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Series A

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SAFETY TESTS ON HAND STACKING OF U-235 CUBES

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Abstract

Critical assembly tests have been made on the Pajarito Universal Machine to determine the safety limits of handstacking cubes of 95% U-235 in soherical geometries preparatory to making critical assemblies of U-235 in an "infinite" tuballoy tamper. The U-235 cubes were stacked as pseudospheres in a cavity at the top of a tuballoy block 12" high and 8" on a side, and the assembly tamped by locating it inside a doughnut shaped water tank whose tamping effect is equivalent to the tamping caused by personnel necessary for hand stacking. Tests were also made on pseudospheres of 50% concentration and 50% density. The critical masses and diameters for these three configurations are given in Table I.

SAFETY TESTS ON HAND STACKING OF U-235 CUBES

In prepartaion for making reactor tests using U-235 with normal uranium tamper, several assembly tests have been made on the universal machine (Topsy) at Pajarito to determine the feasibility and safety limits of hand stacking cubes of U-235 in spherical geometries. These tests consisted of making neutron multiplication measurements on various size pseudospheres when surrounded by a tamper which is an adequate mockup of the personnel required around the assembly for the hand stacking operations.

The tamper used in these tests consisted of a doughnut shaped tank filled with water. The measurements were made with the hand stacked assembly located in the doughnut hole. An arbitrary upper limit of multiplication was set and no pseudospheres were assembled which would give a greater multiplication. The critical sphere diameter was determined by plotting the reciprocal of neutron multiplication as a function of sphere diameter and extrapolating the curve to the zero value of 1/M.

The procedure to be followed in the reactor experiments consists of hand stacking the U-235 cubes in the desired configuration on part of the tamper and inserting this assembly from below into a cavity in the main tamper body, the completed assembly forming a U-235

configuration completely surrounded by tamper (water). Since in hand stacking the U-235 cubes there is considerable tamping by the personnel doing the stacking, it is important to know how great this tamping effect is, and also how much material can be safely stacked by hand.

The experimental setup used in making these safety tests is shown in Fig. 1. The water tank is 36"x36"x18" with a square hole 12" on a side for the placement of the U-235 and tamper section. The U-235 and tamper section assembly consists of two sections, one of which is supported inside the cavity of the water tank while the other is supported on the hydraulic ram. Fig. 2 shows the lower assembly located on the hydraulic ram underneath the water tank. Fig. 3 shows the top of the water tank with the square cavity, and the counters used in making the neutron intensity measurements.

The procedure followed in making the tests is as follows: A small pseudohemisphere of U-235 cubes was stacked in a cavity in the top of a square tuballoy tamper block 12 inches high and 8 inches on a side (Fig. 4). A neutron source (MF-5) was placed in the center of the equatorial plane of the pseudohemisphere. This assembly located on the hydraulic ram was raised by remote control into position in the cavity of the empty water tank. Neutron intensity measurements were made

