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SYSTEM OF ACQUISITION AND ANALYSIS OF ULTRASONIC DATA

VAUBERT Y. C.E.N. SACLAY
BIRAC A.M.
SAGLIO R.

COMMISSARIAT A L'ENERGIE ATOMIQUE FRANCE

SUMMARY :

An original system of acquisition and analysis of ultrasonic data collected during examinations named STADUS-PRODUS has been developed by C.E.A. in Saclay.

First developed for the needs of in-service inspection of PWR vessels, it is now used for the different automatic ultrasonic controls with various tools.

I. PRESENTATION OF THE SYSTEM

STADUS : système de Traitement et d'Acquisition des Données Ultrasonores (System for processing and analysis ultra-sound data) has been developed in the laboratories of the Non-Destructive Testing Section of the CEA since 1976.

Inspections of PWR reactor vessels [1] [2] [3] using ultra-sound provide a large amount of raw data. A comparison between data obtained in successive inspections allow the evolution of any defects, which have been localized, to be followed.

In order to facilitate this comparison, it is obviously desirable to limit the amount of ultra-sound data by imposing rigorous criteria to select the most applicable data.

Valid information associated with the coordinates of the inspection machine is stored in digital form on a "floppy disk" type magnetic support.

Moreover, it is absolutely necessary for the operator responsible for the control to be able to quickly verify the validity of the information being retained during the data acquisition process.

It is for this reason that a system was developed which can constitute images of the controlled zones in the following standard modes : C-SCAN, B-SCAN, A-SCAN.

II. THE FUNCTIONS OF STADUS

II.1 in real time during inspection

- to acquire (in accordance with purely electronic criteria) ultra-sound information from N transducers (N $\leq$ 16), to digitally code this information and to associate the coordinates of the inspection machine with this data ; each of the different information bits acquired in this way constitutes an "event" which groups together all the data necessary for its exploitation.

- to store these events in 30 event blocks in a mass storage memory consisting of a double unit with 8 inch floppy disks having a single face and density i.e. 39.400 events per disk.

- to constitute images of defects in the controlled zone on the screen of a memory display console. C-SCAN is the most widely used display method. However, it si also possible to obtain B-SCAN and A-SCAN images for any transducer (or transducers) or zone which may be chosen.

- to edit an indicating log to periodically indicate the total number of events stored for the different transducers (considered individually even for transducers that have not been selected for the images.

The above described 4 functions are of decreasing order of priority.

II.2 batch processing

- to reread the previously made recordings in order to constitute images of 3 standard types. The large number of criteria for which operator initiative is required enables the information necessary for the images to be selected. This selection process can, for example, be based on the amplitude of the defects or on the thickness of the zone controlled in the bulk of the metal.

- to transfer the recording onto magnetic tapes in order to process them in a computer center and to obtain full scale maps from a plotter.

III. BLOCK DIAGRAM

Figure Nr 1 shows the system to be composed of two main sub-assemblies :

a) an interface between the ultra-sound equipment and the computer system designated STADUS,

b) a minicomputer MULTI-6 to which the following peripheral equipment is associated :

- a floppy disk mass memory
- a memory display console
- a fast printer 180 c/s

The corresponding software is designated PRODUS : Programme de Reconnaissance par Ordinateur de Données Ultra-sons (Program for the Computer Recognition of Ultrasound Data).

IV. STADUS INTERFACE

Figure Nr 2 shows signals coming from the ultrasound equipment.

The "Video" signal is the logarithm of the amplitude of the ultrasound signal from a transducer.

A "gate" signal from the ultrasound equipment defines the time interval over which the video information is taken into account for each of the transducers.

The criteria for determining which signals should be considered and over what period of time are given in figures Nr 3 to 6.

a) amplitude > lower threshold (100 mV)

b) width (at threshold level) > ti ;
in practice ti ≈ 500 ns which enables most spurious signals to be eliminated

c) amplitude < upper threshold (1.5 V) to suppress the effects of large amplitude spurious signals.

d) end of the time during which the video signal drops to below the threshold
- when the value of the peak measured remains constant at least after time T_M (1.5 ns)
- when the amplitude of the signal drops to below the threshold
- when the amplitude of the signal drops to beneath n % of the peak value (normally n = 20).

Figure Nr 7 demonstrates how the U.S. signal is taken into consideration even when the ends of the pulses occur after the window.

Figure Nr 8 is a block diagram representation of the interface showing how the difitalization process is carried out. For each of the signals contained in the gate (3 different signals can be considered for a single gate), the amplitude is digitalized into 7 bits. This leads to an accuracy of 1/3 dB with a dynamic range of 42 dB. The time-of-flight elapsing from the beginning of the gate onwards is given with a resolution of 0.1. micro-second.

V. PRODUS

Figure Nr 9 is a photograph of the complete acquisition system. It shows the double unit floppy disk, the fast printer, the control consol and 4012 visual display and the associated reprography. It is also possible to see the multi-6 computer (32 k memory) Intertechnique and the STADUS interface (underneath the computer).

The PRODUS program, which is in the live memory, is troublesome for the system when operations are carried out in the multi-task real time modei The task hierarchy is such that absolute priority is always given to information coming from the STADUS interface for acquisition in the memory.

