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Metallurgical Project

A. H. Compton, Project Director

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Metallurgical Laboratory

S. K. Allison, Laboratory Director

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HEALTH DIVISION

R. S. Stone, M. D., Division Director

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REPORT FOR MONTH ENDING AUGUST 2, 1948

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Human Subjects Project

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## A. GENERAL SUMMARY

Dr. Robert S. Stone  
Division Director

### Biological Research

Methods of obtaining carrier-free f- products are being worked out by the Biochemical Group for the biological studies.

Enough Xe<sup>127</sup> has been obtained from the Berkeley cyclotron to start an exposure of one animal to a relatively large dosage. Methods of recovering the Xe<sup>127</sup> from the waste gases of the animal chambers have been quite thoroughly worked out. Techniques of dust exposures, external beta ray exposures, and gold fish control are being developed, but no conclusions have as yet been reached.

### Physics Section

One of the main disappointments in the Physics Section has been the large number of unsatisfactory pocket chambers which have been delivered to us from the Victoreen Company. Apparently, the problem of mass manufacture has not been satisfactorily solved.

The problem of film meters is well under way, and actual tests are about to begin. It seems that the film standard may be a valuable check for exposures even up to 10 r or more.

Dr. Pardu, who has taken over the radiation survey work, will have a representative to put pocket chambers on the personnel at many locations. With the thorough cooperation of everybody much valuable information should be obtained.

A report on beta ray measurements, etc. has been prepared during the past month, and will appear as a separate report.

### Clinical Medicine and Medical Research

A considerable amount of time has been spent in pre-employment examinations. The turn-over of non-academic labor places a large volume of physical examination work on the clinical group. The blood counts have revealed no unfavorable trends due to radiation during the past month. Typhoid inoculations and small pox vaccinations have been performed on a large number of the staff, both those moving to Site X and others staying in Chicago

Toxicological experiments continue to show no acute or subacute affects either in dogs or mice when tuballoy is taken by mouth or injected into the lungs.

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Total body radiation experiments on a few people have shown that there were no subjective effects from doses of 30, 60, or 120 r. However, as proof that the subjective effect is not an indication of objective changes, the patients getting 60 r and 120 r did show definite effects on the white blood cells and platelets.

Industrial surveys of plants doing subcontract work for the Du Pont Company have continued on the basis of cooperation between Du Pont physicians attached to our staff and our own staff.

Clinical work has had to be started at the Clinton Laboratories.

First aid and accident care on the Chicago campus has been worked out on a more satisfactory basis. Everyone should read the section dealing with this. In connection with this, we request that no first aid equipment be purchased or installed without consultation with the Health Division.

Sub-Projects

The work at the U. of C. Hospital, S. F., has continued but no further conclusions can be drawn than were drawn last month.

The work at the Memorial Hospital in New York has been renewed and is progressing satisfactorily.

Associated Project - U. of C. Radiation Laboratory

Dr. Hamilton was here during the past month and reported on the work at the U. of C. Radiation Laboratory, Berkeley. At the time of writing this summary his new monthly report had not been received.

Voluntary Collaboration Project

The work at the N. C. I. is progressing and a closer collaboration is being worked out. Members of our staff are reviewing with their staff the work that has been accomplished. The only additional report at the present time is that more of the guinea pigs receiving 8 r in 8 hours out of each day are dying. It will be recalled that the mice receiving this amount of radiation did not die in such short periods of time.

## B. BIOLOGICAL RESEARCH

K. S. Cole, Section Chief

### 1. F-product Separation - W. E. Cohn

Adsorption columns for the isolation of carrier-free f-products have been set up and tested with the assistance of Boyd, Coryell and members of their groups. It was hoped that the f-products in the S-15 nitrate could be separated prior to the isolation of the product but tests could not be completed in time to justify this procedure. Attention has now been turned to the much longer and more difficult adsorption recovery of carrier-free f-products from waste material of the wet B process. Methods are being developed for efficient extraction both here and at Clinton Laboratories. About 70 mC of Beta activity, primarily strontium, are expected from material now on hand.

