METROLAB
Instrument S.A.

PDI 5025

MAGNETIC HYSTERESIS CYCLE MEASUREMENT

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Magnetic hysteresis cycle measurement using the PDI 5025

The PDI 5025 can be used as the basic component of an hysteresis curve determination system. We have measured the hysteresis cycle of three different samples.

The experiment configuration is shown in fig. 1; figures 2 to 9 show the result of the measurement.

In our configuration, the channel "A" of the PDI 5025 measures the voltage across the reference resistor which is proportional to the current and therefore to the applied magnetic field strength H. Channel "B" measures the magnetic flux changes ($\delta\Phi$) within the sample. The magnetic field B is proportional to the flux plus the initial value B_0. By plotting results of channel "B" vs channel "A", we obtain the hysteresis cycle.

The shape of the ramped field cycle (applied magnetic field H) is shown in fig. 2. It starts at point (a) and ends at point (b) lasting 30 seconds. The PDI is programmed in order to get data before and after the field cycle to determine the voltage offset and integrator drift respectively for channel "A" and "B". The offset and drift for both channels are considered for each measurement. The PDI cycle lasts 50 seconds and triggers are generated every 100 ms (TRI,,0/500,100).

An example of the magnetic field measured within the sample's material is shown in fig. 3. Prior to the measurement, the material is demagnetized and the final level represents the sample remanence.

Three different samples with different characteristics have been measured.

- sample #1 : material type P2 with a permeability of about 200000.
- sample #2 : material type P6 with a permeability greater than sample #1 one.
- sample #3 : material type PC with a permeability smaller than sample #1 one.

Figures 4 to 9 show the hysteresis cycles and several enlarged regions of it. All data are corrected for the offset/drift effect.

The PDI 5025 data acquisition sequence

The PDI 5025 is programmed to generate triggers in time:

$$t_i = \delta t * i \qquad i = 1,2,3,4,\ldots,n$$

where: $1 \text{ ms} \le \delta t < 2^{23} \text{ ms}$

Each channel integrates its input voltage during the periods delimited by two consecutive triggers $[t_{i-1} = t_i - \delta t \; ; \; t_i]$:

$$\delta\Phi_i = \int_{t_{i-1}}^{t_i} U(t)\cdot dt \qquad [\text{Volt}\cdot\text{sec}]$$

The channel "A" is used as a voltmeter. Indicating by V_i the voltage at time t_i:

$$V_i = (\delta\Phi_i^A + \delta\Phi_{i+1}^A)/2\cdot\delta t \qquad [\text{Volts}]$$

