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TECHNICAL NOTE

SECOND PRELIMINARY REPORT ON THREE-SHIP MUTUAL INTERFERENCE TESTS (U)

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TRACOR, INC. 1701 Guadalupe St Austin 1, Texas

NObsr-93140
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TRACOR-65-371-C

TECHNICAL NOTE

SECOND PRELIMINARY REPORT ON THREE-SHIP MUTUAL INTERFERENCE TESTS

16 Nov[redacted]65

Approved by:

E. A. Tucker
ASW Manager

Submitted by:

J. L. Collins
Project Director

[redacted]

TRACOR, INC. 1701 Guadalupe St Austin 1, Texas

SECOND PRELIMINARY REPORT ON THE AN/SQS-26 THREE-SHIP MUTUAL INTERFERENCE TESTS (U)

1. INTRODUCTION

This is the second in a series of three reports to describe the results obtained from an analysis of data recorded during the AN/SQS-26, three-ship, mutual interference sea tests, conducted during the period 19-25 July 1965 by the Key West Test and Evaluation Detachment. The first preliminary report, TRACOR Document Number 65-320-C, was issued in September, 1965 and provides a description of the sea tests, methods of analysis, influence identification, and interferences observed to that time.

It was noted in the first preliminary report that two unexpected interferences were observed, namely, interference by off frequency ODT pulses and correlations against off frequency FM pulses. No new or unexpected influences or interferences have been noted during the subsequent analysis.

The actual sea test log, recorded by the Key West Test and Evaluation Detachment during the test, has been corrected for errors identified during the analysis of recorded sea test data. Noted discrepancies between the log and actual results included frequency, transmit schedule, mode, beam orientation, and depression angle errors. Approximately 10% of the total number of events were found to have some type of error. The corrected log is included in Appendix A to this report.

Sonar Performance (i.e., Were the sonar systems operating properly during the tests?) has been partially evaluated for the three ships. Several malfunctions have been noted, including both the transmit and receive sub-systems. These malfunctions include sudden changes in transmitting frequency and bandwidth, → CONT Pg. 2

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and variable times between pings in the triple ping mode. Beam misalignment between transmit and receive orientation was noted at the steeper tilt angles but has not yet been fully evaluated.

END ABSTRACT

Evaluation of expected performance of the AN/SQS-26 CX and AN/SQS-26 AX(Retrofit) has been partially determined on the basis of existing specifications for these systems. An exact prediction is not possible since all filter characteristics for the AN/SQS-26 and AN/SQS-26 AX (the systems used in the three ship sea test) have not yet been obtained. Reasonable approximations have been determined from the data analysis program, and evaluation of future system performance under similar conditions of influence can be estimated. Preliminary analysis, noted in the first report, described the various types of influences observed during analysis of the recorded data. Of particular importance were the levels of direct, specular and rumble influences. These values have been determined by two different methods; the increase in beamformer output level over the normal, expected level has been determined for both a reverberation cycle and a passive cycle (listen mode only). These calculations are a direct measure of the level of influence noted at the beamformer output and must be evaluated in terms of the uniqueness of the sonar data channel. An example of how the increasing uniqueness can reduce the influence as well as eliminate the interference has been calculated for a single echo ranging cycle. This calculation tends to demonstrate how the "CX" performance will be considerably improved over the existing equipment. Similar results were noted when "XN-2" data from the two ship tests were analyzed.

An explanation for the two unexpected interferences has not been completely determined but certain observations can be made regarding these interferences. An example of the ODT, off-frequency, interference is included to illustrate this type of interference in more detail. It can be demonstrated that this "pulse" effect is due to filter characteristics. The off-frequency FM pulse correlations noted are now suspected as being due to a coded channel malfunction, either in the clipper-amplifier or the Deltic processor. A further evaluation of these problems is required before definite conclusions can be reached.

2. SONAR MALFUNCTIONS

Numerous instances of sonar malfunctions have been noted during the data analysis program. These malfunctions are not covered in Section 3 where the discrepancies are associated with operator and/or schedule errors. Sonar malfunctions were noted in numerous modes and for different events. These effects are only reported, and no attempt at explanation is attempted at this time.

Variation in triple ping transmission intervals is illustrated in Figs. 2-1 and 4.2-17 for Event M-614 and G-146, respectively. The transmitted replica is recorded on the timing channel, Channel 5, of the Sanborn record. The interval between the 1st and 2nd ping is different than that between the 2nd and 3rd ping of the series. In some instances, the ODT follow-up pulse in the BB2ØODT mode is completely missing.

Sudden frequency shifts during the triple ping cycle were noted, primarily on McCLOY, and are illustrated in Fig. 3.1-1, for Event M-21. This is a rare event but should be noted. As reported, FM slides with bandwidths of about 200 cps were also noted.

Possible correlator malfunctions have also been noted, but not verified as yet. These effects are noted during transmission intervals and during reception of very large off-frequency signals. This problem is being investigated since so-called "false correlations" may be due to a processor design deficiency. Examples are shown in Figs. 4.2-23(B-578) and 4.2-25(G-614). Causes for this phenomenon are being investigated through Deltic processor simulation.

Beam mis-alignment, either between transmit and receive beams, or in actual orientation of the two, is indicated. Misalignment between the transmit and receive beams has been shown

McCLOY 614

(MODE ACTUALLY BB 2ØODT RATHER THAN LOGGED CZ)

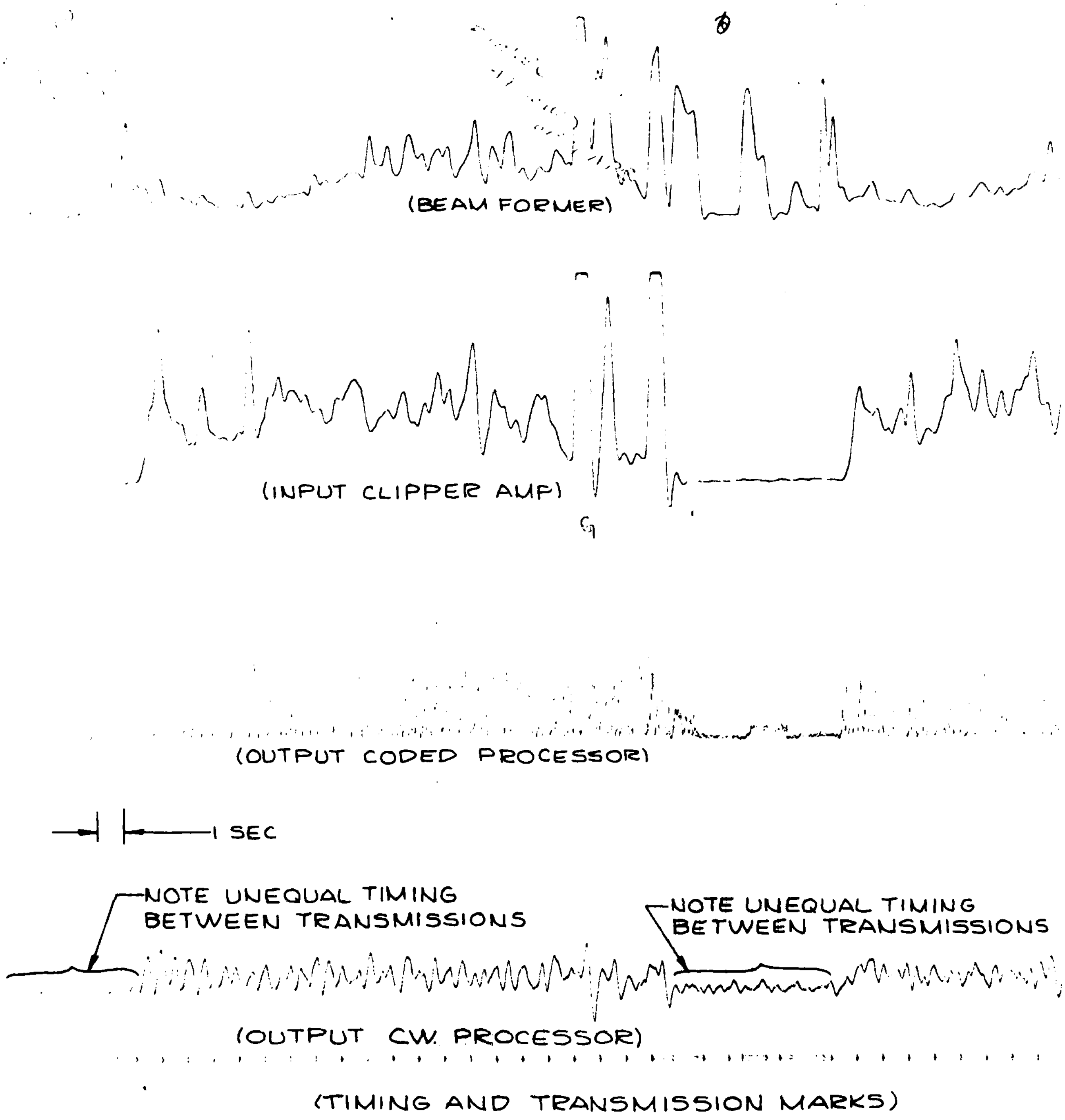

FIG. 2-1

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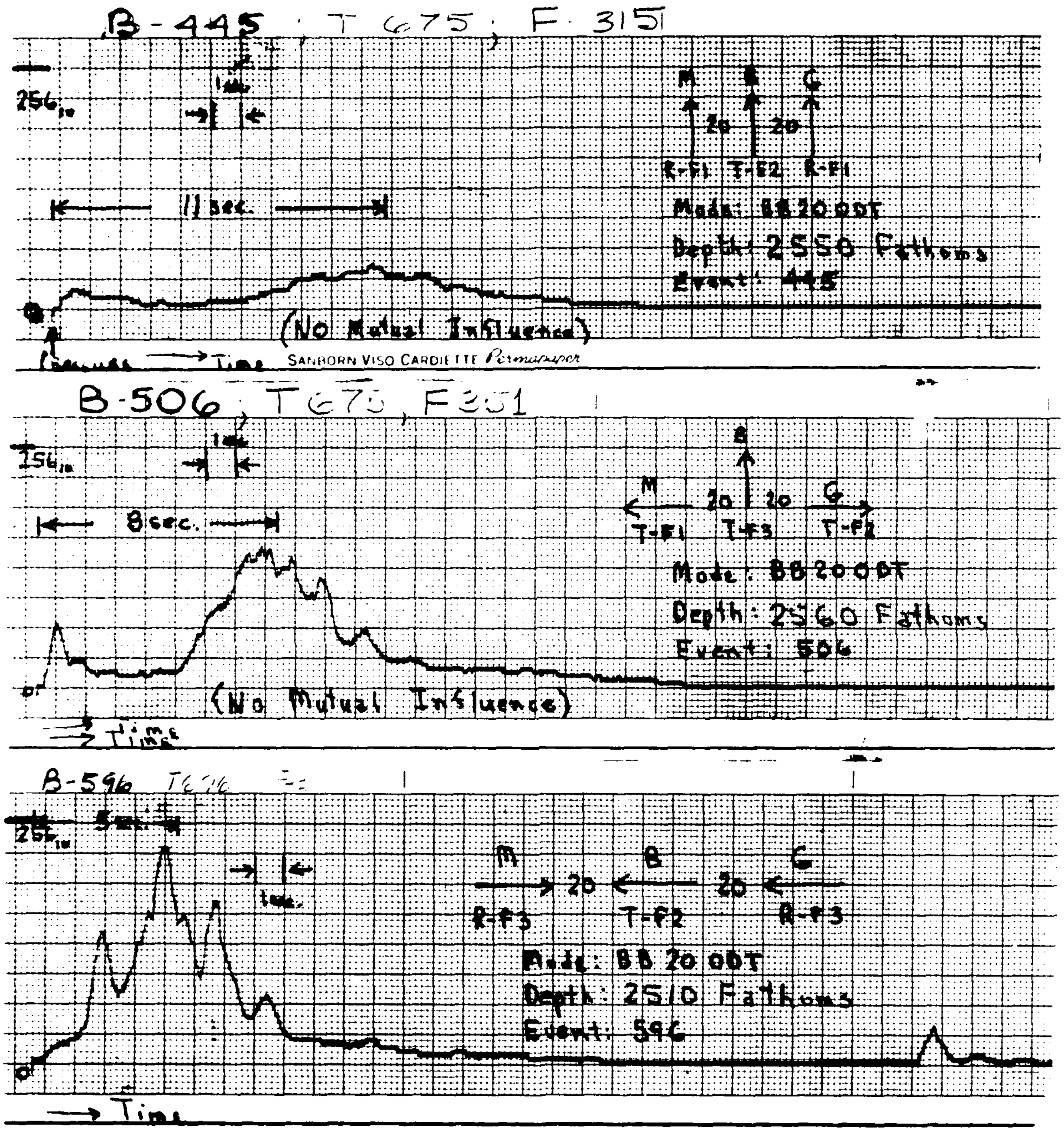
by reverberation modeling to produce a product beam which is not as expected with the sonar. In addition, the true depression angle, relative to that desired, changed during the test on a long time basis.

An example of the long time dependence of beam drift is shown in Fig. 2-2, a series of reverberation cycles from BELKNAP, taken over a period of several hours. These cycles indicate gross changes in the actual beam alignment, even though the mode is reported to be constant. These apparent changes in the reverberation cycle are noted primarily in the time at which the peak in the bottom reverberation occurs. The first curve, Event B-445, indicates a peak near 11 sec. which corresponds to the expected time of the peak as predicted from geometrical considerations (depression angle, water depth, etc.). At a later time, with the same geometry, the peak in the bottom reverberation is now found at 8 sec. after transmission (Event B-506), while still later (Event B-596) the peak occurs about 5 sec. after transmission. Fathometer returns are consistent with the water depths indicated. This trend holds throughout the balance of the test. BELKNAP degradation seems to "set in" after Event B-500, and the magnitude of the misalignment tends to increase beyond this event; the data before Event 500 do not show these effects.

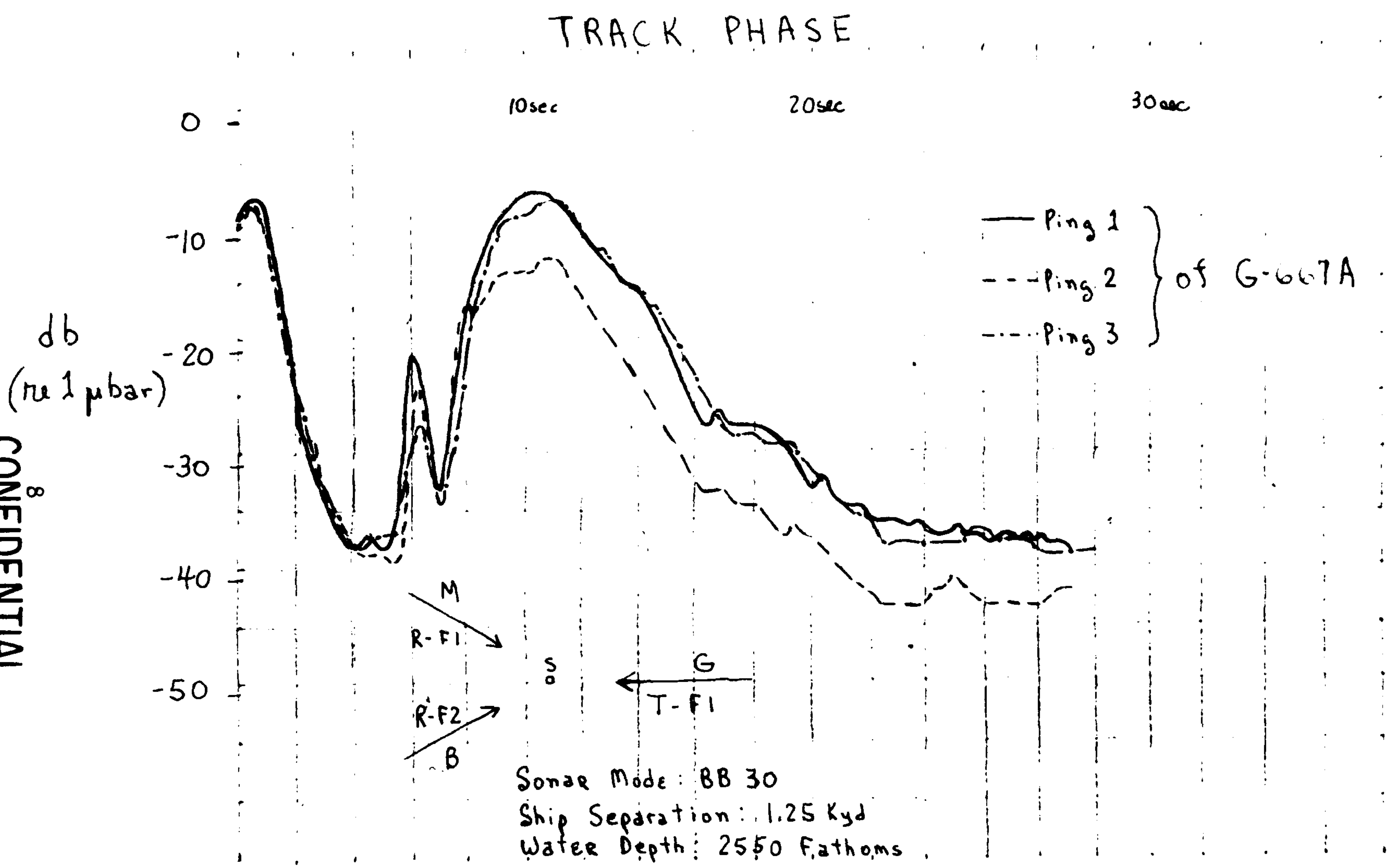
Short duration transmit-receive misalignment as observed aboard GARCIA, is shown in Fig.2-3, a series of three pings in sequence, and in Fig. 2-4, two pings computed on the same mode at different times. These changes cannot be totally explained by changes in bottom and surface scattering and reflection characteristics. The misalignment of the transmit and receive beams is not a consistent effect, since the 1st and 3rd ping cycles of the example in Fig. 2-3 are identical, while the 2nd cycle is considerably different. The basic shape of the bottom reverberation curve indicates a change in the so-called

Variation of Belknap BB200DT



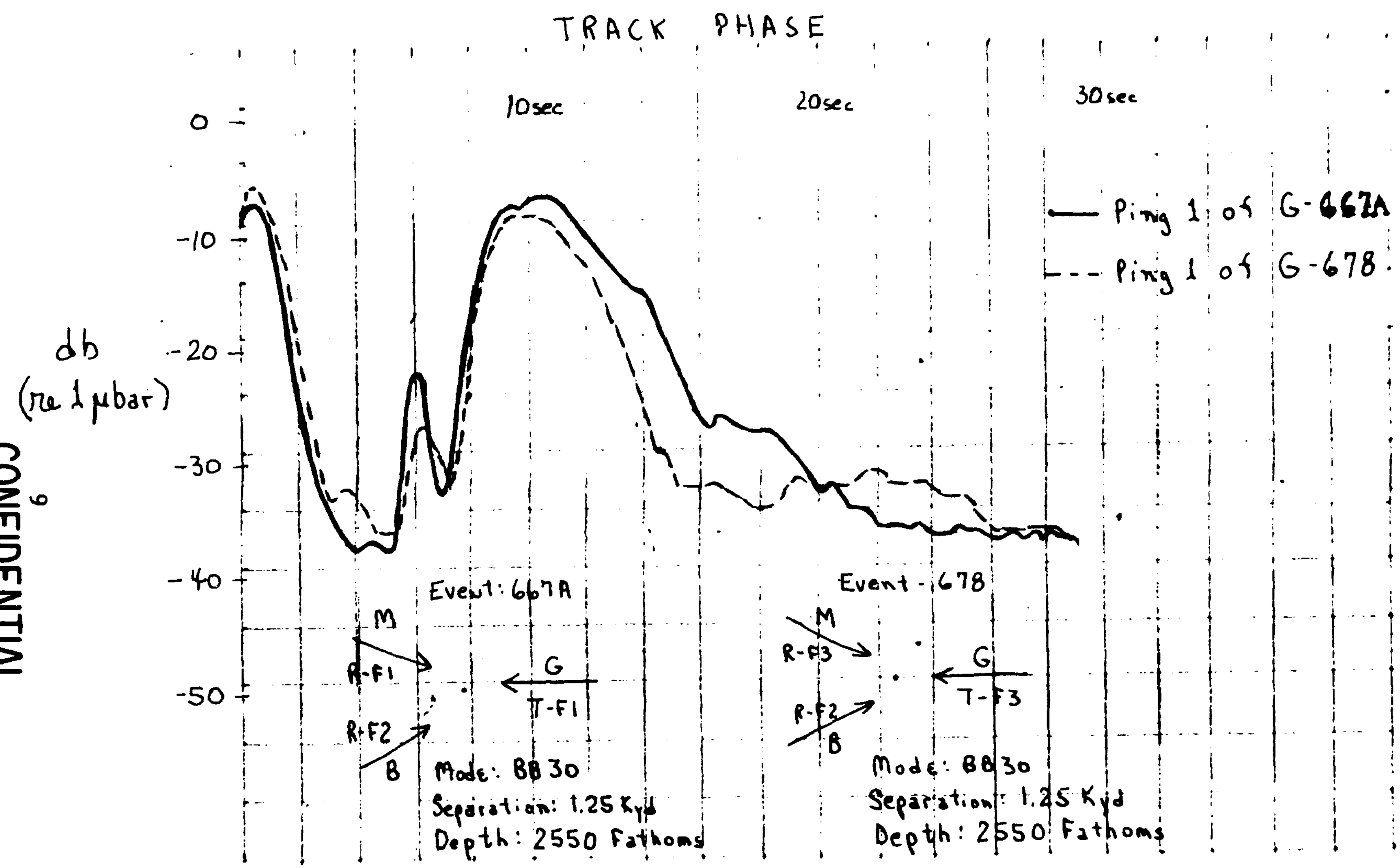
Belknap Mode BB200DT

FIG. 2-2



Three Consecutive Pings from GARCIA-667A
(Single transmission of .5 sec FM and .03 sec. CW)

FIG. 2-3



The First Ping from Two Consecutive BB30 Events on GARCIA
(Single transmission of .5 sec. FM and .03 sec. C.W)

FIG. 2-4

transmit-receive "product pattern," which appears correct in pings 1 and 3 but degraded in the 2nd ping cycle. The same type of difference in the ping cycle is indicated in Fig. 2-4 where the assumed correct ping cycle (ping 1 of Event G-667-A) is compared to another ping cycle in event G-678. These differences do not reflect any mutual interference effects since the other ships in these events were passive for these data. Similar effects as noted on BELKNAP and GARCIA have not been noted on McCLOY.

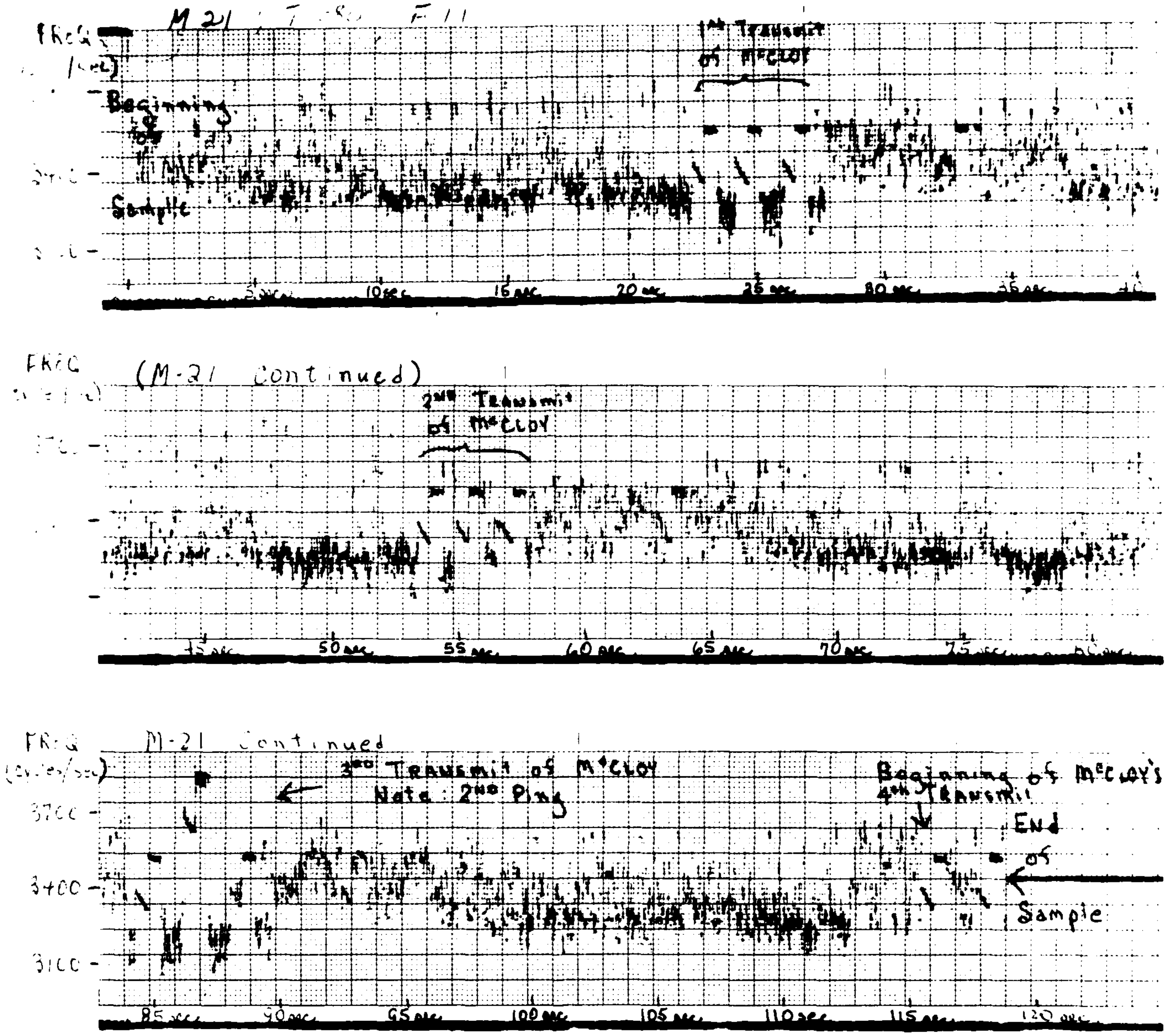
3. CORRECTED SEA TEST LOG

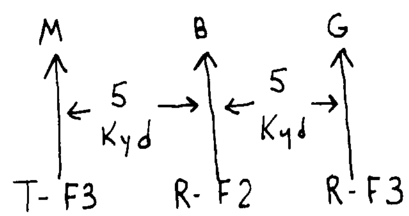
Complete analysis of the 208 events which were run in the mutual interference tests of 19-25 July 1965 has revealed the following deviations from the logs. In thirteen events, at least one of the participating ships was transmitting the wrong frequency, and in three events, at least one ship was in the wrong mode. In seven events, one or more ships were either transmitting when they should have been receiving, or vice versa.

Figures 3.1-1 and 3.1-2 are examples of the analysis used to identify different frequency bands. Figure 3.1-1 displays a frequency analysis which was taken across three pings of the McCLOY. In event 21, McCLOY was scheduled to transmit at F3, but the frequency analysis reveals it transmitted at F2. The third transmission of McCLOY is of special interest, since the second ping of McCLOY's three ping transmission is 300 cps higher than the first and third ping. Figure 3.1-2 illustrates how frequency analyses from all three ships were studied before definite conclusions were drawn about the frequency band transmitted and the frequency band causing mutual influence. In this example, chart #1 shows BELKNAP and GARCIA influencing McCLOY at a higher frequency band. Sanborn chart #2 verifies that McCLOY is one band below BELKNAP's transmitted frequency band. Sanborn chart #3 again verifies that McCLOY is one band below GARCIA and BELKNAP, and that GARCIA and BELKNAP are at the same frequency. The only conclusion left is that BELKNAP was transmitting at F2 rather than the logged frequency of F3.

Figure 3.1-3 is an example of one of the ships transmitting in the wrong mode. In event 614, all three ships were scheduled to transmit 0.5 sec FM, followed by 0.5 sec CW, and 100 ms ODT, in convergence zone mode. Figure 3.1-3 displays clearly that McCLOY was still in a triple ping transmission in the bottom bounce mode. This was verified by a rectified and averaged output of

McCLOY EVENT 21

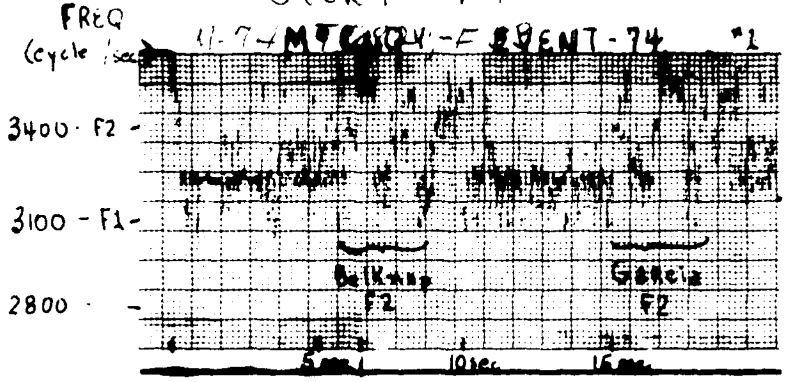


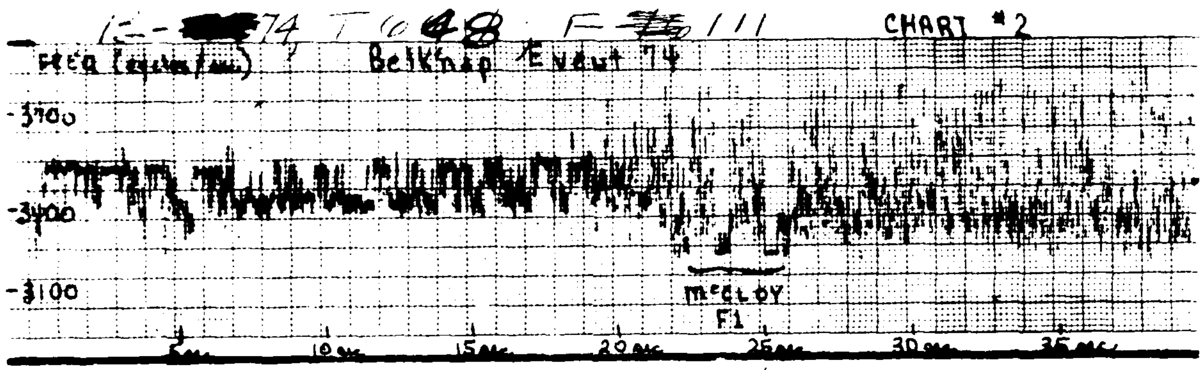


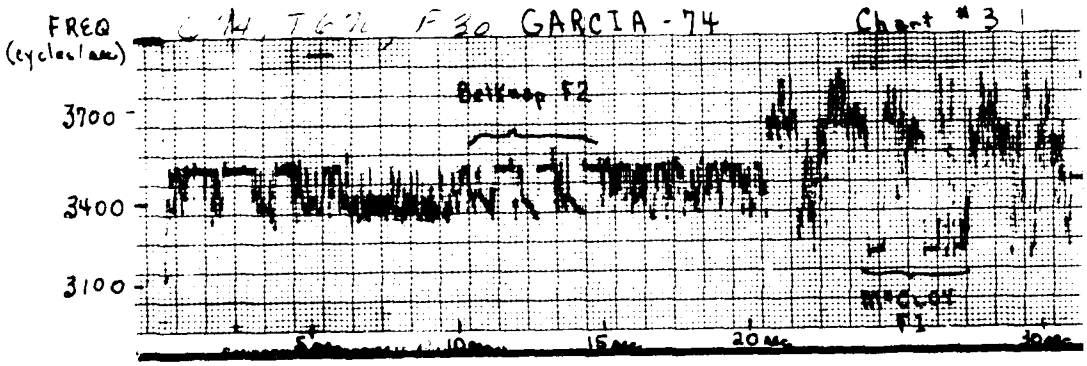
Mode: BB 20 ODT

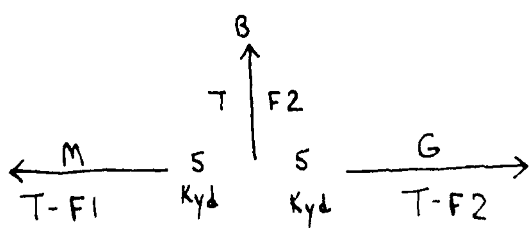
FIG. 3.1-1

Event - 74





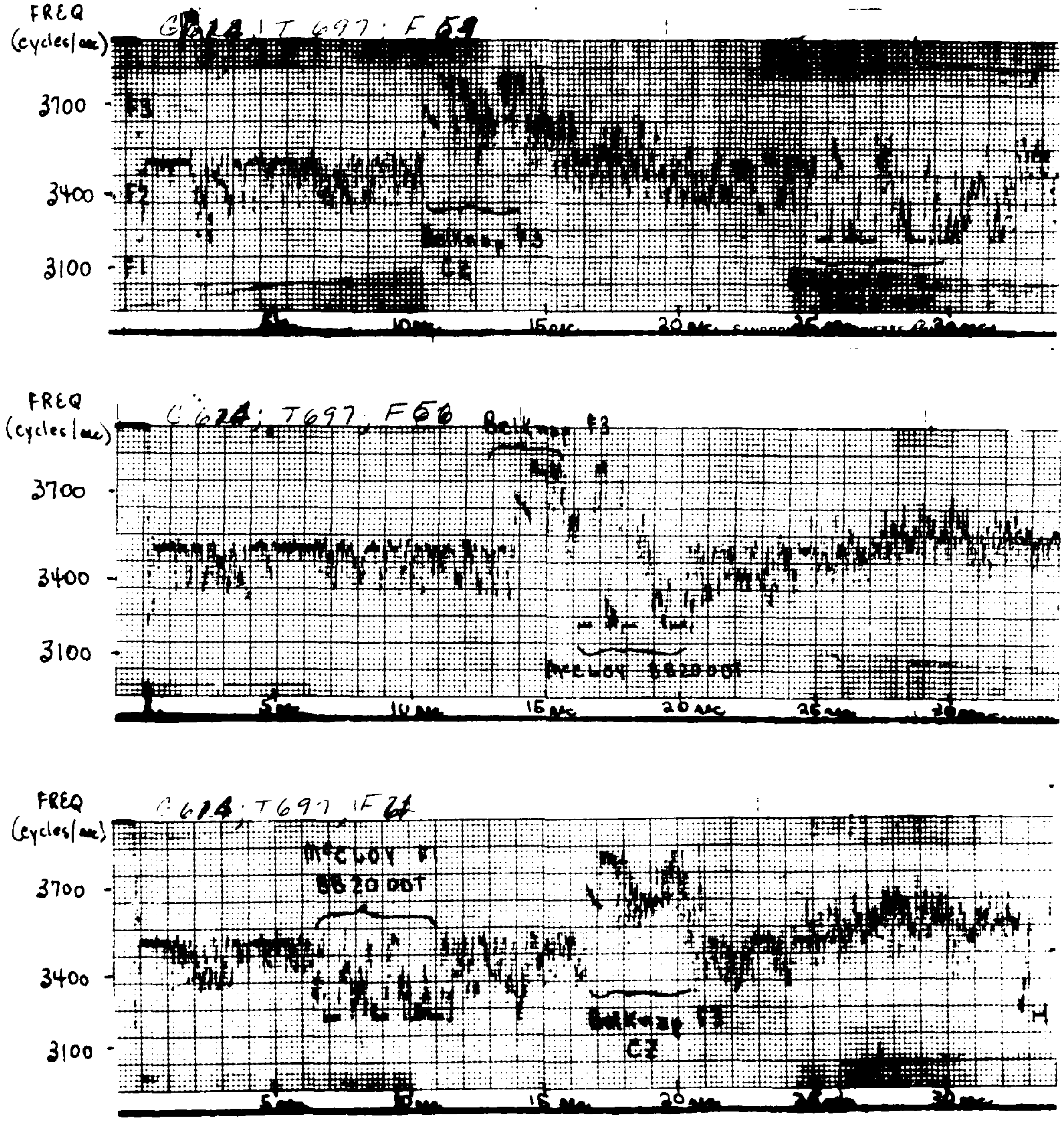


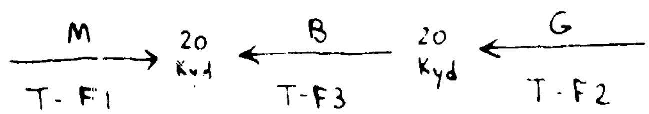


Mode: BB 20 ODT

FIG. 3.1-2

GARCIA 614





Mode CZ - Belknap & Garcia
BB200DT - McCLOY

FIG. 3.1-3

Beam 6 of the McCLOY, which was clearly a bottom bounce reverberation cycle. The seven events in which the transmission schedule was not followed correctly were easily discovered because of the obvious difference between passive and active mode.

The total number of deviations is twenty-three or 11% of the events run. These changes are noted in the corrected mutual interference run summary in Appendix A of this report.

4. INFLUENCES AND INTERFERENCES

4.1 Data Analysis

Basic data reduction and analysis methods were described in the first preliminary report on the three ship test. To further aid in evaluating the data in this report, the basic shipboard recording process is shown in Fig. 4.1-1. These recorded data have been digitized and processed by computer methods for further analysis. Basic characteristics of the record-playback process for each ship are shown in Figs. 4.1-2, 4.1-3 and 4.1-4, for the McCLOY, BELKNAP, and GARCIA, respectively. With these values, which include system gain and beamformer sensitivity, the sound pressure level, in dynes/cm^2, can be determined. Therefore, the following data are calibrated in terms of sound pressure level (dynes/cm^2) or in dB re 1 dyne/cm^2, as indicated. All times are measured after end of transmission.

4.2 Relative Levels of Influence

Representative events have been analyzed to determine the levels of influence as a function of relative sonar bearing, frequency separation, mode, and distance separation of the sonars. Influence can be classified by four types of beam orientation, as shown in Fig. 4.2-1. Levels are classified as to high, medium, or low, depending on their relative effects for a particular orientation.

Direct is meant to include both the direct transmission and specular reflection. Rumble was defined in the first preliminary report. Relative levels are determined via power spectrum techniques.

