E-1932-B (7-47)

BELL TELEPHONE LABORATORIES
INCORPORATED

Yellow

COVER SHEET FOR TECHNICAL MEMORANDA

SUBJECT: Composing Music by a Stochastic Process - Case 38543

COPIES TO:

1 – Case Files (6) ← THIS COPY
2 – R. Bown - J. B. Fisk
3 – H. W. Bode
4 – A. M. Clogston
5 – W. H. Doherty
6 – D. Hagelbarger
7 – A. V. Hollenberg
8 - J. E. Karlin
9 - W. E. Kock
10 - E. Lakatos
11 - W. D. Lewis
12 - D. B. Ling
13 - B. McMillan
14 - B. M. Oliver
15 - L. C. Peterson
16 - R. K. Potter
17 - J. C. Schelleng
18 - C. E. Shannon
19 - W. Shockley
20 - H. A. Stone
21 - L. R. Walker
22 - A. H. White
23 - Miss M. C. Brainard

MM-49-150-29
DATE November 15, 1949
AUTHORS J. R. Pierce
Mary E. Shannon

Filing Subject: Random Music

ABSTRACT

ABSTRACT

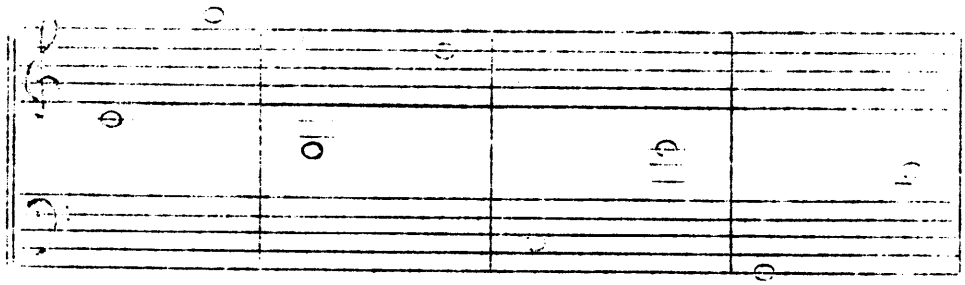
A catalog of chords on root 1 is compiled. The chords are listed in 4 tables as to the position of bass, tenor, alto and soprano. The chords can be shifted to other root positions. In order to choose a chord to follow a given chord, a root motion and the voice in which a common tone is to be held are chosen by chance with certain preassigned weightings. By means of simple relations, the chords fulfilling these conditions are located in the catalog and one of these is chosen by chance. Five short pieces composed in this manner are presented.

Composing Music by a Stochastic Process - Case 38543

MM-49-150-29
November 15, 1949

MEMORANDUM FOR FILE

The first attempt to produce random music resulted in sixteen measures of four chords each. To facilitate selection of chords a catalog of 68 chords in one key was compiled, admitting all intervals but a 7th, and restricted by the ranges and intervals between voices. The ranges allowed were



Intervals of more than an octave were allowed between tenor and bass, but not between soprano and alto or between alto and tenor. It was further required that each chord should have a tone in common with the preceding chord.

The actual selection of chords was accomplished with the aid of a table of four-figure random numbers. The first figure specified the octave in which the root was to be placed, the range covering three full octaves, and the digits 1, 4, 7 indicated the first, 2, 5, 8 the second, and

3, 6, 9 the third octave. The root was given by the second of the four figures, according to the following scheme. If the digit was a number from 1 to 6, the corresponding root was used. If the digit was 7, 8, or 9 it was replaced by the appropriate root given in the table below, thus eliminating sevenths and introducing the possibility of a slight pattern in root choice. The pattern was to be repeated for each group of eight measures.

