HDC-1703

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GENERAL ELECTRIC COMPANY

HANFORD, WASHINGTON

NUMBER OF EFFECTIVE TUBES IN THE "G" PILE

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Distribution:

#1	PE Lowe/HE Grantz	#5	D&C File
#2	HS Isbin/CA Sege	#7	700 File
#3	GH Syrovy	#8	Yellow File
#4	WK Woods	#9	Extra
#5	P Gast	#10	Extra

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NUMBER OF EFFECTIVE TUBES FOR THE "G" PILE

Summary:

The method for calculating relative heat generation as a function of radius of an equivalent "G" type cylindrical pile for specified inhours of ideal flattening is given in INDC-3833. The report has been extended to include flattening curves for the range of zero to 800 inhours. (See Fig. I)

Equations have been integrated to determine average relative power per tube for a fixed amount of flattening. The following empirical equation, based upon a plot of the values obtained from the analytical equation, relates average relative power per tube and number of effective tubes to inhours of flattening.

$$n' = \frac{1115 + \frac{945\,F}{267+F}}{2220} = \frac{N}{2220}$$

where F = Inhours of flattening

n' = Average relative power per tube

N = Number of effective tubes

2220 = Total number of tubes for the "G" pile

Average relative power per tube, number of effective tubes, kw per effective tube, and maximum temperature rise per tube for 34.6 gpm water flow rate per effective tube are tabulated in Table I for several values of flattening of an 800 MW - 2220 tube pile.

Table I *

CHARACTERISTICS OF MAXIMUM PERFORMANCE TUBES
FOR AN 800 MW-2220 TUBE PILE

F Inhours of Flattening	n' Average Relative Power Per Tube	N No. of Effective Tubes	KW Per Effective Tube	Max. Temp. Rise of Water/Tube, °F. (34.6 gpm Flow Rate)
0	.503	1115	717	141.5
100	.618	1372	583	115.1
200	.676	1501	533	105.2
400	.751	1667	480	94.7
500	.778	1727	463	91.4
600	.797	1769	452	89.2
700	.813	1805	443	87.4
800	.831	1845	434	85.7

* Table I based upon analytical calculations.

Discussion:

The method for calculating average power per tube for a specified amount of flattening is given below. Average power per tube was taken relative to a value of 1.00 for a maximum performance tube. The constants to be used in the analytical equations are tabulated in Table II for several values of flattening. An empirical equation (Equation 3), which relates average relative power per tube to inhours of flattening, was fitted to the curve obtained by solving the analytical equations (Equations 1 and 2) for various amounts of flattening. The values of average relative power per tube calculated from the empirical equation agree with the values obtained by solution of the analytical equations within 1.5%. (See Table III).

$$\text{Total Relative Power} = \pi R_f^2 + \int_{R_f}^{565} n \, 2\pi r \, dr$$

where R_f = radius of flattened zone, cm. (See Table II)

n = relative power per tube

r = radius, cm.

565 = radius of an equivalent cylindrical pile for a 2220 tube square array

Total Relative Power contains the conversion factor for the number of tubes per cm^2.

$$\text{Total Relative Power} = \pi R_f^2 + \int_{R_f}^{565} A \left[J_o(br) + K N_o(br) \right] 2\pi r \, dr$$

where b, A, and K are constants (See Table II)

$$\text{Total Relative Power} = \pi R_f^2 + \frac{2\pi A}{b^2} \left[br \, J_1(br) + K \, br \, N_1(br) \right]_{R_f}^{565} \qquad (1)$$

$$\text{Average Relative Power per Tube} = \frac{\text{Total Relative Power}}{\pi (565)^2} = n' \qquad (2)$$

Table II

TABULATION OF CONSTANTS TO BE USED IN EQUATION (1)

Inh of Flattening	R_f (cm)	b (cm^{-1})	K	A
0	0	3.93×10^{-3}	0	1
100	164	4.40×10^{-3}	0.3160	1.218
200	223	4.83×10^{-3}	0.646	1.212
400	231	5.59×10^{-3}	1.738	0.843
800	362	6.83×10^{-3}	-3.538	-0.552

[redacted]

The equation for the number of effective tubes for the "G" pile was patterned after the one used for the present piles:

$$n'' = \frac{971 + \frac{832F}{320+F}}{2004}$$

n'' = average relative power per tube for present piles.

