BUREAU OF MINERAL RESOURCES
DEPARTMENT OF MINERALS AND ENERGY

GEOPHYSICAL SURVEYS OF THE CONTINENTAL MARGINS OF AUSTRALIA, GULF OF PAPUA AND THE BISMARCK SEA

OCTOBER 1970 TO JANUARY 1973

EQUIPMENT DESCRIPTION

COMPAGNIE GENERALE DE GEOPHYSIQUE
6 RUE GALVANI, 91301 - MASSY - FRANCE.

Record 1974/111

MARINE GEOPHYSICAL SURVEY OF THE CONTINENTAL MARGINS OF AUSTRALIA, GULF OF PAPUA AND THE BISMARCK SEA 1970 - 1973

EQUIPMENT DESCRIPTION

by

COMPAGNIE GENERALE DE GEOPHYSIQUE

SUMMARY

(by J. Pinchin, B.M.R.)

A marine geophysical survey of much of the Australian continental margin, the Gulf of Papua and the Bismarck Sea was conducted by Compagnie Generale de Geophysique (C.G.G.) under contract to the Bureau of Mineral Resources between September 1970 and January 1973. The work was divided for administrative convenience into eleven surveys, the Gulf of Papua and Bismarck Sea numbered 5 and the continental margins, 10 to 19. A total of 100 000 nautical miles was traversed in waters between about 50 m and 4500 m deep at a line spacing which varied from 10 nautical miles in the Gulf of Papua to 20 nautical miles off the east coast of Australia and 30 nautical miles in the west.

This report was written by Compagnie Generale de Geophysique to describe the equipment used during the survey. It is divided into four parts. The first is a description of the ship, the second describes the navigation equipment, the third the geophysical equipment, and the fourth part describes the equipment used at the shore station.

The ship started the survey as the "M/V Hamme", but was subsequently renamed "M/V Lady Christine". She was 54.5 m long with a gross tonnage of 769 tons, accommodation for 25 geophysical personnel and a cruising speed of 8 to 10 knots with equipment under tow.

The main navigation equipment was a satellite Doppler system using an I.T.T. satellite receiver and a P.D.P. 8 computer. Marquardt sonar Doppler equipment provided a track of the positions intermediate between the satellite fixes. In addition to the primary navigation equipment, a chernikeeff log, a pressure log, a gyrocompass, Decca radar, a radio direction finder, a forward scan sonar, VLF and Omega navigation equipment were installed.

Total magnetic field measurements were made using a proton precession magnetometer with the sensor towed about 200 m behind the ship. Gravity measurements were made with a LaCoste & Romberg marine gravity meter No. 524 mounted on a gyro-stabilized platform near the centre of the ship.

The seismic energy source was a 120 kilojoule sparker, initially with 4 pairs of electrodes and later with one pair. A "Flexotir" gun was used for a short time as an energy source for refraction work. Two seismic streamer cables were used; one with six channels spaced 200 m apart and the other a single channel cable. Three sets of seismic amplifiers were used successively; the initial set of

HTL 7000 B valve amplifiers was exchanged for a Sercel AS 626 X amplifier bank which in turn was exchanged for SIE PT700 amplifiers. An Ampex model FR 1300 FM tape recorder with 14 channels and a tape speed of 15/16 inches per second recorded the seismic data. Various chart recorders, in particular the EG and G model 254 and EPC model 4100 were used to display the sections. Expendable Aquatronics SM 42 sonobuoys were used to transmit the refracted seismic signals back to the boat.

There were four different water depth recording systems, an Atlas echosounder for depths down to 1000 m, and an Elac echosounder, a Raytheon sounding system and a Digitrack-Edo digitizer for deeper water.

The data aquisition system (D.A.S.) was based on a Hewlett Packard 2116 B computer coupled to a Sercel interface, a digital tape recorder and a teletype. All data other than seismic were recorded via this system. All important measurements were recorded also in analogue chart form, both for monitoring the measurements and for backup in case of failure of the digital system.

A shore station was set up at the closest convenient place to the area under survey to record the diurnal changes in the earth's magnetic field and in the VLF or Omega signal. The shore station initially was operated with a Sud-Aviation proton precession magnetometer, and later with a Varian magnetometer identical to that on the ship. Two VLF and one Omega receiver similar to those used on the ship monitored this diurnal variation.

This report was written by Compagnie Generale de Geophysique; views expressed herein are not necessarily those of the Bureau of Mineral Resources.

BUREAU OF MINERAL RESOURCES

DEPARTMENT OF MINERALS AND ENERGY

GEOPHYSICAL SURVEYS OF THE CONTINENTAL MARGINS OF AUSTRALIA GULF OF PAPUA AND THE BISMARCK SEA CAPO No. 560663 and 560585

October 1970 - January 1973

EQUIPMENT DESCRIPTION

COMPAGNIE GENERALE DE GEOPHYSIQUE
6 Rue Galvani - Massy FRANCE

Area 1	:	Office
2	:	Navigation Room
3	:	Seismic container
4	:	Sparker container
5 and 5'	:	Sparker generator
6	:	Shallow seismic cable winch
7	:	Main seismic cable winch
8 then 8'	:	Magnetometer
9	:	Booms and Sparker electrodes.
Area 10	:	Gravity meter

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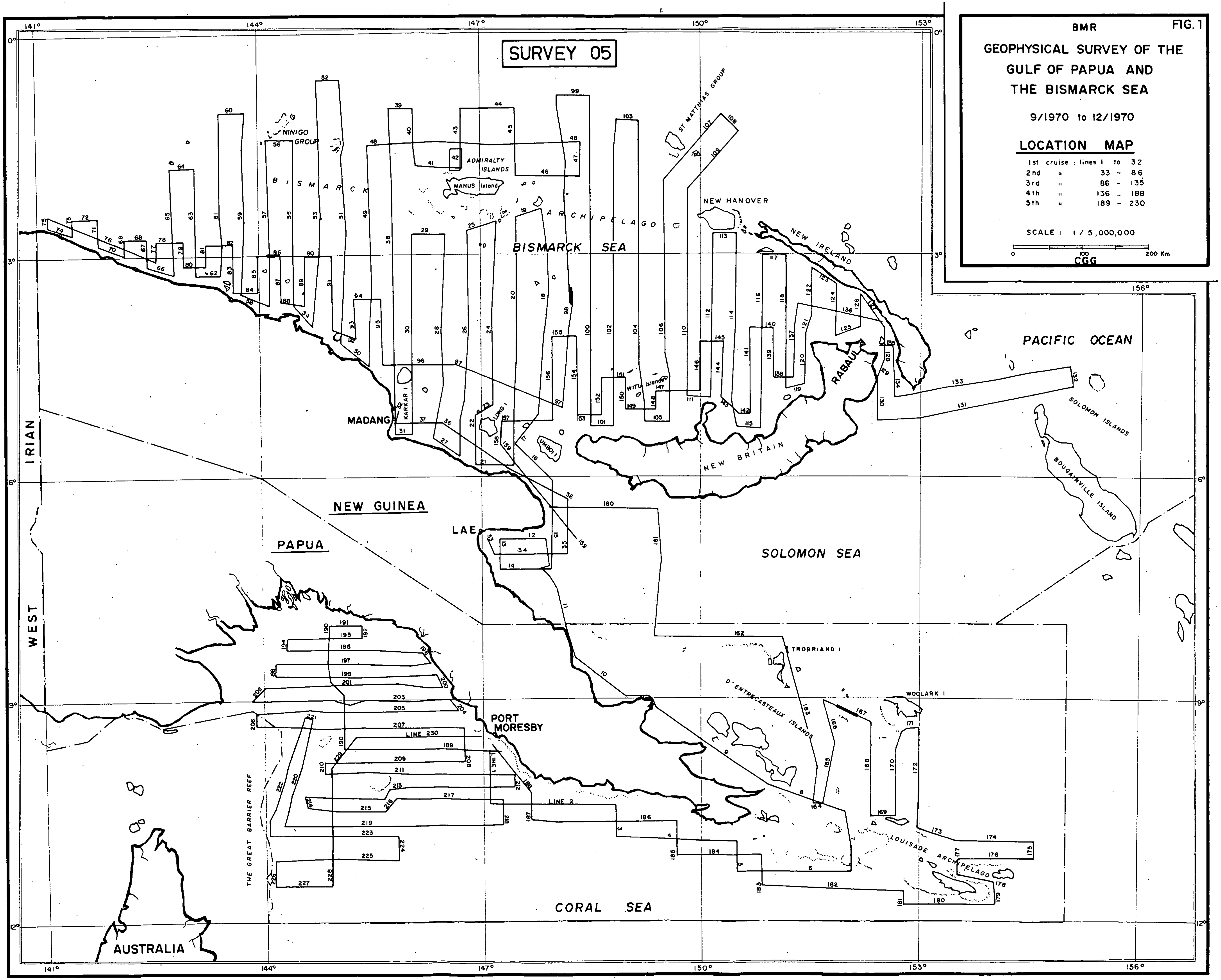
INTRODUCTION

The combined marine geophysical surveys of the Gulf of Papua, the Bismark Sea and the Continental Margins of Australia were carried out from September 4th, 1970 to January 6th, 1973 by Compagnie Generale de Geophysique for the Bureau of Mineral Resources, Department of National Development of the Commonwealth of Australia.

The aim of this report is to describe the equipment used throughout the surveys. When quoted in this report, the geophysical survey of the Gulf of Papua and the Bismark Sea will be called survey 05, the geophysical survey of the Continental Margins of Australia will be represented by surveys 10 to 19. Figures 1 and 2 give the breakdown of the different areas.


SURVEY 05
BMR
FIG. 1
GEOPHYSICAL SURVEY OF THE
GULF OF PAPUA AND
THE BISMARCK SEA
9/1970 to 12/1970
LOCATION MAP
1st cruise : lines 1 to 32
2nd " 33 - 86
3rd " 86 - 135
4th " 136 - 188
5th " 189 - 230
SCALE : 1 / 5,000,000
0 100 200 Km
CGG
141°
144°
147°
150°
153°
156°
0°
3°
6°
9°
12°
NINIGO GROUP
ADMIRALTY ISLANDS
MANUS Island
BISMARCK ARCHIPELAGO
BISMARCK SEA
ST MATTHIAS GROUP
NEW HANOVER
NEW IRELAND
PACIFIC OCEAN
RABAUL
WITU Islands
KARKAR I
MADANG
LONG I
UMBOI I
NEW BRITAIN
SOLOMON ISLANDS
BOUGAINVILLE ISLAND
NEW GUINEA
LAE
PAPUA
SOLOMON SEA
WEST IRIAN
TROBRIAND I
D'ENTRECASTEAUX ISLANDS
WOOLARK I
PORT MORESBY
LINE 230
LINE 1
LINE 2
LOUISADE ARCHIPELAGO
THE GREAT BARRIER REEF
CORAL SEA
AUSTRALIA

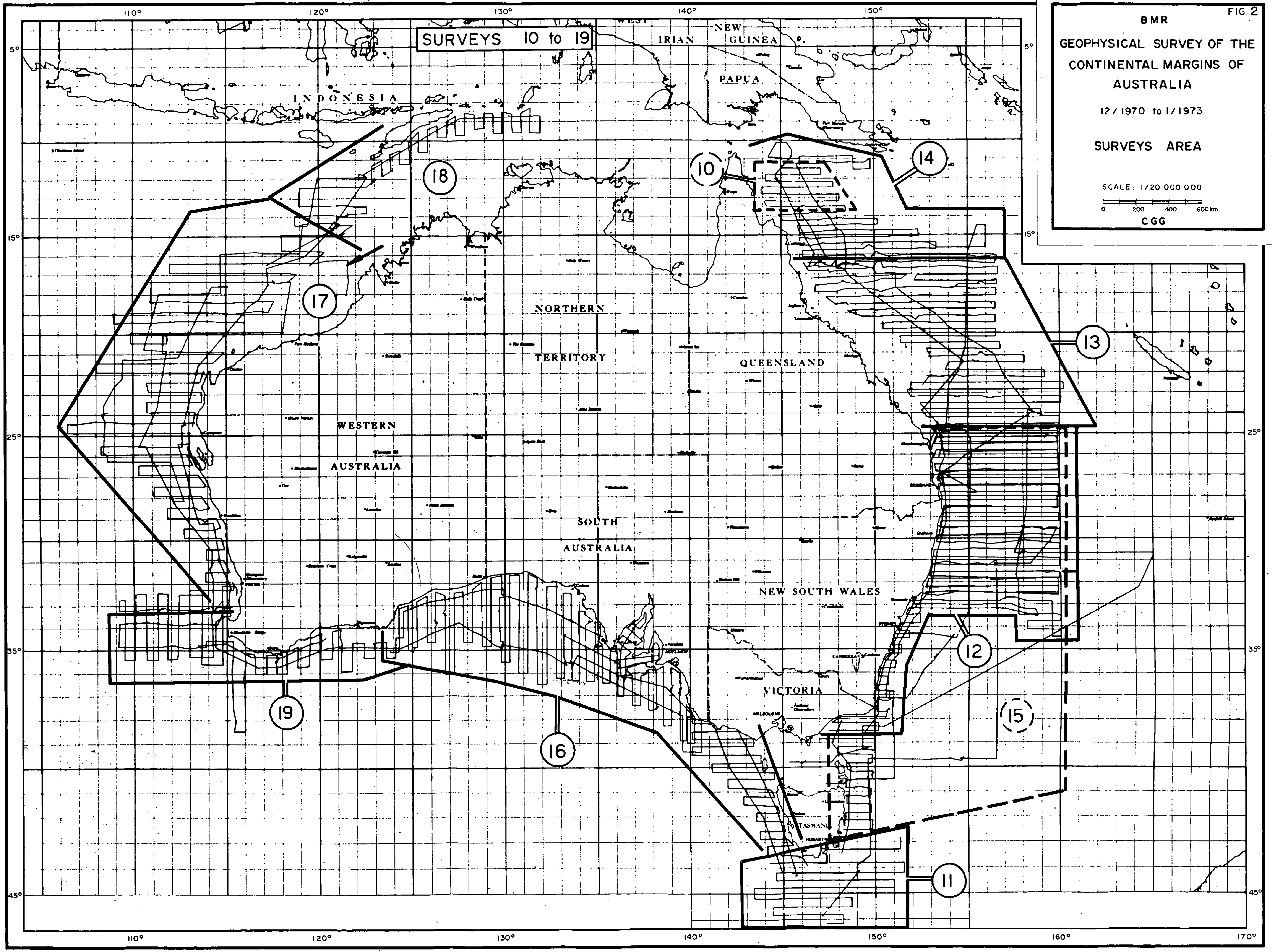


FIG. 2
BMR
GEOPHYSICAL SURVEY OF THE CONTINENTAL MARGINS OF AUSTRALIA
12/1970 to 1/1973
SURVEYS AREA
SCALE: 1/20 000 000
0 200 400 600 km
CGG
SURVEYS 10 to 19
INDONESIA
WEST IRIAN
NEW GUINEA
PAPUA
NORTHERN TERRITORY
QUEENSLAND
WESTERN AUSTRALIA
SOUTH AUSTRALIA
NEW SOUTH WALES
VICTORIA
TASMANIA
10
11
12
13
14
15
16
17
18
19
110°
120°
130°
140°
150°
160°
170°
5°
15°
25°
35°
45°

I - SURVEY SHIP

The ship employed was the motor vessel HAMME, subsequently renamed M.V. LADY CHRISTINE. She was outfitted in Sydney from 21st July, 1970 to 15th August, 1970. The equipment was tested at sea during the voyage to Port Moresby from 15th to 26th August, 1970.

I.1 - TECHNICAL CHARACTERISTICS

Variable pitch propeller

Length	:	54.5 m
Beam	:	10.2 m
Draught	:	4.6 m
Gross tonnage	:	769 tons
Extended mast height	:	20 m
Accommodation	:	25 (geophysical personnel including B.M.R. and visitors)
Maximum speed	:	13 knots
Cruising speed	:	8 to 10 knots with equipment under tow)
Endurance on continuous cruise	:	20 to 25 days

Special characteristics to ensure high stability : ballast.

I.2 - DISPOSITION OF THE GEOPHYSICAL EQUIPMENT

I.2.1 - Upper deck

Area 1	:	Office
2	:	Navigation Room
3	:	Seismic container
4	:	Sparker container
5 and 5'	:	Sparker generator
6	:	Shallow seismic cable winch
7	:	Main seismic cable winch
8 then 8'	:	Magnetometer
9	:	Booms and Sparker electrodes.

I.2.2 - Lower deck

Area 10 : Gravity meter

I.3 - ELECTRICAL SUPPLIES (Enclosure I)

The power for the primary and secondary equipment was supplied as indicated in Enclosure I.

An independent supply consisting of two 220 V, 60 Hz, 50 KVA power plants was used to provide the 120 KJ required by the Sparker System.

M/V HAMME - BREAKDOWN OF THE GEOPHYSICAL EQUIPMENT

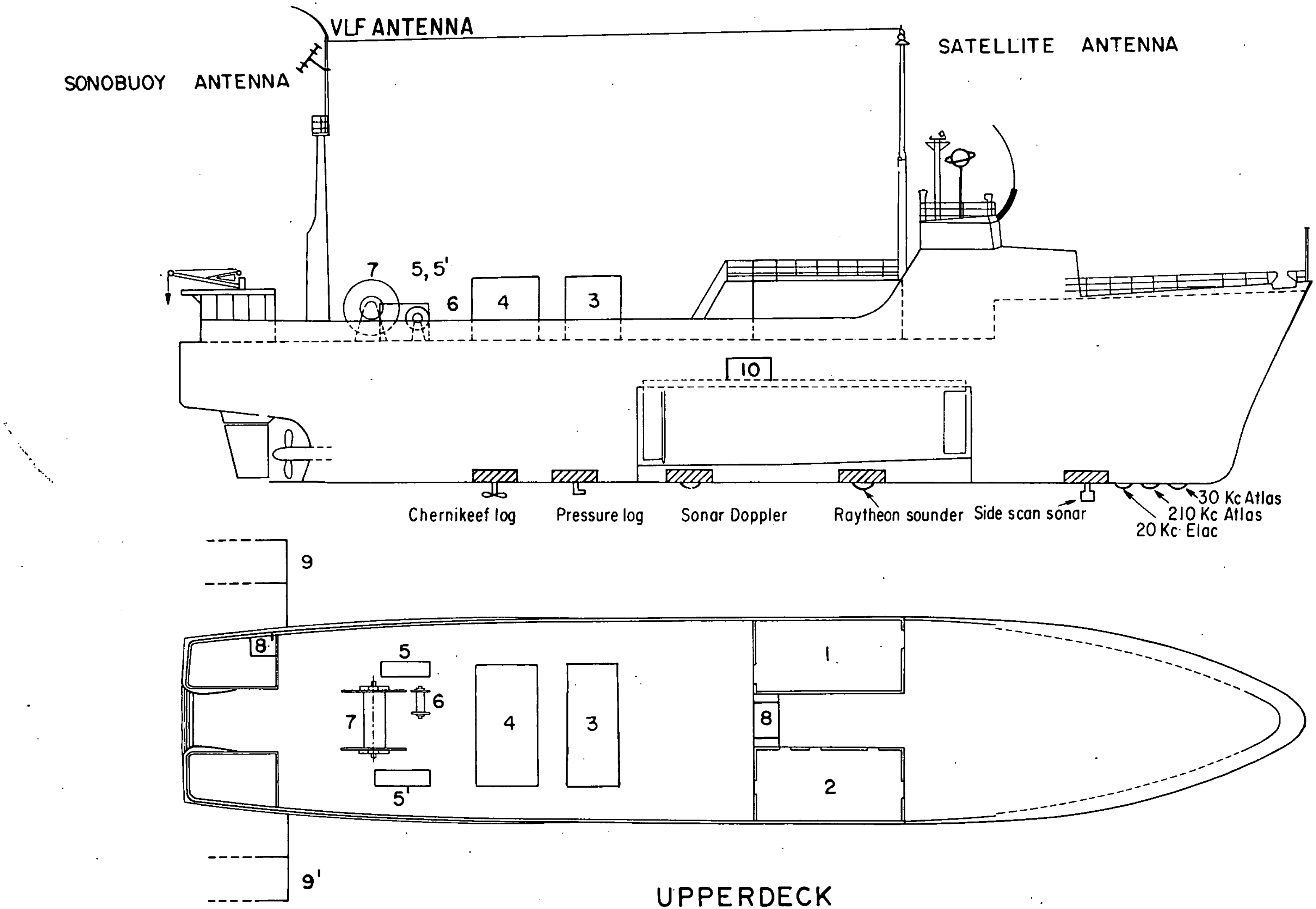


FIG. 3

II - NAVIGATION EQUIPMENT

For description purposes, the Navigation equipment has been divided into :

- Navigational aids
- Main equipment
- Special equipment

II.1 - NAVIGATIONAL AIDS

II.1.1 - Radars

One DECCA 404	: Band 10,000 Mcs Range 48 Nautical miles

with precision range expansion

One DECCA RM 329Z	: Band 10,000 Mcs Range 48 Nautical miles

with precision range expansion.

II.1.2 - Radio direction funder

One TELEFUNKEN type Pe 310/5

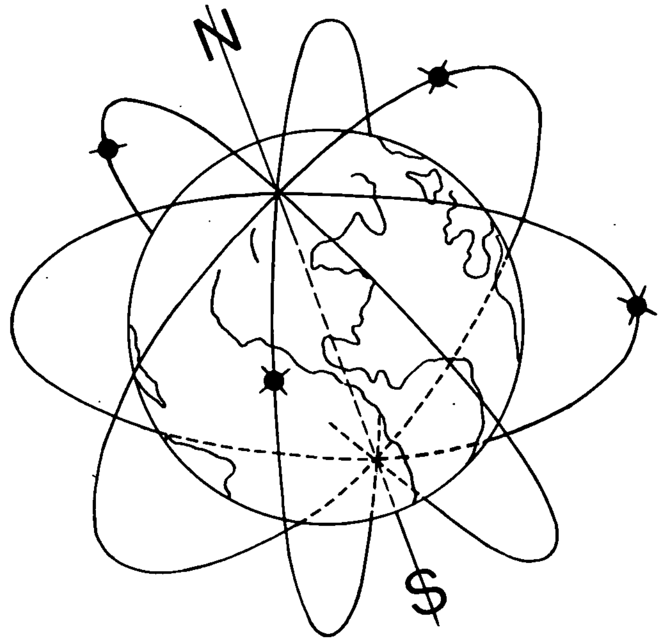
II.1.3 - Forward Scan Sonar

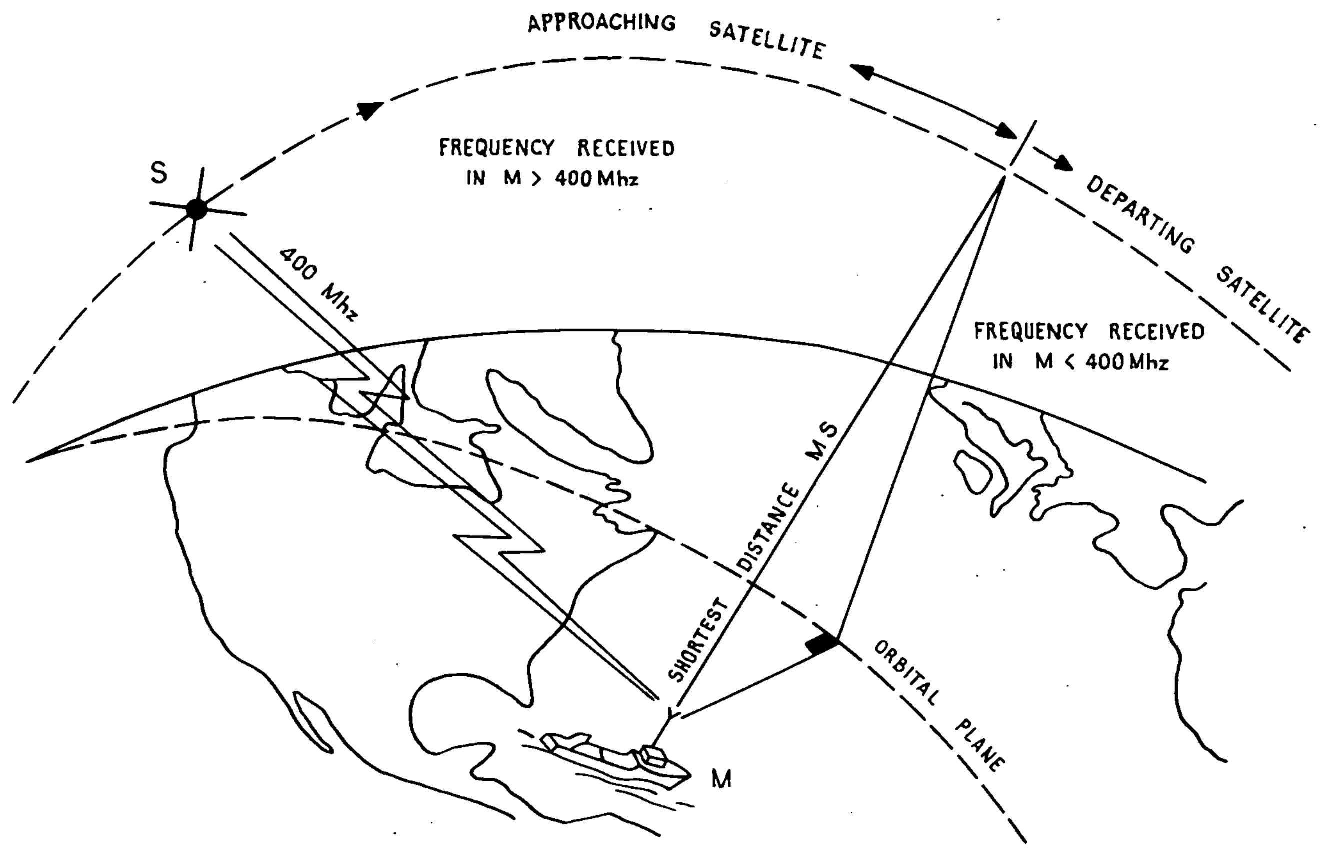
One KRUPP ATLAS PERIPHON F 140 with horizontal and vertical sweep, scanning range 200 to 2,000 metres.

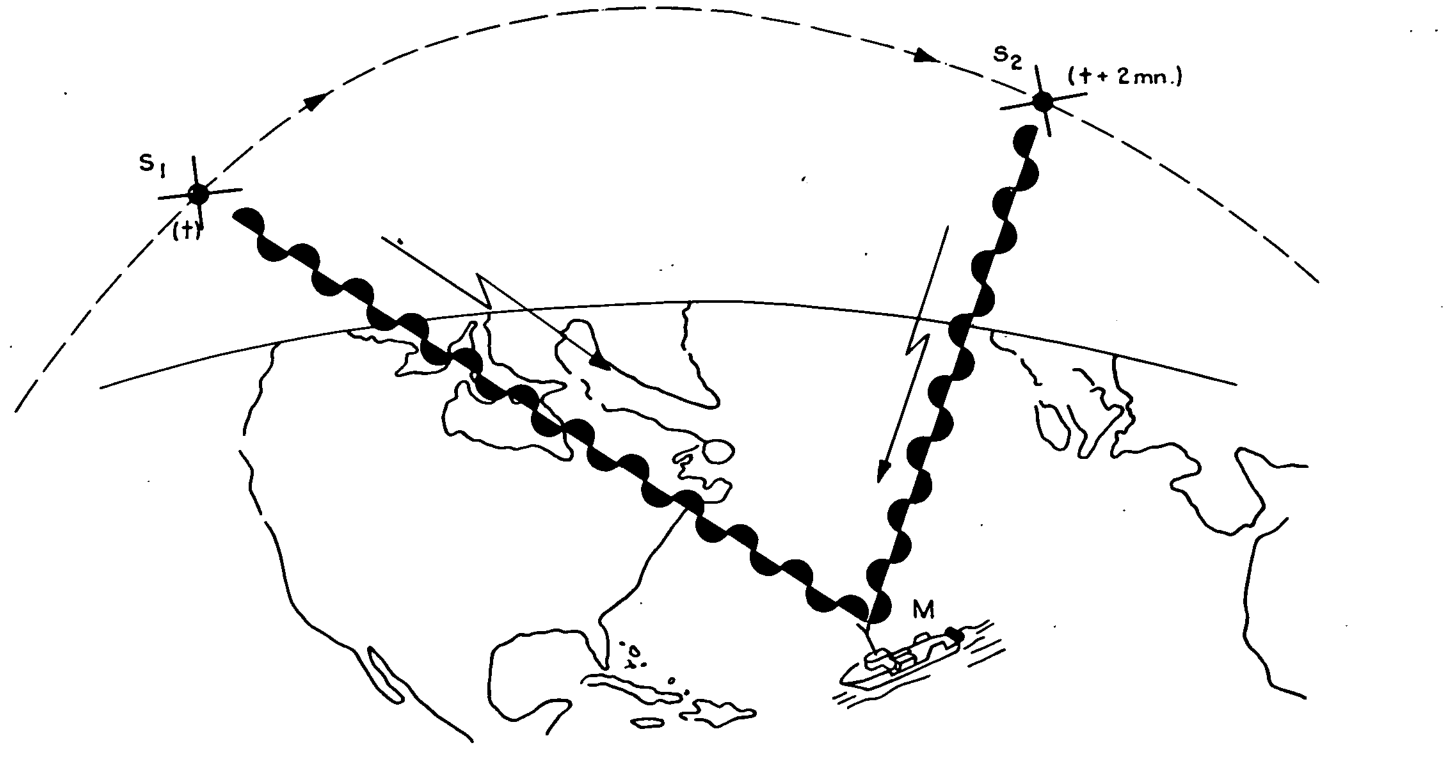
II.2 - MAIN EQUIPMENT

II.2.1 - Satellite Doppler Navigation (S.D.N.)

* Principle : The measurement of the Doppler shift in the radiotransmission from a Satellite whose orbit is known allows the location of an observing station to be determined.

