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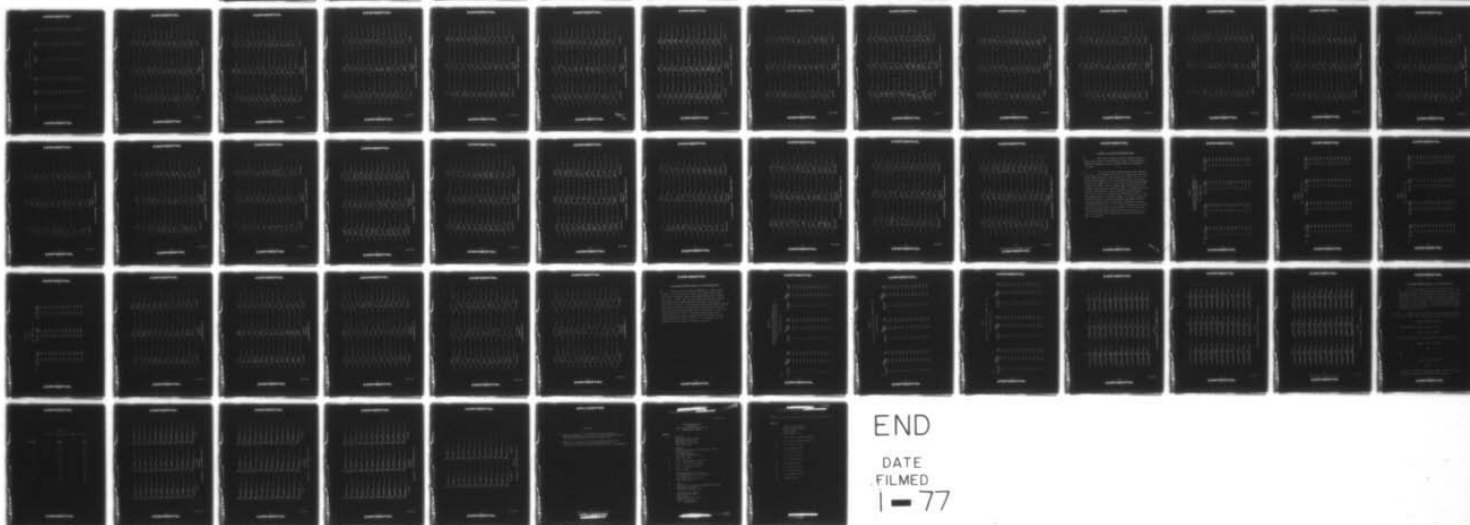
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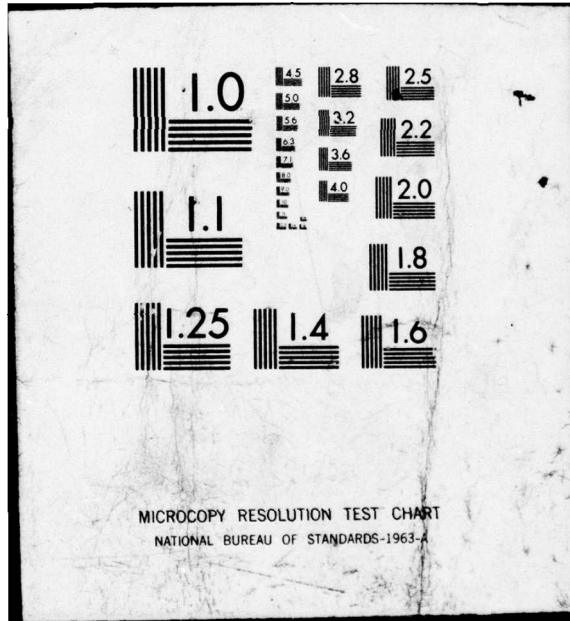
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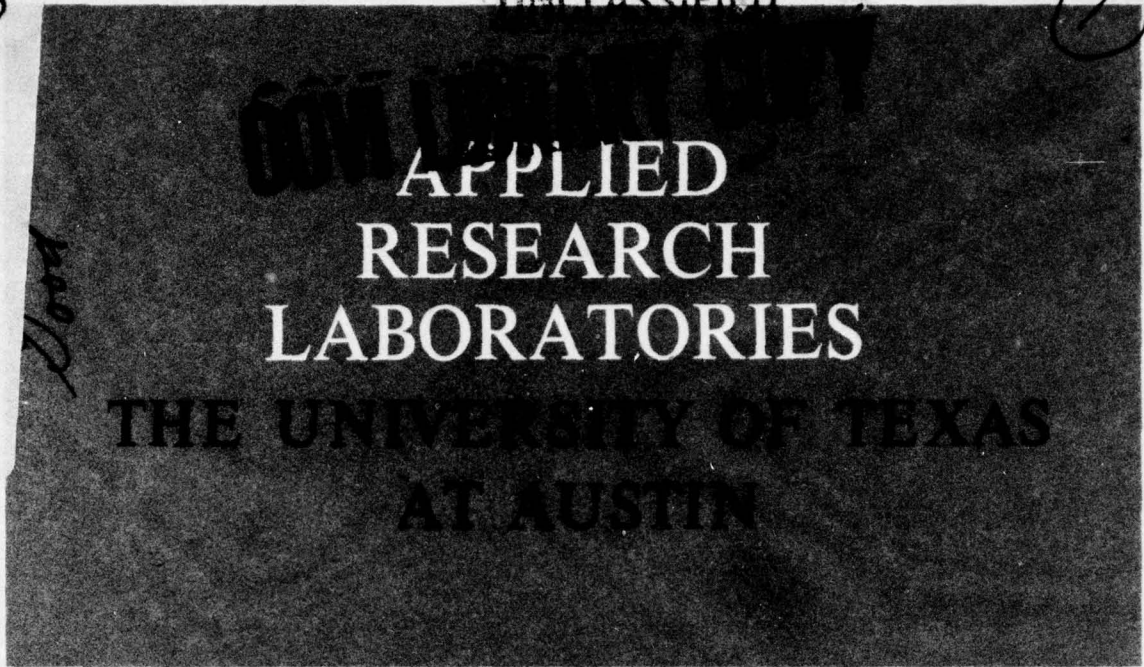
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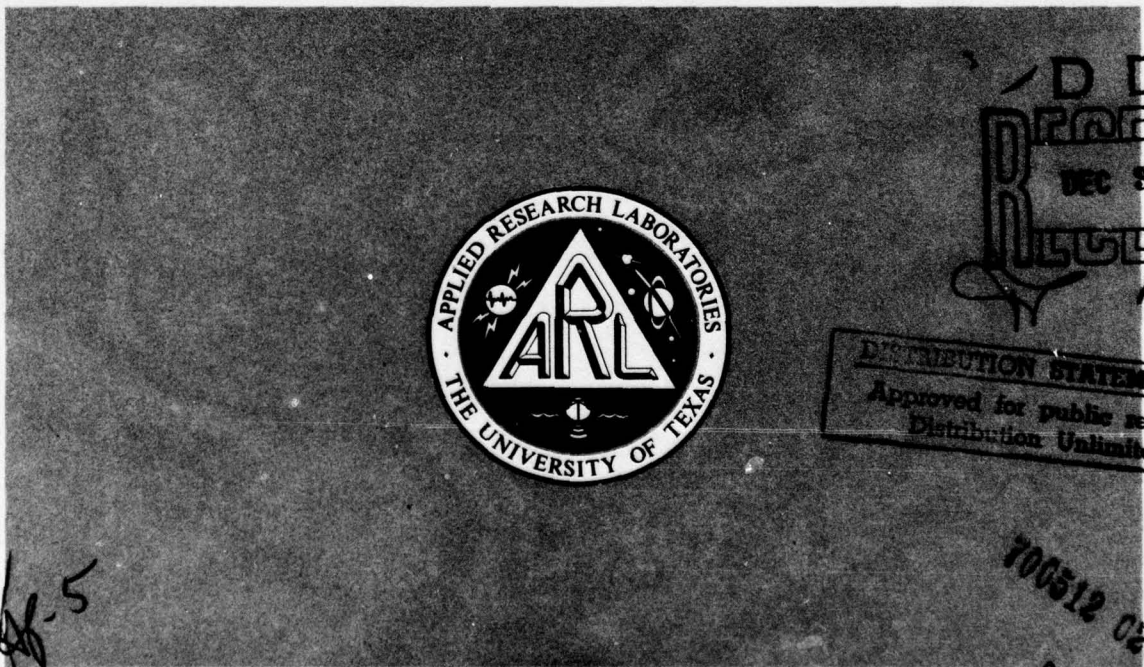
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✓ DIGITIZED SONAR DATA LOG: PART I (U)

T.D. Plemons

✓ NAVAL SHIP SYSTEMS COMMAND
Contract N00024-69-C-1129
Proj. Ser. No. SF 11121100, Task 8515



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10 T.D. Plemons

15 N00024-69-C-1129

NAVAL SHIP SYSTEMS COMMAND
Contract N00024-69-C-1129
Proj. Ser. No. SF 11121100 Task 8515

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INTRODUCTION

(C) This is the first of several collections of various types of digital data obtained by the Signal Physics Division of Applied Research Laboratories (ARL). Future data will not be restricted to echoes but will also contain collections of reverberation data.

(C) The digitized echoes were generated by the ASPECT (Acoustical Short Pulse Echo Classification Technique) mode of the AN/SQS-23 sonar. Echoes from targets corresponding to three target aspect angles are presented. This set of data should prove valuable to those persons doing research in signal processing since use of the digital computer now has a prominent role in this field. The data are readily available since they are stored on ARL's digital tapes which can be easily duplicated. Detailed records of these signals are included. These records provide information pertaining to the transmit signals, target geometry, digitizing technique, etc.

(C) Since the echoes were generated by the ASPECT transmission mode, a high data rate of information from the target is available in that the pulses within a burst of transmitted waveforms are separated by only 375 msec. Figure 1 is a schematic drawing of the ASPECT mode. Here is shown a set of 12 submarine echoes generated by a burst of 12 short pulses.

(U-FOUO) Two types of sampling were used in digitizing these data. Direct sampling refers to sampling the echo waveform, assumed to be narrow band with center frequency f_0 and bandwidth W , at the rate of $4f_0$. Quadrature sampling refers to a sampling technique with which

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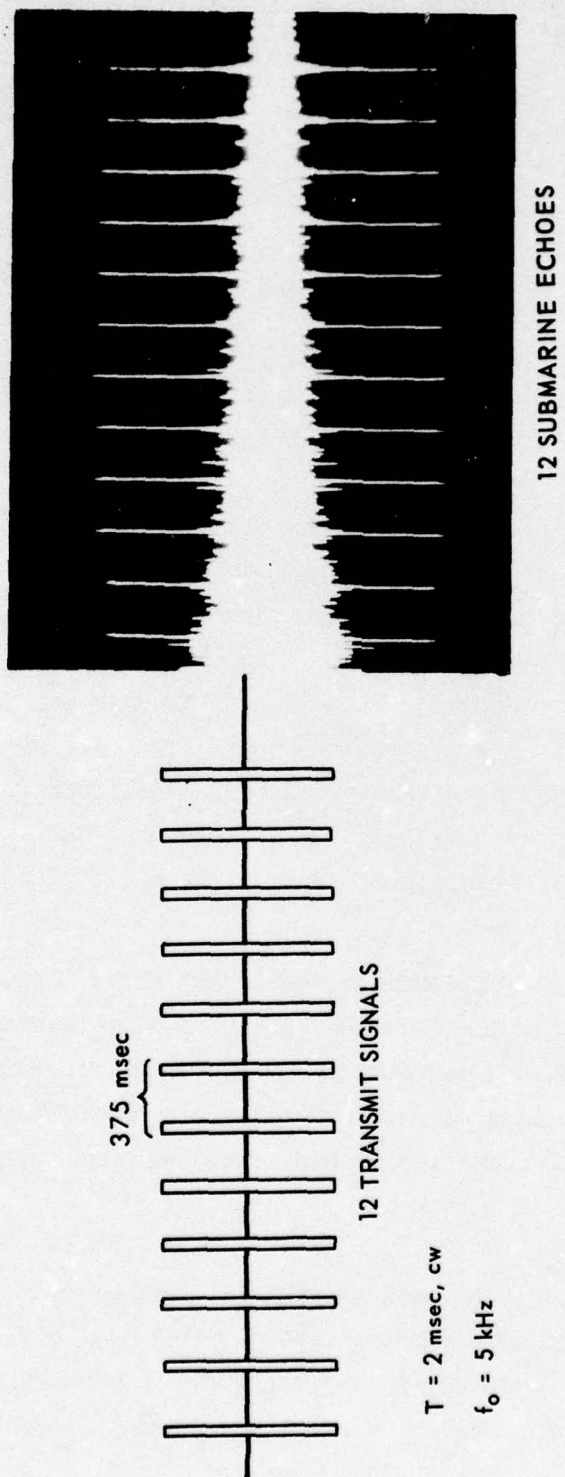


FIGURE 1
A BURST OF 12 TRANSMIT SIGNALS AND THE
CORRESPONDING SET OF SUBMARINE ECHOES

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(U-FOUO) the quadrature components of the signal are obtained directly (Ref. 1).

If the echo $y(t)$ is written in the form

$$y(t) = X(t) \cos 2\pi f_0 t + Y(t) \sin 2\pi f_0 t \quad ,$$

then $X(t)$ and $Y(t)$ are called the quadrature components of the echo $y(t)$. All information, other than the carrier frequency f_0 , concerning $y(t)$ is contained in $X(t)$ and $Y(t)$. Since these functions are bandlimited to the interval

$$|f| \leq \frac{W}{2} \quad ,$$

they are of much lower frequency than $y(t)$ and hence the required sampling rate is lower.

- (C) These data were obtained originally in analog form by ARL personnel in September 1965. Conversion from analog to digital format occurred during the past two years as specific research needs for the data arose. One example of the usefulness of such a data collection can be seen in an ARL report on echo-echo correlation characteristics (Ref. 2). The beam aspect echoes display a considerable variation in the envelope structure from echo to echo. It would be of interest to know the statistical characteristics of this variation. Some important questions that should be investigated are: Is the variation purely random or does it have a deterministic nature? What is the source of this variation? Why do the beam aspect data display a much lower consistency than do the bow or stern data? Would non-submarine targets with submarine-like geometry exhibit similar variations in envelope structure? Accurate determination of the epoch of these echoes is another area of research. This problem is discussed briefly in this memorandum, but no attempt was made to

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(C) attack it in any persistent effort. Highlight structure of the echoes merits attention. Of particular interest is again the beam aspect data since here can be seen the decrease in range resolution as the transmit pulse length increases from 1 to 2 to 5 msec. These are only a very few of the questions or problems concerned with these data that are open to investigation.

(U-FOUO) Each echo is represented by a plot of its envelope. A small interval precedes the beginning of the echo epoch and a similar interval follows the end of the epoch. Epoch was determined by measuring the time occurrence of the 50% level of some consistent or repeatable feature of the envelope. Repeatable refers here to consistency from echo to echo, and not to within one echo. The set was then "aligned" using these threshold points to form a common time or phase among the echoes. An ensemble average of the aligned envelopes was then computed and plotted. The average of several noise envelopes will tend to a constant level, with respect to time (provided the noise process is locally stationary). Whenever the echo is present in the set, a time variation in the average envelope occurs and the epoch can be approximated. The accuracy of this technique increases as the signal-to-noise ratio increases.

(U-FOUO) The envelope was chosen to determine the epoch since it is a more slowly varying time function than is the high frequency waveform which we refer to as the amplitude. The uncertainty inherent in a finite sampling rate would cause the computed average amplitude to mistakenly tend to zero. Accurate calculation of epoch is hampered by any noise present. Also averaging over a finite number of echoes produces an error in the computation of epoch. An optimum determination of epoch was not attempted. The averaging technique was used because of its simplicity and ease of execution. However, the interval preceding and following each echo does allow for error in calculated epoch.

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(U-FOUO) The data are presented in three sections corresponding to beam, stern, and bow aspect submarine targets. At the beginning of each section is a brief description of the data and associated plots, digitizing techniques, etc.

A. Beam Aspect Submarine Echoes

(C) The collection of beam aspect submarine echoes is divided into two groups, A and B. Group A refers to data collected on 15 November 1965, while the data in Group B was collected on 16 November 1965. The echoes of Group A were generated by 1 and 2 msec transmit pulses and the echoes of Group B by 1, 2, and 5 msec transmit pulses.

1. Group A: 1 and 2 msec Transmit Pulses

(C) Group A consists of two parts corresponding to transmit pulse lengths of 1 and 2 msec. The transmit pulse is a cw waveform of frequency 5 kHz. The data were sampled in quadrature, each component being sampled with a rate of 2500 samples per second. Each burst of 12 transmit signals results in a set of 12 echoes.

(C) The digitized data are stored on ARL computer tape 649. Each record on this tape corresponds to an entire set of 12 echoes. Therefore, associated with each record are 12 pairs of numbers each of which give the beginning (IFROM) and end (ITO) of the 12 envelope plots. The odd record numbers in each pair correspond to the X components and the even record numbers to the Y components.

(C) The destroyer and submarine maintained approximately parallel courses, each with a speed of 4 kt. The target aspect was 84 deg from stern. The range was 4000 yd.

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(U-FOUO) Corresponding to the 2 msec transmit pulse there are 18 echo sets, each set containing 12 echoes. Each plotted echo is 120 samples long. Therefore, each plot corresponds to approximately 48 msec since the sample rate was 2500 (sec)^{-1} . In Tables I, II, and III the IFROM and ITO of the plot of the first echo in each set is listed. The IFROMs and ITOs of the remaining 11 echoes in each set can be calculated from the formulas

$$(\text{IFROM})_n = (\text{IFROM})_1 + (n-1)(936) \quad ,$$

and

$$(\text{ITO})_n = (\text{ITO})_1 + (n-1)(936) \quad ,$$

for $n = 1, 2, \dots, 11, 12$.

(U-FOUO) As an example, the IFROM and ITO of the first plot of the third set are 580 and 700, respectively. The IFROM and ITO of the fifth plot of this set are

$$\begin{aligned} (\text{IFROM})_5 &= 580 + (5-1)(936) \\ &= 4324 \end{aligned}$$

and

$$\begin{aligned} (\text{ITO})_5 &= 700 + (5-1)(936) \\ &= 4444 \quad , \end{aligned}$$

respectively.

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(C) Following these tables are Figs. 2 through 7 which contain the individual echo plots. Each column of 12 plots represents a set of 12 echoes resulting from a burst of 12 transmitted signals. Below each column are three numbers written in the form $l(m,n)$. The integer l denotes the particular set of 12 echoes, and m and n are record numbers (computer tape 649) corresponding, respectively, to the X and Y quadrature components. There are 18 echo sets corresponding to the 2 msec transmitted signal. Therefore l , in Figs. 2 through 7, varies from 1 to 18. Similarly the echo sets resulting from the 1 msec transmitted signals are described by Tables II and III and Figs. 8 through 24.

(U-FOUO) The plots corresponding to the 1 msec transmit pulses are 90 samples (= 36 msec) long. The calculation of IFRMs and ITOs for these plots is identical to that of the 2 msec data.

