SOME DATA AND GENERAL CONSIDERATIONS ABOUT HEALTH PHYSICS PROCEDURE CONCERNING THE USE OF A 400 Kv VAN DE GRAAFF, AT IEA, SÃO PAULO

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INTRODUCTION

1. During the installation period of the Van de Graaff and when first put in operation, high levels of gamma-X radiation was observed. Radiometric preliminary surveys, using portable survey - -meters (ionization chambers and geigers), showed that the dose rate variations were from some miliroentgen per hour to 1.5 r/h and even more, having a sensible increase of the radiation levels on the neighbouring rooms. The relatively large differences for doses measured not very far from one another, suggested the construction of the isodose curves of the gamma-X radiation around the apparatus.

2. Since the beginning of its operation, this accelerator as been used as a pulsed neutron source. From the point of view of Health Physics, the problem of neutron monitoring is much more serious than the one of the gamma-X radiation, at least when it regards low acceleration power as in this case.

Unfortunately, up to the present a very complete survey of the neutron levels was not possible. From the view-point of - Health Physics, the fast neutron detection is still an open problem, envolving the knowledge of spectrum, in view of the fact - that the R.B.E. (Relative Biological Efectiveness) has strong variation with the energy. (from 100 kev up to 10 Mev, the R.B.E. changes by a factor 40). It is always necessary to deal with interdependent factors such as the necessary time to accomplish the measurement, the efficiency and the resolution.

At first the Be target was used, with the reaction $Be^9(d,n)\ B^{10}$, which gives neutrons on the energy interval .6—6 Mev for the deuteron energy considered.

With the latter change of the target to tritium, the level of neutrons increased to values much higher than the M.P.E. (Maximum Permissible Exposure) so that the potential had to be reduced. The use of this target complicates the problem, because it not only refers to higher fluxes but also to higher energies (14 Mev in the reaction $T(d,n)He^3$).

The radiometric surveys, having in mind the protection against neutrons, were accomplished with a detector DN-3 (Nuclear Chicago) and for comparative measurements a lòng counter was used.

The tritium target was always partially shielded in paraffin. As it was not possible to measure the spectrum, the operation time was limited, considering all the dose as due to a non degenerated spectrum of the target neutrons. For dose estimative , it was admitted that during an operation period, the yield could vary up to 50% considering possibilities of readjustment in the focusing, acceleration potential, probe tension and admission of ionizable gaz. The geometry of the arrangement did not change.

Actually the Van de Graaff was moved to an outside shed , about 25m far from the nearest place of work. New determinations had not been made yet.

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SPATIAL DISTRIBUTION OF THE BREMSSTRAHLUNG

The examination of the data obtained with portable survey meters showed that the maximum intensity of gamma-X radiation took place on the top central part of the tank. This radiation comes from the electrons that are pulled from the target and from the structure material, being accelerated on opposite directions of the deuterons. The stopping of these electrons occurs in conical pieces of aluminium, situated on the ion source basis. (see fig. 2)

We then have X-rays of a maximum of 400 kv, as some electrons will not suffer all this acceleration, depending on the point from wich they originate.

ARRANGEMENT AND RESULTS

To determine the spatial distribution of the bremss - trahlung, dosimetric films were placed on the nodes of square lattices, with 50 cm side, whose planes are perpendiculars to the axis of the acceleration tube. These planes were denoted A, B, C, D, E.

The films were placed so that the solid angle intercepted by its surface, seen from the center of the tank, would be as large as possible, since the radiation source is approximately at this position. The position of each film is well determined when we associate a coordinate system to each of the above planes. For example, (A, 20, 30) is the position of the films which is on the plane A, with X = 20, Y = 30.

• The estimated errors for the film coordinates are:

$$A, B, C, D, E = \pm 5 \text{ cm.}$$
$$X = \pm 5 \text{ cm}$$
$$Y = \pm 10 \text{ cm}$$

In figure 3 we can see the isodose curves obtained on the vertical planes A, B, C, D, E. Fig.4 gives us isodose curves on the horizontal planes V = 20, Y = 30 and the vertical plane X = 40. The numbers noted are the densities X 100. The correspondent doses for each density may be obtained from the curve in fig.5. Such values are not dose-rate. They correspond with the operation of the V.G. during 6 hours, at 400 kv and 40 μA of beam current.

