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ORALLOY SHAPE FACTOR MEASUREMENTS

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ABSTRACT

Measurements have been made at the Pajarito remote control laboratory to determine the effect of change of shape on system reactivity for oralloy cylinders. Systems tested include cylindrical configurations with various height-to-diameter ratios ranging from slabs to rods. Each system reactivity is referred to that of a sphere in the same tamper. Reactivity tests were made on bare (untamped) Oy configurations, as well as on systems in tuballoy tampers 1.12", 1.87", and 8.0" thick. The amount of reactivity change associated with a particular cylinder height-to-diameter ratio is found to be a function of tamper thickness, and is greatest for very thin tampers.

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ORALLOY SHAPE FACTOR MEASUREMENTS

A. Introduction

The amount of oralloy required to make a critical assembly depends on several parameters such as Oy density, concentration and configuration, and tamper material, density and thickness. This report covers a set of experiments carried out to determine (1) the dependence of Oy critical mass on its configuration for cylindrical and spherical assemblies, both untamped and for different thicknesses of tuballoy tamper; and (2) the height-to-diameter ratio for each cylindrical assembly that results in the smallest critical mass.

An expression useful in describing configuration effects on system reactivity is "shape factor", which may be defined as the ratio of the critical mass of a sphere to the critical mass of some other shape in a tamper of the same material and thickness.

LA-1114 gives some preliminary data on configuration effects of Oy parallelopipeds in an 8" tuballoy assembly. This report extends the measurements to Oy pseudocylinders in a thick (8") tuballoy assembly, as well as measurements on smooth Oy cylinders in 1.87", 1.12", and 0" thicknesses of Tu tamper.

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B. Experimental Procedure

Critical mass (M_c) determinations were made by the usual neutron multiplication method. The M_c for a given configuration is determined by measuring the neutron multiplication (M) for increasing masses of Oy, plotting the reciprocals of the multiplication values as a function of Oy mass and extrapolating the resulting curve to a mass value for $1/M = 0$. This mass value is the critical mass for the particular configuration.

These measurements were made using Topsy and the Comet, two remote control assembly machines at Pajarito Site. Topsy was used in making the measurements in the thick Tu tamper assemblies. The Comet was used in making all measurements on the thin Tu tampers and the untamped assemblies.

The operation of Topsy is described in LA-749. The Comet consists of a hydraulic ram and a supporting table above it. The split assembly method was used on all measurements; i.e., half of the assembly is supported by the table and the other half by the ram. During assembly, the hydraulic ram raises the lower half up until it is in contact with the upper half, thus completing the assembly. Figure 1 shows a section view of the assembly.

The material used consists of Tu and Oy-93.5% sets of universal rings of sufficient size and number to build Tu and Oy cylinders 7.5" o.d., 7.5" high, and additional Tu rings 8" high to increase the Tu cylinder diameter to 10.375". The Tu and Oy rings are interchangeable up to 7.5" diameter and 7.5" height so that any combination of Oy and tamper thickness totalling 10.375" in diameter can be assembled. Table I gives a complete listing of the Tu and Oy units used. Total Oy mass in the universal ring assembly is 100.5 kg, as

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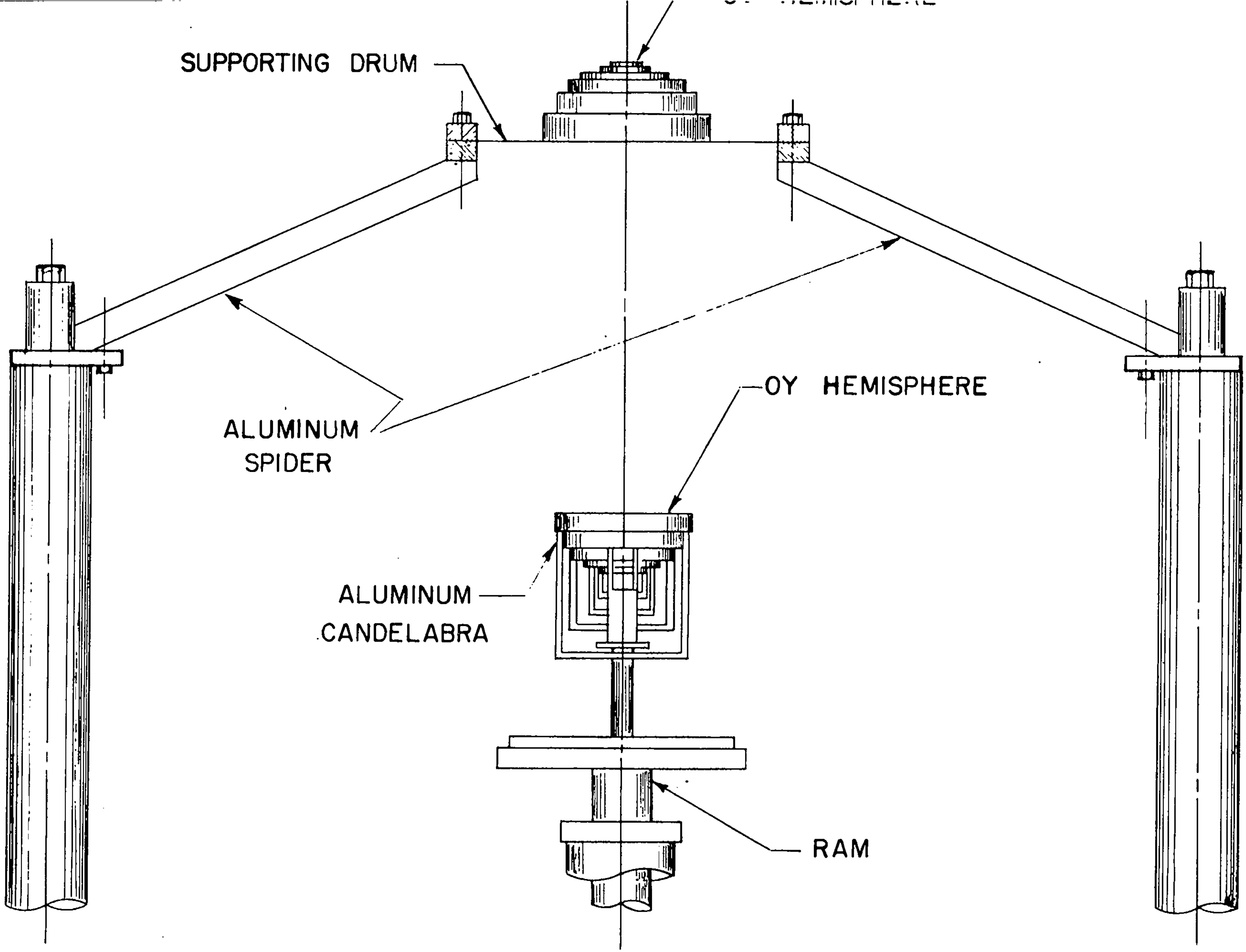

FIG.1

SECTION VIEW OF COMET ASSEMBLY

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TABLE I. Dimensions of Oy and Tu rings.

Ring Diameters: (Tu and Oy-93.5%)

0 - 1.000"	3.980" - 4.750"
1.000" - 1.750"	4.750" - 5.500"
1.750" - 2.500"	5.500" - 6.375"
2.500" - 3.250"	6.375" - 7.000"
3.250" - 3.980"	7.000" - 7.500"

Thicknesses of each diameter: (Tu and Oy-93.5%)

0.140"	0.600"	0.800"
0.240"	0.640"	0.840"
0.340"	0.690"	0.890"
0.590"	0.790"	0.940"

Large size rings: (Tu only)

7.50" - 8.75"	(three 2" high; two 1" high)
8.75" - 9.50"	(three 2" high; two 1" high)
9.50" - 10.37"	(three 2" high; two 1" high)

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compared with 101.7 kg for a solid assembly. The average density for these measurements is therefore about 1.2% low.

The supporting table is shown in Fig. 2. This consists of an aluminum spider assembly supporting a 15" diameter 15 mil stretched stainless steel drumhead. The upper half of the assembly is stacked on this drumhead.

The supporting mechanism located on the hydraulic ram is shown in Fig. 3. This candelabra device consists of a series of coaxial aluminum supports with diameters matching the Oy and Tu rings. These supports can be adjusted in height independently so that the upper surface of the lower assembly is perfectly flat and the lower surface can be any conceivable shape - i.e., flat, elliptical, spherical, conical, or parabolical. This device presents a minimum amount of incidental tamping to the assembly while offering adequate support to the largest assembly possible with the available rings. During assembly, the hydraulic ram raises the lower assembly until its upper surface is in contact with the bottom of the drumhead. The assembly is then complete with the exception of the 15 mil steel diaphragm separating the two halves. The effect of the steel diaphragm on assembly reactivity was tested by multiplication measurements using steel diaphragms 15 mils and 30 mils thick and extrapolating to zero thickness. These tests indicate that the poisoning effect of the steel diaphragm increases M_c by about 0.1%. A similar test in which the amount of supporting material for an untamped assembly was doubled indicates that the incidental tamping effect of the drumhead supports and the candelabra is negligible.

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Fig. 2. Supporting table of the
Comet Assembly.