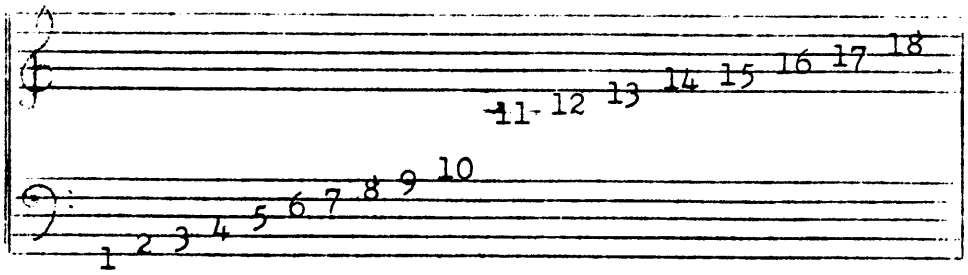
Measure	Root to be used				Measure	Root to be used			
1	1	4	5	2	5	1	4	5	2
2	3	6	3	6	6	3	6	3	6
3	2	5	4	1	7	6	3	6	3
4	6	3	6	3	8	2	4	5	1

The last two figures of the four-figure random number specified the catalog number of the chord.

Chords were chosen by this method, maintaining the common tone restriction, etc., and specifying that measures five and six repeat one and two, and the accompanying Random I is the result.

This method proved to be extremely slow, and gave rise to crossed voices and doubled tones which were not desirable. A means of simplifying the choice was found by the use of a new notation and an improved catalog.

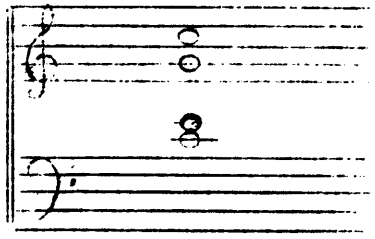
The notes in the range being given numbers as follows



each chord could be expressed in the form

$$R_m C_m = S_m A_m T_m B_m$$

where R_m indicated the root of the mth chord, m indicated the number of a chord in a sequence of chords, C is the number of the chord in the catalog and S_m etc. were the actual notes of each voice of the mth chord. For example, the chord



in the new notation would be $1,92_1 = (18, 15, 13, 11)$.

The new catalog consisted of four sub-catalogs, the complete set of chords being listed in each sub-catalog according to voice. Each sub-catalog was divided into groups corresponding to the various possible positions for

the particular voice. Thus the first, or soprano, sub-catalog consisted of six groups of chords, a group of twenty-four corresponding to S = 11, a group of forty chords possible with S = 13, etc., and similarly for the alto, tenor and bass. This complete catalog is found in Appendix I.

The first chord was chosen at random. The next and successive chords were found by the following process. The root and the voice to be held as common tone were chosen at random as was an index, + or -, indicating motion up or down the staff. The common voice was translated to a position, corresponding to a root-C position for the chord being found, by the relations

$$m + n +, (V_n)_C = V_m - R_n - 1)$$
$$m + n -, (V_n)_C = V_m + 8 - R_n$$
$$m - n +, (V_n)_C = V_m - R_n - 6$$
$$m - n -, (V_n)_C = V_m - (R_n - 1)$$

Where $(V_n)_C$ indicates a voice of the nth chord in C-root position.

The number of the common tone being thus determined, the group of chords having this note in the desired voice was found in the catalog and a chord chosen at random from this group. This chord was then translated from the catalog or C-root position to the corresponding position for the chosen root by means of the following relations:

$$m + n +, V_n = (V_n)_C + (R_n - 1)$$
$$m + n -, V_n = (V_n)_C + (R_n - 1) + 7$$
$$m - n +, V_n = (V_n)_C + (R_n - 1) - 7$$
$$m - n -, V_n = (V_n)_C + (R_n - 1)$$

For example, suppose the first chord, chosen at random, was $1,64 = (18, 15, 11, 6)$.

The dice, when thrown, gave 5, +, and A. The new chord, therefore was to be built on root 5, with motion up the staff and the alto held constant. The alto of the first chord was then translated from note 15 to note 11, the position corresponding to a root-C position of the second chord. From the catalog a random choice was made from the chords having A = 11, giving (13, 11, 4, 1). This chord was then translated to root 5, or $5,32_2 = (17, 15, 8, 5)$.

