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RESEARCH PROGRESS MEETING

H. P. Kramer

December 15, 1948

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RESEARCH PROGRESS MEETING

H. P. Kramer

December 15, 1948

Survey of the Radiation Field of the 184" Cyclotron

B. Moyer

For a number of months a systematic survey of the radiation field outside the shielding of the 184" cyclotron has been under way. The safety of the area has been reaffirmed and it was shown that the neutron beam was very sharply defined. Another interesting result of an investigation of the neutron flux through the shielding is that most likely the main contribution to the flux is made by neutrons that diffuse through the 2' concrete ceiling slabs of the cyclotron shielding rather than through the 10' shielding on the sides. It is expected however that this contribution to the general radiation level will be greatly diminished as soon as the additional 2' layer of concrete is placed over the present ceiling slabs.

The work was carried out with a polystyrene counter. This counter is very suitable to Health Physics work since the polystyrene walls of the chamber present approximately the same absorption characteristics as human tissue. This fact was discovered by comparing the data obtained with this counter to the results of measurements made some six months ago by Drs. G. Failla and H. Rossi from Columbia University with their counters which had 'tissue equivalent' walls and were filled with gas containing chemical elements in the same proportion as in human tissue. The comparison which was made is described in greater detail in The Medical and Health Divisions' Quarterly Report, April, May, June 1948, UCRL 157. The table contained in this report shows that the radiation strengths obtained with polystyrene counters are slightly higher than those which were measured with the tissue equivalent counter. For this reason, they are somewhat more conservative from the view point of personnel safety.

Three dimensional measurements were made in the space surrounding the cyclotron shielding. One set of measurements was taken at different points around the structure at a level of 5' corresponding to shoulder height, another set at fifteen feet, the height of the neutron beam, and another at 25', above the ceiling of the cyclotron but at the level of offices in the building. All results which are shown in Fig. 1 have been corrected for temperature and pressure and normalized to a 1/2 μa beam of charged particles impinging on a 1/2" Be target for the production of neutrons. The normalization was performed in the following fashion. A measure of the strength of the charged beam was indicated by counters which are permanently fixed in the 'yoke' inside the cyclotron. If the radiation measured at this point was 2.0 r/hr the values measured in the polystyrene chamber were left unaltered. If, however, the radiation at the yoke was different from 2.0 r/hr. a linear extrapolation was performed on the polystyrene counter results so that the numbers which are presented in Fig. 1 have all been adjusted to indicate the radiation which would have been measured had the beam been of such strength as to produce radiation of 2.0 r/hr at the yoke inside the cyclotron.

Fig. 2 shows the result of a measurement of the neutron flux through the shielding by means of indium foils. It is a remarkable feature of this graph that at about 1' from the outside of the shielding, the neutron flux discontinues its exponential decrease and veers sharply upwards. This phenomenon has been attributed to neutrons which leave the cyclotron through the relatively thin 2' top shielding, circulate downward to the sides, and then enter the lateral shielding to a depth of 1'. It is expected that the number of neutrons leaving the cyclotron in this way will be greatly diminished when the additional 2' concrete ceiling slabs are installed.

The numbers which are shown in Fig. 1 are in rep units that is, they are multiples of that amount of radiation which will by its ionizing action (direct or indirect) dissipate 83 ergs in one gram of tissue.. The tolerance for slow neutrons with which these measurements are primarily concerned is 2000 $n/cm^2/sec$ over an eight hour period of continuous exposure. The data of Fig. 1 when roughly converted to slow neutron flux indicate between 50 and 100 slow neutrons per cm^2 per sec. on the floor of the building. It is thus seen that the slow neutron effect is very much below the allowable tolerance.

One set of measurements was carried out for the purpose of defining the sharpness of the neutron beam which leaves the inside of the cyclotron through a port hole in the 10' shielding. It was found that the beam is confined to a very small tube so that it is quite safe to work in its vicinity as long as one remains outside the actual path of the particles. The results of this measurement are set down in Fig. 3.

Fast neutrons were measured by means of their proton recoil effect in counters with 1/16" polyethylene walls which were filled with an argon CO_2 mixture. It was deduced that the quantity which was measured, counts/second was proportional to the product of the neutron flux of a certain energy and the energy. The neutron flux was then approximated by setting the energy equal to its mean value, 1 Mev.

