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CONFORMAL/PLANAR ARRAY SONAR DEVELOPMENT PROGRAM FOR APRIL 1966--ETC(U)

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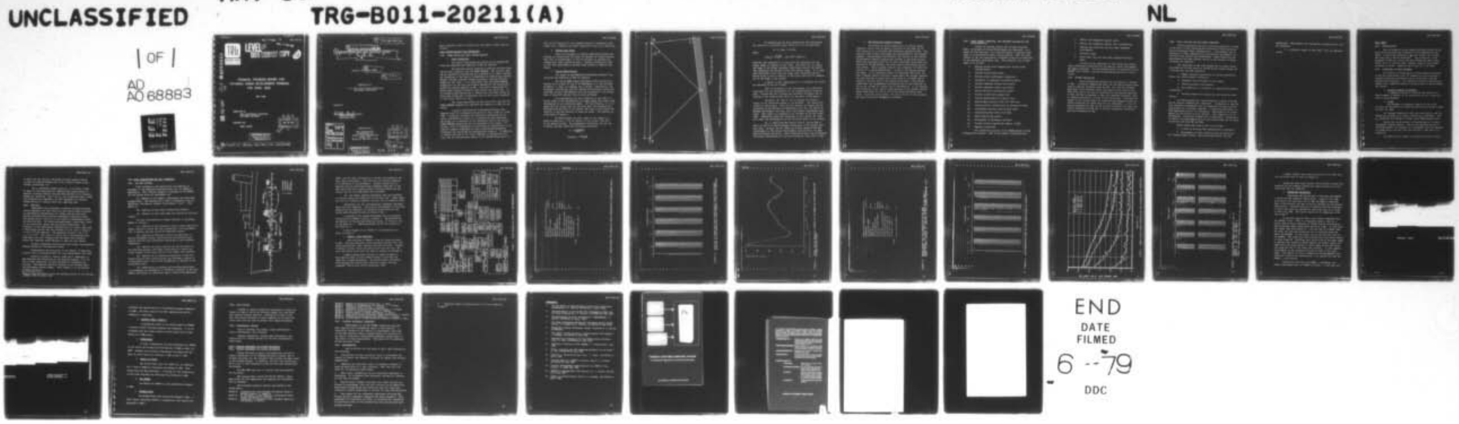

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TRG

CONTROL DATA CORPORATION

TECHNICAL PROGRESS REPORT FOR C/P ARRAY SONAR DEVELOPMENT PROGRAM FOR APRIL 1966

MAY 1966

SUBMITTED TO:

NAVY ELECTRONICS LABORATORY
SAN DIEGO, CALIFORNIA

CONTRACT NO:

NObsr-93023

TRG / A SUBSIDIARY OF CONTROL DATA CORPORATION
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FOR APRIL 1966

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Submitted to:

U. S. Navy Electronics Laboratory
San Diego, California

Approved:

Walton Graham

Walton Graham
Department Head

Submitted by:

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(11) May 1966

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Major technical areas of activity for the month of April were as follows:

1000--SYSTEM ANALYSIS AND INTEGRATION

1100: SONAR SYSTEM AND TOTAL SYSTEM ANALYSIS

1. Sonar Prediction

The report[1] describing the results of the stepped RDT study was completed and submitted to NEL for approval.

The modified pattern function to simulate vertical shading has been installed into the OCEAN SWEEPER. The vertical shading is simulated by multiplying the sidelobes by an input constant; the broadening of the beam is accomplished by reducing the spacing between vertical elements thereby achieving a smaller effective height for the sonar. It is anticipated that the OCEAN SWEEPER program will be run with and without shading for the surface-duct prediction problem supplied by NEL. The report summarizing the direct path analysis[2] should be ready before the end of May. It is currently anticipated that A. Novick will visit NEL during the third week of May and a preliminary copy of the results supplied to the Project Office at time.

The report describing the TRG ocean model used for the OCEAN SWEEPER program[3] was completed and submitted to NEL for approval.

A report describing the forthcoming bistatic echo-ranging study[4] is in progress and should be sent to NEL on 15 May 1966. A possible technique for efficiently generating the bistatic reverberation contour on a boundary has been developed. The method is an extension of the techniques used in the current OCEAN SWEEPER program and will be described in the report. At present, work is progressing in developing the organization of the required computer program(s) as well as associated analytical techniques for evaluating the reverberation integral. In addition, it appears that due to the "poor" behavior of the pattern function, and the discontinuous nature of the reverberating area, it will not be practical to use standard numerical integration techniques (e.g., Simpson) and other schemes will have to be developed.

2. Surface-Duct Model

Work is in progress to develop computerized method for finding all surface-duct ray paths of interest in a given problem. Once this is accomplished, it will be possible to automate the surface-duct sonar prediction model. Current estimates are that it will take approximately another three months to complete this effort.

3. System Effectiveness

The report on the Simplified Performance Measure[5] was rewritten and submitted to NEL for approval.

The Second NMSE System Performance Effectiveness Conference held on April 21 and 22 in Washington, D.C. was attended by Messrs. L. Chin, W. Landauer and A. Novick. Essentially, the conference stressed the need for systems effectiveness studies before PDP; in fact, DOD approval will not be granted to any system where a trade-off analysis has not been performed.

An investigation has been conducted on the effect of bottom slope on the determination of target range from travel time information in an isovelocity medium. For this problem, it is assumed that the travel time for the echo path, the perpendicular distance from the ship to the bottom, the slope of the bottom (denoted by α) and the velocity of sound are known. The geometry is illustrated in Figure 1.

We shall denote the slant range to the target by L, which is given by $L = 1/2\ cT$, where T is the travel time and c is the speed of sound. By trigonometric identities and the law of sines, one may obtain the following expressions