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TABLE I

Group A: 2 msec Transmit Pulse (U)

| (C) | <u>Set No.</u> | <u>IFROM</u> | <u>ITO</u> |
|-----|----------------|--------------|------------|
| | 1 | 614 | 734 |
| | 2 | 617 | 737 |
| | 3 | 580 | 760 |
| | 4 | 517 | 637 |
| | 5 | 515 | 635 |
| | 6 | 518 | 638 |
| | 7 | 520 | 640 |
| | 8 | 526 | 648 |
| | 9 | 527 | 647 |
| | 10 | 531 | 651 |
| | 11 | 529 | 649 |
| | 12 | 531 | 651 |
| | 13 | 534 | 654 |
| | 14 | 536 | 656 |
| | 15 | 535 | 655 |
| | 16 | 543 | 663 |
| | 17 | 551 | 671 |
| | 18 | 560 | 680 |

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TABLE II
Group A: 1 msec Transmit Pulse (U)

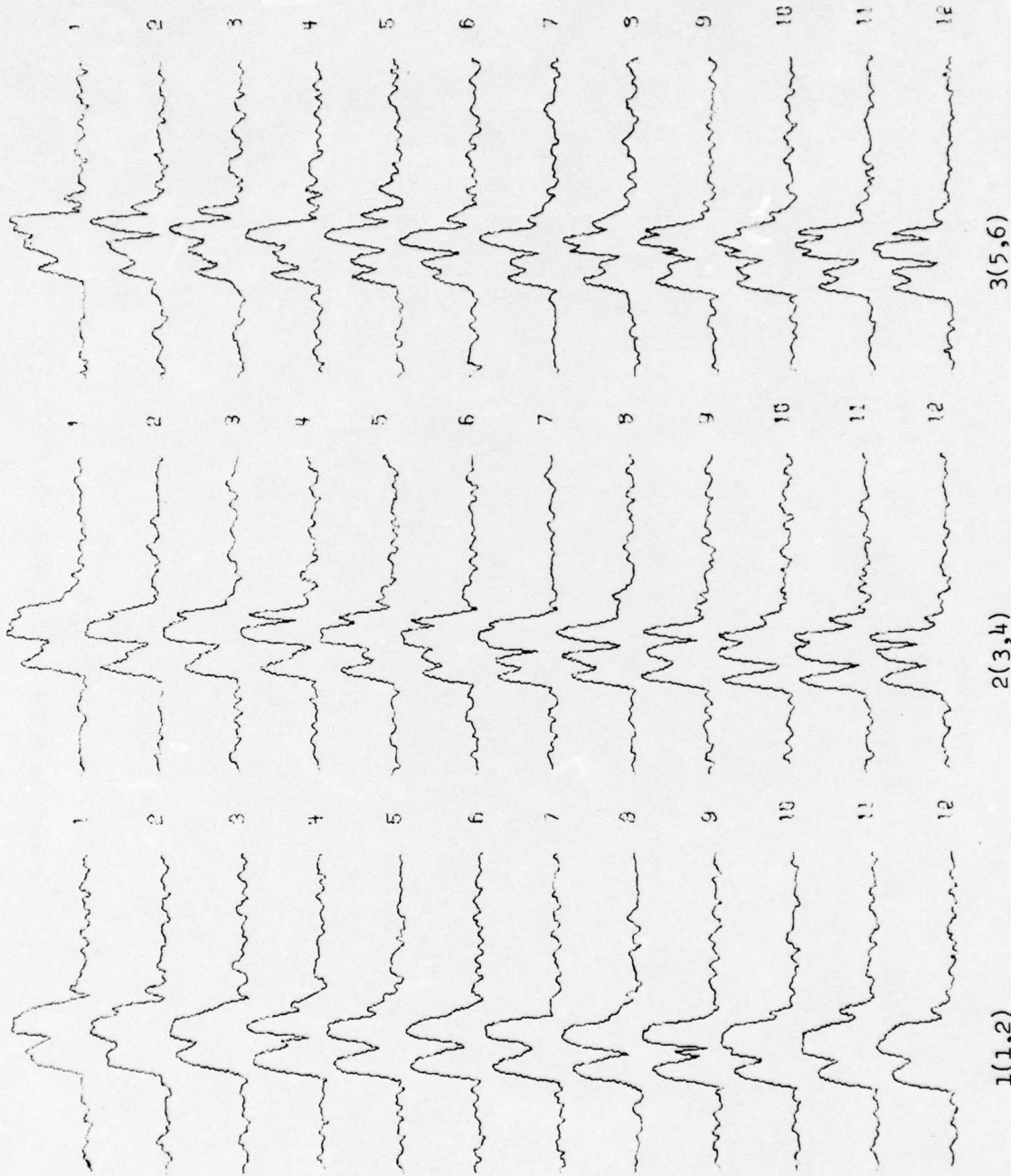
| (C) | <u>Set No.</u> | <u>IFROM</u> | <u>ITO</u> | <u>Set No.</u> | <u>IFROM</u> | <u>ITO</u> |
|-----|----------------|--------------|------------|----------------|--------------|------------|
| | 1 | 579 | 669 | 14 | 519 | 609 |
| | 2 | 582 | 679 | 15 | 499 | 589 |
| | 3 | 592 | 682 | 16 | 510 | 600 |
| | 4 | 601 | 691 | 17 | 506 | 596 |
| | 5 | 608 | 698 | 18 | 512 | 602 |
| | 6 | 614 | 704 | 19 | 524 | 614 |
| | 7 | 618 | 708 | 20 | 519 | 609 |
| | 8 | 622 | 712 | 21 | 530 | 620 |
| | 9 | 622 | 712 | 22 | 461 | 551 |
| | 10 | 630 | 720 | 23 | 459 | 549 |
| | 11 | 629 | 719 | 24 | 468 | 558 |
| | 12 | 633 | 743 | 25 | 480 | 570 |
| | 13 | 572 | 662 | 26 | 478 | 568 |

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TABLE III
Group A: 1 msec Transmit Pulse (U)

| (c) | <u>Set No.</u> | <u>IFROM</u> | <u>ITO</u> | <u>Set No.</u> | <u>IFROM</u> | <u>ITO</u> |
|-----|----------------|--------------|------------|----------------|--------------|------------|
| | 27 | 481 | 571 | 40 | 501 | 591 |
| | 28 | 489 | 579 | 41 | 493 | 591 |
| | 29 | 492 | 582 | 42 | 498 | 588 |
| | 30 | 501 | 591 | 43 | 501 | 591 |
| | 31 | 501 | 591 | 44 | 504 | 594 |
| | 32 | 514 | 604 | 45 | 506 | 596 |
| | 33 | 469 | 559 | 46 | 511 | 601 |
| | 34 | 458 | 548 | 47 | 512 | 602 |
| | 35 | 469 | 559 | 48 | 511 | 601 |
| | 36 | 490 | 580 | 49 | 513 | 603 |
| | 37 | 486 | 576 | 50 | 516 | 606 |
| | 38 | 493 | 583 | 51 | 518 | 608 |
| | 39 | 497 | 587 | 52 | 520 | 610 |

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3(5,6)

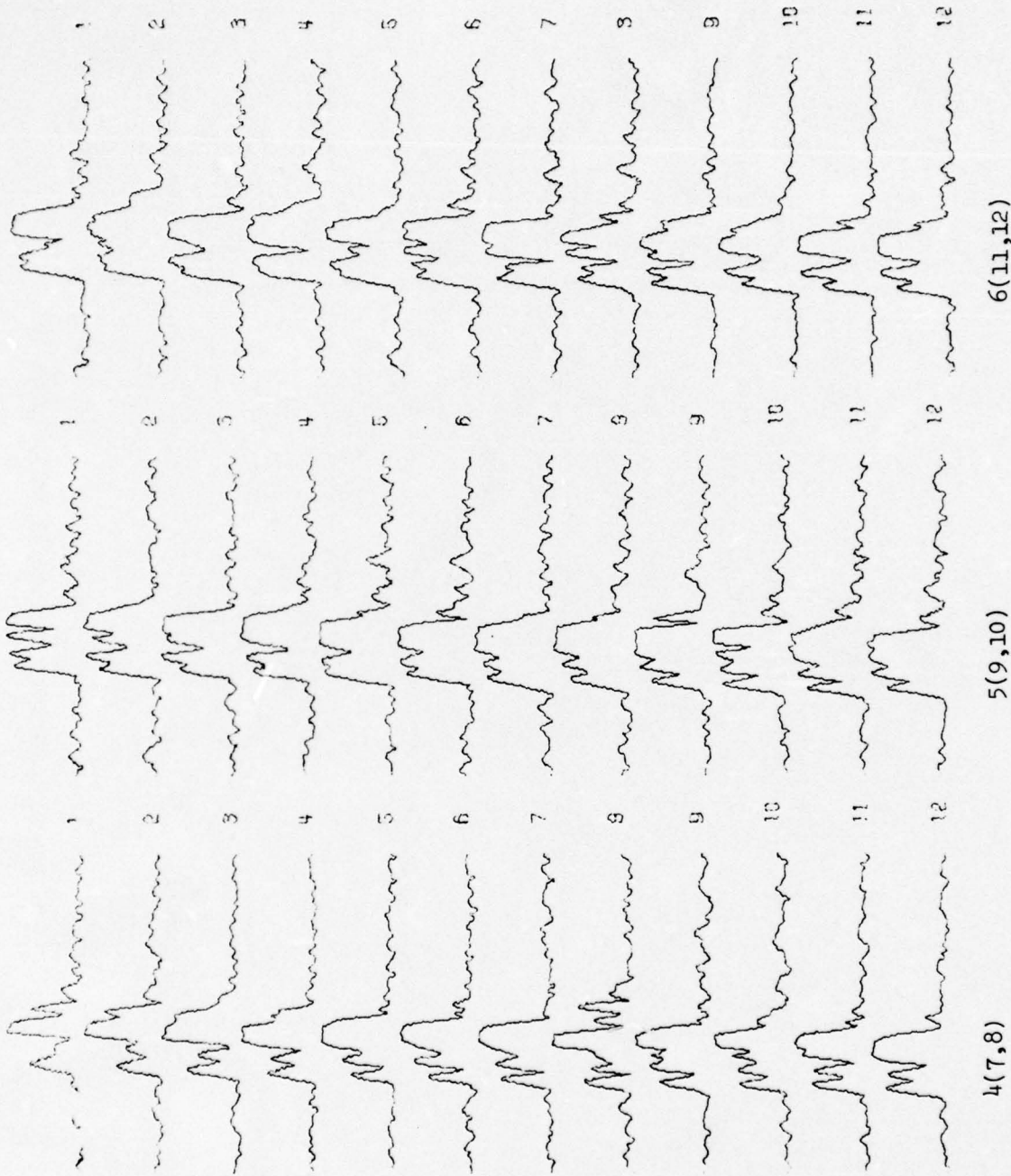
2(3,4)

1(1,2)

FIGURE 2
84 deg BEAM ASPECT: 2 msec TRANSMIT PULSE (U)

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6(11,12)

5(9,10)

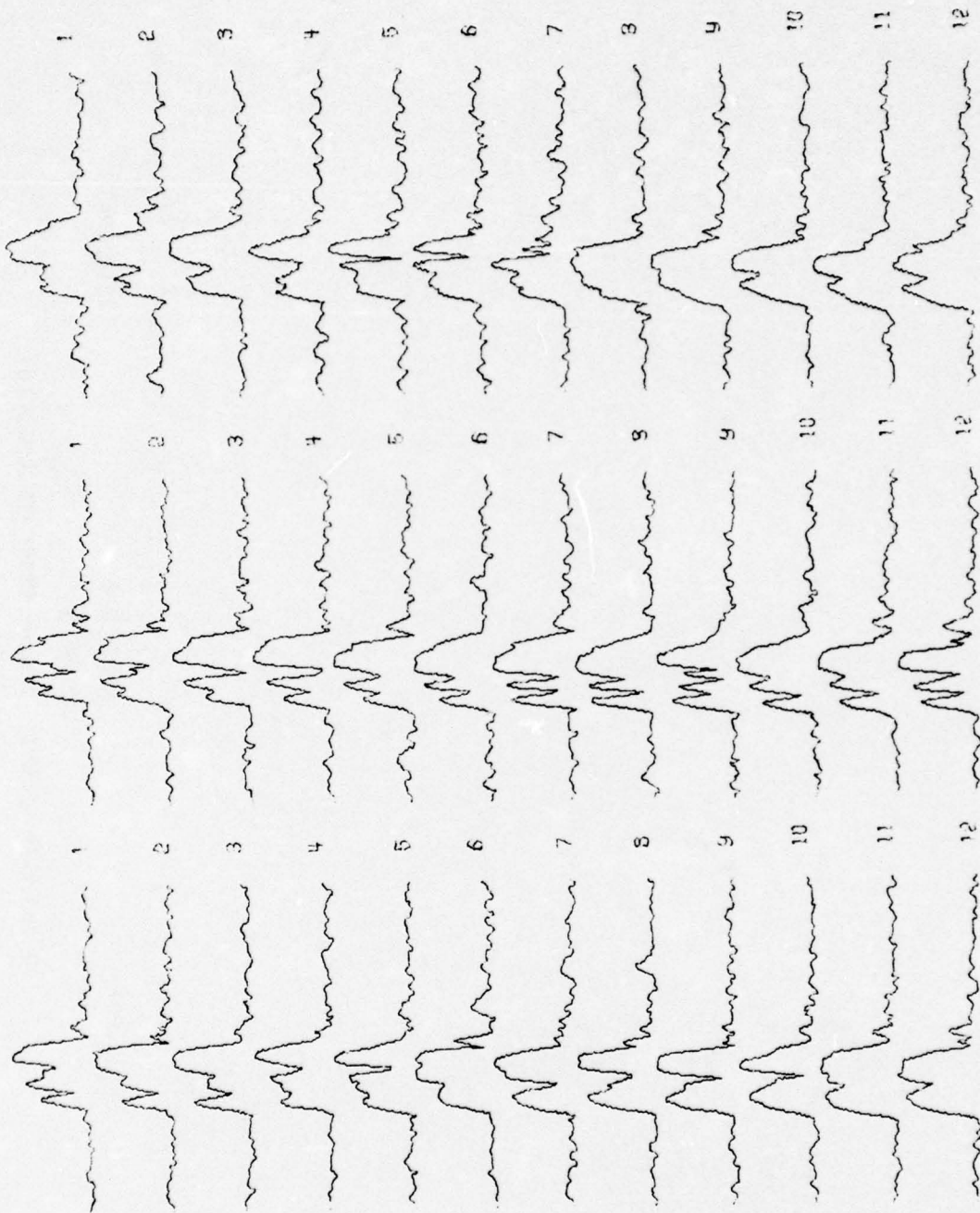
4(7,8)

FIGURE 3

84 deg BEAM ASPECT: 2 msec TRANSMIT PULSE (U)

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7(13,14)

8(15,16)

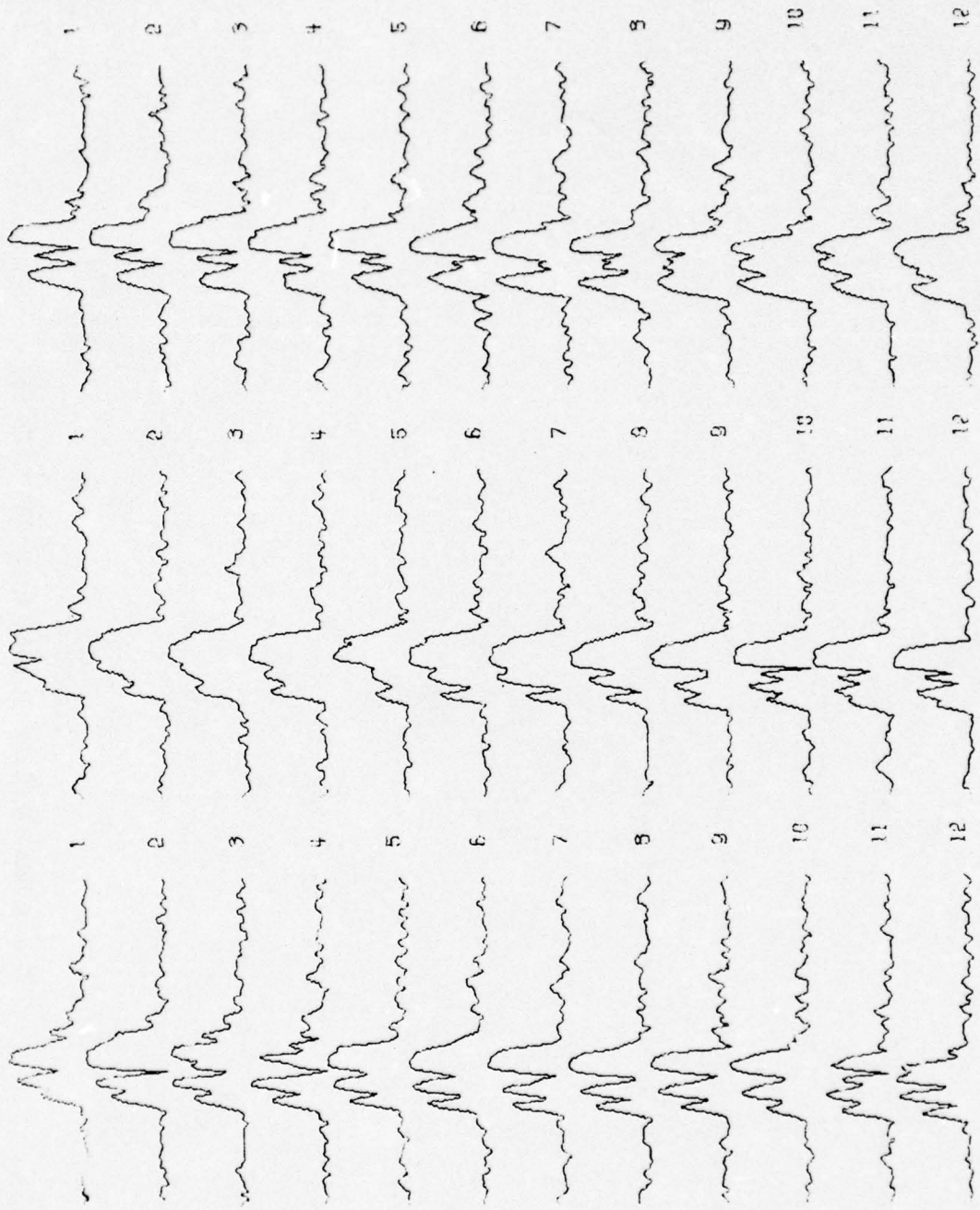
9(17,18)

FIGURE 4

84 deg BEAM ASPECT: 2 msec TRANSMIT PULSE (U)

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10(19,20)

11(21,22)

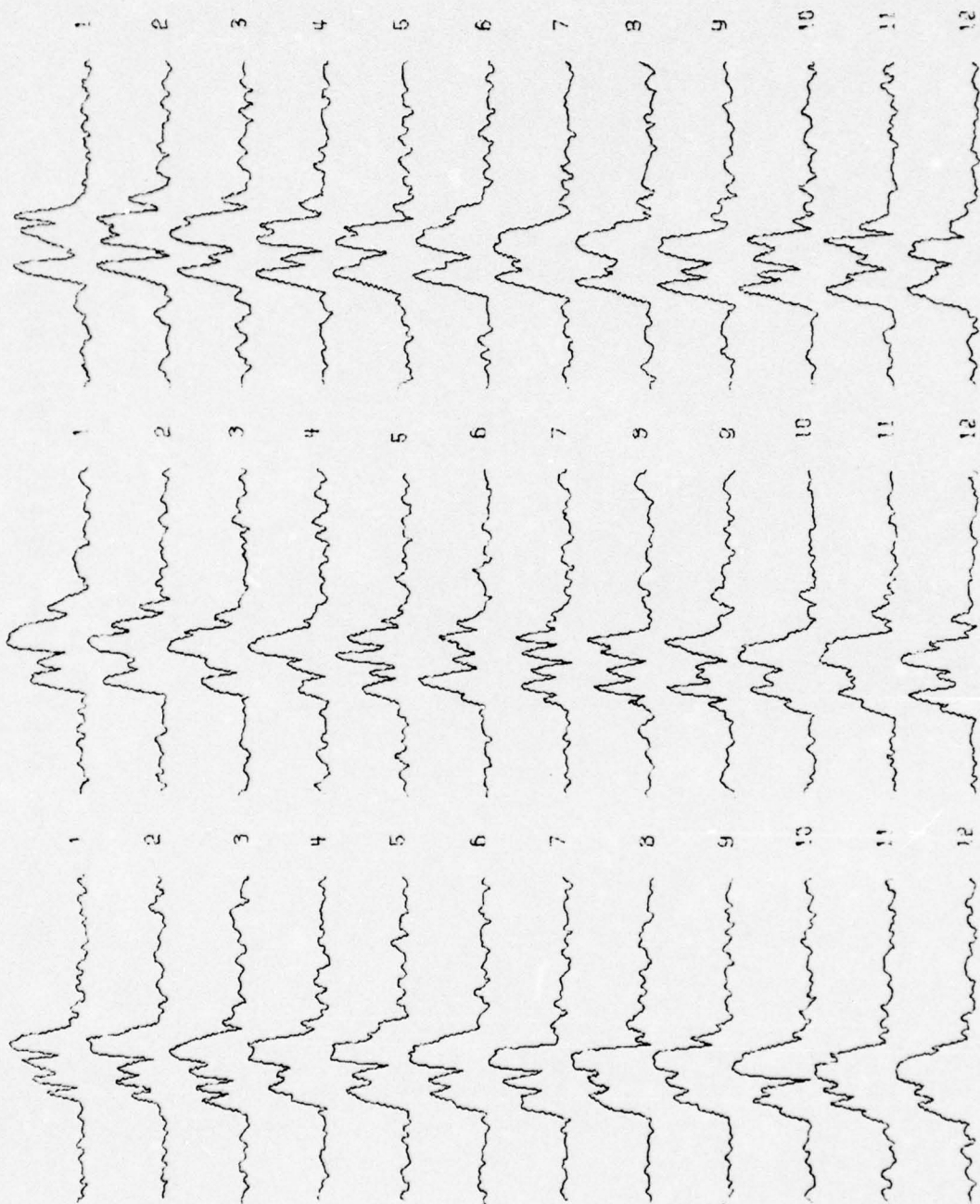
12(23,24)

FIGURE 5

84 deg BEAM ASPECT: 2 msec TRANSMIT PULSE (U)

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13(25,26)

14(27,28)

15(29,30)