### 2. Xenon Exposure and Recovery - R. Abrams.

A guinea-pig exposure to  $1.25 \times 10^{-6}$  C/cc of  $\text{Xe}^{127}$  was started on July 9th. The animal is grossly normal after about 1500 r to the main bronchus and 500 r to the lung in general.

Active carbon has been tested as a means of recovering Xe from waste gases.  $\text{Xe}^{127}$  in air is blown through Dioxorb (soda-lime), Drierite (anhydr.  $\text{CaSO}_4$ ), phosphorous pentoxide, and finally through coconut charcoal which has previously been activated by pumping at  $350^\circ \text{C}$  for 3 hours. The adsorbed gas was subsequently eluted by heating to  $250^\circ \text{C}$ . Both adsorption temperature and flow rate were varied. With the carbon at  $-80^\circ \text{C}$ , the flow rate was varied from 0.2 to 18.9 liters per minute. The yield after elution was over 90% in every case. At  $0^\circ \text{C}$  and at  $29^\circ \text{C}$  the method was effective only at low flow rates. Thus a flow of 0.5 liters/minute gave a yield of 65% at  $29^\circ$ , and 90% at  $0^\circ$ , while 8 liters/minute gave a yield of only 26% at  $0^\circ$ .

### 3. Dust Exposure - R. Abrams

The deposition and metabolism of inhaled dust is being continued with  $\text{X}_2\text{O}_8$  and with  $\text{FeP}^{32}$  diluted with  $\text{Fe}_2\text{O}_3$ . Twelve mice were exposed for 6 hours to a 5.6 mg./liter concentration of  $\text{X}_2\text{O}_8$  having a particle size less than 2 micra. Three animals were sacrificed immediately and the rest had died or were moribund in five days. About 10% of the inhaled dust was deposited in the lungs and retained. Elimination of ingested material was slow; small amounts of metal appeared in kidney and liver after the third day.

### 4. Fast n and x-ray Exposures - R. E. Zirkle

Fast n exposures on rabbits and mice have been continued and x-ray exposures have just been resumed with the new equipment.

### 5. Effect of External Beta Radiation - R. E. Zirkle

At the conclusion of the experiments with external Beta rays from bombarded nitrate, two rats had received 550 r in 25 days and 5 mice had received 415 r in 23 days. All animals appeared healthy. They were sacrificed over a period of two weeks following exposure. No gross pathology could be detected. Slides of skin and other organs are being prepared.

### 6. Experiments on Goldfish - R. E. Zirkle

Control animals are not yet being maintained satisfactorily in the density which will be necessary for experiments with the amounts of f-products to be available in the near future.

### 7. Miscellaneous

Mr. Fermi exposed a mouse in the center of the operating pile. The effect of a 20 gm. mouse on the pile was 0.15 in-hours. After an exposure of 10 kw hours the mouse died in four days.

Drs. Cohen and Zirkle have spent considerable time in both formal and informal training of new personnel.

Dr. Curtis has continued on personnel and Clinton Laboratory problems.

### 8. Work for the Coming Month

1. The f-product isolation will continue and animal experiments may be started.
2. The calculated equivalence of external x-rays and internal beta-emitters must be tested with short-lived isotopes which distribute uniformly in the body. Dr. Cohn's group expect to start this work soon with Na<sup>24</sup> and Br<sup>82</sup> from the Chicago and U. of C. Cyclotrons.
3. The present Xe<sup>127</sup> guinea pig exposure will be terminated, the tissues examined and a new exposure started.
4. The Xe extraction work will be extended to higher flow rates at -80° C, to testing the effects of small amounts of HO<sub>2</sub>, H<sub>2</sub>O and CO<sub>2</sub>, and to a reinvestigation of silica gel as an absorbent. This and the dust work will be limited by personnel available.
5. The fast n- and x-ray exposures, and the goldfish work will be continued. The external beta radiations will not be resumed unless bombarded nitrate becomes available.
6. It would be highly desirable to have a few further animal exposures in the pile.
7. The preparations for migration to Clinton Laboratory will require more time and the first of the personnel will go during the month.