4.2.1 Type I Geometry

Beam orientation for type I geometry produces the minimum influence for both direct and rumble. Primary influence signals are derived from ODT transmissions. The influence due to this

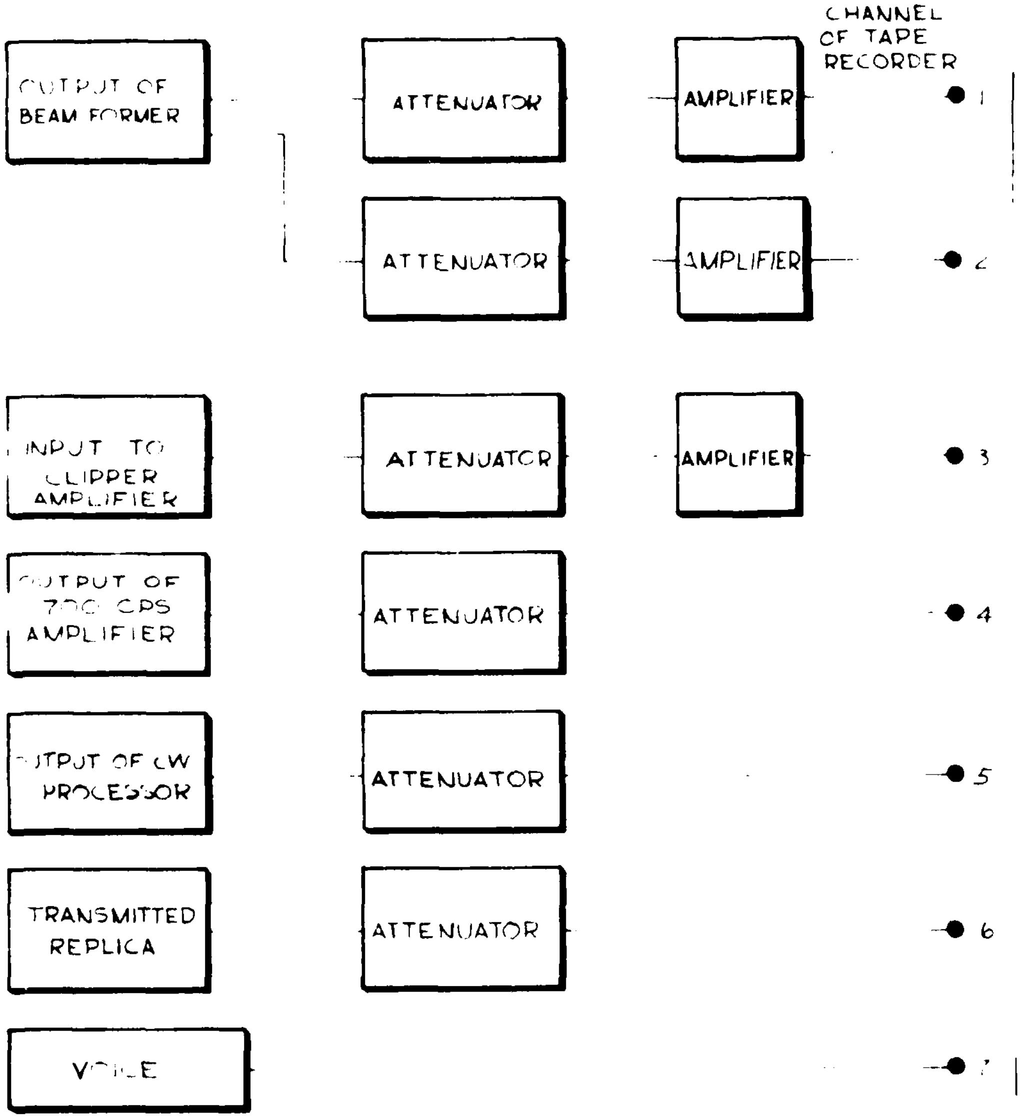


FIG. 4.1-1 BLOCK DIAGRAM OF SHIP BOARD RECORDING SYSTEM

USS McCLOY-DE-1038

TAPE RECORDER GAIN
CHANNEL 1 & 3: ODB RE 1V
CHANNEL 2,4,5 & 6: +6DB RE 1V

BEAM FORMER SENSITIVITY = 55DB RE 1V

EVENT NUMBER	AMPLIFIER CHANNEL 1	AMPLIFIER CHANNEL 2	AMPLIFIER CHANNEL 3	ATTENUATOR CHANNEL 1	ATTENUATOR CHANNEL 2	ATTENUATOR CHANNEL 3	ATTENUATOR CHANNEL 4	ATTENUATOR CHANNEL 5	ATTENUATOR CHANNEL 6
1 TO 407	+40 DB	ODB	+40DB	SET SUCH THAT, ON TRANSMIT; NOISE = -40DB AT INPUT OF TAPE RECORDER	ODB	SET SUCH THAT MAX SIGNAL AT INPUT TO TAPE RECORDER = -6DB RE 1V RMS			
416 TO 529	"	"	+20DB i.e., REDUCED BY 18.7DB	"	"	"			
553 TO END	"	"	"	"	"	"		10DB GAIN ADDED	

GAIN AS DETERMINED FROM CALIBRATION TAPES BEFORE EVENT 407, F = 1 KC

CHANNEL 1			CHANNEL 2			CHANNEL 3			CHANNEL 4			CHANNEL 5			CHANNEL 6		
INPUT	OUTPUT	GAIN	INPUT	OUTPUT	GAIN	INPUT	OUTPUT	GAIN	INPUT	OUTPUT	GAIN	INPUT	OUTPUT	GAIN	INPUT	OUTPUT	GAIN
.0056V	.575V	40.3DB	.48V	.535V	1.0DB	.0081V	.81V	40DB	.97V	.73V	-2.5DB	2.24V	.107V	-6.9DB	2.28V	.105V	-6.5DB
.00187	.005	40.8DB	.145V	.178V	1.8DB	.0029V	.26V	39DB	.195V	.162V	-1.6DB	.80V	.0375V	-6.6DB	.90V	.038V	-7.5DB

FIG. 4.1-2 — RECORD-PLAYBACK GAIN SETTINGS FOR RECORDED SONAR DATA

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USS BELKNAP-DLG-26

BEAMFORMER SENSITIVITY = -51 DB RE 1V

TAPE RECORDER GAIN
CHANNEL 1 & 3 ~ 15.5 DB RE 1V
CHANNEL 2, 4, 5 & 6 ~ 0DB RE 1V

EVENT NUMBERS	AMPLIFIER CHANNEL 1	AMPLIFIER CHANNEL 2	AMPLIFIER CHANNEL 3	ATTENUATOR CHANNEL 1	ATTENUATOR CHANNEL 2	ATTENUATOR CHANNEL 3	ATTENUATOR CHANNEL 4	ATTENUATOR CHANNEL 5	ATTENUATOR CHANNEL 6
1 TO 13	+40 DB	0DB	0DB	7.19 (-6DB)	10.00 (0DB)	10.00 (0DB)	5.00	2.50	10.00 (0DB)
15 TO 31	"	20DB	"	"	"	"	"	"	"
34 TO 146 A	"	40DB	"	"	"	"	"	"	"
146A TO 218A	"	20DB	"	"	"	"	"	"	"
218A TO 362 A	"	40DB	"	"	"	"	"	"	"
SPECIAL RUN BETWEEN 362A & 434	"	20DB	"	"	"	"	"	"	"
434 TO 511	"	40DB	"	"	"	"	"	"	"
515 TO END	"	"	"	"	"	"	"	10.00 (0DB)	"

GAIN AS DETERMINED FROM CALIBRATION AFTER EVENT 623

CHANNEL 1	CHANNEL 2	CHANNEL 3	CHANNEL 4	CHANNEL 5	CHANNEL 6
37 DB		15.5 DB	2DB	3.2 DB	2DB

FIG. 4.1-3 —RECORD-PLAYBACK GAIN SETTINGS FOR RECORDED SONAR DATA

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USS GARCIA-DE 1040

BEAMFORMER SENSITIVITY = -51 DB RE 1V

TAPE RECORDER GAIN
CHANNEL 1 & 3 ~ 12 DB RE 1V
CHANNEL 2, 4, 5 & 6 ~ 0 DB RE 1V

EVENT NUMBER	AMPLIFIER CHANNEL 1	AMPLIFIER CHANNEL 2	AMPLIFIER CHANNEL 3	ATTENUATOR CHANNEL 1	ATTENUATOR CHANNEL 2	ATTENUATOR CHANNEL 3	ATTENUATOR CHANNEL 4	ATTENUATOR CHANNEL 5	ATTENUATOR CHANNEL 6
1 TO 667A	40DB	40DB	20DB	SET SUCH THAT, ON TRANSIT; NOISE = 54 DB AT INPUT OF TAPE RECORDER	SET SUCH THAT LARGEST REVERBERATION DOES NOT EXCEED 1V RMS AT INPUT OF TAPE RECORDER				
669 TO 677A	"	"	"	"	"			SET TO REDUCE OVERDRIVE	"
678 TO END	"	"	"	"	RESET	"		"	"

GAIN AS DETERMINED FROM CALIBRATION TAPES BEFORE EVENT 623

	CHANNEL 1	CHANNEL 2			CHANNEL 3			CHANNEL 4	CHANNEL 5			CHANNEL 6
	GAIN	INPUT	OUTPUT	GAIN	INPUT	OUTPUT	GAIN		INPUT	OUTPUT	GAIN	
F = 1KC	60.3DB	.01V	1.09V	40.9DB	.26V	1.85V	17.1DB	NOT CALIBRATED	3.9V	1.72V	-58DB	NOT CALIBRATED
F = 35KC		.01V	1.00V	40.0DB	F = 109CPS							

FIG. 4.1-4 - RECORD PLAYBACK GAIN SETTINGS FOR RECORDED SONAR DATA

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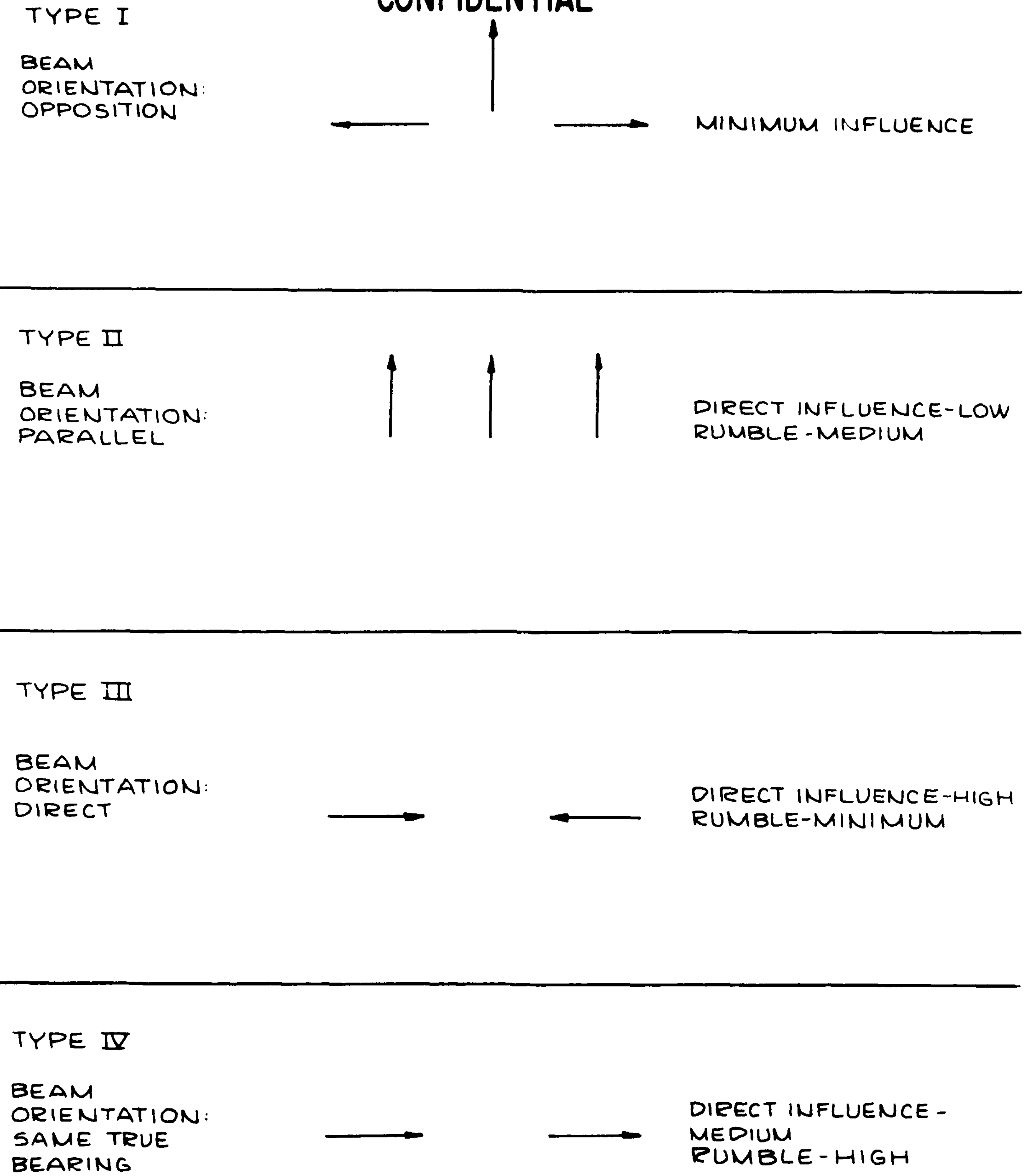

FIG. 4.2-1 TEST GEOMETRIES

geometry is illustrated in Figs. 4.2-2 and 4.2-3, computed for Event B-74. All ships are in the BB2ØODT mode. The direct influence from GARCIA is readily identified. Both CW and FM transmissions are either absent or at a very low level. Rumble due to GARCIA's transmission is of the same order as own ship reverberation, as indicated in the power spectrum calculation. The GARCIA's ODT transmission can be observed in both the clipper amplifier and the output of the CW processor. This is an example of off-frequency pulses generating signals in own frequency band due to filter differentiating effects (GARCIA at F2, BELKNAP at F3).

Figures 4.2-4 and 4.2-5 are the Sanborn four channel output and power spectrum calculation, respectively, for Event G-110, with GARCIA at F2, in the CZ mode. Both direct and rumble influence due to BELKNAP at F3 are identified, and the ships are at a range separation of 5 kyds. Power spectrum calculations indicate the relative levels of rumble and own ship reverberation are as expected.

An additional example is shown in Figs. 4.2-6 through 4.2-9, for BELKNAP and GARCIA during Event 542. Ship separation is 20 kyds and both ships are in the CZ mode. BELKNAP is at F3 and GARCIA is at F2. Signal levels are as indicated and are as would be expected at this range separation. No unexpected or new influences or interferences were noted for this geometry.

4.2.2 Type II Geometry

The parallel beam orientation for type II geometry increases the level of the influence due to both direct and rumble. This orientation can approach the optimum configuration for maximum rumble effects, depending on overall geometry. Examples of rumble and direct influence in this configuration are given in Figs. 4.2-10 and 4.2-11 for Event B-15, where all ships are in the BB2ØODT mode. BELKNAP is at F2 while McCLOY is at F1, at a

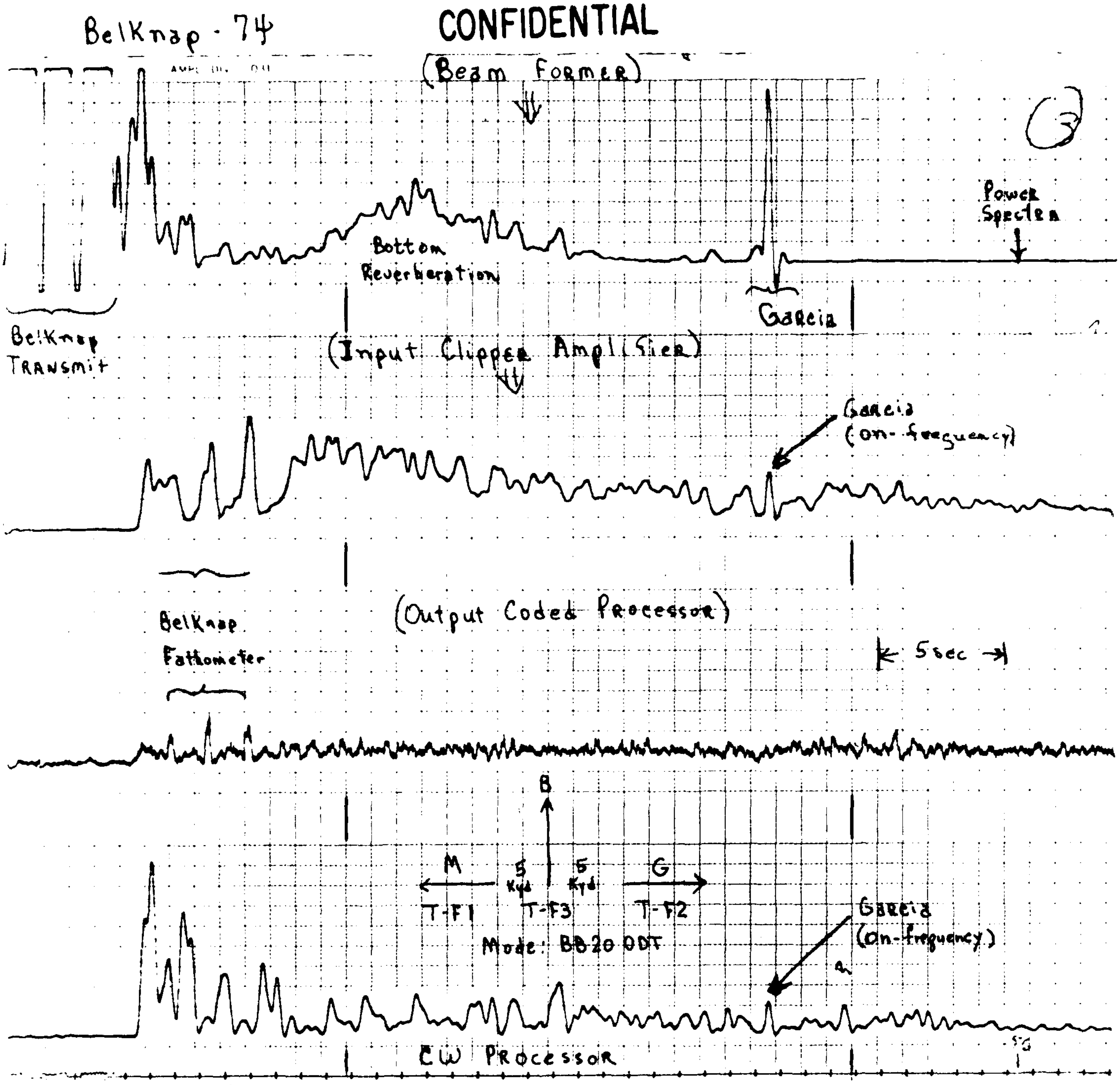

FIG. 4.2-2

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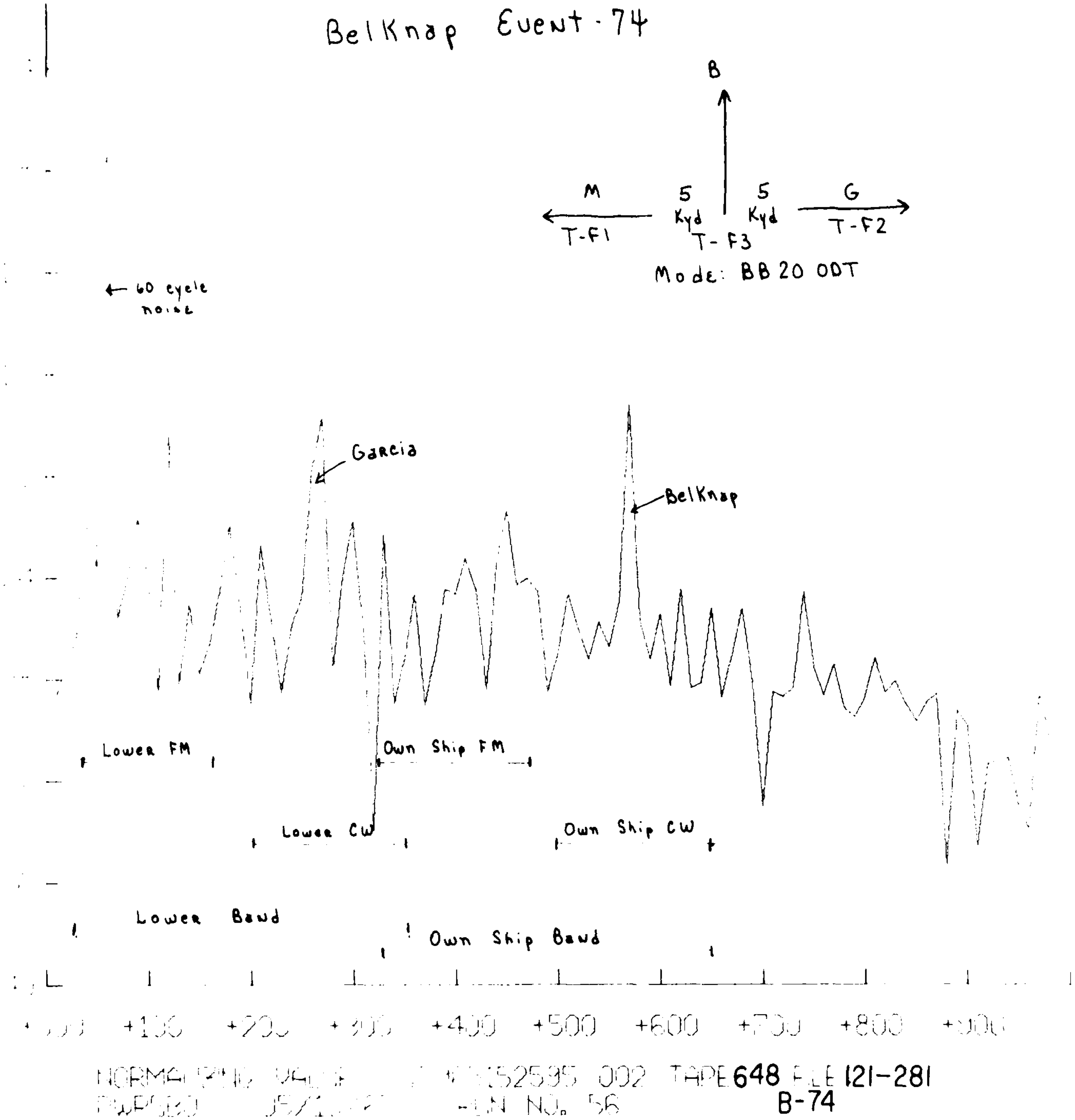
Belknap Event-74
B
M
5 Kyd
5 Kyd
G
T-F1
T-F3
T-F2
Mode: BB 20 ODT
← 60 cycle noise
Garcia
Belknap
Lower FM
Own Ship FM
Lower CW
Own Ship CW
Lower Band
Own Ship Band
+100
+200
+400
+500
+600
+800
TAPE 648
121-281
NO. 56
B-74

FIG. 4.2-3

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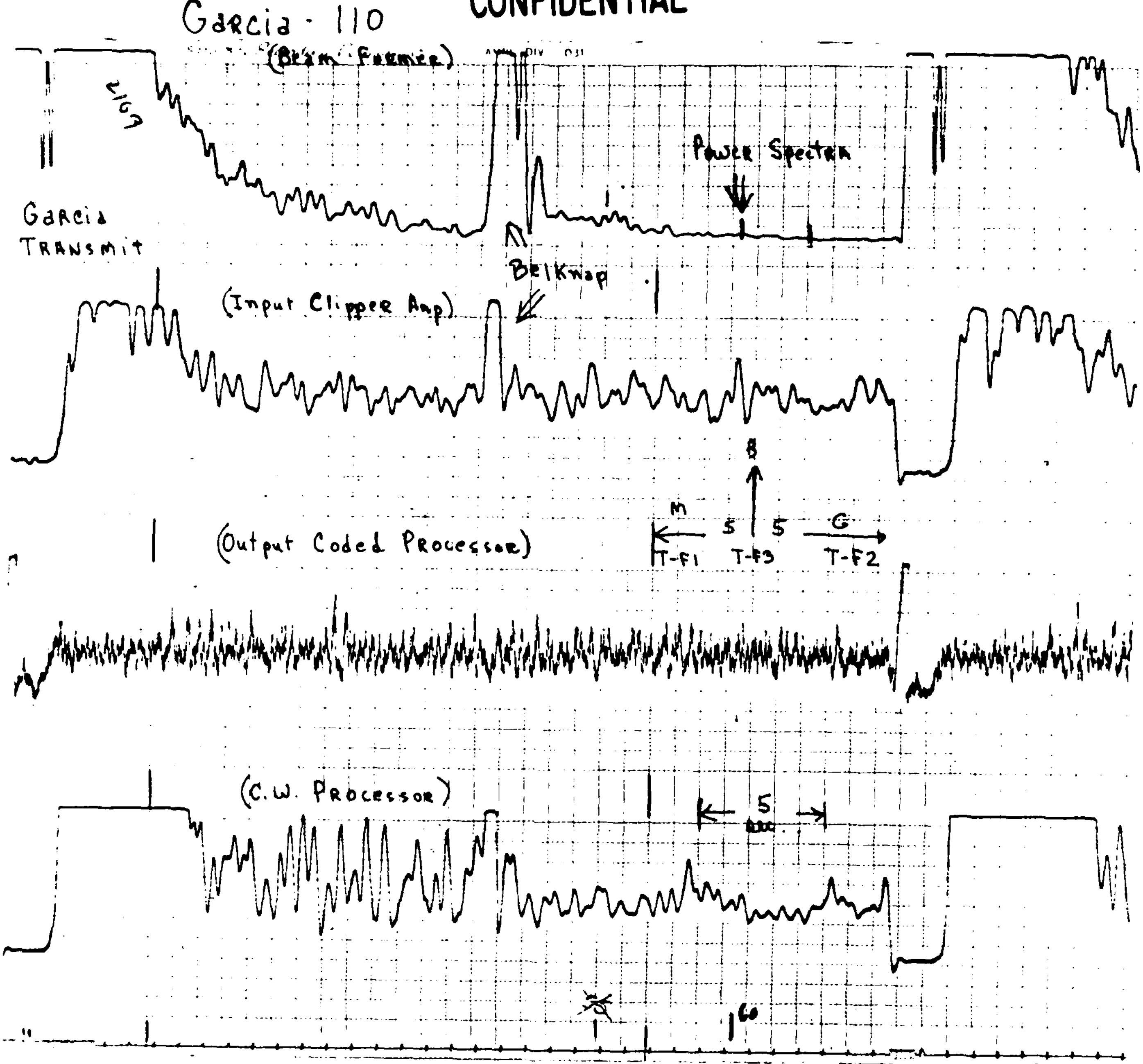

FIG. 4.2-4

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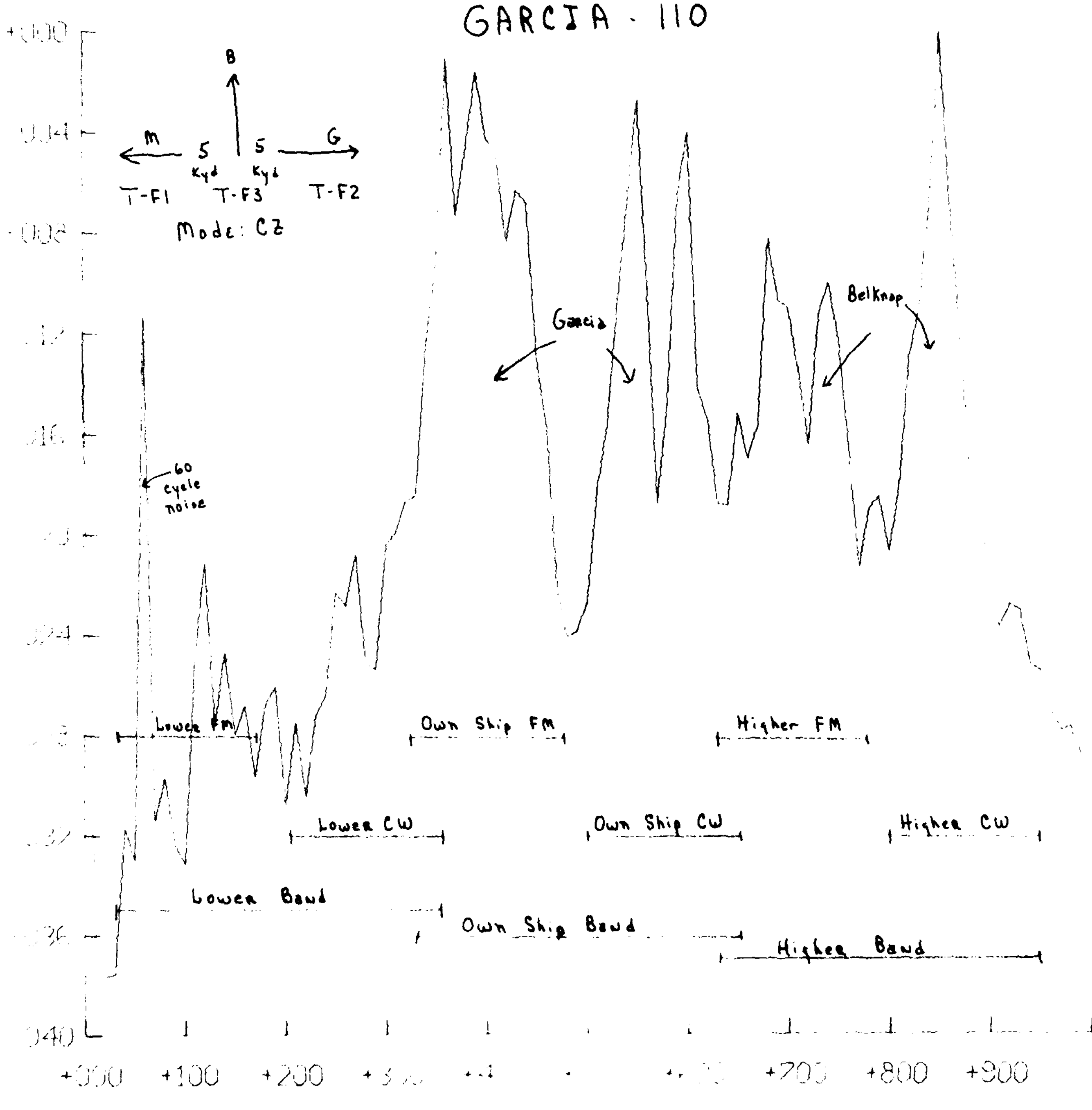

NORMALIZING VALUE ... TAPE 670 FILE 402-221

G-110

FIG 4 2-5

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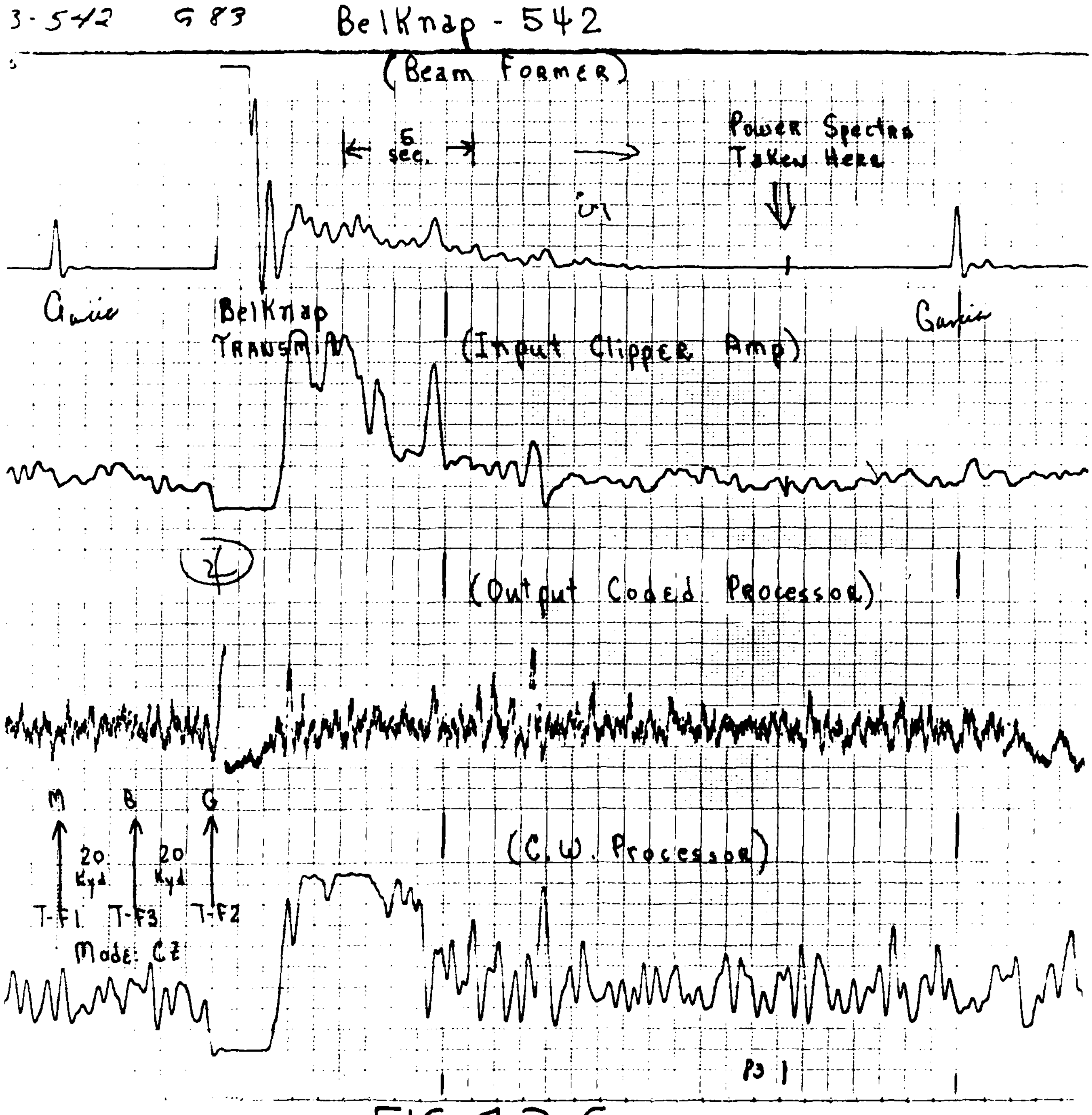

FIG. 4.2-6

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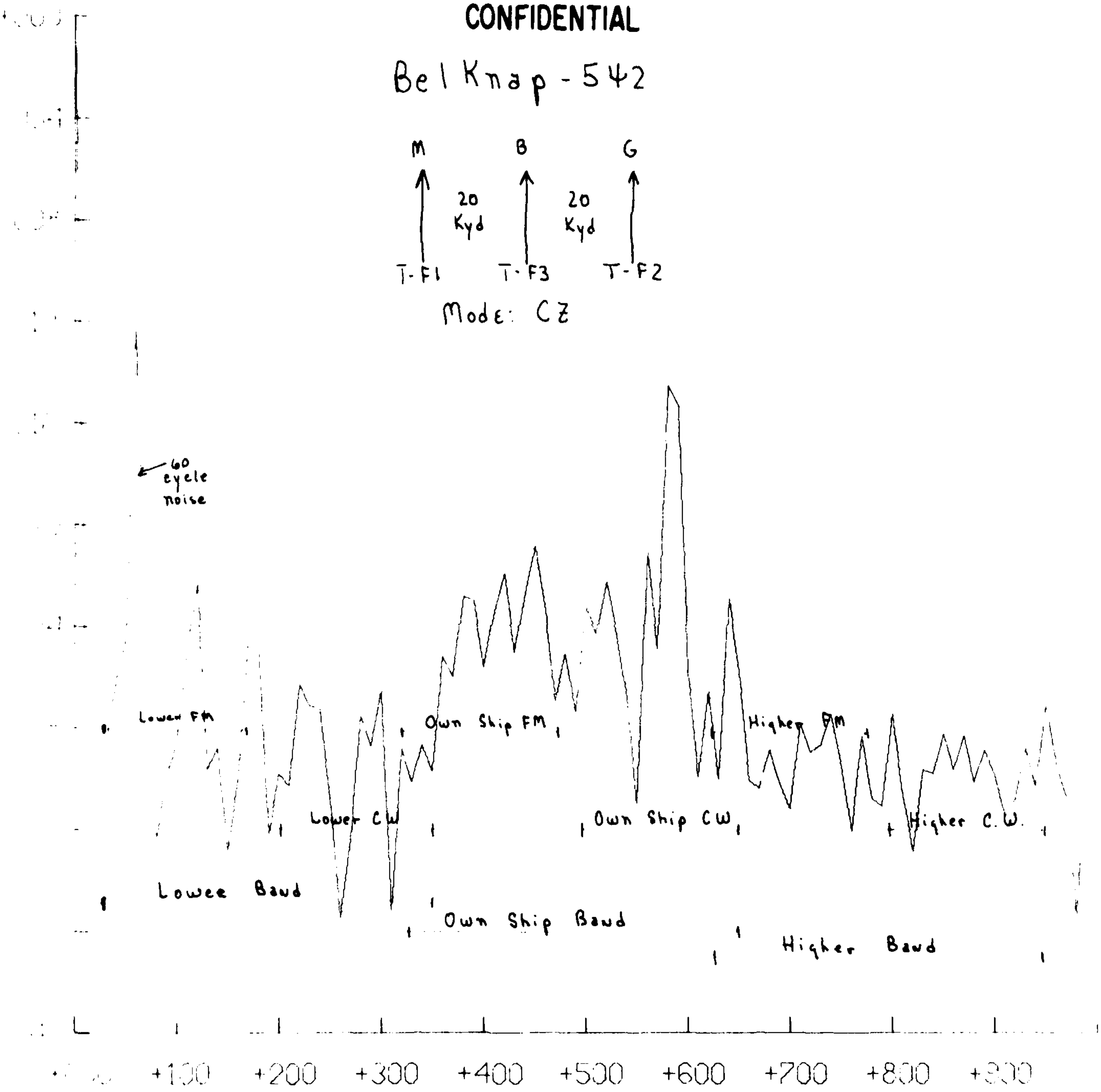

NORMALIZING VALUE .5938509075 002 TAPE 700 FILE 14.164
WPE80 08/10/65 RUN NO. 83 B-542

FIG. 4.2-7

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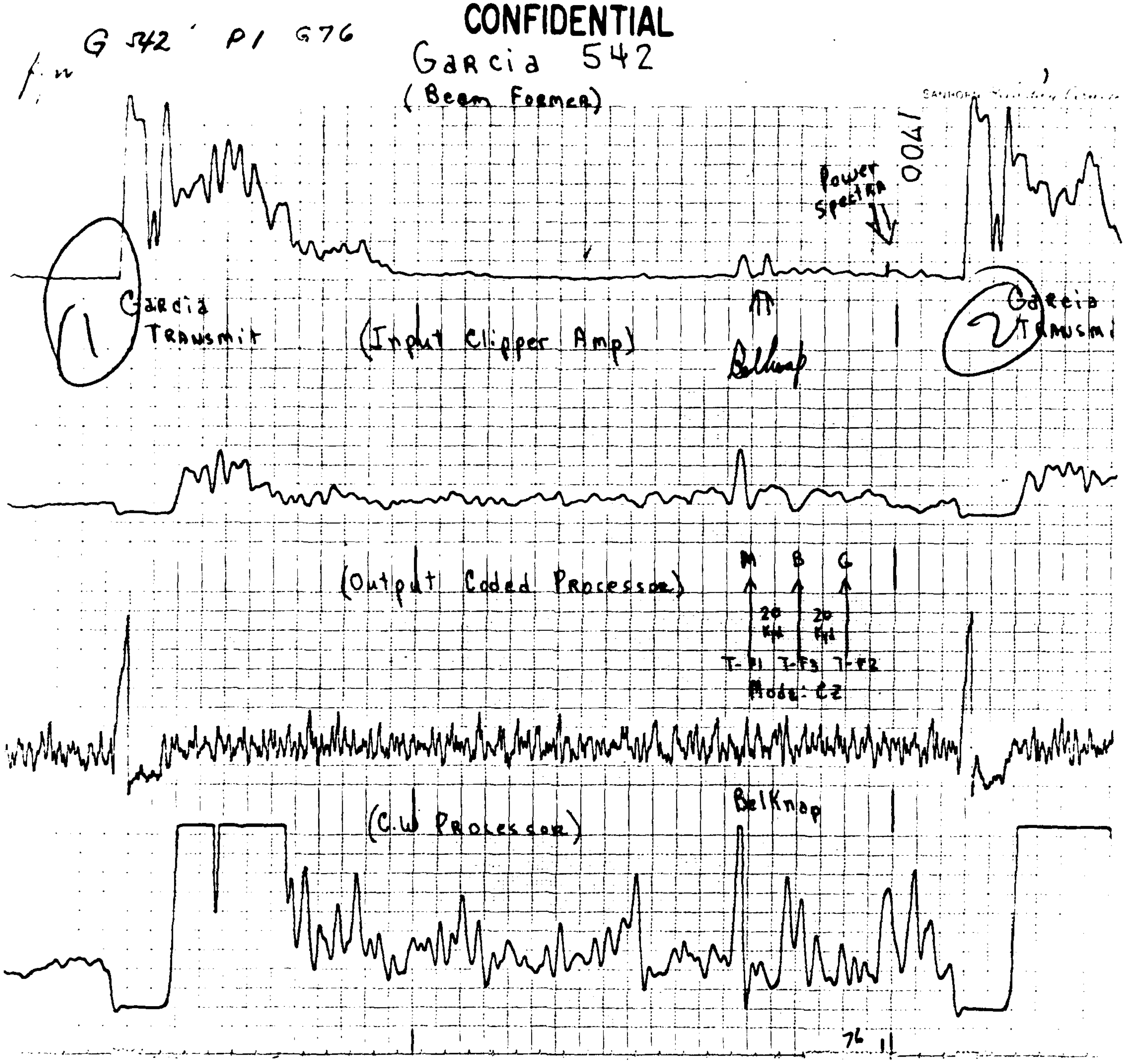

