THE SACLANTCEN INTERACTIVE TIME SERIES ANALYSIS SYSTEM

by

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The purpose of this paper is to describe the new conversational signal processing system which is being developed by the Computer Section at SACLANTCEN. This system, which includes input/output devices, can be used alone or, alternatively, it can be used together with acquisition and preprocessing oriented systems (SPADA and OC Acquisition) as a flexible signal processing module.

It has already been extensively used in various projects and has provided a considerable amount of results which would not have been obtained otherwise, or only at great cost and difficulty. Figure 1 shows the hardward involved.

This facility differs considerably from previous systems in the same field because it is essentially oriented towards an easier communication between the scientist and the computer. It is, therefore, entirely on-line and conversational. It allows the scientist to control it through an application oriented language – quick and easy to learn – provides almost instantaneous results, allows on-the-spot investigations to be carried out with unusual ease and speed. The inputs and outputs of this system are of various kinds and include visual displays, A/D and D/A converter [Fig. 2]. The system can, for example, generate complex sonar waveforms to activate a transmitting transducer, acquire data from a receiving array, process the signals in any programmed way, display the results to the scientist, and file them on some form of digital storage, like disc or magnetic tape. All this in a few seconds; at any given time, any step of the processing can be modified in seconds. In this application the system performs as a general research sonar, whose operation can be varied at will by the scientist and although this is just a good example to illustrate this system, it can operate in many other ways depending on the sort of the data input and on the way it is programmed. It combines the power and versatility of the general purpose computer with the ease of the use and the efficiency of an application oriented software.

The need for a system of this sort has existed for a long time amongst us. It is expected to help the researcher considerably by removing the long delay introduced by program writing, debugging and running with the present scientific computer installation. Also most of the programming used to be lengthy and sophisticated enough to have to be written by dedicated programmers, and this often increased the psychological distance between the researcher and his tool. "Free" investigations were also prohibited because of the high cost or the time required to do them.

The advent of rather cheap mini-computers gave the first opportunity for such systems to be economically feasible. Being mostly designed for process control applications, these computers have just the adequate word and memory size, speed and input/output flexibility for most signal processing applications. Shortly after, one of the first commercial attempts was made by Hewlett-Packard to produce a small general purpose signal processing system, driven by a computer, under the name of "Fourier Analyser 5450". This unit was very successful at the Centre, and it became obvious that the quickest and quite certainly the most efficient way to implement the signal processing facility which was required here, was to adapt, complement and integrate the H.P. unit. A major part of the activity of our team of three has been devoted to that. Through continuous collaboration with the users of our system, we have been able to set up a signal processing facility which has already proved very useful for several research projects.

This system, of course, consists mainly of software operating on our standard mini-computer system, with the help of some dedicated peripherals like control consoles and displays.

Hardwarewise [Fig. 3], the main components of the system are, of course, the computer (HP 2116), and the parts which allow the communication with the user:

Keyboard consoles
CRT displays
Plotters
Two-channel A/D converter
Two-channel D/A converter
Teletype or CRT console

Also included are the usual computer peripherals like paper take reader and punch, disc and magnetic tape.

The system processes time series stored in its memory: the data can be input by blocks up to 4096 words long, via A/D converter, paper tape, disc or magnetic tape. A view of the instrument's keyboard [Fig. 4] gives an idea of the variety of operations which can be executed on the data. To this basic set of operations another set has been added which is controlled by an auxiliary keyboard [Fig. 5]. This set covers more closely the specific needs of SACLANTCEN although one can see that most of the operations are still of rather general use [Fig. 6].