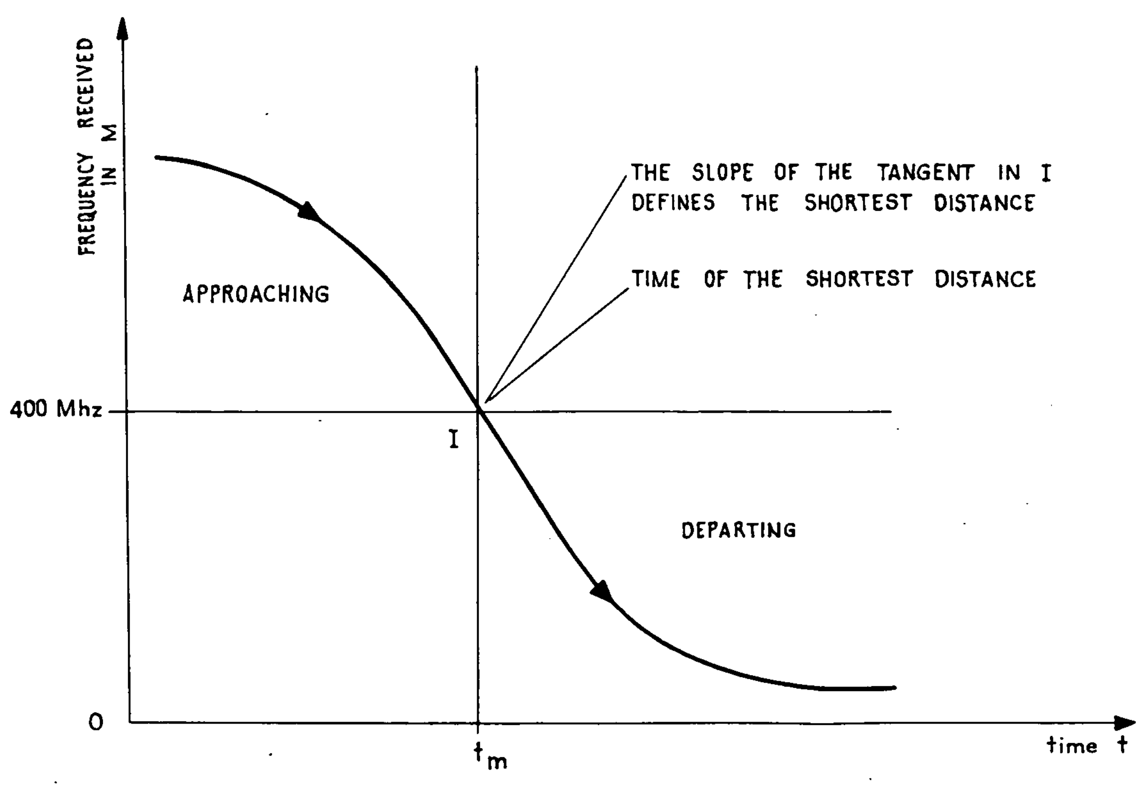




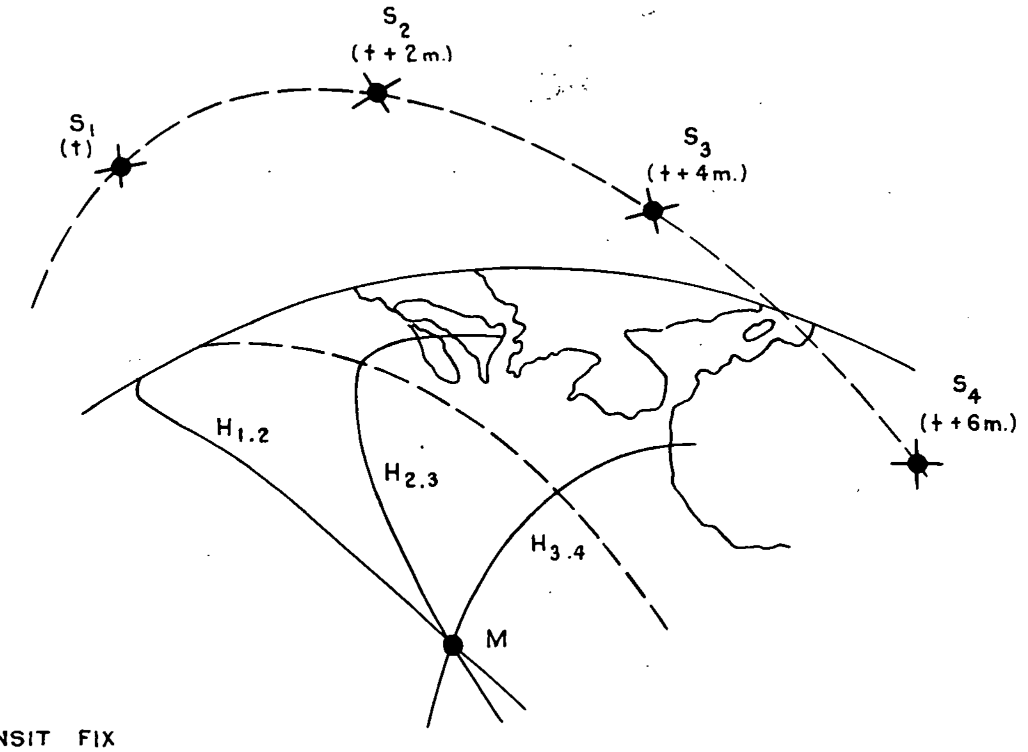


THE INTEGRAL OF THE DOPPLER FREQUENCY IS EQUAL TO THE DIFFERENCE OF PHASES BETWEEN S_1M AND S_2M. FOR ONE COUNT THE MOBILE M IS ON THE ELLIPSOIDIC HYPERBOLOID $H_{1,2}$ WHICH IS THE INTERSECTION OF HYPERBOLOID OF FOCUS S_1 AND S_2 WITH THE EARTHLY ELLIPSOID.

THE NAVIGATIONAL SATELLITES ARE PLACED IN CIRCULAR ORBITS ABOUT EARTH AT AN ALTITUDE OF APPROXIMATELY 600 NAUTICAL MILES. THE ORBITAL PLANES OF THE SATELLITES HAVE A COMMON POINT ALONG THE EARTH'S ROTATIONAL AXIS. EACH SATELLITE ORBITS THE EARTH APPROXIMATELY EVERY 107 MINUTES. THE GEOMETRICAL PLACEMENT OF THE ORBITING SATELLITE ALLOWS AN EARTH BOUND OBSERVER TO CROSS DIRECTLY UNDER THE SATELLITE TWICE DAILY TYPICALLY, THE OBSERVOR RECEIVES DATA FROM THE SATELLITE TWICE EACH TIME HE IS NEAR THE ORBIT BECAUSE THE SATELLITES APPEAR TO TRAVERSE LONGITUDINALLY AS THE EARTH ROTATES. THE EARTH ROTATES 27° LONGITUDINALLY PER SATELLITE PASS. AT THE EQUATOR ABOUT 20 FIXES DAILY ARE POSSIBLE.



VARIATION OF THE FREQUENCY RECEIVED DURING A PASS : DOPPLER EFFECT



TRANSIT FIX

THE FIX IS DEFINED AS THE INTERSECTION OF ELLIPSOIDIC HYPERBOLAS $H_{1.2}$, $H_{2.3}$, $H_{3.4}$, RELATIVE TO LOCATIONS S_1S_2, S_2S_3, S_3S_4 OF THE SATELLITE.

SATELLITE NAVIGATION

* A simplified theory of operation is given in Fig. 4 and 5.

* The equipment used consisted of :

  - a satellite receiver I.T.T. Model 4007 AB including antenna-pre-amplifier,
  - a PDP 8/I computer (8 K memory) with ASR 33 teletype and high speed paper tape reader,
  - a satellite Receiver-Computer Interface I.T.T.,
  - a frequency electronics Model 1100 Frequency standard.

* PDP 8/I Description

The PDP 8/I is a one-address, 12-bit fixed word-length, parallel computer using two's complement arithmetic.

Normal cycle time of the 4096-word, random access, magnetic core memory is 1.5 µs.

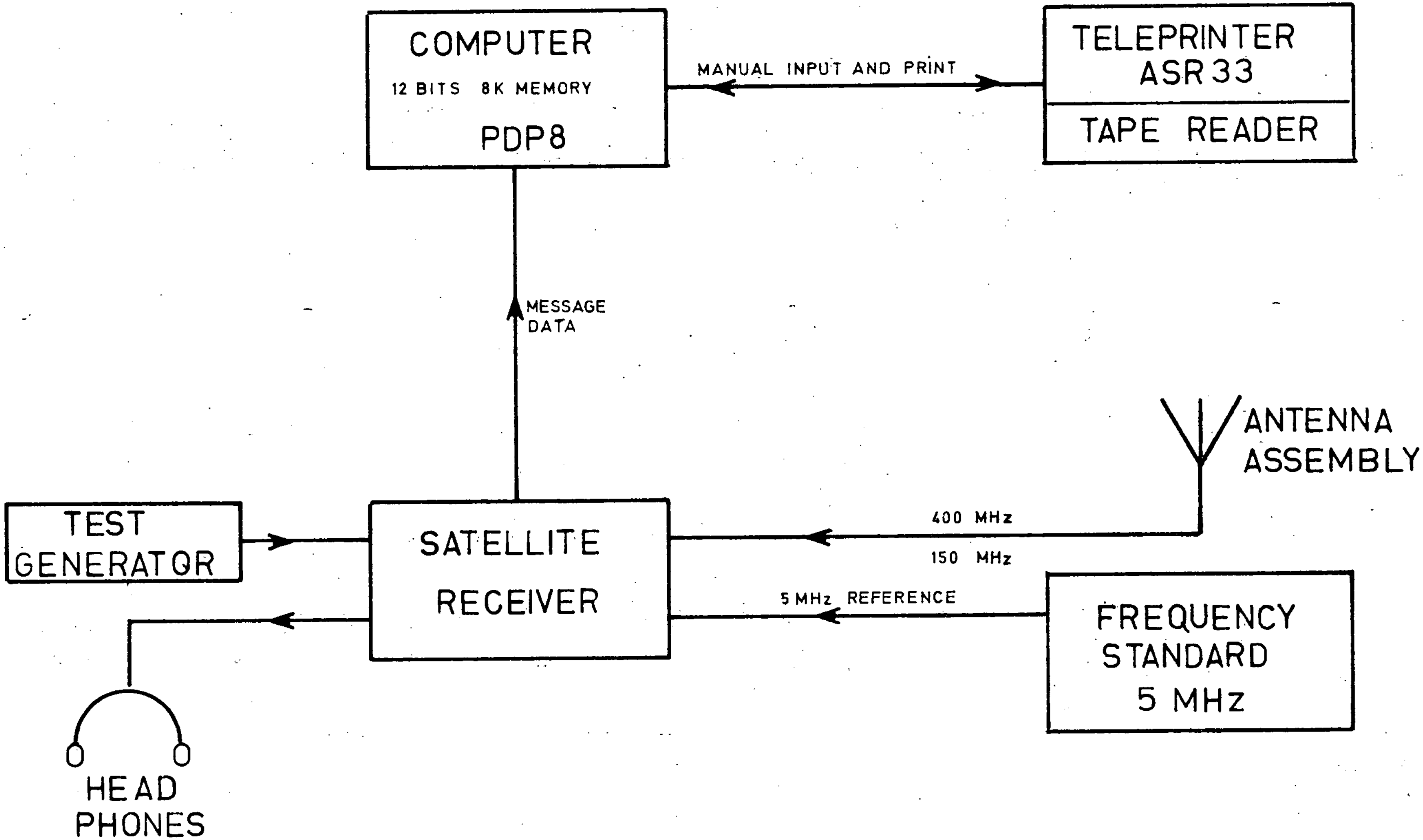
An additional 4 K of memory with extended memory control was added to the system.

A simplified flow diagram of the PDP 8/I is given in Fig. 6.

* Note : a general description of the teletype and of the high speed paper tape reader is given in Chapter III.5.2.

II.2.2 - Sonar Doppler

* Principle : Basically the same as for the S.D.N. A received frequency will shift relative to a transmitted frequency in a manner directly proportional to the relative velocity between the source and the observer. This principle is applied in the Sonar Doppler by comparing the frequency of an echo from the ocean floor (or from a scattering layer when working in deep water) with the transmitted frequency.



SATELLITE SYSTEM FLOW DIAGRAM

FIG. 5

* Theory of operation :

- A crystal controlled oscillator circuit on the transmitter driver circuit board generates 300 KHz power pulses for transmission by the transmitter transducer. The four transmitter transducers are connected in parallel for simultaneous transmission of sonar pulses.

- A portion of the transmitted energy is returned as an echo to the corresponding receiver transducer.

- The received signal (in pulse form) is amplified by a preamplifier located in the transducer array and is subsequently sent to the electronics system console for processing.

- The outputs of the tracker circuits are processed by the demodulators to obtain the doppler difference frequencies which are proportional to the velocity.

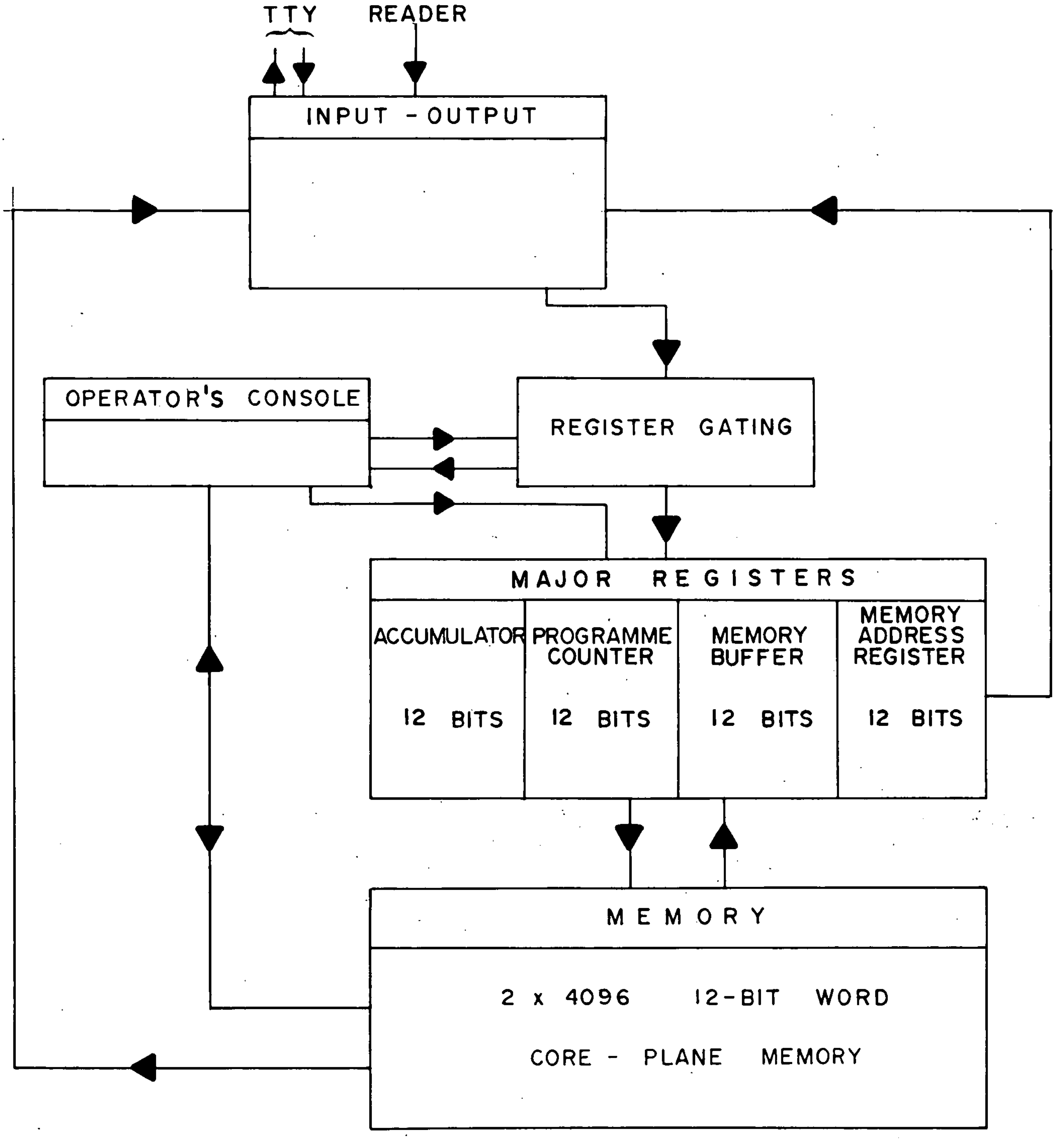
- These frequencies are converted to digital information and distributed to the output lines by the translator circuits.

- The output signals from the translator for each measurement axis appear on one of two lines. One line of each axis is for positive velocity and the other line is for negative velocity. The outputs correspond to the velocity component along that axis.

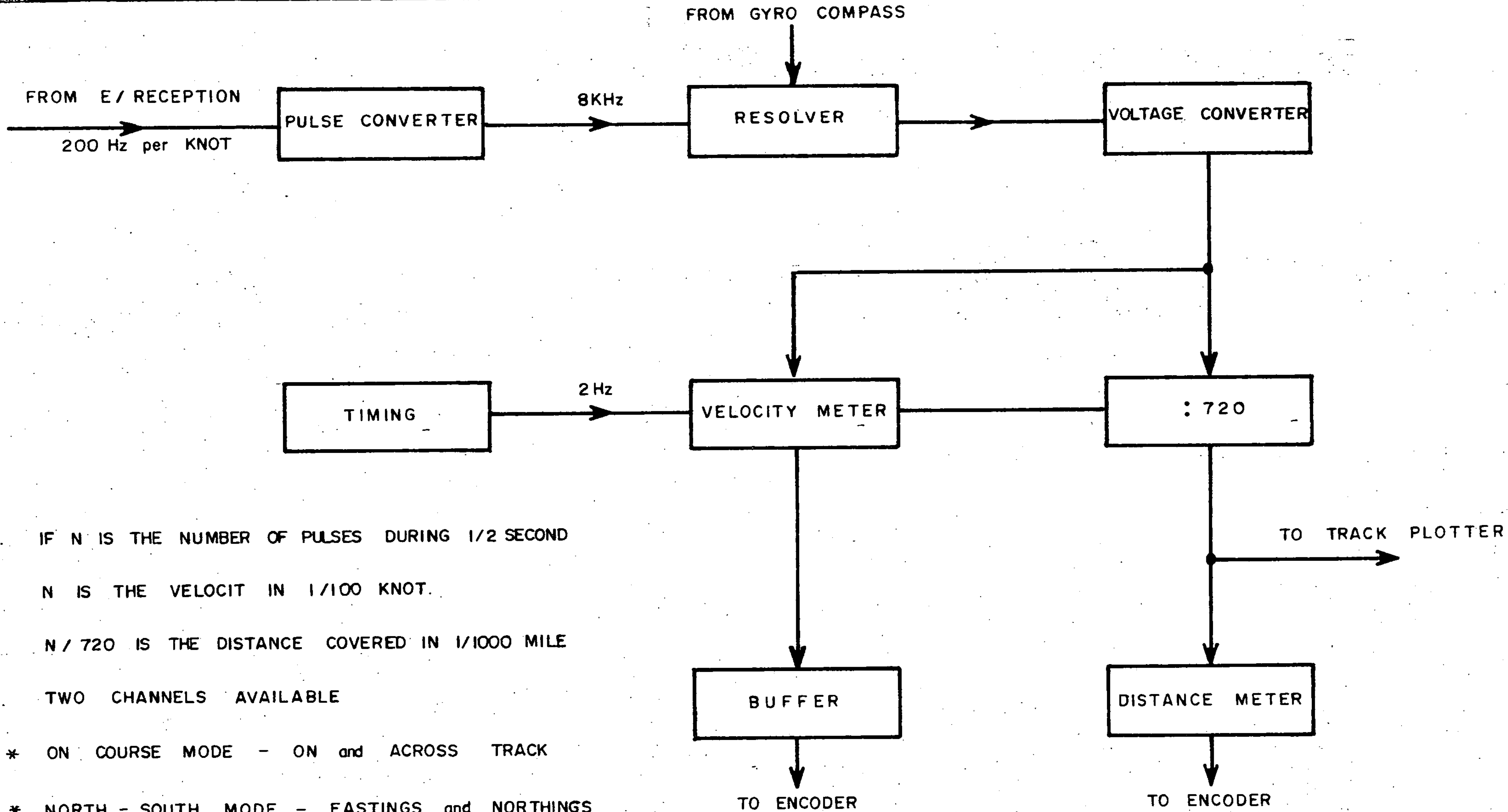
* The equipment used was a MARQUARDT MRG 2015 A integrated with the Gyrocompass ANSCHUTZ 110/301.

* During the whole survey, the equipment was operated in the North oriented mode ; on the display panel, the velocity displays indicated velocity components in the North/South and East/West directions, and the distance displays indicated ship's North/South and East/West components of the distance travelled relative to the bottom (or to a scattering layer when working in deep water).

FIG. 6



PDP 8/I : SIMPLIFIED SYSTEM BLOCK DIAGRAM



1. IF N IS THE NUMBER OF PULSES DURING 1/2 SECOND
N IS THE VELOCIT IN 1/100 KNOT.
N / 720 IS THE DISTANCE COVERED IN 1/1000 MILE
2. TWO CHANNELS AVAILABLE
* ON COURSE MODE - ON and ACROSS TRACK
* NORTH - SOUTH MODE - EASTINGS and NORTHINGS

SONAR DOPPLER ONE-CHANNEL BLOCK DIAGRAM

FIG. 7

* A simplified one channel block diagram is given in Fig. 7.

* The Sonar Doppler system increments every 1/1000 of a nautical mile.

II.2.3 - Chernikeeff Log

* Principle : The rotation speed of an impeller fitted below the hull of the ship provides the ship's speed relative to the water and in the direction of the ship's axis.

* The ship's speed was displayed on a display panel installed in the navigation room.

* The Chernikeeff log increments every 1/100 of a nautical mile.

II.2.4 - Pressure Log (or Pitometer log)

* Principle : The ship's speed relative to the water and in the direction of the ship's axis is a function of the difference between the static pressure of water resulting from the depth of the instrument protuding through the hull of the ship, and the dynamic pressure due to the motion of the ship through the water.

* The equipment used was an electrical Hartmann and Braun with totalizator.

* The ship's speed was displayed on a display panel installed in the ship's navigation room.

* The pressure log increments every 1/10 of a nautical mile.

II.2.5 - Gyrocompass

* Principle : The gyrocompass contains a gyroscope controlled in a manner to make it seek and continuously align itself with the meridian and point to true North. An external gimbal system mounts the gyrocompass binnacle to provide a pendulously stabilized horizontal reference plane for azimuth data.

* The equipment used was an ANSCHUTZ 110/301 with an absolute accuracy of 0.5 degree and a sensitivity of 0.1 degree.

II.2.6 - Automatic Pilot

* Principle : The system consists of a servo-motor adjusting the motion of the rudder to ensure that the ship retains the required heading. The automatic pilot is linked to the gyrocompass which is the basic reference of heading.

* The equipment used was ANSCHUTZ.

II.2.7 - Sagem Interface - Potentiometer SIN - COS

* The SAGEM interface digitizes the course with an accuracy of 1 % and provides analogue data for the analogue recorder LINAX.

* The potentiometer SIN - COS provides the sine and cosine of the course with an accuracy of 1/1000.

* Both the SAGEM and Potentiometer SIN - COS are driven by a synchro-emitter ANSCHUTZ.

II.3 - SPECIAL EQUIPMENT : VLF AND OMEGA

* Principle : Long Range navigational information can be derived from the frequency stabilized transmissions of very low frequency (VLF) radio-stations.

* Fig. 8 gives a listing of the VLF and OMEGA stations used during the whole survey. Fig. 9 gives the OMEGA transmission format.

* Receiving equipment : two kinds of receiver were used :

  - receiver TRACOR Model 599 G : for VLF stations only.
  - receiver TRACOR Model 599 Q : for OMEGA and VLF stations.

LIST OF VLF AND OMEGA STATIONS

TRANSMITTER STATION CALL SIGN	LOCATION	GEOGRAPHIC COORDINATES		FREQUENCY Kc/UT2
		LAT.	LONG.	
GBR	Rugby, UK	52° 22'N	001° 11'W	16,0
NAA	Cutler, Maine, USA	44° 39'N	067° 1~~2~~7'	17,8
NPG	Jim Creek, near Seattle, Washington USA	48° 12'N	121° 55'	18,6
NPM	Lualualei, Oahu, Hawai, USA	21° 26'N	158° 10'	23·4 ~~26,1~~
NWC	NW Cape, Australia	21° 19'S	114° 10'	22·3 ~~15,5~~

* Receiver 599 Q : description (See Fig. 10)

Note : Although primarily intended for reception of the OMEGA navigational signals, the 599 Q is also capable of receiving signals from any of the other VLF stations transmitting a stable carrier.

- A local oscillator signal differing in frequency by 1 KHz from the received signal is generated in the synthesizer and mixed with the incoming RF to produce a 1 KHz I F signal.

- This signal is gated sequentially by means of OMEGA segment gates, into 4 extremely narrow filters.

- The resulting signal is heterodyned in each filter with the local standard (1 KHz) to form 2 quadrature dc components that are low-pass filtered, and then remodulated by the local standard (1 KHz) joining the original 1 KHz.

- A linear phase comparator is associated with each narrow filter.

- The four phase comparator outputs are available for external chart recording and application to the front-panel meter.

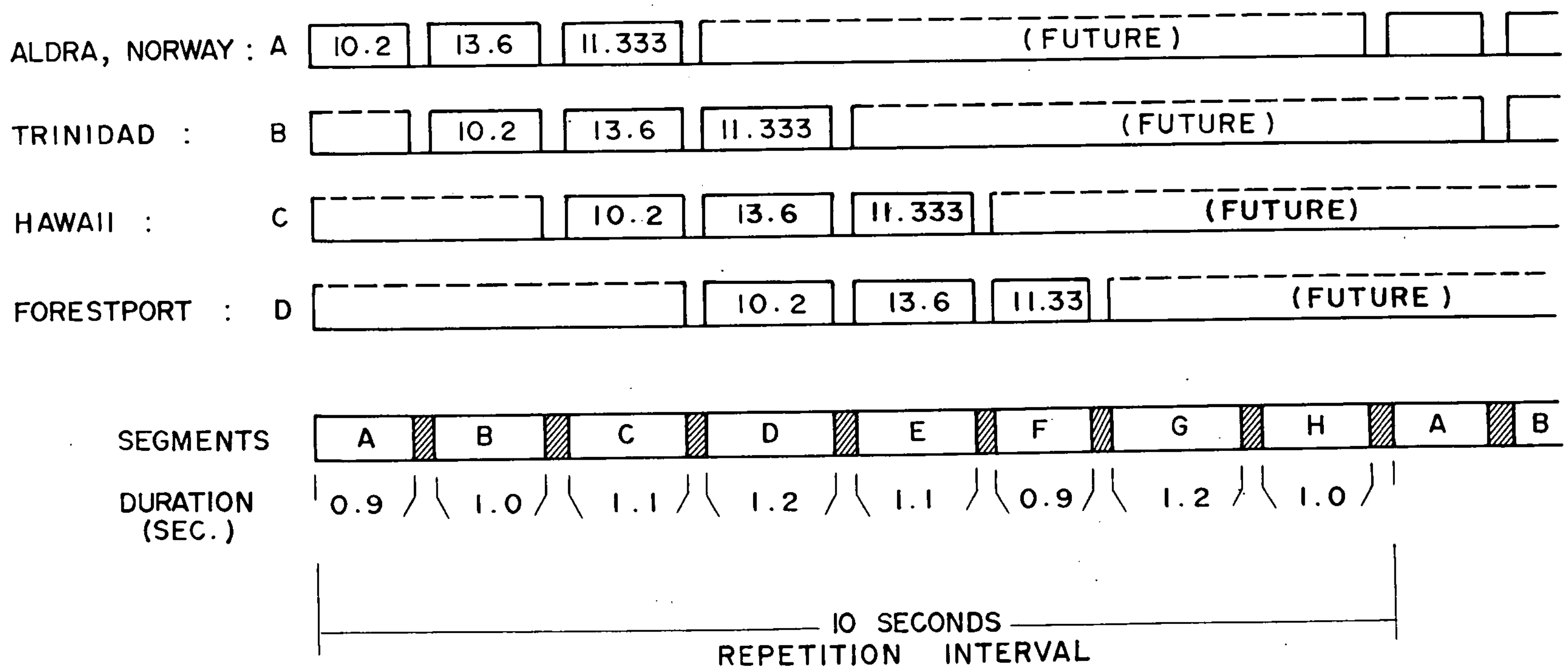
- Each filtered 1 KHz output from the remodulators is amplitude detected. The detected signals are available for connection to an external recorder and for application to the front-panel meter.

* The frequency standard used was SULZER.

* Analogue recorders :

From survey 05 to survey 16, Cruise 4, phases and amplitudes were recorded on two analogue graphic WESTRONICS recorders.

From survey 16, cruise 4 to survey 19, phases and amplitudes were recorded on two analogue graphic SPEEDOMAX recorders.



OMEGA TRANSMISSION FORMAT

FIG. 9

III - GEOPHYSICAL EQUIPMENT

The description of the geophysical equipment includes the following :

- Gravity meter
- Magnetometer
- Seismic equipment
- Bathymetric system
- Data acquisition system.

III.1 - GRAVITY METER S24

* Principle : The Lacoste and Rombert air-sea gravity meter model S consists of a highly overdamped spring type of gravity meter mounted on a gyro stabilized platform with the associated electronics for obtaining gravity readings and recording the results on strip chart and magnetic tape recorder.

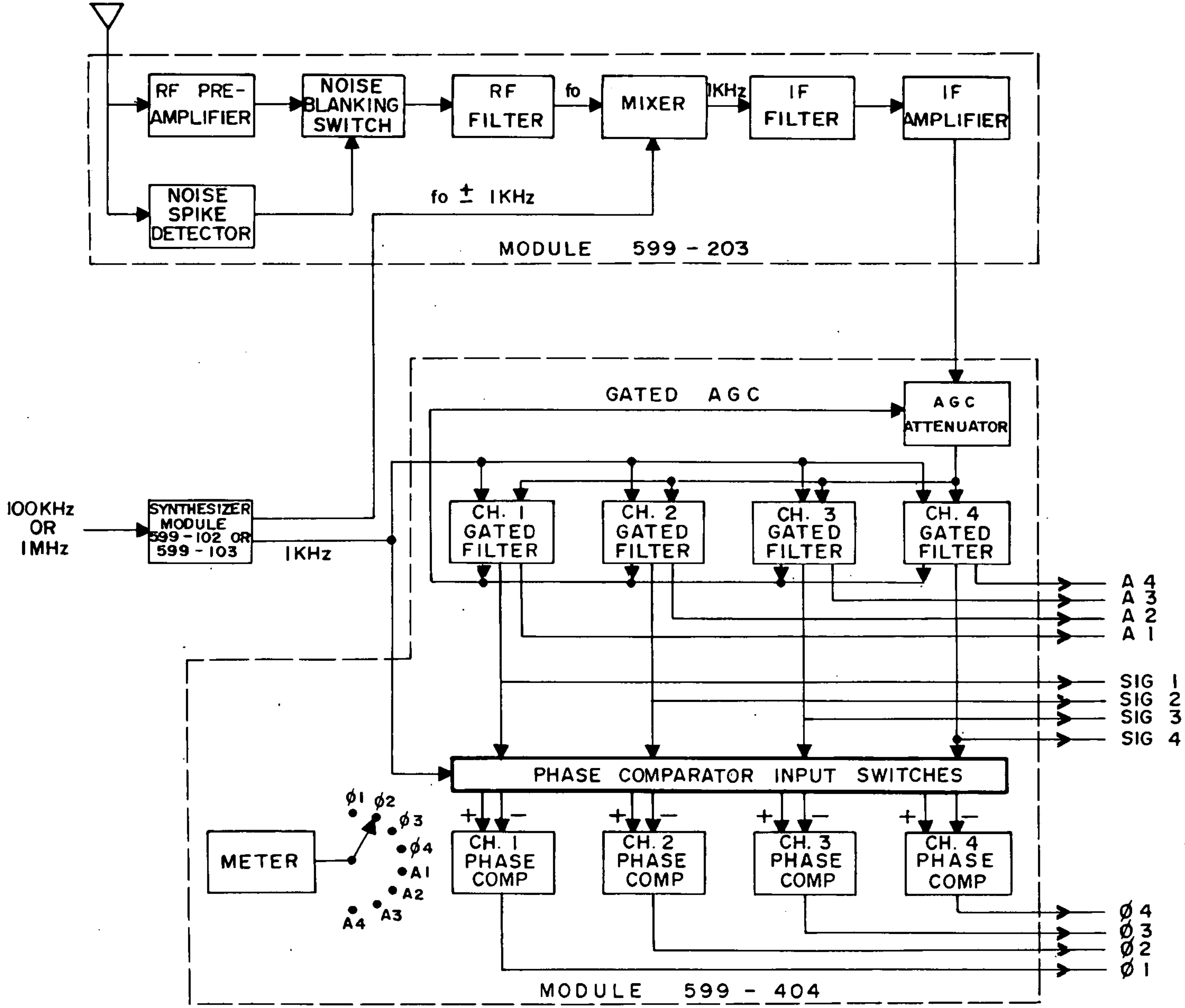
The model S gravity meter has a range without resetting of 12,000 milligals and a static accuracy of better than 0.01 milligals. However, readings are recorded only to the nearest tenth milligal.

* A simplified theory of operation is given in Fig. 11 and 12.

* Gravity readings - Definition of the different components :

The gravity value shown on the model S gravity meter is derived from 8 different components :

- the spring tension ST
- the term K x dB/dt proportional to the velocity of the beam (K : a constant which is a function of the average beam sensitivity and the damping)
- the inherent cross coupling, or VCC, which is a function of X".Z' and Y".Z'



SIMPLIFIED BLOCK DIAGRAM
OF MODEL 599Q VLF/OMEGA RECEIVER

FIG. 10

- the long imperfection cross coupling, function of X".Z".
- the cross imperfection cross coupling, function of Y".Z".
- the vertical error, function of Z''^2.
- the horizontal error, function of X''^2.
- the horizontal error, function of Y''^2.

dB/dt, or the angular velocity of the beam is proportional to Z" and therefore, the deviation of the beam with respect to the horizontal is proportional to Z'.