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G. HEALTH PHYSICS

E. O. Wollan, Section Chief

Report prepared by H.M.Parker  
Acting Section Chief.

9. Personnel

Dr. K. Z. Morgan, Research Associate, Dr. O. G. Landsverk, Research Associate, and Mr. J. C. Hart, Research Assistant joined the Section this month.

10. Pocket Chambers - H. M. Parker

Two hundred of the new pocket chambers and one Projection Minometer, made according to our suggestions, arrived.

The new Minometer was quite satisfactory and increased the speed of reading the chambers from 100 per hour to 140 per hour. Alternatively it would now be possible to read at the steady rate of 100 chambers per hour for three hours continuously without undue strain.

The charging mechanism jammed after a few days but this was probably teething trouble of the first model. Suggestions for improving the legibility of the scale have been made to Mr. Victoreen.

The chambers were disappointing. One hundred leaked as much as 0.02r per day and 80 of these leaked more than 0.1 r per day. Inasmuch as these were the first chambers bearing the dessicator caps proposed by us, it was important to determine whether the effects were referable to humidity trouble. The chambers were divided into five groups -

- 1.- untreated
2. Kept in air-conditioned room
3. Kept in air-conditioned room with cap off
4. Dessigel cap roasted, replaced on chamber and kept air-conditioned.
5. Chamber and cap dried in oven and subsequently kept in air-conditioned room

There was no significant difference in the behavior of the groups. It was concluded that humidity was not the determining factor. The faulty chambers have been returned to Mr. Victoreen. No report on the trouble is yet to hand.

The principal disadvantage of pocket chamber methods as compared, for example, with film methods is that the reading is liable to be totally lost by faulty insulation. If this is of frequent occurrence, the utility of the method

is called into question. It is too early yet to state how many of the new chambers break down in service. The casualty rate at present is apparently about 10% per week. On this basis 1 in 60 readings is lost. Then, by issuing 2 chambers to each individual the chances of both readings being lost becomes rather small. By comparison, the special beta-ray chambers made in the laboratory by C. Camertsfelder and J. G. duPont have now been extensively used and have never given an apparent spurious reading. Their rate of leak is negligible. Furthermore, chambers constructed by Sievert in Stockholm, and Parker in Seattle have been demonstrated to hold their full charge within a few percent over periods as long as 5 weeks. The present difficulty must therefore be due to some fault in manufacture which could be rectified.

## 11. Film Radiation Meters - E. O. Mollan and N. Goldstein

a) The work reported in OH-708 for lead filters on films has been extended to copper and tin (in lieu of silver as previously proposed). Copper was less desirable than lead. The results with tin are given in Figure #1, from which it can be seen that the best general fit for equal blackenings per roentgen is given by a tin filter of thickness 1.35 mm. The average blackening per roentgen would be about  $0.32 \pm 0.04$ , quite close to the result with lead.

