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DISPLAY REQUIREMENTS FOR THE PASSIVE SUBSYSTEM, C/P ARRAY SONAR--ETC(U)
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Contract N123(953)54996A
TRACOR Project No. 002-009-12
Document Number
TRACOR-SD-67-011-C

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TECHNICAL MEMORANDUM,

DISPLAY REQUIREMENTS FOR THE PASSIVE SUBSYSTEM, C/P ARRAY SONAR PROJECT (U)

Submitted to

U. S. Navy Electronics Laboratory
San Diego, California 92152

Attention: Code 2110

 May 1967

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63p.

18 May 1967

Approved:

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Project Director

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ABSTRACT

This technical memorandum discusses the display requirements for the passive search/detect mode in the Experimental Ship System of the C/P Array Sonar Project. Current work on the passive subsystem is reviewed and a candidate subsystem configuration for the ESS is described.

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TABLE OF CONTENTS

TRACOR, INC. 3065 ROSECRANS PLACE, SAN DIEGO, CALIFORNIA 92110

LIST OF TABLES

TRACOR, INC. 3065 ROSECRANS PLACE, SAN DIEGO, CALIFORNIA 92110

LIST OF ILLUSTRATIONS

K-1998 (2 of

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1. INTRODUCTION

Task assignment 12 of the C/PAS Contract N123(953)54996A includes a study of the display requirements for the Experimental Ship System. One of these requirements is display of data from the passive subsystem. As part of the study, current work on the passive subsystem was reviewed for those functions likely to be implemented in the Experimental Ship System. A "most likely" subsystem was selected as the basis for deriving the functional requirements of the passive display segment. These requirements are discussed in this report in as much detail as is presently available. The implications of various changes in the subsystem are examined and simulations of several of the display functions are suggested.

2. SUMMARY OF CURRENT SUBSYSTEM WORK

General Electric has discussed the passive subsystem in several project reports. (Refs. 1, 2, 3, and 6). Of these, Ref. 6 is the most recent. It lists the subsystem goals and constraints, summarizes previous work and describes in detail the current work in passive data processing being done at G. E. Most of the work done to date by G. E. has involved the subsystem planned for the prototype system. The subsystem description which follows was summarized from the G. E. reports and is based on the number of beams, data rates, etc., planned for the prototype.

The frequency band selected for passive detection is a 1 Khz band extending from 800 to 1800 Hz. Because the active beamformer will also be used for passive beamforming, the lower frequencies in the passive band result in overlapping beams. In general, the passive beams will be about twice as wide as the corresponding active beams. G. E. proposes about 144 passive beams for 360° coverage in the prototype system with 300 active surface duct beams. Division of the 300 beamformer outputs is done by selecting approximately every other output for inputs to the 144 passive signal processing channels.

2.1 PASSIVE SIGNAL PROCESSING

Figure 1 illustrates the passive signal flow from the array elements through the signal processor. After separation from the active signals by bandpass filtering, the passive signals from each array element are quantized to levels of -1 or +1 by hard limiting. They are then summed with the quantized active signals in the surface duct beamformer. The beamformer outputs will be digital words containing both active

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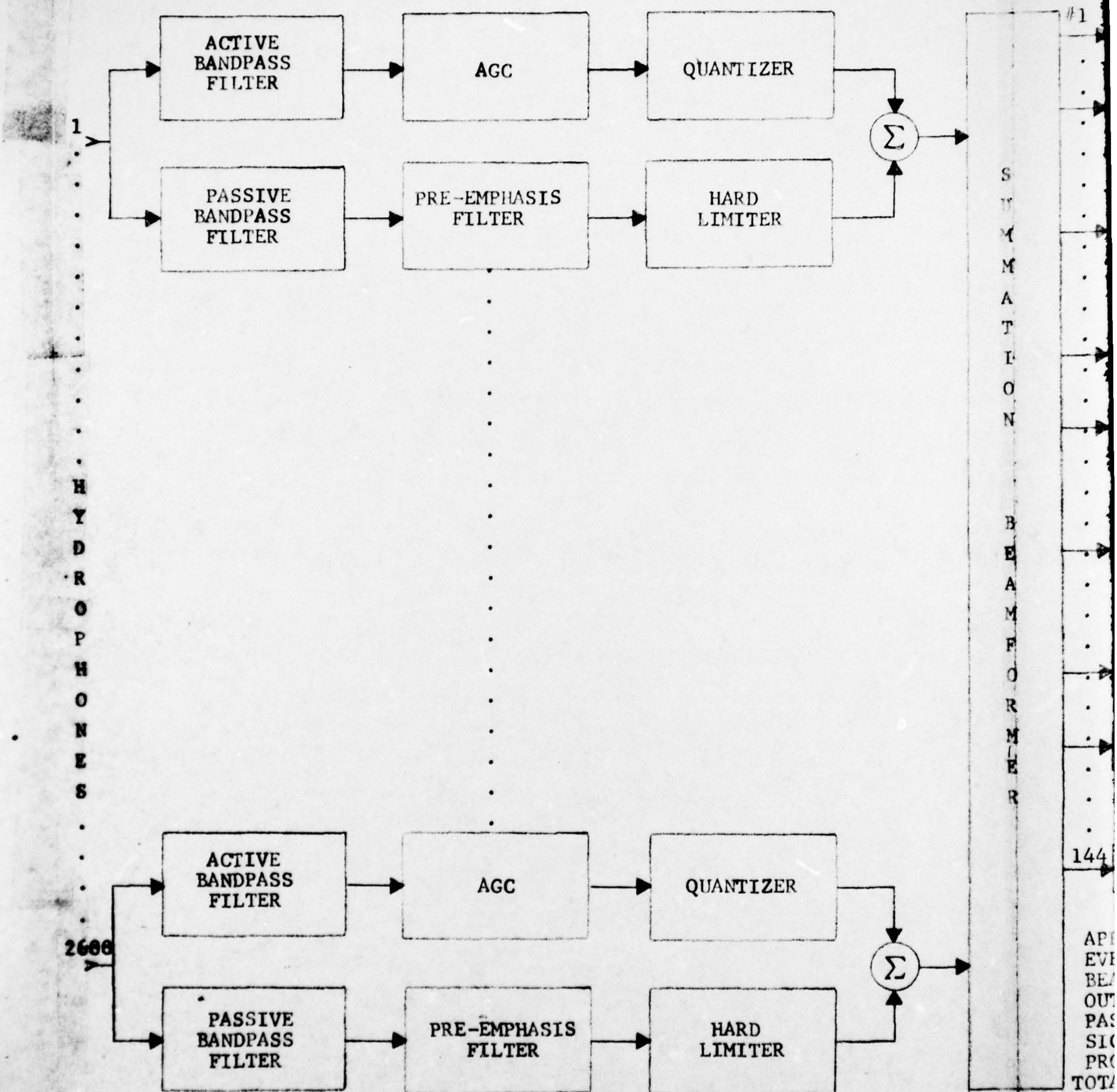

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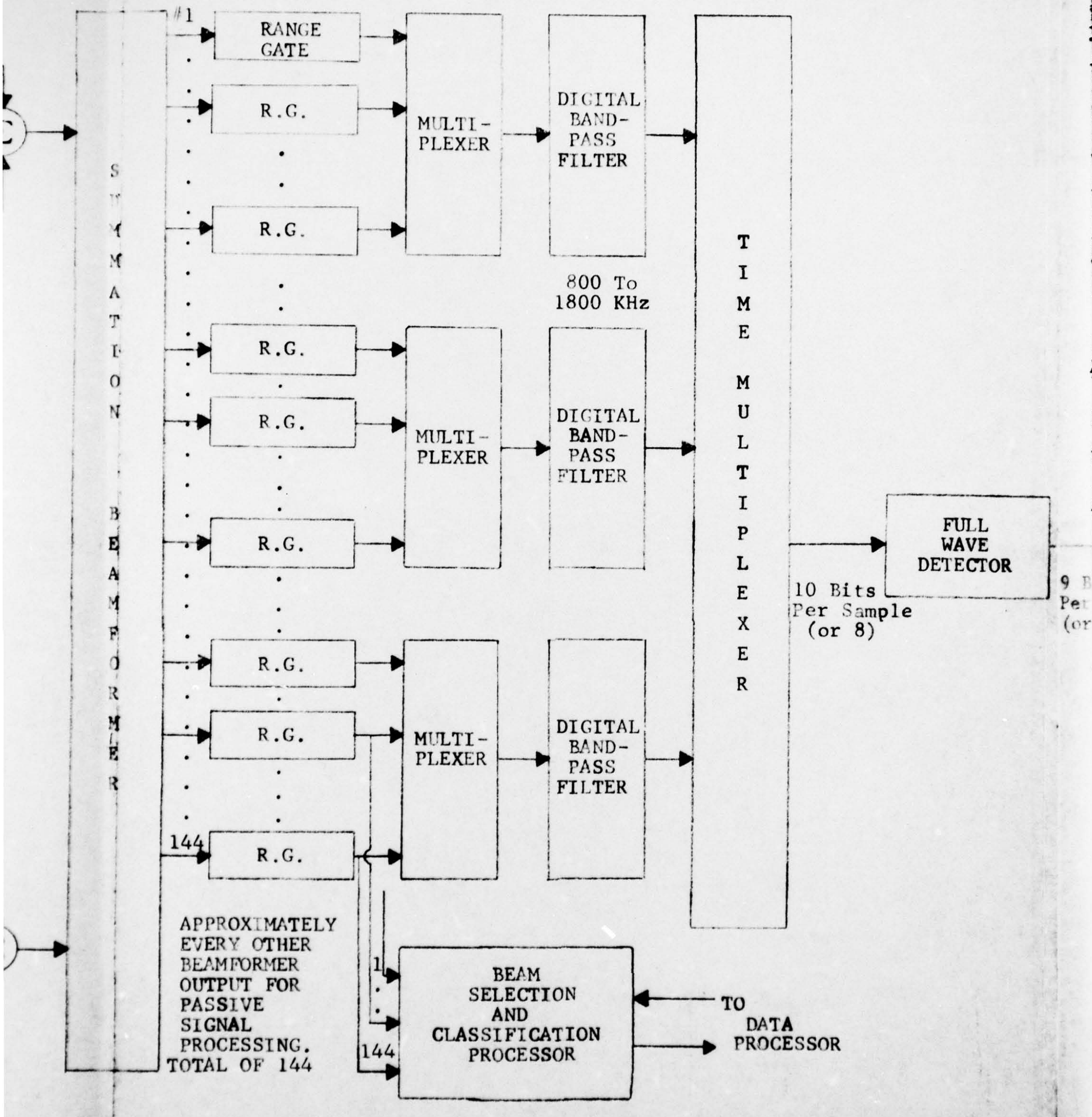

S U M M A T I O N
B E A M F O R M E R
#1
RANGE GATE
R.G.
MULTI-PLEXER
DIGITAL BAND-PASS FILTER
800 To 1800 KHz
T I M E M U L T I P L E X E R
FULL WAVE DETECTOR
10 Bits Per Sample (or 8)
144
APPROXIMATELY EVERY OTHER BEAMFORMER OUTPUT FOR PASSIVE SIGNAL PROCESSING. TOTAL OF 144
1
BEAM SELECTION AND CLASSIFICATION PROCESSOR
TO DATA PROCESSOR

2

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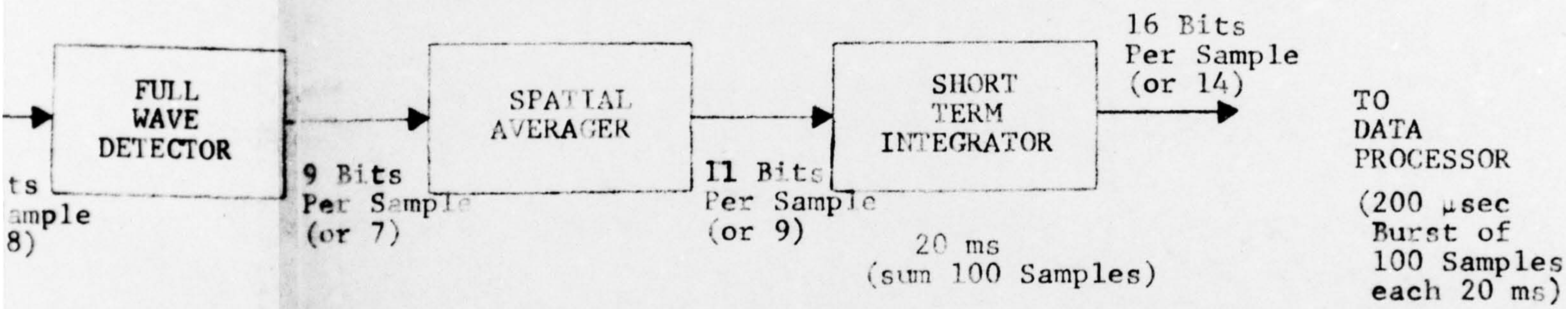

FIG. 1. PASSIVE SIGNAL PROCESSING

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and passive data. Eight bits comprise a word and the sample rate for each beam will be about 10 Khz. The output on each beam will be a string of eight-bit words at a rate of 10,000 words/sec. Studies are currently being conducted to determine the adequacy of the proposed eight-bit quantization. This may be increased to ten bits to adequately cover the dynamic range of signals expected with the required sensitivity to small changes in signal level.

If the frequency selected for surface duct transmissions is at the lower end of the active band, there may be considerable spillover of reverberation energy into the passive band. It may be necessary to include range gating in the passive subsystem to gate out the spillover until the reverberation from active transmissions has diminished to acceptable levels. The range gates are shown in Fig. 1 between the outputs from the beamformer and the inputs to the passive processor channels. However, they could conceivably be located elsewhere in the subsystem.

After range gating (if required), the beamformer outputs are multiplexed into digital bandpass filters to separate the passive data from the active data. It is not known at this time how many channels may be multiplexed through each filter. The outputs from the filters are then multiplexed into a single channel for further processing. The sample rate proposed for this multiplexing is 5 Khz per beam. The outputs from the filters are scanned in such a way that a sample from one beam is followed by a sample from the next and so on. A complete scan of the beams consists of a group of 144 samples in a period of 200 μsec. Each sample in the group is separated from the next by 1.39 μsec. The output from the multiplexer is a train of sample words at a rate of 720 Khz. The original beamformer quantization will probably be carried through the

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filtering and multiplexing. Thus, a sample word of the output of the multiplexer contains eight (or ten) bits.

Following the multiplexing, a linear full-wave detector is used as an energy measuring device. The proposed detector complements the negative sample words and passes the positive words unchanged. The input to the device is assumed to be Gaussian with zero mean distributions for both noise and signal plus noise samples. Due to the rectification, the outputs will have positive means with the signal plus noise mean being greater than the noise mean, providing a basis for detection.

The next signal processing function is called spatial averaging. This subtracts the positive mean of the noise distribution from the samples on the multiplexed beams. Doing so tends to produce a zero mean for noise alone and a non-zero mean for signal plus noise at the input to the time averager. The noise mean to be subtracted is obtained by averaging the values of the samples from the beams adjacent to the beam (B_i) of current interest. The assumption is that signals will appear on only one (or a very limited number) of beams, while noise will be relatively constant across several beams.