X" and Y" being the horizontal accelerations along the long (X) axis and the cross axis (Y) respectively , they are derived from the output voltages of the two accelero-meters placed on the stable platform.

Z" is the vertical acceleration, or more exactly the short period part of the vertical acceleration , it is obtained as a voltage derived from the beam position B.

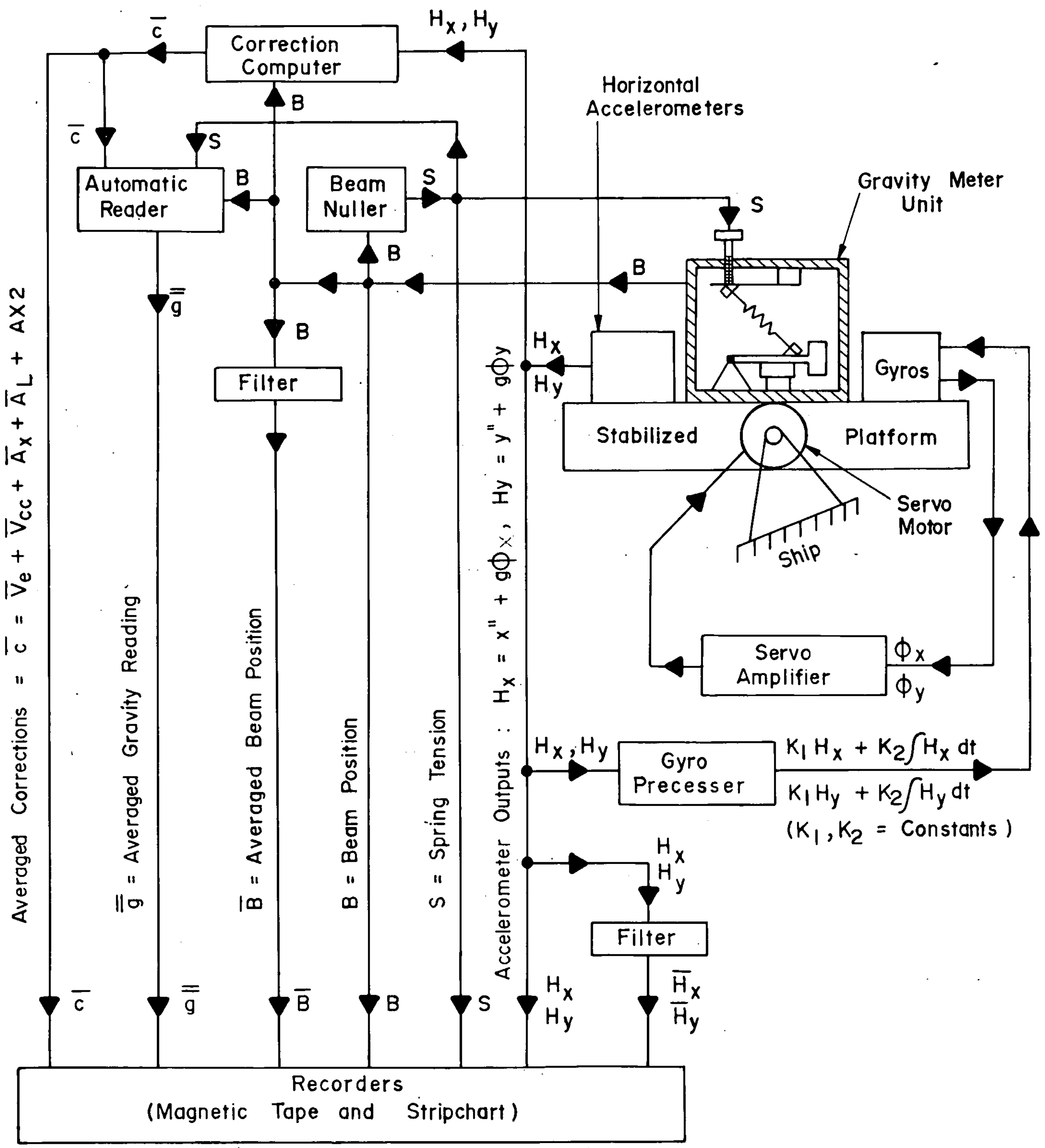
Basically, three analog outputs or voltages are used to build up the component terms of the gravity value (Fig. 12/3)

- the Z' or B, beam position , a differentiating circuit produces the dB/dt term proportional to Z".
- the X" or long axis acceleration.
- the Y" or cross axis acceleration.

The first problem is to define the correct calibration constants necessary to convert the output voltages into the correct accelerations, Z" X" and Y".

The term Z' is in fact proportional to the beam angle with respect to the horizontal, and in the cross coupling VCC term, it is the beam angle which is used.

This would lead to a definition of 4 constants in order to calibrate the four output signals.



BLOCK DIAGRAM OF LA COSTE and ROMBERG AIR-SEA GRAVITY METER

THE "BEAM NULLER" USES THE BEAM POSITION B TO CONTROL THE SPRING TENSION S TO APPROXIMATELY NULL THE BEAM POSITION.

THE CORRECTION COMPUTER USES THE BEAM POSITION B AND THE HORIZONTAL ACCELEROMETER OUTPUTS HX AND HY TO COMPUTE RELATIVELY SMALL CORRECTIONS REQUIRED BECAUSE OF POSSIBLE SMALL IMPERFECTIONS IN THE GRAVITY METER UNIT. THESE CORRECTIONS C ARE FED TO THE AUTOMATIC READER ALONG WITH THE SPRING TENSION S AND THE DERIVATIVE OF THE AVERAGE BEAM POSITION $\bar{B}'$.

THE AUTOMATIC READER COMPUTES THE GRAVITY METER READING g FROM THESE INPUTS AND FILTERS THE HIGHER FREQUENCIES OUT OF ITS g OUTPUT.

THE FILTERED GRAVITY OUTPUT $\bar{\bar{g}}$ IS FED TO THE STRIP CHART AND THE DATA ACQUISITION SYSTEM ALONG WITH OTHER VARIABLES WHICH ARE USED FOR MONITORING.

ϕX : ANGULAR DISPLACEMENT ABOUT THE HORIZONTAL AXIS NORMAL TO THE LONG AXIS.

ϕY : ANGULAR DISPLACEMENT ABOUT THE HORIZONTAL AXIS NORMAL TO THE CROSS AXIS.

In the model S gravity meter, the error analysis introduce constructional errors (geometrical imperfection errors) as well as errors relating to the principle of the meter (inherent cross coupling).

Dr. Lacoste points out in his paper "Gravity measurements at sea and in the air (1967)" that G may be considered as the sum of the following terms :

$$G = ST + K \frac{dB}{dt} + e$$

where :

$$e = a_1 X''^2 + a_2 Y''^2 + a_3 Z''^2 + a_7 X''Z' + a_8 Y''Z' + a_9 X''Z'' + a_{10} Y''Z'' + \dots$$

the terms a_i being constants defined experimentally for each meter by the builder.

The inherent cross coupling equals $a_7 X''Z' + a_8 Y''Z'$; this expression of the inherent cross coupling accounts for construction imperfections of the meter as Y" should not intervene for a theoretical meter.

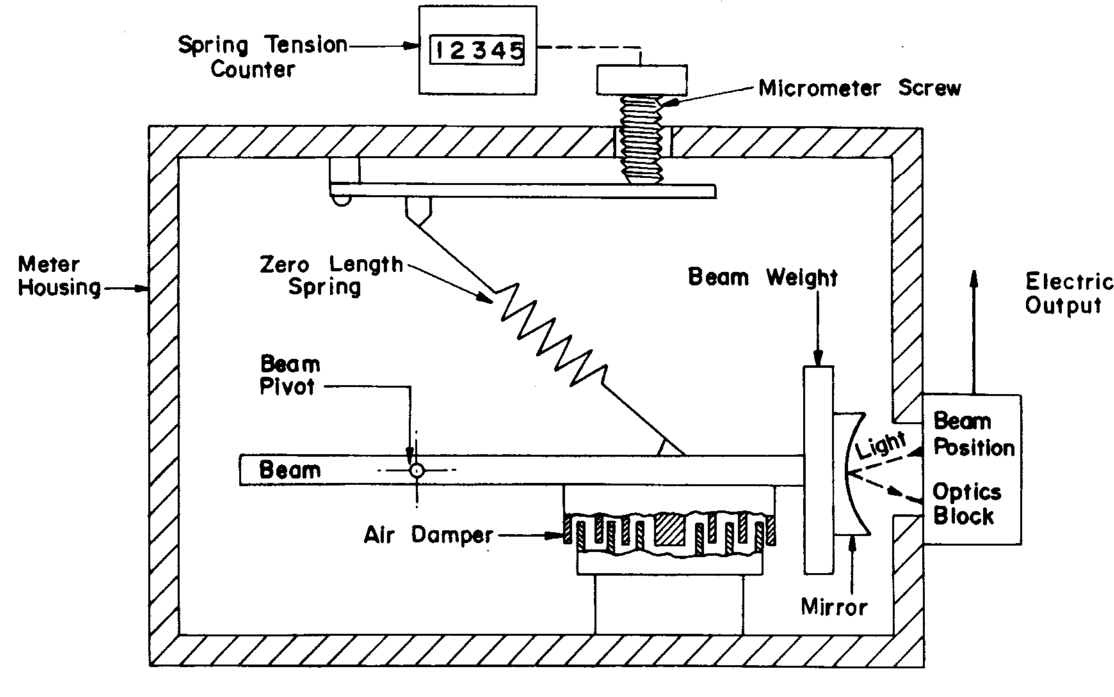
The long imperfection cross coupling is equal to $a_9 X''Z''$, and the cross imperfection cross coupling is equal to $a_{10} Y''Z''$.

The first two terms account for stabilized platform performance ; the third term accounts for gravity meter nonlinearity.

* Analogue recorders : Three different analogue recorders are used in conjunction with the main equipment :

  - Texas Instrument recorder : it displays the following traces :
    - Gravity
    - Spring tension or beam position
    - Cross coupling or average beam
    - Total correction.

FIG. 12



GRAVITY SENSOR
FIG. 1

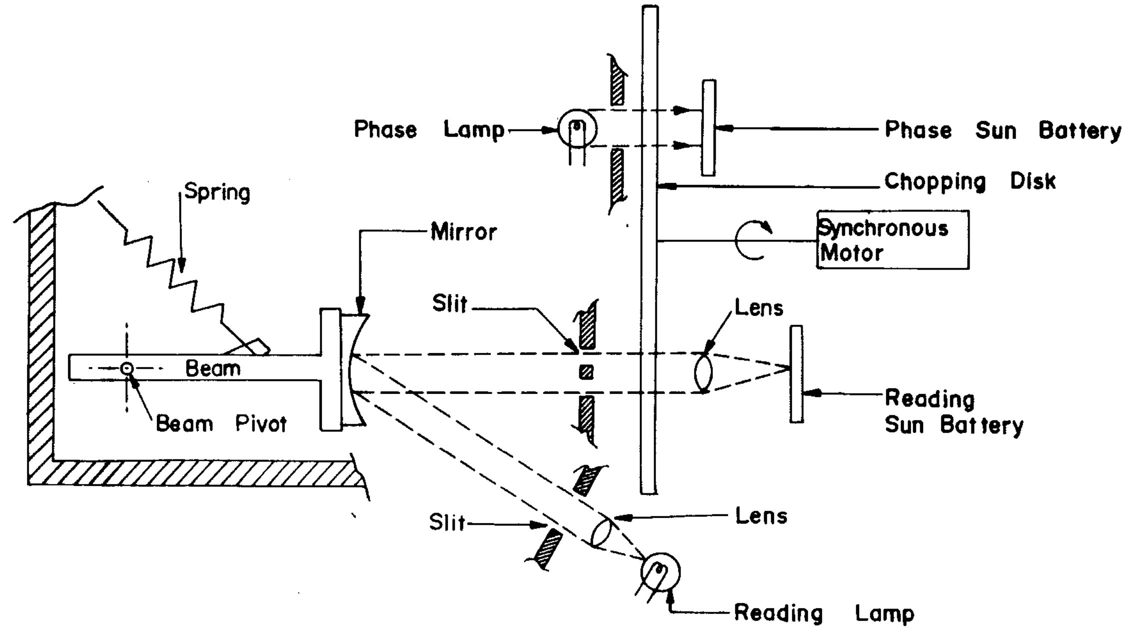
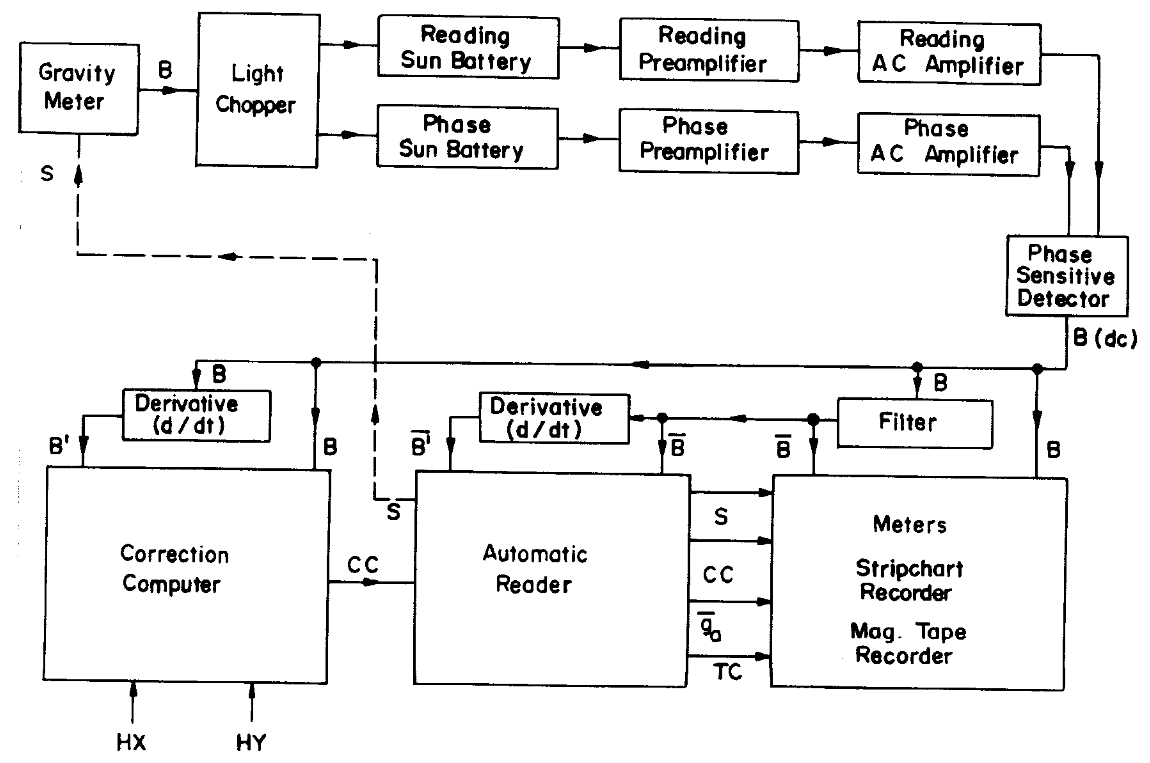
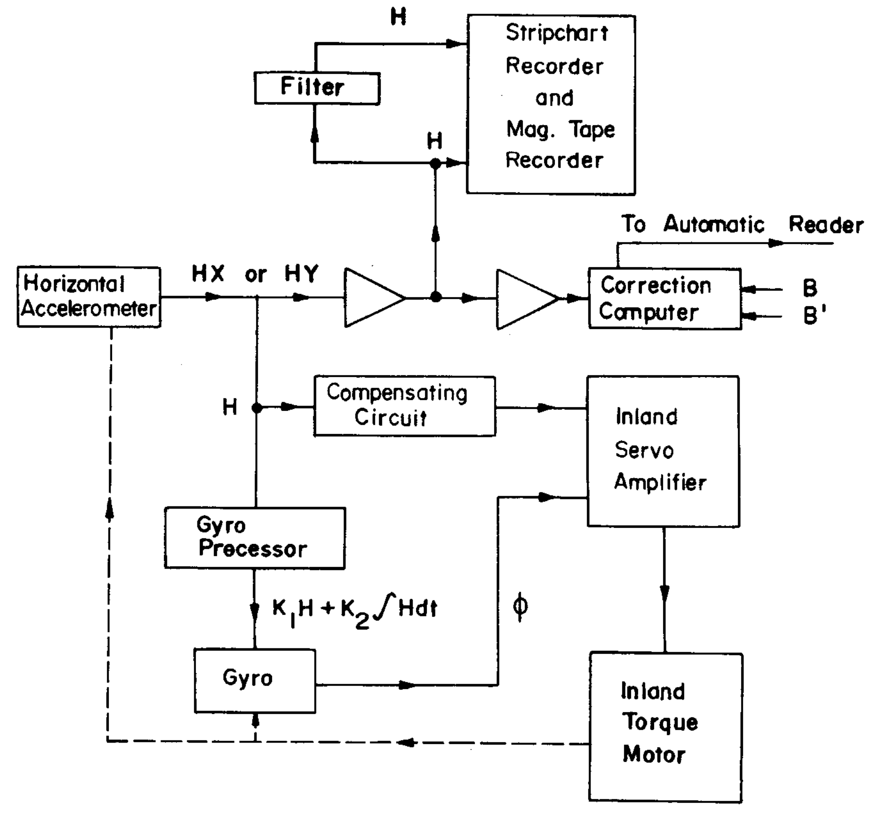


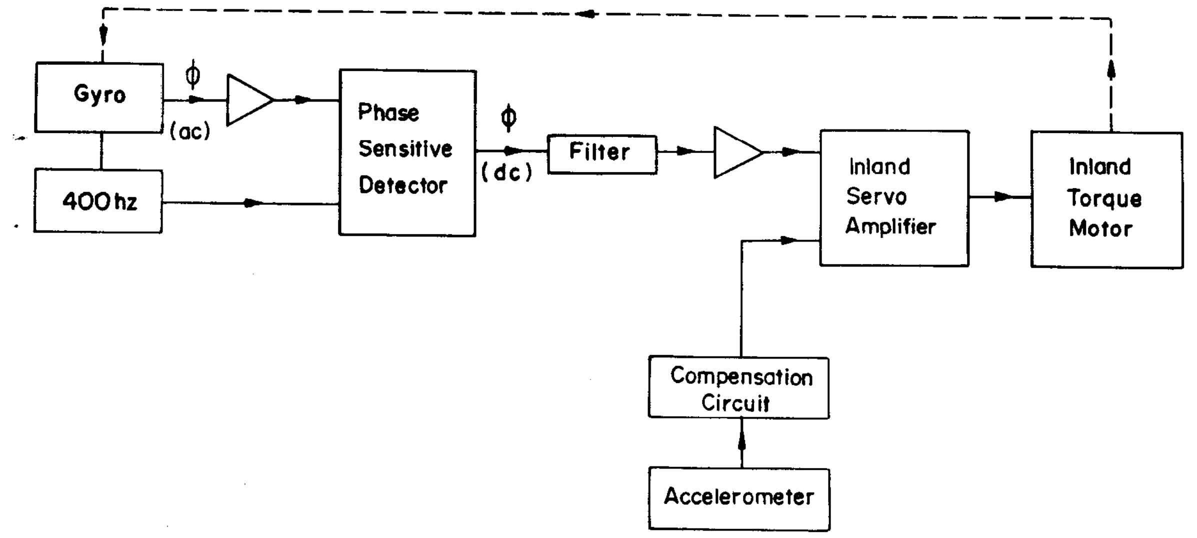
DIAGRAM OF PHOTOELECTRIC SYSTEM
FOR READING BEAM POSITION
FIG. 2



BLOCK DIAGRAM OF BEAM
POSITION CIRCUITS
FIG. 3



BLOCK DIAGRAM OF ACCELEROMETER
FIG. 4



GYRO STABILIZATION CIRCUIT
FIG. 5

FIG. 1 THE METER IS VERY HIGHLY DAMPED AND IT IS MADE VERY SENSITIVE BY USING A ZERO LENGTH SPRING TO SUPPORT THE BEAM

FIG. 2 A MIRROR MOUNTED ON THE BEAM PRODUCES AN IMAGE OF AN ILLUMINATED SLIT, AND THE POSITION OF THE IMAGE MOVES WITH THE POSITION OF THE BEAM. WHEN THE BEAM IS DISPLACED FROM NULL, THE OUTPUT OF THE READING SUN BATTERY VARIES AT THE FREQUENCY OF THE CHOPPER AND WITH AN AMPLITUDE OF VARIATION PROPORTIONAL TO THE DISPLACEMENT OF THE BEAM FROM ITS NULL POSITION ; THE PHASE OF THE VARIATION IS DETERMINED BY THE BEAM FROM ITS NULL, THE OUTPUT OF THE PHASE SUN BATTERY IS ACTING AS A PHASE REFERENCE.

FIG. 3 NO COMMENT

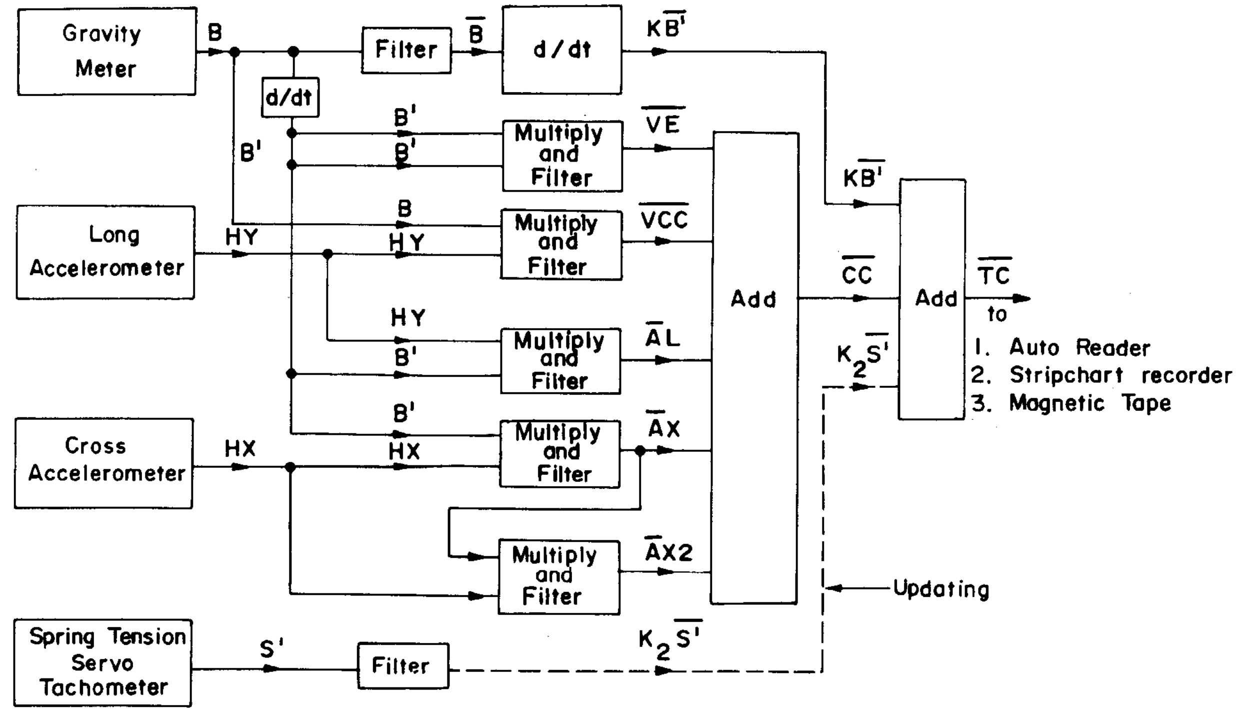
FIG. 4. ACCELEROMETER OUTPUTS ARE APPLIED AS INPUTS TO THE CORRECTION COMPUTER AND ARE USED TO PROCESS THE GYROS TO LEVEL THE STABILIZED PLATFORM ; ALSO, A FUNCTION OF THE ACCELEROMETERS IS APPLIED AS A SMALL COMPENSATING CORRECTION TO THE STABILIZED PLATFORM SERVOS TO COMPENSATE FOR SLIGHT GYRO IMPERFECTIONS AND PHASE DIFFERENCES BETWEEN ACCELEROMETER AND GYROS.

FIG. 5 THE GYRO OUTPUT (400 Hz.) IS RECTIFIED BY A PHASE SENSITIVE DETECTOR ; THE RECTIFIED OUTPUT PLUS A SMALL COMPENSATING VOLTAGE DERIVED FROM THE CORRESPONDING ACCELEROMETER DRIVES THE INLAND SERVO AMPLIFIERS

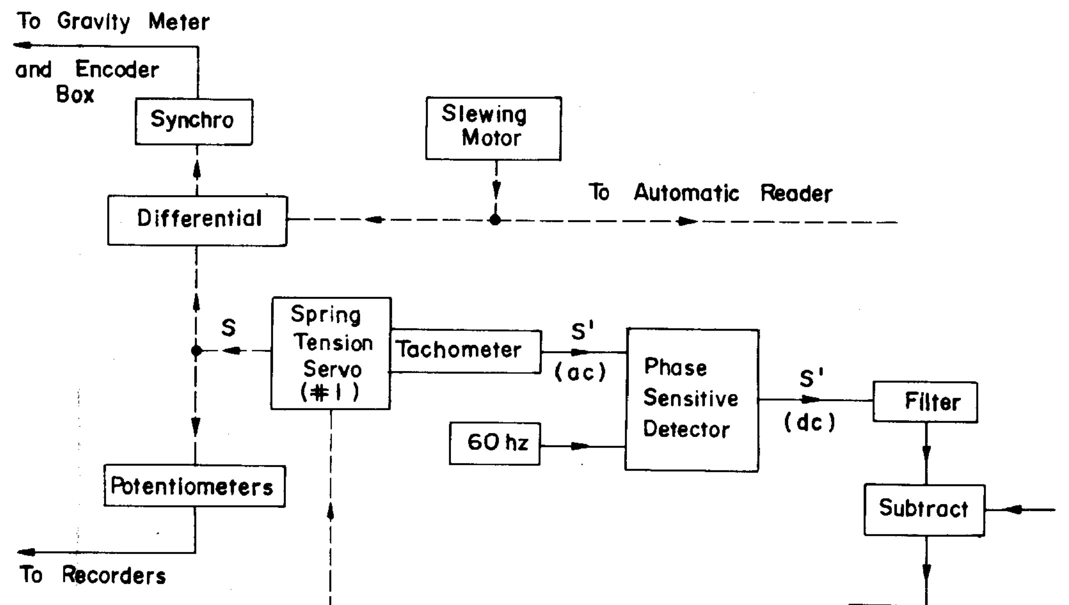
FIG. 6 TOTAL CORRECTION IS COMPUTED FROM B', HX, HY.

FIG. 7 THE BEAM NULLER COMPUTES A VALUE OF SPRING TENSION THAT WILL KEEP THE AVERAGE BEAM POSITION APPROXIMATELY NULLED.

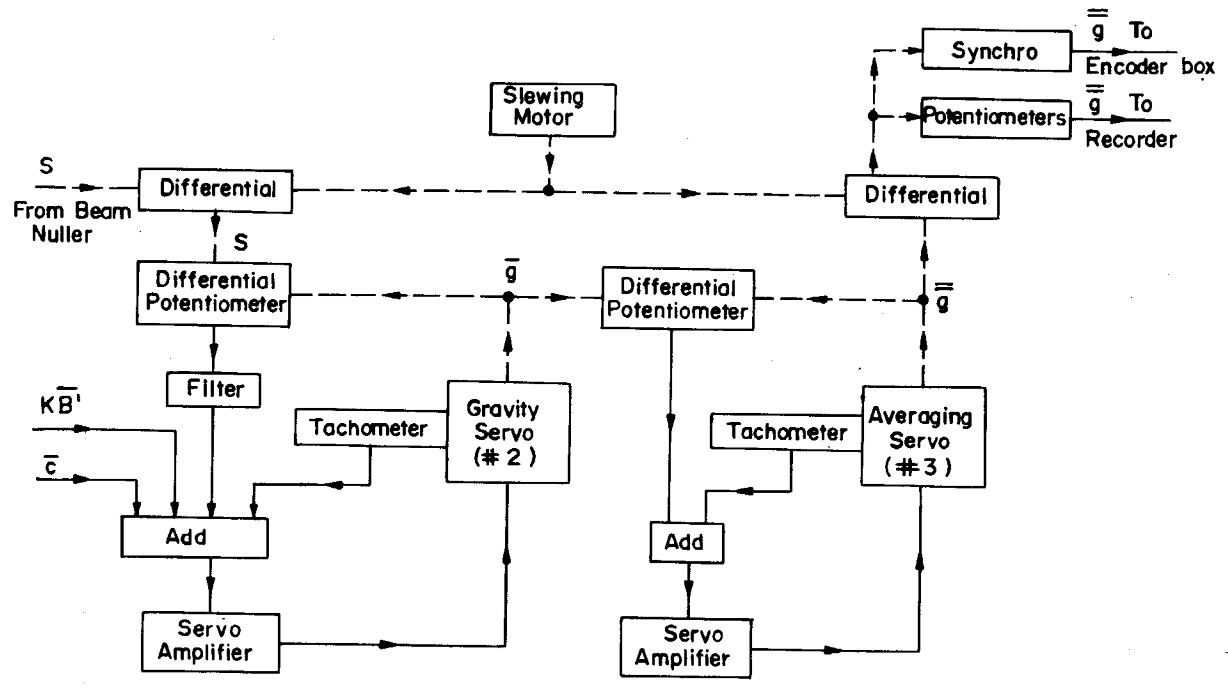
FIG. 8 GRAVITY READER : COMPUTES AN AVERAGE VALUE OF GRAVITY FROM EQUATION : G = ST + KB' + CC



BLOCK DIAGRAM OF CORRECTION CIRCUITS
FIG. 6



BLOCK DIAGRAM OF BEAM NULLER
IN AUTOMATIC READER
FIG. 7



BLOCK DIAGRAM OF GRAVITY READER
FIG. 8

FUNCTIONING OF THE S 24 GRAVITY METER

- Two Esterline Angus recorder ; they display the following traces :
  - Filtered accelerometer outputs,
  - Unfiltered accelerometer outputs.

- For checking purposes, the analogue recording of the cross-coupling components was carried out on a RIKADENKI recorder from survey 15 to survey 16, Cruise 4, then on a SPEEDOMAX recorder.