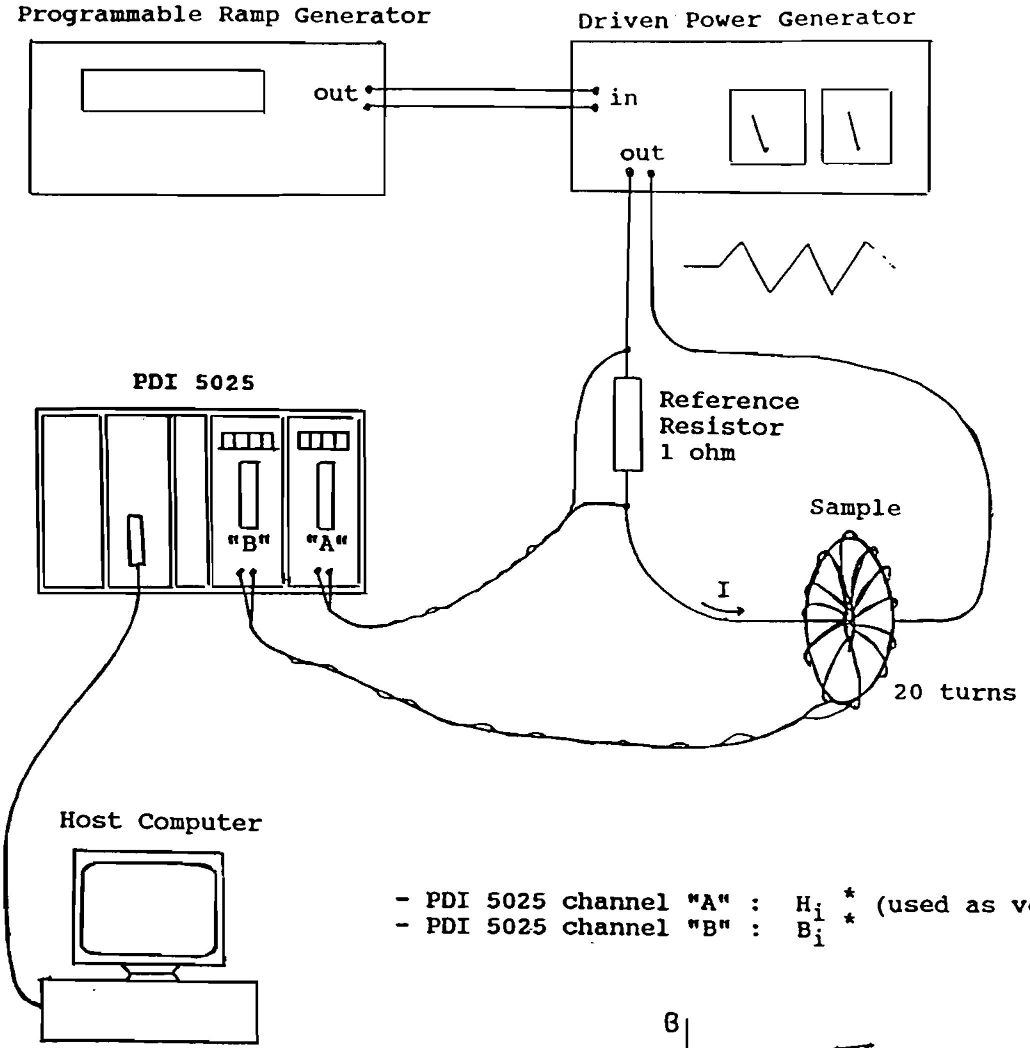
The voltage measured in this way represents an average value during the time period $[t_i - \delta t \; ; \; t_i + \delta t]$.

The channel "B" is used as an integrator measuring the magnetic field at time B_i:

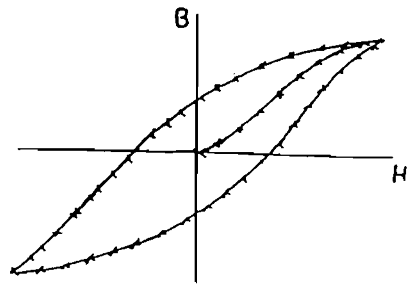
$$(N\cdot A)\cdot B_i = \sum_{j=1}^{i} \delta\Phi_j^B + (N\cdot A)\cdot B_0 \qquad [\text{Tesla}]$$

where: B_0 = field at t=0 and $N\cdot A$ = coil surface (m^2)

Experiment configuration layout



- PDI 5025 channel "A" : H_i * (used as voltmeter)
- PDI 5025 channel "B" : B_i *



* - Channel "A" measures the voltage across the reference resistor which is proportional to the applied magnetic field strength H.

- Channel "B" measures the difference of magnetic flux within the material from the starting point.