FIG. 4.2-8

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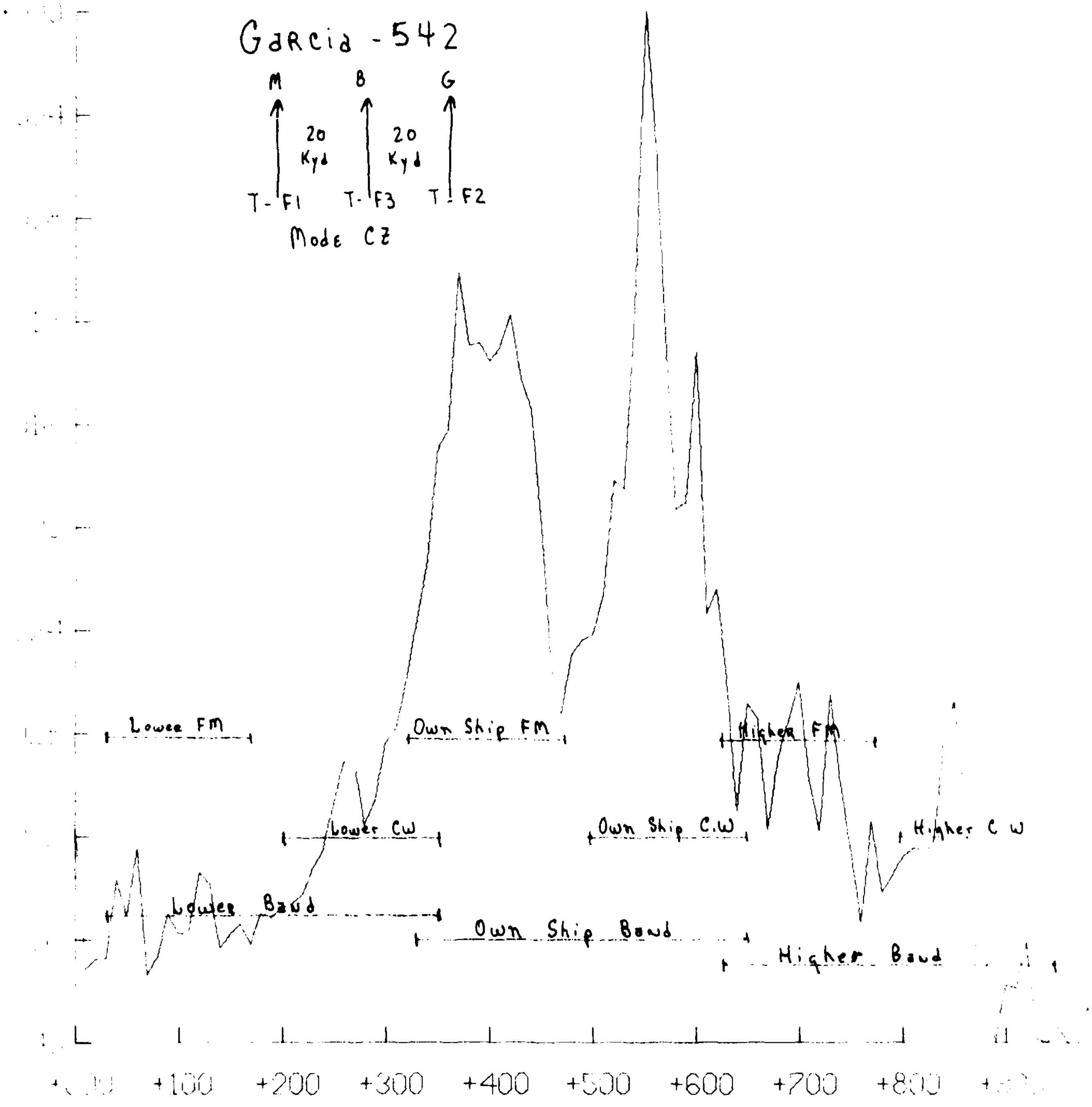

NORMALIZING VALUE .3433199646 002 TAPE 696 FILE 126.242
PWRSRO 06/10/65 RUN NO. 76
G-542

FIG. 4.2-9

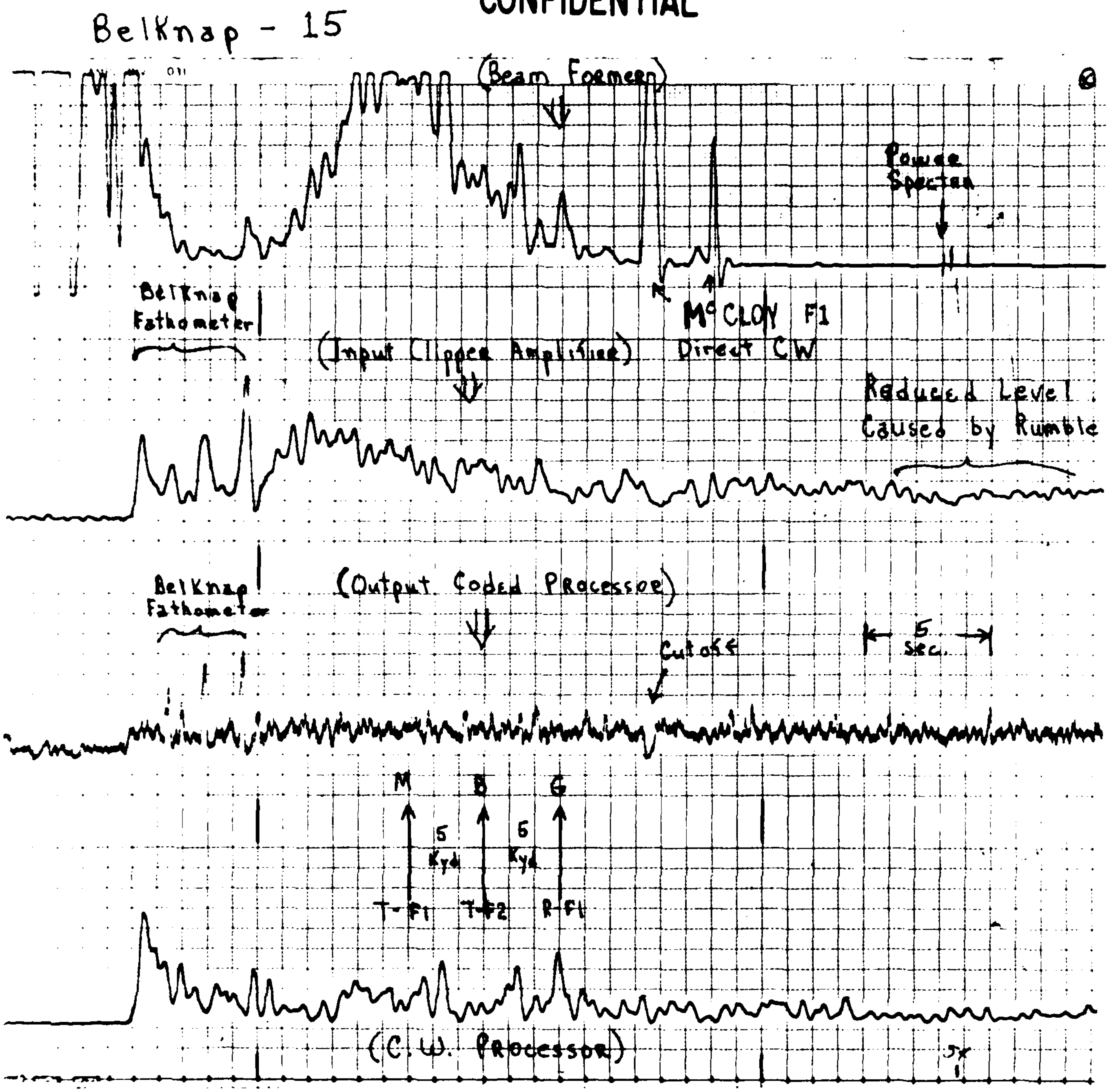

FIG 4.2-10

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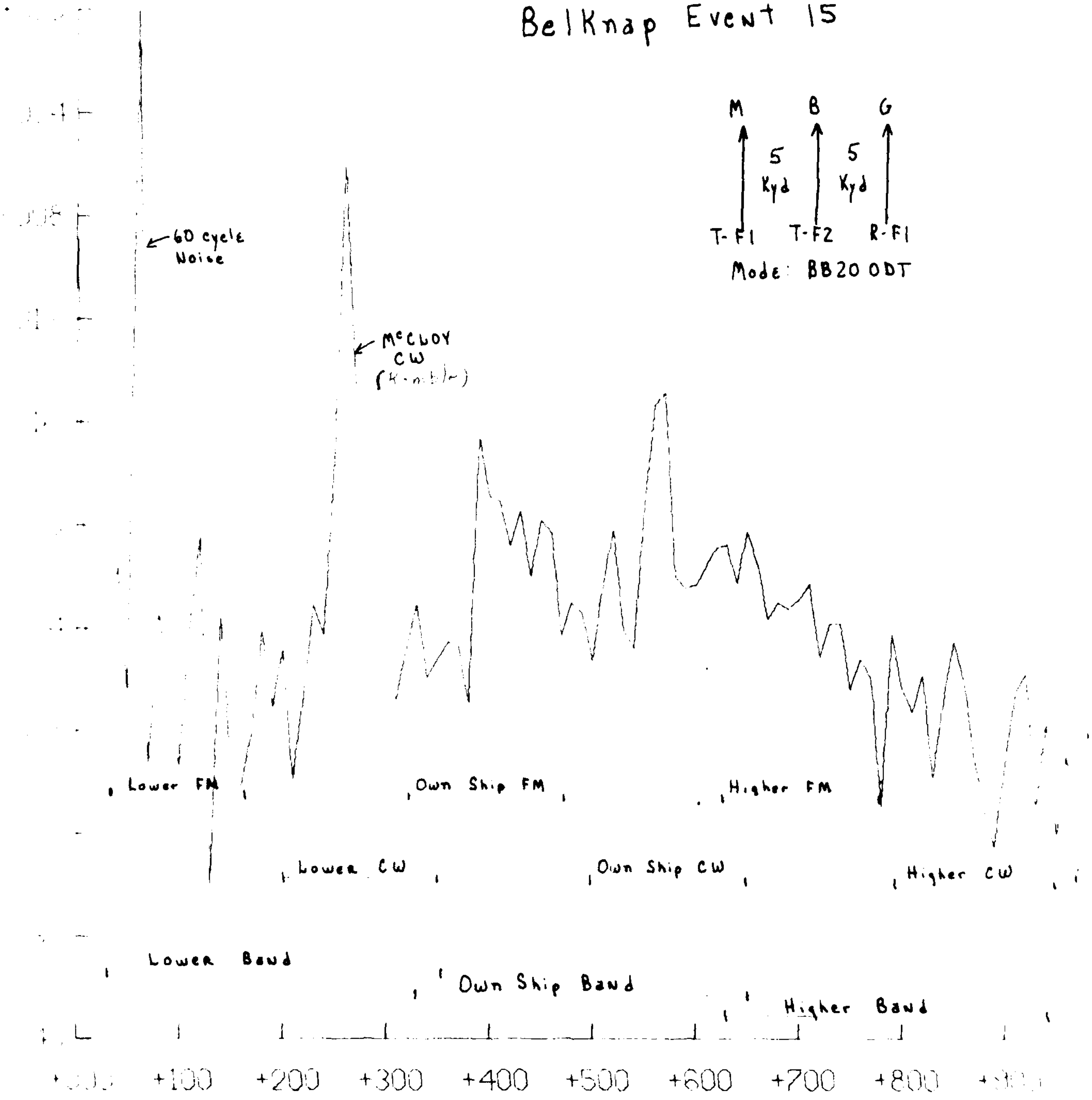
Belknap Event 15



NORMALIZING VALUE -.5908361849 002 TAPE 647 FILE 43-268

05/10/65 RUN NO. 54 Belknap Event 15

FIG. 4.2-11

range of 5 kyds. FM influence is below system noise level but the 0.5 sec CW and the ODT signals are received at about the same level as own bottom reverberation. The higher level, off-frequency, CW influence is sufficient to cause AGC cutoff of own signals as noticed at the input to the clipper amplifier. The ODT pulse differentation effect from McCLOY's transmission is also noted. The power spectrum calculation was computed in the region where off-frequency rumble was at a maximum, corresponding to the region (Fig. 4.2-10) where the AGC was cut off. Here, the rumble is about 9 dB above own ship CW reverberation and 14 dB above own ship FM reverberation (Fig. 4.2-11).

Figures 4.2-12 and 4.2-13 are similar examples except that the sonars are operating in the CZ mode. These data are for Event B-60, with BELKNAP at F2 and McCLOY at F3. Ship separation is 5 kyds. Heterodyne images are indicated at the input to the clipper amplifier. Both direct and specular influences from McCLOY have been identified. The band overlap effect is also noted due to McCLOY's FM overlap into BELKNAP's CW band (Fig.4.2-13).

Figure 4.2-14 is similar to an earlier example in that for this event, Event B-452, BELKNAP is at F2 and is operating in the BB20ODT Mode, but ship separation is 20 kyds. Influences due to both McCLOY and GARCIA are present. It should be noted that levels due to McCLOY are much lower than expected, even when considering the known 5 dB reduction in source level. Signal levels received from GARCIA appear at a higher level than expected, being of the order of those measured at 5 kyds.

Figure 4.2-15 is for Event B-470, with BELKNAP at F3 in the CZ mode. This illustrates the effects of F2 into F3, due to GARCIA at F2.

4.2.3 Type III and Type IV Geometry

These two types of geometry are grouped together because the data tend to illustrate both types of geometry simultaneously.

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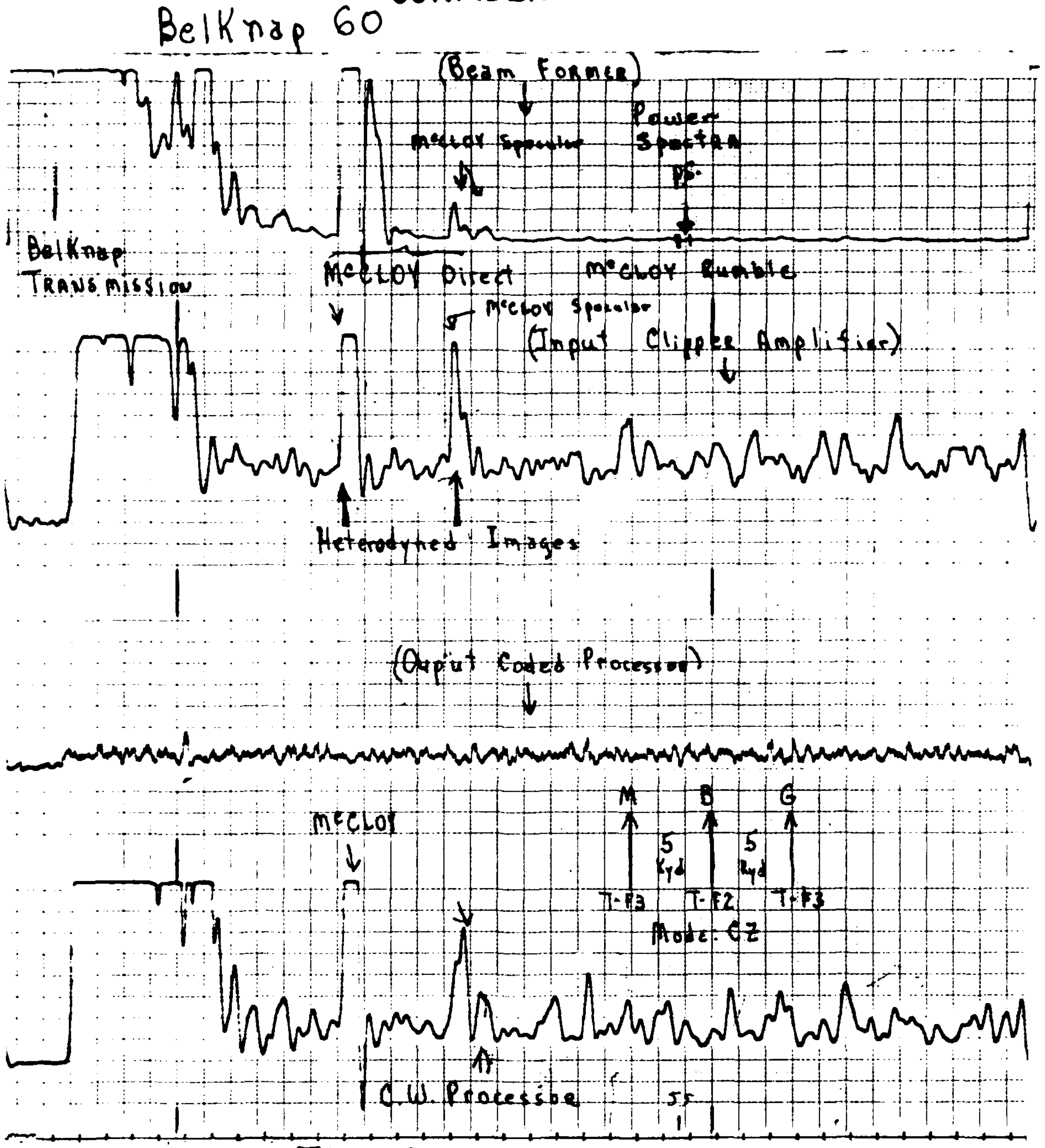

FIG. 4.2-12

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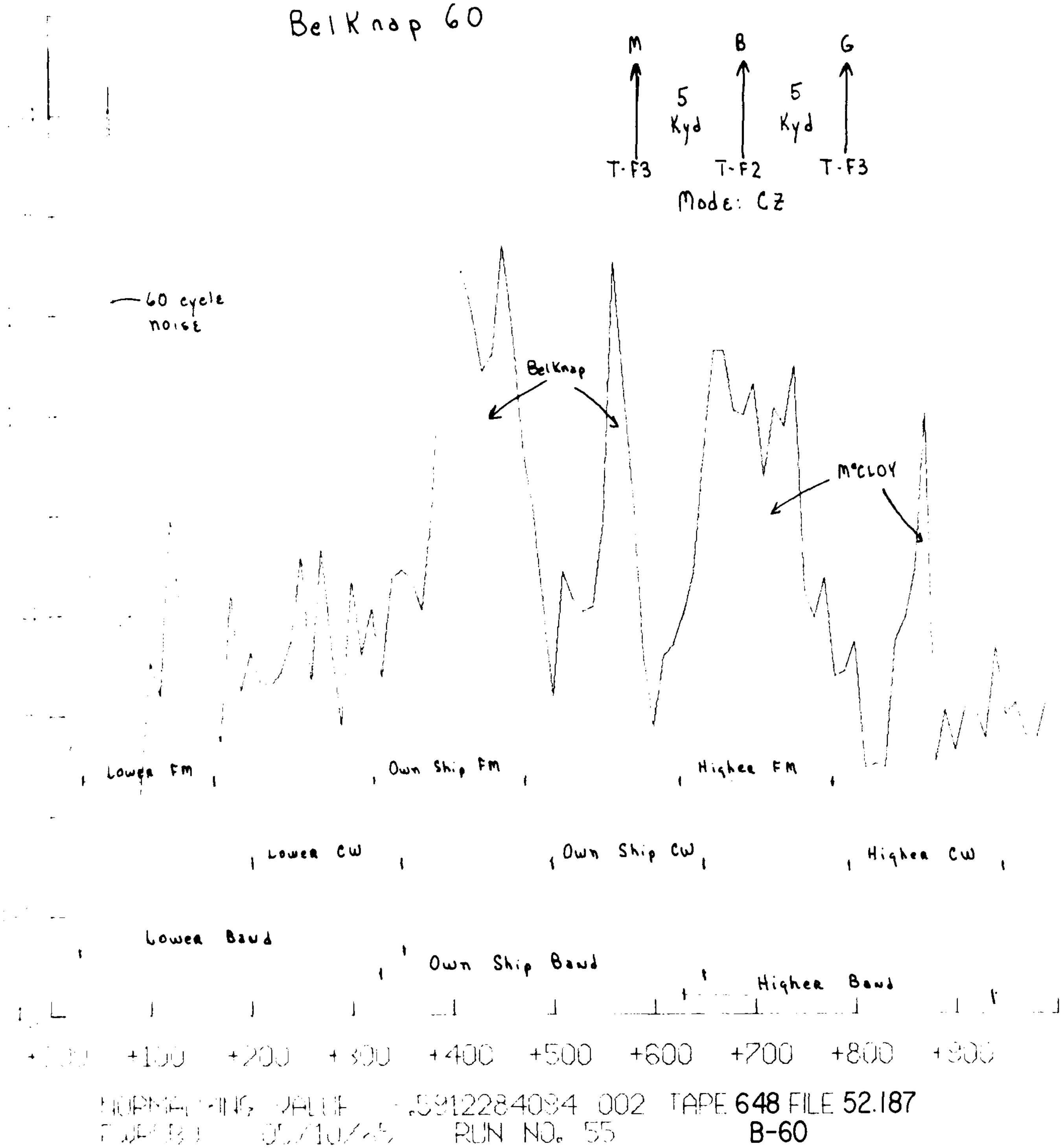
Belknap 60
M
B
G
5 Kyd
5 Kyd
T-F3
T-F2
T-F3
Mode: CZ
60 cycle noise
Belknap
McCLOY
Lower FM
Own Ship FM
Higher FM
Lower CW
Own Ship CW
Higher CW
Lower Band
Own Ship Band
Higher Band
+100
+200
+300
+400
+500
+600
+700
+800
TAPE 648 FILE 52.187
RUN NO. 55
B-60

FIG. 4.2-13

Belknap - 452

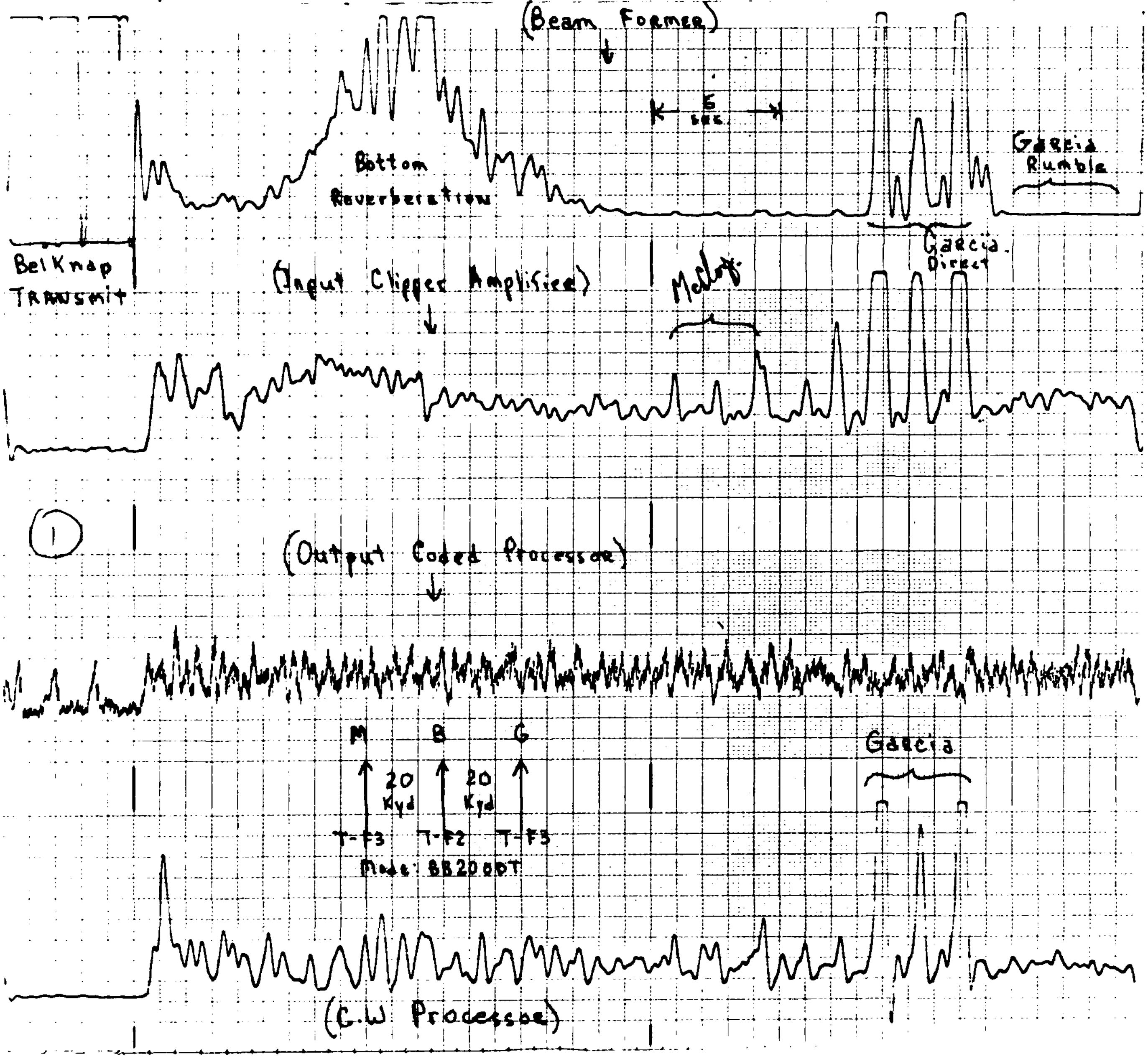

FIG. 4.2-14

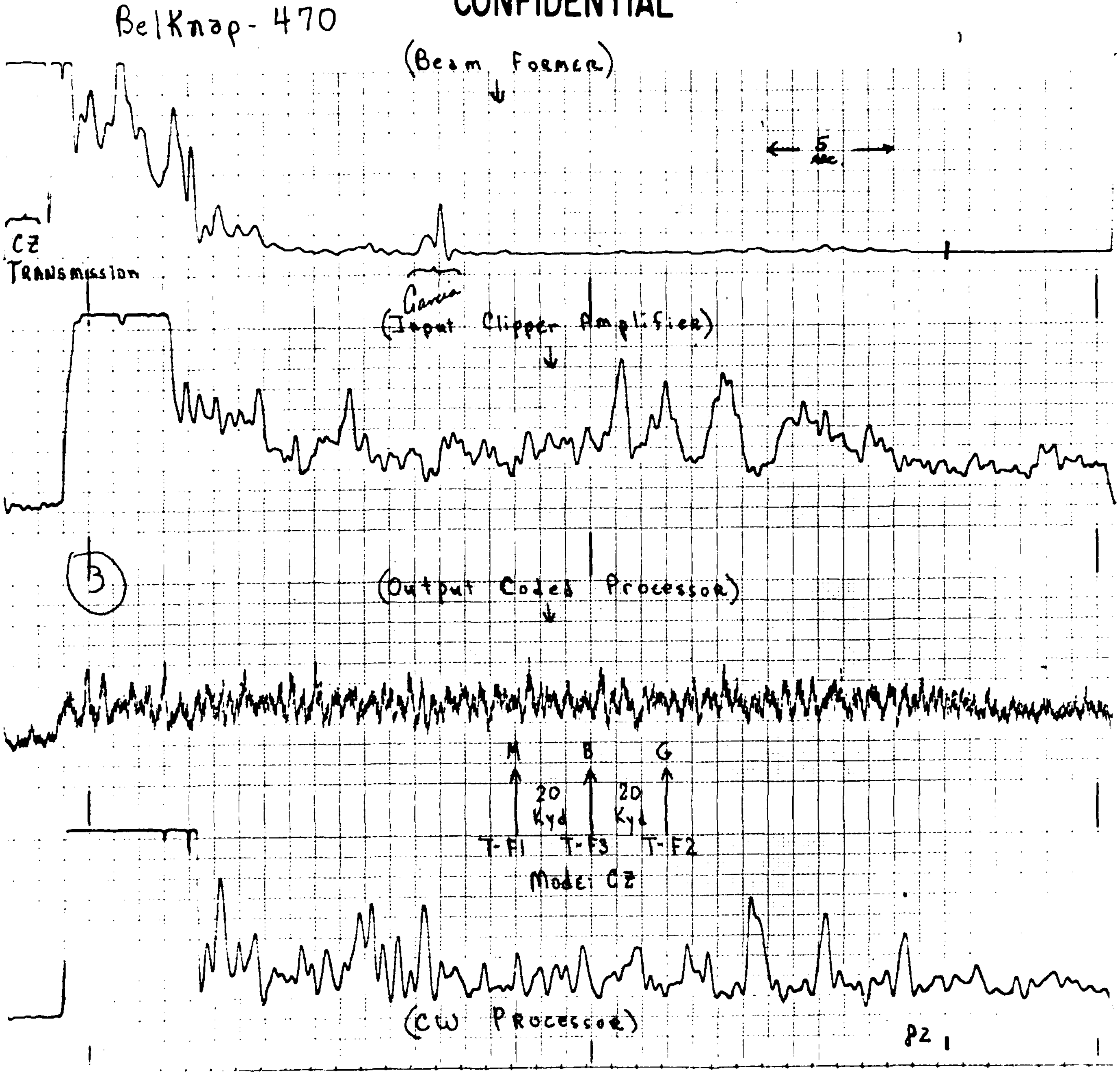

FIG. 4.2-15

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Type III geometry causes the largest amount of direct influence but a minor amount of rumble. In Type IV geometry, the direct influence is less severe but rumble can be a maximum, depending on actual geometry.

Figures 4.2-16 through 4.2-18 are Sanborn records and power spectra for Event G-146, with GARCIA at F2, BELKNAP at F3 and McCLOY at F1. The sonar mode is BB2ØODT with a ship separation of 5 kyds. Both type III and type IV geometries are illustrated. McCLOY's direct is pronounced even though at a distance of 10 kyds, with no rumble associated with McCLOY. BELKNAP, at a distance of 5 kyds, has produced large directs but also a very large level of rumble, as might be expected. The computed power spectrum indicates the BELKNAP rumble at about 24 dB above own ship reverberation (Fig. 4.2-18).

Similar effects are shown for McCLOY in Figs. 4.2-19 and 4.2-20, Event M-146. This is all type III geometry, with two ship separations. The extremely high levels, due to BELKNAP, produce outputs at the beamformer and clipper-amplifier input, even though BELKNAP is at F3.

Figures 4.2-21 and 4.2-22 illustrate Event G-182, with all ships in the CZ mode, at a range of 5 kyds. There is rumble due to BELKNAP but none due to McCLOY. Correlations due to McCLOY's transmission arise because McCLOY is at own frequency. An echo, due to a reflection from BELKNAP, is noted in both the CW and FM processor outputs.

Figures 4.2-23 and 4.2-24 are again similar examples, with ship separation of 20 kyds. This example is for Event B-578, BB2ØODT. Rumble effects due to GARCIA are noted as influencing the clipper-input channel. Power spectrum calculations indicate the rumble is 28 dB above own frequency CW reverberation. A possible false correlation against GARCIA's transmission is indicated but not explained.

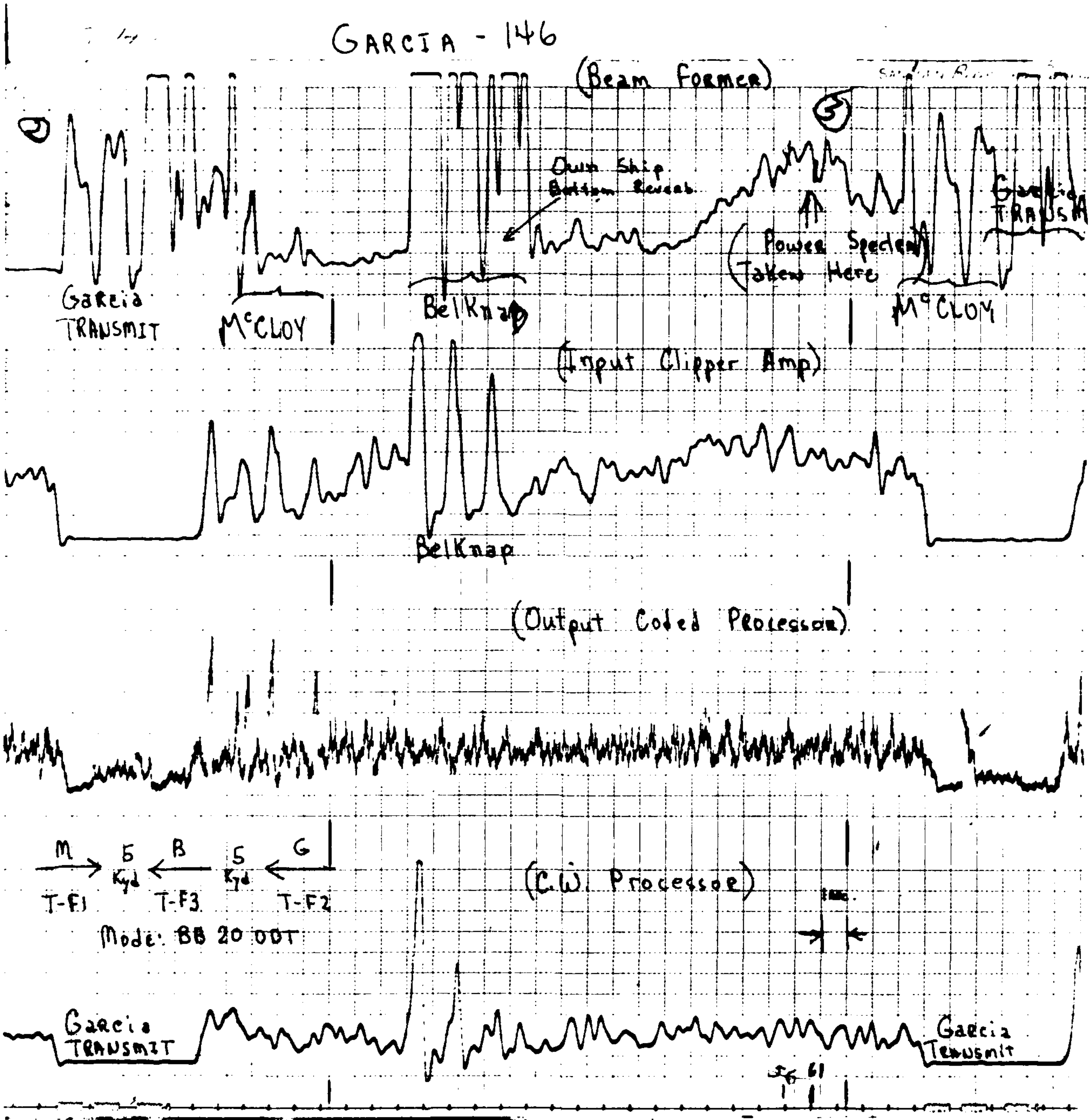

GARCIA - 146
(Beam Former)
Own Ship Bottom Reveal.
Power Spectra Taken Here
Garcia TRANSMIT
McCLOY
Belknap
McCLOY
Garcia TRANSMIT
(Input Clipper Amp)
Belknap
(Output Coded Processor)
(C.W. Processor)
M → 5 Kyd ← B 5 Kyd ← G
T-F1 T-F3 T-F2
Mode: BB 20 ODT
Garcia TRANSMIT
Garcia Transmit