Programming of the system is done by pressing the keys. Simultaneously a listing is produced on a teletype or a memoscope console. The program can be stored and run indefinitely. Program modification is straightforward. The result of any operation can be displayed after the execution which never lasts more than a few seconds. Fast access program and data storage areas are large (700 000 words). Control of external equipment by the system is easy. All these features will probably be better shown during the demonstration after the talk. To give an idea, a typical sonar classification processing including correlations, filtering, spectral analysis, input and output, can be programmed in less than an hour; each processing takes between 6 and 20 seconds depending on the parameters chosen; the resulting curves are available on photographic paper or from a plotter, or can be stored on disc or magnetic tape. The system is connected to the acquisition equipment in a straightforward manner [Fig. 7]. Decisions from the scientist during program execution can be transmitted through the various control units, allowing much interaction. Examples of results are given from Target Classification [Fig. 8] and Oceanography [Fig. 9]. Figure 10 shows processed explosive signals obtained during a joint Target Classification-Sound Propagation cruise. The system has been used as a major monitoring and processing tool in several sea trials and has processed the data presented in several reports.

The system follows strictly all the Centre's computer standards for files and format, and can exchange data with various acquisition/ pre-processing systems like SPADA or Oceanography Acquisition.

The system can operate in conjunction with other software like RTE or BCS as long as our standard format has been used for the files; the software can be changed rapidly in and out of the computer core memory from and to the disc, under program control. This is illustrated on Fig. 11. The computer is thus fully occupied by only one software at a time. A drawback of this method, however, is that other operations like low speed data acquisition cannot go on while the signal processing software is in core, and vice versa. But our future systems will solve this problem.

Present Situation - Main Needs [Fig. 12]

We have now reached a level where a comprehensive signal processing system exists which has been adapted to our needs and can be connected on an exchange basis to both RTE — including SPADA — and BCS systems. It is, however, desirable to integrate completely the system into the RTE in order to increase a great deal its capacity for communicating with peripherals and software and to allow simultaneous data acquisition and processing, making it possible for one single computer to take care of all the operations of a large sea-trial. Also, since the system is being used by more and more users for more and more complicated processing a definite need seems to appear for an FFT hardware unit which would increase the overall operation speed by a factor of 20 to 50.

Apart from giving a much better real time performance for the acoustical processing at sea, this unit would also release the CPU from a great deal of special computation and would make the single CPU concept much more workable. The great interest of the present system is that it is conversational, and thus very well adapted for obtaining quick and reliable results under a scientist's control. Not all operations, however, are possible. We have tried, for the time being, to solve users' problem by writing additional special instructions. As a much more powerful and general solution, we are planning to link the Analyser to a general purpose conversational language like Basic. This would solve almost any of the problems currently met in sonar data processing in a very convenient way.

Taking into account our workload in assistance to users, this new system is expected to be available in autumn 1972. In the meantime our present system should be sufficient, after a few more improvements have been made.