Fig. 1

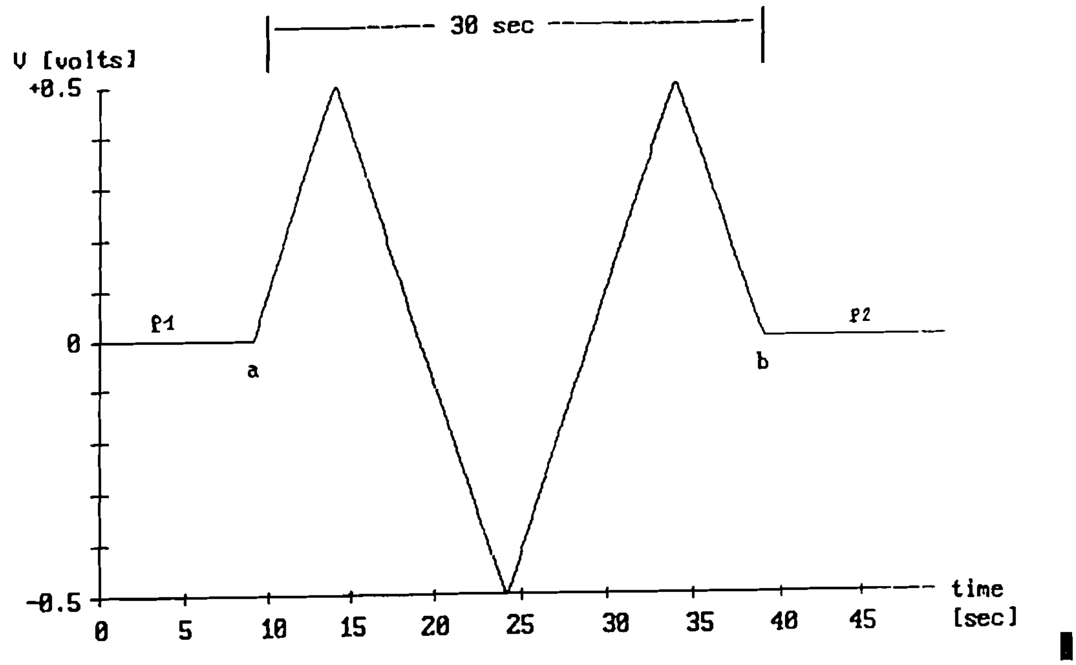


Fig. 2

Voltage across the reference resistor : the P1 and P2 plateaus are used to determine the channel input offset.

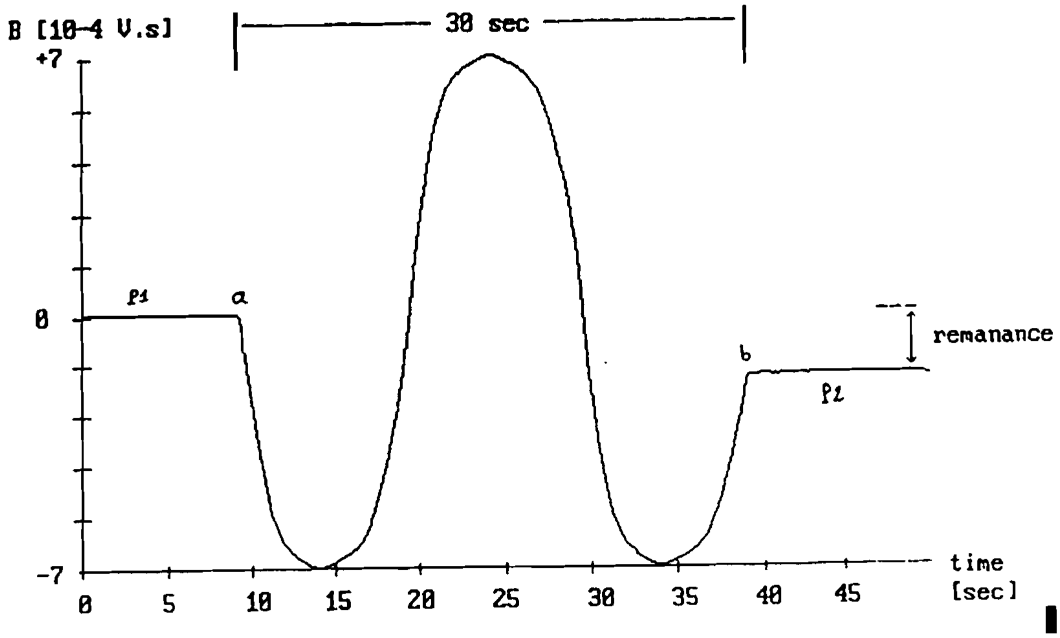


Fig. 3

Example of magnetic field within a sample: the P1 and P2 plateaus are used to determine the drift of the channel.