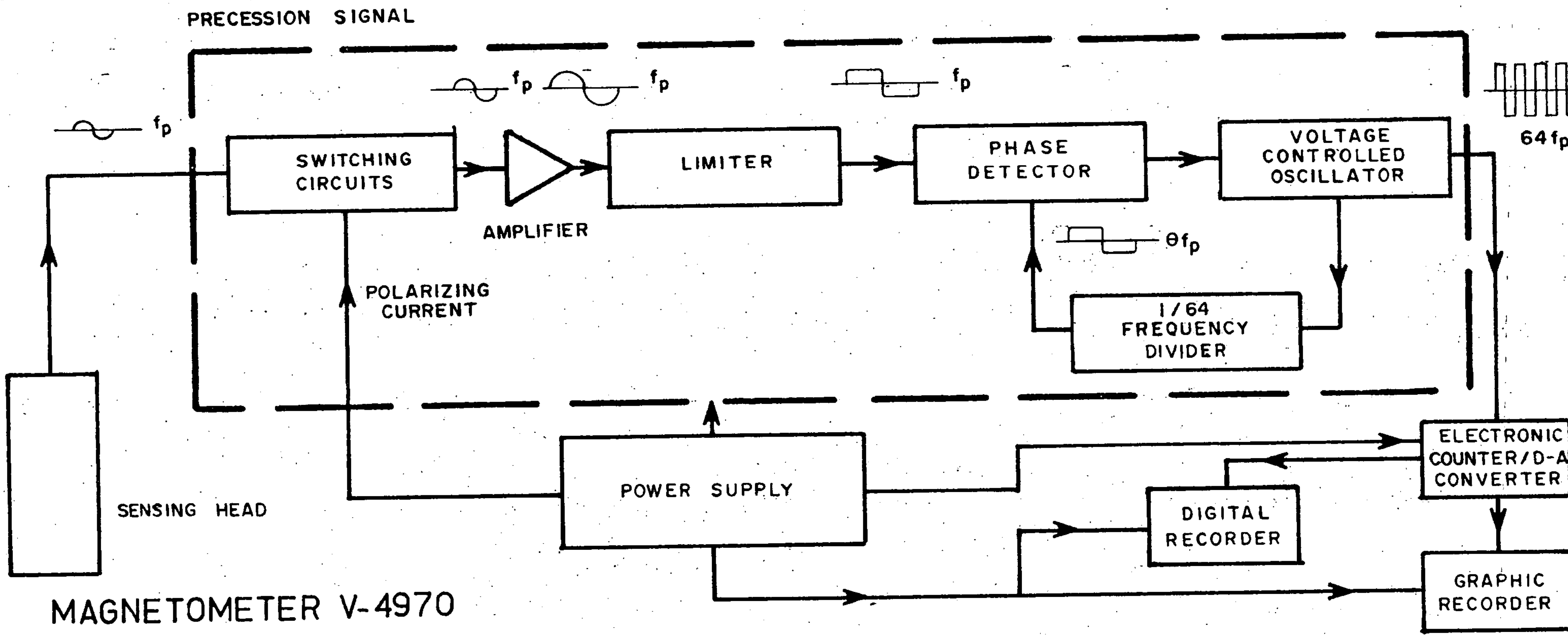
* Modifications to the equipment :

During survey 15 (cruises 2 and 3) the gravity meter S24 was sent back to Austin (Texas) for overhauling and updating ; the value of the internal analog filter of the meter was changed and the information for time lags in readouts became :

ENCODER READOUTS	From surveys 05 to 15/01	From surveys 15/04 to 19
Spring Tension	0	0
Gravity	2.5 mn	3 mn
Cross coupling	1.5 mn	1 mn
Total correction	1.5 mn	1 mn

STRIP CHART READOUTS	From surveys 05 to 15/01	From surveys 15/04 to 19
Spring tension	0	0
Gravity	2.5 mn	3 mn
Beam position	0	0
Total correction	2.5 mn	3 mn
Average beam	2.5 mn	3 mn
Cross coupling	2.5 mn	3 mn
Horizontal Acc.	0	0
Filtered horizontal Acc.	0.5 mn	1 mn

FOR 1 GAMMA SENSITIVITY : $H = M(f_p)\,T$, WHERE M IS AN EXACT MULTIPLE OF THE PRECESSION FREQUENCY (64 IN THE V 4970 MODEL), T IS THE COUNTING TIME WHICH MUST BE 0.366992 SECOND FOR A x 64 FREQUENCY MULTIPLICATION. THE FREQUENCY DIFFERENCE BETWEEN f_p AND θf_p WILL GENERATE A dc VOLTAGE TO CHANGE THE VCO FREQUENCY TO EXACTLY $64 f_p$. IF THE $64 f_p$ SIGNAL IS NOW COUNTED FOR THE CORRECT GATE PERIOD, THE FREQUENCY COUNTER WILL COUNT EXACTLY 23.4875 TIMES f_p. THE EARTH'S MAGNETIC FIELD IS THUS READ DIRECTLY FROM THE DIGITAL FREQUENCY COUNTER.



MAGNETOMETER V-4970
BLOCK DIAGRAM

FIG. 13

Note 1 : The analogue filter referred to is a multistage analog short period filter which has a Laplace transform of $\frac{wo^3}{(s + wo)^3}$ where s is the Laplace operator and wo = 1/(10 seconds)

Note 2 : To correctly apply time lags to strip chart readouts, the position of the pens on the specific recorder must be taken into account. The gravity pen is approximately 10 seconds ahead of the spring tension pen and the total correction pen is approximately 10 seconds behind the spring tension pen.

The other updating of the S24 consisted of :

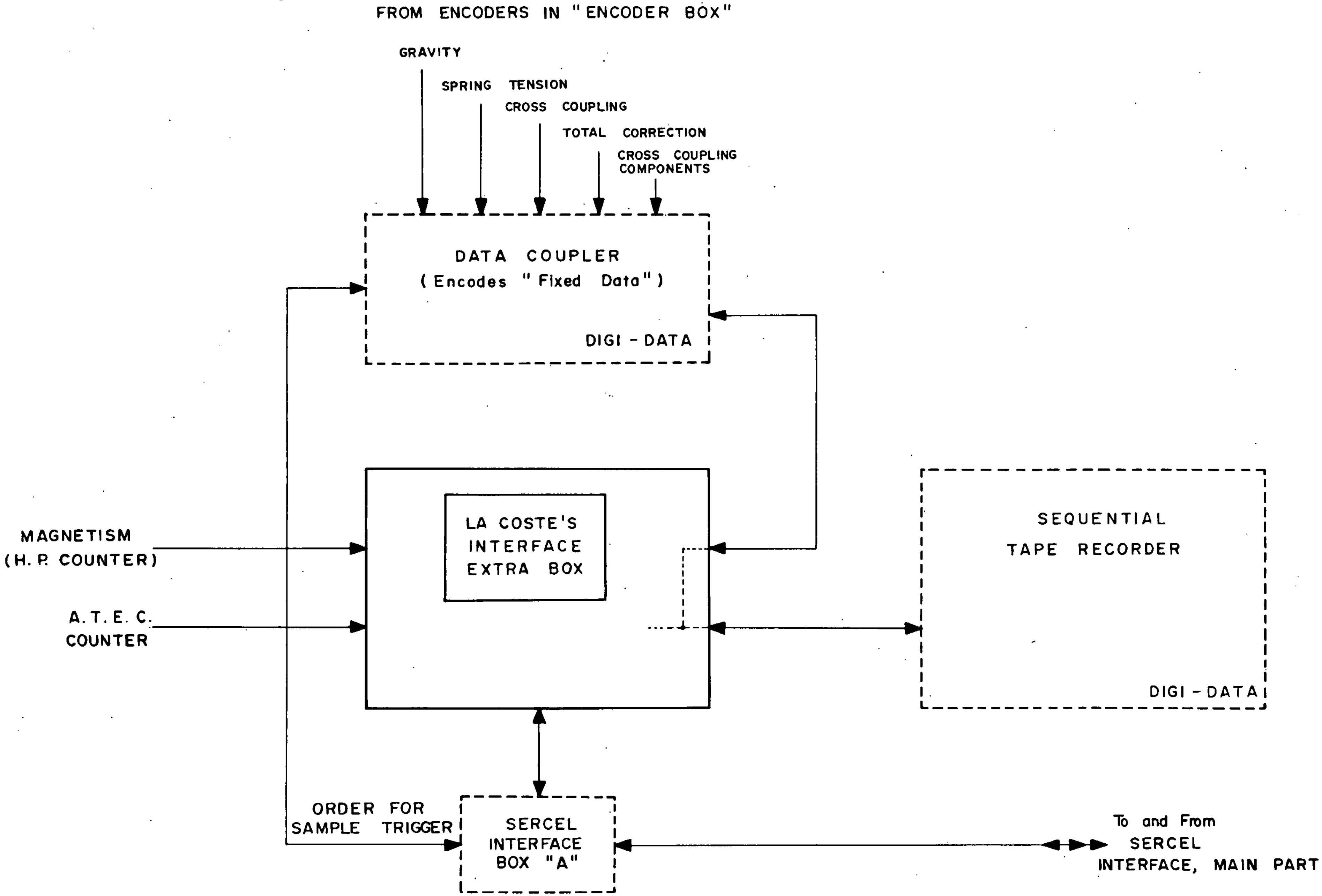
- Creation of a special output allowing digital and analogue recording of the components of the total cross coupling : VCC, AL ($a_9X''Z''$), AX($a_{10}Y''Z''$), vertical acceleration squared VE($a_3Z''^2$), and finally AX2, a second order cross coupling correction proportional to the product of the vertical acceleration multiplied by the cross acceleration squared ($a_nZ''Y''^2$).
- Improvement of the stabilization circuits.
- Improvement of the total correction circuits.

III.2 - MAGNETOMETER SYSTEM

* The equipment used was a proton magnetometer VARIAN, model 4970.

This type of magnetometer utilizes the proton-free-precession principle : the protons spins continously about its axis with a precise angular momentum.

Due to its positive charge the spinning proton also possesses a magnetic moment ; it can be thought of as a tiny spinning magnet ; if these "nuclear" magnets are subjected to an external magnetic field of sufficient strength, their axes will try to align themselves with the applied field. Instead of jumping directly into alignment, however, the proton axis will precess (rotate) about the external field vector. The frequency at which the protons precess is directly proportional to the strength of the external field and is given by the relationship :



GRAVITY METER - MAGNETOMETER

SIMPLIFIED SCHEMATIC OF LOGIC CONNECTIONS AND OUTPUT TO DATA ACQUISITION SYSTEM

FIG. 14

H gammas = 23.4875 fpHz
where fp = precession frequency

The figure 23.4875 represents the proton constant.

The source of protons is a hydrocarbon fluid (kerosene). A strong magnetic field (of approximately 100 oersteds) is applied to the hydrocarbon sample from an external coil surrounding it. This strong field polarizes the protons in one direction. The field is suddenly removed and the protons, trying to align themselves with the earth's field, precess around it and induce a voltage in the coil at the precession frequency. It is this signal that is need to measure the earth's magnetic field strenght.

Readings obtained are absolute (± 1 gamma for a 1-gamma sensitivity setting) due to the digital nature of the signal processing and counting techniques employed.

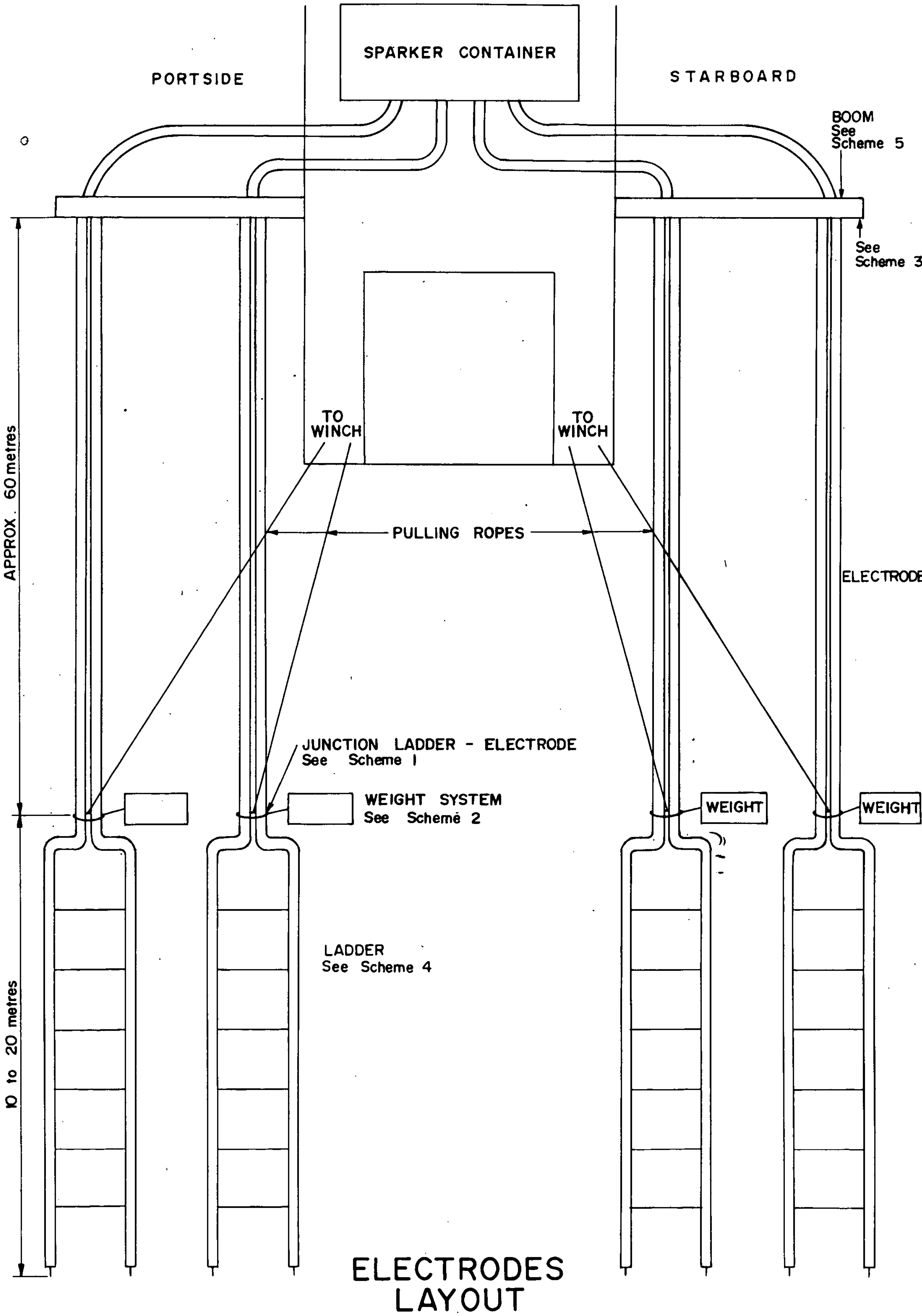
* The functioning of the Varian Model 4970 is explained in Fig. 13.

* Particulars of the sensor : the sensing coil is an ellipsoidally shaped toroid of unique construction which is both omnidirectional and noise cancelling. An improvement in the magnitude of the precession signal is obtained due to the ellipsoidal shape of the toroid core in the axial plane ; this improves the signal-to-noise ratio and thus the resolution in the magnetometer readout.

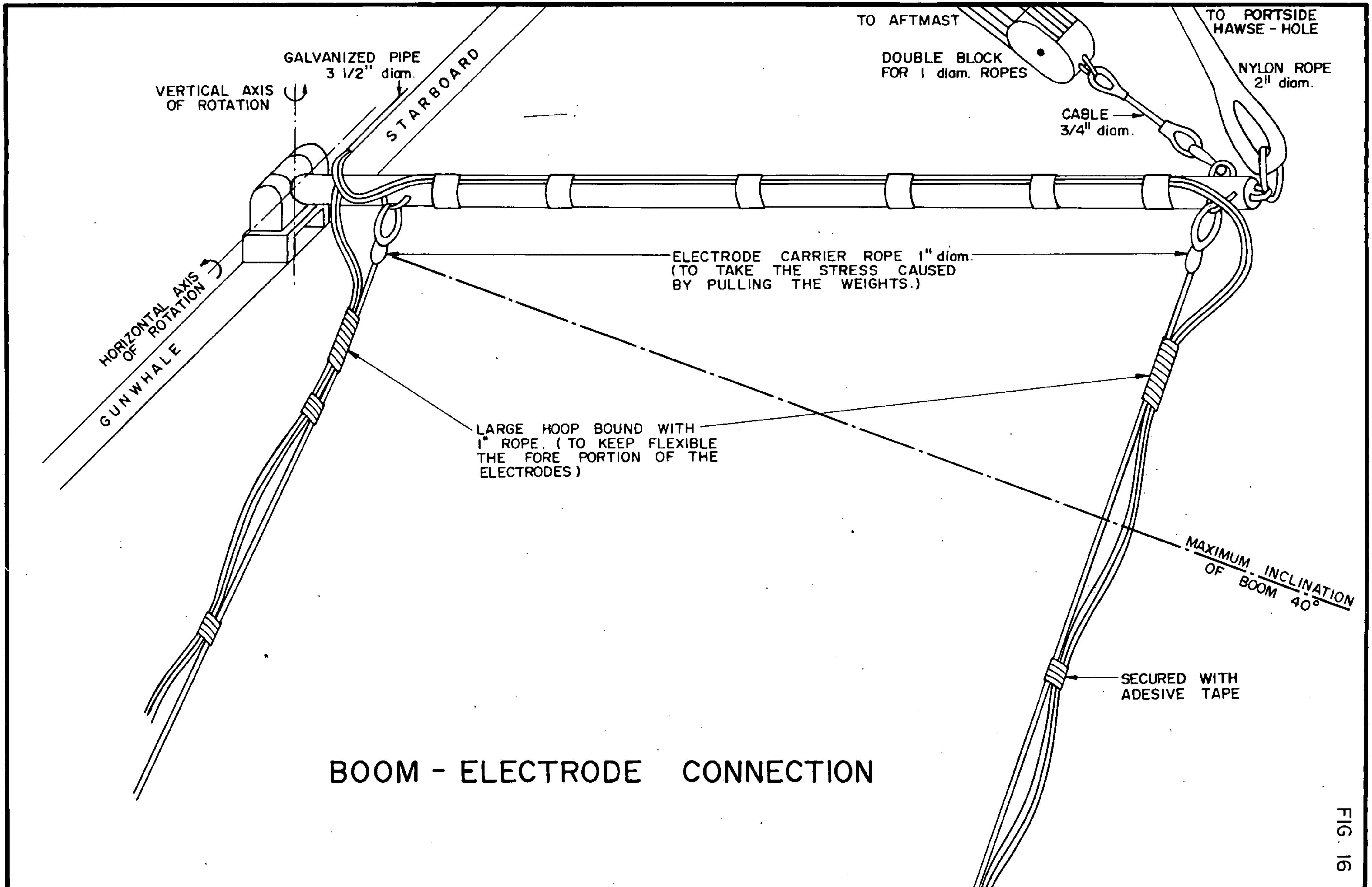
* Operation : the data is collected by towing the marine proton sensor on the end of a cable beyond the magnetic heading error created by the ship, i.e. at a distance from the stern of the ship that is approximately equal to three times the length of the ship.
The cable winch was first set up in area 8' of the ship (see fig. 3) and later (in the middle of survey 05) in area 8 to avoid radio interference.

* The magnetic trace was recorded on a Varian 10-inch G-300 analogue recorder.

FIG. 15

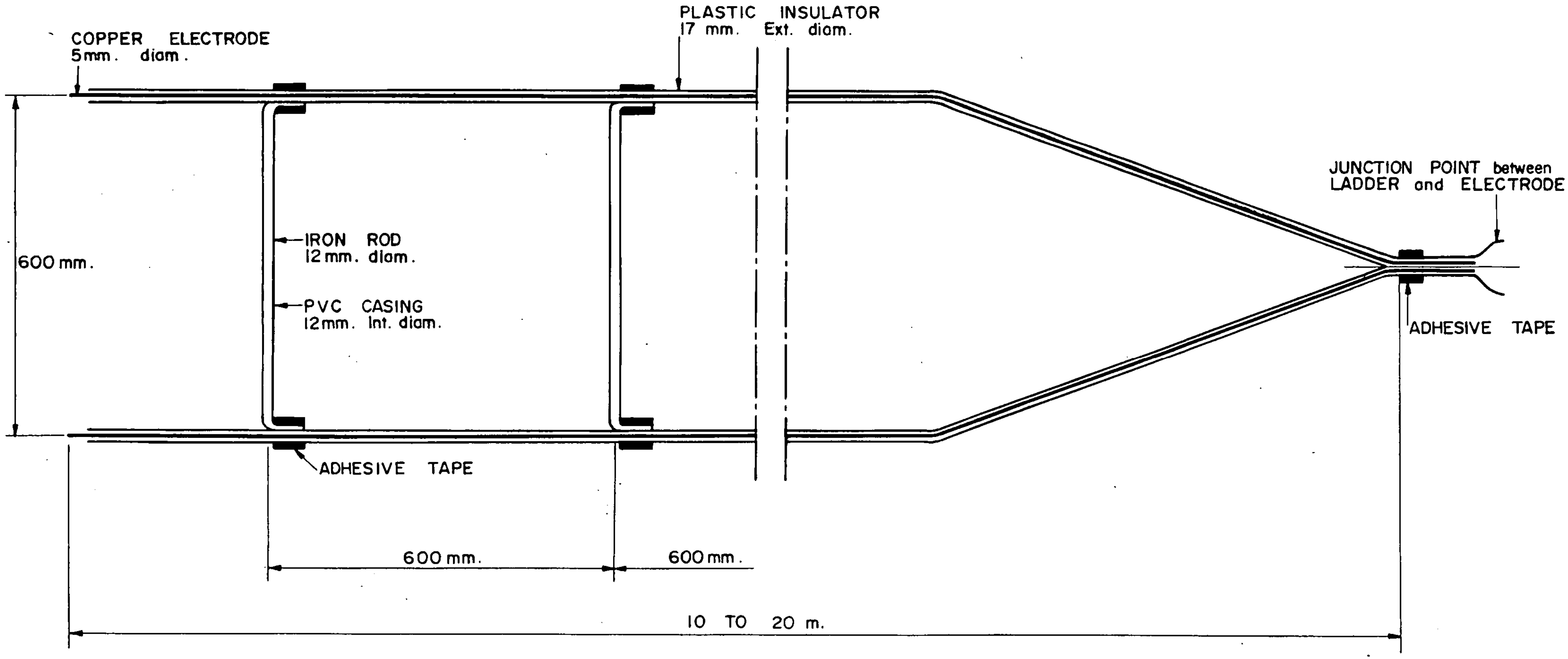


ELECTRODES LAYOUT



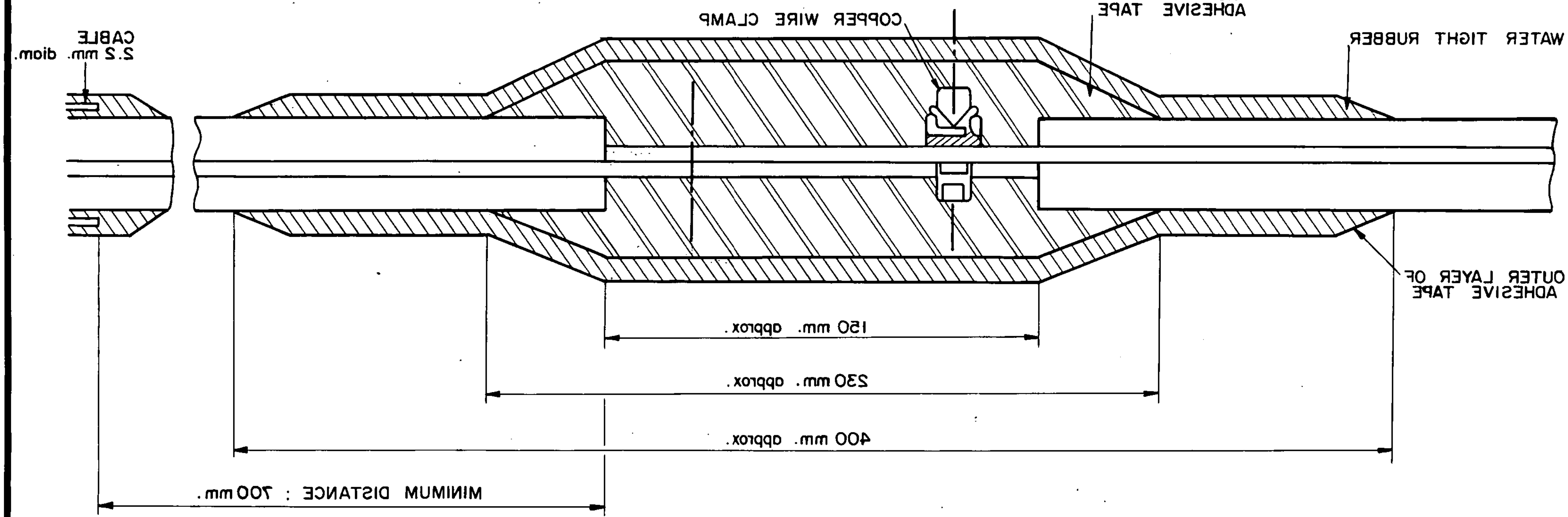
BOOM - ELECTRODE CONNECTION

FIG. 16



LADDER - ELECTRODE

FIG. 17



LADDER – ELECTRODE CONNECTION IN DETAIL

FIG. 18

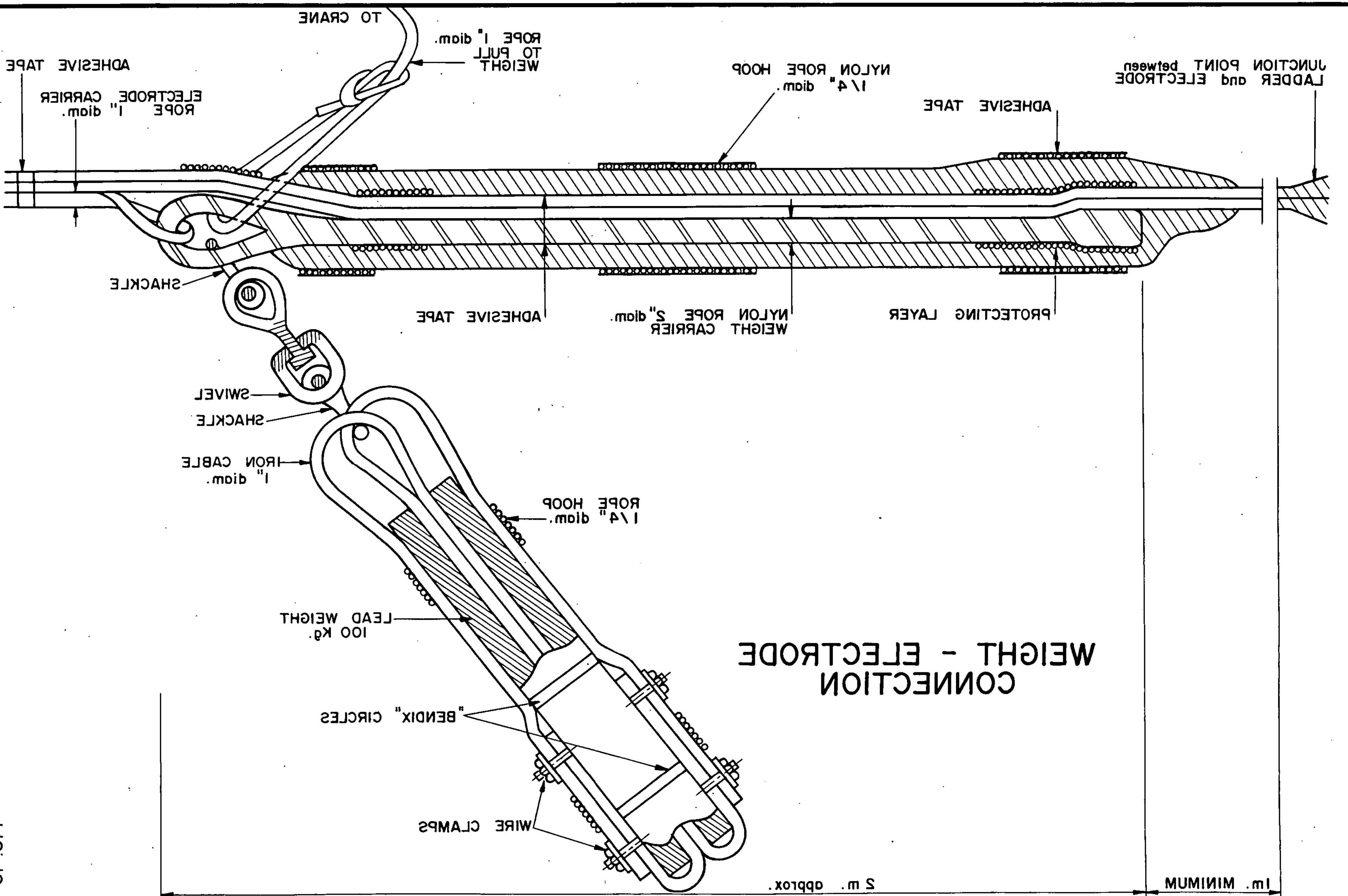

WEIGHT - ELECTRODE CONNECTION
TO CRANE
ROPE 1" diam. TO PULL WEIGHT
ADHESIVE TAPE
ELECTRODE CARRIER ROPE 1" diam.
NYLON ROPE HOOP 1/4" diam.
JUNCTION POINT between LADDER and ELECTRODE
ADHESIVE TAPE
SHACKLE
ADHESIVE TAPE
NYLON ROPE 2" diam. WEIGHT CARRIER
PROTECTING LAYER
SWIVEL
SHACKLE
IRON CABLE 1" diam.
ROPE HOOP 1/4" diam.
LEAD WEIGHT 100 Kg.
"BENDIX" CIRCLES
WIRE CLAMPS
2 m. approx.
1m. MINIMUM

FIG. 19

* Note : Connection of both the gravity meter and the magnetometer to the D.A.S. : Fig. 14 gives a simplified diagram of logic connections and output to Data Acquisition System.

III.3 - SEISMIC SYSTEM (Enclosures 2, 3, 4 and 5)

III.3.1 - Sources

a) - SPARKER System (Encl. 5)

* Principle : The SPARKER system operates on the principle that the discharge of stored electrical energy between two electrodes or more in salt water, can be used to generate seismic energy. Electrical energy from storage banks consisting of high voltage condensors is discharged between electrode (s) towed behind the vessel.

* The SPARKER system used was a (4 x 30.000) joules GEOTECH, supplied by two 220 V, 60 Hz, 50 KVA power plants. The GEOTECH system is basically composed of :

- four capacitor banks ; total capacity : 4 x 8 x 24 = 768 microfarads.
- four Open Air Thyratron units (O.A.T.)
- four high voltage transformers
- four trigger units which aim to produce "very hot" sparks to trigger the discharge of the capacitors.

* Simplified theory of operation of the GEOTECH system : (Encl. 5).

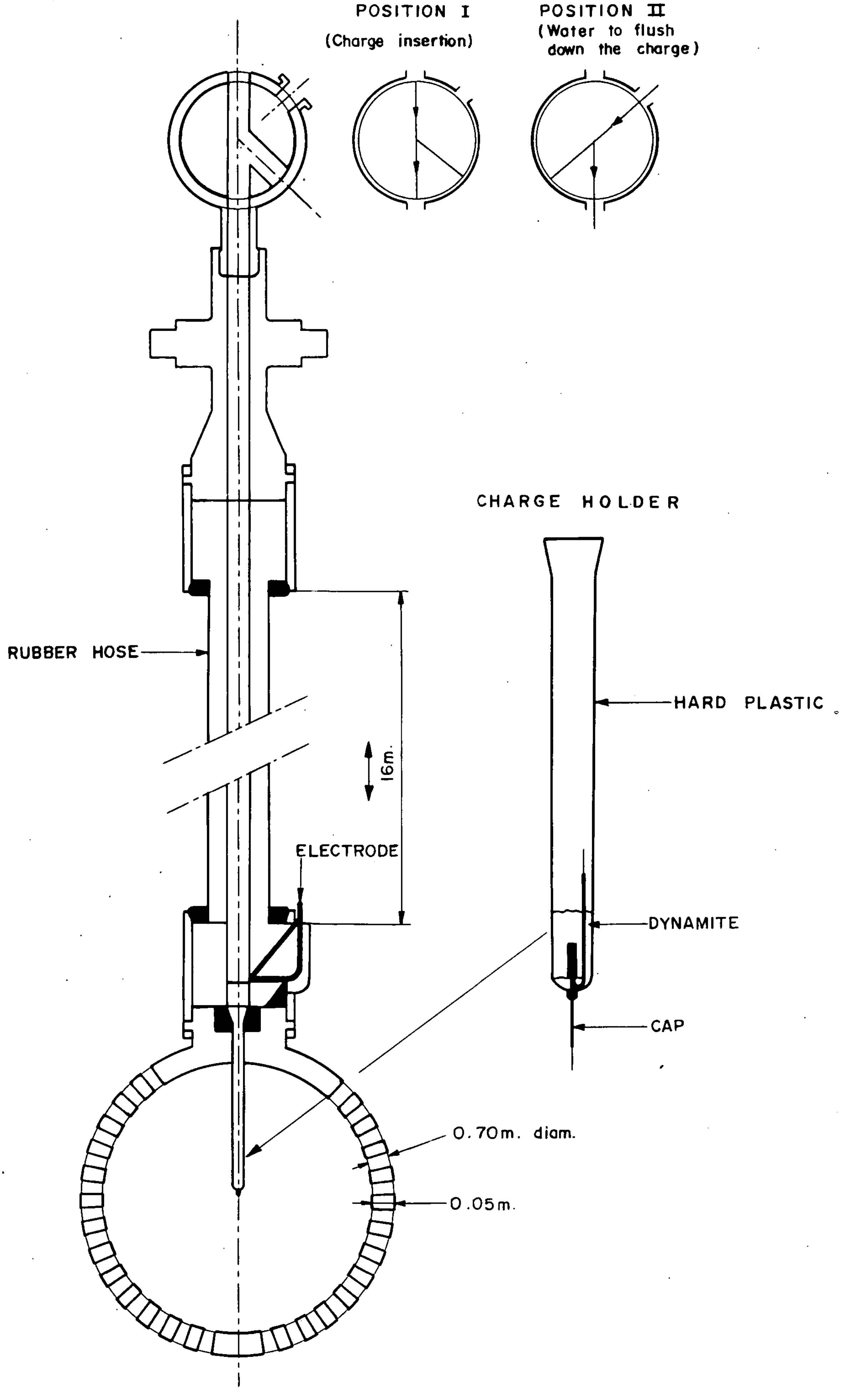
i - An alternator provides an alternative current 220 V - 60 Hz which enters a transformer.

ii - The secondary of the transformer provides a voltage of 12,540 V RMS which enters a diode bridge.

iii - The diode bridge provides 18,000 V d.c.

iv - The energy is stored in 4 x 8 capacitors in parallel .