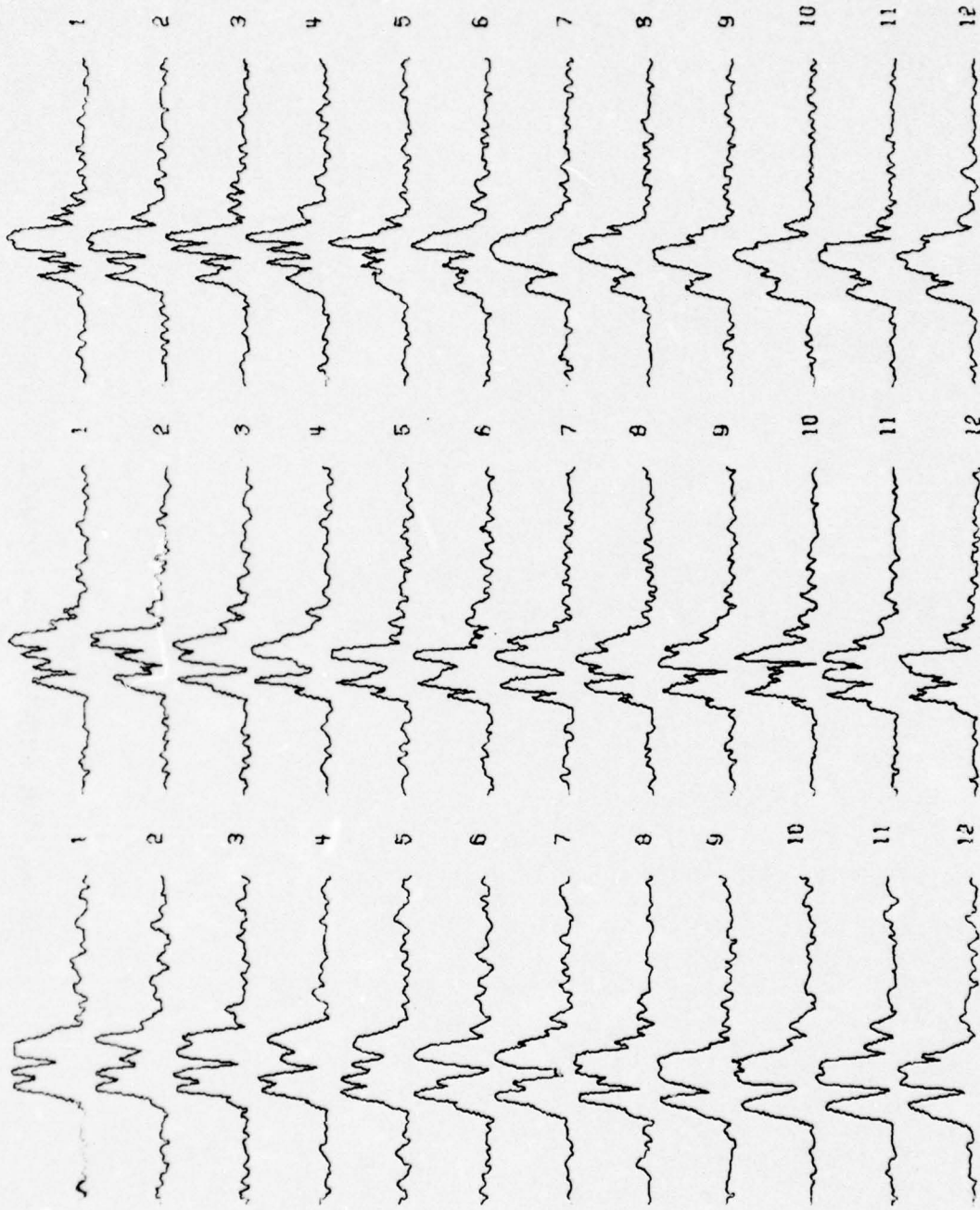
FIGURE 6

84 deg BEAM ASPECT: 2 msec TRANSMIT PULSE (U)

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166712 020

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16(31,32)

17(33,34)

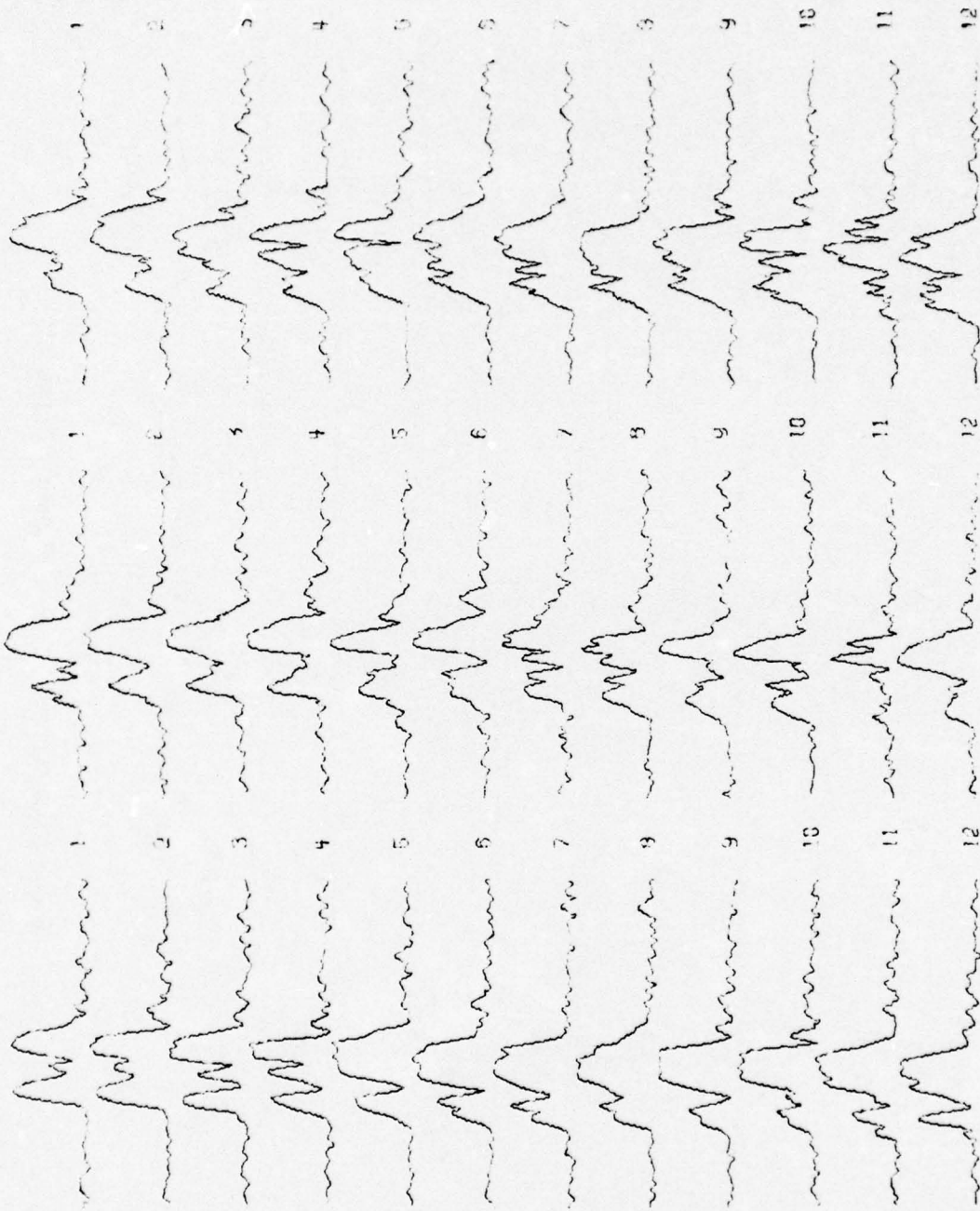
18(35,36)

FIGURE 7

84 deg BEAM ASPECT: 2 msec TRANSMIT PULSE (U)

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3 (41, 42)

2 (39, 40)

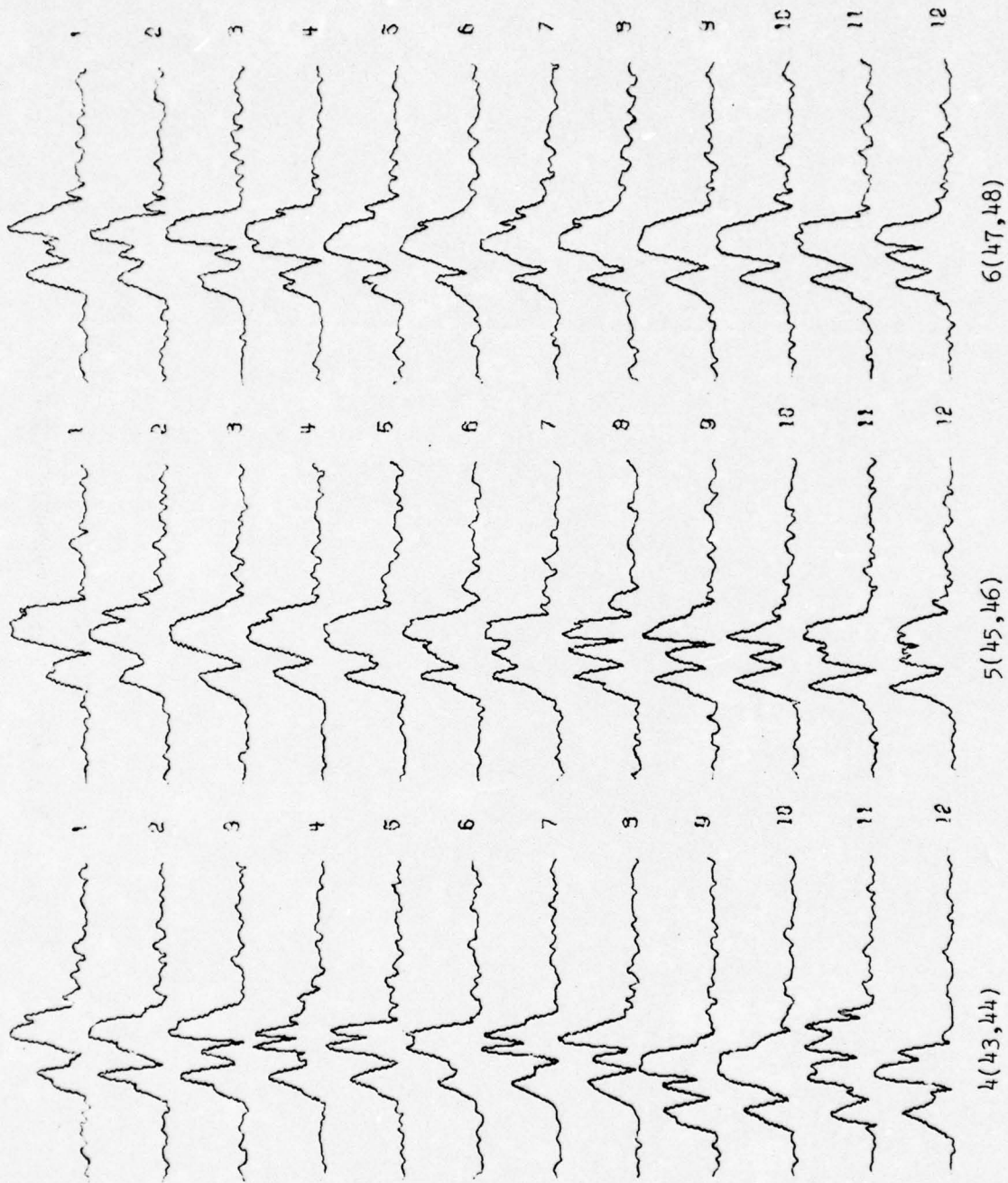
1 (37, 38)

FIGURE 8

84 deg BEAM ASPECT: 1 msec TRANSMIT PULSE (U)

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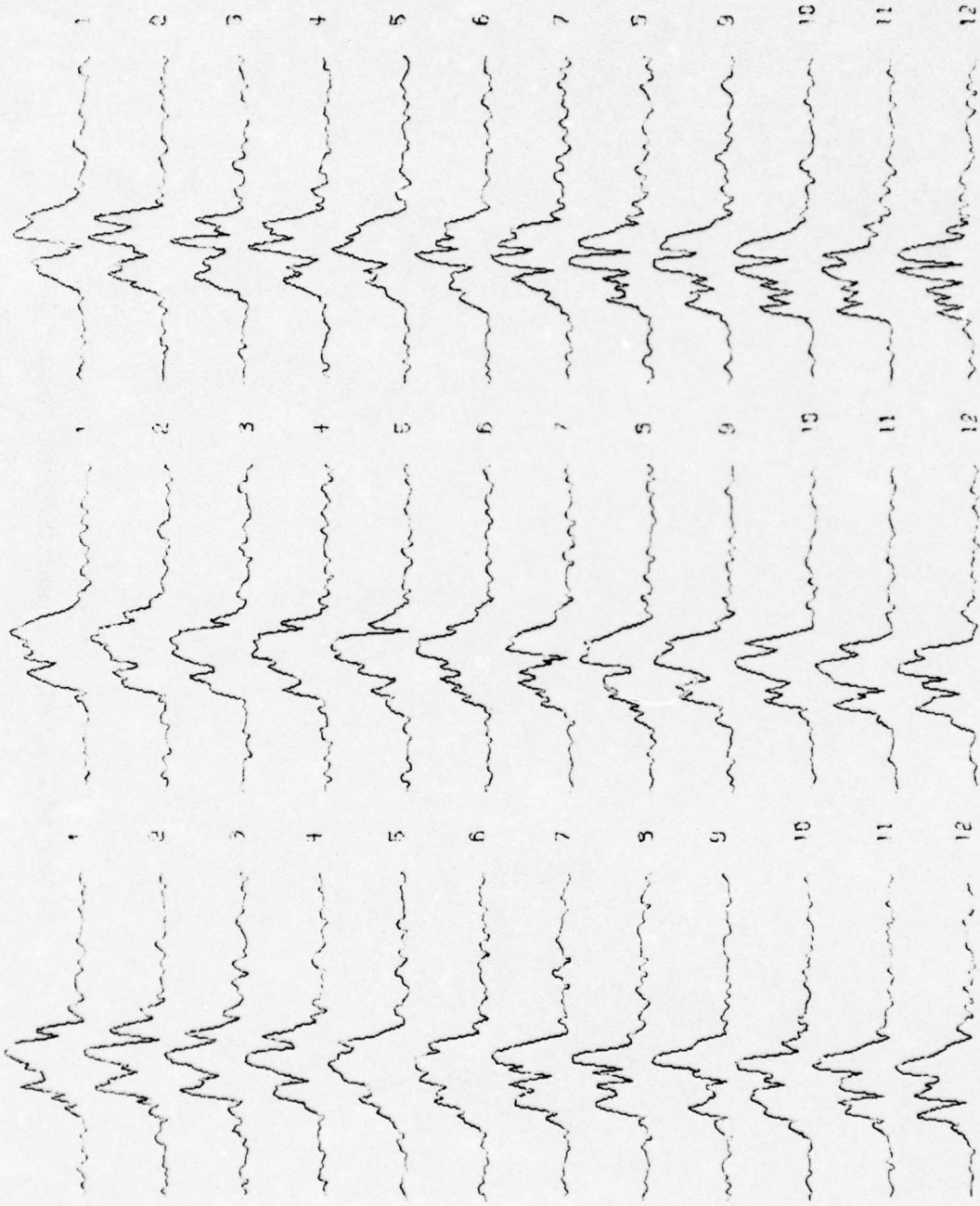


84 deg BEAM ASPECT: 1 msec TRANSMIT PULSE (U)

FIGURE 9

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9(53,54)

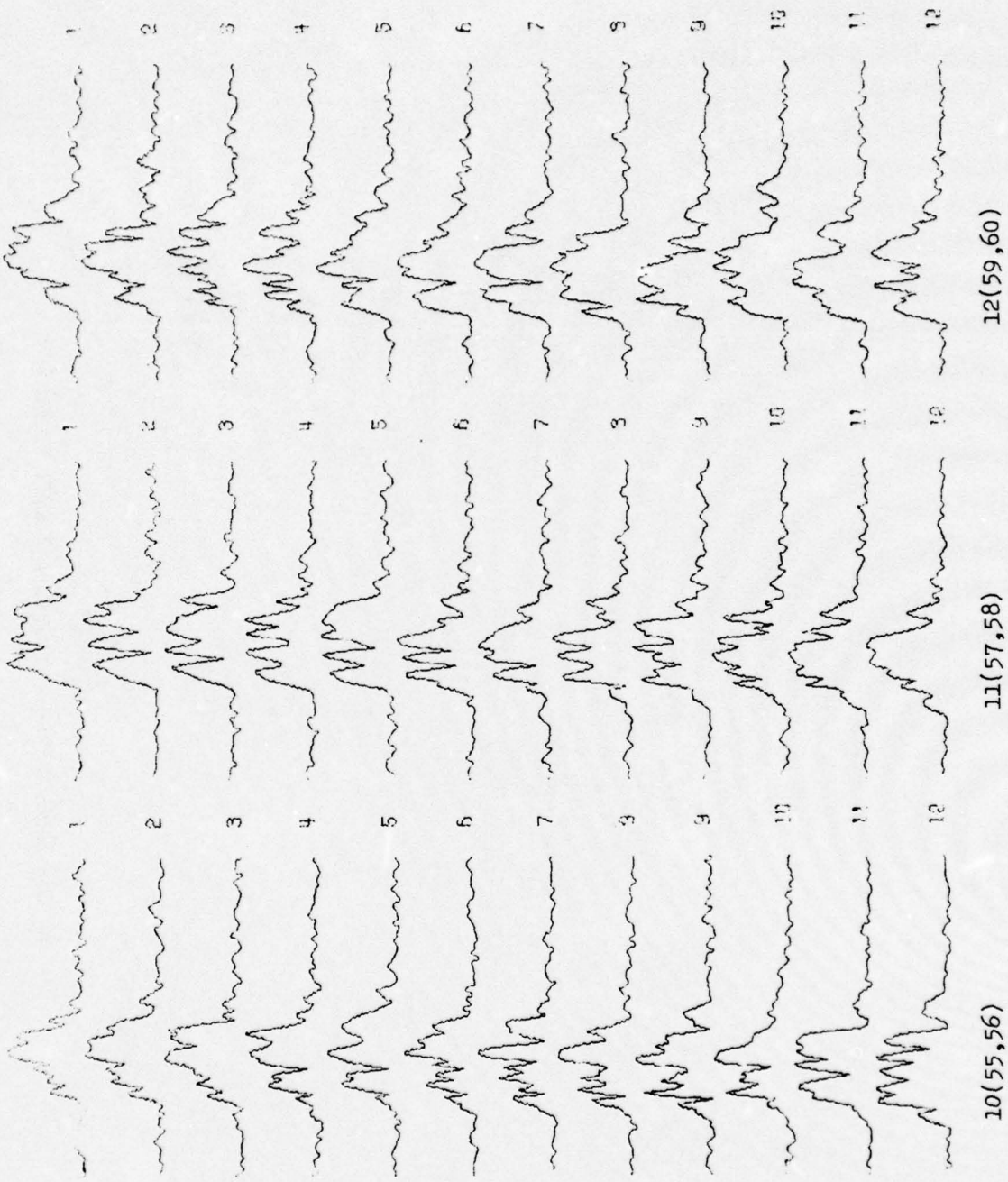
8(51,52)

7(49,50)

84 deg BEAM ASPECT: 1 msec TRANSMIT PULSE (V)
FIGURE 10

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10(55,56)

11(57,58)

12(59,60)

FIGURE 11

84 deg BEAM ASPECT: 1 msec TRANSMIT PULSE (U)