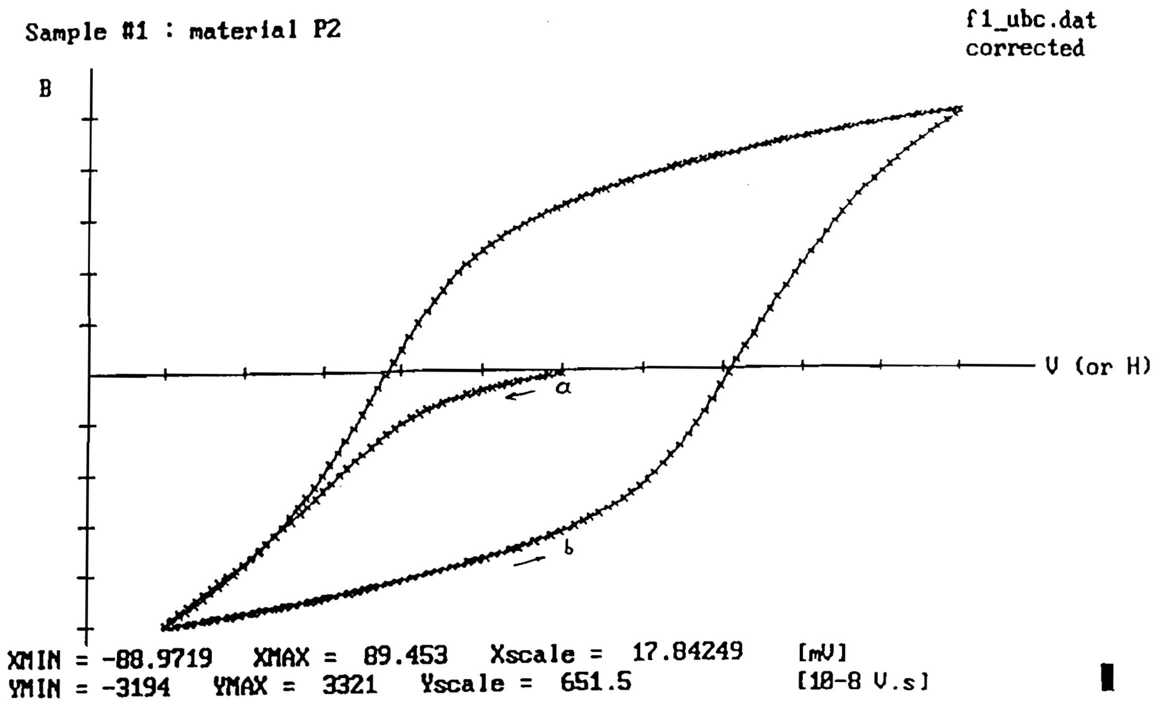


Fig. 4

Hysteresis cycle for sample #1. The material does not reach the full saturation.