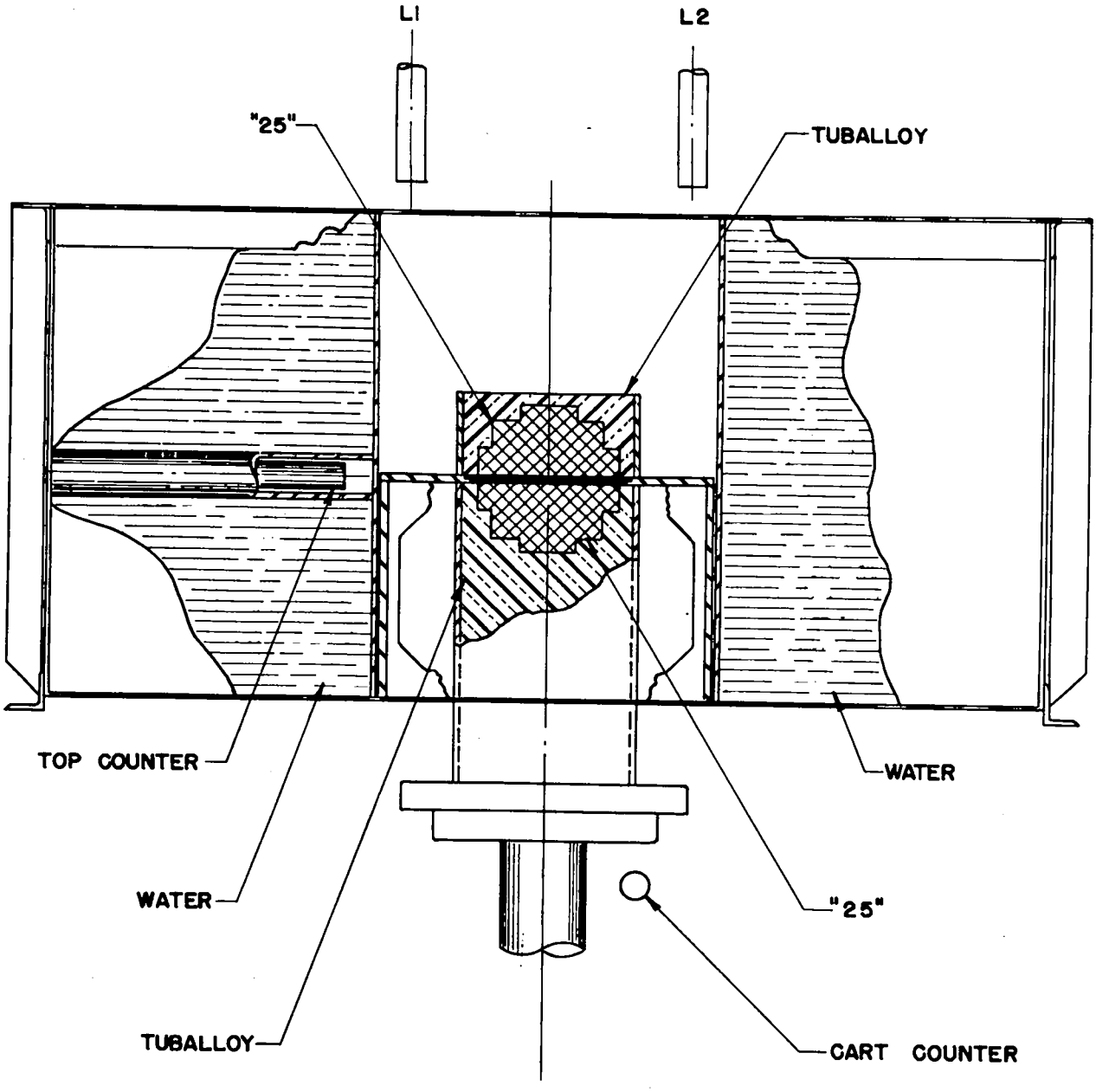

FIG 1

SECTION VIEW OF TANK ASSEMBLY AND TUBALLOY CAN

Fig. 2

Water tank and tamper assembly.