$$R = \frac{L\cos(\theta+\alpha)}{\cos\alpha}$$

$$\sin(\theta+2\alpha) = \frac{2d\cos\alpha}{L}$$

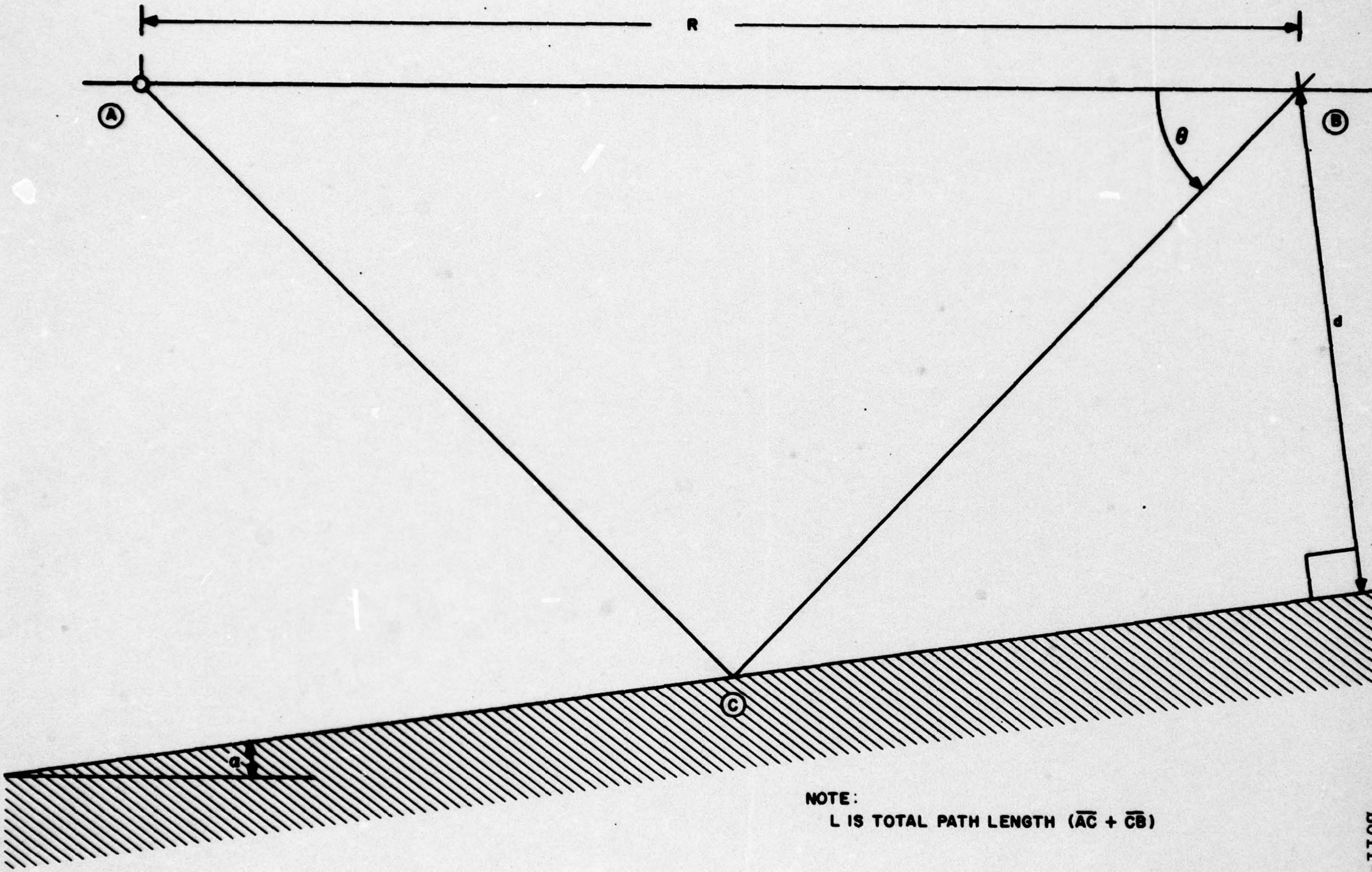


FIGURE 1. GEOMETRY OF RANGE-DETERMINATION PROBLEM

By manipulating the above expressions and restricting our interest to relatively small values of α, it is found that

$$R \doteq L \cos\theta_o + 2d \sin\alpha$$

where

$$\cos\theta_o \equiv \frac{L^2-4d^2}{L}, \text{ and } \sin^2\alpha \tan^2\theta \ll 2$$

From the last equations it is seen that the expression for the target range is composed of two terms. The first term is simply the range to the target assuming a horizontal bottom; the second term represents the deviation from this nominal range. It is somewhat startling to note that the range error resulting from the bottom slope is only a function of the water depth and is independent of the range to the target!

A report on this investigation is in progress and should be available by the end of May[6].

Work is proceeding on the development of an effectiveness model for the optimization of the conformal/planar array design. Leonard Chin has reviewed the available literature and is setting up the effectiveness model for the sonar investigation.

Currently, Mr. Chin is in the process of writing a report on the theoretical phase of the problem[7]. The report will consist of three parts. Part one will discuss the theory and applications of the Calculus of Variations; part two, the Theory of Maximum and Minimum, and part three, the Dynamic Programming technique. This report is estimated to be finished by the end of May 1966. Immediately after the completion of this report, Mr. Chin will start the investigation on the Procedure phase of the problem.

Mr. L. Cohen from NEL Project Office, visited TRG on April 25 and 26 to review progress being made in the systems analysis area. On April 26, Mr. Cohen and several members from TRG participated in C/P system effectiveness discussions at the Navy Applied Science Laboratory. These discussions were only preliminary and further discussions will be held during the early part of May.

4. ASW Simulation Computer Program

The memory and speed capabilities of current digital computers require that an apriori selection of the depth of detail required for a realistic ASW simulation program be made. The selection made largely determines the organization of the computer program. During January and February two versions of the mission effectiveness computer program were written or partially written which were organized about six or seven functional areas which are involved in an ASW mission, and which used a fixed memory allocation scheme. These programs proved to be inadequate to handle the details of a complex ASW mission. In March, the current program was begun. It is organized around ten functional ASW areas, and uses a dynamic memory allocation scheme where the storage required for each function is drawn from a pool when it is needed and returned to the pool when it has served its purpose. This scheme complicates the programming considerably and is less efficient as far as the storage of a given item of information. It is, however, more efficient in an overall sense because of the dynamic sharing which takes place in time as the action being simulated takes place. As of the end of April, the pilot version of this program has been written and debugging is underway.

1200: TOTAL SYSTEM, SUBSYSTEM, AND COMPONENT RELIABILITY AND MAINTAINABILITY

During the meeting between TRG and NASL personnel, NASL's philosophy of System Effectiveness was discussed. As a result of this meeting, a list and description of specific work tasks to be performed by TRG is being prepared. This list will conform to the new requirements contained in Section 10 (Revised) of the Technical Development Plan. The tentative list of work tasks is as follows:

1. Develop system block diagram with various block configurations.
2. Develop effectiveness model
3. Perform system performance comparisons
4. Assignment of component availability goals
5. Develop component failure rate matrix
6. Develop component repair rate matrix
7. Derive and solve availability models
8. Develop reliability program plan
9. Develop maintainability progress plan
10. Develop RFQ evaluation plan (for R/M only)
11. Perform special studies/tests as directed by NASL
12. Investigate previous sonar problem areas
13. Coordinating FISC effort with NASL
14. Human engineering support
15. Development of packaging technique
16. Provide Liaison engineering support at NASL
17. Manpower estimation.

The reliability aspects of the PRIMAG method of beam forming were reviewed. Some of the aspects considered were:

1. Effects and safeguards against shock.
2. Effects and safeguards against dirt contamination.
3. Bearing type lubricant and life under shipboard environments.
4. Redundant drums.
5. Drive motor type and life under shipboard environments.

A review of the experience of other drum-type devices under operational conditions will be made by contact with Hughes and Sperry personnel. The forthcoming report on evaluation of the PRIMAG[8] will contain a section pertaining specifically to reliability.

1300: SYSTEM INTEGRATION

System integration manpower was discussed at a meeting at NEL. A proposed organization chart for the R/M and System Integration team was discussed with the PTD. The need for possible additional future manpower above that shown on the chart in the FISC areas and in the area of specification writing was mentioned to TRG, and TRG is planning to make this manpower available, within funding constraints, as soon as the need arises. Personnel assigned to the various areas are familiarizing themselves with the system components for which they will be responsible. A list of reports generated by GD/E and GE has been reviewed, and those considered important for TRG use in systems integration activities have been requested by TRG.

1400: FAULT LOCATION AND SELF-CHECK SUBSYSTEM

Effort expended during April consisted primarily of study of the basic factors affecting the selection of Fault Isolation and Self-Checking (FISC) implementation. A preliminary set of objectives of FISC implementation and specific requirements for the FISC study efforts were established. These objectives and requirements have been drafted and are in the process of being finalized for submittal.

The objectives of the FISC program are to assure proper consideration of FISC functions during initial system design and to insure that the FISC subsystem:

1. Makes a maximum contribution to system availability within cost effectiveness constraints.

2. Maximizes user confidence in the system.

3. Reduces personnel requirements.

4. Has capability to contribute to shipboard performance estimations.

5. Provides support for preventive and corrective maintenance.

The FISC program will include efforts to define both ESS and CF (Concept Formulations) subsystems. Information on specific test parameter requirements will be requested from each activity responsible for a specific component. Alternative approaches to FISC implementation will be considered. Requirements for stimuli generators and sensors will be defined. Test schedules will be established. Functional diagrams will be generated. Coordination of efforts and requirements will be maintained among the C/P sonar contractors and with NEL and NASL.

Effort during the month of May will include:

1. A study of existing FISC implementation techniques.

2. Development of first iteration test specifications for transmit power drivers, receive pre-amplifiers, and the

beamformers. Requirements for testing the transducers will also be considered.

3. A technical report in this area[9] will be submitted in May.

2000--ARRAY

2100: PRE-AMPLIFIER

Work in progress on the converter-filter portion of the front end electronics was terminated at the beginning of the month. A report was prepared on the test results up to April and submitted to NEL as requested[10]. The filter has a 3 db bandwidth of 200 cps, 60 db stop-band attenuation and a shape factor of 2.2:1 at 60 db down. Dynamic range of the up-down converter is 90 db. Operation was in the 2 to 3 Kc band.