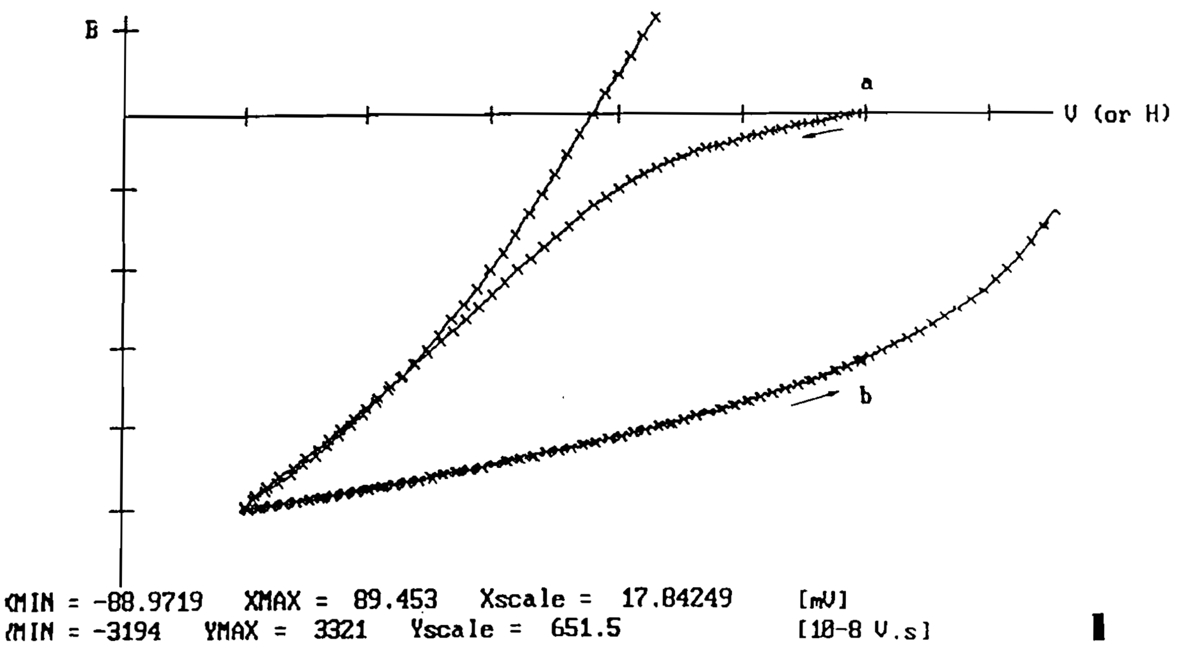


Fig. 5

Detail of the cycle of Fig. 4 showing the initial magnetization.

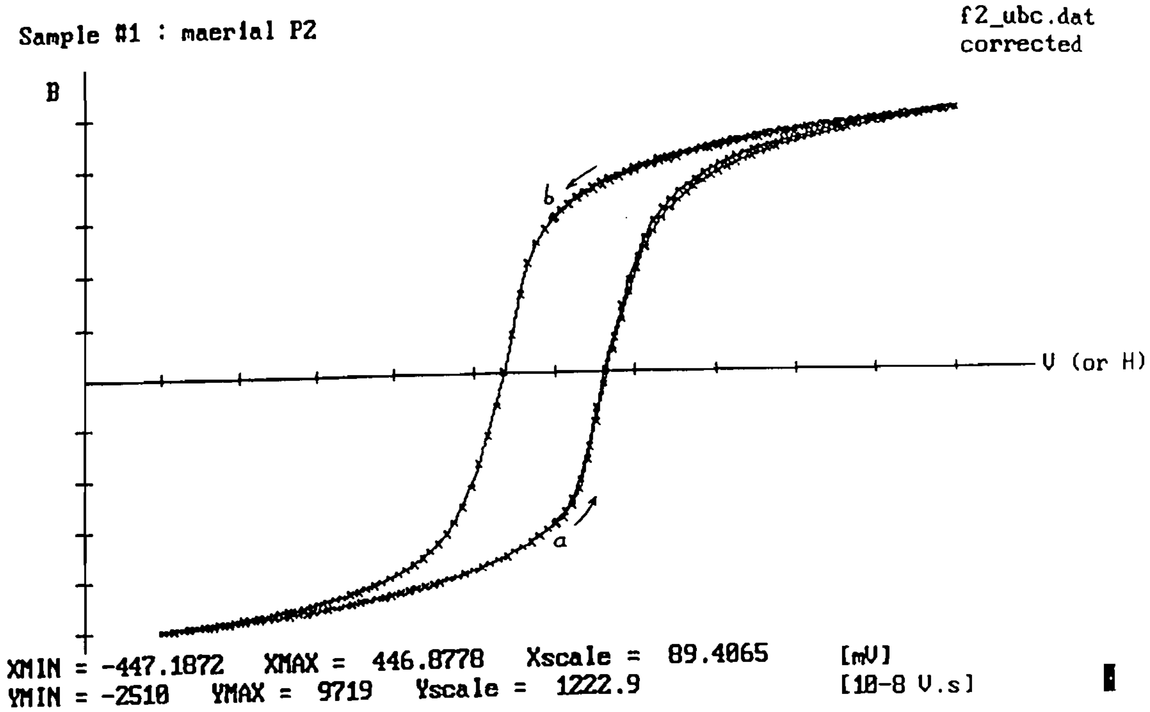


Fig. 6

Hysteresis cycle for sample #1. The cycle starts from a non zero magnetized state.