General Electric has tentatively proposed a spatial averager scheme which subtracts the sum of the samples on beams B_{i-4}, B_{i-3}, B_{i+3}, and B_{i+4} from four times the value of the sample on B_i. This is done in serial as the samples from the multiplexer pass through the rectifier and the spatial averager at a 720 Khz rate. (See Ref. 2 for a more detailed description of this process).

Short-term integration is the next passive signal processing function. This process adds samples from each beam for a predetermined period of time as a means for increasing the

S/N ratio. Assuming zero noise mean and non-zero noise plus signal mean, integration over a period of time will produce greater sample values for beams with signals present than for those without.

The integration period selected for the short-term integrator is designed for the detection of acoustic transients. The transients of interest last from 200 msec to 800 msec; (operation of bow and stern planes and the rudder of a submarine--see Ref. 4). Based on the minimum transient length and display marking considerations, G. E. has selected an integration period of 20 msec. Since the sample rate per beam is 5 Khz, 100 samples are added and accumulated for each beam. After sample 100 is added, the accumulated samples for all 144 beams are output and the process started over on the next group of samples from the spatial averager. The output from the short-term integrator is a burst of 144 words lasting 200 μsec and occurring every 20 msec. The interval between words in the burst is 1.39 μsec. This output is passed on to the data processing segment which is a G. P. digital computer. Some form of data rate smoothing or buffering will probably be required between the signal processor and the data processor. This buffering may be combined with thresholding.

In Ref. 2, General Electric has analyzed the dynamic range and resolution requirements of the passive subsystem. Assuming hard limited outputs from the transducers and a dynamic range sufficient to handle variances in signal amplitudes up to three times the standard deviation without register overflow, they have derived the quantization required at the various stages of the passive signal processor. They recommend a quantization of ten bits per sample in the beamformer. After detection, the sign bit on each sample can be dropped resulting in nine bits per sample into the spatial averager. The multiplication, weighting and adding in the spatial averager result in an eleven-bit word into the short-term integrator. Adding together 100 samples in the short-term integrator produces a sum with a maximum of 18 bits. However, 16 bits per sample out of the short-term integrator are felt to be adequate if provision is made for rare cases of register overflow.

If the beamformer quantization is maintained at the presently planned eight bits per sample, the number of bits carried through each stage of the signal processor would be reduced by two. The resulting quantizations are shown in parenthesis on Fig. 1.

There is some indication that requantization can be done at several points in the signal processor without severe degradation in overall performance. Future studies may result in recommendations for a lower number of bits per sample to be carried through the spatial averager and short-term integrator.

2.2 PASSIVE DATA PROCESSING

In Ref. 3, General Electric has listed the functions to be performed in the passive data processor segment. The approaches being followed to develop these functions are described and progress to date is summarized. This work has been directed toward detection of submarines and torpedoes. Very little consideration has been given to classification or tracking pending further clarification of the techniques to be used (LOFAR, DEMON-LOFAR or others).

During active operation, it is intended that the passive subsystem will be unmanned. The data processor will automatically detect passive signals of interest and alert one or more of the operators who would normally be viewing active data. If feasible at that time, the operator will

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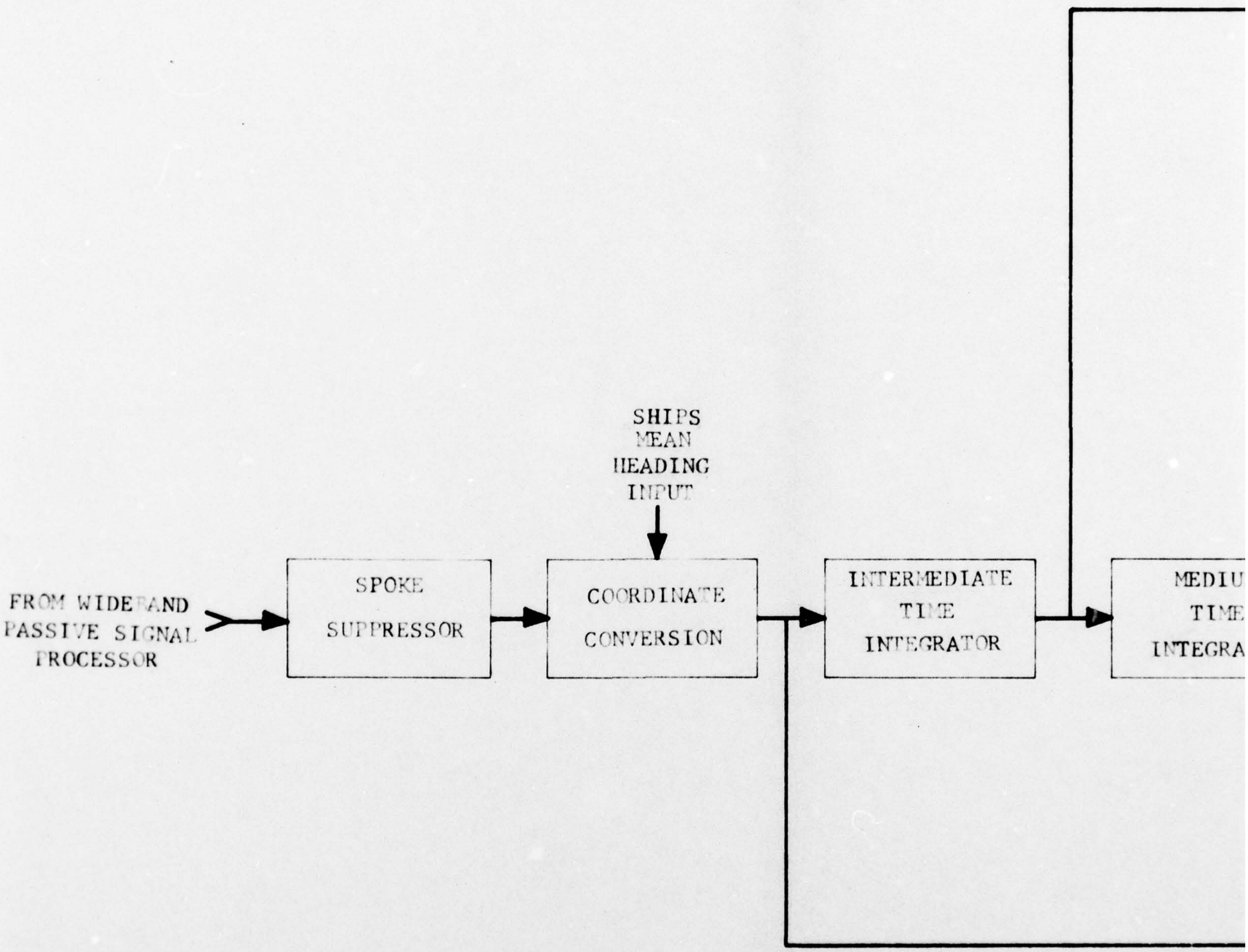
switch his display to the passive mode for further action on the passive data. In the case of torpedo detection, appropriate alarms will also be activated automatically. This implies that completely automatic passive detection of submarines and torpedoes must be accomplished in the data processor. General Electric has based their work in passive data processing on this requirement.

Figure 2 is a block diagram of the passive data processing tentatively proposed by General Electric. Three data paths are shown; one for automatic detection of submarines, one for detection of torpedoes, and one for detection of transients. All three are provided with manual backup capability.

The first function shown, spoke suppression is designed to suppress constant directional interference from such sources as the ship's screws. Initially, it was thought that this suppression could be provided by subtracting a long-term average of the level on each beam from the value of the current sample on each beam. The average could be derived by integrating the samples over a long period of time--perhaps as long as 15 minutes. This integration period must be considerably longer than the length of time a target could be expected to remain in one beam. Otherwise, of course, target noise would be suppressed along with interference. The effectiveness of such suppression in a system with highly stabilized receive beams such as are intended for the C/P Array System has not been completely evaluated. Studies presently being conducted may result in the choice of some other suppression technique. (See also Ref. 6, Section 3.2).

After interference suppression, the passive bearing data are converted to true bearing coordinates. This function will probably be accomplished by a simple table lookup scheme relating beam numbers and the current ship's heading relative



SHIPS MEAN HEADING INPUT
FROM WIDEBAND PASSIVE SIGNAL PROCESSOR
SPOKE SUPPRESSOR
COORDINATE CONVERSION
INTERMEDIATE TIME INTEGRATOR

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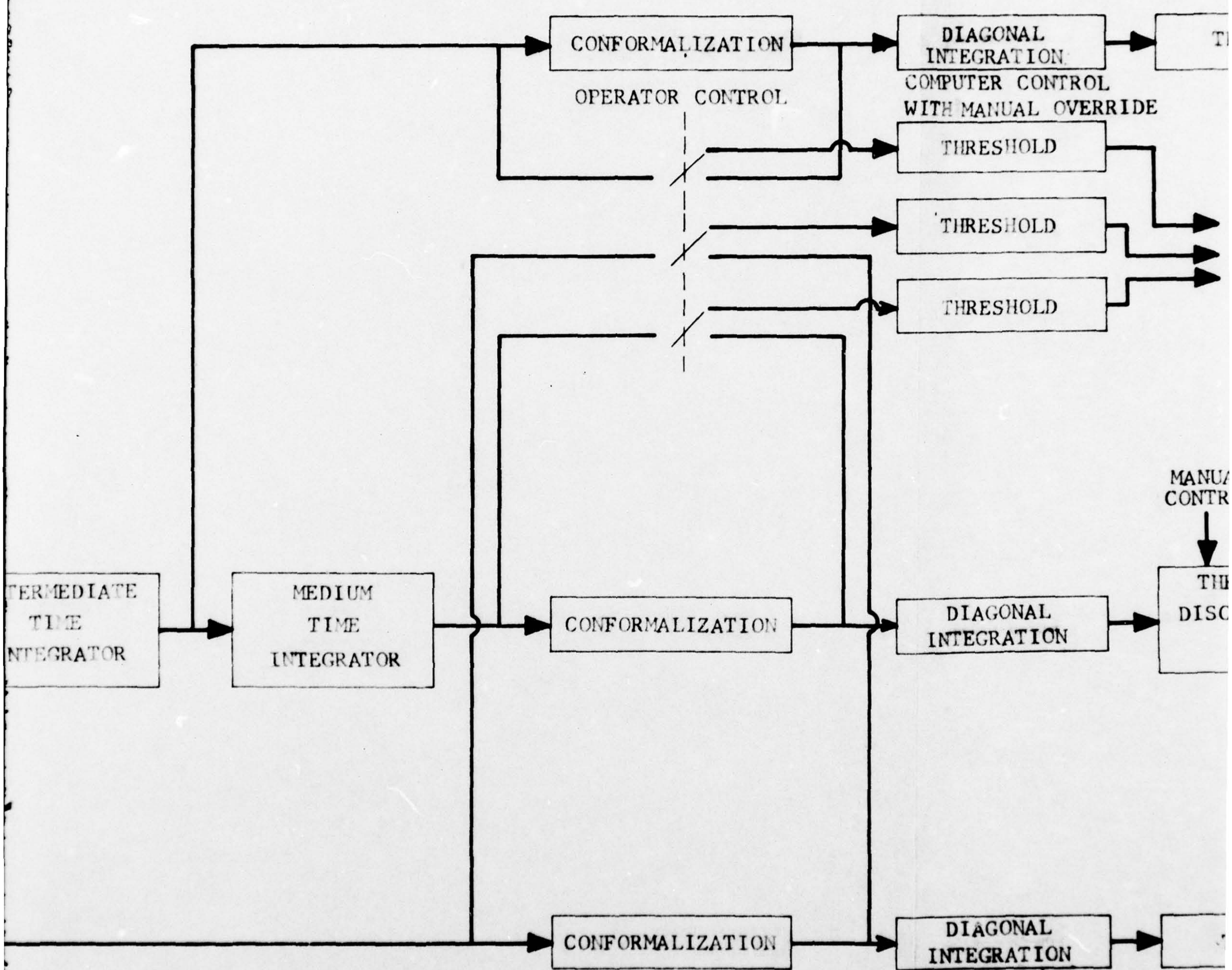

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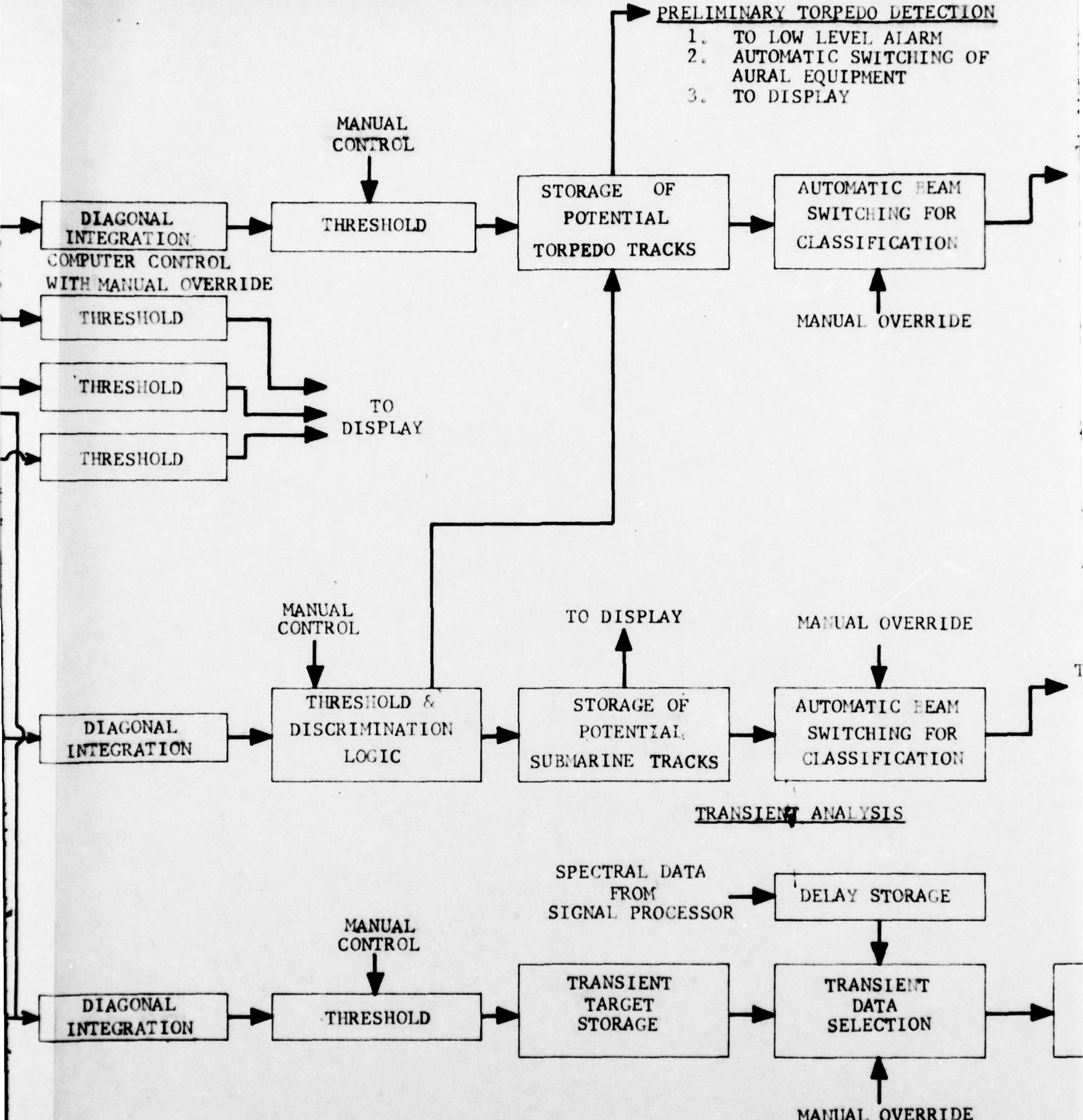
PRELIMINARY TORPEDO DETECTION
1. TO LOW LEVEL ALARM
2. AUTOMATIC SWITCHING OF AURAL EQUIPMENT
3. TO DISPLAY
MANUAL CONTROL
DIAGONAL INTEGRATION
THRESHOLD
STORAGE OF POTENTIAL TORPEDO TRACKS
AUTOMATIC BEAM SWITCHING FOR CLASSIFICATION
COMPUTER CONTROL WITH MANUAL OVERRIDE
THRESHOLD
MANUAL OVERRIDE
THRESHOLD
TO DISPLAY
THRESHOLD
MANUAL CONTROL
TO DISPLAY
MANUAL OVERRIDE
DIAGONAL INTEGRATION
THRESHOLD & DISCRIMINATION LOGIC
STORAGE OF POTENTIAL SUBMARINE TRACKS
AUTOMATIC BEAM SWITCHING FOR CLASSIFICATION
TRANSIENT ANALYSIS
SPECTRAL DATA FROM SIGNAL PROCESSOR
DELAY STORAGE
MANUAL CONTROL
DIAGONAL INTEGRATION
THRESHOLD
TRANSIENT TARGET STORAGE
TRANSIENT DATA SELECTION
MANUAL OVERRIDE

