Larry Polansky (CCM/Music Dept.)
Faculty Colloquia
4/21/83
Mills College

Formal Theories of Musical Syntax

I. Introduction to musical artificial intelligence and formal syntaxes.

A. Function of Modeling
1. Thom's kinematic and dynamic theories
2. Parametrization and prediction.

B. Role of theoretical constructs in music.
1. Revolutionary composition; Canetti's "decay of information and retardation of evolutionary progress".
2. Theoretical constructs as progressive steps-grounds for new composition.
3. Breakdown of conventional theoretical dogma.

C. Musical/historical role of theory
1. Often composers/theorists present musical and theoretical ideas simultaneously.

D. Development of a Formal Language
1. Simulation of natural languages.
2. Use of high speed intelligent devices.
3. Storage, decision making, and phenomenological stability of these devices.
4. Simulation of natural musical languages is in three categories: perception, composition, and performance.
5. Perceptual experiments.
6. Compositional experiments.
7. Performance experiments.

E. Statistical and morphological theories of musical language.
1. Language must integrate all three domains of musical activity.
2. Might be other classifications of theoretical investigation.

II. Tenney's Perceptron-Design of a Statistical Formal Language
1. Proper design of musical parameters.
2. Gestalt segregation and cohesion.
Ex. 1 — 3. Peak detection.
4. Hierarchical structuring.
Ex. 2-7 — 5. Selected Examples
a. Sample input to program (from Varese).
b. First page of score of same with TG's.
c. First page of Ruggles' Portals.
d. 2 selected pages from FORTRAN program.
e. excerpt from Ruggles' paper showing comparison between perceptron and more conventional analysis.
f. map of intensity profiles-showing first hints of morphological considerations.

III. Morphological Theory

A. Practical usage.

1. Experimentation prior to complete statement of formal theory.
2. Rosenboom's On Being Invisible.
    a) chart of performance system. — Example 8
    b) recording of performance (excerpts). — M. Ex. 1

B. Morphological Metric spaces

1. Dynamic theory.
2. Shape.
3. Metric topology.
4. Metric= well-ordered space.
5. Sample metric (rough "curvature").
6. Other metrics.
7. Invariants.
8. Relationship to traditional musical terminology (esp. serialism).
9. Continuity--perception dependant.
10. L. Polansky Four Voice Canon #3 and #4 — M. Ex. 2
11. Page from Bemsha Swing (Polansky). — Ex. 9
12. Nazca Liftoff (Rosenboom) — M. Ex. 3

Selected References

Berlioz, H. Treatise on Instrumentation; trans. by Theodore Front; N.Y.; Kalmus, 1948
(Good example of ostensibly theoretical treatise being more a statement of revolutionary compositional design).

Greenberg, M.J. Euclidean and Non-Euclidean Geometries ; S.F.; Freeman and Co.; 1973
(Projectional geometry is essentially a study of morphological transformations--Greenberg's work is a good introduction to this powerful tool).

Hiller, L., and Isaacson, L. "Illiac Suite for String Quartet"; score; New Music; April; 1957
(This piece is one of the pioneering examples of "stochastic" simulation of conventional form).

Dugundji, James Topology ; Allyn and Bacon; 1966.
(The standard introduction and advanced text on point-set and beginning algebraic topology).

Polansky, L. "A Hierarchical Gestalt Analysis of Ruggles' Portals"; proceedings of 4th Int. Comp. Music Conference; 1977; Northwestern U. Press.
" Notes on the Proposed 68000 FORTH system music language" Internal CCM document, 1982.
"Four Voice Canon #3 and Four Voice Canon #4"; 1975 and 1979/82; availible (rec.) on CCM Anthology Tape.

Rothenberg, D. "A Model for Pattern Perception with Musical Applications" Part I-III; Jrnl. of Math. Systems Theory; #11 and 12; 1978
(Rothenberg's work is unique in its approach to the formalization of musical parameters and transformations. This is just one example of his voluminous output, much of it unpublished).

Rosenboom, D Biofeedback and the Arts; Toronto; ARC Pub.; 1976
On Being Invisible (LP); ARC Recordings; 1977.
Future Travel (LP); Street Records SRA-002; 1981
"The Qualities of Change: "On Being Invisible": Steps Towards Transitional Topologies of Musical Form (1977:78: 82)" (unpublished ms.) 1982

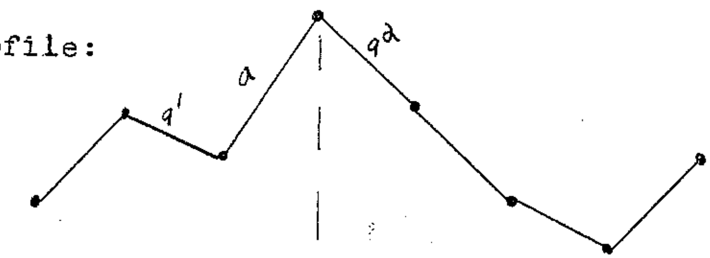
Tenney, J (with Larry Polansky) "Hierarchical Temporal Gestalt Perception in Music: A 'Metric Space' Model"; Jrnl. of Music Theory; 1979.
"META Meta/Hodos"; Jrnl. of Experimental Aesthetics; Vol 1 #1; Micheal Byron, Ed.; Vancouver; ARC Pub.; 1978.