This deduction was carried out in the following fashion. For a thin plate,

$$\eta(E_0) = \frac{NA}{10} J(E_0) \left[\sigma (E_0) R_0 \right],$$

where $\eta(E_0)$ is the number of protons knocked out of the wall per sec., N is the number of neutrons impinging per cm^2 per sec, $J(E_0)$ is that fraction of N which comes in with the energy E_0, A is the exposed area, σ is the cross section for the process, and R is the range of protons in the material of the wall. If one enters a mean value into the above equation for the cross section and the range, and a flux corresponding to a known neutron source, and if one furthermore discovers the empirical factor which converts the above formula derived for a flat plate to the formula descriptive of a cylinder, one may compound these influences into the factor .012 and arrive at the formula

$$\eta(E_0) = .012\ J(E_0)\ E_0$$

The energy range to which the mechanism is sensitive is 0.1 to 10 Mev. The results of measurements with this counter are shown in Fig. 4.

In the future measurements will be made with a coincidence counter containing two chambers which are separated by a septum. It is also contemplated to use a counter consisting of a cadmium shell which encases a block of paraffin surrounding a BF_3 filled cavity.

Tin Isotopes

A. Newton

The tin isotopes that are formed as products in the slow neutron induced fission of thorium stirred interest which led to a further study of Sn isotopes. A tentative result of this investigation is the discovery of three isomers of Sn^{123}.

In the fission of thorium, the following periods are seen: 70 min. (probably the same as our 40 min. period), 62 hr. (probably the same as our 28 hr. period), 10 d., and 130 d. All of these are β^- emitters. When tin is bombarded with slow neutrons, the following β^- emitters are observed: 10 min., 40 min., 28 hr., 10 d., and 130 d. The 10 min. period has been assigned to Sn^{125} and the 28 hr. period has been assigned by I. Perlman to Sn^{121}.

When the Oakridge separated isotope Sn^{120} was bombarded with deuterons two β^- emitting periods were found. One had a half life of 36 min. and emitted 1.5 Mev β^- and the other had a half life of 28 hr. and emitted 0.4 Mev β^-. Neither one of these β^- emitters gave evidence of γ radiation. When Sn^{124} of unknown analysis was bombarded with deuterons, a 39 min. 3 Mev β^- emitter which was accompanied by Sb x-rays was observed. Furthermore, two β^- emitters of 10 and 130 d. respectively were seen. These were not, however, accompanied by γ or x-rays. It must be pointed out that no 28 hr. period was found.

Of all the tin isotopes, only three, Sn^{121}, Sn^{123}, and Sn^{125}, can be β emitters. The 39 min. activity which resulted from the bombardment of Sn^{124} could not possibly be assigned to Sn^{125} since it registered only 300 counts/min. whereas, it has been calculated, had it been due to Sn^{125} it would have had to show a count of 1000/min. Neither can the 39 min. activity be assigned to Sn^{121} since it has been seen that Sn^{121} has two β activities which invariably accompany each other, 36 min. and 28 hr., and a 28 hr. period was not observed. Moreover, the 36 min. period of Sn^{121} is not γ active whereas the 39 min. period resulting from the bombardment of Sn^{124} emits Sb x-rays. The conclusion must be drawn therefore that two periods exist of approximately 40 min., that one must be assigned to Sn^{121} and the other one to Sn^{123}. Finally, since neither the 10 d. activity nor the 130 d.

activity, gave any indication of decaying to Sb^{125} (2.7 yr. β) these periods must also be assigned to Sn^{123}.

Thus the only assignment which seems possible is:

Sn^{121} (36 min., 28 hr.)

Sn^{123} (39 min., 10 d., 130 d.)

The Bevatron

[illegible]

W. Brobeck

A 1/12 scale magnet model which is energized by a condenser bank has been used extensively to verify the d.c. model characteristics.

A 1/4 scale model of a 20° segment of the magnet has been used to verify the field strength and radial uniformity. It was pulse operated at a rate comparable to that of the full scale machine. Theoretical predictions were verified. The effect of the stainless steel vacuum tube was also investigated and it was found that its introduction produced only a negligible effect on the field.