2200: TOLERANCES OF ARRAY ELEMENTS

The effects of random errors in the element excitations on the far field pattern will be compared for an array with a uniform excitation distribution and an array with a tapered excitation distribution. The theoretical analysis has been performed; and a computer program is being written to obtain numerical results.

1. Acoustic Effects of Bubbles

A computer program to calculate the effects of a finite number of bubbles on the sound field of one or more pistons is being debugged.

2. A-IDA

We designed a transducer element for the A-IDA activity and delivered the supporting data and the design to NEL on April 19, 1966.

All designs submitted to NEL were very similar, and the design was selected on a single criterion (Z_{oc} bandwidth). The Z_{oc} bandwidth from design to design varied approximately 10%.

We are now in the process of fabricating two of these preliminary system elements. One will be dumiload tested to establish whether its response is in agreement with the theoretical predictions, and the other will be sent to NEL when it is completed.

Our exact-invert scheme is working well and we intend to write out the velocity distribution and/or pseudo inverse on tape for post-processing such as VA, electric field in the ceramic, efficiency, etc.

For a transducer element whose Z_{oc} is at least 5 times as great as the characteristic impedance the system matrix is moderate strongly diagonal and therefore amenable to an iterative scheme for inverting. Since the Z_{oc} will be greater than 5 times the characteristic impedance, we will implement an iterative scheme because it requires much less computing time.

2300: DUMILOAD

Experiments were performed to measure unloaded matching section impedance for both thick and thin walled tubes including an experimental determination of a known load for each case. Studies performed after previous experiments indicated a need for paying special attention to the effect of measurement errors, and this was done. The resulting experimental values were closer to the theoretical values than previously experienced. For instance, in the experimental determination of a known load using a thin walled section and the $j\omega M$ model for the load, a value of $j\ 1.32 \times 10^4$ was expected. The measured value was $1.54 \times 10^2 + j\ 1.17 \times 10^4$. This value is within 12% of the expected value (the small real part resulted from the phase shift observed across the temporary bonds* employed to make the test setup).

Previous experiments had produced much larger discrepancies between theoretical and measured values.

Consideration was also given to the effects of laboratory acoustic noise interference when low level measurements were made.

On April 19, 1966, D. Carson of NEL and T. DeFilippis of TRG discussed the redirection of the Dumiload program. As a result of that discussion, we have proceeded to reorganize our activity. The Dumiload Education Program is now centered about the preliminary system element. This element is in the process of being developed.

*Dental cement was used to bond the matching section to the driving element, and the known load.

7000--NAVAL ARCHITECTURE AND HULL INTERFACES

7100: SEA TEST SUPPORT

Work continued on the modification and addition of equipment to the Shipboard Recording Center for the PURVIS II experiments. The essential changes of equipment on the PURVIS for the second series of experiments are:

(1) Removal of all PURVIS I hydrophones and associated preamplifiers. The installation of TRG 5" hydrophones and pre-amplifiers, and special windows in Sea Chests 1 and 2. (See Figure 2).

(2) Addition of four sonar transmitting elements.

(3) Addition of four flow-flags with electrical position outputs.

The data instrumentation changes required to accomodate PURVIS II include:

(1) Addition of four frequency sources, power amplifiers, remote controls to drive the four transmitters, and instrumentation to monitor and tape record the amplifier outputs.

(2) Addition of band-pass filters and amplifiers to monitor hydrophone outputs resulting from simultaneous transmission from the four transmitters operating at four different frequencies.

(3) Addition of remote controls for the excitation to the flow-flag sensors, and signal conditioning to record the output signals on the ship's motion (slow speed) tape recorder.

(4) Addition of an Indicator-Transmitter to read the sensed velocity from an E/M velocity log instrument located on a retractable strut. One of the transmitters is mounted on the retractable strut.

(5) Modification of cabling and recording patch panel to accommodate new hydrophones at different locations on the hull. DTMB is providing, (a) additional signal conditioning amplifiers

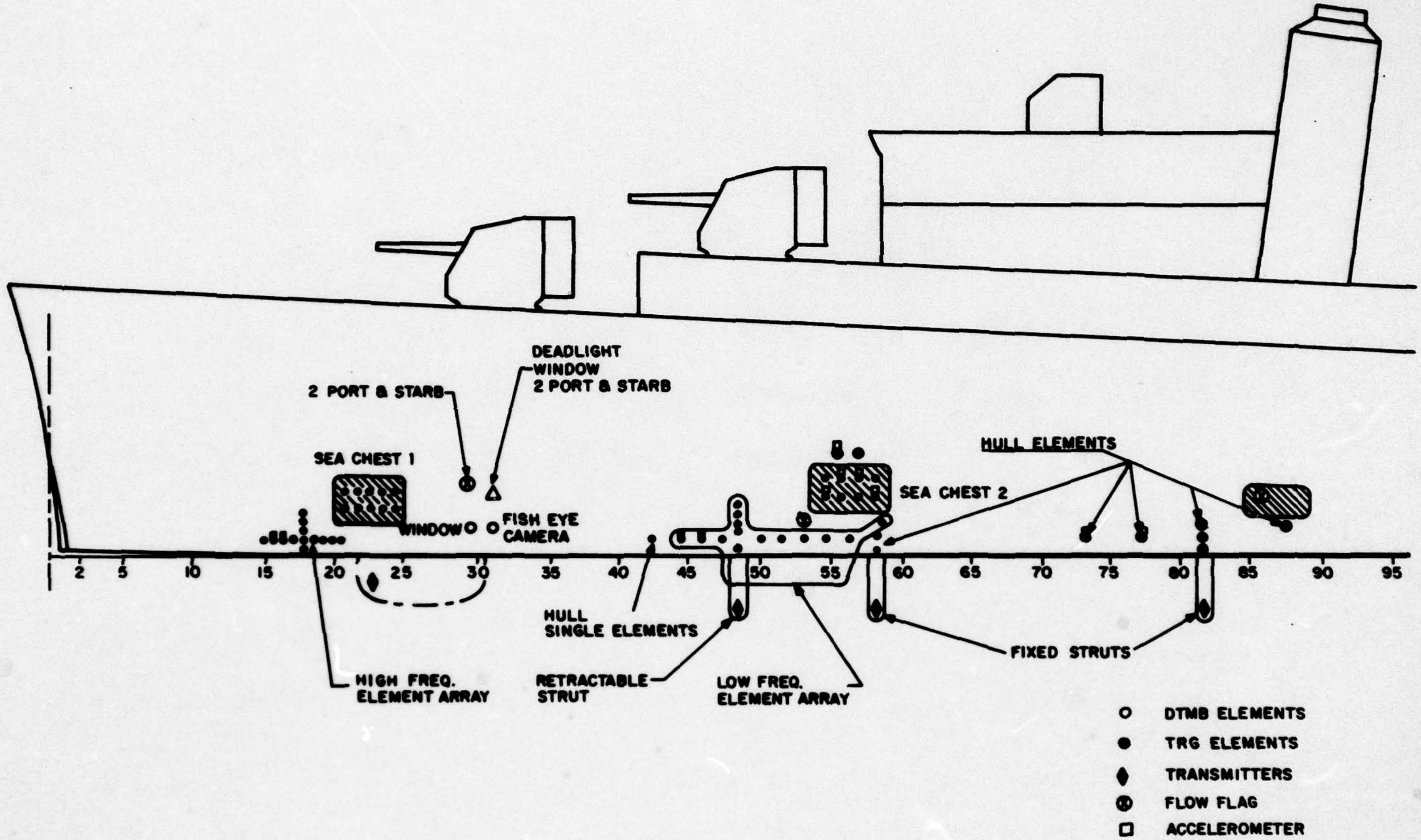


FIGURE 2. PURVIS II TRANSDUCER INSTALLATION

(SCA), and (b) input attenuators to prevent overloading of the tape record electronics. Each SCA will be directly connected to a hydrophone or accelerometer. Triaxial cables will be employed from the Recording Center bulkhead connectors to the SCA inputs with the recording patch occurring between the SCA outputs and the four high-speed tape recorders.