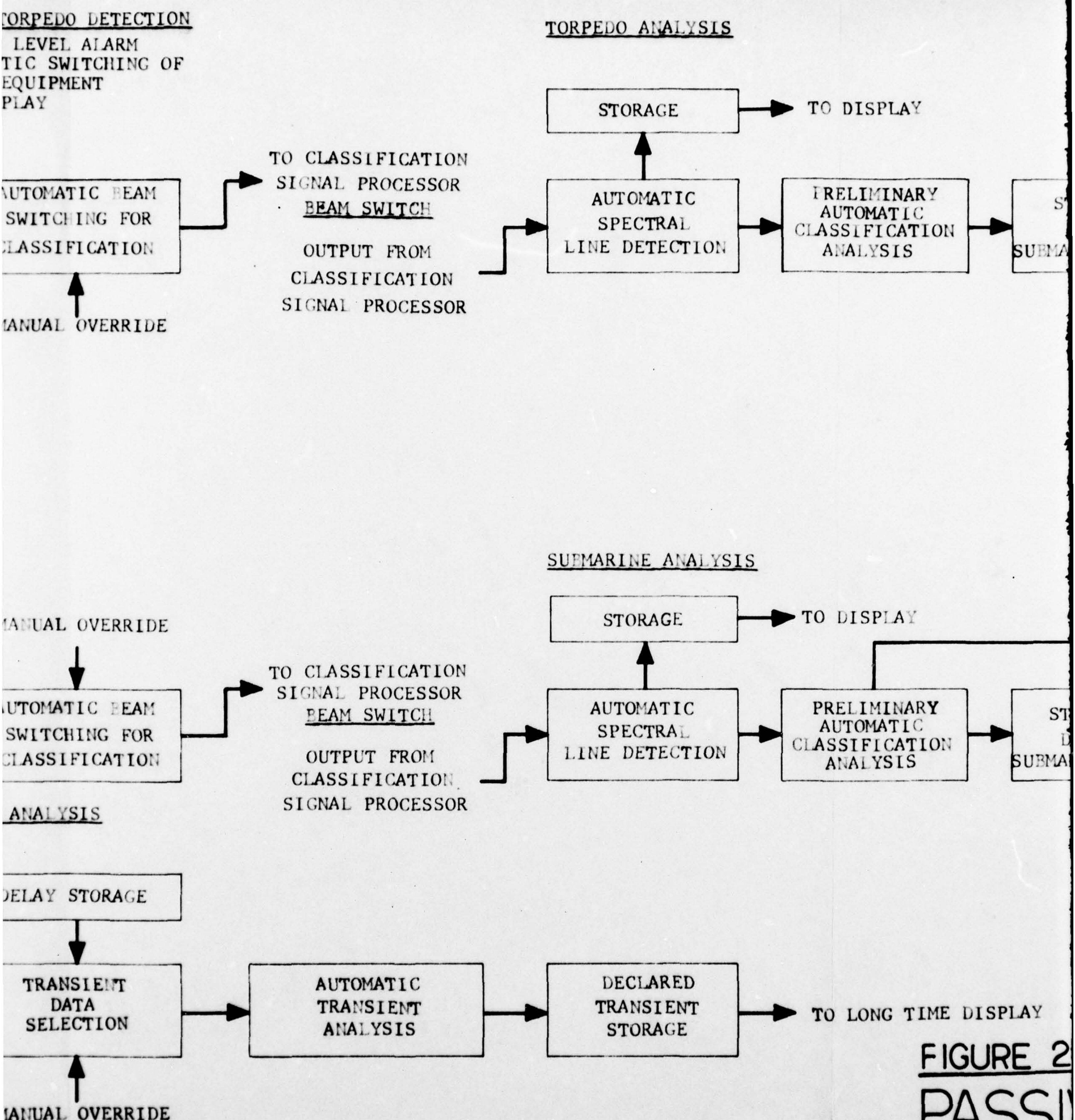

FIGURE 2
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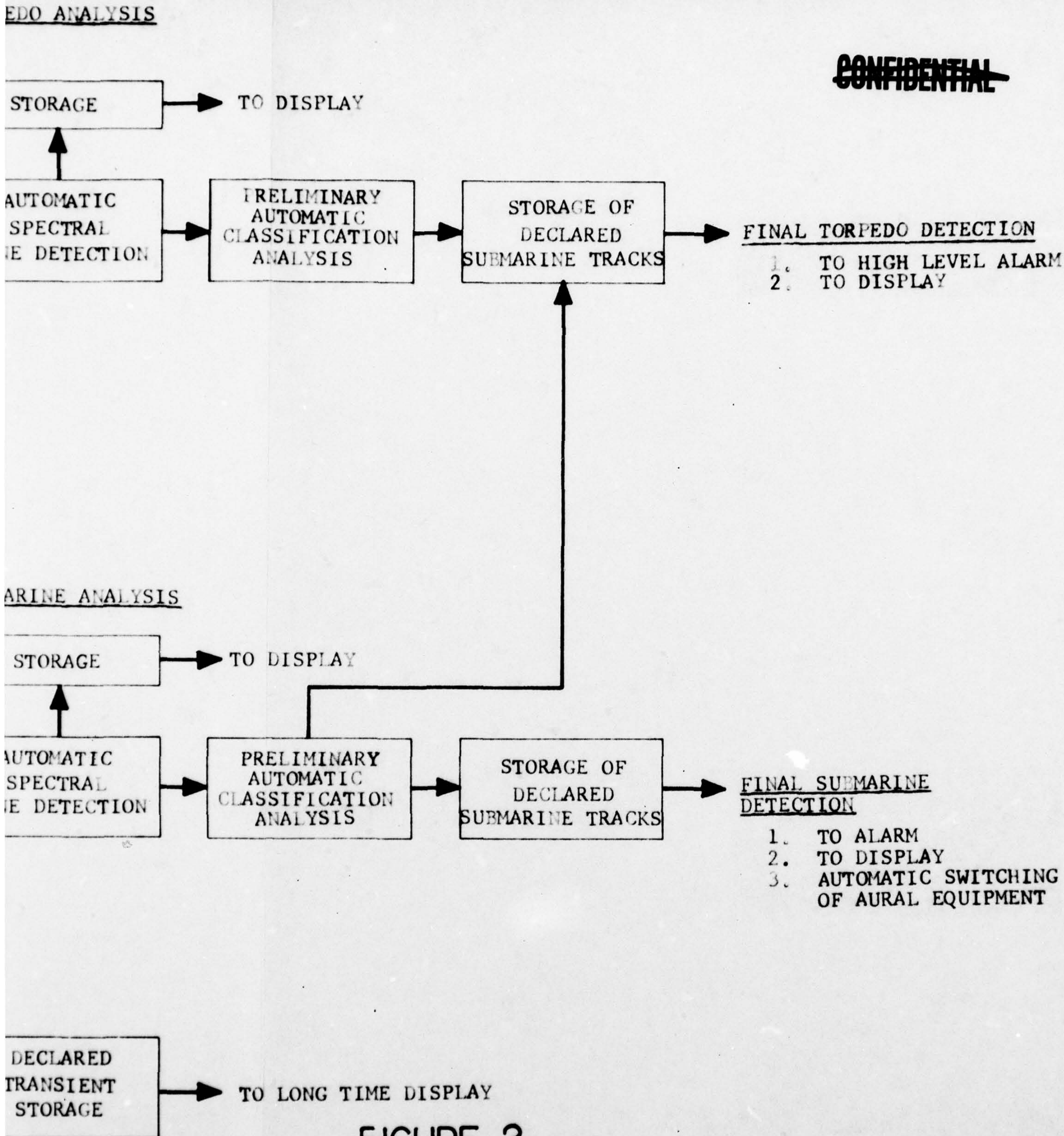

FIGURE 2

PASSIVE DATA PROCESSING

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5

to true North. This coordinate conversion is necessary to provide stabilized data to the long-term integrators and true bearing data for the displays.

After coordinate conversion, the data are passed on to one or more time integrators. Use of multiple integrators allows detection of a wide range of target types. Short-term integration provides fast detection of high S/N, high bearing rate sources such as torpedoes. Conversely, low S/N sources can only be detected by long-term integrators. Although the exact number of integrators required is not yet defined, it is likely that at least two will be included in the data processor. Representative integration times might be $T_2 \approx 100 - 200$ msec, and $T_4 \approx 1$ sec. Counting T_1 (about 20 ms), these three integrators would provide the time constants needed for detection of transients, torpedoes and submarines. Presumably, the automatic detection processes will be able to detect target signals in all three of the integrator outputs.

Conformalization refers to the manner in which the beamwidths are represented on the display. A time-bearing format is proposed for the detection display. The abcissa of the format is divided into increments, each of which represents the bearing of a particular beam. In a "conformal" format, the width of each increment will be proportional to the azimuthal coverage of the corresponding beam. These widths are unequal for the C/P Array format because the beams have unequal coverage. An alternative method is to assign some average coverage to all beams and make all abcissa increments equal in width. This is called linear bearing representation.

The conformal format gives the operator an indication of the azimuthal resolution of the system and allows him to determine the accuracy of a bearing reading. However, it is more difficult to generate. The bearing and width of each beam

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must be represented whereas bearing only is needed for a linear format. Also, in a true bearing conformal format, rotation of the ship will cause a change in the relative positions of the wide and narrow increments. (The beams rotate to new bearings). This may be confusing to the operator because the older data on the display will maintain the original spacing while new data will be marked according to the new ship's heading. A linear display is probably less confusing, but gives less accurate bearing information. General Electric has suggested that both formats might be used. A linear format would be used for detection. Once detection has been made, the display would be switched to a conformal format to obtain accurate bearing data on the target. The automatic detection process will use conformal bearing data only.

The process called diagonal integration is the basis of the automatic detection scheme proposed by General Electric. This function will attempt to recognize target-like patterns in the outputs from the time averagers. One such pattern might be created by a target which maintains a constant true bearing from own-ship. The outputs from a corresponding bearing bin in a time integrator will have greater than normal amplitudes for as long as the target remains on the same bearing. This pattern would be relatively easy to recognize automatically. (In fact, the time integrators are designed to make tentative detection of just such patterns). The problem is complicated, however, by targets which possess bearing rates. In this case, the pattern of high amplitude samples progresses across adjacent bearing bins over a period of time. (This pattern appears as a diagonal line on a time-bearing display). Conceivably, a signal source can be detected by integrating the samples taken along one of these diagonal paths over a period of time. If the result exceeds a threshold, tentative detection would be declared. Further sequential tests might then be applied to attempt classification of the source. When the number of beams and the possible target bearing rates are considered, it is apparent that a large number of diagonal patterns are possible. Examination of the patterns is expected to require a significant portion of the passive data processing segment. Reference 6 discusses the diagonal integration technique in detail.

As pointed out in Ref. 3, rough classification of the signal source is provided by using more than one time integrator, diagonal integrator combination. It is expected that torpedo sounds in the passive band will differ from submarine sounds in that they may have higher S/N, higher bearing rates or possibly, rapidly increasing S/N. Signals of this nature may appear as high amplitude outputs from the short or medium-term integrators. Such outputs may be tentatively classified as torpedoes, whereas those from the long-term integrators may be considered submarines. Other clues, such as non-linear diagonal paths might provide additional classification information.

As shown in Fig. 2, the outputs from the diagonal integrators are thresholded, stored as potential targets, and displayed. The manner in which the final thresholding will be done has not been described.

General Electric has examined classification by LOFAR and DEMON LOFAR to a limited extent. Figure 2 shows the general processing required for DEMON-LOFAR. It includes manual or automatic selection of beams for input to the processor, automatic detection of spectral lines, classification analysis, and declared target storage and display.

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General Electric has not described automatic or computer-aided manual tracking of passive sources in any of their reports. However, considerable work in this area is being done as part of the New Sub Sonar Project at NEL. This work is being followed closely by the C/P Array Project Office for possible application to the C/P Array Sonar System. No details on implementation of the tracking process are available yet.

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3. PASSIVE SUBSYSTEM FOR EXPERIMENTAL SHIP SYSTEM

In order to make a realistic estimate of the display requirements, it is necessary to assume a system configuration. This has been done for the passive subsystem of the Experimental Ship System. The description which follows is not, of course, a firm design. Rather, it represents the most likely configuration of the subsystem based on currently available data. This configuration will probably change as a result of studies presently being conducted. The changes, however, may not affect the display requirements significantly. It is thought that the display requirements derived from the subsystem described are reasonably close to the final requirements.

