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 SEPTEMBER 4, 1943

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Table of Contents — Page

A. GENERAL SUMMARY

Dr. Robert S. Stone
Division Director

Clinical Medicine and Medical Research

Dr. J. J. Nickson is the Acting Section Chief of this Section. No evidence of radiation damage either to the blood or hands has been found during the past month. Typhoid inoculations have been given the staff at Argonne as well as those going to Oak Ridge. Industrial surveys continue in cooperation with the Dupont physicians. Dr. Nickson sums up the conditions looked for in the various plants in this month's report. The object of the surveys is to see that the men are not exposed to inhalation of tuballoy dust nor to direct contact with the metal. The Medical Committee of the Manhattan District, composed of Dr. Stafford Warren, Dr. R. S. Stone and Dr. Hymer Friedell has tentatively set a local skin tolerance dosage of 0.5 r per day for beta ray exposures. It is emphasized that this is for the hands, for localized exposure and for beta rays. Dr. Parker's measurements have shown that direct contact with the bare metal gives roughly .25 r per hour. Thus, two hours' contact gives a tolerance dose. There are very few operations which require more than two hours direct contact with the metal.

No new results have come from the toxicology experiments and total body radiation treatments.

Health Physics

H. A. Wilson has considered a cadmium covered ionization chamber as a detector for slow neutrons. He shows that such a chamber can be used to determine the ionization that would be caused in the body by slow neutrons. He further shows that a hydrogen filled cadmium covered ionization chamber can be developed such that it will measure the ionization due to gamma rays, slow neutrons and fast neutrons. The fast neutron ionization is weighted in such a way as to balance the greater biological effectiveness. (Separate report to appear later).

The cause of the large number of faulty pocket chambers has apparently been located by Dr. Parker and it is hoped that the future supply will be much more satisfactory.

Film meters have been further refined by Drs. Parker, Pardue and Goldstein. It now seems that it will be possible by the use of two films of different types in a packet to get a moderately accurate estimate of radiations of a wide range of quality and quantity.

A practical instrument for the measurement of fast neutrons is now available with a sensitivity such that it will be possible to measure three fast neutrons per cm^2 per second in an observation extending over two minutes.

Meteorology work at Site W continues and plans for some work at Site X are developing.

The Health Division is to lose the direct services of Dr. E. O. Wollan who has acted as the Section Chief of its Physics Section since its formation. We will miss Dr. Wollan and wish him well in his new association with the General Physics Section.

Biological Research

In attempting to get carrier-free non-contaminated radio-elements from the separation wastes for biological research, it has become clear that this is almost impossible. Some alternate procedures must be developed and these are being investigated.

Experiments with commercial gas mask canisters seem to indicate that they have a very definite value in removing Xenon from the air passing through the canister. This is being further investigated.

Further comparisons of the effects of fast neutrons and X-rays indicate differing ratios according to the biological index chosen. In the studies presented in this monthly report x/n ratios of 10 and 7 were found for lethal effects on mice.

Some mice were exposed to internal pile radiations. The minimum exposure was 5.8 kw-hrs. All of the mice died in four days or less. It is estimated that 1 kw-hr is equivalent in effect to 200-250 r of X-rays or 20-23 n of fast neutrons in producing 50% mortality in about three days.

A considerable part of the work in the Biological Research Section continues to be of "scout" type, getting prepared for the time when sufficient f-products will be available in large quantities.

Associated Projects:

Radiation Laboratory

The Radiation Laboratory work for the past month was concerned mostly with Yttrium, Columbium, Cesium and Barium. The Yttrium was found to be absorbed rather more rapidly from the lungs than the previous experiments indicated.

Radio-autographic studies of the pulmonary distribution of Y^{86} reveal a very diffused distribution in the lungs.

It is expected that Dr. Hamilton will be here in person to report in October when a much fuller report will be given.

N.C.I.

Dr. Henshaw has been studying the incidence of leukemia in physicians on the assumption that physicians were more exposed to high energy radiations than the population as a whole. The results of his study show a distinctly higher incidence of leukemia in physicians.

Dr. Henshaw's experiments have shown that recuperation becomes slower as an animal is exposed over longer periods of time, and that the peripheral leucocyte blood level tends to be fixed at a lower point.

The continued gamma ray exposures being made under Dr. Lorenz and associates continues to reveal that different species respond differently. The mice exposed on the 8 r per day level are just beginning to show some blood effects after having received 1300 r. The guinea pigs getting 8 r per day are killed by that dose. Acute exposures of 12.5 and 50 r added on top of the chronic exposures seem to have only transient effects.

Animals killed after having been on the 8 r and 4 r per day levels do show some pathological changes.

Animals exposed continuously for 24 hours daily to test genetic effects by observing the litter size show that those receiving as much as 500 r at the rate of 8 r per 24 hours still have normal litter sizes.

For a discussion of the pathological changes found in various animals, one must study the complete report.

Sub-Projects

U. of C. Hospital, S.F.:- Further blood studies on some patients previously treated, and on three new ones indicate that the total leucocyte counts tend to fluctuate during the treatments and to fall in the first few weeks after treatment but to recover shortly after that to normal. In general, the treatments were to 300 r in a period shorter than one month.

[redacted]

[redacted]

B. Clinical Medicine and Medical Research Section

J. J. Nickson, Acting Section Chief

1. Clinical and Laboratory Control

For the month of August the necessary pre-employment and blood examinations were done.

During follow-up examinations of the hands on the members of Seaborg's, Burton's and Coryell's groups no evidence of radiation damage to the hands was found.

No low white blood counts were found which could be attributed to radiation exposure.

Typhoid fever inoculations for the persons going to X were completed during the month. Because of the water supply at Argonne, typhoid and paratyphoid inoculations were begun on the personnel there. Tetanus inoculations were given to the individuals working at Site B Annex.

2. Toxicology

Dr. Tannenbaum is continuing to sacrifice and analyze those animals which have been fed nitrate or oxide. It is planned to start work with other tuballoy compounds in the near future.

3. Total Body Radiation

One new case was treated during the month. Observations on the previously treated cases were continued. One patient was hospitalized in the Billings Hospital for further study. The preliminary results mentioned in CH-843 are not altered by the months observations.

4. Industrial Surveys

A reading was taken in Room 108, Site B. This room is used by some members of Foote's group. Grinding and cutting operations on tuballoy are carried out there. A value of 3000 μ grams per cubic meter of air was found. This value is 20 times the assumed tolerance level of 150 μgrams per cubic meter of air. On the basis of this reading, the installation of a ventilating system has been recommended.

Visits were made by Dr. Norwood to four plants concerned with the processing of tuballoy. Readings of dust and fume concentrations were made, and the physical condition of the personnel was investigated. Details of the visits to the various plants can be obtained from letters, MUC-HG-209, 210, 215, and 226.

Perhaps a few words about the health problems in the manufacturing plants visited by us would be in order here, as the problem heretofore has only been discussed piecemeal.

The problem of safeguarding the persons processing tuballoy prior to its exposure in the pile resolves itself into two main divisions:

1. Keeping the amount of tuballoy dust in the air below tolerance levels. The tolerance figure now accepted is 150 micrograms per cubic meter of air. This figure is derived from the tolerance level set for lead by the United States Public Health Service. Lead was used since it is a heavy metal which has been extensively studied. It is felt that tuballoy will not be more toxic than lead when inhaled.

2. Protection of the hands while handling the metal.

The first problem is best handled by prevention of the formation of fumes or dust. The next best method is to remove the contaminants from the plant atmosphere. The least satisfactory method is to use respirators.