Thom, R. Structural Stability and Morphogenesis; Trans. D.H. Fowler; W.A. Benjamin Inc.; 1975.

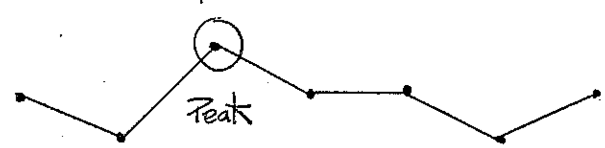
Xenakis, Iannis Formalized Music ; Indiana U. Press; 1971
(Early statement by this groundbreaking composer on the possibilitie of stochastic and algorithmic and probabilistic music).

EXAMPLE OF EVENT PROFILE AND CONSEQUENT DISJUNCTION MEASURE PROFILE.

Event profile:



Disjunction measure profile:



(disjunctions calculated as absolute values of corresponding events)

$a > a'$
$a > a^2$

IX.B. Programme Output.

Input data : Varèse

N	DUR	RST	PITCH	A.1	A2	TMBR
1	0.30	0.00	6.00	4.50	4.00	0.00
2	0.30	0.00	5.00	4.00	4.00	0.00
3	2.40	0.00	7.00	4.00	5.00	0.00
4	2.00	0.00	7.00	5.00	4.00	0.00
5	0.60	0.00	2.00	4.00	4.00	0.00
6	0.40	0.00	7.00	4.00	4.00	0.00
7	1.20	0.30	2.00	4.00	4.00	0.00
8	2.40	0.00	8.00	2.00	5.00	0.00
9	3.60	1.20	8.00	5.00	2.00	0.00
10	0.30	0.00	6.00	4.00	4.00	0.00
11	0.30	0.00	5.00	4.00	4.00	0.00
12	1.20	0.00	7.00	4.00	4.00	0.00
13	1.40	0.00	8.00	4.00	4.00	0.00
14	0.40	0.00	2.00	4.00	4.00	0.00
15	1.20	0.00	8.00	4.00	4.00	0.00
16	0.20	0.00	7.00	4.00	4.00	0.00
17	0.20	0.00	8.00	4.00	4.00	0.00
18	1.40	0.00	7.00	4.00	4.00	0.00
19	2.60	0.00	5.00	4.00	3.00	0.00
20	0.80	0.00	2.00	5.00	2.00	0.00
21	1.20	0.40	8.00	2.00	2.00	0.00
22	0.40	0.00	2.00	4.00	4.50	0.00
23	0.80	0.00	8.00	4.50	5.00	0.00
24	2.00	0.00	10.00	5.00	4.00	0.00
25	1.20	0.00	11.00	4.00	3.00	0.00
26	3.20	0.40	11.00	3.00	5.00	0.00
27	0.80	0.00	8.00	2.00	2.00	0.00
28	0.80	0.00	11.00	2.00	2.00	0.00
29	0.60	0.00	8.00	2.00	2.00	0.00
30	1.80	0.00	11.00	2.00	2.00	0.00
31	1.20	0.00	13.00	2.00	5.00	0.00
32	1.20	0.30	13.00	5.00	2.00	0.00
33	0.30	0.00	14.00	6.00	6.00	0.00
34	0.30	0.00	13.00	6.00	6.00	0.00
35	3.60	0.30	14.00	6.00	7.00	0.00
36	0.30	0.00	13.00	4.00	4.00	0.00
37	2.00	0.00	14.00	4.00	4.00	0.00
38	0.40	0.00	13.00	4.00	4.00	0.00
39	0.60	0.00	14.00	4.00	4.00	0.00
40	1.00	0.00	13.00	4.00	4.00	0.00
41	0.40	0.00	14.00	4.00	5.00	0.00
42	0.40	0.00	13.00	5.00	6.00	0.00
43	4.40	0.40	15.00	7.00	7.00	0.00
44	0.40	0.00	21.00	5.00	5.00	0.00
45	0.80	0.00	15.00	5.00	5.00	0.00
46	0.40	0.00	9.00	5.00	5.00	0.00
47	0.60	0.00	15.00	5.00	5.00	0.00
48	0.20	0.00	21.00	5.00	5.00	0.00
49	0.40	0.00	4.00	5.00	5.00	0.00
50	0.60	0.00	10.00	5.00	5.00	0.00
51	1.80	0.60	16.00	5.00	6.00	0.00
52	0.60	0.00	22.00	6.00	6.00	0.00
53	0.60	0.00	10.00	6.00	6.00	0.00
54	1.80	0.00	23.00	6.50	7.00	0.00
55	6.60	1.80	29.00	7.00	7.50	0.00
56	0.30	0.00	17.00	2.00	2.00	0.00
57	0.30	0.00	16.00	2.00	2.00	0.00
58	2.40	0.30	18.00	2.00	1.00	0.00

IX.B. Programme Output.