FIG. 20



PRINCIPLE ELEMENTS OF FLEXOTIR "GUN"

v - The discharge occurs between 4 x 2 copper electrodes plunged in the sea water, via the four O.A.T. ; (the "secondary" sparks produced by the four trigger units ionize the space between electrodes in the O.A.T. and so enable the discharge to occur).

* Modifications to the equipment

Until survey 16, cruise 1, work was carried out with four pairs of electrodes. (Electrodes lay out and technical detail are given in Fig. 15 to 19). At the end of cruise 1, the GEOTECH system was modified to accept only one O.A.T. (Model S.I.G. 200 KJ) ; thus, from survey 16 cruise 2, work was carried out with only one pair of electrodes.

* Characteristics of the electrode system : immersion depth :

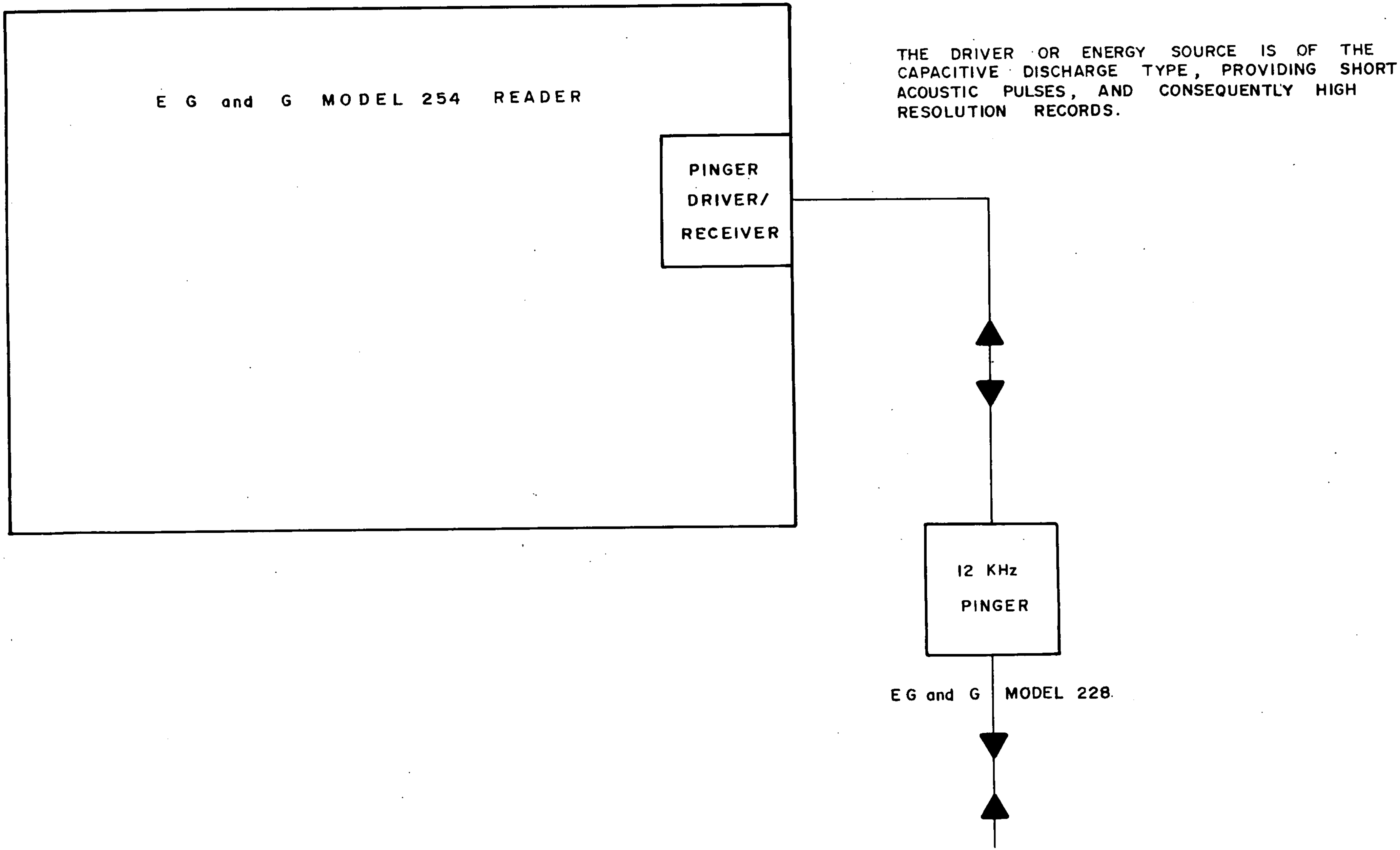
i - With 4 x 2 electrodes :
4 metres at 9 knots (length of each pair of electrodes at the beginning of a cruise : 80 m ; additional weight : 100 kilogrammes).

ii - With 1 x 2 electrodes :
6 metres at 9 knots (length of the electrodes at the beginning of a cruise : 100 m ; additional weight : 200 kilogrammes).

b) - FLEXOTIR system

* The FLEXOTIR system employs a small plastic encased dynamite charge (50 or 100 grammes) which is exploded electrically at a depth of 40 feet (for a working speed of 5 knots) in the centre of a perforated cast iron cage into which it is flushed down a flexible loading hose by sea water at 7 kg/cm^2. This water cleans the cage of fragments after the explosion.

The energy of secondary bubble pulses is strongly damped in the intense turbulence generated when the bubble front passes through the holes of the sphere.



PINGER E G and G MODEL 228 — SIMPLIFIED BLOCK DIAGRAM

FIG. 21

* The FLEXOTIR system was intended to be used for refraction work. This was done until the middle of survey 05. From that period, the SPARKER was the only system used for both reflection and refraction work.

c) - PINGER system

* The PINGER probe is a 12 KHz source used to obtain high resolution profiles of sub-bottom sedimentary layers in shallow waters.

* The equipment used was the EG and G Model 228, associated with the EG and G Model 254 recorder, which has a built-in driver/receiver (fig. 21).

* The PINGER was only used during the first part of survey 05. For various reasons (unsatisfactory installation, towing speed), this system was unable to give satisfactory results.

III.3.2 - Seismic cables

a) - C.G.G. main cable

* It consists of 6 active elements separated by dummy elements, each element being 50 m long. Each trace is composed of a transparent polymer sheath filled with kerosene. It includes :

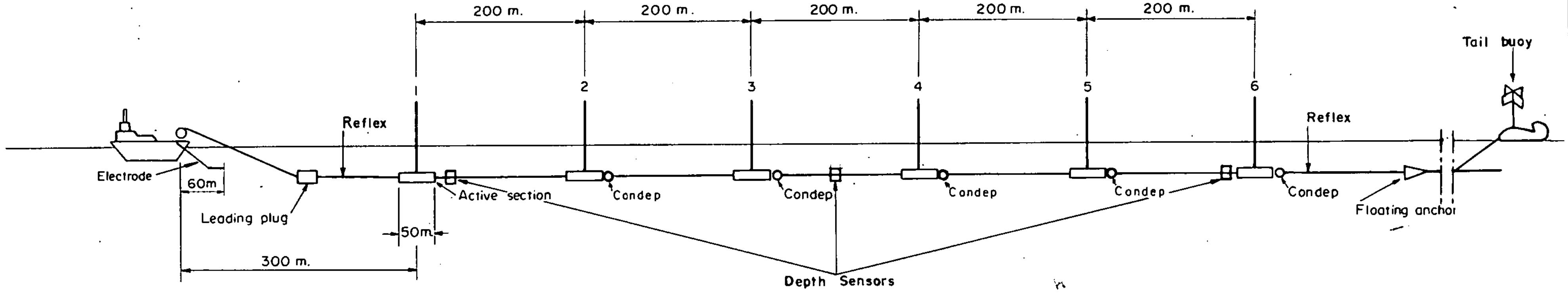
- antigyrating traction cables
- a cable with 110 conductors
- foamed cylinders distributed in order to maintain the traction and conductor cable spacing and to ensure the floatation
- piezoelectric geomecanique H.C. 301 hydrophones
- electric cables connecting hydrophones to transformers.

* The typical geometrical configuration adopted during the two main surveys is given in Fig. 22.

* An active trace is composed of 48 GEOMECANIQUE HC 301 hydrophones arranged in 3 series of 16 hydrophones mounted in parallel (Fig. 23).

CGG STREAMER CABLE - 6 CHANNELS

1000 metres 48 hydrophones per trace



TRACE DIAGRAM 48 hydrophones HC 301 (2 sensors per phone)

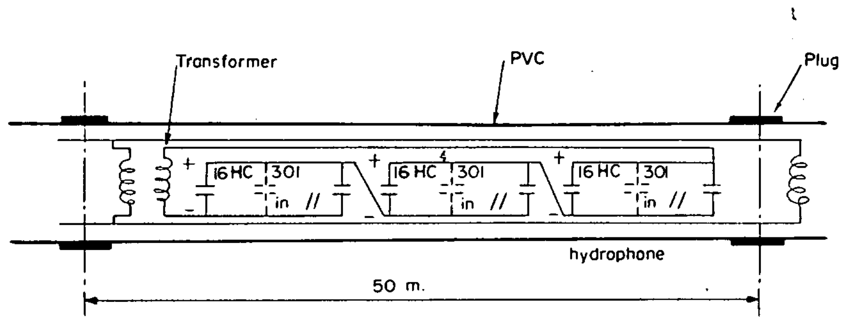
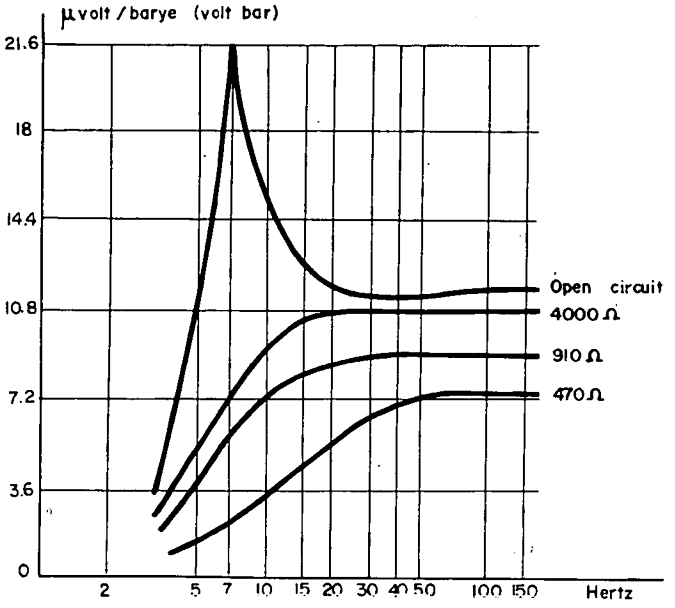


FIG. 22

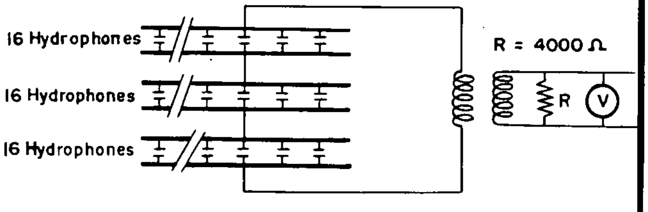
C.G.G. CABLE - ACTIVE TRACE



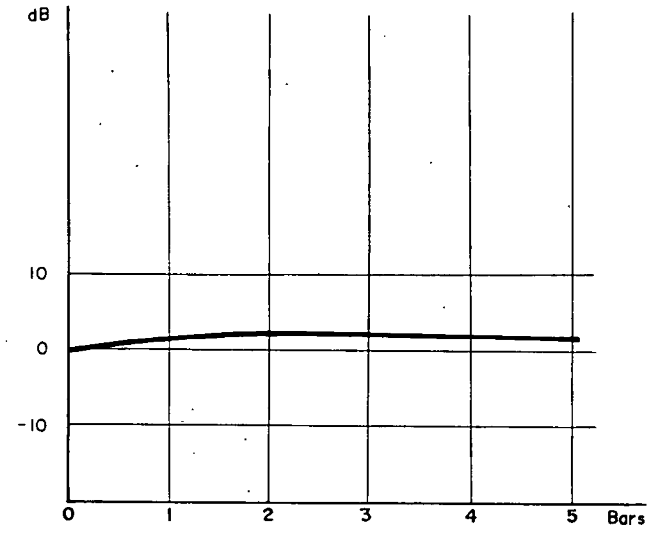
48 UNITS

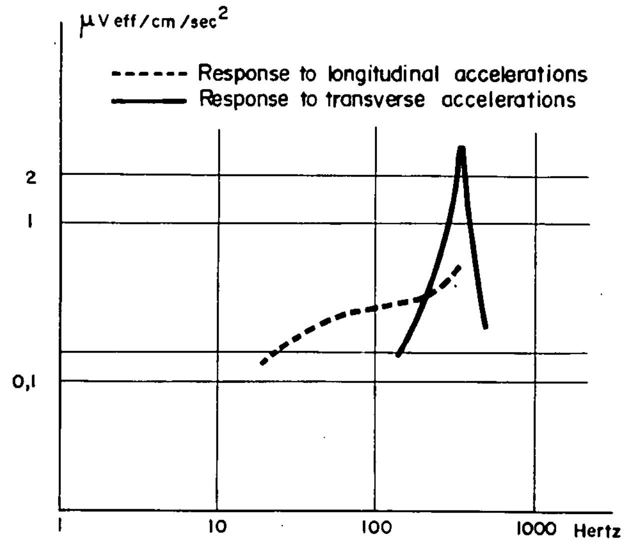
C = 60,000 pF

transformer	: ratio	10/1
primary	: self	: 20000 H
	: resistance	: 30000 Ω
secondary	: self	: 100 H



sensitivity vs static pressure





48 TRACE ACTIVE ELEMENT INCLUDES

1° - SOURIAU CONNECTOR = 110 PINS

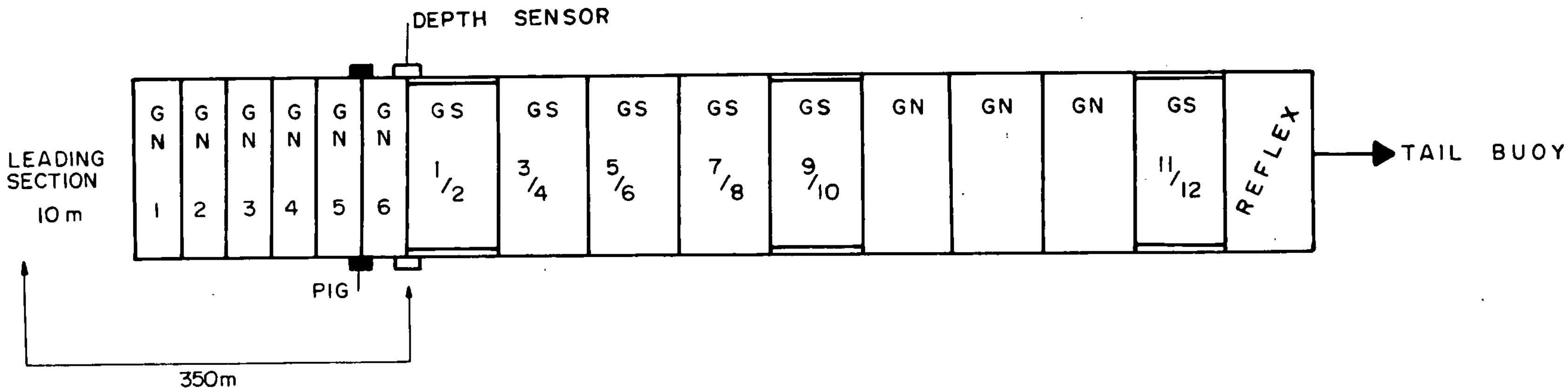
2° - ELECTRIC CABLE = 110 CONDUCTORS

3° - 3 STEEL TRACTORS 5mm. DIAM.

4° - 48 HC 301 HYDROPHONE GROUPS : 3 SERIES OF 16 HYDROPHONES MOUNTED IN PARALLEL

DIAMETER	=	53 mm.
LENGTH	=	50 meters
WEIGHT	=	112 kg.
SENSITIVITY	=	10.8 µV / BARYE
CAPACITY	=	60,000 pF

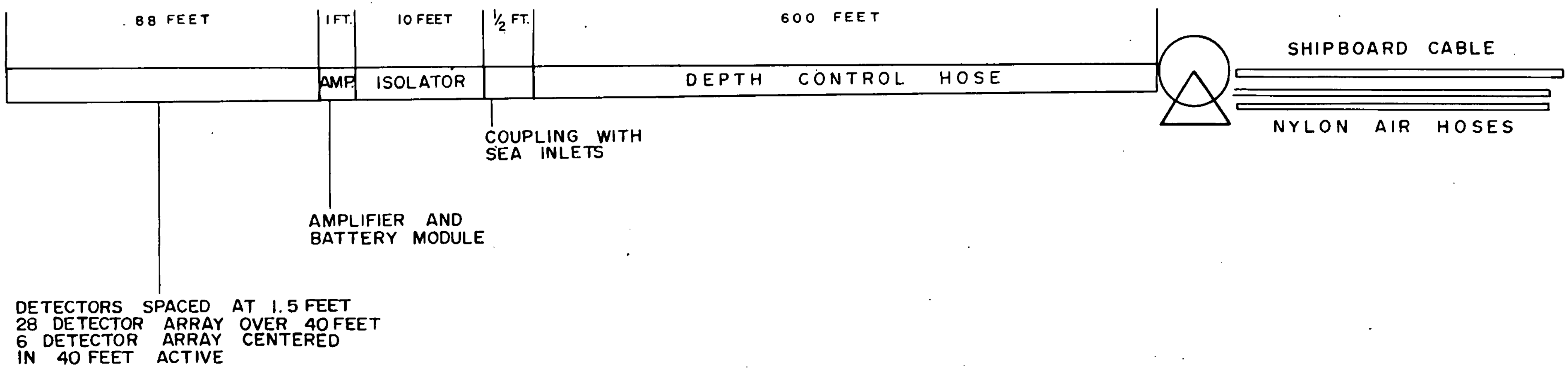
MAXIMUM STATIC PRESSURE = 10 BARS



C. G. G. MAIN CABLE

SIMPLIFIED DIAGRAM OF A MODIFICATION CARRIED OUT DURING SUB-SURVEY 15, CRUISE I

FIG. 24



GEOTECH CABLE

GEOMETRICAL CONFIGURATION

FIG. 25

* Immersion of the streamer

Constant cable depth was maintained by five depth controllers plus one adjustable leading plug (or pig) and checked by three manometers, incorporated in connecting units placed between the elements of the cable, and electrically connected to the seismic container (Fig. 22).

* Depth controller : consists of a torpedo-shaped paravane with an internal air chamber, a pair of adjustable hydrofoil wings and fixed tail fins. It functions on the principle of using forces of differential pressures of air inside the unit and water on the outside. When the pressure in the air chamber is equal to the pressure of water surrounding the controller, the wings spring back to a nearly horizontal position. Differential pressure between the air chamber and surrounding water automatically adjusts pitch of wings upward and downward thereby keeping unit on a constant glide path.

* Special features : the main cable was equipped with 2 "Reflex nylon dummy elements" or, stretching elements. The first one was installed between the pig and the first trace, the second one between the last trace and the tail buoy (catamaran). The use of these two elements considerably reduces the noises which propagate at 1500 m/s (the components of these noises are in the seismic frequency band 20 - 50 Hz, thus, their apparent wave length λ is between 75 and 30 m).

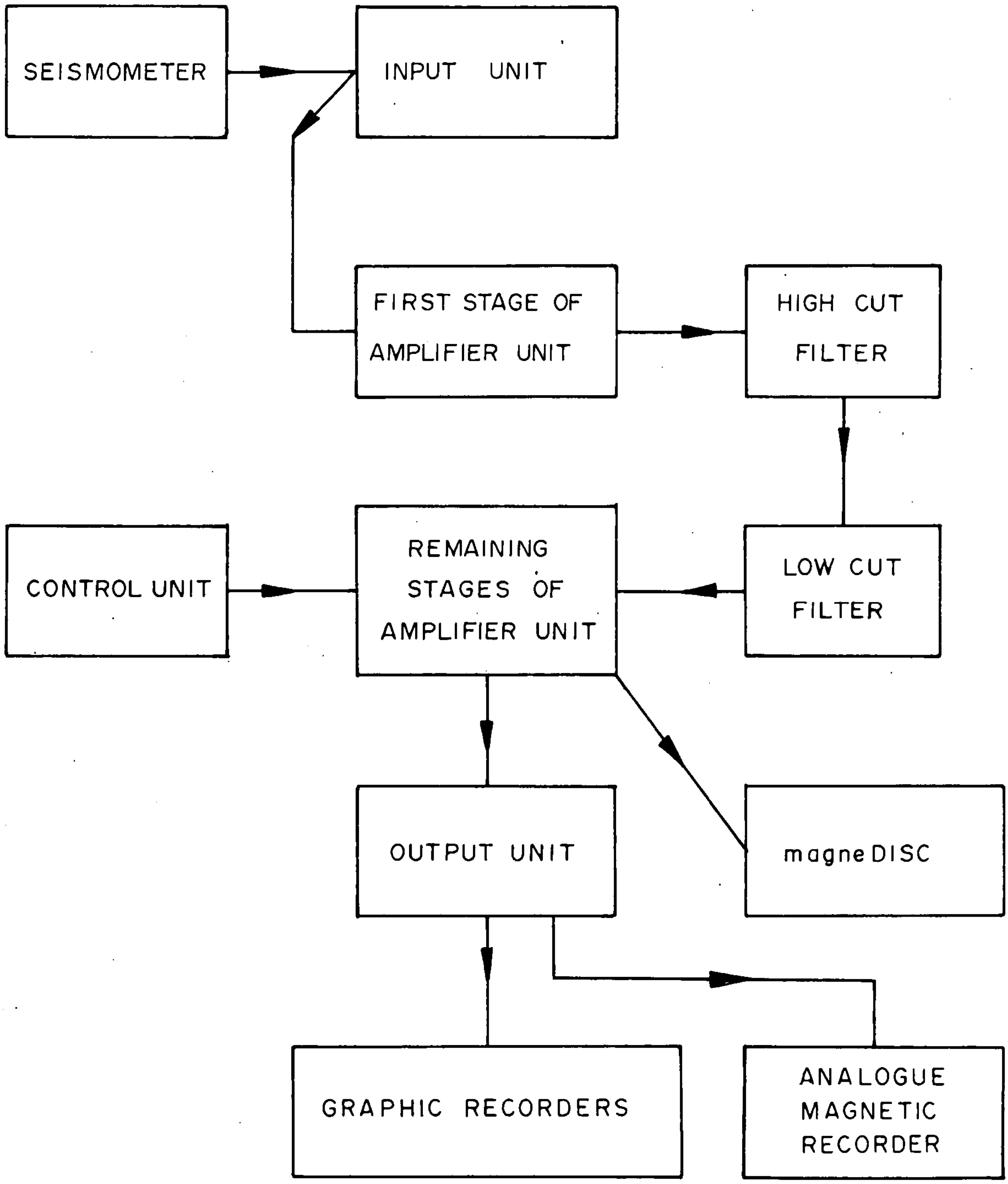
* Modifications to the main cable : the most noteworthy modification occured during survey 15, cruise 1. Following the loss of the main cable in heavy seas, a new cable was designed from the spare traces kept on board the ship ; its geometrical configuration is given in Fig. 24.

b) - GEOTECH cable

* The GEOTECH cable, often referred to as "shallow cable" is a high resolution type cable designed by better resolution of High Frequency shallow reflections.

FIG. 26

HTL 7000B
FLOW DIAGRAM



Note : The 7000 B is a valves equipped seismic amplifier

* The geometrical configuration is given in Fig. 25.

* The hydrophones are of the type HP-1 (manufactured by RECON Electronics Corp. Houston) and the active section is fitted with 28 detectors spaced 1.5 feet apart and spread over 40 feet plus a separate set of 6 detectors spaced 1.5 feet apart located in the center of the 40 feet active length. Each array is connected to a different self powered preamplifier. The cell which powers the amplifiers has a charge life of about 180 hours and can be recharged in twelve hours.

* The towing depth of the GEOTECH cable was controlled from the ship by pneumatic means.

III.3.3 - Seismic Amplifiers

* During the two main surveys (05 and 10 to 19), three different seismic amplifiers were used :

  - HTL 7000 B : during surveys 05 and 10
  - Sercel AS 626 X : from survey 11 to survey 16, cruise 2
  - SIE PT 700 : from survey 16, cruise 3 to survey 19.

a) - HTL 7000 B

* General principle : (Fig. 26)

- The inputs go to the Input Unit for metering and paralleling. For a normal shot, the Input Unit is not a part of the circuit.

- For a normal shot, the inputs are fed directly to the Amplifier Units. After the first stage of amplification which is not affected by AGC, the signals are filtered by the High and Low Cut Filter Units.

- After filtering, the signals return to the remaining stages of the Amplifiers where the AGC control signal from the Control Unit limits the gain to a pre-determined level.

HTL 7000B : TECHNICAL CHARACTERISTICS

NUMBER OF CHANNELS	UP TO 24
FREQUENCY RESPONSE	3 DB, 5 TO 500 CPS.
AGC EFFECTIVE	7 CPS UP
DISTORTION	LESS THAN 1 % INPUT STAGE (BEFORE FILTERING) WITH INPUT VOLTAGE OF 50 mV OR LESS.
CROSS FEED	BETTER THAN - 70 DB, CHANNEL TO CHANNEL
INPUT	50 hy TRANSFORMER
OUTPUT IMPEDANCE OF AMPLIFIER UNIT	6.7 OHMS NOT LESS THAN 2 OHMS (DAMPING RESISTANCE ADDED TO MATCH GALVANOMETERS).
LOW CUT FILTER	TYPES K, L, KK, MK, MM 12 CUT - OFF FREQUENCIES FROM 18 TO 210 CPS.
HIGH CUT FILTER	TYPES K, L, KK, MK, MM 12 CUT OFF FREQUENCIES FROM 20 TO 320 CPS.

POWER REQUIREMENTS

AMPLIFIER SYSTEM	40 AMPS, 12 V 150 ma, 100 V	24 CHANNELS
DYNAMOTOR	10 AMPS, 12 V	
CAMERA	14 AMPS, 12 V	

NOTE : THE PRESENCE OF A HIGH FREQUENCY NOISE IN THE AMPLIFIER OUTPUT EQUAL TO APPROXIMATELY 0.2μ VOLTS AT THE INPUT, IS A NORMAL INDICATION OF THE IMPROVED HIGH FREQUENCY RESPONSE.

- The outputs of the Amplifiers go to the output unit for mixing, if desired, and then, to the Magnetic recorder and the analogue paper recorders.

* A tabulation of the technical characteristics is given in Fig. 27.

b) - SERCEL AS 626 X

* General principle (Fig. 28)

- Common Gain Thresholds.

The input signal is attenuated so as to allow the adaptation of gain control possibilities (range 100 dB) to the energy of the shot. These attenuations can be individually regulated by amplifier from 0 to 50 dB, in 5 dB steps. The values which can be set up are from 0.1 μV to 32 μV.
As a rule, the thresholds should be identical for all the traces. However, when for whatever reason, it is found that a trace is more or less sensitive than the others, it is necessary to restore the balance with the help of that trace's attenuator. (Increasing the threshold level means diminishing the amplification of the corresponding trace).

- Automatic volume control : A.V.C.

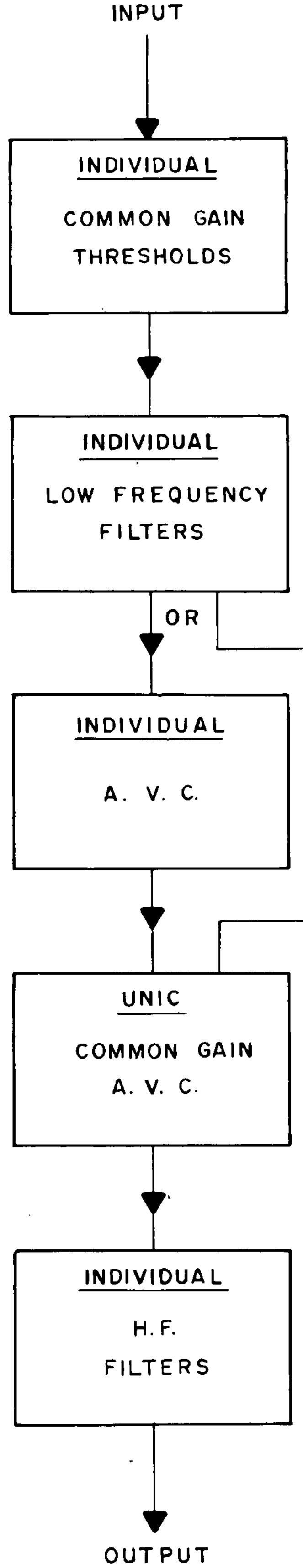
The individual A.V.C. circuits included in the amplifiers allow these to sustain level which surpass the upper limit of the range of common gain. These A.V.C. circuits can be by passed or adjusted to admit very high levels from the commencement of recording.
When the individual A.V.C. of an amplifier is working, the gain of that amplifier is unknown.

- Common Gain AVC

It operates continually but has two phases :

* Initial phase during which the "compression" speed is relatively high (from 15 dB/s to 70 dB/s depending on the type of the amplifier) and the expansion speed is great (about 200 dB/s) ; a HF signal can be added to the LF of the traces (pre-suppression).

FIG. 28



AS 626 X - SIMPLIFIED FLOW DIAGRAM

Note : The 626 X is a completely transistorized seismic amplifier

* Final phase during which the "compression" speed becomes very slight (less than 4 dB/s) ; a HF signal can be added to the low frequency. The passage from initial to final is governed by a relay the triggering of which can be delayed with regard to time break from 100 to 1200 milliseconds by steps of 100 ms or from 50 to 600 ms by steps of 50 ms.

c) - SIE PT 700

* Main characteristics : for field recording, there are separate master "early" and final gain controls. Additional individual early gain trimmers are provided to adjust first arrival amplitudes for various spread configurations.

Metering is provided for signal levels, all vital voltages, control signals and geophone continuity and leakage.

Dual line balance controls provide for minimum 60 cps interférence.

* A simplified flow diagram is given in Fig. 29.

* Figure 30 gives the technical characteristics for one amplifier TGA 7.