In general, the extrusion plants, the out-gasing plants and the straightening plants have amounts of dust and fumes in the air that are far above the tentative tolerance level, at least in certain areas of the plants. Prevention of dust or fume formation is not at present possible. Ventilation should be installed as soon as possible in the present plants. Any future plant in which the above processes are to be used should have ventilation installed prior to the beginning of operations. Determinations of the amounts of tuballoy dust and fumes in the air should be made at frequent intervals. Any necessary alteration indicated in the ventilating system should be made promptly.

Masks should be, and by and large are, worn wherever the ventilation is inadequate. However, masks at best are an unsatisfactory solution to the problem both from the workers and from our standpoint. This is true because the masks are uncomfortable and inevitably some of the men will either refuse to wear them or will wear them for the most part around the neck rather than over the mouth. Also, the masks so muffle the voice that foremen, etc., cannot do their job properly while wearing them. Masks should be regarded only as a temporary measure to be used until an adequate ventilation system is installed and is working satisfactorily. The best mask that we have found is the Wilson Respirator #570, Bureau of Mines Approval #2149, which can be obtained from the Wilson Products Company, Reading, Pennsylvania. It is possible that these masks will be equipped with a speaking diaphragm in the near future.

In general, the dust and fume formation in the plants doing machining is under or near the tolerance levels. This statement is true only if the proper use of the water cooling system is made. To insure "proper use", most water cooling systems must be redesigned so that a flow of 50 gallons per minute is available. A reservoir of 3-4 inches of coolant in the pan of the bath is necessary. Frequent removal of the accumulated chips must be practiced. If the above precautions are taken, the hot fragments fall into the reservoir, or are otherwise promptly quenched. In such instances, the installation of a ventilating system is unnecessary as the amount of fumes produced never exceeds the tolerance concentration in the

air. Masks, of course, are not needed.

Insofar as is now known the amounts of tuballoy in the air during the jacketing process does not exceed the tolerance concentration.

The Medical Committee of the Manhattan District has tentatively set a local skin tolerance level of 0.5 r per day for beta ray exposure. Contact exposure of the bare hands to the bare metal gives 0.25 r per hour to the skin from the beta rays. Thus, a tolerance dose is received after two hours contact with the metal. At the present time, only the inspectors of the machined bars routinely over-expose themselves. Their work, as at present set up, requires manipulation of both the bar and of measuring devices. It has been suggested (MUC-HG-226) that the job could be redesigned so that the exposure would be reduced to below tolerance levels. If this is not possible, the number of inspectors should be increased so that each man receives no more than two hours exposure.

5 Maintenance of Equipment

In general, the companies concerned have been most cooperative in procuring the recommended masks and gloves. However, the maintenance of this equipment usually has left much to be desired. Equipment which is allowed to deteriorate is probably worse than no equipment at all. Masks should be cleaned and inspected daily, and damaged masks repaired or replaced. Extra filters should be available for prompt replacement of filters too dirty to permit easy breathing. Protective gloves are commonly allowed to be used for weeks on end, becoming encrusted both inside and outside with dirt, much of which is from tuballoy. Gloves in this condition are more a menace than a protection. Any glove supplied should be inspected frequently for holes, replaced when worn, and cleaned before they get more than moderately dirty. The maintenance, replacement and selection for cleaning of masks and gloves should be the responsibility of one man in each plant, and not left to chance.

6. General Plant Environment

Several of the plants which have been visited do not provide adequate washing facilities, and some do not furnish soap or towels. It is our feeling that in any plant in which the metal is to be handled, complete washing facilities, including showers, should be provided, and the men required to use them at the end of each day.

Clothing should be provided and should be laundered frequently.

The above general measures, although relatively simple, are quite important in the protection of the personnel. All too frequently contamination of the hair and clothes is a source of long continued exposure which is easily preventable.

7. Site X

Dr. Cantril left for Site X during the last month.

8. Histological Studies of Radiation Effects

The work in Dr. Bloom's group is progressing according to plan.

9. Work for the Coming Month

1. Continuance of surveys on Health and Hazards
2. Continuance of total body radiation studies in man.
3. Continuance of toxicologic properties of X-metal and its compounds.
4. Continued industrial surveys.
5. Studies of histologic effects of radiation.
6. Continuation of blood studies and physical examinations on personnel.

C. Health Physics

1. Ionization due to slow neutrons in cadmium coated ionization chambers - H. A. Wilson

a. A Spherical Chamber

If $\bar{n}$ denotes the average over the ionization chamber surface of the number of neutrons per cm^2 falling on the surface the energy absorbed is $3/2\,\mu E_\gamma \bar{n} V$. where μ is the linear absorption coefficient of the γ-rays in the gas of chamber, E_γ is the energy of the γ-rays and V is the volume of the chamber.

If the neutrons falling on the chamber are all moving in the same direction and n pass through 1 cm^2 perpendicular to this direction, then the energy absorbed is $3/8\,\mu E_\gamma nV$.

b. Cylindrical Chamber

For a chamber long compared to its diameter the energy absorbed is $2\mu E_\gamma nV$ where $V = \pi b^2 \lambda$.

For a short chamber the calculations are more complicated and are a function of the ratio of length to radius. The following table gives values of a parameter m as a function of λ/b for the chamber coated on the cylindrical surface only and for the ends also coated. m = the average γ-ray flux over the chamber per neutron/cm^2

Table I

λ/b	m (cylinder covered with Cd)	m (ends also covered with Cd
1	0.836	1.742
2	1.132	1.676
3	1.32	1.702
4	1.406	1.706
∞	2.000	2.000

Using the values of m the energy absorbed in the chamber from the emitted γ-rays is given by

$$m\,\bar{n}\,\mu E_\gamma V \quad \text{where } V = \pi b^2 \lambda$$

where it is supposed that $\bar{n}$ is the average number of slow neutrons/cm^2 striking the surface from all directions. If the chamber is exposed to a parallel beam of slow neutrons (n per cm^2) the ionization depends on the direction of the beam relative to the chamber. For example if $\lambda/b = 2$ and the beam is perpendicular to the chamber axis then m = 0.36 with the flux of n neutrons/cm^2 taking the place of n in the above formula.

2. Ionization in a hydrogen filled cadmium coated ionization chamber due to γ-rays, slow neutrons and fast neutrons.

It would be advantageous to have an ionization meter with which a single reading would give a direct measure of the biological dose from a mixed beam of γ-rays, slow and fast neutrons. A hydrogen filled, cadmium covered chamber has been considered as a solution to this problem.

A complete report on the above subjects will be issued in the near future.

3. Pocket chambers - Parker

The bad results with new pocket chambers reported last month have been traced to faulty processing of the insulators. About 20 chambers were dismantled here and it was found that the polystyrene bushings had a milky appearance, which seems to imply poor surface condition or internal strain or both. Mr. Victoreen has now found a technique to avoid the defect. As suspected before the trouble is of the type arising when a hand made product is first put into mass production.

4. Film meters - Parker, Pardue, Goldstein

The status of film meters is that the method has been demonstrate to be satisfactory in principle as a record of normal weekly exposure and a check on accidental overexposure. Refinements are in progress on the following points:-

(1) Badges
It was felt that the final form of film holder could be combined with the regular badge for use at W, and that the same holder could be used here and at X. Consultation with Mr. Bugbee indicates that it is not yet possible to proceed with this. Wollan and Parker will therefore design a badge that can serve here and at X.

(2) Daily records
For some special purposes it might be desirable to use film sensitive enough to give daily readings. Eastman Type K seems to be the most sensitive film available. A blackening curve of the samples tested is given in Figure 1. Type K would be sensitive enough for two-day records. Its blackening curve is non linear above o.5r; it might not be entirely reliable as a routine weekly film. The blackening seemed to be less reproducible than that obtained on other films, possibly due to the large grain size and the indifferent method of development used.