The examination of the experimental conditions, showed that the largest errors on the doses, would come from the conversion of optical density to dose. The largest exposition dose was obtained near the tank, on plane D; the integrated dose was of 5000 mr or a dose rate of 833 mr/h. The correspondent density is 1.45.

From 1.5 m of the acceleration tube, over the tank, the dose rate is of the order of 15 mr/h.

CONSIDERATIONS

It should be pointed out that the above discriminated dose rates are intimately related to the operation conditions of the apparatus. Its main value is that they are necessary elements to construct the isodose curves. Qualitatively we may see that the vertical plane X = 40 which contains the V. G. axis, is also roughly a simetry plane for the spatial distribution of the isodose curves. Besides, the largest doses are above the horizontal plane Y = 20 which comprehends the same axis (this is not a symetry plane for the doses). The isodose curves for the region beyond the plane E, were not determined but the first surveys showed well that, on this region, the doses are much lower.

Relating the angular distribution of the bremsstrahlung, no strict comparison with the theoretical previsions was tried, since our experimental conditions are quite special: 1) the electron beam is not monoenergetic, its spectrum being unknown; 2) the measured radiation has a spectrum that is not the original one, for it is "hardened" by the presence of the tank and of structural materials, which act as filters; 3) for the considered energies we must take the target thickness as being infinite.

The accuracy of the employed method is sufficient for the purpose of Health Physics, but not for a comparison with theoretical results or experiments of good geometry[3].

The smaller doses on the target region (beyond plane E) were expected. First the base plate of the machine which is about 4 cm thick (fig.2), shields completely the radiation that comes directly from the tank. In second place, the radiated energy intensity varies with the inverse of the mass square of the stopped particle. Taking as basis the levels found on the tank center, we see that in the target, the bremsstrahlung should be about 10^3 times smaller[4].

To shield the bremsstrahlung, the V. G. crew provided the placement over the tank, of a Pb cover, 12 mm thick, calculated for 400 kv X-rays, which eliminated almost completely the emergent X-rays. On the experimental conditions the radiation levels were reduced to values near the M.P.E.

CONCLUSIONS

Neutrons are the most serious problem, at least concerning low energy accelerators. In our case, the best criteria seems to be the control of the operation conditions and the removal of the apparatus to an isolated place. The use of shields have serious inconveniences as high cost and in many cases its presence - is undesirable for it renders difficult the experimental data collecting.

In the present case, the determination of the isodose curves for the gamma-X radiation is possibly an excess of caution , since the radiation is of low energy and easily shielded. But , with higher accelerators, such procedures could probably propiciate more efficiency to radiological protection work, and turn out to be an economy factor, for the delimitation of critical areas.