3.1 BEAMFORMING AND SIGNAL PROCESSING

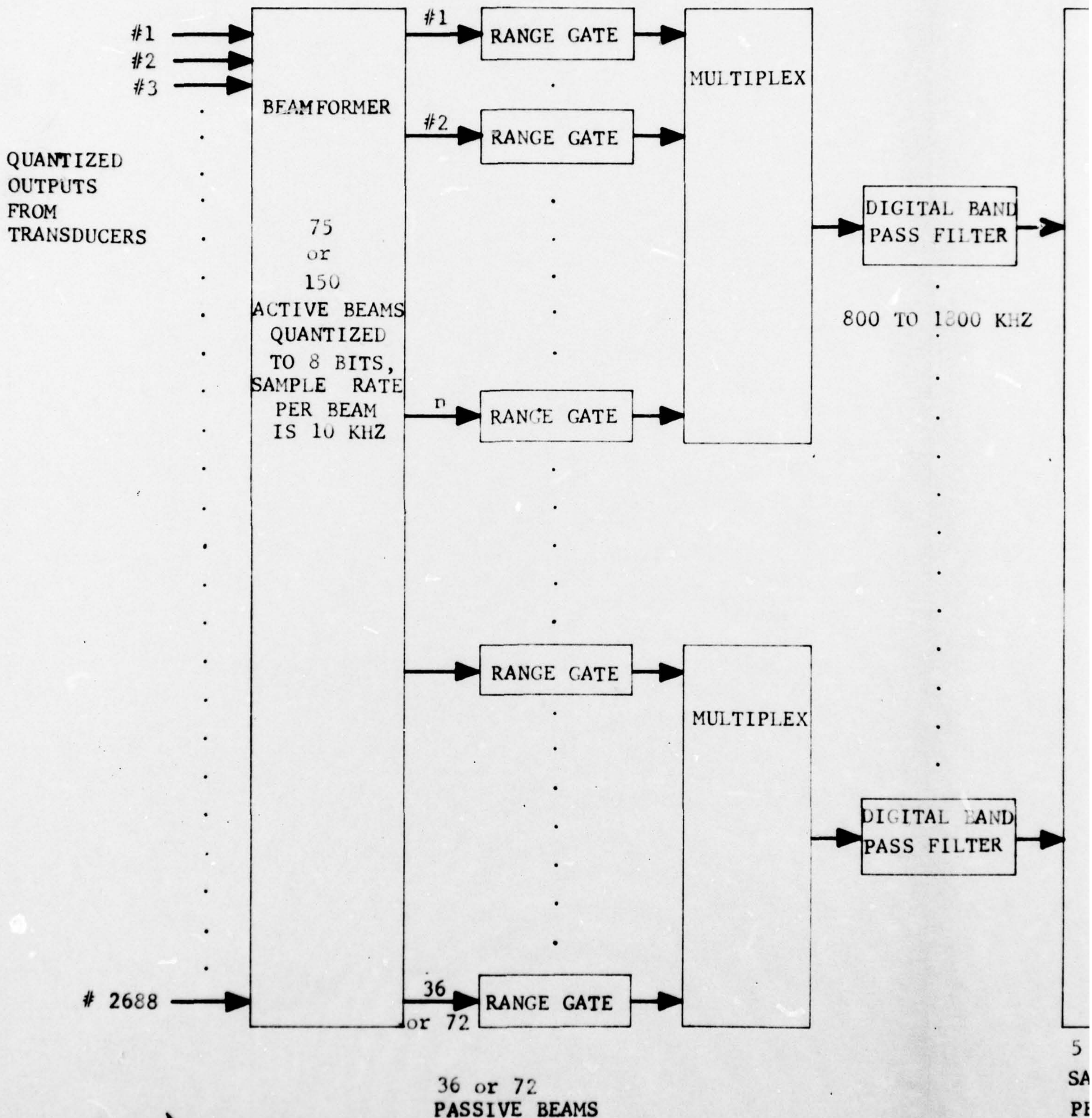
As currently planned, the ESS will have one array of 2688 hydrophones on one side of the ship. Prior to beamforming, the output from each hydrophone will probably be treated as shown in Fig. 1. The passive signals will be bandpass filtered, amplified and quantized by hard limiting.

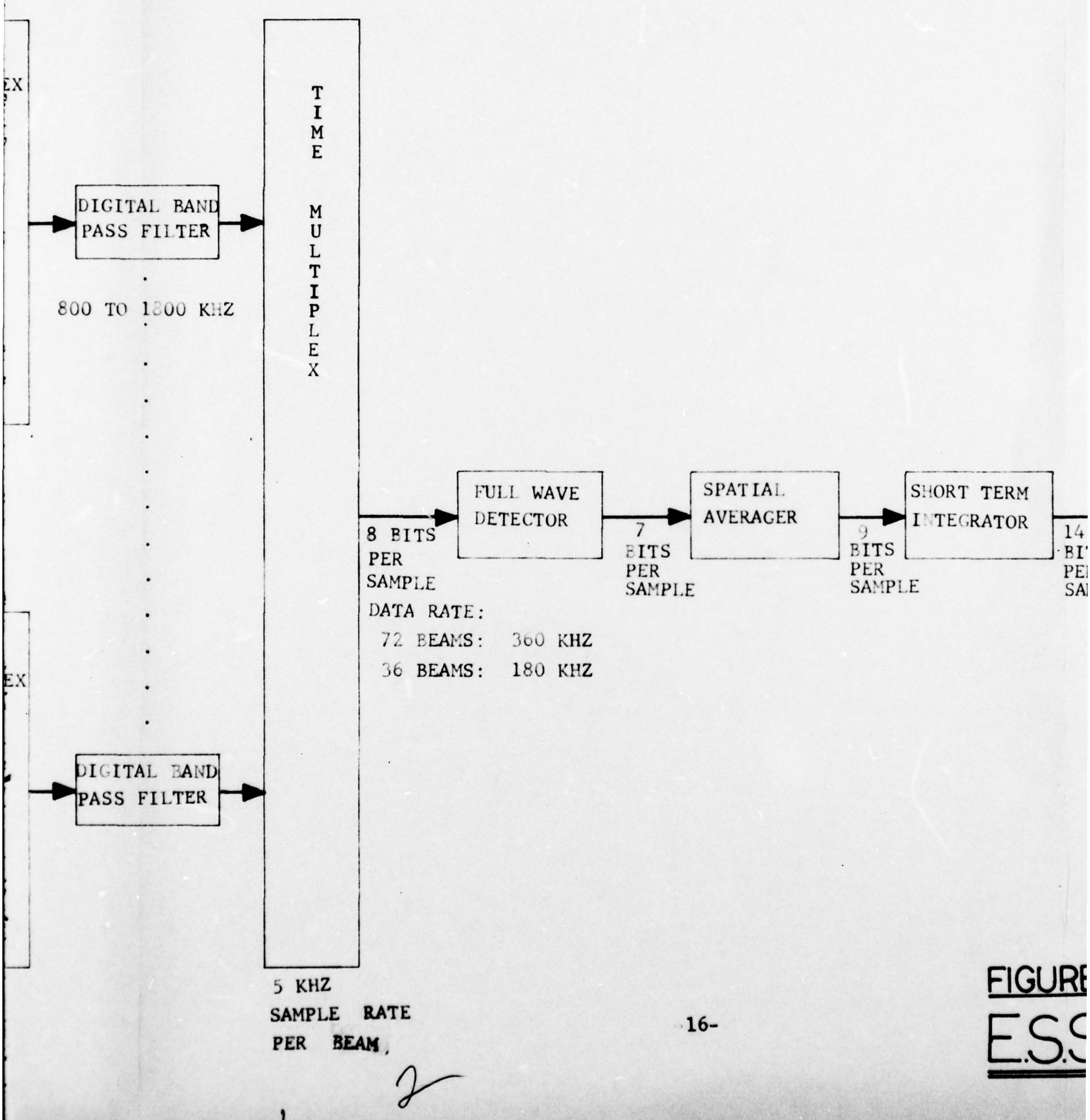
The ESS will have a single beamformer which is capable of simultaneous operation in surface duct and bottom bounce modes. Cost-effectiveness studies are currently in progress to determine the number of beams to be implemented for the ESS. There are two candidate configurations. The first is a partial sector, steerable to any azimuth angle. For this configuration, in either mode, about 75 active beams will be formed to give a sector coverage that varies from 90° (0° to 90°, or 90° to 180°), to about 60° (60° to 120°), depending upon the azimuthal steering angles used. The difference results from the beams near endfire being considerably wider than those formed near broadside to the array. The second candidate configuration is a full 180° coverage system with 150 beams. As with the prototype system, the beams will overlap in the passive band, (800 to 1800 cps). Full coverage within the sector can be achieved by processing signals from about half (every other one) of the beamformer outputs.

Figure 3 is a block diagram of the passive signal processing segment. Except for the smaller number of processing channels, it is similar to that planned for the prototype system (Fig. 1). Depending on the number of beams formed, either 36 or 72 passive channels will be required. Alternate outputs from the beamformer will be selected for inputs to the processing channels.

Range gating may be required to eliminate reverberation spillover into the passive band during simultaneous active and passive operation. These gates will normally be controlled from a central system control unit. The length of "on time" depends on the surface duct transmission frequency. If the transmission is placed at the low end of the active band (2-3 Khz), reverberation will dominate the passive band for about 40% of the receive time between pings, (See Ref. 3). The gates will not be required, of course, if the passive subsystem is not operated simultaneously with active surface duct operation. However, since simultaneous active and passive operation is required by the TDP, the capability to do so should be included in the Experimental Ship System.

After range gating, the samples from each beam are multiplexed through digital bandpass filters. The number of filters required is not currently known. Breadboard development and testing of the filters are being conducted at General


#1
#2
#3
QUANTIZED
OUTPUTS
FROM
TRANSDUCERS
2688
BEAMFORMER
75
or
150
ACTIVE BEAMS
QUANTIZED
TO 8 BITS,
SAMPLE RATE
PER BEAM
IS 10 KHZ
#1
RANGE GATE
#2
RANGE GATE
n
RANGE GATE
RANGE GATE
36
or 72
RANGE GATE
MULTIPLEX
MULTIPLEX
DIGITAL BAND
PASS FILTER
800 TO 1800 KHZ
DIGITAL BAND
PASS FILTER
36 or 72
PASSIVE BEAMS
5
SA
PE


EX
DIGITAL BAND PASS FILTER
800 TO 1800 KHZ
EX
DIGITAL BAND PASS FILTER
TIME MULTIPLEX
5 KHZ SAMPLE RATE PER BEAM
8 BITS PER SAMPLE
DATA RATE:
72 BEAMS: 360 KHZ
36 BEAMS: 180 KHZ
FULL WAVE DETECTOR
7 BITS PER SAMPLE
SPATIAL AVERAGER
9 BITS PER SAMPLE
SHORT TERM INTEGRATOR
14
FIGURE
E.S.

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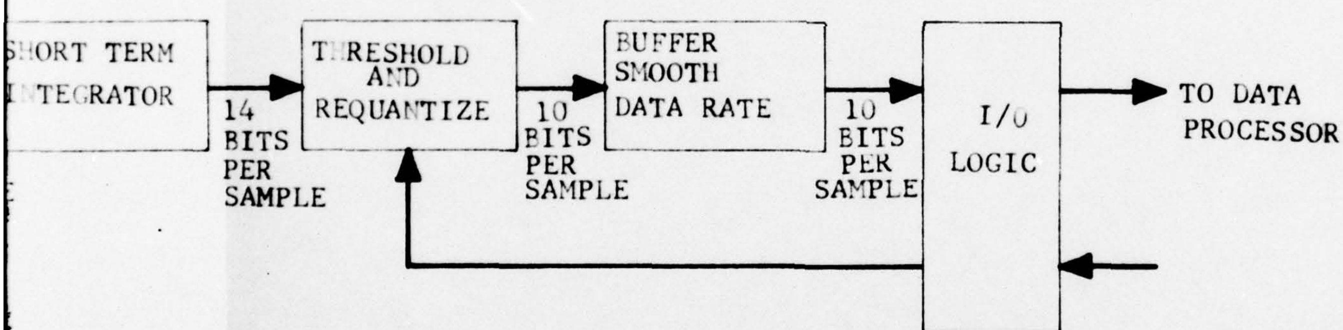

FIGURE 3

E.S.S. PASSIVE SIGNAL PROCESSING

Electric. Additional information on them is expected in late June. This effort is considered to be relatively high risk. If the cost, complexity, or performance of the digital filters prohibit their use in the ESS, analog filters will be used along with D to A and A to D converters at the inputs and outputs of the filters.

After filtering, additional multiplexing reduces the data flow into a single channel. The sampling rate proposed for this multiplexing process is 5 Khz per beam. The outputs of the filters will be scanned in such a way that a sample from beam #1 is followed by a sample from beam #2 and so on. If 72 passive beams are formed, the output from the multiplexer will consist of a string of eight-bit samples at a rate of 375,000 samples per second. A group of 72 samples in the string represents one complete scan of the beam outputs. This scan repeats every 200 μsec.

The linear full-wave detection, spatial averaging and short-term integration processes are identical to those previously described for the prototype system. As is obvious, both should be provided with a wider range of adjustment for the ESS than will probably be necessary for the prototype. For instance, the spatial averager should be designed such that different combinations of adjacent beams could be used to derive the average that is subtracted from the beam of interest. The proposed scheme, $4B_i - (B_{i-4} + B_{i-3} + B_{i+3} + B_{i+4})$, may not be optimum and, if the averager is implemented as described in Ref. 2, it may be difficult to try other schemes.

The same considerations apply to the short-term integrator. The integration time used should be adjustable over a fairly wide range (e.g., 20 msec. to 100 msec.). It seems desirable to use as long an integration time as possible because of two effects. Higher effective signal-to-noise ratios are achieved unless the integration time selected is longer than the length of the transient signal being detected (200 ms to 800 ms). Also, a considerable reduction of the data rate occurs in the short-term integrator. The shortest integration time proposed, 20 msec, reduces the amount of data into the data processor by a factor of 100. Longer integration times would reduce the data by correspondingly greater factors. There is, of course, the problem that longer integration times result in fewer scan lines on the display being marked by a given transient. The resulting vertical line of marks will be smaller and less likely to be noticed by the operator. This problem will be discussed in later sections.

The number of bits per sample resulting from the various stages of processing is as follows, (assuming eight-bits per sample quantization in the beamformer). Eight bits per sample will be carried through the filtering and multiplexing. Full-wave rectification results in seven-bits per sample. The spatial averager outputs nine-bits per sample and the short-term integrator outputs 14 or 15 depending upon the integration time used.

It appears that the samples from the short-term integrator could be requantized to a lower number of bits before being transferred to the data processor. This requantization could take the form of a thresholding operation in which the lower order bits are truncated. Alternatively, a digital compression scheme might be used. It seems reasonable to expect that no more than ten bits per sample would be transferred into the computer. The requantization should probably be controlled from the computer as shown in Fig. 3.

Data from the short-term integrator occur in bursts of 72 (or 1 per beam) integrated samples at the end of each integration period. As shown in Fig. 3, a buffer will probably be required to hold at least one burst of samples until the computer is ready to accept new data. A limited amount of logic circuitry will also be required to control the interface operations with the computer.

3.2 PASSIVE DATA PROCESSING FOR THE ESS

Figure 4 shows the passive data processing segment for the Experimental Ship System. The discussion which follows relates to detection only. At present, there is not sufficient information on classification or tracking to allow more than a tentative guess on the data processing required for these functions. The detection processing shown is based on General Electric's work on the prototype subsystem and the requirements of the display segment planned for the Experimental Ship System. In most respects, it is similar to the passive data processing proposed for the Prototype System.

The first operation performed on the data from the signal processor is termed interference suppression. As previously described, (Section 2.2), this function suppresses interference from own-ship's screws and other sources aboard or adjacent to the ship. The manner in which this will be done is undetermined at present. If the previously described scheme (subtracting a long-term mean from the current sample on each beam), proves inadequate, it may be necessary to use a technique which incorporates a measure of the variances as well as the mean into the normalization procedure.