A cumulative A-SCAN is shown in figure Nr 10. This A-SCAN represents all the signals occuring between the XDEF (XDEF + DELTA X and RDEF (RDEF + DELTA R) coordinates by individual vectors. The vertical lengths of each of these vectors is proportional to the maximum amplitudes of the signals. The horizontal positions of these vectors represent the time elapsing between the start of the gate signal and the moment when the electronic threshold value S_i is attained. It is possible to use this sort of presentation for all types of transducer and in any DELTA X or DELTA R zone ; the zone in question can be reduced to 1 point X, R EDF. A zoom effect is possible depending on the time axis chosen.

A cumulative B-SCAN is shown in figure Nr 11. This B-SCAN represents all the signals coming from a group of transducers situated between the coordinates X, (X + ECHX) and RPOS (RPOS + DELTA R). The operator can select either XORG, ECHX, RPOS, DELTA R and has the choice of the video threshold to be employed and the number of the transducer (in the group) to be exploited. The images are presented in such a way as to take the individual parameters associated with each of the transducers (e.g. angle of incidence of the US beam, position of the captor in its holder) into consideration. A zoom effect is possible depending on the depth (Z) axes.

A C-SCAN is shown in figure 12. This C-SCAN represents all the signals existing between the X.ORG (X.ORG + ECHX) along the abscissa and the RDEP, (RDEP + ECH.R) along the ordinate coordinates. The operator can select the origins of these axes, the two scales, the video threshold and the way in which the transducers are grouped. The operator can also limit the volume to be represented by taking the echos occuring after a given reference time and in a DELTA T "window" of values into consideration.

The STADUS-PRODUS system allows the operator a large degree of freedom to modify image representation parameters. It enables a very detailed examination of anomalies revealed by the focussed transducers to be performed.

The use of a PRODUS program to operate the system in real time enables an optimum utilization to be made of the U.S. information, even though, as is obvious, the signals to be processed arrive in a random way. At the present time, the system can process and store permanent reference information with a period T = 3 ms.

The efficiency of the system has been demonstrated in a large number of PWR reactor vessel inspections and especially in the evaluation of under cladding craks.

VI. CONCLUSION

The equipment developed by the French Atomic Energy Commission has therefore the advantage of the ultra-sound information being collected by a large number of transducers (up to 16) and of a simultaneous processing of this information with an instantaneous presentation of the A, B and C-SCAN images of the controlled zone. Furthermore, the STADUS-PRODUS system enables a highly detailed examination of the information recorded to be performed.

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R. SAGLIO SMIRT 6 août 1981 PARIS