ACKNOWLEDGEMENTS

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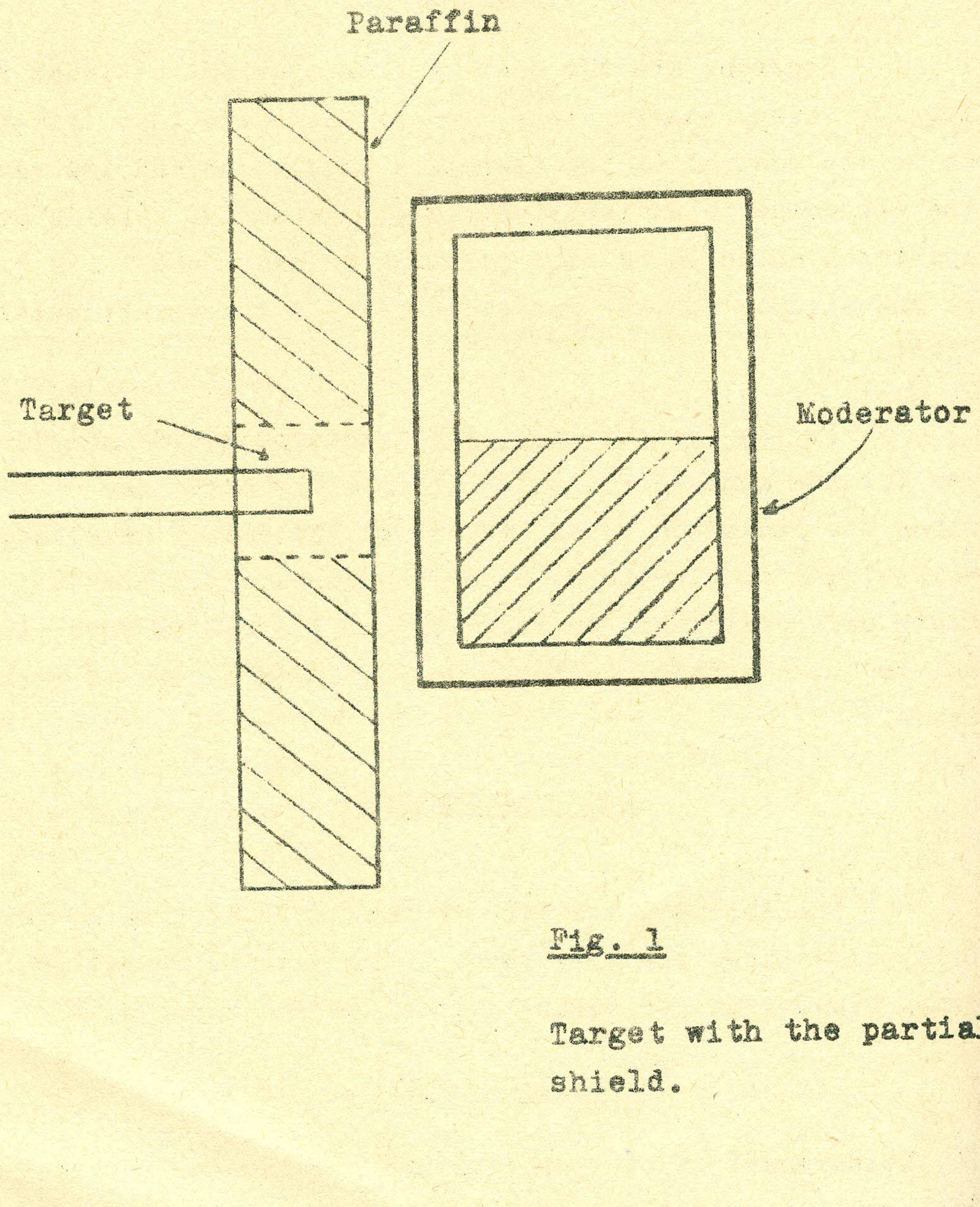


Fig. 1

Target with the partial shield.

