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SURVEY MEASUREMENTS OF WIRE CHAMBER BEHAVIOUR IN TIME

P. Baehler, J.L. Bénichou, R. Colemagne, Ph. Gavillet, K.K. Geissler, J. Pothier

1. INTRODUCTION

The need of high precision measurements of track points in each detector of the EHS spectrometer has often been underlined [1]. Among the many requirements to fulfill in order to reach the necessary level of accuracy, ranges the knowledge of the behaviour in time of the large size wire chambers used to define the tracks in the downstream part of the spectrometer [2].

One of the more important parameters which can affect the stability of a chamber is certainly the temperature variation. It can induce dilatations and consequently secondary effects such as small instabilities of the chamber orientation which would result in systematic errors (partially randomized over long periods) the magnitude of which may become non negligible. Purposely the materials used for the wire chamber frame (Vetronite) and their supports (Inox or Antico) have been chosen because their dilatation coefficients are close one to each other. One can therefore estimate that for chambers which are hanging on supports of comparable vertical size, a quasi complete compensation of dilatations would occur.

In the case of the EHS spectrometer, we are dealing with chambers ranging from about 2 to 5 m height and placed in the EHN1 hall area where daily variations of temperature as large as 8°C (Fig. 1) have already been registered. A rough estimate shows that a 5 m Inox support will dilate by more than half a millimeter under such conditions, which seems far above the 50 - 100 μ accuracy expected from the chambers. So, as pointed out by G. Neuhofer and F. Bruyant, it is of interest to check to which extent the compensation of the dilatations of the chamber frame / support is effective and to measure any sizeable secondary effect originated from these dilatations.

For this purpose it has been decided to survey carefully during the previous test runs (period 6C-79 and 1C-80) one of the available chambers: (the D4 Vienna Drift chamber) by collecting a complete set of temperatures, dilatations, orientation measurements on the chamber frame itself and its support. In section 1, we describe the various apparatus used or built up for these measurements. In section 2, we indicate how the data collection has been made, interfacing the various devices to the monitoring NORD-10 computer. In section 3, we present the results of the analysis of the D4 survey data and in section 4 we discuss the preliminary conclusions which can be drawn from our observations.

2. DESCRIPTION OF THE APPARATUS

2.1 Measurement of the Temperatures

Degussa platinum thermometric resistances : W 60/7 have been used to pick up the temperatures of the chamber frame, its support and of the surrounding atmosphere. Between (0, 850° C) the resistance variation as a function of the temperature can be obtained from the quadratic law:

$$R_T = R_o\ (1 + AT + BT^2)$$

R_T = resistance (Ohms) at temperature T

R_o = " " " " 0° C

T = temperature (°C)

A = $.390784076.10^{-2}\ {}^oC^{-1}$

B = $-.57840840.10^{-6}\ {}^oC^{-2}$

The stability at fixed temperature was estimated around .01 °C but the scatter between different W60/7 sensors was not clearly known. So we decided to calibrate the thermo-sensors before use.

For that, we immerged the cylindrical sensors in holes of about the same diameter made in a plate of Inox 304L (used for the D4 support).

Heater transfer compound was put all around the sensors in their holes to ensure a perfect thermic contact. The sensors were connected to a digital thermometer (J. Pothier) and measurements were made over a 10 days period with varying temperature conditions. During these observations the connections of the sensors to the digital thermometer were regularly interchanged to cancel the possible systematic errors due to the thermometer.

Comparing in this way about 15 thermo-sensors, we noticed temperature differences as large as half a degree, but a remarkable stability ($\sim .01^{\circ}$ C) and negligible response time. So, we chose to normalize all the sensors to one of them by attributing to each the offset value to the referenced one.

The implementation of the thermo-sensors is shown on fig. 2. Two were hanging in air at the summit and bottom of the D4 chamber, four were entered along the support and three in the chamber, to give at least three levels of temperature taking.

2.2 Measurement of Dilatations

The dilatation measurements were achieved by means of digital length gauges: METRO 3010, manufactured by Dr. J. Heidenhain & Co. and lent by K.K. Geissler. These instruments are capable of measuring distances of up to 30 mm with an impressive accuracy of $\pm$ 1 μ. They are connected to a digital METRO counter with external control facilities (PRESET, RESET...).

Two dilato-sensors were mounted on top and bottom of the D4 chamber with reference to small plates fixed on a quartz tube (fig. 3) the dilatation coefficient of which is negligible compared to those of the Vetronite, Inox and Antico materials. This simple dilatometer device built up by J.L. Bénichou and R. Colemagne allows to measure easily the integrated dilatation (chamber frame and support) at any point with an accuracy which is essentially the one of the METRO gauges. As it was designed, it could be used without any major modifications for any measurement of the same kind as dilatations, on any detector.

2.3 Measurement of the Chamber Orientation

The possible movements of the D4 chamber which is hanging on its support in the beam direction and transversally to it, were measured using two clinometers constructed by the SPS Survey Group [3] and already in use in various experiments. Their precision reaches .01 mm/m, so they are capable of detecting very tiny changes in orientation.

They were installed at the right-hand side bottom region of the chamber (fig. 3) on a small plate fixed on the chamber.

2.4 Measurement of the Ground Stability (projected)

As the ground of the EHS area may be subject to small fluctuations which could not be detected by the dilatometer, we projected to implement three hydrostatic stations, one close to LEBC, the second one near the D4 chamber and the third one in the FGD region to survey the stability of the whole spectrometer.

The hydrostatic stations, also designed by the SPS Survey Group [4] should be able to register any ground movement larger than .05 mm over a distance of 25 m. They still have to be fully tested. This was our purpose, but unfortunately we were too short in time to complete the installation of these stations.

3. ON-LINE SURVEY DATA COLLECTION

We chose to link our various instruments to the NORD-10 computer reserved for the EHS monitoring in order to allow an automatic recording of the data at regular time intervals.

The interface between the sensors and the computer was realised by P. Baehler, A. Guiard-Marigny and J. Pothier. It consists of a connection of the two METRO digital counters to a MPX module and of individual cable links of the nine thermo-resistances and the two clinometers to the existing scanner reserved for further RCBC temperature and pressure measurements.

Both the MPX module and the scanner can be addressed by the NORD-10 computer. For this purpose, P. Baehler wrote a real time Nodal program reading these devices and collecting data every 15 minutes. Then, these data were written on disc with a few words of identification and the created disc file was dumped on floppy disc at the end of the run.

Some attempts were made to display the data using the existing histogram package, but the detailed analysis has been carried out, off-line, on the 7600 CDC computer, starting from the floppy to mag-tape copy of the survey information. It is clear that this last step from NORD-10 data collection to CDC 7600 analysis is not very elegant, but was considered to be safer.

4. ANALYSIS OF THE D4 SURVEY DATA

A small FORTRAN program has been written to both display the survey measurements as a function of time and analyse in detail the correlations between the dilatations, the two angles controlled by the clinometers and the temperature variations.

4.1 Display of the Survey Data

4.1.1 Temperatures

Fig. 4 and 5 show the 9 temperature evolutions for the two runs of data taking. On fig. 4 and 5(a) one notices that temperatures are gradually lower from the top of the chamber to the ground level (except for temperature 8 which was always ~ 2° C higher than expected, without any clear explanation). This observation was previously made by D. Güsewell (fig. 1) who concluded to the existence of stratification of temperatures. One can further remark the fast step variations analoguous to those of fig. 1 and corresponding to working day periods of ~ 8 hours during which the large doors of the EHN1 hall are frequently left open. Their magnitude can reach almost 4° C close to the ground level and is seen to decrease with increasing height, which indicates that a gradient of temperature variation is created by opening the doors. One can further see that these variations of temperature show up with a certain delay in the chamber frame and its support.

On Fig. 5(b) we have selected only the two air temperatures (2 and 9) and the three chamber temperatures (4,6,8) for period 1C, so one can better see large oscillations of about ± .8° C amplitude. They correspond to a week-end period, when the doors are not opened and are caused by the heating ON/OFF alternation. One can also see that the heating coming from the upper part of the hall, a temperature gradient (not as important as the previous one) is created from the top to the bottom of the chamber.

As préliminary conclusion of the examination of figs 4 - 5(b) we might say that during the winter session :

- Fast drop of temperatures is happening each working day with an amplitude at maximum 4° C close to the ground level, decreasing with increasing height above ground.
- Reversively : oscillations of about ± .8° C are observed during the week-end coming from the upper part of the hall and slightly more sensitive in the top region of the chamber.
- The chamber frame and its support respond to these temperature variations with a certain delay.

4.1.2 Dilatations

Fig. 6 shows the dilatations measured during period 6C where the two sensors were fixed in the upper and lower part of the chamber (points A and B on fig. 2 respectively; $\overline{AB}$ = 1.273 m). The comparison of fig. 4 and 6 reveals immediately the correlation between the fast drops of the temperatures and the fluctuations of the dilatation curves, the maximum dilatation corresponding to ~ 130 μ when the temperature variation was of ~ 4° C. In this region the variation of the distance $\overline{AB}$ is of ~ 30 μ.

Fig. 7 shows the dilatations for period 1C (the sensor in position A being moved now to position O close to the centre of the chamber $\overline{OB}$ = .715 m). One still sees that the dilatations follow well the temperature variations, but one notices that the variation of the distance $\overline{OB}$ is not maximum in the step variation region as previously. The maximum dilatation is now about 110 μ.

