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Statistic Committee

International Council for
the Exploration of the Sea.

DANA's Computer Facility

A dedicated System for Onboard Laboratory Automation

Civ. ing. (M.Sc.E.E.)
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Abstract: The computer system developed for the danish research vessel Dana is described. The system is organized with a central computer supported by two front-end processors all of which are connected to a variety of other equipment onboard. The fundamental job of the system is to provide a flexible tool for data acquisition and registration. The system could be considered as a multidisciplin data concentrator, in which information flows from many sources to a number of data bases placed in bulk memory on magnetic tapes. In this way the majority of the scientific material obtained from an expedition should be immediate ready for use in computing centers ashore at the returning to port of the vessel.

Introduction

The general structure of DANA's computer facility was laid down in 1978 and presented in a tender document together with all other constructional requirements for the vessel. The description of the computer facility was held in 3-4 pages including as well hardware requirements as functional characteristics and in no way emphasized in advance of other equipment.

From a computer system contractors point of view this was a rather unusual situation, which indicated that a considerable development work had to be included in the production phase in order to end up with a satisfying system. This expectation certainly was fulfilled by utilizing the first 6 months of the project period to define in details the characteristics of the system. The results are more than 400 pages thorough description of scientific and technical functions illustrated with VDU screen picture layouts and operating guides. The work was carried out in cooperation with the future users and with contributions from suppliers of other equipment interfaced to the computer system. During the process of defining the system requirements, different useful extensions to the originally planned system were detected and to a certain degree included in the total delivery.

Hardware considerations

The hardware architecture of the system is illustrated in fig. 1. The onboard system is composed of 3 interconnected processors each equipped with a dedicated set of peripheral units. The 3 processors are all of make Digital Equipment Corp. belonging to the PDP 11 product line of that company. They are:

The central computer, which controls the formation of data in the databases and runs a large number of data-entry tasks by means of its 4 VDU terminals.

The laboratory computer ("chemistry-computer") which is a front-end system to the central computer and takes care of

on-line data acquisition from transducers and laboratory equipment.

The acoustics computer which too is a front-end to the central computer and takes care of on-line data acquisition from the scientific echo-sounder equipment.

The delivery comprises a fourth computer (not shown in the figure), which is located in the oceanographic center ashore and is used for software development and testing, staff training, and postexpeditional adjustments of the material brought back. Its functions will not be further described in this paper.

The distribution of computing power on 3 processors serves several purposes. Besides the distribution of load which is very convenient when dealing with high priority, automatic data input, this structure introduces a redundancy in the total system. In this way the risk of returning without computer-readable data from an expedition (due to a hardware error) is practically eliminated.

Each of the processors is equipped with a dualized bulk memory which may be used as load medium and for data storage. Like this the 3 computers may all operate physically independent of the others and execute their normal, dedicated functions with the exception of data exchange. Stored data are in this situation carried manually via diskettes from the front-end processors to the diskette station of the central computer.

Furthermore a principal difference is maintained between the two front-end processors and the central computer. The front-end processors are from a user point of view black boxes which will execute only their preprogrammed functions and support user manipulation according to well defined and safe operator communication procedures. All user manipulation is constrained to the attached VDU terminals which will support visualization of data and entering of certain commands.

The central computer too has its dedicated preprogrammed functions

and specific operator communication procedures, but furthermore it serves as a general purpose minicomputer allowing the users to work with software development in high level languages, execution of programmes in batch mode, etc. For the same reason the central computer is equipped with hardcopy peripherals (printer and plotter) and abundant memory, while the front-end processors do not leave much spare memory for user defined programs.

System functions

The distribution of functions between the 3 processors is reflected in the geography of the computer facility. The central computer is found in the computer room and the acoustics computer in the echo-sounder room both on the bridge deck. The laboratory computer is installed in the chemical laboratory on the main deck together with 2 VDU-terminals from the central computer (cf. fig. 2). Communication between the units is established by means of serial, asynchronous transmission lines (point-to-point).

Besides these internal communication lines all 3 processors are equipped with individual connections to the computerized navigation system of the vessel. This navigation system, supplied by Decca, will at any moment when requested by any of the 3 processors transmit a fixed-formatted data block to the requesting processor. The data block contains standard nautical information, like:

date, time (GMT)
compass heading
speed
position
depth

This information is typically used as a label for accurate positioning of experimental and other scientific data.

The 3 processors perform each their dedicated functions with the common objective to obtain as complete and extensive data records as possible. The 2 front-end processors could with a simplified picture be considered as relay stations acquiring information

via on-line signal input from electrically connected scientific equipment. They will after an initial validity check and data-reduction retransmit the information to the central computer, where more elaborate calculations and data reduction strategies may be applied. The central computer, on its part, supplements the data acquisition functions by providing facilities for comprehensive input via the VDU's for off-line generated data.