(3) Paired films
A pair of films in which one gives adequate blackening for exposures in the range 0 to 1r and the other sustains very high exposures is required. Eastman film Type F, is satisfactory for the first purpose. At the present time Type M is the best for high exposure. Dose up to 20r can be interpreted.

(4) Wavelength dependence
It would be desirable that the selected pair of films should have the same wavelength dependence characteristics. That this will not be true in general is evident from the blackening curves for constant exposure given in Figure 3. These readings were made with a filter of 0.6 mm Pb as at present used. Type F requires a thinner filter; Type M a thicker one. The reader should note that the blackening per roentgen for gamma radiation was 1.15 in this test. In Figure 1 it was 0.75. This is typical of the differences arising in separate developments.

(5) Effect of angle of incidence
It was mentioned last month that the blackening observed through a 0.6 mm Pb filter will depend on the angle of incidence of the radiation on the film. For 100 KV quantum radiation it can be calculated that if the blackening for normal incidence is 1, the blackening for 45° incidence will be 0.5. That for radiation incident uniformly at all angles would be 0.3. Experimentally it is found that the blackening does fall to approximately one-half for incidence of 45° to 60° with radiation of average energy 80 KV approximately.

5. Measurement of fast neutrons - Parker, Gamertsfelder, Morgan

Wollan and Gamertsfelder have previously described a method of measuring ionization by fast neutrons as the difference in current in two chambers, balanced for gamma radiation but giving unequal response to neutrons. This technique is to be used for shielding measurements at Clinton Laboratories. Considerable time has been spent in refining the instrument.

(a) Saturation curves for more intense gamma radiation than will be encountered have been obtained for ethylene up to 50 lbs/in^2, and in methane up to 170 lbs/in^2.

(b) Saturation curves for neutron radiation in ethylene have so far been obtained. The curve at 29 lbs/in^2 is shown in Figure 4. The gamma-ray curve, divided by 30 is also given. The gamma-ray intensity increases by 2% as the collecting voltage charges from 500 to 1000 volts. This corresponds to 60% of the "neutron" current and makes it troublesome to obtain the neutron saturation curves. For the higher pressures contemplated methane will be preferred to ethylene as the saturation curve exhibits a better plateau.

(c) When the chambers are balanced in a pure gamma-ray beam and sheets of paraffin are interposed the balance is disturbed. This is due to degraded radiation which gives rise to excess photoelectric effect in the unlined chamber. The effect is reduced with aluminum lining in the brass chamber. The chambers for use at Clinton will be preserve tanks. The walls of both will be iron. The off balance current is expected to be low.

(d) It is now clear that the sensitivity of the final instrument will enable us to measure 3 fast neutrons per cm^2 per second in an observation extending over 2 minutes.

6. Meteorology report for Site W - Phil E. Church

During the month of August, the work on the wind pattern at Site W has gone forward. The men in the field there during this past month have been making balloon flights almost solely during the night in order to even up the number of observations on the wind direction and vertical velocity gradient over a twenty-four hour period during the driest season of the year.

Plans for a meteorological program to be maintained at Site X are now in the process of formulation.

Future activities of this section

The physics section now consists of

E. O. Wollan - section chief

Group I

H. M. Parker - group leader
L. A. Pardue - research associate
Carl Gamertsfelder - research associate
Karl Morgan - research associate
Norman Goldstein - research assistant
J. C. Hart - research assistant
R. Coveyou - research technician

Group II Meteorology

Phil E. Church - group leader
H. G. Winsor - research assistant
O. Newton - research assistant
Carl Gosline - research assistant
J. F. Mattingly - research assistant

Group III

E. O. Wollan - group leader
R. R. Sawyer - research associate
O. G. Landsverk - research associate
Herbert Vandersall - research associate
Richard Lester - research assistant

On September 6 a reorganization is being effected which involves the transfer of E. O. Wollan as section chief in the newly formed General Physics Division with Dr. William W. Watson as director. There is also involved in the next month the transfer of most of what is now Group I under Parker to the Clinton Laboratories. Those going from this section to the Clinton Laboratory will be:

H. M. Parker - section chief, Medical Physics
Carl Gamertsfelder - research associate
Karl Morgan - research associate
J. C. Hart - research assistant
R. Coveyou - technician

The Meteorology group under P. E. Church will most likely remain attached to the Health Division here.

The section going over to the new physics division will include:

E. O. Wollan - section chief and group leader
R. R. Sawyer - research associate
O. G. Landsverk - research associate
Herbert Vandersall - research associate

The group remaining with the Health Division under the direction of E. O. Wollan as consultant section chief:

L. A. Pardue - group leader
Norman Goldstein
Richard Lester

The group under Pardue will take care of all the physics problems which are of immediate interest to the Health Division and remain as custodian of radium. They will handle all radiation survey work and work with films and pocket meters. This group will function in this capacity and E. O. Wollan will be available for consultation on health physics problems until such time as other arrangements are made.