So we can draw preliminary conclusions on the absolute dilatations:

- They follow at first glance the temperature variations as expected.
- Even the chamber frame / support dilatation compensation taken into account, they can be as large as 130 μ for $\Delta T \sim 4^{o}$ C.
- The variation of a distance of $\sim$ 1.3 m between two chamber points can reach 30 μ ($\Delta T \sim 4^{o}$ C) but the way this distance behaves depends upon the way the temperatures change in the chamber environment. This is a first indication that the chamber response to a ΔT is not homogeneous.
- The observed scatter of the dilatation measurements in the regions of regular small temperature variations does not exceed 1 - 2 μ. This, in our mind, proves two interesting facts :

  (i) The dilatometer device including its interface to the NORD-10 computer,via the MPX module, is really capable of measuring distances with a precision of a few microns.

  (ii) Tide or swell induced instabilities of the ground, if they are sensitive in the EHN1 hall are very smooth variations, otherwise they would certainly have produced differential variations of the chamber support and the quartz tube. (This point has been checked with J. Gervaise). To be more specific, that is to say that the local ground stability is within a few microns over a running period.

4.1.3 Chamber orientation

Fig. 8 gives the evolution of the two angles sensed by the two clinometers for period 6C. We observe two very different behaviours. While one angle is very stable, the other corresponding to a pendulum movement of the chamber, seems to fluctuate according to the temperature variations with an amplitude reaching .1 mr.

It is not very clear at this stage how the dilatation which is vertical would generate a movement of the chamber in the beam direction. We shall see later a possible explanation of this phenomenon.

4.2 Analysis of the Dilatations as Function of the Temperature Variations

The obvious correlation between dilatations and temperatures mentioned above has been analysed in detail with the hope in mind to establih later a forecast of chamber behaviour based on temperature measurements alone.

4.2.1 Chamber frame dilatation

The simplest dilatation to be studied first is the chamber frame dilatation since it should not depend upon the support behaviour. So we have tried to correlate quantitatively the variation of length of the distance $\overline{AB}$ (surveyed during period 6C), to the variation of the various recorded temperatures.

We assumed a linear dependence :

$$\ell = \ell_o \,(1 + k\,(T - T_o)\,) \qquad (1)$$

ℓ : distance measured

ℓ_o : " at reference time t_o

k : chamber dilatation coefficient

T : temperature at observation time t

T_o : " " reference time t_o

In fact, as we know that the chamber presents a certain response time, we have considered instead of T, the temperatures at earlier times. In this way, the response time is obtained from the analysis as the time interval between the observation time and the time corresponding to those temperature measurements which give the best fit to equation (1).

In practice we have tempted to fit (1) to the nine temperatures by χ^2 minimization method. Table 1 gives the results of the fits made in one of the fast T variation of period 6C over 12.5 hours (50 points) The setting error of the dilatation measurements was fixed to 1 μ which is a bit too low but allows from the χ^2's comparison to detect systematic deviations of the fit from the experimental points.

Table 1

	Temperature		χ^2	Response time in min.	Chamber dilatation coefficient $k.10^{-6}$ $m.^{o}C^{-1}$
1	Air:D4	Summit	643	60	2.3
2	support	Summit	606	54	4.4
3	support	Top	414	51	6.5
4	support	Middle	182	24	7.2
5	support	Bottom	60	21	5.7
6	chamber	Top	298	57	10.1
7	chamber	Middle	78	36	11.3
8	chamber	Bottom	28	18	9.4
9	Air:D4	Bottom	152	51	4.1

To illustrate the quality of the fits, Figs 9(a) and 9(b) display the projection of the fitted law on the experimental points for the best fit 8 and fit 4 which uses the temperature measured on top of the chamber instead of the bottom. One sees how sensitive the fit is to the choice of the right temperature, in this case the temperature picked up in the vetronite of the chamber, in the region where the variation of temperature occurred. The χ^2 values support this observation as well as they show that, when dealing with the chamber, the relevant temperatures to consider are those taken in the frame, as expected. The response time is fitted to about 20 mins, the vetronite dilatation coefficient to $\sim 10 \cdot 10^{-6}$. These values are clearly model dependant. We have made the assumption of homogeneous structure of the chamber and of constant temperature variation everywhere. We know that the latter assumption is not correct, since we have observed a vertical gradient of temperature variations. We see the incorrectness of our assumption in the fact that the dilatation coefficient is too low compared to the one of the vetronite ($\sim 15.10^{-6}$ $m.^{o}C^{-1}$).

Anyway, we can say at this stage that a simple model of linear dilatation assuming the same variation of temperature at any point, is able to fit very well the data, provided that one considers the temperature in that region where its variation originates.

4.2.2 Chamber support dilatation

To investigate the resulting chamber and support dilatation we have made first the naïve hypothesis of linear variation of a unique medium defined by its dilatation coefficient. In this way, equation (1) still describes the behaviour in time of the distances surveyed by the two METRO sensors. As done before, we tried to correlate the variation of these distances to the nine temperature measurements. Table 2 shows the results of the corresponding fits for a 60 hours (240 data points) in beam period 6 C, for the distance $\overline{GB}$.

Table 2

	Temperatures		χ^2	Response time in min.	Chamber Support dilatation coef. $k'.10^{-6}$
1	Air:D4	Summit	71536	60	12
2	support	Summit	66696	51	15.1
3	support	Top	26940	33	17.4
4	support	Middle	5727	24	18.3
5	support	Bottom	2064	24	15.1
6	chamber	Top	35267	39	22.3
7	chamber	Middle	11459	27	24.4
8	chamber	Bottom	5275	18	22.0
9	Air:D4	Bottom	10669	51	12.8

Fig. 10 shows the results of the best fit corresponding, as before to the temperature taken close to the ground, but now on the support instead on the chamber. One can see that the fit is rather good in spite of the large χ^2 values, which are due to the underestimation of the setting error).

One notices that the average scatter of the points around the fitted curve is a few microns only and the largest difference does not exceed 10 μ. So we may conclude that the simple model, assuming linear dilatation of a single material, works surprisingly well, provided that the right temperature is considered. In this case it is the bottom temeperature which is relevant, indicating that the support motion predominates the chamber motion(*). The overall response time is 24 minutes and the dilatation coefficient ($15 \cdot 10^{-6}$ m $^oC^{-1}$) has to be interpreted as a phenomenological coefficient averaging the vetronite and the Inox coefficients.

In spite of the efficiency of the simple model we have tried to improve it by now decomposing the summed dilatation into two contributions, one coming from the support, the second from the chamber, according to equation (2) :

$$\vec{\ell} = \vec{\ell}_1(1+k_1(T^1-T^1_o)) + \vec{\ell}_2(1+k_2(T^2-T^2_o)) \qquad (2)$$

$|\vec{\ell}_1|$, k_1, T_1: height GH, dilatation coefficient, temperature of the Inox support.

$|\vec{\ell}_2|$: distance HA or HB between the upper part of the support and the METRO sensor.

k_2, T_2 vetronite dilatation coefficient and temperature.

We have chosen the same regions of fast variations of temperatures for high sensitivity to the model dependence of the fits. Table 3 gives the results of fits of the two models in the case point A.

Table 3

Model	Temperature	χ^2	Response time in min.	Dilatation coeff. $.10^{-6}$m $^oC^{-1}$
1	T = bottom of support	2064	24	k = 15.1
2	T1= bottom of support T2= bottom of chamber	998	Inox: 18 Vetronite: 66	Inox: 9.1 Vetronite: 13.2

*) Other temperature choices result in bad fits with systematic deviations from the data of the order of 20-40μ.

The fit is significantly improved (see Fig. 11). The response times for the support and the chamber frame look different. In particular the fit yields to a response time of 60 min at the level of point A, in the present case of ground temperature variation. If we repeat the previous fit for point B we get a shorter respone time (30 min.) for the frame, as expected since point B is at the lower part of the chamber. If we remember that we have observed for this period a gradient of the temperature variations, we can say that the chamber support which is exposed to such a gradient of temperature variations (with maximum amplitude close to the ground) behaves in the following inhomogeneous way. First the support dilates with a time delay of about 20 mm, then the chamber reacts in a differential way (differential dilatation) depending on how far from the perturbation region the point is considered. The dilatation coefficients of the vetronite and Inox materials are found to be too low. This comes directly from the fact that they have been calculated assuming that the whole lengths $\ell 1$ of Inox and $\ell 2$ of Vetronite have suffered the variations of temperatures observed in the bottom region of the support and the chamber respectively.

So we can conclude that the overall D4 detector dilates in a manner which depends both upon its geometry and the type of temperature variations. Simple models are able to fit very well the timely behaviour of this detector. Unfortunately, they require the precise knowledge of the characteristics of the temperature variations and they deliver output parameters such as response time and dilatation coefficients which depend on the model assumptions for the type of variations of temperatures considered. As such they cannot be preset to infer unambiguously the dilatation of any detector when the temperature variation is recorded.

In the chapter "conclusions" we come back to these specific points.