(6) The masker (bubble) generators have been modified to provide control and indication of air flow rate. These items will not be recorded on magnetic tape but will be manually noted.

Procurement for the instrumentation equipment described above has been completed. Fabrication and assembly of electronic chassis will be completed for shipboard installation at the Boston Naval Shipyard during the month of May.

A diagram of the planned hydrophone and accelerometer installation on PURVIS is given in Figure 2. TRG hydrophones are mounted in low and high frequency arrays, on the hull, and in Sea Chest No. 2. DTMB hydrophones (FS-13) are mounted in Sea Chest No. 1.

A block diagram of the PURVIS II instrumentation is given in Figure 3.

1. PURVIS I DATA REDUCTION

Data recorded on PURVIS I runs are being processed at NEL. The data reduction being performed includes auto- and cross-correlations, power spectrum and time histories. Samples of header records, cross-correlation print-out and plot, and auto-correlation print-outs are shown in Figures 4a through 4e.

A sample analog power spectrum is shown in Figure 5. Four spectra taken at four different ship's velocities are shown for a single hydrophone. An interim report containing selected spectral density data reduction results has been prepared[11] and will be issued during May, 1966.

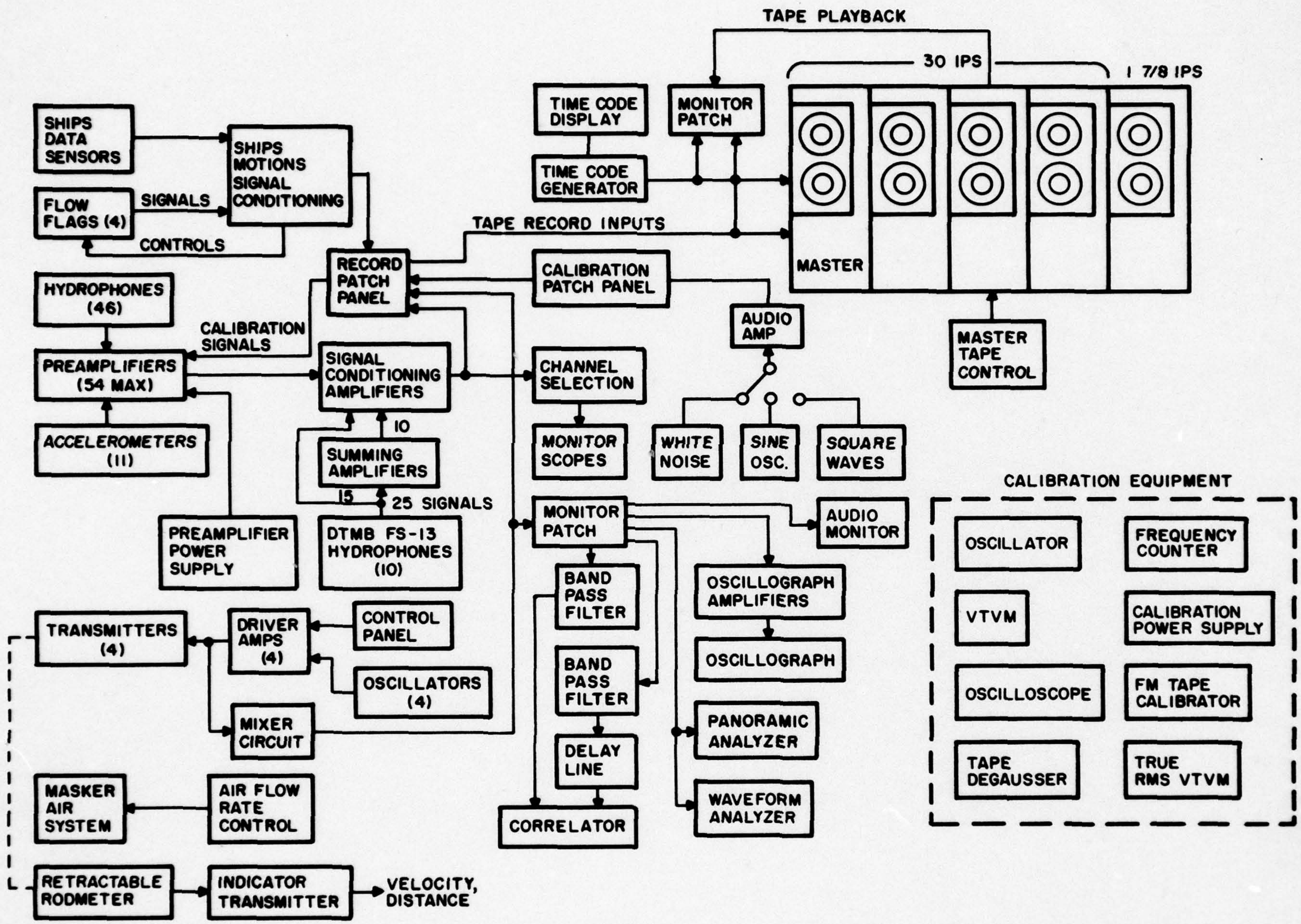


FIGURE 3. BLOCK DIAGRAM OF PURVIS II INSTRUMENTATION

0045839

PROGRAM TO FORMAT DIGITIZED ANALOG DATA RUN NO 3-8

OPERATORS NAME	T C GARST III
DATE ANALOG TAPE RECORDED	
CURRENT DATE	7 APR 66
CHANNELS MULTIPLEXED	2
TRACK NO.S BEING DIGITIZED	01 09
STARTING TIME OF SAMPLE FORMATTED	22*34*20.0
ENDING TIME	22*34*20.3
LOW FREQ AND HI FREQ FILTER SETTINGS	50*100
SAMPLING RATE DIVIDE SETTING IS	8
RECORDING SPEED OF ANALOG TAPE	30 IPS
PLAYBACK SPEED OF ANALOG TAPE	15
CALIBRATION RUN NUMBER IS	