Looked upon in greater detail, the data acquisition functions of the different processors have the following features:

The acoustics computer interfaces to a scientific echo-sounder equipment of make Decca/Simrad. The interface connections provide for control of the echo-sounder operations/measurements from the computer and transfer of experimental results to the computer. Two connections are established: a standard two-way transmission line carries commands to the echo-sounder and printable measuring results back to the computer while a customized high speed DMA-interface allows the computer to get hold in real time of entire series of raw measured values for specialized data analysis.

From a user point of view all attention may be concentrated on the VDU attached to the acoustics computer. The VDU supports 18 different commands and provides the user with a window through which he can inspect the results obtained before they are sent on to the central computer. The set of commands comprises start and stop of echo-sounder operation, change of device parameter settings, selection of different display types (alphanumerical presentation/graphical presentation) look-up of specific measuring results etc. A standardized display screen layout, dividing the screen area into 4 different sections, secures room for simultaneous presentation of different types of information no matter which command is currently being used.

The laboratory computer interfaces to a variety of more or less complex measuring devices. These devices are selected from different manufacturers according to a functional requirement for their use in the laboratory and without special consideration of inter-

facing standards. Consequently each device is connected through a dedicated interface module specially supporting the electrical characteristics of the device in question. From a software point of view this necessitates a structure which will provide corresponding individualized support of the specific functions in dedicated program tasks. The measuring devices connected are:

autoanalyzer equipment
spectrophotometer
spectrofluorometer
CTD/oxygen sonde
Rosette sampler
Quantameters
Turbiditymeter
TS sonde

Furthermore, the laboratory computer is able to control (wind up/out) the winch and has been prepared for later attachment of other devices (meteorological equipment).

In spite of the apparent lack of homogeneity in the job profile of the laboratory computer a functional solution is established similar to the solution of the acoustics computer. All operations are initiated via the VDU/keyboard and the datapresentation facilities on the screen are identical in the 2 systems. Furthermore the majority of the commands are the same in the 2 cases, so that staff familiar with one of the systems will be able to run the other too. A special command of the laboratory computer's operatorcommunication permits the user to select the type of device on which to proceed the work.

The central computer takes care of the final storage of data in files on disk or magtape, and is for this purpose equipped with comprehensive file handling software. The system functions of this computer are based on the utilization of the file handling software with the purpose to facilitate data storage (and retrieval).

With data arriving from as well the front-end processors as the VDU-terminals connected to the central computer, the corresponding system functions are falling in 2 main groups

The one that supports handling of data from the front-end processors comprise routines, that allow the system to set up basic information for operations in the front-ends and are able to "escort" the received data safely to the predetermined storage positions. These routines are of great importance to the full use of the automated data acquisition, and they are designed to be as anonymous as possible in order to be operational without the need of operator communication. The individuality of the different measuring devices connected to the front-end processors is reflected in the existence of different handling routines (in principle one per device) in the central computer.

The other group of system functions in the central computer provide the users with comprehensive data entry facilities for off-line generated data via the 4 VDU-terminals. The data-entry functions are organized around approximately 40 different preprogrammed screen pictures. Each picture has a layout like an individual form in which the user may write data in fixed positioned fields. The forms are of the following types:
ORIENTATION FORMS (survey forms) which are used as basis for selection of all other forms.
OPERATION or STATION FORMS which are used to set up (initialize) information of operations to come and to recall such information set up at an earlier occasion.
SELECTION FORMS for acoustics, laboratory or fishery applications. These forms are used to select functions, which can be carried out within the different applications.
DATA FORMS which are used for the actual entering or display of data related to the different applications.

Examples of forms are shown in figures appended. Use of the forms is guided by different remedies included in the system. Like this a cursor-based positioning mechanism facilitates the user's "moving

around" in the form and a validity check of entered data sorts out trivial keying errors (e.g. misplacing of decimal points, use of wrong type of datafield). Furthermore, a reservation mechanism will protect the users from mixing up data in simultaneous use of one file from more than one terminal. Each screen-picture holds besides the form a special system area in which error messages are presented and an updated display of realtime is always visible. Also, several of the forms (typically the orientation forms) contain subareas currently updated with continously refreshed measuring values from the front-end processors or the computerized navigation system.

Data structures

The principal data organization is illustrated in fig. 4. All collected data from the front-end processors and the VDU-terminals of the central computer are at first stored at disk for later transfer to permanent storage on magtape.

For this purpose a number of disk resident databases are created each with a content of a number of "stations" in which data are placed. An ensemble of several databases (a considerable number) adds up to the total amount of information obtained from an expedition.

Each station holds information with a natural relationship due to period of time or position of vessel. Like this, a station may comprise data from a number of measuring devices used at a given position or from a sequence of data entry sessions with the same form, thus describing e.g. an entire trawl operation. To support repeated use of the same equipment at one station a version number may be applied to the station.