Using this system of progression, Random II was produced. Here, as in Random I, measures 1 and 2 reappear as 5 and 6. In addition it was specified that chords 1, 16, and 32 be built on root 1, and chords 15 and 31 be built on either root 4 or root 5.

An attempt to introduce some scale pattern was then made, but soon abandoned, since it had been found that the new enlarged catalog also produced far too many doubled voices. To remedy this, a third catalog was compiled with the chords subject to the restriction that root, third and

fifth be present in each chord. A total of fifty-nine chords met this restriction, and form Appendix II.

With the short catalog, Randoms IV, V and VI were rapidly developed. The same conditions were imposed as in the earlier attempts. For each chord the root, voice, and index are chosen by a throw of the three dice, and the position of the tone to be held common is noted. The catalog is entered, and one of the entries corresponding to this voice position is chosen with the aid of a random number table. The chord is translated to its final position as in the earlier methods, and so on for the succeeding chords.

This results in a simple, rapid method, one which could easily be set up systemically in file form. Each chord could be entered, together with all possible following chords. Since the number of possible chords is small, this would not be impractical, even considering the number of available roots and positions. The problem then would be a completely mechanical one, the first chord being chosen at random and the succeeding choices being made from the indicated groups in the file.

The various pieces have been played over a number of times. The surprising thing about them is that they sound rather musical. Dr. D. P. Ling was able to render them more acceptable by adding a certain amount of phrasing and "expression" in playing them. Random IV seems to be the best;

Random I is rather striking, with Random VI perhaps a third choice. A tape recording has been made of these three, and it is available to the curious.

By a change of rules, the character of the product could certainly be changed and could probably be improved. For instance, requiring a common tone in succeeding voices rules out many progressions, as, from the fourth to the fifth.

Other defects of the present scheme are the neglect of rhythm and the lack of any connection of longer range than that of a chord with the preceding chord.

An observed defect is that the voices tend either to cling to one note or to jump wildly. Perhaps something could be added to favor a melodic line in at least one voice.

J R Pierce
Mary E Shannon

J. R. PIERCE
MARY E. SHANNON

Attached:
Catalog I
Catalog II
Samples of Random I, II, IV, V and VI

Appendix I

Complete Catalog

S = 11

Chord #	A	T	B	Chord #	A	T	B
1	8	6	4	179	8	8	1
29	8	4	1	182	11	11	1
35	8	6	1	186	11	4	4
108	11	4	1	187	8	8	4
109	11	6	1	193	11	11	4
111	11	8	1	205	11	6	6
117	11	6	4	207	8	8	6
119	11	8	4	210	11	11	6
121	8	4	4	223	8	8	8
136	8	6	6	226	11	8	8
149	11	8	6	229	11	11	8
177	11	11	11				

S = 13

Chord #	A	T	B	Chord #	A	T	B
2	8	6	4	150	13	8	6
4	11	6	4	152	13	11	6
10	11	8	4	158	13	11	8
30	8	4	1	180	8	8	1
32	11	4	1	183	11	11	1
36	8	6	1	188	8	8	4
38	11	6	1	194	11	11	4
41	11	8	1	197	13	13	4
50	11	8	6	206	13	6	6
110	13	6	1	208	8	8	6
112	13	8	1	211	11	11	6
114	13	11	1	214	13	13	6
118	13	6	4	224	8	8	8
120	13	8	4	227	13	8	8
122	8	4	4	230	11	11	8
124	11	4	4	233	13	13	8
130	11	6	6	243	11	11	11
137	8	6	6	246	13	11	11
139	11	8	8	249	13	13	11
146	13	11	4				

