

DATE: March 21, 1972

TO : MED File

FROM : John Alcorn

SUBJECT: DC Magnetization (B vs H) Curves used by SLAC's Nutcracker Program.

Since time immemorial, and specifically since the publication in April 1966 of SLAC Report No. 56 (A Computer Code for Variable Permeability Magnetostatic Field Problems) by Burfine, L. Anderson, and H. Brechna, we users of NUTCRACKER have been told and unquestioningly believed that the B vs H curve built into it represented a "typical annealed low carbon steel, such as C1010."

We now know differently -- such is the price of unquestioned beliefs.

It turns out that the B vs H curve actually employed by NUTCRACKER from initial issue to the present (it is not set up for regular user input B vs H data) was apparently based upon that found in Metals Handbook, Vol. I (Am Soc. for Metals), DC Magnetization Curve No. 4, "Ingot Iron, annealed." According to my metallurgy book, "ingot iron" means "relatively pure material of 99.75+ percent iron."

A more realistic curve for most relatively high quality annealed mild steel applications might be that given in the U.S. Steel Engineering Manual for Electrical Steel Sheets, 4th Ed., p. 258, Curve No. 4 (Hot Rolled Low Carbon Steel Plate, C1010, annealed at 1500° F).

However, in order to be somewhat more cautious (and incidentally to more accurately represent the product which we will be getting for the Leith Solenoid project), I have prepared for NUTCRACKER data from the following source:

Magnetic Properties of Plain Carbon Steel Castings, Data Sheet No. 4 (by Steel Casting Developments Committee, U.K.), Feb. 61: Table III, Steel No. 2, 0.14% C. Cast and Annealed Plain Carbon Steel.

This data is now installed on the NUT V5 disk, and is presented in this memo in curve and numerical form available from either Steve St. Lorant or me.

JA:mz

cc: Larry Brown
W. Brunk
J. Voss
D. Leith
Davies-White
Joe Cobb

LEITH 2M DIA x 25KG
SOLENOID - UAMH BINN

Alum

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REVISION OF NUTCRACKER IRON
PERMEABILITY (B vs. H) DATA

DATA MARKED "OLD" BELOW INDICATES
THAT USED BY NUTCRACKER FROM
FIRST ISSUE THROUGH VERSION 5.5

DATA MARKED "NEW" BELOW IS FOR
ANNEALED CARBON STEEL CASTINGS
OF THE FOLLOWING COMPOSITION (%):

C: 0.14; Si: 0.39; Mn: 0.60; S: 0.029;
P: 0.041; Ni: 0.09; Cr: 0.02; Mo: 0.003

DATA FROM: MAGNETIC PROPERTIES
OF PLAIN CARBON STEEL CASTINGS,
DATA SHEET 4, STEEL CASTINGS
DEVELOPMENT COMMITTEE (U.K.), 1961