FIG. 4.2-16

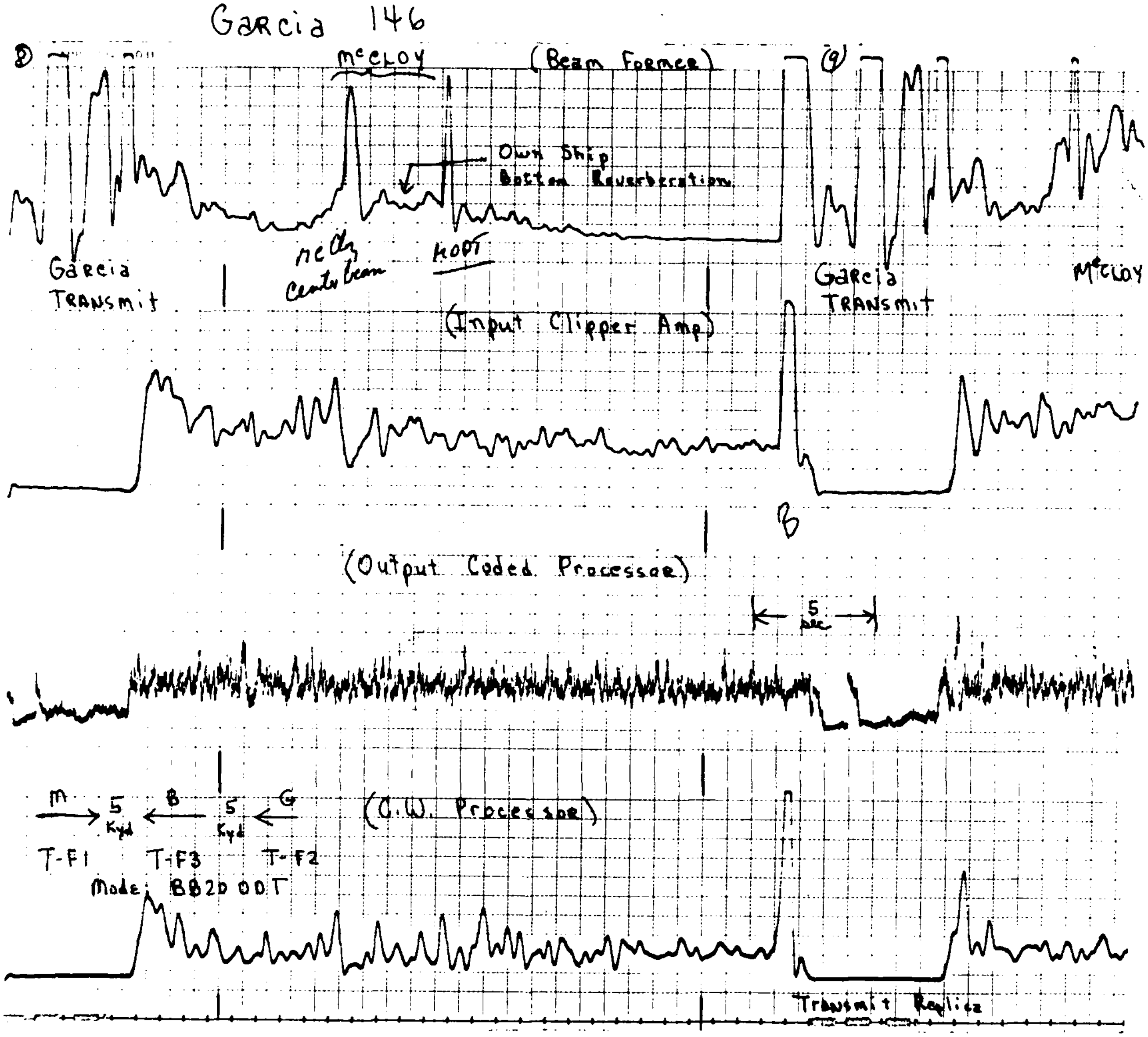
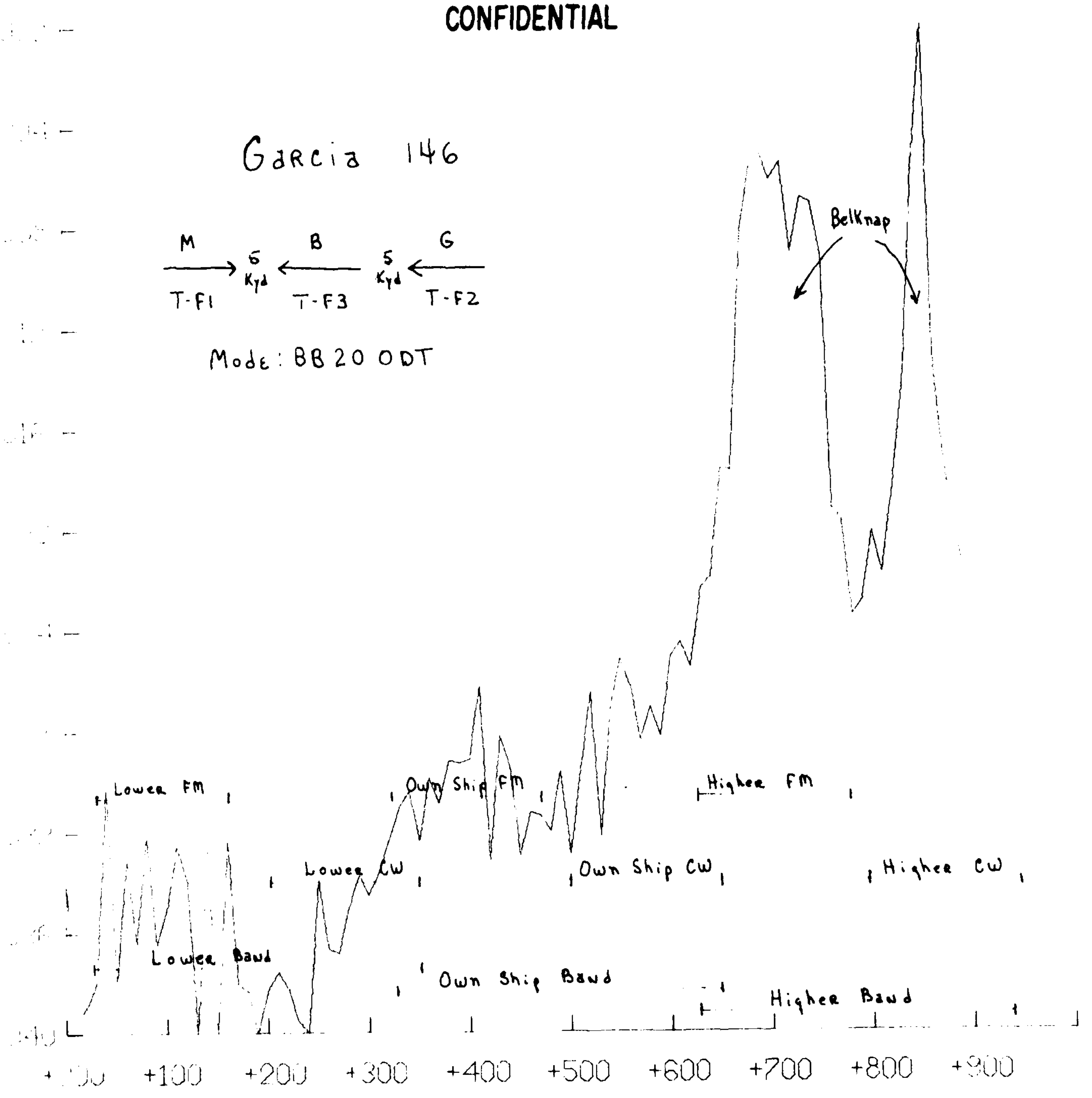

Garcia 146
McCLOY
(Beam Former)
Own Ship
Bottom Reverberation
Garcia
TRANSMIT
Garcia
TRANSMIT
McCLOY
(Input Clipper Amp)
(Output Coded Processor)
5 sec
(C.W. Processor)
M
5 Kyd
B
5 Kyd
G
T-F1
T-F3
T-F2
Mode: BB20 00T
Transmit Replica

FIG. 42-17



NORMALIZING VALUE -.2477520504 002 TAPE 671 FILE 107-195
FWRSBO 05/10/65 RUN NO. 61 G-146

FIG. 4.2-18

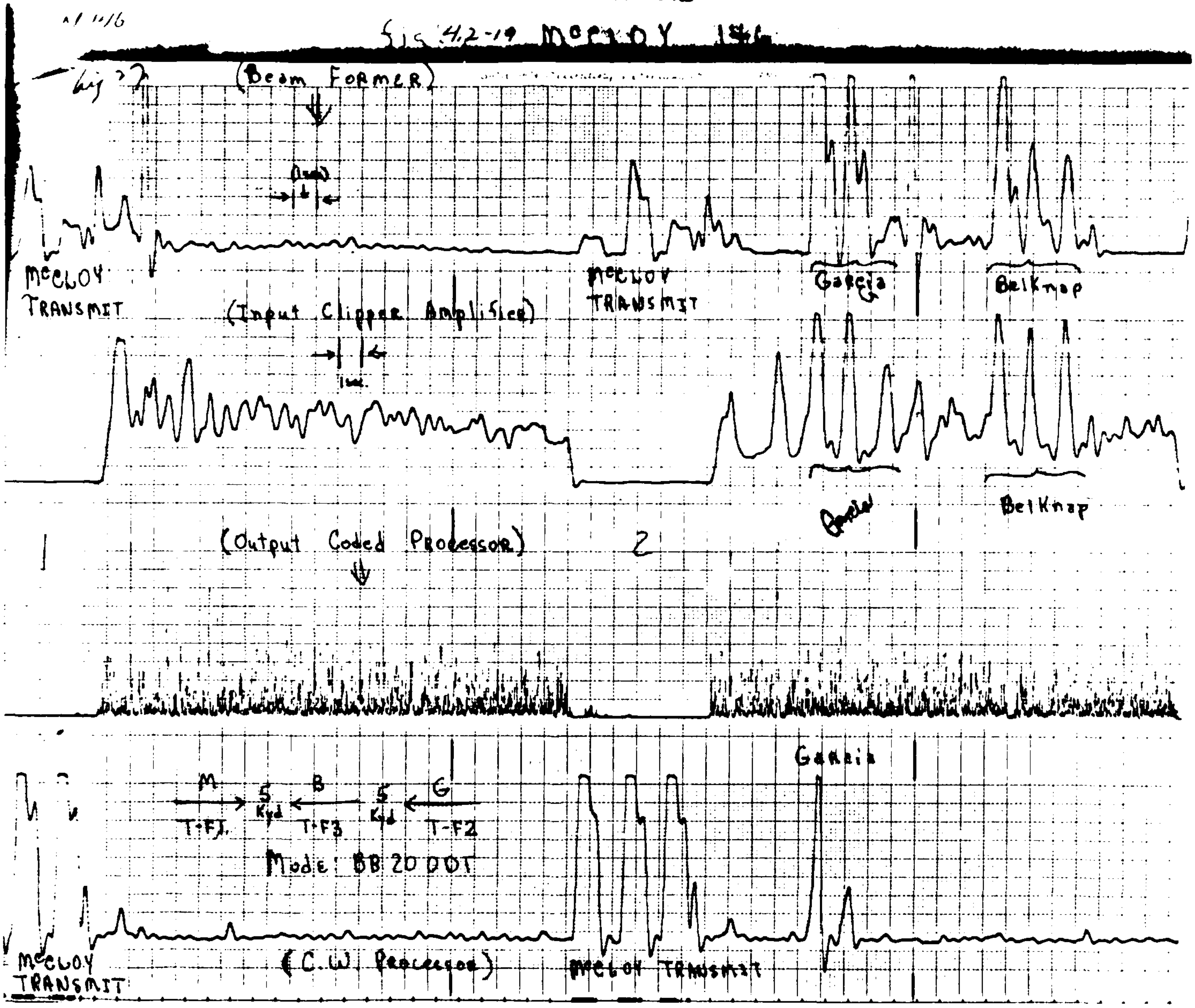


FIG. 4.2-19

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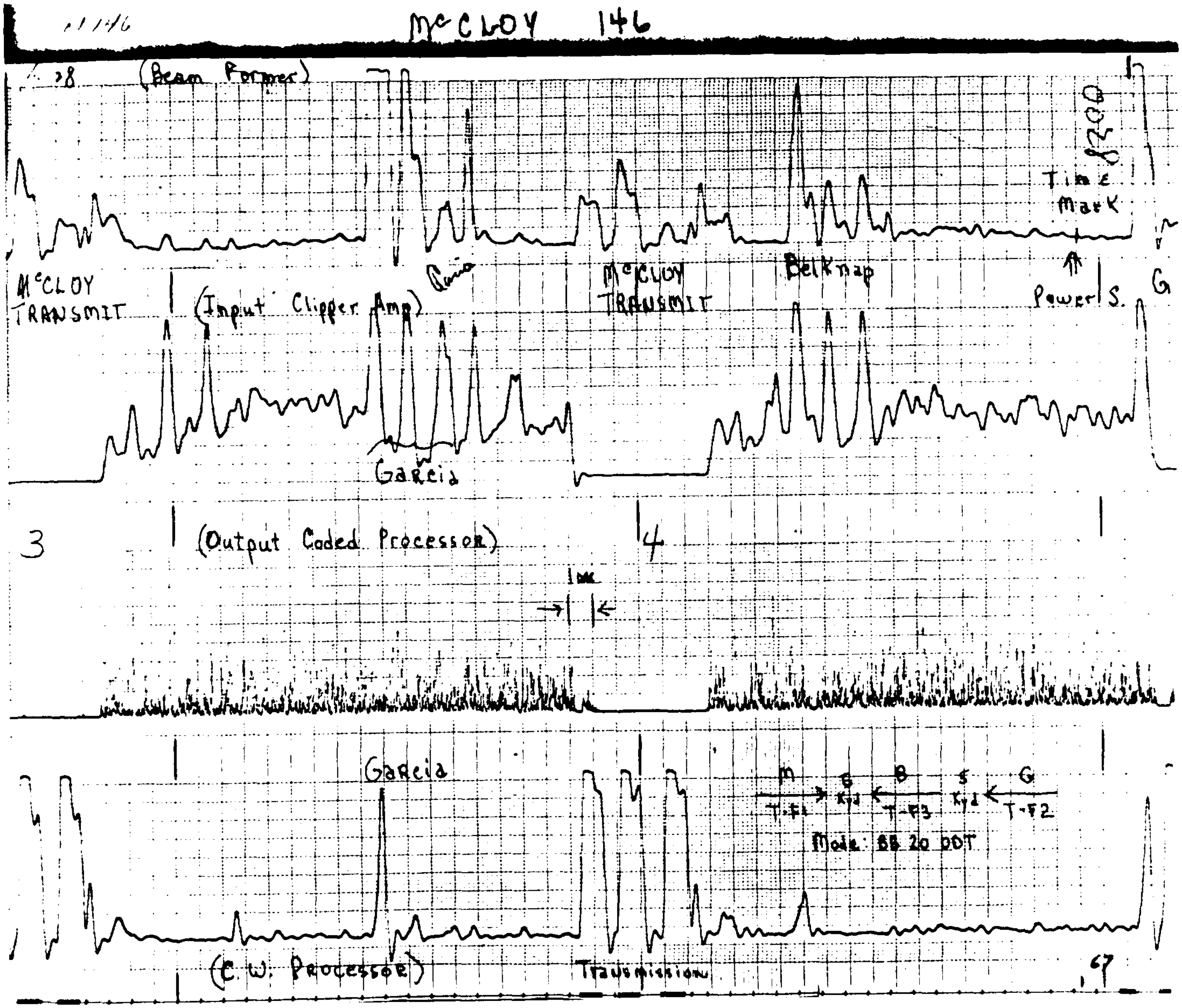

FIG. 4.2-20

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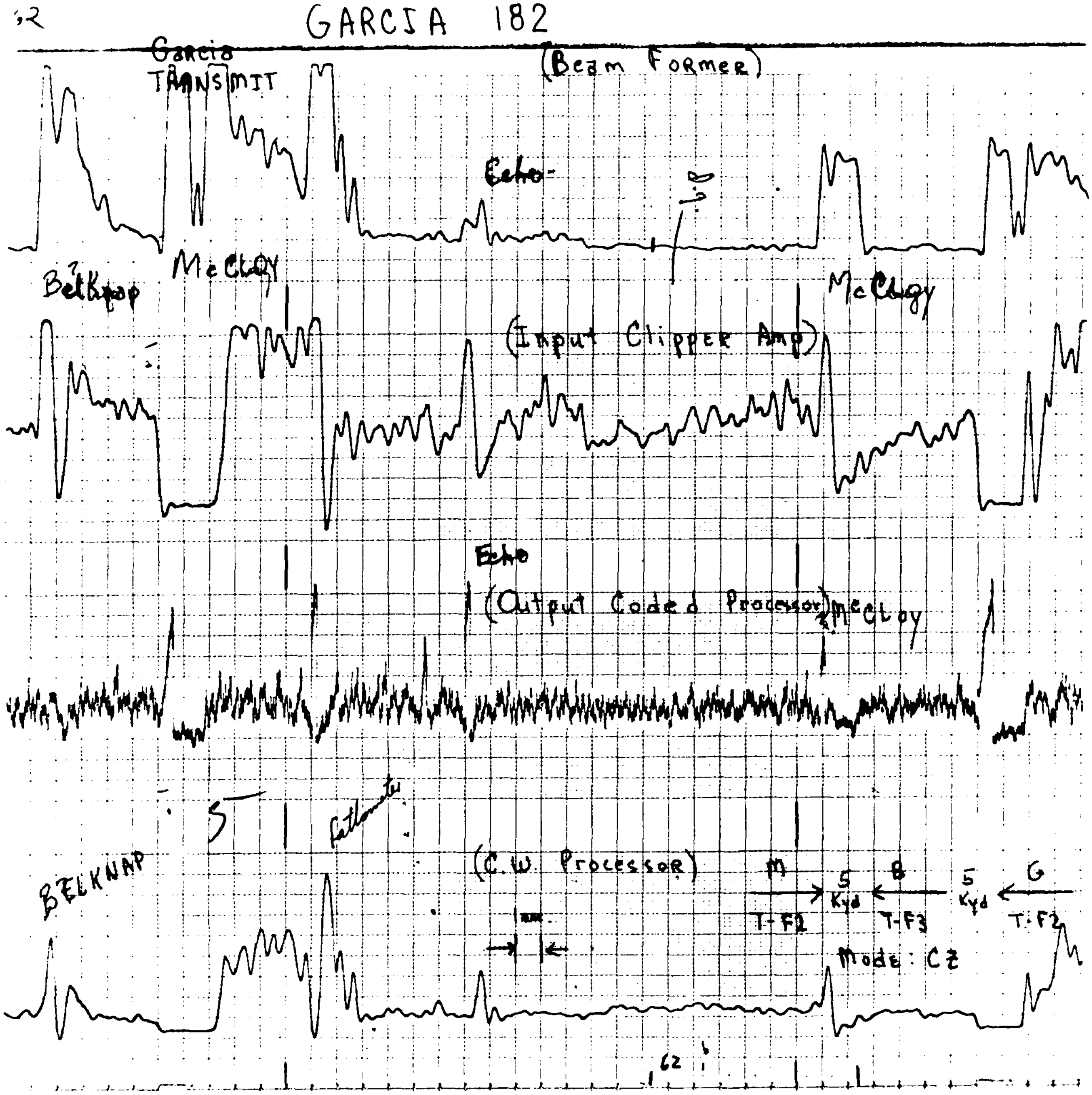

FIG. 42-21

TRACOR, INC. | DWG
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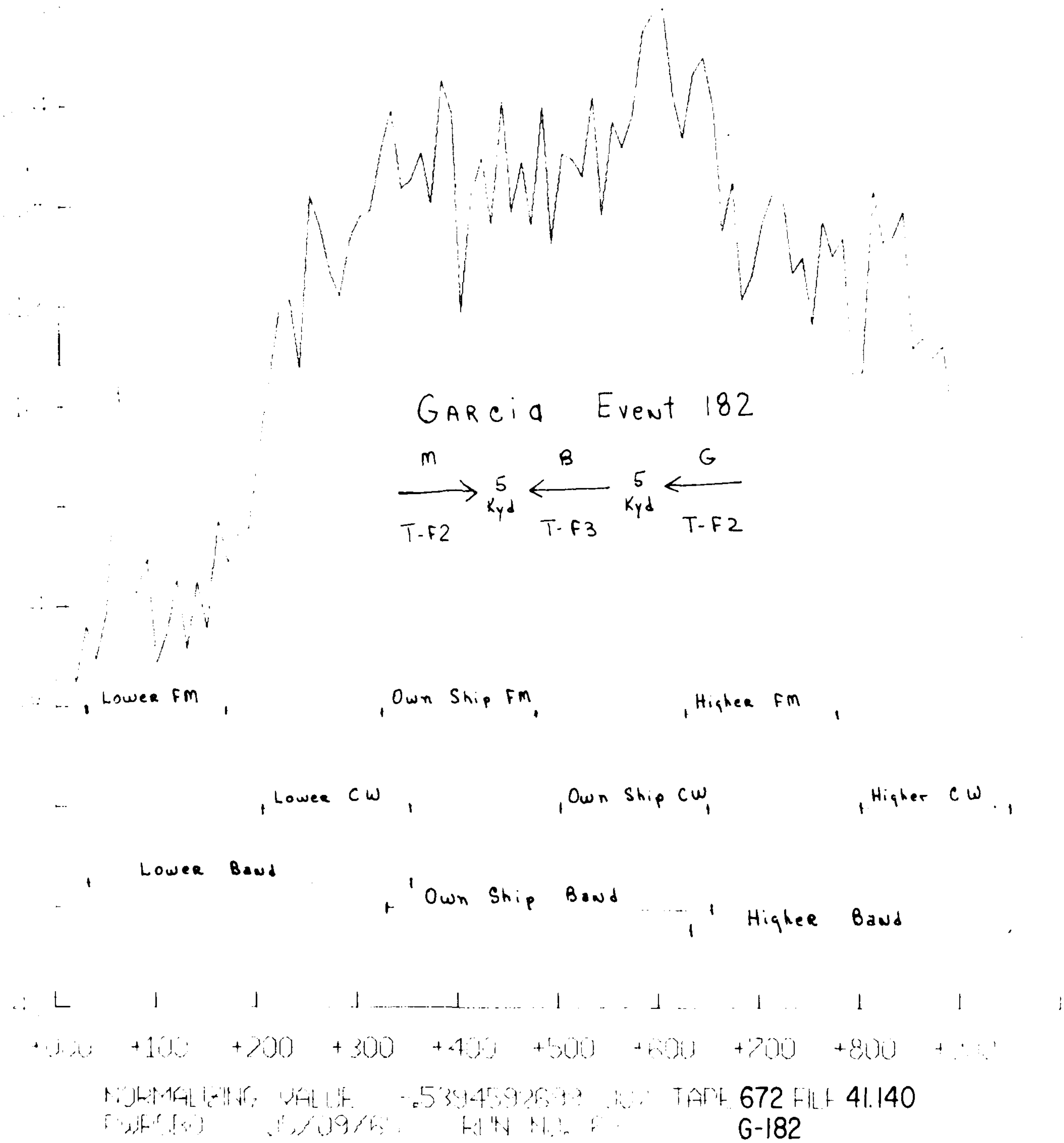

FIG. 4.2-22

TRACOR, INC DWG
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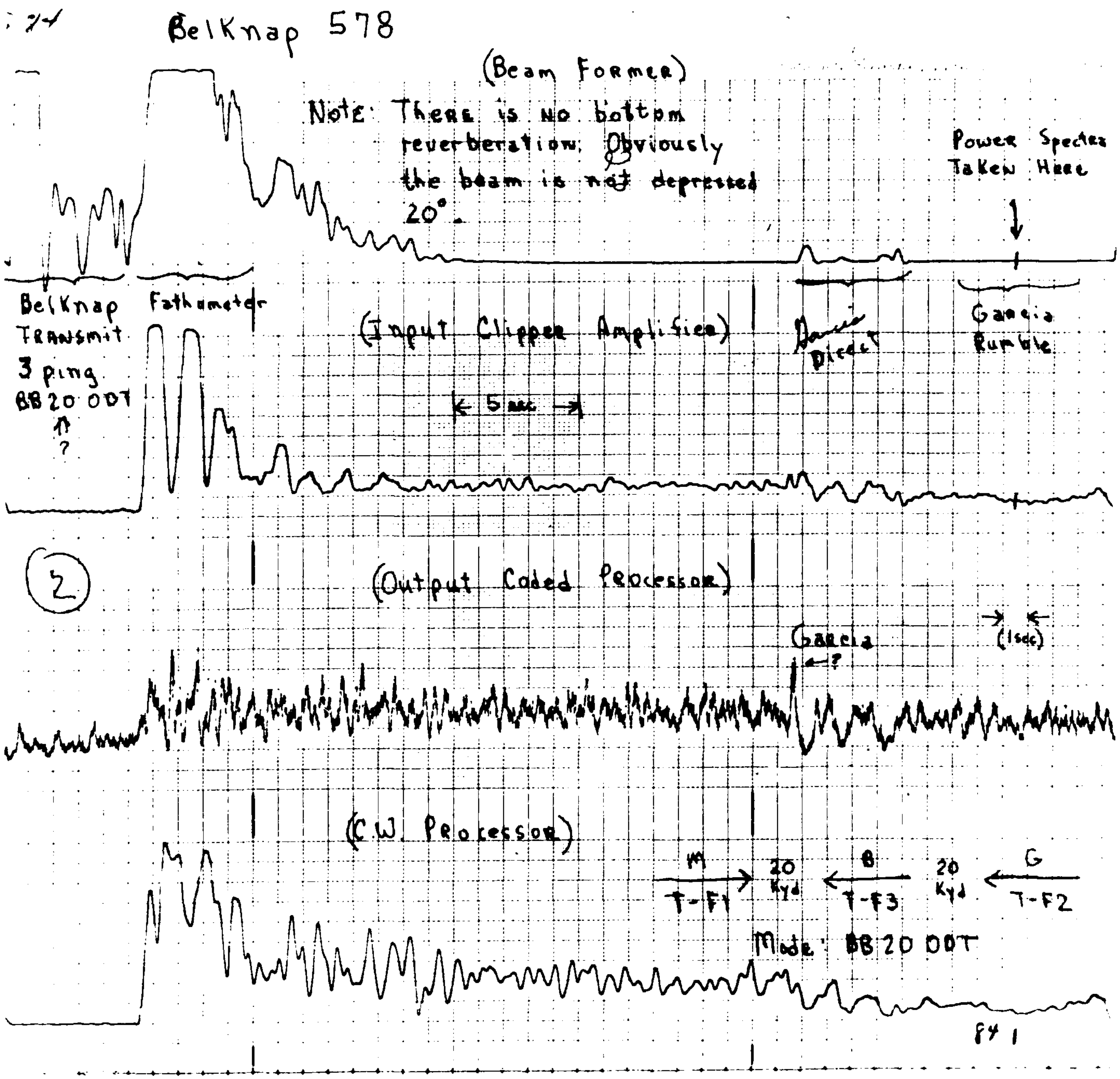

FIG. 4.2-23

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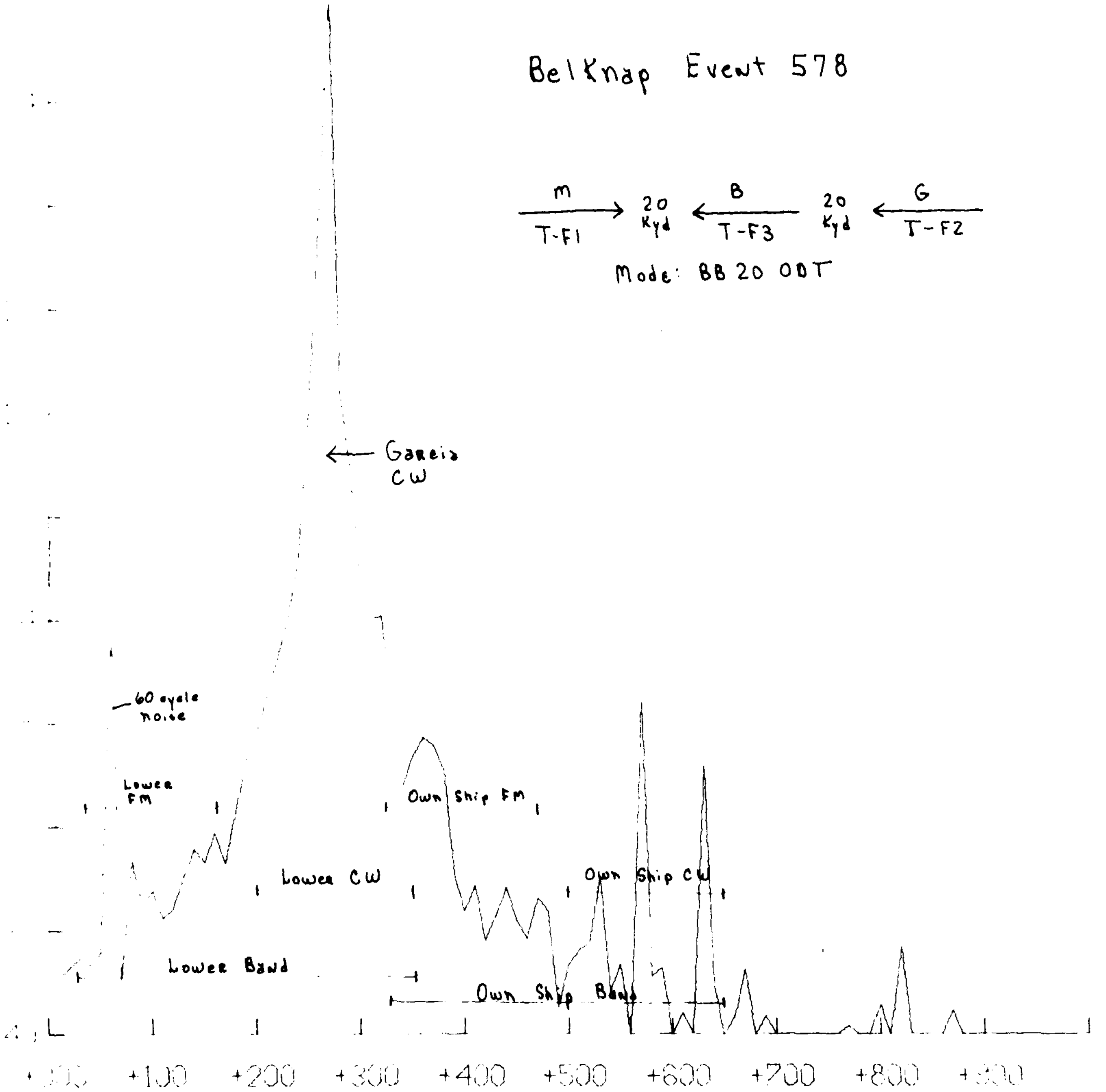

NORMALIZING VALUE .4180448254 002 TAPE 700 FILE 47-281
PWRERO 06/10/65 RUN NO. 84 B-578

FIG. 4.2-24

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Event G-614 was computed with McCLOY erroneously transmitting in BB2ØODT while the other sonars are in the CZ mode. The ships are separated by 20 kyds. These data are shown in Figs. 4.2-25 and 4.2-26, with McCLOY at F1, GARCIA at F2, and BELKNAP at F3. BELKNAP rumble is readily apparent, as expected, and McCLOY directs are noted with little or no rumble. Some unexplained correlations are also present in these data as with certain other examples.

These techniques are being used to aid in evaluating sonar performance in an influence field as well as helping to estimate expected AN/SQS-26 CX and AX(Retrofit) performance in similar influence fields.

4.3 Filter Characteristics at Output of Beam Former

The power spectrum shown in Fig. 4.2-22 is an approximate representation of the spectral bandpass of the sonar up to the output of the beam former. This power spectrum was taken in the echo region of a ping cycle in Event 182 (CZ mode-5kyd-GARCIA) during which both own ship's reverberation and influence were at very low levels. The principal energy component was wideband sea noise and hence the power spectrum of the beam former output under these conditions provides an approximate measure of the bandpass of the system up to the beamformer output. The response is down approximately 6 dB at the nominal CW frequency of the next lower band. The response at the nominal CW frequency for the next higher band is down only 2 dB and the FM frequency at the next higher band is not affected. This indicates a slightly broader bandwidth than expected on the basis of in-port measurements of either SQS-26 or SQS-26 AX sonars but is not unreasonable. Subsequent analysis may refine this measurement. The response at the upper limit of the FM frequency in the lower band is below the noise level in the recording system which is indicated at approximately - 26 dB from the maximum value.

Filter characteristics, as specified in the AN/SQS-26 AX

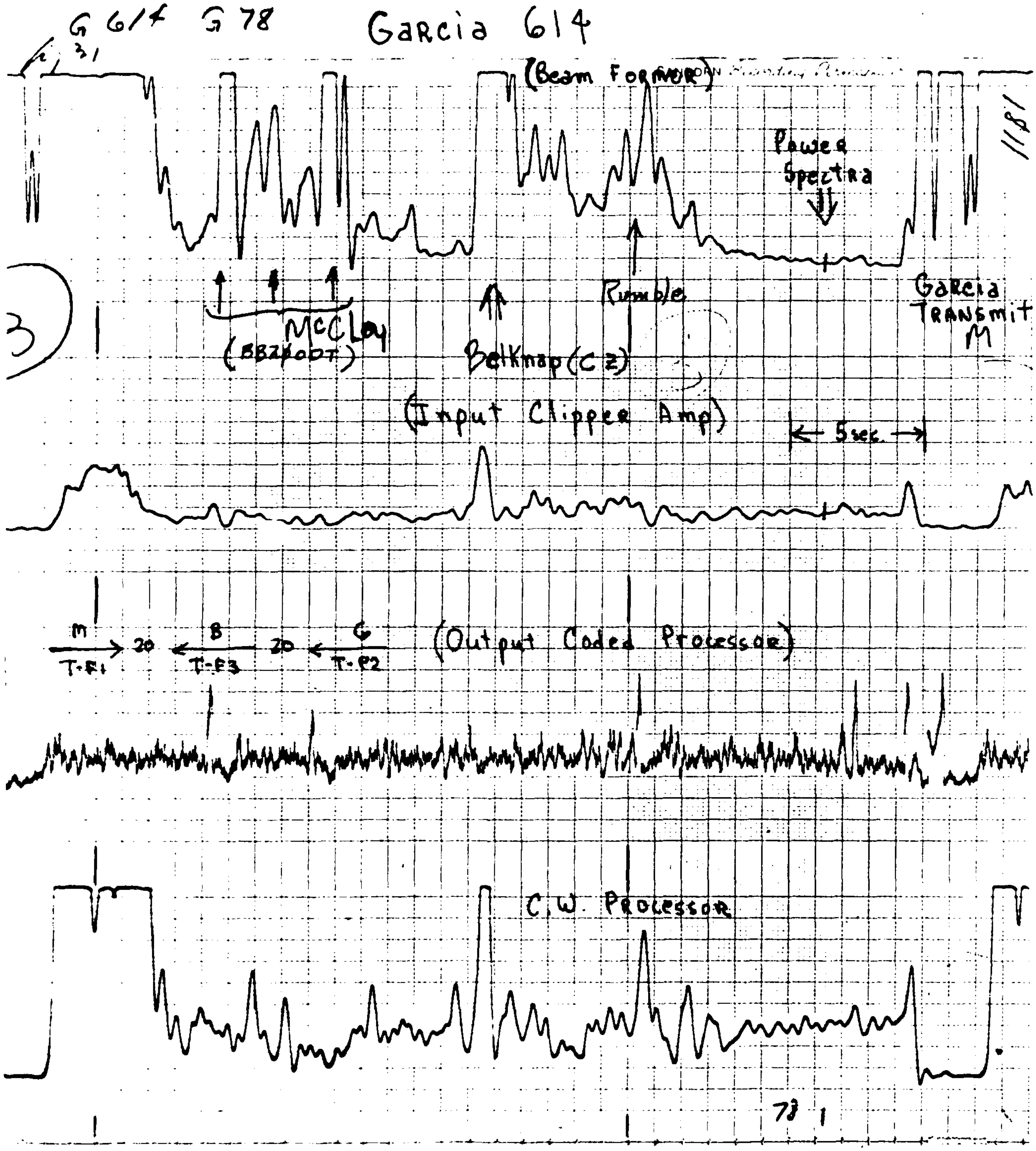

FIG. 4.2-25

TRACOR, INC. DWG.
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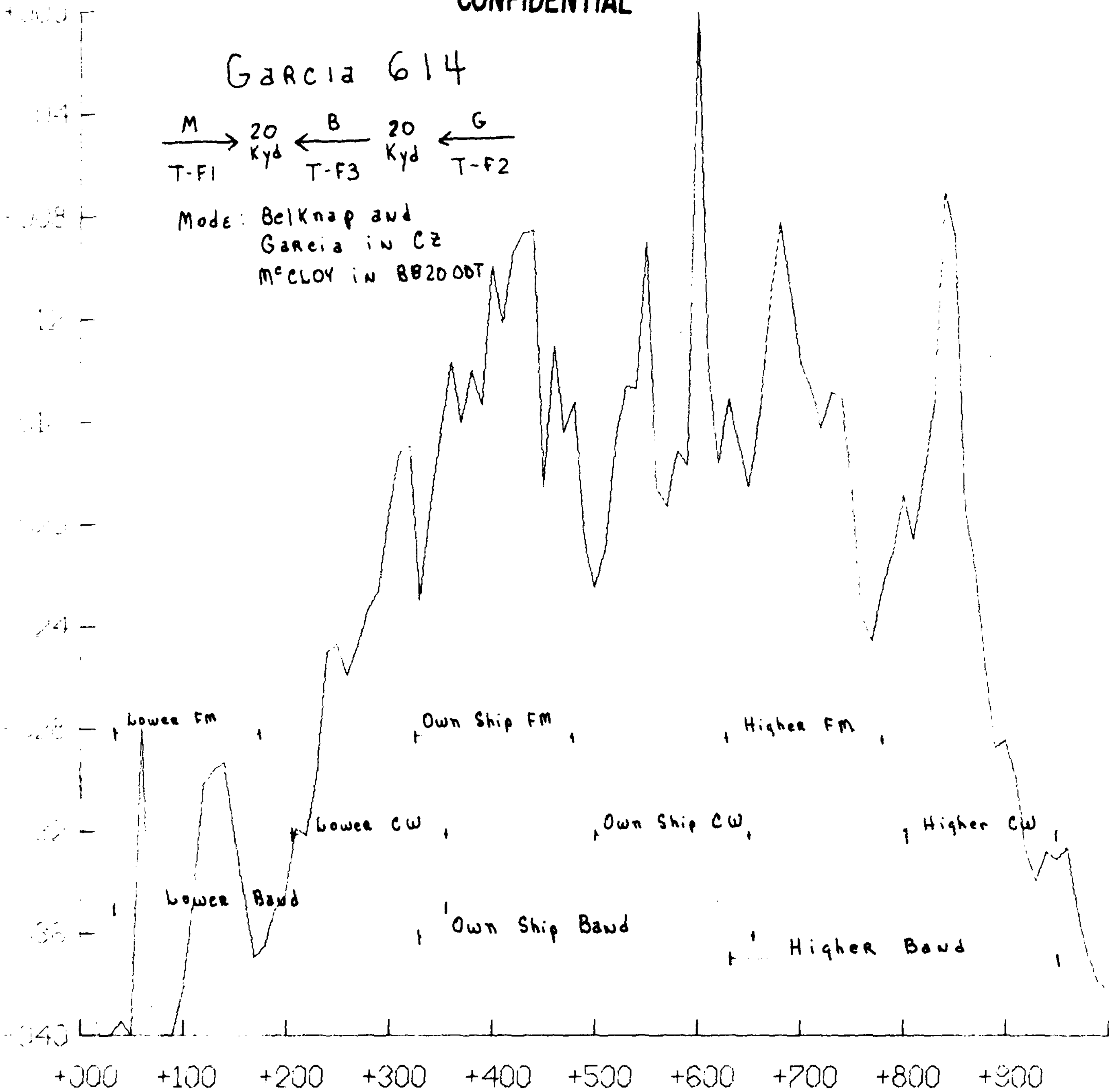

NORMALIZING VALUE .4002821967 002 TAPE 697 FILE 61-234
PWRSRO 06/10/65 RUN NO. 78 G614

FIG. 4.2-26

TRACOR, INC. DWG.
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for the vertical and horizontal beamformer modulator filters, have not yet been obtained.