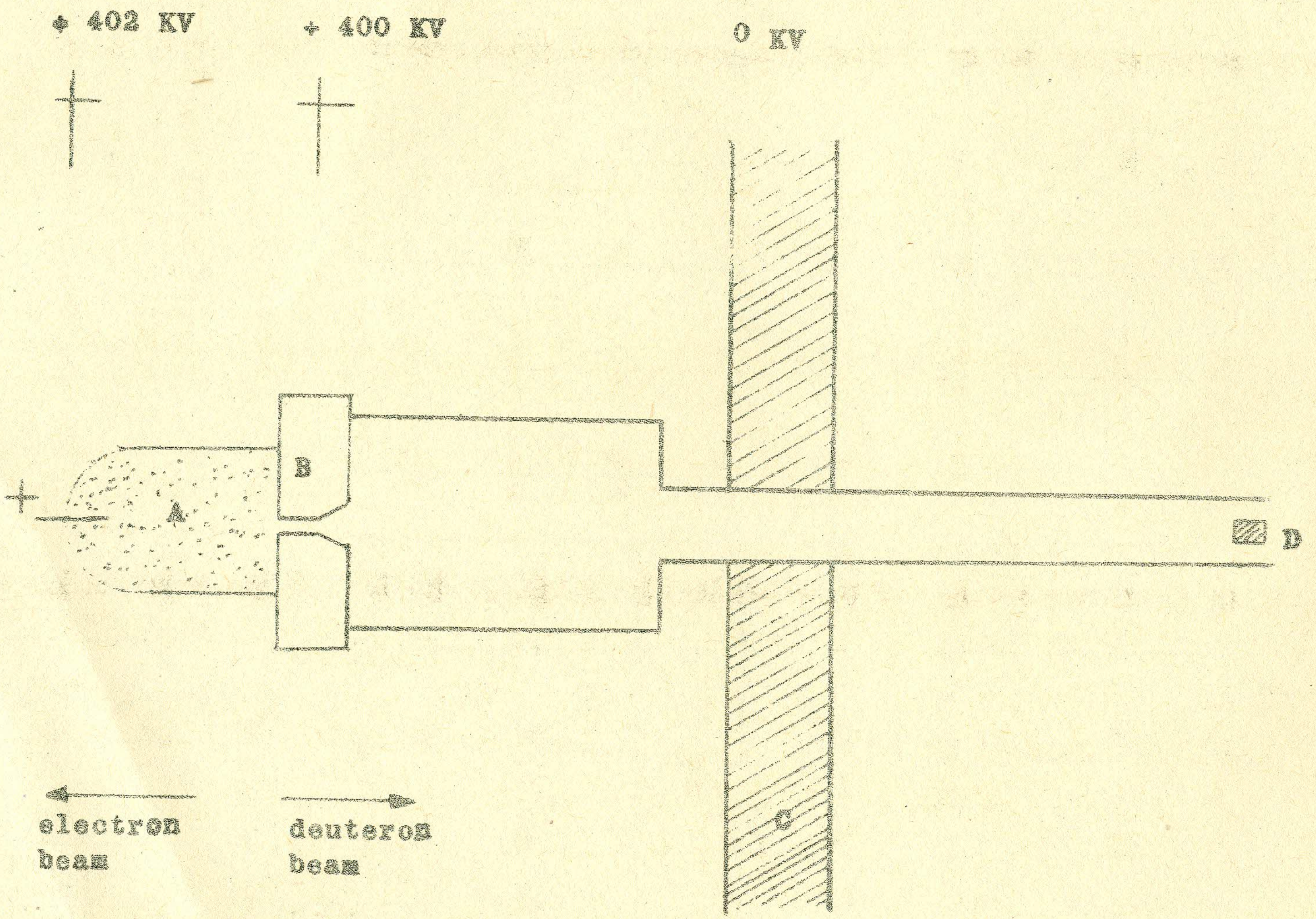
