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A Study of X-Rays from the Berkeley Van de Graaff Generator

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ABSTRACT

These are the results of a brief investigation of x-ray conditions produced by the 4 MV Van de Graaf Generator at the Radiation Laboratory. The study was made to determine what personnel protection is required and to find what if any are the factors which will ultimately limit the beam size.

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By means of an x-ray telescope it was determined that the source of x-rays was distributed along the length of the accelerating tube being maximum near the high voltage shell. It is interesting to note that absorption measurements indicate the greatest number are between 500 and 600 thousand volts. This corresponds to an acceleration across about ten electrodes. By varying the 90° defelcting magnet to resolve ions at lower energies than 4 MV one can actually count the electrodes.

The half thickness of lead required is 3 to 4 mm. At the present time no shielding other than the pressure tank is used. The control desk is about 25 feet from the high voltage end and 10 feet from the low voltage end of the accelerating tube. Radiation at the desk under normal operating conditions with pulsed beam is 2 milli-roentgens per hour.

We are about to install a magnetic ion source which is expected to increase the ion currents by more than ten times. Therefore it is quite possible that lead shielding will be necessary.

Last summer the accelerating column was rebuilt after which three weeks were required to work up the beam and voltage to a satisfactory operating condition. During this time x-ray levels at the control desk often exceeded 50 mr./hour. Under these conditions the x-ray production increased very sharply with the voltage above 3.5 MV. At present this voltage effect begins at 4 MV fortunately.

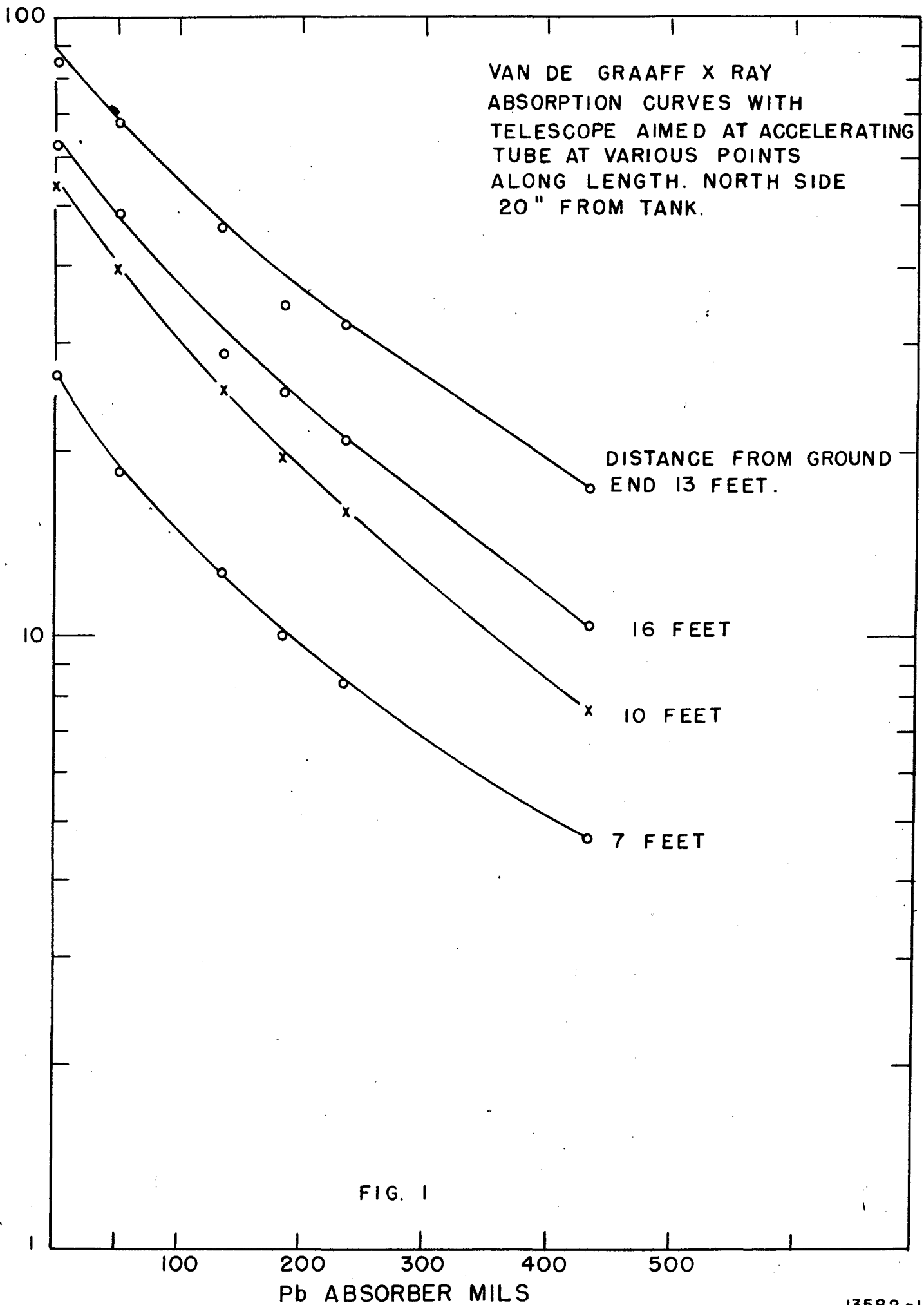
The x-ray level vs. gas pressure in the tube has been a subject of much