Input data: Varèse

N	DUR	/ RST	PITCH	A1	A2	TMBR
1	0.30	0.00	6.00	4.50	4.00	0.00
2	0.30	0.00	5.00	4.00	4.00	0.00
3	2.40	0.00	7.00	4.00	5.00	0.00
4	2.00	0.00	7.00	5.00	4.00	0.00
5	0.60	0.00	2.00	4.00	4.00	0.00
6	0.40	0.00	7.00	4.00	4.00	0.00
7	1.20	0.30	2.00	4.00	4.00	0.00
8	2.40	0.00	8.00	2.00	5.00	0.00
9	3.60	1.20	8.00	5.00	2.00	0.00
10	0.30	0.00	6.00	4.00	4.00	0.00
11	0.30	0.00	5.00	4.00	4.00	0.00
12	1.20	0.00	7.00	4.00	4.00	0.00
13	1.40	0.00	8.00	4.00	4.00	0.00
14	0.40	0.00	2.00	4.00	4.00	0.00
15	1.20	0.00	8.00	4.00	4.00	0.00
16	0.20	0.00	7.00	4.00	4.00	0.00
17	0.20	0.00	8.00	4.00	4.00	0.00
18	1.40	0.00	7.00	4.00	4.00	0.00
19	2.60	0.00	5.00	4.00	3.00	0.00
20	0.80	0.00	2.00	5.00	2.00	0.00
21	1.20	0.40	8.00	2.00	2.00	0.00
22	0.40	0.00	2.00	4.00	4.50	0.00
23	0.80	0.00	8.00	4.50	5.00	0.00
24	2.00	0.00	10.00	5.00	4.00	0.00
25	1.20	0.00	11.00	4.00	3.00	0.00
26	3.20	0.40	11.00	3.00	5.00	0.00
27	0.80	0.00	8.00	2.00	2.00	0.00
28	0.80	0.00	11.00	2.00	2.00	0.00
29	0.60	0.00	8.00	2.00	2.00	0.00
30	1.80	0.00	11.00	2.00	2.00	0.00
31	1.20	0.00	13.00	2.00	5.00	0.00
32	1.20	0.30	13.00	5.00	2.00	0.00
33	0.30	0.00	14.00	6.00	6.00	0.00
34	0.30	0.00	13.00	6.00	6.00	0.00
35	3.60	0.30	14.00	6.00	7.00	0.00
36	0.30	0.00	13.00	4.00	4.00	0.00
37	2.00	0.00	14.00	4.00	4.00	0.00
38	0.40	0.00	13.00	4.00	4.00	0.00
39	0.60	0.00	14.00	4.00	4.00	0.00
40	1.00	0.00	13.00	4.00	4.00	0.00
41	0.40	0.00	14.00	4.00	5.00	0.00
42	0.40	0.00	13.00	5.00	6.00	0.00
43	4.40	0.40	15.00	7.00	7.00	0.00
44	0.40	0.00	21.00	5.00	5.00	0.00
45	0.80	0.00	15.00	5.00	5.00	0.00
46	0.40	0.00	9.00	5.00	5.00	0.00
47	0.60	0.00	15.00	5.00	5.00	0.00
48	0.20	0.00	21.00	5.00	5.00	0.00
49	0.40	0.00	4.00	5.00	5.00	0.00
50	0.60	0.00	10.00	5.00	5.00	0.00
51	1.80	0.60	16.00	5.00	6.00	0.00
52	0.60	0.00	22.00	6.00	6.00	0.00
53	0.60	0.00	10.00	6.00	6.00	0.00
54	1.80	0.00	23.00	6.50	7.00	0.00
55	6.60	1.80	29.00	7.00	7.50	0.00
56	0.30	0.00	17.00	2.00	2.00	0.00
57	0.30	0.00	16.00	2.00	2.00	0.00
58	2.40	0.30	18.00	2.00	1.00	0.00