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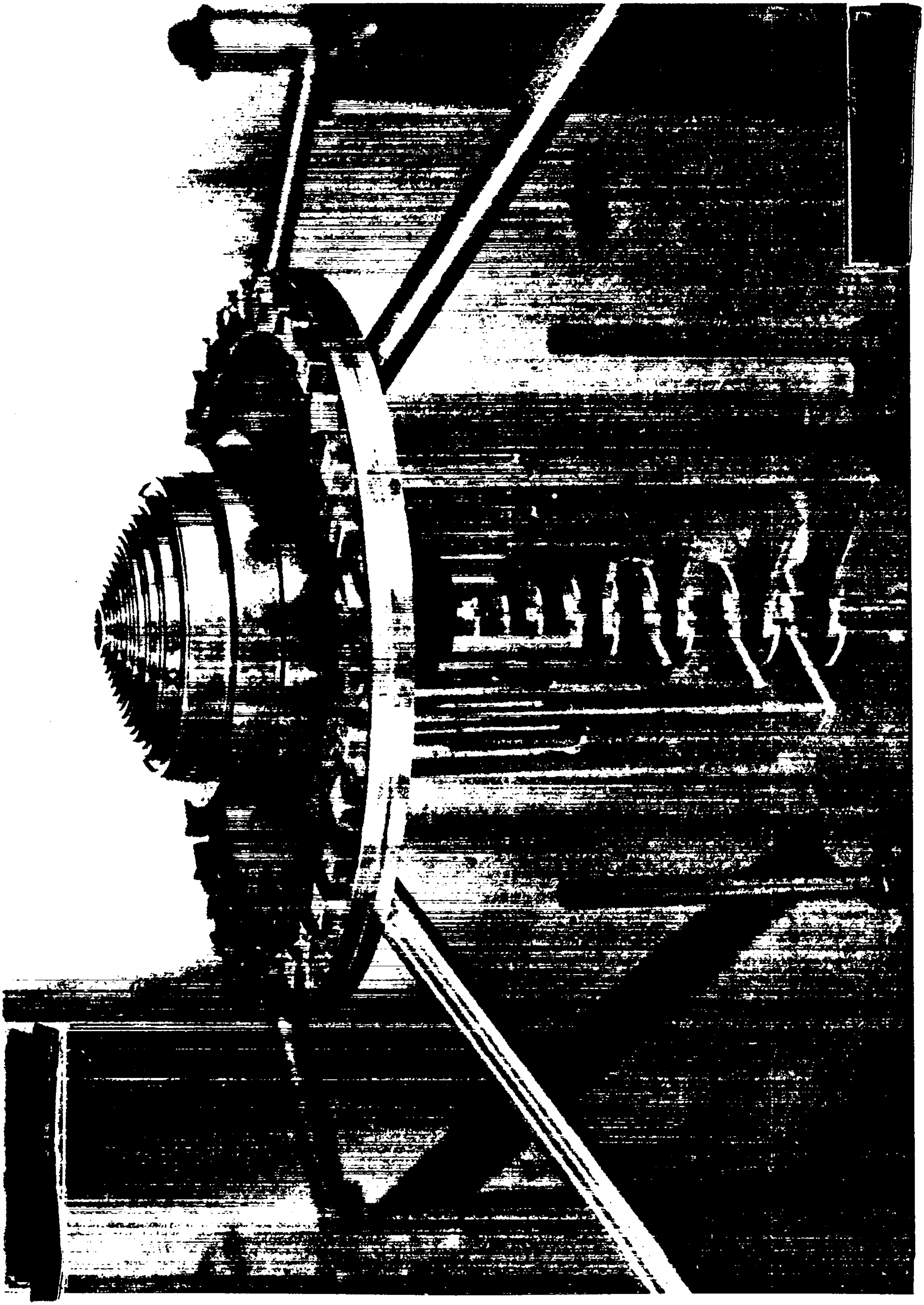

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Fig. 3. Supporting mechanism located
on the Comet ram.

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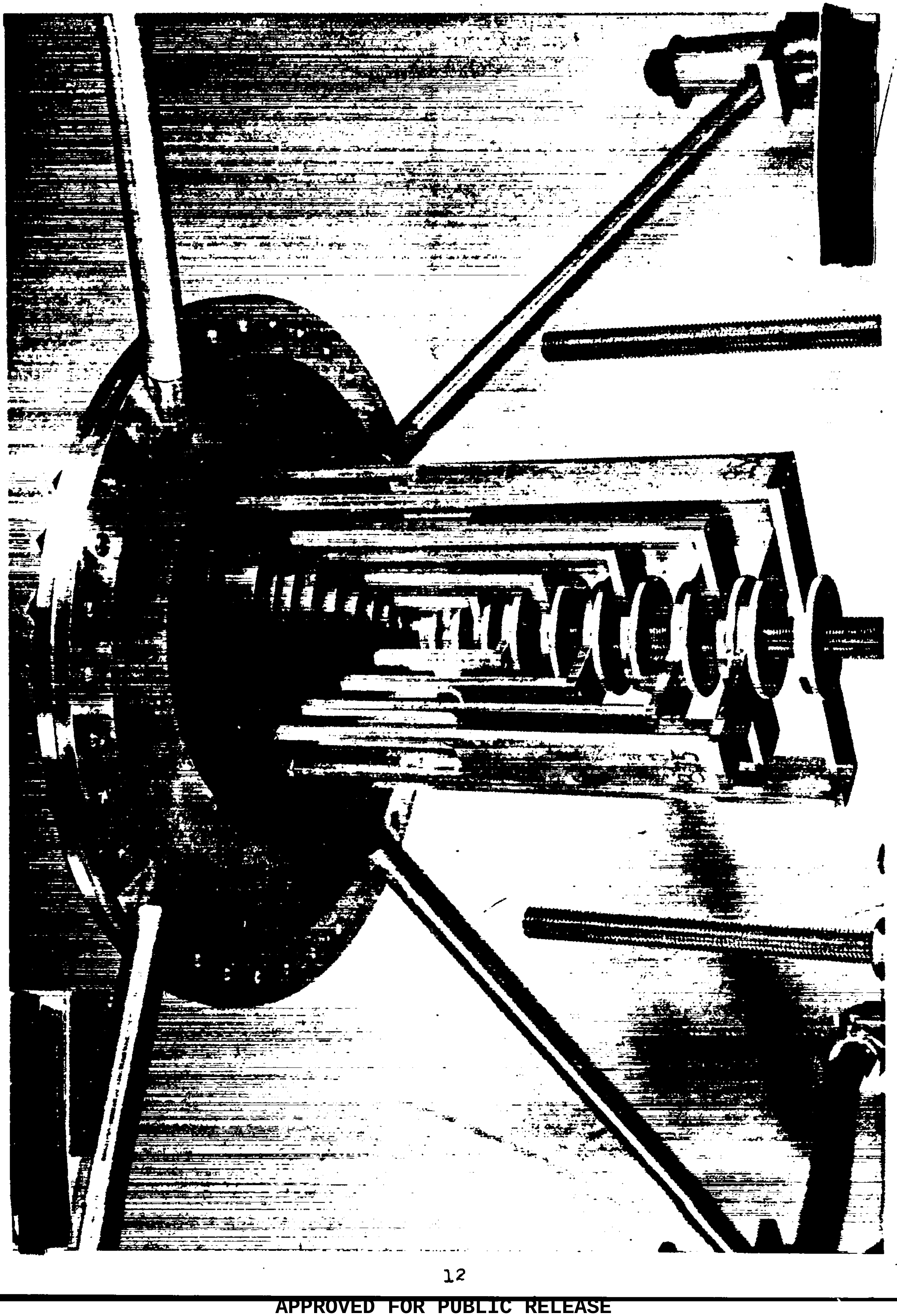

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The first series of measurements was made before the candelabra support was completed, using assemblies in 1.87" and 1.12" thick Tu tampers. The lower half of each assembly was stacked on an aluminum plate one inch thick bolted to the ram platen, with two inches of aluminum spacers between the aluminum plate and the steel platen. The additional tamping effect of the aluminum plate and the steel platen was not known at the time, and it was hoped that check measurements with the candelabra when it became available would show the effect to be negligible. Unfortunately this was not the case, particularly for the pancake type assemblies; and several of these were repeated using the candelabra support, enough points being taken to indicate clearly the reactivity difference near critical (Figs. 8 - 10). The dashed curves in Figs. 11 and 12 represent estimates for the 7.00-inch and 7.50-inch cylinders based on the measured reactivity differences for the 4.75, 5.50, and 6.37-inch cylinders.

The neutron source MF#11 was placed in a cavity located along the axis at the upper surface of the lower assembly. The active material was added on both the top and bottom assembly so that the central position of the source was maintained throughout the experiment. Figure 4 shows a typical pseudospherical assembly stacked on the candelabra and drumhead.

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Fig. 4. Typical pseudospherical assembly stacked on the candelabra and drumhead of the Comet.

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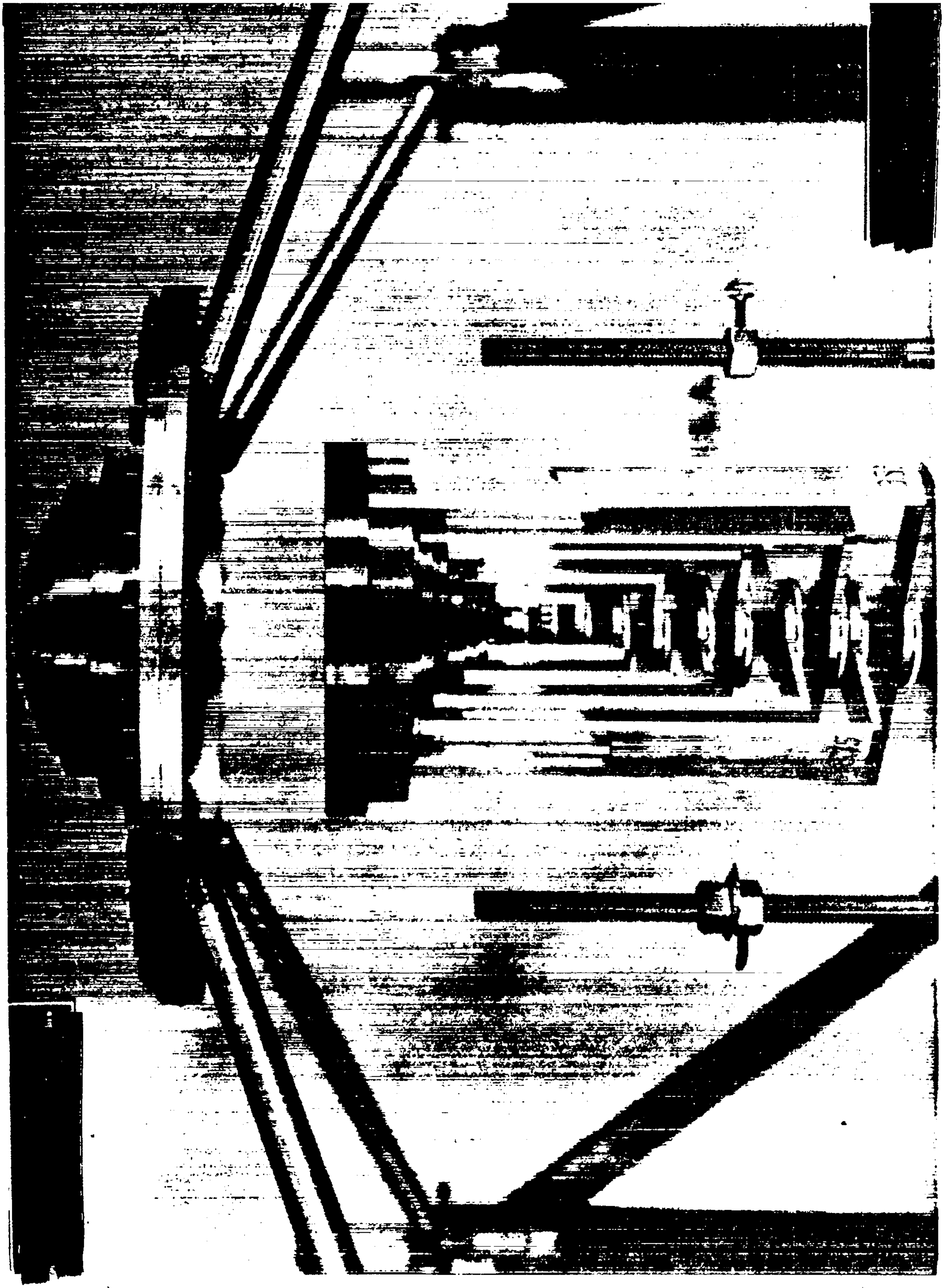

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C. Results

Figures 5 through 12 show critical mass determinations for right circular cylinders of Oy 2.50", 3.25", 3.98", 4.75", 5.50", 6.37", 7.00", and 7.50" in diameter. Measurements were made using untamped Oy cylinders, as well as Oy cylinders tamped by tuballoy 1.12" and 1.87" thick.