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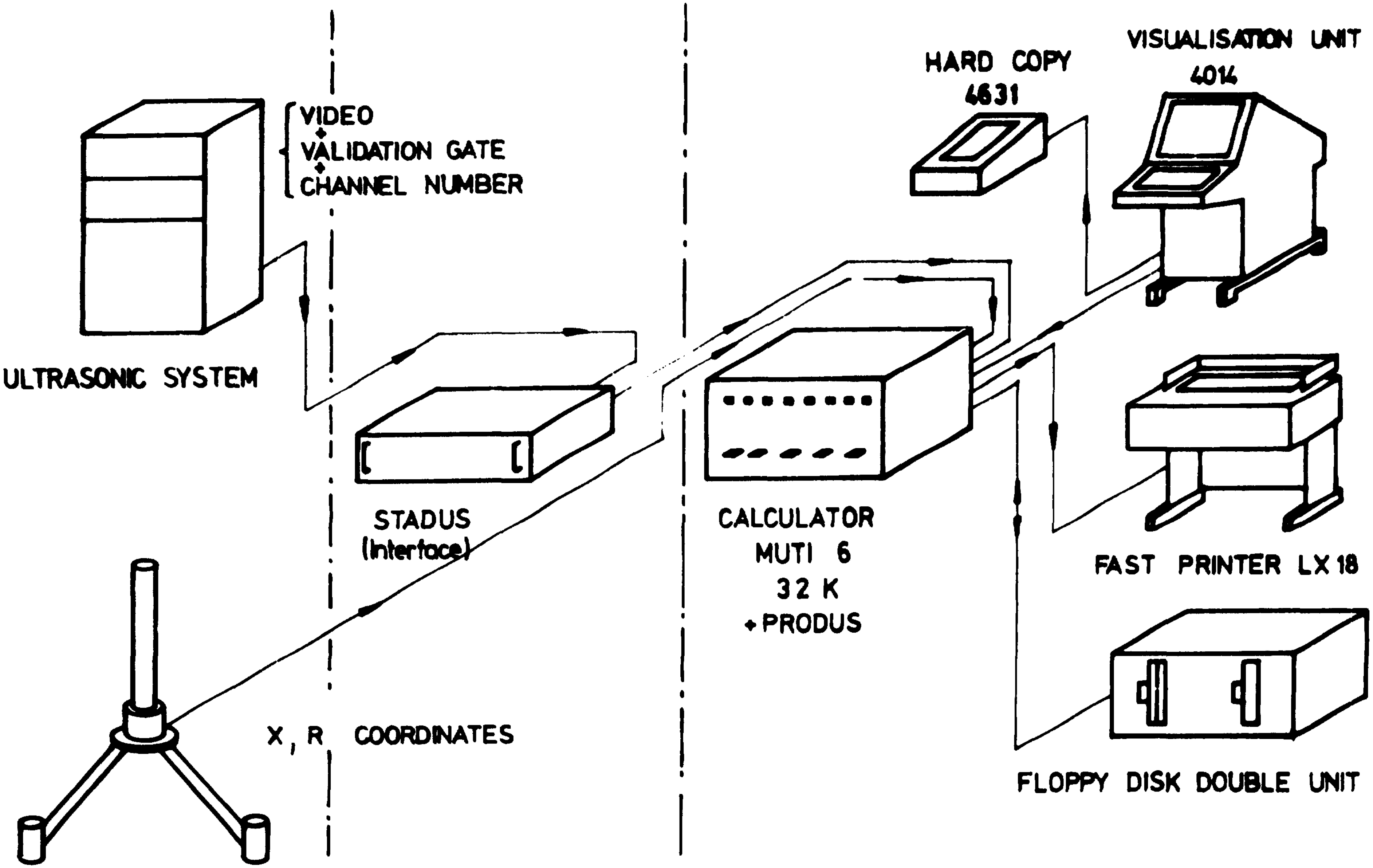