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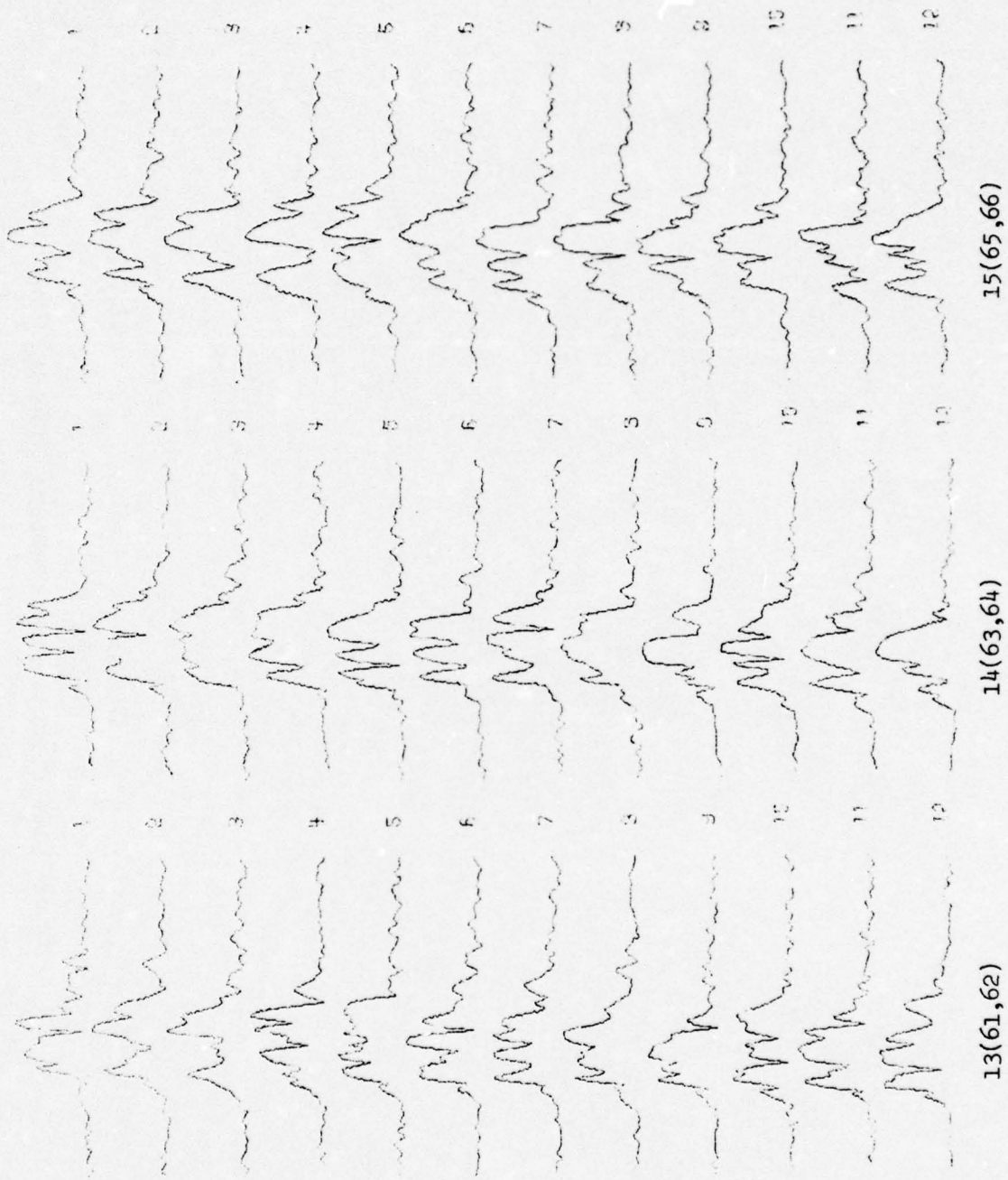
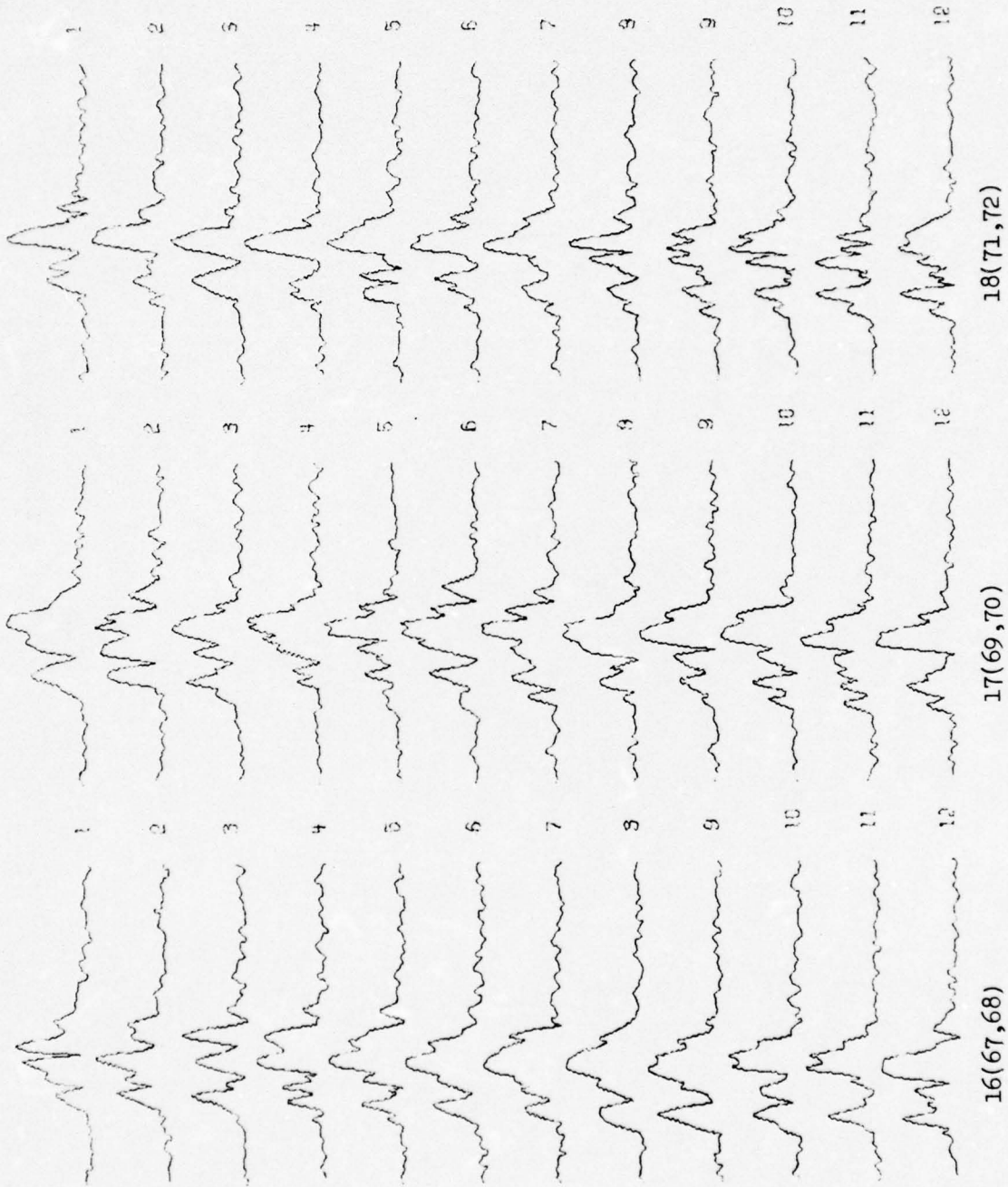


FIGURE 12

84 deg BEAM ASPECT: 1 msec TRANSMIT PULSE (U)

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18(71,72)

17(69,70)

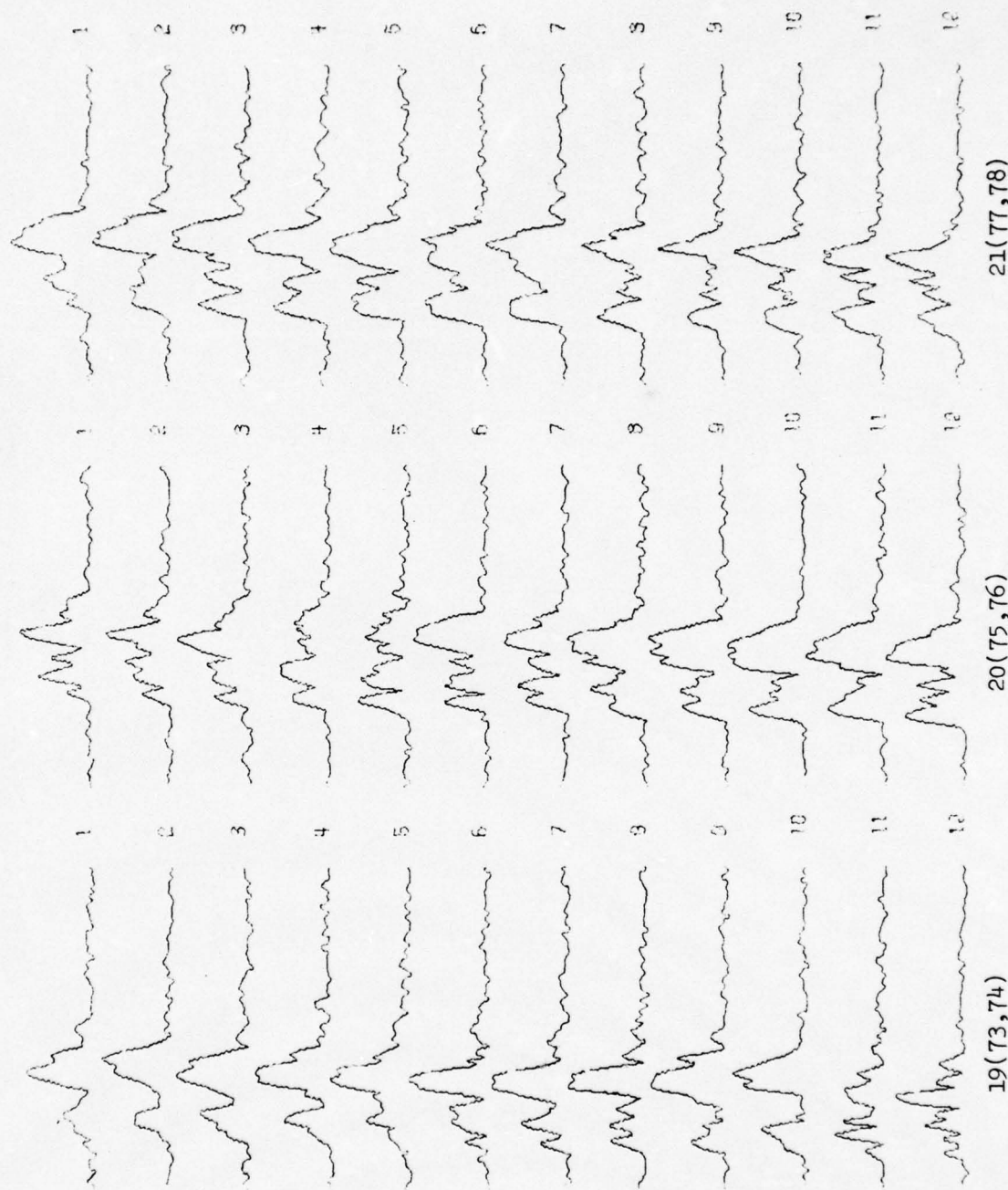
16(67,68)

FIGURE 13

84 deg BEAM ASPFCT: 1 msec TRANSMIT PULSE (U)

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84 deg BEAM ASPECT: 1 msec TRANSMIT PULSE (U)

FIGURE 14

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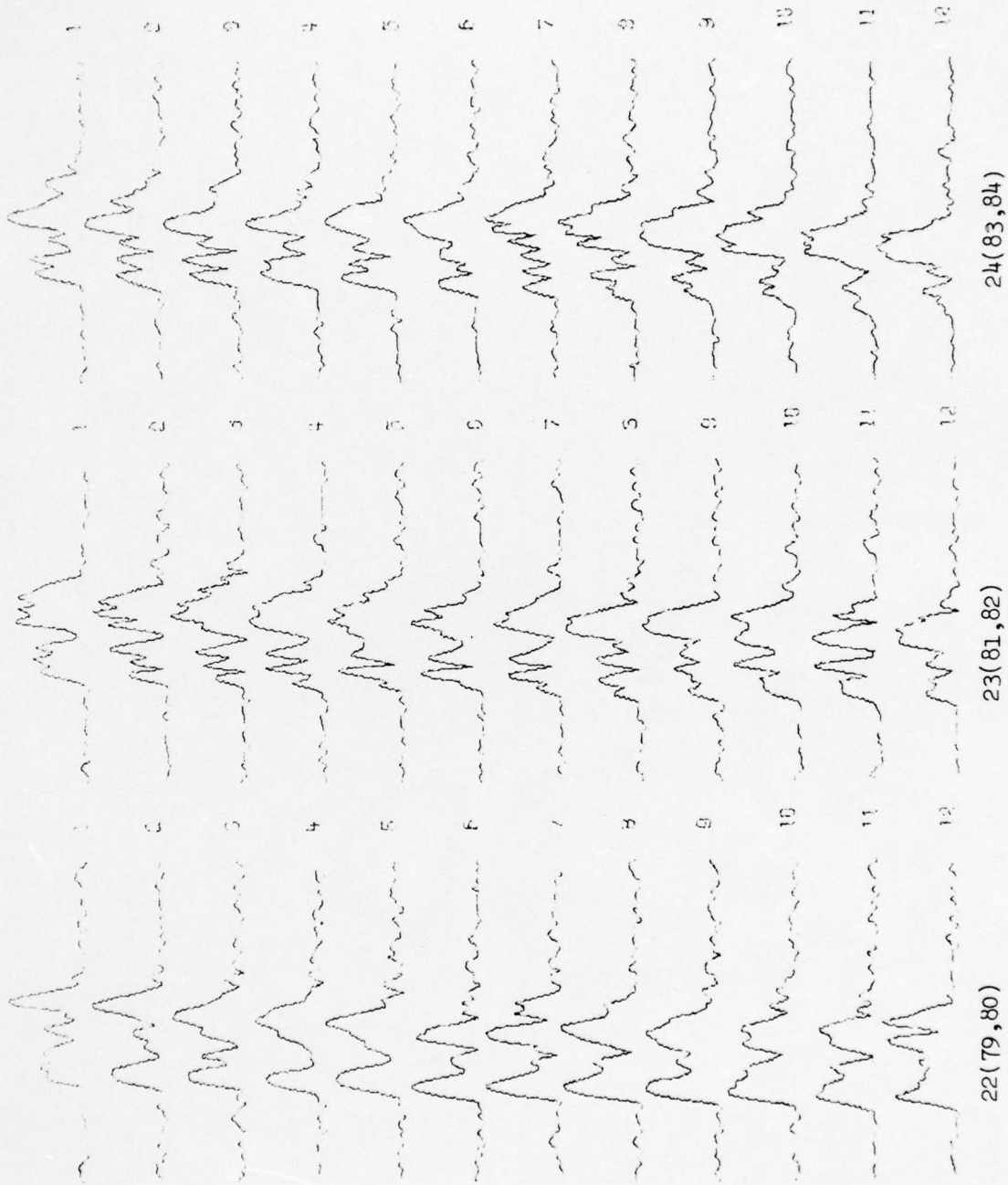
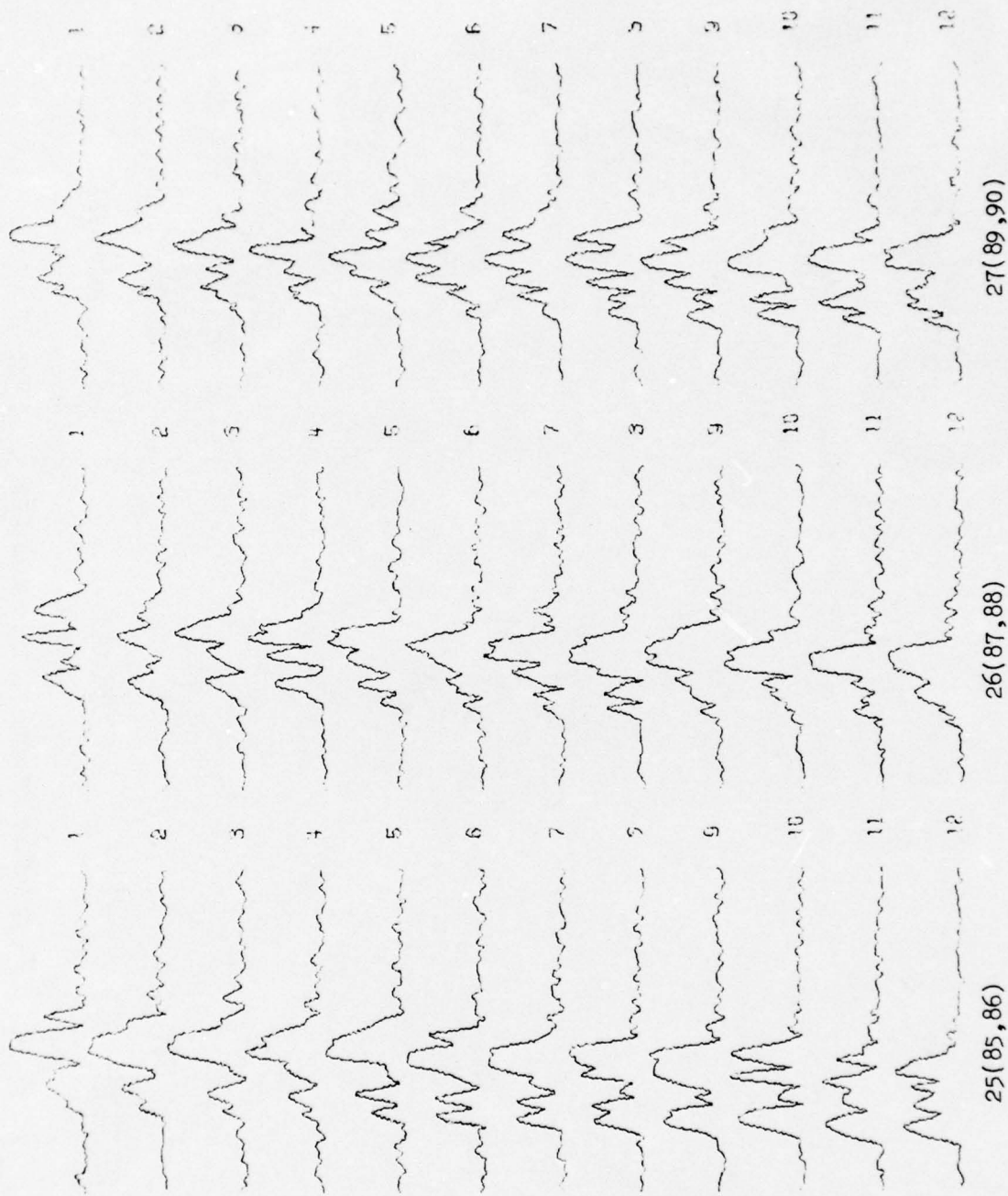


FIGURE 15

84 deg BEAM ASPECT: 1 msec TRANSMIT PULSE (U)

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25(85,86)

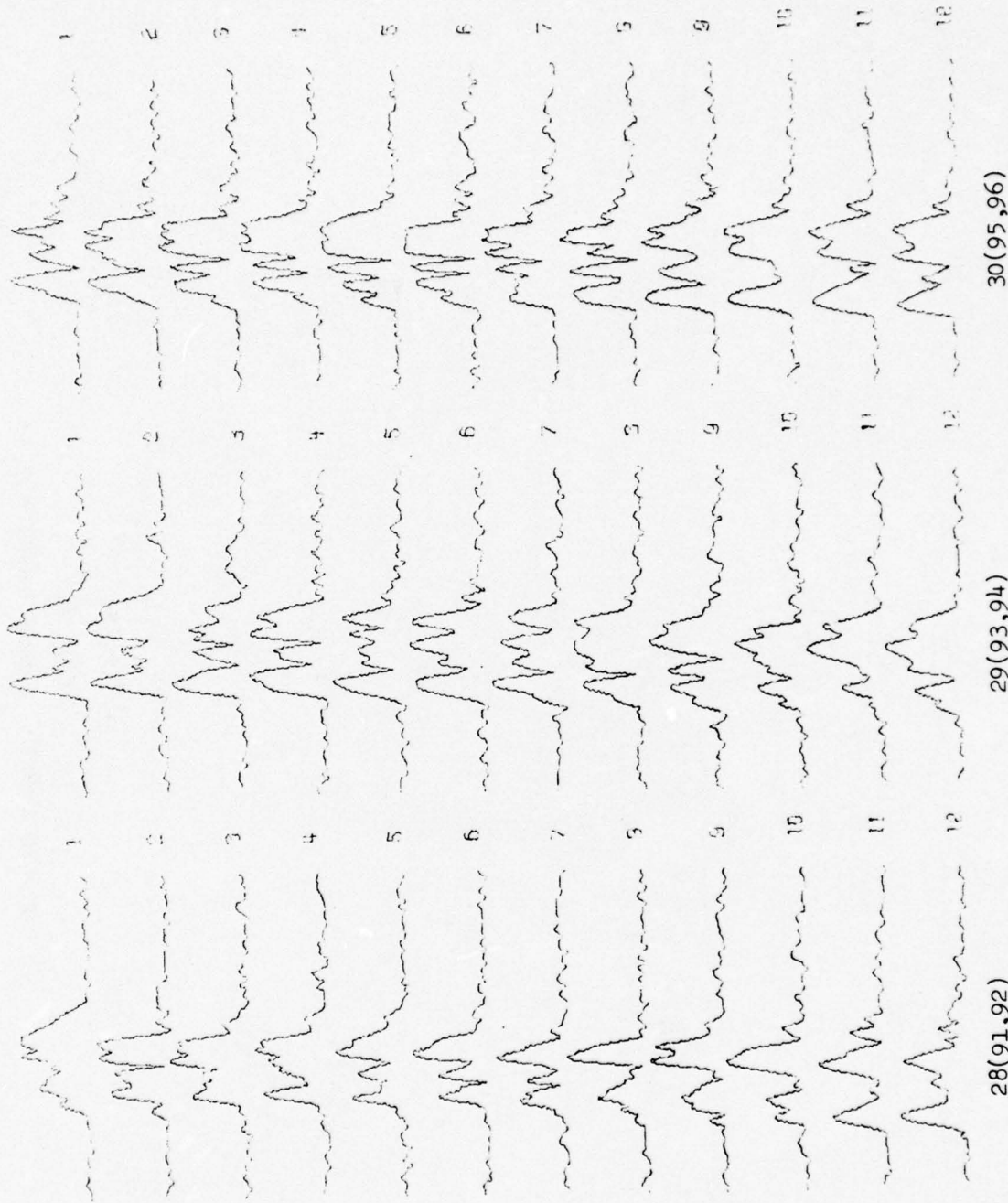
26(87,88)

27(89,90)

84 deg BEAM ASPECT: 1 msec TRANSMIT PULSE (U)
FIGURE 16

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30(95,96)

29(93,94)

28(91,92)

FIGURE 17

84 deg BEAM ASPECT: 1 msec TRANSMIT PULSE (U)