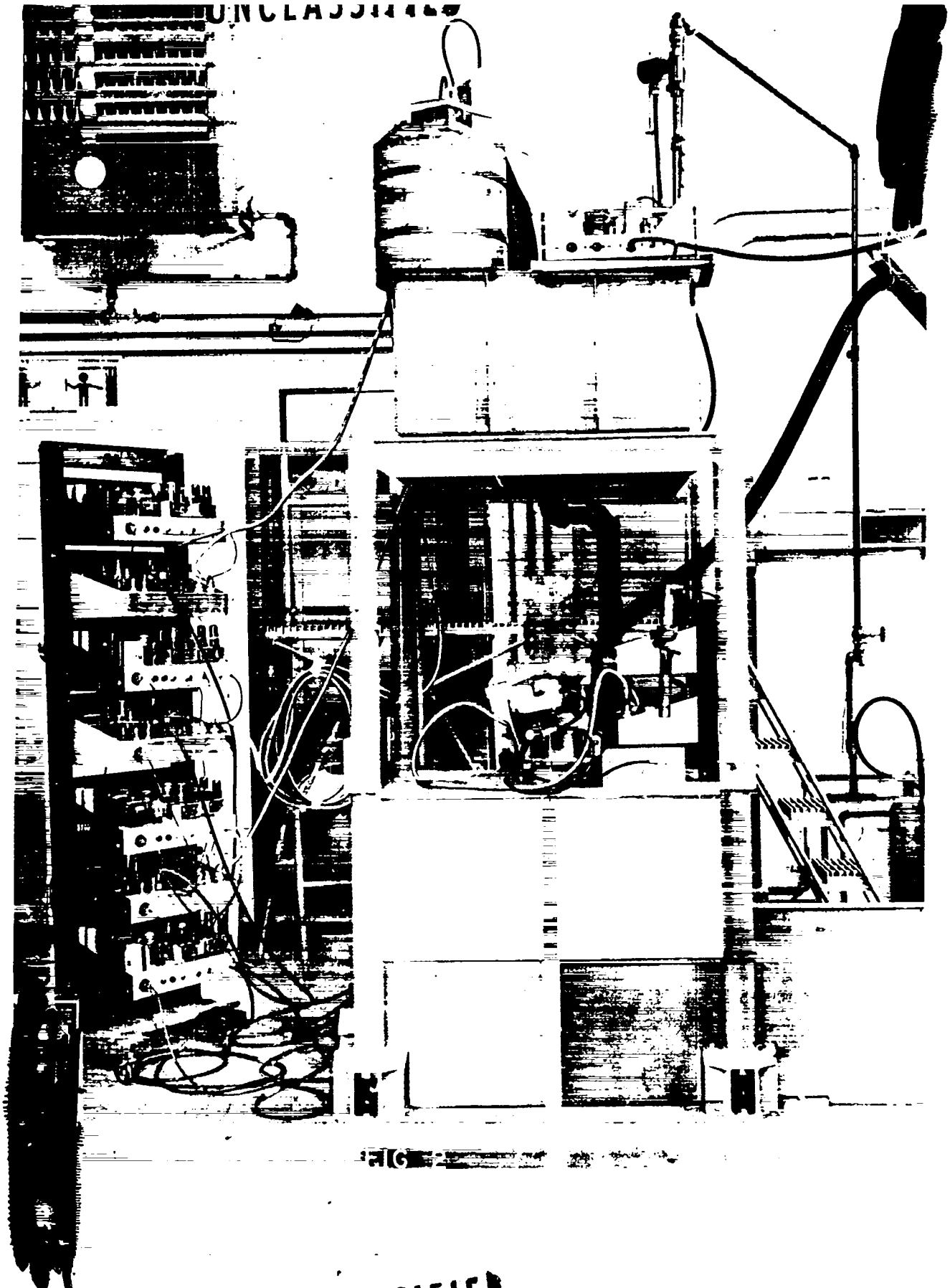

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Fig. 3.