Figure 13 illustrates critical mass measurements made using various Oy pseudocylinders in 8 inches thick tuballoy tamper on the Topsy machine. In addition to the data shown, a 4.0-inch diameter equilateral pseudocylinder built up using Oy blocks with a mass of 17.72 kg was just critical in the Topsy machine.

The results of measurements made to determine the critical mass of Oy pseudospheres in thin tuballoy tampers and in no tamper are shown in Fig. 14. Using these results along with the results of previous pseudosphere measurements in thick Tu tampers, a curve showing the variation of critical mass with Tu tamper thickness for Oy spheres is obtained (Fig. 15).

In cases where the amount of data available made such plots feasible, critical mass determinations were also made for specific height-to-diameter ratios (Figs. 16, 17 and 18).

The detailed results of these measurements are summarized in Tables II, III, IV, V and VI. These results are used in Fig. 19 to plot Oy shape factor as a function of cylinder height-to-diameter ratio. Use of a logarithmic scale for the h/d ratios indicates near-symmetry of the curves about h/d = 0.88, which is the height-to-diameter ratio for cylinders which results in the smallest critical mass.

From Fig. 19, shape factor is clearly a function of tamper thickness, and is particularly sensitive for very thin tampers.

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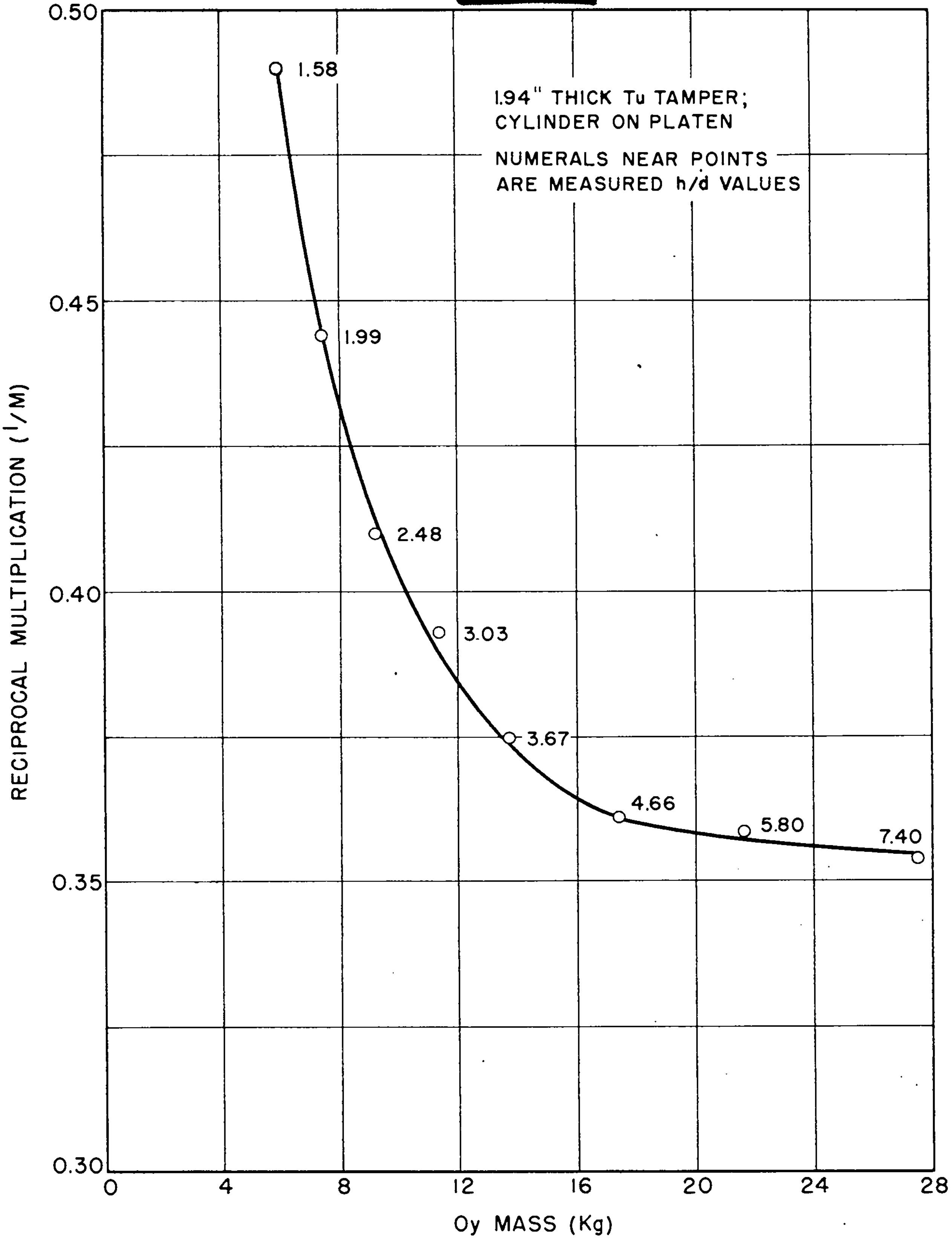

FIG. 5 RECIPROCAL MULTIPLICATION MEASUREMENTS ON 2.50" DIAMETER Oy CYLINDER

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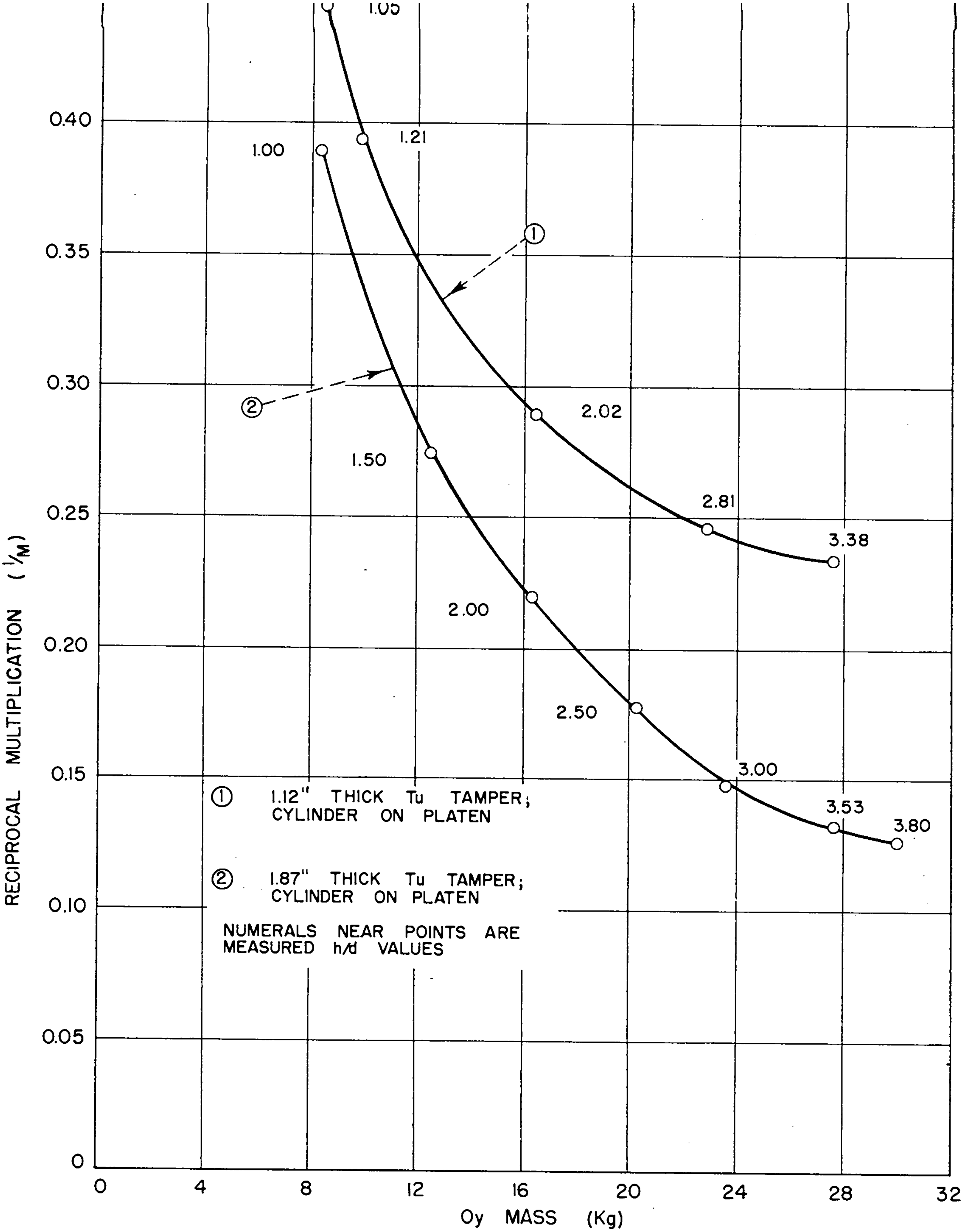