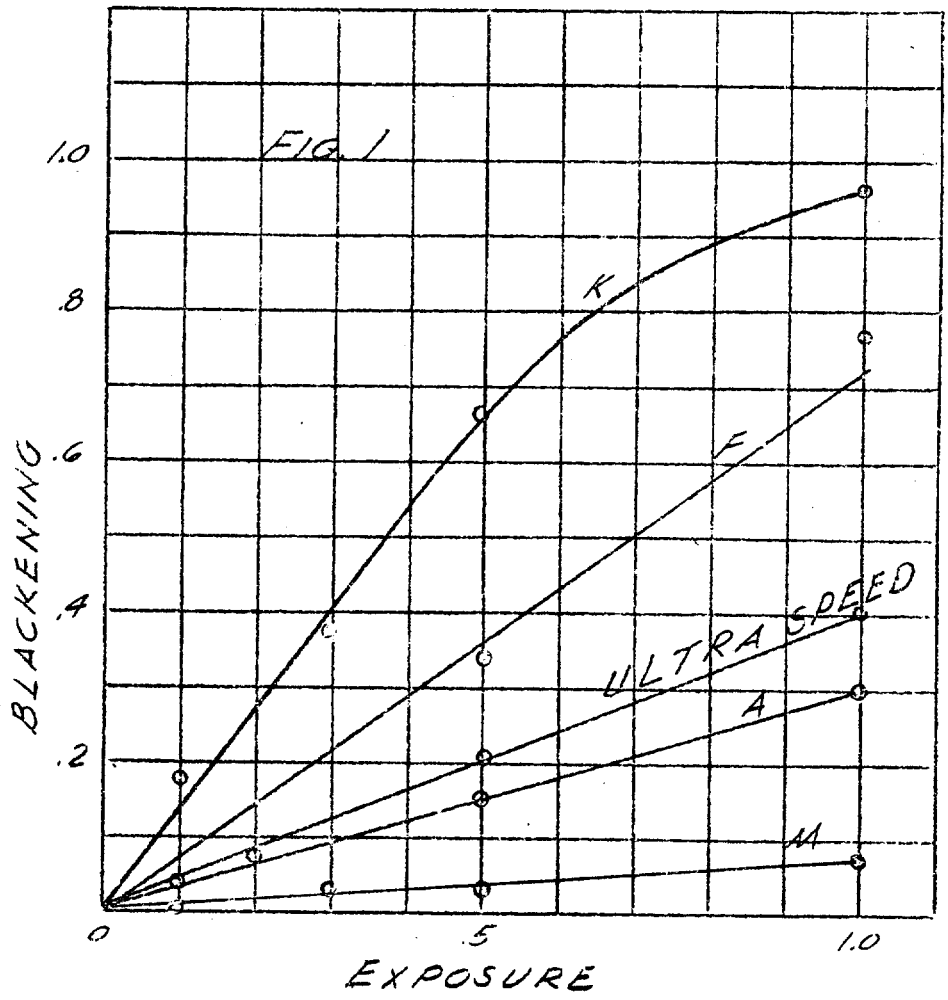

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Figure 2

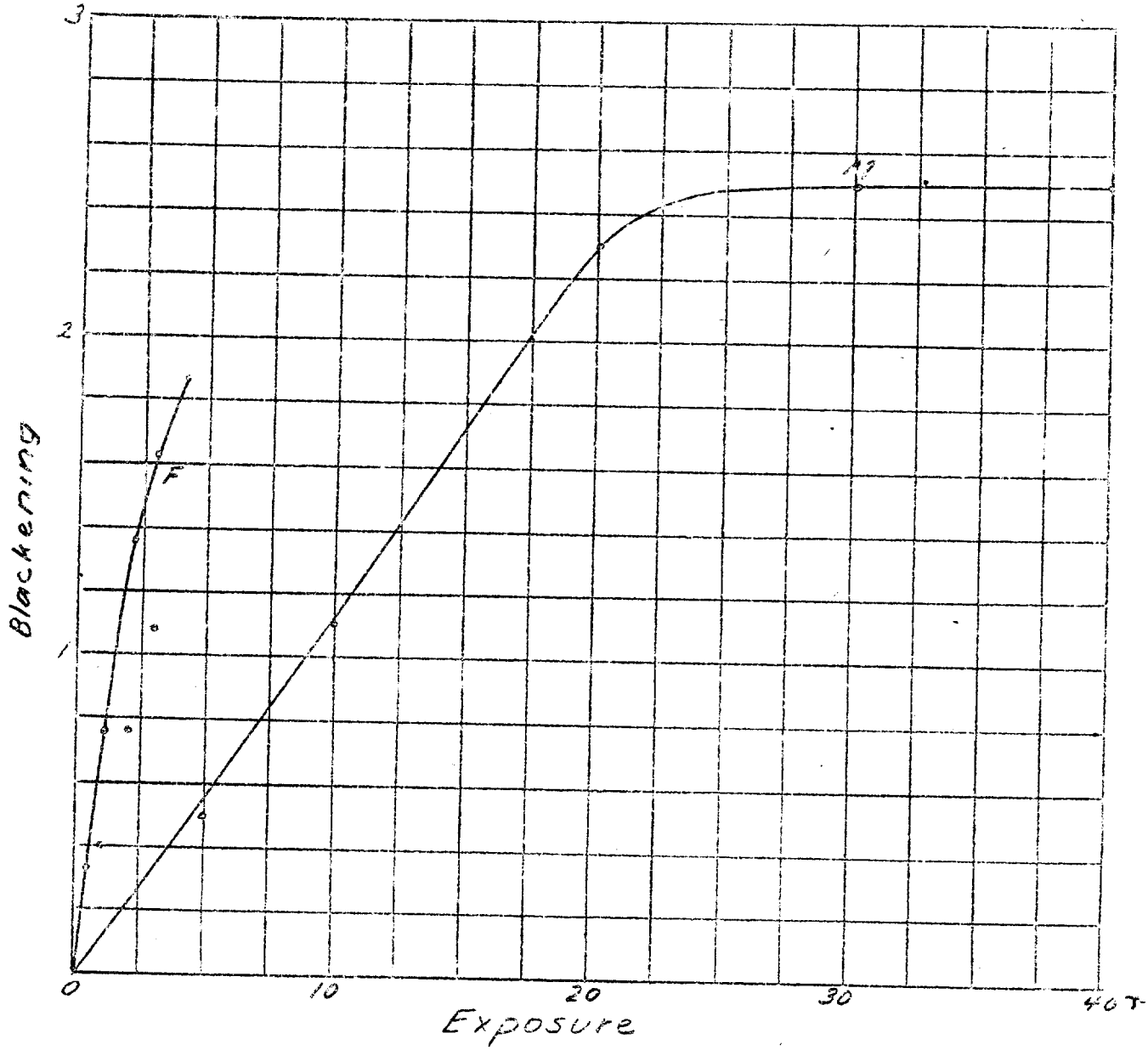

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FIGURE 3

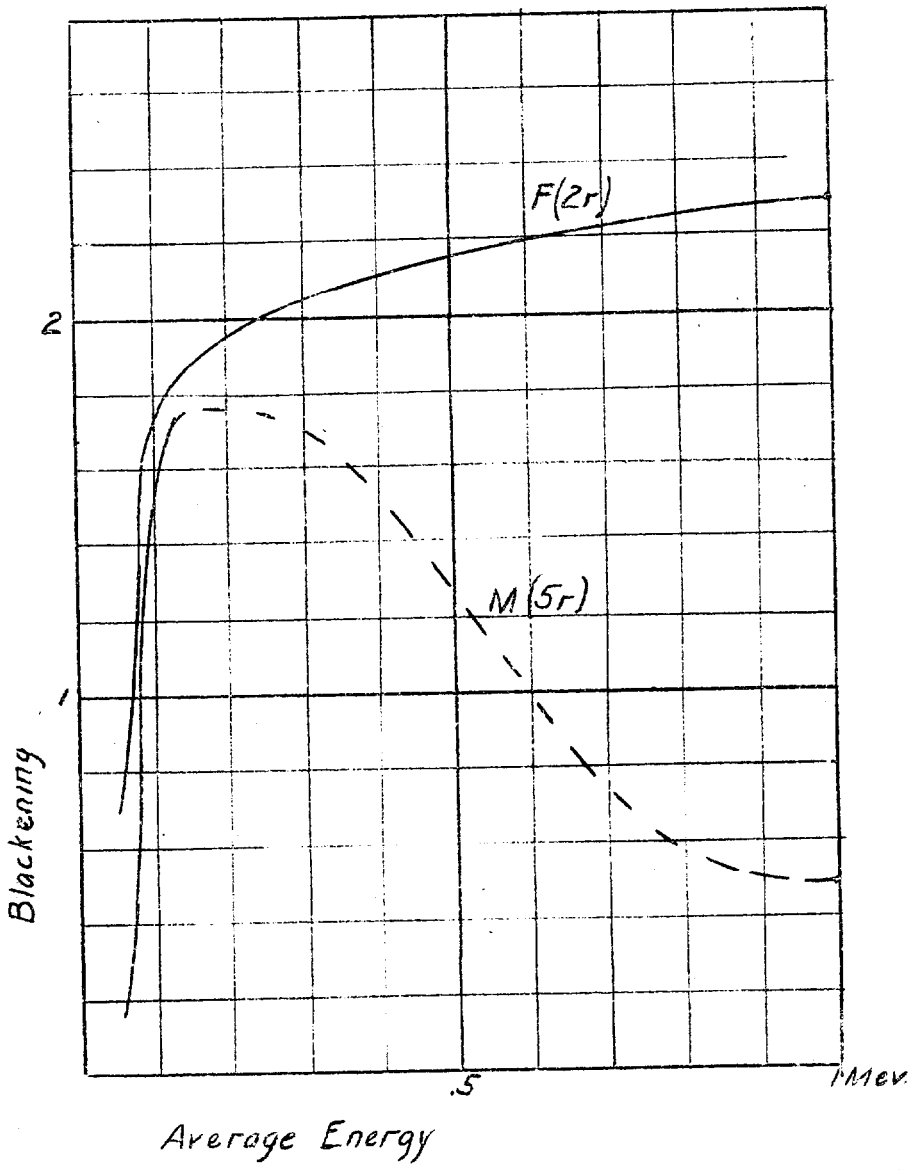
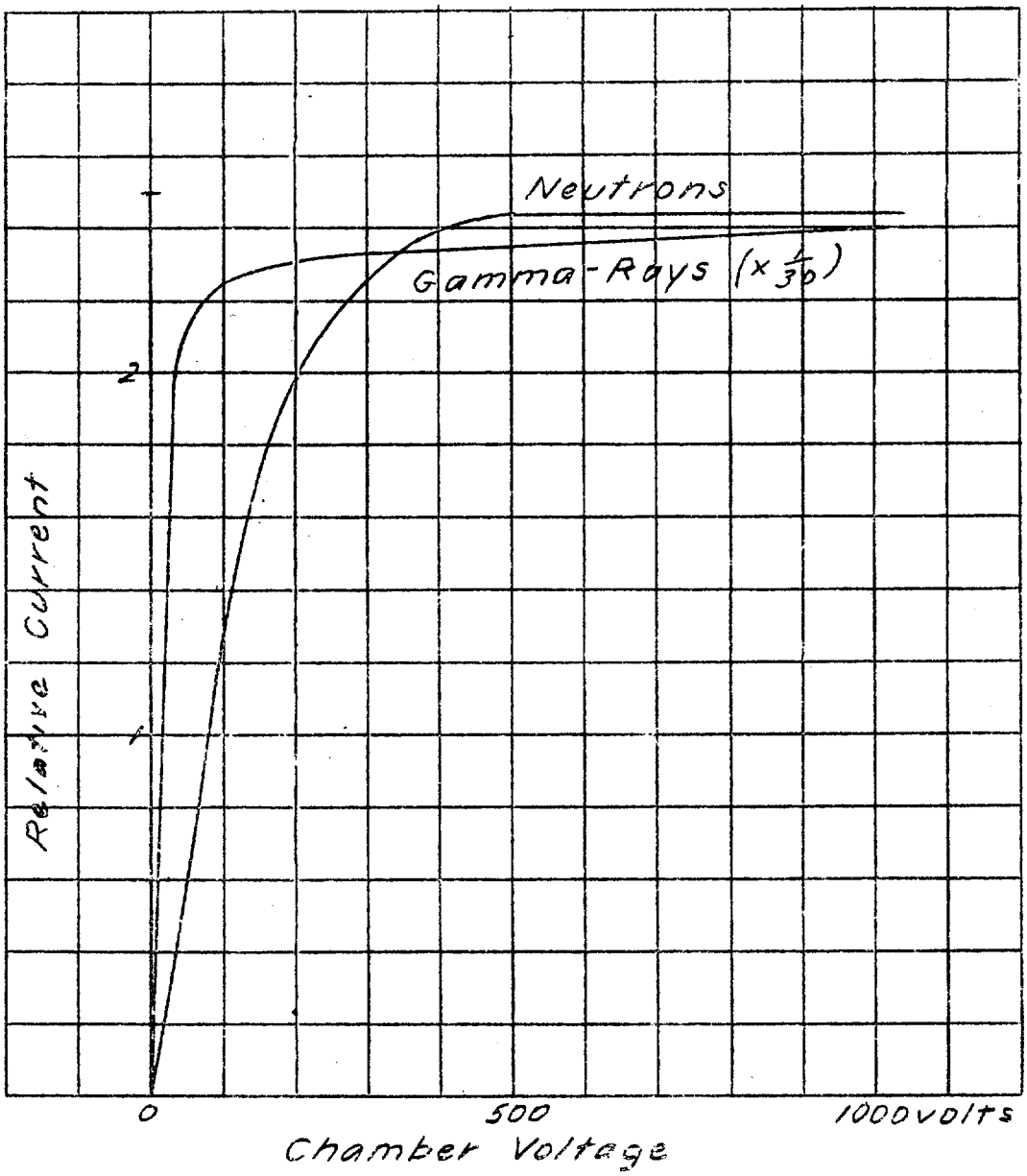


Figure 4



D BIOLOGICAL RESEARCH

K. S. Cole, Section Chief

1 F-product Separation - W. E. Cohn

The sources of F-products available at present for biological experiments are the waste liquors and precipitates from the product separations of Cunningham and Boyd. The activity separated from the S15 HF supernatent by the column procedure was badly contaminated with Ca, Ni and Cr. However, several fractions have been obtained which may yield some activity sufficiently free from carrier for animal experiments.

Some of the column effluents, after recrystallization as UNH and ether-extraction, contained a large amount of Ni probably from the recrystallizer. The activity is being removed by a $Fe_2(CO_3)_3$ precipitation to develop a technique for future separations.

2. Radio-sodium and bromine experiments - R. E. Finkle

In the best experiment to date with Na^{24} from the Chicago cyclotron a specific activity of only 25 mC/gm NaCl has been obtained. A group of mice were injected with 1 mC each but a large part of the activity was rapidly excreted because of the excessive NaCl. Consequently, a satisfactory radiation exposure was not obtained.

The sample of Br^{82} from the U. of C. cyclotron yielded a specific activity of 2 mC/gm NaBr. Approximately ten times this figure is needed for mouse exposures.

3. Xenon exposure - R. Abrams

The guinea pig exposed to 1.25×10^{-6} C/cm^3 of Xe^{127} died on the 25th day. The average beta exposure of the lung was 450 r and the cause of death is unknown. The animal was normal on gross examination. The active gas has been recovered and another exposure started but higher concentrations are needed.