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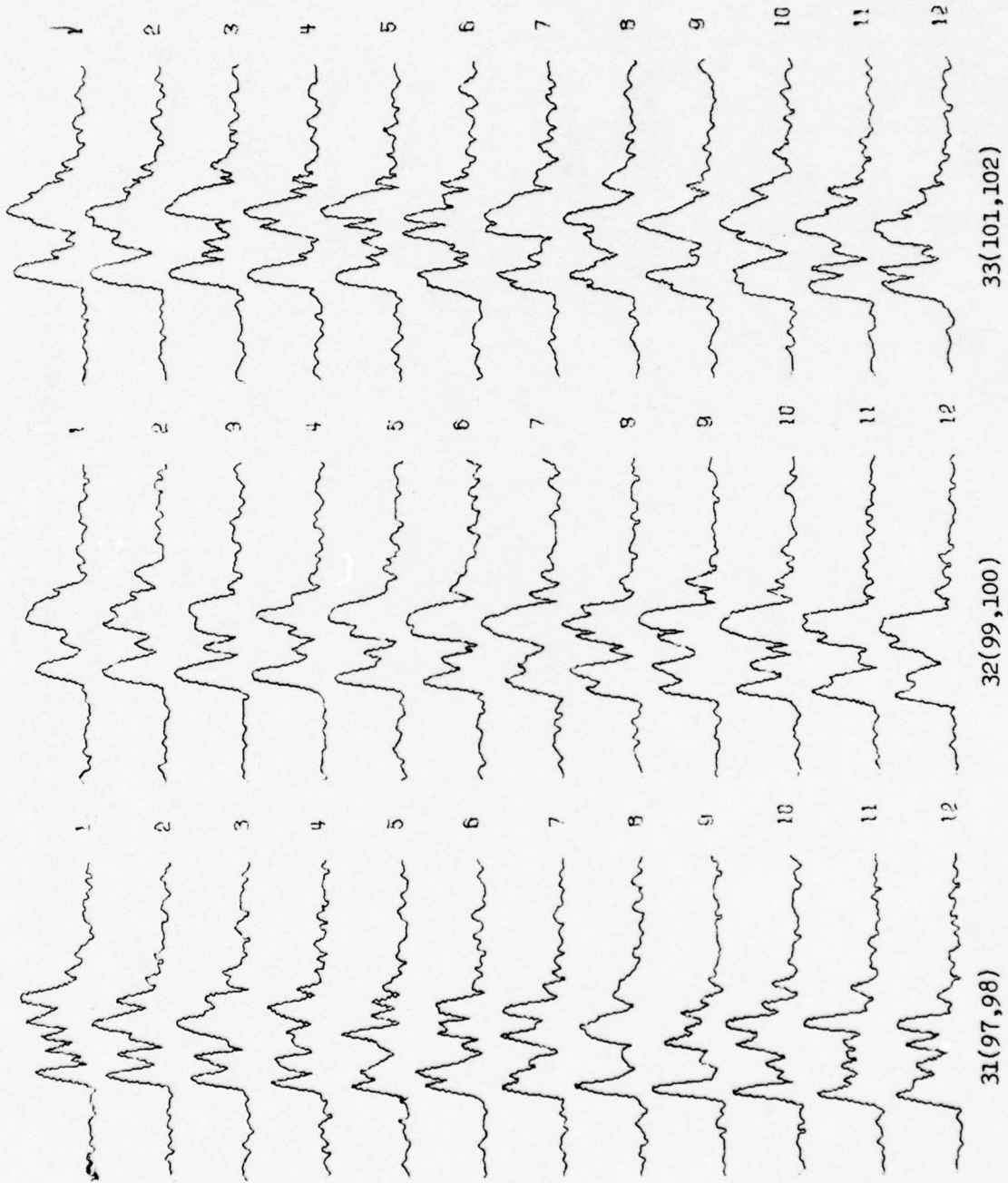


FIGURE 18

84 deg BEAM ASPECT: 1 msec TRANSMIT PULSE (U)

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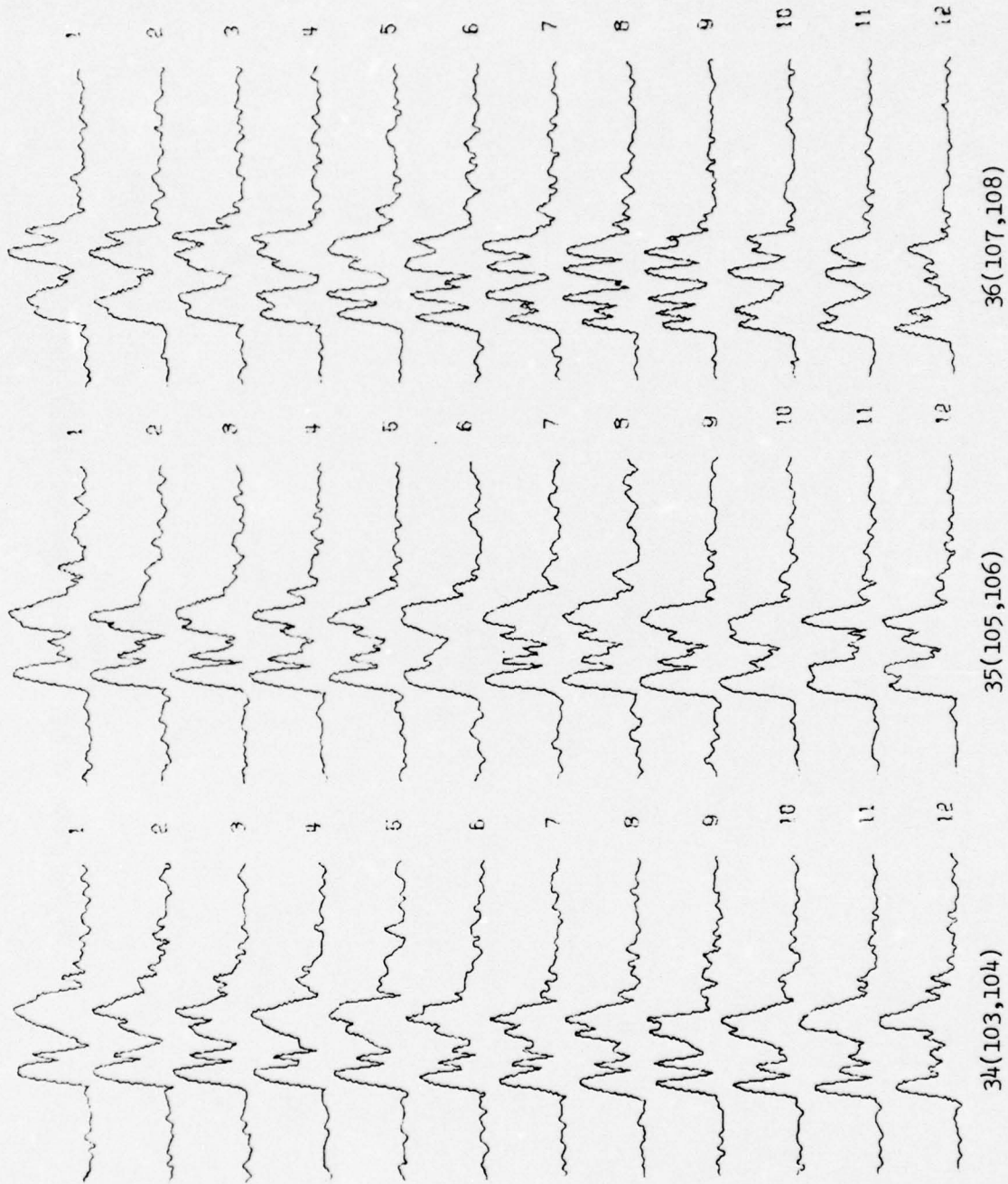
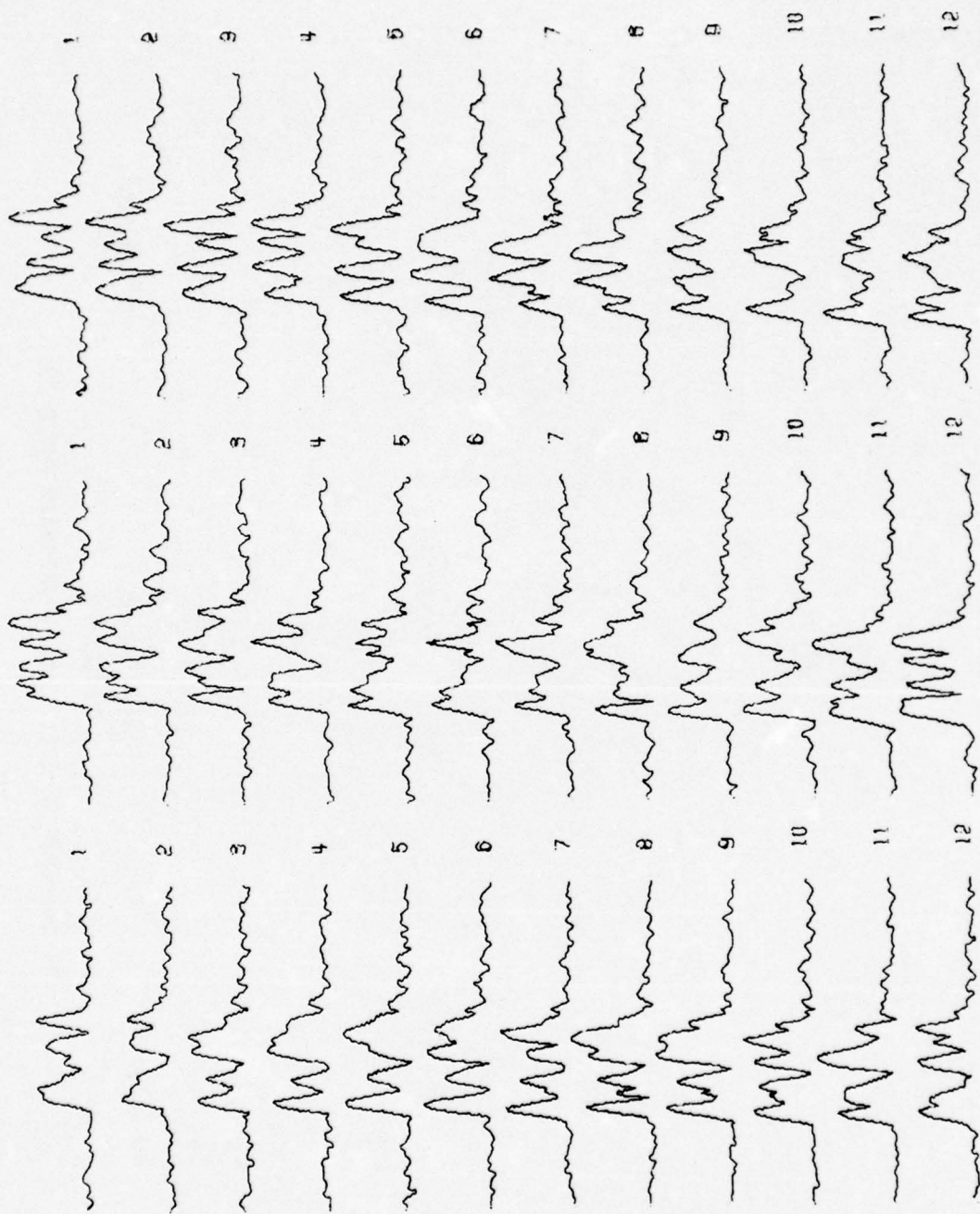


FIGURE 19
84 deg BEAM ASPECT: 1 msec TRANSMIT PULSE (U)

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37(109,110)

38(111,112)

39(113,114)

FIGURE 20

84 deg BEAM ASPECT: 1 msec TRANSMIT PULSE (U)

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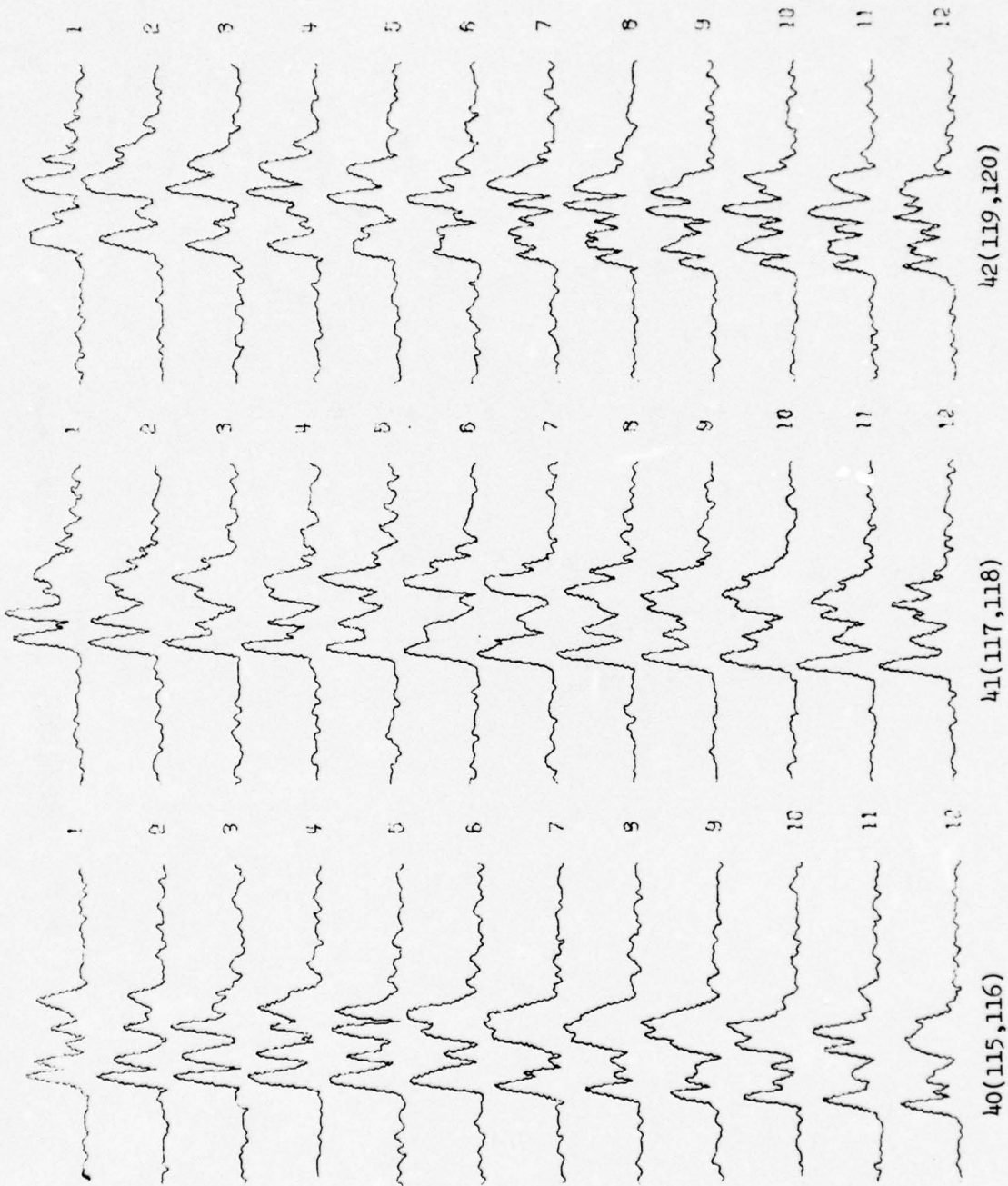
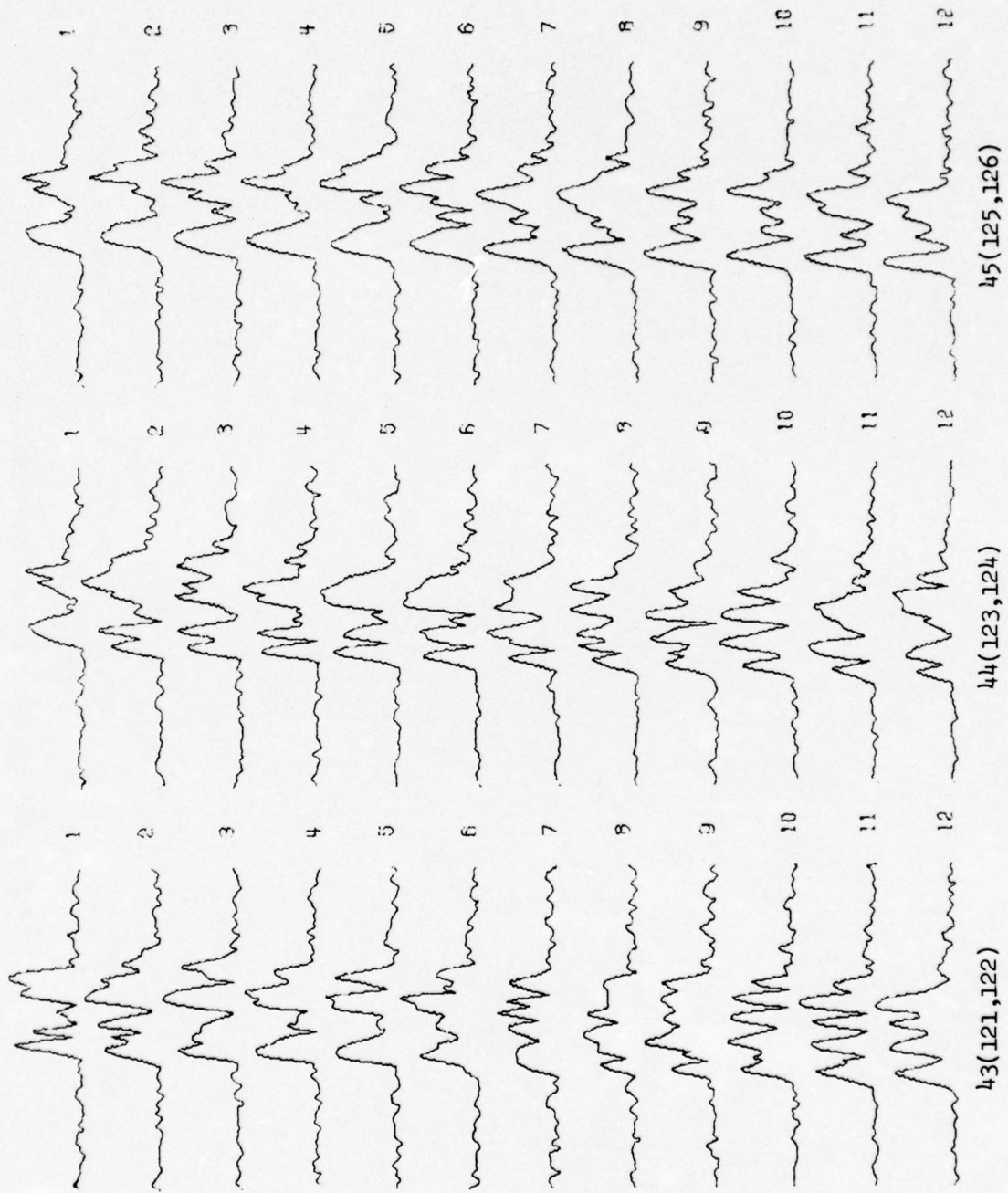


FIGURE 21
84 deg BEAM ASPECT: 1 msec TRANSMIT PULSE (U)

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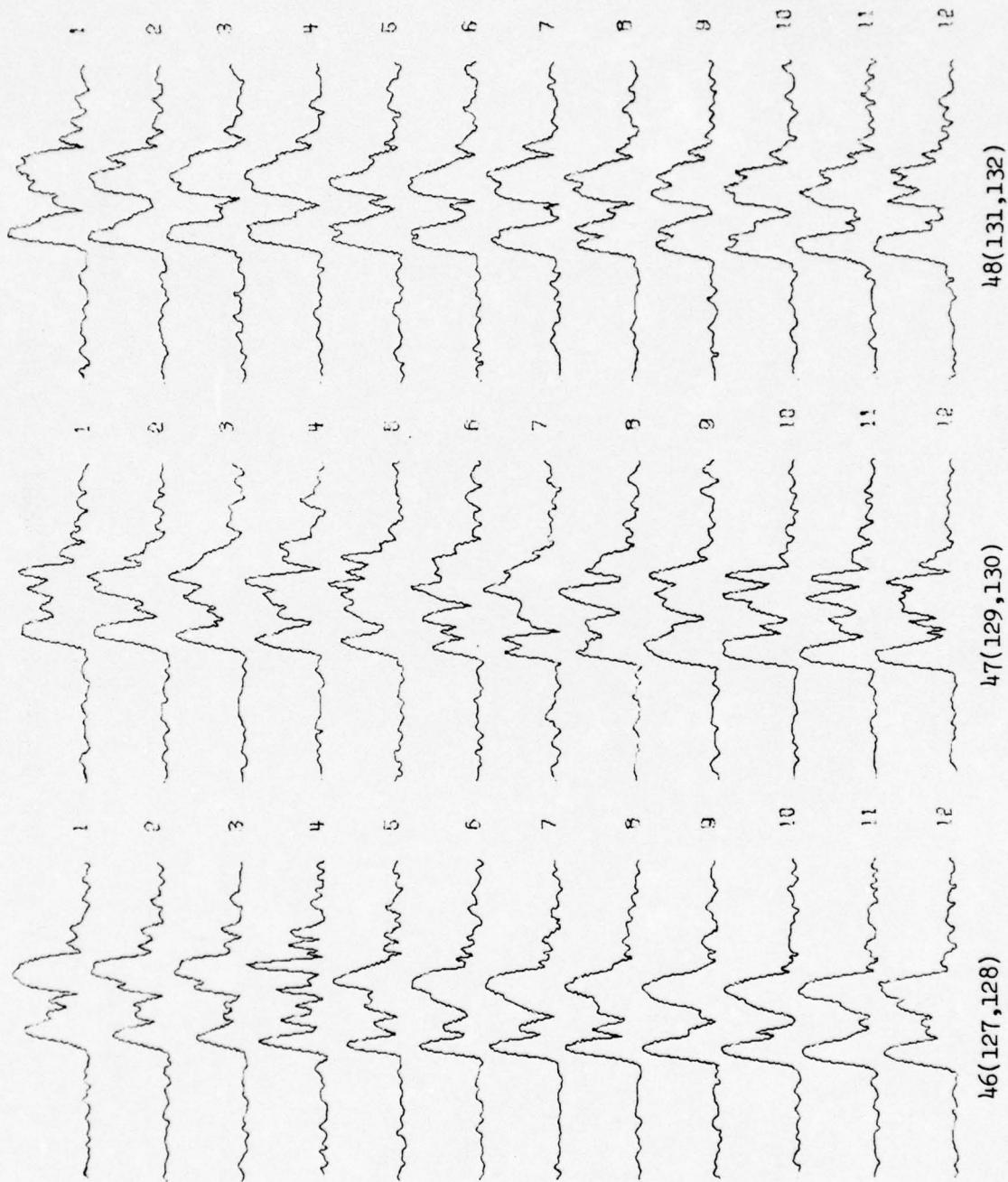
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84 deg BEAM ASPECT: 1 msec TRANSMIT PULSE (U)
FIGURE 22