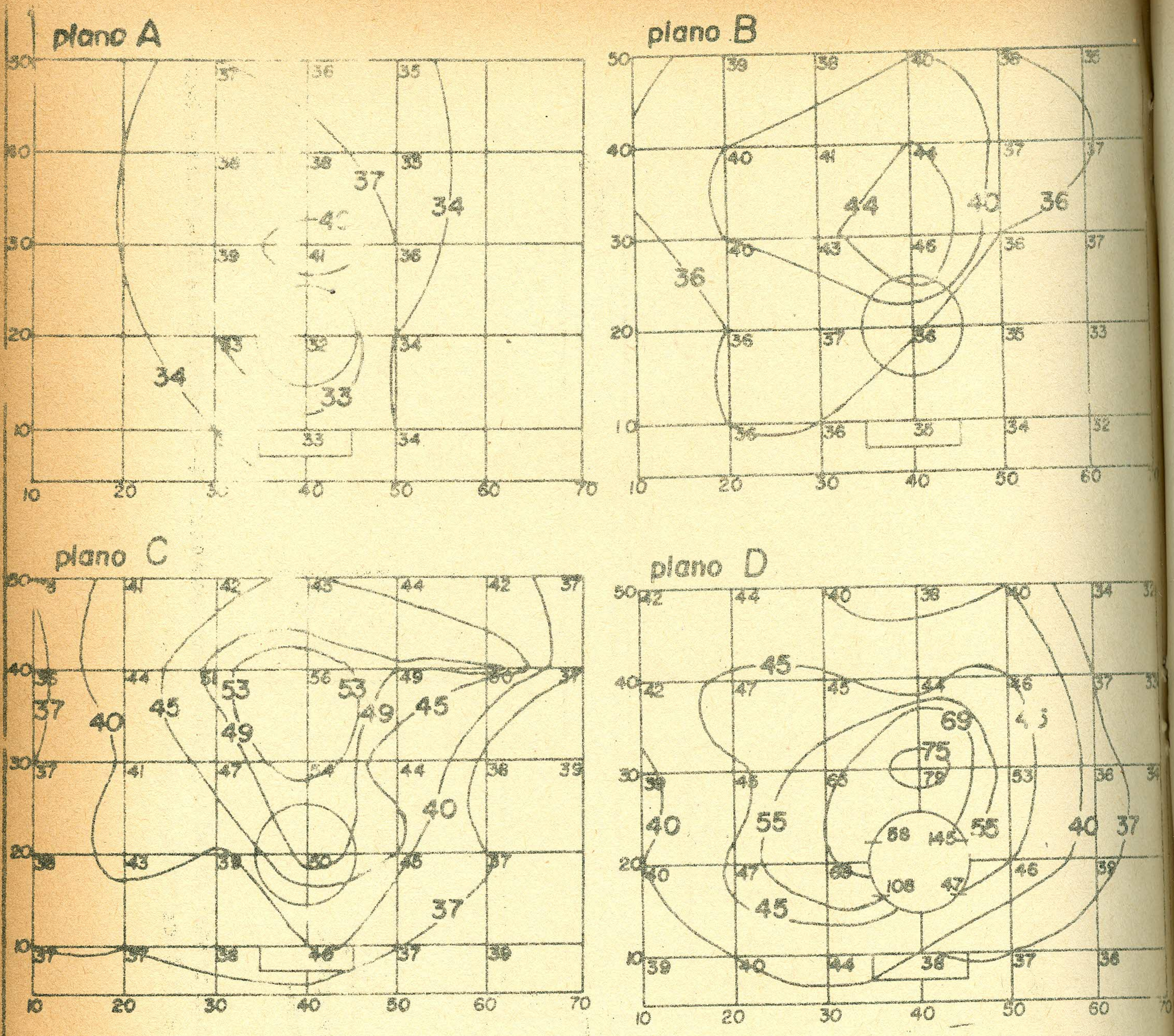


