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Memorandum M-1152

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Project Whirlwind
Servomechanisms Laboratory
Massachusetts Institute of Technology

SUBJECT: VISIT TO UNIVERSITY OF ILLINOIS AND ENGINEERING RESEARCH ASSOCIATES.

To: E.S. Rich, J.A. O'Brien, H. Fahnestock, P. Youtz, S.H. Dodd R.W. Read, C. Corderman, N. Daggett, W.J. Nolan, W.G. Welchman C.H. Weiser.

From: J.W. Forrester, R.R. Everett, N.H. Taylor.

Date: January 22, 1951

The week of January 8 to January 13 was spent in visiting the University of Illinois at Urbana and Engineering Research Associates at St. Paul.

The Illinois version of the IAS computer was demonstrated and discussed by Messrs. R. Meagher, Nash and Taub of the Illinois Computer group. It is progressing very well and is in the following state of completion. The arithmetic element is set up for addition or multiplication and can be controlled by interim control circuits to do repetitive arithmetic operations where a cyclic pattern appears on neon indicators. The arithmetic operation giving this pattern is thus self-checking and gives some measure of the reliability of this portion of the equipment. Several runs of 8 hours' duration have been achieved without error. The control circuits are yet to be constructed and some design changes are being made in the Illinois version of this part of the computer. While IAS uses batteries as a power supply with multiple taps for a large number of voltages, Illinois has installed regulated power supplies similar to the Whirlwind installation and obtains the necessary voltage level by bleeders and circuit changes which tolerate the supplies.

The machine is a 40-digit parallel device with 4 registers which are used in the arithmetic operations. The add-time is approximately 39 microseconds not including storage access and the multiplication time for the full 40 digits approximately 1000 microseconds depending on the number of ones in the multiplier. Access time to the Williams storage is specified at 20μs per reference.* The 40-digit word length permits

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* The storage regenerates continually, also at 20μs per spot, whenever not actually being used. There is at least one regeneration per reference; therefore, the effective access time is close to 40μs.

two 20-digit orders per word in which 10 digits are used for instruction and 10 for address. About 25 different instructions are provided; the 10-digit instruction allows some simplification of the central control. The machine has now about 1300 tubes installed with the final total about 2300. Tube complement will consist mostly of the dual 6J6 triode, 2C51, 5687, 12AX7, 6AL5, 6AK5, 12AT7.

The 40-digit Williams memory is now under test with about 20 tubes in place. These are standard RCA 3KP1 cathode ray tubes. Tests are being carried on with a density of 1024 spots per tube. The tests are cyclic in nature and consist mainly in transferring a static pattern from one tube to another and back again. Very little work has been done on spot interaction as we define it and work is just starting on repetitive reference to a given spot. The output of the Williams tube amplifier is designed to give about a 35 volt signal. The amplifier gain is approximately 7500 and the signal level is approximately 500 microvolts across a 15,000 ohm register at the pickup electrode. Signal to noise ratio at the gate tube was approximately 30:1.

A magnetic drum is being studied by the Illinois people as a means of supplemental storage and also a means of rapid transfer of information in and out of the Williams memory. A single channel of this arrangement was demonstrated. A drum is on order from the University of California at Berkeley.

The group at Illinois consists of 6 full-time engineers with 2 to 4 part-time assistants. The math and coding group consists of 6 or 8 people. The construction and wiring have been done at the University by a small shop group under the same jurisdiction as the engineers. The machine is scheduled for shipment November 1 of 1951.