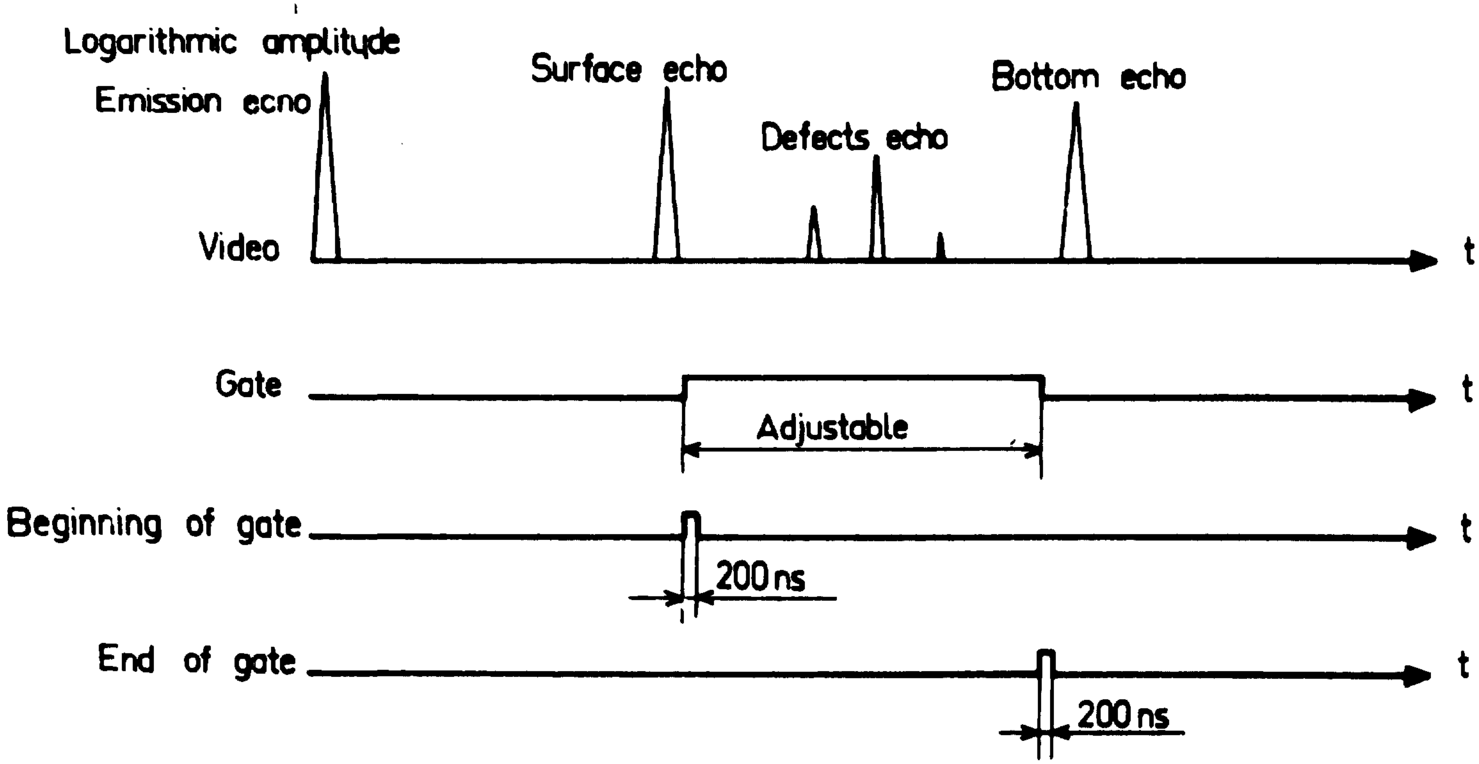
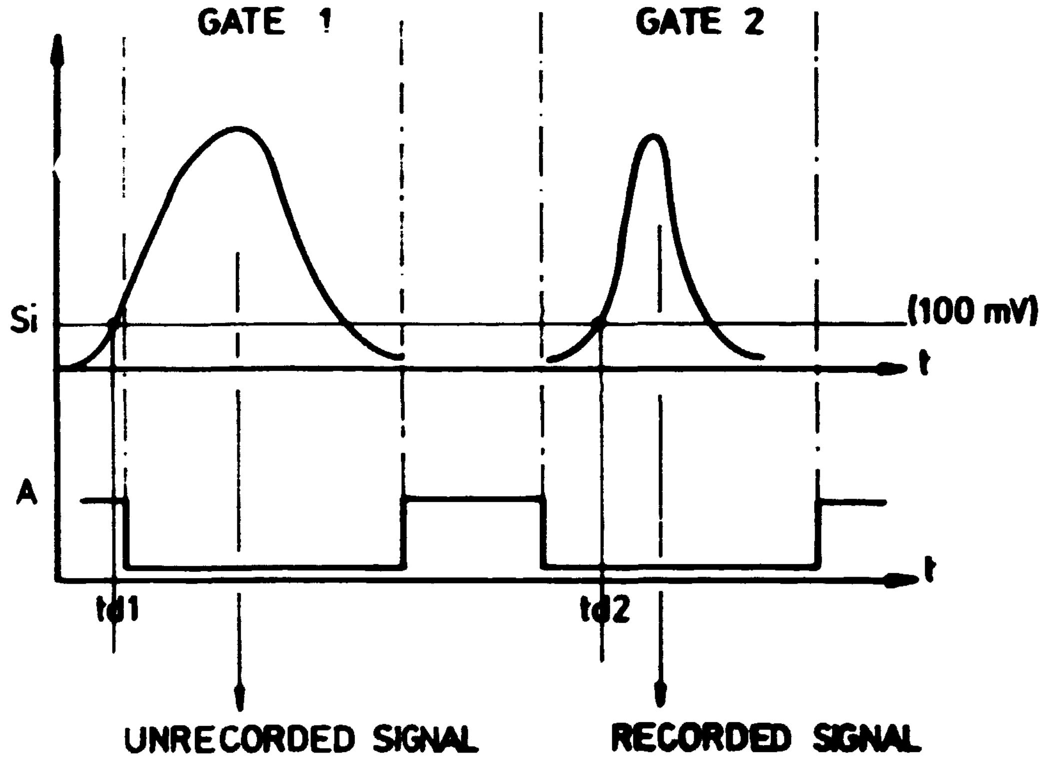