Top view of water tank, showing counters.

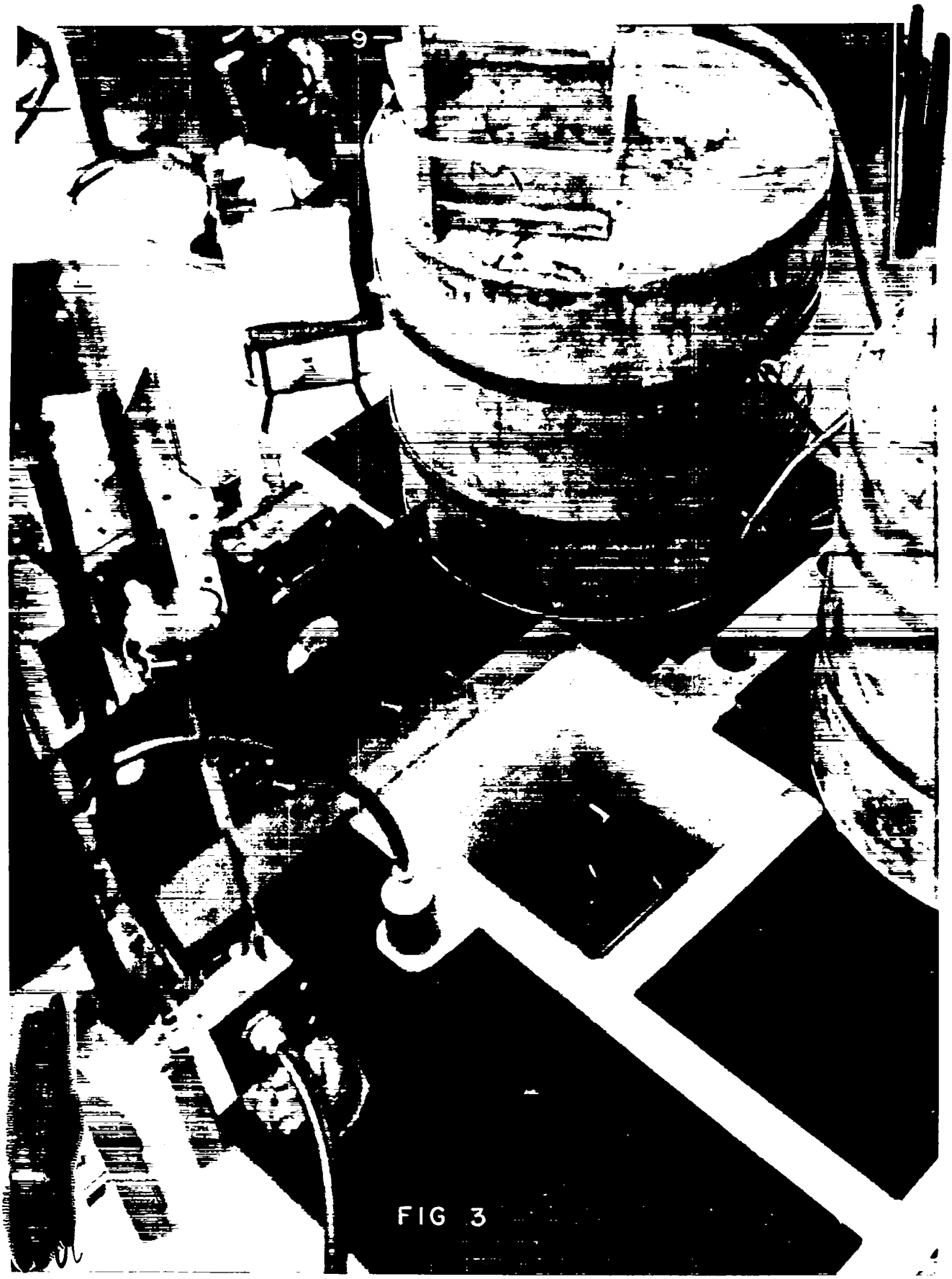


FIG 3

Fig. 4

Location of pseudosphere in cavity.