4.4 ODT Pulse Differentiation

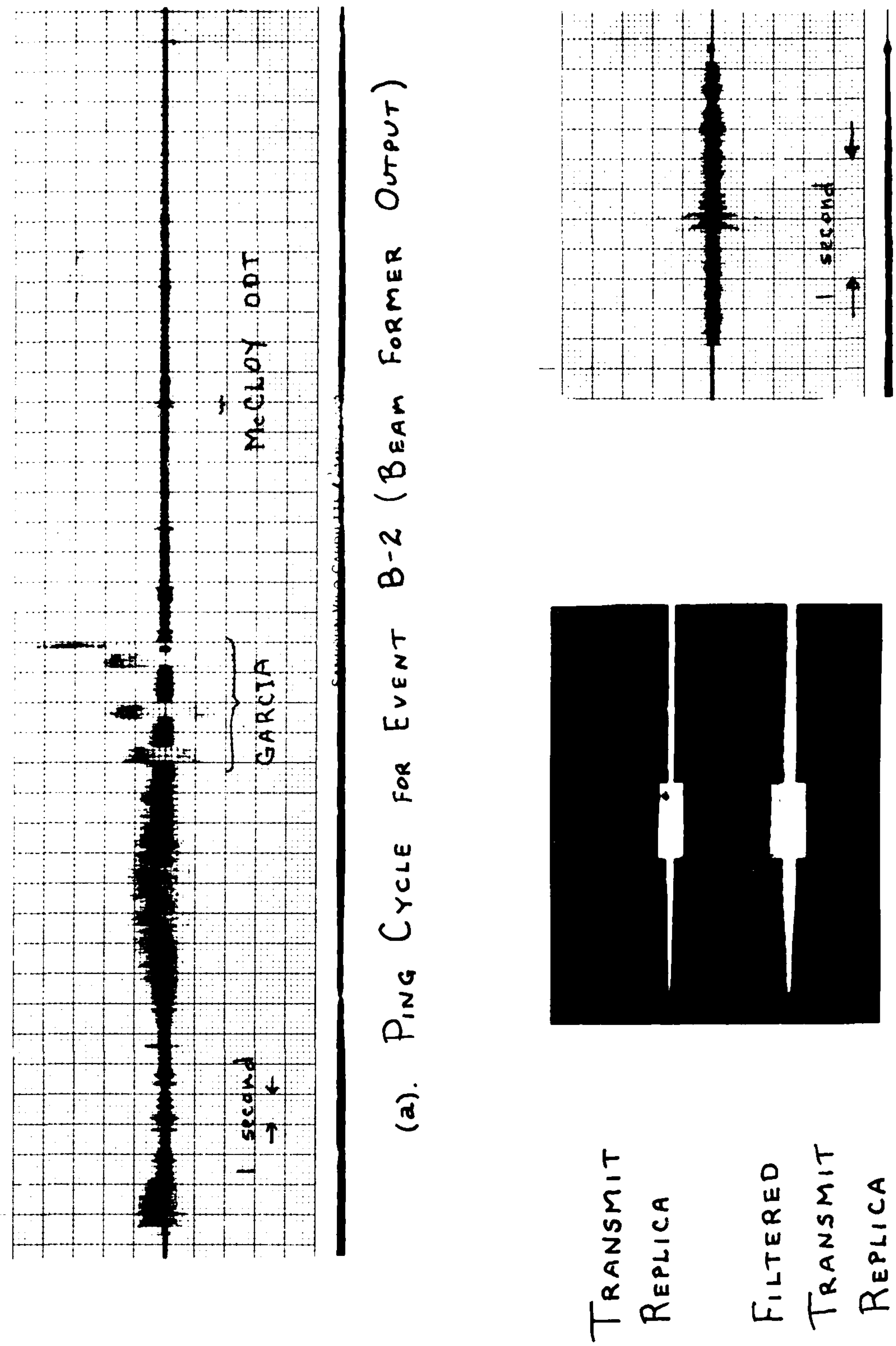
The phenomenon previously identified as "ODT Interference" in the first Preliminary Report (TRACOR Document Number 65-320-C, Section 5.3.1) has subsequently been investigated in greater detail and it has been determined that differentiation of the off frequency pulse may be the major effect.

Shown in Fig. 4.4-1(a) is a Sanborn strip chart on which is displayed a ping cycle from Event B-2. This display was produced from digitized data in which the output data rate was reduced to be compatible with the Sanborn recording mechanism. The digitized analog data were recorded at the output of the beamformer.

The influences from GARCIA and McCLOY are identified in the ping cycle. Comparison of the width of the ½ second CW pulses from GARCIA, and the GARCIA and McCLOY ODT pulses serves to confirm the identification as an ODT pulse of 100 ms duration.

Immediately below the full ping cycle display is a further time and level expanded display, Fig. 4.4-1(c) of the ODT pulse from McCLOY at F1, two frequency bands away. The level is significantly above the reverberation and noise only at the beginning and end of the pulse, a characteristic of pulse differentiation.

Further evidence that this is a characteristic of the filtered signal is shown in the reproduction of the oscillographs shown in Fig. 4.4-1(b). A replica of the sonar transmission recorded in BELKNAP was reproduced from magnetic tape, amplified, passed through a low pass filter having an attenuation slope of 96 dB per octave, and again amplified. Both the transmitted replica and the filtered signal were simultaneously displayed on an oscilloscope and photographed.



(a). PING CYCLE FOR EVENT B-2 (BEAM FORMER OUTPUT)

(b).

(c). McCLOY ODT (Expanded)

FIGURE 4.4-1

The higher level spikes at the beginning and end of the filtered signal are readily seen. These spikes are also present in the FM and CW transmissions. This observation indicates that higher frequency energy is present in the transmissions. In general, only the ODT transmissions are received at a sufficiently high level for this effect to be observed as interference but it has been observed for both FM and CW in the clipper amplifier channels and CW processor. This pulse differentiation effect is especially noticed when sonar beams are aligned toward each other.

4.5 DB Measurements

Six figures in this section show mutual influence while the sonar is in passive mode. These examples provide for accurate estimates of mutual influence without having to separate out own ship's reverberation. The relative levels of influence are measured in dB re 1 μbar as a function of real time. The output of the beamformer (beam 6) was rectified and averaged, and the output was converted to a dB level. Calibration data are given in the tables of section 4.1.

Figure 4.5-1 provides a measurement of sea noise (approximately -43 dB re 1 μbar) which can be used as a reference in the following figures to determine how much the influence is above sea noise. In Fig. 4.5-1 all ships were passive, but the cycling of GARCIA's transmitter affected the sea noise. Hence our measure of -43 dB was taken 25 seconds after the transmitter cycled.

Figure 4.5-2 illustrates influence at the same frequency, from 10 kyds away. It is interesting to note the difference in levels between the two consecutive McCLOY direct influences. The first directs are about 20 dB above sea noise while the second directs are only 10 dB above sea noise. Figure 4.5-3 displays extremely high direct and rumble levels caused by a medium frequency into a lower frequency band. The geometry is the same as in Fig. 4.5-2; GARCIA is still passive at F1, McCLOY is still transmitting at F1, but now BELKNAP is transmitting at F2. It

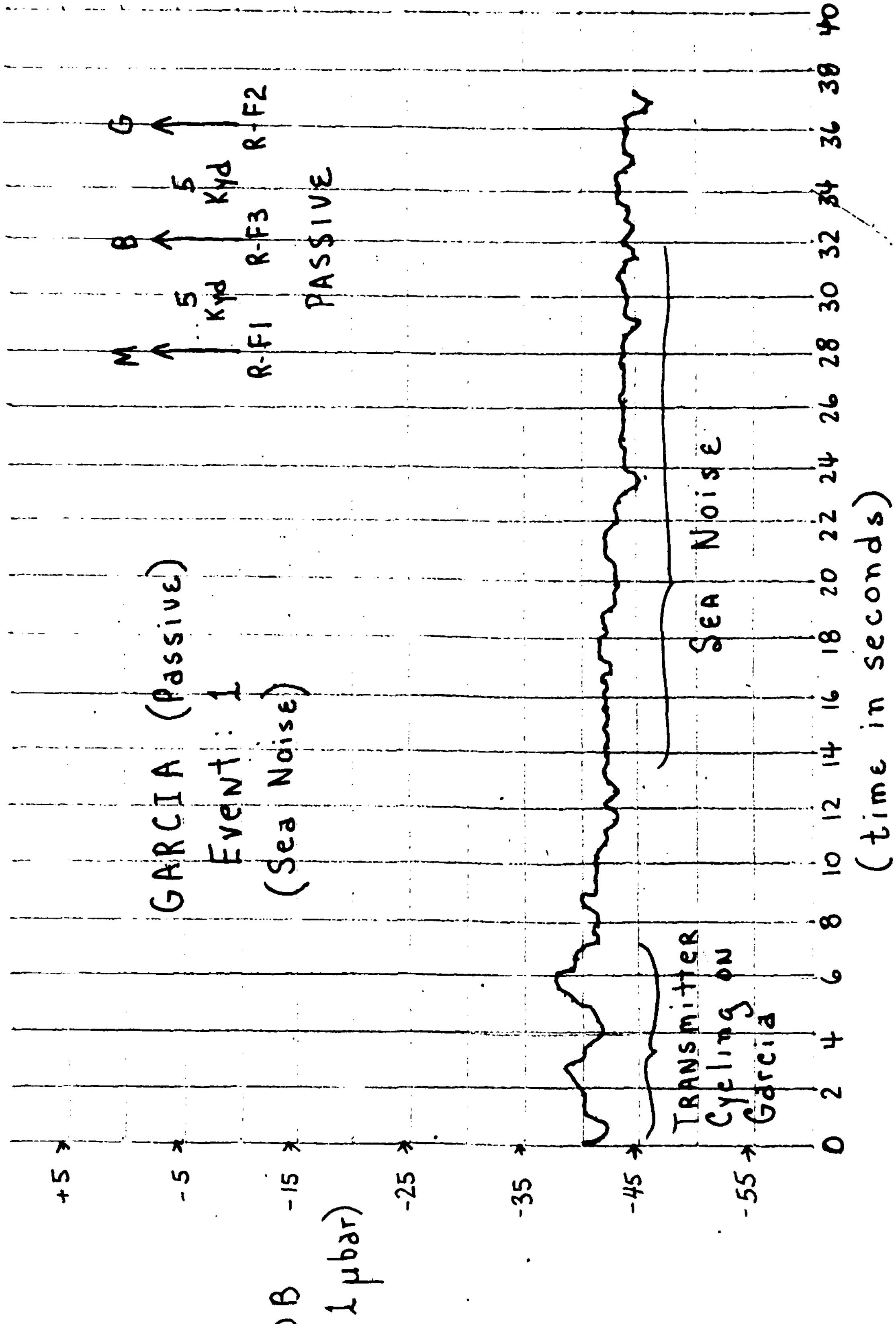

GARCIA (Passive)
Event: 1
(Sea Noise)
M
B
G
5
Kyd
5
Kyd
R-F1
R-F3
R-F2
PASSIVE
Sea Noise
Transmitter
Cycling on
Garcia
+5
-5
-15
-25
-35
-45
-55
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
(time in seconds)
DB
(re 1 µbar)

Figure 4.5-1

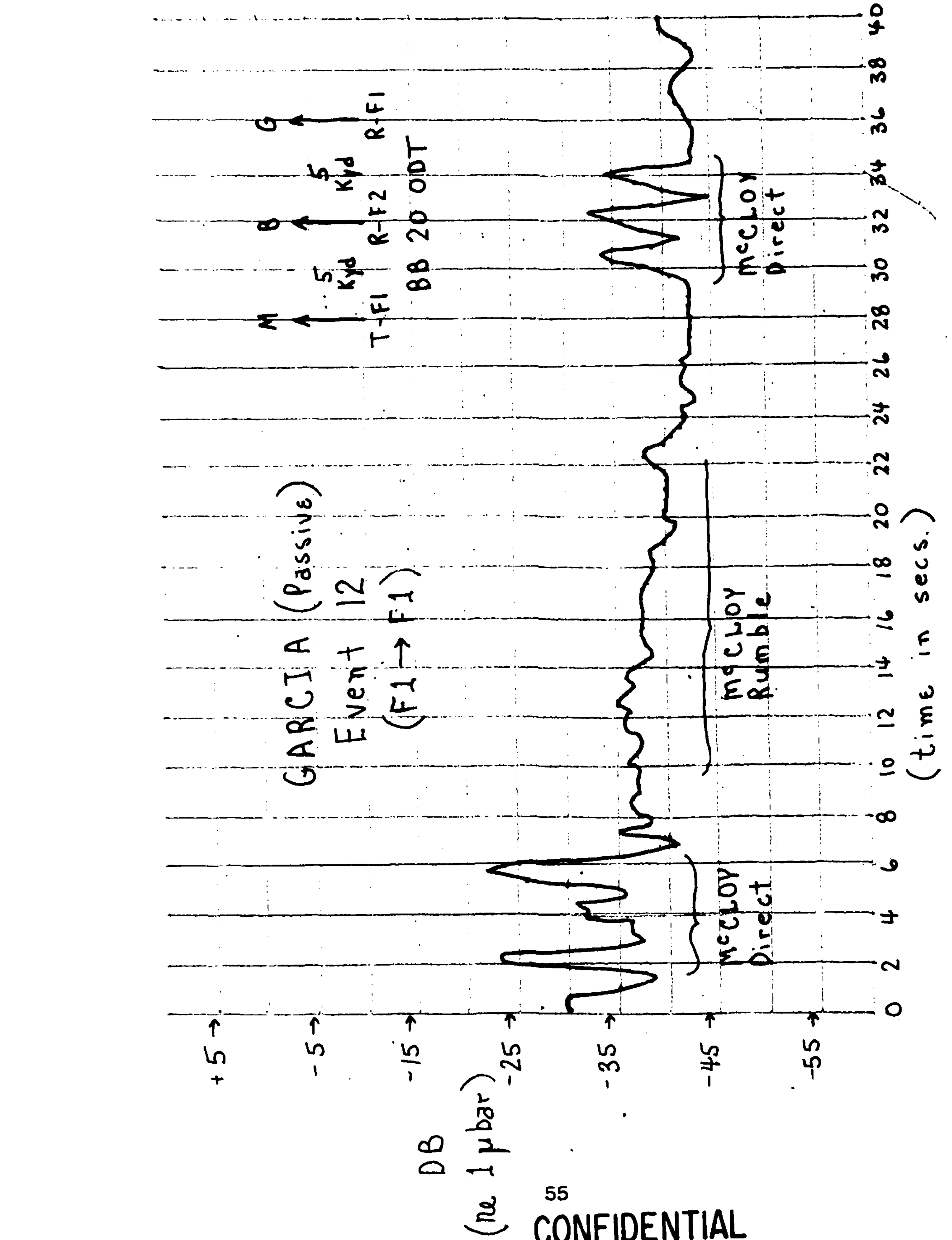

GARCIA (Passive)
Event 12
(F1 → F1)
M
T-F1
5 Kyd
B
R-F2
5 Kyd
G
R-F1
BB 20 ODT
McCLOY Direct
McCLOY Rumble
McCLOY Direct
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40
(time in secs.)
+5 → -5 → -15 → -25 → -35 → -45 → -55 →
DB (re 1 μbar)

Figure: 4.5-2

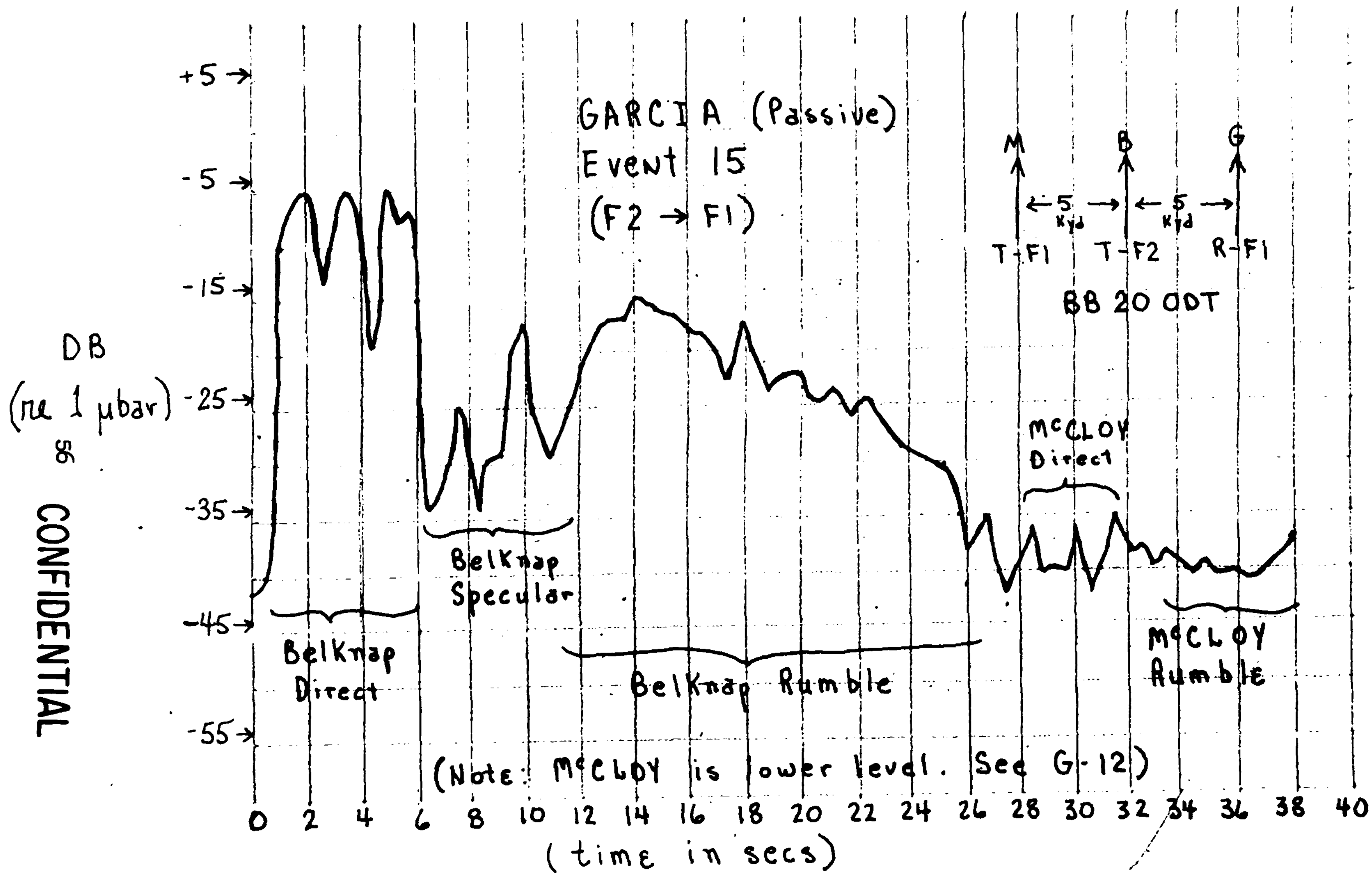

GARCIA (Passive)
Event 15
(F2 → F1)
M
B
G
← 5 Kyd →
← 5 Kyd →
T-F1
T-F2
R-F1
BB 20 ODT
DB
(re 1 μbar)
+5 →
-5 →
-15 →
-25 →
-35 →
-45 →
-55 →
Belknap Direct
Belknap Specular
Belknap Rumble
McCLOY Direct
McCLOY Rumble
(Note: McCLOY is lower level. See G-12)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
(time in secs)

Figure: 4.5-3

should be noted that the distance to BELKNAP is 5 kyd while the separation between McCLOY and GARCIA is 10 kyd. The direct influence from BELKNAP is 38 dB above sea noise and the rumble is as high as 28 dB above sea noise some 8 seconds after the last direct influence. It is difficult to distinguish McCLOY's influence, although McCLOY is at the same frequency.

Figure 4.5-4 is an example of a medium frequency into a high frequency in bottom bounce mode. The ODT influence is distinguishable and is 38 dB above the sea noise. In this example, rumble is as high as 10 dB above sea noise some 14 seconds after the direct influence.

Figures 4.5-5 and 4.5-6 illustrate influences in the CZ mode, and again measurements are taken from GARCIA while its sonar is in passive mode. Figure 4.5-5 pictures BELKNAP's influence at a higher frequency. It should be remembered that in the CZ mode there is one transmission of ½ sec FM followed by ½ sec CW whereas in bottom bounce there are three consecutive pings of ½ sec FM and ½ sec CW followed by an ODT. BELKNAP's direct is 28 dB above sea noise while its rumble reaches a level about 12 dB above sea noise. Figure 4.5-6 displays own frequency influence from a range of 10 kyd. Here the direct is 23 dB above sea noise and the rumble is as high as 15 dB above sea noise.

Since the primary interest of the sonarman is influence levels while his ship is transmitting, the next seven figures display relative levels of influence while own ship is transmitting. The relative levels of influence are measured in dB re 1 μbar as a function of time. On each figure, Sanborn Chart #1 displays a rectified and averaged output of the beamformer (beam 6), i.e., a plot of pressure vs time. Sanborn Chart #2 illustrates a frequency analysis of beam 6. Sanborn Chart #3 displays a dB plot of beam 6 as a function of time. Sanborn Chart #4 is the result of taking the difference in dB between a three ping average of an event without any mutual influence and one ping of

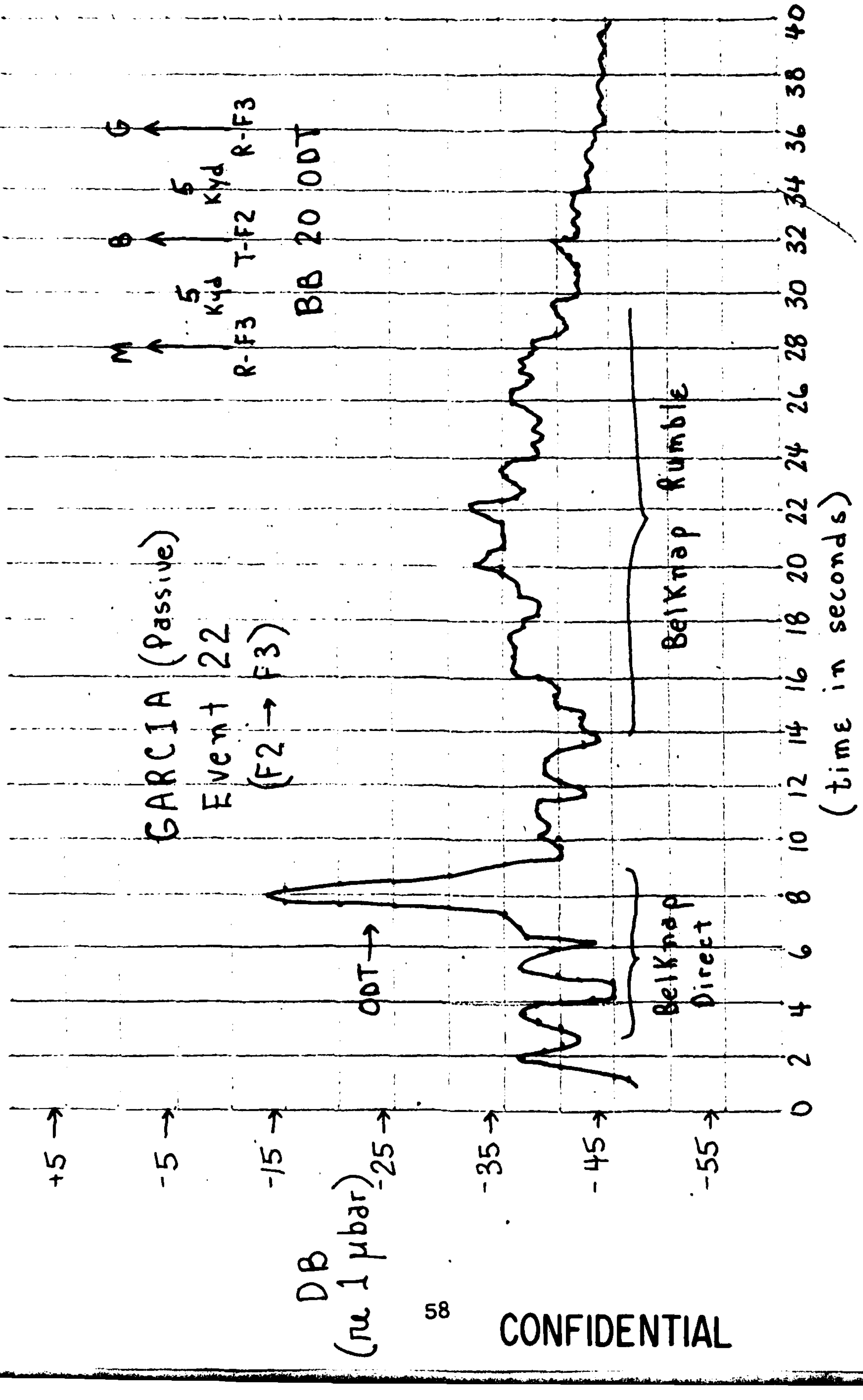

GARCIA (Passive)
Event 22
(F2 → F3)
M
R-F3
5 Kyd
B
T-F2
5 Kyd
G
R-F3
BB 20 ODT
ODT →
Belknap Direct
Belknap Rumble
+5 →
-5 →
-15 →
-25 →
-35 →
-45 →
-55 →
DB
(re 1 μbar)
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40
(time in seconds)

Figure: 4.5-4

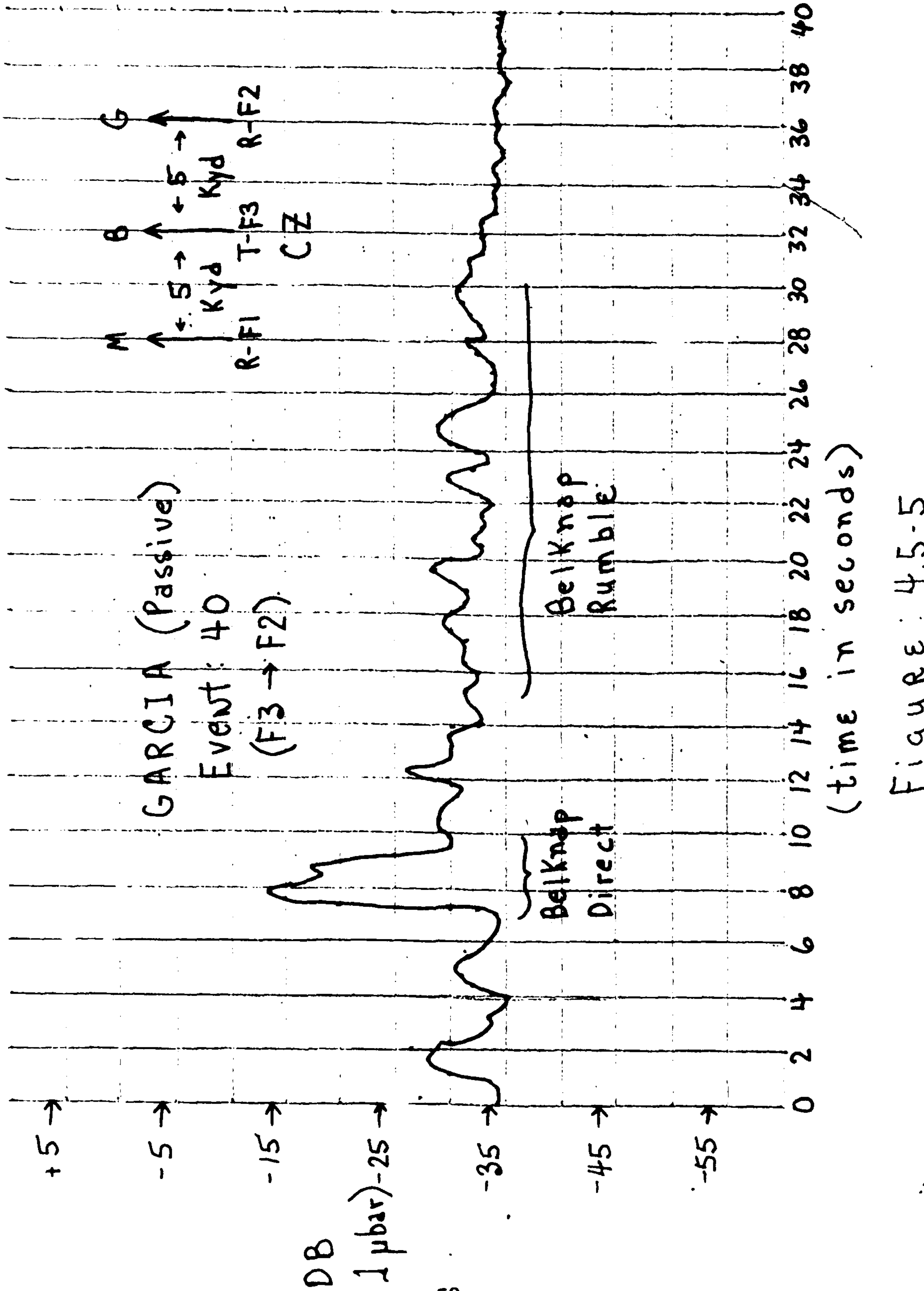

GARCIA (Passive)
Event 40
(F3 → F2)
M
B
G
R-F1
← 5 →
Kyd
T-F3
CZ
← 5 →
Kyd
R-F2
Belknap Direct
Belknap Rumble
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40
(time in seconds)
+5
-5
-15
-25
-35
-45
-55
DB
(re 1 μbar)

Figure 4.5-5

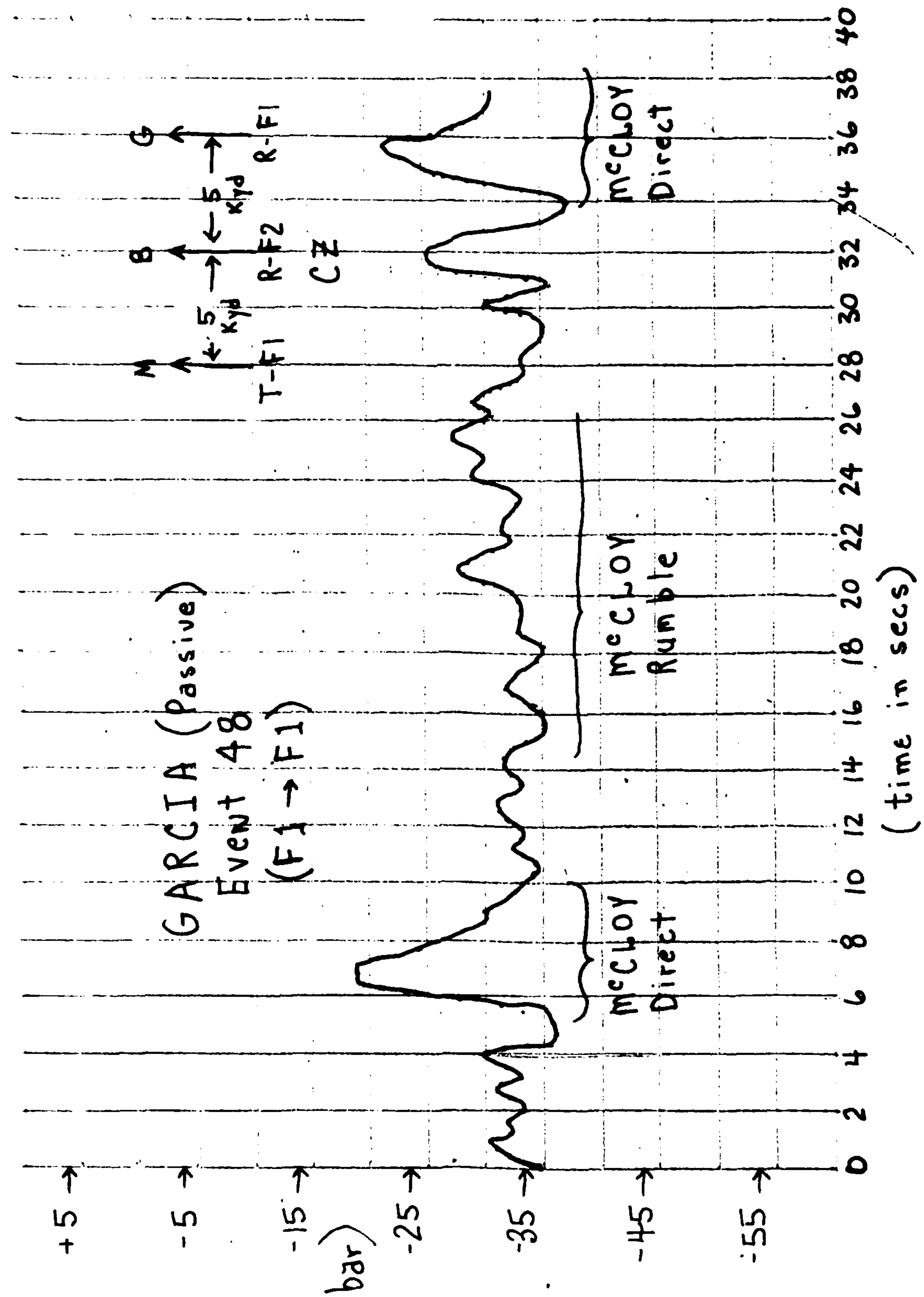

GARCIA (Passive)
Event 48
(F1 → F1)
McCLOY Direct
McCLOY Rumble
McCLOY Direct
M
B
G
T-F1
R-F2
R-F1
CZ
← 5 Kyd →
← 5 Kyd →
(time in secs)
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40
+5 → -5 → -15 → -25 → -35 → -45 → -55 →
DB (re 1 μbar)

Figure 4.5-6

another event with the exact same conditions, but with mutual influence present. The three ping average mentioned here was displayed in the first preliminary report, TRACOR Document Number 65-320-C. As mentioned above, all four displays are a function of time, with time beginning at the end of the transmission cycle.

Figures 4.5-7 to 4.5-9 show mutual influence while own ship is in CZ mode. Figure 4.5-7 does not show any direct influence and the level of rumble is low. This can be seen on Sanborn Chart #4 since the difference in dB oscillates about -5 dB. The reason McCLOY's transmission cycles are shorter than the other ship's was to insure that mutual influence would occur in different positions of the reverberation cycle throughout the test.

Figure 4.5-8 illustrates influence from BELKNAP which is at a higher frequency. The direct influence is 20 dB above own ship reverberation while the rumble holds on at about 5 dB above the reverberation level. Figure 4.5-9 displays a high and a medium into a medium frequency. Both interfering ships are 5 kyd away. Before these comparisons are made, it should be noted that McCLOY's source level was consistently 5 to 10 dB below the source levels of the other ships. The rumble from the higher frequency averaged about 4 dB above the reverberation level when BELKNAP was the only ship transmitting as in Event 58. The rumble from GARCIA, which was on BELKNAP's frequency, was about 10 dB.

Figures 4.5-10 and 4.5-11 illustrate mutual influence in the bottom bounce mode. Figure 4.5-10 pictures a medium into a high frequency. The directs are about 15 dB above the reverberation level while rumble raises the noise level about 8 dB. In Fig. 4.5-11, the opposite frequency effect is indicated but with a separation distance between influencing ships of 10 kyds rather than 5 kyds. GARCIA's direct raises the noise level 5 to 10 dB while the rumble ranges from 1 to 3 dB.

Figures 4.5-12 and 4.5-13 also illustrate mutual influence in the bottom bounce mode. It is interesting to note the extreme

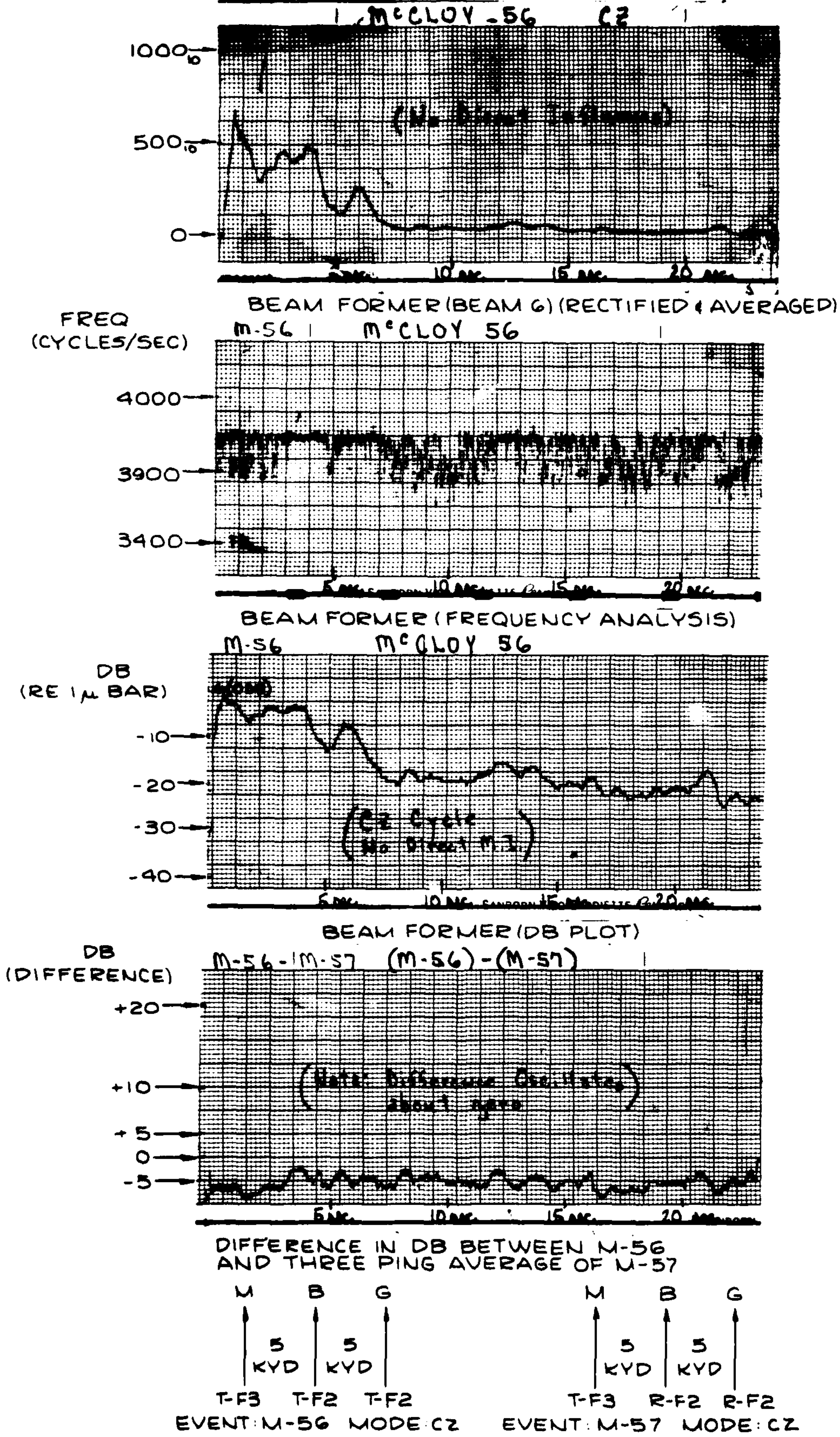

McCLOY-56 CZ
1000
500
0
5 SEC.
10 SEC.
15 SEC.
20 SEC.
BEAM FORMER (BEAM 6) (RECTIFIED & AVERAGED)
FREQ (CYCLES/SEC)
M-56
McCLOY 56
4000
3900
3400
BEAM FORMER (FREQUENCY ANALYSIS)
DB (RE 1 μ BAR)
M-56
McCLOY 56
-10
-20
-30
-40
BEAM FORMER (DB PLOT)
DB (DIFFERENCE)
M-56-M-57
(M-56)-(M-57)
+20
+10
+5
0
-5
DIFFERENCE IN DB BETWEEN M-56 AND THREE PING AVERAGE OF M-57
M
B
G
5 KYD
5 KYD
T-F3
T-F2
T-F2
EVENT: M-56 MODE: CZ
M
B
G
5 KYD
5 KYD
T-F3
R-F2
R-F2
EVENT: M-57 MODE: CZ