The information of one station is organized in files each holding a bounded set of related data, e.g. data from an operation with a measuring device or data from a number of screen forms. The files may differ in organization depending on the type of data they hold.

A further subdivision of the files in elements serves the purpose of grouping data of more narrow, common origin like the use of a measuring device in a given depth or information from one single screen form, e.g. measuring of a fish specimen.
The layout of an element depends entirely of the data contained, but the layout of all elements in a file is the same. I.e. is the contents of one element a read-out from one measuring device like depth, pressure and temperature, then all elements of the file will hold a similar group of data.

The diskmemory of the central computer is prepared to hold a limited number of databases. When a database is filled up with information it is moved to magnetic tape storage to provide room for the creation of a new database. However, databases may be transferred back from magtape to disk for later completion or for subsequent investigation.

Subsequent investigations may take place with practically no limitations at all, since they may comprise execution of any off-line written program under the general-purpose operating system RSX11-M of the central computer. Such programs could be written in assembler or high-level language (FORTRAN, PASCAL) with routines for controlled acces of the database and output to other bulkmemory files, printer terminal or the attached full-graphic plotter.

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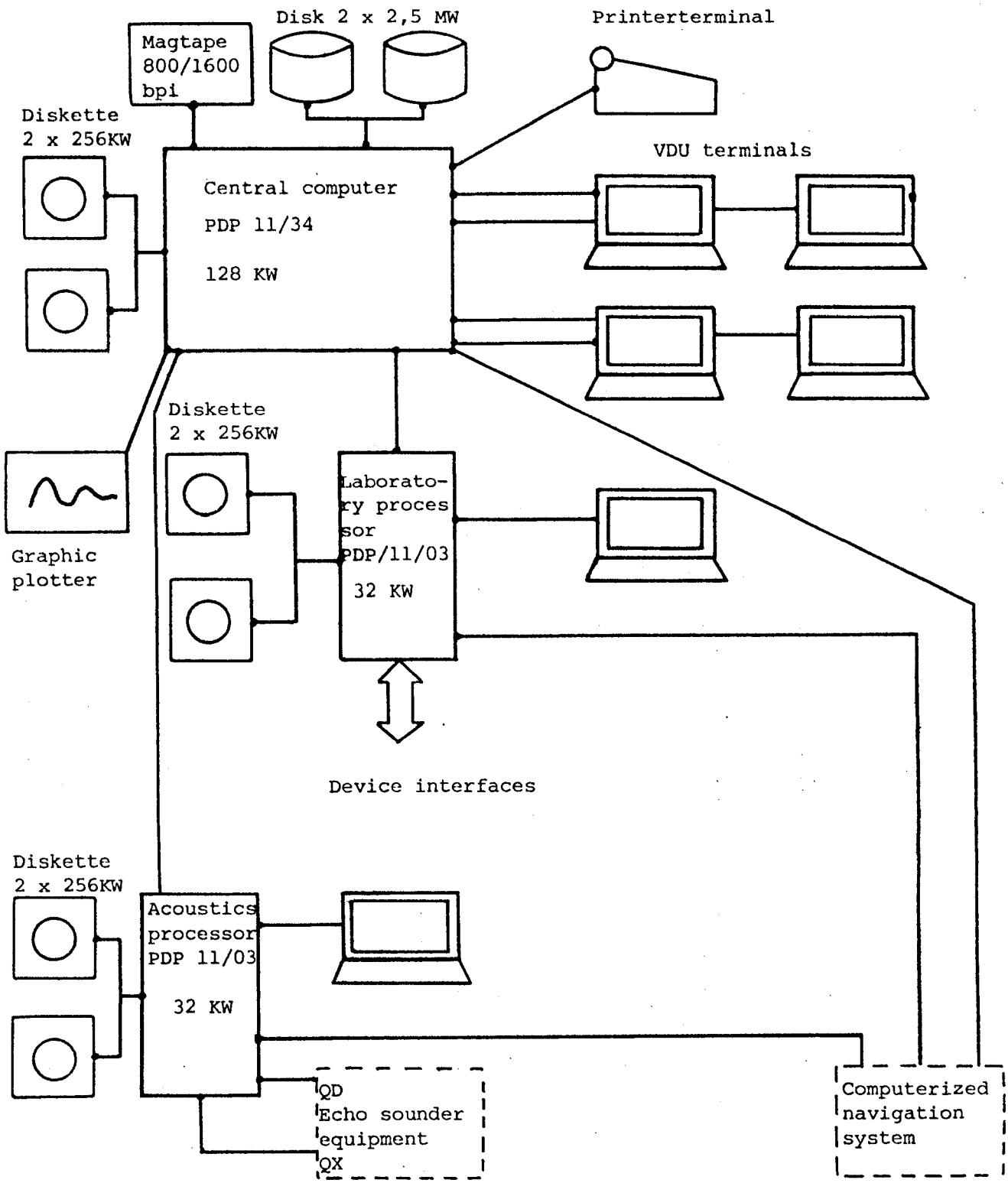


