only was obtained.

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C. Industrial Hygiene (F.E. Adley, Group Head)

Problem 699.51 - Determination of Characteristics of Air Cleaning Filters (R.H. Scott, F.E. Adley)

The test apparatus for determining collection efficiencies of various paper filter media was completed. Preliminary runs were made using freshly generated carbonblack as a test medium; it was found that most of the filter paper holders were distorted sufficiently during fabrication to make them unfit for satisfactory use. The correction of these plates and also a major change in the electrostatic precipitator power supply were undertaken.

Problem 699.70 - Development of Improved Electrostatic Precipitator (P.L. Eisenacher, F.E. Adley)

The design criteria for the improvement of existing precipitators were determined. Instruments are to contain 15 KV power supplies and permit long-period operation. One type was designed primarily for laboratory application, and the other for field use with fan and airflow register.

D. Geology (R.E. Brown, Group Head)

Problem 691.43 - Ground Water Studies (M.W. McCaniga)

Water table surveys of the region between Richland and the Works Laboratory were made monthly during the quarter. About 20 wells in and about the reactor areas have been located and reactivated for a monthly survey of this region.

The ground water mound beneath Area 2 maintained its recently attained height, but showed little to no additional rise during the last 6 months. The lateral spread of the mound was, however, clearly indicated by the continuous rise of the water table in all wells around the area. Recently completed wells in and about the area provided timely additional monitoring points. The rise of the water table and consequent movement of the ground water was also corroborated by the movement of the contamination in the water in the vicinity of the test contaminated wells.

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Problem 693.44 - Waste Disposal - Field Investigations Area 1
(L.P. Rolph)

The beta-gamma activity in the sediments ranged from 0.16 to 12.7 μc/kg. Continued spread of contamination was definitely confirmed in test hole #4. No significant alpha activity has ever been detected in any of the test holes.

The beta-gamma and alpha activity density in the ground water test contaminated zone continued to decrease as previously reported. No evidence has yet been found that the ground water is moving or has moved at measurable rates since 1947.

Problem 693.45 - Waste Disposal - Field Investigations Area 2
(R.E. Brown, L.P. Rolph, A.J. Weidhold)

The movement of the ground water in the test contaminated zone was confirmed to be to the southeastward from the point of origin of contamination. The distance of movement was estimated as 200 to 300 feet during the last year, although the additional wells being completed will more adequately define this distance and the exact direction. This ground water movement is due to the increase of water added to the surface of Area 2 during the past year, and the consequent buildup of the ground water mound beneath.

Problem 693.46 - General Geologic Studies (M.W. McConiga, R.E. Brown)

Geologic studies were concentrated in new plant areas where numerous excavations permitted a detailed study of the subsurface conditions.

Problem 693.47 - Waste Disposal Field Investigations - Works Laboratory Area
(M.W. McConiga)

The rise of the Columbia River and the reversal of the flow of the ground water spread the alpha (uranium) contamination to record distances from the pumps. Alpha contamination is now present about 2,000 feet west of the area, about 500 feet farther west than in 1950. The contaminated zone is now about

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6,600 feet long and 4,800 feet wide, north-south and east-west, respectively. The ground water was sampled in 13 wells outside the area and in 4 sanitary wells in the area. Temperatures were taken in all wells. Biweekly sampling, temperature measurement, and the use of 4 water stage recorders in addition to biweekly tape readings, gave a thorough picture of the changes taking place.

E. Meteorology (M.L. Barad, Group Head)

Problem 694.53 - Statistical Studies of Diffusion (200 Mile Scale)
(M.L. Barad, G.R. Hilst, P.W. Mickola, T.L. Winter)

Computations of trajectories of hypothetical emission clouds leaving the Hanford Works, and summaries of these trajectories in terms of areas covered by three-hours, were continued during this quarter. A summary of the trajectories of the Spring quarter (March through May) appeared in Document HW-21414 (6-19-51).