FIG. 4.5-7

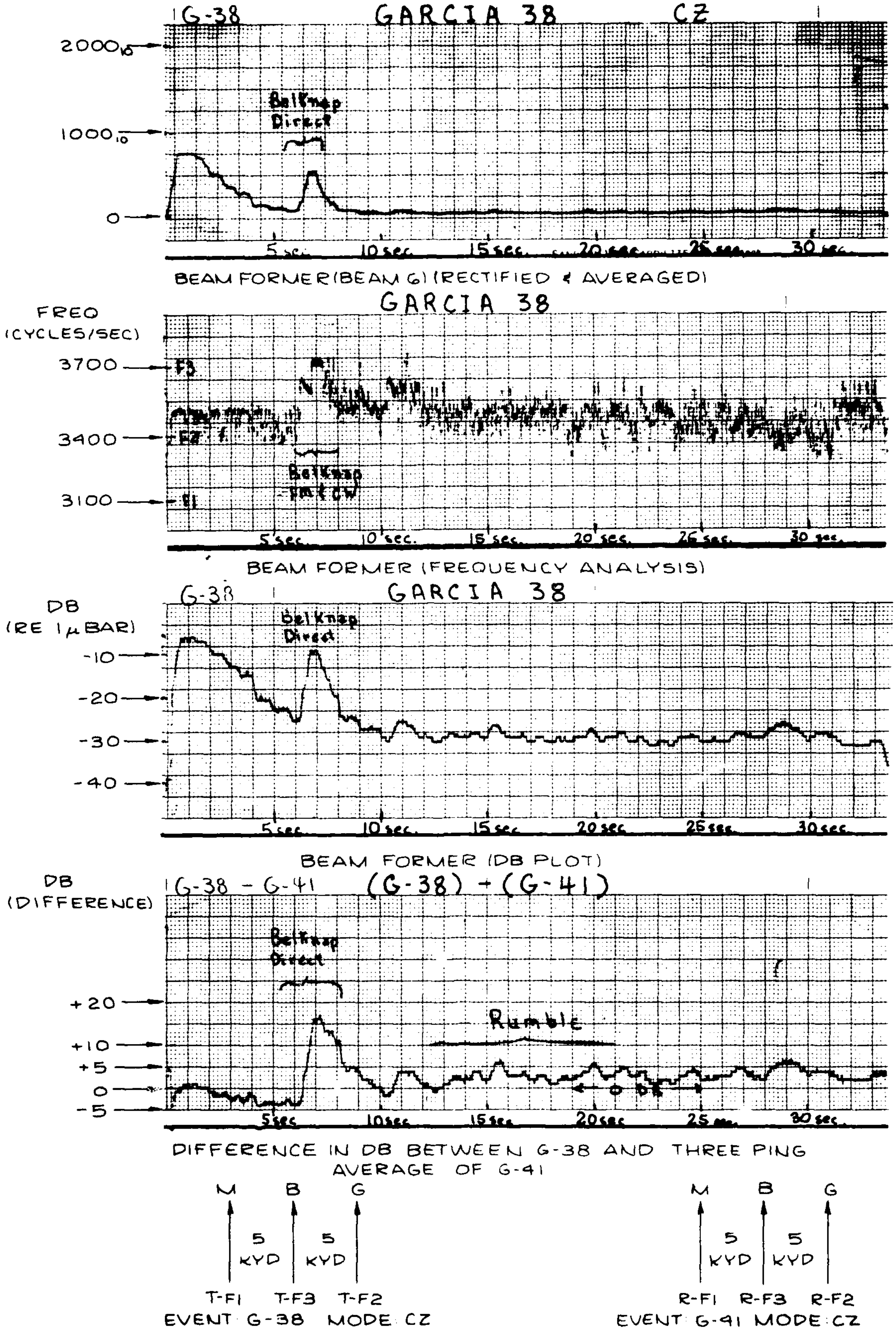
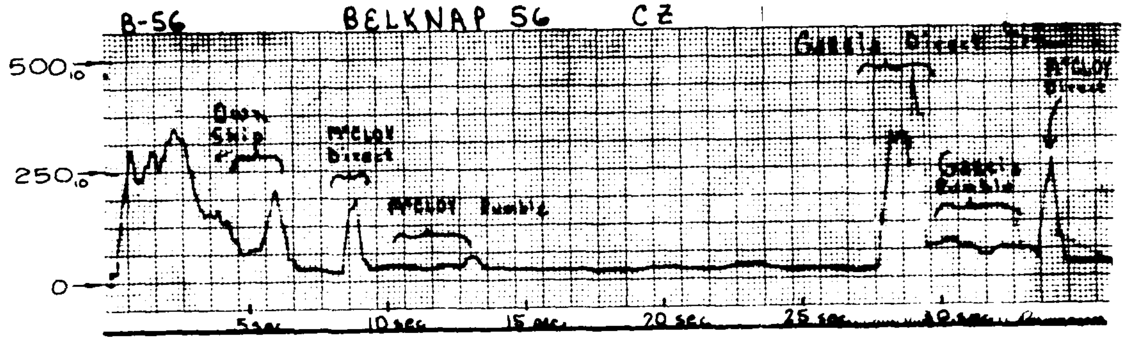
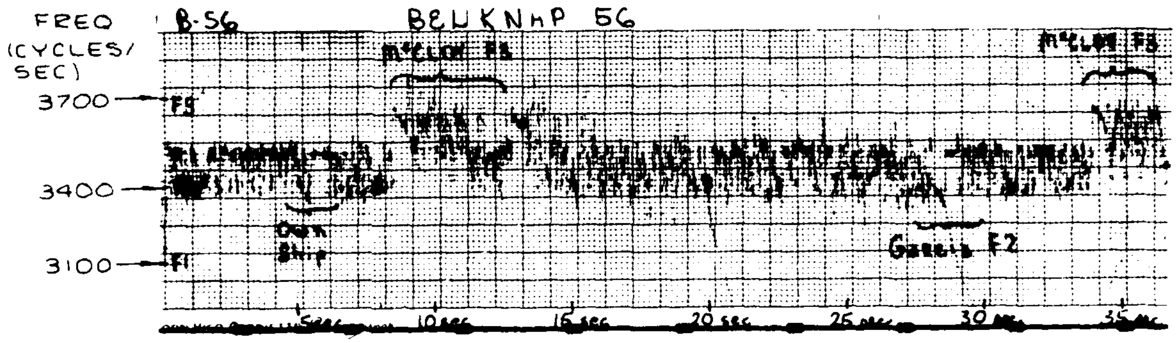

G-38
GARCIA 38
CZ
2000
1000
0
Belknap Direct
5 sec.
10 sec.
15 sec.
20 sec.
25 sec.
30 sec.
BEAM FORMER (BEAM 6) (RECTIFIED & AVERAGED)
FREQ (CYCLES/SEC)
GARCIA 38
3700
3400
3100
F3
F2
F1
Belknap FM & CW
BEAM FORMER (FREQUENCY ANALYSIS)
DB (RE 1 μ BAR)
G-38
GARCIA 38
-10
-20
-30
-40
Belknap Direct
BEAM FORMER (DB PLOT)
DB (DIFFERENCE)
G-38 - G-41
(G-38) - (G-41)
+20
+10
+5
0
-5
Belknap Direct
Rumble
0 DB
DIFFERENCE IN DB BETWEEN G-38 AND THREE PING AVERAGE OF G-41
M
B
G
5 KYD
5 KYD
T-F1
T-F3
T-F2
EVENT G-38 MODE CZ
R-F1
R-F3
R-F2
EVENT G-41 MODE CZ

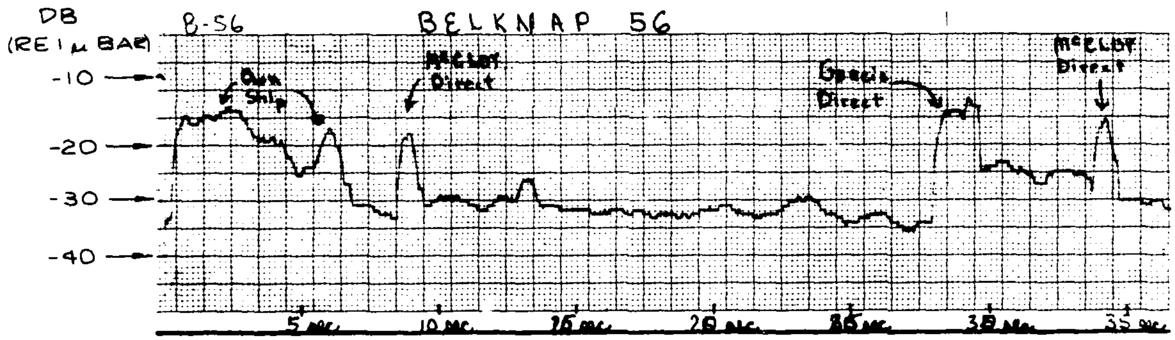
FIG. 4.5-8



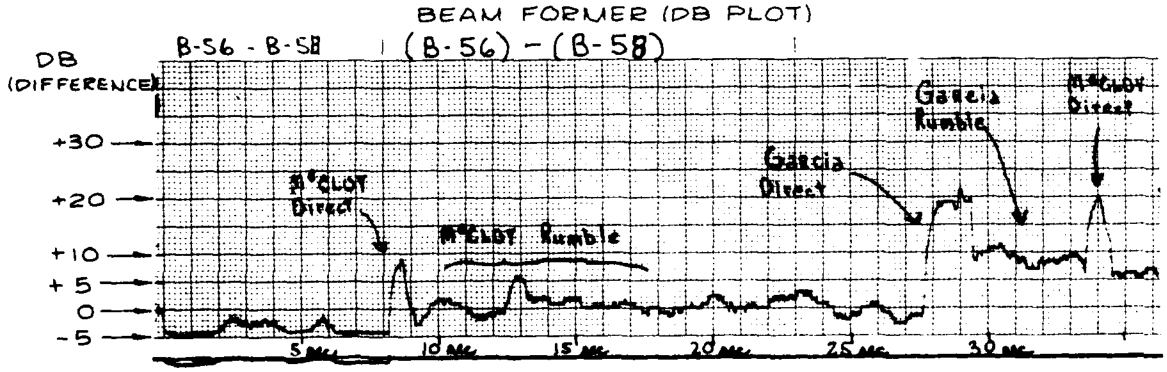
BEAM FORMER (BEAM 6) (RECTIFIER & AVERAGER)



BEAM FORMER (FREQUENCY ANALYSIS)



BEAM FORMER (DB PLOT)



DIFFERENCE IN DB BETWEEN B-56 AND THREE PING AVERAGE OF B-58

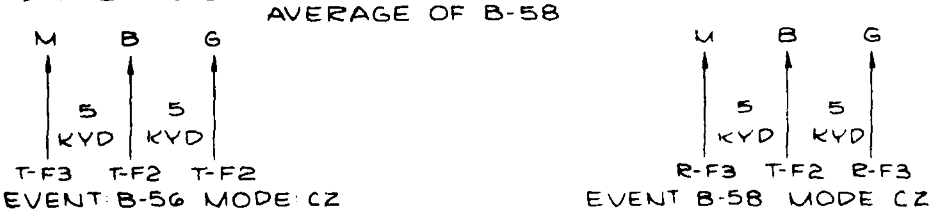


FIG. 4.5-9

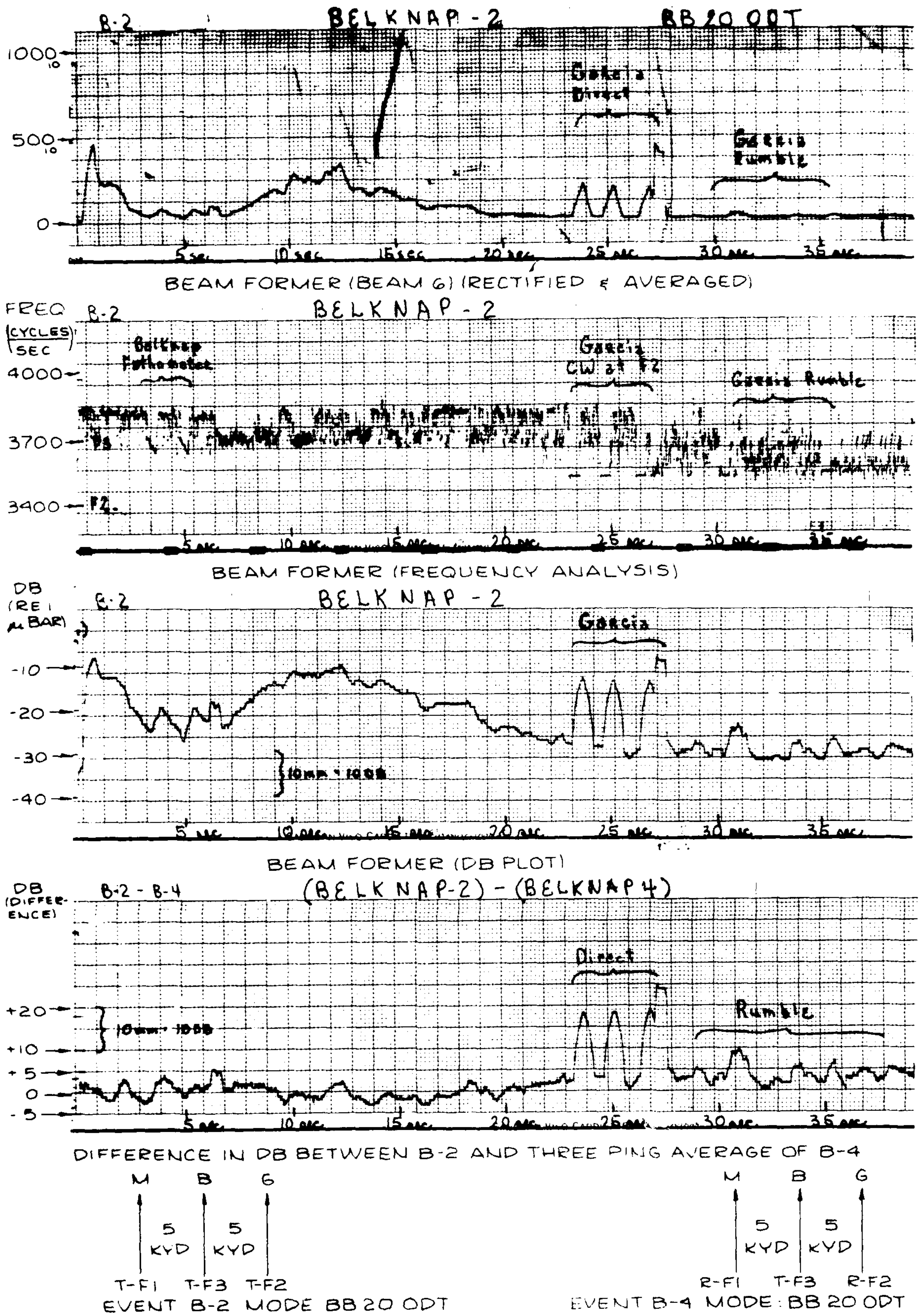

B-2
BELKNAP-2
BB 20 ODT
1000
500
0
Direct
Rumble
5 sec
10 sec
15 sec
20 sec
25 sec
30 sec
35 sec
BEAM FORMER (BEAM 6) (RECTIFIED & AVERAGED)
FREQ (CYCLES / SEC)
B-2
BELKNAP-2
4000
3700
3400
F2
CW at F2
BEAM FORMER (FREQUENCY ANALYSIS)
DB (RE 1 μ BAR)
B-2
BELKNAP-2
-10
-20
-30
-40
BEAM FORMER (DB PLOT)
DB (DIFFERENCE)
B-2 - B-4
(BELKNAP-2) - (BELKNAP 4)
Direct
Rumble
+20
+10
+5
0
-5
DIFFERENCE IN DB BETWEEN B-2 AND THREE PING AVERAGE OF B-4
M
B
G
5 KYD
5 KYD
T-F1
T-F3
T-F2
EVENT B-2 MODE BB 20 ODT
M
B
G
5 KYD
5 KYD
R-F1
T-F3
R-F2
EVENT B-4 MODE: BB 20 ODT

FIG 45-10

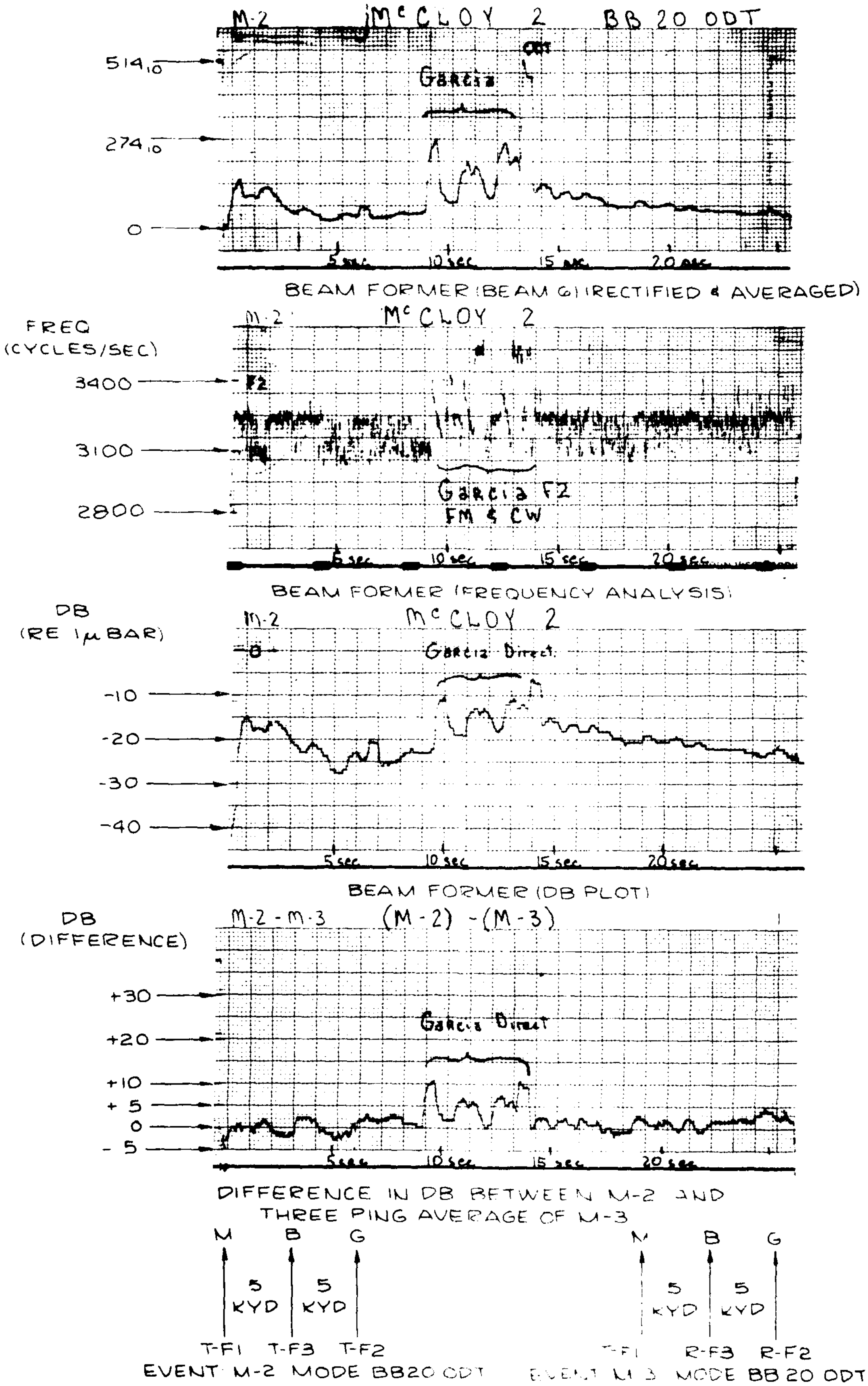
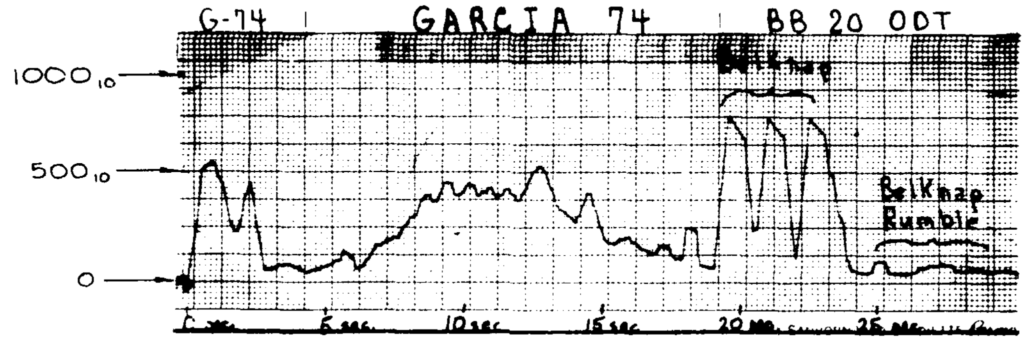
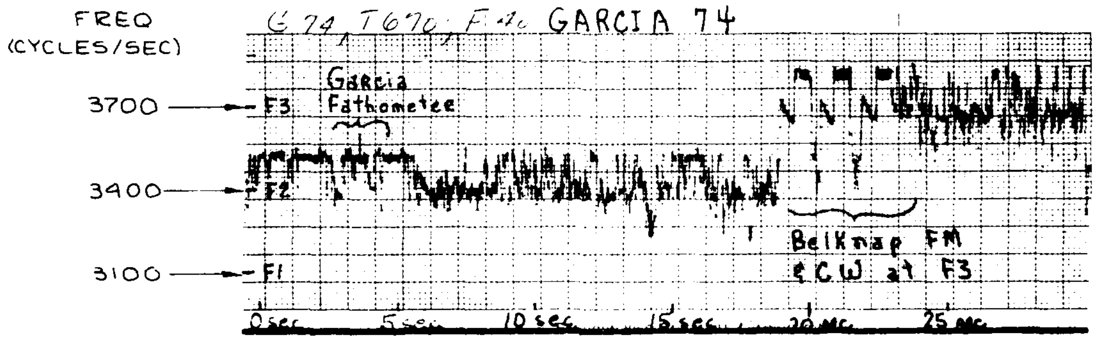

M-2
McCLOY 2
BB 20 ODT
514.10
274.10
0
Garcia
5 sec
10 sec
15 sec
20 sec
BEAM FORMER (BEAM 6) (RECTIFIED & AVERAGED)
FREQ (CYCLES/SEC)
M-2
McCLOY 2
3400
3100
2800
F2
Garcia F2
FM & CW
BEAM FORMER (FREQUENCY ANALYSIS)
DB (RE 1μ BAR)
M-2
McCLOY 2
0
-10
-20
-30
-40
Garcia Direct
BEAM FORMER (DB PLOT)
DB (DIFFERENCE)
M-2 - M-3
(M-2) - (M-3)
+30
+20
+10
+ 5
0
- 5
Garcia Direct
DIFFERENCE IN DB BETWEEN M-2 AND
THREE PING AVERAGE OF M-3
M
B
G
5 KYD
5 KYD
T-F1
T-F3
T-F2
EVENT M-2 MODE BB20 ODT
M
B
G
5 KYD
5 KYD
T-F1
R-F3
R-F2
EVENT M-3 MODE BB 20 ODT

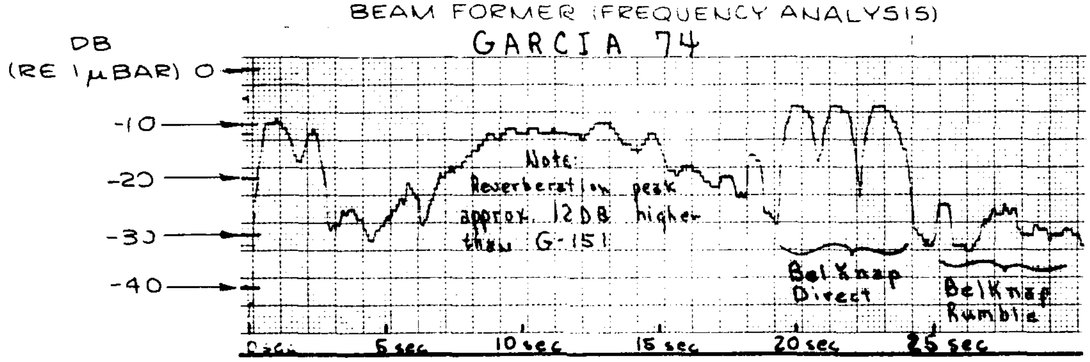
FIG 4 5-11

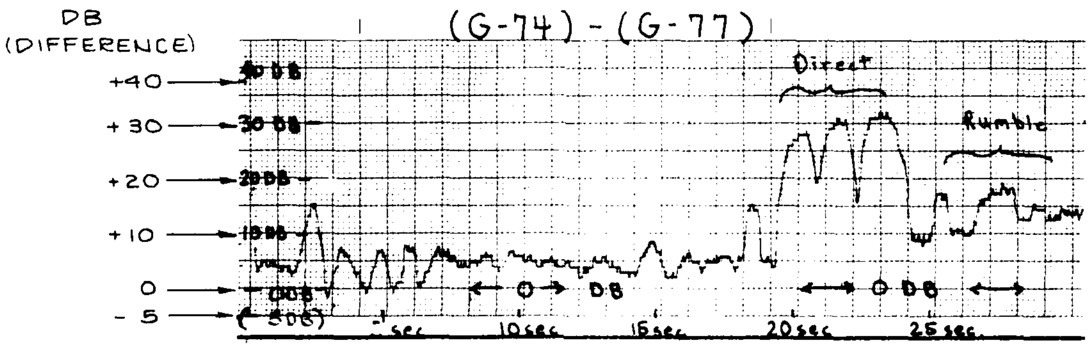


BEAM FORMER (BEAM 6) (RECTIFIED & AVERAGED)

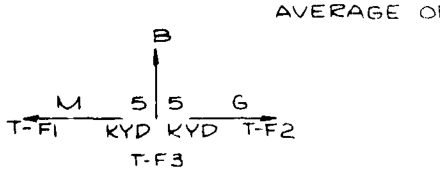


BEAM FORMER (FREQUENCY ANALYSIS)

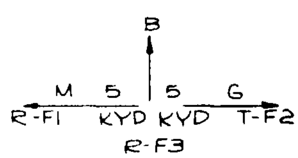




DIFFERENCE IN DB BETWEEN G-74 AND THREE PING AVERAGE OF G-77



EVENT G-74 MODE BB 20 ODT



EVENT G-77 MODE BB20 ODT

FIG 45-12

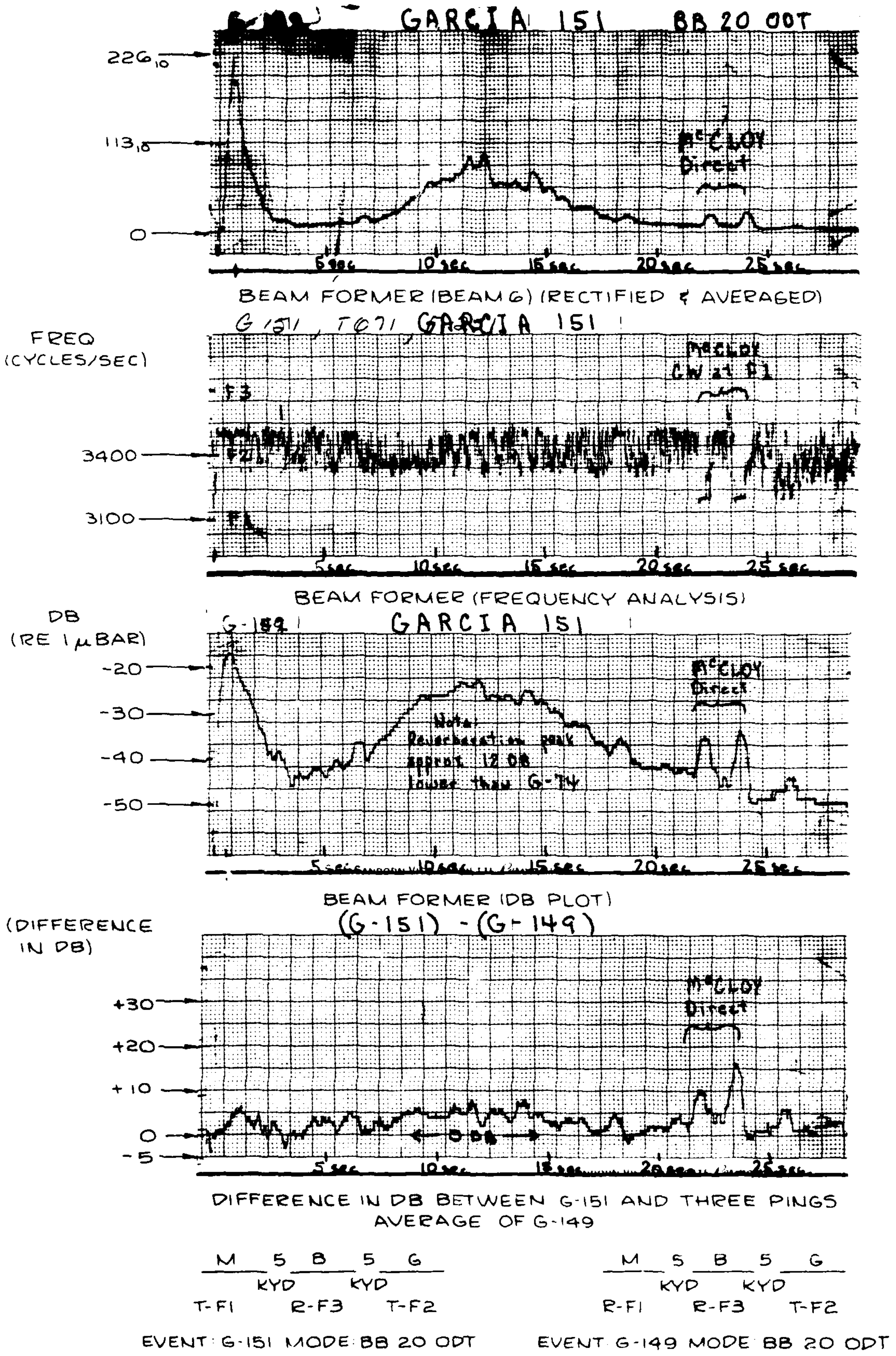

GARCIA 151 BB 20 ODT
226,10
113,8
0
McCLOY Direct
5 sec 10 sec 15 sec 20 sec 25 sec
BEAM FORMER (BEAM 6) (RECTIFIED & AVERAGED)
GARCIA 151
FREQ (CYCLES/SEC)
McCLOY CW at F1
F3
3400
F2
3100
F1
5 sec 10 sec 15 sec 20 sec 25 sec
BEAM FORMER (FREQUENCY ANALYSIS)
DB (RE 1 μBAR)
GARCIA 151
-20
-30
-40
-50
McCLOY Direct
Note: Reverberation peak approx. 12 DB lower than G-74
5 sec 10 sec 15 sec 20 sec 25 sec
BEAM FORMER (DB PLOT)
(DIFFERENCE IN DB)
(G-151) - (G-149)
+30
+20
+10
0
-5
McCLOY Direct
0 DB
5 sec 10 sec 15 sec 20 sec 25 sec
DIFFERENCE IN DB BETWEEN G-151 AND THREE PINGS AVERAGE OF G-149
M 5 B 5 G
KYD KYD
T-F1 R-F3 T-F2
EVENT G-151 MODE BB 20 ODT
M 5 B 5 G
KYD KYD
R-F1 R-F3 T-F2
EVENT G-149 MODE BB 20 ODT

FIG. 45-13

difference between the levels of the reverberation peaks. The only change in conditions is that GARCIA is transmitting (in Event 151) in a direction 180° from the previous transmission. A port beam transmission appears to be approximtely 6 dB lower in source level than a starboard beam transmission. Causes of this deviation in source level with bearing are not known.

5. AN/SQS-26 CX and AN/SQS-26 AX (RETROFIT) EXPECTED PERFORMANCE.

5.1 Description of AN/SQS-26 AX, CX, and AX(Retrofit)

A partial analysis has been made of the expected characteristics of the AN/SQS-26 CX and AN/SQS-26 AX(Retrofit) receiving systems with emphasis on the aspects most pertinent to mutual interference. These can be compared with the characteristics of the older AN/SQS-26 AX when comparable specifications for these units are obtained.

Figure 5.1-1 shows a simplified block diagram of the beamforming, receiving, and signal processing subsystems for the SQS-26 AX. Only those units applicable to the signal outputs for the A scan and PPI displays are shown, with all audio and B scan circuits omitted in the interest of simplicity.

Figure 5.1-2 shows the comparable breakdown for the SQS-26 CX and SQS-26 AX(Retrofit). Comparison with Fig. 5.1-1 shows that the only major difference is the use of independent receivers in the CX to handle the 12 beam coded and CW signals, in lieu of the single receiver used in the AX to process both signals simultaneously.

The single receiver has the disadvantage that the AGC reacts to the combined effects of coded pulse reverberation, CW reverberation, and noise in the passband. Any of these can dominate the AGC and therefore situations can arise where a particular signal of interest is not normalized to its own mean but to that of one of the other components. The dual receiver, when accompanied with proper filtering, permits independent AGC of the coded pulse and CW signal, thus minimizing the probability of this occurring.

A more subtle difference in the SQS-26 AX and SQS-26 CX

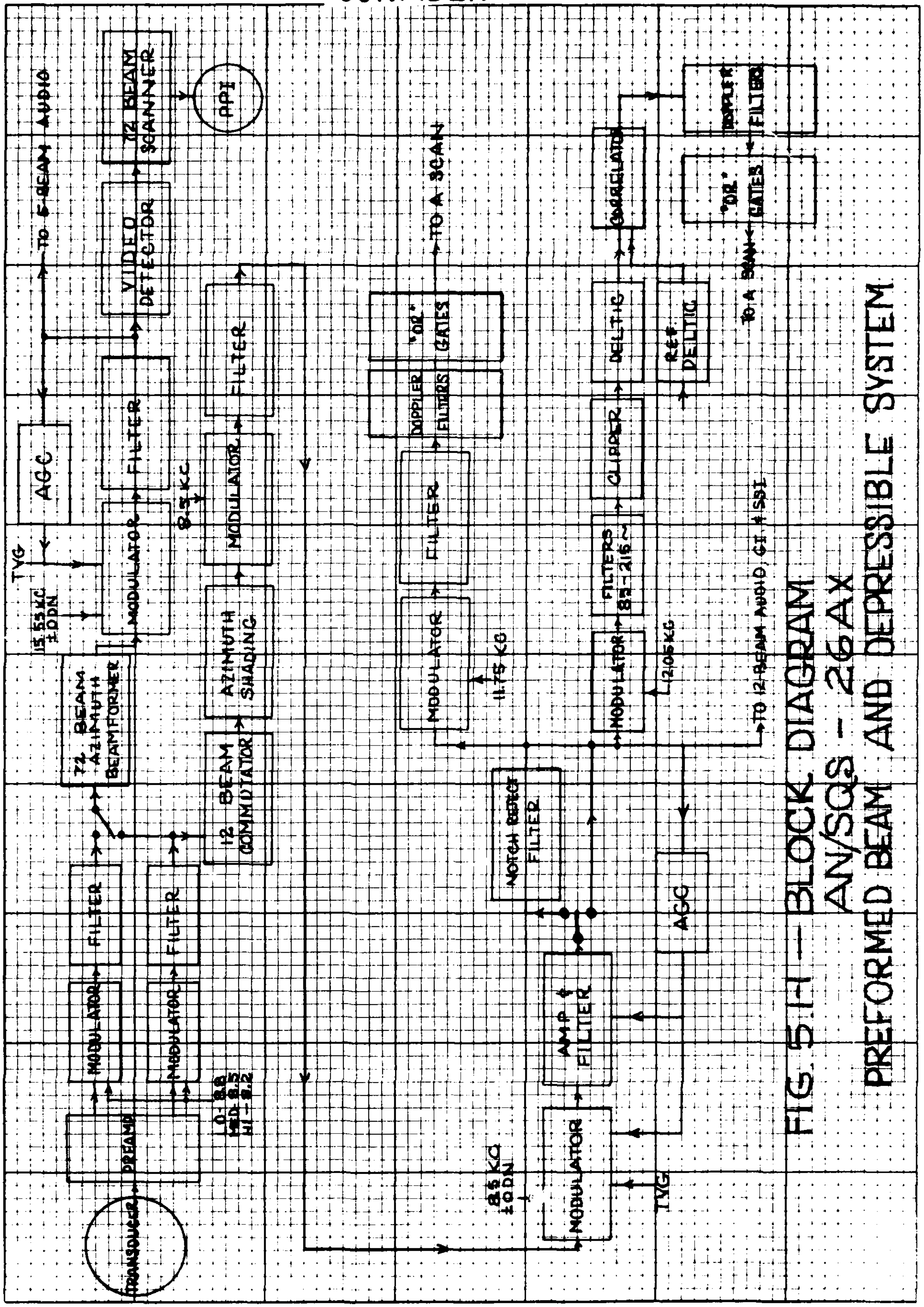


FIG 5.14 — BLOCK DIAGRAM
AN/SQS - 26AX
PREFORMED BEAM AND DEPRESSIBLE SYSTEM

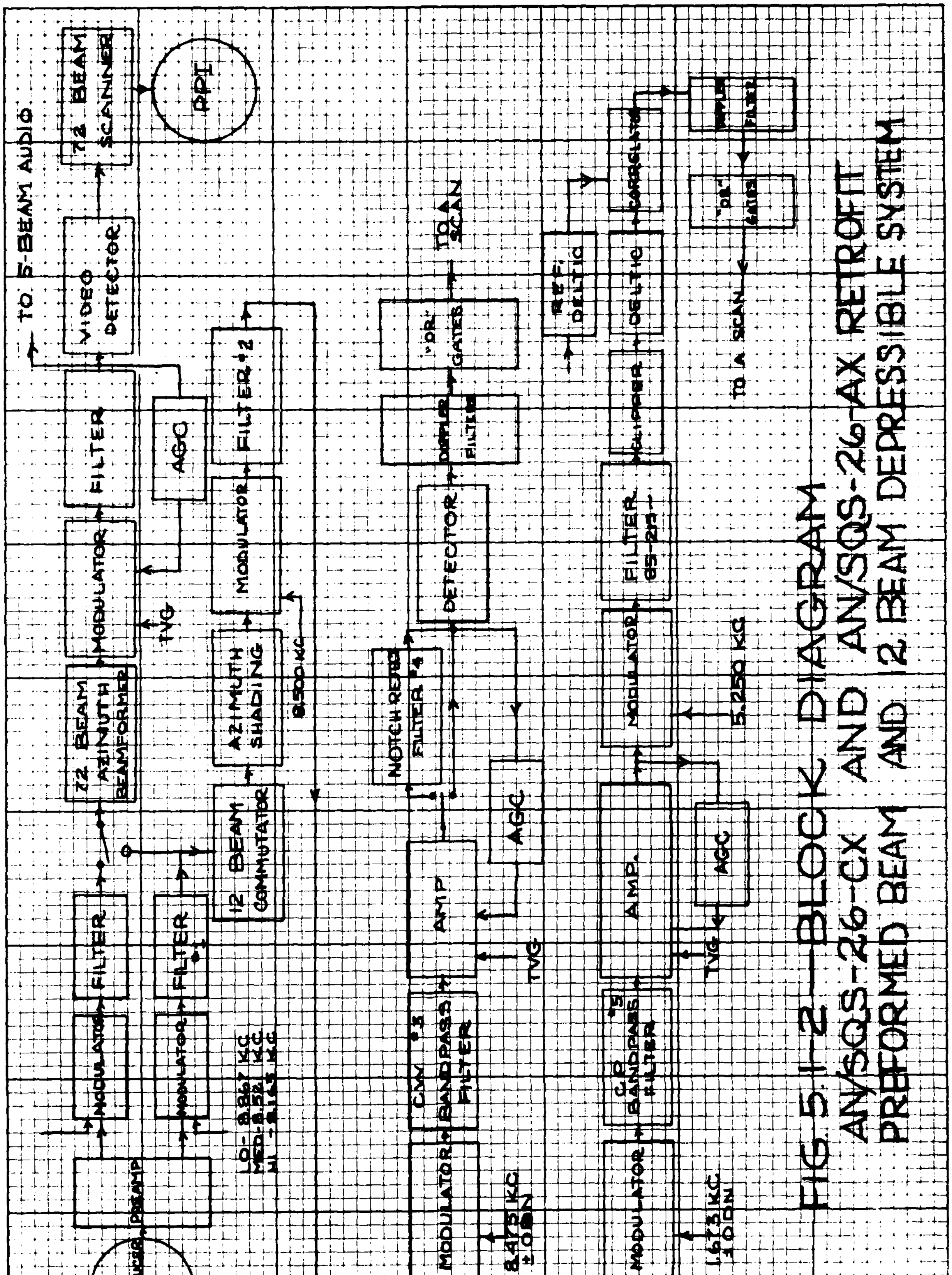


FIG. 5.1-2 BLOCK DIAGRAM
AN/SQS-26-CX AND AN/SQS-26-AX RETROFIT
PREFORMED BEAM AND 2 BEAM DEPRESSIBLE SYSTEM

occurs in the effective bandwidths of the receivers and preceding stages of the two systems. At present, specific design data are not available for the filters in the AN/SQS-26 AX. However, rough response measurements made through the beamformer of the AN/SQS-26 AX and the nominal values quoted in the sonar manual indicate that the bandwidth in the beamformer is in the range 650-700 cycles. This is further confirmed by the mutual interferences observed caused by transmissions from sonars operating on adjacent bands.