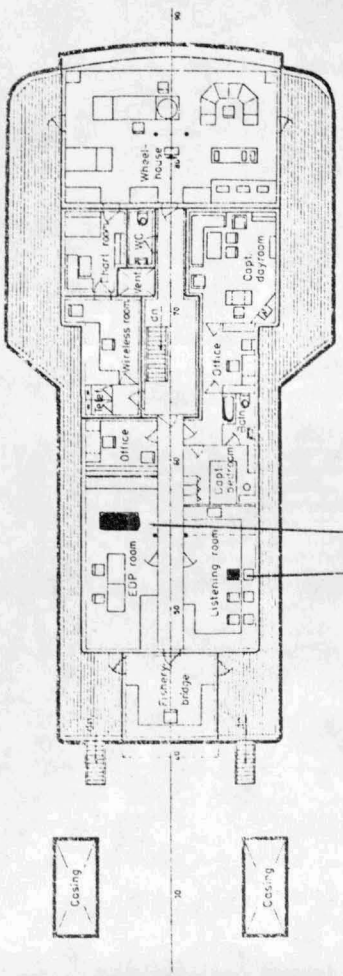
Fig. 1.

Computer Facility of DANA

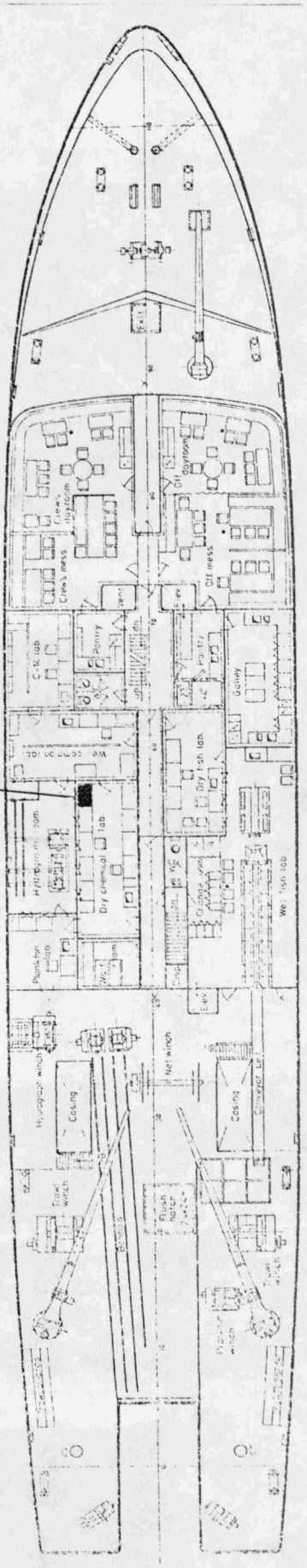
Fig. 2 a

Geography of Computer installation
onboard DANA

Horizontal plan
Bridge deck



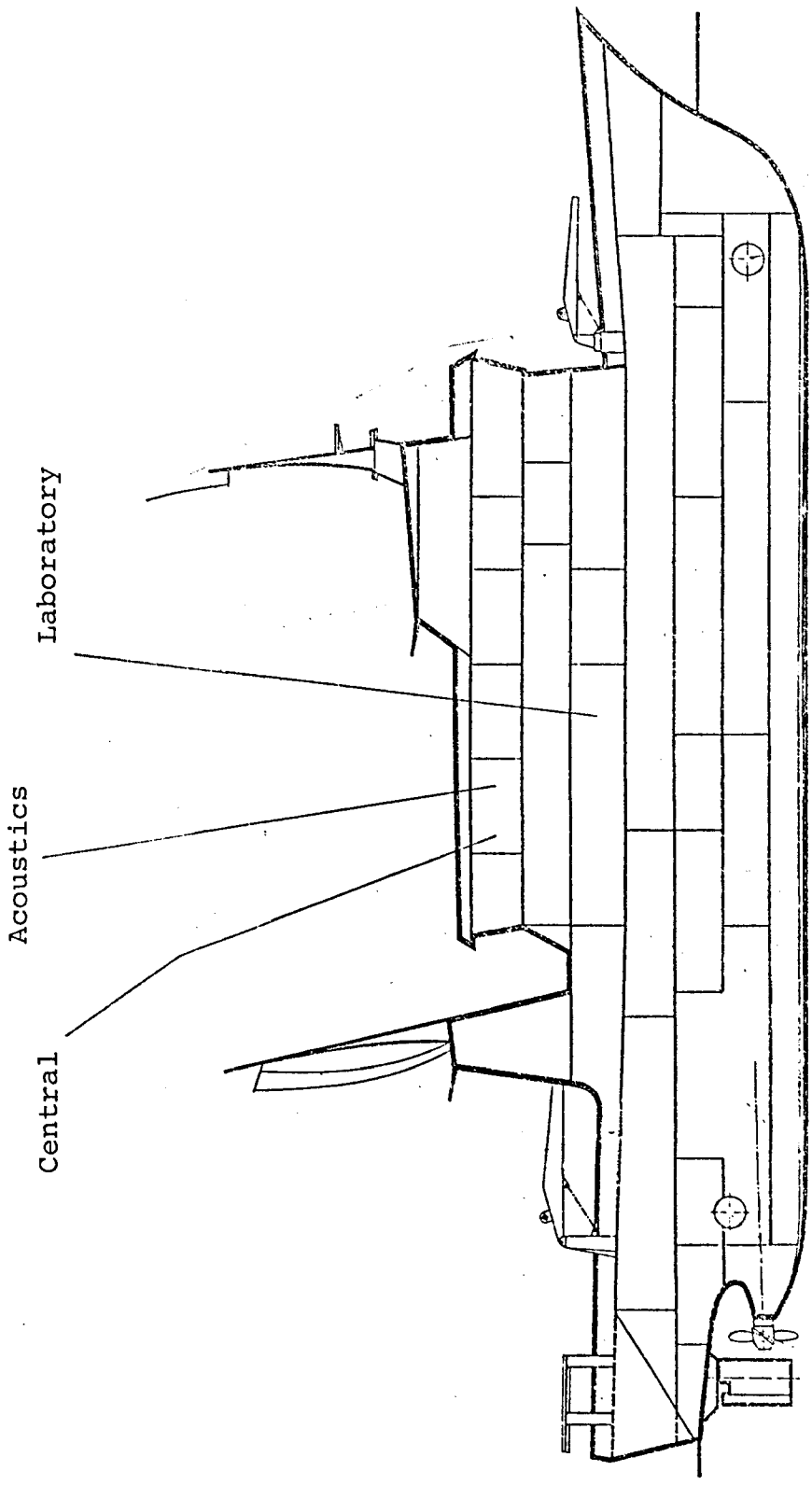
Central
Acoustics
Laboratory



Horizontal plan
Main deck

Fig. 2 b

Geography of Computer Installation
onboard DANA



Commands of the operator communication for the laboratory computer.

SST	Start station
AST	Terminate station
SDL	Start data acquisition from measuring device
ADL	Terminate data acquisition from measuring device
LOG	Include point value in log area on screen
SID	Remove point value from log area on screen
SLO	Clear log area on screen
EXP	Expand log area
PLT	Plot values as a curve on screen
AKT	Display survey of devices in use
PAR	Display parameter list
OPR	Display description of operation
SPA	Modify parameter no. X
PVD	Insert point value
MAN	Display operator manipulation
TYP	Specify type of measurement