The machine is completely D-C coupled, uses no crystals or condensers except in some power supply filter networks. All circuits are designed with a high-valued resistance in the grid circuit so that positive grid drive causes grid current to flow and the "on" tube grid voltage seeks cathode potential. The switching time of most circuits for this arrangement is approximately 2 1/2 to 3 microseconds. The Illinois people feel that the use of tubes in this manner places much less of a burden on the tube characteristics than in our pulse gating system. They feel that the resultant loss in speed would be more than made up with the increased reliability obtainable from this type of tube operation. However, in the first 1200 hours of operation, and neglecting failures during the first 50 hours, they have removed 12 tubes most of which have shown up as intermittents, due in part to loose particles between grids. It is too early to make direct comparisons between this machine and Whirlwind, but more experience will show whether this philosophy of design is superior to the pulse method used in faster systems here and at ERA.

Two days were spent at the Engineering Research Associates in discussions of many phases of their computer experience and its relation to future work in the field. Mr. J. Coombs, J. Hill, H. Boekoff, Cohen, J. Kelar and Dr. S.M. Rubens, of ERA took part in the meetings.

Discussion started with their evaluation of the magnetic drum as a reliable element in computing systems. Considerable study has been made at ERA as to the density of pulses on a drum which can give completely reliable operation. Their present system uses 80 pulses per inch around the circumference and 16 pulses per inch along the axis. The surface speed used is approximately 1600 inches per second. A timing channel is used giving signals which are formed into read-out pulses, quarter microsecond in duration. Read-out heads are spaced 2 mils from the surface of the drum and the heads are made with 1 1/2 mil gap in the pick-up. The reading signal from the magnetic pick-up is amplified and formed into a 4 microsecond gate which is applied to the #3 grid of a 6AS6 gate. Each reading head is followed by a 7 tube amplifier but pre-amplifiers allow the use of each read-out channel to be shared by several heads.

Two types of writing circuits are available -- a thyratron gas discharge type which can write at 2000 microseconds intervals and a hard tube system which can write at 8 microsecond intervals. The latter is subject to a 25% duty factor limitation. In the reading circuit it is possible to read in a given channel 50 microseconds after writing in this same channel.

The philosophy of ERA's design is to use small high-speed drums with only one head per channel. This makes mechanical requirements on the adjustments of such heads within the physical limitations of production manufacture. They do not believe that multiple heads to improve access time are very practical, due to the timing problems involved in their adjustment. ERA has made about 40 of these magnetic drums including their experimental models and they feel that this system is well understood and ready for use as a packaged piece of equipment A demonstration which they made for us seemed to bear this out both in performance and in the general commercial appearance of the equipment which they are prepared to ship.

In discussing some of the applications and drums we were acquainted with a message reduction system in which a magnetic drum is used as a delay line in which new information is continually preserved on random arrival while old information is thrown away whenever there is a lack of space on the drum. A report is available on this system and will be placed in the library. It is entitled "A Magnetic Drum Technique for Telegraph Storage Relay Applications".

ERA is working with a group of approximately 10 people on electrostatic storage. They are working with a breadboard type of test equipment on a bank of 5 Williams tubes and are making preparations for extensive testing of the Williams system under conditions closely simulating systems operation. They are attempting to place 1024 spots on a 5-inch tubes No tests have been made to date which indicate that spot interaction may be a problem with the Williams system but they do seem pleased with the reliability they have obtained in the static reading and writing tests which are under way. One striking difference in their design was the use of two 5687 tubes to deflect a simulated 17 tube storage bank in 2 1/2 microseconds. Indications were that the ERA program may not be as far along as the Illinois storage tube work.

A second project studying the possible use of the RCA Selectron is being initiated. ERA is not too enthusiastic about this method of storage because of the higher voltage and fast rise of voltage pedastals which are required to operate this tube. They have two selectron tubes undergoing tests.

Discussion with Mr. Cohen of their Logic group indicated that their future thinking in machine logic is leaning toward special purpose codes for particular applications. The two-address system is favored for some work. The main reason seems to be due to the proposed register length of 36 digits. Most of ERA's designs follow a pattern similar to Whirlwind in which a pulse passes through a gate circuit which is opened by some sort of a memory device. They did not care to venture whether this was the best approach to the computer problem but they are very pleased with the operation of a system which they have recently built using these techniques. They feel that more time is needed to evaluate the present system before it can be determined as to how practical it can be made.