The gas was collected when 100 lbs. of bombarded UNH were dissolved in ether. Only 2 mC of Xe^{133} were obtained because of the low activity of the UNH.

4. Dust exposure - R. Abrams

The design and construction of equipment for dust exposures is continuing. The experiments with X_3O_8 have been repeated. Twelve mice were exposed for 4 3/4 hours to 33.5 mg/liter and all died within 5 days. Approximately 20 mg X/gm tissue were deposited in the lungs and intestinal tract and this amount remained essentially constant over the 5 day period.

An attempt has been made to prepare a beta-active dust by grinding FeP^{32} with Fe_2O_3. Two groups of mice showed no lung activity after exposure. It is assumed that the FeP^{32} particles were too coarse to enter the lungs.

5. Xenon recovery - R. Abrams

Preliminary results on the removal of Xe from activated charcoal at 80° C showed that up to 40 liters of N_2 could be passed over 20 gm. of charcoal before desorption of Xe began. After 240 liters of N_2 about 50% was lost.

Several experiments have been carried out to test the efficacy of gas mask cannisters for removal of Xe. With an air flow of 5 liters/min. for ten minutes, an M-S-A All Service Cannister retained all of the Xe.

6. Fast n and x-ray exposure -R. E. Zirkle

Groups of 15 mice each have been exposed to 8 different X-ray doses ranging from 500 to 1500 r and to 10 different neutron doses ranging from 54 to 154 n. All of the X-ray doses were 100% lethal within two weeks. Neutron doses ranging from 55 to 70 n allowed some survival even after three weeks. In general, for both radiations, the length of survival was shortened with increase in dose. The relative effectiveness of the two radiations appears to vary with the death rate after irradiation. In the production of 50% mortality in about three days, 114 n are equivalent to 1150 r; this indicates an x/n dosage ratio of 10. On the other hand, in producing 50% mortality in 8 days, 500 r are equivalent to a neutron dose lying somewhere between 69 and 83 n this indicates an x/n dosage ratio of not more than 7.