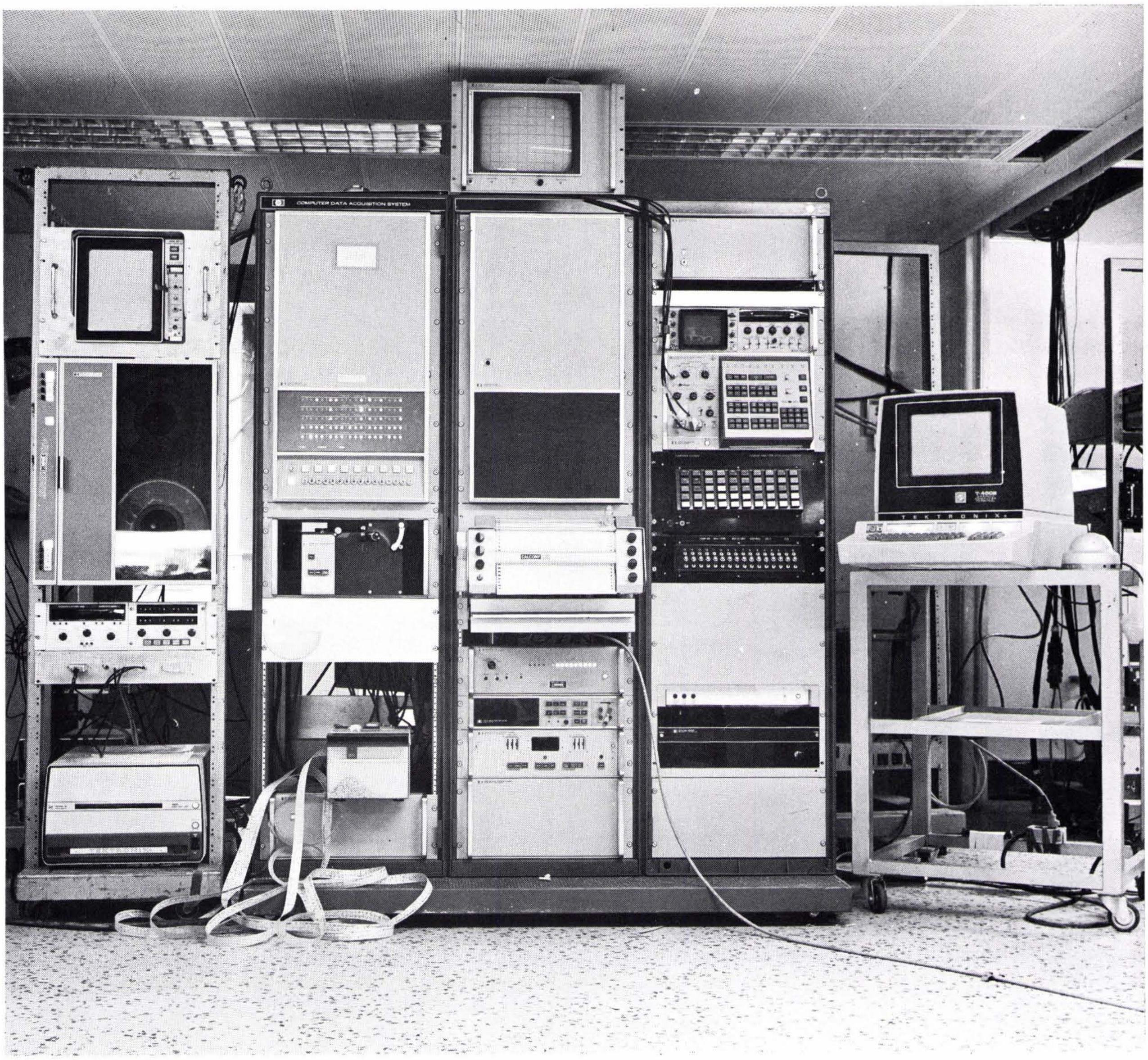


FIG. 1

MAJOR FEATURES

CONVERSATIONAL

ON-LINE OPERATION

SIMPLE LANGUAGE

ADEQUATE DATA INPUT AND OUTPUT

FIG. 2

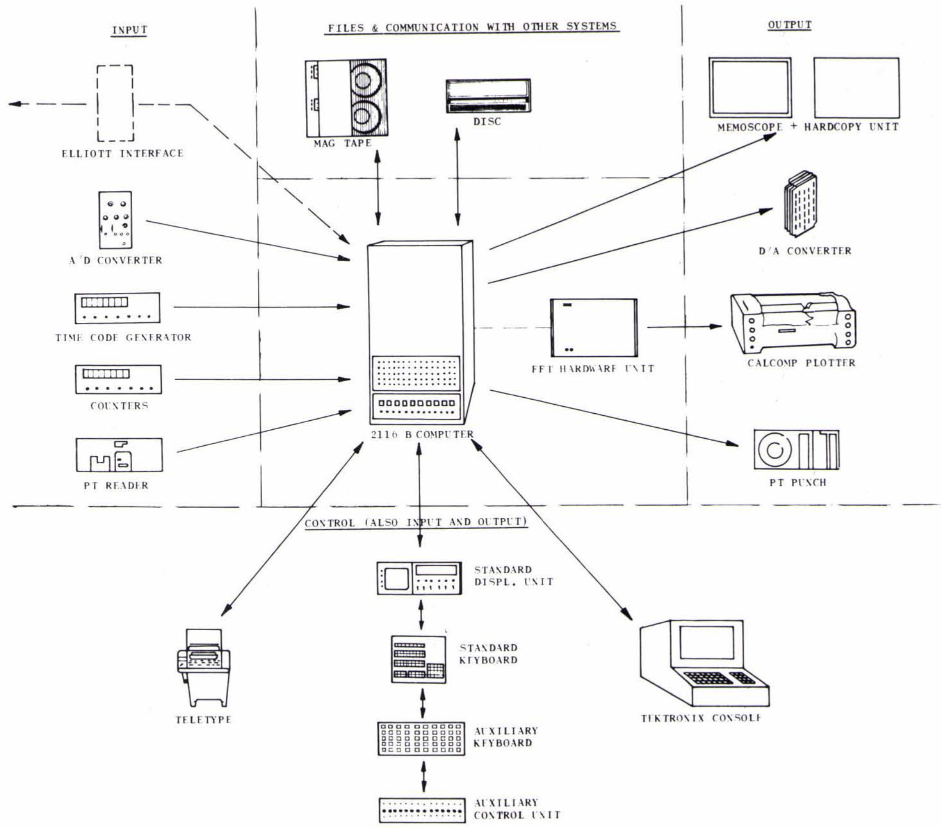

INPUT
FILES & COMMUNICATION WITH OTHER SYSTEMS
OUTPUT
ELLIOTT INTERFACE
MAG TAPE
DISC
MEMOSCOPE + HARDCOPY UNIT
A/D CONVERTER
D/A CONVERTER
TIME CODE GENERATOR
FFT HARDWARE UNIT
CALCOMP PLOTTER
COUNTERS
2116 B COMPUTER
PT READER
PT PUNCH
CONTROL (ALSO INPUT AND OUTPUT)
STANDARD DISPL. UNIT
STANDARD KEYBOARD
TELETYPE
TEKTRONIX CONSOLE
AUXILIARY KEYBOARD
AUXILIARY CONTROL UNIT