REMARKS

ANALOG TAPE TRANSPORT NUMBER IS	101

FIGURE 4a. HEADER RECORD FOR NORMALIZED CROSS-CORRELATION OF BAND-LIMITED NOISE

CROSS-CORRELATION SUMMARY PAGE 1

P	R^{K}_{XY}	$S^{1\ K}_{X}$	$S^{2\ K}_{Y}$	R^{K}_{YX}	$S^{1\ K}_{Y}$	$S^{2\ K}_{X}$
0	1.00000	67.31177	67.31177	1.00000	67.31177	67.31177
1	0.99263	67.33432	67.06579	0.99263	67.33432	67.06579
2	0.98057	67.35688	66.87981	0.98057	67.35688	66.87981
3	0.96082	67.38208	66.67417	0.96082	67.38208	66.67417
4	0.93362	67.40908	66.50602	0.93362	67.40908	66.50602
5	0.89937	67.43705	66.33756	0.89937	67.43705	66.33756
6	0.85850	67.46505	66.20337	0.85850	67.46505	66.20337
7	0.81149	67.49319	66.10019	0.81149	67.49319	66.10019
8	0.75880	67.52135	66.03746	0.75880	67.52135	66.03746
9	0.70109	67.54882	65.98650	0.70109	67.54882	65.98650
10	0.63931	67.57475	65.97463	0.63931	67.57475	65.97463
11	0.57425	67.60070	65.97733	0.57425	67.60070	65.97733
12	0.50647	67.62427	65.99563	0.50647	67.62427	65.99563
13	0.43694	67.64786	66.02204	0.43694	67.64786	66.02204
14	0.36606	67.66822	66.04968	0.36606	67.66822	66.04968
15	0.29490	67.68859	66.07286	0.29490	67.68859	66.07286
16	0.22424	67.70897	66.07833	0.22424	67.70897	66.07833
17	0.15387	67.72937	66.07725	0.15387	67.72937	66.07725
18	0.08571	67.74568	66.04158	0.08571	67.74568	66.04158
19	0.01954	67.76199	65.97105	0.01954	67.76199	65.97105
20	- 0.04427	67.77337	65.88710	- 0.04427	67.77337	65.88710
21	- 0.10483	67.78474	65.74141	- 0.10483	67.78474	65.74141
22	- 0.16222	67.79032	65.57793	- 0.16222	67.79032	65.57793
23	- 0.21607	67.79588	65.39578	- 0.21607	67.79588	65.39578
24	- 0.26597	67.80143	65.194 7	- 0.26597	67.80143	65.19407
25	- 0.31197	67.80031	64.99200	- 0.31197	67.80031	64.99200
26	- 0.35354	67.79917	64.78957	- 0.35354	67.79917	64.78957
27	- 0.39082	67.79800	64.56666	- 0.39082	67.79800	64.56666
28	- 0.42341	67.79681	64.34334	- 0.42341	67.79681	64.34334
29	- 0.45172	67.78807	64.13978	- 0.45172	67.78807	64.13978
30	- 0.47544	67.78682	63.93585	- 0.47544	67.78682	63.93585
31	- 0.49462	67.78554	63.75090	- 0.49462	67.78554	63.75090
32	- 0.50969	67.77670	63.58413	- 0.50969	67.77670	63.58413
33	- 0.52049	67.76782	63.45158	- 0.52049	67.76782	63.45158
34	- 0.52725	67.75890	63.33479	- 0.52725	67.75890	63.33479
35	- 0.53020	67.75750	63.23295	- 0.53020	67.75750	63.23295
36	- 0.52968	67.75607	63.15875	- 0.52968	67.75607	63.15875
37	- 0.52585	67.75461	63.08441	- 0.52585	67.75461	63.08441
38	- 0.51905	67.75313	63.04539	- 0.51905	67.75313	63.04539
39	- 0.50944	67.75835	63.00628	- 0.50944	67.75835	63.00628
40	- 0.49790	67.76355	62.99498	- 0.49790	67.76355	62.99498

FIGURE 4b. PRINT-OUT OF NORMALIZED CROSS-CORRELATION OF BAND-LIMITED NOISE (ACTUALLY AN AUTO-CORRELATION SINCE CHANNELS X AND Y ARE IDENTICAL)

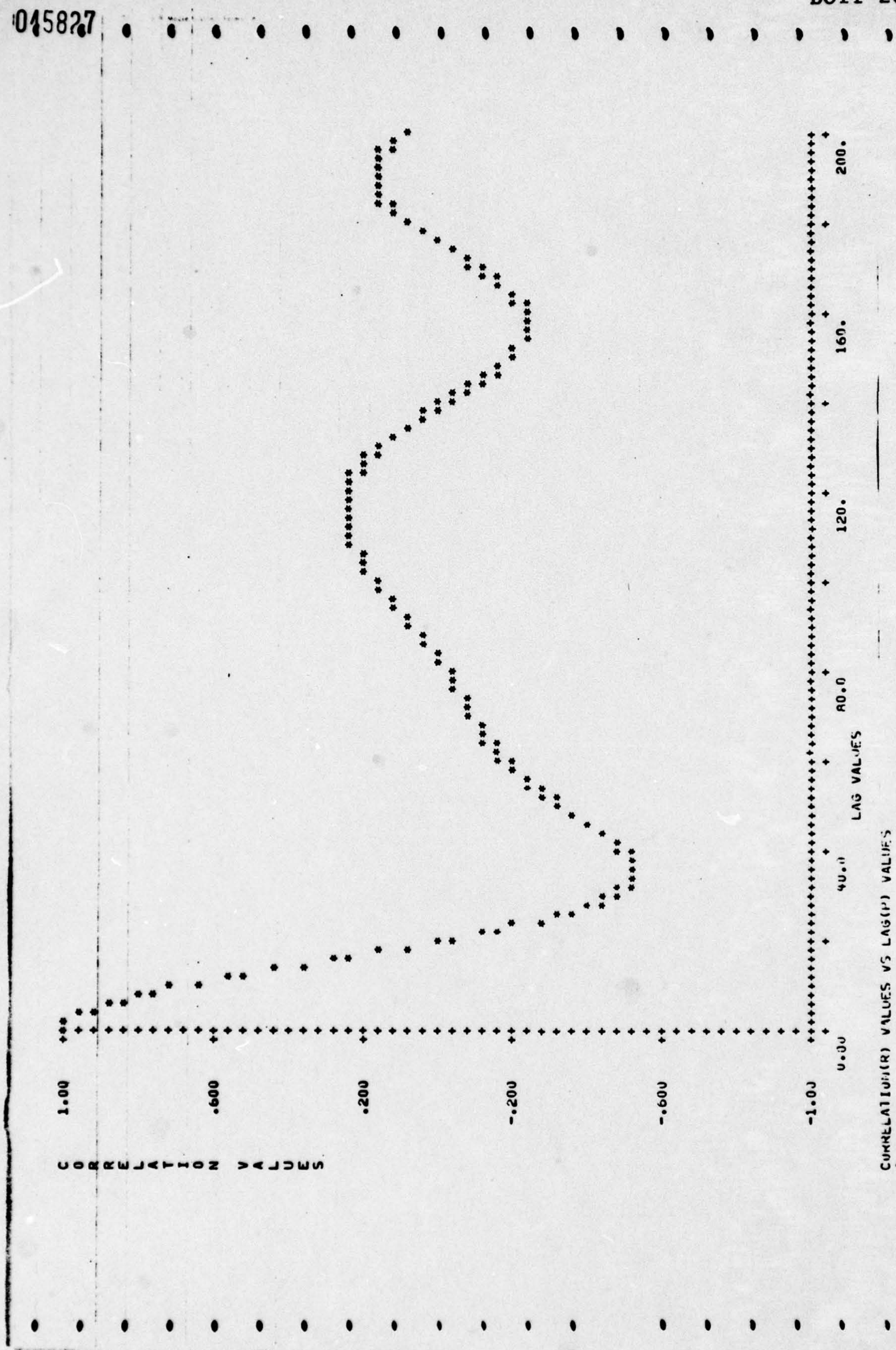


FIGURE 4c. SAMPLE PLOT OF PRINT-OUT (FIGURE 4b) OF NORMALIZED CROSS-CORRELATION OF BAND-LIMITED NOISE

```
PROGRAM TO FORMAT DIGITIZED ANALOG DATA RUN NO 317
OPERATORS NAME                              T C GARST III
DATE ANALOG TAPE RECORDED
CURRENT DATE                                5 MAY 66
CHANNELS MULTIPLEXED                        2
TRACK NO.S BEING DIGITIZED                  01   03
STARTING TIME OF SAMPLE FORMATTED           15*56*30.0
ENDING TIME                                 15*56*31.0
LOW FREQ AND HI FREQ FILTER SETTINGS        50*500
SAMPLING RATE DIVIDE SETTING IS             8
RECORDING SPEED OF ANALOG TAPE              30 IPS
PLAYBACK SPEED OF ANALOG TAPE               15
CALIBRATION RUN NUMBER IS
REMARKS
ANALOG TAPE TRANSPORT NUMBER IS             110
```

FIGURE 4d. HEADER RECORD FOR AUTO-CORRELATION OF SEA DATA (HYDROPHONES: FS1; NO'S 1665 and 1657 LOCATED IN SEA CHEST 2. SPEED: 20 KNOTS: HEADING: 0°, RELATIVE TO SEA; ELEMENT SEPARATION: 3/4")

