Fermilab

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1600

AC LOSS TEST OF D10-3 MAGNET

R. Yamada, H. Ishimoto and R.E. Pighetti

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The coil of this 10-foot magnet, D10-3, is wound with MCA 17 unsoldered cabled wire. This magnet has ceramic support rings. The one-foot counterpart magnet, D1-7, is made of the same unsoldered wire, but has titanium support rings. The other major difference is insulation method of individual wire. The coil of the one-foot magnet is made of four-inch straight part and two three-inch end parts. But that of 10-foot magnet is made of mostly straight section. Therefore we can expect a better agreement between measured data and simple calculation.

This magnet, D10-3, is the first 10-foot magnet on which AC loss was measured electrically. Measurements were done without steel on December 22, using the power supply system of the Energy Doubler Group, after their boil off measurement. We did not have enough time to do an extensive study, nor was the system optimized.

With this power supply system, we could not get a symmetrical triangular current waveform due to a large inductance value of the 10-foot magnet. The downward current waveform was determined by the time constant (~3 sec) of the circuit, especially at high ramp rate and also at low field. This fact caused some ambiguities in the data of ramp rate dependence.

The ramp rate dependence was measured and the data are shown in Fig. 1. There are three sets of data. The data set of 0 to

10.5 kG is affected by the time constant (3 sec) of the system, and the data points beyond 3 kG/sec need some upward corrections. The other two data sets are relatively free from this time constant problem.

The data set of 0 to 26 kG shows an increase of 100% in AC loss over 0 to 10 kG/s which is in agreement with calculations as shown later. The data set of 6.7 to 33.5 kG shows a much steeper and non-linear curve, instead of a linear one. This is due to the fact that above 30 kG there is something happening in the magnet and AC loss is not a major energy loss as explained later.

The maximum field dependence was measured at a constant ramp rate of 3.2 kG/sec. The data are shown in Fig. 2 with black circled points. There is another set of data, white circled points, in Fig. 2. They were taken with constant time period, thus with different ramp rates. These data are converted to a fixed ramp rate of 3.2 kG/sec, using the data of ramp rate dependence. These two sets of data agree well with each other, as shown in Fig. 2.

