ANS SF3-20
Version 2

USER MANUAL

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1 WARNING

PRELIMINARY MEASURES

⚠ Always observe the basic precautions, safety rules and instructions listed in this document to ensure the safety of persons and to prevent damage to the device or the instruments connected to it. It is equally essential to comply with the legal and safety requirements for the relevant application during use.

For safety reasons the device may only be operated by authorized personnel. The device must be used exclusively for the tasks for which it is intended and within its specified limits of application. It may only be opened within the limits of the operations listed in this document. Do not attempt to disassemble the internal components or modify them in any way.

The device is a link in the measuring chain. Equipment installers and operators must plan, implement and meet the safety requirements of the device, the instruments connected to it and the measurement technology

SETUP GUIDELINES

⚠ Use only the voltage required by the measuring instrument. Make sure that the instruments or network supplying the voltage to the instrument corresponds to the voltage marked on the instrument.

The electrical safety of this appliance is only ensured if it is properly connected to a grounding system in accordance with electrical safety standards. It is essential to check whether this basic safety requirement is met. During installation, a two-pole switch with at least 3 mm opening between the contacts must be used.
Protect the unit from direct contact with water and observe the maximum permissible ambient temperatures. Operation of the unit in direct sunlight, in very hot or very humid, dirty or dusty locations, in locations subject to strong vibrations or in the vicinity of magnetic fields can lead to malfunctions.

Do not place any objects in front of the air vents of the measuring instrument, as this will interfere with the proper ventilation of the internal components and lead to overheating.

If the measuring instrument shows signs of malfunction, or if you detect an unusual smell or even smoke, switch it off immediately and have it serviced by a MEIRI qualified technician.

WARRANTY

MEIRI measuring instruments are guaranteed for 1 year (parts and labour, return to factory), unless otherwise specified.

The warranty will not apply in the following cases:

If the unit has been operated on a voltage other than that indicated on the unit's nameplate. If the user uses or modifies the unit delivered to him in an abnormal or abusive way. If the user causes damage due to negligence, insufficient maintenance, inexperience or use of harmful products.

Exchanges or repairs carried out under the guarantee resulting in the detention of the equipment for less than seven days cannot extend the duration of the guarantee. For the application of this warranty, the user must contact the MEIRI distributor who sold him the device. Repairs under warranty are carried out in our laboratories. The device must be returned in packaging that ensures its safety during transport. The user is responsible for the cost of postage and packaging for the return of the unit to the factory. MEIRI or its distributor will pay the postage and packing costs for the return of the device after repair in metropolitan France only. No compensation is due if the unit is detained for repair under warranty.

1 Introduction

1.1 Applied method

Among the methods available to detect and measure cracks propagating in structural metallic component, the so-called "electrical potential" method is one of the most widely used in fatigue testing laboratories.

Its principle is extremely simple, but leads to a more or less easy implementation depending on the technique adopted:

- An electric current of constant amplitude is passed through an insulated conductive specimen and the resulting voltage is measured between two potential taps on either side of the crack to be observed. The evolution of this crack leads to a variation in the measured voltage and, with the help of a prior calibration, it is possible to deduce the progress of the crack. Hence, continuous monitoring is possible, which is one of the great advantages of the electrical method.

- In the CELIANS device, the technique used is similar to that of "direct current" although the current is applied in the form of pulses, but of sufficient duration to reach an established electrical state. This peculiarity makes it possible to obtain the following important characteristics, compared to the classical technique mentioned above.

  - Improved sensitivity and accuracy
  - Very high stability
  - Limitation of the average current flowing through the specimen, resulting in lighter connections and reduced heat generation
  - Possibility to synchronize the measurement with the load during dynamic tests.

In addition, the calibrations established with the conventional technique remain valid when using this instrument.

2 - Theory

DEVELOPMENTS IN THE METHOD OF ELECTRIC POTENTIAL. APPLICATION TO THE MEASUREMENT OF CRACKS LENGTH OR SHAPE.

Sources G. BAUDIN, H. POLICELLA : Office National des Etudes et Recherches Aérospatiales

(National Office for Aerospace Studies and Research)

2.1.1 ABSTRACT

A description of the improvements in the application of the electrical method in the area of crack progression testing is provided. These improvements relate to the equipment itself as well as to three-dimensional calibration techniques. As an illustration, real-life application examples are given: continuous crack monitoring in thin sheet metal, non-destructive crack front measurement in thick workpieces, and priming detection.

2.1.2 INTRODUCTION

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Principle:

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Implementation:

Two main techniques are used, each with its advantages and disadvantages [1] :

- The DC method is the simplest to implement. Given the low voltages needing to be measured, (they are proportional to the current injected) one can be led to use high currents (up to 100 A.) hence the problems of connections and heating. In addition, thermal interference voltages disturb the measurement and their elimination is the main obstacle to overcome.
- The AC method, which requires more advanced electronic equipment, gives an excellent measurement free of the thermal component and most parasitic noise. The currents used are then lower (up to 10 A.) When the frequency is low, the calibrations established with DC remain valid. At high frequencies, however, the skin effect occurs, which further improves the sensitivity of the measurement and may lead to a further reduction in current (≈ 1 A.). But calibration depends on frequency and radiation hence introducing measurement errors.

The method developed at ONERA is of the DC type in principle but its results are closer to the AC type with simpler electronic equipment. It also has the original characteristic of being able to synchronize the measurement and the load of the specimen during a cracking test [2].

The good sensitivity obtained, made it possible to apply the electrical method to three-dimensional crack measurement problems by combining it with an analog calibration technique [3].

2.1.3 DEVELOPED ELECTRICAL METHOD

Remember that the basic problem is to measure a very low pseudo-continuous voltage (a few µV.) which it is therefore necessary to amplify, hence the risks of error due to noise and amplifier drift. Moreover, this voltage is to some extent affected by a component of thermal origin at the level of the potential taps (thermocouple effect).
It is thus a question of extracting from this amplified voltage the component due solely to the passage of the current.

The procedure is as follows (fig. 2) (For example IMAX= 10 A, FREQ=25 Hz, PULSE=20 ms):

- The current is injected into the test piece in the form of pulses of IMAX constant amplitude with a duration of approximately 20 ms, after which time the electrical potential is considered to be established. The output voltage V1 of the amplifier is then stored analogously and the current is then cancelled.
- Exactly 20 ms. later a second storage occurs (V2). 0ne then has the voltage ΔV = V1 - V2, which is free of quasi-static interference and is the required voltage.

These operations are repeated with each impulse.
Noise is attenuated by limiting the amplifier bandwidth to 100 Hz, and noise due to the mains is practically eliminated due to the two 20ms memorizations. Finally a last filtering on the ΔV output voltage offers a sensitivity of 0.1 µV. for a response time of 1 second.

Another important feature of this method is the ability to synchronize the pulses, and thus the measurement, with the loading cycle in crack propagation tests under variable loading or other conditions involving many compressive loads. Synchronization is achieved by means of a threshold triggered by the force signal from the testing machine and an adjustable delay (fig. 3). The measurement can thus be carried out at constant force or at maximum force when the crack is completely open.

2.1.4 APPLICATION TO THE MEASUREMENT OF CRACK LENGTH IN THIN PLATES (Two-dimensional case)

One of the most common application examples is when the specimen takes one of the simple shapes shown in Figure 4 and where the supply conditions ensure a constant current density in the sections "away" from the crack. In this case the calibration is given by an analytical expression [4]:

(1) $V(a,d) = \alpha U$

(2) $U = 2/\pi \cdot ch^{-1} (ch(\pi d/2w) / \cos(\pi a/2w))$

V(a,d): measured voltage

A: crack length or half-length

D: half distance of theptential taps

W: width or half width of the specimen

A: factor of homogeneous proportionality to a voltage taking into account current density, resistivity and amplification

The U function set up in d/W is shown in figure 5 where we can see that the sensitivity is better for short cracks the smaller the d distance is.

The usual procedure to eliminate α is to take the value a from the expression:

(3) $V(a,d) / V(a_0,d) = U (a,d) / U (a_0,d)$

A0 being the initial length of the crack at the beginning of the test. However, the hard d accuracy can be a problem especially during repetitive tests. To eliminate this possible uncertainty we propose the following procedure, noting that U (0,W) = 1 :

Before the start of the test, a preliminary measurement is carried out with potential taps at a distance of 2d = 2W, e.g. with the aid of a gauge (Fig. 6). We call this measurement V reference which is actually the measurement of α:

(4) $V(0,w) = \alpha = V_{REF}$

The measurement V(a0,d) then allows us to determine the expression A as a function of d:

(5) $V(a0,d) / V_{REF} = U (a_0,d)$

(6) and $A = ch(\pi d/2w) = \cos(\pi a0/2w) \cdot ch(\pi/2 \cdot V(a_0)/V_{REF})$

- during the test, the a crack length is determined from the measurement V(a) :

(7) $V(a) / V_{REF} = 2/\pi \,.\, ch\text{-}1 \, (A / \cos(\pi \, a / 2w))$

(8) $a = 2w / \pi \,.\, \cos^{-1} (A / ch(\pi/2 \,.\, V(a)/V_{REF}))$

This procedure is commonly used at one of our crack testing facilities and does not require the operator to weld the potential taps exactly where they are intended to. For a light alloy specimen 25 mm. wide and 2 mm. thick the sensitivity is ± 10-2 mm and the accuracy is better than ± 5.10-2 mm. with an IMAX current = 5 A.

Continuous monitoring of the crack length and the use of a real time computer offer great ease of automation. As an example, Fig. 7 shows the performance of a cracking test at constant speed.

The electrical method also gives very good results in cracking-fluttering tests on an IN 100 bending specimen heated to 1000°C. by a high-frequency induction system.