4.3 Analysis of the Orientation of the D4 Chamber as Function of the Temperature Variations

As we have observed a small but clear pendulum motion of the chamber directly related to the temperature variations, we were interested to know if this motion was a consequence of the dilatation which can be thought of having induced small changes of positioning via the mechanical stresses created in the materials. Therefore we have tried to fit the orientation fluctuations to a simple proportionality law:

$$\Delta\alpha = K (T - T_o) \qquad (3)$$

K: proportionality coefficient

To, T temperatures at reference and observation times

We also introduced a response time here, as previously given by the analysis and tempted to fit relation (3) to the nine temperatures. Table 4 gives the results of these fits for the same time interval as Table 2,3.

Table 4

	Temperatures		χ^2	Response time in min.
1	Air:D4	Summit	2321	0
2	Support	Summit	2718	-9
3	Support	Top	1765	-27
4	Support	Middle	1228	-30
5	Support	Bottom	912	-27
6	Chamber	Top	1822	-9
7	Chamber	Middle	1246	-15
8	Chamber	Bottom	1231	-33
9	Air:D4	Bottom	635	0

It is readily seen that the best fit is obtained when the temperature in the air, close to the ground, is considered (Fig. 12). The response time is close to zero. The other fits are worse and give larger negative response times, which imply that the change of orientation of the chamber would occur before the chamber (or support) has registered a change in the temperature conditions. In other words, it seems that the change of orientation would happen before the dilatation itself, which is a nonsense. Inspection of Fig. 12 shows that the best fit reproduces well the data even the small fast fluctuations. We have checked (Fig. 2) that the air temperature in the bottom region of the chamber had the same fluctuations.

All these facts lead us to the conclusion that the observed variations of orientation came from the clinometer itself and not from the chamber-frame. It is indeed more natural to think that one clinometer had a smaller mechanical inertia than the other (both having a negligible thermal inertia compared to the chamber) and became sensitive to the temperature variations. It would be easy to check this affirmation by puting the clinometer on a stable surface and controlling its values when changing the temperature in the surrounding atmosphere.

5. CONCLUSIONS

We already drew provisional conclusions during our study. We can now summarize them, enlarging those which will be more relevant in the future.

5.1 Apparatus - Survey Data Collection

- Thermosensors:

The W60/7 Degussa platinum resistances are good (and cheap) for air temperature measurements. Their accuracy is far better than needed one, but unfortunately they would need an absolute calibration before use. Their implementation on any material is simple and their link to the scanner via four wire cables is easy, as special panels have already been foreseen for such chambers.

- Dilatometer:

This simple device has been found to be very accurate. It should be flexible for the application of very high precision survey of any detector. In itself, it is sufficient to completely survey the absolute dilatation of any detector component. The connection to MPX station (two sensors per module) worked perfectly well. A limitation comes from the counter-box which has to be put not very far away from the sensor itself, as the manufacturer warrants only a 10 m transmission distance.

- Clinometers:

Provided that they are shielded against temperature variations, they are able to monitor very accurately the variations of orientation of a detector. Their connection to the scanner made in an "ad hoc" way would have to be changed for longer use.

- Use of the Nord 10 monitoring computer:

We have certainly not made use of all the facilities already available from the Nord 10 monitoring system, as we were just interested in data recording for off-line analysis. It was for us the opportunity to start using some of these facilities and to consequently estimate that the existing system is very well designed for the purpose of easy monitoring.

5.2 Characteristics of the Behaviour of a Wire Chamber and of its Environment

We can only make partial conclusions on the behaviour of wire chambers in the EHN1 hall. This is because we just study the D4 drift chamber and only in winter period. We can anyway resume our observations in particular those which should be valid for any detector at any time.

We first confirm the existence of temperature stratifications in the EHS area, with the higher temperatures at the top of the detectors (~ 4 m height). In winter time the average temperature difference between the ground and the top of the detectors is about 1°C. Fast drop of temperatures occur each working day, due to the opening of the hall doors. This fast variation reaches 4°C close to the ground of the hall, but is less pronounced on top of the detectors. Reversively, smooth oscillations of temperatures arise during the weekend with an amplitude of ± .8°C and are more pronounced on top of the hall, because they come from the switching ON/OFF of the heating. So we can say that the EHS spectrometer stands in inhomogeneous temperature conditions which show differential variations from the gound to top levels.

Resulting dilatations are observed, even after compensation of chamber frame versus support. For the D4 chamber, the upper part of the chamber moved by ∿ 130 μ with respect to the ground. By extrapolation we can guess that in summer period this displacement would reach ∿ 250 μ between night and day times. The chamber frame itself dilated by 30-50μ (60-100μ in summer).

As a byproduct of the dilatation measurements we remarked that the local ground stability is perfect.

No change of the orientation of the chamber was clearly noticed during the survey, so we can state that the installation of clinometers on each detector is not necessary, unless motions coming from other origine than temperature variations (vibrations, ...) are expected.

5.3 Monitoring of the Dilatations

We recall that one of the goals of the survey of the D4 chamber was to judge if it would be possible to infer the dilatation of a chamber by measuring only the temperature variations, in order to correct for this dilatation if it were estimated to be too large compared to the expected accuracy of the chamber.

Unfortunately there is no straight-forward conclusion as to this point. We have shown that it is possible to use simple models to calculate accurately the dilatation from the temperature measurements, but these models have two major faults:

i) they require to know the characteristics of the temperature variations to decide in particular which temperature is relevant to consider;

ii) as they have to deal with the fact that in general the variations of temperature have a vertical gradient, the parameters characterising the chamber-frame and support such as dilatation coefficients, thermal response times cannot be used as input parameters to calculate the dilatation from the temperature variations. On the contrary, they are obtained from the fit and have to be interpreted as phenomenological parameters specific of the chamber support and the temperature variation under study.

Therefore it seems difficult to apply these models to monitor the dilatation of a wire chamber detector without making some approximations which would lead to some loss of accuracy. We have, for instance, tried to recompute the observed dilatations of points A and B during period 6C under the following hypothesis:

- the simplest model (Eq. (1)) of a single material holds
- the average dilatation coefficient is $k \sim 15\times10^{-6}\ m^{o}C^{-1}$
- the initial temperature To is taken as the average of nine recorded temperatures at the initial time of data taking when the METRO sensors were set to zero
- the response time of the D4 detector is 20 min.

So we have just calculated the following quantity:

$$\ell_{A,B} = \ell_{o_{A,B}}\ k\ (T_i - \bar{T}_o) \qquad i = 1,\ldots,9$$

and compared it to the measurements made during period 6C. The results can be guessed from our previous discussion (Fig. 13), (sect. 4.2.2) i.e. : when we take the temperatures close to the ground, we are able to reproduce reasonably well the two measured dilatations, but with a loss of precision which can reach 30% of the maximum amplitude in the region of rapid temperature variation. While, when we consider the temperatures on top of the chamber, we do not compensate more than 50% of the dilatations.

So it seems that to monitor with a sufficient accuracy these dilatations, one should at least know where to pick up the temperature.

In any case, it is necessary to calibrate each wire chamber detector to know which assumptions can be reasonably made concerning its overall behaviour in time, its response time, the dilatation coefficient one should use. This can only be achieved by measuring both the temperatures and the dilatations for at least one example of each kind of chamber, during a run period. The best, but more expensive solution is to equip each chamber with a dilatometer which will deliver, at any time, the absolute position of well chosen points of the chamber.

REFERENCES

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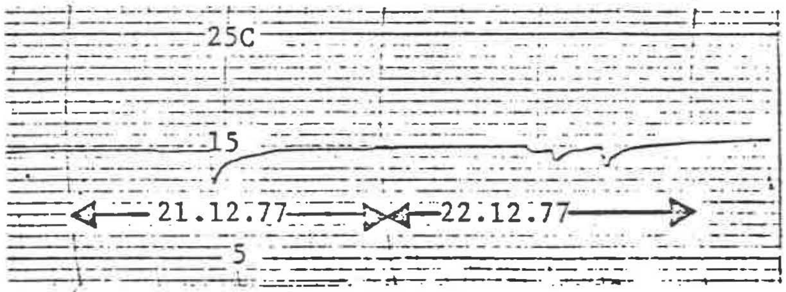
[3] 1979 Technology exhibition note: "S3 clinomètre électronique"

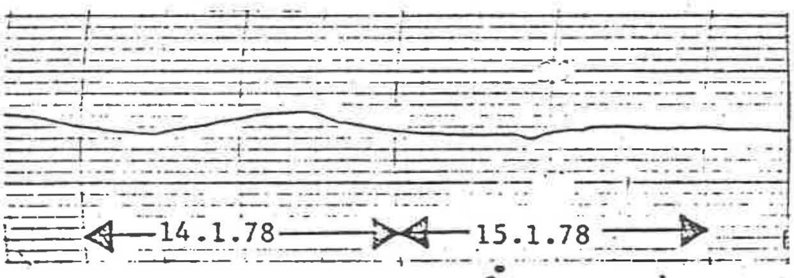
[4] 1979 Technology exhibition note: "S4 Niveau hydrostatique automatique".