FIG. 6 RECIPROCAL MULTIPLICATION MEASUREMENTS ON 3.25" DIAMETER Oy CYLINDERS

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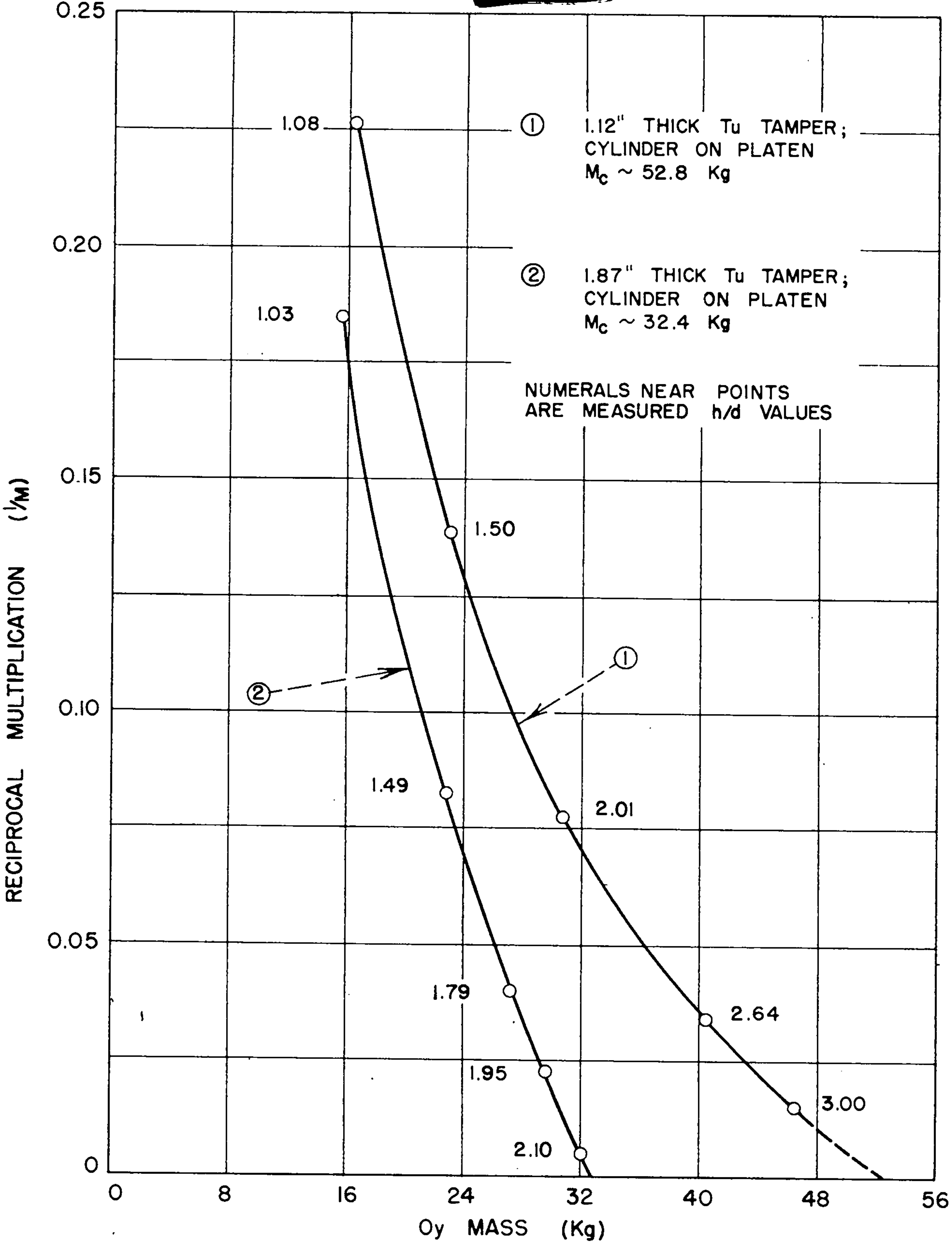

FIG. 7 RECIPROCAL MULTIPLICATION MEASUREMENTS ON 3.98" DIAMETER Oy CYLINDERS

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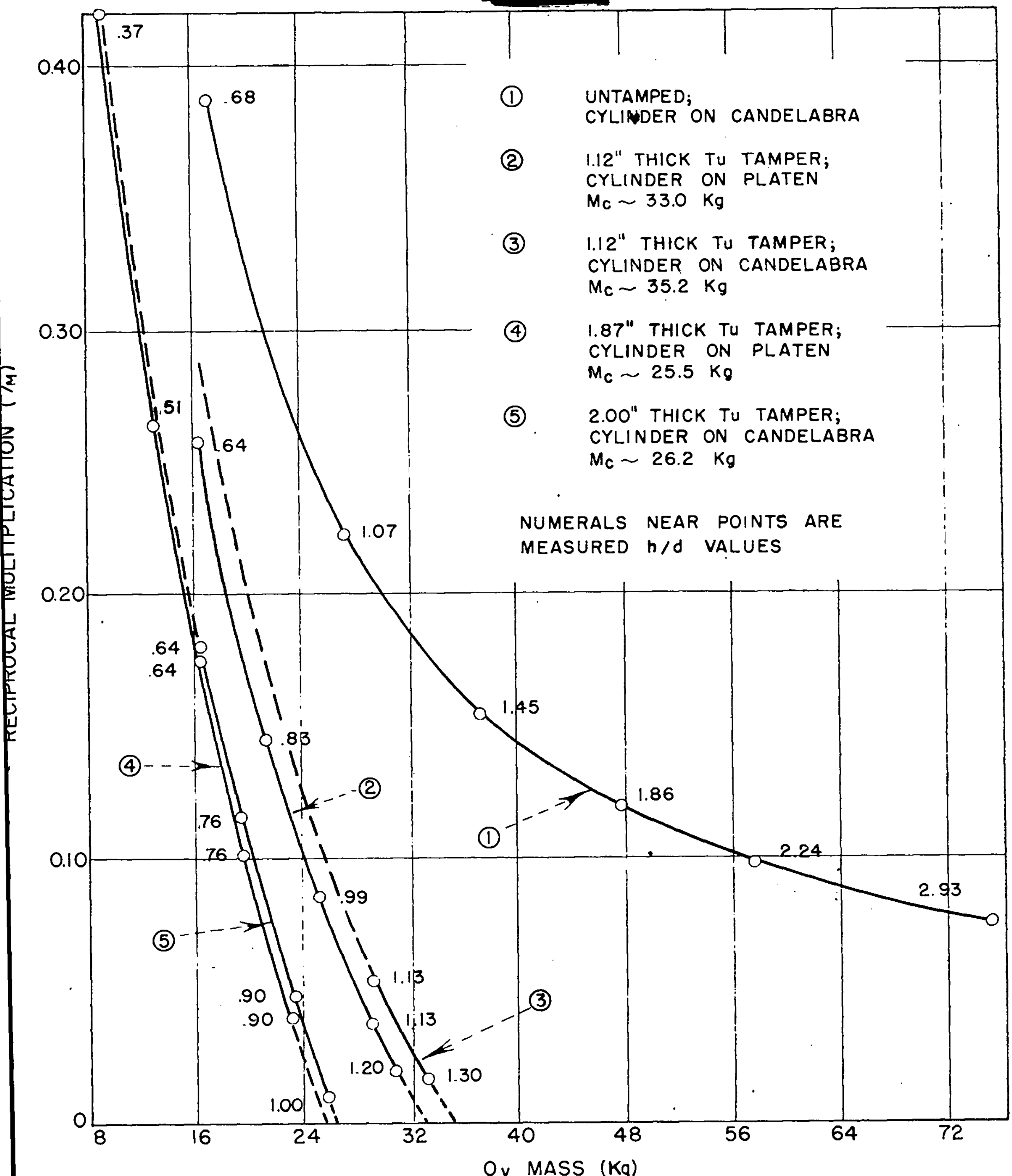

FIG. 8 RECIPROCAL MULTIPLICATION MEASUREMENTS ON 4.75" DIAMETER Oy CYLINDERS

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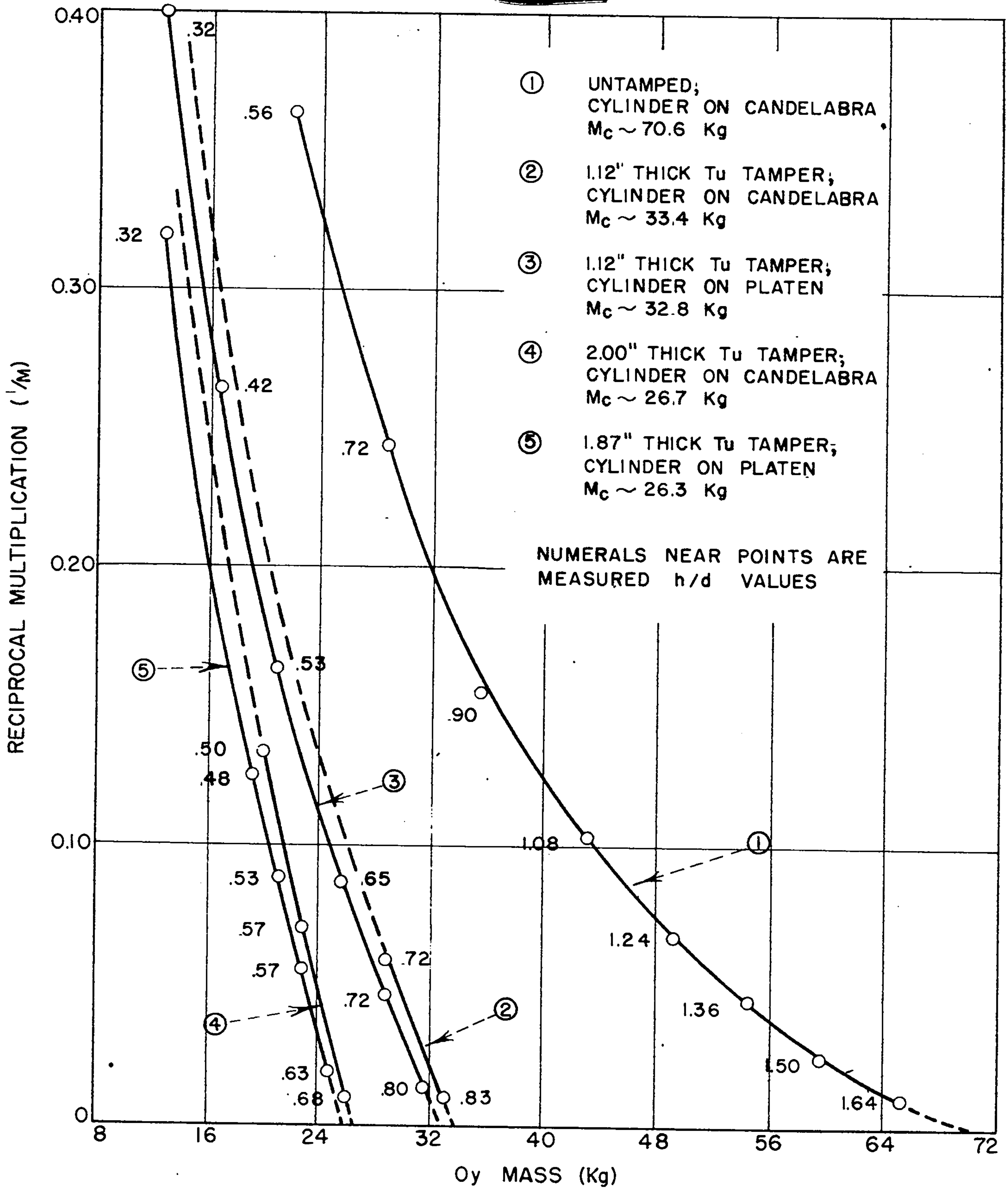