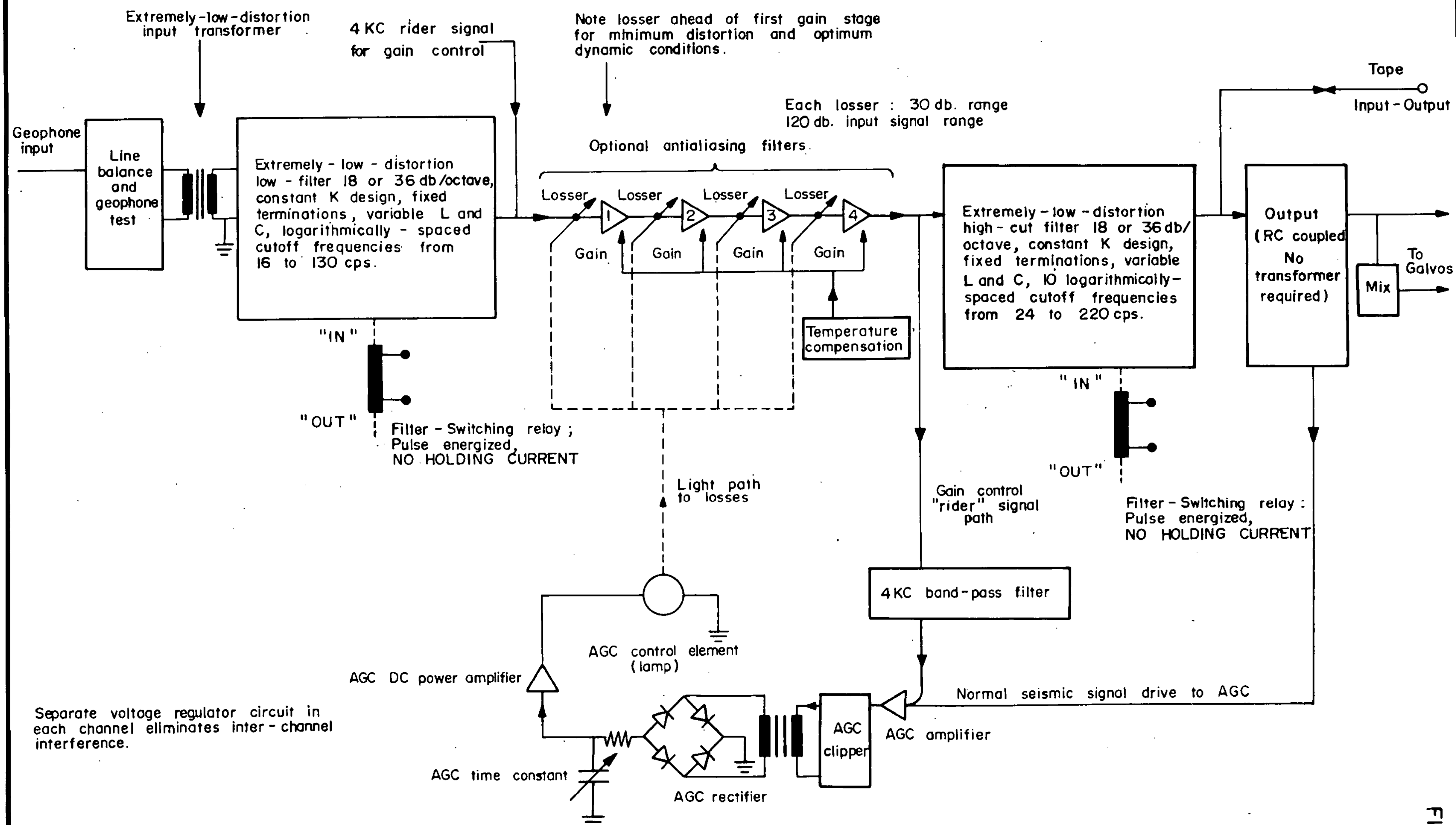
* Figure 31 shows the organization of the seismic room with the PT 700 in use.

III.3.4 - Analogue recorders

a) - Magnetic recorder

* The magnetic recorder used during the whole survey was an AMPEX, Model FR 1300.

* Technical characteristics



SEISMIC AMPLIFIER PT700 – SIMPLIFIED FLOW DIAGRAM

FIG. 29

SEISMIC AMPLIFIER PT 700 TECHNICAL CHARACTERISTICS

TRANSISTORIZED GEOPHYSICAL AMPLIFIER (TGA-7)

ITEM	DESCRIPTION
INPUT POWER	- 20 V dc (Reg.) 125 ma + 15.5 V dc (Reg.)14 ma - 12 V dc, momentary for filter IN/OUT switching 0.75 ma for 20 m sec per relay (3 relays per amplifier)
INPUT SIGNAL	
Standard Impedance	2500 Ω shunted by 800 h primary inductance
Level	0.3 μV to 1 V rms (with input configuration as above)
LINE BALANCE	Dual controls for high-line rejection (capacative and resistive).
FREQUENCY RESPONSE	
High Level Output (With AGC in OFF or SLOW-SLOW positions)	Within 3 db, 3.0 to 250 cps for a 1 msec sampling rate. Within 3 db, 3.0 to 125 cps for a 2 msec sampling rate.
High Level Output (With AGC in FAST, MEDIUM, or SLOW positions)	Within 3 db, 6.0 to 250 cps for a 1 msec sampling rate. Within 3 db, 6.0 to 125 cps for a 2 msec sampling rate.
AUTOMATIC GAIN CONTROL	
Control Range	1 μV to 1 V
Speed Selection	FAST, MEDIUM, SLOW, SLOW-SLOW.
GAIN CONTROL	External 4 KC rider signal applied for control Control Range - 80 db above 1 μV.
GANGED AUTOMATIC GAIN	Control Range - Approximately 110 db.

ITEM	DESCRIPTION
DISTORTION (TOTAL)	
Steady State	Less than 0.2 % , 1 μV to 100 mV 8 to 250 cps with 1 msec sampling rate.
	Less than 0.2 % , 1 μV to 100 mV 8 to 125 cps with 2 msec sampling rate.
15 db Burst-Out	Less than 1.7 % , 1 μV to 100 mV 20 to 250 cps with burst-out up to 15 db.
NOISE	0.1 μV peak-to-peak for 10 to 100 cps, 0.30 V, peak-to-peak, for 5 to 200 cps.
HIGH LEVEL OUTPUT AMPLIFIER	
Impedance	900 Ω.
Nominal Gain	10 (Range of approximately 6 to 30).
Nominal Level	6 V peak-to-peak with 15 db burst-out capability.
Maximum Level	20 V peak-to-peak.

BLOCK DIAGRAM OF THE ORGANISATION OF THE SEISMIC ROOM WITH PT 700 IN USE

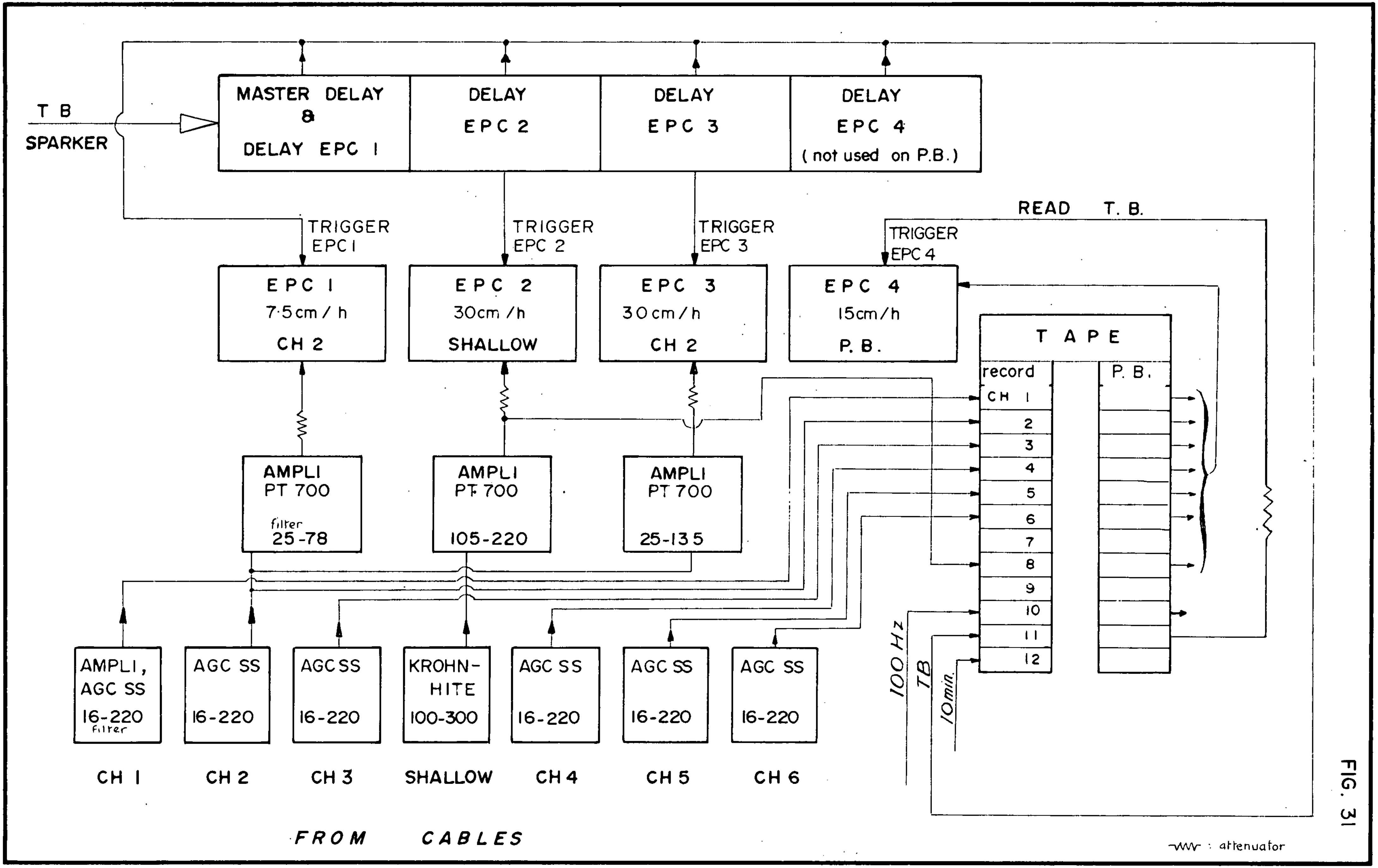


FIG. 31

- Magnetic tape
  - Width : 1"
  - Length : 2400'
  - Spool : 10.5" diameter
  - Hub : 3" diameter NAB
  - Speed : 15/16" per second

- Recorder
  - Channels : 14

* Channel functions

1	:	CGG long cable, trace 1	FM
2	:	CGG long cable, trace 2	FM
3	:	CGG long cable, trace 3	FM
4	:	CGG long cable, trace 4	FM
5	:	CGG long cable, trace 5	FM
6	:	CGG long cable, trace 6	FM
7	:	Stacked trace	FM
8	:	GEOTECH shallow cable	FM
9	:	Refraction	FM
10	:	100 Hz	FM
11	:	Time break (and delays)	FM
12	:	10-minute mark	FM
13	:	Nil	FM
14	:	Spit-out - move out corrected	FM

b) - Graphic recorders

* Several different graphic recorders were used during the surveys :

- EG and G recorders : used during survey 05 and surveys 10 to 12.

- Esterline Angus recorders : used during survey 05 and surveys 10 and 11.

- Raytheon recorder : used during survey 05, cruise 5 and survey 10.

- EPC recorders : used from surveys 12 to 19.

Only EG and EPC graphic recorders will be described here.

b.1) - EG and G recorders

* The equipment used was the Model 254.
* Description of recorder : This completely transistorized recorder utilizes an 11-inch helical recording head ; it has stable sweep speeds which provide eight depth scales between 120 and 24,000 feet which are selected by a step switch. The fixed speed settings are accurate to ± 1 % with trim adjustment. A continuously variable helix speed control of 0 to 1000 rpm is supplied as that the equipment can be synchronized to independent sources of signals.

Reference lines, calibrated in milliseconds, are selectable with an adjustment for line darkness.

Frequency-selective filters (active transistor type with 30 db per octave) in six bands are supplied. Switches are provided to use or to bypass any or all of the filters as desired. Provision is also made to select from 1 to 6 sweeps per trigger from the recorder drum with selective printing.

* Recording Mechanism : The ALDEN recording head contains a helix wire mounted on a revolving drum and a steel blade loop electrode. The special electrochemical paper is placed between the two electrodes and slowly advance by means of rubber pressure rollers. As the helix wire electrode revolves, its contact point with the blade electrode sweeps across the paper. To make a graphic impression on the paper, current is passed from the blade electrode at the point of contact through the paper to the helix electrode. The variable current (varies with signal strength) and produces a chemical reaction which deposits iron ions on the paper. The blade electrode is slowly moved by two small clock type motors to prevent uneven wear.
* A summary of main characteristics is given in Fig. 32.
* Up to two EG and G recorders were used during the survey.

E G and G MODEL 254

SUMMARY OF LEADING PARTICULARS

DEPTH SCALES	120 : 250 : 600 : 2400 : 6000 : 12,000 AND 24,000 FEET
HELIX SPEED ADJUSTMENTS	1 TO 1000 RPM
CALIBRATED REFERENCE LINES	10 : 40 : 100 : 400 : 1000 MILLISECONDS
FILTER BANDS	20 - 80 CPS 80 - 200 CPS 200 - 800 CPS 800 - 2000 CPS 2000 - 8000 CPS 8000 - 20000 CPS
INPUT IMPEDENCE	100 KILOHMS
MIN. INPUT VOLTAGE	10 μ VOLTS AT MAX. SWEEP SPEED
MAX. INPUT VOLTAGE	1 VOLT
OUTPUT TRIGGERS	+ 12 VOLT OR + 300 VOLT PULSE
POWER REQUIREMENTS	115 VOLTS : 50 - 60 CPS. : 200 WATTS
OUTLINE DIMENSIONS	22 - 1/2 INCH. x 33 INCH x 8 INCH. (WITH COVER ON, HEIGHT INCREASES TO 12 INCH.)

b.2) - <u>EPC recorders</u>

* The equipment used was the Model 4100.

* Principle of operation

The input signal is applied to the first preamplifier, whose gain can be carried from 0 to 10.

From the preamplifier, the signal is applied to an external filter and then to the linear spreading amplifier.

The linear spreading amplifier feeds a full wave rectifier with unity gain, the output of which is applied to the main print amplifier.

At this point, the signal is changed from a voltage signal to a current signal and is fed to the stylus.

The scale lines, auto event marks, and manual event marks are inserted into the print amplifier, which is the last stage of amplification ; the calibration signal is inserted into the circuit at the input amplifier stage.

A digital stepping motor drives the stylus. The clock frequency for the stepping motor is derived from a series of count down stages controlled by a 320 KHz crystal. So are the scale lines. A front panel ACCUTRON^{R} clock acts as an independent time base reference and generates the calibration signal and the auto event marks.

* Note : An external motor drive BNC connector is provided for the direct application of external pulses to the motor drive circuit.

b.3) - Cameras

* A SIE VRO 6 type Camera was installed in the seismic container at the beginning of survey 11 ; it was intensively used for checking and testing purposes.

* Main technical characteristics

Display mode : conventional wiggle, photosensitive paper or film (or variable density).

Galvanometers : 28, or 32 (camera Model DF), type 11SS, 125 Hz, 62 mm/mA, 28 mm optical path.

Timing line : by "Flash" tube, driven by a frequency standard and or, external 100 Hz (camera model DF).

Paper speed = 6 inches per second.

* Note : The VRO 6 camera replaced a VISIGRAPHSANE camera and complemented a Hewlett Packard oscilloscope, type 181 A.

III.3.5 - Refraction equipment

* Refraction probes were regularly performed during the whole survey. The equipment used was :

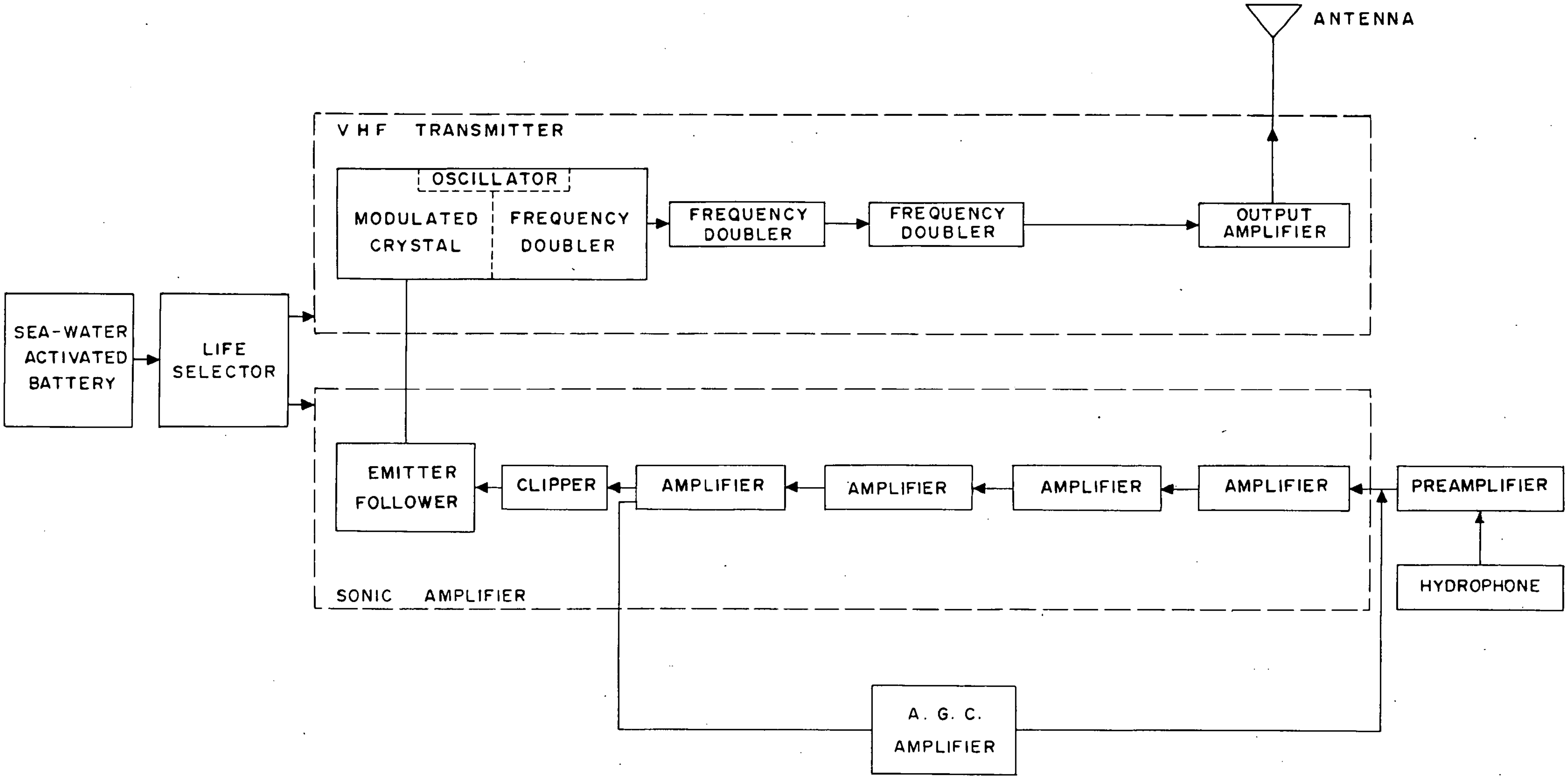
- Expendable sonobuoys, two types were successively used :
  - Model AN/SSQ-41 at the beginning of survey 05
  - Model AQUATRONICS SM42-4.
- Receiving system - The main equipment consisted of two AQUATRONICS receivers.

a) - Sonobuoys

a.1) - Model AN/SSQ-41

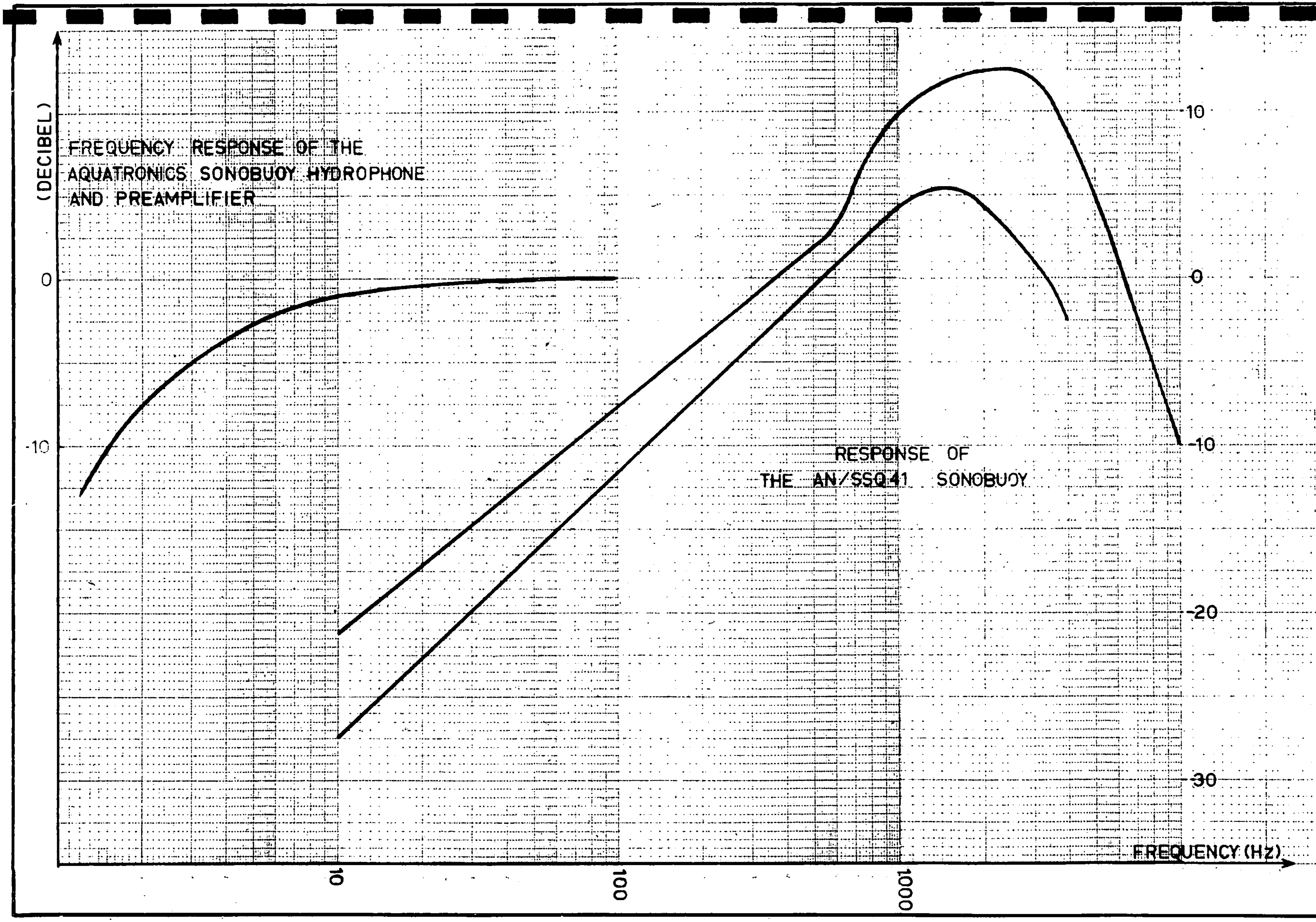
* General principle (see Fig. 33)

- Sonobuoy AN/SSQ-41 was designed to be launched from aircraft. Upon impact with the water the hydrophones release, the battery is activated and the sonobuoy becomes operative within 3 minutes. The operating depth for the hydrophones is either 60 feet or 300 feet.



SONOBUOY AN/SSQ-41, FUNCTIONAL BLOCK DIAGRAM

FIG. 33



(DECIBEL)
FREQUENCY RESPONSE OF THE
AQUATRONICS SONOBUOY HYDROPHONE
AND PREAMPLIFIER
0
-10
10
0
-10
-20
-30
RESPONSE OF
THE AN/SSQ41 SONOBUOY
FREQUENCY (Hz)
10
100
1000

FIG. 34

- Signals detected by the hydrophones are converted into electrical voltages.

- These electrical voltages are amplified by a preamplifier in the termination mass prior to being applied to the sonic amplifier.

- The output of the preamplifier is amplified by the sonic amplifier to a level sufficiently high to modulate the transmitter output.

- An AGC circuit is provided to prevent the overmodulation of the transmitter.

* The response of the system is given in Fig. 34.

* The transmitter frequency channels are given in Fig. 35.

* During the surveys, the AN/SSQ-41 sonobuoy was used by setting up manually all devices which would be put automatically into action during the fall, for example from an aircraft.

a.2) - <u>Model AQUATRONICS SM42-4</u>

* General principle (see functional block diagram Fig. 36)

- When the sonobuoy is dropped overboard, within 60 seconds the following automatically occurs : Antenna releases, Hydrophone system releases, Transmitters and all Electrical system are powered.

- Signals detected by the hydrophone are amplified and used to frequency modulate the transmitter.

* Main characteristics

- The hydrophone is omnidirectional over the frequency range of 2 to 200 Hz. The selectable hydrophone operating depths are 30 ft, 60 ft or 120 ft.

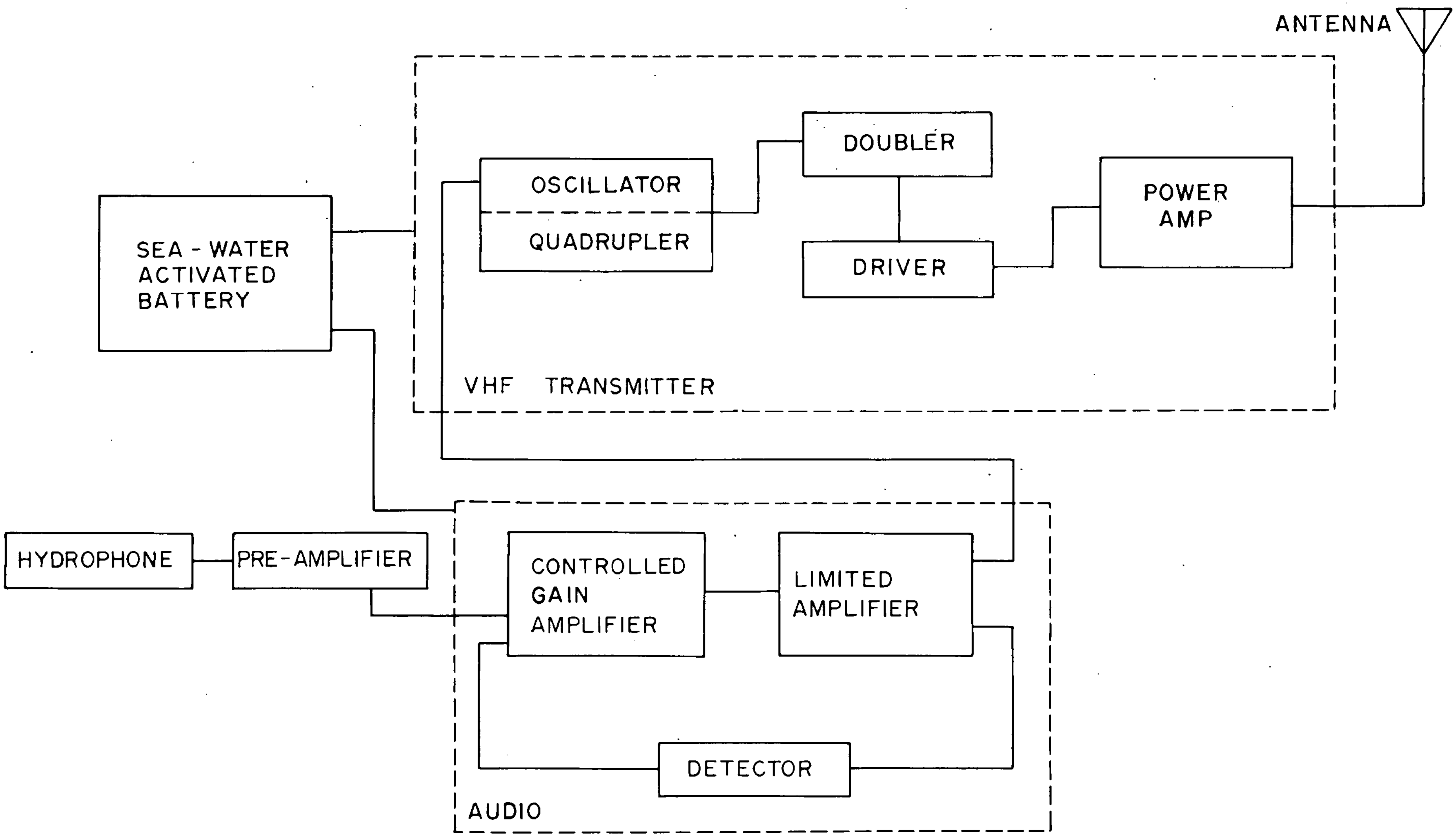
TRANSMITTER FREQUENCY CHANNELS

1. AQUATRONICS SM 42 - 4

CH.	FREQ. (MC)	CH.	FREQ (MC)
1	162 . 25	17	162 . 625
2	163 . 00	18	163 . 375
3	163 . 75	19	164 . 125
4	164 . 50	20	164 . 875
5	165 . 25	21	165 . 625
6	166 . 00	22	166 . 375
7	166 . 75	23	167 . 125
8	167 . 50	24	167 . 875
9	168 . 25	25	168 . 625
10	169 . 00	26	169 . 375
11	169 . 75	27	170 . 125
12	170 . 50	28	170 . 875
13	171 . 25	29	171 . 625
14	172 . 00	30	172 . 375
15	172 . 75	31	173 . 125
16	173 . 50		

2. AN/SSQ - 41

CH.	FREQ. (MC)	CH.	FREQ. (MC)
1	162 . 25	9	168 . 25
2	163 . 00	10	169 . 00
3	163 . 75	11	169 . 75
4	164 . 50	12	170 . 50
5	165 . 25	13	171 . 25
6	166 . 00	14	172 . 00
7	166 . 75	15	172 . 75
8	167 . 50	16	173 . 50



AQUATRONICS SONOBUOY
FUNCTIONAL BLOCK DIAGRAM

FIG. 36

- The sea water activated batteries have a minimum continuous life of 4 hours.

- The transmitter has a frequency stability within ± 25 KHz of the selected channel frequency.

- The normal floating life of the sonobuoy runs from 9 to 20 hours.

* The response of the system is given in Fig. 34.

* The transmitter frequency channels are given in Fig. 35.

b) - Receiving system

* The receivers are simple basic FM telemetering receiver.

* Note : The result of each sonobuoy was displayed on a graphic recorder and recorded on magnetic tape (Ampex recorder).