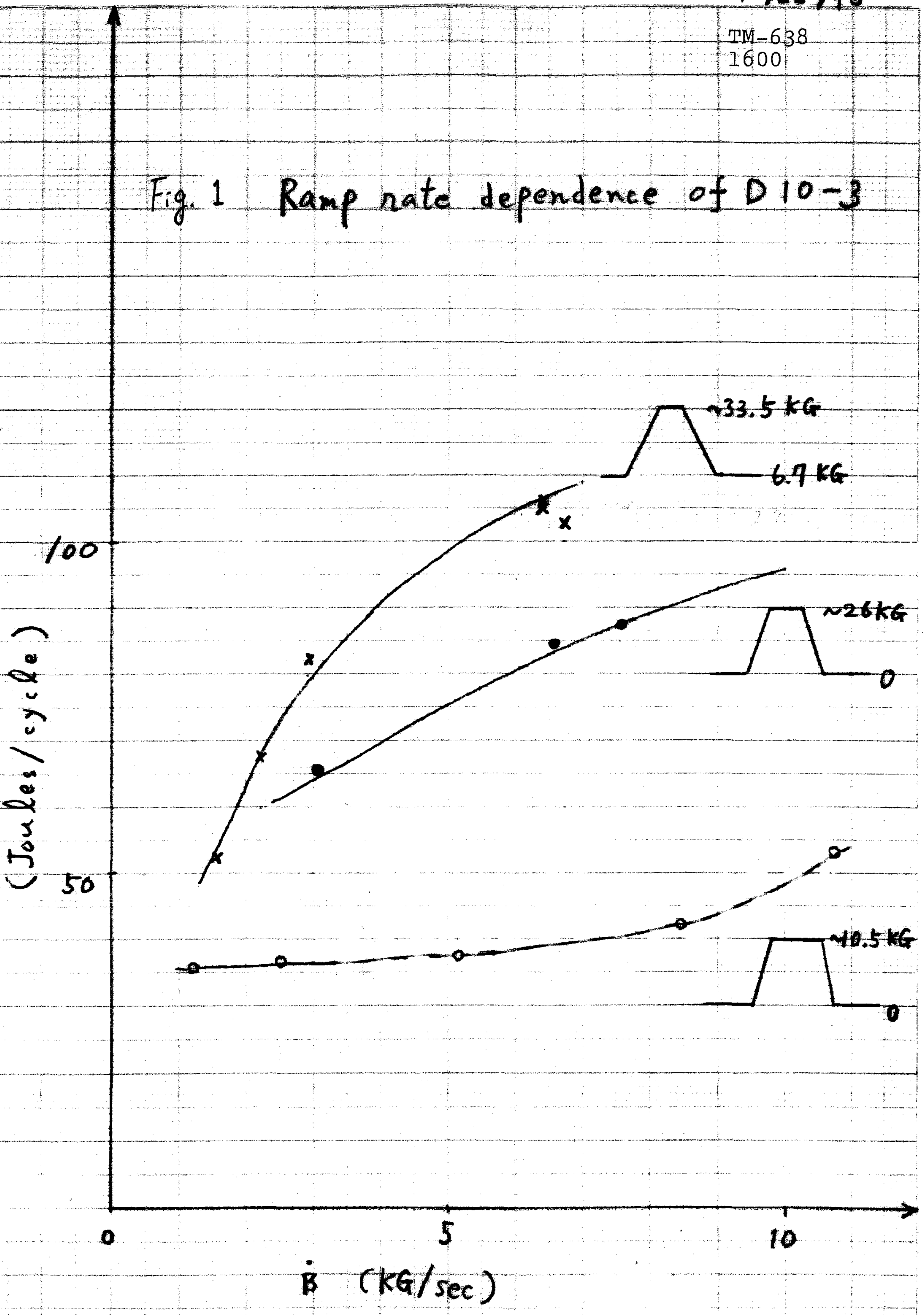
At 30 kG, the AC loss curve in Fig. 2 shows a shape upward bend, which seems fourth powered and higher than quadratic. With other one foot magnets with unsoldered wire the bend occurred around 15 ~ 23 kG, and leading to quadratic rises. These rises were attributed to mechanical movement. The sharp rise of D10-3 may be due to mechanical movement or due to the rise of resistivity of wire, because this magnet quenches at 34 kG at central field. The corresponding highest field in the magnet coil is 40 kG at end, arriving about 95% of short sample data.

This fact may mean the new ceramic rings are strong enough and wire are bound tight enough to prevent the mechanical movement of coil, which were observed on other one-foot magnets.

The AC loss curve of D10-3 shows roughly the power of 0.7 between 5 and 30 kG. This is smaller than linear, but it agrees well with the hysteresis loss curve of MCA 17 strand in Fig. 3, which was measured with field perpendicular to the narrow side of the wire. As the straight section part of the coil is dominant over end sections, it should show a curve like that.

The extrapolation of this curve indicates 100 Joules/cycle/10-foot magnet at 45 kG and at 3.2 kG/sec. The calculated data for AC loss of D type magnet is shown in Fig. 4. It shows 32 Joules/cycle/meter of magnet for the same condition. They agree with each other, although we expect 10~20% errors in measurement and calculation. The calculation in Fig. 4 also shows an increase of 50% in AC loss over 0 to 5 kG/sec for the case of 0-45 kG with unsoldered wire. This agrees well with the measured ramp rate dependence of 0-26 kG in Fig. 1.