Six of the meteorological field stations were installed. The procedures to be followed in the reading of the wind tapes, the logging of the information, and the preparation of streamline and trajectory charts, was established. Forms and templates were prepared.

Problem 694.54 - Diffusion Experiments 20 Mile Scale (M.L. Barad, G.R.Hilst)

In preparation for the study of the lateral spread of smoke or oil-fog emitted from a ground source, members of the group laid out three courses in the form of circular arcs. Wooden stakes 2.5° apart served as markers to determine lateral spread by photography.

Five field experiments were conducted. Ground sources were employed in all experiments; elevated sources were also used in two of the experiments. Smoke grenades, smoke pots, and an oil-fog generator were employed in the ground-source tests; smoke pots were used in the elevated-source experiments.

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Photography in all experiments was done with either a Speed Graphic or a Bell and Howell, 70-DA, 16 mm camera, modified to allow for single-frame release. Results to date included:

(1) development of best photographic technique for oil fog and chemical smokes.

(2) selection of persistent smokes for long-range experiments.

(3)* clear proof of contact of smoke at high concentration with ground within one to two stack heights (stack was 183 feet high) in a wind of 3 to 4 mph. No current theoretical equation (e.g. Sutton) contemplates this.

(4) in ground generation, under stable conditions, remarkable shear occurred in the first 100 feet. The plume cross-section assumed an approximately elliptical form with the major axis subtending an angle of 10 to 15°, at the source, and tilted at 20° to 30° to the horizontal. Again, no theoretical study incorporates these features, which may have a profound effect upon emergency conditions.

Problem 694.56 - Particle Pickup (G.R. Hilst, M.L. Barad)

A re-examination of the instrumentation required in the particle pickup program began.

A fifth or filter stage for the cascade impactor was prepared.

Problem 694.57 - Emergency Conditions (G.R. Hilst, M.L. Barad)

Work done is included in Problem 694.53.

Problem 694.58 - Micrometeorology (M.L. Barad, G.R. Hilst, P.W. Nickola, I.L. Winter)

Theoretical studies of the path of an effluent plume immediately after

* This was known in a general way from P.E. Church's earlier work at Hanford, and, of course, from observed I^{131} concentrations at the ground near the plant stacks.

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discharge from a tall stack were conducted.

A paper describing the theory and the effects of the vertical temperature distribution in turbid air was prepared in cooperation with the Department of Meteorology and Climatology of the University of Washington.

The secondary parameters employed in the theoretical studies of Prof. O. G. Sutton were recomputed. The corrected parameters have been used in the determination of maximum ground concentrations and the distances at which the maxima occur for various combinations of stability, wind, and stack height. A report of this work appeared in Document HW-21415 (6-19-51).

F. Soil Science (D.W. Rhodes in Charge)

Problem 672.61 - Physical Properties of Hanford Soils* (D.W. Rhodes)

X-ray diffraction patterns of the clay fraction of soils, obtained from a proposed new disposal site near Area 2, indicated that the approximate ratio of montmorillonite to kaolinite was about 3 or 4 to 1, with considerable amounts of mica also present. These clays, which are apparently distributed in small amounts (1% to 7%) throughout the profile in this particular area, are fundamental in the retention of activity by the soil particles.

Since there is a possibility that soluble oil (Ucon)-water emulsions may have to be cribbed in one area, it was deemed advisable to have some information regarding the percolation of these emulsions through the soil. No oil "film buildup" was observed in soil columns containing particles greater than 50 μ diameter. Neither was there any observable decrease in the percolation rate from one run to the next. The percolation rate was found to increase rapidly with increasing particle size (50 μ to 1mm particles) and with increasing

* This was incorrectly titled "Typical Properties of Hanford Soils" in the previous report.

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water to oil ratio. Columns having 20% of the particles less than 50 μ diameter would not pass significant amounts of a 1:1 Uo2n-water mixture.