The blood studies on rabbits are continuing at capacity, and further lethal exposures have been made.

The X-ray exposures of rats and guinea pigs are necessary to furnish a comparative basis for the effects of f-products and have been begun.

About a dozen chicks and several Amphiuma have been irradiated for Dr. Bloom's studies on the blood-forming tissues.

7. Experiments on Goldfish - R. E. Zirkle

As background for further studies on lethal action of general body irradiation, lots of 15 goldfish have been given single doses of X-rays ranging from 570 to 1900 r. Doses of 570 and 900 r are only partially lethal after three weeks; the others are completely lethal in that time and produce 50% mortality in from 6 to 10 days. The rate of death increases with increasing dose, but the data shows some quantitative irregularities which will only be smoothed out by further experiments.

As an approach to the problem of general beta effects on fish, seven goldfish are being exposed in an aquarium containing 1.2×10^{-4} C/cm^3 of Na^{24} from the cyclotron by Mr. Finkle.

8. Lethal Action of Internal Pile Radiations - J. R. Raper and C. W. Hagen

Five groups of 15 mice each were exposed in CP2 by Mr. Zinn. None of the mice survived more than 4 days. The times for 50% survival are as follows:

Exposure (kw-hrs)	5.8	7.1	12.2	18.0
50% survival (hrs)	70	54	33	22

The last three lots of mice died much faster than those exposed to any doses of X-rays or fast neutrons used to date. Those given 5.8 kw-hrs died at about the same rate as those which previously had received 114-134 n and slightly faster than those given 1250-1500 r. It thus appears that 1 kw-hr is equivalent to 200-250 r of X-rays of 20-23 n of fast neutrons in producing 50% mortality in about three days.

9. Site X preparations

The difficulties encountered in the separation of carrier-free f-products indicate that it will be impractical to obtain the necessary activities from the separation wastes. Alternative procedures are being investigated and tentative plans drawn up.

A tentative program for the production of Xe has been set up with the Technical Division, D.P. and Clinton.

The design of boron carbide shields to be interposed between the animals and the source of slow neutrons is being developed. A phantom approximating the size and atomic composition of the human trunk has been designed for the investigation of the distribution of capture gamma radiation, of slow neutron concentration and of injurious biological action in slow neutron exposures.

10. Miscellaneous

Preparations are being made to use the radio-autograph technique in connection with the radio-chemical and histological examinations of the distribution and effects of f-products.

The source of supply of mice has not been satisfactory and other arrangements are being made.

Facilities for storage and handling of active samples have been improved and several other safety hazards have been eliminated.

11. Work for Coming Month

1. The present f-product separations will be continued, a LaF_3 precipitate will be worked up for Ce, and other sources will be separated as they become available.

2. Animal and fish experiments with f-products, Na^{24} and Br^{82} will be made if material is available.

3. The present I^{127} exposure will be continued.

4. Lower concentration dust exposures will be made with bombarded UNH converted to X_3O_3

5. Fast n and X-ray exposures will continue.

6. Lower dose exposures in CP2 will be made if possible.

7. The previous training lectures will be repeated rapidly for a new group and then carried on for this and the previous group.

8. Design of the separation and other facilities necessary for Clinton will proceed.

9. The diffusion of Xe from bombarded X_3O_8 will be investigated as a possible source of Xe.

I. Radiation Laboratory, University of California
J. G. Hamilton and Associates

TECHNICAL PROGRESS REPORT ON THE METABOLIC STUDIES OF FISSION PRODUCTS

1. Yttrium (Y^{86})

A series of intramuscular experiments have been initiated in order to supplement the earlier intraperitoneal data which gave an unsatisfactory picture of the metabolism of this element by the intra-abdominal organs following injection. Successful studies have been completed up to and including sixteen days and the metabolic pattern under these conditions shows that relatively little is accumulated by the liver as compared to the intraperitoneal data. Lung experiments with Y^{86} have also been repeated due to the very preliminary character of the earlier studies and it has been found that 60% is retained in the lung at one day, 18% at four days, and about 3% at sixteen days. The absorbed fraction goes almost entirely into the skeleton. It is apparent that the retention of Y^{86} by the lungs following intrapulmonary administration is far less prolonged than has been observed for Lanthanum and Cerium.

2. Emanation Studies

The emanation experiments have been repeated on a group of three animals which are to be shortly sacrificed and their tissues assayed. An attempt is being made to secure a higher degree of activity in the tissues so that more accurate determinations can be made. It is of interest to point out that in the previous experiments approximately 6% of the activity passing through the system enclosing the animals was taken in by way of the lungs and retained by each of the three animals. Apparently over 20% of the activity in the body was deposited in the upper respiratory tract.

3. Radio-Autographic Studies

Radio-autographic studies of the pulmonary distribution of Y^{86} following intrapulmonary administration reveals a very diffuse distribution. It is probable that this is due to the more rapid absorption of Yttrium from the lungs as compared to Cerium, Ruthenium, Raw Fission Products, and Zirconium.

4. Columbium (Cb^{93})

A small and thoroughly purified Cb^{93} sample free from inert carrier has been isolated and injected into a four day group of animals. It is anticipated that we will shortly have available a large sample of some fission material that will soon be placed at our disposal. This preparation of Columbium, if satisfactorily pure, will be used on the usual routine studies.

5. Cesium (Cs^{134})

Attempts to prepare Cs^{134} by the Ba-d-α reaction resulted in the formation of a very small amount of radioactive material which proved to by Rb^{86} and was produced from the small traces of Strontium impurities in the C. P. Barium salt used as a target. No detectable amounts of Cs^{134} were found from this preparation. A sample of Cs^{134} from the Cs-d-p reaction was prepared and has been given to Professor Chaikoff. This sample has a specific activity

of approximately one microcurie per ten milligrams of Cesium. This is to be used for some preliminary tracer studies pending the separation of some radio-Cesium from Uranium fission.

6. Barium (Ba^{133})

It has been found that the sixteen day data from Ba^{133} is not satisfactorily accurate due to the extraordinarily weak activities resulting from the decay of this 40 hour Barium over such a long period of time. At the present time we are engaged in an attempt to prepare Ba^{140} from fission material free from inert Barium, Radio-Strontium, and inert Strontium. If this separation is successful it will be possible to extend the Barium experiments for a period of at least a month and possibly six weeks.

7. Decontamination Studies - Professor D. M. Greenberg and Dr. D. Copp

A series of detailed experiments in which tricalcium phosphate was orally administered together with the radio-strontium indicated that this process is of no practical value in diminishing absorption. The effect of Vitamin D and A.T. 10 (Hytakerol) on the elimination of intraperitoneally injected radio-strontium without carrier has been invesitgated and there was no significant net increase of elimination of the Strontium. However, there was a reversal of the mode of excretion in that the elimination in the treated animal was predominantly by way of the urine.

8. Reports

Tracer studies with Ruthenium, Fission Mixture, and Zirconium have now been completed and will shortly appear in a detailed report.

9. Projected Studies for the Next Two Months

Tracer studies are to be continued with Columbium, Cesium, and Barium. Experiments are to be started shortly with Neptunium which is now being prepared. Emanation experiments, Radio-Authography, and Decontamination studies are to be continued. Studies with Xenon are to be repeated in more detail, and tracer experiments with Tellurium will be started if time permits.

II. N. C. I.

REPEATED HIGH INTENSITY XRAY EXPOSURES

P. S. Henshaw and A. Nettleship

A series of papers is being written dealing with the problem of Experimental Roentgen Injury. A list of these is shown on the accompanying page. In addition, another paper is being written dealing with the incidence of leukemia in physicians.