A tour of the ERA facilities indicates considerable manufacturing space for both machine work and assembly and wiring. Of their 550 employees 140 are engineers and the remaining 400 are divided between shop and clerical help.

One product which they are now making is a shaft position to binary number converter. This is a small magnetic drum which measures by counting procedure the distance between a recorded spot indicating a shift position and certain reference marks in another recording and reading channel. Considerable electronic equipment is needed to use this device but the whole system is in production and apparently available.

Another project of interest is being carried on by Dr. S.M. Rubens of ERA with several assistants. A static reading head for use with magnetic tape has been built which will read pulse densities up to

80 per inch. Dr. Rubens' scheme depends on the operating on the knee of a b-h curve where the presence or absence of a magnetized spot at the gap of his pickup head takes the operating point of the head into the flat region or up the knee of the curve. A high-frequency carrier* is used to sense the position of this operating point and the second harmonic of this carrier can be amplified and detected. The bias produced by presence or absence of the magnetic spot on the tape is enough to change the level of the second harmonic content of the output wave by a factor of 10:1. To obtain this signal to noise ratio it is necessary to apply bias voltage on the head which will counteract the effects of stray magnetic fields due to such disturbances as the earth's field itself. Dr. Rubens indicated his willingness to correspond with our group regarding this static head and suggested some references for us to consult before proceeding too far in this direction. The problem of defects in magnetic tape was discussed by Dr. Rubens. Although he did not expect trouble with commercial tape at densities of pulses of 100 per inch, he suggested that a discussion of the problem with Dr. W.W. Wetzel of Minnesota Mining, Sound Tape Division, St. Paul, would be helpful. The present tape is made inexpensively for sound work and certain imperfections, such as lint in the coating are known to be annoying. Dr. Rubens thought that a special tape with a thicker coating may be helpful. He feels sure that tapes can be made to do the job if adequate specifications can be written and a premium price paid.

ERA is also starting, under Dr. Rubens, investigation of a dielectric medium as a method of recording information. This work is in a very early stage but indications are that certain materials, after being subject to the corona caused by high voltage, have the property of memory for a matter of hours or days. This process is not yet reversible nor is it far enough along to be considered as a competitor for the magnetic tape.

Some discussion with Mr. James G. Miles indicated that their work with magnetic amplifiers is proceeding actively. This group is working on the magnetic amplifier as a flip-flop and also as a gating circuit. ERA would like to make a computer with a minimum of tubes to avoid all the problems of emissions in cathodes. Magnetic flip-flops running up to 200 KC are available in their laboratory. Mr. Miles was very interested in our work on a magnetic memory system. While his

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* This frequency is probably 10 KC, but this point should be verified as the notes in this point are incomplete.