If the test specimen or the test conditions do not allow a mathematical expression to be used as a calibration, it can then be established by direct measurement in preliminary tests, by analogy [5] or by computer calculation using the finite element method [6]. In this case, the locations of the connections of the current and potential supply lines must be perfectly fixed and respected for reproducibility. Figure 8 shows an example of a calibration on a cross specimen used in a crack bifurcation study: a judicious choice of the location of the connections gives a single calibration for the total length of the crack regardless of the bifurcation angle of the crack.

2.1.5 THREE-DIMENSIONAL CRACK FRONT DETERMINATION

We consider here the case of an open crack substantially developing in a plane perpendicular to the face of the specimen. For a given crack front, the method consists in taking a voltage reading on the specimen at several points on the lips of the crack and then using, according to a procedure to be defined, an analog means of calibration which is here a rheoelectric tank.

Specimen measurement:

Figure 9 gives the principle of it. The potential measurement is carried out by a double-contact probe whose translation is automated. The signal from the probe is applied to the input of our equipment whose output signal is itself connected to channel Y of a graphic recorder, while channel X receives a signal proportional to the displacement of the probe.

The result is, for example, one of the curves of the grating in figure 10, grating measured during a crack progression test on a specimen with a section of 80 x 20 mm. in AU2GN - T6, under tensile stress, the initial crack being semi-circular with a radius of 7 mm.

Use of the rheoelectric tank:

The electrical potential existing in the cracked specimen is reconstituted in a conductive medium. This conductive medium is simply water and the tank made of insulating material has the shape of the useful part of the specimen in a given similarity ratio. Finally, the crack is simulated by a thin insulating plate and the potential pick-ups are carried out using a mobile probe in the same way as in the mechanical test.

The principle for determining the crack front is then as follows (Fig. 11):

- The voltage measurement V (1) taken along the lips of the actual crack is available (Fig. 11a).

- We then try to reconstruct a curve V' (1') similar to V (1) on the tank by successive modifications of the insulating plate representing the cracked surface. These approximations are made by simply cutting the plate (fig. 11b).

- the concordance of curves V and V' leads to the conclusion that real crack front and simulated crack shape are similar if one assumes a one-to-one relationship between front shape and stress reading. From a practical point of view the stresses and displacements are rendered dimensionless by introducing a VREF reference stress and the W specimen width.

We have just described the general method of using the tank to find a crack front. Conversely, the tank also allows to quickly establish networks of V (1) curves corresponding to simple crack front shapes but close to real cases. It goes without saying that all the operations on rheoelectric tanks can be replaced by the use of three-dimensional calculation programs if the cost of calculation is not an obstacle.

<u>Application examples:</u>

Figure 12 describes a first example. The specimen is a bar with a square cross-section (45 x 45 mm.) made of light alloy subjected to a 4-point bending corrugated load. The two corner cracks propagate in the central section from two fissures with a radius of 5 mm. The conditions of application of the electrical method are shown in the figure. During the crack progression test, several tension readings were taken along the crack lips on the underside of the bar. Some fronts were also marked by ink injection. The four corresponding readings are shown in the figure. It can be noted that the tension readings give a good idea of the shape of the fronts and their increase. In particular, the examination of the readings indicates that the right crack propagated slightly faster than the left one.

Assuming the unbroken test specimen, i.e. the unknown real fronts, we then have to establish their shapes from the readings. Given the initial quarter-circle shape, we could assume that this shape would be more or less preserved during the test. For this reason, the corresponding measurements were taken on the tank. In figure 13 the grid shown refers to configuration a. For case b, which is of interest to us, it is sufficient to shift the left half of the grid to the right and vice versa.

Figure 14 shows three attempts to determine a real front (front No. 3, right corner). For the first one, we match the crack depth given by the two-dimensional calibration in figure 5 at each tension survey point. The result is obviously disappointing. In the second one we use the maximum tension-crack radius relationship given by the 3D calibration for quarter-circle cracks, with a more realistic result. Finally, the general method by approximation on the tank gives a very correct result with an uncertainty of less than 0.2 mm. on the real front.

A second example concerns the initiation study on a cylindrical tensile test specimen Φ = 20 mm. in AISI 316 with a stress concentration coefficient given by a groove 2 mm. deep and a notch bottom radius of 0.5 mm. (fig. 15).

In order to detect the initiation according to the number of load cycles, the evolution of the tension is simultaneously recorded at three points located at 120° around the groove. Experience shows that the initiation is almost simultaneous at all points of the groove bottom and that the crack propagates almost at the same speed. An average crack depth is therefore measured from the average of three tensions and the calibration in Figure 15. As the material is very brittle, the beginning of the evolution of the measured tension is due to the plastic deformation of the specimen and not to the initiation. Therefore we also have recorded the evolution of this deformation and, taking into account the linear relationship between stress and plastic displacement [7], the appearance of a pronounced bend in the graph ΔV-ΔLp (Fig. 16) indicates the start of initiation. This is confirmed by examination of the faces after the specimens have broken and it can be seen in Fig. 15 that the electrical measurements give results very close to reality within 0.1 mm.

2.1.6 CONCLUSION

The electrical method, with its various application techniques, and in particular those described here, is a very attractive laboratory method for crack propagation studies. Its field of application can be extended to other fields: measurement of deformation and damage at high temperature [7], non-destructive testing on real structures. Concerning this last point, an attempt is being made on a reaction vessel turbine disc.

2.1.7 REFERENCES

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2 – BAUDIN G. et POLICELLA H. : Nouvelle méthode de mesure électrique de longueur de fissure - Recherche Aérospatiale n° 1976-6, p. 340-358.

3 - BAUDIN G. et POLICELLA H. : Détermination de fronts de fissure dans les pièces métalliques tridimensionnelles par mesure électrique - Recherche Aérospatiale n° 1979-1, p. 73-85.

4 - JOHNSON H.H.: Calibrating the electrical potential method for studying slow crack growth - Material Research of Standars, vol. 5, 1965, p. 442-445.

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6 - RITCHIE R.O. and BATHE K.J. : On the calibration of the Electrical Potential Technique for Monitoring Crack Growth using Finite Elément Methods. Int. Journal of Fracture Mech., vol. 15 (1979), p. 47-54.

7 - CAILLETAUD G., POLICELLA H. et BAUDIN G. : Mesure de déformation et d 'endommagement par méthode électrique. Recherche Aérospatiale n° 1980-1, p. 69-75.