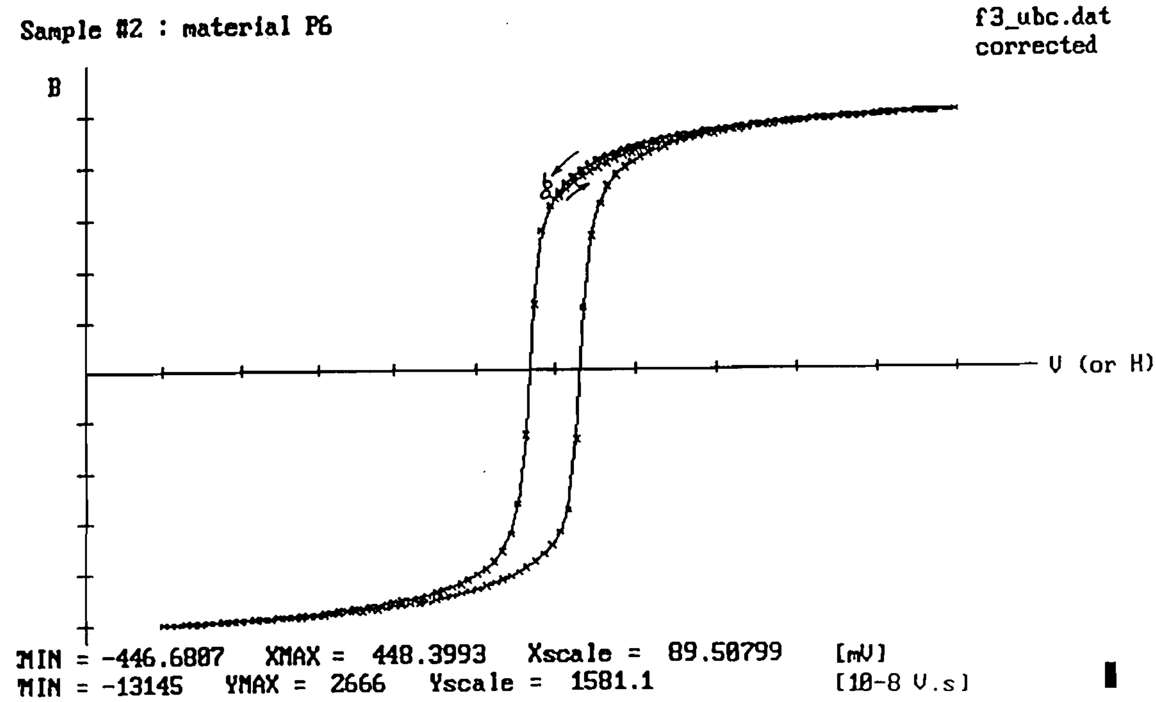


Fig. 7

Hysteresis cycle for sample #2. The cycle starts from a non zero magnetized state.