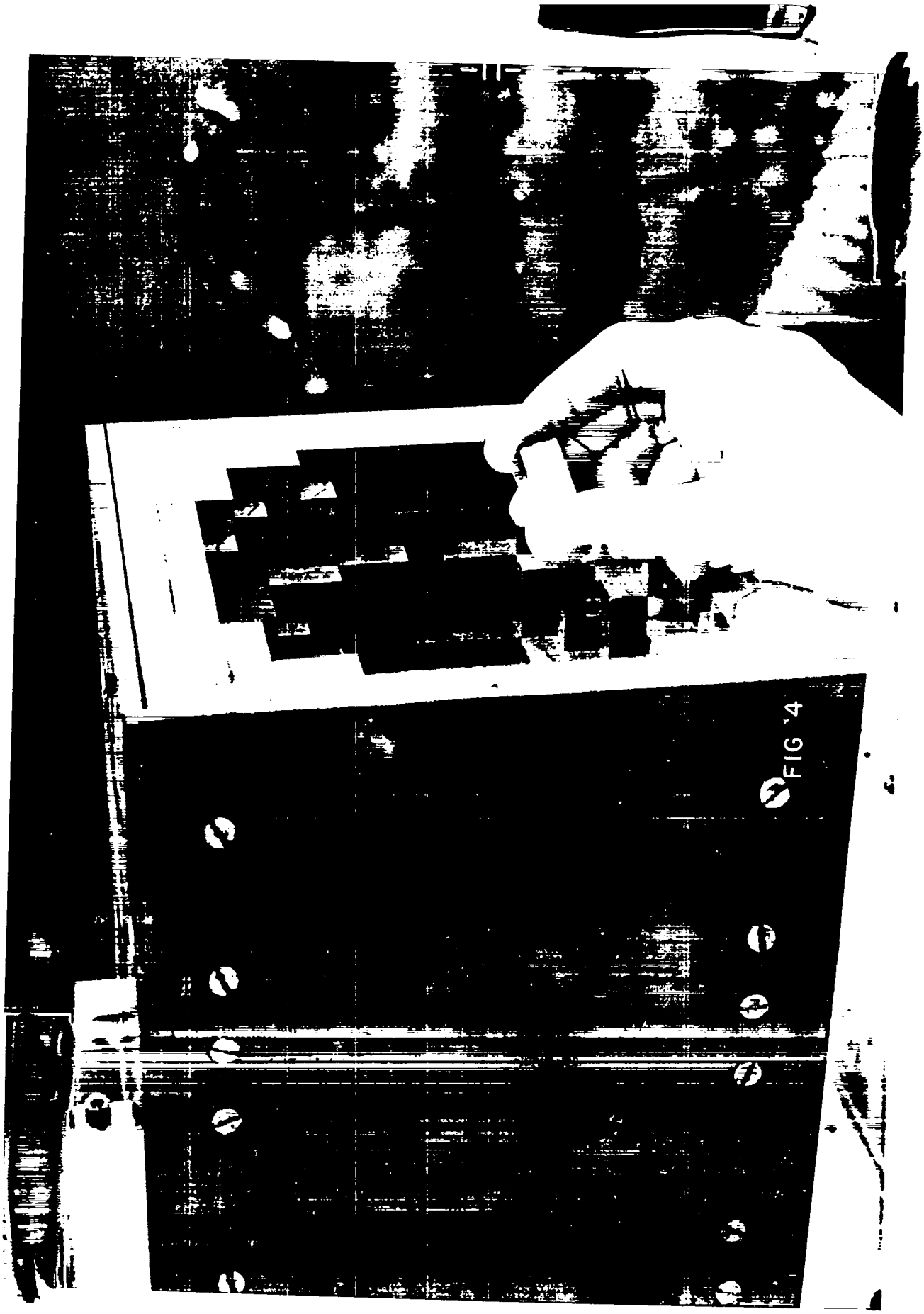


FIG '4

while the tank was being filled with water, and the neutron multiplication at any point determined by dividing the neutron intensity for a U-235 assembly by the intensity previously obtained from a similar tuballoy assembly. If the multiplication obtained from this pseudohemisphere in the full water tank was sufficiently low, a similar pseudohemisphere was stacked on a U-235 plate and surrounded with a tuballoy to form a block 8"x8"x4" (Fig. 5), and this assembly placed manually on a support in the cavity of the water tank. The lower section of the U-235 and tamper assembly was again raised by remote control up into the cavity until it was in contact with the upper section of the assembly. The tank was again filled with water and a neutron multiplication determined. If this assembly was considered safe, then the next size pseudohemisphere was stacked in the lower section of the assembly and the process repeated until the previously set limit of multiplication had been reached. The succeeding diameters of pseudospheres are chosen such that the mass of the pseudohemisphere being stacked is always less than the mass of the previous pseudosphere assembled. In this way, the personnel are always handstacking a smaller mass than has already been assembled by remote control inside the water tamper.

Since there was some question as to the effect

Fig. 5

Upper tamper section.