A 1/4 scale model of the entire apparatus is being built now. The coils are being wound and the steel is being put in place. It should be ready at the end of December. The ion source is expected to be ready at the end of January. The vacuum tube sections are being tested and it is thought that tests and assembly will have been completed by the end of February.

Theoretical work is being continued. It has been calculated that in the 1/4 scale machine only 2% of the beam will remain after scattering at an operating pressure of 10^{-5} mm Hg. Clearance of the injector has also been considered theoretically. The clearance is not perfect since the beam contracts only about .005" per revolution with the magnet current rising. It is estimated that 3/4 to 1/2 of the beam will be lost in this fashion.

Fig. 4 and Fig. 5 show a preliminary layout and an artist's sketch of the building for the full scale machine. This building will have an outer diameter of 220' and will provide space for offices, shops, and facilities; It is expected that the building will be ready at the end of the coming summer.

Progress Report on the Synchrotron

E. McMillan

At 1:30 AM on the morning of December 14, the first evidence of synchrotorn operation was seen. An anthracene detector which was placed in the doughnut and connected to an oscillograph emitted a pulse caused by synchrotron operation. The pulse was about 1/4 to 1/2 as intense as the pulse from the betatron beam. A schematic diagram of the oscillograph trace is reproduced in Fig. 6.

It is also possible to observe phase oscillation by changing the frequency and amplitude of the RF voltage.

It was decided to look for x-rays. They were found by exposing a photographic plate 2 2-1/2 m from the target. It showed a well defined spot 1" x 1 1/2" in area. The magnet was run at 6.5 kv which is about 1/3 of full excitation. At this voltage the x-rays which are produced possess an energy of 120 Mev.

The main problems which now remain are to lengthen the pulse and to increase the voltage so that the adjustment is less critical.

Since the radial distance through which the electron beam moves during acceleration is very small one would be put to the inconvenience of using a very thin target. However, a proposal has been advanced to remove this difficulty. It is thought that if the beam is scattered by a Be sample, perhaps a thicker target might be used without interfering with the trajectories which are at less than peak acceleration. (Fig. 7).

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HW/1-11-49

	Height Above Floor		
	5'	15'	25'
1.	.375	.528	.893
2.	.403	.484	.535
3.	.283	.302	.600
4.	.252	.312	.583
5.	.340	.356	.720
*6.	.695	.484	1.04
7.	.375	.360	.720
**8.	1.03	.680	.707
9.	.342	.400	.715
10.	.328	.407	.948
11.	.994	2.36	2.02
12.	1.31	1.14	1.17
13.	.423	.540	.820

µr/hr.

*Target bench contains Ra sample.
**Near 1 gr. Ra-Be source.