PICTURE.N°1 - STADUS -

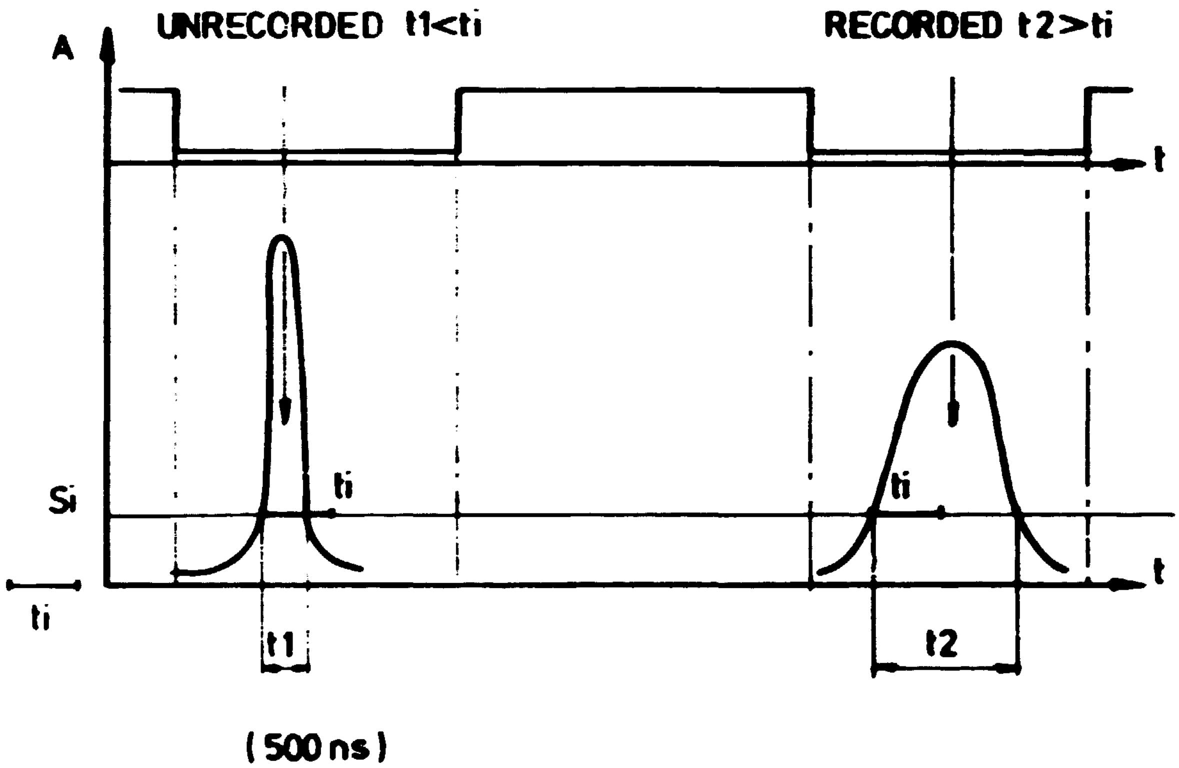
SIGNALS ARRIVING TO STADUS



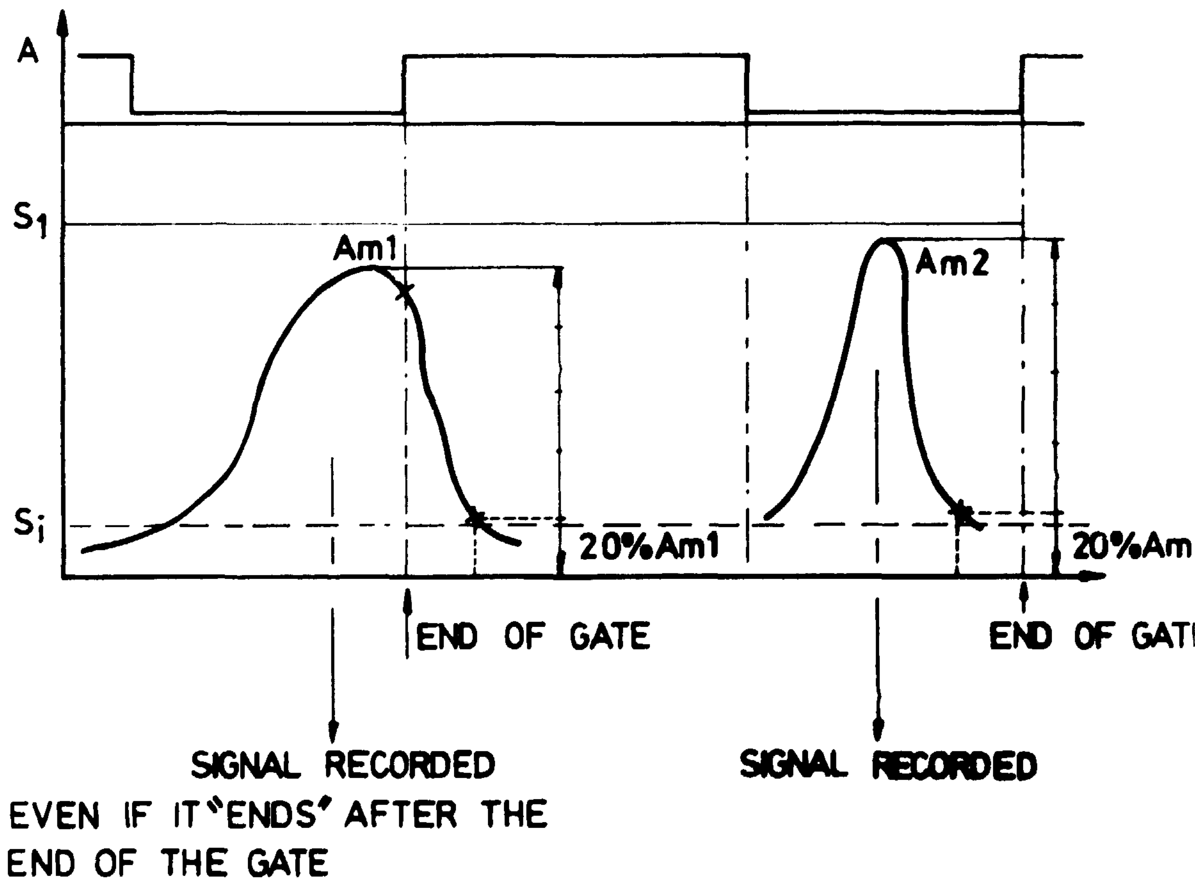
PICTURE : N°2



PICTURE N°3_AMPLITUDE > MINIMUM THRESHOLD

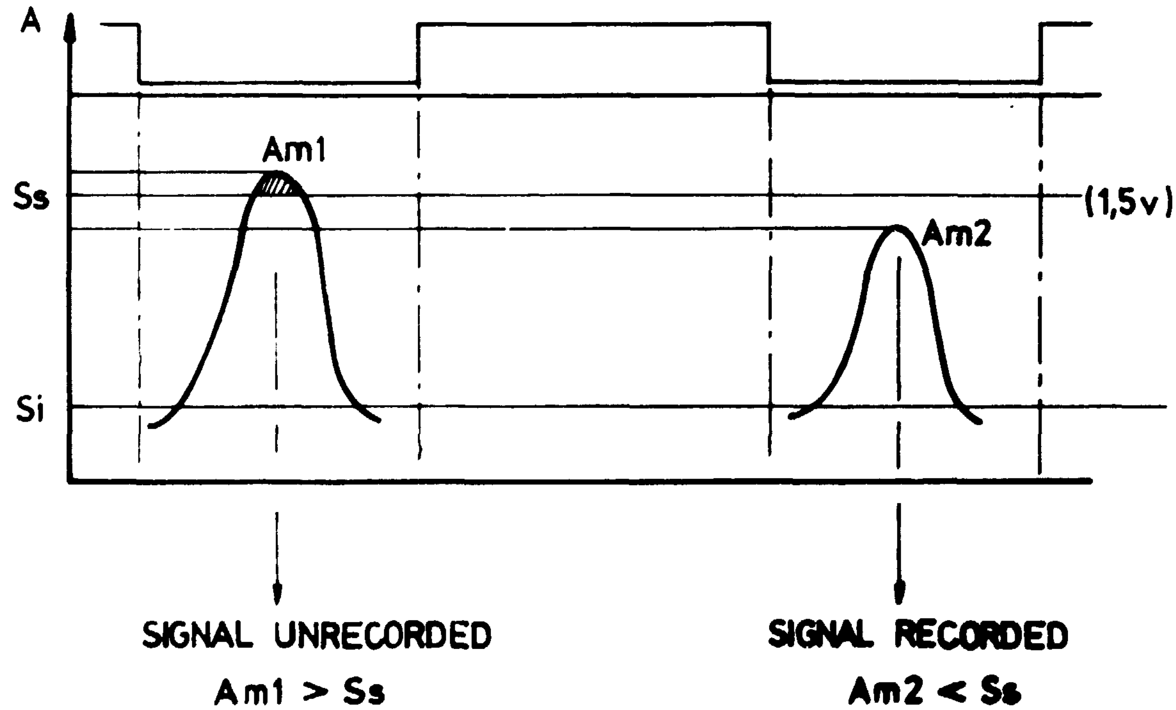