2004 = total number of tubes in present piles

The equation developed for "G" pile is:

$$n' = \frac{1115 + \frac{945F}{267+F}}{2220} \qquad (3)\ *$$

The values of n' calculated from the empirical equation (3) for various amounts of flattening are compared with those obtained by integration (equations 1 and 2) in Table III.

Table III

COMPARISON BETWEEN VALUES OBTAINED FROM EQUATION (3) AND ANALYTICAL VALUES OF AVERAGE RELATIVE POWER FOR A 2220 TUBE PILE

Inbourn of Flattening	n', Average Relative Power per Tube	
	Empirical Value (Eq'n. 3)	Analytical Value (Eq'ns 1&2)
0	.503	.503
100	.618	.618
200	.684	.676
400	.757	.751
600	.796	.797
800	.822	.831

* The term, $\frac{945F}{267+F}$, may be approximated by the simpler term, $\frac{10F}{.01F+3}$. Other constants can be evaluated to make the equation fit the calculated results at three points.

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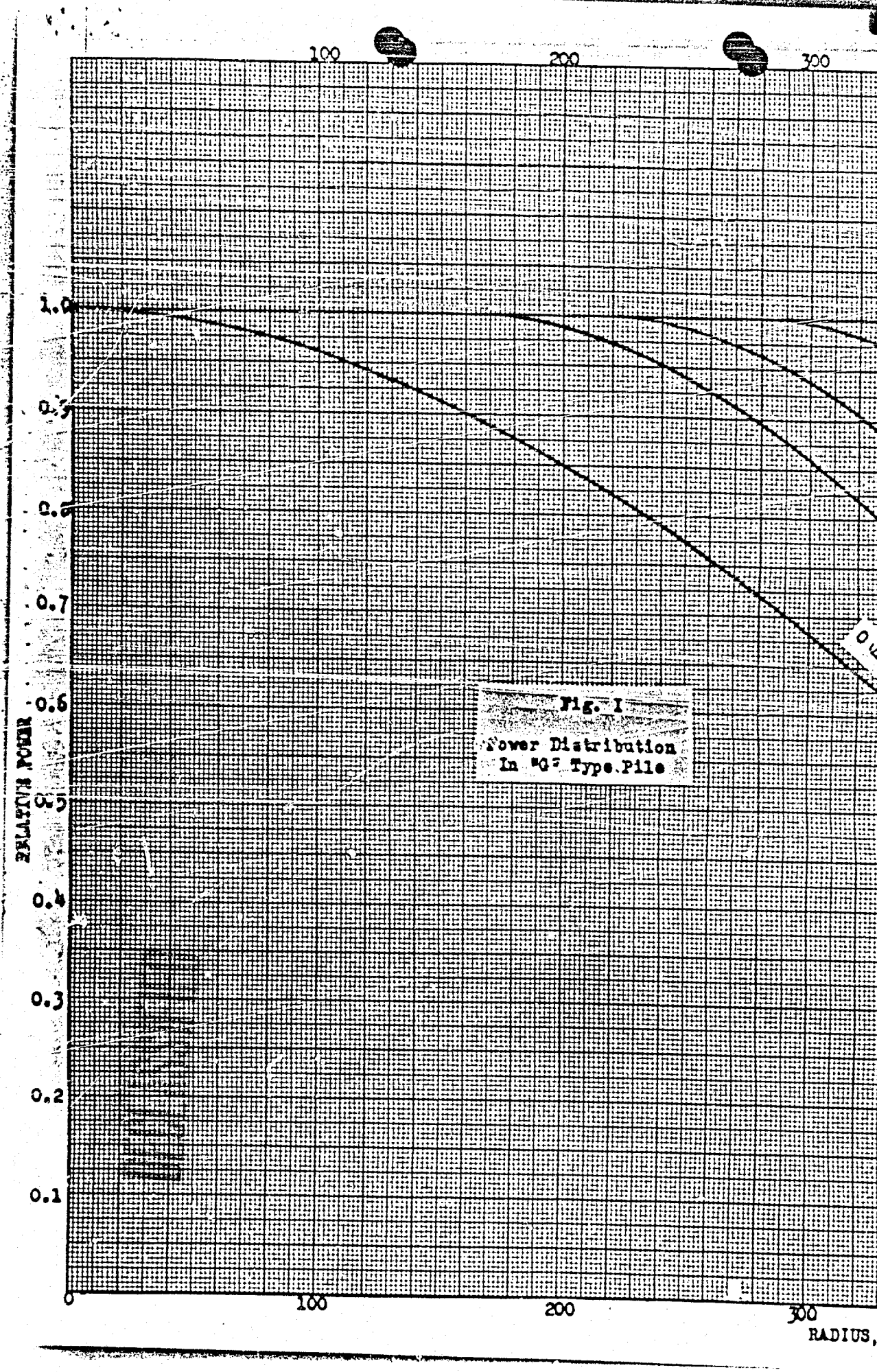
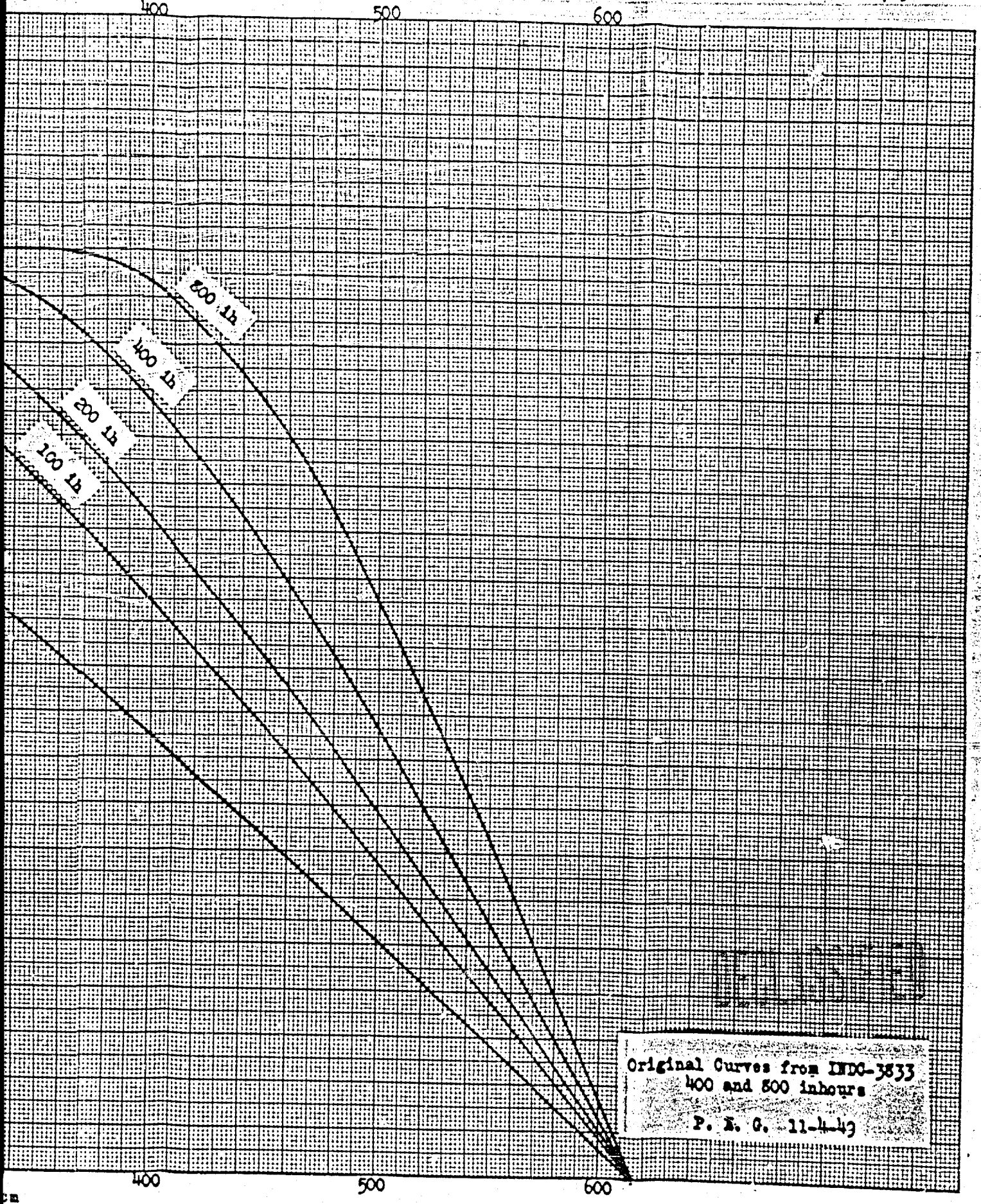


Fig. I

Power Distribution
In "G" Type Pile



Original Curves from NDC-3833
400 and 500 inhours

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