FIG. 9 RECIPROCAL MULTIPLICATION MEASUREMENTS ON 5.50" DIAMETER Oy CYLINDERS

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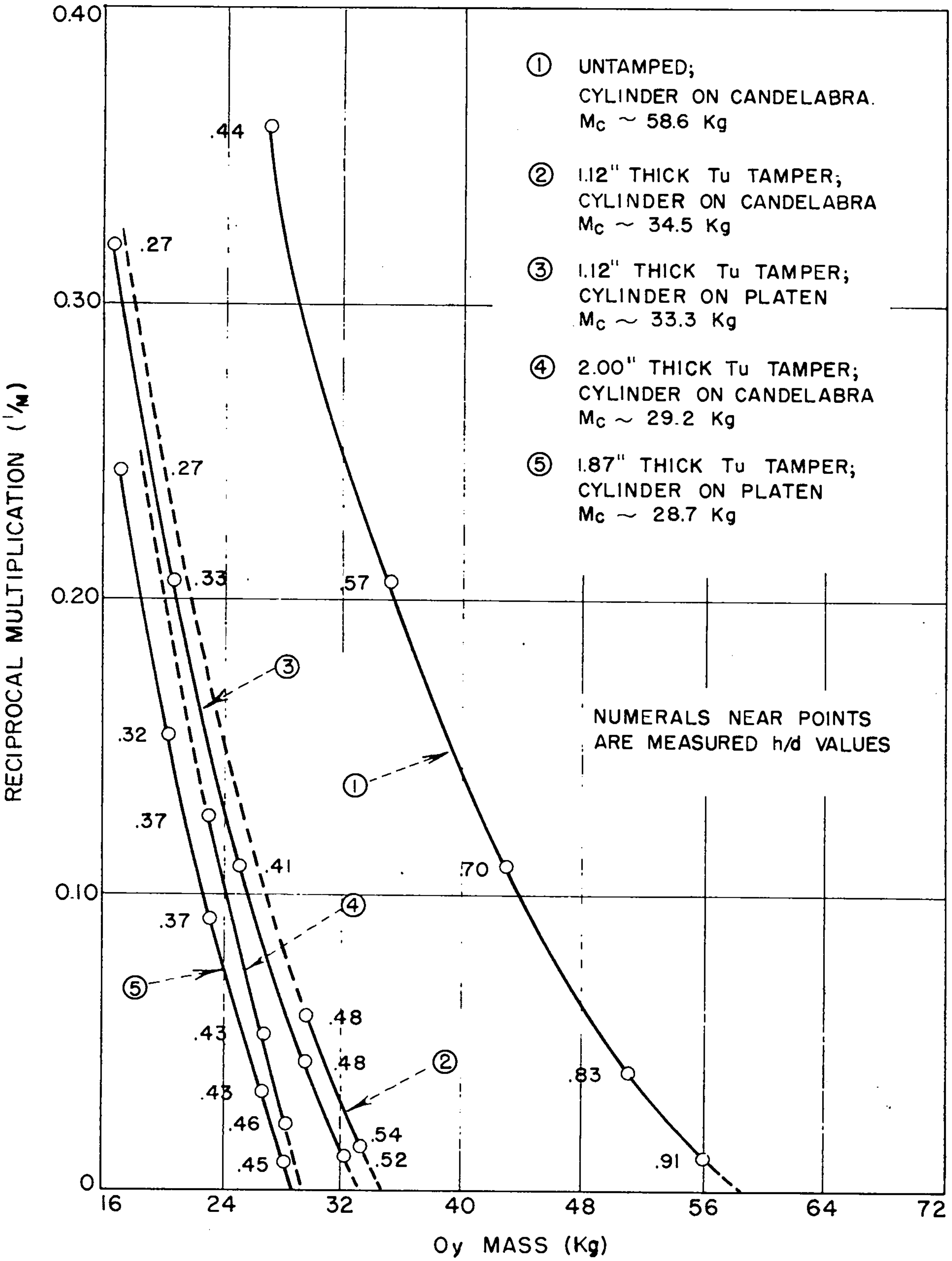

FIG. 10 RECIPROCAL MULTIPLICATION MEASUREMENTS ON 6.37" DIAMETER Oy CYLINDERS

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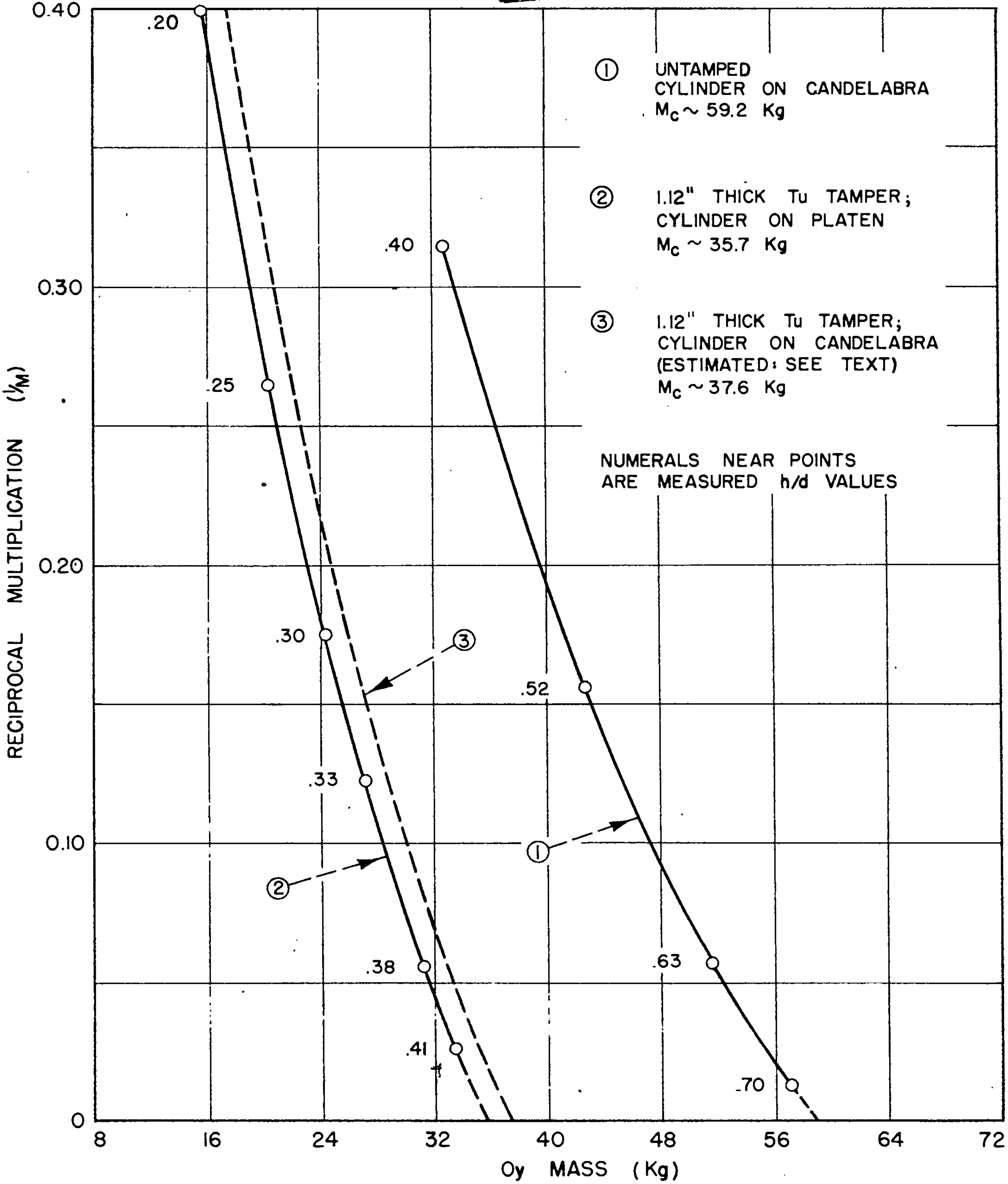

FIG. 11 RECIPROCAL MULTIPLICATION MEASUREMENTS ON 7.00" DIAMETER Oy CYLINDERS

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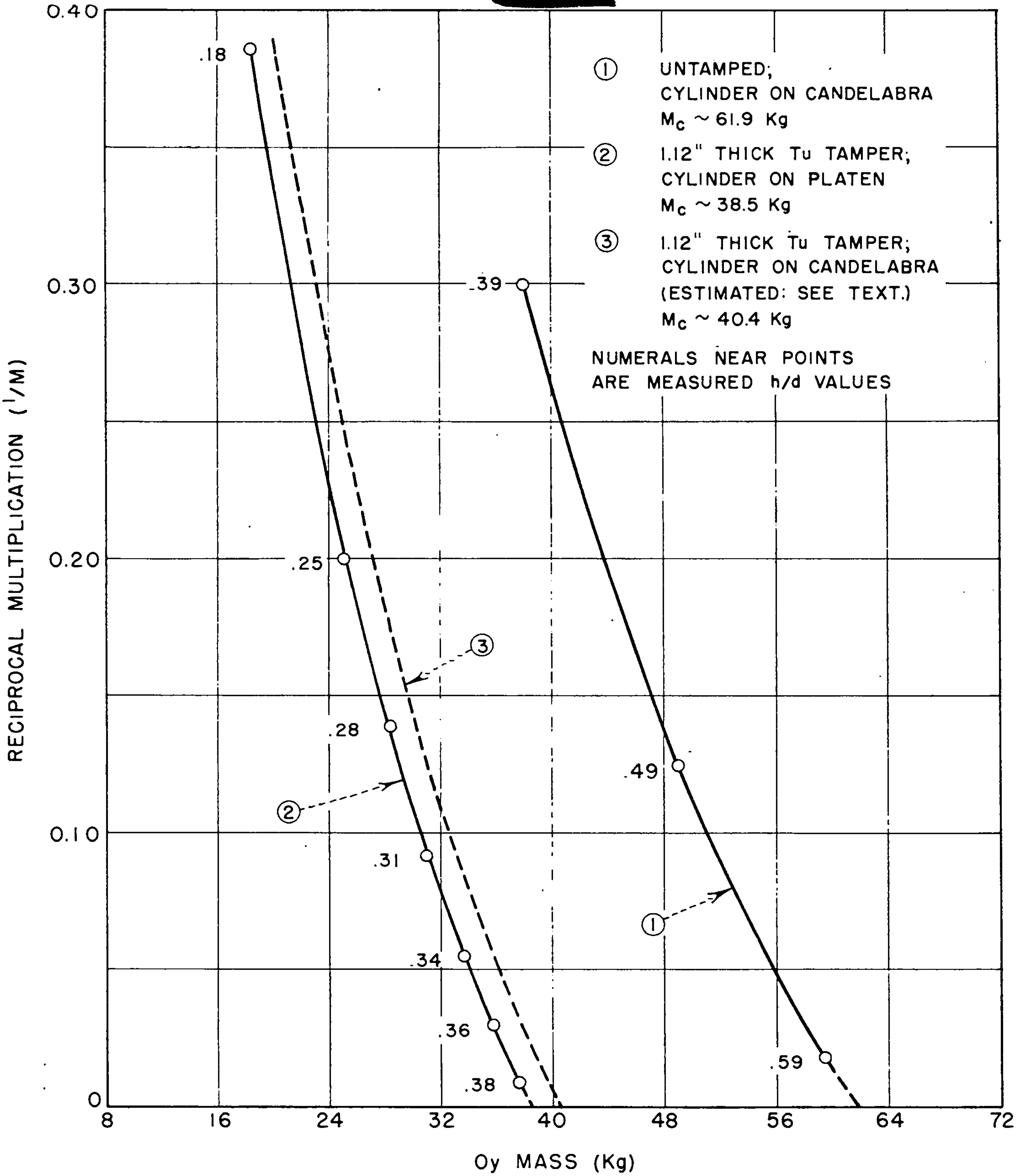