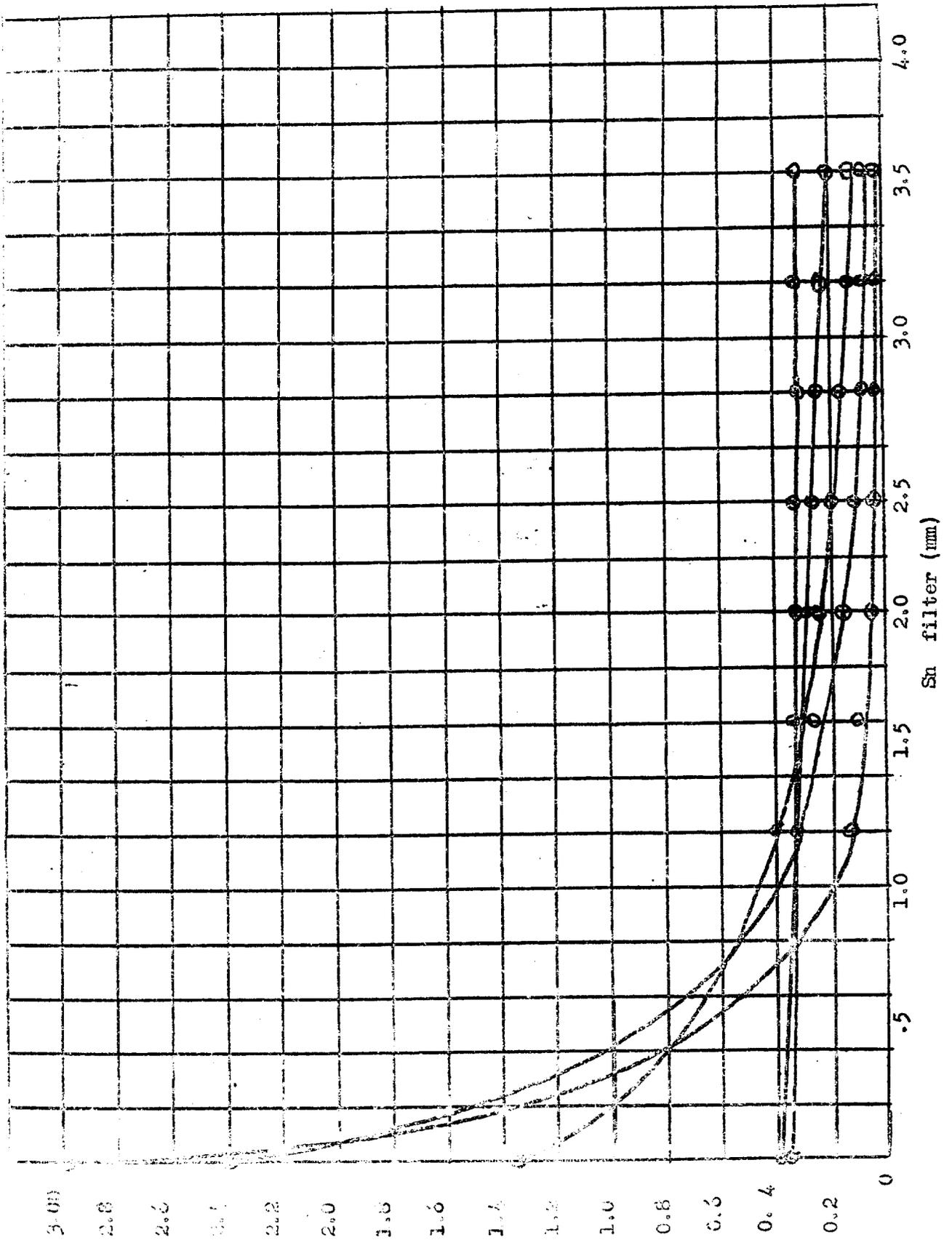
In order to cover the range down to 100 KVP (approximately 50 KV. average energy) it would be necessary to choose a filter approximately 0.8 m thick with blackening per roentgen of  $0.45 \pm 0.1$ . This leads to indefinite results over the range that will normally be covered by the incident radiations. It seems better to take the thickness of 1.35 mm. and consider the results good to an average energy of 70 KV. Superficially the figures for tin do not seem better than the previous ones for lead, but this must be the case; the Pb filter has an absorption limit in the neighborhood of 88 KV and therefore cannot yield consistent results in this range. The tin filter, with an absorption limit at 29 KV. should handle radiations down to perhaps 60 KV.