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84 deg BEAM ASPECT: 1 msec TRANSMIT PULSE (U)
FIGURE 23

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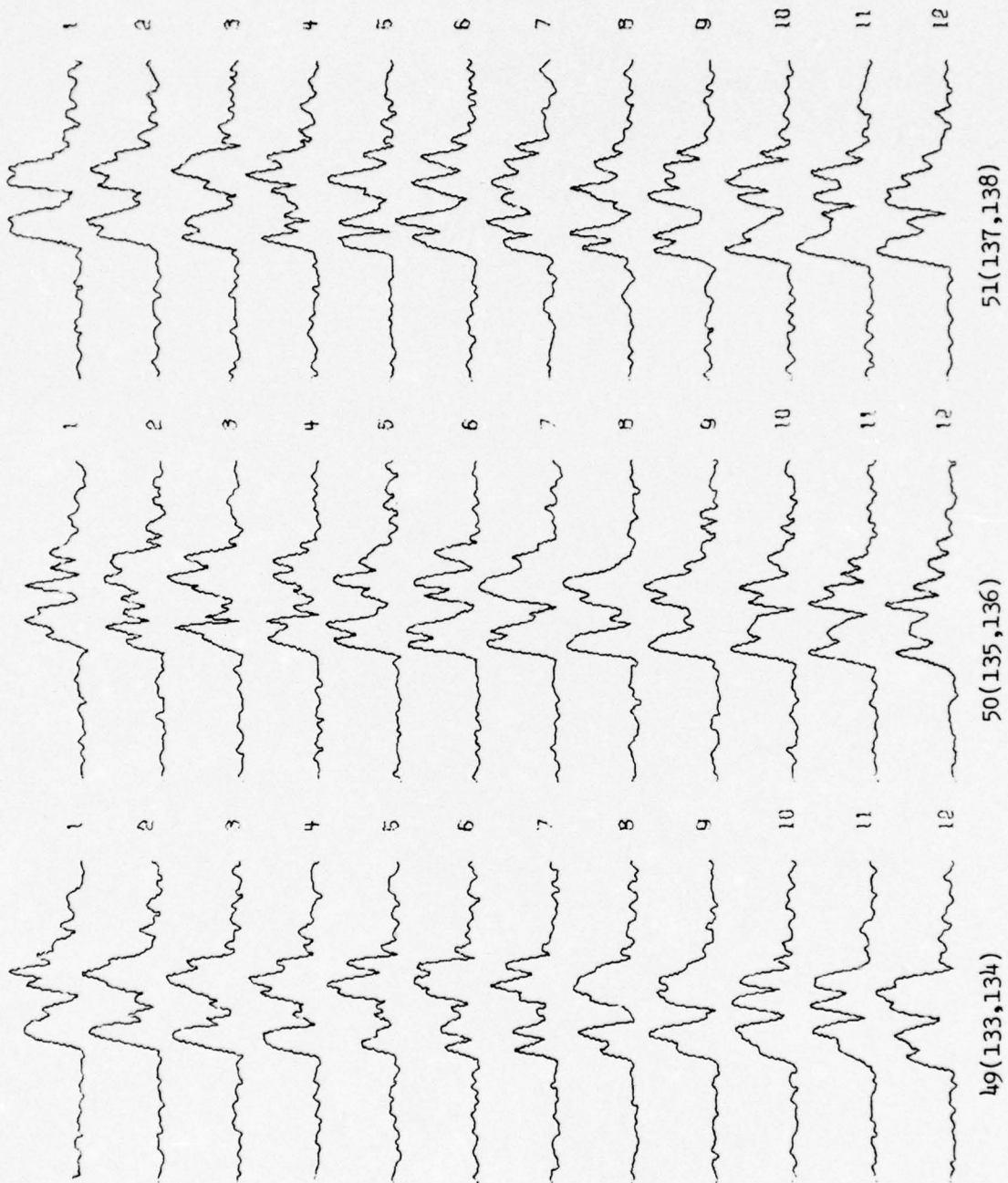


FIGURE 24

84 deg BEAM ASPECT: 1 msec TRANSMIT PULSE (U)

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2. Group B: 1, 2, and 5 msec Transmit Pulse

- (C) The echoes of Group B are from a submarine having a target aspect angle of 77 deg relative to stern. The destroyer and submarine had parallel courses, a range of 3900 yd, and speeds of 3 kt each.
- (C) The analog data were sampled directly with a sampling rate of $4f_0 = 20,000$ samples per second. The digital data are stored on ARL computer tape 646. Each record, which contains one echo, on tape 646 is 3000 samples long. The computer plots are 1000 samples = 50 msec long. Tables IV, V, VI, and VII list the first sample number of each plot (IFROM). The last sample number of each plot (ITO) is obtained by adding 1000 to that plot's IFROM. For example the plot of the third echo of Echo Set 1 has an IFROM of 1804 and an ITO of $1804 + 1000 = 2804$. Also these data are from record 3 (Rec. No. 3) of ARL computer tape 646. As another example, note that the sixth echo of Set 3 is found in record 31 of tape 646. The IFROM and ITO of the corresponding plot are 1348 and 2348, respectively. The first five sets of echoes (Sets 1, 2, 3, 4, and 5) correspond to the 1 msec transmit pulse, the second five sets (Sets 6, 7, 8, 9, and 10) to the 2 msec transmit pulse, and the last five sets (Sets 11, 12, 13, 14, and 15) to the 5 msec transmit pulse. The plots are given in Figs. 25 through 29.

TABLE IV
 Group B; Beam Aspect; SANSFIELD Reel 33
 12 Flings/Burst; Computer Tape 646
 1 Set of 12 Echoes (U)

ITO = IFROM + 1000

| (C) | Set 1, 1 msec Rec. No. IFROM | Set 2, 1 msec Rec. No. IFROM | Set 3, 1 msec Rec. No. IFROM | Set 4, 1 msec Rec. No. IFROM |
|-----|---------------------------------|---------------------------------|---------------------------------|---------------------------------|
| 1 | 844 | 13 656 | 26 768 | 38 636 |
| 2 | 1332 | 14 1136 | 27 1252 | 39 1120 |
| 3 | 1804 | 15 1620 | 28 1740 | 40 1600 |
| 4 | 1792 | 16 1608 | 29 1720 | 41 1584 |
| 5 | 572 | 17 736 | 30 872 | 42 860 |
| 6 | 1060 | 18 1216 | 31 1348 | 43 1340 |
| 7 | 1540 | 19 1692 | 32 1828 | 44 1816 |
| 8 | 1520 | 20 1676 | 33 1812 | 45 1796 |
| 9 | 376 | 21 536 | 34 140 | 46 172 |
| 10 | 864 | 22 1020 | 35 616 | 47 652 |
| 11 | 1344 | 23 1500 | 36 1096 | 48 1132 |
| 12 | 1328 | 24 1476 | 37 1084 | 49 1112 |

TABLE V
Group B

ITD = IFROM + 1000 (U)

| (C) | Set 5, 1 msec Rec. No. IFROM | Set 6, 2 msec Rec. No. IFROM | Set 7, 2 msec Rec. No. IFROM | Set 8, 2 msec Rec. No. IFROM |
|-----|---------------------------------|---------------------------------|---------------------------------|---------------------------------|
| | 50 700 | 62 360 | 74 428 | 86 804 |
| | 51 1184 | 63 844 | 75 908 | 87 1284 |
| | 52 1668 | 64 1328 | 76 1388 | 88 1768 |
| | 53 1652 | 65 1308 | 77 1368 | 89 1748 |
| | 54 996 | 66 400 | 78 520 | 90 632 |
| | 55 1472 | 67 888 | 79 1004 | 91 1116 |
| | 56 1952 | 68 1358 | 80 1488 | 92 1600 |
| | 57 1932 | 69 1348 | 81 1464 | 93 1580 |
| | 58 280 | 70 644 | 82 584 | 94 668 |
| | 59 756 | 71 1124 | 83 1064 | 95 1148 |
| | 60 1240 | 72 1604 | 84 1544 | 96 1632 |
| | 61 1220 | 73 1592 | 85 1520 | 97 1612 |

TABLE VI

Group B

ITO = IFROM + 1000 (U)

| (C) | Set 9, 2 msec Rec. No. IFROM | Set 10, 2 msec Rec. No. IFROM | Set 11, 5 msec Rec. No. IFROM | Set 12, 5 msec Rec. No. IFROM |
|-----|---------------------------------|----------------------------------|----------------------------------|----------------------------------|
| | 98 668 | 110 532 | 122 576 | 134 592 |
| | 99 1144 | 111 1020 | 123 1072 | 135 1080 |
| | 100 1632 | 112 1504 | 124 1540 | 136 1556 |
| | 101 1616 | 113 1488 | 125 1550 | 137 1530 |
| | 102 760 | 114 868 | 126 192 | 138 532 |
| | 103 1240 | 115 1344 | 127 672 | 139 1000 |
| | 104 1716 | 116 1820 | 128 1140 | 140 1474 |
| | 105 1700 | 117 1804 | 129 1112 | 141 1444 |
| | 106 812 | 118 288 | 130 1068 | 142 1094 |
| | 107 1292 | 119 768 | 131 1564 | 143 1558 |
| | 108 1780 | 120 1252 | 132 2044 | 144 2024 |
| | 109 1768 | 121 1232 | 133 2020 | 145 2010 |

TABLE VII

Group B

ITO = IFROM + 1000 (U)

| (c) | Set 13, 5 msec Rec. No. IFROM | Set 14, 5 msec Rec. No. IFROM | Set 15, 5 msec Rec. No. IFROM |
|-----|----------------------------------|----------------------------------|----------------------------------|
| | 146 628 | 158 644 | 170 600 |
| | 147 1112 | 159 1126 | 171 1060 |
| | 148 1578 | 160 1572 | 172 1544 |
| | 149 1564 | 161 1556 | 173 1536 |
| | 150 484 | 162 452 | 174 500 |
| | 151 980 | 163 920 | 175 972 |
| | 152 1460 | 164 1400 | 176 1452 |
| | 153 1432 | 165 1372 | 177 1432 |
| | 154 996 | 166 968 | 178 40 |
| | 155 1468 | 167 1444 | 179 516 |
| | 156 1960 | 168 1968 | 180 980 |
| | 157 1916 | 169 1888 | 181 956 |

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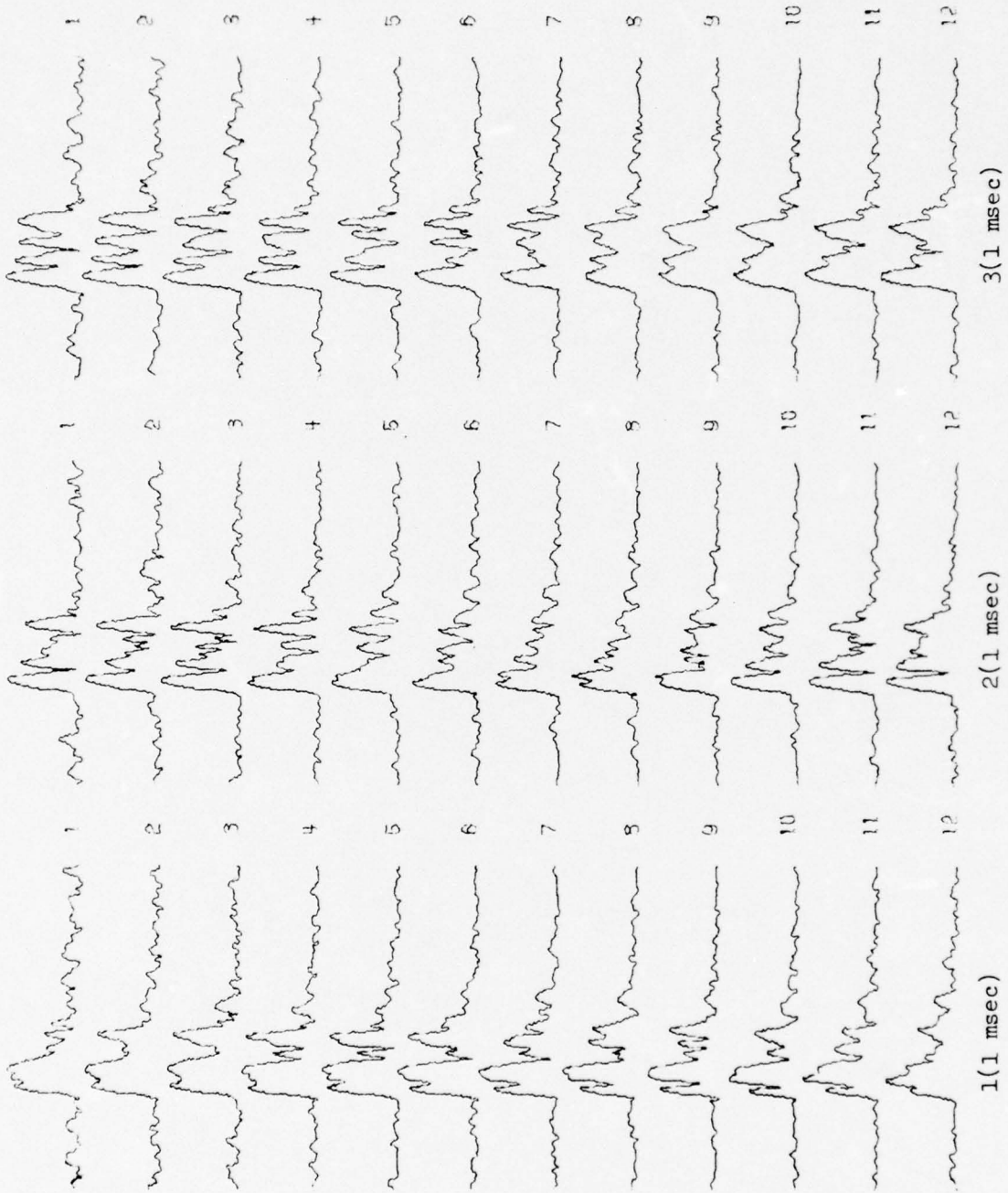


FIGURE 25
77 deg BEAM ASPECT (U)

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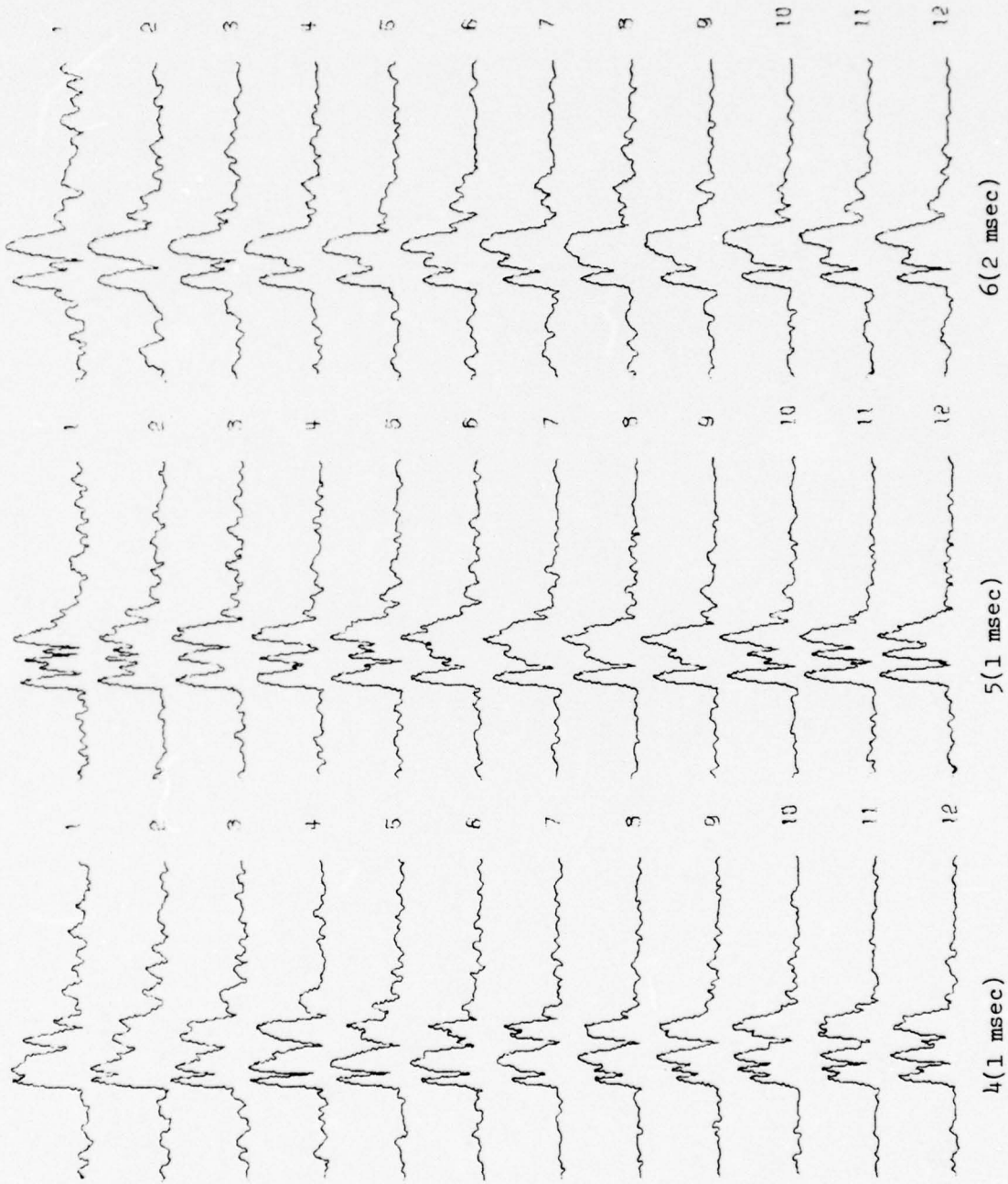


FIGURE 26

77 deg BEAM ASPECT (U)