After interference suppression, the bearing data will be converted from relative to true bearing by a process which

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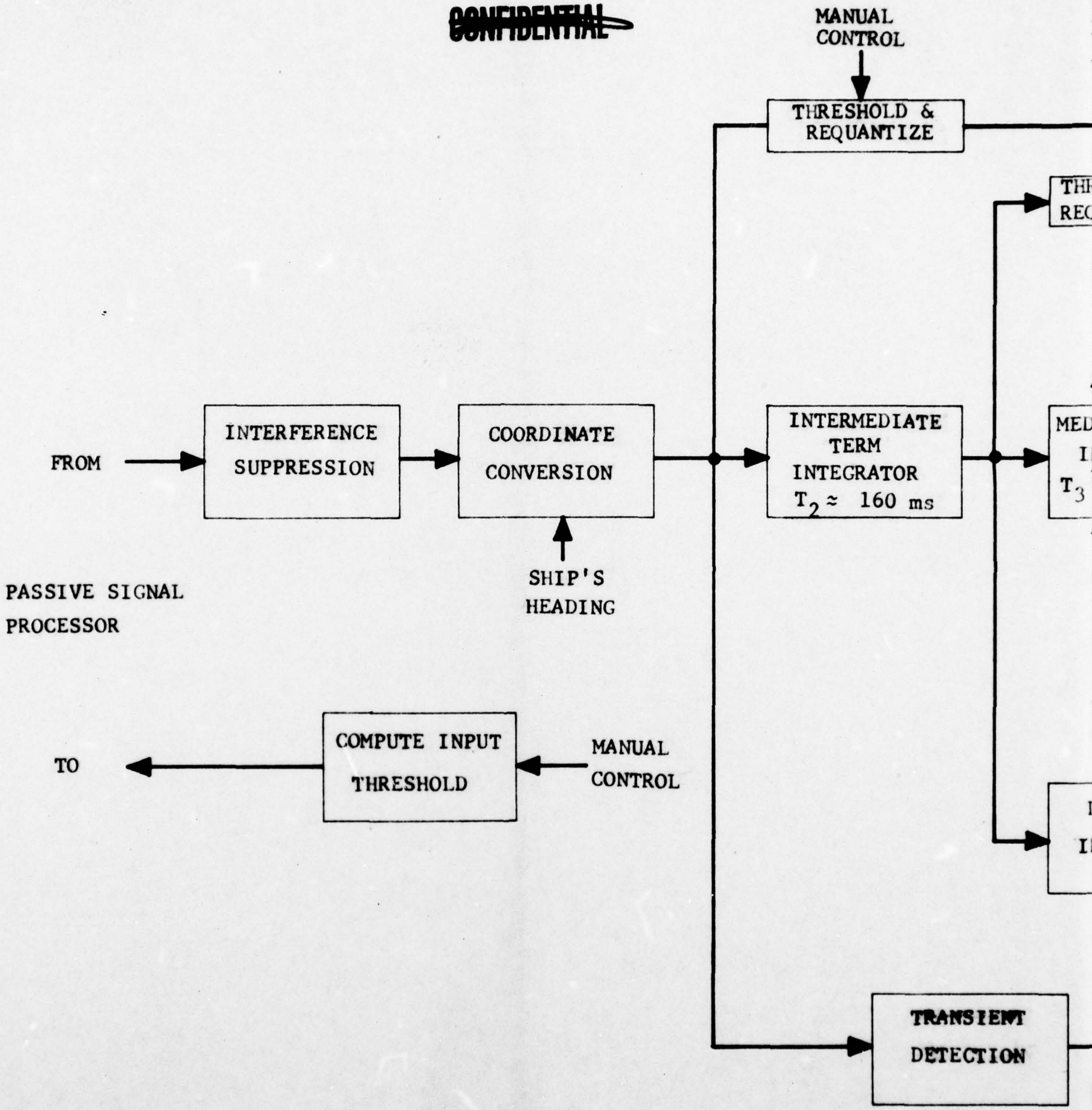

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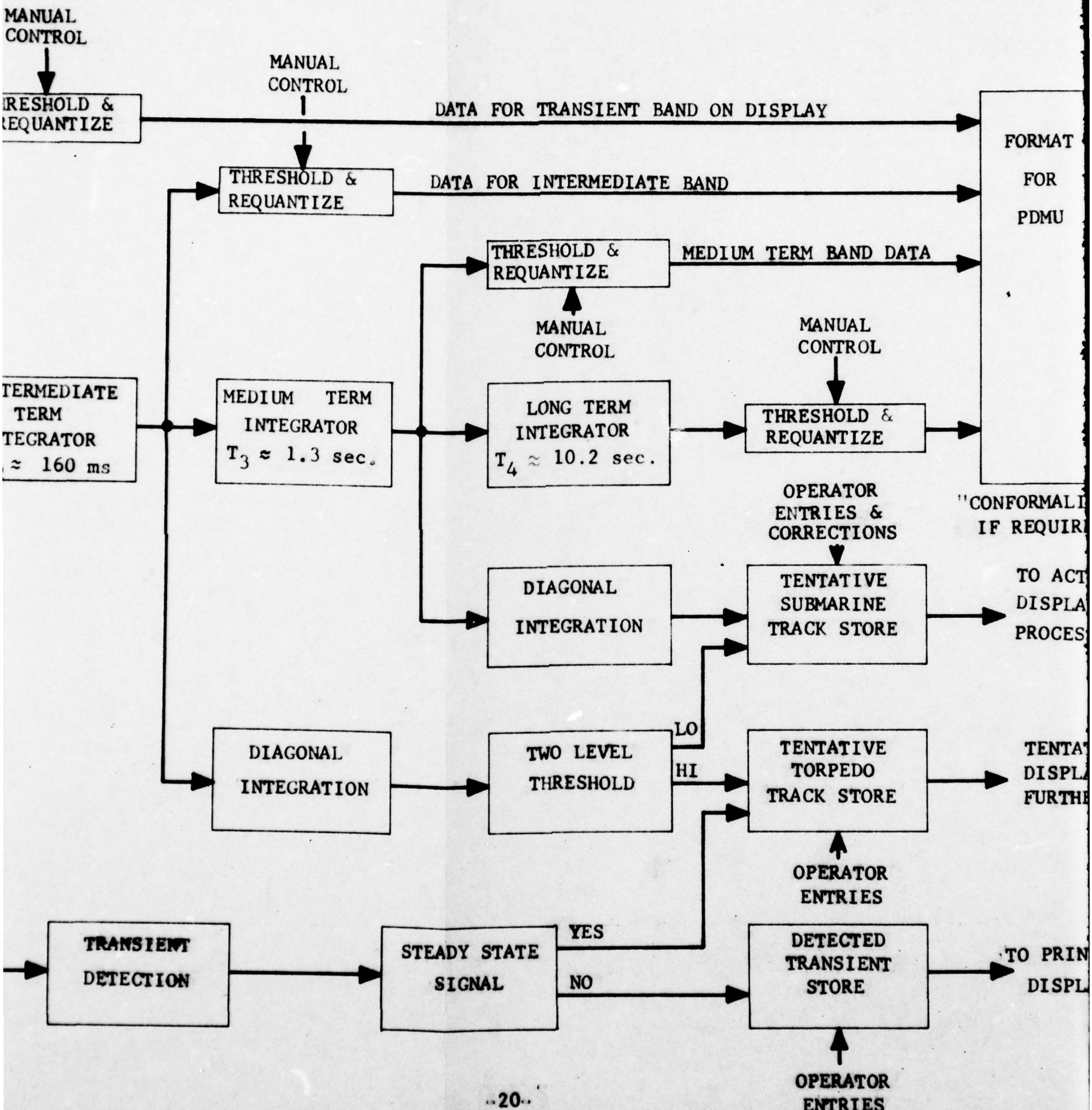

MANUAL
CONTROL
RESHOLD &
REQUANTIZE
MANUAL
CONTROL
DATA FOR TRANSIENT BAND ON DISPLAY
FORMAT
FOR
PDMU
THRESHOLD &
REQUANTIZE
DATA FOR INTERMEDIATE BAND
THRESHOLD &
REQUANTIZE
MEDIUM TERM BAND DATA
MANUAL
CONTROL
MANUAL
CONTROL
TERMEDIATE
TERM
TEGRATOR
≈ 160 ms
MEDIUM TERM
INTEGRATOR
$T_3 \approx 1.3$ sec.
LONG TERM
INTEGRATOR
$T_4 \approx 10.2$ sec.
THRESHOLD &
REQUANTIZE
"CONFORMALI
IF REQUIR
OPERATOR
ENTRIES &
CORRECTIONS
DIAGONAL
INTEGRATION
TENTATIVE
SUBMARINE
TRACK STORE
TO ACT
DISPLA
PROCES
DIAGONAL
INTEGRATION
TWO LEVEL
THRESHOLD
LO
HI
TENTATIVE
TORPEDO
TRACK STORE
TENTA
DISPLA
FURTHE
OPERATOR
ENTRIES
TRANSIENT
DETECTION
STEADY STATE
SIGNAL
YES
NO
DETECTED
TRANSIENT
STORE
TO PRIN
DISPL
OPERATOR
ENTRIES

2

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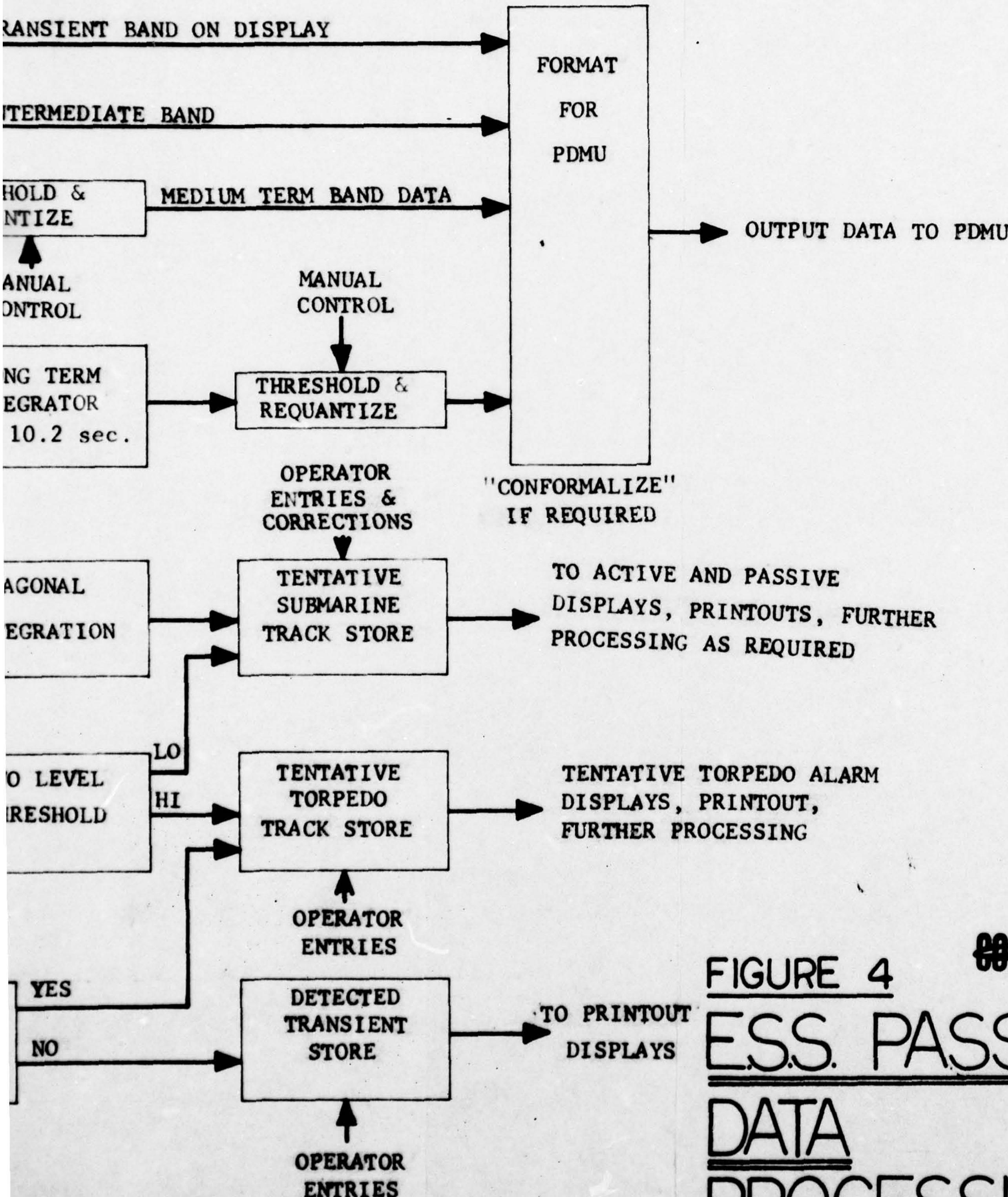

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FIGURE 4

E.S.S. PASSIVE DATA PROCESSING

relates current ship's heading and beam numbers.

After coordinate conversion, the data paths are divided to provide parallel automatic and manual detection. The latter is provided by the basic detection display format in which data are presented in time and bearing coordinates. The format is built up from scan lines; each line represents a scan of the outputs from the bearing bins in a time integrator. High amplitude samples show up as bright dots in the line. Typically, the bottom scan line in the format is the most recent. Previous scans are shifted upward to form the time history of the display. Thus, a series of high amplitude samples on a given bearing will form a vertical line of bright dots. If the noise source has a bearing rate, a diagonal line will be formed. The display format intended for the ESS has four bands, each of which is a separate history with different integration times for the data, (See Fig. 7). The lower band presents transient data from the output of the shortest term integrator. The other three bands present data integrated over progressively longer periods. The length of time represented by each band is, of course, dependent on the integration period between scans and on the number of scan lines in the band. The number of lines per band, integration time per line, and history per band for the proposed display are shown in Fig. 7.

The data processing required for manual detection includes integrations for the various bands, thresholding, formatting data for the display and processing of operator entries or requests. The data paths through these functions are shown in Fig. 4. The short-term (20-40 ms) integrator in the signal processor provides data for the transient band. After coordinate conversion, these data are passed directly to thresholding and formatting for display. Three additional integrators are required in the data processor for the other three bands on the display. Representative integration times are shown. If the integrators are placed in series as shown, each will sum approximately eight samples (for each bearing bin) from the preceding integrator to give the times shown.

The processing for automatic detection includes two diagonal integrators, a transient detector and various associated thresholding, sequential testing, and storage functions.

The technique used for transient detection will probably be similar to diagonal integration. Presumably, the transient would appear as a series of higher-than-normal amplitude samples from a particular bearing bin in the short-term integrator. The samples would be summed until a threshold crossing occurs at which time a tentative transient detection would be declared. Since typical transients are short (200 to 800 ms) in duration, they will have no bearing rate and integration across bearing bins will not be required. Tentative transient detections will probably be tested further before display. For example, the duration of a detected signal from the short-term integrator should be tested to ensure that it is a transient and not a continuous signal. Detection of a continuous signal might indicate a torpedo at close range since only relatively strong signals (S/N of 5 to 9 dB) will be detectable in the outputs from the short-term integrator. Such detections might be considered tentative torpedo tracks as shown in Fig. 4.

The intermediate and medium integrators shown in Fig. 4 have integration times which are considered close to optimum for inputs to the two diagonal integrators. Hence, they can probably be used in both manual and automatic detection as shown. Targets detected by these diagonal integrators will be transferred to tentative track storage areas for display and further action by the operator. Also, it may be possible to perform further tests on the tentative targets to increase detection confidence. Such tests might include examining the data for changing bearing rates and for rapidly increasing signal-to-noise ratios. As mentioned previously, considerable work on automatic detection remains to be done.