For the AN/SQS-26 CX and Retrofit AX, measured response data on the actual system has not been obtained. In this case, however, design specifications for the system filters are available. When coupled with practical constraints on the realizability of filters, this information is sufficient to permit reasonably close estimates of the frequency responses of the finished units. As the estimated responses of the units are discussed, it will become more clear why this is so.

Figure 5.1-3 shows an estimated response for the filter in the vertical beamformer of the depressible beam system of the SQS-26 CX. Its location in the system is shown in Fig. 5.1-2. Since the response of the transducer, preamps, and phasing modulators can be expected to be essentially flat across a bandwidth as narrow as that shown, the filter response also defines the expected frequency response of the sonar from the water up to the vertical beamformer output. The specification for filter #1 calls for a 3 dB bandwidth of 355 cycles minimum, and 400 cycles maximum. The skirts must be at least 20 dB down at 300 cycles either side of the nominal center frequency (12.015 kc) and at least 60 dB down below 9.0 kcs and above 15.0 kcs. The allowable passband ripple is 0.5 dB maximum. To show how this defines the probable response, some results from modern network and filter theory must be observed. It is well known that the transfer function of a network can be represented as a rational polynomial

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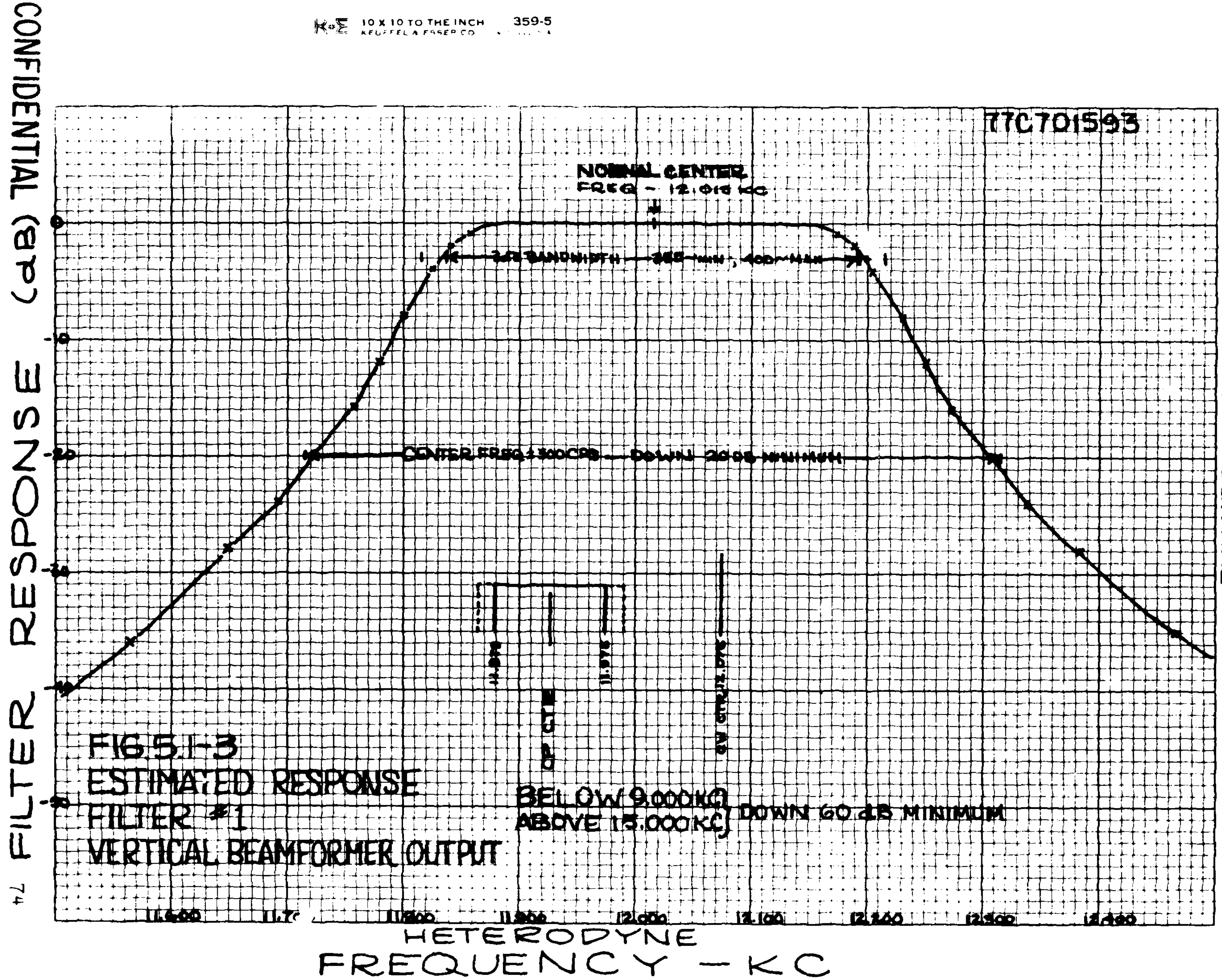

FIG 5.1-3
ESTIMATED RESPONSE
FILTER #1
VERTICAL BEAMFORMER OUTPUT

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in the complex frequency. Network theorists have examined these expressions and shown that given skirt cut-off slopes and passband ripple, requirements can be assured provided that the transfer function of the network has a minimum number of poles and the elements' Q's exceed a lower bound. Nomograms are available which give the relationship between these quantities. In practice it is found the filter shapes actually achieved conform closely to the predictions. Therefore this represents a good starting point for the filter designer in estimating how complex the required design must be. The specification given in Fig. 5.1-3 can be met with a 4-pole filter and it is assumed therefore that actual design will approximate the 4-pole filter response shown. In making this assumption it has been tacitly assumed that the filter will not be overdesigned. This is reasonable since an overdesign usually will be more complex and more costly to produce. From this it can be inferred that the bandwidth at the 20 dB points will not be any narrower than necessary and the 3 dB bandwidth will not be wider than necessary. Some allowance must be made for variability in production but usually this will not be large.

Figure 5.1-3, in addition to showing the estimated filter response, indicates the expected frequency relationship of the zero-doppler coded pulse and CW pulse reverberation returns to the filter response. These are shown by the rectangle and line in the approximate center of the bandwidth. In calculating these, it is assumed that the heterodyning frequencies inserted into the vertical beamforming modulators are such as to center the band of frequencies covering the coded pulse and CW returns along with their possible doppler shifts into the center of the filter. This can be calculated from noting the following from the system specifications: (1) The upper edge of the coded pulse band (defined as band center for transmission purposes) is 100 cps below the CW pulse frequency. (2) The coded pulse bandwidth is

96 cps. (3) Provision must be included for 90 cps (34 kts) of target up doppler on the CW echo and 15 cps (6 kts) of target down doppler on the coded pulse echo. Other target dopplers do not constrain the required bandwidth.

Combining the requirements given, indicates that the minimum bandwidth with no provision for own ships doppler must be 301 cps. Since the vertical beamforming filter bandwidth may be as narrow as 355 cps, only 54 cps may be available to accommodate the total range of shifts due to own doppler. It has been assumed that this will be divided equally between up and down doppler. This would permit a maximum own doppler component of ±27 cps (approximately ±10 kts). Operating under these conditions, the appropriate heterodyning frequencies are those shown on Fig. 5.1-3.

Figure 5.1-4 shows the estimated response of the filter following the azimuth beamformer modulators (No. 2 on Fig. 5.1-2). The minimum 3 dB bandwidth is specified to be 400 cps, with the skirt requirements indicated. The design for this filter should be similar to that for filter #1 with about the same complexity required.

Figure 5.1-5 shows the expected composite effect of filters #1 and #2. This represents the expected total frequency response of the system up to the beamformer output.

Following the beamforming, the coded pulse and CW pulse signals are separated by heterodyning and filtering as shown on Fig. 5.1-2.

Figure 5.1-6 shows the estimated response of the bandpass filter for the CW signal. The specifications for this filter require a very high rate of cut-off on the lower skirt. The estimated lower skirt response plotted represents a 7-pole cut-off rate. The specifications for the upper skirt are relatively lax, however. Presumably this was intentional since the realization

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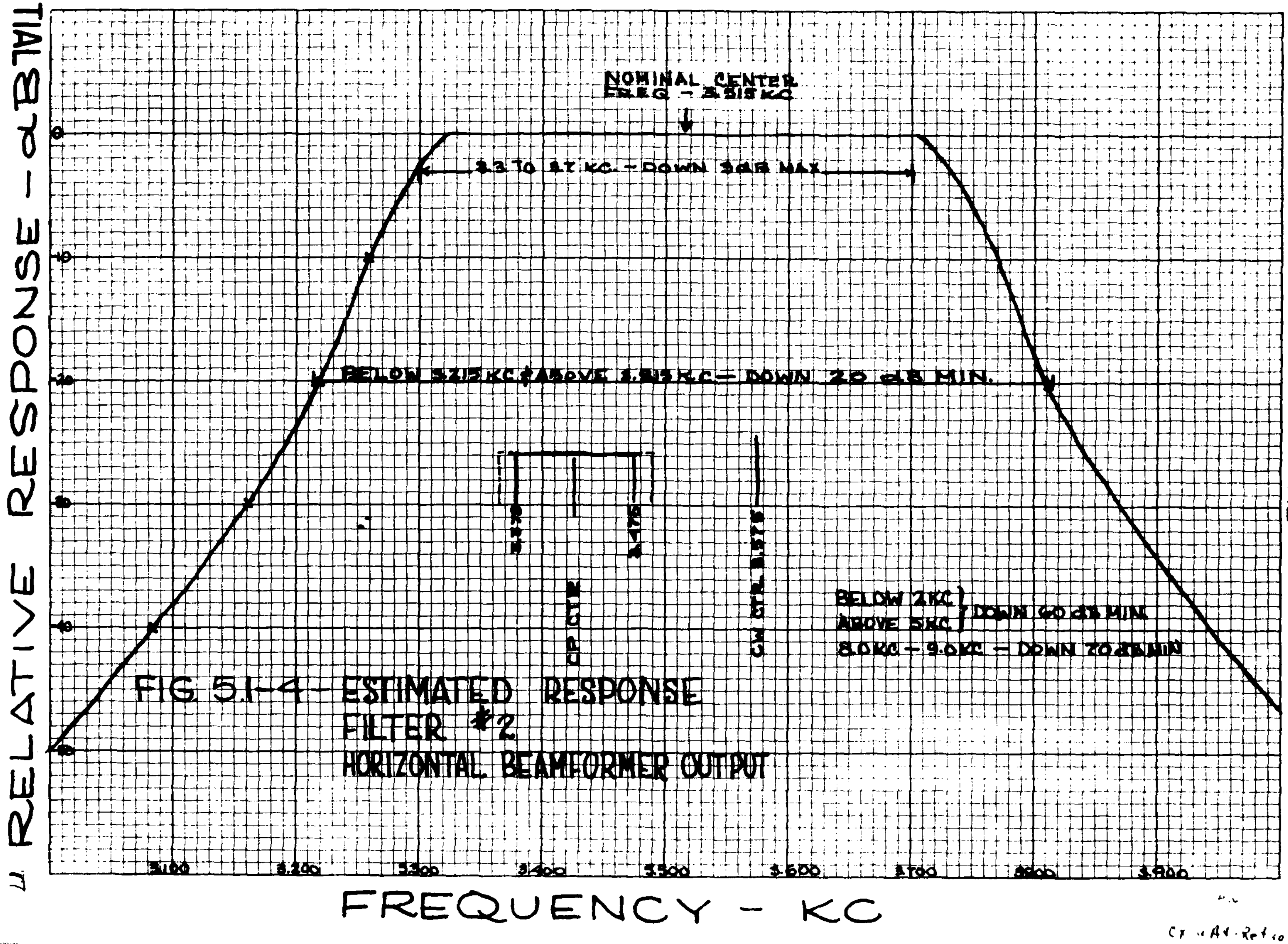

FIG 5.1-4 - ESTIMATED RESPONSE
FILTER #2
HORIZONTAL BEAMFORMER OUTPUT

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K•E 10 X 10 TO THE INCH 46 0703
7 X 10 INCHES MADE IN U.S.A.
KEUFFEL & ESSER CO.

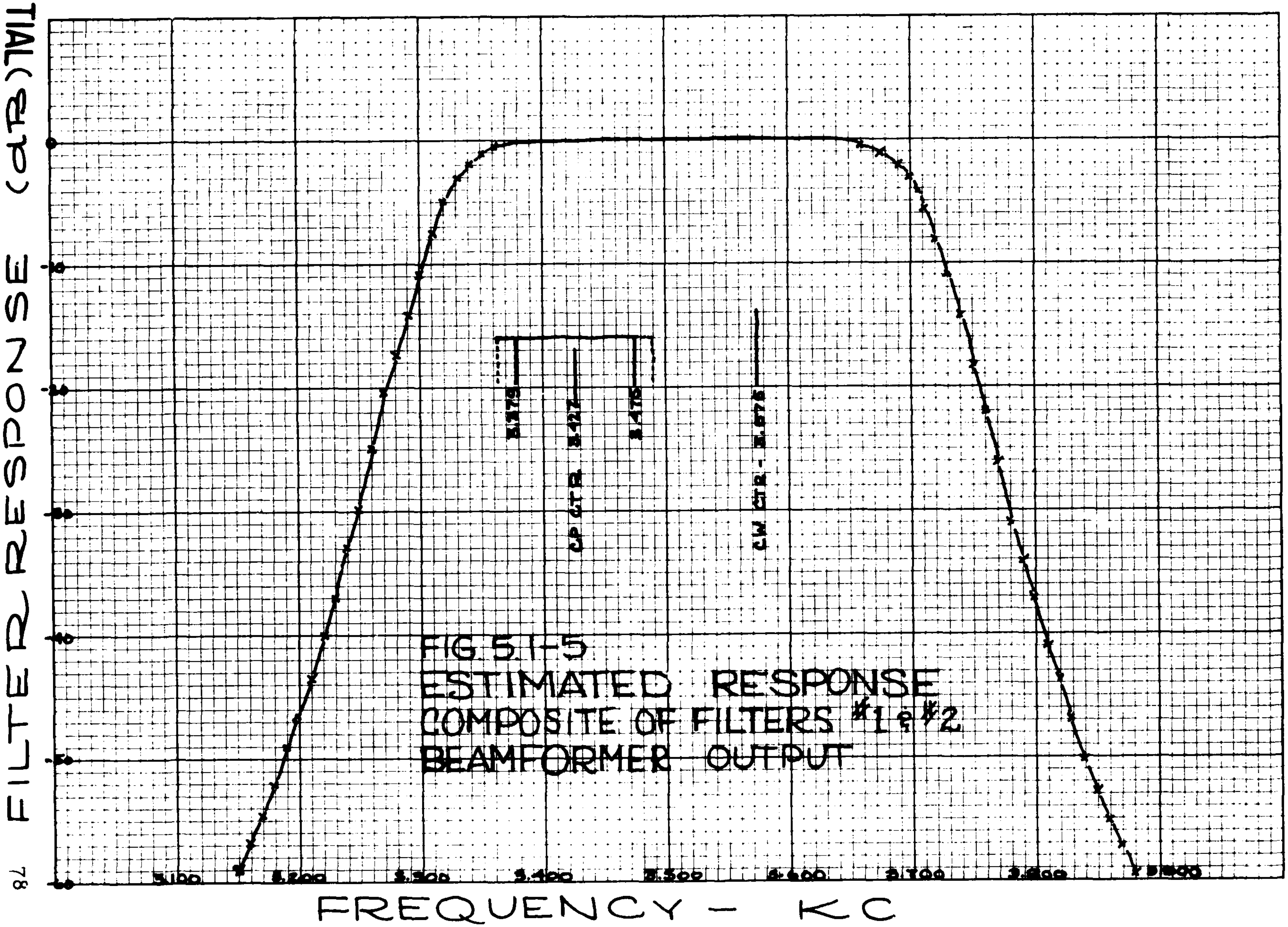

FIG 5.1-5
ESTIMATED RESPONSE
COMPOSITE OF FILTERS #1 & #2
BEAMFORMER OUTPUT

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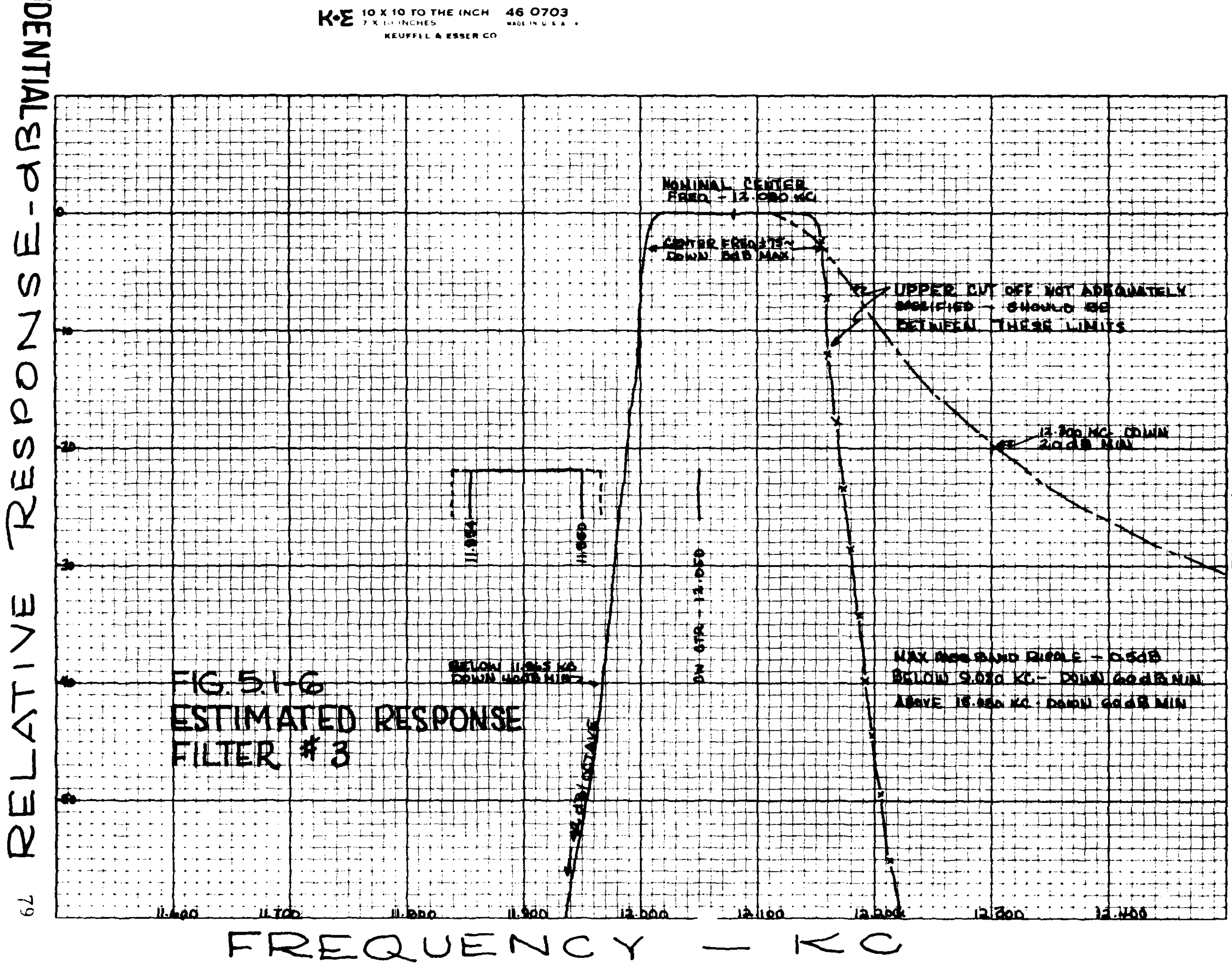

FIG. 5.1-6
ESTIMATED RESPONSE
FILTER #3

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of lower skirt response may be eased by allowing the filter to have an asymmetrical response. Under these conditions, the upper skirt response cannot be predicted accurately. Limits, however, can be set within which it should lie. These are shown by the limiting curves indicated. The poorer curve represents a skirt which will just satisfy the requirements. The better skirt results if the filter is symmetrical, with identical upper and lower skirts. In the actual design neither of these extremes is likely to occur so that true response should be somewhere between these.

Figure 5.1-7 shows the expected system response due to the combined beamformer and CW bandpass filters. This also represents the response at the CW receiver output when the reverberation notch reject filter is not used. Also shown are the expected frequency positions for various own ship transmissions and those due to SQS-26 CX or Retrofit AX sonars operating on adjacent bands. It will be observed that for most of these, the rejection should exceed 60 dB and these will not be discussed further.

The principal possible interference observed on the CW channel occurs from a requirement included in the CX specification. This stipulates that the ODT transmission must be at a frequency 300 cps away from the CW transmission. To conform to this the ODT transmission would have to be at a frequency below the coded pulse transmission, resulting in interference with a sonar operating on the next lower band. These are the origin of the signals indicated "ODT center - next higher band." It is understood that the indicated requirement on the ODT transmission will be removed, however, and that ODT transmissions will be at the same frequency as the CW pulse. When this change is made, the only interference observed should be due to own ship's ODT or a transmission in the same band. These will be at the frequency indicated as "Own band CW center."

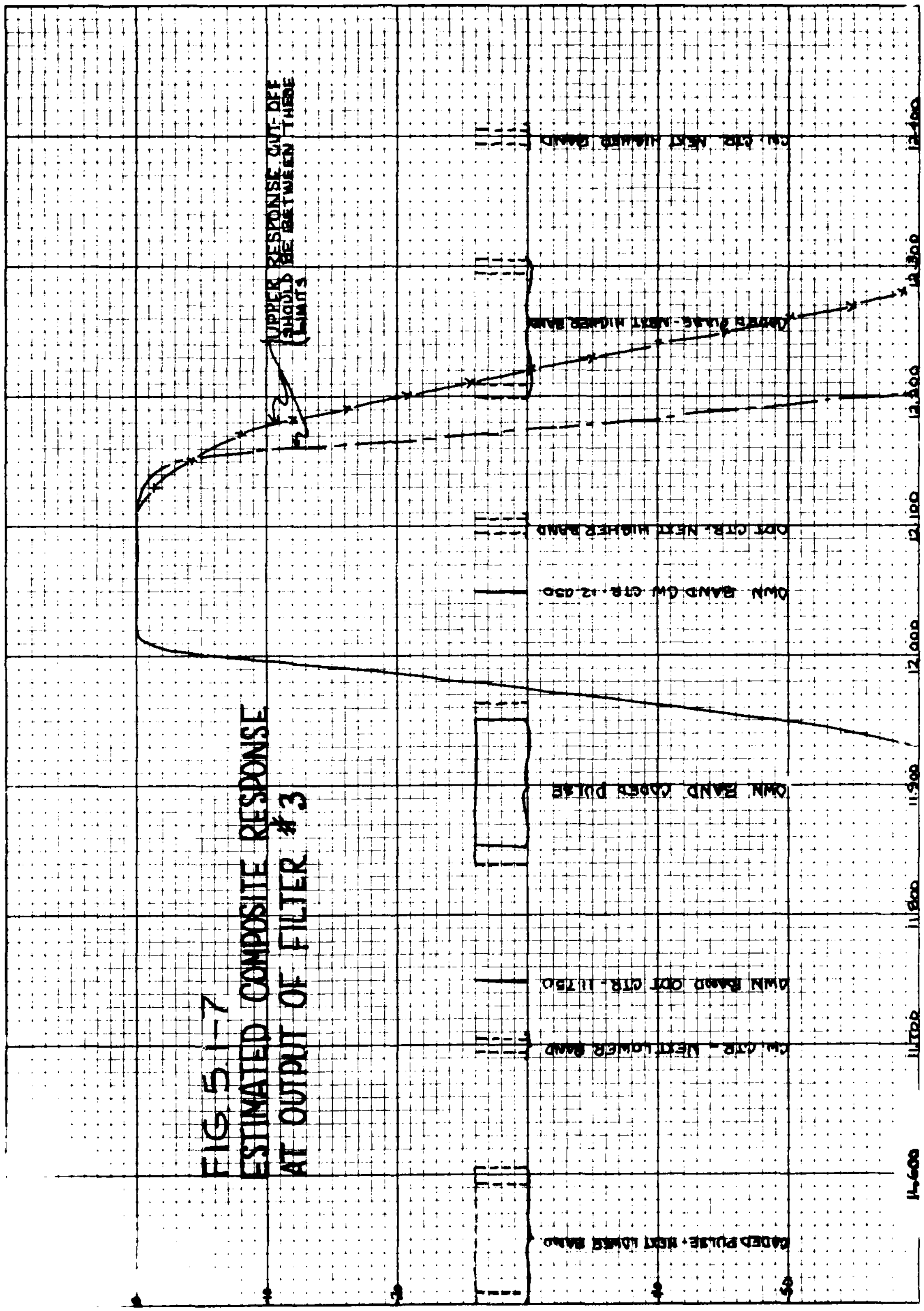


FIG 5.1-7
ESTIMATED COMPOSITE RESPONSE
AT OUTPUT OF FILTER #3

After the ODT, the next most significant interferences in the CW output might result from possible leakage of high level coded pulse transmissions through the system response skirts. Since the coded pulse transmissions spread across the skirts of the filters, an accurate value of the amount of rejection is difficult to estimate. However, the rejection clearly should be in excess of 60 dB.

Figure 5.1-8 shows the estimated response of the notch reject filter in the CW receiver. The composite effect of this with the system bandwidth can be evaluated by comparing it with the preceding response. This is easy since the reject notch lies entirely within the system passband and does not affect the outer skirts of the system passband.

Figure 5.1-9 shows the estimated response of the bandpass filter #5 used for separating out the coded pulse signals. From a frequency response standpoint, this filter should not be difficult to realize. However, the required phase linearity may require some widening of the passband. Allowing for this, it is estimated that the 3 dB bandwidth will be about 160 cps.

Figure 5.1-10 shows the estimated composite system response at the coded pulse receiver output. This includes the combined effects of the coded pulse bandpass filter and beamformer filters. Also shown are the frequency positions of potential interfering signals. Ignoring the ODT signals, the only important interference remaining occurs due to possible leakage of own-band CW thru the upper skirt. If the coded pulse bandpass filter upper skirt is as estimated, the rejection for this leakage will be only about 20 dB. This may be adequate, however, since the correlator is insensitive to CW signals.

Figure 5.1-11 shows a plot, on a common frequency scale, of the system response for both the coded pulse and CW signal channels. This shows directly the estimated relative system rejection between the two channels.

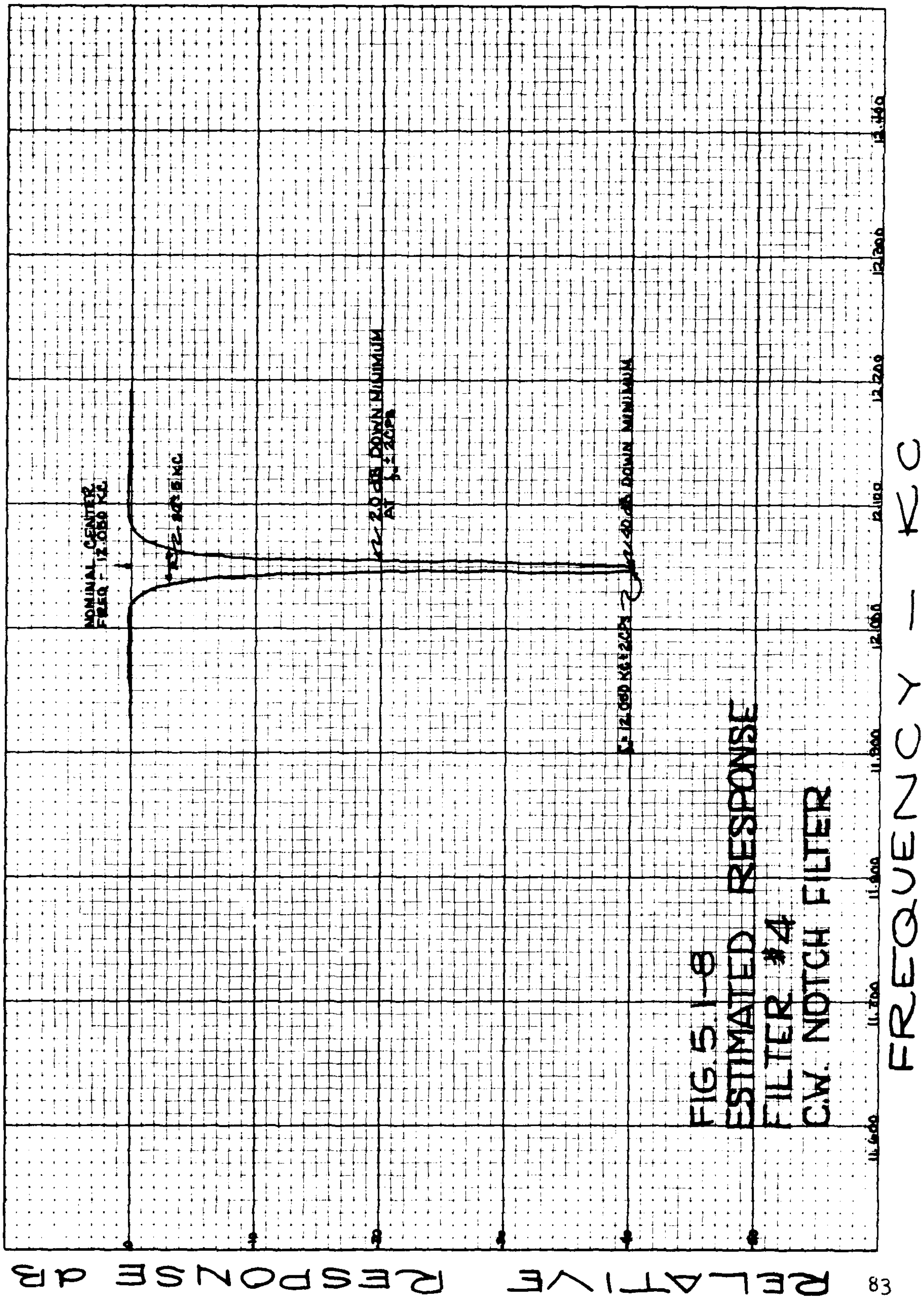
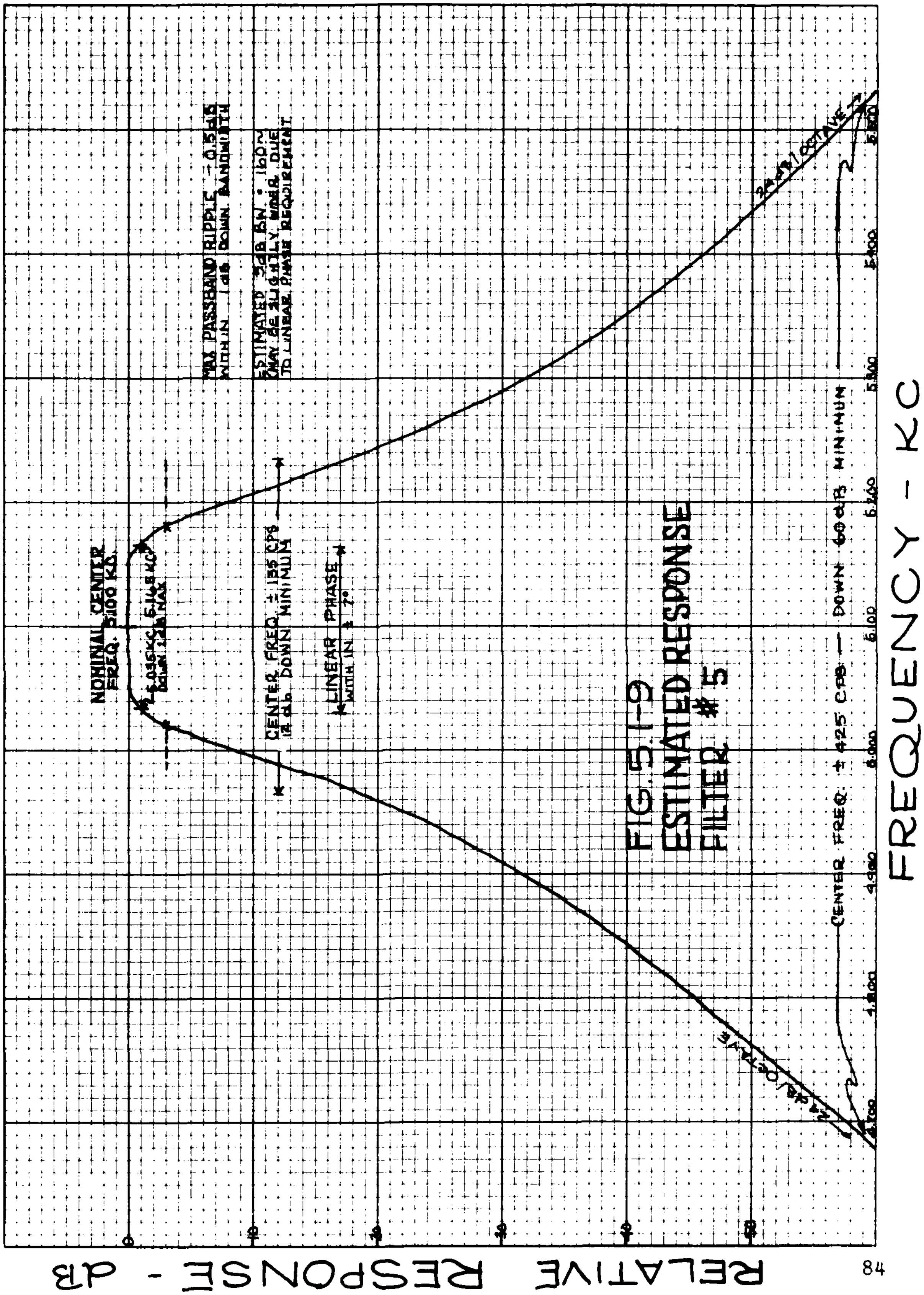


FIG. 5.1-8
ESTIMATED RESPONSE
FILTER #4
C.W. NOTCH FILTER



K·E 10 X 10 TO THE INCH 46 0703
7 X 10 INCHES MADE IN U.S.A.
KEUFFEL & ESSER CO.

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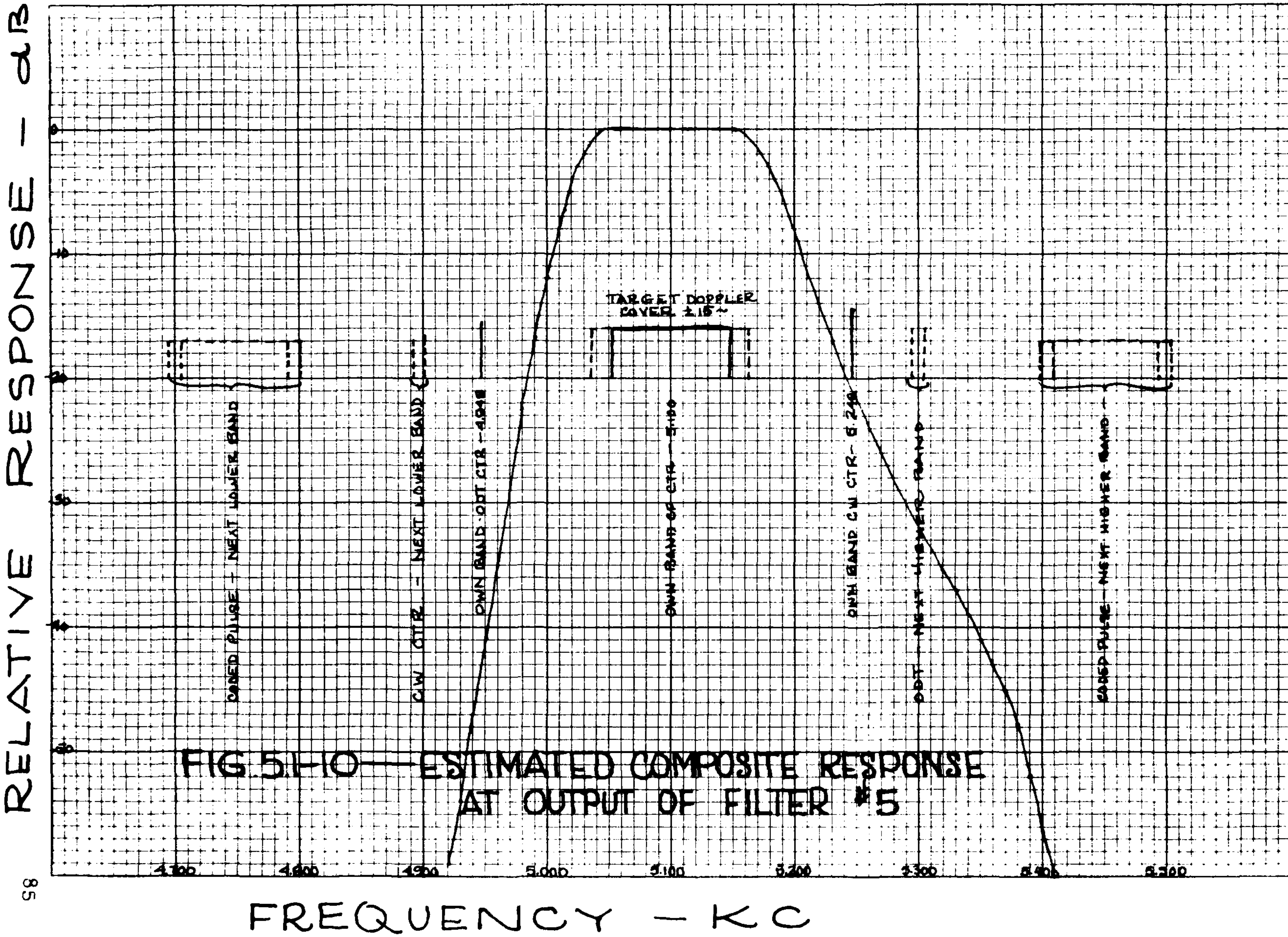

FIG. 5.1-10 — ESTIMATED COMPOSITE RESPONSE AT OUTPUT OF FILTER #5

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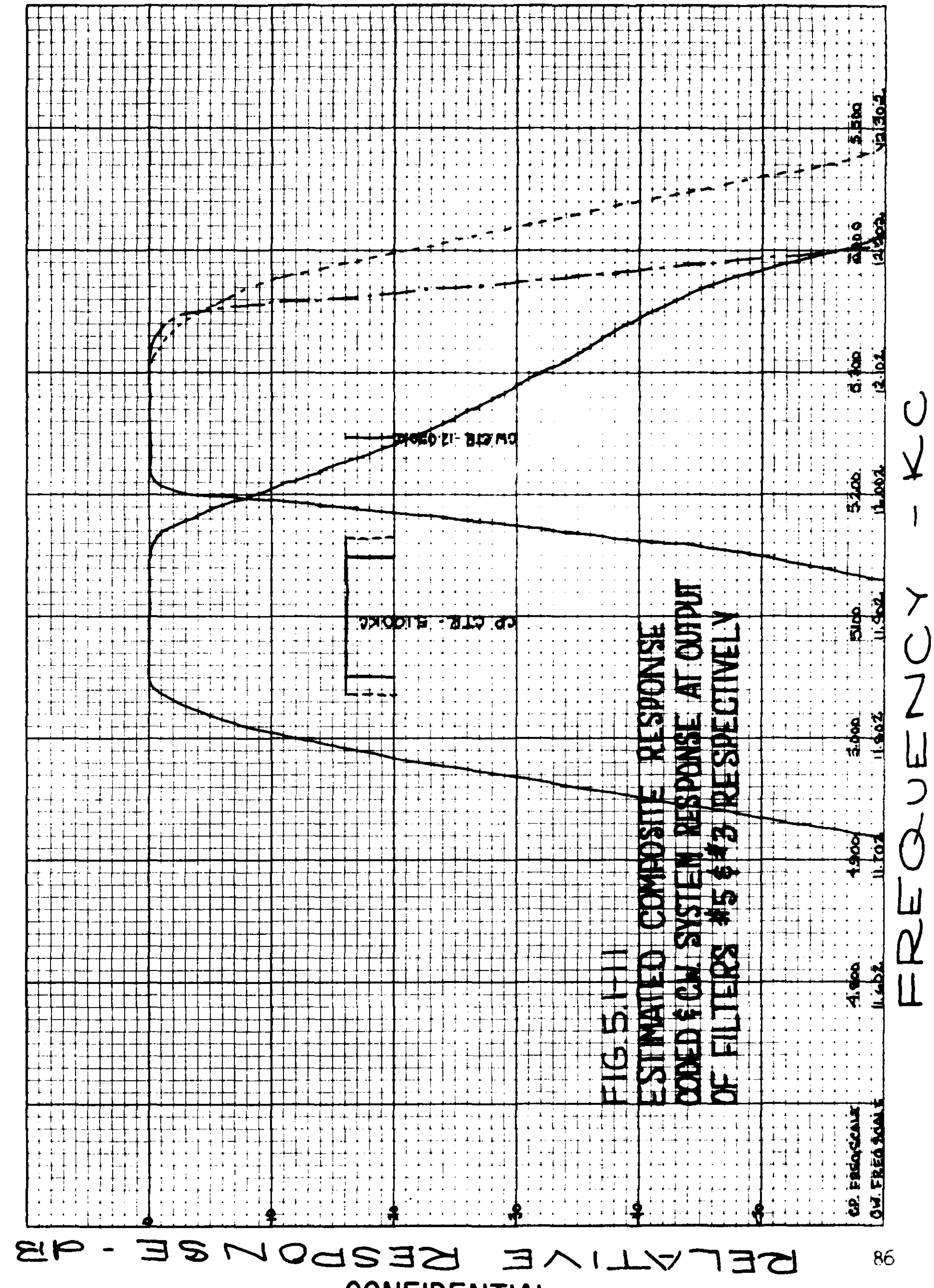

FIG. 5.1-11
ESTIMATED COMPOSITE RESPONSE
CODED & C.W. SYSTEM RESPONSE AT OUTPUT
OF FILTERS #5 & #3 RESPECTIVELY

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5.2 Filter Effects

In order to demonstrate the effect of the filters in the CX system, a computer program which bandpass-filters digitized sea data was prepared for the CDC 3200 digital computer. The method of filtering used was to correlate a reference function with digitized sea data. The reference function used was

$$f(t) = A \sin\left\{2\pi\left[fo + \frac{(fm-fo)t}{2\tau}\right]t\right\} \tag{5.2-1}$$

where fm and fo are the maximum and minimum filter frequencies, τ is the correlator length and A is a scale factor.