2.1.8 DIAGRAMS

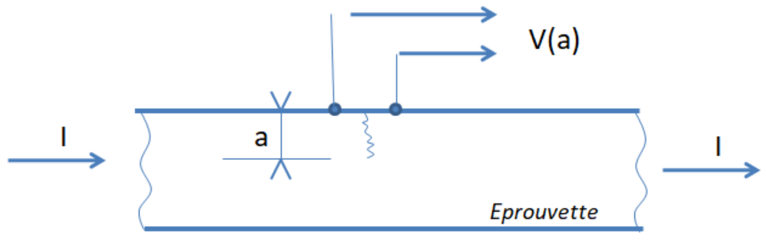


Figure 1 : Principle of the electrical mehtod

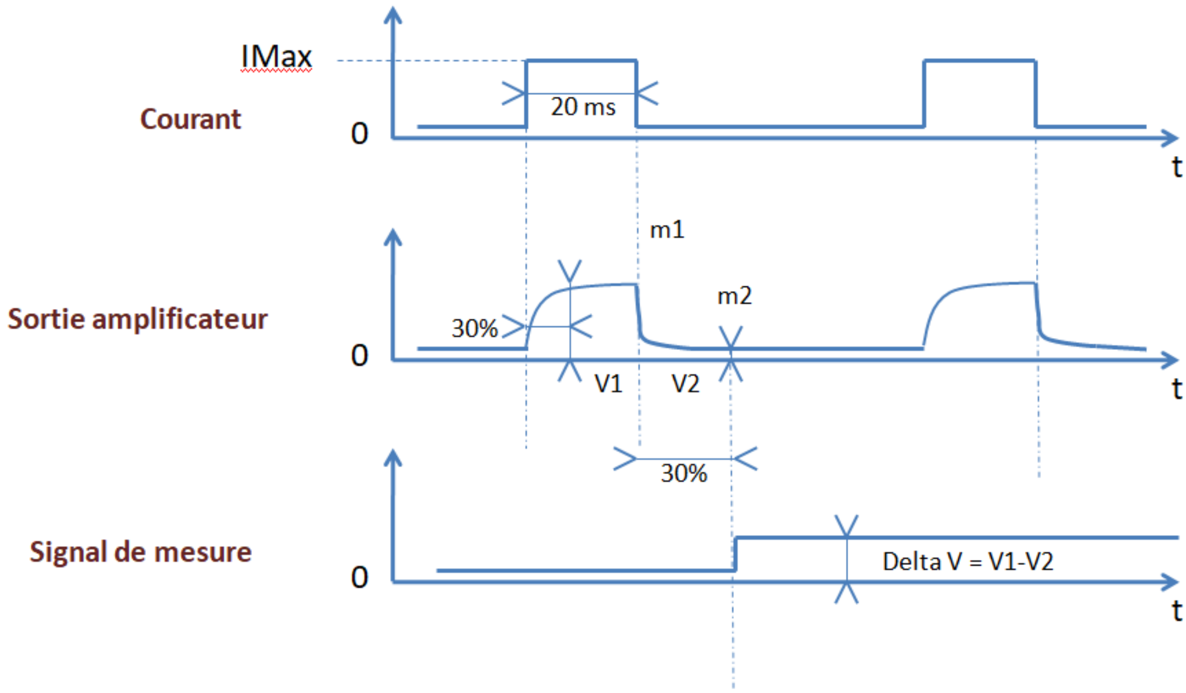


Figure 2 : Principe de la mesure

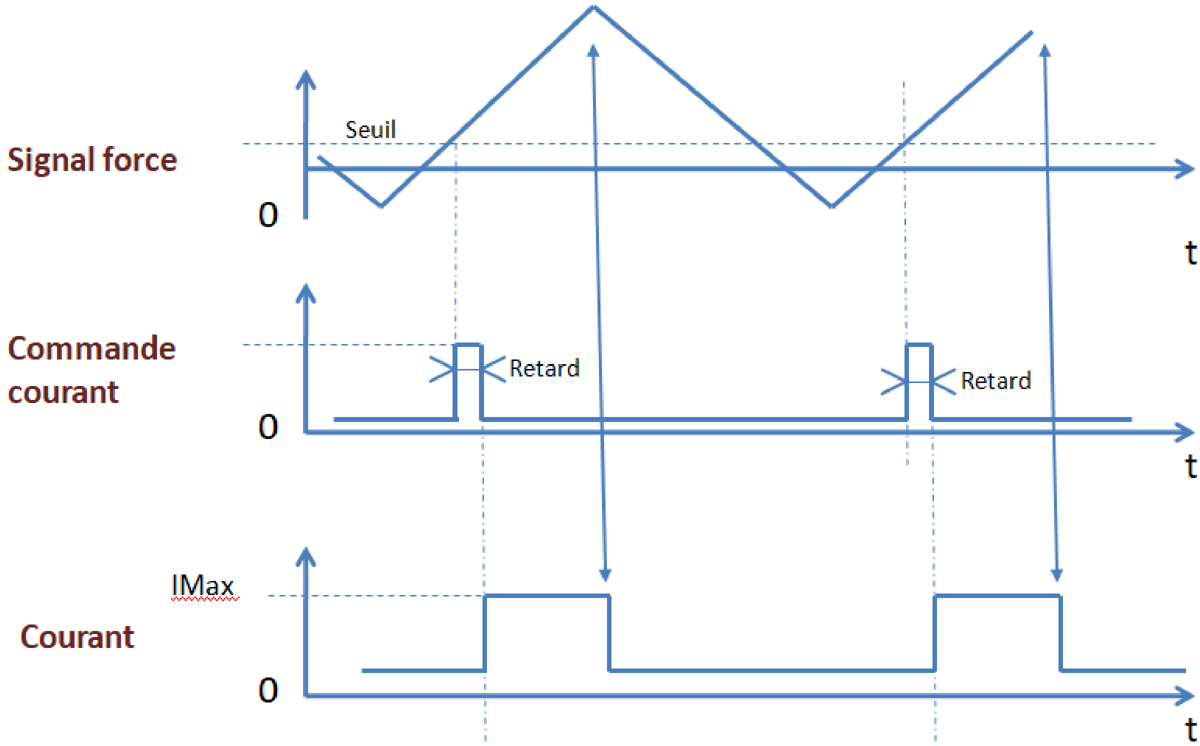


Figure 3 : Synchronisation de la mesure

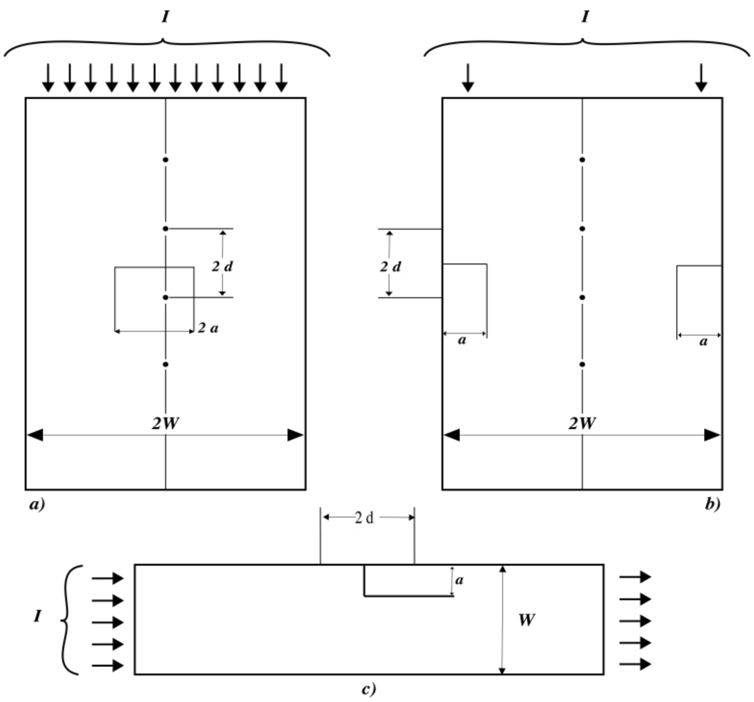


Fig. 4 - Méthode électrique : cas de calcul possible.
Formes d'éprouvettes.

a) Panneau en traction.
b) Panneau en traction.
c) Éprouvette flexion.

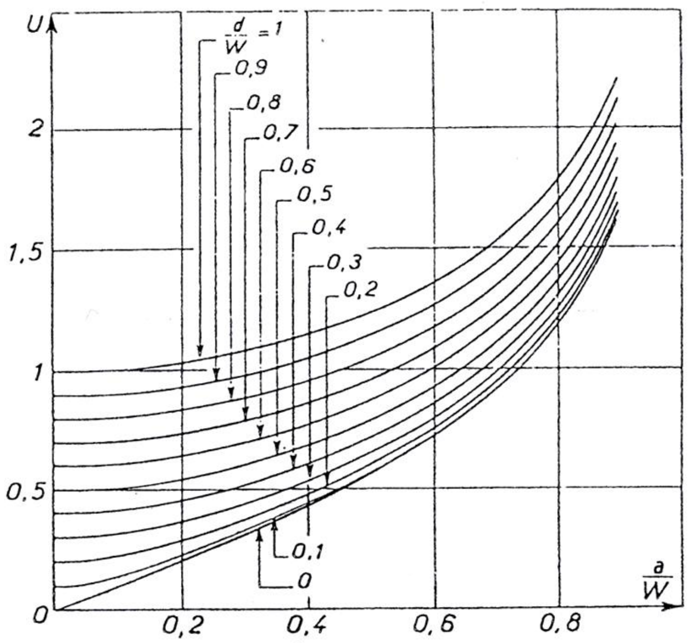


Fig. 5 — Représentation de la fonction U.

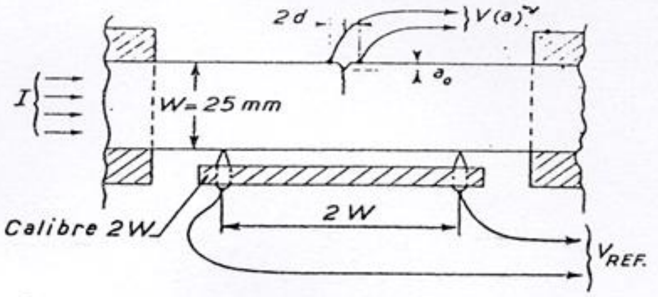


Fig. 6. — Éprouvette de flexion. Mesures initiales V_{REF} et $V(a_0)$.

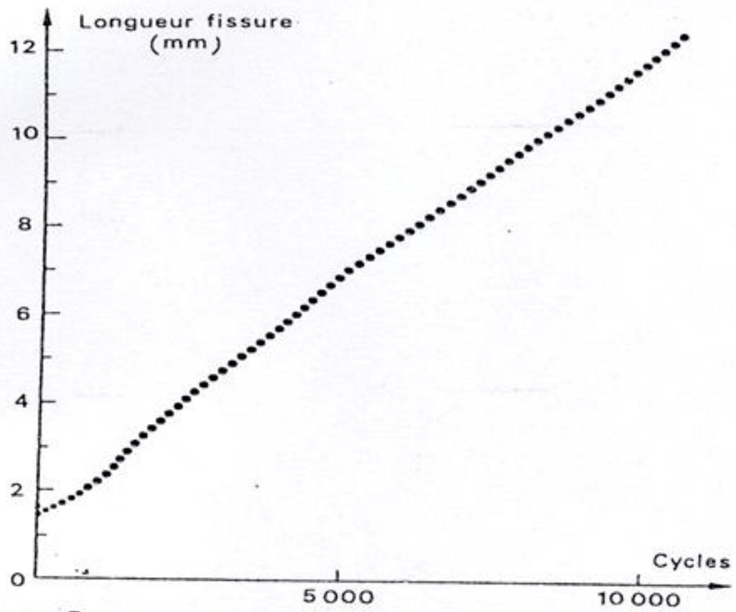


Fig. 7. — Essai à vitesse de fissuration constante (éprouvette flexion).

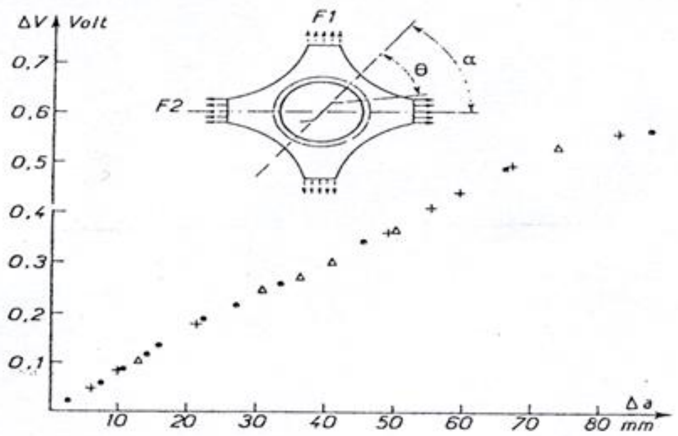


Fig. 8. — Essai de bifurcation : courbe d'étalonnage de la mesure électrique.