FIG. 12 RECIPROCAL MULTIPLICATION MEASUREMENTS
ON 7.50" DIAMETER Oy CYLINDERS

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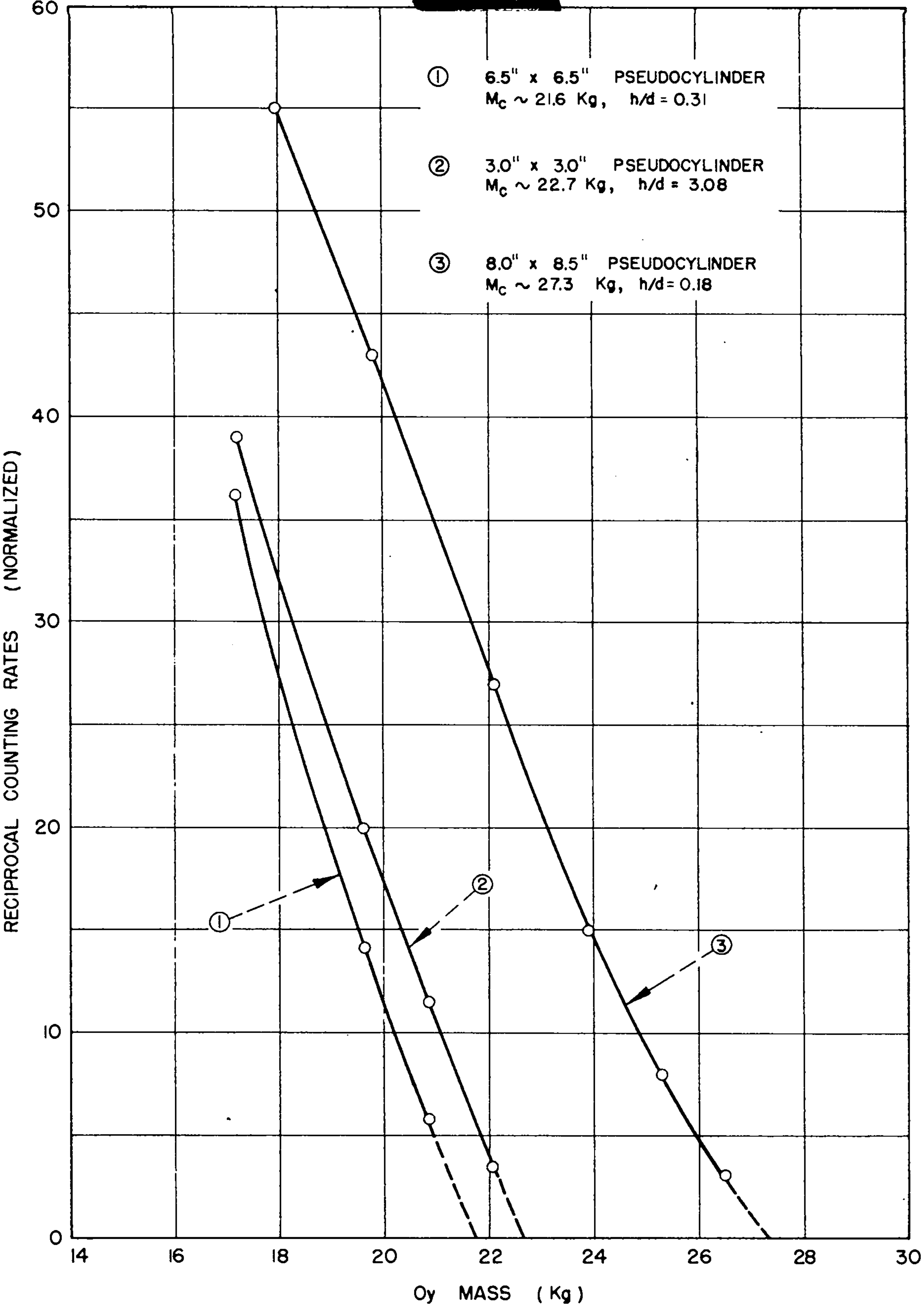

FIG. 13 RECIPROCAL COUNTING RATE MEASUREMENTS ON Oy PSEUDOCYLINDERS IN 8.0" THICK Tu TAMPER

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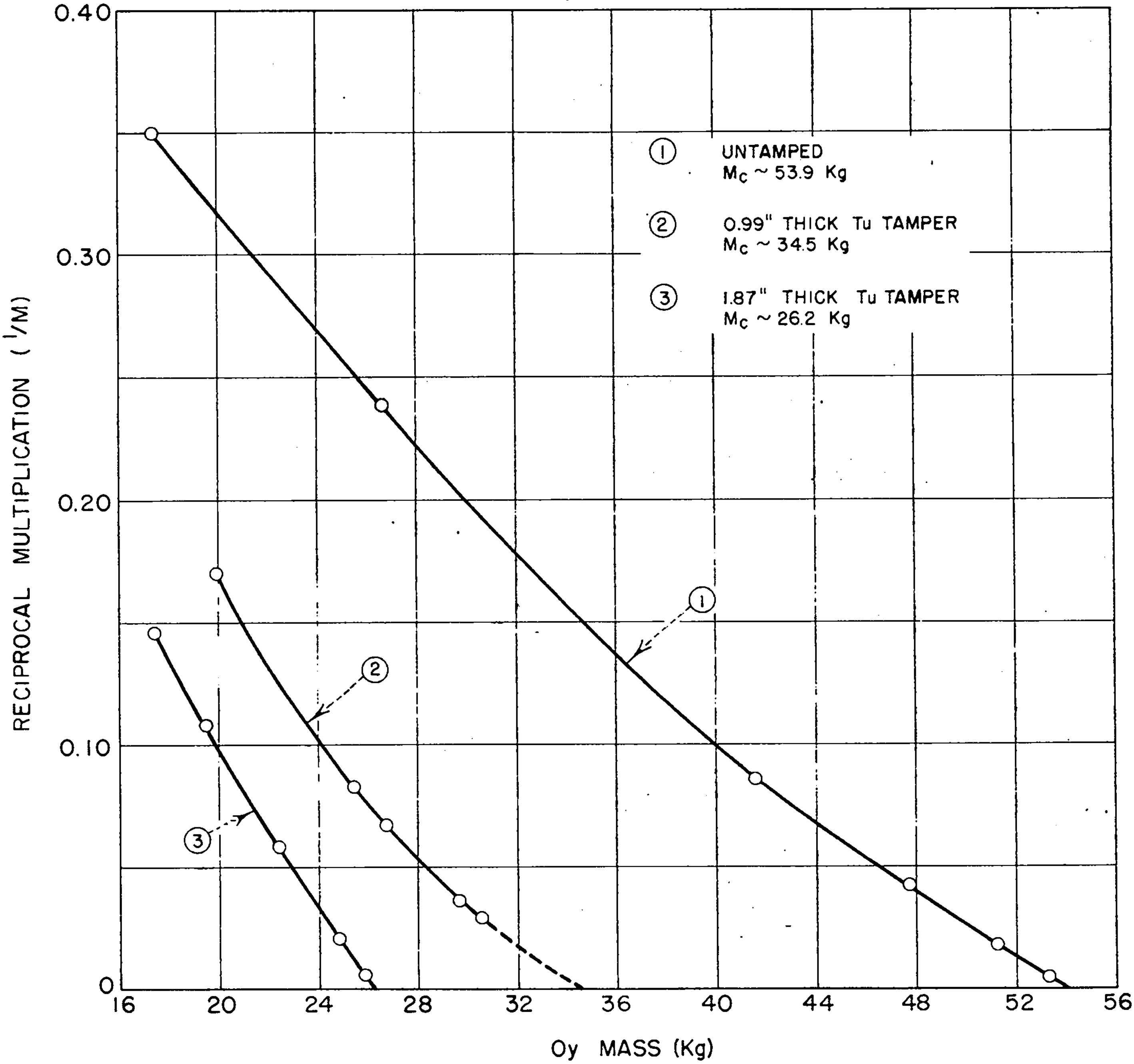