The characteristics of this filtering process were determined in two ways:

1) Digitized white noise in the frequency range between 50 cps and 350 cps was bandpass filtered between 100 cps and 200 cps.

2) A digitized 200 cps tone was bandpass filtered between 150 cps and 250 cps.

The power spectra of the white noise, before and after filtering, are shown in Figs. 5.2-1 and 5.2-2, respectively. The power spectrum of the 200 cps tone, after filtering, is shown in Fig. 5.2-3.

From Figs. 5.2-2 and 5.2-3, it is seen that this digital filter does not meet the specifications of the filters in the CX system, as shown in Figs. 5.1-6 and 5.1-9. That is, the filter skirts have less slope and dynamic range than called for in the sonar specifications. However, it may be used to demonstrate the feasibility of removing the effects of mutual interference, due to a higher or lower frequency influence seen in the sea data, by bandpass filtering.

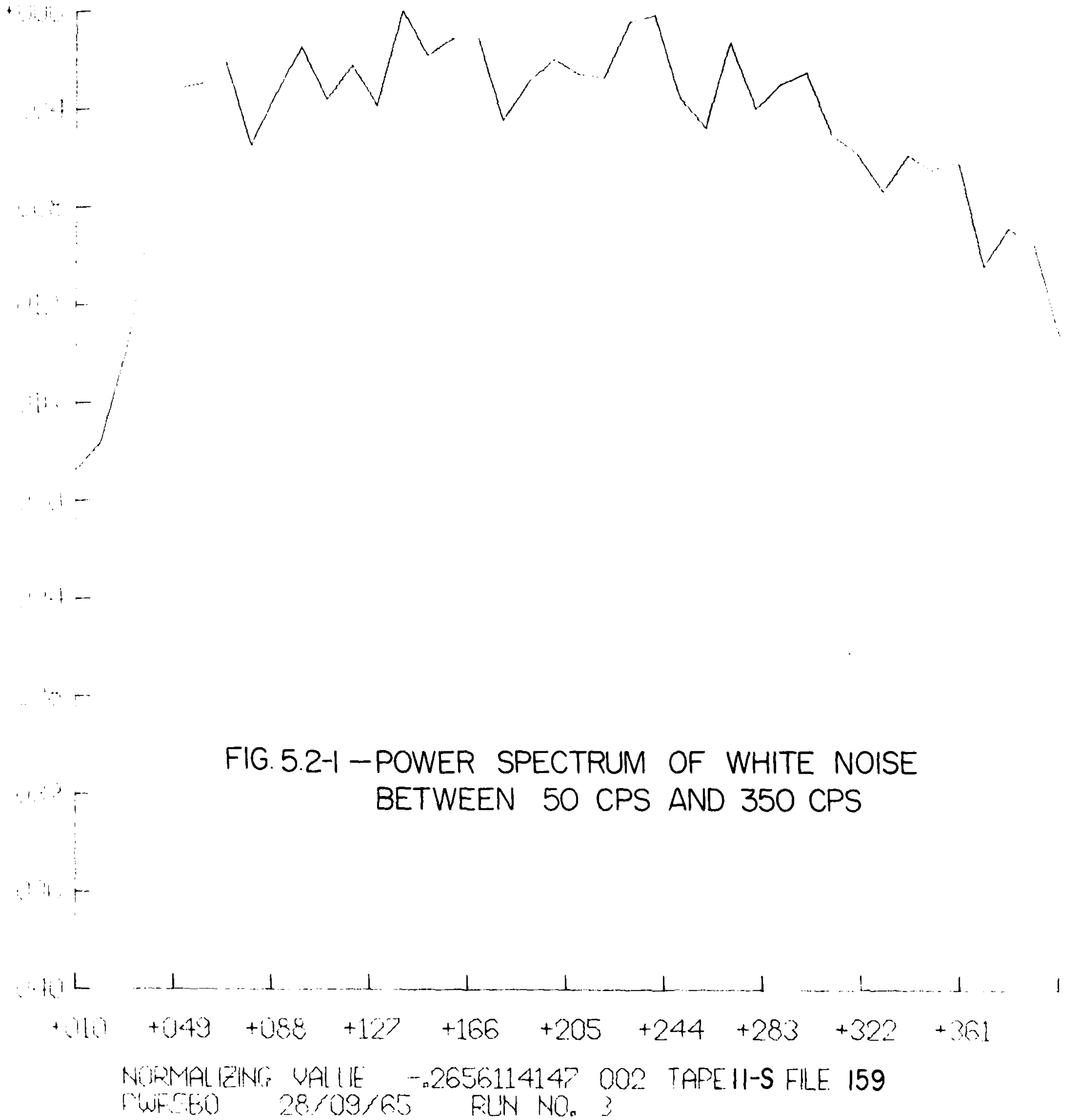

FIG. 5.2-1 — POWER SPECTRUM OF WHITE NOISE BETWEEN 50 CPS AND 350 CPS

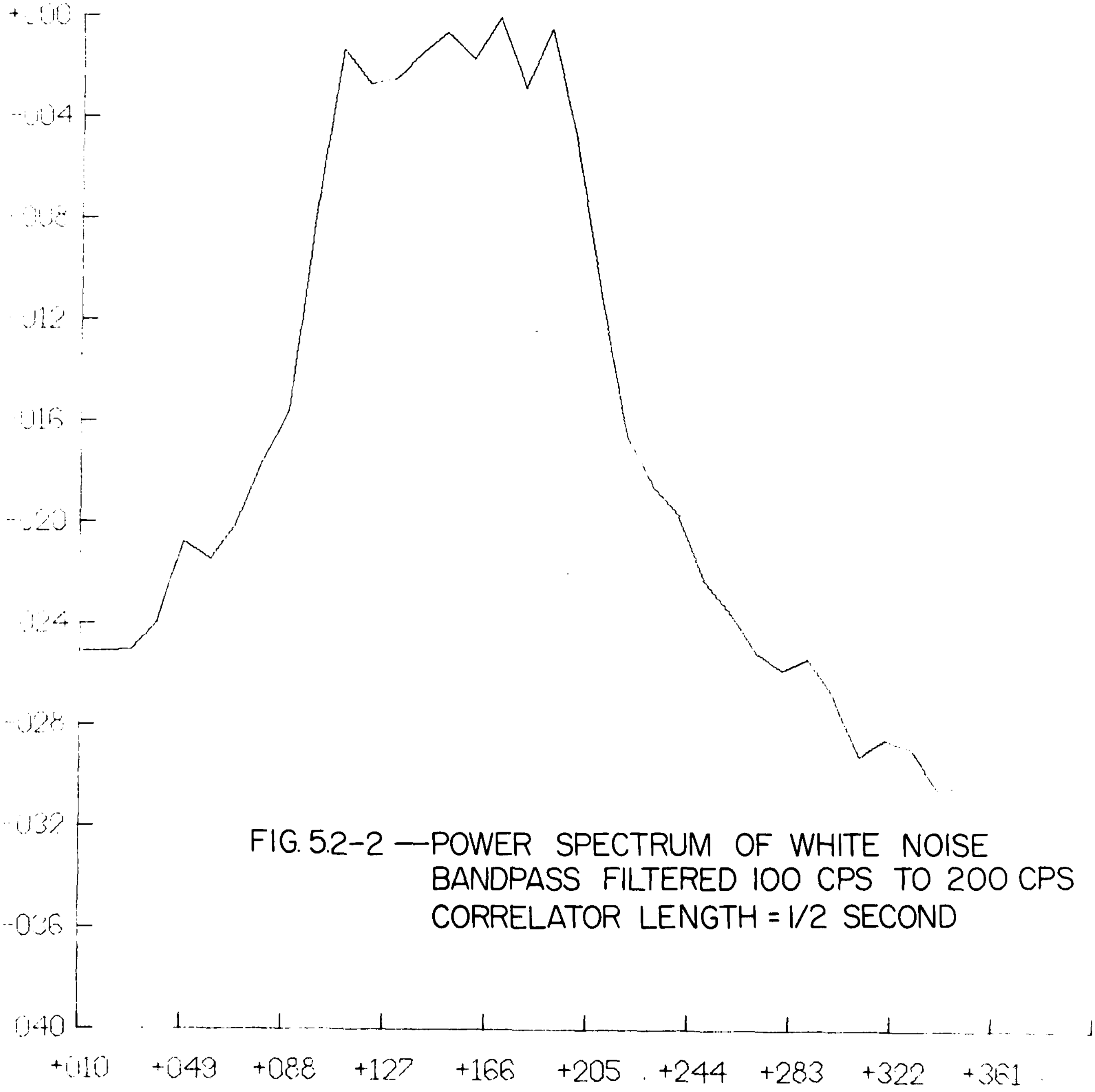

FIG. 5.2-2 —POWER SPECTRUM OF WHITE NOISE
BANDPASS FILTERED 100 CPS TO 200 CPS
CORRELATOR LENGTH = 1/2 SECOND

NORMALIZING VALUE -.5144096562 002 TAPE 8-S FILE 247_{10}
PWFSB1 28/09/65 RUN NO. 4

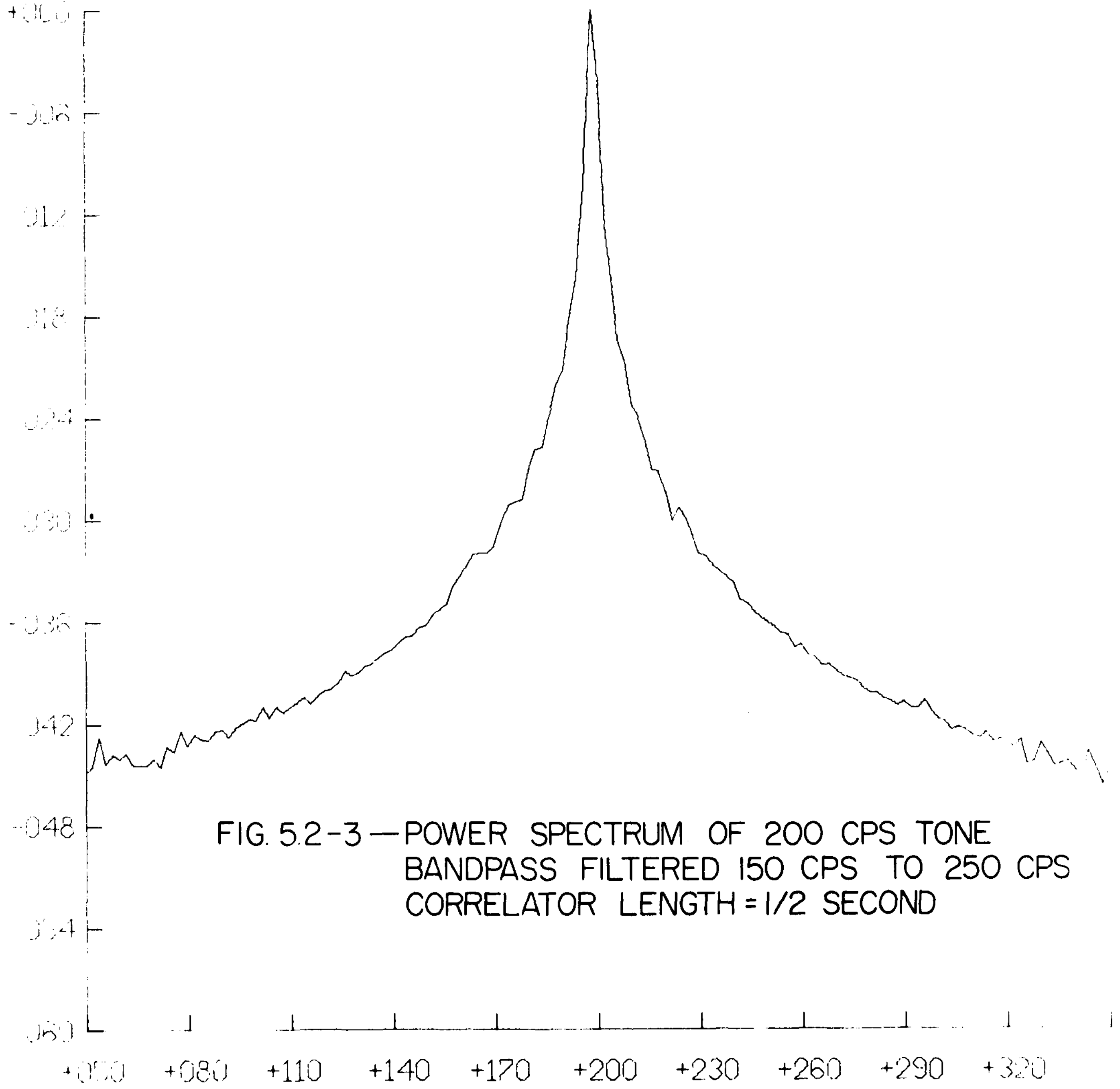

FIG. 5.2-3 — POWER SPECTRUM OF 200 CPS TONE BANDPASS FILTERED 150 CPS TO 250 CPS CORRELATOR LENGTH = 1/2 SECOND

NORMALIZING VALUE -.4987423512:02 TAPE 706 FILE 7
PWRSBO 15/10/65 RUN NO. 1

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To demonstrate the effect of this filter on recorded mutual interference data, a ping cycle was chosen which contained an echo and mutual interference. The data chosen was the second ping cycle of event 745A, from the GARCIA.

From the logs, this event was:

Run Type:	Track
Participating Units:	SENNET, BELKNAP, McCLOY, GARCIA
Formation:	SENNET Guide Station 0, BELKNAP 240R, McCLOY 300R, GARCIA 090 @ 10 kyd.
Sonar Mode:	BBØ - Track
Keying Interval Zone Start:	5 kyd

GARCIA was transmitting at F_2, BELKNAP was transmitting at F_3, and McCLOY was in receive mode. GARCIA was closing on SENNET from 10 kyd.

Two computer runs were made: One to bandpass filter the own ship FM and the other to bandpass the own ship CW. Fig. 5.2-4 shows the rectify and average, and frequency analysis, before and after the filtering process. The frequency limits used were taken from the 3 dB down points of the CX, FM filter: fo = 320 cps, fm = 480 cps. The scale factor A in Eq. (1) was A = 30. Figure 5.2-5 shows the same data, filtered with fo = 455 and fm = 600, which were taken from the 3 dB down points of the CX, CW filter. In this case, A = 70. The correlator length τ, in Eq. (5.2-1), was taken as ½ sec. in both cases. As illustrated in Fig. 5.2-4, a relatively poor filter, in combination with existing AX filtering, removes the direct interference signal from the FM band, similar to the performance expected in the CX and AX(Retrofit). Again, slight additional filtering of the data rejects the interference from the CW channel. In both cases, the echo has not been influenced and remains intact. The expected processing of the CX and AX(retrofit) filters will exceed the total filtering demonstrated and should eliminate this type of interference, except in very severe cases.

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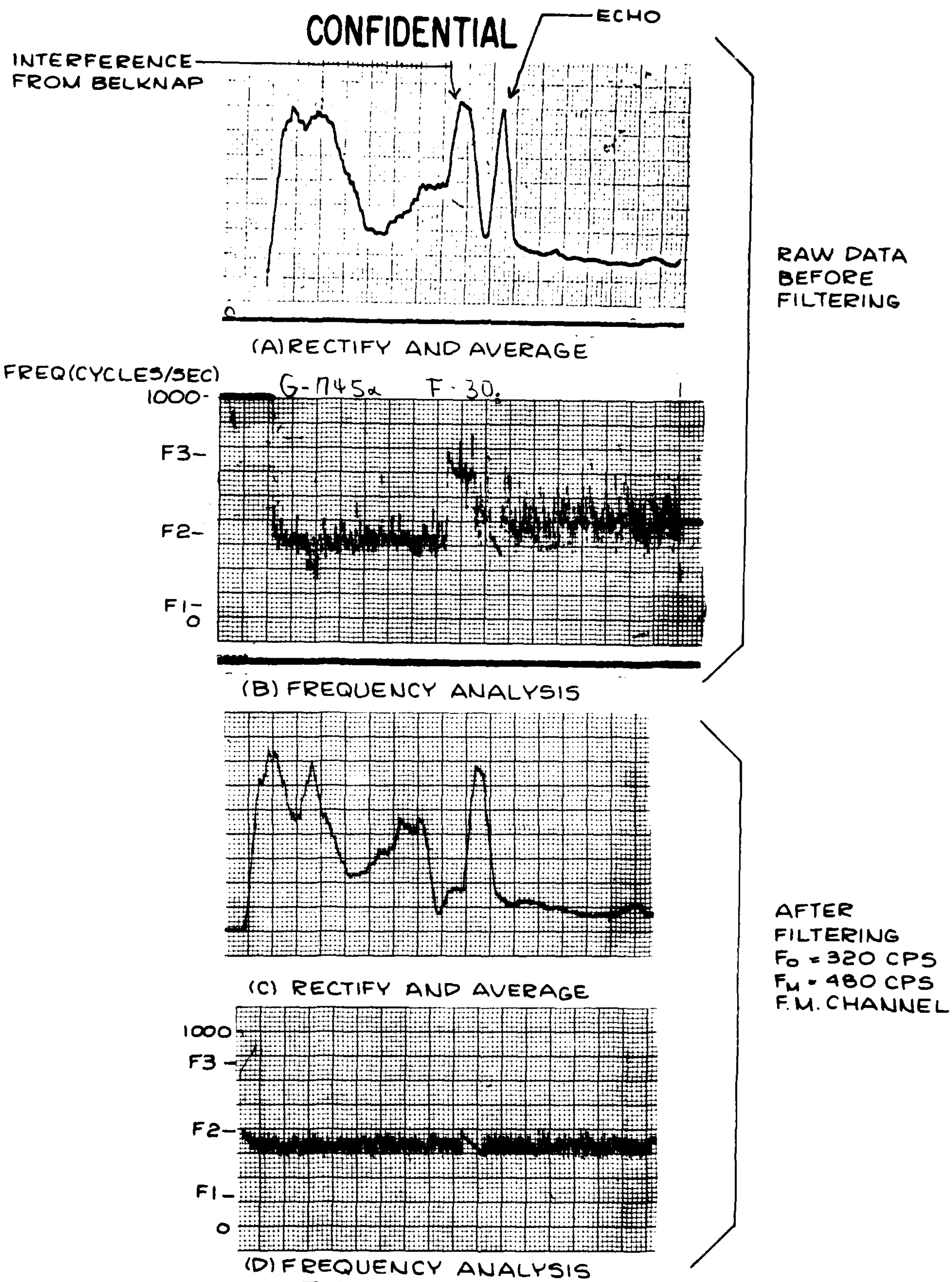

FIG. 5.2-4

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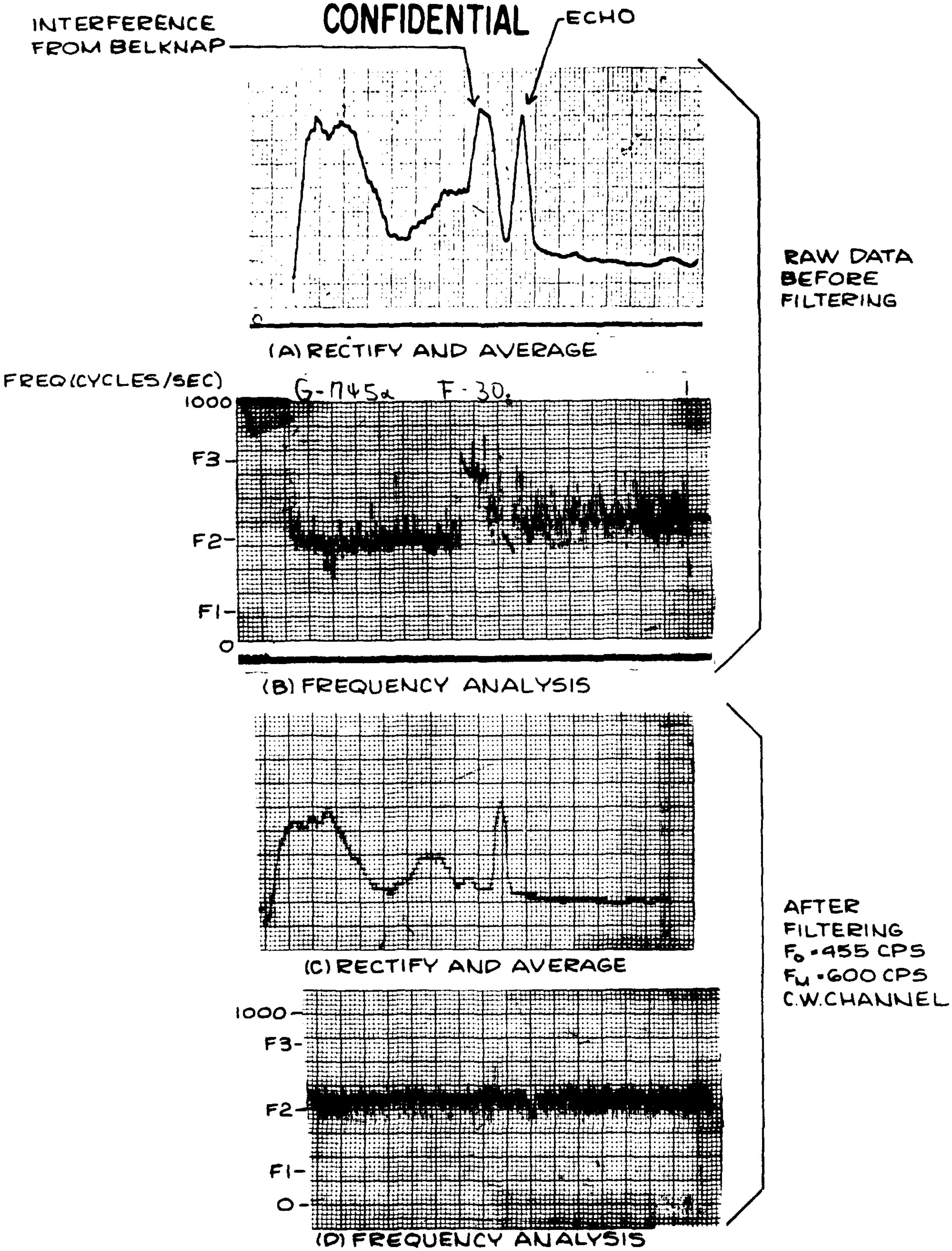

 FIG. 5.2-5

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APPENDIX A

AN/SQS-26 TESTS 19-25 JULY 1965

SEARCH PHASE

Participating Units: BELKNAP (DLG 26)
McCLOY (DE 1038)
GARCIA (DE11040)

Event No.	Sonar Mode	Ship Separation	Sonar Rel. Brg.			Xmit Sked			Freq Sked		
			McCLOY	BELKNAP	GARCIA	McCLOY	BELKNAP	GARCIA	McCLOY	BELKNAP	GARCIA
1	BB2Ø0DT	5 Kyd	↕	↕	↕	R	R	*[1]R	F1	F3	F2
2	↓	↓				T	T	T	↓	↓	↓
3						T	R	R			
4						R	T	R			
5						R	R	T			
6						T	T	R			
7						T	R	T			
8						R	T	T			
10						R	R	R	F1	F2	F1
11						T	T	T	↓	↓	↓
12						T	R	R			
13						R	T	R			
15						T	T	R			
20						T	T	*[2]R	F3	F2	F3
21						*[3]T	R	R	↓	↓	↓
22						R	T	R			
24						T	T	R			
29						T	T	T	F3	F1	F3
31						R	T	R	↓	↓	↓
34						T	R	T			
38	CZ					T	T	T	F1	F3	F2
40	↓					R	T	R	↓	↓	↓
41						R	R	T			
42						T	T	R			
43						T	R	T			
47						T	T	T	F1	F2	F1
48						T	R	R	↓	↓	↓
49						R	T	R			
52						T	R	T			
56						T	T	T	F3	F2	F2

*[1] GARCIA transmitted during first 1/4th of event

*[2] GARCIA did not transmit during first 1/3 of event

*[3] McCLOY has one transmit in which 2nd ping higher frequency

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Event No.	Sonar Mode	Ship Separation	Sonar Rel. Brg. McCLOY	Sonar Rel. Brg. BELKNAP	Sonar Rel. Brg. GARCIA	Xmit Sked McCLOY	Xmit Sked BELKNAP	Xmit Sked GARCIA	Freq Sked McCLOY	Freq Sked BELKNAP	Freq Sked GARCIA
57	CZ	5 Kyd	↕	↕	↕	T	R	R	F3	F2	F3
58						R	T	R	F3	F2	F3
60						T	T	R	F3	F2	F3
65						T	T	T	F3	F1	F3
67						R	T	R			
70						$*_4$T	R	T			
74	BB2ØODT					T	$*_5$T	T	F1	F3	F2
76			←	↑	→	$*_6$R	T	R			
77						R	R	T			
78						T	T	R			
79						T	R	T			
83						T	T	T	F1	F2	F1
85						R	T	R			
88						T	R	T			
92						T	T	T	F3	F2	F3
93						T	R	R			
96						T	T	R			
110	CZ					T	T	T	F1	F3	F2
112						R	T	R			
113						R	R	T			
114						T	T	R	F1	F3	F2
119						T	T	T	F1	F2	F1
128						T	T	T	F3	F2	F3
129						T	R	R	F3	F2	F3
146	BB2ØODT		→	←	←	T	T	T	F1	F3	F2
146A	BB2ØODT	5-10 Kyd				T	T	T	F1	F3	F2
148		5 Kyd				R	T	R			
149						R	R	T			
150						T	T	R			
151						T	R	T			
155						T	T	T	F1	F2	F1
157						R	T	R			
160						T	R	T			
164						T	T	T	F3	F2	F3
166						R	T	R	F3	F2	F3
182	CZ					T	T	T	F2	F3	F2
184						R	T	R	F1	F3	F2
191						T	T	T	F1	F2	F1
193						R	T	R	F1	F2	F1
200						T	T	T	F3	F2	F3

$*_4$McCLOY started in passive, later switched to transmit

$*_5$BELKNAP transmitted at F2 at start of event

$*_6$McCLOY started in transmit, later switched to passive

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Event No.	Sonar Mode	Ship Separation	Sonar Rel. Brg. McCLOY	Sonar Rel. Brg. BELKNAP	Sonar Rel. Brg. GARCIA	Xmit Sked McCLOY	Xmit Sked BELKNAP	Xmit Sked GARCIA	Freq Sked McCLOY	Freq Sked BELKNAP	Freq Sked GARCIA
218	BB2ØODT	10 Kyd	↑	↑	↑	T	T	T	F1	F3	F2
220						R	T	R			
221						R	R	T			
222						T	T	R			
223						T	R	T	↓	↓	↓
227						T	T	T	F1	F2	F1
229						R	T	R			
232						T	R	T	↓	↓	↓
236						T	T	T	F3	F2	F3
238						R	T	R			
241						T	R	T	↓	↓	↓
245	↓					T	T	T	F3	F1	F3
254	CZ					T	T	T	F1	F1	F2
256						R	T	R		F3	
259						T	R	T	↓	↓	↓
263						T	T	T	F1	F2	F1 FREQ ANALYSIS
264						T	*7R	R			
268						T	R	T	↓	↓	↓
272						T	T	T	F3	F2	F3
281	↓					T	T	T	F3	F1	F3
290	BB2ØODT		↓	↓	↓	T	T	T	F1	F3	F2
292				↑		R	T	R			
294			←	↑	→	T	T	R	↓	↓	↓
299						T	T	T	F1	F2	F1
301						R	T	R			
304	↓					T	R	T	↓	↓	↓
308	BB2ØODT					T	T	T	F3	F2	F3
310						R	T	R	F3	F2	F3
317	↓					T	T	T	F3	F1	F3
326	CZ					T	T	T	F2	F3	F2
328						R	T	R	F1	F3	F2
335						T	T	T	F1	F2	F1
344						T	T	T	F3	F2	F3
353	↓					T	T	T	F3	F1	F3
362	BB2ØODT	↓	↓	↓	↓	T	T	T	F1	F3	F2
362A	BB2ØODT	10-20 Kyd				T	T	T	F1	F3	F2
364	BB2ØODT	10 Kyd	→	→	←	R	T	R	F1	F3	F2

*7BELKNAP started event in transmit, later switched to passive

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Event No.	Sonar Mode	Ship Separation	Sonar Rel. Brg.			Xmit Sked			Freq Sked		
			McCLOY	BELKNAP	GARCIA	McCLOY	BELKNAP	GARCIA	McCLOY	BELKNAP	GARCIA
365	BB200DT	10 Kyd	→	←	←	R	R	T	F1	F3	F2
366	↓	↓	↓	↓	↓	T	T	R	↓	↓	↓
371						T	T	T	F1	F2	F1
373						R	T	R	F1	F2	F1
380						T	T	T	F3	F2	F3
381	↓					T	R	R	F3	F2	F3
398	CZ					T	T	T	F1	F2	F2
400	↓					R	T	R	↓	↓	↓
401						R	R	T	↓	↓	↓
407						T	T	T	F1	F2	F1
416						T	T	T	F3	F2	F3
425	↓		↓	↓	↓	T	T	T	F3	F1	F3
434	BB200DT		↑	↑	↑	T	T	T	F1	F3	F2
436	↓					R	T	R	↓	↓	↓
437		↓				R	R	T	↓	↓	↓
439		20 Kyd				T	R	T	↓	↓	↓
443		↓				T	T	T	F1	F2	F1
445						R	T	R	F1	F2	F1
452						T	T	T	F3	F2	F3
453						T	R	R	↓	↓	↓
461	↓					T	T	T	↓	F1	↓
470	CZ					T	T	T	F1	F3	F2
472	↓					R	T	R	↓	↓	↓
473						R	R	T	↓	↓	↓
479						T	T	T	F1	F2	F1
488						T	T	T	F3	F2	F3
497	↓		↓	↓	↓	T	T	T	F3	F1	F3
506	BB200DT			↑		T	T	T	F1	F3	F2
508	↓		→	↑	←	R	T	R	↓	↓	↓
509			↓	↓	↓	R	R	T	↓	↓	↓
510						*8 T	T	R	↓	↓	↓
511						T	R	T	↓	↓	↓
515						T	T	T	F1	F2	F1
517						R	T	R	F1	F2	F1
524						T	T	T	F3	F2	F3
529	↓	↓	↓	↓	↓	T	R	T	F3	F2	F3

*8 McCLOY changed to F2 for part of this event

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Event No.	Sonar Mode	Ship Separation	Sonar Rel. Brg.			Xmit Sked			Freq Sked		
			McCLOY	BELKNAP	GARCIA	McCLOY	BELKNAP	GARCIA	McCLOY	BELKNAP	GARCIA
533	BB2ØODT	20 Kyd	←	↑	→	T	T	T	F3	F1	F3
538	↓	↓				T	R	T	F3	F1	F3
542	CZ					T	T	T	F1	F3	F2
544	↓		↓	↓	↓	R	T	R	F1	F3	F2
553						R	T	R	F1	F2	F2
561						T	R	R	F1	F2	F3
578	BB2ØODT					T	T	T	F1	F3	F2
587	↓		→	←	←	T	#T	T	F1	F2	F1
596			↓	↓	↓	T	T	T	F3	F2	F3
605						T	T	T	F3	F1	F3
614	CZ					*T	T	T	F1	F3	F2
623	CZ					T	T	T	F1	F2	F1

*McCLOY was in BB2ØODT for events 614 and 623

#BELKNAP is not depressed 20°. There is no bottom reverberation.

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TRACK PHASE

Participating Units: BELNAP, McCLOY, GARCIA, SENNET

Formation: Sennet Guide Sta 0, Belnap 240 R, McCLOY 300 R, GARCIA 090 R

Event No.	Sonar Mode	Ship Separation	Keying Interval Zone Start (kyd)	Xmit Sked McCLOY	Xmit Sked BELKNAP	Xmit Sked GARCIA	Freq Sked McCLOY	Freq Sked BELKNAP	Freq Sked GARCIA
649	ODT	1.25 Kyd	2.5	R	R	R	F1	F3	F2
651A	ODT	↓	2.5	R	T	R	↓	↓	↓
657	BBØ	↓	0	R	R	T	↓	↓	↓
658	BB3Ø	↓	0	R	R	T	↓	↓	↓
660	ODT	↓	2.5	T	T	T	F1	F2	F1
668	BBØ	↓	0	R	R	T	↓	↓	↓
#667A	BB3Ø	↓	0	R	R	T	↓	↓	↓
669	ODT	↓	2.5	*T	T	T	F3	F2	F3
677	BBØ	↓	0	R	R	T	↓	↓	↓
678	BB3Ø	↓	0	R	R	T	↓	↓	↓
680	ODT	↓	2.5	T	T	T	F3	F1	F3
688	BBØ	↓	0	R	R	T	↓	↓	↓
689	BB3Ø	↓	0	R	R	T	↓	↓	↓
690	ODT	↓	2.5	T	T	T	F1	F2	F3
691	ODT	5 Kyd	10	R	R	R	F1	F3	F2
692	ODT	↓	10	T	T	T	↓	↓	↓
694	ODT	↓	10	R	T	R	↓	↓	↓
700	BBØ	↓	0	R	R	T	↓	↓	↓
701	BB3Ø	↓	0	R	R	T	↓	↓	↓
703	ODT	↓	10	T	T	T	F1	F2	F1
711	BBØ	↓	0	R	R	T	↓	↓	↓
712	BB3Ø	↓	0	R	R	T	↓	↓	↓
714	ODT	↓	10	T	T	T	F3	F2	F3
721	ODT	↓	10	T	T	T	↓	↓	↓
722	BBØ	↓	0	R	R	T	↓	↓	↓
723	BB3Ø	↓	0	R	R	T	↓	↓	↓
725	ODT	↓	10	T	T	T	F3	F1	F3
733A	BBØ	↓	0	R	R	T	↓	↓	↓

*McCLOY began event in transmit, but switched to passive

#GARCIA transmitted BB2ØODT triple ping

[redacted] UNCLASSIFIED

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Event No.	Sonar Mode	Ship Separation	Keying Interval Zone Start (kyd)	Xmit Sked McCLOY	Xmit Sked BELKNAP	Xmit Sked GARCIA	Freq Sked McCLOY	Freq Sked BELKNAP	Freq Sked GARCIA
734	BB3Ø	5 Kyd	0	R	R	T	F3	F1	F3
735	ODT	↓	10	T	T	T	↓	↓	↓
737	ODT	10 Kyd	15	T	T	T	F1	F3	F2
745	BBØ	↓	5	R	T	T	↓	↓	↓
745A	BBØ	↓	5	R	R	T	↓	↓	↓
746	BB3Ø	↓	5	R	R	T	↓	↓	↓
747	ODT	↓	15	R	R	R	F1	F2	F1
748	ODT	↓	15	T	T	T	↓	↓	↓
756	BBØ	↓	5	R	R	T	↓	↓	↓
757	BB3Ø	↓	5	R	R	T	↓	↓	↓
759	ODT	↓	15	T	T	T	F3	F2	F3
767	BBØ	↓	5	R	R	T	↓	↓	↓
768	BB3Ø	↓	5	R	R	T	↓	↓	↓
770	ODT	↓	15	T	T	T	F3	F1	F3
778	BBØ	↓	5	R	R	T	↓	↓	↓
779	BB3Ø	↓	5	R	R	T	↓	↓	↓
780	ODT	↓	15	T	T	T	F1	F2	F3
801	BB42	10 Kyd	7 kyd	T	T	T	F1	F2	F3
802	↓	↓	↓	T	R	R	↓	↓	↓
803	↓	↓	↓	R	T	R	↓	↓	↓
804	↓	↓	↓	R	R	T	↓	↓	↓
805	↓	↓	↓	T	T	T	F1	F3	F3
806	↓	↓	↓	T	R	R	↓	↓	↓
807	↓	↓	↓	R	T	R	↓	↓	↓
808	↓	↓	↓	R	R	T	↓	↓	↓

[redacted] UNCLASSIFIED