● $\alpha = 80°$, $\theta = 64°$.
+ $\alpha = 50°$, $\theta = 55°$.
△ $\alpha = 0°$, $\theta = 0°$.
($I_{MAX} = 16A$, $G = 25\ 000$).

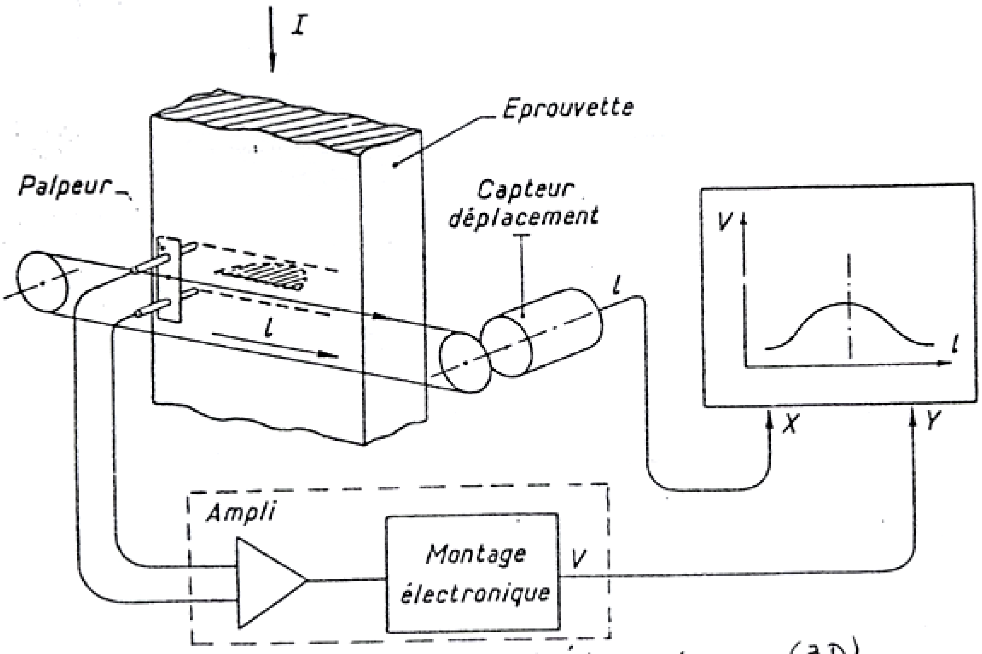


Fig. 9. — Principe de la mesure électrique sur éprouvette.(3D)

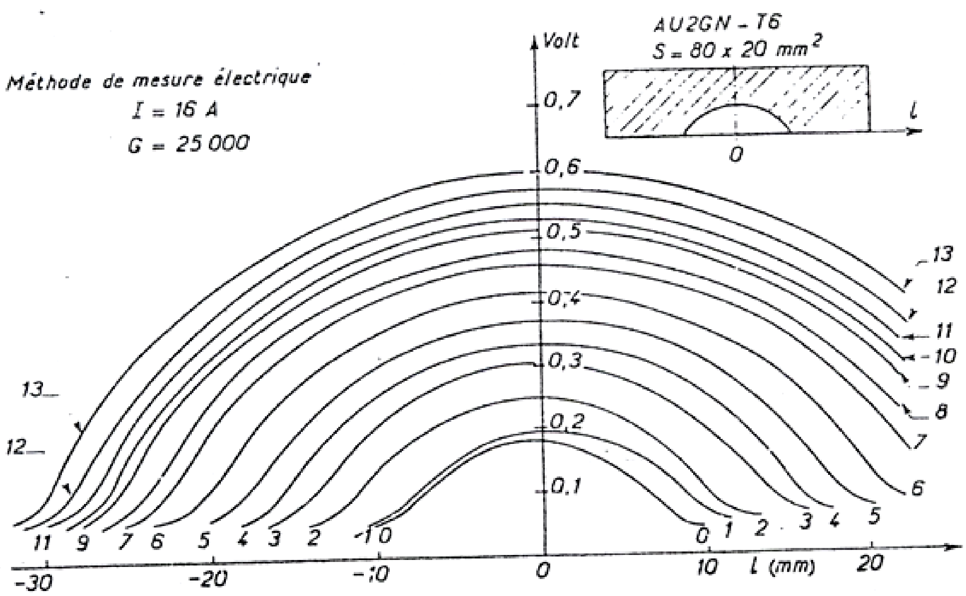


Fig.10– Essai de progression de fissure : relevés de tensions.

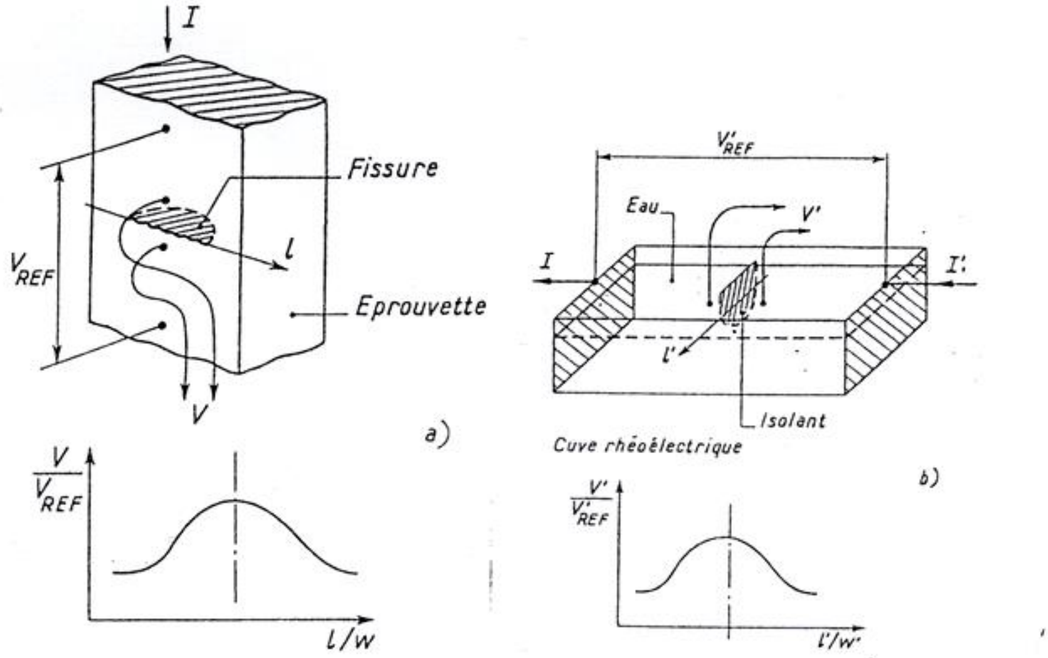


fig 11. Determination par analogie d'un front de fissure.

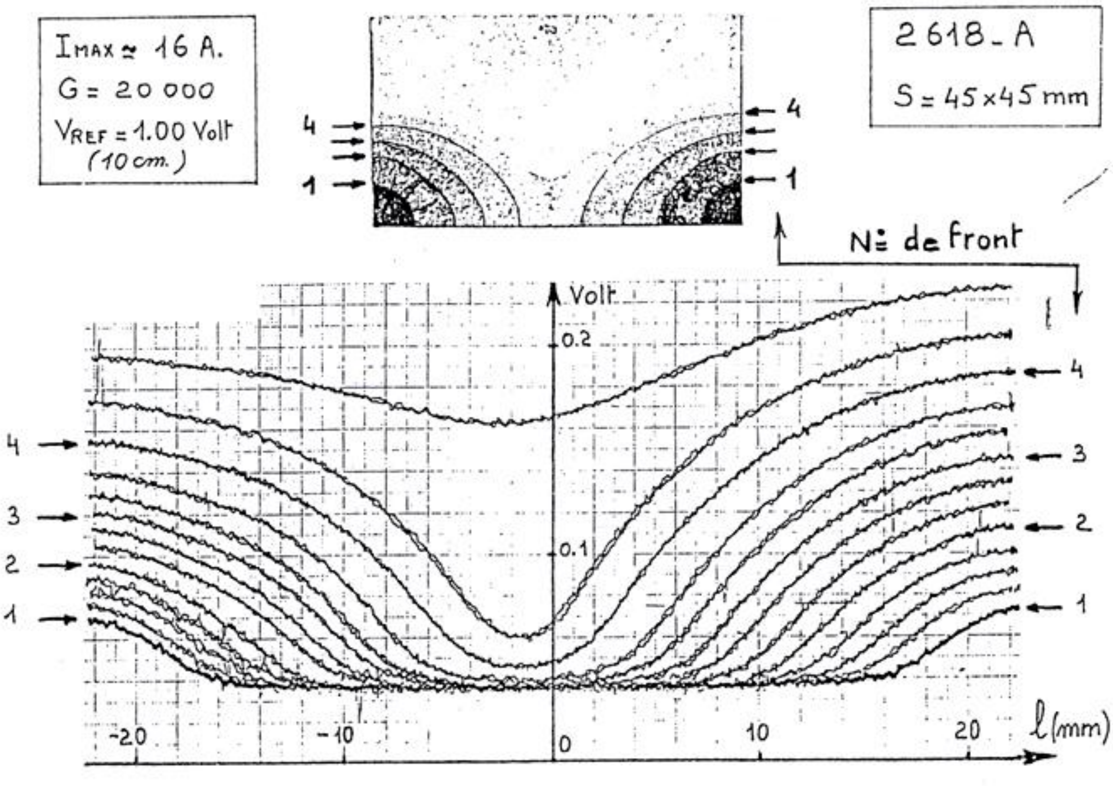


fig 12. Progression de fissures dans un barreau. Mesure electrique.