Temperature Variations in the EHS Area of EHN1

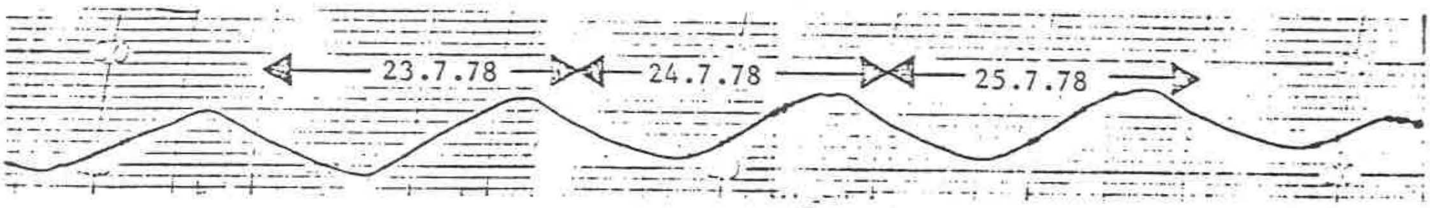
- First survey using a simple temperature recorder -



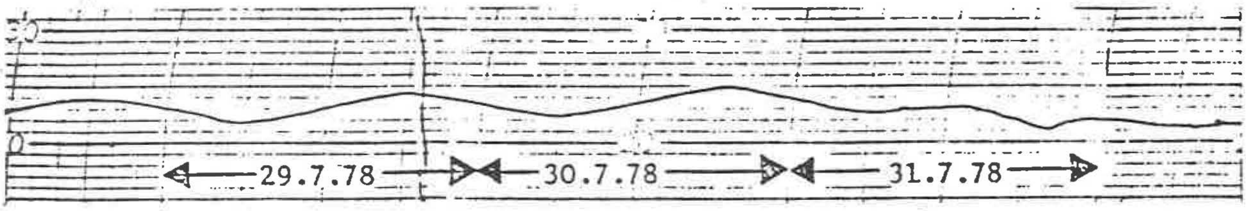
A: Winter time
Outdoor temperature 0...-5C, measurement near ground, 20 m from hall door.



B: As A, but measurement in 4 m height.



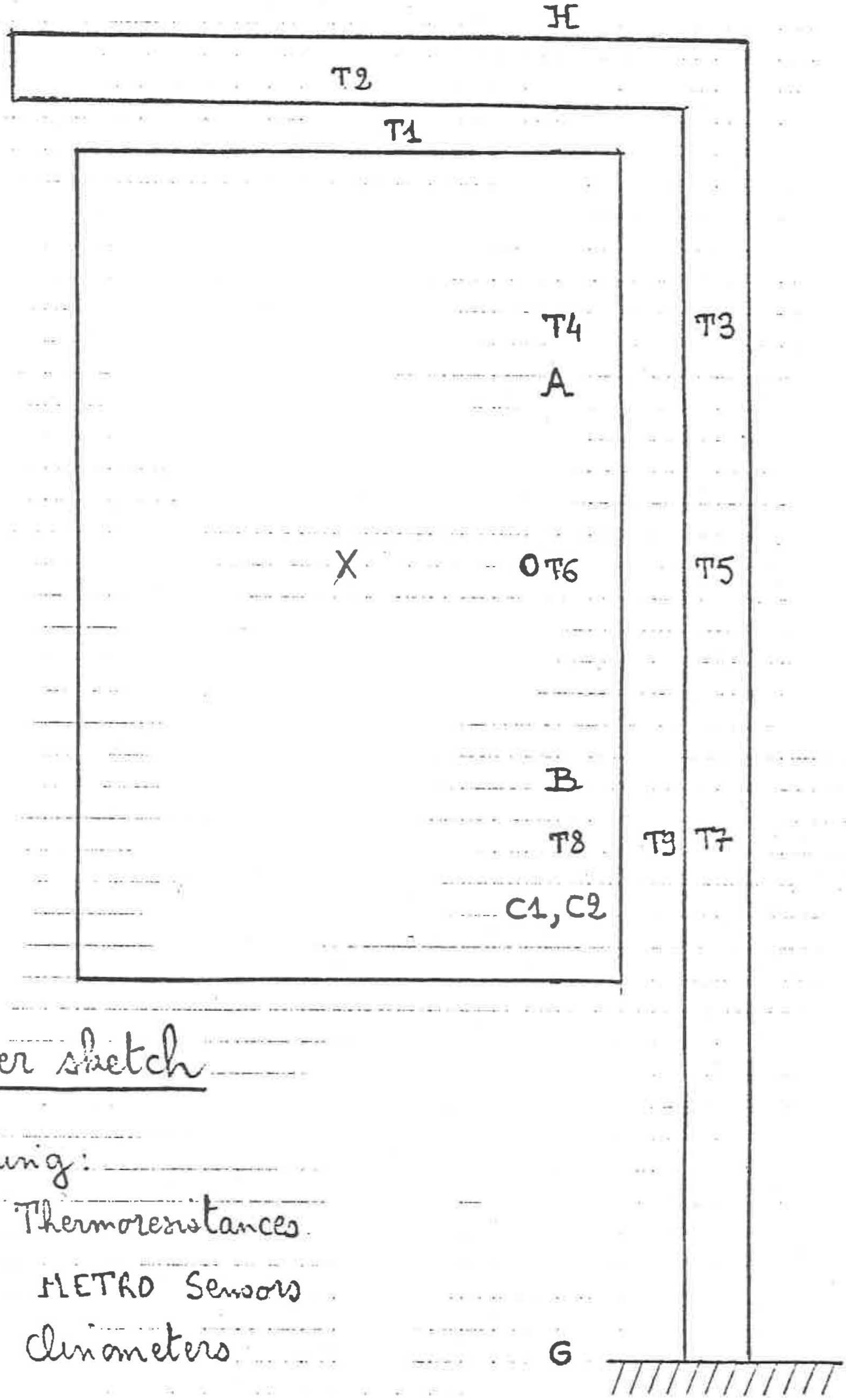
C: Summer time, hot period; measurement in 4 m height, 20 m away from hall door.



D: As C, measurement near ground.

Conclusions: At winter time, temperature rather stable around 15C. Opening of the big hall door near to EHS area produces sharp drop of temperature near ground by probably more than 3C (A). Influence of door not visible in 4 m height, so presence of stratification (B). During sunny summer periods, periodic daily variations of temperature by up to ± 3.5 C. Average between 20 and 25C (C). Daily variations less pronounced near ground (D).

Fig. 1



D4 Chamber sketch

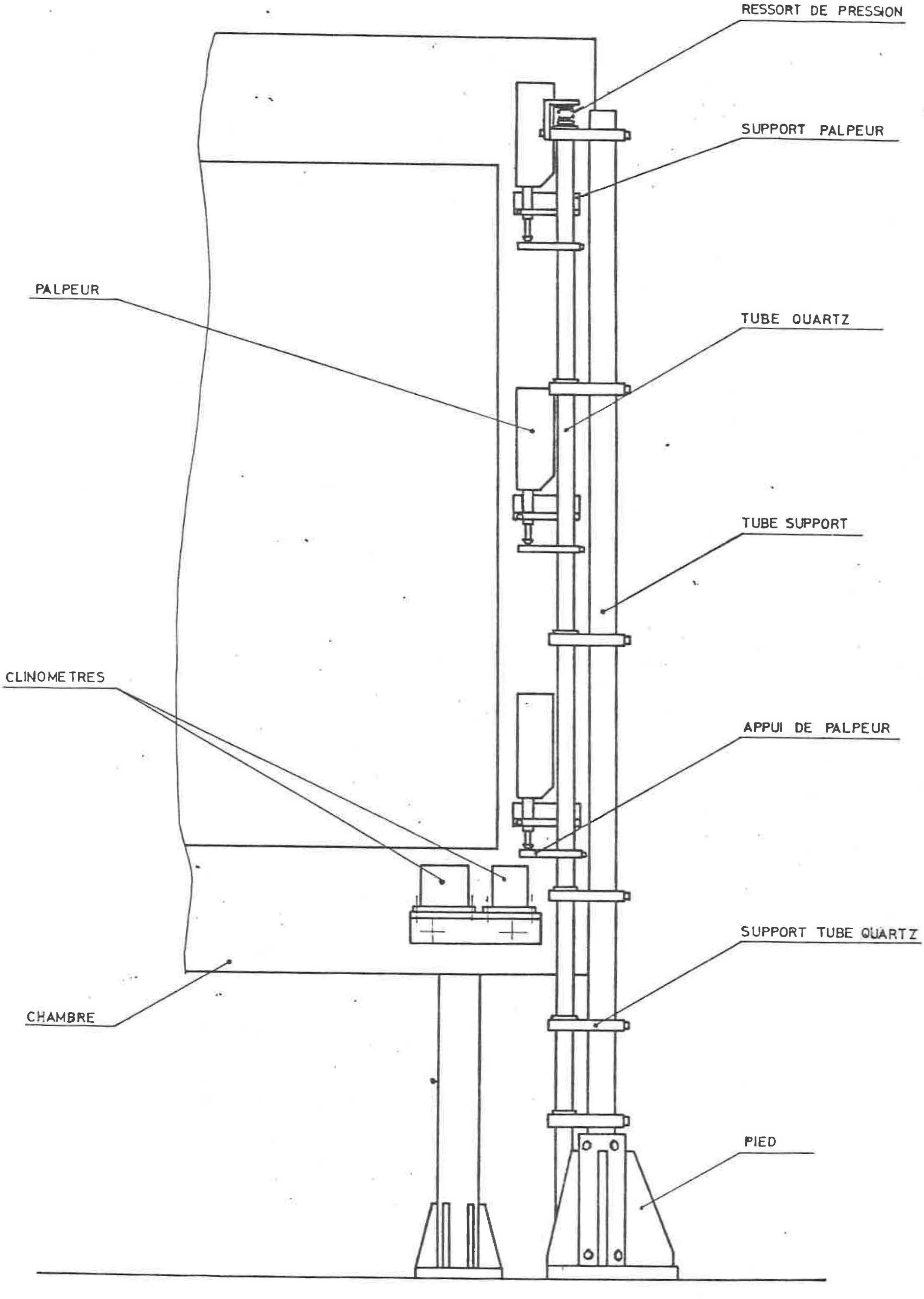
Positionning:

T1 → 9 Thermoresistances

A, O, B METRO Sensors

C1, 2 Clinometers

Fig. 2



Dispositif de contrôle de dilatation des chambres

Fig. 3

R.C.