Fig. 1 Ramp rate dependence of D 10-3



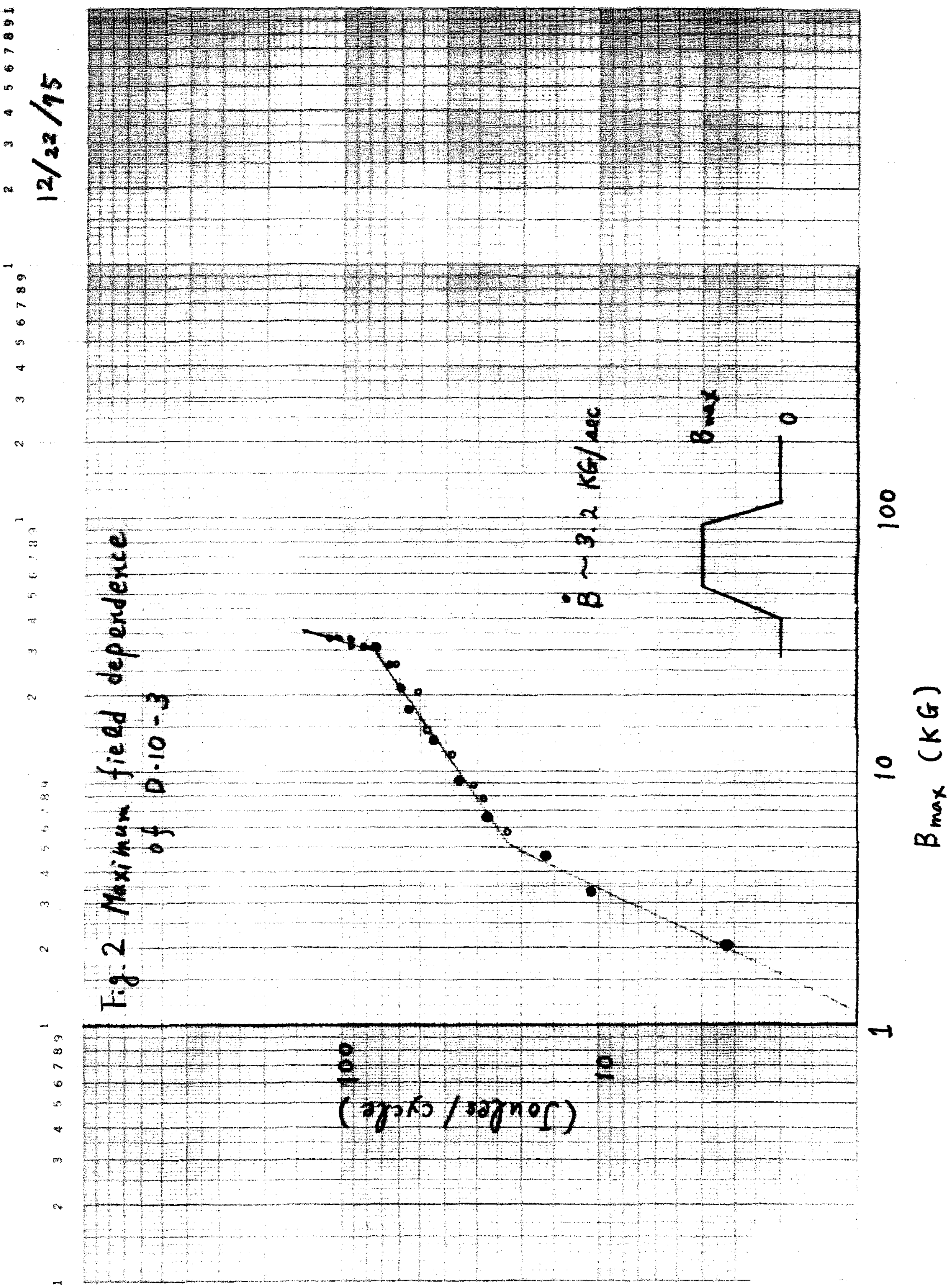


Fig. 2 Maximum field dependence of D-10-3

Fig. 3 Histeresis Loss Curves of MCA Wires