III.3.6 - Marine Processing System (MPS)

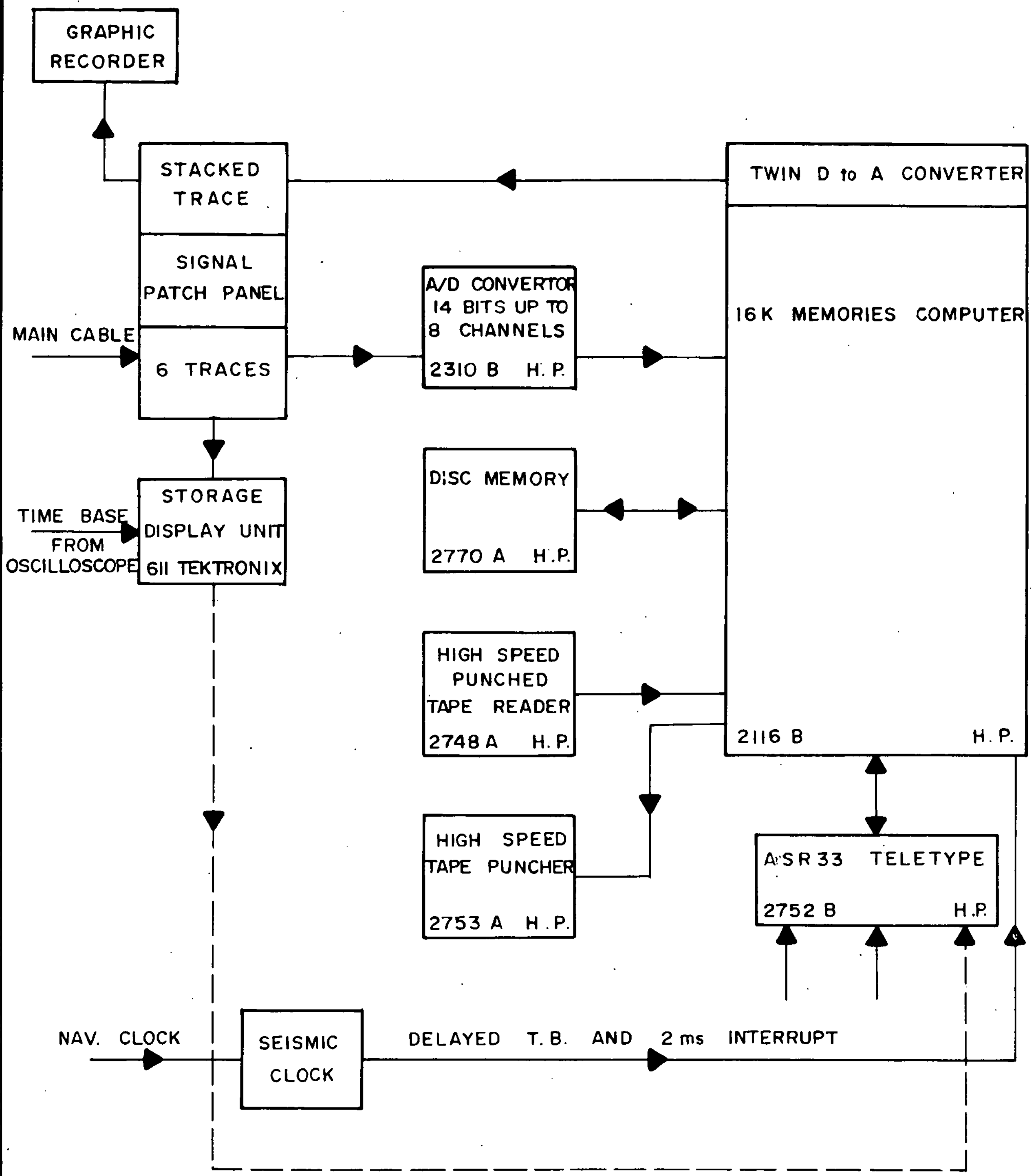
* In the MPS, data from the 6-trace cable are stored in analogue form. Hewlett Packard 2 116 B computer is used to produce stacked results as work proceeds after analogue-digital conversion.

* General principle :

Shooting is performed every 50 metres, providing four six-fold coverages which are processed on board as exploration proceeds. The data are converted to digital form by a Hewlett Packard Multiverter, corrected for normal move out and stored on a disc memory awaiting the corresponding C.D.P. traces. When four consecutive CDP traces are available, the four stacks are performed and mixed. Basic parameters (velocity function, distances, mutes) are introduced via an ASR 33 teletype.

* The simplified flow diagram of the MPS is given in Figure 37.

FIG. 37



MARINE PROCESSING SYSTEM SIMPLIFIED FLOW DIAGRAM

* The main equipment used consisted of :

i - a Hewlett Packard computer 2116 B with 16 K memory,
ii - an A/D converter Model HP 2301 B,
iii - a Disc Memory Model HP 2770 A
iv - a High Speed Punched Tape Reader, Model HP 2748 A,
v - a High Speed Tape Puncher, Model HP 2753 A,
vi - an ASR 33 teletype.

Items (i), (ii), (iv) and (vi) will be described in chapter III.5.2 (Data Acquisition System - equipment description).

* High Speed Tape Puncher HP 2753 A - Description :

The HP 2753 A operates at a speed of up to 120 characters/second or twelve times faster than the teleprinter.

Operation is asynchronous, which means that data are recorded at whatever speed the computer supplies it, up to the maximum rate of the punch.

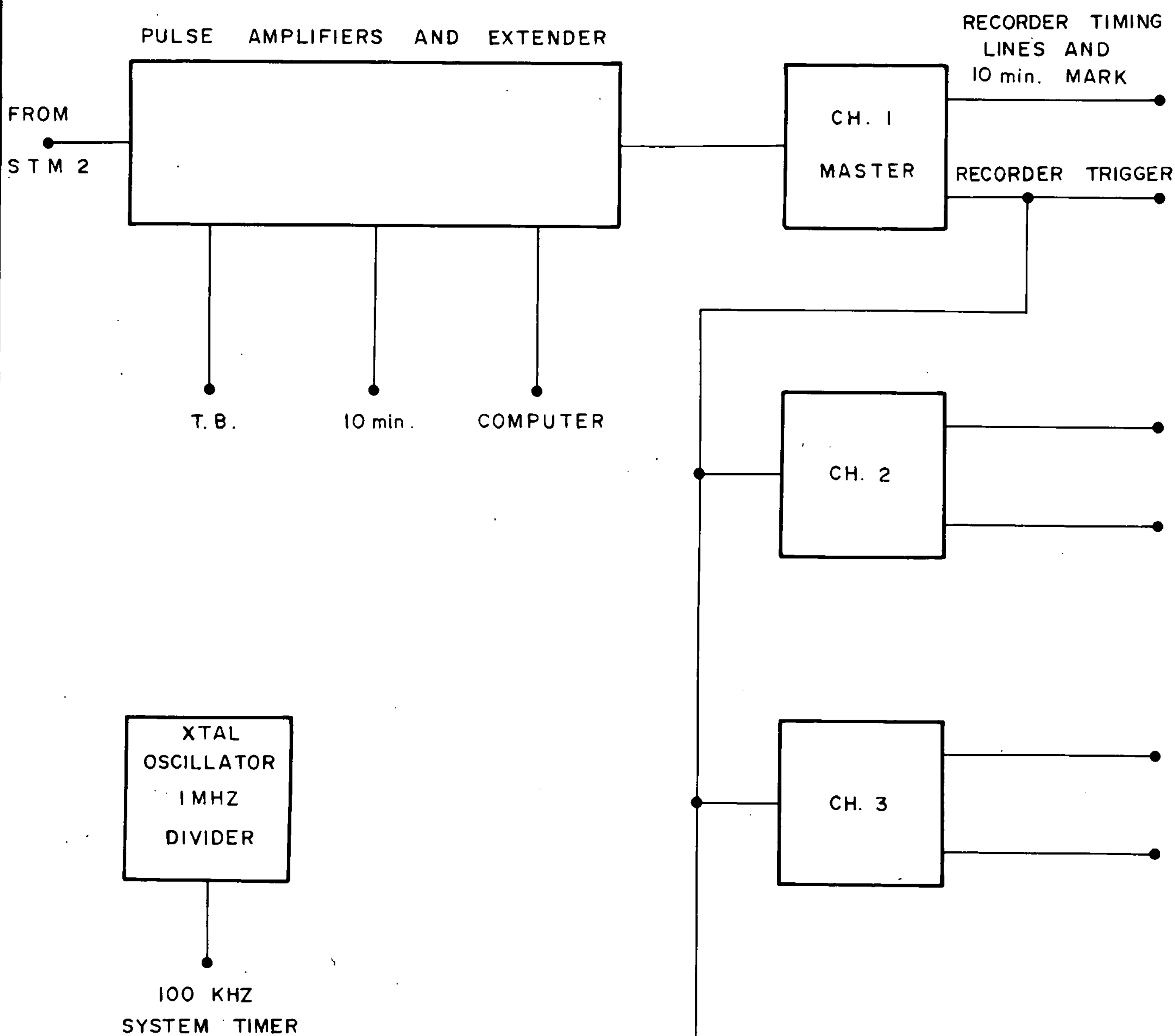
* Disc Memory HP 2770 A - General description :

The Disc Memory is a bulk storage medium ; it consists essentially of a magnetic oxide coated disc (protected by rhodium plating) which rotates in contact with a read/write head. The data is recorded as a series of magnetically saturated points along the circular track traced by the head. As on magnetic tape, information can be read without destroying it, or it can be erased and new information recorded in its place.

Note : The marine processing equipment was disembarked at the beginning of survey 14.

III.3.7 - BMR seismic clock SMX3

* The SMX3 or Delay Box, provided the recorders timing lines and the 10-minute mark.



DELAY BOX SMX 3
CONNECTION DIAGRAM

* Figure 38 is an explanatory drawing of the SMX3 function.

III.4 - BATHYMETRIC SYSTEMS (Enclosure 6)

* Three different bathymetric systems and one Digitizer were used during the whole survey ; they are :

- ATLAS DESO EDIG Echosounder ; was used from survey 05 to survey 19,
- ELAC Echosounder ; was used from survey 05 to survey 19,
- DIGITRACK-EDO digitizing system ; was used from survey 10 to survey 19,
- RAYTHEON sounding system ; was used from survey 14 to survey 19.

III.4.1 - ATLAS DESO EDIG Sounder

* This sounding system is equipped with two transducers :

- a 30 Kc transducer for work in deep water
- a 210 Kc transducer for work in shallow water.

The two transducers are magnetostriction type.

* The ATLAS system provides two outputs :

- an analogue output displayed on a graphic recorder,
- a digital output displayed on a display panel and sent to the Data Acquisition System via the SERCEL interface.

* Performance range

- Analogue output : 1500 metres
- Digital output : 1000 metres

III.4.2 - ELAC Sounder

* This sounding system is equipped with a 20 Kc magnetostriction type transducer (A magnetostriction transducer transforms electric impulses into mechanical oscillations of ultra-sounds and reverse).

* This system provides an analogue output displayed on a ELAC graphic recorder.

* Performance range : 4000 metres.

III.4.3 - DIGITRACK System

* This system is a digitizer to use in conjunction with an other equipment, such as the ELAC or a seismic cable for example.

* Theory of operation :

- Measurement of depth is made by measuring the time difference between the transmitted pulse and the echo from the bottom. (A two-way sound path is based on a velocity of sound in water of 1500 metres/second).

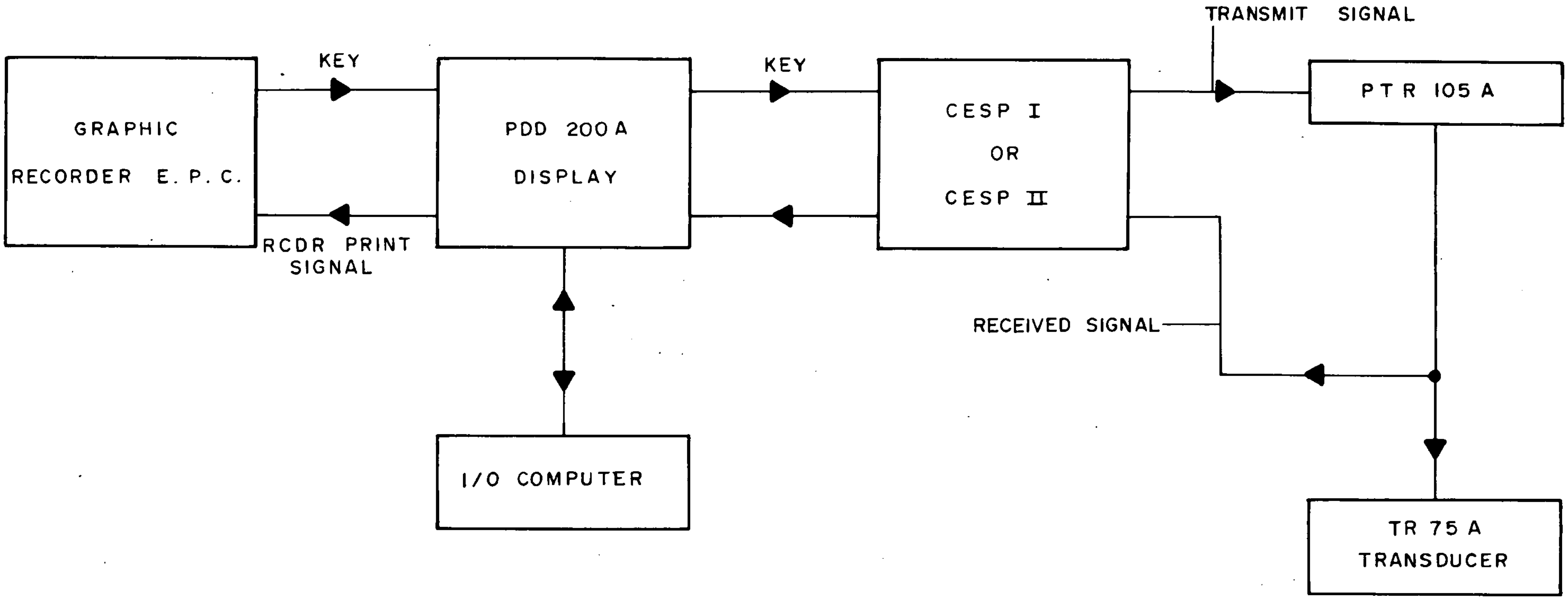
- Problem of the identification of the proper return : the effects of unwanted reflections and reverberations are limited by means of a tracking gate. During the time interval that the gate is open, an adjustable detector threshold at the input circuit rejects any received signal below the threshold voltage. Also, an AGC input circuit whose gain is dependent upon the ambient sea state noise conditions is used to maintain a constant 10 db signal-to-noise ratio for all echoes, even in the presence of rapidly changing sea state noise conditions.

- Once the proper echo has been received, the depth information is transferred to memory circuits.

- The stored information is available for numerical display or for transfer to external data handling equipment.

III.4.4 - RAYTHEON sounding system

* This bathymetric system is basically composed of 5 main parts :



SIMPLIFIED FLOW DIAGRAM OF THE RAYTHEON SYSTEM

FIG. 39

- Transducer (TR)
- Transceiver (PTR)
- Precision Depth Digitizer (PDD)
- Correlator (CESP)
- Analogue recorder

* Description (See Fig. 39)

- TR model 75 A - This transducer is designed for use in the 3.5 to 4.5 KHz frequency range. The active radiating portion is a circular piston, driven by lead zinconate-titonate elements.

- PTR model 105 A - This transceiver is a complete 2000 watt sonar transmitter, combined with a highly sensitive receiver. Main characteristics are given in Fig. 40.

- PDD model 200 A : converts bottom echoes into digital numbers ; basically, the Digitizer is a counter which counts a selected frequency from time of transmission to time of echo reception. Thresholding, reverberation gating and selection of first peak, or last echo in the gate reduces the probability of false alarms and of initiating track or interfering echoes (see Fig. 41).

- CESP : it consists of transmitter preamplifier receiver amplifier, shift register matched filter, timing and synchronising, and output conditioning circuits. It is a comparison type of echo sounder which uses replica correlation signal processing to provide reliable bottom depth data for profiling.

- Recorder : the model used was an EPC 4100 (description of this recorder is given in the seismic chapter). In the Raytheon system, the recorder controls the timing of the system and keys the correlator which generates the transmit signal to the receiver.

TRANSCEIVER PTR 105 A

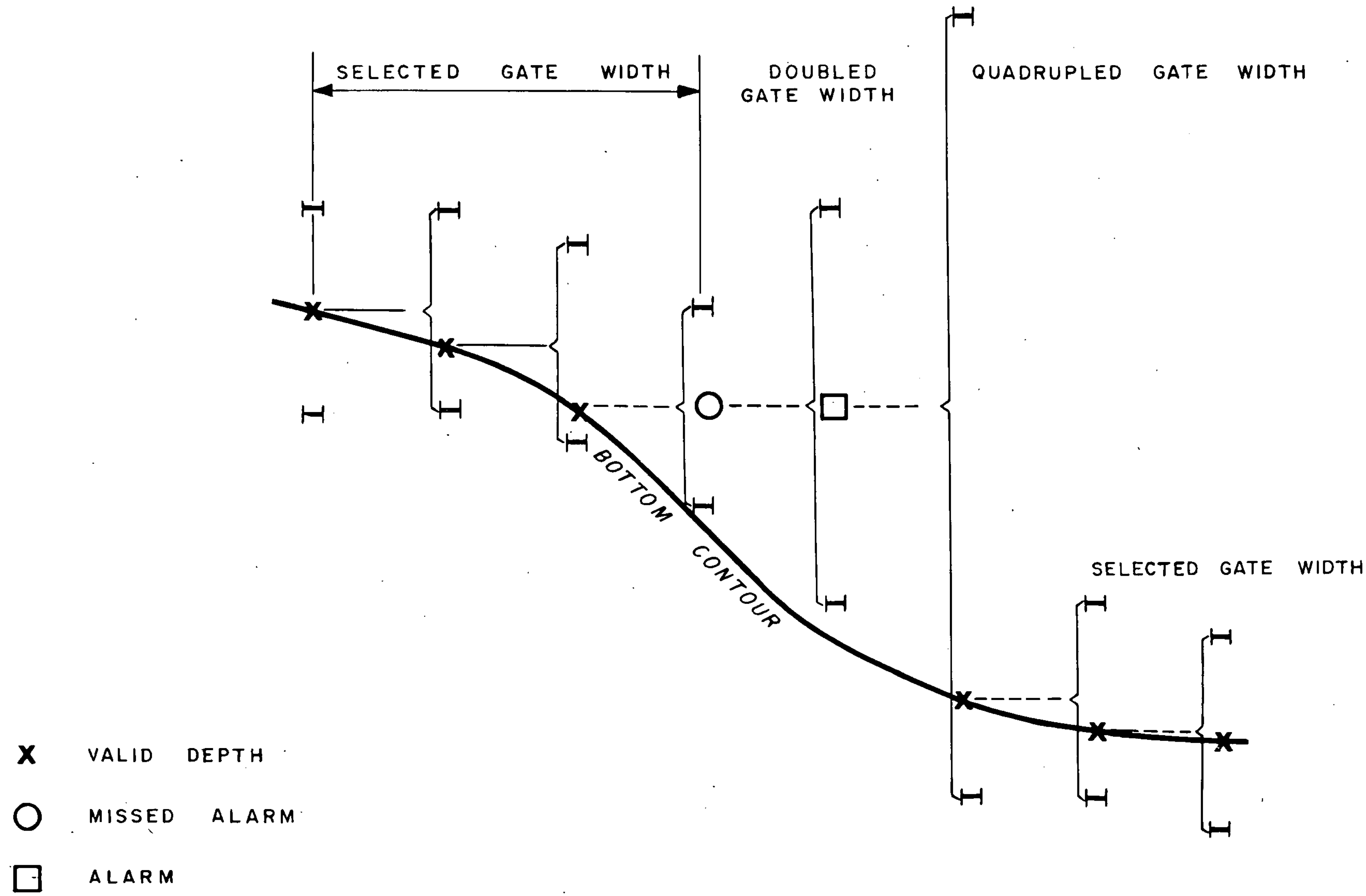
MAIN CHARACTERISTICS

TRANSMITTING SECTION

POWER OUTPUT	2000 WATTS
PULSE LENGTH	VARIABLE : 0.1 msec. to 30 msec
MAXIMUM PULSE RATE	480 PPM
TRANSMIT FREQUENCY	2 kHz TO 50 kHz
DRAFT COMPENSATOR	0 TO 50 FEET

RECEIVER SECTION

FREQUENCY	2 kHz TO 50 kHz
BAND WIDTH	2 kHz STANDARD
MINIMUM DETECTABLE SIGNAL	0.5 V
GAIN	106 DB
GAIN CONTROL	2 MODES, MANUAL HIGH / LOW AND AGC SLOW / FAST



RAYTHEON PRECISION DEPTH DIGITIZER
GATE SYSTEM

FIG. 41

III.5 - DATA ACQUISITION SYSTEM (DAS) (Encl. 6)

III.5.1 - Theory of operation (Fig. 42)

* Thirty two information channels are recorded in analogue and digital form for cross-checking and back-up purposes. Channels 1 to 12 have their own logic source but had to be adapted and interfaced with the computer. Channels 13 to 32 are recorded in analogue form ; they are converted from A to D via the Hewlett Packard 2310 B multivertes. The sampling interval, triggered by the BMR master clock, is 10 seconds. Information is buffered in the computer, and then recorded onto the magnetic tape in blocks of 2.5 minutes, i.e. 15 scans.

III.5.2 - Equipment

* The equipment which composed the DAS was as follows :

- a H.P. 2116 B computer
- SERCEL interface
- Tapes recorders : HP 2020 B and HP 7970
- a multiverter : HP 2310 B
- ASR 35 teletype
- BMR master clock STM II
- High speed punched tape input HP 2748 A.

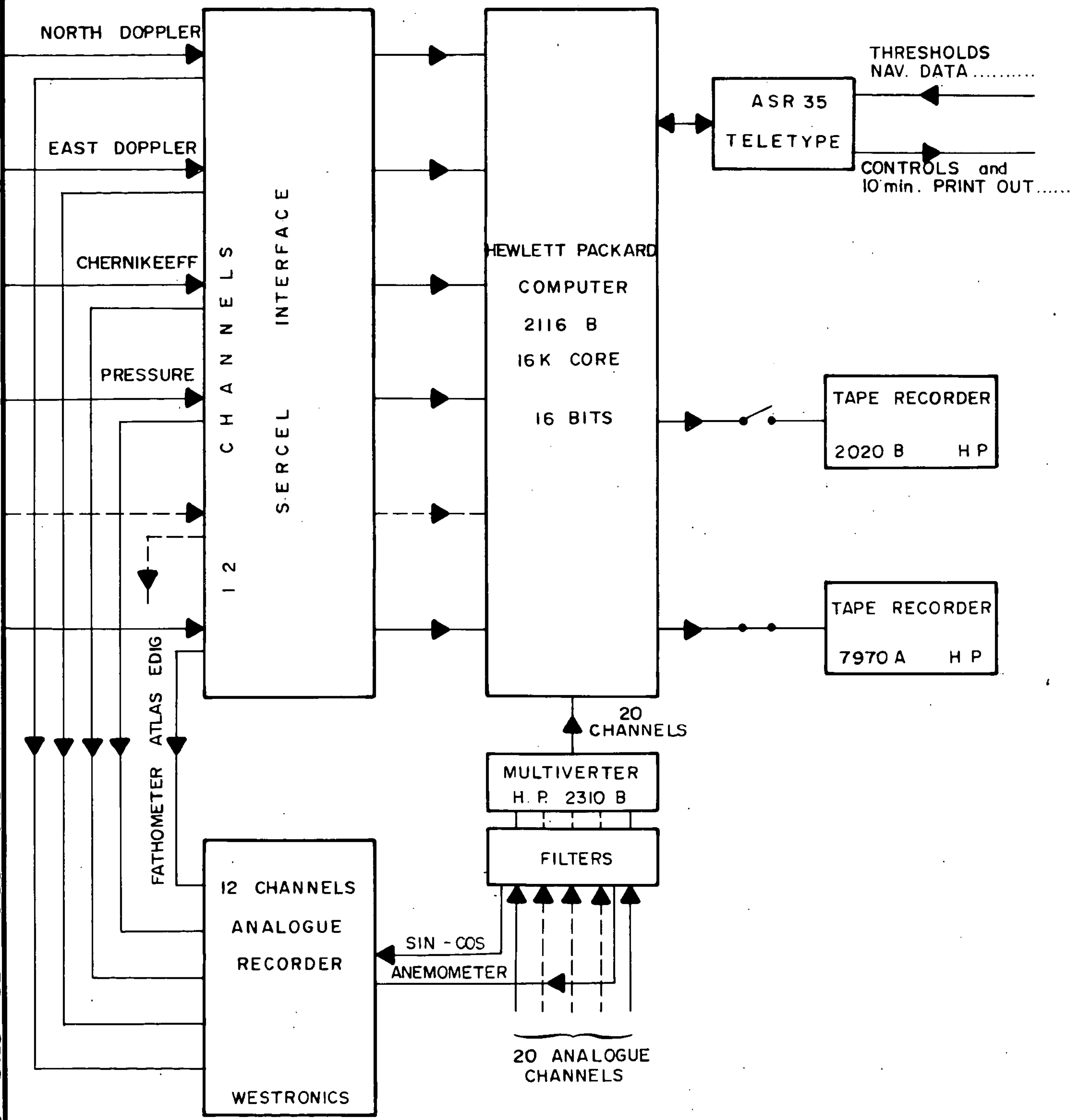
a) - HP 2116 B computer

* Principle of operation (See Fig. 43)

- Input section : its basic function is to translate the external data from the form in which it is received, into a form in which it can be stored in the computer memory.

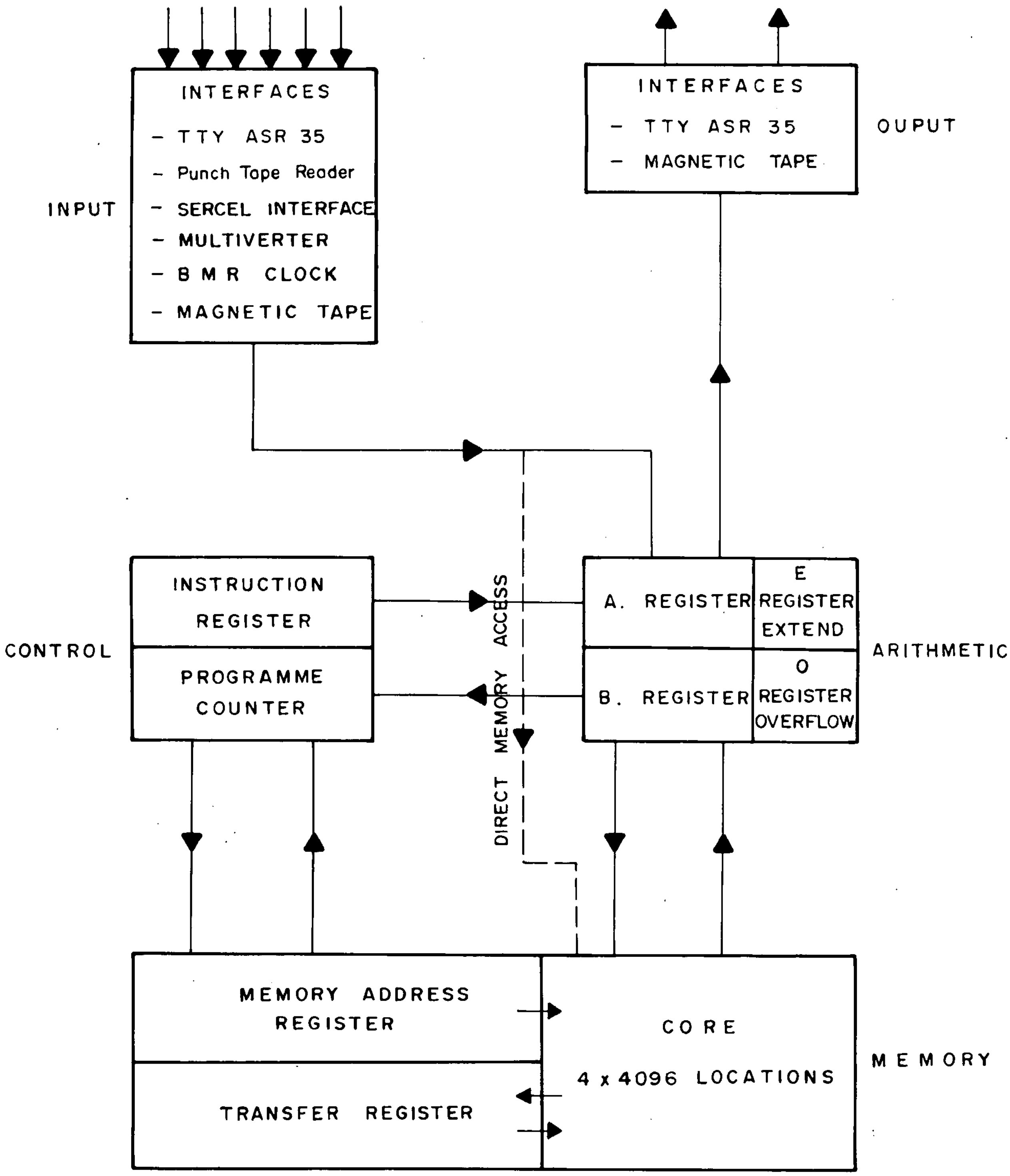
- Arithmetic unit : it is used to perform calculation and to manipulate data - there are two sixteen bit working registers, A and B, addressable as 0 and 1 respectively, and two one bit working registers, E (extend) and O (overflow).

FIG. 42



SIMPLIFIED FLOW DIAGRAM OF THE D. A. S.

FIG. 43



SIMPLIFIED FLOW DIAGRAM
OF HP 2116 B TYPE COMPUTER

- Memory : it consists of an intricate matrix of ferrite cores, each capable of storing 1 bit of information. During the BMR surveys, the storage was made of $40,000_8$ $(16,384_{10})$ words of 16_{10} bits with one extra parity bit for each word.

- Memory speed : An internal 10-megahertz timing generates read/write memory cycles every 1.6 μ.seconds. There are four machine phases, fetch, indirect, execute, interrupt, of which the first three include a memory cycle. Thus a load register instruction, without an indirect phase takes 2 cycles or 3.2 μ.seconds.

b) - SERCEL Interface

* It interfaced data from 12 channels with the HP 2116 B computer. A simplified flow diagram is given Fig. 44.

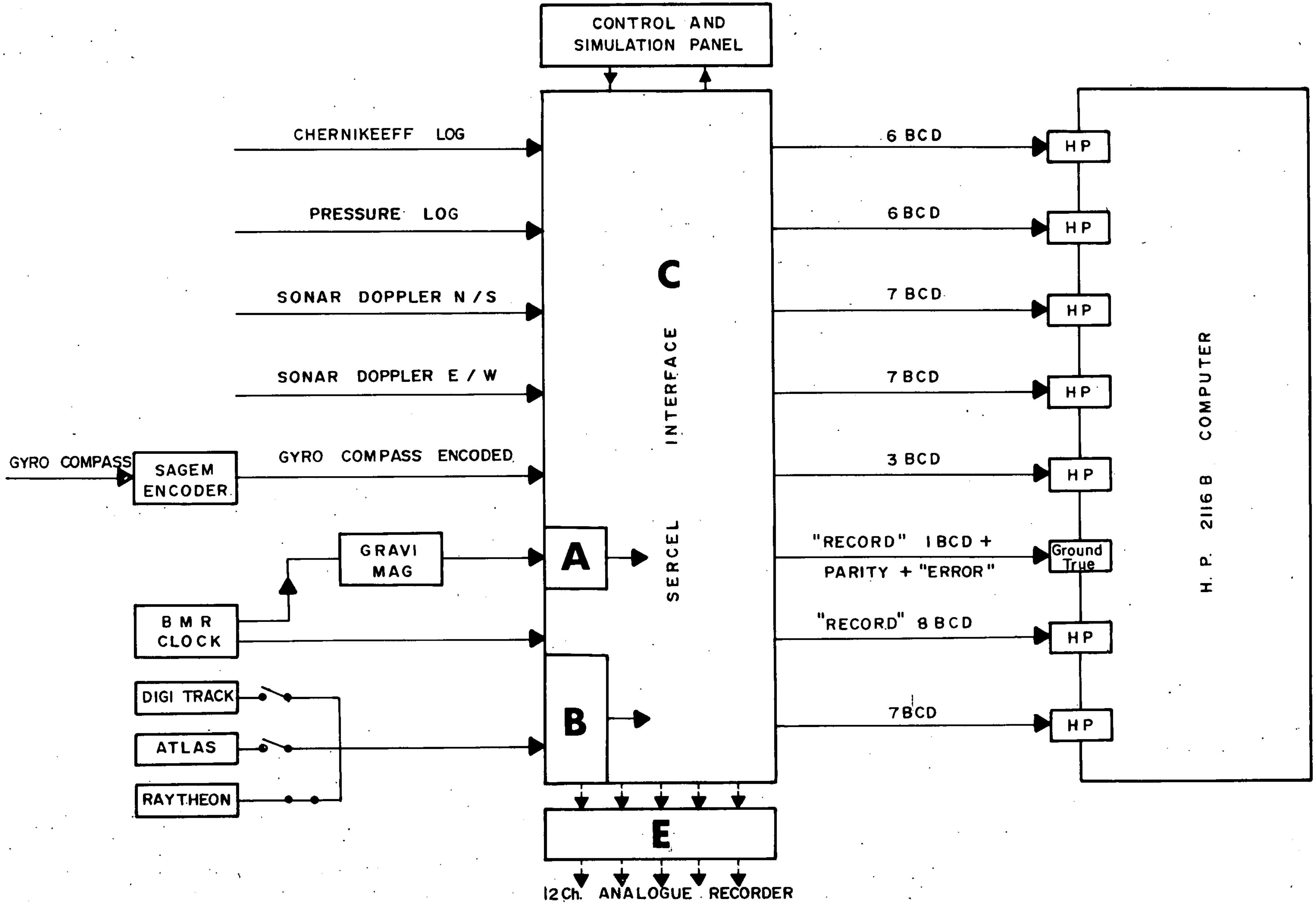
* The SERCEL interface is composed of 5 compact sets :

- Set A : adaptation of gravity-magnetism for line transmission
- Set B : inputs the Atlas Edig or Edo Digitrack outputs and sends them to the computer through Set C
- Set C : final outputs to computer and test panels
- Set E : five converters with resolution 1/100 used to send Logs, Sonar Doppler and sounder data to the 12-channel analogue recorder
- A special panel allows it to simulate any input and to display any output.

c) - Tape recorders

c.1) - HP 2020 B

* This tape recorder was used in operations from survey 05 to survey 13 ; from beginning of survey 14, it was replaced by the HP 7970 A but kept on board as a spare recorder.