Temperatures ($T_1 \to T_9$) = f(time) - Period 6C-79

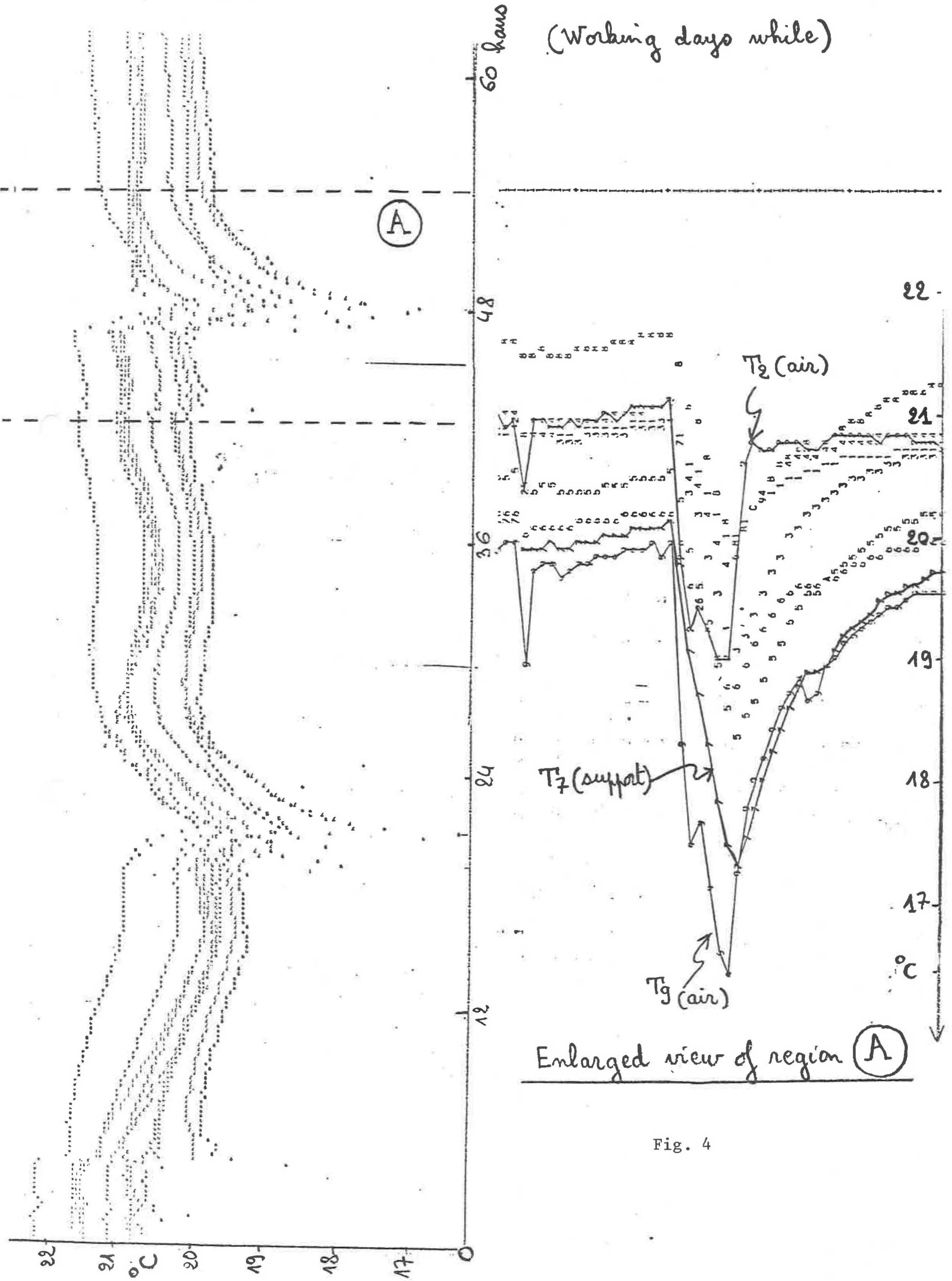


Fig. 4

Temperatures ($T_1 \rightarrow T_9$) = F(time) - Period 1C-80

(Week-end while)

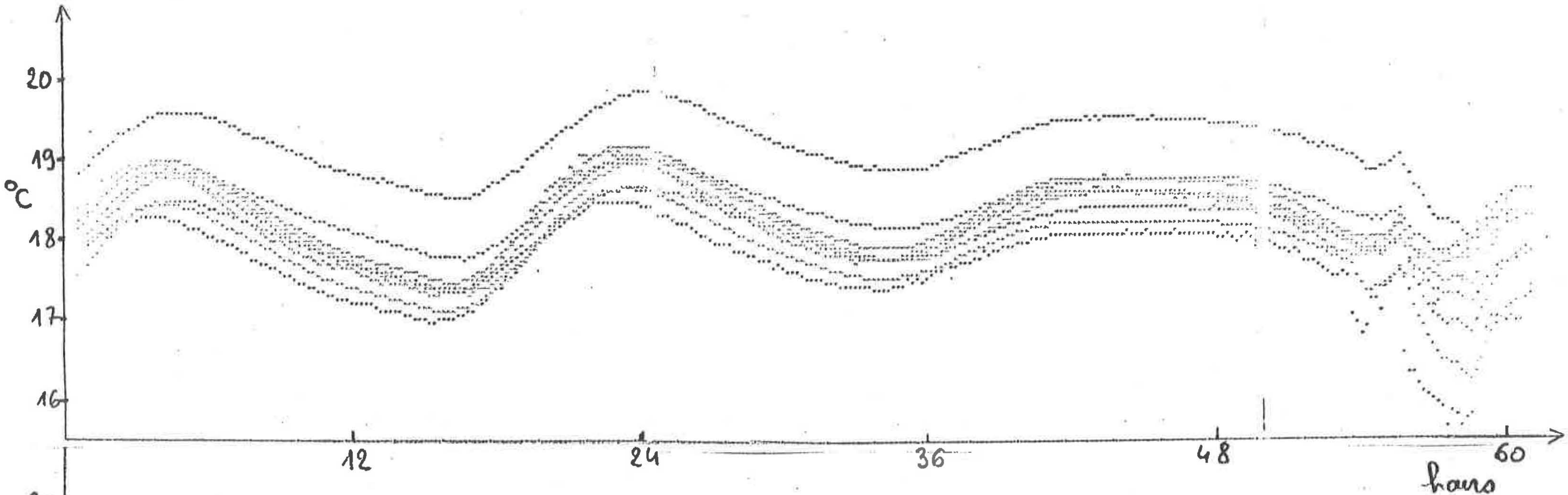


Fig. 5(a)

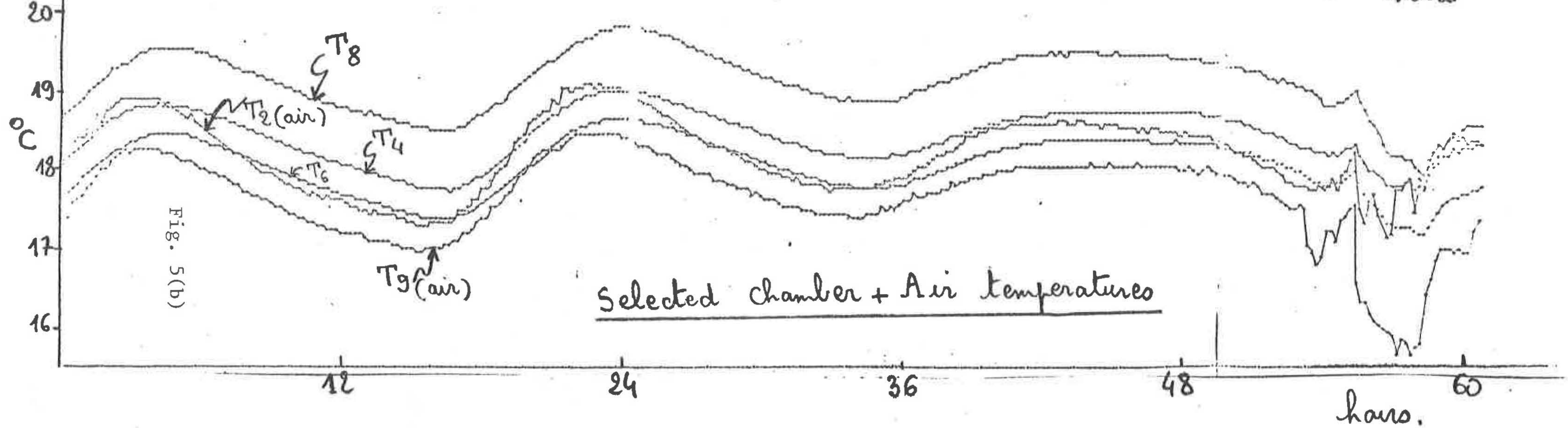


Fig. 5(b)