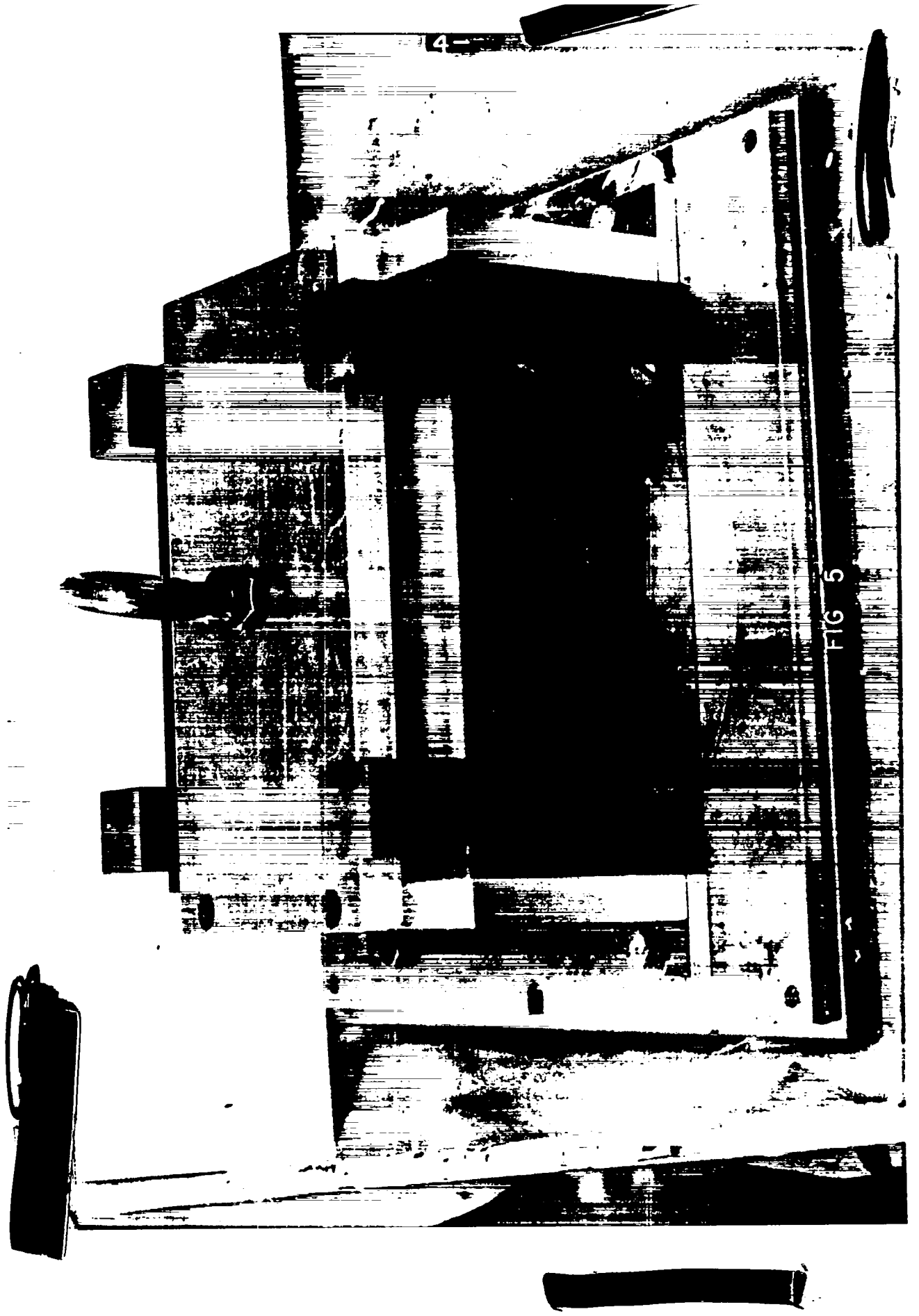
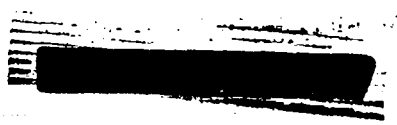


FIG 5

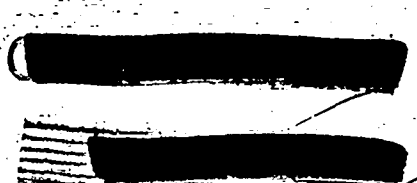


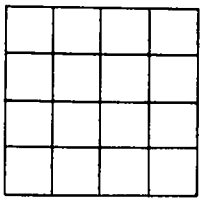
of the steel in the water tank on these neutron multiplication measurements, one pseudosphere (4.2 inches in diameter) was stacked in the top of the tuballoy block on the hydraulic ram, and this assembly was raised up into a cavity in a block of paraffin 24 inches on a side. The neutron multiplication observed in this test agreed within limits of experimental error to that obtained in the water tank test.

The pseudospheres used were built up using $\frac{1}{2}$"x$\frac{1}{2}$"x$\frac{1}{2}$" U-235 cubes as the smallest building unit. Fig. 6 shows the stacking diagram followed in building up a 5" diameter pseudosphere. Other size pseudospheres were built up from similar stacking diagrams.