In considering the accuracy of the film meter method it should be noted that the experiments were made with the radiations incident normally on the film and filter. With random distribution of angle, the absorption of soft radiation will be appreciably affected by oblique filtration (e.g. with 70 kv. average energy the absorption of a beam incident at  $45^\circ$  will be 5 times that for normal incidence on a tin filter 1.35 mm. thick). This point is being further investigated.

b) Choice of Film. The tests were made with duPont film. It is now apparently impossible to obtain this in the right size. For routine use Eastman Kodak #0 Radiatized film will be used. Sensitivity tests have had to be repeated. With 0.6 mm. Pb filter the blackening per roentgen was 0.31, identical with that previously obtained with the duPont film.

One batch of films was used which gave spurious results at the lower end of the scale. It was subsequently found that the film was old. In future samples will have to be developed before the film is issued.

c) Measurement of larger doses. Films were exposed to doses of x-radiation of various intensities up to  $10 \times 10^4$  rads in order to determine the possibility of estimating an accidental gross over-exposure of personnel. The accuracy up to



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5 r was essentially the same as in the normal working range. At 10 r there was a departure from the linear blackening curve, but the dose could probably be quoted to within 25%. In this respect the film method is ideal. If the fact of over exposure were known it would be possible to take one of the films in each meter, together with a special set of standards and develop the group for a controlled short time. In this manner doses appreciably higher than 10 r could be read. Alternatively, with the cooperation of the film makers it would be simple to assemble one thick emulsion double sided film and one thin emulsion single sided film in the same package. The sensitivity ratio to be expected would be about 5. Therefore doses between 0.5 r and 50 r could probably be measured to within 25 - 30%.

## 12. Routine Surveys

Pardue and Goldstein have begun the regular daily measurement of pocket chambers on all personnel, as far as the present stock permits. Routine use of films is just beginning.

Pardue has made a thorough radiation survey of every room in the New Chemistry Building without locating untoward circumstances. At Site B Chemistry, he found a crock containing glass-cleaning solution that had accumulated activity giving 1 r per 8 hours in close proximity and 0.1 r per 8 hours at 3 feet. Similar activation of cleaning solutions is liable to occur elsewhere.

A new survey at Argonne revealed nothing more than is covered by CH-708, paragraph 25.

## 13. Slow Neutrons

H. A. Wilson has calculated body tissue ionization arising from exposure to slow neutrons under the anticipated circumstances. This will be a separate CH report.

He has also computed the ionization in cadmium walled chambers of different geometry when exposed to slow neutrons.

This correlates with the experimental study of slow neutron chambers begun by Pardue. Several possibilities are being investigated with a view to routine use at X.

## 14. Extrapolation Chambers.

Parker, Gamertsfelder and Pardue have made measurements on the depth dose of beta-rays from P<sup>32</sup>. These agreed well with theoretical calculations. Details appear in the beta-ray report available this month. The ionization close to different surfaces subjected to constant beta-ray irradiation was measured with the following results.

<u>Surface</u>	<u>Ionization (esu/hr.)</u>
Catalin	31.5
Aluminum	36
Brass	47
Lead	61

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As the ionization in contact with lead is more than twice that in contact with organic material the effect cannot be solely a measure of the number of reflected beta-rays, which it was hoped to determine.

#### 15. Other work.

Lester has constructed a system for assembling G-M counter tubes. Hart has become familiar with ionization measurements using the Dersham electrometers and the Minometers. He has assembled 25 aluminum type pocket chambers for use at Argonne. Parker and Gemertsfelder has designed special ionization chambers for use both by this section and the biological section at Clinton.

#### 16. Meteorology.

Work was continued on the thermographs. One instrument has been developed which seems to operate successfully.

The group at Site W has devoted most of its time to making simultaneous balloon ascents at various locations. In addition to working on the wind pattern at Site W, the group has been requested to observe river stages and inform the engineers of certain critical maximum and minimum temperatures and maximum and minimum humidities.

The group has also been requested to furnish twenty-four hour forecasts for construction purposes and also a three-day outlook for the same purposes.