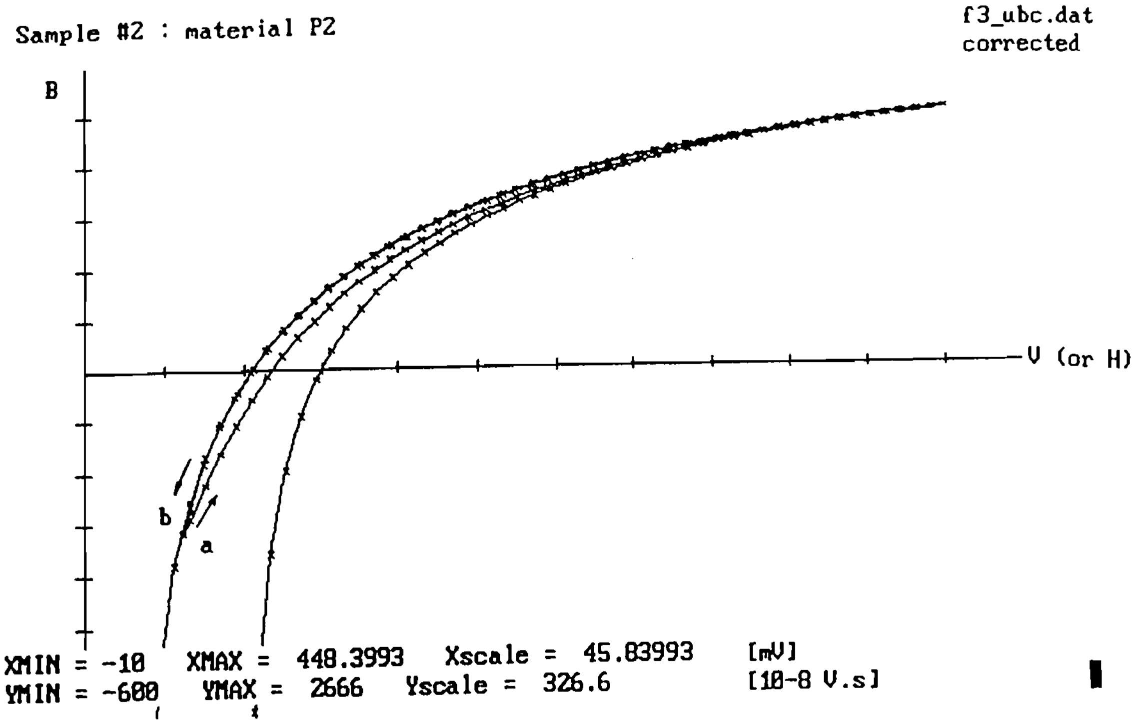


Fig. 8

Detail of the cycle of Fig. 7 showing the effect of the inversion of the scan trajectory.

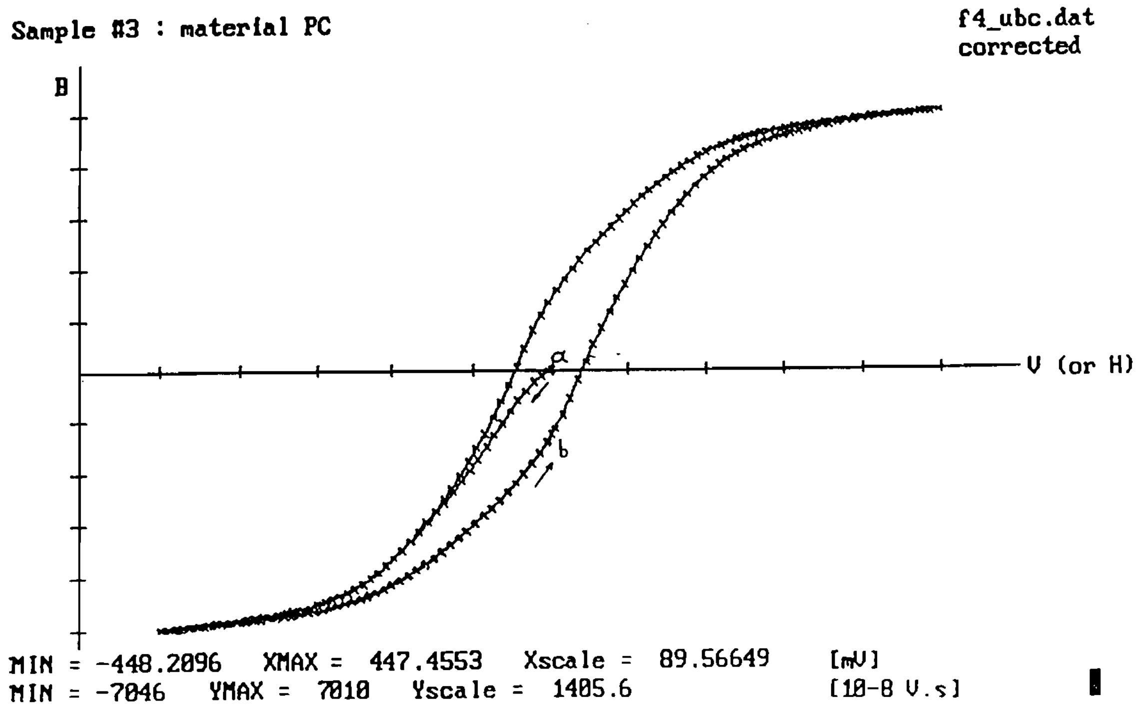


Fig. 9

Hysteresis cycle for sample #3.