D4 Chamber frame + Support dilatations

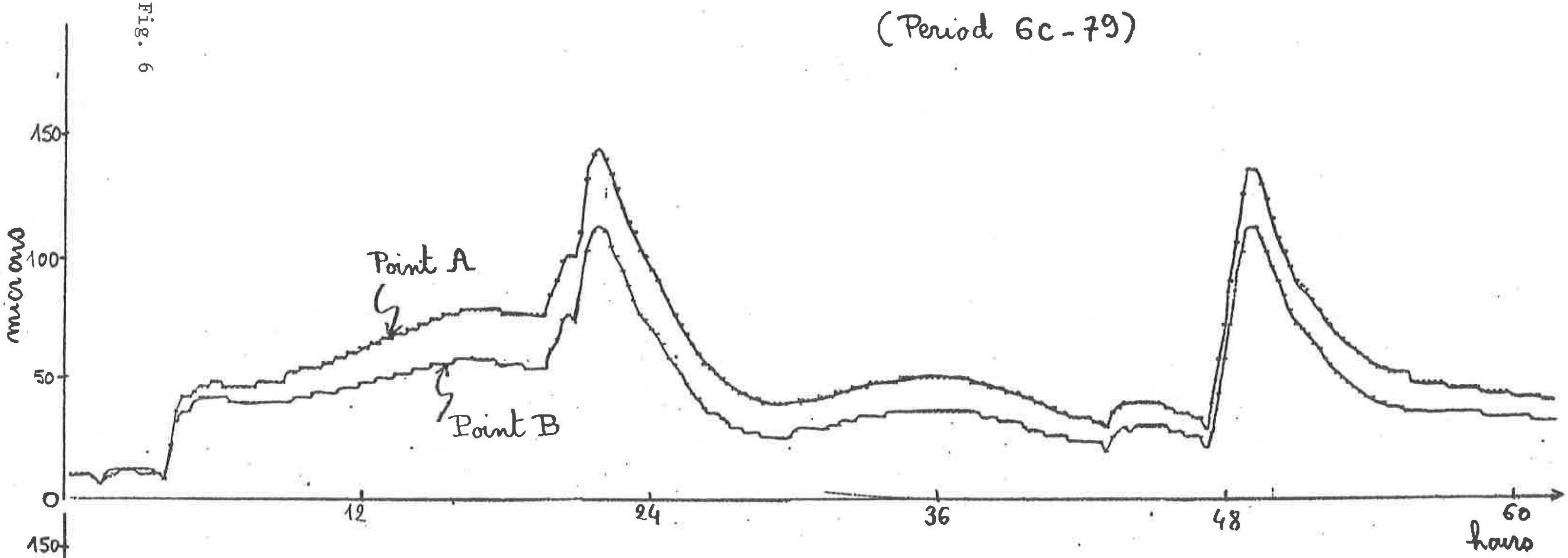


Fig. 6

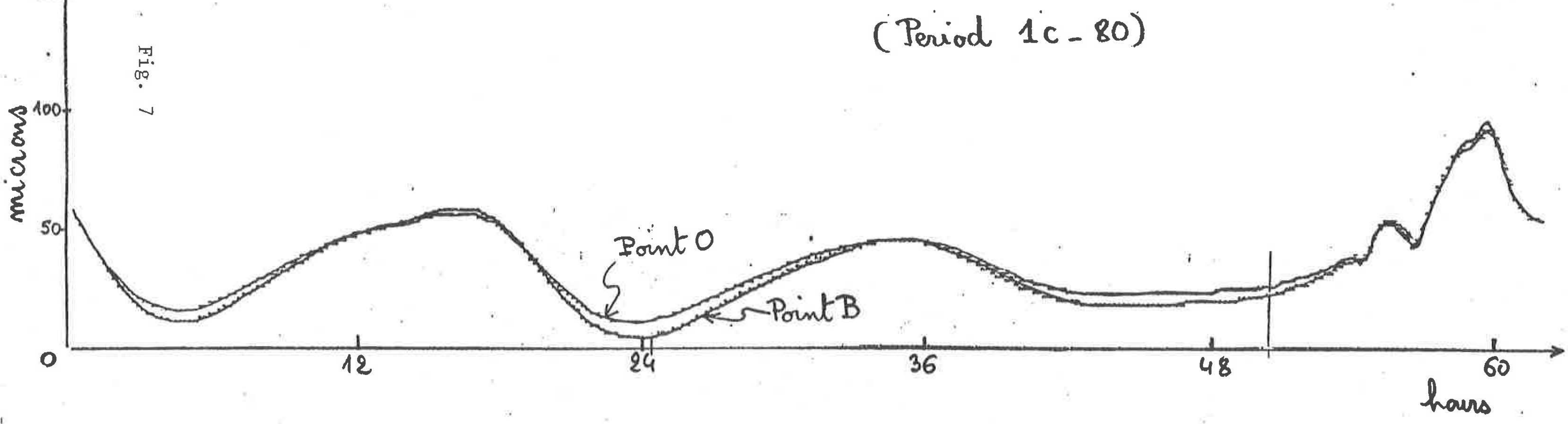


Fig. 7

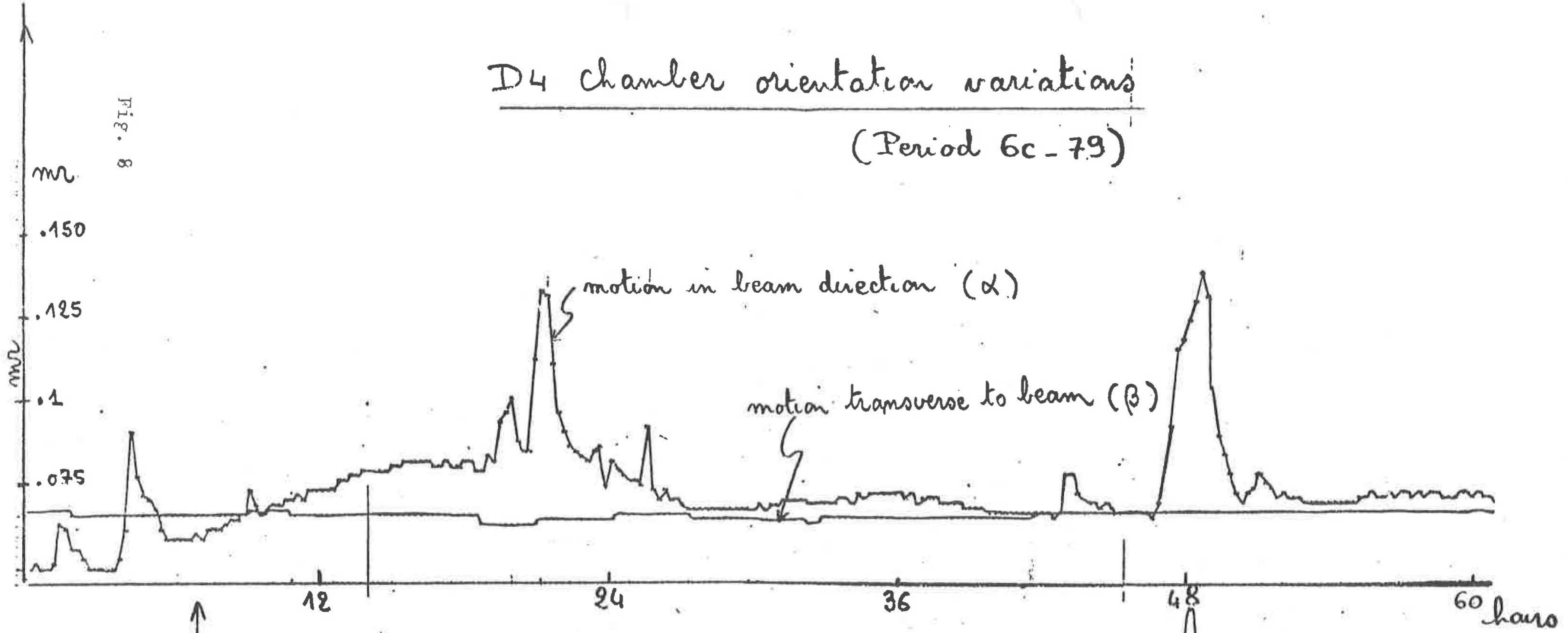

D4 chamber orientation variations
(Period 6c - 79)
mr
.150
.125
.1
.075
motion in beam direction (α)
motion transverse to beam (β)
12
24
36
48
60
hours