PICTURE. N°4 GATE LENGTH > ti



PICTURE.N°5

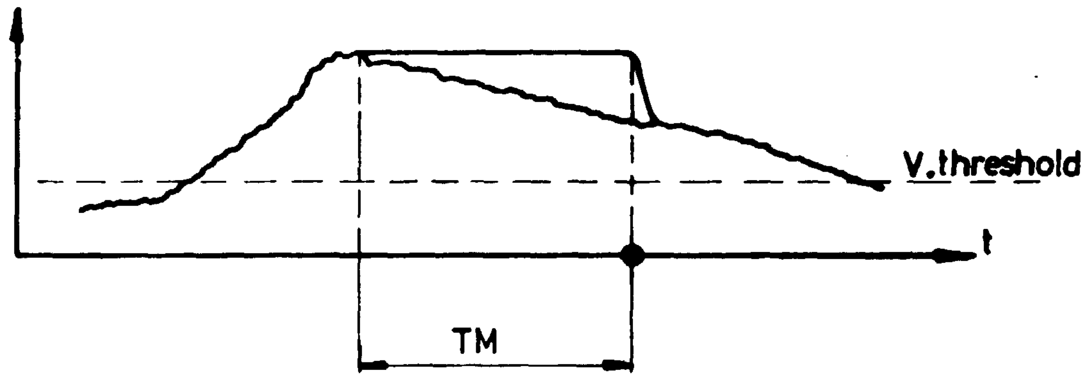
STA 167 81



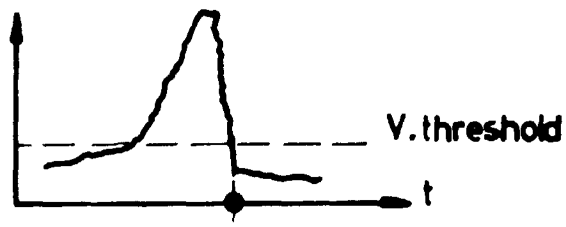
PICTURE.N°6 AMPLITUDE < MAXIMUN THRESHOLD

STA168.81

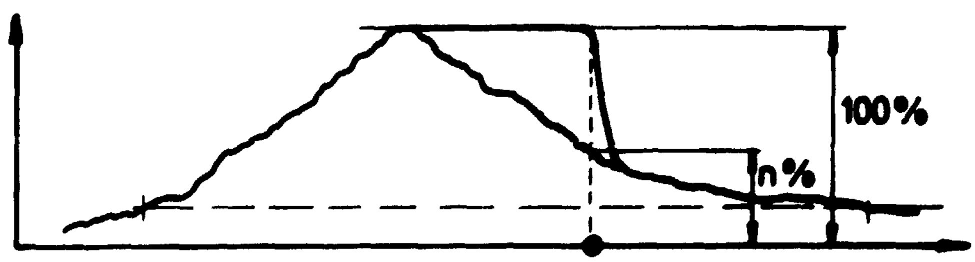
PEAK STABLE > TM (1,5 µs)