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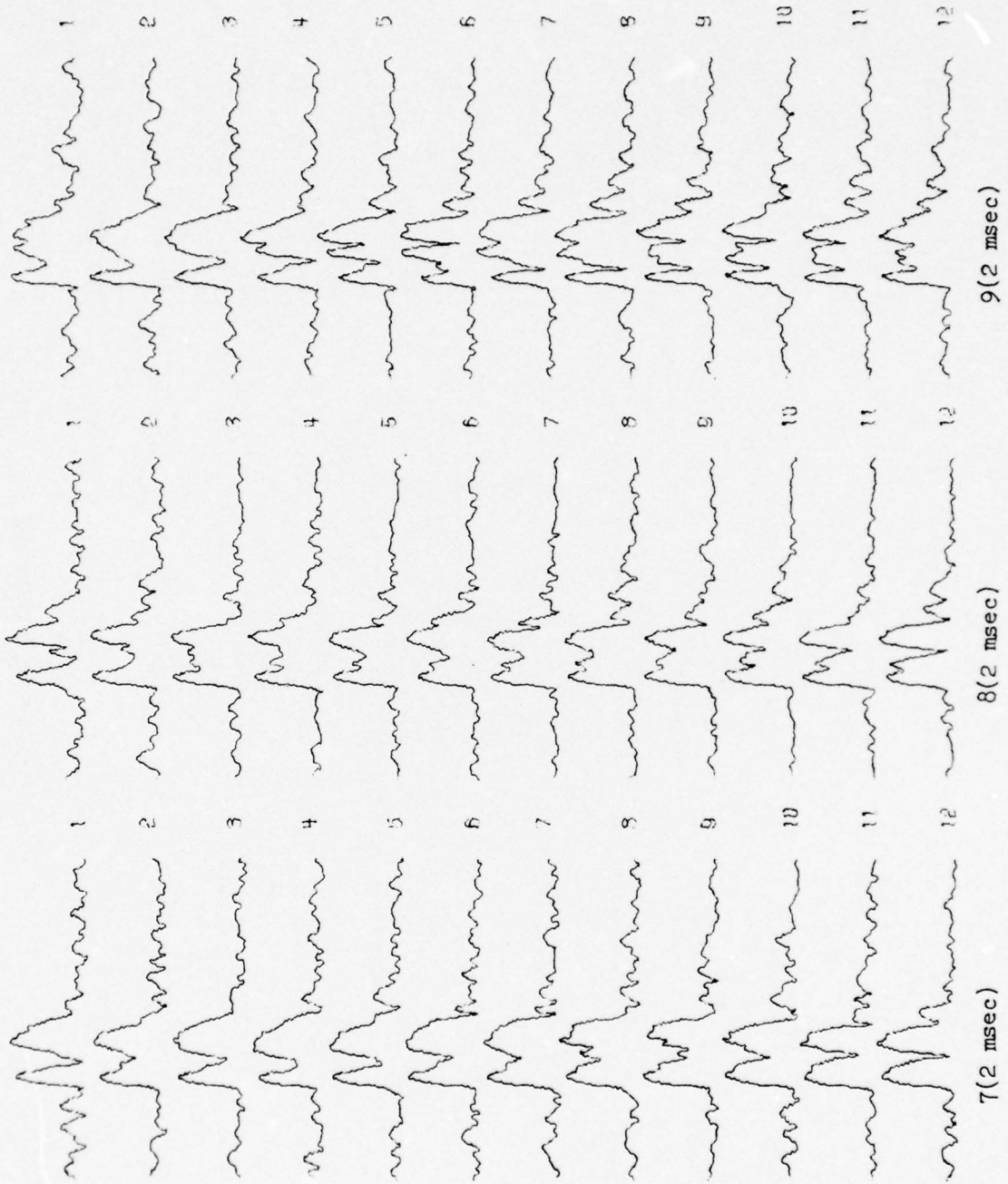


FIGURE 27
77 deg BEAM ASPECT (U)

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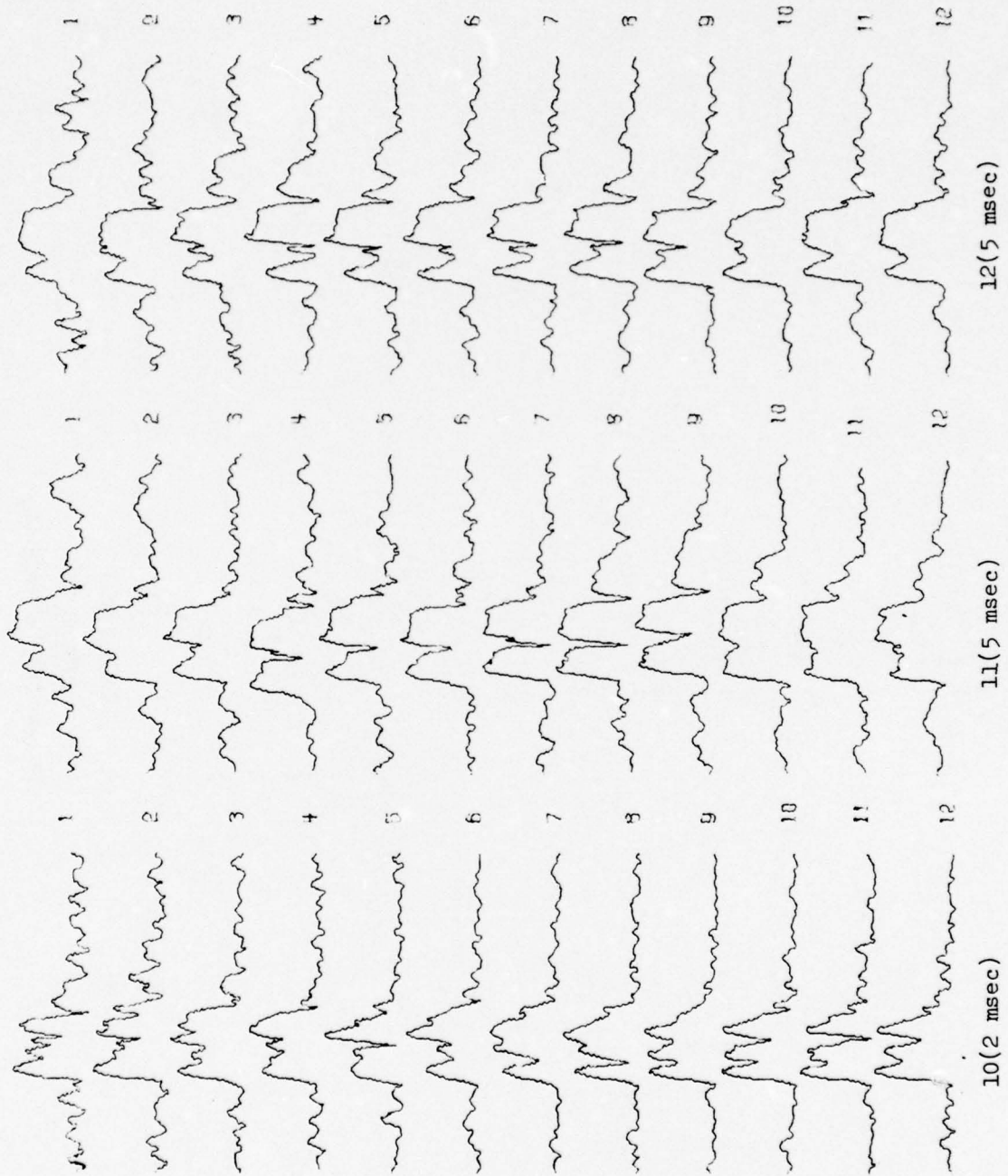


FIGURE 28
77 deg BEAM ASPECT (U)

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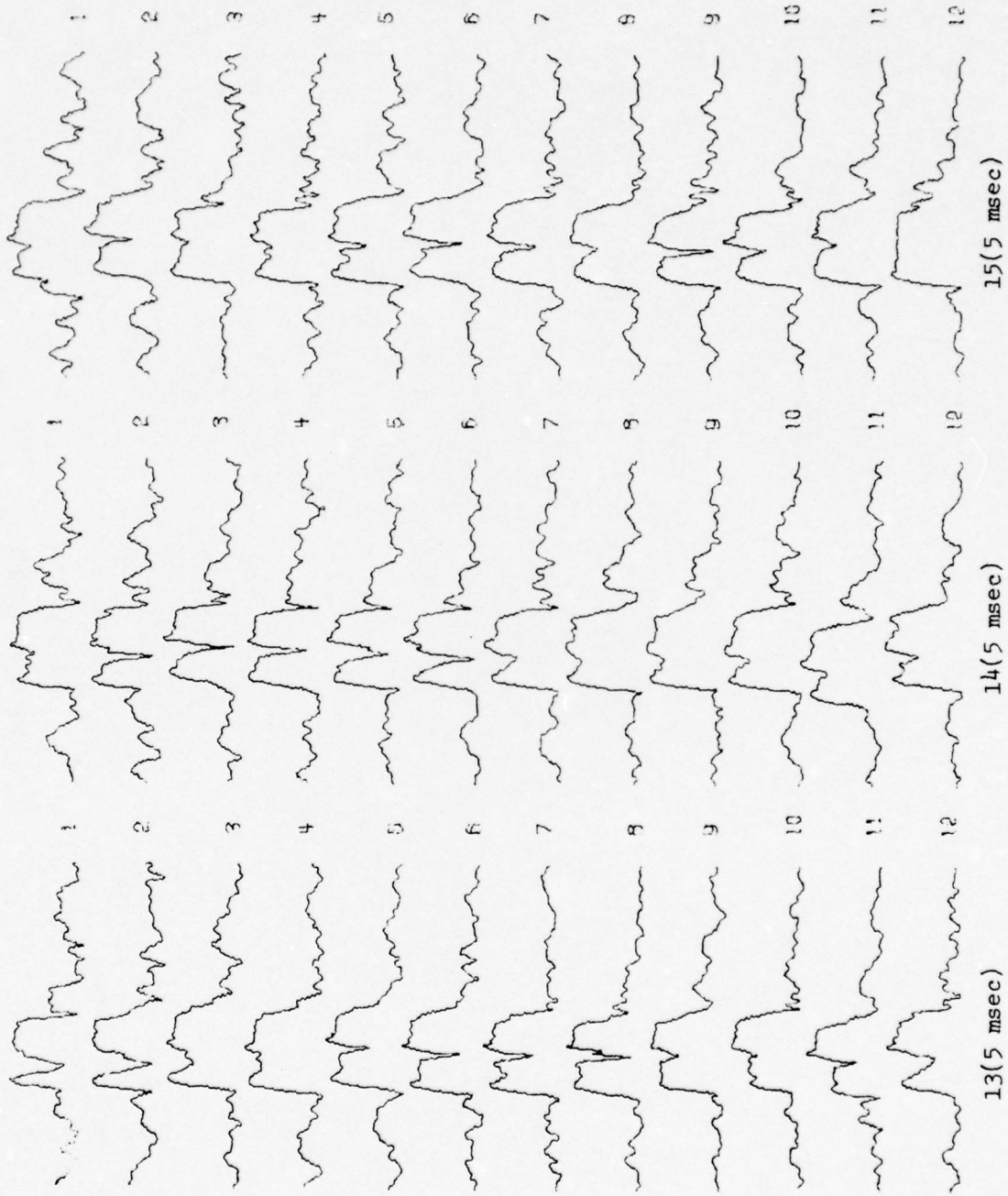


FIGURE 29
77 deg BEAM ASPECT (U)

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B. Stern Aspect Submarine Echoes: 5 msec Transmit Pulse

(C) This collection of data was generated by a submarine with an aspect of 20 deg relative to stern. The transmit pulse length was 5 msec. The analog echoes were sampled directly with a sampling rate of $4f_0 = 20$ kHz. Nine echo sets, each set containing 12 echoes, are plotted and the IFROMs and ITOs of these plots are listed in Tables VIII, IX, and X. These data can be found on ARL computer tape 648. Each record of this tape is 4000 samples long and contains one echo. The epoch of the echo was estimated to be 2440 samples = 122 msec long. The following plots contain a 100-sample interval preceding the beginning of the echo and a 100-sample interval following the echo. Thus each plot has a length of $2440 + 200 = 2640$ samples = 132 msec. Figures 30 through 32 give the individual echo plots.

TABLE VIII

Group II; Stern Aspect; SANSFIELD Reel 39
 12 Pings/Burst; Computer Tape 648, 20 kHz Sample Rate
 1 Ensemble of 12 Echoes, ~116 msec (U)

5 msec Transmit Pulse

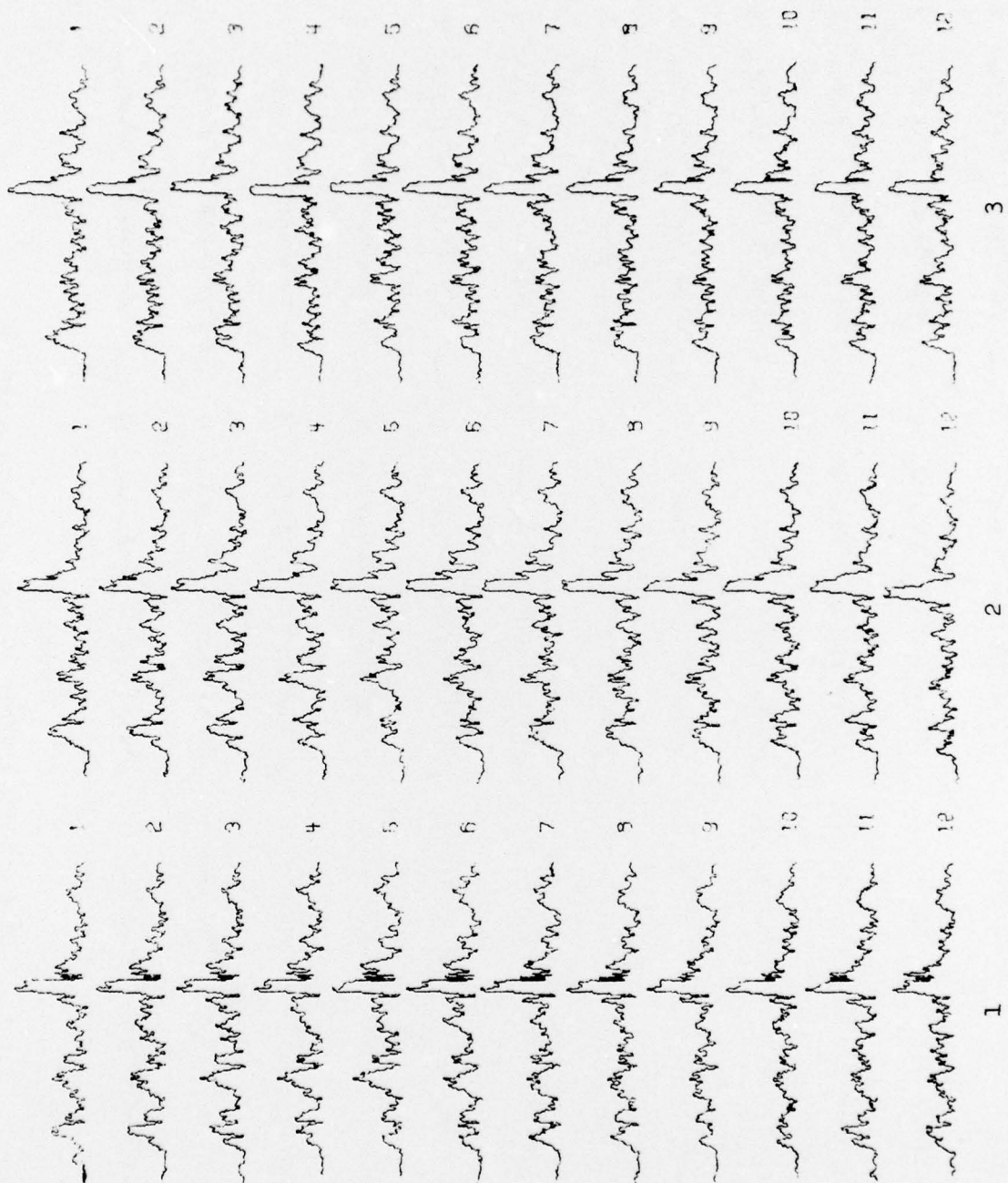
(c)

| Rec. No. | SET 1 | | SET 2 | | SET 3 | |
|----------|-------|------|-------|-----|-------|------|
| | IFROM | ITO | IFROM | ITO | IFROM | ITO |
| 1 | 712 | 3352 | 13 | 712 | 25 | 3332 |
| 2 | 692 | 3332 | 14 | 692 | 26 | 3284 |
| 3 | 680 | 3320 | 15 | 704 | 27 | 3272 |
| 4 | 408 | 3048 | 16 | 432 | 28 | 3032 |
| 5 | 388 | 3028 | 17 | 384 | 29 | 3020 |
| 6 | 376 | 3016 | 18 | 356 | 30 | 3008 |
| 7 | 268 | 2908 | 19 | 280 | 31 | 2876 |
| 8 | 252 | 2892 | 20 | 276 | 32 | 2860 |
| 9 | 296 | 2936 | 21 | 256 | 33 | 2848 |
| 10 | 560 | 3200 | 22 | 576 | 34 | 3148 |
| 11 | 552 | 3192 | 23 | 572 | 35 | 3136 |
| 12 | 496 | 3136 | 24 | 564 | 36 | 3134 |

TABLE X
Stern Aspect: Computer Plots' IFROM, ITO (U)
5 msec Transmit Pulse

| (c) | SET 7 | | SET 8 | | SET 9 | |
|-----|----------|-----------------------------------|----------|-----------------------------------|----------|-----------------------------------|
| | Rec. No. | $\frac{\text{IFROM}}{\text{ITO}}$ | Rec. No. | $\frac{\text{IFROM}}{\text{ITO}}$ | Rec. No. | $\frac{\text{IFROM}}{\text{ITO}}$ |
| 73 | 732 | 3372 | 85 | 776 | 97 | 852 |
| 74 | 740 | 3380 | 86 | 764 | 98 | 812 |
| 75 | 720 | 3360 | 87 | 752 | 99 | 808 |
| 76 | 556 | 3196 | 88 | 548 | 100 | 608 |
| 77 | 544 | 3184 | 89 | 536 | 101 | 604 |
| 78 | 532 | 3172 | 90 | 532 | 102 | 572 |
| 79 | 400 | 3040 | 91 | 448 | 103 | 508 |
| 80 | 384 | 3024 | 92 | 440 | 104 | 508 |
| 81 | 368 | 3008 | 93 | 428 | 105 | 516 |
| 82 | 688 | 3328 | 94 | 688 | 106 | 796 |
| 83 | 672 | 3312 | 95 | 672 | 107 | 792 |
| 84 | 660 | 3300 | 96 | 668 | 108 | 780 |

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3

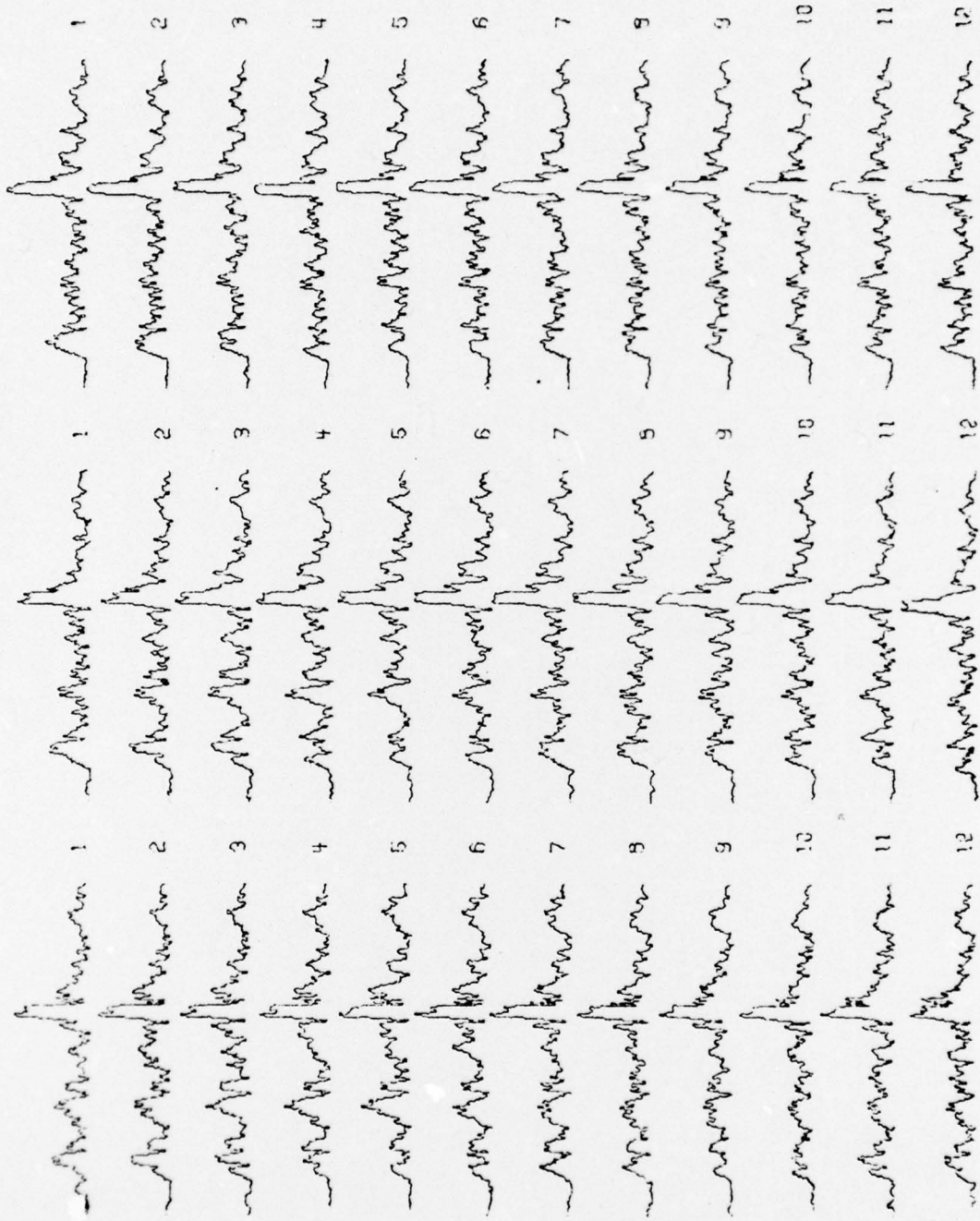
2

1

FIGURE 30
20 deg STERN ASPECT: 5 msec TRANSMIT PULSE (U)