#### 17. Work for the Coming Month

1. Meteorology program to continue.
2. Routine surveys
3. Developments of new meters for both fast and slow neutrons.
4. Preparations for Clinton Laboratories.
5. Completion of counter equipment.
6. Design of recording equipment using a new technique.

D. CLINICAL MEDICINE AND MEDICAL RESEARCH

S. T. Cantril, M.D., Section Chief

18. Clinical and Laboratory Control.

For the month of July, 150-pre-employment examinations were conducted.

Low white blood counts were found in two people during the month. Both of these were directly attributable to other than occupational causes. One was associated with an allergic episode, and the other with a respiratory infection. Both have recovered satisfactorily.

The chemist, reported in the June CH report as having a low white blood count has returned to work not involving radiochemistry. His blood count is now ~ 4500.

Personnel moving to Site X and others on the Project so desiring are being inoculated for typhoid and smallpox. It was urged that all personnel going to Site X receive the inoculations. The response has been almost unanimous. Those not receiving inoculation at Chicago, may receive them at Site X.

19. Toxicology

Dr. Tannenbaum is continuing to sacrifice and quantitatively analyze animals which have been fed nitrate or oxide over a period of 9 months. As soon as these analyses and those of injection experiments are concluded, a detailed report will be made. Other compounds of various tube-alloy compounds will be fed. Further experiments are planned that will involve injection and inhalation of various compounds and the feeding of new compounds.

Dogs which have been fed from 0.3 - 0.6 gm of oxide or metal per day show no external evidence of toxicity after 8 months of feeding. Other dogs which have had a total of ~ 20 grams of oxide or metal powder blown directly into the lungs likewise remain in good health. Neither of these groups shows evidence of stippling of red blood cells, as would be encountered in lead given by comparable methods of administration.

20. Total Body Radiation

In March 1943 we undertook to study the effect on the circulating blood of total body radiation given to incurable cancer patients. The radiations being used are x-rays generated at 400 kv, filtered through 3 mm. Cu. To date 6 patients have been treated with single exposures ranging from 30 to 120 r. The dosage-rate is ~1 r per minute. ←

Because of the limited number of exposures we cannot reach any general conclusions from a detailed analysis of results to date. However, certain trends seem worthy of comment at this time.

- a) None of the 6 exposures caused any radiation sickness, i.e. weakness, nausea, vomiting or fatigue.

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- b) The 30 r exposure produced no striking effect which could be noted after 51 days.

Three of the four 60 r exposures produced a leukopenia (low total white count) within 2 - 4 hours after exposure. In 2 of these the drop was ~ 50%. The 4th caused no definite effect on the circulating blood. The three which had an immediate leukopenia recovered to a normal total white blood count in from 4 - 14 days, but in all of these the lymphocytes have remained at a depressed level (~ 40% drop). The longest of these has been followed for ~ 4 months. These 3 patients also showed a reduction in the number of a blood platelets. The platelet fall in these individuals was gradual, reaching an ~ 25% loss after 3 - 4 weeks with beginning recovery thereafter which however in 2 of the 3 has not returned to the pre-exposure level.

The one exposure to 120 r produced a relative fall in total white blood count (~30%) but with recovery within 7 days. The platelets dropped from 203,000 to 70,000 within 24 hours, with a return to the pre-exposure level within 4 days.

- c) There has been no effect seen in the red blood cell or hemoglobin levels.
- d) The outstanding findings in the majority of this small group are a sustained fall in the lymphocyte level and a lesser but apparently significant fall in the platelet level.
- e) The effect seen on the blood platelets has called to our attention the possible importance of this effect as an earlier index than we had heretofore considered. These will be followed in a selected and in a control group of personnel.