Fig. 3

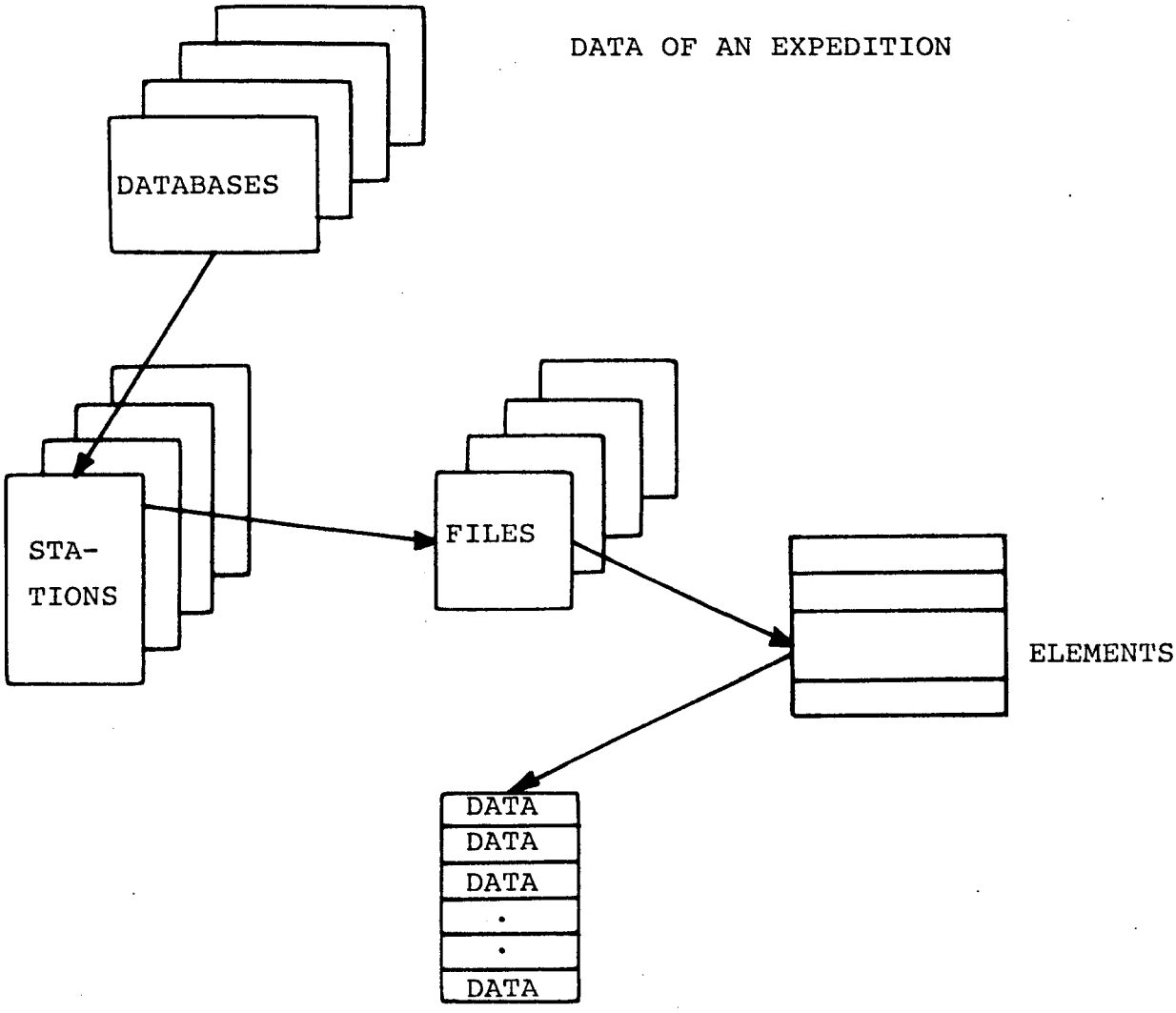


Fig. 4. DATASTRUCTURES

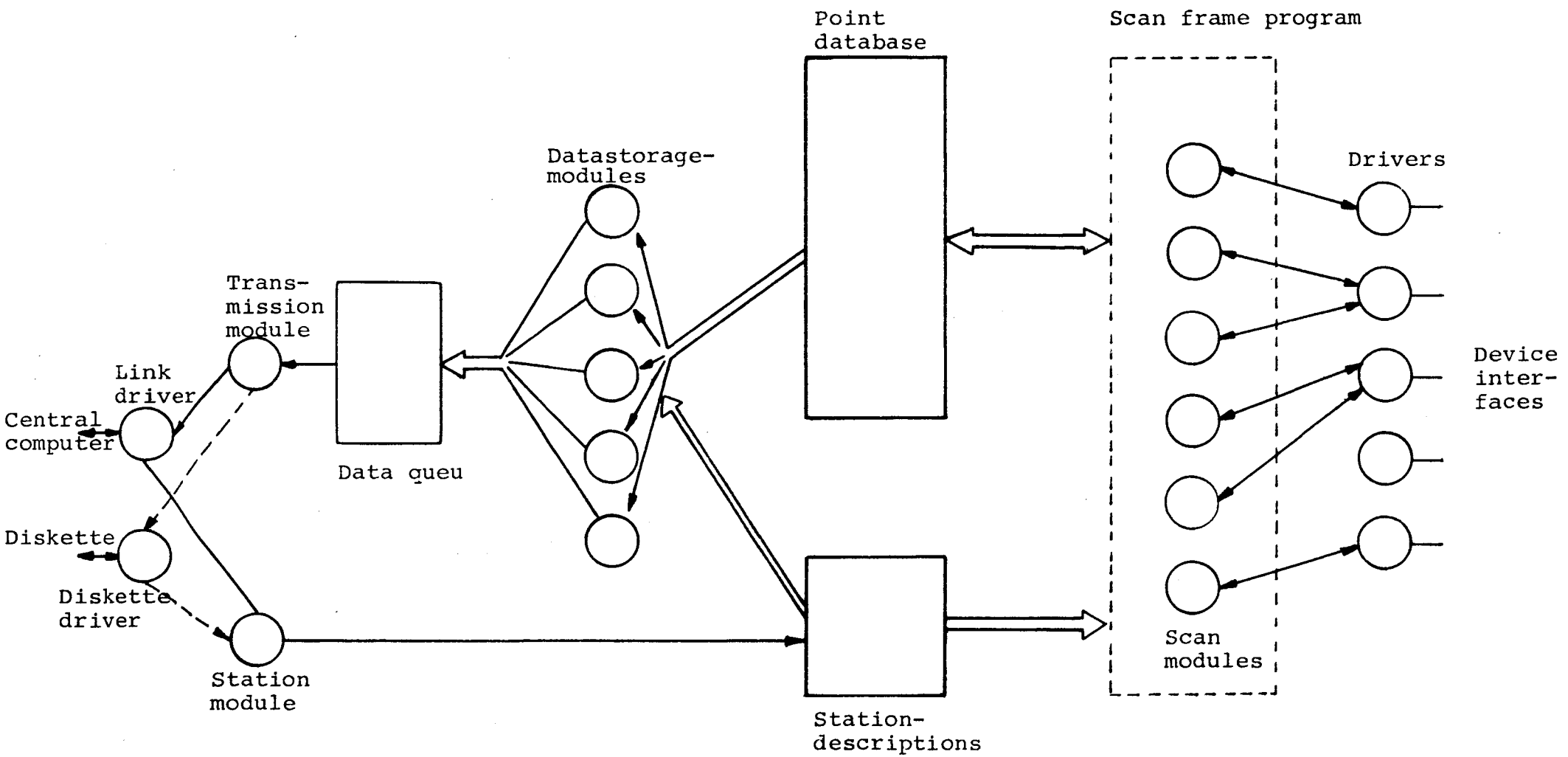


Fig. 5. DATA/PROGRAM STRUCTURE OF THE LABORATORY COMPUTER

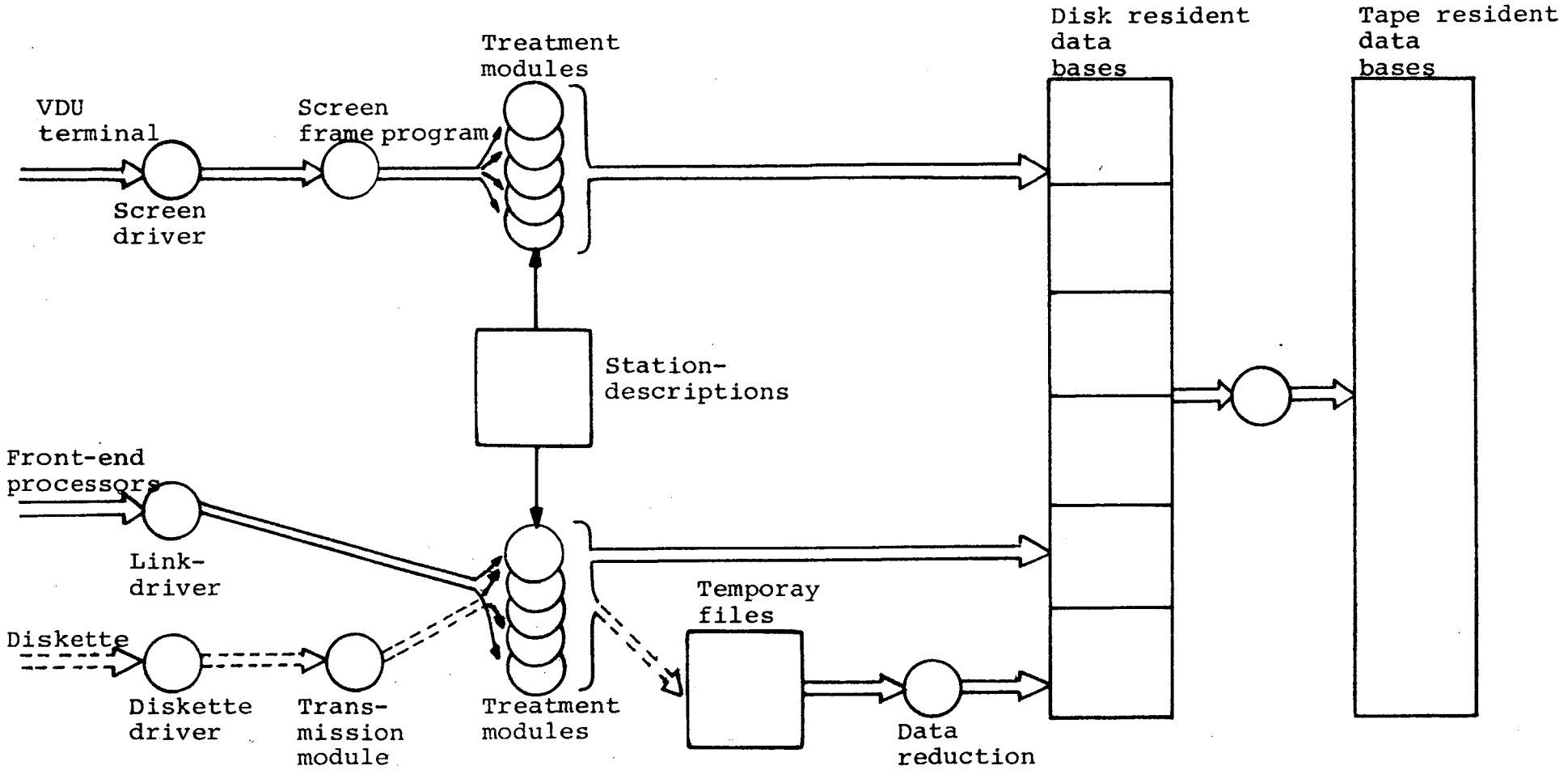


Fig. 6 DATA/PROGRAM STRUCTURE OF THE CENTRAL COMPUTER

ORIENTATION FORM

```
STATION NR:                                   TOGT NR:
                    D A N A  D A T A E N T R Y  S Y S T E M

                                O V E R S I G T

NAVIGATION:
          POS: B:    9.61.00      NAVIGATIONS TYPE: SAT
               L:   13.00.45      SIDST OPDATERET:  14.35
          KURS:  20.5  FART G. VAND: 33.60  FART O. BUND:  8.60  DYBDE:   101

METEOROLOGI:     VAND                    LUFT                    VIND

TEMPERATUR   11.5 C     VISUEL INDST    0.1 W/M2      VINDHAST    6.48 M/S
SALINITET    8.50 %.    TOTAL INDST     8.73 W/M2     VINDRETN  104.60 GRAD
DAEMPNING   17.80 1/M   KVANTA INDST   44.87 E14/M2S  MAX. VIND  11.70 M/S
SPREDNING    3.34 1/M   TRYK           66.50 DBAR
KLOROFYL C   8.40 G/M3  TEMPERATUR     18.90 C
                        FUGTIGHED      38.60 %
FUNKTIONER:
   STATIONSDATA:     OPERATIONSDATA:    NY OPERATION - TYPE:   DATAENTRY:

DANA DATAENTRY SYSTEM                                DATO: 1980.09.23 KL 14.48
```