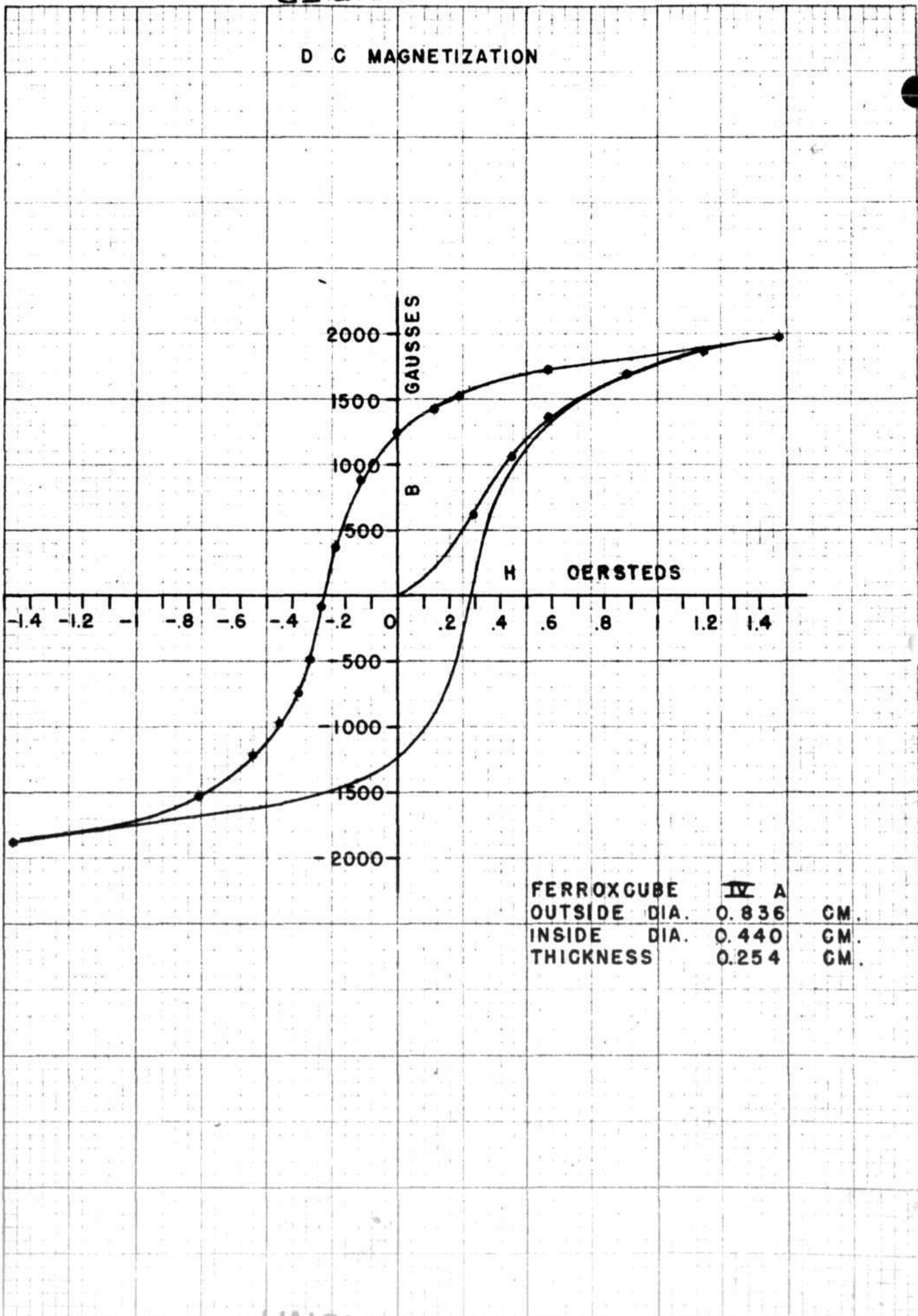
work is all on magnetic characteristics with a rounded knee, he suggested several materials which we might use with suitable modifications. Some materials which he thought would be of interest are listed below:

Stackpole Ceramic 5N		
High mu	4B	Ferroxcube Corp. of America (Phillips Subsidiary)
Ferramic	H	
Ferroxcube	4R	Curves of these materials
	4B	are attached to the library
	4C	copy of this report.
	4D	
	4E	

Mr. Miles further suggested our contacting Mr. Adams of the Ferroxcube Corp. of America, 50 East 41st Street, New York for a discussion of our problem. A report by Miles and Titman "High Frequency Loss Loops on Saturable Magnetic Cores" has been placed in the library.