Problem 679.62 - Gross Reaction of Fission Products and Plutonium With Soil
(D.W. Rhodes, B.V. Anderson)

The influence of pH on the removal of plutonium from simulated waste solutions by earth materials, representative of a new disposal area, was tested. Percent removal was as follows:

pH	0	1	2-3.5	3.5	3.5-8	8-12	13-14
%	47	58	> 99	99.88	> 99	> 83	99.97

A wide practical range pH 3 to pH 7 appeared appropriate for disposal. The unexpected rise of retention again at very high pH, while of no practical value, may provide clues to the complex mechanisms involved.

Dialysis studies suggested that Pu^{239} may form a different ionic or molecular species at different pH values which affects the retention of the isotope when it comes into contact with the soil. Adjusting the pH to an optimum value (3 to 7) resulted in a species which was readily adsorbed.

Montmorillonite clay was found to be considerably more effective in retention of Pu^{239} than kaolinite, mica, or quartz sand.

Breakthrough data were obtained for the plutonium solutions, with promising initial results. Such data will have to be repeated under a wide variety of potential disposal conditions before the results can be applied generally.

Retention experiments on the troublesome Ru^{106} isotope gave the following preliminary results:

pH	0-1	2.6	4.7	6.6	8.5	9-12.5	13-14
%	v.low	11	84	97.5	93	~ 65	80-90

Satisfactory removal of ruthenium would require careful control of pH. The

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optimum ranges for Pu & Ru did not overlap completely. The best Pu for the mixed solution would be 6 to 7. In the ruthenium study, there was again the sharp rise in retention at very high pH.

G. Methods (J.W. Healy, Section Chief)

Problem 691.19 - Electrodeposition Methods for Plutonium (L.C. Schwendiman)

The program of testing this procedure at the Bioassay Laboratory was completed at the end of the quarter, and the entire process was deemed adequate for routine application. Standard procedure involved plating on 38.5 mm^2 discs in plastic cells.

The yields from samples spiked with 3.2 d/m of plutonium averaged close to 100% with standard deviations on the order of 12%. Samples with 0.16 and 0.064 d/m individual yields consistently above 100% presumably due to the original calibration on the alpha counters for source size. The average of blank samples has changed from one period to the next for, as yet, unexplained reasons. Change of lanthanum source used in the T.T.A. procedure explained some, but not all, of this. The sensitivity of the procedure, estimated from the results for the first half of the period was about 0.06 d/m on a 99% confidence level. The blanks for this data averaged 0.017 d/m; for the current blank of about 0.04 d/m, the sensitivity would be on the order of 0.11 d/m per sample.

A new electrodeposition unit to accommodate 16 samples in a minimum of space has been designed for routine use. Studies were made on the effect of plate diameter on yield. At 25 mm^2, the yields were 90-100%, while at 20 mm^2 they fell to about 60%.

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Problem 691.20 - Alpha Film Studies for Low Level Plutonium
(L.C. Schwendiman)

Routine measurements of integrated background during this period indicated a value of about 0.005 d/m, after eradication and exposure to a stainless steel plate for one week. Attempts to measure the emulsion yield (number of tracks/disintegrations) resulted in an average value close to 50% but with deviations higher than expected, and apparently not well correlated with actual yield.

Problem 691.21 - Fission Film Studies

Problem will be dropped, temporarily at least, because 691.19 and 691.20 can clearly be developed into an adequate sampling system.

Problem 691.22 - Counting Procedures for Tritium (J.D. McCormack)

The attempts to calibrate tritium oxide samples by filling Geiger counters with an alcohol-argon mixture and adding a small amount of tritium-hydrogen gas resulted in values about 50% of those expected from the activity calculated from the volume of gas burned. Three GM tubes one inch in diameter and 6 inch, 12 inch, and 18 inch long were used. Plateaus were reasonably good - usually over 100 volts in length and with a slope of less than 5% per 100 volts. Comparison of C^{14} results with those obtained on the mica window counter indicate that the loss of counting rate was in the counting or filling system, and was not specific to the tritium case. Studies are being continued in an attempt to determine the cause of this factor. Neither counter data nor ion chamber data at Hanford Works are in close agreement with theoretical expectations for tritium activity. Inter-project comparisons are being sponsored.