ORIENTATION FORM

```
STATION NR:                                   TOGT NR:
FISKERI: LENGDE-VEGT-ALDERSFORDELING. OPERATION NR:  4
POUNDER NR:  7     STIKPROVE NR:  9
ARTSKODE: ROD                      KON: F DECADE NR 1 AF 3
LGD ANTAL VEGT GNS.VEGT
                                                ANTAL JRRINGE
SCM        G       G        -2   2    3    4    5   -5
200   23  47.900 2.0826                 6    8   10
201   23  56.000 2.4348    34   56     3
202   45  98.000 2.1778
203   34  34.000 1.0000                 6   24    8    2
204  418  450.00 1.0766    10   34    48   53   27   11
205   45  67.000 1.4889                45    7
206    8  56.000 7.0000     3          78    8        12
207    7  9.0000 1.2857
208    7  29.000 4.1429
209
LGD  F.JRRING

DANA DATAENTRY SYSTEM                          DATO 1980.09.23 KL 14.50
```

Fig. 7 a

Examples of screen forms from the VDU-terminals of the central computer.

SELECTION FORM

```
STATION NR:                          TOGT NR:
KEMI:  OPERATION NR:  1
-------------------------------------------------------------------------------

FUNKTIONSVALG:
DATAREDUKTION:
INSTRUMENT:
DATAPRESENTATION:
TABELVISNING:
          INSTRUMENT:

KURVEVISNING:
          INSTRUMENT:
          X:
          Y:

PROVER:
         INSTRUMENT:      PROVE NR:
-------------------------------------------------------------------------------

DANA DATAENTRY SYSTEM                              DATO 1980.09.23 KL 14.49
```

DATA FORM

```
-------------------------------------------------------------------------------

STATION NR:                              TOGT NR:
FISKERI: OPERATIONSDATA.  OPERATION NR:  4
REDSKAB: LR-TRW    LUKKE-RINGTRAWL

NAVIGATION:  GEOGRAFISK POSITION: SATURN
             START TID:   1980.05.12 KL 11.57   SLUT TID:   1980.05.12 KL 11.57
             START POS: B:   32.08.36           SLUT POS: B:   32.64.36
                        L:   29.00.48                      L:   29.00.48
    KURS:  45.4  FART G. VAND: 68.60  FART O. BUND: 58.40  DYBDE:   209
METEOROLOGI:
             VEJR: DAARLIGT                SKYDEKKE:  0   SØ:  5
             VINDHASTIGHED:  7.50      VINDRETNING: 98.90  STRØMRETNING: SSV
ANDET:
             BUNDART: TANG
             BEMERKNING: HHJJJKKKKLLLLJHGF
-------------------------------------------------------------------------------
FUNKTIONSVALG:
             START OPERATION:    AFSLUT OPERATION:
DANA DATAENTRY SYSTEM                              DATO 1980.09.23 KL 14.51
```

Fig. 7 b

Examples of screen forms from the VDU terminals of the central computer