Fig. 8

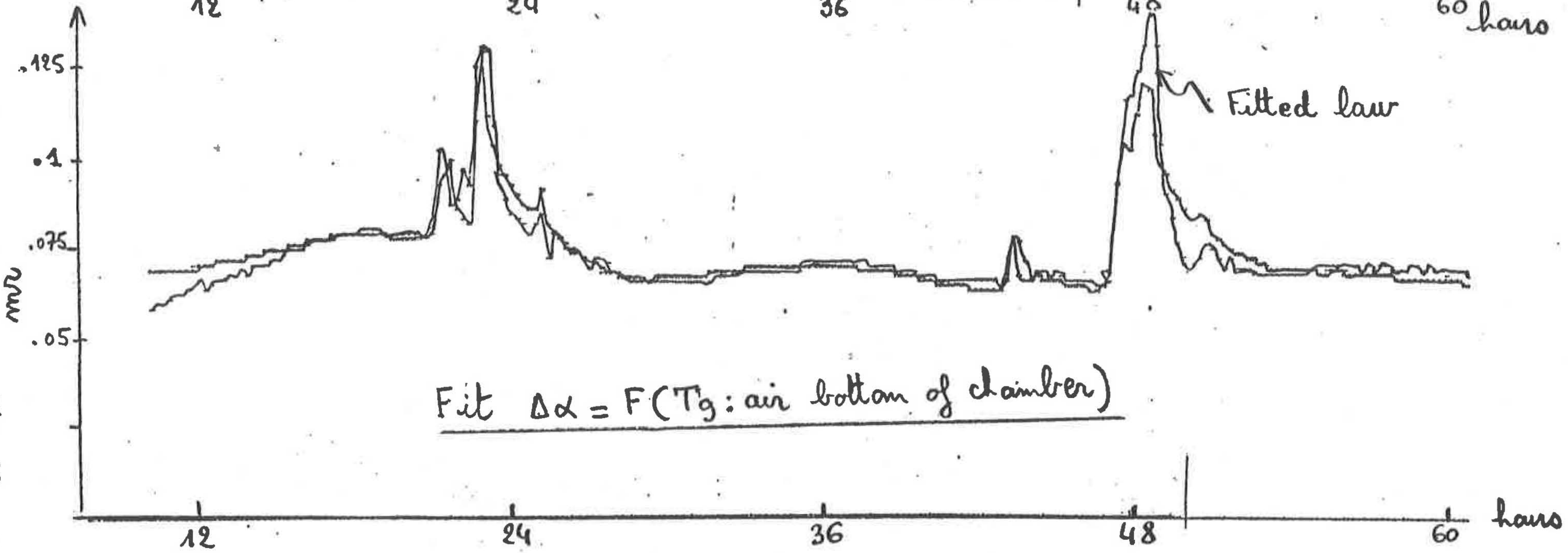

.125
.1
.075
.05
mr
Fitted law
Fit Δα = F(Tg : air bottom of chamber)
12
24
36
48
60
hours

Fig. 12

Fit of $\Delta_{AB} = F(T)$

(Period 6c - 79)

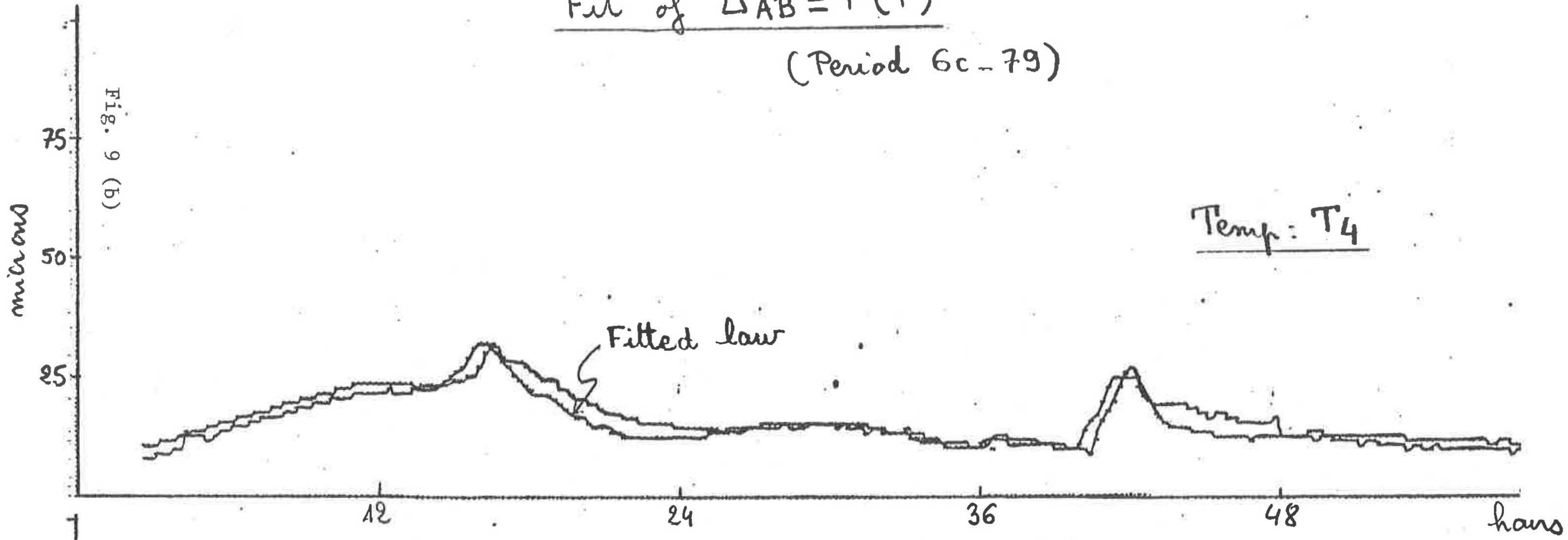


Fig. 9 (b)

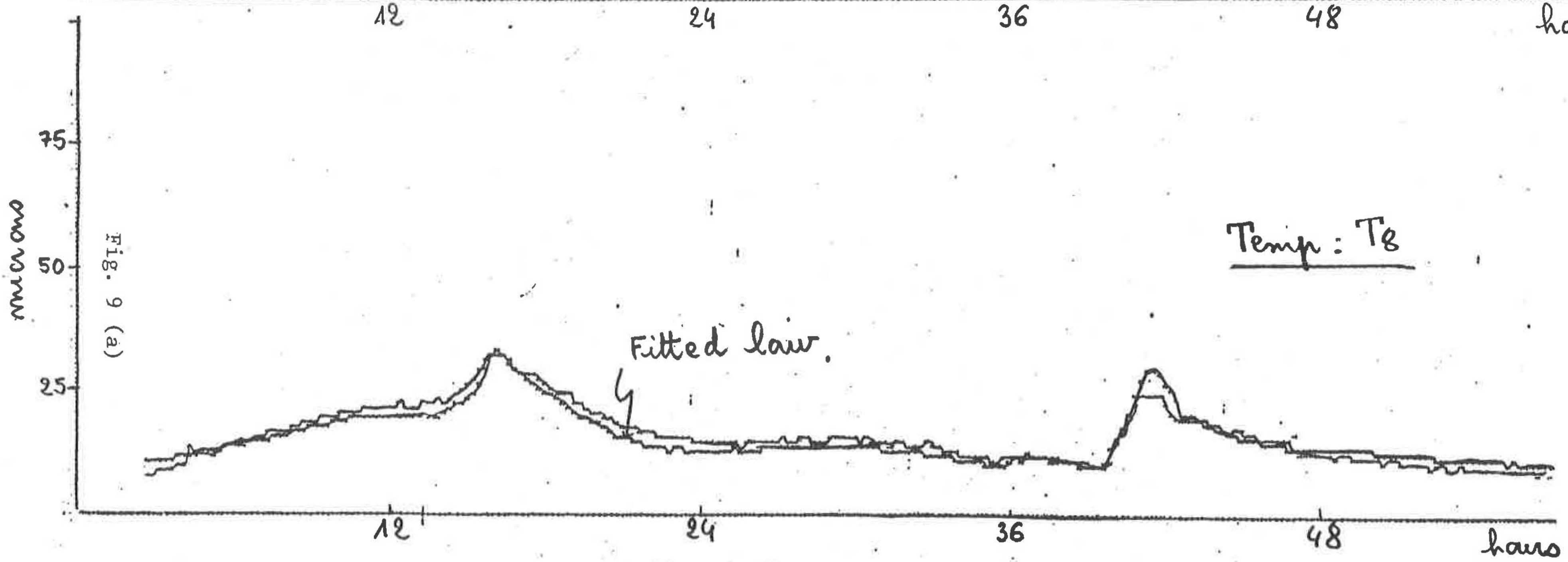


Fig. 9 (a)

Fit of $\Delta_{GB} = F(T)$ (Period 6c.79)