In regard to the latter, it has been assumed that physicians as a group are exposed more to high energy radiations than the population as a whole. The results show a distinctly higher incidence in physicians.

The experiments dealing with the effects of repeated acute doses and recuperative rates have progressed sufficiently far to demonstrate clearly that recuperation becomes slower and that the peripheral leukocyte blood tends to become pitched at a lower level. Thus, whereas the original objective of the experiment has been attained, some of the animals are being kept under observation as it is believed that some will become leukemic.

The papers on Experimental Roentgen Injury will present a careful correlation of peripheral blood picture, histological changes (particularly of the testis and hemopoietic organs) and various treatment procedures and in the end will give a general histological picture out of which certain neoplasia arises. Continuous blood records are now available on animals from the time of treatment to the time of death due to leukemia.

M. U. C. I.

BIOLOGICAL ACTION OF GAMMA AND x-RADIATION

E. Lorenz, W. E. Heston and A. Eschenbrenner

1. Remarks on protective measures

In the last report (July 1, 1943) it was stated that the protective measures in combination with the time each person spends near the sources were such that nobody receives a larger dose than 0.1 r per week. These protective measures were rechecked with a Geiger counter, calibrated in "r" units and measurements were taken at various points throughout the building. It was found again that the exposures of the personnel working in the neighborhood of the sources are confined to approximately 0.1 r per week.

2. Continuous exposure for 8 hours daily

Daily doses: 8 r, 4 r, 2 r, 1 r.

These experiments are going according to schedule. The experiment of the 0.1 r level has been going for 7 months and the others for 5½ months with the exception of the rabbit experiments which have been going for almost 2 months. All animals (experimental and control) are alive with the exception of 10 guinea pigs, exposed on the 8 r level, and a few mice which were accidentally killed in handling, or were killed according to plan.

The results of the blood counts of the mice on the different levels is briefly as follows: No definite effect of the radiation on the total white count has been observed so far on the mice of the 0.1r, 1 r, 2 r, and 4 r levels, although the total dose of the mice on the 4 r level is approximately 650 r at present. In these groups as well as in the control groups the average total white count is approximately 5000. The mice on the 8 r level (having received so far a total dose of 1300 r) show an average total white count below 5000 (between 3000 and 4000). In all experimental groups red count, hemoglobin, and differential count have remained within the limits of the normal controls.

The effect of the additional acute exposures of 12.5 and 50 r on the animals of the different levels seems to have been only transient (if present at all) because their blood picture at present, 3½ months after the acute exposure does not differ from that of the other animals of the same level.

In addition to the animals of the 8 r and 4 r levels killed and autopsied 2 months after the beginning of the experiments, 8 more mice (2 males and 2 females of each level) were killed 4 months after the beginning of the experiment (total dose approximately 1000 and 500 r). Grossly all organs appeared normal with the exception of the testes of the mice on the 8 r level, which appeared somewhat smaller than normal.

Some pathological damages were found in the hematopoietic and genital system which will be discussed in detail under Section 5.

The results of the blood counts of the guinea pigs are the following: No definite effect of the radiation on the total white count has been observed so far on the guinea pigs of the 0.1 r, 1 r, 2 r levels (average count approximately 8000); a possible lowering of the total white count on the animals of the 4 r level (average count approximately 5000), and a strong effect on the animals of the 8 r level (average total white count below 4000). In all experimental groups red count, hemoglobin and differential count have remained within the limits of the normal controls with the exception of the animals on the 8 r level. In 10 (out of 18) a sudden drop in hemoglobin and red count appeared beginning in one animal with a total dose of approximately 650 r (50 r were given in 5 hours 3 weeks before autopsy), the remaining 9 animals came to autopsy or died after receiving total do ranging from 800 to 1300 r. The effect of the additional exposures of 12.5 and 50 r again seems to have been transient on all experimental guinea pigs, with the possible exception of the first guinea pig that came to autopsy. Grossly, animals that came to autopsy showed a uniform picture: paleness of organs, ecchymoses of upper small intestine, petechiae of the wall of the stomach and heart and hemorrhagic lymph nodes. The pathologic observations will be discussed in Section 5.

3. Continuous exposure for 24 hours daily

Daily doses: 8 r, 4 r, 2 r, 1 r, 0.5 r.

In addition to the data given in the report of June 3rd and July 1st, 1943, the following data can be added:

2 r level

Total dose: 300 r Average litter size 7.7
Average litter size of controls 8.8

1 r level

Total dose: 300 r Average litter size 3.8 (incomplete)
Average litter size of controls 4.0 (incomplete)

From the data presented here and previously, it can be seen that animals have bred with a normal litter size after receiving as much as 500 r on the 8 r level, as much as 400 r on the 4 r level and as much as 300 r on the 2 r level. The only possible indication of a decrease in litter size was that of the group receiving 200 r on the 1 r level. It should be noted, however, that animals receiving as much as 300 r on the 1 r level did breed. All these animals were put into the radiation field at the age of 1 month.

To test the age influence, one group of 16 females, 3 months of age, and a second group of 16 females, 4 months of age, have been put on the 4 r level to be exposed to a total dose of 400 r. Later a third group 5 months of age will be exposed identically.

4. Continuous exposure of 8 hours daily plus daily acute exposures of 5 r given in one hour

These experiments have been going for 5 months by now (total acute dose 450 r). The blood picture of these animals is still within the normal limits.

Nine more female mice are being exposed to the daily dose of 5 r in 1 hour. Three of these animals will be bred after a total exposure of 300 r, 3 more after a total exposure of 400 r, and the last 3 after a total exposure of 500 r. This preliminary experiment was undertaken to study the effect of the rate of administration of dose.

5. Pathology. Summary of microscopic findings, guinea pigs, to date

8 r per 8 hours level

Autopsy No.	Date autopsied	Animal No.	Sex	Approx. Total Dose
C-5368	7-13-43	H-6	f	950 r
C-5494	7-21-43	H-4	f	1000 r
C-5547	7-26-43	H-3	m	1000 r

Bone Marrow: Sternal and femur bone marrow showed moderate degree of atrophy of hemopoietic elements with fatty replacement. There was no fibrosis. Epiphyseal lines were normal. These changes were uniform in all animals.

Spleen: All spleens were small with slightly irregular surfaces suggesting contraction. Microscopically germinal centers were small and in each case there was destruction although this varies in location and degree. In most instances there was a small central area in which there was fragmented nuclear debris and an amorphous eosinophilic ground substance. Occasionally this was at the periphery rather than in the center of the Malpighian body. Mitoses were not prominent. Sinuses contained little blood. Scattered small islands of hemopoiesis were present in some (H-4, H-3).

Lymph Nodes: Grossly all nodes were a faint pink in color, regardless of anatomic location. They appeared normal or slightly enlarged. Microscopically there was found degeneration of variable type in different nodes of the same animal and approximately equal in all animals. In some, germinal centers were very small with small areas in their center containing necrotic nuclear debris and a variable amount of amorphous eosinophilic ground substance. In others the germinal centers were rather large and contained large central areas of destruction. In still others might be one or two large areas of densely packed lymphocytes with scattered small irregularly shaped areas of necrotic substance. The latter picture suggested migration of lymphocytes from the germinal center outward rather than enlargement of the center from within the limits of the surrounding stromal elements. These sections are being stained for reticulum. If such a large accumulation of lymphocytes were originally a small germinal center it was not a generalized reaction for other centers in the same node would be quite small.

In none of the nodes was there much mitotic activity, being normal or less in degree.