FIG. 14 RECIPROCAL MULTIPLICATION MEASUREMENTS ON Oy PSEUDOSPHERES

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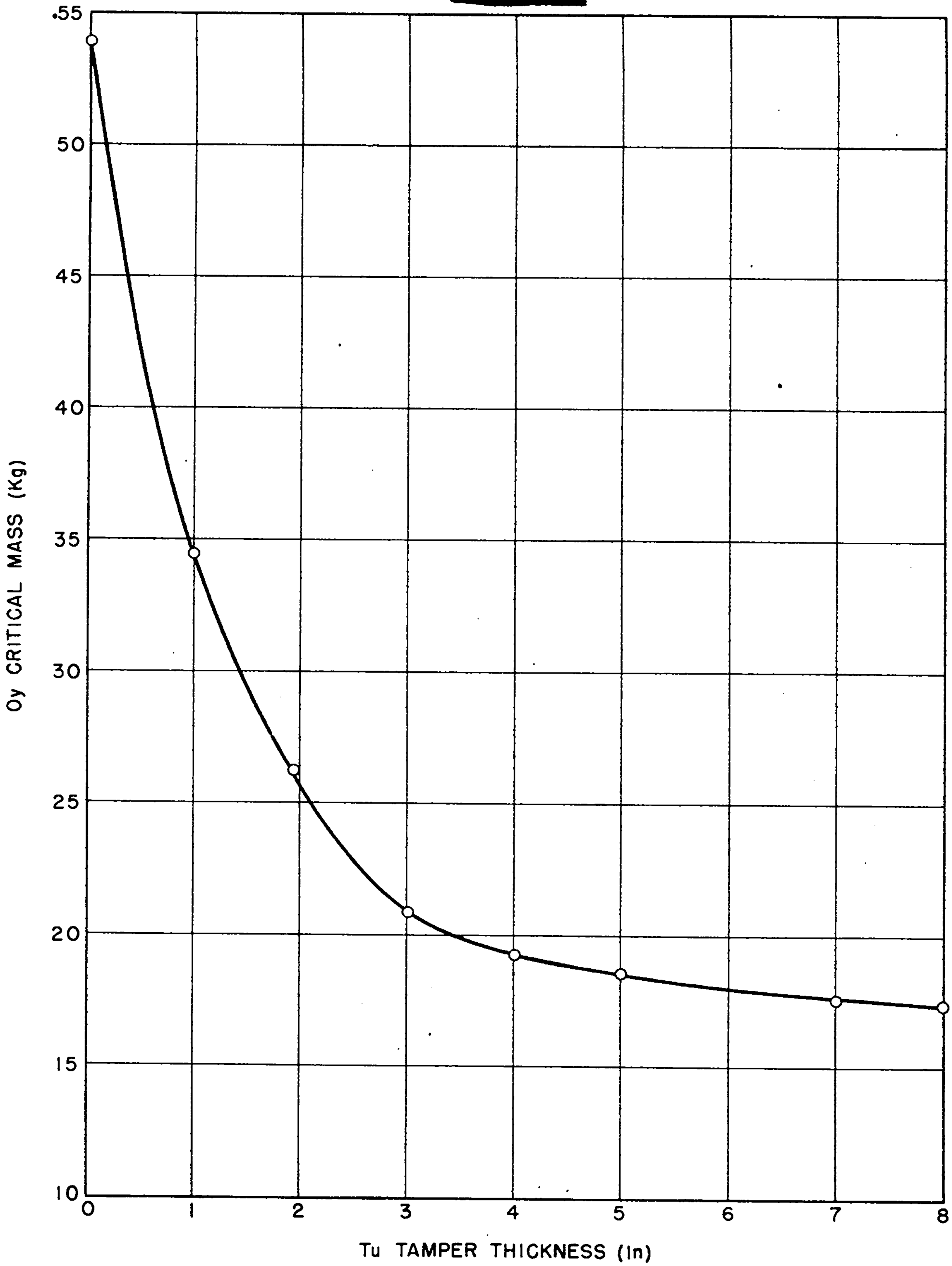

FIG. 15 Oy CRITICAL MASS VS Tu TAMPER THICKNESS FOR SPHERES

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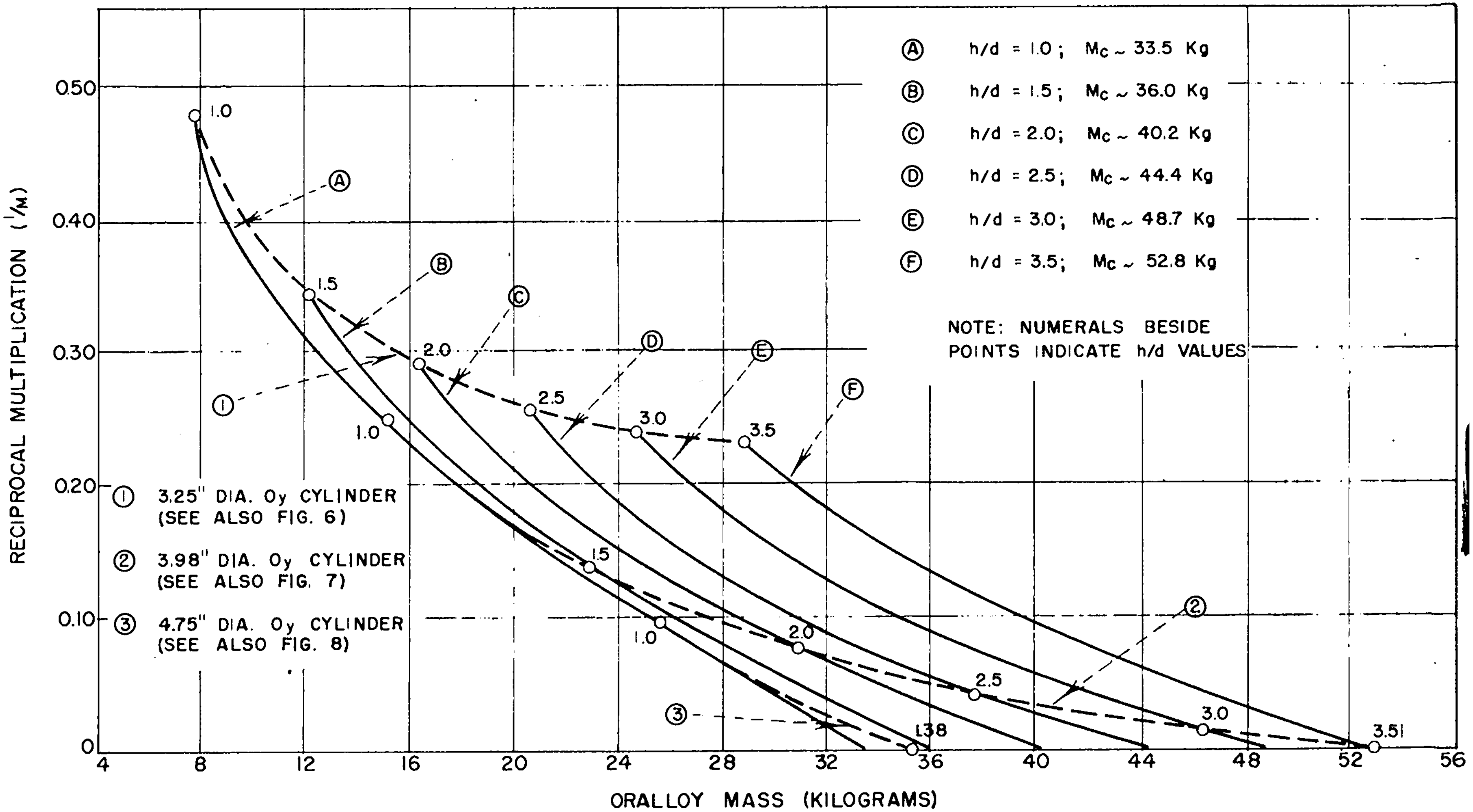

FIG. 16 CRITICAL MASS DETERMINATIONS FOR ORALLOY CYLINDERS WITH CONSTANT h/d RATIOS IN 1.12" THICK TUBALLOY TAMPERS (h/d > 1.0)

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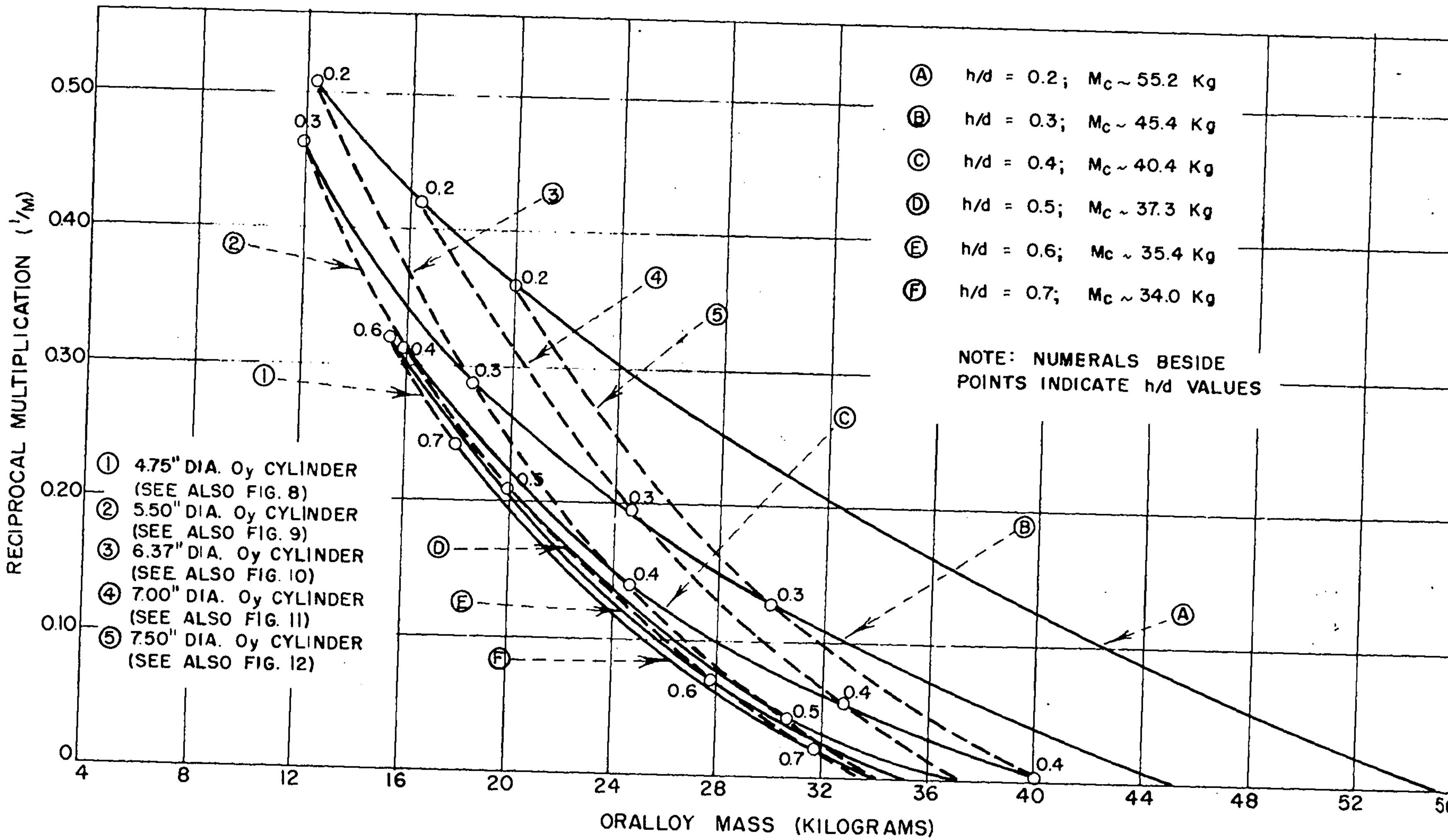

FIG. 17 CRITICAL MASS DETERMINATIONS FOR ORALLOY CYLINDERS WITH CONSTANT h/d RATIOS IN 1.12" THICK TUBALLOY TAMPERS

(h/d < 1.0)