NHT:bm

N. H. Taylor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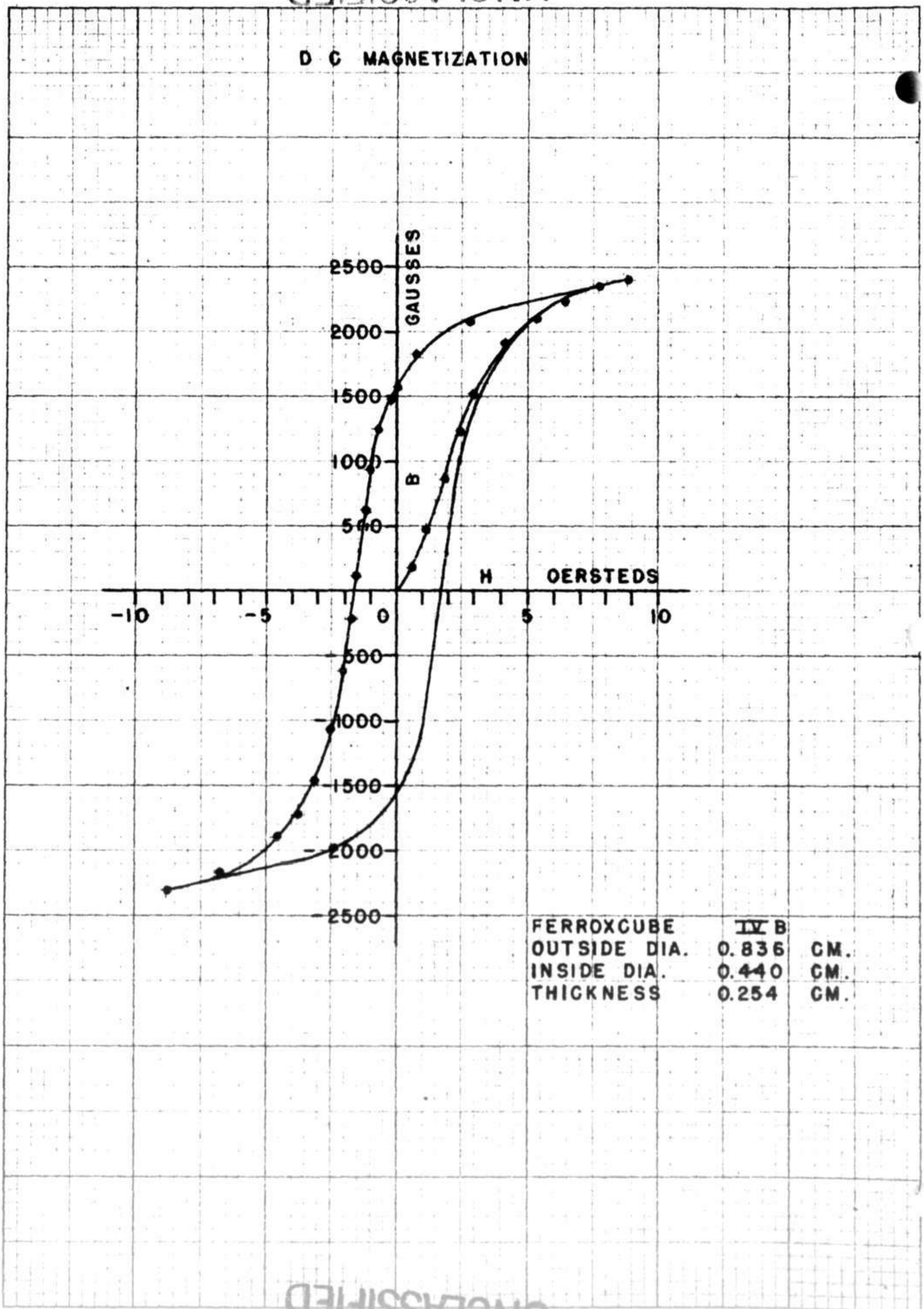
INSIDE DIA. 0.440 CM.
THICKNESS 0.254 CM.