Measured Perpendicular to Wire

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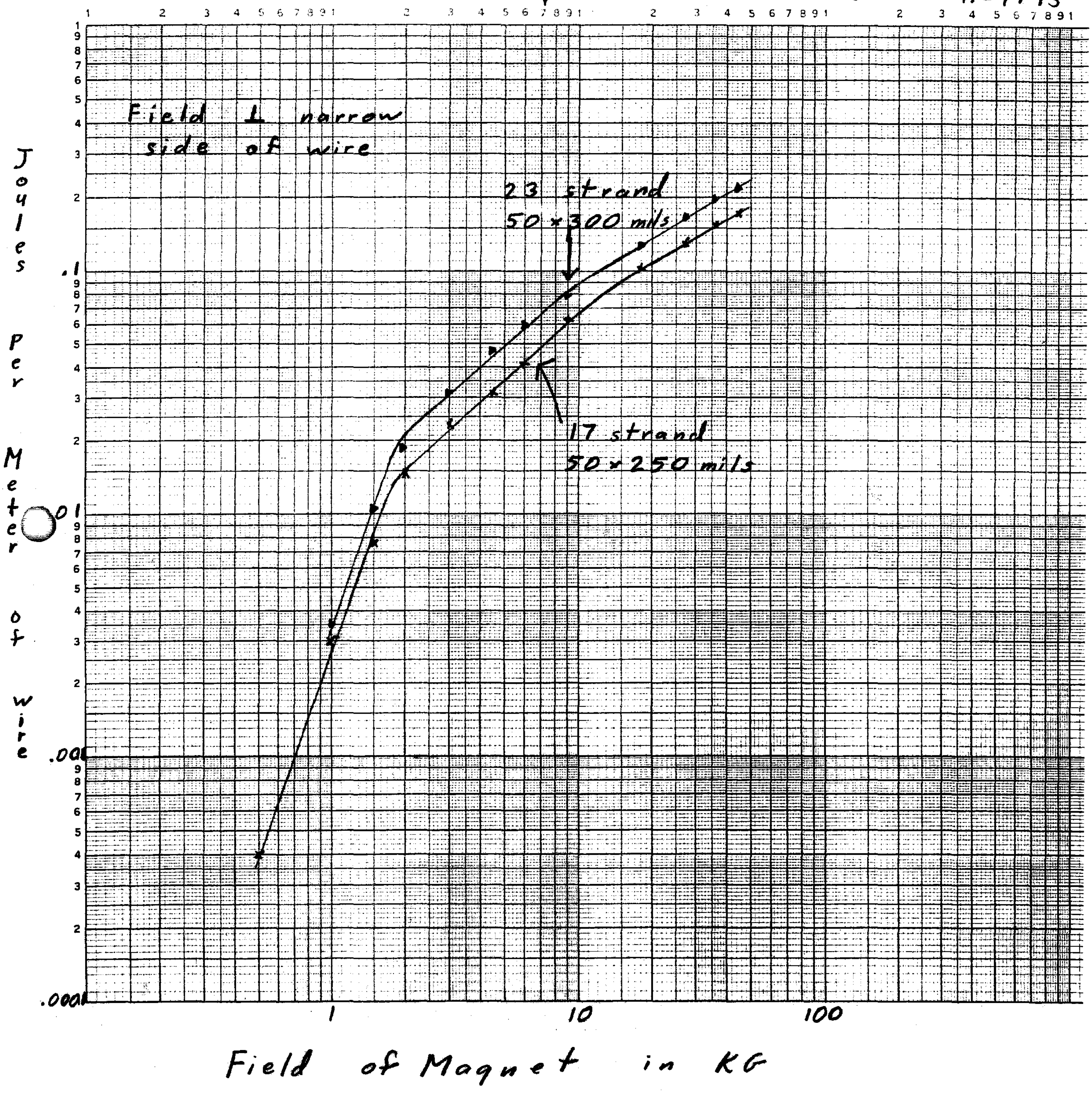

$\dot{H} \sim .5$ KG/sec

Fig. 4
RAMP RATE DEPENDENCE
of D Magnet