Ovaries: The female in this group had apparently normal ovaries. Small follicles were rather inconspicuous but no significance is laid to this observation at the present time.

Testes: In contrast with the ovarian picture the two male animals showed marked testicular changes. Tubular atrophy was extreme, there being a single layer of Sertoli cells (at times discontinuous). No spermatogonia were seen. Interstitial tissue appeared increased in amount. Whether this is a relative or an absolute increase will be determined by measure in the near future.

Intestines: In all animals there was a variable amount of what appeared grossly to be subserosal hemorrhages confined to the proximal half of the small intestine. Microscopically these were chiefly confined to the submucosa, although occasionally they were subserosal, and involved the longitudinal layer of muscle (H-4). The circular muscle layer was not involved. In one instance the extravasation of red blood cells extended into the mucosal villi.

Lungs: One animal (H-6) had small patches of old organizing hemorrhage, another had a few scattered small spherical collections of lymphocytes adjacent to small arterioles. There were no other changes noted.

Other Organs appeared normal.

8 r per 8 hour level plus acute exposure of 12.5 r in 5 hours.

Autopsy No.	Date autopsied	Animal No.	Sex	Approx. total dose
C-5283	7-6-43	H-11	f	800 r plus 12.5 r
C-5489	7-20-43	H-9	m	900 r plus 12.5 r
C-5583	7-29-43	H-8	m	1000 r plus 12.5 r

These animals showed no changes not consistent with those described for the first group. In one (H-11) small accumulations of red blood cells were present between muscle fibers just beneath the epicardium of the heart.

8 r per 8 hour level plus acute exposure of 50 r in 5 hours

Autopsy No.	Date autopsied	Animal No.	Sex	Approx. total dose
C-4933	6-12-43	H-17	f	600 r plus 50 r
C-5487	7-20-43	H-14	m	900 r plus 50 r
C-5505	7-23-43	H-16	f	900 r plus 50 r

Findings in these three animals were similar to those described in the first group. In addition, however, animals H-17 and H-14 had intussusceptions involving the small intestine. These were terminal, no significant necrosis

having occurred in the intussuscepted portions. One animal, H-17, had a prominent wide zone of necrosis surrounding the germinal centers in the spleen. This was composed of amorphous eosinophilic material with scattered intact nuclei. This zone contained no fibers that could be demonstrated with reticulum or collagen stains.

Mice

8 r per 8 hour level

Autopsy No.	Autopsy Date	Animal No.	Sex	Approx. total dose
C-5460	7-17-43	H-11 13667	m	1000r
C-5461	7-17-43	H-11 13668	m	1000 r
C-5462	7-17-43	H-12 13610	f	1000 r
C-5463	7-17-43	H-12 13611	f	1000 r

Bone Marrow: Appears normal

Spleen: Germinal centers moderately large, and contain a few scattered small groups of necrotic debris and moderate number of cells in mitosis.

Lymph nodes: Contain moderate sized and giant germinal centers with a rather large amount of necrotic debris in small masses scattered throughout the centers. Moderate number of cells in mitosis.

Testes: Most of tubules in active spermatogenesis. Several tubules contain none or only a few spermatogonia. Average diameter of tubules seems a little smaller than normal and interstitial tissue relatively increased in amount. This impression will be checked by measurement later.

Ovaries: In serial sections of entire ovaries, the number of developing follicles seems decidely decreased. Undulation of the surface in places suggests general contracture of the organ. Numerous atretic follicles and "interstitial gland" present. Primordial follicles are present.

4 r per 4 hour level

Autopsy No.	Autopsy date	Animal No.	Sex	Approx. total dose
C-5467	7-17-43	G-8 13685	f	500 r
C-5468	7-17-43	G-8 13679	f	500 r
C-5469	7-17-43	G-7 13760	m	500 r
C-5470	7-17-43	G-7 13759	m	500 r

Bone Marrow: Sternal and femur bone marrow appears normal.

Spleen and Lymph Nodes: Germinal centers are of moderate size with inconstant finding of small masses of necrotic debris in their centers.

Ovaries: Appear normal. Numerous developing and atretic follicles.

Testes: Appear normal

8 r per 8 hour level plus
acute exposure of 50 r in 5 hours

Autopsy No.	Autopsy date	Animal No.	Sex	Approx. total dose
C-5453	7-17-43	H-5 13585	m	1000 r plus 50 r

The single animal in this group had moderate atrophy of the testes, other tissues appearing normal. Many of the tubules of the testes contained only Sertoli cells or in addition a few spermatogonia. Mature spermatozoa were present in only a few of the tubules. Interstitial tissue seemed increased in amount but this may be only relative and will be measured later.

F. SUB-PROJECTS

A. M. Hospital, New York -- Routine exposures continuing. No new results.

B. U. of C. Hospital, S. F. -- Total Body Radiation Treatments. Further findings on some of the patients previously reported (C.H.708), and three new patients are considered.

[redacted], [redacted], [redacted], [redacted], and [redacted] have not returned for further observation.

[redacted] (Cancer of Breast with metastasis), age58, was given 221 roentgens to the whole body between 11/9 and 11/20/42; and 295 roentgens between 2/4 and 2/27/43. As reported her W. B. C. fell to a low of 3000 on 4/15/43, but recovered to 6,100 on 4/29/43 and has been in a normal range up to 7/8/43.

[redacted] (Spondylitis), age 29 was treated from 1/7/43 to 3/6/43 with 28 treatments of about 10r each. The first ten with 100 Kv x-rays, the rest with 200 Kv. His W.B.C. fluctuated a lot during treatment but dropped from around 9000 average during treatment to 5100 on 4/24/43. Since then it has been back within normal limits.

[redacted] (Lymphoblastoma), age 61, who received 151 r total body radiation 10/13 to 10/16/42, 116 r 11/17 to 11/20, and 100 r 1/6 to 1/9/43; and who later had some localized treatments had a total W. B. C. of 2,600 on 3/5/43. On July 20 her W.B.C. was 5,500 -- almost as high as at any time since last blood count.

[redacted] (Rheumatoid arthritis), female, age 51 was treated from 5/4 to 5/20/43 at the rate of 20r/day to a total of 307 r with 200 Kv x-rays. During treatments she was tired and experienced some nausea. Her W.B.C. fluctuated a lot during treatments but was always above 7000. On 6/17/43 it had fallen to 3,500 but on 7/1/43 was back to normal and till 8/10/43 was at a high normal.

[redacted] (Malum Coxa Semilis), male, age 66 was treated with 200 Kv x-rays from 4/14/43 to 4/29/43 receiving about 20 r per day to a total of 300 r. He occasionally felt fatigued during the treatments. His W.B.C. fluctuated a great deal during treatments, but fell gradually after treatments stopped to 4,200 on 5/22/43. On 7/26/43 it was still 4,500.

[redacted] (Advanced Rheumatoid arthritis), female, age 66, was treated with 200 Kv x-rays from 5/25/43 to 6/8/43 getting 13 treatments of about 20 r each to a total of 257 r. Patient had no reaction due to the treatments. Her W.B.C. remained within the normal range during treatment, but fell somewhat afterward to 4,400 on 7/21/43 and 5,200 on 7/30/43.

General Comments

(1) These patients nearly all show a tendency to marked fluctuations of the W.B.C. at or above normal, during treatment, but a tendency to fall a few weeks after treatment is stopped, and recovery a few weeks after that.

(2) A more specific analysis of the cells affected must await further studies.

(3) The R.B.C., Hemoglobin and platelets were not noticeably affected by the treatments.

(4) One patient getting 20 r per treatment and two getting more were nauseated. None vomited.