SERCEL INTERFACE FLOW DIAGRAM

FIG. 44

* Main characteristics :

- Tape speed is 30 ips
- The HP 2020 B reads and records at both 200 and 556 bpi
- Data read/write rates are : 6,000 characters/second at 200 bpi, and 16,700 characters/second at 556 bpi.

c.2) - HP 7970 A

* Main characteristics :

- Tape speed is 25 ips
- Density used : 556 bpi
- Data read/write rate is : 13,900 characters/second at 556 bpi.

d) - Multiverter HP 2310 B

* General description : This instrument combines an A-D converter, sample and hold amplifier and multiplexer in one chassis. Resolution is 13 bits (plus sign bit) for a 50 nanosecond aperture time. Multiplexing capacity is 64 channels standard. Conversion rate, including multiplexing is 18 KHz. Input range is $\pm$ 10 volts, full scale.

e) - ASR 35 Teletype

* Main characteristics : This device combines a typewriter, punched tape reader and tape punch.

Data and instructions may be entered from punched tape or the key board.

Output information is always recorded on the typewriter, and may be recorded simultaneously on the tape punch.

The teleprinter operates at a speed of 10 characters/second for both data entry and recording. (The teleprinter is a bit serial entry device, but buffer storage is included in the interface to permit transfer of complete 8-bit characters at a time, thus saving the time that would otherwise be lost in servicing interrupts for each bit).

Note : The above description applies also to the light duty ASR 33 teletype.

f) - High Speed Punched Tape Reader HP 2748 A

* A draw back of the teleprinter is its slow operating speed, both in reading and punching tape.

* Operation : the H.S.P.T.R. is a photoelectric device that reads tapes at 300 characters/second, thirty times faster than the teleprinter.

The roll of tape to be read is placed in a container mounted on the front panel. After reading, the tape is rewound on a separate rewinding unit.

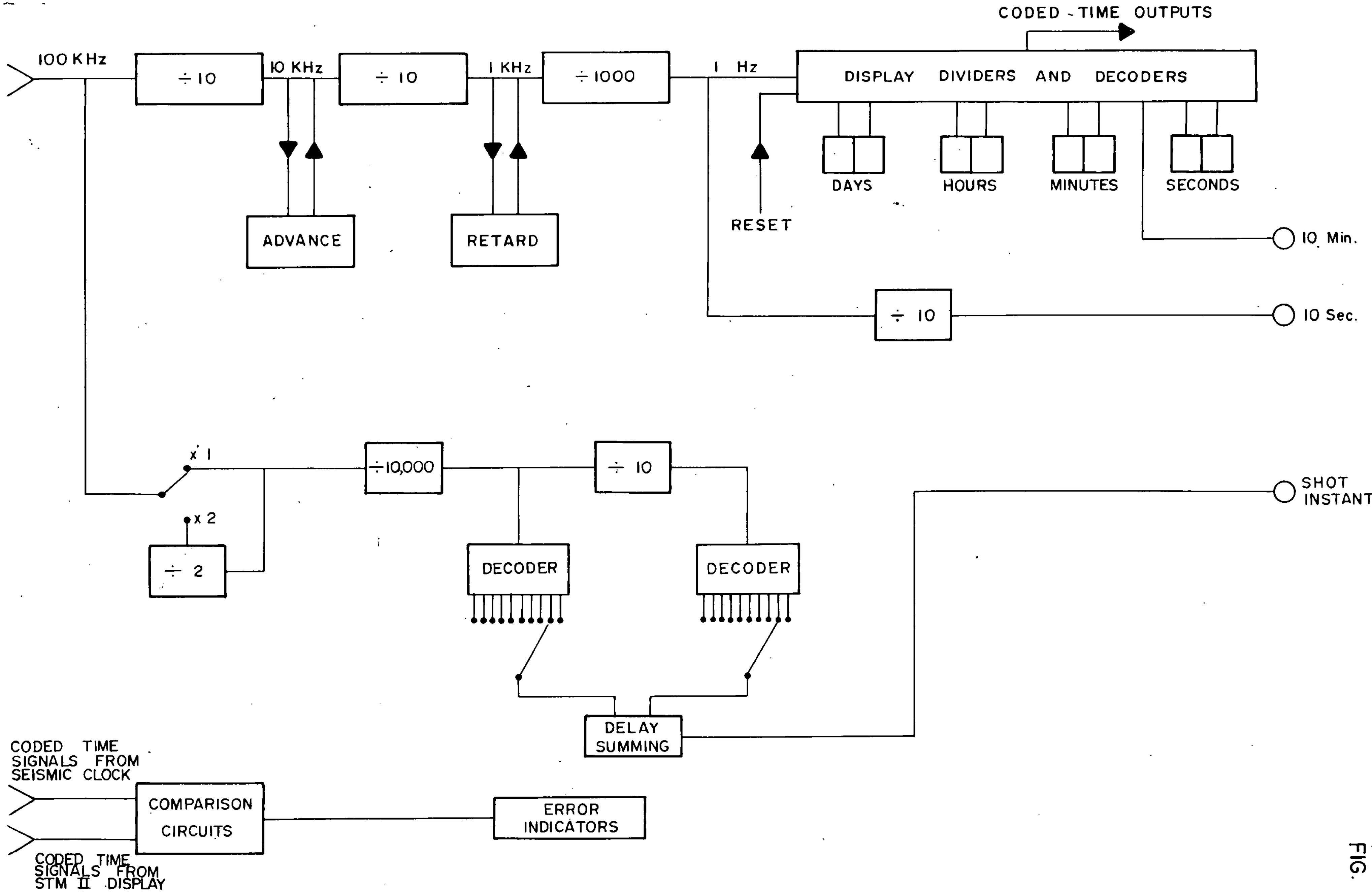
g) - BMR STM II Timer

* Theory of operation : The STM II timer provides a digital time display and outputs to control the Data Acquisition System, seismic equipment and time marks to all analogue and graphic recorders.

All outputs are derived from a 100 KHz signal supplied by a rubidium vapour frequency standard.

* Outputs

i - Sparker shot instant pulses : pulses with a repetition rate variable in 0.1 second steps, from 10 pulses per second to 1 pulse per 19.8 seconds. This output triggers the sparker equipment and the seismic recording equipment.



STM II - BLOCK DIAGRAM

FIG. 45

ii - <u>10-minute pulses</u> : a pulse every 10 minutes which activates relays which apply a 10 minute fiducial mark to all analogue and graphic recorders.

iii - <u>10-second pulses</u> : to control the data sampling rate of the Data Acquisition System.

iv - <u>Digital Time Display</u> : eight Nixie tubes display the following :

DD HH MM SS

where DD = survey day
HH = hours
MM = minutes
SS = seconds

The display can be reset, advanced and retarded manually.

* <u>Note</u> : Coded time pulses from the seismic container clock are received and compared with coded time pulses generated by the digital time display of the STM II. Time differences between the two clocks are indicated by indicator lights.

* A simplified block diagram of the STM II is given in Figure 45.

IV - SHORE STATION

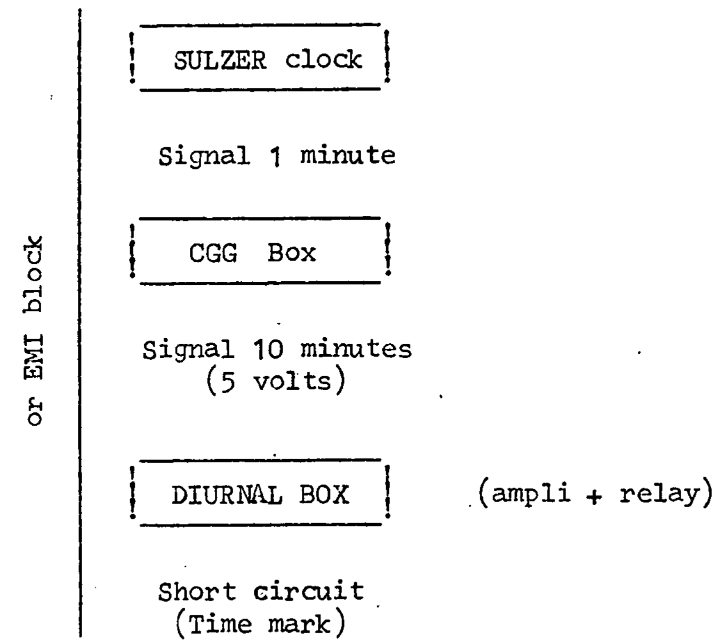
To record diurnal variation of magnetic field of the earth and of VLF (or OMEGA) signal, a shore station was set up close to the working area of the ship.

IV.1 - MAGNETIC STATION

Two different equipments were successively installed.

* Survey 5 and 10 : magnetometer SUD-AVIATION and recorder SERVOGOR. This system was a precession magnetometer working as explained in paragraph III.2. The time marks of the recordings were originating of the geomagnetic observatory of Port Moresby where the equipment was running.

* From survey 11 : a magnetometer Varian V4870 identical to the ship's system was set up ; the recorder used was a G.1000 model from Varian. The time marks were coming from a SULZER clock in the following way :



From survey 16 an EMI clock was used to replace the CGG and diurnal boxes.

From survey 14 cruise 2, a WESTRONIC recorder was used instead of the G.1000 recorder.

IV.2 - <u>VLF/OMEGA STATION</u>

To record diurnal variation of VLF and OMEGA signal, a station with similar equipment to this one used on board the ship. This equipment was used from survey 5 to survey 14 cruise 2 included.

A P P E N D I X

APPENDIX

EQUIPMENT REFERENCES

I - SEISMIC SYSTEM

- Seismic amplifiers: SERCEL model AS 626 X
- Seismic amplifiers: SIE PT 700
- Programmed gain control : SIE model GCU-3E
- Oscillograph : SIE model VRO-6
- E.M.I. clock
- Marine seismic timer : model STM-1
- Marine seismic timer : model STM-3
- C.G.G. cable depth monitor
- Seismic signal patch panel
- Oscilloscope HEWLETT - PACKARD model 181 AR
- GEOTECH hydrostreamer (geophysical)
- GEOTECH hydrostreamer model 24257
- GEOTECH cable monitor
- GEOTECH air compressor
- GEOTECH cable reel
- Sonobuoy receiver AQUATRONICS model 1401 S/N 224
- Sonobuoy receiver AQUATRONICS model 1401 S/N 225
- Sonobuoy antennas
- Power supply H.P. Model 6269 A (2)
- Hard copier TEKTRONIX model 4601
- Storage oscilloscope TEKTRONIX model 611
- KROHN-NITE filter model 315 A
- Seismic amplifiers T.I. model 7000 B
- Amplifier control bank for T.I. 7000 B
- Graphic recorders EPC 4100 S/N 118, 119, 120, 133, 134, 136

- AMPEX tape recorder model FR 1300 S/N 1130936, 7300243
  S/N 2221209
- C.G.G. 6 channel cable
- E.G.G. recorder model 254 S/N 254-5X and 254-18X

II - SEISMIC PROCESSING SYSTEM

- Central processor	H.P. 2116 B	S/N 914 - 00303
- Auxiliary power supply	H.P. 2160 B	S/N 817 - 00179
- Disc memory	H.P. 2770 A	S/N 929 - 00106
- Tape reader	H.P. 2748 A	S/N 937 - 00767
- Teletype	H.P. 2752 A	S/N 630 - 00910
- Tape panel	H.P. 2753 A	S/N 713 - 00574
- Multiverter	H.P. 2310 A	S/N 929 - 61170
- Power supply (disc memory)	H.P. 2772 A	

III - SPARKER

- GEOTECH
- Open air thyratron SIG

IV - BATHYMETRIC SYSTEM

* RAYTHEON System

- Transceiver	model PTR - 105 A
- Correlator	model CESP -1- A
- Digitizer	model PDD - 200 A
- Transducer	model 74

* ELAC System

- Recorder model LAZ 17DDL
- Switch box model SCHK 31
- Connection box model VK 16B
- Pulse generator model RGN 4F/L

- DIGITRACK EDO model 261 B

* ATLAS System

- Atlas Deso 10 S/N 196 009.0171
- Transducer SH 6006A2 S/N 286 006.0171
- Atlas Edig AZ 6017 A1 S/N 196 017.0029

V - MAGNETOMETER

* Ship

- Varian magnetometer V4970
- Varian sensor

* Shore

- Varian magnetometer V4970
- Varian sensor

VI - GRAVITYMETER

- Lacoste and Romberg S24

VII - OMEGA AND VLF SYSTEM

- Receiver Model 599Q n° 1, 2, 3, 4
- Receiver Model 599G n° 5, 6
- OMEGA gating unit, TRACOR model 533S 12units
- Rubidium frequency ; standard general technology model 304 B
- Quartz frequency ; standard general technology model 5 B
- Power supply general technology model 311 A
- Power supply general technology model 312 B
- Antenna multicoupler TRACOR model 607
- Linear phase detector TRACOR SULZER Model 1
- Quartz clock TRACOR SULZER model S1-401 M7/8
- Quartz clock TRACOR SULZER model S1-401 M7/8

- Recorder WESTRONICS model M11 B (3 units)
- Recorder WESTRONICS model M11 D-2 (2 units)
- RIKADENKI recorder

VIII - NAVIGATION SYSTEM

- Central processor	H.P. 2116 B	S/N 969 - 00705
- Auxiliary power supply	H.P. 2160 B	S/N 817 - 00320
- Tape reader	H.P. 2748 A	S/N 973 - 00713
- Tape recorder	H.P. 2970 B	S/N 1123A- 00694
- Tape recorder	H.P. 2020 B	S/N 1016 - 02797
- Multiverter	H.P. 2310 A	S/N 0950 - 0796
- Teleprinter	H.P. 2754 B	S/N 825 - 00576

- SERCEL interface
- Anemometer ALCYON Model NEZ
- Navigation room clock STM-2
- Chernikeeff Log
- Gyrocompass repeater
- MARQUARDT Sonar Doppler model 2015 A S/N 1021
- ITT satellite navigation system
- SAGEM interface S/N 1
- LINAX recorder model LS 144 K1 S/N 270 - 891
- Recorder model 601 HV S/N 7698

BUREAU OF MINERAL RESOURCES

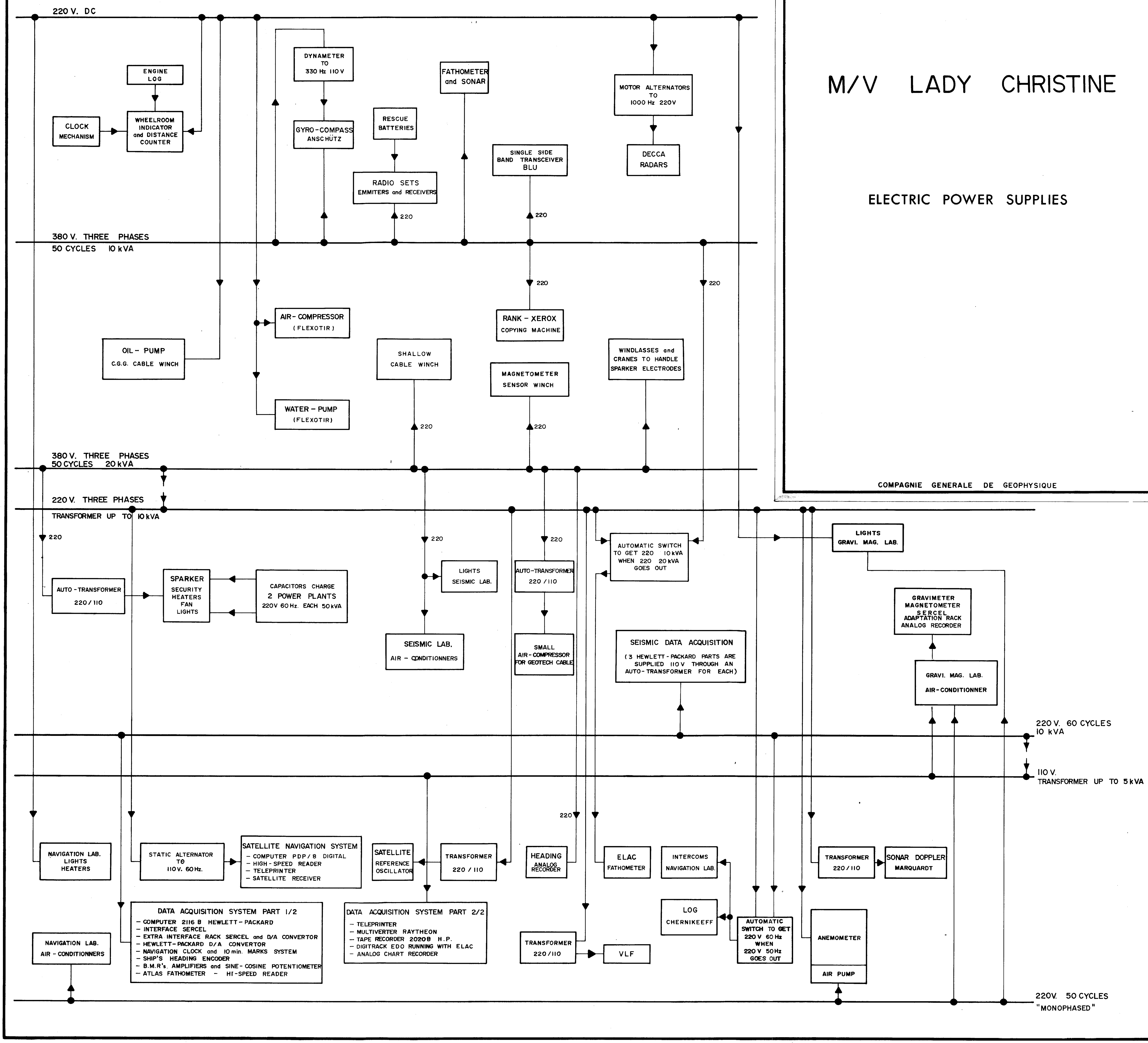
1974/111

ENCL. N°1

M/V LADY CHRISTINE

ELECTRIC POWER SUPPLIES

COMPAGNIE GENERALE DE GEOPHYSIQUE



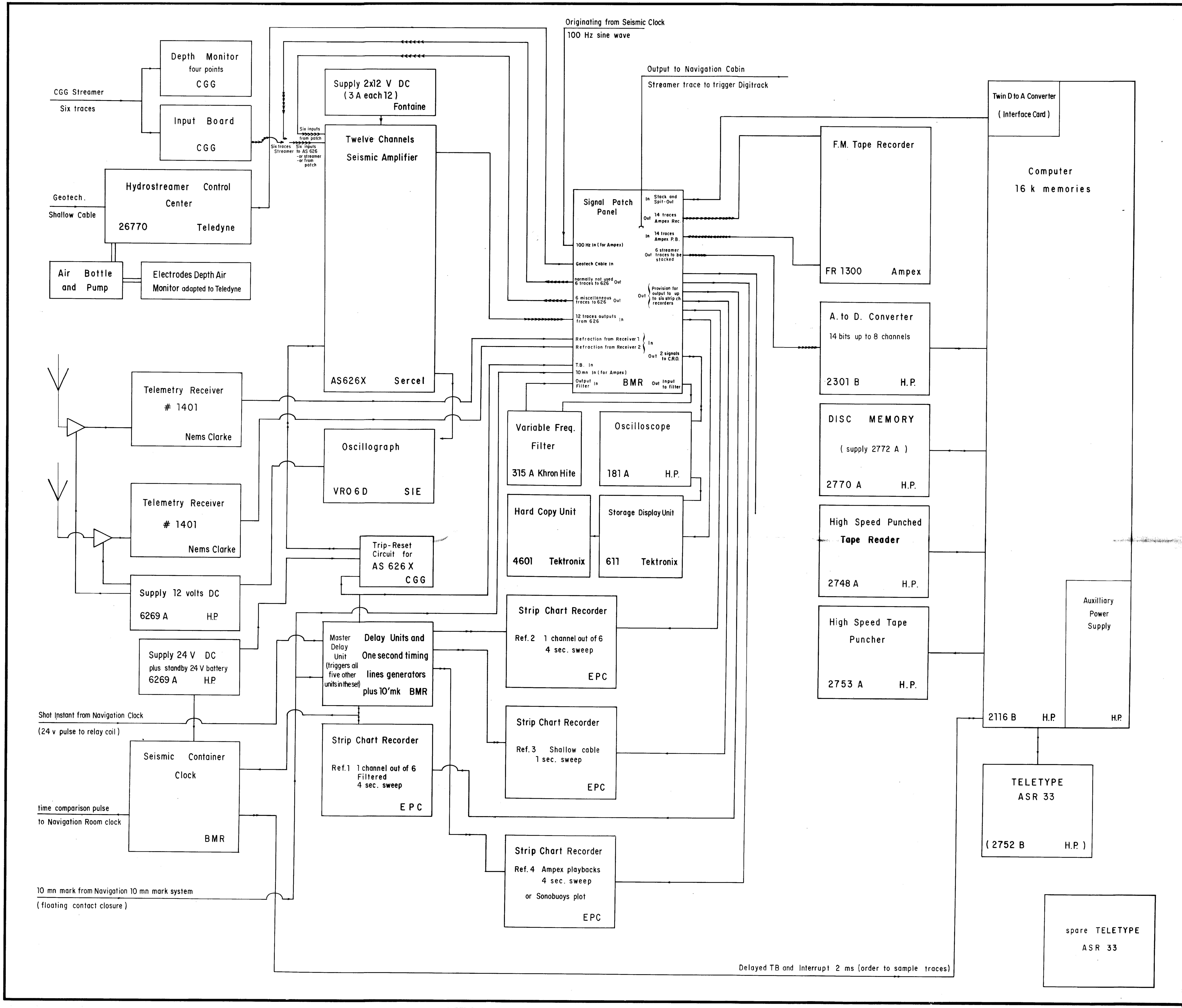
BUREAU OF MINERAL RESOURCES

ENCL. N° 2

M/V LADY CHRISTINE

SEISMIC SYSTEM

COMPAGNIE GENERALE DE GEOPHYSIQUE
6, Rue Galvani - 91301 - MASSY - FRANCE



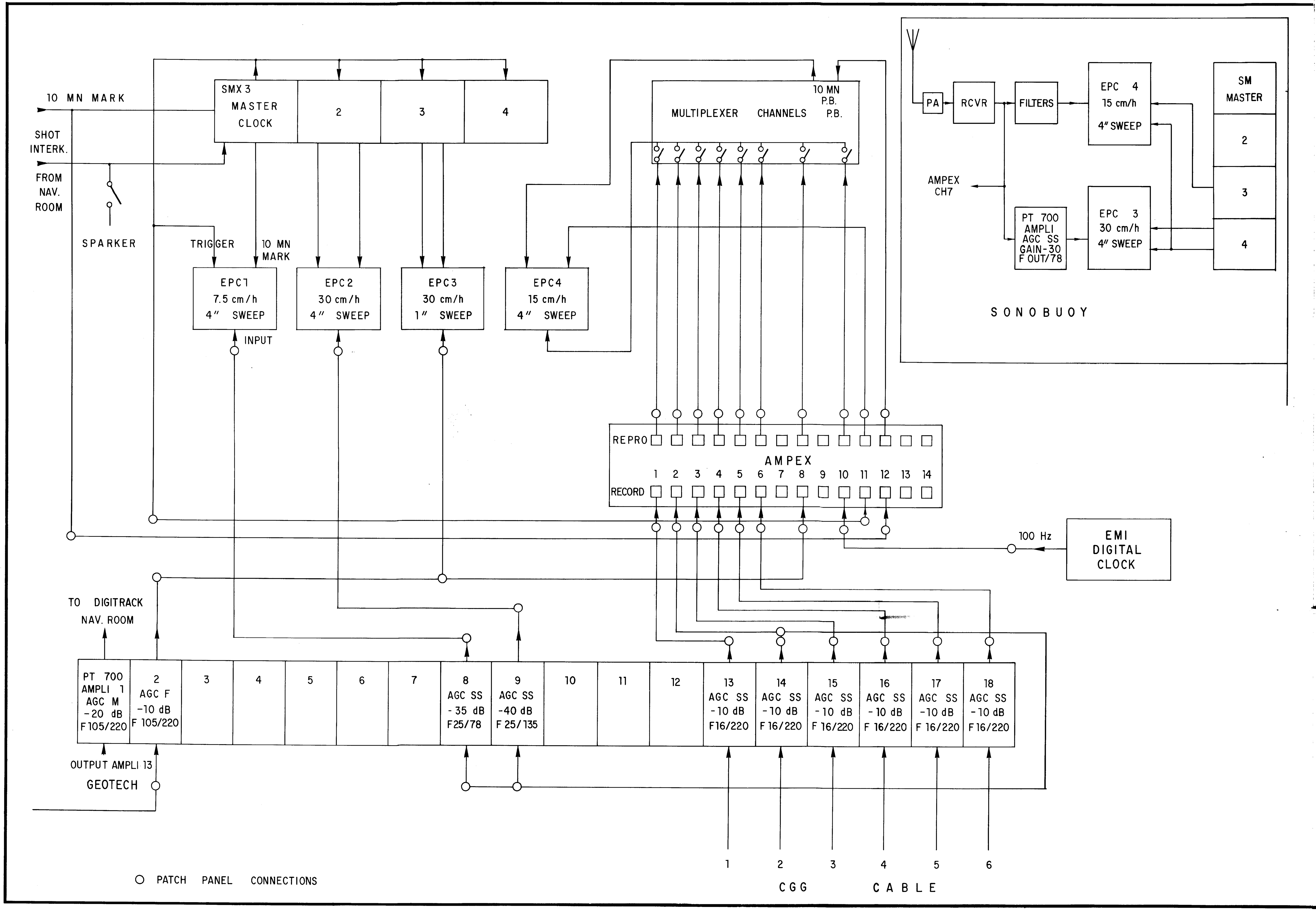
BUREAU OF MINERAL RESOURCES

ENCL. N°3

M/V LADY CHRISTINE

SEISMIC SYSTEM

COMPAGNIE GENERALE DE GEOPHYSIQUE
6, Rue Galvani - 91301 - MASSY - FRANCE



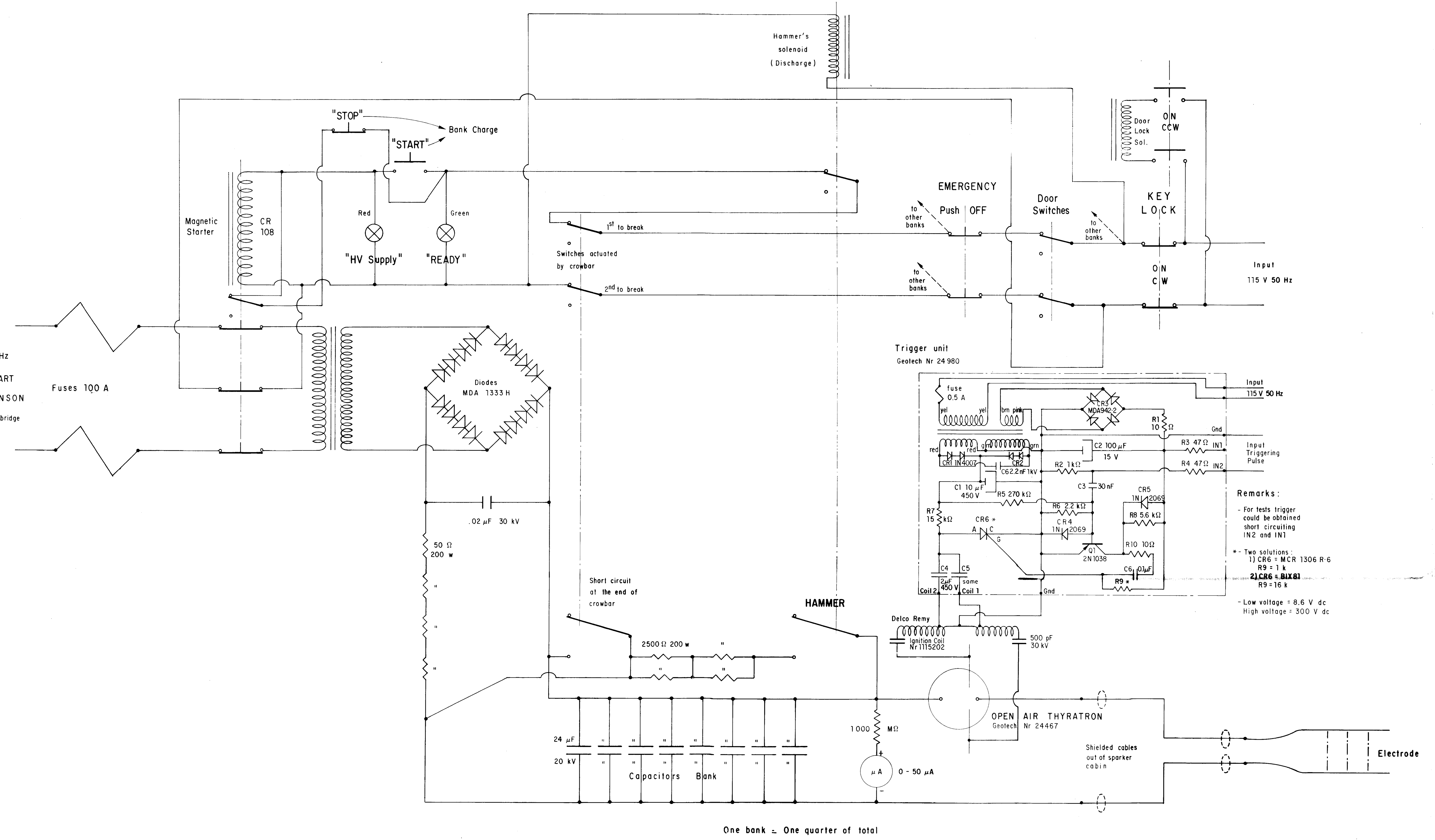
BUREAU OF MINERAL RESOURCES

ENCL.N°4

M/V LADY CHRISTINE

SEISMIC SYSTEM

COMPAGNIE GENERALE DE GEOPHYSIQUE
6, Rue Galvani - 91301 - MASSY - FRANCE



BUREAU OF MINERAL RESOURCES

ENCL. N°5

M/V LADY CHRISTINE

SPARKER SYSTEM

COMPAGNIE GENERALE DE GEOPHYSIQUE
6, Rue Galvani - 91301 - MASSY - FRANCE

BUREAU OF MINERAL RESOURCES

ENCL. N°6

M/V LADY CHRISTINE

DATA ACQUISITION SYSTEM

COMPAGNIE GENERALE DE GEOPHYSIQUE