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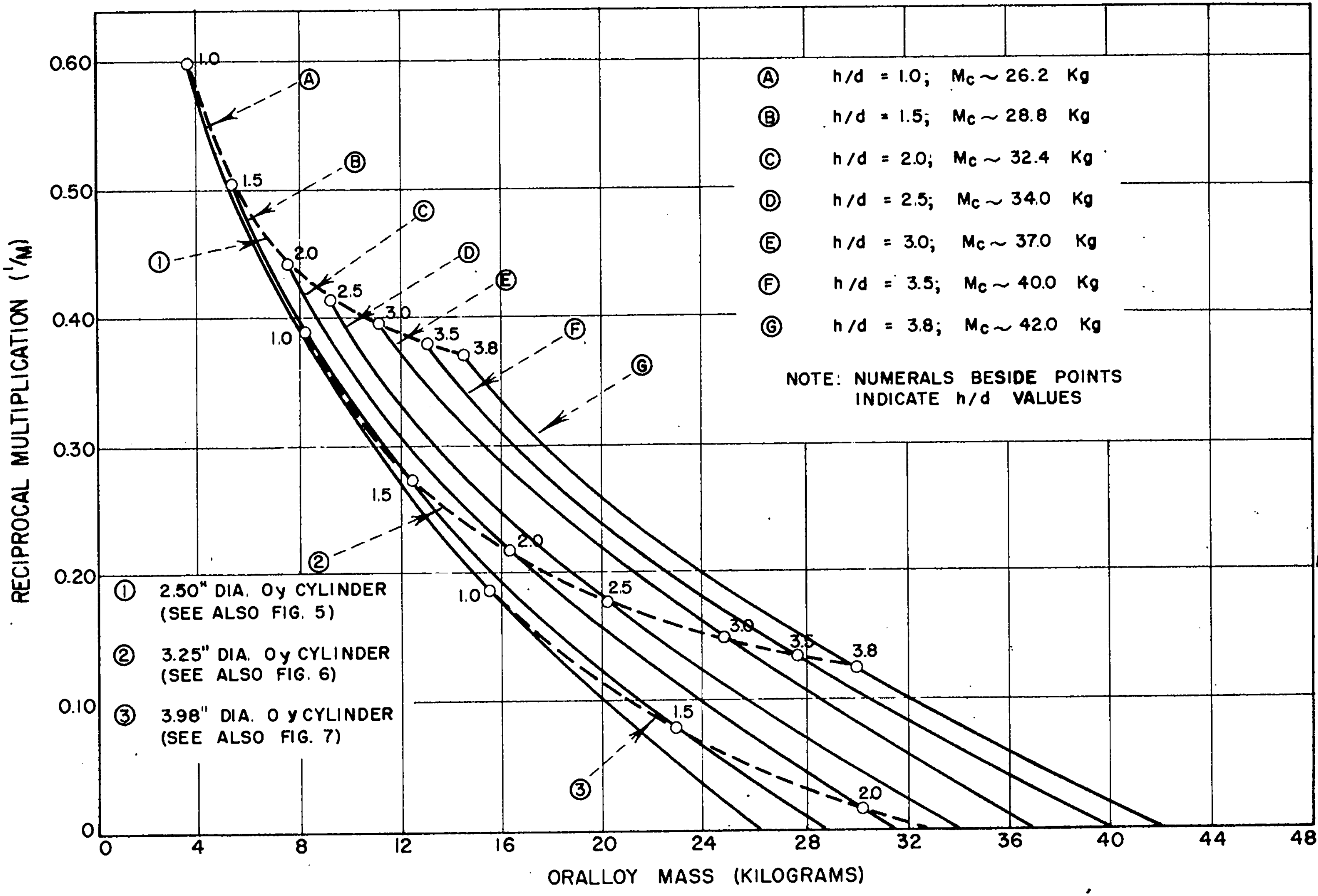

FIG. 18 CRITICAL MASS DETERMINATIONS FOR ORALLOY CYLINDERS WITH CONSTANT h/d RATIOS IN 1.87" THICK TUBALLOY TAMPER

(h/d > 1.0)

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TABLE III. Shape factor data on oralloy cylinders in 1.12" Tu tamper.

Ratio of Cylinder Height to Diameter	M_c Cylinder (kg)	M_c Sphere (kg)	Shape Factor	Reference
0.20	55.2	32.4	0.587	Fig. 17
0.30	45.4	32.4	0.715	Fig. 17
0.40	40.4	32.4	0.802	Fig. 17
0.50	37.3	32.4	0.868	Fig. 17
0.60	35.4	32.4	0.915	Fig. 17
0.70	34.0	32.4	0.953	Fig. 17
0.84	33.4	32.4	0.971	Fig. 17
1.00	33.5	32.4	0.967	Fig. 16
1.38	35.2	32.4	0.920	Figs. 8 & 16
1.50	36.0	32.4	0.899	Fig. 16
2.00	40.2	32.4	0.804	Fig. 16
2.50	44.4	32.4	0.729	Fig. 16
3.00	48.7	32.4	0.665	Fig. 16
3.51	52.8	32.4	0.614	Figs. 7 & 16

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TABLE IV. Shape factor data on oralloy cylinders in 1.87" and 2.00" Tu tamper.

Cylinder Diameter (in)	Height at Critical (in)	h/d at Critical (estimated)	Tu Tamper Thickness (in)	M_c Cylinder (kg)	M_c Sphere (kg)	Shape Factor	Reference
6.37	2.99	0.47	2.00	29.2	25.4	0.870	Fig. 10
5.50	3.68	0.67	2.00	26.7	25.4	0.950	Fig. 9
4.75	4.89	1.03	2.00	26.2	25.4	0.970	Fig. 8
**	**	1.50	1.87	28.8	26.2	0.910	Fig. 18
**	**	2.00	1.87	31.5	26.2	0.832	Fig. 18
3.98	8.60	2.15	1.87	32.4	26.2	0.810	Figs. 7 & 18
**	**	2.50	1.87	34.0	26.2	0.770	Fig. 18
**	**	3.00	1.87	37.0	26.2	0.708	Fig. 18
**	**	3.50	1.87	40.0	26.2	0.655	Fig. 18
**	**	3.80	1.87	42.0	26.2	0.624	Fig. 18

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TABLE V. Shape factor data on oralloy pseudocylinders in 8.0" Tu tamper.

Cylinder Diameter (in)	Height at Critical (in)	h/d at Critical (estimated)	M_c Cylinder (kg)	M_c Sphere (kg)	Shape Factor	Reference
8.3	1.50	0.180	27.3	17.42	0.640	Fig. 13
6.5	2.00	0.308	21.6	17.42	0.805	Fig. 13
4.0	4.00	1.00	17.72	17.42	0.982	Page 16
3.0	9.25	3.08	22.7	17.42	0.768	Fig. 13

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TABLE VI. Critical mass data for oralloy spheres, untamped, and in various tuballoy tampers.

Tu Tamper Thickness (inches)	Sphere Diameter (inches)	Critical Mass (kg)
Untamped	6.96	53.9
0.99	6.00	34.5
1.87	5.47	26.2
3.0	5.07	20.9
4.0	4.94	19.3
5.0	4.88	18.6
7.0	4.79	17.6
8.0	4.76	17.4

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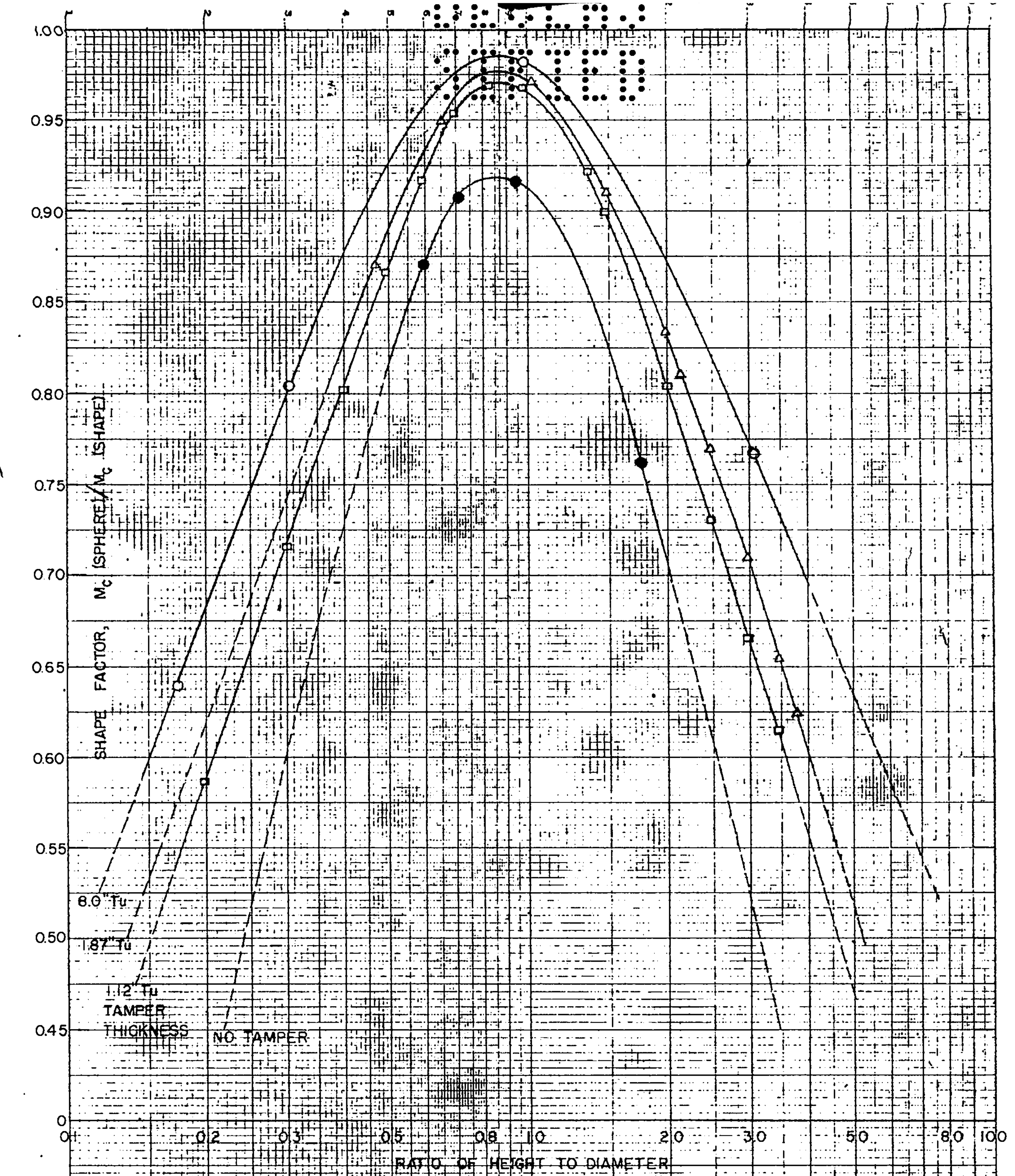

FIG 19 SHAPE FACTOR DATA FOR ORALLOY CYLINDERS IN VARIOUS TUBALLOY TAMPERS

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