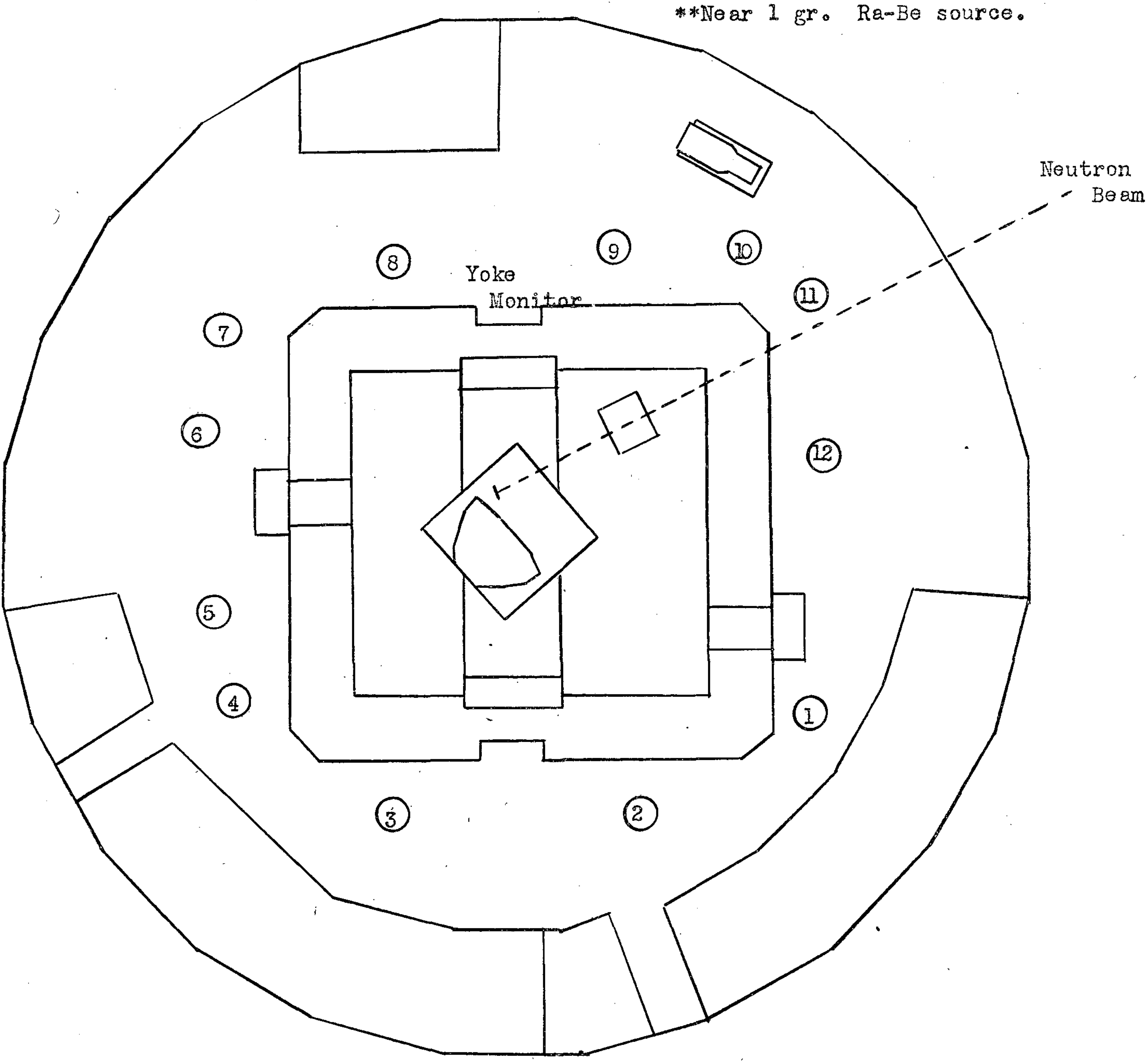


Fig. 1
Radiation Field Outside the Shielding in µr/hr.