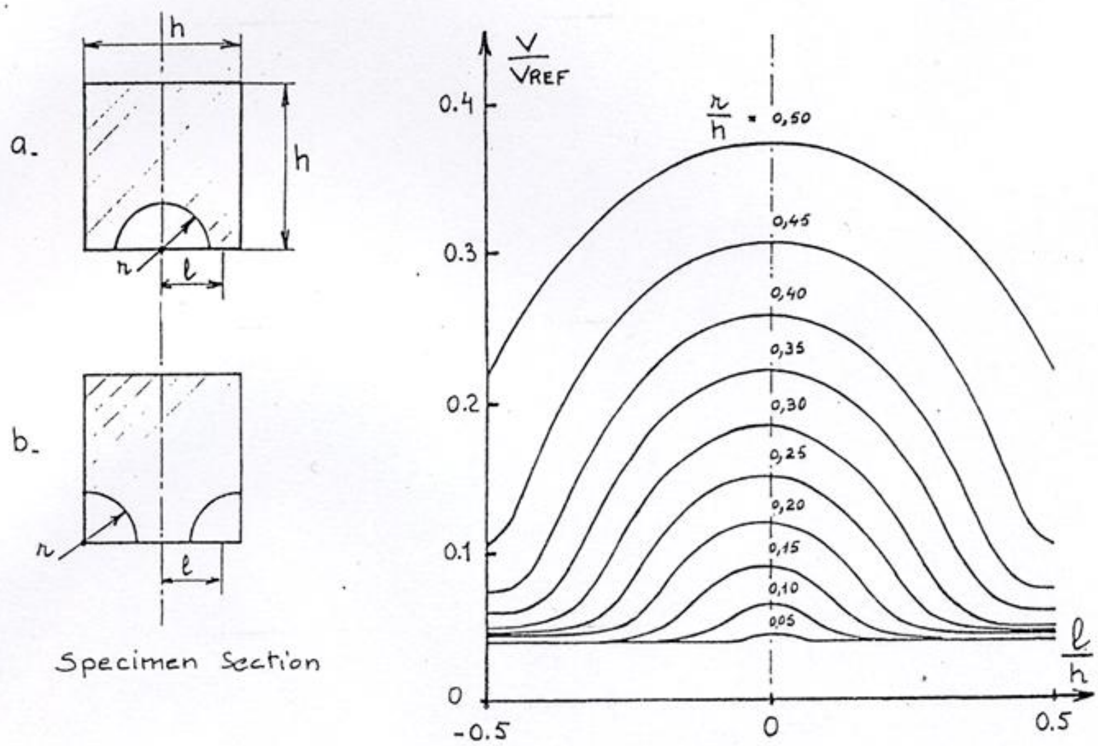


fig 13. Etalonnage sur cuve rhéoélectrique.

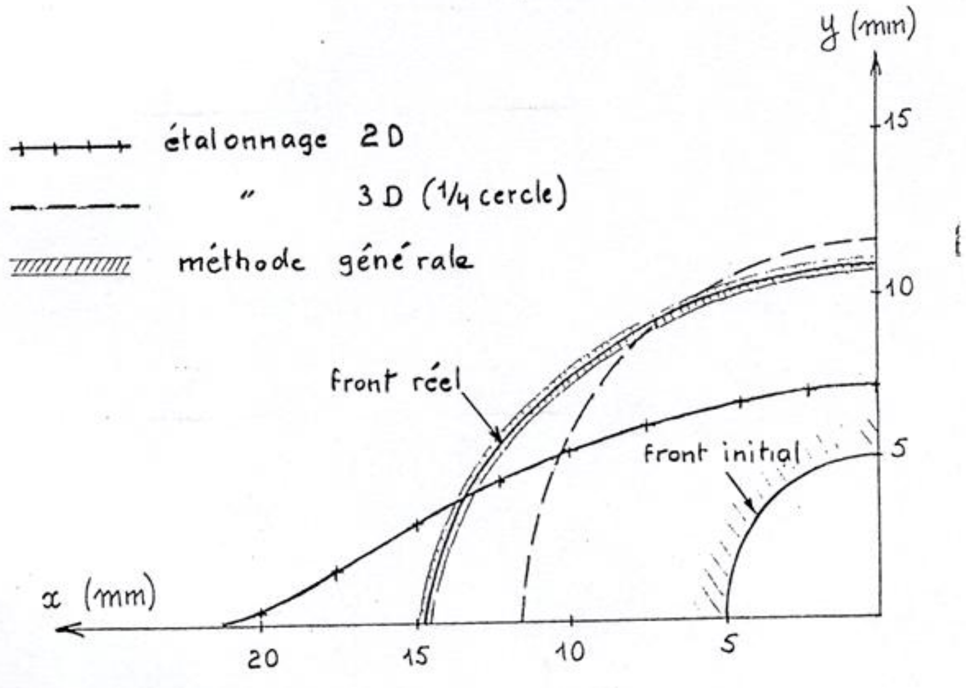


fig 14. Détermination d'un front de fissure.

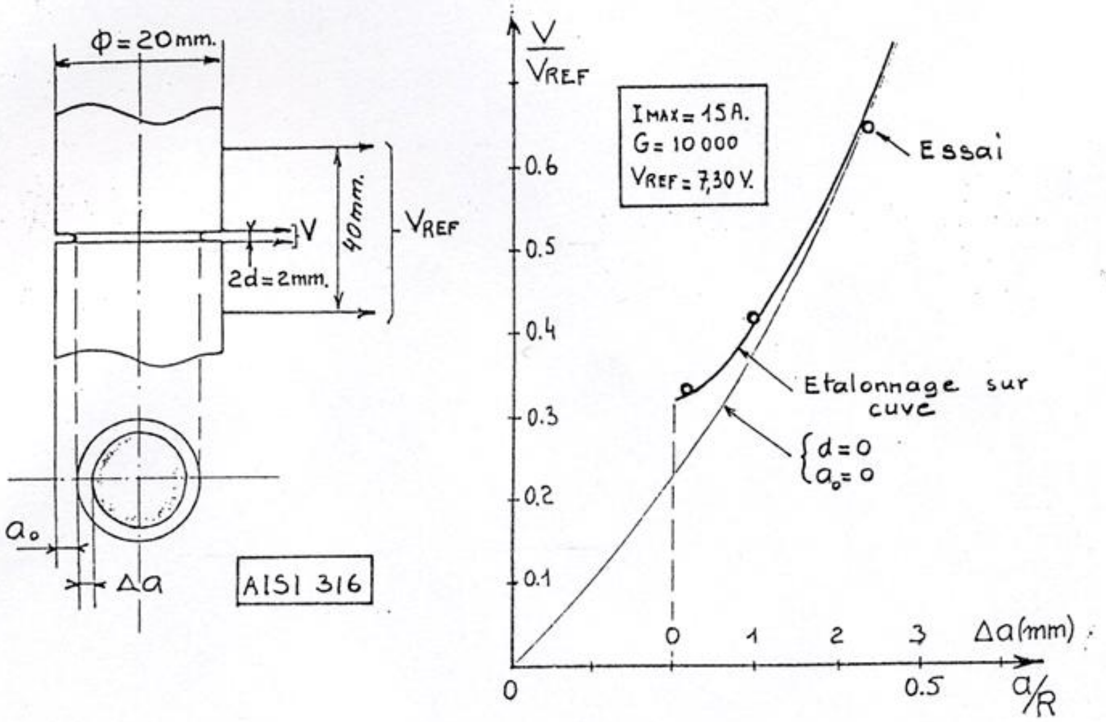


fig 15. Amorçage et progression de fissure dans une éprouvette cylindrique entaillée -

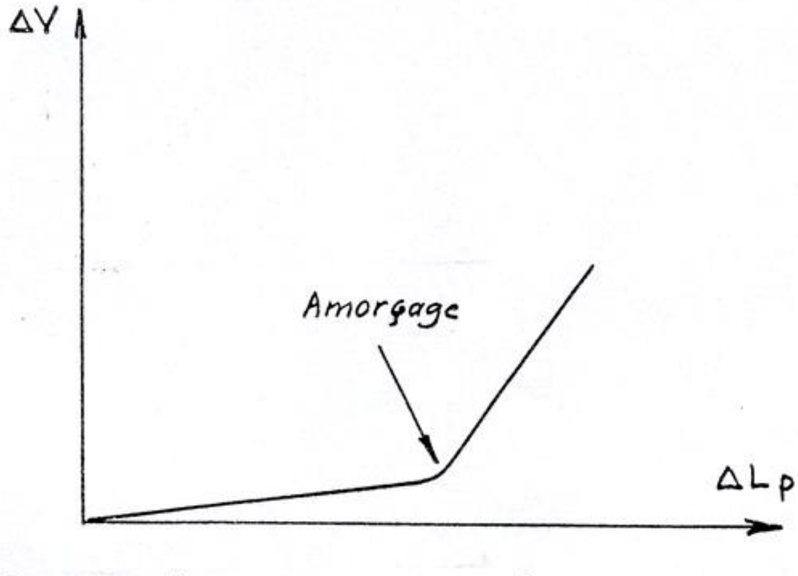


fig 16. Détermination de l'amorçage.

3 - PRINCIPLE OF MEASUREMENT OF CELIANS CRACKS TRACKER

As described in the previous chapter, the approach is as follows (fig 1):

❖ The current is injected into the specimen in the form of pulses of constant IMAX amplitude and at a programmed duration (high pulse, for example 20ms). The first 30% of the pulse is not measured to allow time for the signal to stabilize, then several measurements are made on the rest of the pulse and these measurements are averaged. This average is the measured electrical potential (V1). The output V1 voltage of the amplifier is then memorized and the current is cancelled for a certain time (low pulse, for example 30ms).

❖ Identical to the high pulse measurement, the first 30% of the low pulse (i.e. no current) is not measured, and then several measurements are made to average V no current. This value is saved as V2. We then have the voltage DV= V1 - V2, free of any quasi-static interference, which is the voltage we are looking for. These operations are repeated with each pulse.