D C MAGNETIZATION
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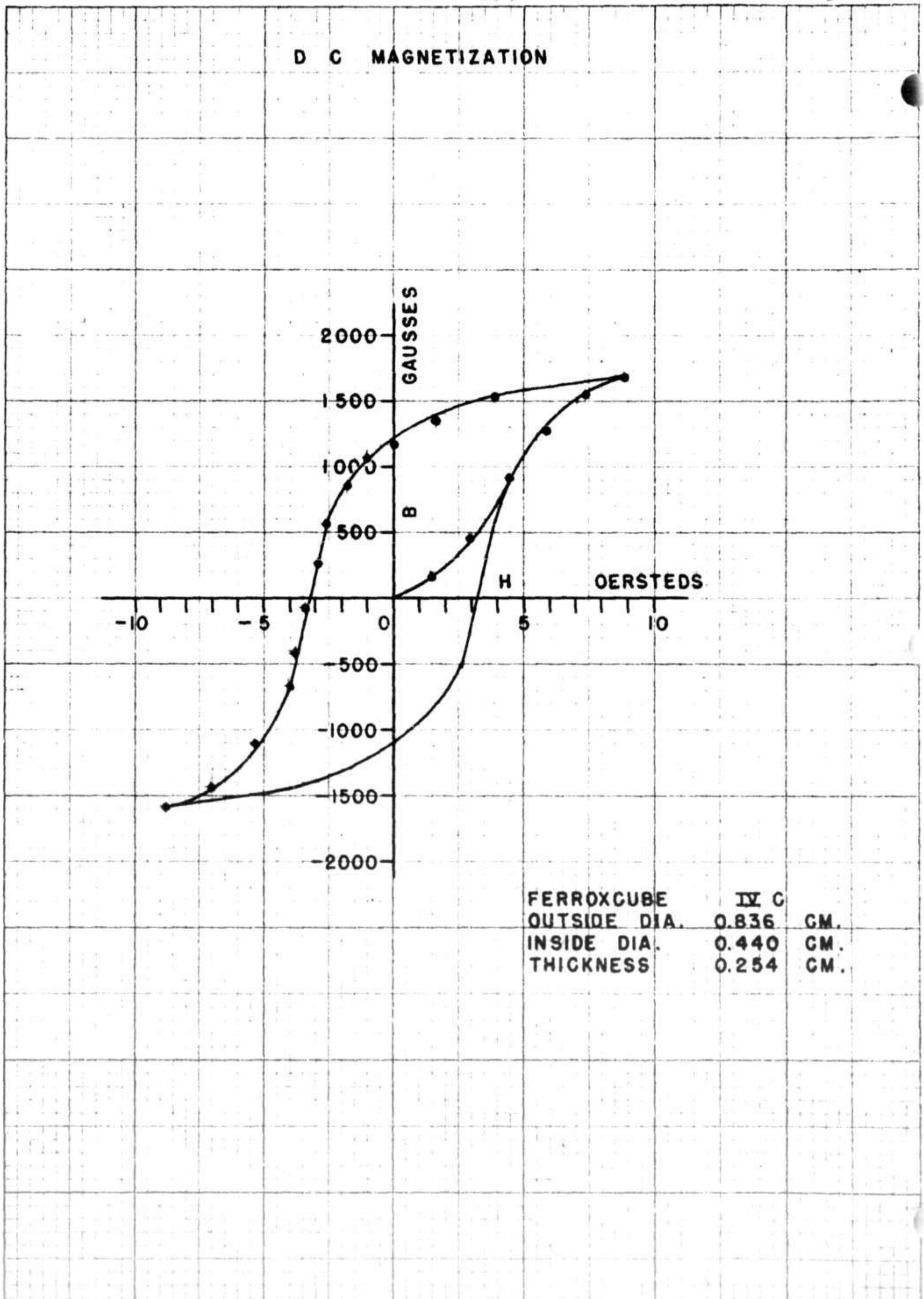
THICKNESS 0.254 CM.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