## 21. Industrial Surveys

On July 24, an extruding operation was visited by Dr. Norwood and Dr. Nickson. The occasion was the first extrusion run at that plant. The situation in general was fair, and, pending some changes, is potentially satisfactory from the health standpoint. Measurement of the dust concentration in the air were taken with the electrostatic precipitator and the Deraham electrometer. The readings obtained were:

Next hearth furnace - 0.580 mgm. per cubic meter of air

Next extrusion press operator - 0.203 mgm. per cubic meter of air.

Next butt removal operation. - 2.32 mg. per cubic meter of air.

The tentative tolerance level for metal in air is 0.150 mgm. per cubic meter. It is planned to change the method for separating the dummy butt from the metal butt. It is hoped that this change will diminish the amount of material in the air. Further measurements will be made.

Dr. Norwood examined the personnel prior to beginning operations at the above plant. Forty-nine men were examined, of whom 9 were rejected for work on the metal. Dr. Norwood also visited, at the request of the company, a plant machining metal cylinders. An epidemic of diarrhea had occurred among the employees of that company. It was felt by the company that exposure to the metal might be a factor. Dr. Norwood could find no indication that such was the case. Dust measurements were made, the highest of which was 110  $\mu$ g., a figure well below the tentative tolerance level now accepted.

## 22. Site X

Dr. Fuqua and two hematology technicians have moved to Site X to begin work on pre-employment examinations and to begin organization of the Medical Department and equipment. Other members of the staff will begin work there within a month.

## 23. Histological Studies of Radiation Effects.

Dr. Bloom has added Dr. Raymond Murray to his group as an associate group leader. Dr. Murray is organizing the tissue laboratory in Site B and is beginning detailed studies of cytological effects produced by radiation in animals. This is in collaboration with Dr. Jacobson, Dr. Zirkle, Dr. Abrams and other members of Dr. Cole's Group.

Reports on this work will be made at appropriate times by those engaged in its various aspects.

## 24. First Aid and Accident Care.

Dr. Margaret Nickson and Mr. Rapier made a survey of first aid equipment in the laboratories. The practice of having first aid kits scattered about the Project is under question by the University authorities. It is hoped that a decision will be reached soon. If the kits are to be continued, Mr. Rapier's Group will keep them stocked with a uniform supply.

Arrangements for care of accidents on a more satisfactory basis has been made with the University Clinics. All accident care during the day (Except Saturday and Sunday) up to 4 P.M. will be taken care of by Dr. Spurr, 351M Billings Hospital, to whom the injured person should report immediately. In case of accident requiring transportation, call the Hospital Admitting Office, MIDway 0800, Extension 478. At night care will be given through the Billings Hospital Admitting Office. These instructions are being publicized through the first issue of the Safety Bulletin, which gives detailed instructions as to location of accident care in the Hospital.

## 25. Work for the Coming Month.

1. Continuance of surveys on Health and Hazards.
2. Preparations for X-Health Program.
3. Continuation of studies in total body radiation in man.
4. Continuation of toxicologic studies of x-metal and its compounds.

5. Continued industrial surveys.
6. Survey of health aspects at SL cyclotron.
7. Studies in histological effects of radiation.
8. Continuation of blood studies and physical examinations on personnel.

Metallurgical Project

A. H. Compton, Project Director

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Metallurgical Laboratory

S. K. Allison, Director

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HEALTH DIVISION

R. S. Stone, M.D., Division Director

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SUPPLEMENT TO REPORT CH-843

August 18, 1943

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J. G. Hamilton.

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TECHNICAL PROGRESS REPORT ON THE METABOLIC STUDIES OF FISSION PRODUCTS

1. Ruthenium ( $Ru^{104}$ )

The sixty-four day groups of animals have been sacrificed and assays on the distribution of the  $Ru^{104}$  are now being carried out. A complete report including Radio-Autographic studies will be prepared shortly.

2. Barium ( $Ba^{133}$ )-Professor I. L. Chaikoff

Oral, intraperitoneal, intramuscular and lung studies up to sixteen days have now been completed. The data is being computed and it is apparent that Barium is handled in the body in a manner very similar to Strontium. No significant fraction of Barium was retained in the pulmonary tissue following its administration directly into the lungs.