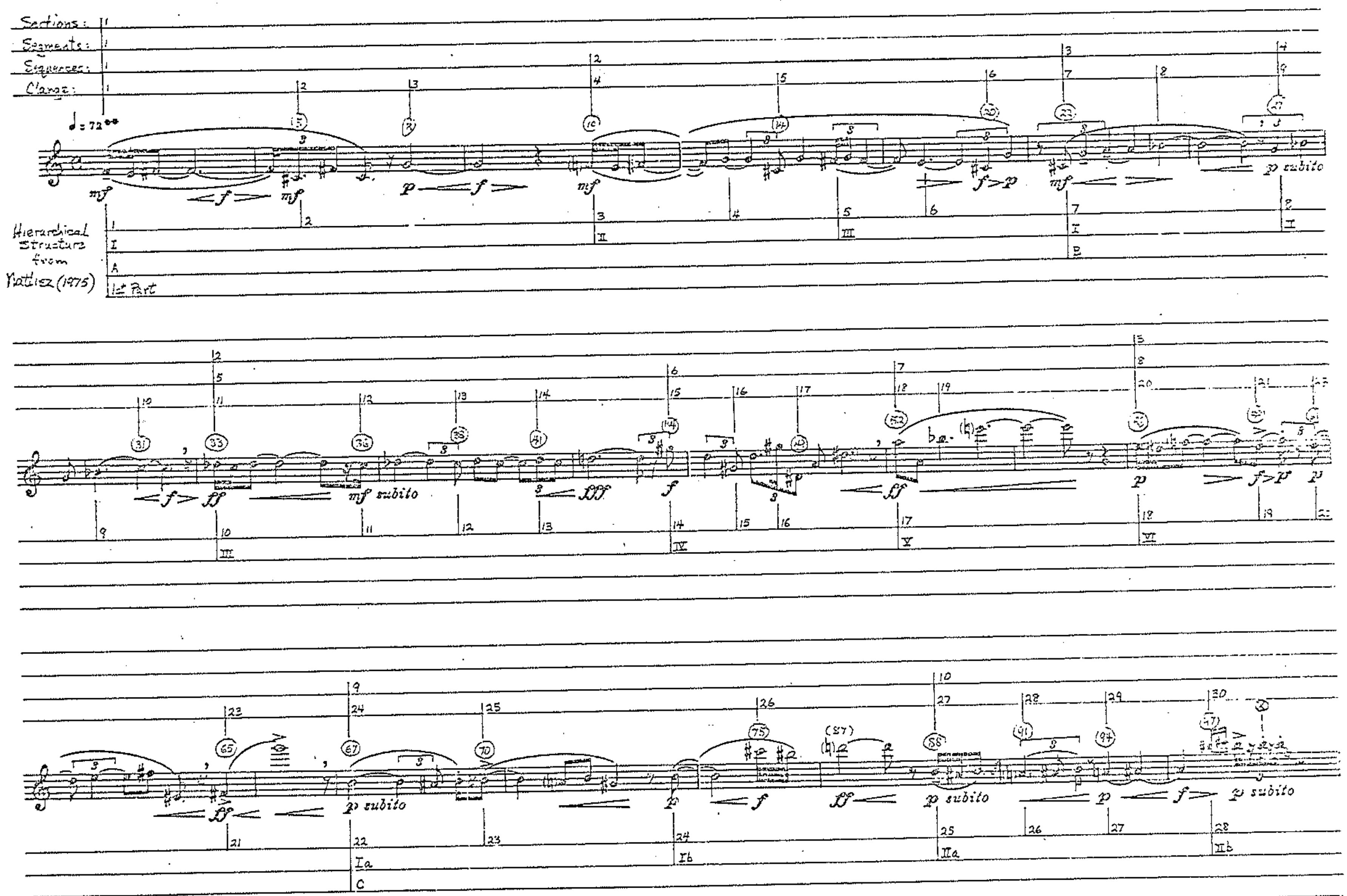


Figure IV.1. Edgard Varèse: DENSITY 21.5 -- final results with "optimum" weightings (above), and segmentation according to Nattiez (below).

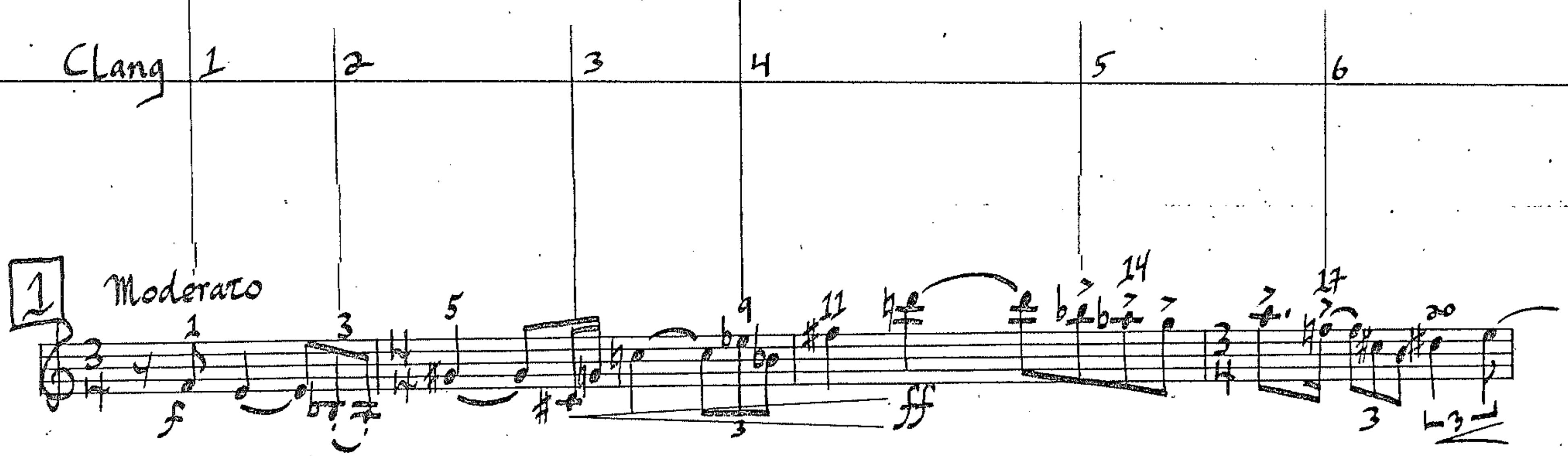
Ruggles: Portals (melodic line)