Fig. 2 - The V.G. schematic view showing some components. A- Ion Spurce.B-Source Base C-Support Plate (4 cm thick). D-Target



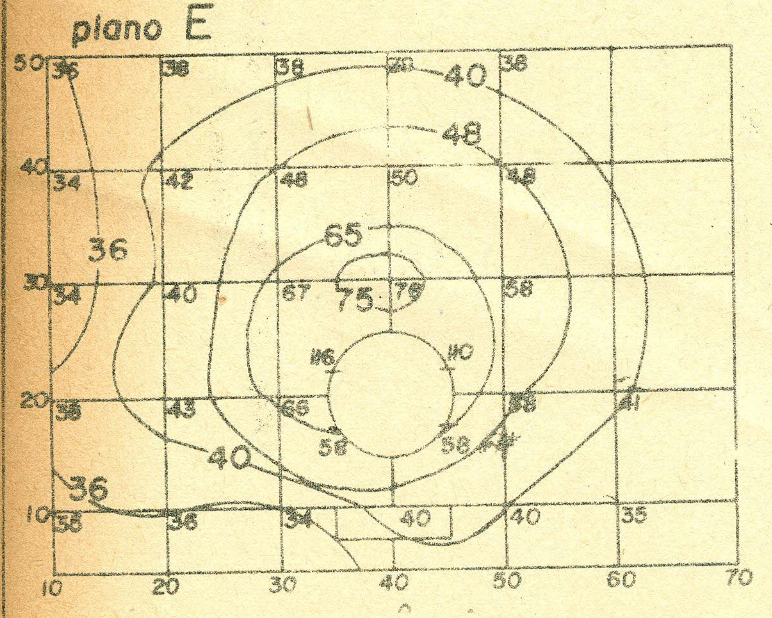
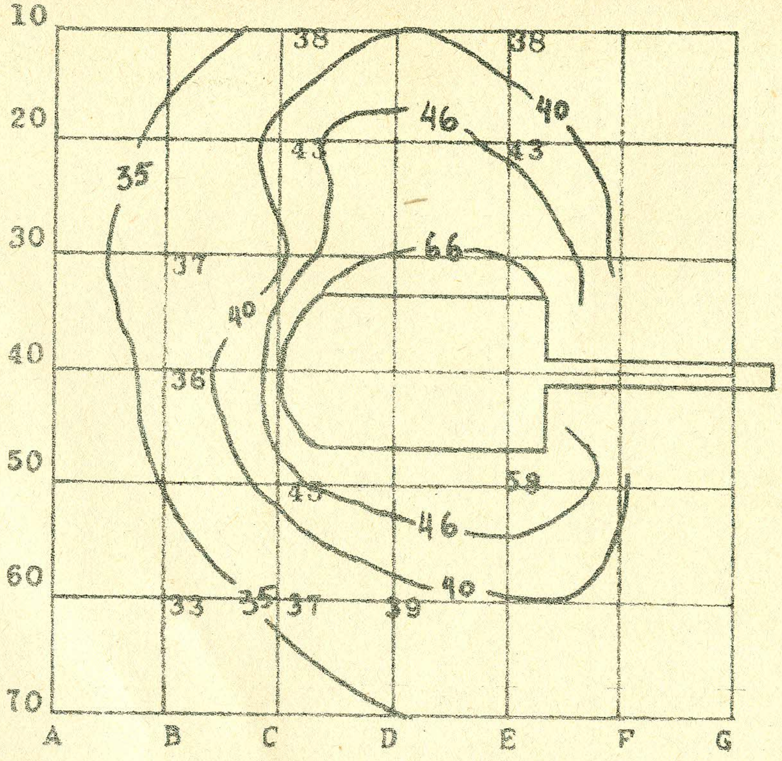
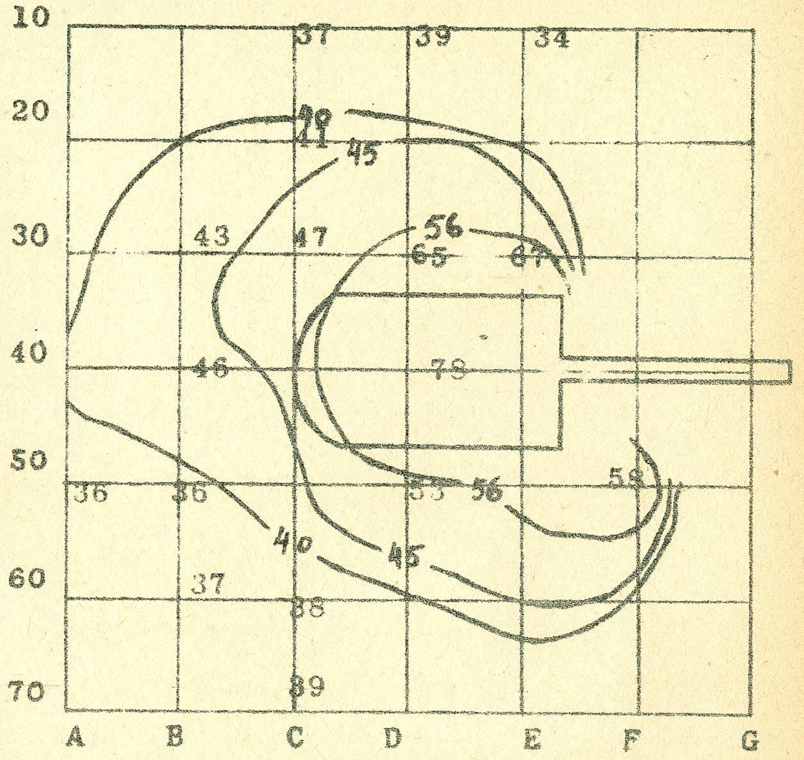