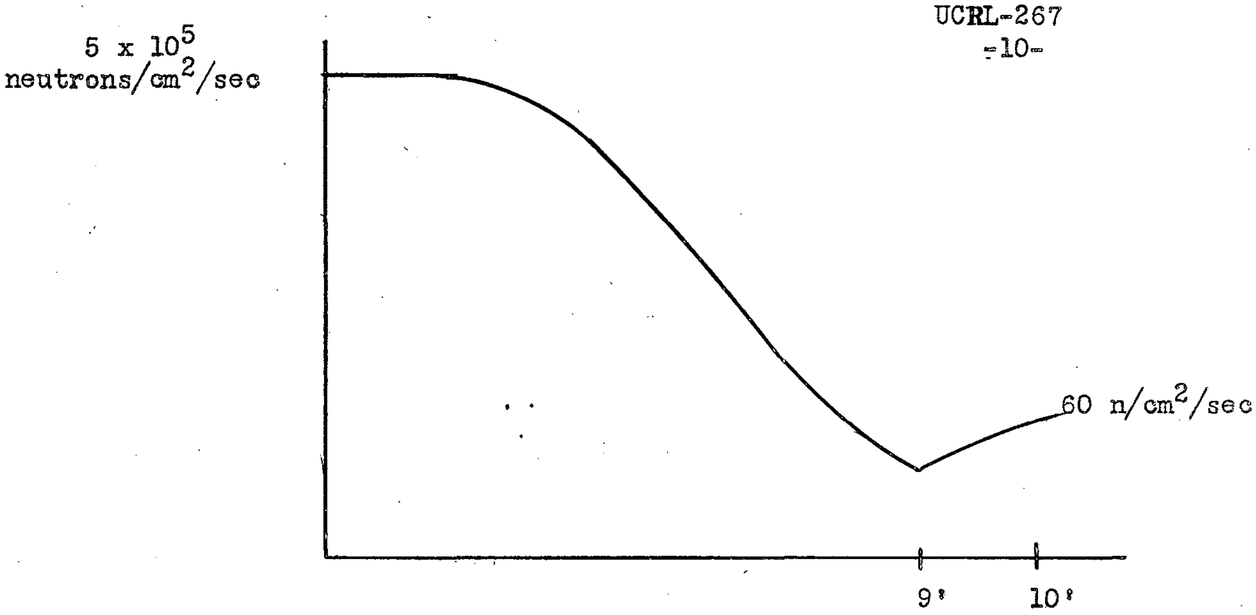


Fig. 2

Thickness of Shielding
Variation of Neutron Flux