AMPLITUDE < V.threshold

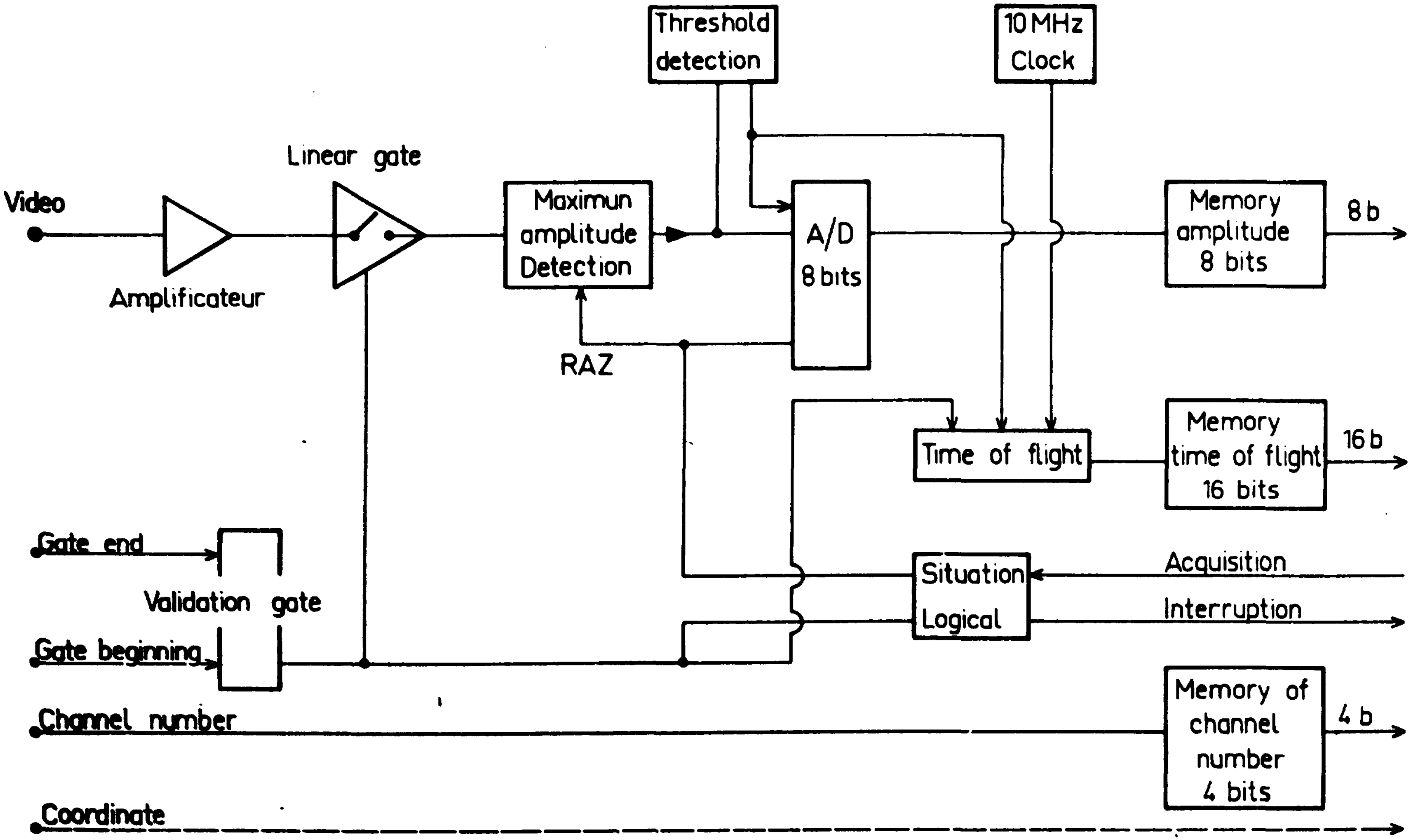


AMPLITUDE < n% OF MAXIMUM SIGNAL



PICTURE N°7

DETECTION



PICTURE : N° 8

STADUS PRODUS

PICTURE N°9

FA 131 01

ASCAN

CONTROLE=CV1
N.SOUDURE=FDS008
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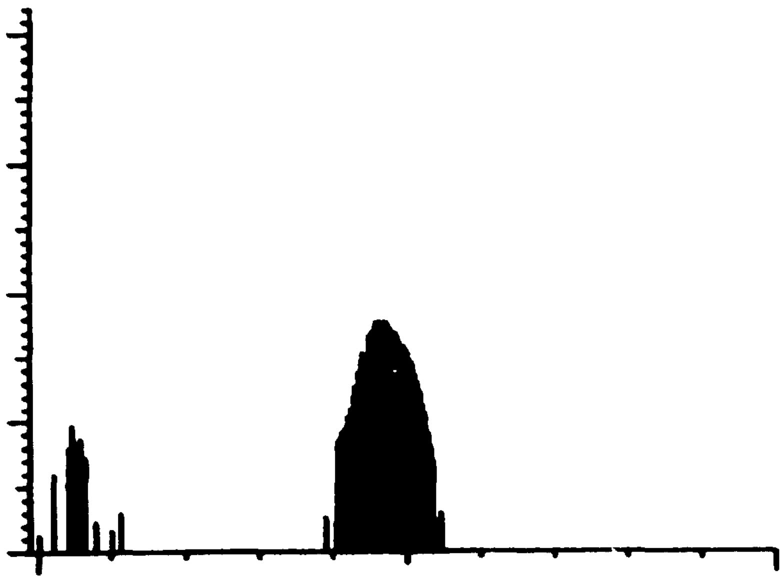
N.MM=0000
RP:000023E-2DG XC:000000MM HC:000000MM



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DT= 100
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$R DEF= 470
$DELTA R DEF= 80
$X DEF= 0
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FIN DE LECTURE