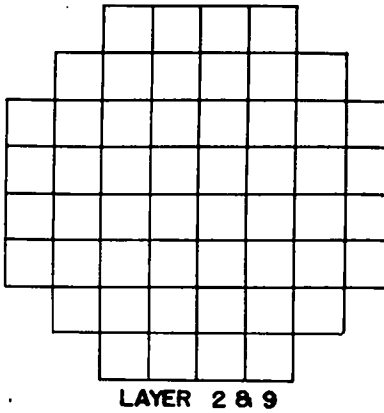
Since the work to be carried out in future reactor experiments includes critical mass determination as a function of U-235 concentration and density, hand stacking tests have been made on pseudospheres of 50% U-235 concentration and 50% U-235 density. The 50% density was achieved by stacking the pseudospheres of U-235 blocks and aluminum spacers in a checkerboard lattice. The aluminum spacers used were made of 20 mil wall $\frac{1}{2}$" diameter tubing $\frac{1}{2}$" long.

The results of the hand stacking tests for 100% and 50% density pseudospheres are shown in Fig. 7. Here, the reciprocal of multiplication is plotted as a

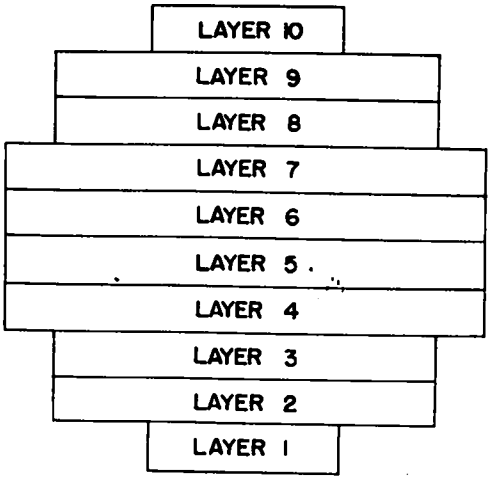


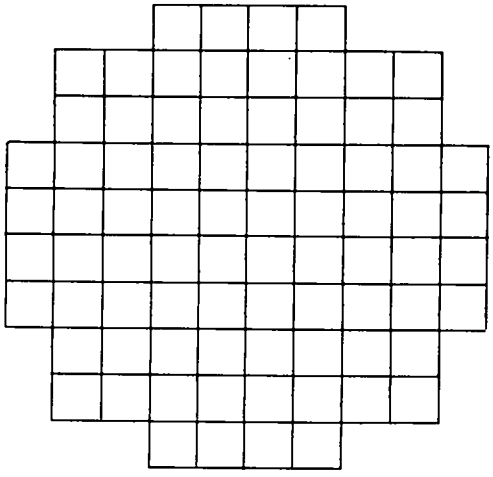


LAYER 1 & 10

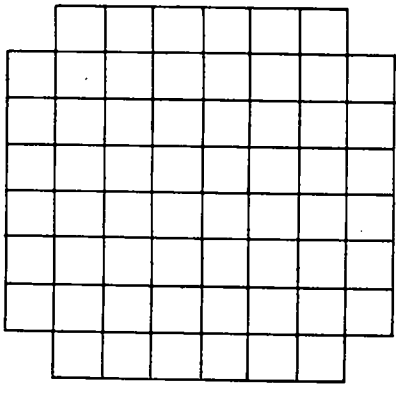


LAYER 2 & 9





LAYER 4,5,6 & 7



LAYER 3 & 8

FIG 6

STACKING DIAGRAM FOR 5" PSEUDOSPHERE

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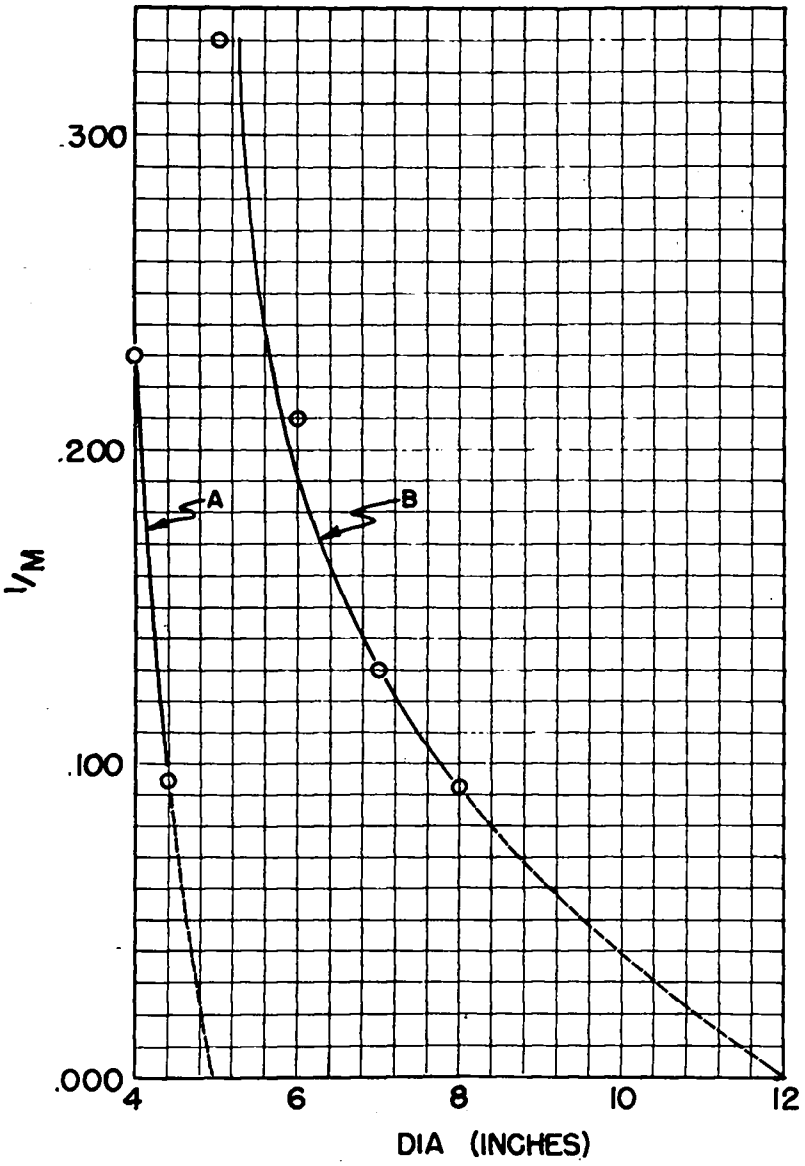


FIG 7

$1/M$ AS A FUNCTION OF DIAMETER OF U-235 PSEUDOSPHERE OF

A 100% DENSITY &

B 50% DENSITY IN

WATER TANK

function of sphere diameter for (a) 100% density and (b) 50% density of U-235. The experimental arrangement for the 50% density pseudosphere is shown in Fig. 8. The results of the hand stacking tests for 100% and 50% U-235 concentration pseudospheres are shown in Fig. 9. A test was also made on one size (6") pseudosphere of 50% concentration using a pseudospherical shell lattice instead of the checkerboard lattice, with the source surrounded by the first U-235 shell one-half inch thick. This configuration was found to be much more critical than the corresponding checkerboard configuration. In comparing the curves for 100% density and 100% concentration in Figs. 7 and 9, it will be noticed that the slopes are different, but the intercepts are the same. The reason for this is that data from two different counter geometries were plotted in the two cases, showing that the neutron multiplication values became identical for all counter geometries for near-critical assemblies.

A tabulation of the results obtained in these tests is given in Table I.

Fig. 8

Stacking arrangement for 50% density pseudosphere.