Through 10' Shielding

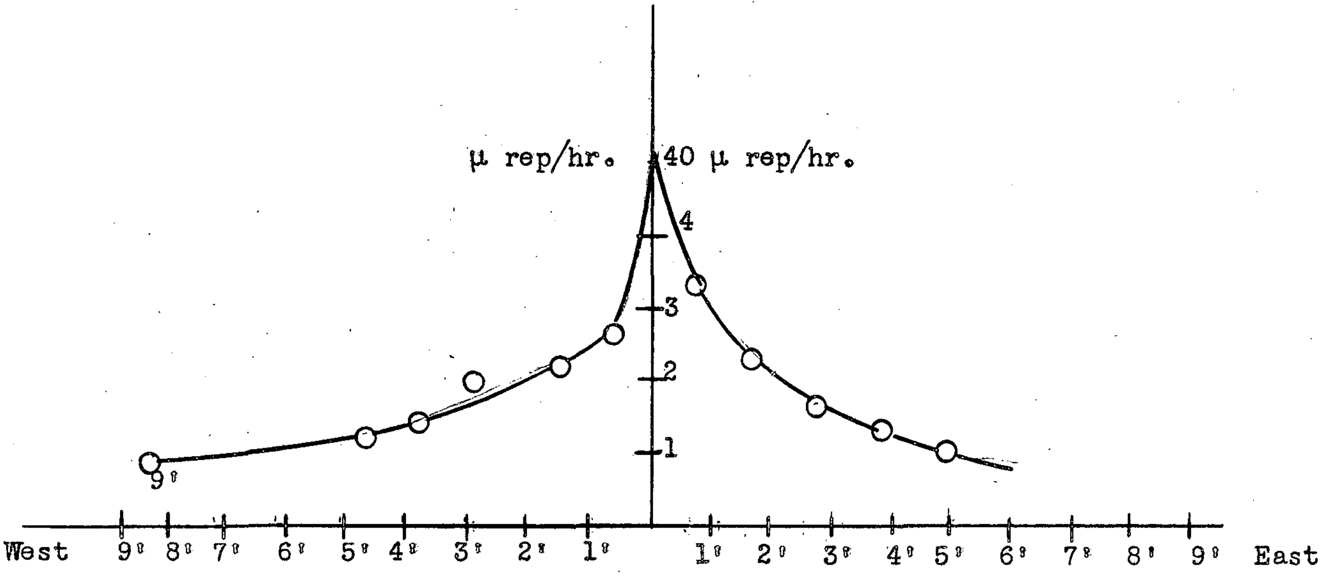
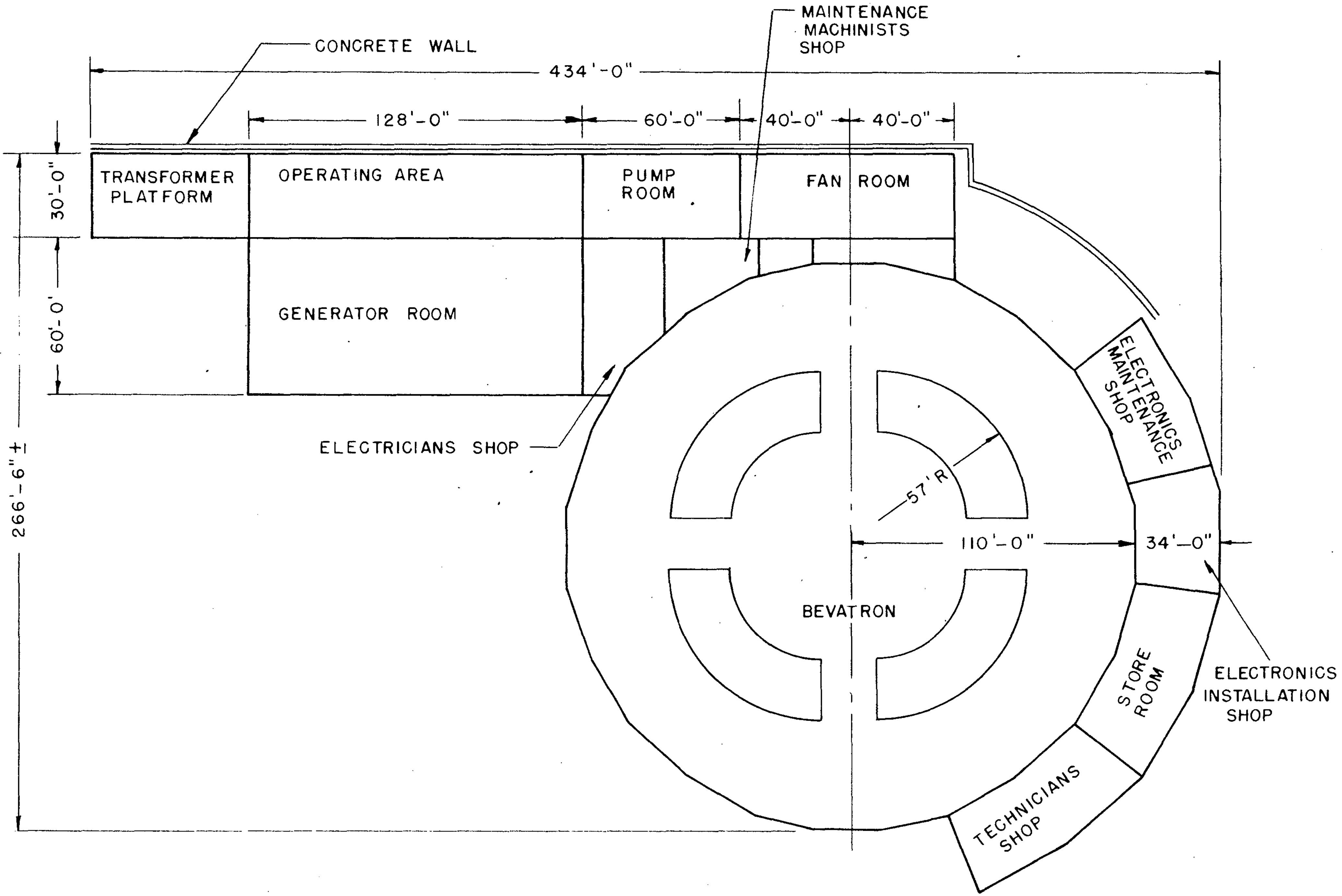