interest. The beam is pulsed for 300 μ seconds at a repetition rate of 15 per second. The tube pressure will tolerate higher currents in a pulse than with a d.c. beam because it can recover from multiplication effects during the off time. So far operations have in no way been limited by pulsed beam size, the maximum of resolved protons being 200 μ amps. during the pulse. The d.c. beam is seldom used. Its maximum is limited by tube breakdown.

The x-ray output is an exponential function of tube pressure. The operating pressures are 10^{-5} mm of mercury at the ground end and about 10^{-4} mm at the high voltage end.

The list of figures includes:

- Fig. 1. Absorption curves of x-rays originating at four areas along the tube.
- Fig. 2. Total x-rays as a function of a distance from the low voltage end on a line parallel to the accelerating tube.
- Fig. 3. X-ray intensity as function of voltage.
- Fig. 4. X-ray intensity as a function of beam current with approximately constant tube pressure and with constant voltage.
- Fig. 5. X-ray intensity as a function of tube pressure with output of ion the source constant.



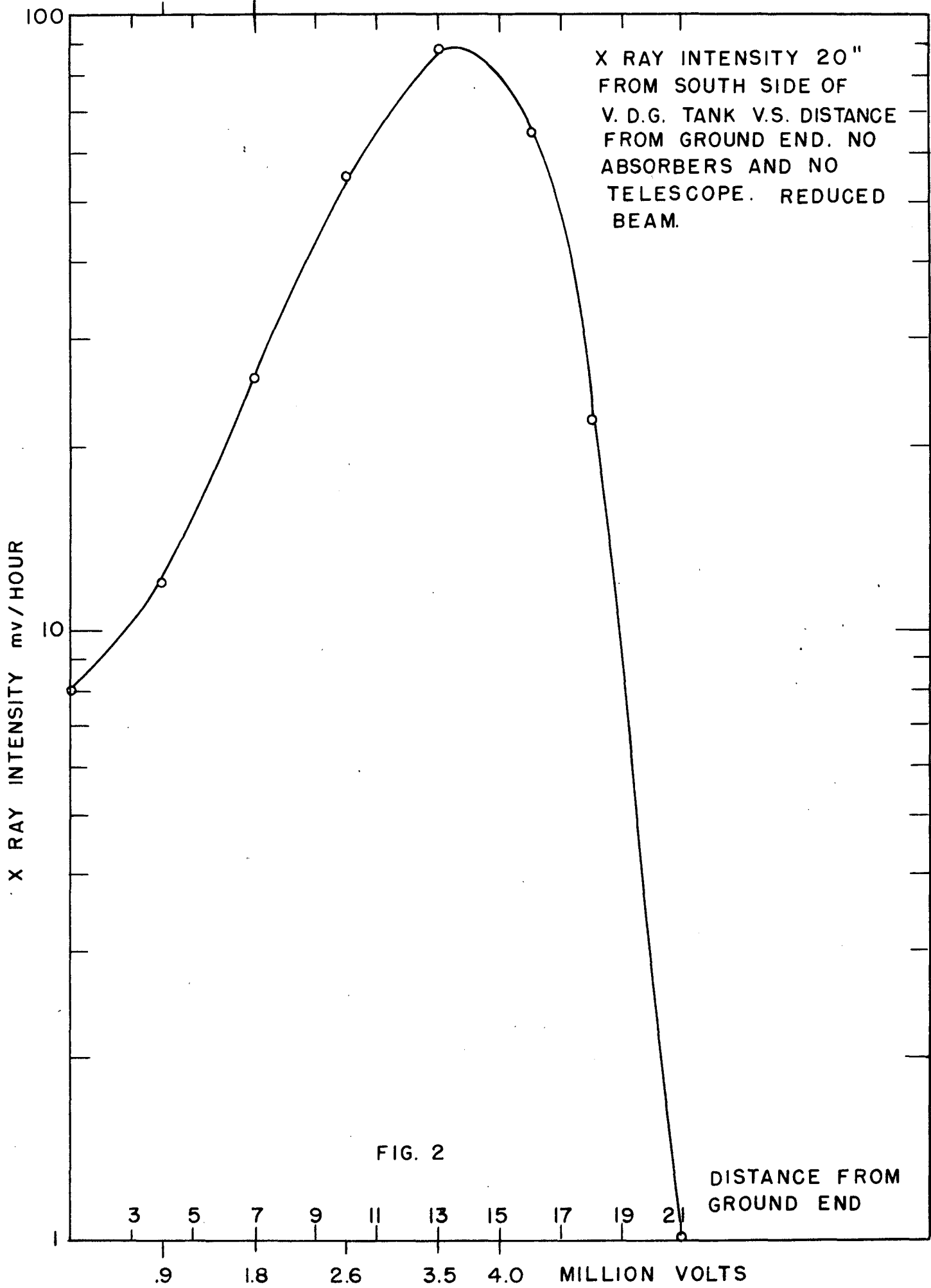


FIG. 2

DISTANCE FROM
GROUND END

.9 1.8 2.6 3.5 4.0 MILLION VOLTS

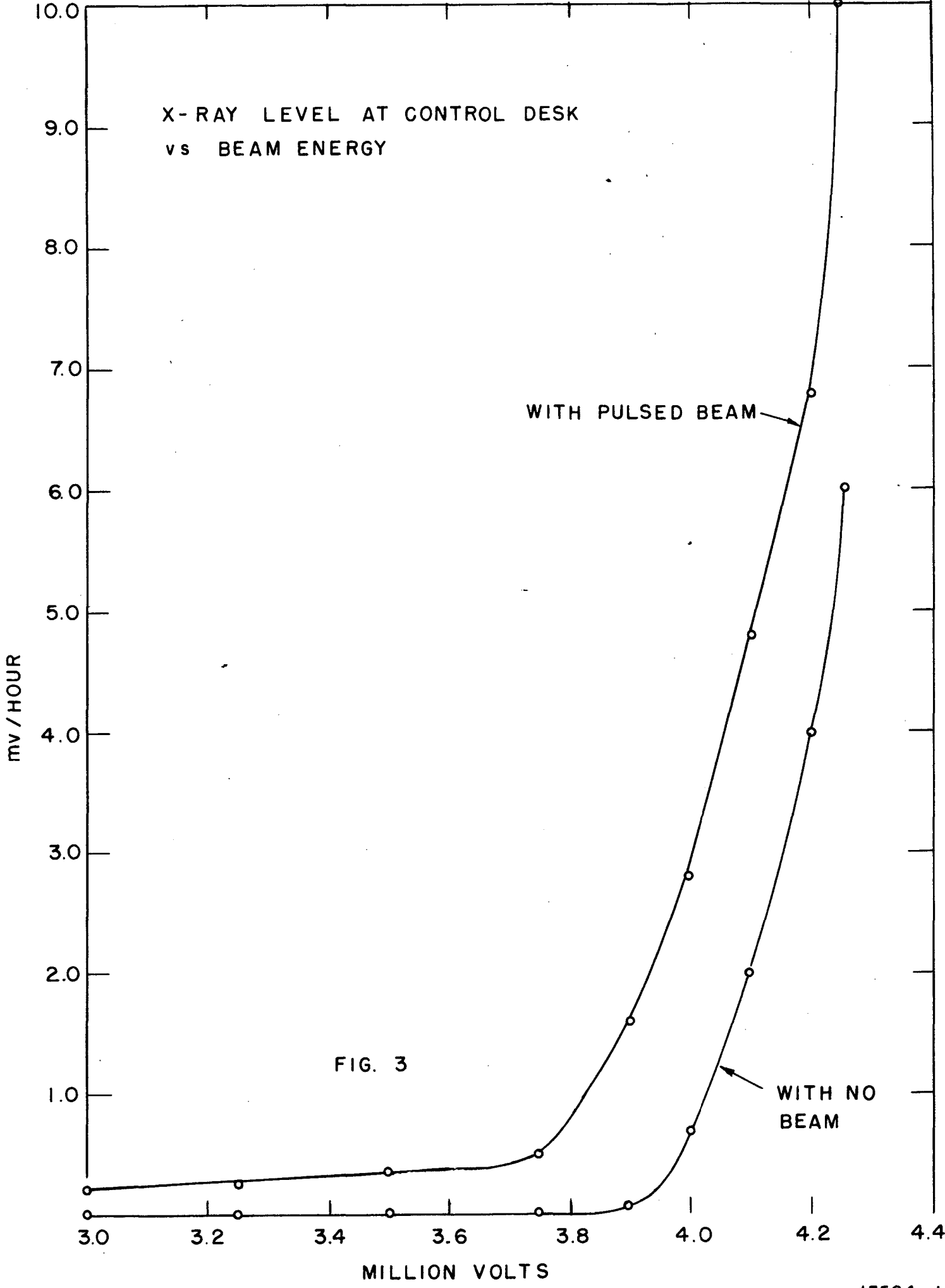


FIG. 3

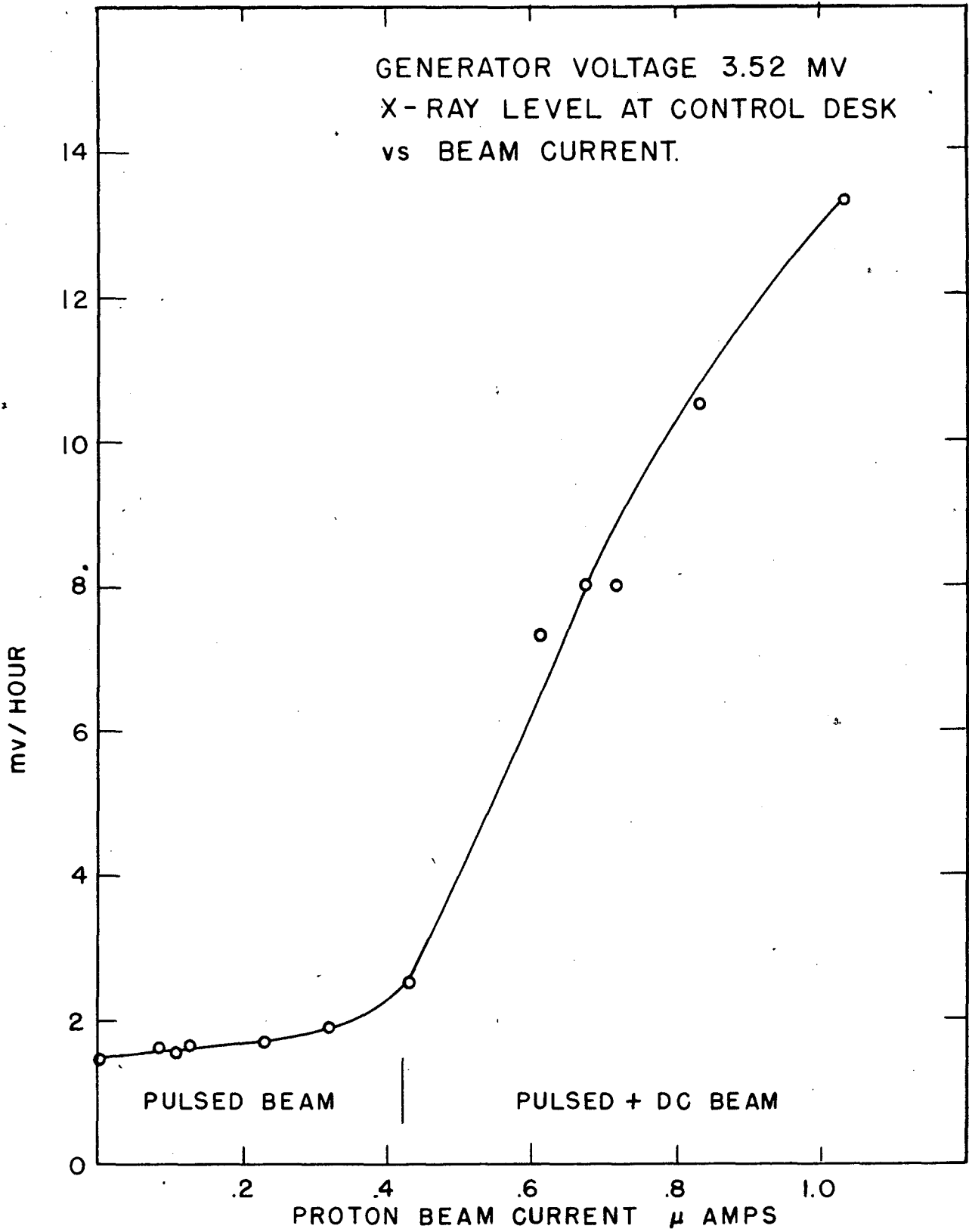


FIG. 4

X-RAY LEVEL AT CONTROL DESK
vs TUBE PRESSURE. BEAM CONSTANT
AND VOLTAGE AT 3.50 MV

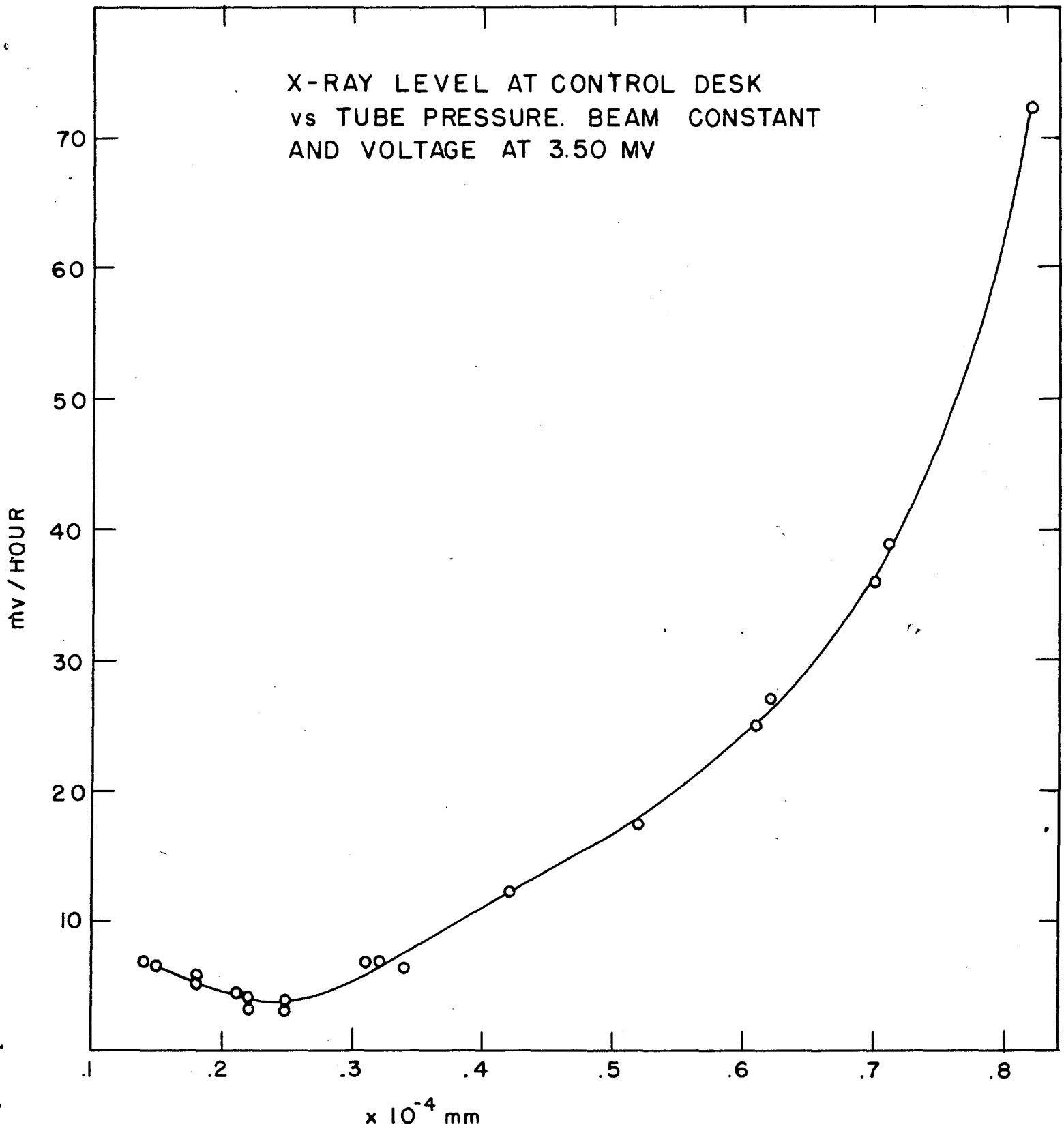


FIG. 5