AUTO-CORRELATION SUMMARY PAGE 1

P	K R X	1-K X	2-K X	K B X	K D X	K DELTA X
0	1.00000	2.35908	2.35908	446.96240	0.00000	0.00000
1	0.92616	2.35548	2.35614	414.17604	65.76373	- 0.19101
2	0.72372	2.35204	2.35629	324.00893	246.25129	- 0.34435
3	0.43563	2.34968	2.36011	195.60351	503.14117	- 0.42339
4	0.12098	2.34941	2.36694	55.30634	783.72821	- 0.41608
5	- 0.16218	2.35064	2.37536	- 71.00094	1036.31097	- 0.38427
6	- 0.36993	2.35313	2.38429	- 163.78279	1221.88462	- 0.39422
7	- 0.48012	2.35679	2.39222	- 213.22680	1320.86552	- 0.48709
8	- 0.49392	2.36095	2.39774	- 219.87465	1334.34799	- 0.67387
9	- 0.43061	2.36562	2.40025	- 192.29000	1279.39807	- 0.89324
10	- 0.32001	2.36979	2.39924	- 143.73833	1182.52317	- 1.12168
11	- 0.19386	2.37321	2.39514	- 88.33893	1071.90991	- 1.30724
12	- 0.07875	2.37495	2.38894	- 37.93914	971.27378	- 1.47067
13	0.00763	2.37494	2.38173	- 0.33521	896.21524	- 1.61999
14	0.05812	2.37326	2.37460	21.40793	852.87275	- 1.76380
15	0.07454	2.37056	2.36846	28.29881	839.20628	- 1.87910
16	0.06490	2.36719	2.36409	24.09858	847.66266	- 1.93502
17	0.04009	2.36382	2.36189	13.76827	868.32823	- 1.93997
18	0.01059	2.36104	2.36146	1.97698	891.91057	- 1.93972
19	- 0.01553	2.35816	2.36270	- 7.83896	911.60268	- 1.99993
20	- 0.03370	2.35512	2.36504	- 13.91201	923.88436	- 2.13553
21	- 0.04276	2.35174	2.36763	- 16.07294	928.36611	- 2.29541
22	- 0.04400	2.34844	2.37022	- 15.24298	926.78208	- 2.37130
23	- 0.04012	2.34505	2.37181	- 12.85310	921.99175	- 2.36072
24	- 0.03410	2.34242	2.37255	- 10.30843	916.83467	- 2.29299
25	- 0.02838	2.34088	2.37212	- 8.60507	913.41128	- 2.27631
26	- 0.02446	2.34085	2.37017	- 8.17718	912.64785	- 2.36867
27	- 0.02271	2.34226	2.36704	- 8.90300	914.23059	- 2.49976
28	- 0.02274	2.34435	2.36340	- 10.31190	917.10252	- 2.55389
29	- 0.02358	2.34668	2.36010	- 11.75821	919.89211	- 2.45086
30	- 0.02413	2.34843	2.35898	- 12.63531	921.49864	- 2.30320
31	- 0.02355	2.34926	2.36116	- 12.56247	921.30628	- 2.25653
32	- 0.02160	2.34890	2.36706	- 11.50394	919.27085	- 2.33816
33	- 0.01875	2.34761	2.37566	- 9.76936	915.83235	- 2.36882
34	- 0.01594	2.34556	2.38486	- 7.91503	912.02425	- 2.26937
35	- 0.01422	2.34308	2.39205	- 6.54940	909.17775	- 2.15414
36	- 0.01438	2.34128	2.39458	- 6.13562	908.44043	- 2.24436
37	- 0.01651	2.34007	2.39255	- 6.79304	909.96157	- 2.45066
38	- 0.02004	2.33945	2.38628	- 8.30670	913.11540	- 2.57717
39	- 0.02366	2.33934	2.37780	- 10.09523	916.67225	- 2.55696
40	- 0.02601	2.33999	2.36957	- 11.49468	919.41008	- 2.49590