3.3 PASSIVE DISPLAYS

3.3.1 Display Segment Description

Figure 5 indicates the equipment currently intended for the ESS display segment. It includes two multi-mode sonar consoles (MMSC) and one passive data memory unit (PDMU). Reference 5 lists the specifications for these units. The following is a brief review of the operation of the display segment in the passive mode.

As its name implies, the MMSC has the capability to operate in several modes. At least one of these modes will be used for passive operation. The basic detection format which will be displayed on a console in the passive mode is shown in Fig. 7. As previously described, bearing is shown as the horizontal coordinate, and time as the vertical coordinate. The four bands share a common bearing scale, but differ in duration of history and the integration times of the data. Each band is separated from another by approximately 0.5 inches. Processed data symbols denoting operator-entered or automatically detected targets appear in the areas between bands. The horizontal coordinate of each symbol corresponds to the bearing on which the target was detected. The symbol shape indicates the classification entered for the target.

The bands are generated by horizontal scan lines. The upper two bands each have 256 lines and the lower two each have

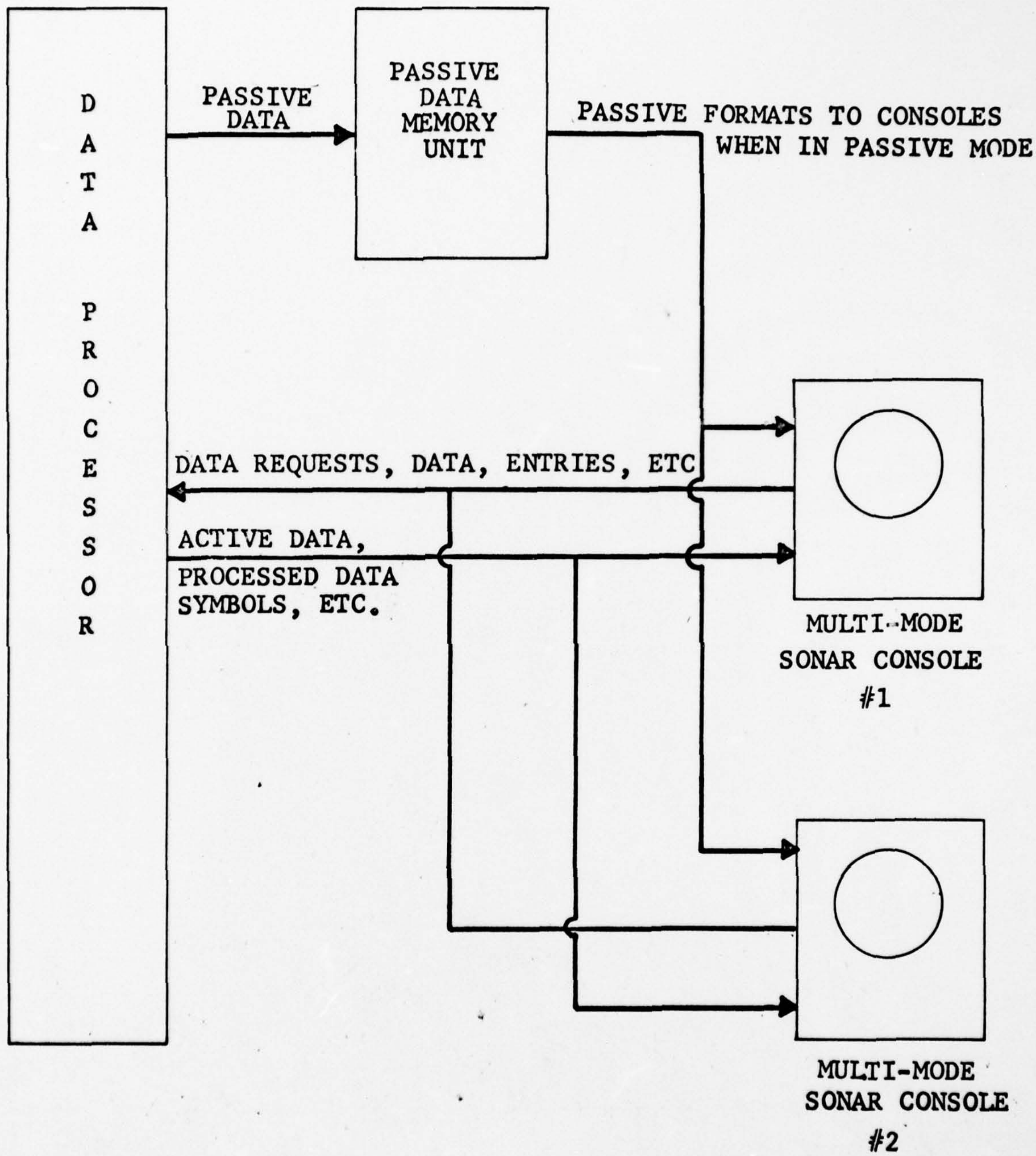


FIGURE 5

E.S.S. DISPLAY COMPONENT

128, making a total of 768. Up to 144 points on each line can be brightened. Each point represents a time-averaged sample taken from one beam. A point can have any of eight levels of brightness (including off as one level).

The scan lines are generated by sweep circuits within each MMSC, but sweep timing pulses originate in the PDMU. The data are stored in the PDMU as three-bit brightness codes. Each three-bit group represents one point on a scan line. Since there are 768 lines, each with 144 points, the total storage required is 3 x 144 x 768 = 331,776 bits. These data are recirculated continuously to the brightness circuitry in the MMSC in synchronization with the sweep timing pulses. The frame rate is sufficiently high (35 or 50 cps) to generate a flicker-free display.

Passive data from the computer are sent to the PDMU one line at a time. Normally, the line will consist of a group of 36 or 72 (depending on the number of passive beams) samples from one of the time integrators. The line must be transferred at the end of the integration period. The PDMU will store these data in a position corresponding to the lowest line in the appropriate band, shift the other lines upward one position and drop the oldest (uppermost) line in the band.

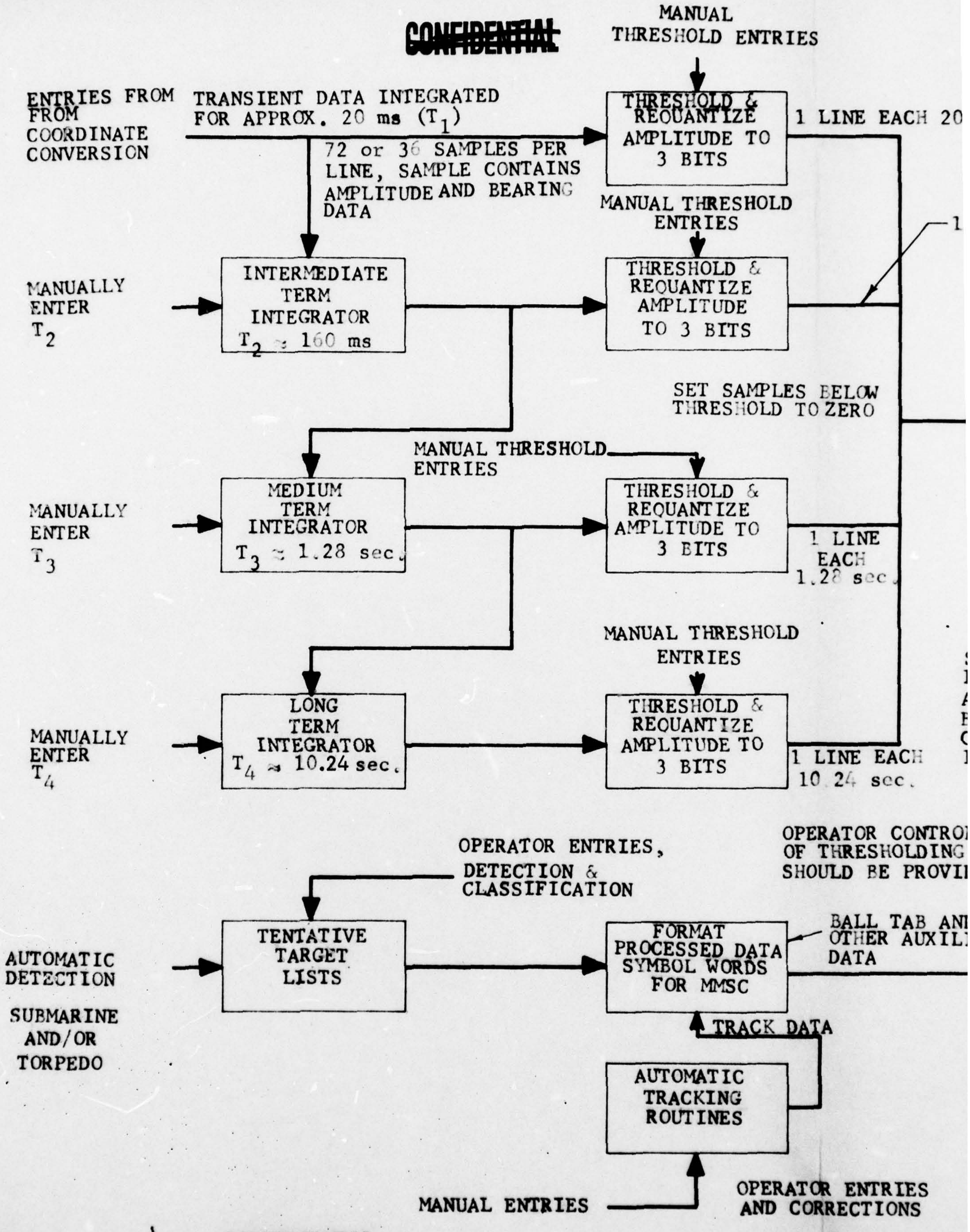
The memory in the PDMU is organized in four groups, each corresponding to a band in the format. Coding within each line of samples from the computer indicates the band for which the line is intended. Approximately 12 computer words (30 bits per word) are required to transfer one line of 72 samples. The memory organization of the PDMU is such that it can be used for either 144 or 72 beams. The outputs from a smaller number of beams (such as 36) can be stored and displayed, but doing so will probably require that brightness codes of zero be loaded into the unused positions in the store. Hence, the number of computer words required to transfer a line to the PDMU will be the same for either 72 or 36 passive beams. It is likely that one or two of the 12 words will be control words. The remainder will be data words containing sample amplitudes and possibly, band designation codes. The structures of the control and data words exchanged across the computer-PDMU interface are presently undefined.

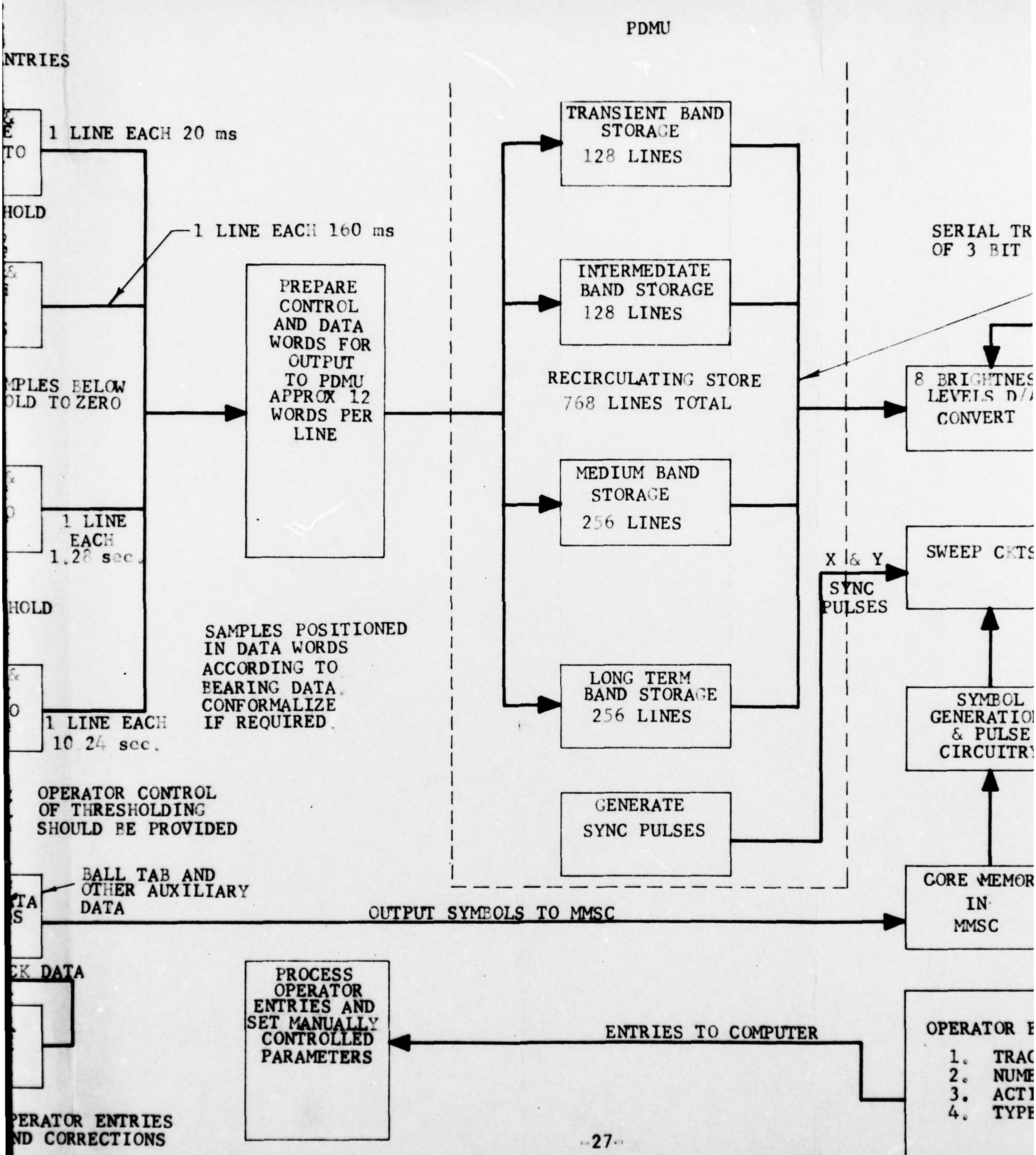
Figure 6 summarizes the data flow paths associated with the passive format. Note that conformalization of the data for display, if required, will be done as a part of the display formatting process.

3.3.2 Comments on the Passive Format

The transient band in the format contains 128 scan lines. If the transient integration time proposed by G. E.(20 ms) is used, the total history represented by the transient band will be 2.56 seconds. The transients of interest last from 200 ms to 800 ms. A minimum length transient will brighten ten scan lines which occupy about 0.15 inches. Thus, a 200 ms transient will appear as a vertical line 0.15 inches in length at the bottom of the band. The line will move upward and disappear off the top of the band in 2.56 seconds. The period that a transient is visible may be too short for detection by even moderately alert operators and it appears that a longer history would be desirable.