As for noise, it is first attenuated by limiting the amplifier bandwidth to 100Hz.
To eliminate mains noise, it may be useful to set the tracker to "LINE" mode, with this mode the tracker will lock to the mains frequency. In this way, the measurements are always performed at the same time as the mains pulse. The "DELAY" parameter allows you to take a measurement every 2,3,4, ..., 10 pulses for example.

Finally, a last filtering on the DV output voltage allows you to obtain a sensitivity of 0.1µV for a response time of 1 second.

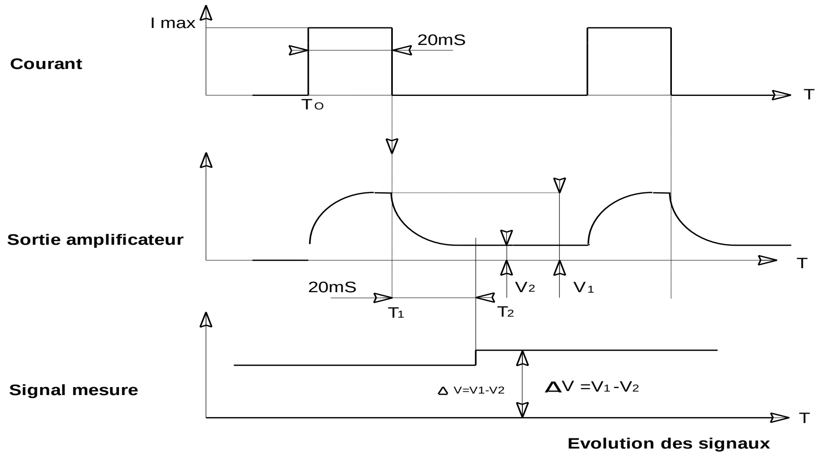


Fig. 1 PRINCIPE DE LA MESURE

Another important feature of this method is the ability to synchronize the pulses, and thus the measurement, with the loading cycle in crack propagation tests under variable loading or otherwise, involving many compressive loads. Synchronization is achieved by means of a threshold triggered by the force signal (Threshold) of the testing machine and an adjustable delay (fig. 2). The measurement can thus take place at constant force or at maximum force when the crack is completely open.

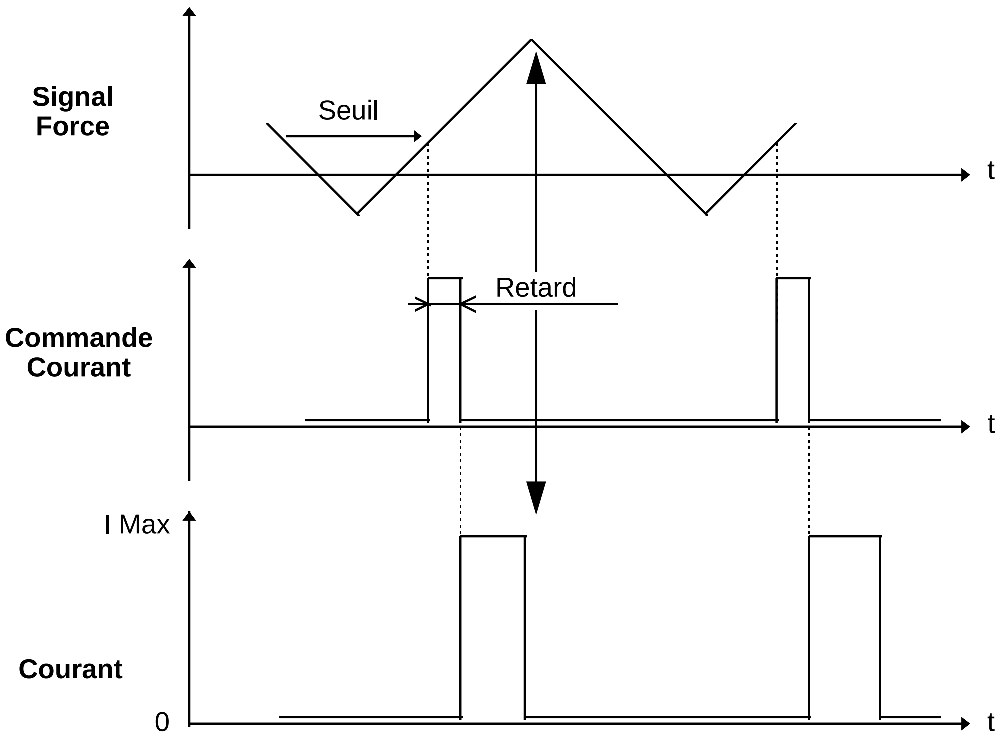


Fig. 2 SYNCHRONISATION DE LA MESURE

It should be noted that the instrument has an output delivering the stored value of the synchronization voltage at the time of the actual measurement. It is therefore possible to establish a "force-crack opening" graph during a loading cycle and a dynamic test by manually varying the delay and possibly the threshold value.

4- OPERATING DESCRIPTION

The device essentially performs three functions:

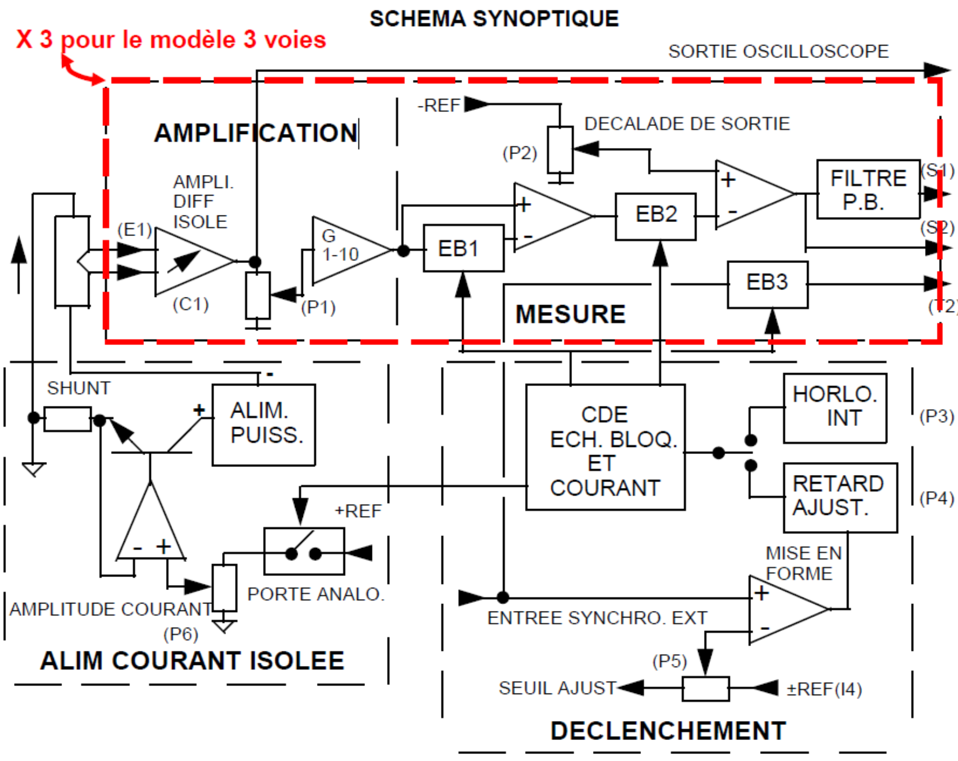
Power supply to the specimen,

Triggering of the measurement,

Amplification and measurement of the voltage measured on the specimen (X 3 channels)

The corresponding circuits are shown in the block diagram.

The individual controls are listed in the chapter "Operation".



4.1.1 AMPLIFIER AND MEASUREMENT

This first part, tripled in the 3-channel model, consists of an isolated differential amplifier, the gain of which is adjustable from 0 to 20,000 by means of a knob (GAIN, on each channel) and the possibility of an offset (OFFSET, in V).

4.1.2 TRIGGERING -SYNCHRONIZATION

A selector switch (**IN, LINE, OUT**) gives the choice between three triggering modes:

1 – Triggering by internal clock

- Internal trigger (**IN** position). The measurement frequency is given by an internal clock which delivers a square signal with a frequency adjustable by a button (**FREQ**) from 1HZ to 150 Hz (depending on the pulse width in ms). The pulse width is controlled by the button (**PULSE** in ms). The intensity in amperes sent into the specimen is controlled by the knob (**IMAX** in A). In principle, the measurement is independent of this frequency, but the lower the frequency, the lower the average current in the specimen and the fewer the dissipation problems. On the other hand, a high measurement frequency reinforces the role of output filtering. It is therefore up to the experimenter to adopt the position that suits him.

Operational functions: **IMAX, PULSE, FREQ, GAIN and OFFSET channels**

Non-operational functions: **DELAY, THRESHOLD, FRONT**

2 – Triggering by the mains signal (mains noise reduction mode):

- Triggering by mains signal (50 Hz, Pulse 10 ms, no current 10 ms by default) (**LINE** position). The mains signal is therefore the force signal delivered. The signal is shaped by a comparator. The threshold is not operational in this mode, it is set to zero. On the other hand the delay time (from 0 to 200 ms) is fully operational as well as the pulse width in ms (max 12 ms).

Operational functions: **IMAX, PULSE, DELAY, FRONT, GAIN and OFFSET channels**

Non-operational functions: **FREQ, THRESHOLD**

3 - Déclenchement par le signal externe

- Triggering by an external signal (**OUT** position). The advantages of this operating mode have already been discussed in the previous chapter. Generally, the external signal is the force signal delivered by the test machine. The signal is shaped by a comparator whose threshold can be adjusted between 0/10V using the knob (V-shaped **THRESHOLD**). The selector (**/**, ****) allows you to choose the rising or falling edge of the synchronization signal. The control of the current pulse can then be delayed by operating the potentiometer (**DELAY** in ms) (delay adjustable from 0 to about 250ms).