Fig. 3

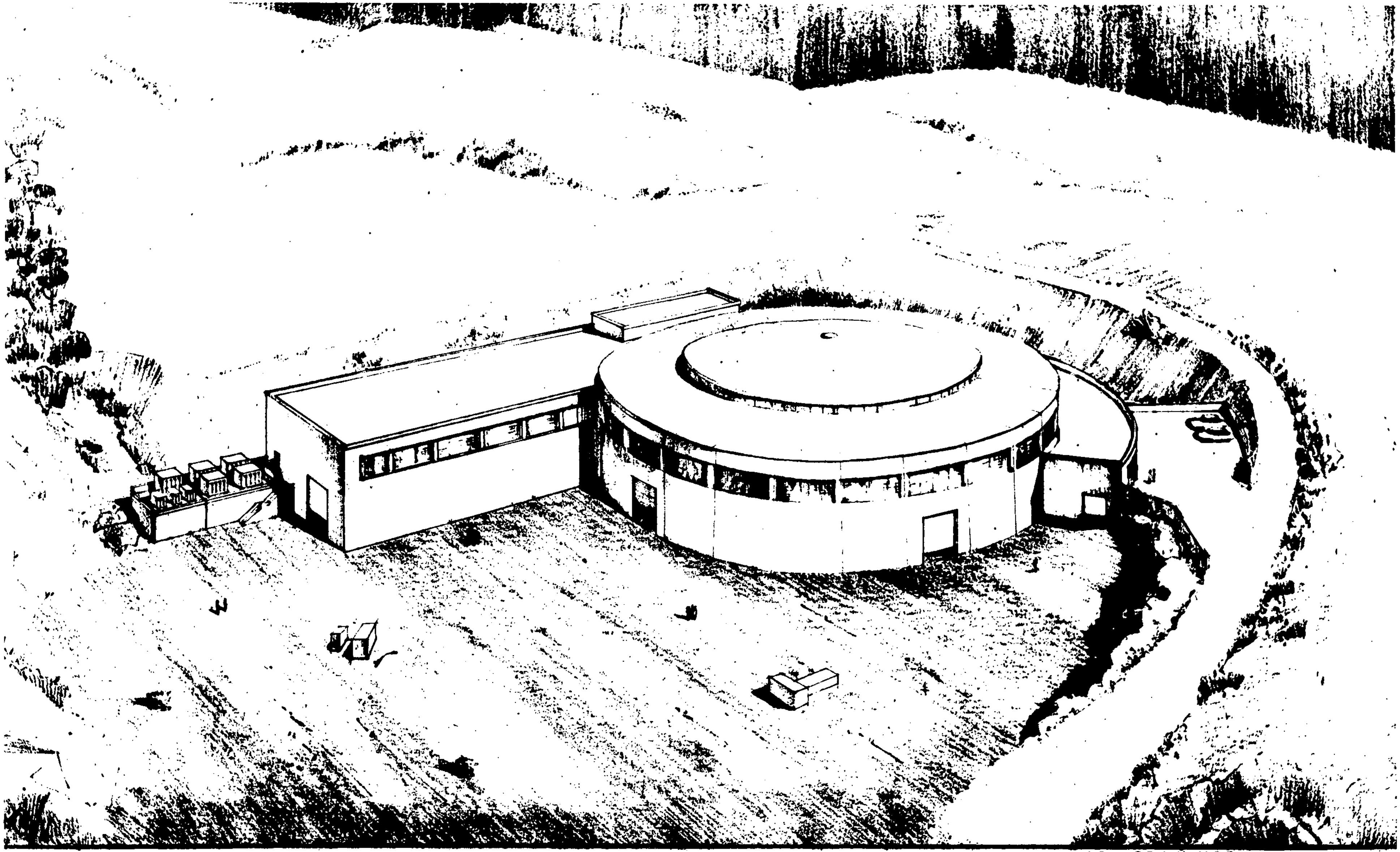
Lateral Spread of Neutron Beam at Beam Height
and 15' from the Shielding



NOTE: OFFICES AND CONTROL ROOMS
ON GROUND FLOOR

FIG. 4

13235 I



PRELIMINARY DRAWINGS

UNITED STATES ATOMIC ENERGY COMMISSION

BEVATRON BUILDING
UNIVERSITY OF CALIFORNIA AT BERKELEY
RADIATION LABORATORY BUILDING Nº 51

1

MASTEN & HURD - ARCHITECTS
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FIG. 5