ACQ= 0 $LEC= 1   DESC   PAR   VISU(A,B,C)=   TETE=   E.MM= 0

PICTURE N°10

BSCAN

.ONTROLE=CU1
...COUDURE=FDS008
NOM EXP=UKAEA CEA TOLE 2 REVETUE PLATINE 1MHZ POSITION 1
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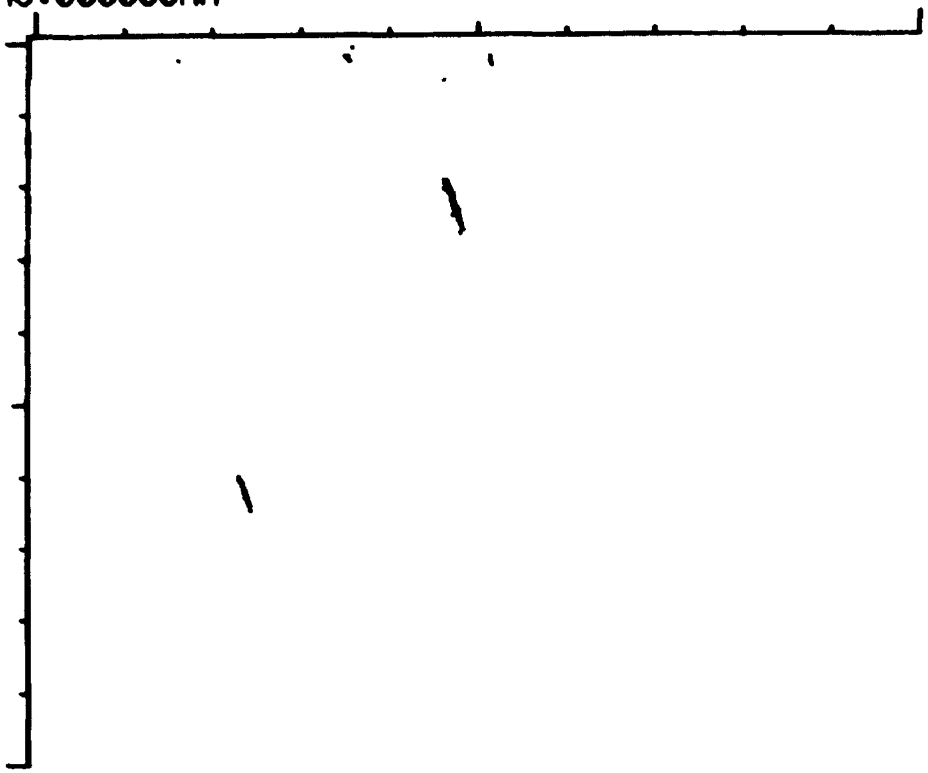
RP:000023E-2DG XC:000000MM HC:000000MM
T:1,3,9



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DX= 60
$Z.ORG= 0
$ECH.Z= 166
DZ= 16
$GR.TRANSD= 5
$SEUIL IMAGE= 9
$R POS= 470
$DELTA R= 80

FIN DE LECTURE

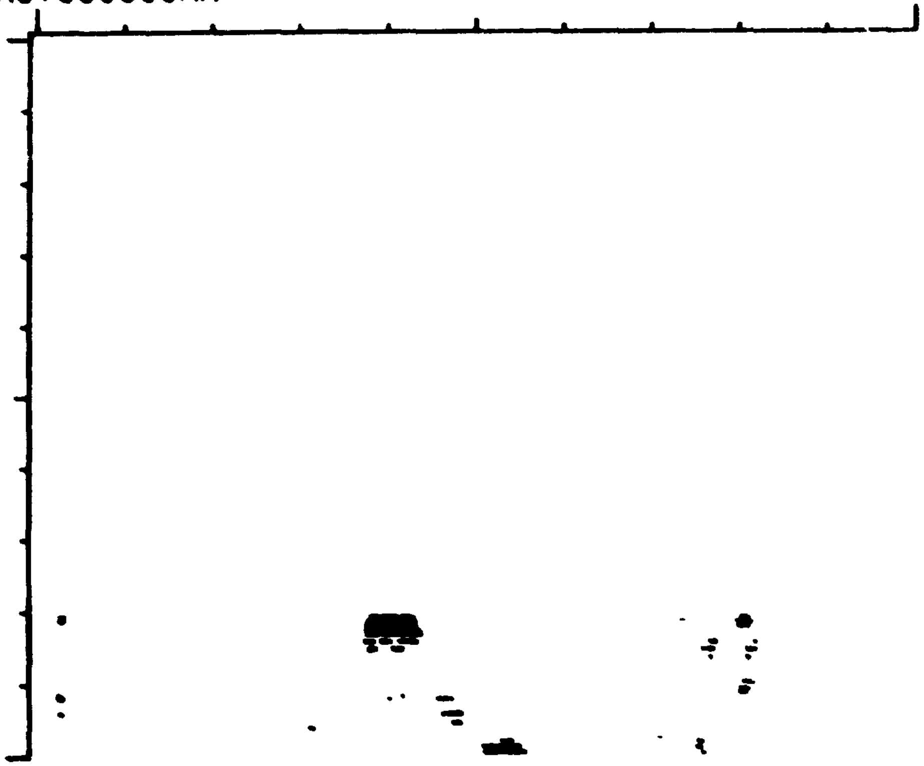
ACQ= 0 $LEC= 1 DESC PAR VISU(A,B,C)= TETE= E.MM= 0

PICTURE.N°11

CSCAN

CONTROLE=CV1
N.SOUDURE=FDS008
NOM EXP=UKAEA CEA TOLE 2 REVETUE PLQTINE 1MHZ POSITION 1
N.MM=0000
RP:000023E-2DG XC:000000MM HC:000000MM
T:1,3,9

0



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DX= 60

$ECH.R= 500
DR= 50
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$SEUIL HISTORIQUE= 18
$PERIODE HISTORIQUE= 1
$R DEP= 400
$TEMPS REF= 0
$DELTA T= 16000

ACQ= 0 $LEC= 1 DESC PAR VISU(A,B,C)= TETE= E.MM= 0

PICTURE N°12