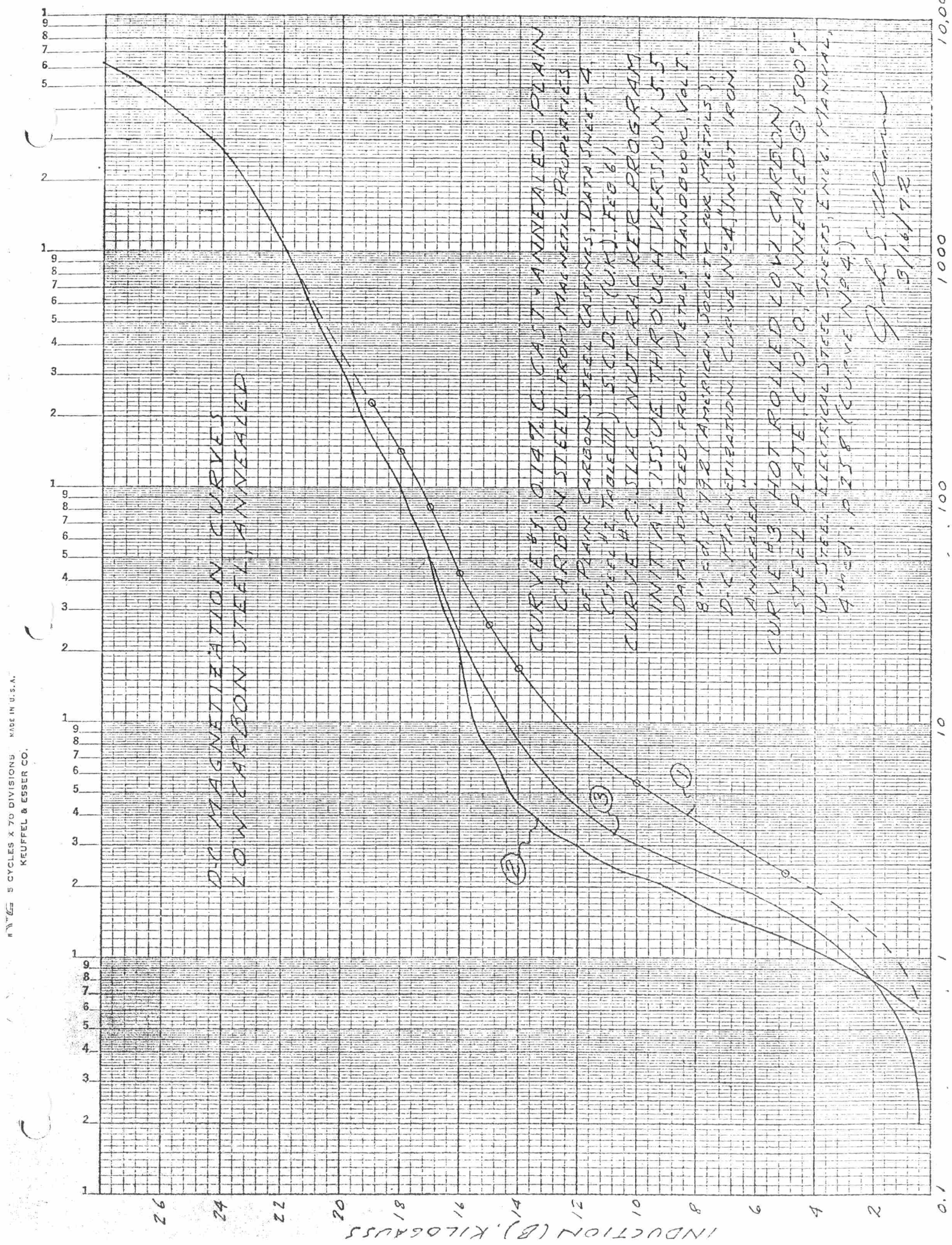
REAL H (AMP/M)	H OERSTEDS REAL H x 0.01259	REAL PERM (M) OLD	B (MH) TESLA OLD	B (MH) TESLA NEW	REAL PERM (M) NEW
0.0	0.0	6.62500E-04			6.62500E-04
47.7479	.60	1.04717E-03	.05	.035	7.325E-04
55.7059	.70	2.24393E-03	.125	.05	8.97E-04
63.6639	.80	3.14150E-03	.200	.075	1.178E-03
79.5798	1.00	4.46093E-03	.355	.125	1.570E-03
119.370	1.50	5.86413E-03	.70	.27	2.260E-03
159.160	2.00	5.65470E-03	.90	.41	2.578E-03
198.950	2.50	5.52903E-03	1.10	.55	2.762E-03
238.740	3.00	5.02640E-03	1.20	.65	2.72E-03
278.529	3.50	4.66737E-03	1.30	.74	2.66E-03
318.319	4.00	4.24102E-03	1.35	.82	2.58E-03
358.109	4.50	3.90942E-03	1.40	.89	2.485E-03
397.899	5.00	3.59387E-03	1.43	.95	2.385E-03
437.689	5.50	3.31285E-03	1.45	1.00	2.28E-03
477.479	6.00	3.05772E-03	1.46	1.045	2.19E-03
557.059	7.00	2.65681E-03	1.48	1.115	2.00E-03