Fig. 10

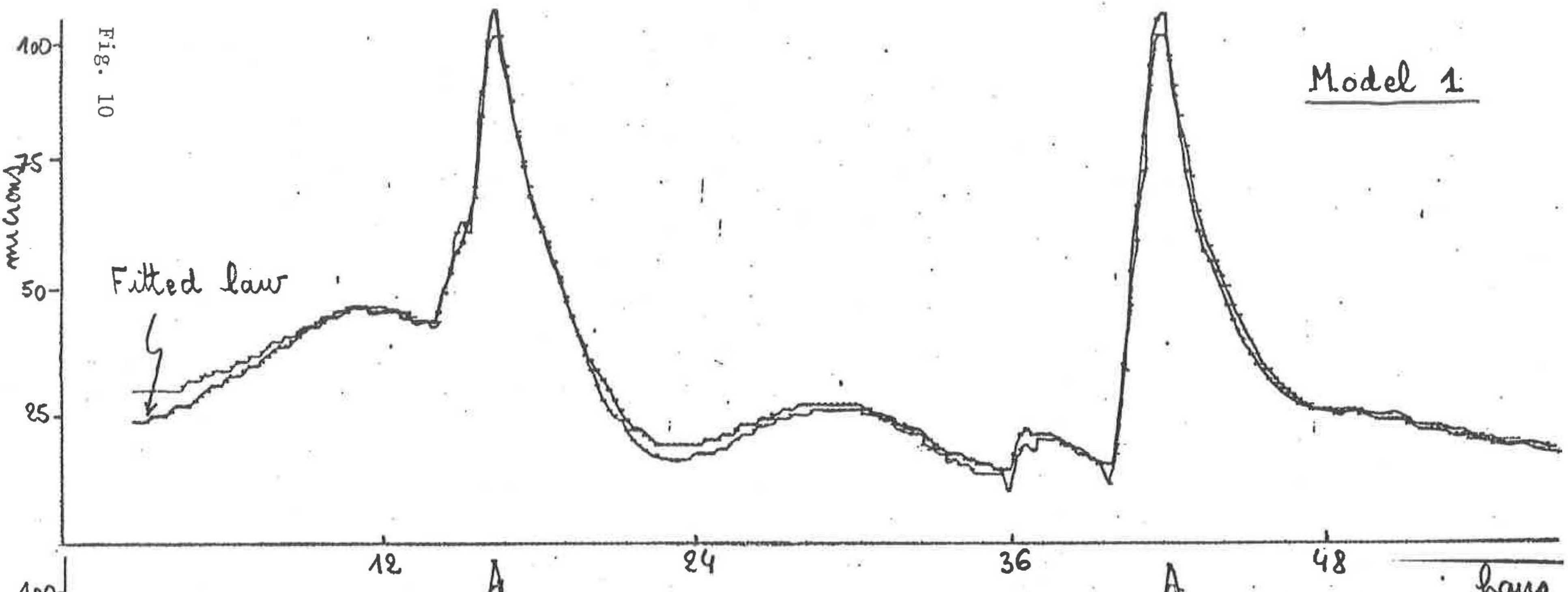
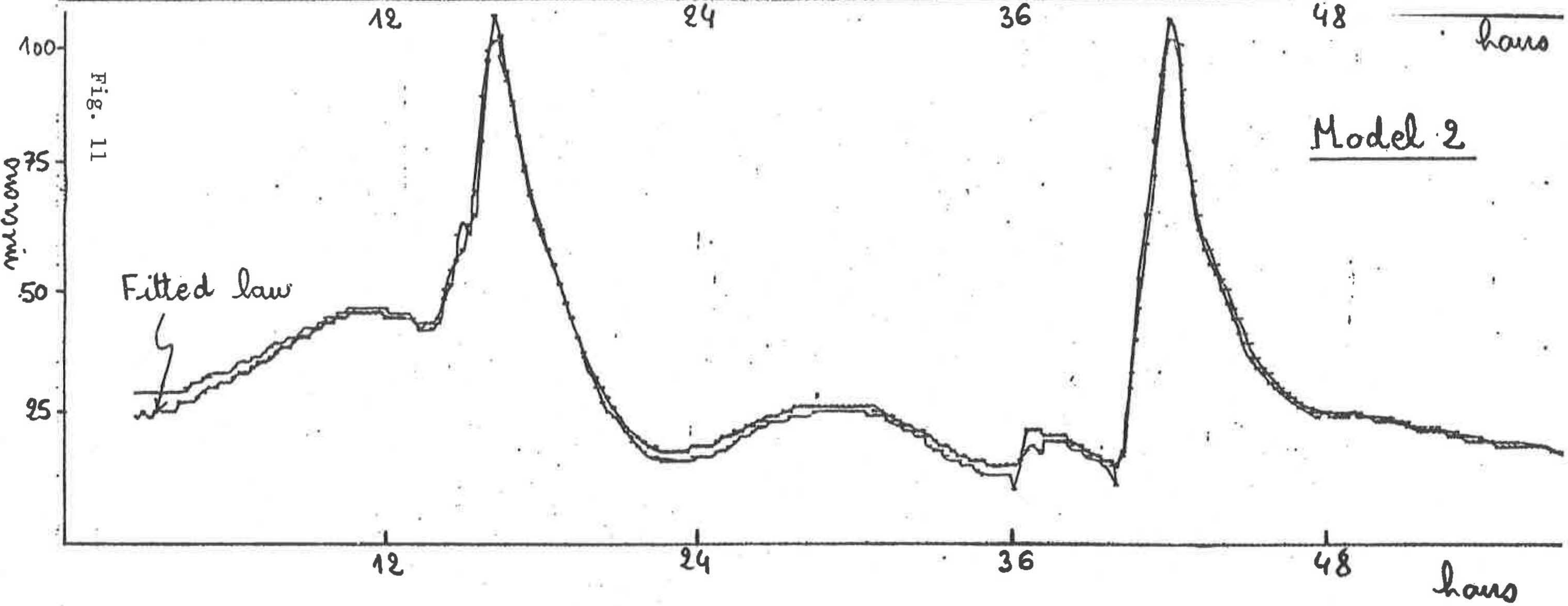


Fig. 11



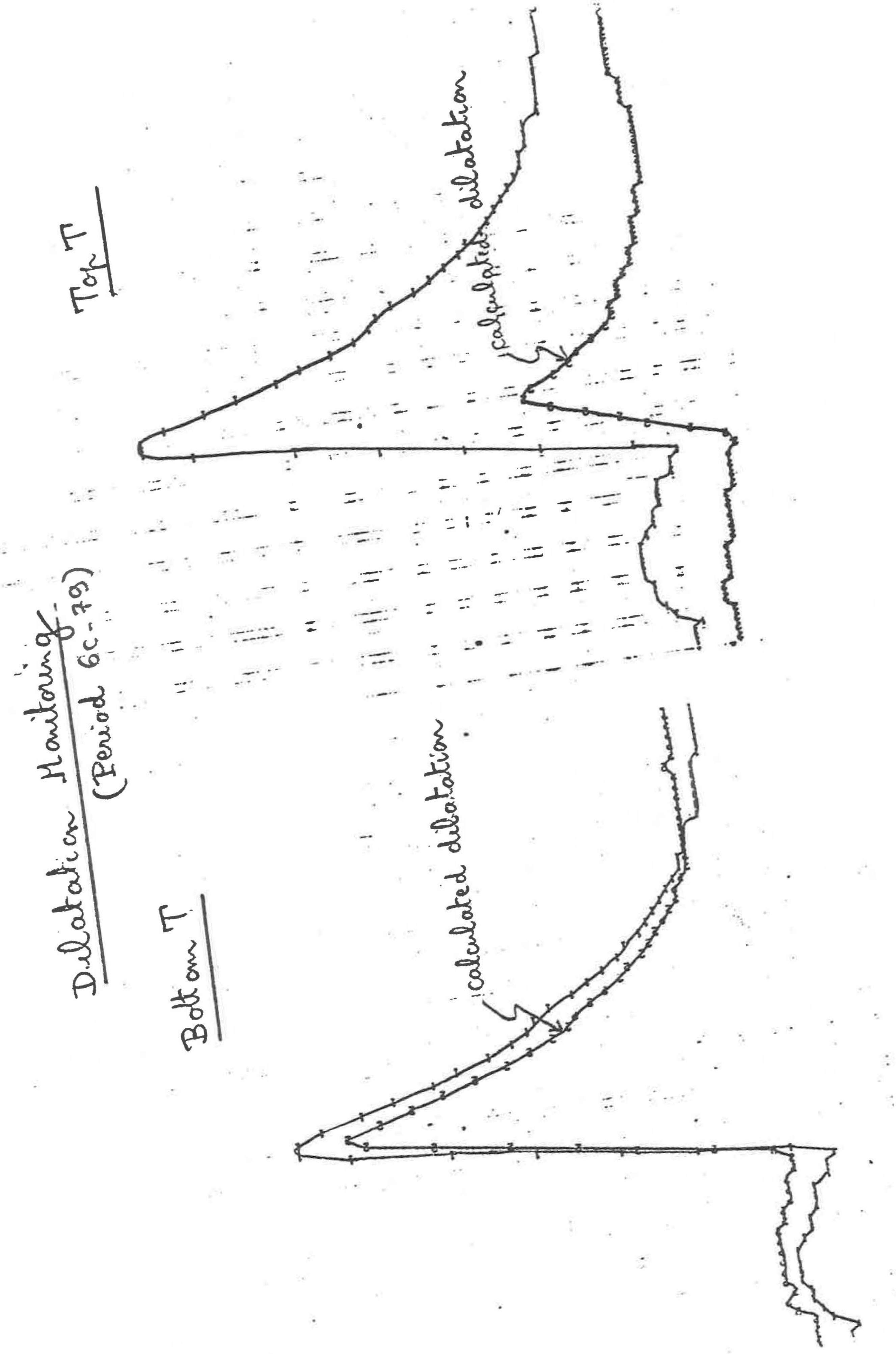

Dilatation Monitoring
(Period 6c-79)
Top T
calculated dilatation
Bottom T
calculated dilatation

Fig. 13