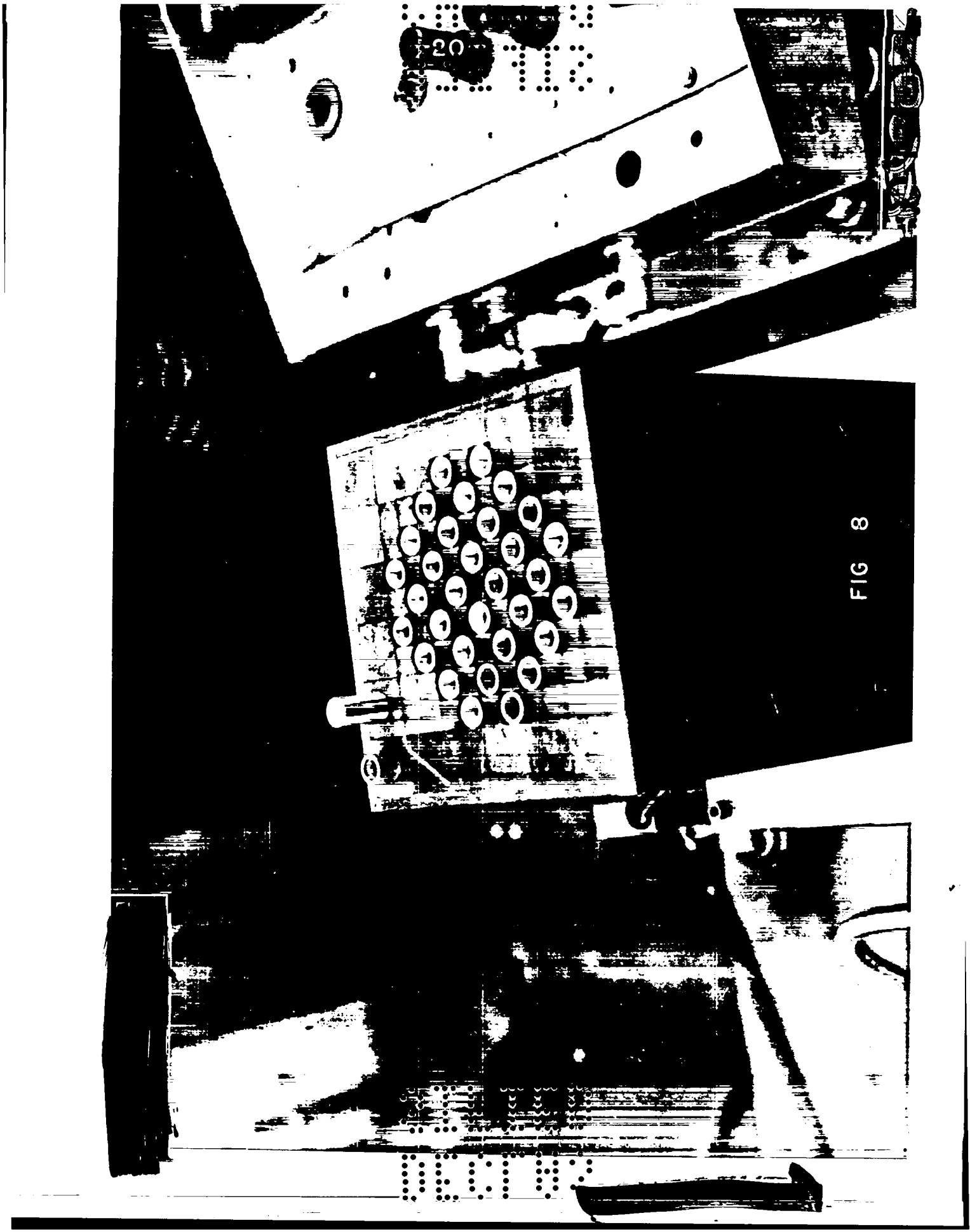


FIG 8

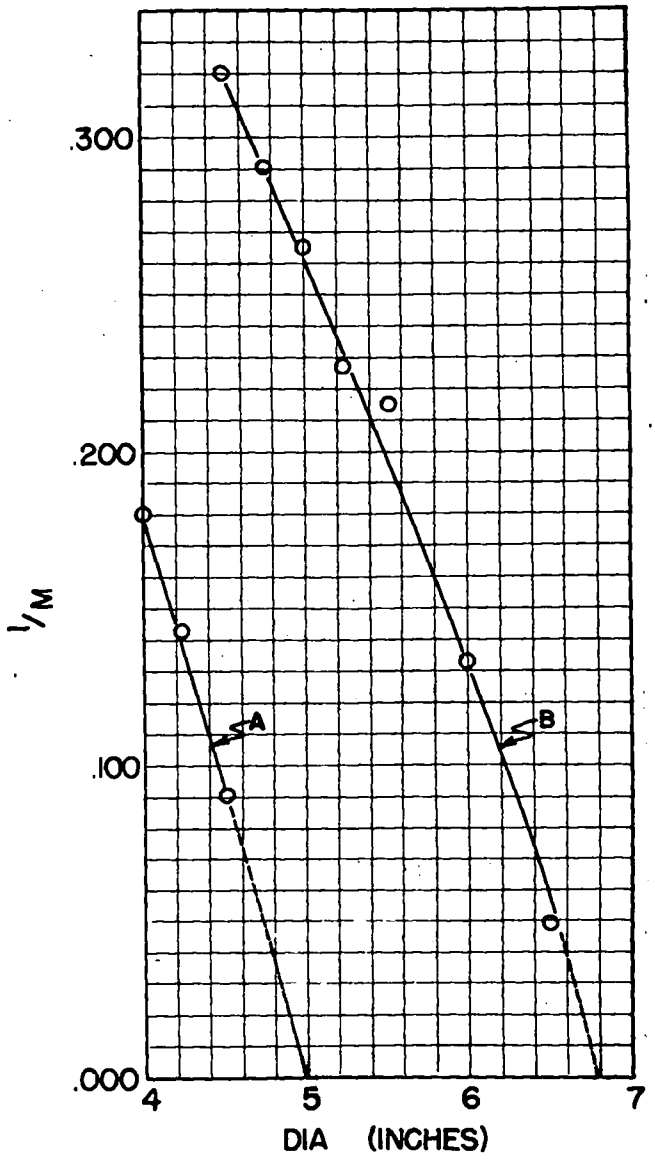


FIG 9

1/M AS A FUNCTION OF DIAMETER OF U-235 PSEUDOSPHERE

OF

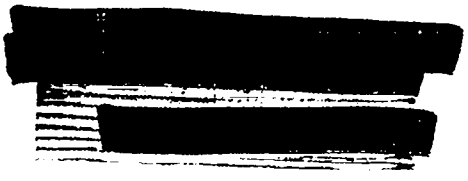
A 100% CONCENTRATION &

B 50% CONCENTRATION IN

WATER TANK

TABLE I

Type of pseudosphere	M_c in Kg	Critical diameter
100% density & concentration	22.2	5"
50% concentration (checker-board lattice)	56	6.8"
50% concentration (shell lattice)	< 52.2	< 6.5"
50% density	127	12"



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