3. Fission Mixture

At sixty-four days following intramuscular administration 47% of the dose was found in the skeleton with 2% retained by the liver. None of the other tissues contained significant quantities of this material. Sixty-four days after intrapulmonary administration 7.5% of the total activity in the body was still in the lungs, 74% in the skeleton and 3.5% in the liver. At this interval 2% of the dose was absorbed from the digestive tract and 95% of the absorbed activity was in the skeleton.

4. Radio-autographic Studies

These experiments are being continued and a large group of reproductions are being prepared for distribution in a report at an early date. Radio-autographic studies on the pulmonary distribution of  $Y^{86}$  have been initiated.

5. Emanation Studies

A plate of Uranium metal was subjected to 100 micro-ampere hours bombardment by 16 MeV deuterons in a 15 cc. bell jar. The fission products were carried into a specially designed vessel of 150 cc. volume by means of a stream of Helium gas flowing at a rate of 30 cc. per minute. A separate flow of oxygen at a rate of 40 cc. per minute was introduced into this vessel. Three rats were exposed to this environment. At the end of one hour, one rat was removed and the wet tissues assayed. The highest activity was found in the blood. The remaining two animals were exposed for three hours and sacrificed four days later. At the end of that time a preliminary assay revealed the thyroid to be approximately eighty times more active per gram than the next most active tissues which were the lung and bone. The ashed tissues are now being assayed together with the decay products from the gas environment to which the animals were exposed.

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## 6. Decontamination Studies -- Professor D. M. Greenberg and Dr. D. Copp

Further work with the combined action of Strontium and di-sodium phosphate in reducing the oral absorption of Radio-Strontium is being continued.

## 7. Zirconium ( $Zr^{89}$ )

The sixteen day groups of animals receiving this radio element intramuscularly, intraperitoneally, and by lung have been sacrificed and their tissues assayed. Ninety percent of the activity was retained in the lungs, 3% was present in the skeleton, 1% in the liver, in the group of animals that received  $Zr^{89}$  by intrapulmonary injection. The intramuscular group at sixteen days showed 78% unabsorbed at the site of injection, 9% in the skeleton, 1% excreted in the urine, 2% in the feces. The activity per gram of the spleen and kidney was roughly one-third of the corresponding value for bone. When injected intraperitoneally over 50% remained unabsorbed at the end of sixteen days in the peritoneal cavity indicating the difficulty with which Zirconium is absorbed by the tissues.

## 8. Columbium ( $Cb^{93}$ )

A small series of four day oral, intramuscular, and pulmonary experiments have been done with  $Cb^{93}$  without carrier. Oral absorption was negligible. Approximately 85% of the intramuscular dose was unabsorbed at the site of injection, 4% was in the skeleton, 3% in the urine, 2% in the feces. More than 80% was retained in the lungs in the animals which received  $Cb^{93}$  by pulmonary injection. The data is only of qualitative accuracy since only very weak radioactive samples were available due to the extreme difficulty involved in the preparation of  $Cb^{93}$  without carrier and free from both radioactive and inert Zirconium.

## 9. Cesium ( $Cs^{134}$ )

$Cs^{134}$  without carrier is now being prepared by the deuteron transmutation of Barium. This material is shortly to be placed in the hands of Dr. Chaikoff for tracer studies.

## 10. Projected Studies for the Next Two Months

Tracer studies are to be continued with Columbium, Cesium, and extended with Barium by the use of  $Ba^{140}$  if this material can be prepared without carrier and free from both  $Sr^{89}$  and inert Strontium. Evacuation experiments, radio-autographic, and decontamination studies are to be continued. More complete lung studies on Yttrium will be followed up and similar studies extended to include Cerium. Tracer studies are to be initiated with Neptunium and Praseodymium if the latter can be prepared free from carrier and without the presence of other rare earth elements.