2-12-14

REVISION OF NUTCRACKER Bvs. H DATA *Alcorn*

(2)

REAL H (AMP/M)	H OVERSTEPS	REAL PERM OLD	B OLD	B NEW	REAL PERM NEW
596.849	7.50	2.51320E-03	1.50	1.14	1.91E-03
795.798	10.00	1.93516E-03	1.55	1.25	1.57E-03
1591.60	20.00	1.00528E-03	1.60	1.44	9.06E-04
2387.40	30.00	6.91130E-03	1.65	1.53	6.41E-04
3978.99	50.00	4.27244E-04	1.70	1.62	4.08E-04
5570.59	70.00	3.14150E-04	1.75	1.67	3.00E-04
7957.98	100.0	2.26188E-04	1.80	1.73	2.18E-04
1.0 × 10 ⁴	125.9	1.855E-04	1.85	1.77	1.77E-04
1.194 × 10 ⁴	150.0	1.5745E-04	1.88	1.81	1.52E-04
1.592 × 10 ⁴	200.0	1.21231E-04	1.93	1.87	1.175E-04
2.0 × 10 ⁴	251.8	9.79E-05	1.96	1.92	9.60E-05
5.0 × 10 ⁴	630	4.2256E-05	2.115	2.10	4.20E-05
8.0 × 10 ⁴	1007	2.73566E-05	2.185	SAME AS (B) OLD	SAME AS REAL PERM-OLD
1.0 × 10 ⁵	1259	2.23066E-05	2.230	"	"
2.0 × 10 ⁵	2518	1.19716E-05	2.394	"	"
3.0 × 10 ⁵	3780	8.4566E-06	2.54	"	"
5.0 × 10 ⁵	6300	5.6166E-06	2.81	"	"
8.0 × 10 ⁵	10070	3.9941E-06	3.20	"	"
1.0 × 10 ⁶	12590	3.4566E-06	3.456	"	"
3.0 × 10 ⁶	37800	1.99097E-06	}	}	"
5.0 × 10 ⁶	63000	1.6976E-06			"
8.0 × 10 ⁶	100700	1.5326E-06			"
1.0 × 10 ⁷	125900	1.4776E-06			"
5.0 × 10 ⁷	630,000	1.3009E-06			"
1.0 × 10 ⁸	1.259 × 10 ⁶	1.2788E-06			"
1.0 × 10 ⁹	12.59 × 10 ⁶	1.07E-06			"
1.0 × 10 ¹⁰	125.9 × 10 ⁶	0.87E-06			"
57 * 0.01		57 * 0.01			"



DC MAGNETIZATION CURVES
LOW CARBON STEEL, ANNEALED

CURVE #1: 0.14% C CAST, ANNEALED PLAIN CARBON STEEL. FROM MAGNETIC PROPERTIES OF PLAIN CARBON STEEL CASTINGS, DATA SHEET 2 (STEEL'S TABLE III), S.I.C. (UK), FEB 61

CURVE #2: SIAC NUT CRACKER PROGRAM INITIAL ISSUE THROUGH VERSION 5.5 DATA ADAPTED FROM METALS HANDBOOK, VOL. 8, 1978 (AMERICAN SOCIETY FOR METALS), D.C. MAGNETIZATION CURVE N/A, INGEST IRON ANNEALED.

CURVE #3: HOT ROLLED LOW CARBON STEEL PLATE, C1010, ANNEALED @ 1500°F

U.S. STEEL - ELECTRICAL STEEL SHEETS, ENG. MANUAL, 4TH ED., P 258 (CURVE N04)

John S. Keuffel
9/16/78