FIG. 3

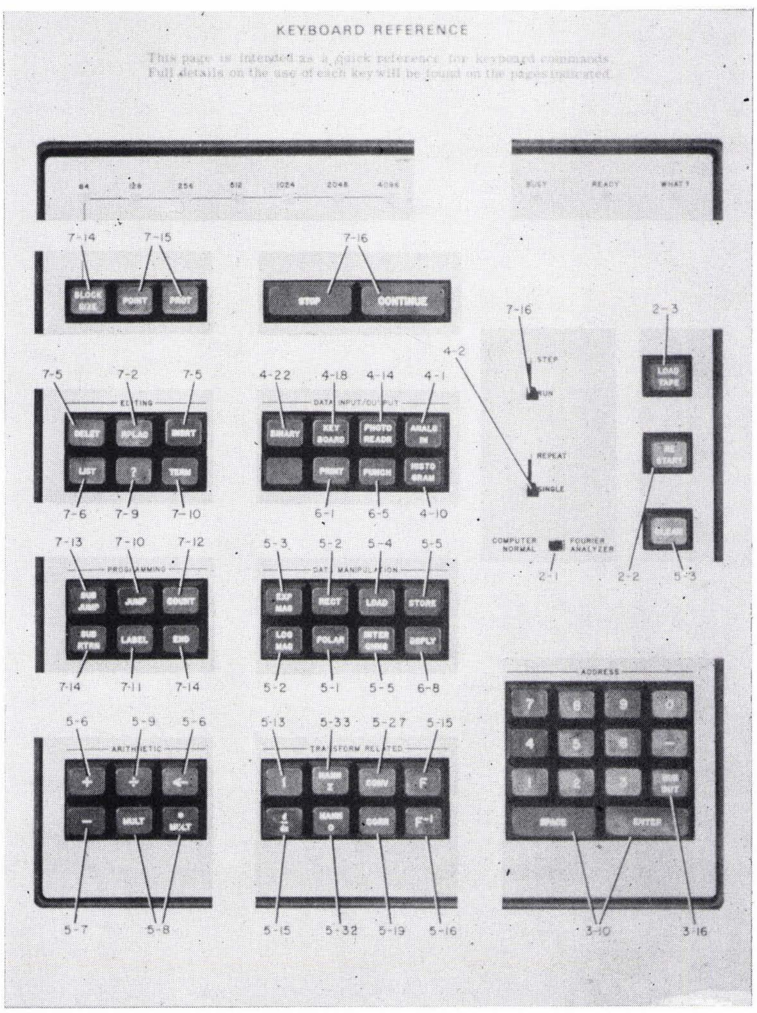

KEYBOARD REFERENCE
This page is intended as a quick reference for keyboard commands.
Full details on the use of each key will be found on the pages indicated.
EDITING
DATA INPUT/OUTPUT
PROGRAMMING
DATA MANIPULATION
ARITHMETIC
TRANSFORM RELATED
ADDRESS
STOP
CONTINUE
STEP
RUN
REPEAT
SINGLE
COMPUTER NORMAL
FOURIER ANALYZER

FIG. 4

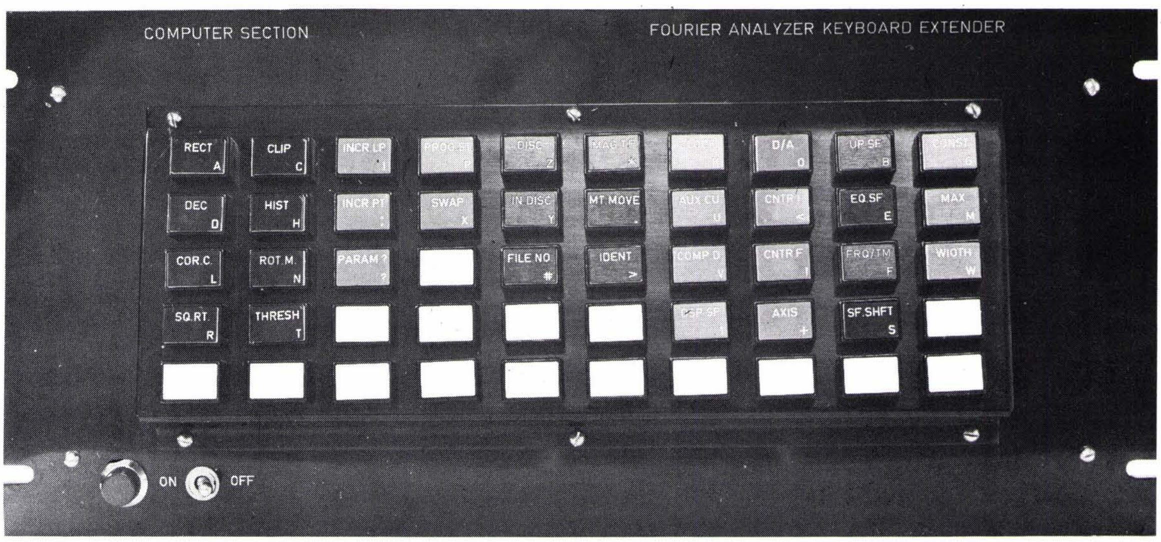


FIG. 5

NEW KEYBOARD

1. DATA MODIFICATION
   - RECTIFICATION
   - CLIPPING
   - DECIMATION
   - HISTOGRAMS
   - THRESHOLD DISPLAY
   - ... ETC ...
2. PROGRAM MANAGEMENT
   - "FOR" STATEMENTS, ETC...
   - PROGRAM AND SUBROUTINES ⇄ DISC
   - SWAPPING

   ... ETC ...
3. FILE HANDLING
   - DISC
   - MAGNETIC TAPE
4. ACCESS TO PERIPHERALS
   - TIME CODE GENERATOR
   - D/A
   - AUXILIARY CONTROL UNIT
   - COUNTERS