The longer history can be obtained in two ways; by assigning more scan lines to the transient band or by using a longer integration time for each line. The latter seems preferable because additional lines can be obtained only at the expense of the other bands. A longer integration time would have several advantages. It would give a longer history in the transient band; it would reduce the data rate through the data


MANUAL THRESHOLD ENTRIES
ENTRIES FROM FROM COORDINATE CONVERSION
TRANSIENT DATA INTEGRATED FOR APPROX. 20 ms (T1)
THRESHOLD & REQUANTIZE AMPLITUDE TO 3 BITS
1 LINE EACH 20
72 or 36 SAMPLES PER LINE, SAMPLE CONTAINS AMPLITUDE AND BEARING DATA
MANUAL THRESHOLD ENTRIES
MANUALLY ENTER T2
INTERMEDIATE TERM INTEGRATOR T2 ≈ 160 ms
THRESHOLD & REQUANTIZE AMPLITUDE TO 3 BITS
SET SAMPLES BELOW THRESHOLD TO ZERO
MANUAL THRESHOLD ENTRIES
MANUALLY ENTER T3
MEDIUM TERM INTEGRATOR T3 ≈ 1.28 sec.
THRESHOLD & REQUANTIZE AMPLITUDE TO 3 BITS
1 LINE EACH 1.28 sec.
MANUAL THRESHOLD ENTRIES
MANUALLY ENTER T4
LONG TERM INTEGRATOR T4 ≈ 10.24 sec.
THRESHOLD & REQUANTIZE AMPLITUDE TO 3 BITS
1 LINE EACH 10.24 sec.
OPERATOR ENTRIES, DETECTION & CLASSIFICATION
OPERATOR CONTRO OF THRESHOLDING SHOULD BE PROVI
AUTOMATIC DETECTION
SUBMARINE AND/OR TORPEDO
TENTATIVE TARGET LISTS
FORMAT PROCESSED DATA SYMBOL WORDS FOR MMSC
BALL TAB AN OTHER AUXILI DATA
TRACK DATA
AUTOMATIC TRACKING ROUTINES
MANUAL ENTRIES
OPERATOR ENTRIES AND CORRECTIONS



PDMU
NTRIES
1 LINE EACH 20 ms
HOLD
1 LINE EACH 160 ms
MPLES BELOW
OLD TO ZERO
1 LINE EACH 1.28 sec.
HOLD
1 LINE EACH 10.24 sec.
PREPARE CONTROL AND DATA WORDS FOR OUTPUT TO PDMU APPROX 12 WORDS PER LINE
SAMPLES POSITIONED IN DATA WORDS ACCORDING TO BEARING DATA. CONFORMALIZE IF REQUIRED.
OPERATOR CONTROL OF THRESHOLDING SHOULD BE PROVIDED
TRANSIENT BAND STORAGE 128 LINES
INTERMEDIATE BAND STORAGE 128 LINES
RECIRCULATING STORE 768 LINES TOTAL
MEDIUM BAND STORAGE 256 LINES
LONG TERM BAND STORAGE 256 LINES
GENERATE SYNC PULSES
X & Y SYNC PULSES
SERIAL TR
OF 3 BIT
8 BRIGHTNES
LEVELS D/A
CONVERT
SWEEP CKTS
SYMBOL GENERATIO
& PULSE
CIRCUITRY
CORE MEMOR
IN MMSC
BALL TAB AND OTHER AUXILIARY DATA
OUTPUT SYMBOLS TO MMSC
CK DATA
PROCESS OPERATOR ENTRIES AND SET MANUALLY CONTROLLED PARAMETERS
ENTRIES TO COMPUTER
OPERATOR E
1. TRAC
2. NUME
3. ACTI
4. TYPE
PERATOR ENTRIES
ND CORRECTIONS

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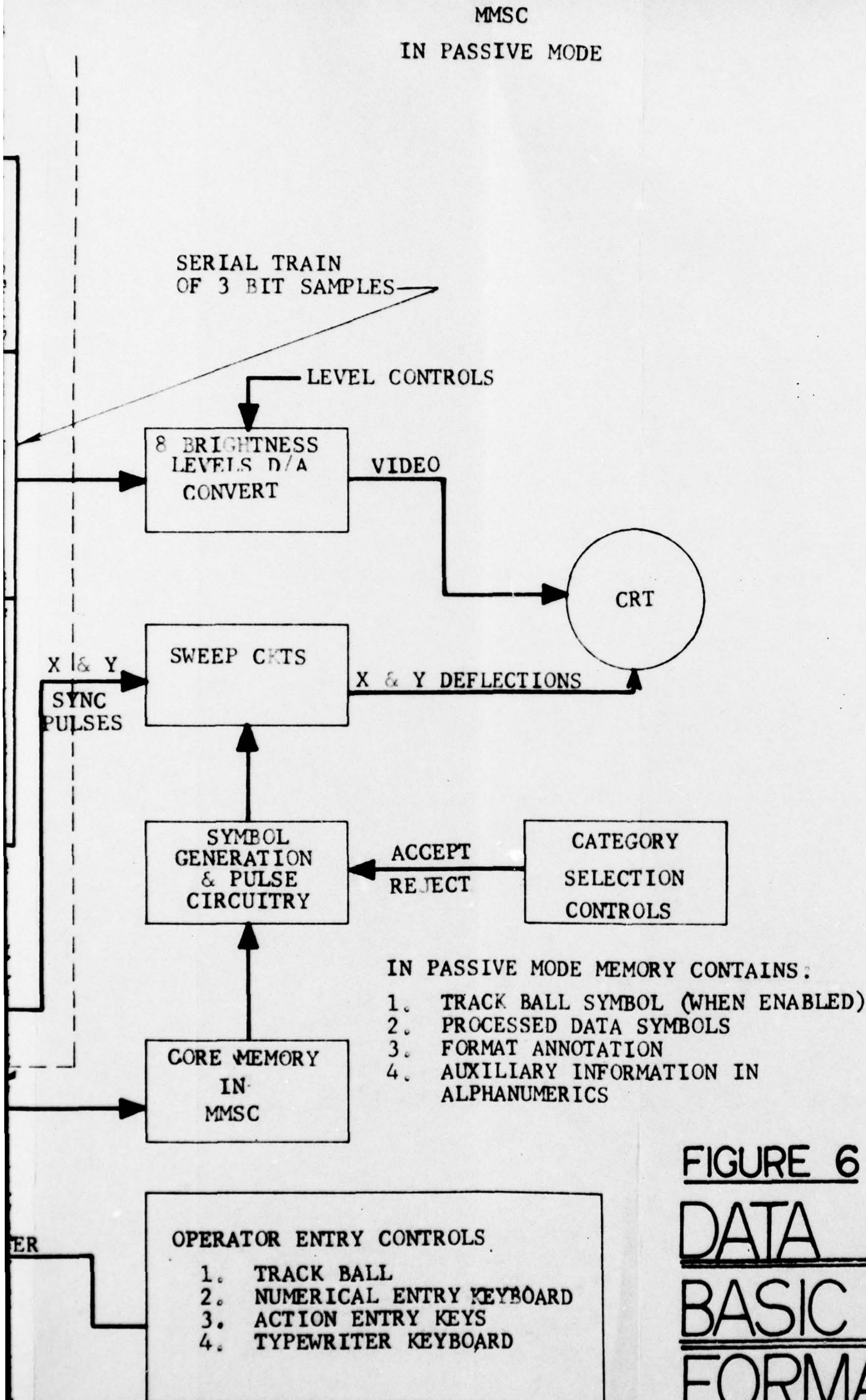

FIGURE 6

DATA FLOW FOR BASIC PASSIVE FORMAT

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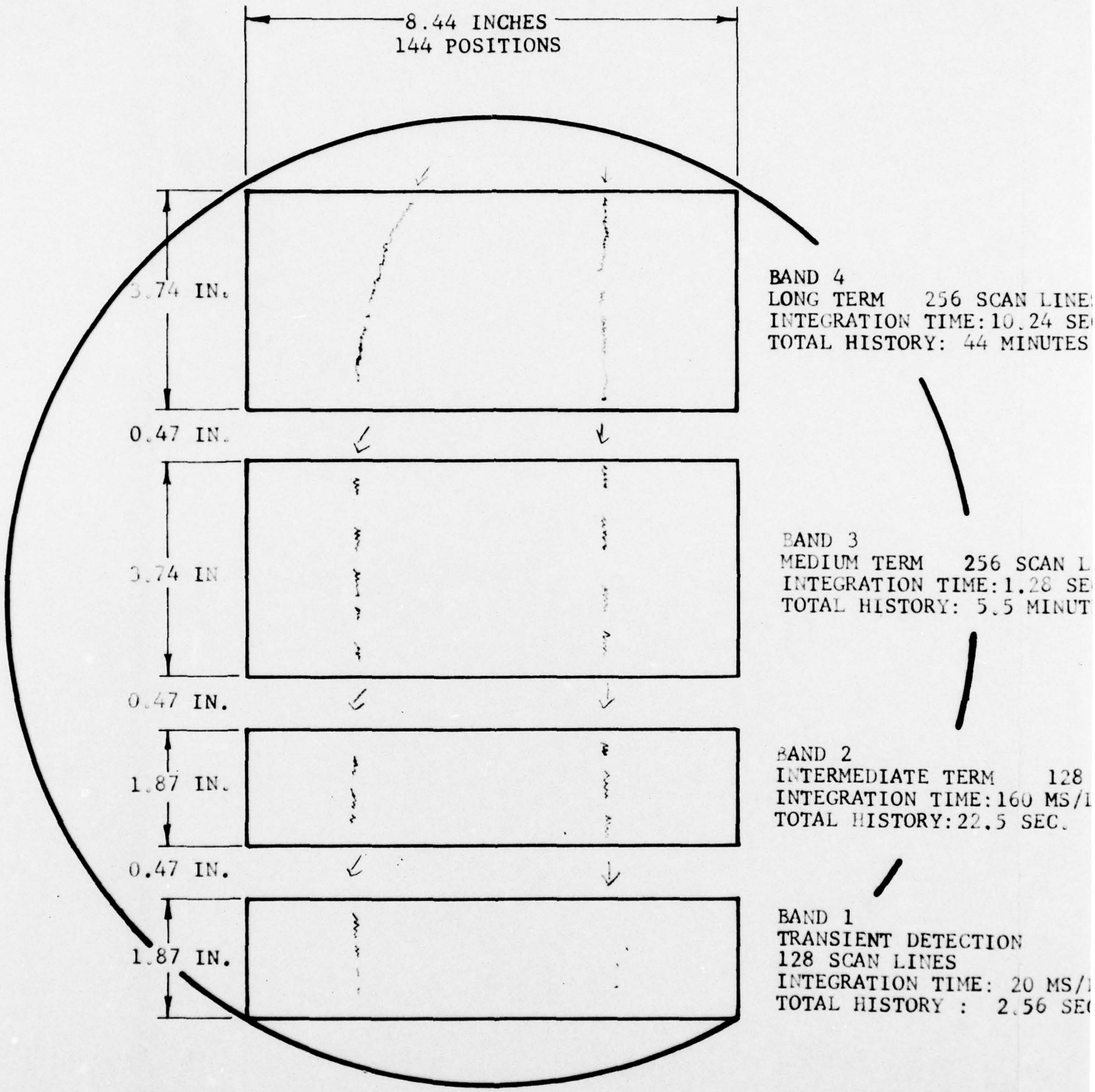
8.44 INCHES
144 POSITIONS
3.74 IN.
0.47 IN.
3.74 IN
0.47 IN.
1.87 IN.
0.47 IN.
1.87 IN.
BAND 4
LONG TERM 256 SCAN
INTEGRATION TIME:10.24
TOTAL HISTORY: 44 MINUTES
BAND 3
MEDIUM TERM 256 SCAN
INTEGRATION TIME:1.28
TOTAL HISTORY: 5.5
BAND 2
INTERMEDIATE TERM 128
INTEGRATION TIME:160
TOTAL HISTORY:22.5 SEC.
BAND 1
TRANSIENT DETECTION
128 SCAN LINES
INTEGRATION TIME: 20
TOTAL HISTORY : 2.56

SEARCH

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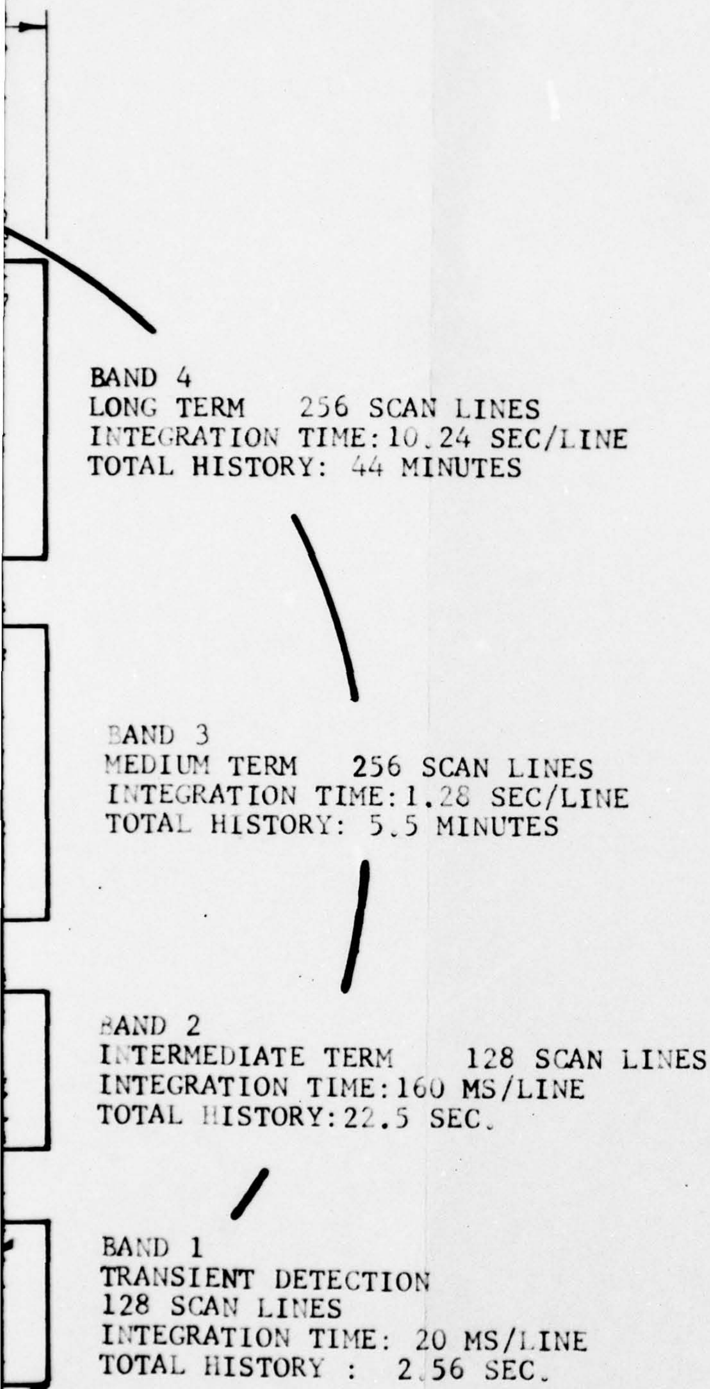

FIGURE 7

BASIC PASSIVE SEARCH & DETECT FORMAT

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processor; and it would possibly produce a higher S/N from the short-term integrator if the selected integration time does not exceed the minimum transient length. The latter assumes that scintillations in amplitude during reception of the transient do not cause the integrated level to be lower than would be produced with a shorter integration period.

The disadvantage of a longer integration period is that the vertical line made by a given transient will be shorter because fewer scan lines will be brightened at the bearing coordinate of the transient. As the period is lengthened, a point is reached where the vertical line becomes too short for reliable recognition as a transient by the operator.