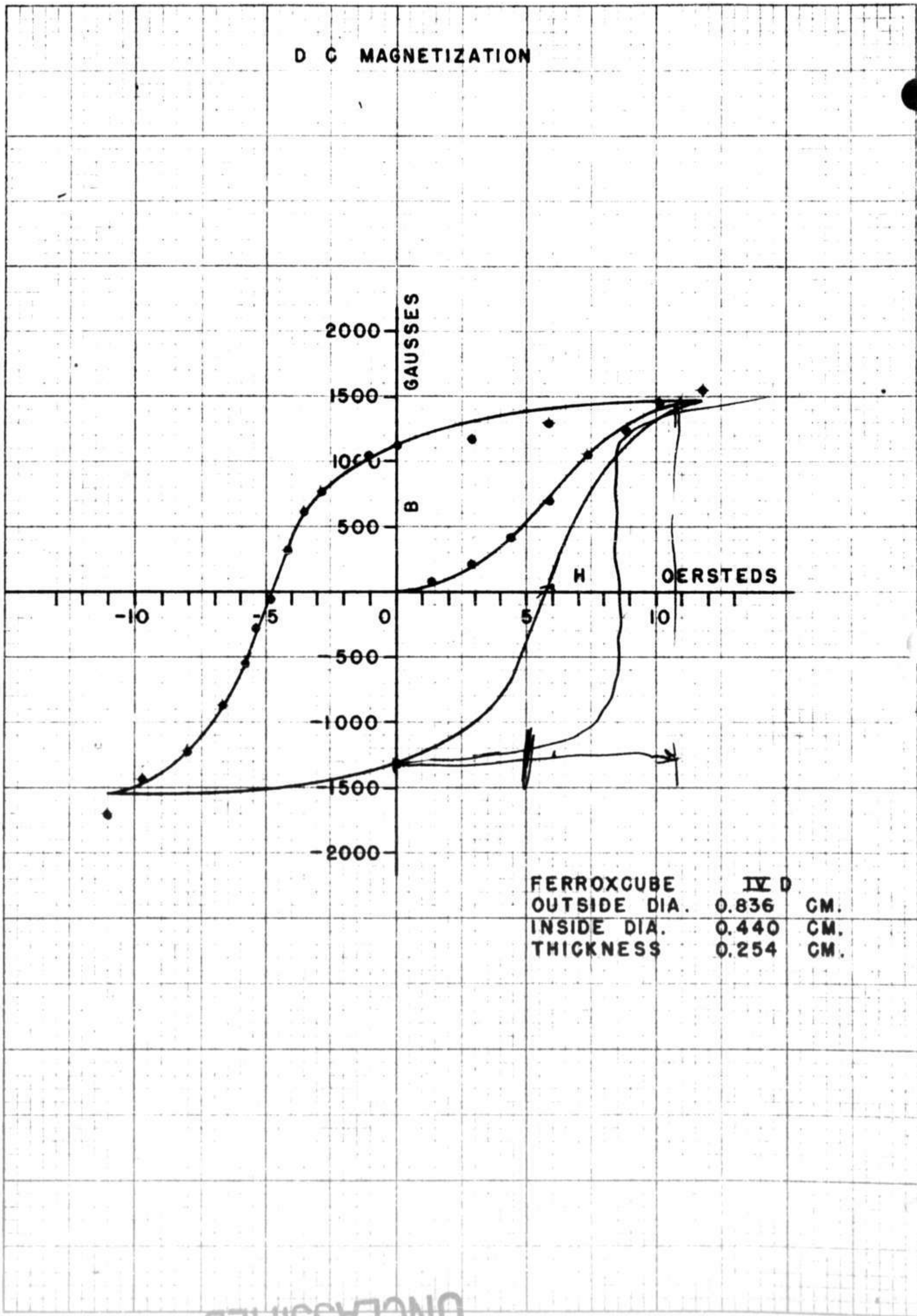
THICKNESS 0.254 CM.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FERROXCUBE IV D
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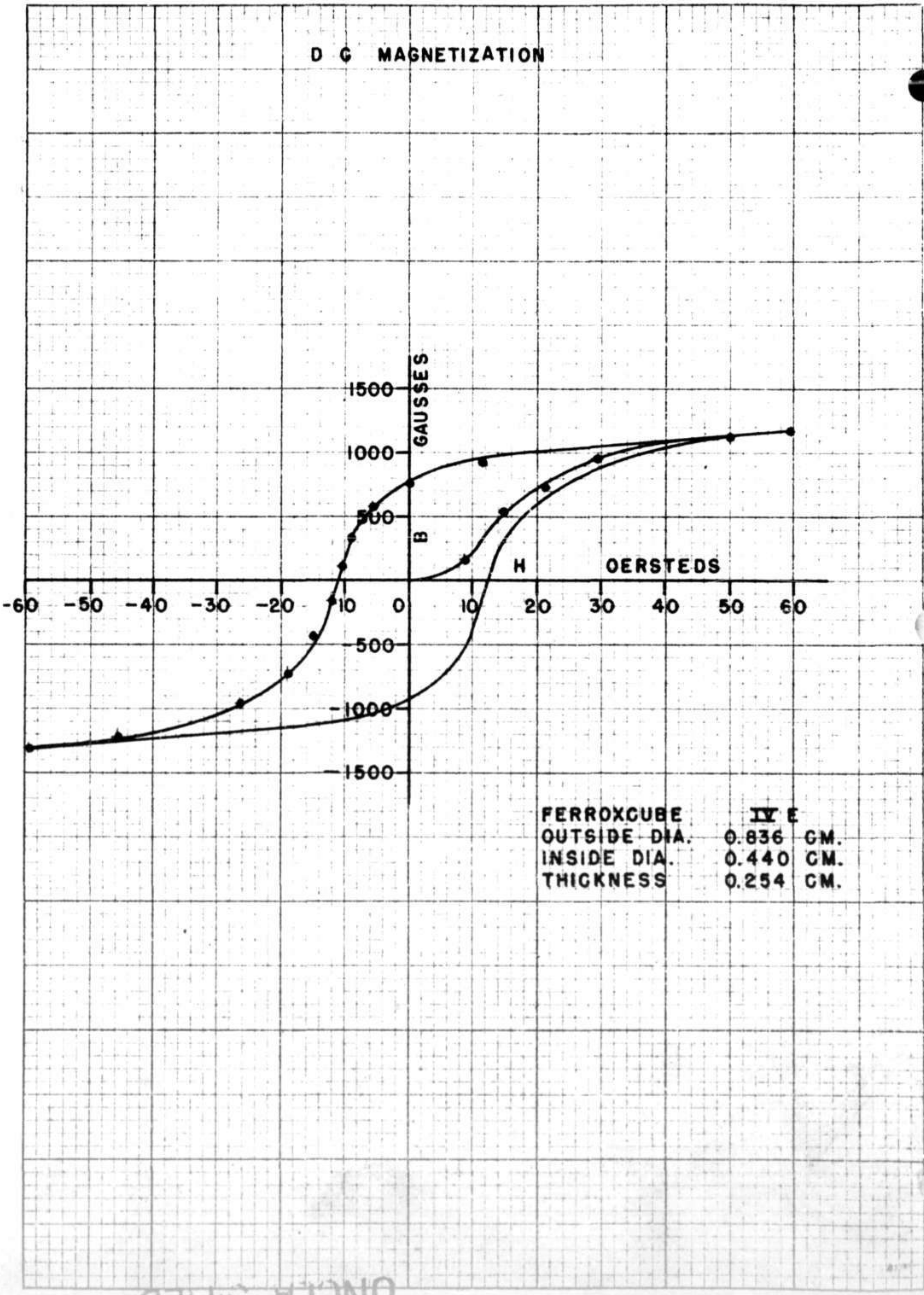
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FERROXCUBE IV E
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INSIDE DIA. 0.440 CM.
THICKNESS 0.254 CM.