   ... ETC ...
5. MISCELLANEOUS

FIG. 6

EXAMPLE OF EQUIPMENT CONFIGURATION
FOR SFC SONAR EXPERIMENT

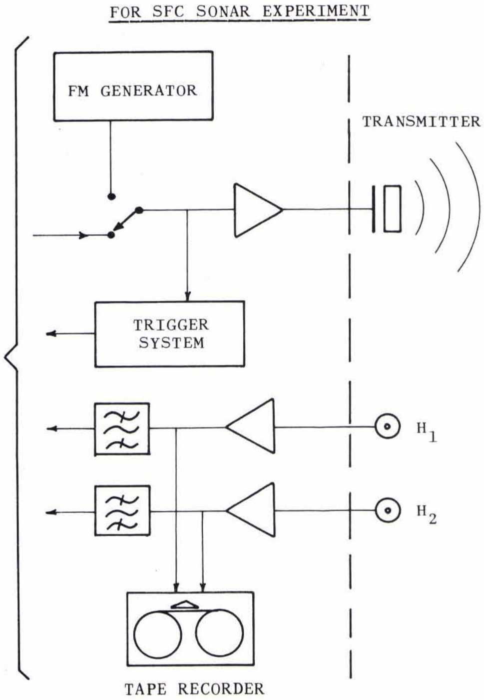


FIG. 7

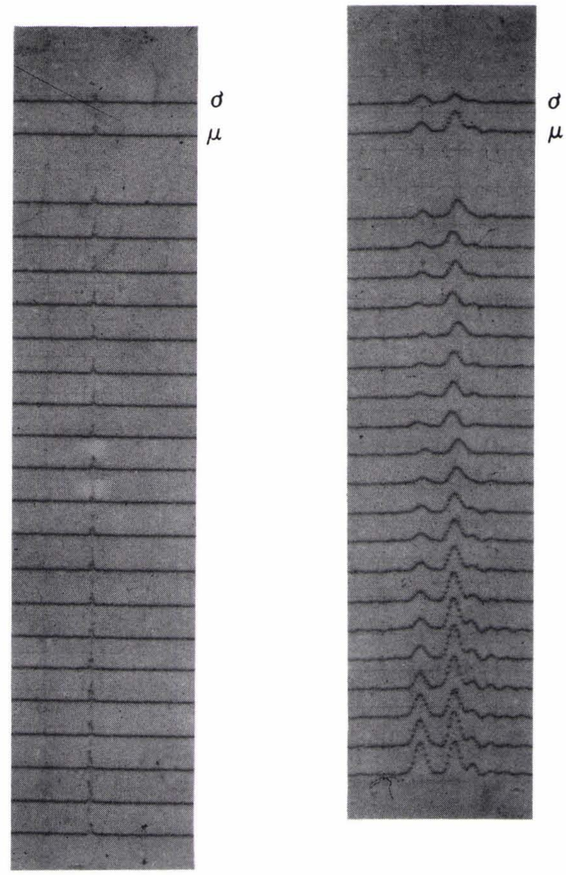
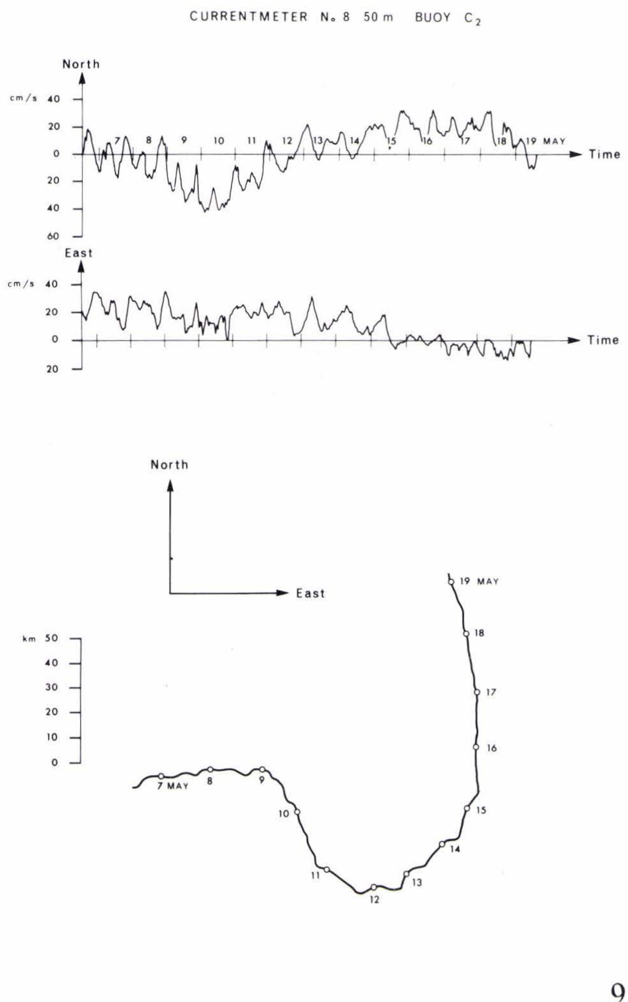