Section 1

Segment 1

Optimal weights: Proximity = 1; Pitch (PW) = .5; Intensity (IW) = 1
Temporal Density = 1; Timbre = .2

Sequence 1 2



Variant weightings: PW = .3 (all other parameters as above)
PW = .6 (all other parameters as above)
IW = 3 (all other parameters as above)

```
     2  F5.2,' TIMBRE=',F5.2)
        WSUM=PW+DW+TDW+AW+TW
        PW=PW/WSUM
        DW=DW/WSUM
        TDW=TDW/WSUM
        AW=AW/WSUM
        TW=TW/WSUM
        DO 76 K=1,10
76               COUNT(K)=0
        DO 78 K=1,1000
            DM(K)=0.0
      DMST(K)=0.
        DMD1(K)=0
        DMD2(K)=0
                 IEND(K)=0
78               ISTART(K)=0
C
                         DW=DW*10.0
C
C                INTIALIZES  BOUNDARIES  ON  FIRST  LEVEL
      DO 1777 I=2,N
                 PI=PW*(P1(I)-P2(I-1))
                 TDI=0.0
                 DI=DW*(RST(I-1))
                 IF (RST(I-1).EQ.0.)ALAST=A2(I-1)
                 IF(RST(I-1).GT.0.)ALAST=0.
                 AI=AW*(A1(I)-ALAST)
                 DM(I)=(ABS(DI)+ABS(PI)+ABS(TDI)+ABS(AI))
        DM(I)=DM(I)*2.0
C
1777    CONTINUE
        DO 80 I=501,1000
                 P(I)=0
                 DUR(I)=0
                 AMP(I)=0
                 TD(I)=0
                 TIM(I)=0
                 RST(I)=0
80      CONTINUE
C
        LEVEL=0
C
C
C                MAIN PROGRAM
C
C
C       SETS NEW LEVEL,CLEARS COUNTER(CHECK), AND  INITIALIZES
C       FLAG, WHICH TELLS YOU IF YOU'VE FINISHED ON A LEVEL.
C       CHECK IS A VARIABLE WHICH SEES IF THERE ARE ENOUGH
C       TG'S CURRENTLY TO COMPUTE FOR INITIATION.
C
100     CHECK=0
        ET=0.
        FLAG=0
        LEVEL=LEVEL+1
C
C
C                SETS ARRAY  INDICES.
        LOLEV= (2.0**(LEVEL-1))
        HILEV= (2.0**(LEVEL))
```

```
      K1=1000.0-((1.0/LOLEV)*1000.0)
      K2=1000.0-((1.0/HILEV)*1000.0)
      WRITE(6,9375)
C
C     IF NUMBER<4, THEN NOT ENOUGH TG'S ON THIS HIGHEST LEVEL
C     TO TRY AND MAKE DISTINCTIONS. SO PROGRAM TERMINATES.
      IF (NUMBER(LEVEL).LT.4) GO TO 9000
      HICNT=1
      ISTART(K2+1)=K1+1
C
C              SPECIFIC PLANAR COMPUTATION
  500 COUNT(LEVEL)=COUNT(LEVEL)+1
      TCOUNT=COUNT(LEVEL)
      CHECK=CHECK+1
      IF(TCOUNT.LE.NUMBER(LEVEL))GO TO 550
      FLAG=1
      GO TO 700
C
C
C     KEEPS TRACK OF ELAPSED TIME IN TG.
  550 ET=ET+DUR(TCOUNT+K1)
C
C     CHECKS FOR 'ONE ELEMENT CLANGS'.
      IF(CHECK.LT.2)GO TO 500
C
C              COMPUTE INTERVAL (DISJUNCTION MEASURE)
      IND=(TCOUNT+K1)
C
C              MEAN INTERVALS
      PI=PW*(P(IND)-P(IND-1))
      DI=DW*DUR(IND-1)
      IF (LEVEL.GT.1)DI=0.
      TDI=TDW*(TD(IND)-TD(IND-1))
      AI=AW*(AMP(IND)-AMP(IND-1))
      TI=TW*(TIM(IND)-TIM(IND-1))
C              SUMS MEAN INTERVALS.
      ABSUM=ABS(PI)+ABS(TDI)+ABS(AI)+ABS(TI)+DI
C
C
C              "CITY-BLOCK" METRIC.
      DM(IND)=.5*DM(IND)+ABSUM
C
      IF(TCOUNT.LT.4)GO TO 650
C
C     COMPUTES DIFFERENCE OF PEAK WITH SURROUNDING DM'S TO GIVE
C     ROUGH IDEA OF STRENGTH OF INITIATOR.
      DMD1(IND-1)=1.0-(DM(IND-2)/DM(IND-1))
      DMD2(IND-1)=1.0-(DM(IND)/DM(IND-1))
C
  650 IF (CHECK.LT.4) GO TO 500
C
C     CHECKS MINIMUM TG LENGTH.
      ETCHK=ET-(DUR(IND-1)+DUR(IND))
      IF(ETCHK.LE.CMIN)GO TO 500
C
C              TESTS FOR PEAK.
      IF ((DMD1(IND-1).LT.EPS1).OR.(DMD2(IND-1).LT.EPS1))
     1 GO TO 500
C
C     IF DMST POSITIVE, THEN PEAK. IF ZERO, THEN NOT PEAK.
```