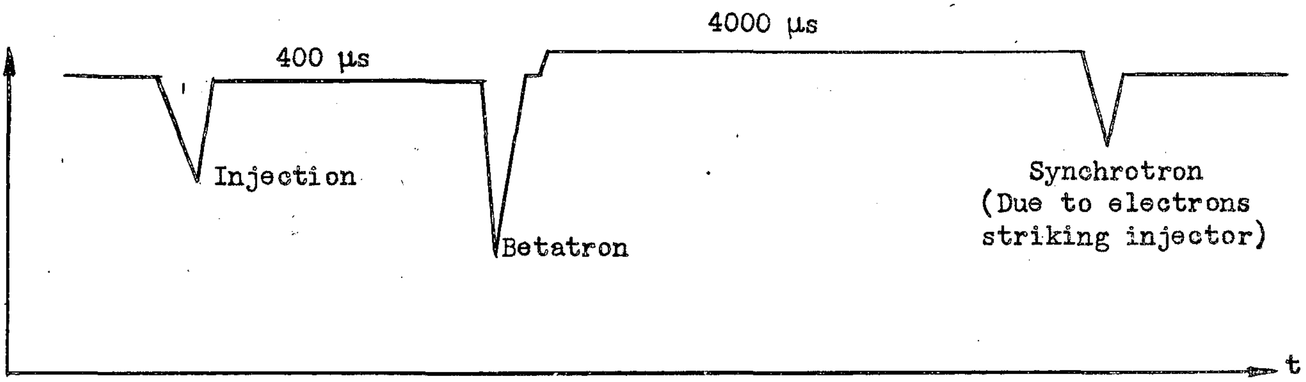

Fig. 6

Oscillograph Trace Showing Synchrotron Operation

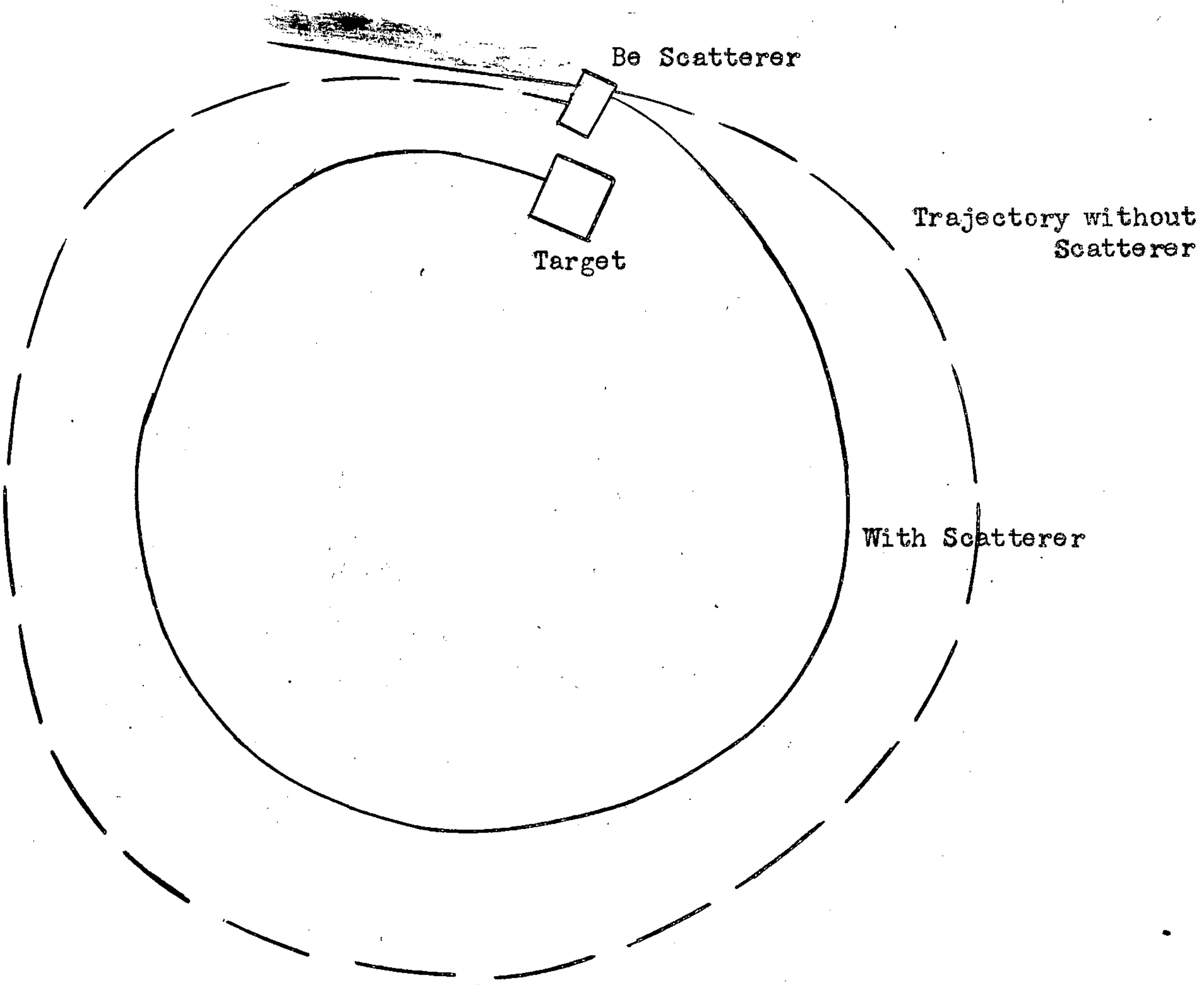

Fig. 7

Effect of a Scatterer