FIGURE 4e. AUTO-CORRELATION PRINT-OUT FOR HEADER RECORD OF FIGURE 4d

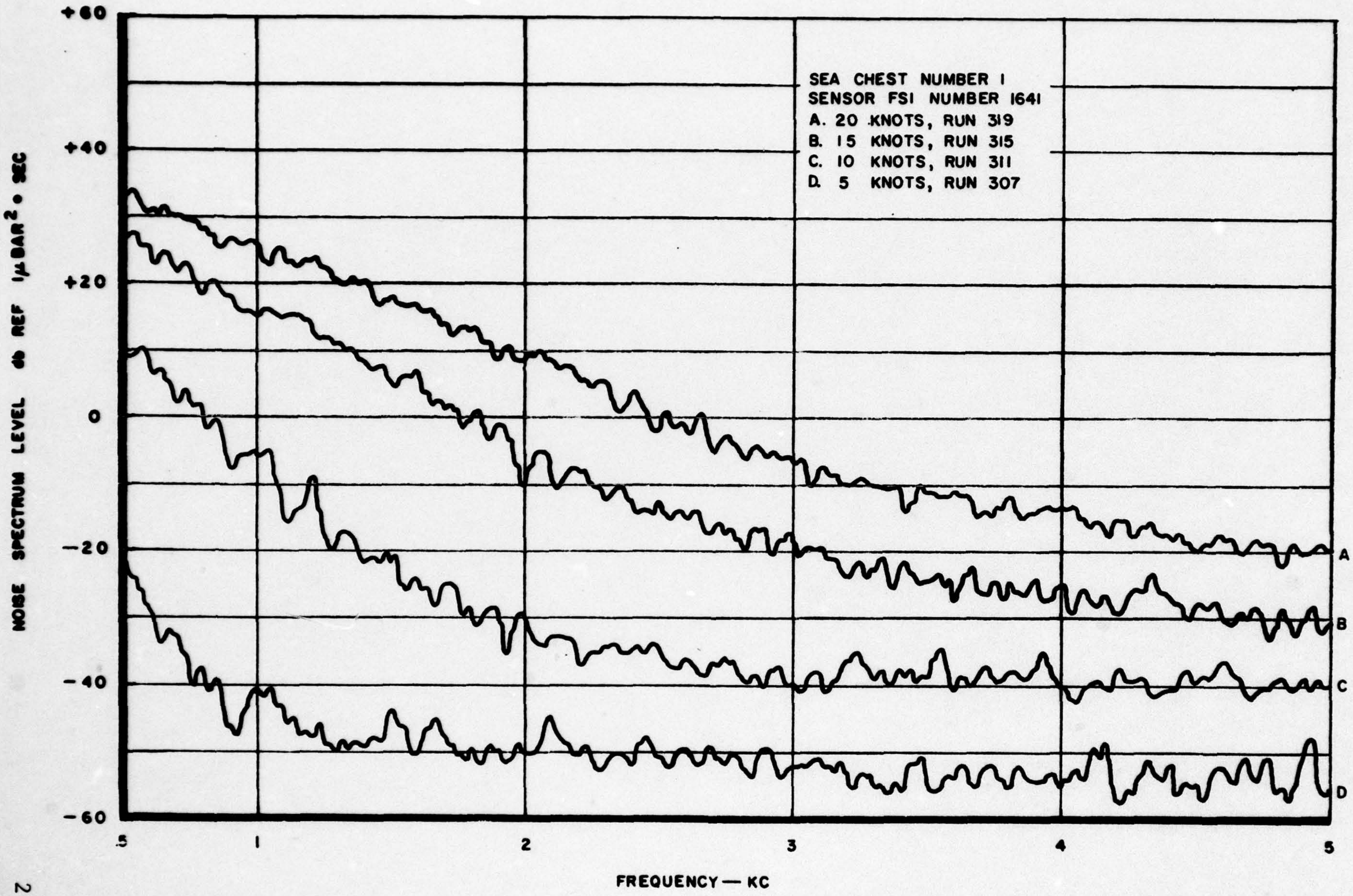


FIGURE 5. SAMPLE ANALOG POWER SPECTRUM FOR FOUR DIFFERENT SHIP VELOCITIES

SPECTRAL DENSITY PAGE 9

F	G DB X	G DB Y	MAG G XY	THET A	RE G XY	IM G XY
0.000	-28.85494	-25.46546	3.83976	-136.10761	-2.62305	2.[illegible]
31.250	-24.48067	-17.33470	0.59631	-145.70289	-0.49264	-0.[illegible]
62.500	-7.84705	-5.16370	0.90611	-91.04850	-0.01660	0.90596
93.750	-1.32164	0.39638	0.84977	-109.29663	-0.28083	0.80202
125.000	1.36840	3.34784	0.79813	-131.91423	-0.53318	0.59391
156.250	3.02751	5.50476	0.78623	-165.01792	-0.75951	0.20322
187.500	4.82756	7.07702	0.79182	167.59728	-0.77335	-0.17003
218.750	5.14677	7.60706	0.73197	144.04735	-0.59254	-0.42973
250.000	4.60045	7.70314	0.66152	110.27756	-0.22928	-0.62052
281.250	5.21253	7.91102	0.63821	72.31760	0.19384	-0.60806
312.500	5.56530	8.01414	0.61566	38.63873	0.48088	-0.38442
343.750	5.42879	8.10862	0.54943	5.87059	0.54655	-0.05619
375.000	5.92235	8.22021	0.46340	-27.19138	0.41219	0.21176
406.250	6.78697	8.67590	0.50676	-65.55679	0.20968	0.46135
437.500	7.54594	9.19497	0.50180	-91.73332	-0.01519	0.50157
468.750	8.06689	9.23111	0.37672	-127.41556	-0.22890	0.29920
500.000	8.14502	9.03349	0.29261	-157.24040	-0.26983	0.11319
531.250	7.76870	8.86804	0.11797	166.47252	-0.11470	-0.02759
562.500	7.87089	8.55391	0.18027	82.03788	0.02496	-0.17853
593.750	8.84310	8.44807	0.27759	68.97820	0.09957	-0.25912
625.000	9.38550	9.16220	0.34014	47.43072	0.23010	-0.25050
656.250	9.32063	9.19371	0.29558	16.82375	0.28293	-0.08555
687.500	9.31718	8.36956	0.25812	-38.70385	0.20143	0.16140
718.750	9.26189	8.32982	0.30915	-60.52090	0.15213	0.26913
750.000	9.16059	8.62285	0.31336	-64.96718	0.13259	0.28392
781.250	9.21192	8.81724	0.32682	-72.74705	0.09692	0.31212
812.500	9.47161	8.87987	0.35604	-95.40169	-0.03352	0.35445
843.750	9.44137	8.76694	0.32101	-128.31067	-0.19901	0.25188
875.000	8.76275	8.25995	0.25595	-165.51808	-0.24782	0.06399
906.250	8.47757	7.06056	0.19464	175.36211	-0.19400	-0.01572
937.500	8.33901	6.08242	0.06272	173.62329	-0.06233	-0.00696
968.750	7.43022	5.41929	0.08128	15.00090	0.07851	-0.02103
1000.000	6.89749	4.63830	0.14149	4.53827	0.14105	-0.01119
1031.250	7.05439	3.83126	0.14397	-41.66287	0.10756	0.09570
1062.500	6.88274	3.12065	0.15488	-54.43954	0.09007	0.12599
1093.750	5.85781	2.90166	0.13109	-48.64200	0.08661	0.09839
1125.000	4.31692	2.40538	0.14880	-87.77345	0.00577	0.14869
1156.250	3.50213	1.25103	0.10381	-116.39838	-0.04615	0.09298
1187.500	2.51578	-0.19383	0.07089	156.47531	-0.06500	-0.02829
1218.750	1.44464	-1.54240	0.09043	156.68080	-0.08304	-0.03579

FIGURE 6. CROSS-SPECTRAL DENSITY PRINT-OUT; RUN 317
CHANNEL X: FS1 1665, SEA CHEST 2
CHANNEL Y: FS1 1657, SEA CHEST 2
SPEED: 20 KNOTS; 0° HEADING RELATIVE TO SEA; ELEMENT SEPARATION 3/4"

A sample digital power spectrum print-out for band limited hydrophone data is shown in Figure 6.

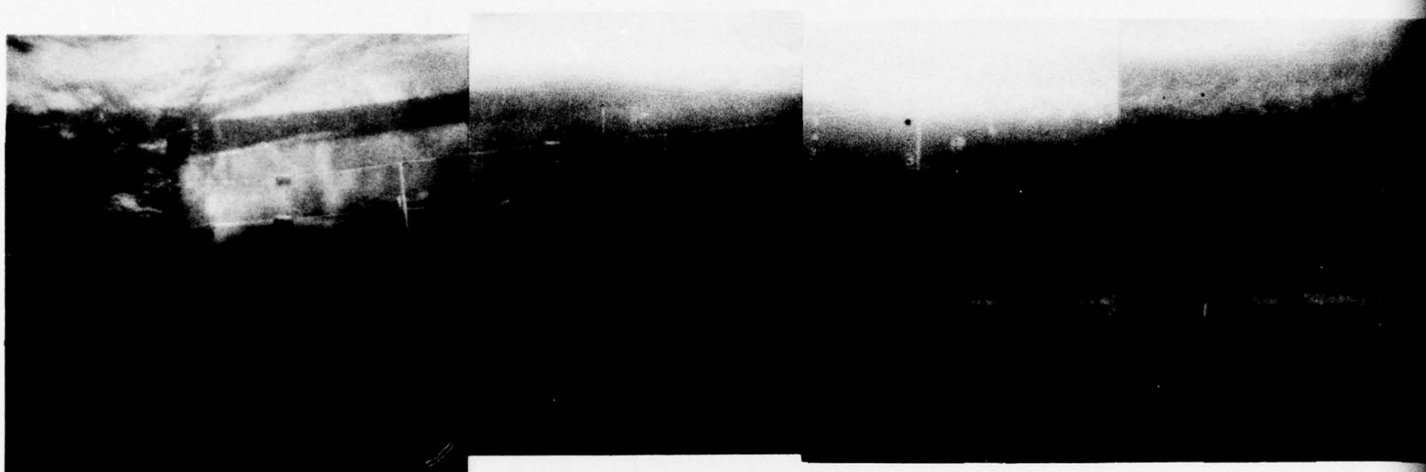
During the next report period, the reduction of data will continue and the computer program for computer plots of all reduced data will be completed.

2. UNDERWATER PHOTOGRAPHY

Processing and duplicating of film data from PURVIS I trials was 90% completed during April. Copies of the 16mm color movie film data were sent to NEL and DTMB as requested. Most of the material has been initially analyzed for qualitative observations. Detailed analysis of selected runs was continued. A letter outlining the preliminary report was sent to S. Crump on April 28, 1966. The report itself will be submitted at the end of May.[12]

On the next page we show a trial mosaic assembled from the PURVIS I data. This is a sequential mosaic, that is, a mosaic made up from a sequence of frames from one (relatively) fixed platform camera (35mm black and white film). In this case, the frames came from camera No. 3 for Run 108 of 22 March 1966. The ship, sea and wind conditions are as indicated below the mosaic photograph. In the mosaic, we can see the port side of the PURVIS. The lower grid line extends across the entire mosaic to about Frame 88. The bilge keel can be seen in the upper right. It appears that naturally formed bubbles (or bubble clouds) are swept below the water surface at about Frame 20 and then swept aft along the hull to the bilge keel location. It also appears that bubbles on the starboard side may be seen in the lower right. This mosaic is only an example of the photographic data reduction, analysis and presentation to be carried out with the PURVIS I trial results.

Discussions were held with DTMB, J. Greenberg, and others concerning plans for PURVIS II trials. A test plan and



SEQUENTIAL MOSAIC

RUN NO. 108 - 22 MARCH 1966, 10
CAMERA NO. 3, FRAMES 11,13,15,17,1

MARCH 1966, 10:35 AM
RAMES 11,13,15,17,19,21,23

SHIP SPEED 20 KNOTS, COURSE 238°
SEA STATE 1, FOLLOWING SEAS
WIND SPEED 14 KNOTS, DIRECTION 087°

2

procedure was agreed upon and a preliminary proposal submitted to DTMB. The final proposal was 80% completed and will be submitted in early May.