Operational functions: **IMAX, PULSE, THRESHOLD, DELAY, FRONT, GAIN and OFFSET channels**

Non-operational functions: **FREQ**

In all three trigger modes, the resulting logic signal drives a set of flip-flops and gates that provide the following three signals:

- the control of the current flow in the specimen (signal of predefined width)
- the control of the samplers EB2 and EB3 (0.5ms width) which coincides with the end of the previous control
- the control of the EB2 sampler exactly 20ms offset from the previous one.

4.1.3 POWER SUPPLY OF THE SPECIMEN

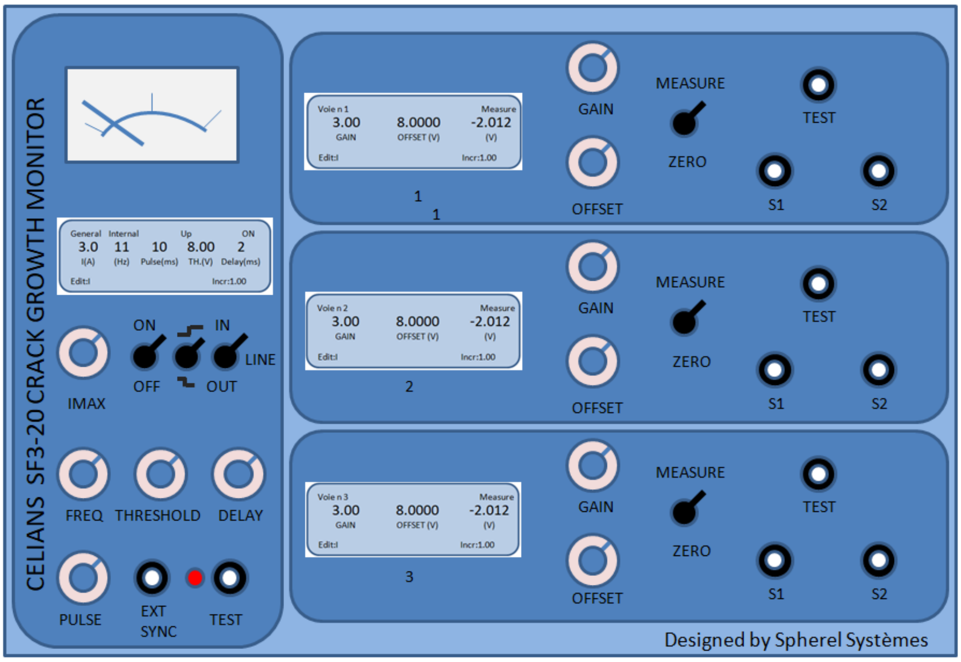
This circuit comprises a primary power supply (ª 10V, 20A) which flows into the specimen via a power transistor and a 0.05□ shunt placed in series.

Classically, an amplifier controlling the power transistor imposes a given reference voltage across the shunt (i.e. 1V) resulting in a constant current of 20A in the circuit of the test piece. This 1V reference voltage is applied to the amplifier via an analog gate activated during the control from the trigger circuits. The control amplifier therefore has a reference voltage of 0 to 1V. This corresponds to a zero or 20A current.

Moreover, the analog gate being an optoelectronic circuit, the "specimen supply" circuit is electrically isolated from the rest of the device, which leaves the operator free to choose a grounding point. Finally, the knob (IMAX) allows the current to be adjusted between 0 and 20A.

5 - USE

5.1 OVERVIEW



5.1.1 FRONT PANEL

GAINi,i=1,2,3	Gain adjustment knob (*0 à 20000*) per channel
ZEROi,i=1,2,3	Zeroing/Measuring the amplifier input voltage per channel
MESUREi,i=1,2,3	
TESTi,i=1,2,3	Test socket. Amplifier output channel n(BNC)
S1i, i=1,2,3	Measurement output. Response time 1 second (BNC)
S2i,i=1,2,3	Measurement output. Reponse time 0.2 second (BNC)
OFFSETi	Output Offset button *(0V to 10V)*
Vi,i=1,2,3	Digital voltmeter connected to output S1, digital display
IN, LINE, OUT	Choice of trigger type (*internal, external or mains*)
FREQ	Internal clock frequency control button – With a pulse of 4 ms, max freq = 150 Hz, – With a pulse of 200 ms, max freq = 3 Hz
THRESHOLD	Threshold voltage adjustment potentiometer (*from -10V to 10 V*)
FRONT	Choice of trigger edge
DELAY	Delay adjustment button (*Max 250 ms*)
Control LED	(lights up when a current control signal is present)
ON/OFF	Allows current to flow or not
IMAX	I MAX Current setting knob
A specimen.	Ammter : gives the value of the average current flowing in the specimen.
EXT SYNC	In OUT mode (External Synchro.), the external signal is fed to this pin.
TEST	Value of the synchronization signal at the time of a measurement.

5.1.2 REAR PANEL

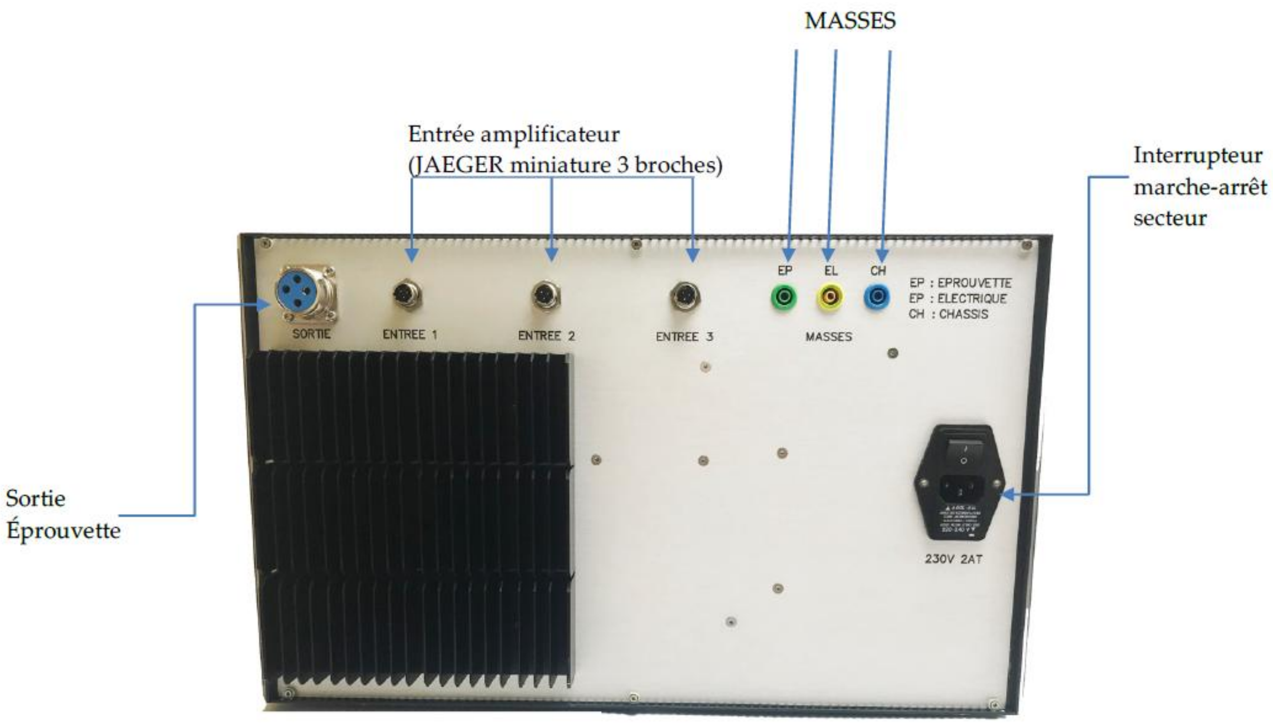
Ei, i=1,2,3	Amplifier inputs (*3-pin miniature JARGER*), (*on the back of the unit*)
M	Mains ON/OFF switch (*on the back of the unit*)

<u>MASSES</u>

EP	Specimen
EL	Electric
CH	Frame

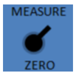
<u>Output</u>

Output	Specimen outpt



5.2 COMMON FUNCTIONALITIES (FRONT PANEL)

5.2.1 Switches

They allow you to switch from one mode to another. 

For example MEASURE/ZERO.

5.2.2 The buttons

The buttons are composed of 2 encoders (up and down encoder). The information given below is generic for all buttons. 

To change a parameter, press and release the encoder up. For example, the gain.

If a press has been detected, the following phrase is displayed on the associated screen.

Edit:Gain Incr:1.00

This means that you have switched to edit mode, in edit mode, the measurement values are not refreshed.

2 actions are now possible:

- modify the gain by turning the encoder up,
- modify the gain increment with the low encoder, the choices are 1000.00, 100.00 10.00, 1.00, 0.10, 0.01, if the increment is suitable, you can modify the gain again with this increment.

When the desired value for the gain is displayed, an additional press on the high encoder allows you to validate the choice of the gain value and to modify the internal parameters of the tracker to achieve the requested gain. The tracker is no longer in edit mode, the measured values are displayed regularly.

5.3 SUPPLY CIRCUIT OF THE SPECIMEN

Generally, the specimen must be electrically insulated from the test machine, but since the device has a power supply which is itself insulated, complete insulation of the specimen is not necessary.

The following options are available:

- ❖ Isolate only one docking head from the specimen, the power supply circuit is then referenced to the mechanical ground of the machine via the second docking head.
- ❖ Do not isolate the specimen at all, if the resistance presented by the latter is negligible compared to that presented by the test machine frame. This can easily be checked by comparing the measurement obtained with the mounted and dismounted and thus isolated specimen.