Fig. 3

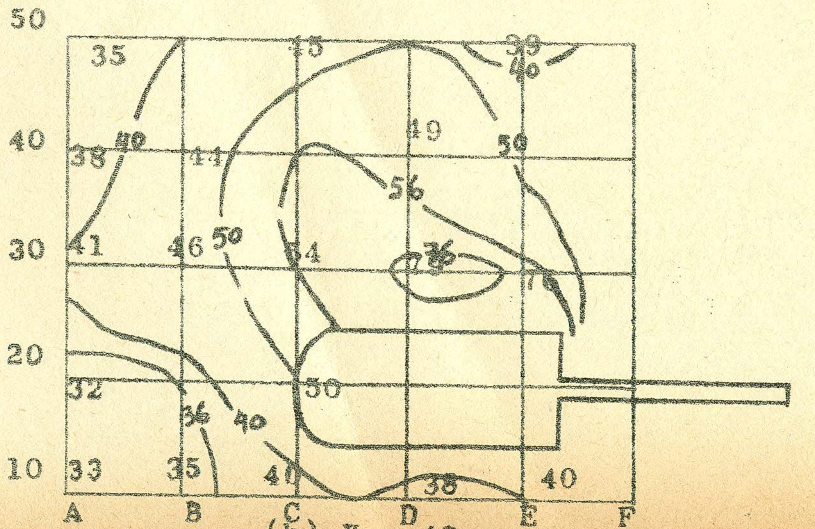
Isodose curves in vertical planes A, B, C, D and E. Numbers inside reticulate are optical densities at each position.



(a) Y = 20



(a) Y = 30



(b) X = 40

Fig 4

Isodose curves (a) Horizontal planes
Y = 20 and Y = 30
(b) Vertical plane
X = 40

The numbers inside reticulate are optical densities X 100,

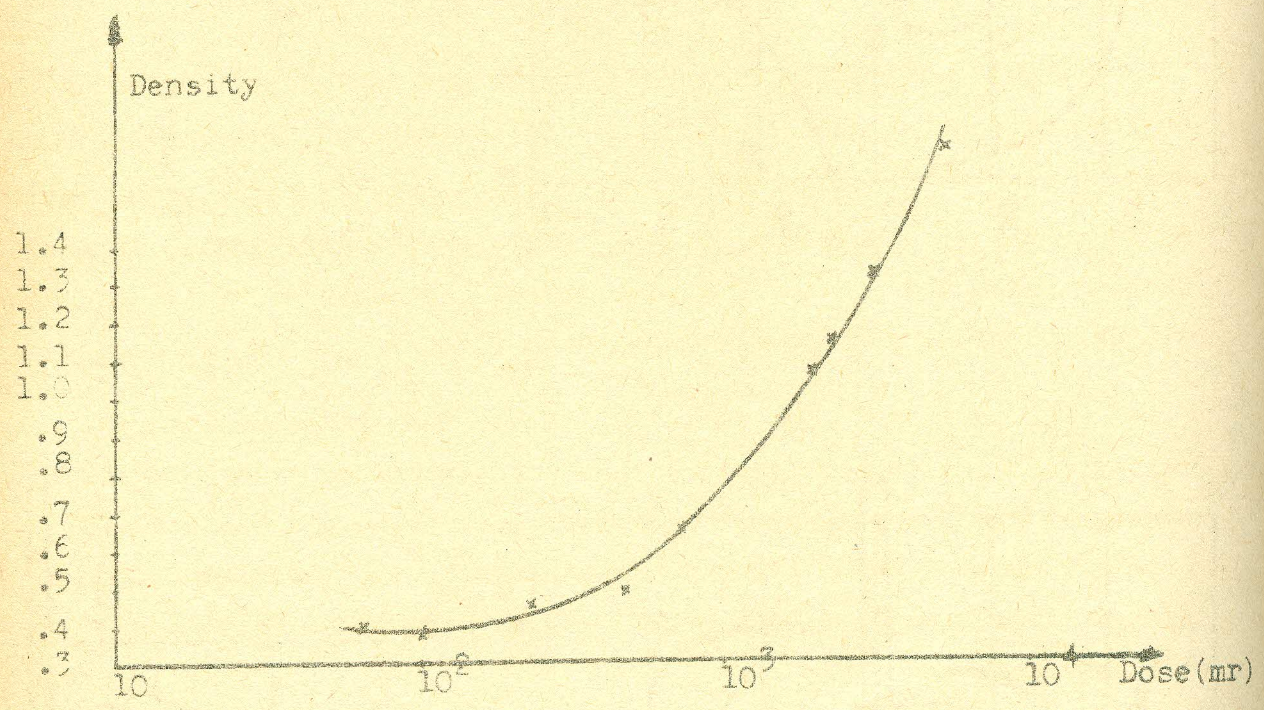


Fig. 5 - Calibration curve for dose determination in dosimetric films