3. ACOUSTIC TESTS, PURVIS I

A preliminary draft of an interim report on PURVIS I acoustic tests[11] has been prepared and submitted. It is anticipated that this final version of this report will be submitted as a DTMB report.

4. HYDROPHONES

A final configuration for the hydrophones for PURVIS II was tested and accepted by Fred Schloss of DTMB on April 25, 1966. Assembly and testing of hydrophones has begun with the first 21 units slated for delivery to BNS on May 9, 1966.

5. PURVIS II STRUTS

The second fixed strut for PURVIS II, as requested by I. Cook of DTMB was fabricated and shipped to BNS. Both struts have now been delivered. A fairing for the intersection of the strut and ship was fabricated and delivered to BNS.

6. SEA CHESTS

Sea Chests for PURVIS II were modified and shipped to BNS.

7. PREAMPLIFIERS

60 preamplifiers were tested and shipped to BNS. A final report describing PURVIS II preamplifier test results was submitted to NEL.[13]

7200: HULL STUDIES

Testing of various cylindrical resonators is being continued in order to evolve an efficient design for a sea chest with required dynamic response. Ascertained to date is the fact that hollow cylinders of small diameter act as solid cylinders when both are used as quarter wave length resonators.

7600: HYDRODYNAMIC SUPPORT

Work on low-drag ship design, using quadrilateral source distributions, was continued.

Davidson Laboratory, working under subcontract, has started work on a bubble emitter for the flow visualization model tests.

9000 -- PROGRAM MANAGEMENT AND SYSTEM ENGINEERING

9100: PROGRAM MANAGEMENT AND SYSTEM ENGINEERING

During the month of April, the program was revised to reflect redirection of the DUMILOAD Education Program, and to include activities for the transducer heat problem and TRG's input to the GD ARAB Program. In addition, the front end electronics, WP 21-1 and -2 were terminated by NEL and have been deleted from the program.

The NEL PERT Time and cost reports have been updated, for the month.

TRG received NEL's letter SS 048 001 (08537), dated April 19th, and all suggestions and requests for information will be answered.

The following technical reports were mailed to NEL during April:

TM-66-12	Tolerances for Array Element Excitations Based on Sidelobe Ratios, V. Mangulis
TM-66-10	On the Choice of Beam Spacing in Rotational Directional Transmission, A. Novick
TM-66-14	Properties of Transducer Array Inpedance Matrix and its Inverse, R. Wilson

TN-66-11	Results of Converter-Filter Test, J. Cabot
TM-66-9	PURVIS II Pre-Amplifier Test Results I, J. Golden
TN-66-9	Transducer Shock Testing, I. Melnick
TN-66-7	Transducer Corrosion and Fouling Studies, R. Goldman
TN-66-10	Report on Potentiostatic Tests, R. Goldman
TM-66-16	Interim Report on Sonar Performance, A. Novick
TM-66-3	Simplified System Performance Study (Revision B), A. Novick
TM-66-15	Acceleration Sensitivity Test Results I, J. Golden
TM-66-18	Interim Report on ASW Simulation Computer Program, D. Cope

9300: ADVANCED ELECTRONIC TECHNIQUES

Measurements on the STL PRIMAG evaluation unit have been completed and a documentary report is 90% complete[8]. A theoretical estimate of the effects of interchannel cross-talk on the beam patterns formed is being prepared for inclusion in the report, along with a preliminary beamformer design based on the results of these measurements. The report will be submitted during the month of May.

9400: ENVIRONMENTAL

Work on WP 94-1 for the month of April 1966 consisted of the following:

1. Continuation of water absorption tests on elastomeric materials in natural and synthetic sea water at ambient and elevated temperatures.

2. Immersion and efficiency tests on transducer elements located at Ocean City, N.J. were continued. This test will continue for an additional eight months.

3. Water vapor transmission test on elastomeric materials is continuing. It is expected that additional testing will continue for the next six months.

4. Reduced scale cathodic protection test under velocity conditions is continuing. This test will continue for an additional three months during which time sufficient data will have been collected to permit predictions to be made for long term protection.

5. Test panels for the cavitation experiments are being fabricated and the transducer components are being assembled. This experiment will determine the effect of operating the transducers at cavitation levels on the standard Navy anticorrosion and antifouling coatings.

6. Technical report on potentiostatic tests was submitted to NEL.[14]

REFERENCES:

1. "On the Choice of Beam Spacing in Rotational Directional Transmission," A. Novick, 023-TM-66-11, April 1966.

2. "Interim Report on the Surface-Duct Propagation Model for C/P Sonar Predictions," A. Novick, 023-TM-66-24; May 1966.

3. "Interim Report on Sonar Performance," CONFIDENTIAL, A. Novick, 023-TM-66-16, April 1966.

4. "On Sonar Performance Estimation for Remote Source and Receiver," R. Seegal and A. Novick, 023-TM-66-23, May 1966.

5. "Simplified System Performance Study," Revision B, A. Novick, 023-TM-66-3.

6. "The Effect of Bottom Slope on Bottom Bounce Echo Ranges," A. Lehmann, 023-TM-66-25, May 1966.

7. "Mathematical Techniques for Cost-Effectivenss Optimization," L. Chin, 023-TM-66-21, May 1966.

8. "Analysis of Results of STL PRIMAG," J. Franceschini, June 1966.

9. "Fault Isolation and Self-Checking Equipment in C/P Sonar," D. Cox, 023-TM-66-22, May 1966

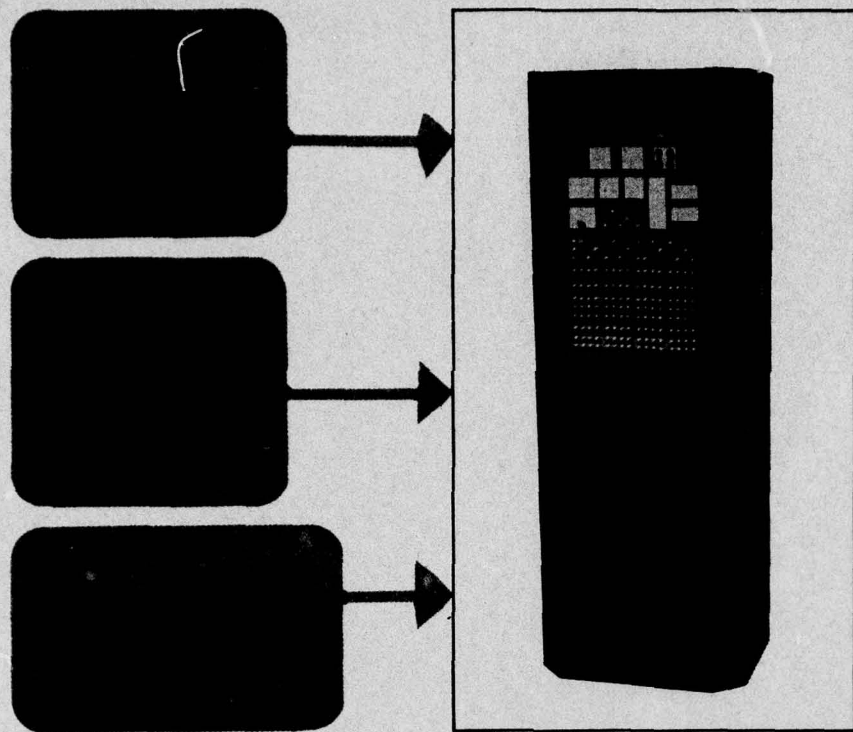
10. "Results of Converter-Filter Test," J. Cabot, 023-TN-66-11, April 1966.

11. "Interim Report on PURVIS I Acoustic Tests," S. Gardner, 023-TM-66-19, May 1966.

12. "Initial Photographic Data Reduction for PURVIS I Sea Trials," A. Raff, May 1966.

13. "PURVIS II Preamplifier Test Results I," J. Golden, 023-TM-66-9, May 1966.

14. "Report on Potentiostatic Tests," R. Goldman, 023-TN-66-10, April 1966.



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