Problem 691.23 - Constant Monitor for Tritium Oxide

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Problem 691.24 - Separations Plant Stack Monitor
(L.C. Schwendiman, S.V. Anderson)

A constant monitor for the I^{131} emitted from the stack was studied. To obtain design data on the fluctuations expected, a vibrating reed electrometer was used to measure the ionization current from a chamber surrounded by a coil through which flowed the solution from a continuous scrubber. Difficulties with variation of solution level, and resultant variations in air flow and pressure were attacked by running the scrubber outlet into a vessel connected on the suction side of the scrubber.

Preliminary applications of this equipment to the operating case indicated peaks in I^{131} concentration on the order of 3×10^{-3} $\mu c/cc$. Since the rate of flow through this scrubber is such that scrubber volume is replaced only every 25 to 30 minutes, the actual peak may be higher than this value.

A new ion chamber designed to permit shielding and a [illegible] amplifier with a range changing device to give a factor of 1,000 on the scale is being designed as a permanent installation. Studies of scrubber design are being made to decrease the time constant from hold-up in the scrubber.

Problem 691.25 - I^{131} Measurements - Inactive

Problem 691.26 - Purification of Lanthanum - Inactive

Problem 691.27 - Naturally Active Materials in Water (P.L. Koehmstedt)

A colorimetric procedure for the determination of thorium in water, soil, etc is currently being tested. Difficulties are encountered in removing rare earths, phosphates, and zirconium, without some interference with reagents used. Major expenditures, however, in this field are deemed inappropriate, and the problem will be abandoned if not readily solved.

Problem 691.28 - Diffusion Experiments - Inactive

Problem 691.29 - Strippable Coatings - Inactive

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Problem 691.30 - Extraction of Air Samples - Inactive

Problem 691.64 - Calibration of Windowless Beta Counters - Inactive

Problem 691.65 - Study of Group Analyses (W.B. Silker)

A study of the qualitative group analysis scheme used in this laboratory to identify various unknown radioactive isotopes was started by running several isotopes in distilled water using representative carriers for each group. Cerium, iron, and cesium, gave relatively clean separations in the proper group, regardless of the amount of carrier for these elements added. The separation of group 3 into the 2 subgroups, however, was poor with a fraction of the activity in each portion. Radio-phosphorus carried in groups 3 and 4 when no carrier was added, but this contamination was reduced by the addition of 10 milligrams of inert phosphate.

The same type of experiment carried out with Sr^{90}-Y^{90}, Co^{60}, and Ca^{45}, except that 2 milligrams of about twenty different elements were added, indicated seperation into groups with, however, amounts between 1% and 10% carried in other groups.

The ultimate objective here was to scope the feasibility of an essentially continuous automatic group analyzer.

Problem 691.66 - Solubility Analysis of Noble Gases - Inactive

Problem 691.67 - Analysis of Gross Beta Emitters - Inactive

Problem 691.69 - Dilution of Reactor Effluent in the Columbia River (J. S. Hanstond)

Two groups of surveys, at low water and at high water, were completed during this quarter. Those surveys included sampling at various distances and depth across the river, making depth soundings, and measuring rough velocity patterns. The results were not completely plotted and interpreted as yet, but

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the dilution patterns appeared to be about as expected with narrow channels near the area, diffusing to broad bands and covering the entire river at distances of six to eight miles. Considerable difficulty was encountered in obtaining good samples, and positioning the boat, because of high currents in the river.

Manager
HEALTH DEPARTMENT DIVISIONS

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