At the viewing distance involved, (about 18 in.), an operator with normal vision can resolve an object with a diameter of about 0.01 inches. He can be expected to resolve the individual scan lines in the format. In general, however, for good recognition the height of a displayed symbol should be seven to ten times the width of a minimum resolvable element in the symbol. As a rough guess then, the vertical line made by a transient should be at least 0.07 inches in length. If a 40 ms integration time is selected, points on five lines will be brightened by a 200 ms transient. This will appear as a 0.075 inch vertical line which will remain in the band for 5.12 seconds.

These figures are only approximate because it is probably unrealistic to compare a vertical line made up from points on several scan lines with an alphanumeric or processed data symbol. Also, the background of smaller, but similar patterns made by random noise may be confusing enough to require that transients be represented with more scan lines than that given above. It appears that the optimum length of the vertical line can best be determined experimentally. Tests of this nature will be carried out with the ESS, of course, but it would also be desirable to determine the various parameters of the passive format before the ESS equipment and programs are designed.

If possible, the passive format should be simulated using the passive display simulator currently being developed by Code 3180 at NEL. Answers to the following questions are needed.

1. What is an optimum integration time for the transient band assuming transient lengths of 200 ms to 800 ms? What range of integration times should be available?

2. How long does the history of the transient band need to be?

3. What is an optimum marking density for the passive format? At what background level should the thresholds for the four bands be set? What effect does the availability of multiple brightness levels have on the optimum threshold levels?

The description of the passive subsystem assumes that the PDMU design has no effect on selection of the integration period. That is, a line of data can be loaded into the unit at the end of any reasonable integration period. The description of the memory organization in the proposed PDMU implies, however, that this is not the case. Apparently, a new line of data cannot be loaded more often than every 30 ms, (the line is loaded at the end of the recirculation cycle which lasts 30 ms) and only one line can be loaded each cycle. This means that transient band integration periods shorter than 30 ms cannot be used, and the periods that are selected must be multiples of 30 ms. Also, if the transient integration period is made 30 ms, no time will be left to transfer lines to the other bands. If true, this is an unreasonable constraint to place on the subsystem design. A more flexible memory loading scheme should be devised for the PDMU.

Simulation of the basic format will also help determine how the azimuthal beam pattern should be represented on the display. The format that will be generated by the proposed PDMU allocates equal spaces along the abcissa for each beam. This is not a true representation of the beam pattern formed by the C/P Array System. In the passive band, the azimuthal coverage of individual beams varies from about 20 degrees in the forward and aft directions to about 1.5 degrees in the direction broadside to the array. An automatic tracking program will consider this pattern in determining the true bearing of a target. In the manual backup mode however, the operator may have to estimate, from an observed bearing rate, the actual bearing of a target which has crossed into a wide beam. If he knows the widths of the beams, he can determine the bearing rate from beam crossings and then, through extrapolation, estimate the target's bearing within the wide beam. General Electric has suggested that a "conformal" format is needed for this purpose. (See Section 2.2).

In a conformal format, the increments of a scan line are not equal; they vary in length to conform to the azimuthal beam pattern. The length of an increment brightened by a signal sample is determined by the width of the beam on which the sample was received. The relative positioning of the wide and narrow increments is not constant; it represents the orientation, relative to true North, of the beam pattern at the time the samples for the scan line were received. If the ship is changing heading, the positioning of the various increments may change from one scan line to the next.

If possible, a conformal format should be simulated for comparison with the "linear" format generated by the proposed PDMU. The accuracy to which an operator can estimate bearing should be determined for both formats.

A linear format may be adequate if the computer can be used to calculate and display the true bearing of a target which has been detected by the operator. To do this, a program would estimate the true bearing of a target by relating the apparent bearing (designated with the track ball cursor) to the width of the beam on that bearing. This method appears to be feasible if the operator can establish a bearing rate by entering successive apparent bearings as the target moves across beams. Operations of this nature would be used as manual backup to an automatic tracking routine.

If required, a conformal format representing the 36 beams formed by the ESS can be generated with the proposed PDMU. The unit provides storage for 144 sample positions in each scan line. From the description of the unit, it appears that the line segments corresponding to these positions overlap slightly on the display. If so, a conformal format can be generated by marking (brightening) one segment for narrow beams and two or more adjacent segments for wide beams. The scheme whereby the 144 segments are allotted among 36 beams will be determined when the actual beam pattern has been specified.

It is unlikely that the PDMU could be used to generate a conformal display of more than 36 beams. If the system forms a larger number, such as 72, two formats might be required. A linear format showing all 72 beams can be used for search and detection. Once a target has been detected, the display can be changed to an expanded bearing, conformal format which shows only a few beams in the same azimuthal sector as the target. The operator would then be able to accurately estimate the true bearing of the target.

If both formats are required, a means for rapidly switching from one to the other must be developed. Normally, the format builds up line by line as new data become available. Completely changing the display to another bearing representation with new data only will require far too long (about 40 minutes) and result in a display with mixed bearing data until all of the old data have been replaced. It will probably be necessary to build a fast loading mode into the PDMU whereby all of the data can be replaced within one or two cycle times. Changing the formats in this fashion will require that an image of at least one of the two formats be maintained at all times in the computer memory. The amount of storage needed is quite large--about 11K words for a format displaying 144 beams and about half that amount for the ESS beam configuration. An alternative method for changing the format is to read the data in the PDMU back into the computer, reorganize the format, and return it to the PDMU. Unfortunately, this method cannot be used with the proposed PDMU because the memory in the unit cannot be conveniently accessed by the computer.

3.3.3 Other Passive Formats

The MMSC has the capability to display other formats in the passive mode if they are required. These include detection formats which are extensions of the basic format and other formats which may be needed for tracking and classification.

3.3.3.1 Expanded Bearing and Extended History Detection Formats.

Expanded bearing and extended history formats are extensions of the basic format which could be displayed. Considering the limited number of passive beams available in the ESS, it is unlikely that an expanded bearing format will be required for search and detection. Data from either 36 or 72 beams can be displayed in a linear format with adequate bearing resolution. Operator actions, such as designation of a target with the track

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ball cursor, are feasible on the MMSC with a 72 beam presentation. An expanded bearing, conformal format might be required as previously discussed.

It will be desirable to have extended history formats available for the ESS. Relatively short histories are represented by the three lower bands in the basic format. These histories are probably adequate for detection in an operational situation, but they may not be sufficient for evaluation and adjustment of the integration times and thresholds in the ESS. Three or four additional formats should be provided for experimental work. Each of these will allow one of the bands in the basic format to be extended full length on the display by assigning the integration time of that band to all 768 scan lines in the format.

The data processing required for the extended formats is relatively straight forward. The operator will select a band to be extended with one of the function code entry buttons on the console. Upon receipt of the code, the computer will sequentially transfer outputs from the integrator assigned to that band to all four band storage areas in the PDMU. It may be desirable to have the computer erase all data in the PDMU before the extended format is generated. Otherwise, a mixed format would be presented until all of the old data have been replaced. Changing from an extended format back to the basic format will be done by erasing the data in the PDMU and then regenerating the basic format from new data. An alternative method would be to maintain an image of the basic format in the computer's memory while the extended format is being presented. Changing back to the basic format would then be done by transferring the image to the PDMU. This method will be feasible only if a fast loading mode is built into the PDMU. Transferring a complete image to the PDMU as it is presently proposed will require about 23 seconds (768 lines x 30 ms/line).

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3.3.3.2 Tracking and Classification Formats. Special formats for passive tracking and classification may be required for the ESS. If an automatic tracker is included in the data processor, it will be desirable to have a format which allows the operator to monitor and correct the tracking process. Manual tracking may also require a special format which gives the operator the ability to use the computer in obtaining tracking solutions. The nature of these formats cannot be specified until more details on the tracking methods are available. Special classification formats, such as LOFARGRAMS, may also be required. Again, however, the passive classification methods have not been chosen and specification of formats cannot be done at this time.

3.3.4 Manual Controls

Most of the control functions required for passive operations cannot be specified at this time because the passive data processing is largely undefined. Also, the operational doctrine and experimental purposes of the ESS in the passive mode have not been specified. To a certain extent, these also have an affect on the design of the controls needed at the consoles. It is apparent, however, that there will be considerable operator-computer interactions during passive operations. Several of the processing parameters will be manually controlled. The operator must be able to monitor and adjust the various automatic processes such as detection, tracking and classification. Full manual backup of these processes will also be required so that their effectiveness can be assessed. All of these requirements imply that a high degree of flexibility will be needed in the controls provided on the consoles. This flexibility has been specified for the MMSC. (See Ref. 5).

The only control operations which can be specified in detail at this time are those related to the passive search/detect mode using the basic format previously described. The following list of operator tasks gives an indication of the controls which will be required for this mode.

Assuming that the console is activated, the initial setup for the passive mode requires that the operator:

1. Select passive mode.
2. Select basic search/detect format.
3. Select desired threshold (or false alarm rate) for each band.
4. Select desired integration time for each band.

Items one and two will probably be accomplished as follows:

1. Operator presses the "Initiate" key.
2. Computer displays a list of available modes.
3. Operator selects number of desired mode on numerical entry keyset and presses "Enter" key.
4. Computer removes mode list and displays list of formats available for that mode.
5. Operator selects and enters the number of the desired format.
6. If the selected format is currently stored in the PDMU, the computer will cause the console to begin displaying that format. Otherwise, the console will be switched to the PDMU and the computer will start building up the requested format in the PDMU. As previously discussed, there may be a delay until the new format is completely available.

When the console is changed to the passive mode, the labels on the various entry keys will change as described in Ref. 5. The new labels will reflect the use of these keys in the passive mode. (The computer interprets the codes entered by these keys according to the current mode recorded for that console).

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Entering the desired thresholds and integration times for the bands in the basic passive format will be done with the numerical entry keyset, a "select threshold" or "select integration period" key and the "Enter" key. The actual number entered for either a threshold selection or an integration time selection will probably be a percentage of an available range for a particular band. For example, the operator might enter 1.50 to set the marking density of band one at 50 percent. This would set the threshold for band one such that about half the samples from the short-term integrator will be transferred to the PDMU for display. Similarly, entering 1.50 as an integration period selection will result in the band one integration period being set at the half-way point in its available range. Normally, the selection of thresholds and integration periods will be done after the operator has viewed the display for a short period. Predetermined values will be automatically assigned to the thresholds and integration periods until the operator makes his selections. Table I summarizes the initial setup operations and the controls used.

TABLE I

CONTROLS USED IN INITIAL SETUP OF SEARCH/DETECT MODE

OPERATOR FUNCTION	KEY NAME
Select Mode	"Initiate", Numerical Keyset, "Enter"
Select Format	"Select Format", Numerical Keyset, "Enter"
Select Integration Time	"Integration Time", Numerical Keyset, "Enter"
Select Threshold	"Threshold", Numerical Keyset, "Enter"

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Once the initial setup for the passive search/detect mode has been completed normal operation in the mode is started. Table II summarizes some typical operator functions, controls used, and associated computer actions that might be required for the passive mode. This list is not complete of course. The experimental nature of the ESS precludes a complete listing of the control requirements for the passive mode. Additional controls will be included in this list as the system and operational doctrine for the experimental ship are developed.

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TABLE II

OPERATOR FUNCTIONS IN THE PASSIVE SEARCH/DETECT MODE

OPERATOR FUNCTION	CONTROLS USED	COMPUTER ACTIONS
Change Format	1. "Select Format" Key 2. Numerical Entry Keyset 3. "Enter" Key	Display Format List. Generate Selected Format.
Enter New Track	1. "Enable Track Ball" Key 2. Track Ball 3. "Enter Track" Key	Display Ball Tab Symbol Update Ball Tab Position. Assign Track Number. Store Track Number and Bearing. Display Track Symbol and Track Number.
Enter Track Classification	1. "Enable Track Ball" Key 2. Track Ball 3. "Unknown", "Friend", "Hostile", "Sub", "Torpedo", "Surface", or "Non-Sub", Key	Display Ball Tab Symbol. Update Ball Tab Position. Enter Classification for Indicated Track. Change Track Symbol. To New Classification
Drop Track	1. "Enable Track Ball" Key 2. Track Ball 3. "Drop Track" Key	Display and Update Ball Tab Symbol. Drop Indicated Track From Storage
Correct Track Position	1. "Enable Track Ball" Key 2. Track Ball 3. "Hook" Key 4. "Position Correct" Key	Display and Update Ball Tab Symbol. Generate Hook Symbol Around Indicated Track. Update Track Bearing. Move Track Symbol to New Bearing.
Enter Estimated Range	1. "Enable Track Ball" Key 2. Track Ball 3. Numerical Keyset 4. "Enter Range" Key	Display and Update Ball Tab Symbol. Enter Range for Indicated Track.

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TABLE II (Cont'd)

OPERATOR FUNCTIONS IN THE PASSIVE SEARCH/DETECT MODE

OPERATOR FUNCTION	CONTROLS USED	COMPUTER ACTIONS
Callup Track Data	1. "Enable Track Ball" Key and Track Ball, or Numerical Keyset (Enter Track Number). 2. "Track Callup" Key	Display and Update Ball Tab Symbol if Required. Display all Pertinent Data on Indicated Track in Alphanumerics in Auxiliary Readout Area on CRT.

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4. COMMENTS AND CONCLUSIONS

This report describes only the manual search/detect mode of the passive display requirements for the ESS. The remainder of these requirements cannot be specified until several segments of the passive subsystem are better defined. Specific information is needed on the following items.

1. The passive classification techniques and equipment to be used in the ESS are undefined. DEMON-LOFAR is a likely candidate technique. If so, means for integrating a DEMON-LOFAR processor into the passive signal processing and data processing segments must be developed. Once this has been done, work can proceed on development of classification formats and controls for display.

2. The automatic detection and tracking processes are not sufficiently defined to allow development of the corresponding display requirements. An investigation into the ways in which an operator can monitor and assist these processes is needed.

3. It appears that a computer-aided, manual tracking technique could be developed as a backup to the automatic tracker. The technique should be defined so that the format, operator actions and controls can be specified.

As was pointed out in Section 3.3.2, the PDMU proposed for the ESS lacks the flexibility that would be desirable in an experimental unit. The following comments should be considered in the first design review meeting on the PDMU.

1. The proposed method for loading new lines of data into the unit's memory places an unreasonable constraint on the design of the passive subsystem. The PDMU should be modified such that new lines of data can be loaded more often than every 30 msec. Otherwise, it will not be feasible to use transient

band integration periods shorter than 30 to 40 msec.

2. More than one type of passive format may be required. If so, the ability to quickly change from one format to another will be very desirable. The proposed design of the unit has no provision for fast changes in formats. Transferring a complete format from the computer's memory to the PDMU will require a minimum of 23 seconds, (768 lines x 30 msec per line). If possible, the design of the unit should be modified so that a new format (assuming that one is available in the computer's memory) can be transferred within one or two display refresh cycles.

3. It appears that the storage requirements of the computer might be significantly reduced if the data in the PDMU could be quickly accessed by the computer. Certain tasks, such as changing formats, will require large blocks of storage in the computer unless access to the data stored in the PDMU is provided. In addition, it might be feasible to use the PDMU as working storage for the diagonal integration and automatic tracking processes. The usefulness of computer access to the data stored in the unit should be explored before the design of the unit is frozen.

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