If the specimen is already fully insulated, the specimen supply circuit must be earthed at a single point. The green and blue terminals on the back of the device are used to check whether or not there is insulation.

The specimen is supplied through the 4-pin JAEGER socket on the rear panel (see socket wiring). The cable-test piece circuit must have a resistance of less than 0.1W to limit the voltage drop in this circuit to 2V. (To do this, use a cable of sufficient diameter according to the length of the connection, take care of the connections, etc.). The two supply cables must be kept close together or even twisted to limit the radiation created by the current pulses.

5.4 INPUT CIRCUIT OF THE DEVICE

The two potential sockets on the test specimen are connected to the device by a shielded wire (2 conductors + shield) and a miniature 3-pin JAEGER connector which locks onto the socket (Ei) on the rear panel. On the device side, the shielding is therefore connected to the guard of the input amplifier. On the specimen side, the shield is either left in the air or connected to one of the two potential test sockets. To facilitate connection, there is no disadvantage in using an intermediate connector between the end of the shielded cable and the two wires soldered or screwed to the test tube.

3. CONNECTIONS TO CONTROL AND MEASURING DEVICES

- An oscilloscope examination of the amplified voltage is necessary. Connect an oscilloscope to the BNC TESTi output during test setup.

- The measuring or recording instrument has to be connected to the BNC output (S1i or S2i).

- In the "external trigger" mode, the external synchronizing signal is fed to the BNC input EXT SYNC.

- In the "mains triggering" mode, the synchronizing signal is set to the mains, 50Hz,

- The BNC TEST output provides the value of the synchronization signal in stored form when a measurement is made. It can be used to adjust the threshold (THRESHOLD) and delay (DELAY) values by connecting a voltmeter to it and to find the maximum value of the synchronization signal, which is normally the force signal of the testing machine.

5.5 STARTING UP-SETTINGS

Activate the following choices:

ON/OFF	OFF
Position/voie	ZERO
Offset	0
Mode	IN (Internal)
IMAX	10
FREQ	30
PULSE	20

The digital voltmeter (V) shall indicate 0 with an oscillation of ± 2 on the last digit (millivolt), set to MEASURE. The noise of the signal from TEST, read on the oscilloscope, must be less than 10mVdc; the voltmeter (V) remaining at 0.

If not, check the insulation and grounding.

Return to ZERO position, set ON/OFF(I5) to ON position and find IMAX towards 10. The voltmeter (V) remains at 0 and the ammeter (A) indicates an average current of approximately 6A. The average current can be reduced without reducing I MAX by decreasing the measurement frequency inter per FREQ (e.g. 15 Hz).

Return to the MEASURE position.

Find the appropriate amplification by acting on GAIN with its position always equal to or greater than 1. Check on the oscilloscope that the "square" signal at the output of the test (TEST) is between ± 10V and that the voltmeter V indicates a stable voltage lower than 10V.

The instrument is then in normal operation with internal triggering.

The following checks can be carried out:

- The output signal is proportional to the gain (GAIN).
- The output signal is proportional to the current I (IMAX).
- Inversion of the wires of the specimen supply causes the sign of the output signal to change.
- The same applies to the inversion of the input wires.
- A typical recording of the output signals is shown (Fig. 4).

Use in external research

This mode of operation is useful when the phenomenon of contact between the lips of the crack is sensitive, but it is only of interest if the test frequency is higher than about 1Hz. Below this, any recorder is capable of monitoring fluctuations in the output signal at the test frequency, so that the maximum values can be derived, which are the only significant values for inferring the length of the crack.

The mode switch is then in the EXT position. The threshold is adjustable between 0 and 10V by THRESHOLD.

Observe with the double trace oscilloscope the "square" signal of the TEST output and the synchronization signal. First set DELAY to 0 (minimum delay) and try to make the descent of the "square" signal coincide with the maximum of the sync signal.

Then use DELAY to fine-tune the setting.

This delay can be used to "skip" one or more cycles if the test frequency is above 20Hz. The control LED flashes at each measurement. If it remains off, the synchronization does not work, check the presence of the synchronization signal, or edit the threshold setting.

Finally, should the ammeter (A) indicate an average current higher than 10A the device will stop immediately for abnormal operation.

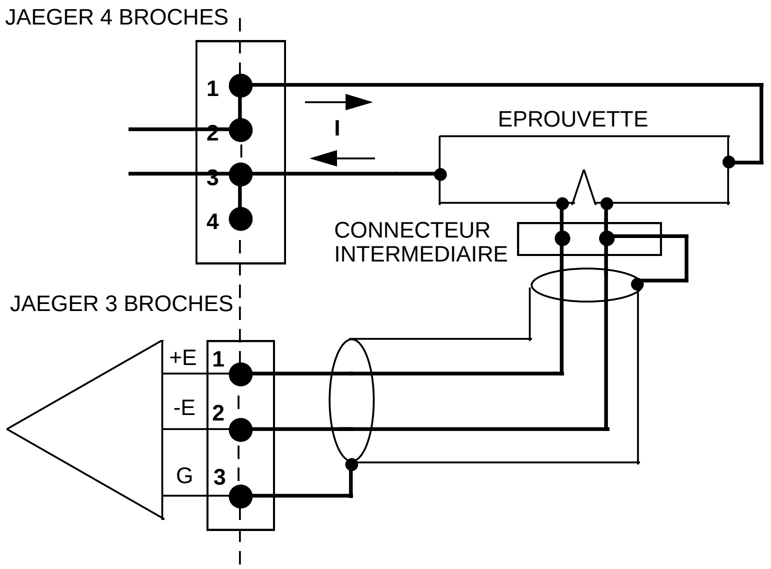


Fig 3 Connections appareil-eprouvette

5.6 Changing the tracker IP Address

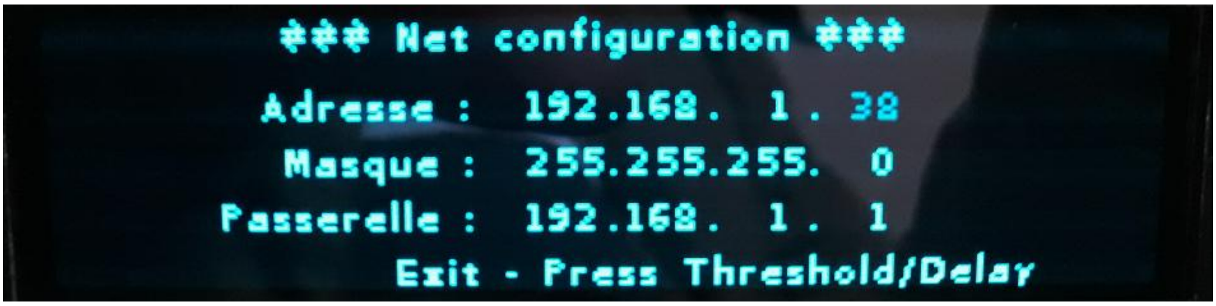
By clicking on the "THRESHOLD" and "DELAY" buttons simultaneously, it is possible to change the network parameters of the tracker. The following screen is displayed.

By using the thumbwheels (1st level and 2nd level (sub-button)) of "CURRENT ", " FREQ " and " DURATION ", you can move through the different fields.

Button "CURRENT " for the IP address,

FREQ" button for the network mask,

DURATION" button for Gateway address



When the parameters are correct, press the " THRESHOLD " and " DELAY " buttons simultaneously to take into account the new parameters. The tracker is automatically rebooted to take into account the new addresses.

5.7 Tracker IP port numb er

It is not possible to change the port number, it is fixed.

Tracker port number: **2707**

5.8 Channel 3 Specific Mode

It is possible to use channel 3 (only) in calculation mode on the first 2 channels.

In this mode, it is possible to make an output of channel 3 on the following operations :

Channel1 - Channel2

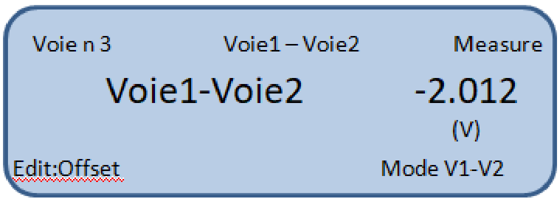
Track2 - Track1

Track1 / Track2

Track2 / Track3

To switch channel 3 into this mode, press on the GAIN or OFFSET button on channel 3, then turn the associated sub-button left or right until "Mode V1-V2", "Mode V2-V1", "Mode V1/V2" or "Mode V2/V1" appears.

Channel 3 screen display



6 – TECHNICAL FEATURES

Current intensity of the specimen current	Adjustable from 0 to 20A
Pulse widths	Adjustable from 0 to 200 ms
Pulse frequency	Adjustable from 0 to 150 Hz (for a 4 ms pulse)
Execution mode	Internal pulse, Sector pulse, External pulse
External signal input	+/- 10V
Gain	from 0 to 20000
Tripping threshold	0/10V
Delay times	0 to 200 ms, for mains or external pulse
Current stability	10^3
Measurement voltage	0 to ± 10V
Measuring channels	3, 1 of which takes as input the other two (A-B)
Output current	5mA
Voice response time measurement	0.2 to 1s
Variable gain	By multiplying button 0 to 20000
Power supply voltage	220V ± 10% 50Hz
Dimensions	EURONORM 3U - 81 TE box
- **Length**	445.5 mm
- **Width**	132.5 mm
- **Depth**	430 mm
Male plug 4 contacts	Rapid JAEGER 530 754, test specimen
Sockret 3 contacts	JAEGER miniature 530 232, channels
Cable clamp	JAEGER 530 331

END OF DOCUMENT