σ
μ
σ
μ

FIG. 8


CURRENTMETER N. 8 50 m BUOY C_2
North
cm/s
40
20
0
20
40
60
7
8
9
10
11
12
13
14
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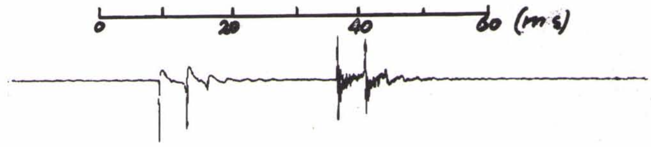
16
17
18
19 MAY
Time
East
cm/s
40
20
0
20
Time
North
East
km
50
40
30
20
10
0
7 MAY
8
9
10
11
12
13
14
15
16
17
18
19 MAY

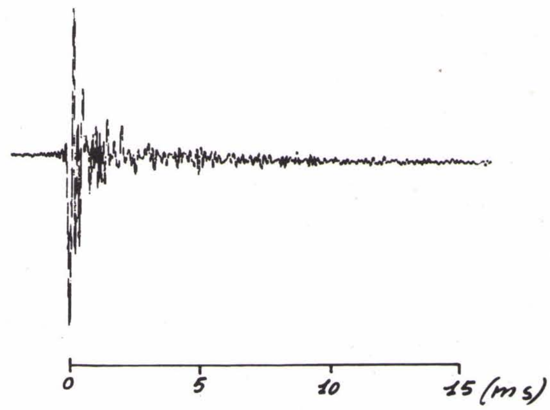
FIG. 9

EXAMPLE OF ON-LINE PROCESSING RESULTS



DIRECT ARRIVALS & SURFACE ECHOES
[EXPLOSION AT 130 m, ARRAY AT 250 m, RANGE 0.73 n.mi]

FIG. 10



DE-CONVOLVED SURFACE ECHO

EXAMPLE OF PROGRAM SWAPPING

STEP 1 - ACQUISITION AND FILING UNDER RTEX

STEP 2 - SWAPPING { RTEX: FROM CORE TO DISC
SIG. PROCESS: FROM DISC TO CORE

STEP 3 - PROCESSING OF FILED DATA BY SIG. PROCESS SOFTWARE
FILING OF RESULTS

STEP 4 - SWAPPING

STEP 5 - SPECIAL PLOTTING PROGRAM (RTEX) PLOTS THE FILED RESULTS

RETURN TO STEP 1

FIG. 11

NEXT STEPS

FIG. 12

1 INTEGRATION INTO THE RTEX

2 ATTACH BASIC INTERPRETER

3 SPEED UP WITH FAST FOURIER TRANSFORM HARDWARE UNIT