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6

5

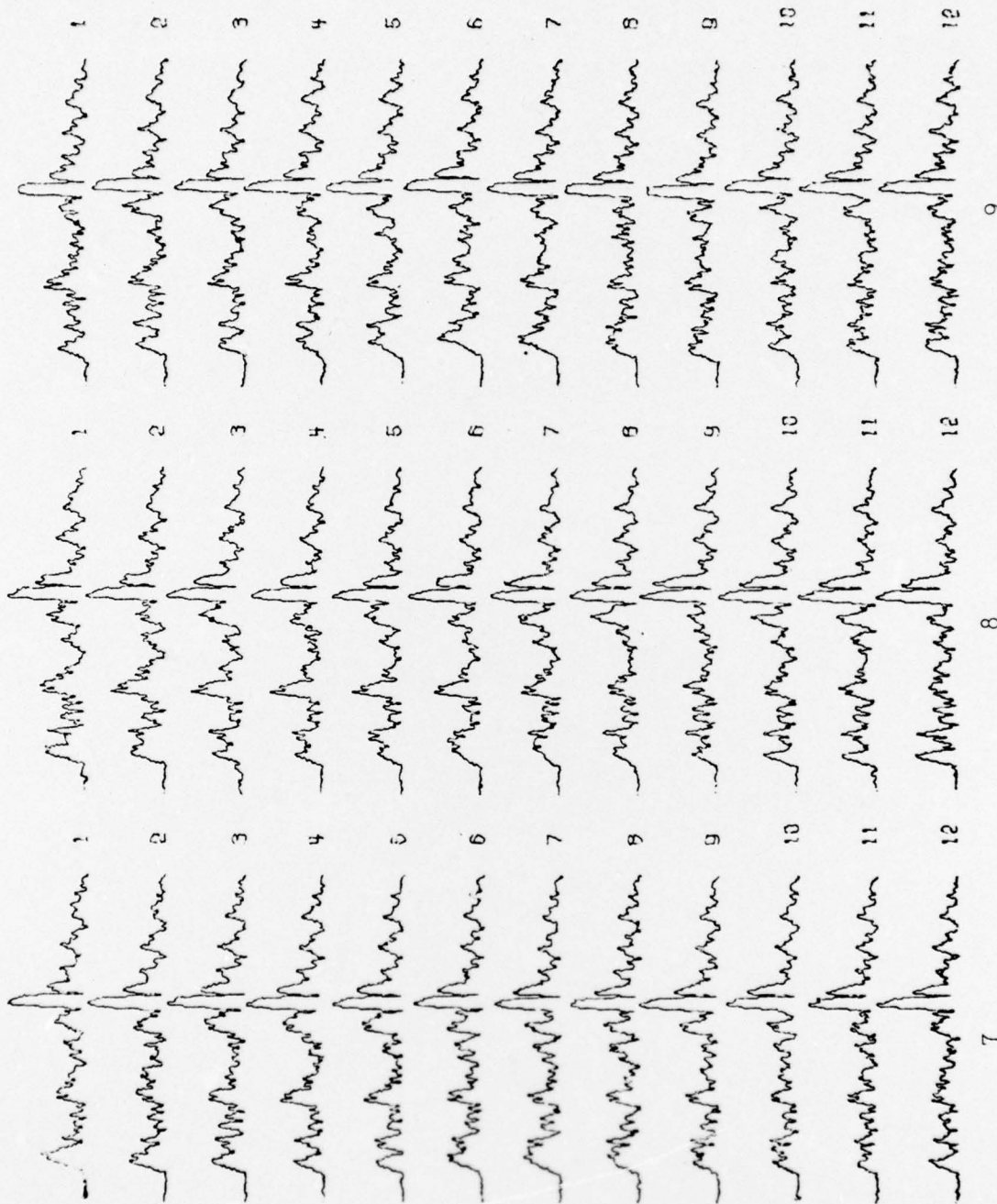
4

FIGURE 31

20 deg STERN ASPECT: 5 msec TRANSMIT PULSE (U)

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9

8

7

FIGURE 32
20 deg STERN ASPECT: 5 msec TRANSMIT PULSE (U)

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C. Bow Aspect Submarine Echoes: 1 msec Transmit Pulse

(C) This is a collection of 11 sets of bow aspect echoes. Each set contains 12 echoes. The transmit pulse length was 1 msec. The quadrature components of the analog data were digitized, each component being sampled at a rate of 2500 samples per second. The range of the target was 4000 yd, although the exact target geometry that produced these data is unknown. However, it is very likely that the destroyer and submarine had a target aspect, as estimated from the echo epoch, of about 20 deg relative to bow.

(U-FOUO) Table XI gives the IFROM and ITO of the first plot of each set of 12 echoes. The $(IFROM)_n$ of the n^{th} echo of a set is given by

$$(IFROM)_n = IFROM + (n-1)(943) \quad .$$

Similarly the corresponding $(ITO)_n$ is given by

$$(ITO)_n = ITO + (n-1)(943) \quad .$$

Thus the IFROM and ITO of the eighth echo of the fifth echo set is

$$\begin{aligned} (IFROM)_8 &= 1615 + (8-1)(943) \\ &= 8116 \quad , \end{aligned}$$

and

$$\begin{aligned} (ITO)_8 &= 1935 + (8-1)(943) \\ &= 8436 \quad . \end{aligned}$$

Each plot is 320 samples = 128 msec in length. The 11 sets, each set containing 12 echoes, are shown in Figs. 33 through 36.

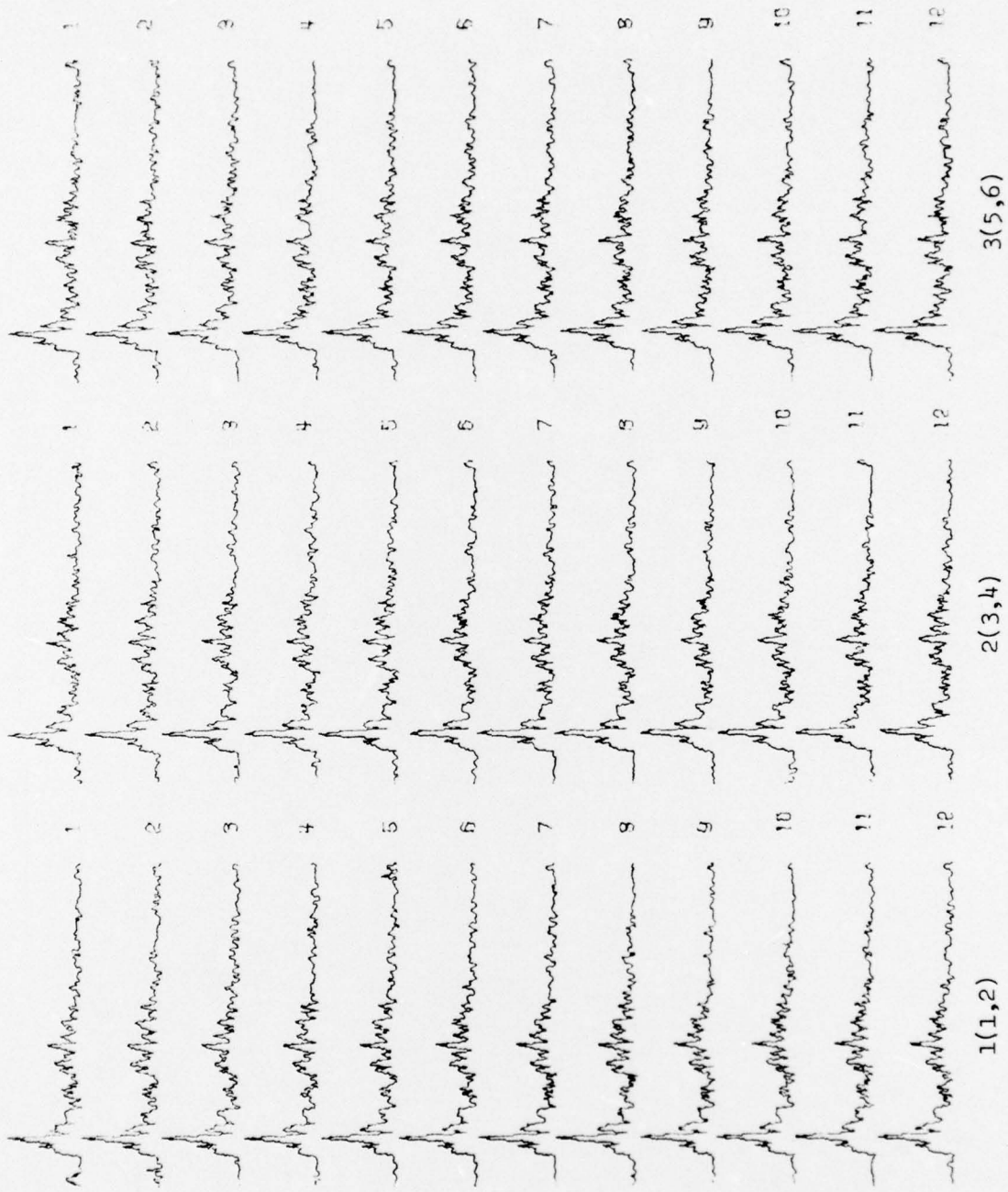
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TABLE XI

Bow Aspect: Computer Plots' IFROM, ITO (U)

| (C) | <u>Rec. No.</u> | <u>IFROM</u> | <u>ITO</u> |
|-----|-----------------|--------------|------------|
| | 1 | 1600 | 1920 |
| | 2 | 1598 | 1918 |
| | 3 | 1601 | 1921 |
| | 4 | 1610 | 1930 |
| | 5 | 1615 | 1935 |
| | 6 | 1619 | 1939 |
| | 7 | 1626 | 1946 |
| | 8 | 1633 | 1953 |
| | 9 | 1640 | 1960 |
| | 10 | 1644 | 1964 |
| | 11 | 1646 | 1966 |

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3(5,6)

2(3,4)

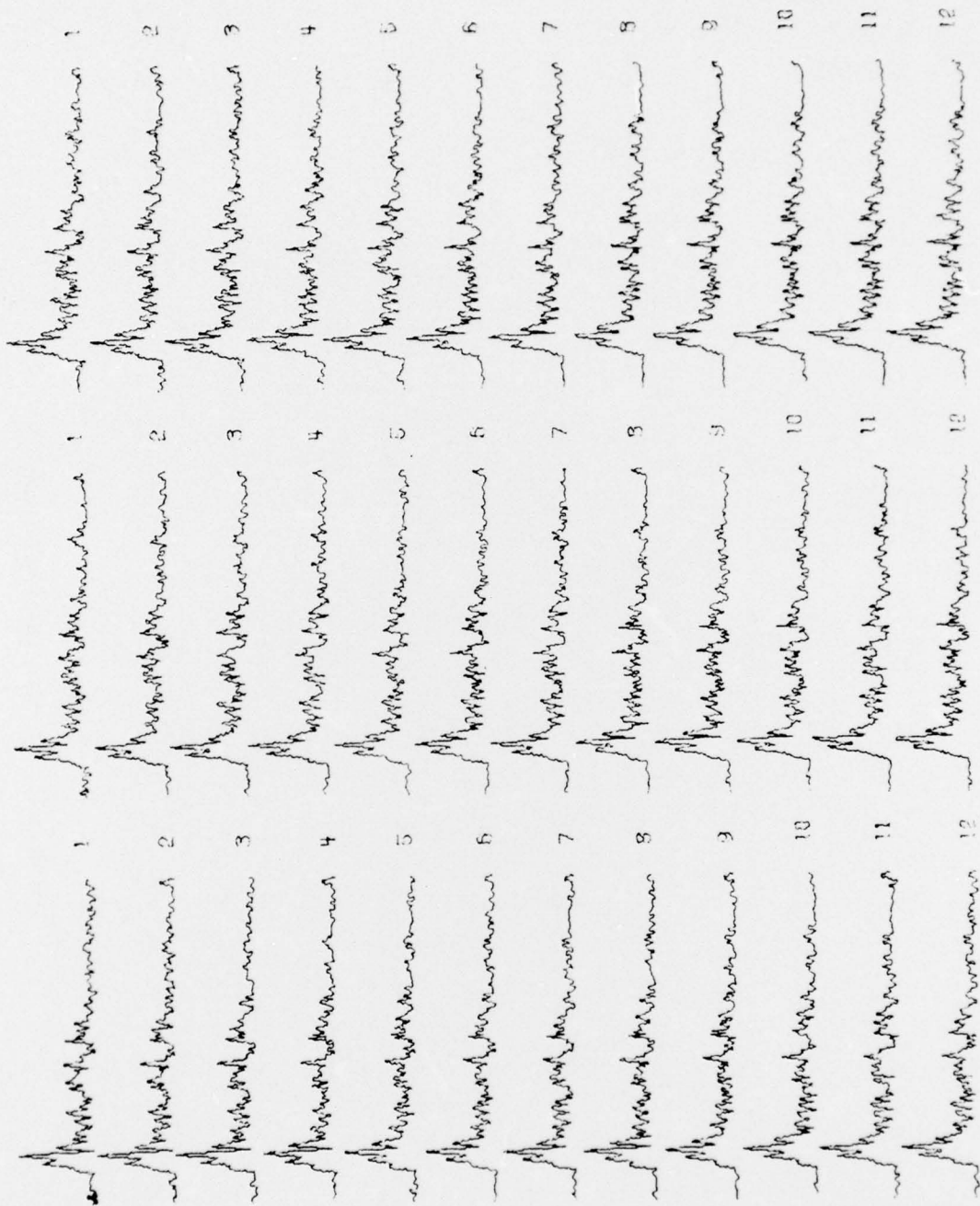
1(1,2)

FIGURE 33

BOW ASPECT: 1 msec TRANSMIT PULSE (U)

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6(11,12)

5(9,10)

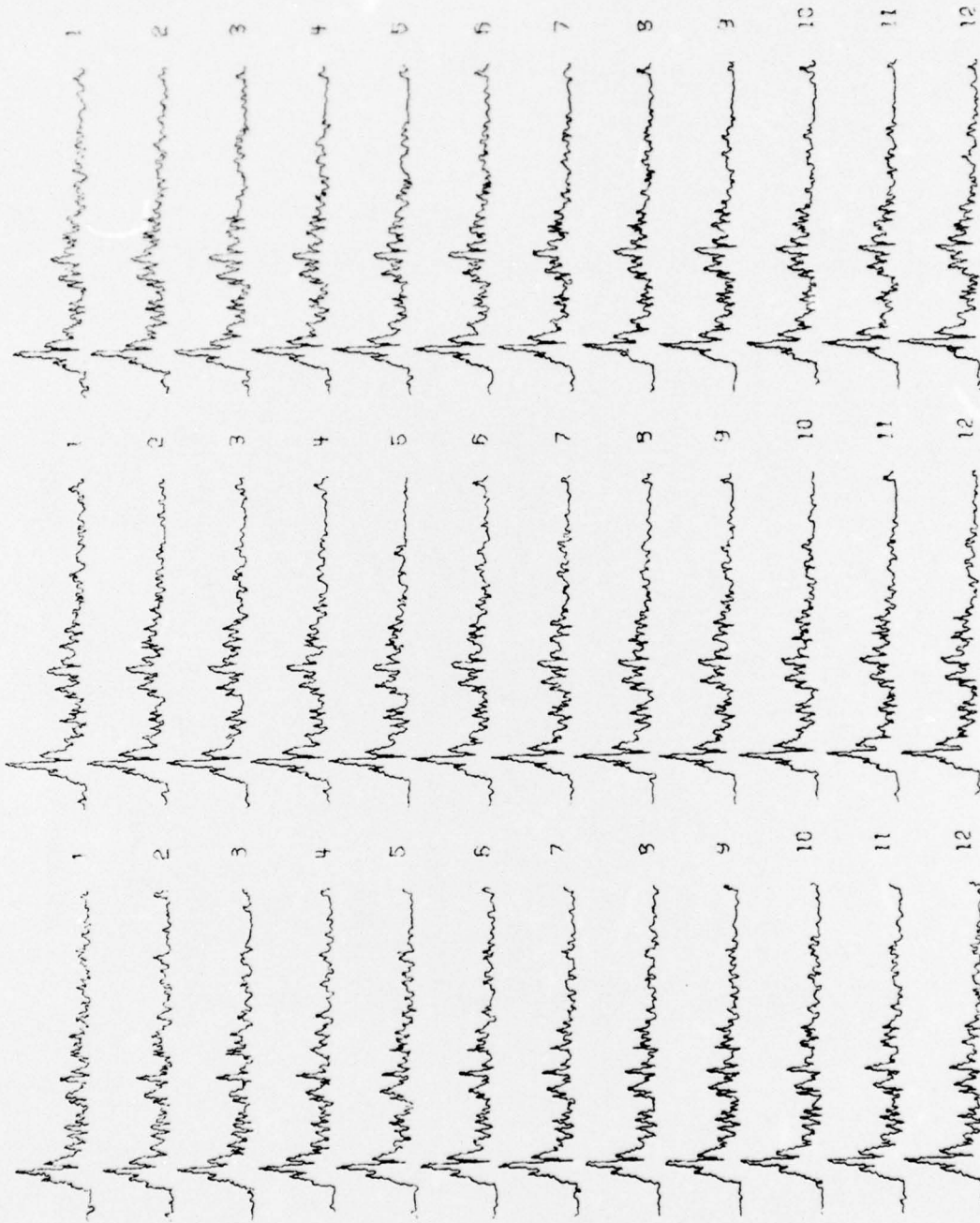
4(7,8)

FIGURE 34

BOW ASPECT: 1 msec TRANSMIT PULSE (U)

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9(17,18)

8(15,16)

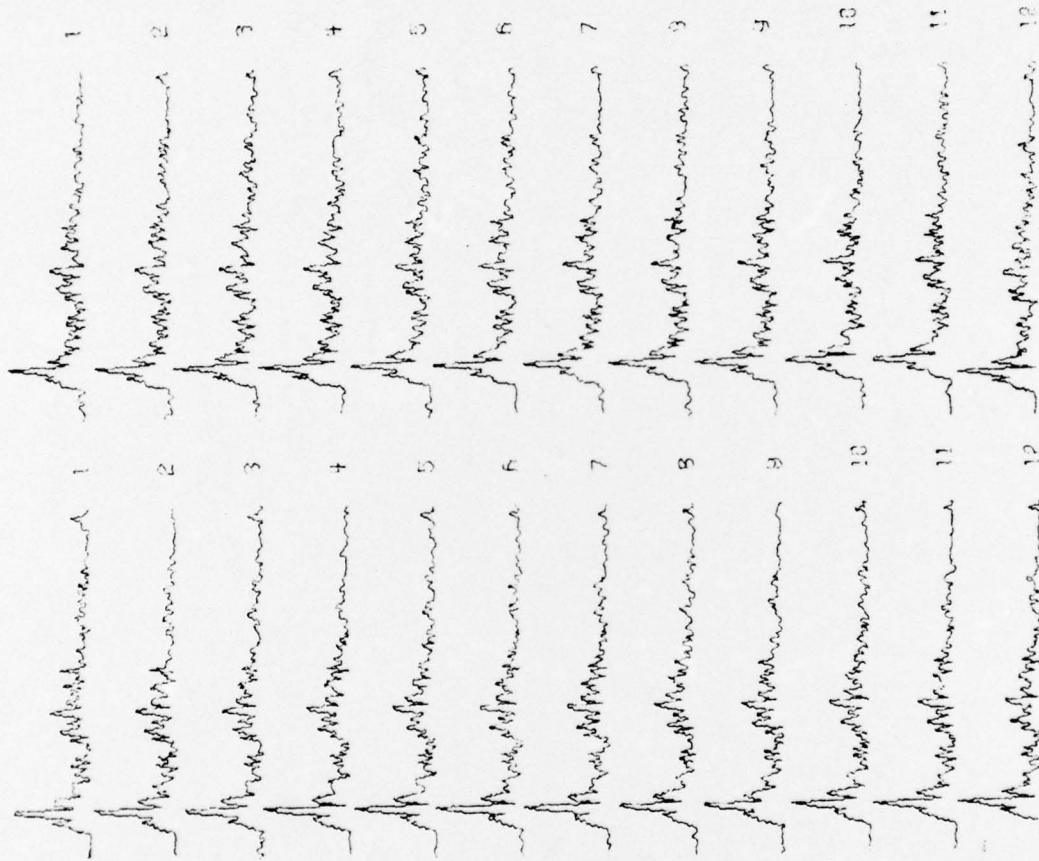
7(13,14)

FIGURE 35

BOW ASPECT: 1 msec TRANSMIT PULSE (U)

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10(19,20)

11(21,22)

FIGURE 36

BOW ASPECT: 1 msec TRANSMIT PULSE (U)

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REFERENCES

1. Pitt, S. P., and O. D. Grace, "Signal Processing by Digital Quadrature Techniques," DRL-TR-68-39, Defense Research Laboratory, The University of Texas at Austin (30 December 1968).
2. Plemons, T. D., "An Echo-Echo Correlation Analysis of Submarine Echoes" (U), ARL-TR-70-7, Applied Research Laboratories The University of Texas at Austin (26 February 1970). (CONFIDENTIAL)

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