GENERAL COMMENTS

The larger hierarchical segmentation resulting from the optimal weights is as follows:

		EL. #	MEASURES
SECTION I	SEGMENT 1	1-24	1-6
	SEGMENT 2	25-46	6-9
	SEGMENT 3	46-57	10-13
SECTION II	SEGMENT 4	58-89	13-19
	SEGMENT 5	90-128	19-25
SECTION III	SEGMENT 6	129-188	26-35
	SEGMENT 7	189-207	36-38
	SEGMENT 8	208-249	39-46
	SEGMENT 9	250-261	47-50
SECTION IV	SEGMENT 10	262-292	50-54
	SEGMENT 11	293-320	54-59
	SEGMENT 12	321-379	59-69
	SEGMENT 13	380-408	70-75

Thomas Peterson, in The Music of Carl Ruggles, states that Portals has "... a certain semblance to rondo form, since the principle idea recurs (albeit in freely varied fashion) four times during the course of the work, as well as providing the material for the coda. A plausible attempt at conventional analysis might be made as follows:

A	1-6	B	43-50	
B	6-13	D	50-62	
A'	13-19	A^3	62-70	
C	19-26	CODA	70-75	(based on A)"[1]
A^2	26-43			

Intensity Profile (all levels)
(section III)

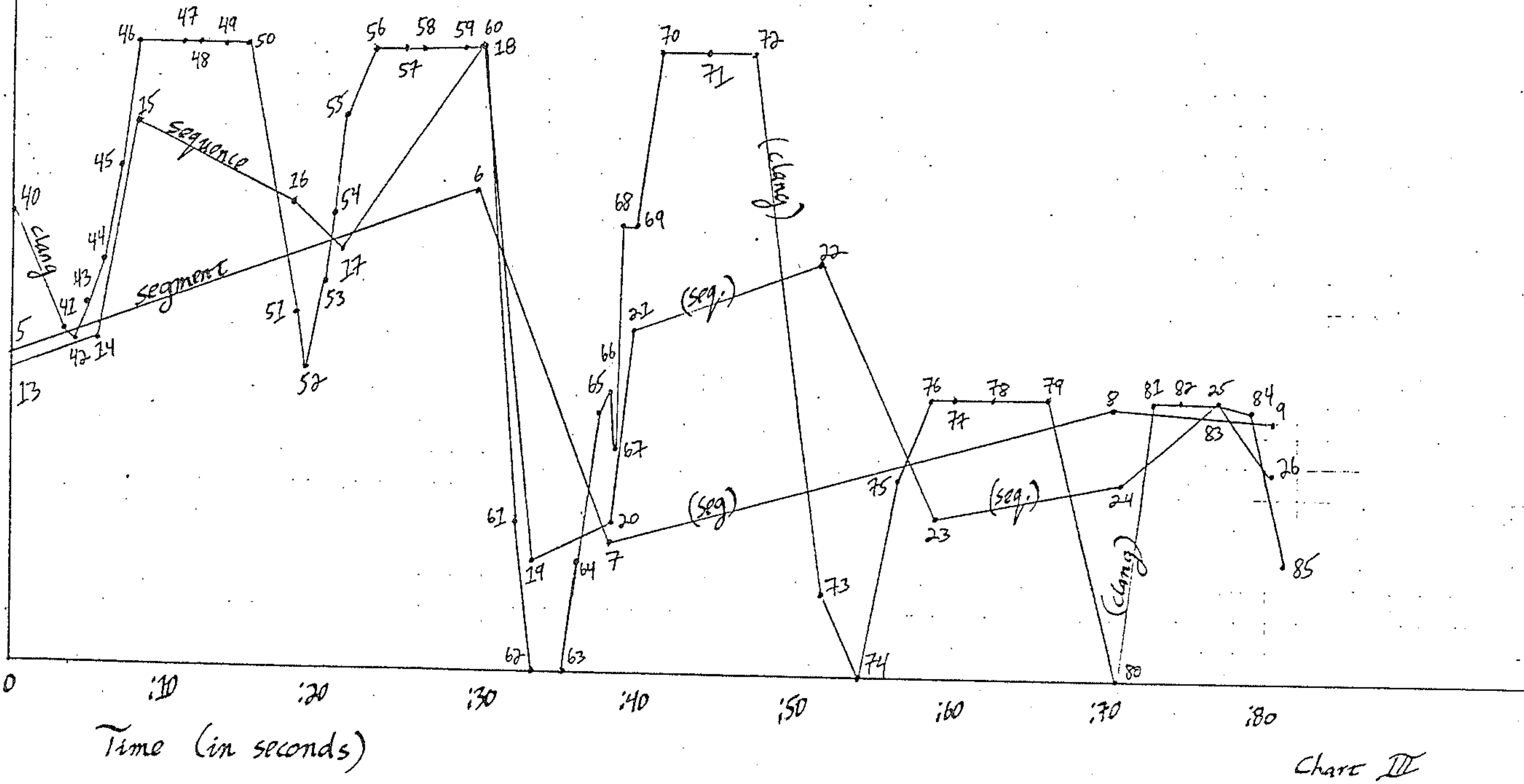


Chart III

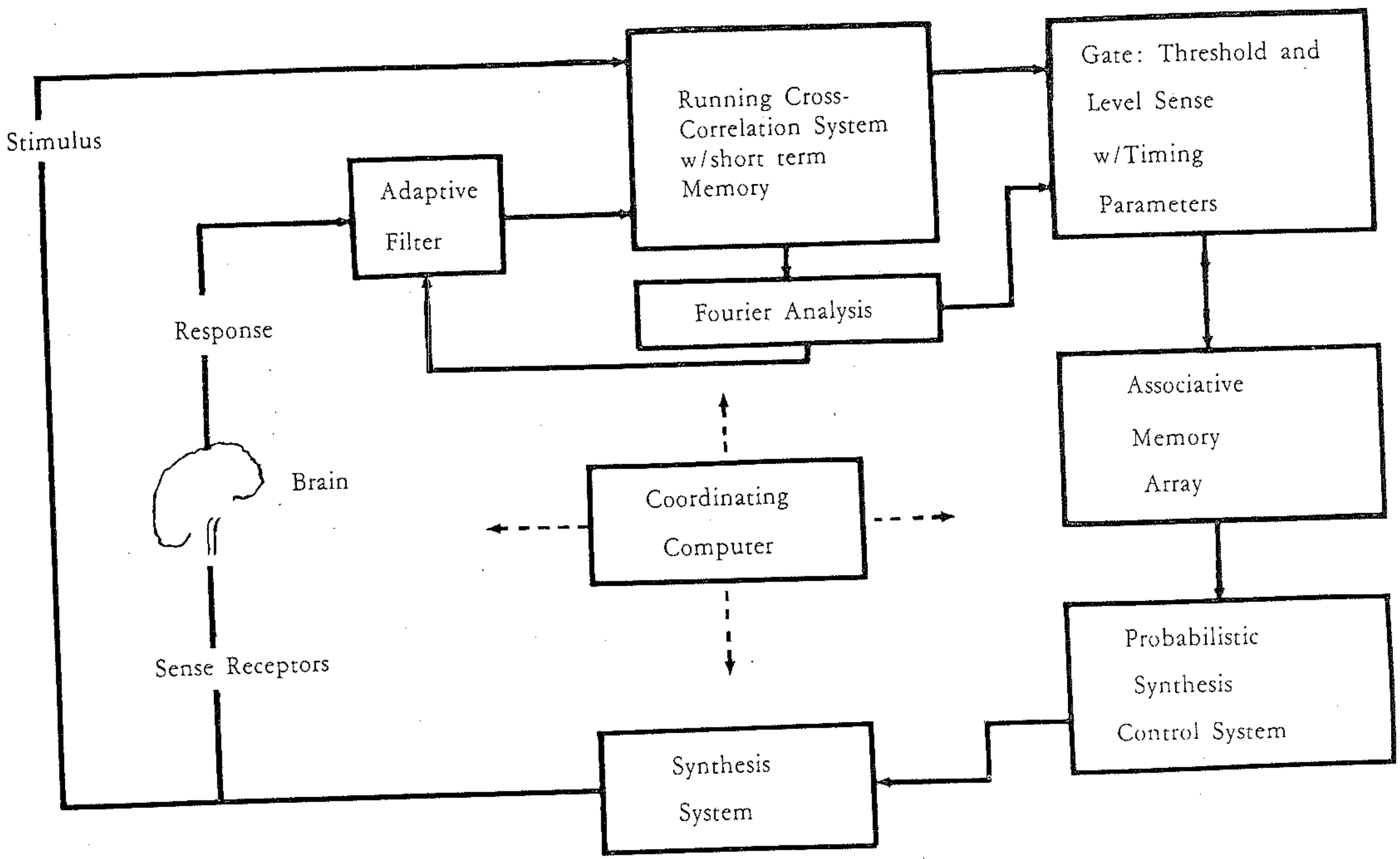
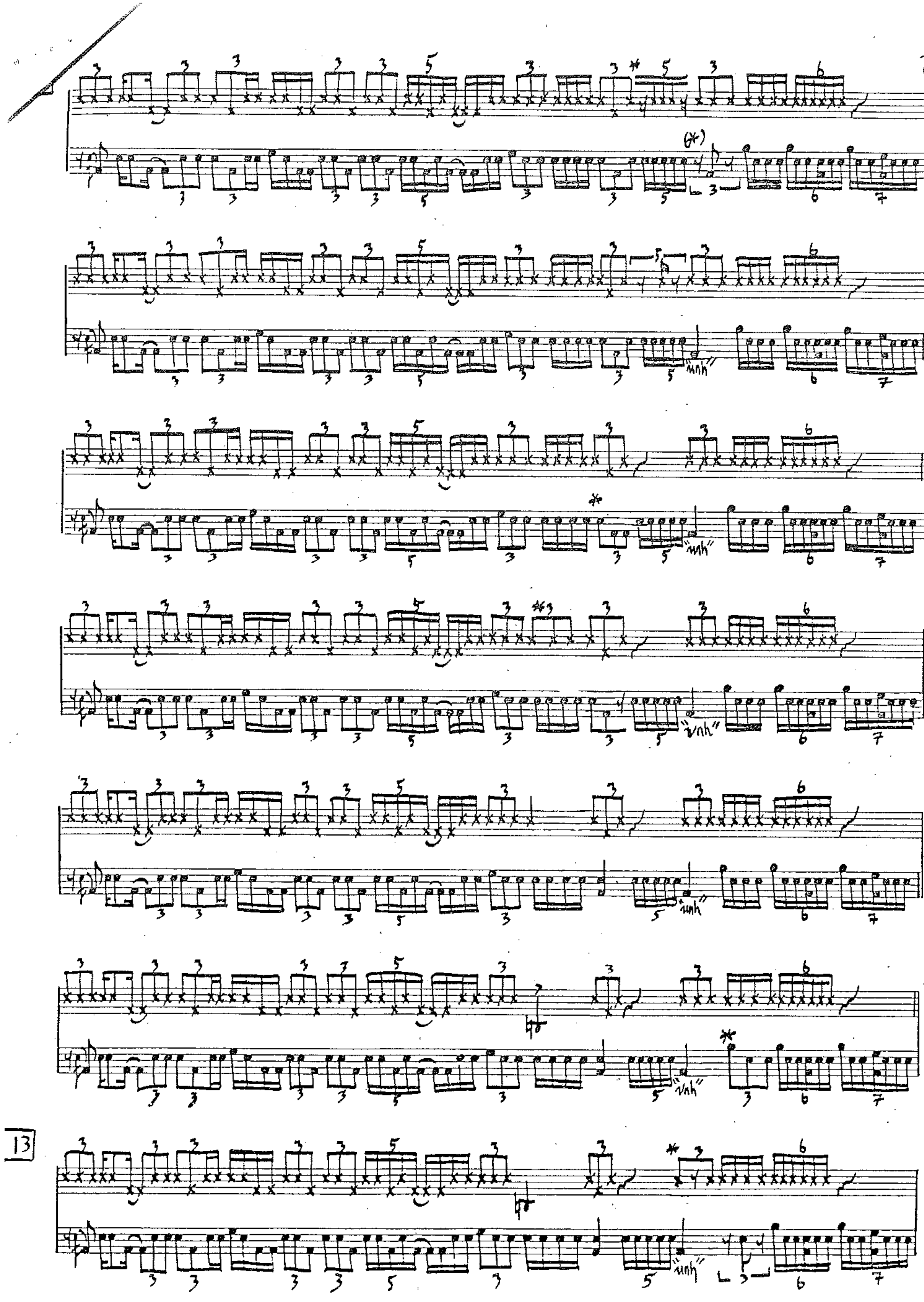

Stimulus
Adaptive Filter
Running Cross-Correlation System w/short term Memory
Gate: Threshold and Level Sense w/Timing Parameters
Fourier Analysis
Response
Brain
Sense Receptors
Coordinating Computer
Associative Memory Array
Probabilistic Synthesis Control System
Synthesis System

Figure 2.


(*)
"unh"
"unh"
"unh"
"unh"
"unh"
"unh"
13