S = 15

Chord #	A	T	B	Chord #	A	T	B
3	8	6	4	151	15	8	6
5	11	6	4	153	15	11	6
7	13	6	4	155	15	13	6
11	11	8	4	159	15	11	8
13	13	8	4	161	15	13	11
16	13	11	4	164	15	13	8
31	8	4	1	167	13	6	1
33	11	4	1	170	13	8	1
37	8	6	1	181	8	8	1
39	11	6	1	184	11	11	1
42	11	8	1	189	8	8	4
44	13	11	1	195	11	11	4
51	11	8	6	198	13	13	4
53	13	8	6	201	15	13	4
61	13	11	6	209	8	8	6
77	13	11	8	212	11	11	6
100	13	11	11	215	13	13	6
113	15	8	1	219	15	15	6
115	15	11	1	225	8	8	8
123	8	4	4	228	15	8	8
125	11	4	4	231	11	11	8
131	11	6	6	234	13	13	8
133	13	6	6	239	15	15	8
138	8	6	6	244	11	11	11
140	11	8	8	247	15	11	11
142	13	8	8	250	13	13	11
145	15	8	4	255	15	15	11
147	15	11	4				

S = 18

Chord #	A	T	B	Chord #	A	T	B
6	11	6	4	47	15	11	1
8	13	6	4	52	11	8	6
12	11	8	4	54	13	8	6
14	13	8	4	56	15	8	6
17	13	11	4	62	13	11	6
19	15	11	4	64	15	11	6
22	15	13	4	69	15	13	6
34	11	4	1	78	13	11	8
40	11	6	1	80	15	11	8
43	11	8	1	85	15	13	8
45	13	11	1	92	15	13	11

Chord #	A	T	B	Chord #	A	T	B
97	15	8	8	168	13	6	1
101	13	11	11	171	13	8	1
103	15	11	11	173	15	8	1
116	18	11	1	185	11	11	1
126	11	4	4	190	15	8	4
132	11	6	6	196	11	11	4
134	13	6	6	199	13	13	4
141	11	8	8	202	18	13	4
143	13	8	8	213	11	11	6
148	18	11	4	216	13	13	6
154	18	11	6	220	15	15	6
156	18	13	6	232	11	11	8
157	18	15	6	235	13	13	8
160	18	11	8	240	15	15	8
162	18	13	11	245	11	11	11
163	18	15	11	248	18	11	11
165	18	13	8	251	13	13	11
166	18	15	8	256	15	15	11

S = 20

Chord #	A	T	B	Chord #	A	T	B
9	13	6	4	93	15	13	11
15	13	8	4	95	18	13	11
18	13	11	4	98	15	8	8
20	15	11	4	102	13	11	11
23	15	13	4	104	15	11	11
25	18	13	4	106	18	11	11
27	18	11	4	135	13	6	6
46	13	11	1	144	13	8	8
48	15	11	1	169	13	6	1
55	13	8	6	172	13	8	1
57	18	11	1	174	15	8	1
59	15	8	6	191	15	8	4
63	13	11	6	200	13	13	4
65	15	11	6	203	20	13	4
67	18	11	6	217	13	13	6
70	15	13	6	218	20	13	6
72	18	13	6	221	15	15	6
75	18	15	6	236	13	13	8
79	13	11	8	237	20	13	8
81	15	11	8	241	15	15	8
83	18	11	8	252	13	13	11
86	15	13	8	253	20	13	11
88	18	13	8	257	15	15	11
90	18	15	8	259	18	15	11

S = 22

Chord #	A	T	B	Chord #	A	T	B
21	15	11	4	89	18	13	8
24	15	13	4	91	18	15	8
26	18	13	4	94	15	13	11
28	18	11	4	96	18	13	11
49	15	11	1	99	15	8	8
58	18	11	1	105	15	11	11
60	15	8	6	107	18	11	11
66	15	11	6	175	15	8	1
68	18	11	6	192	15	8	4
71	15	13	6	204	20	13	4
73	18	13	6	222	15	15	6
74	20	13	6	238	20	13	8
76	18	15	6	242	15	15	8
82	15	11	8	254	20	13	11
84	18	11	8	258	15	15	11
87	15	13	8	260	18	15	11

A = 8

Chord #	S	T	B	Chord #	S	T	B
1	11	6	4	138	15	6	6
2	13	6	4	179	11	8	1
3	15	6	4	180	13	8	1
29	11	4	1	181	15	8	1
30	13	4	1	187	11	8	4
31	15	4	1	188	13	8	4
35	11	6	1	189	15	8	4
36	13	6	1	207	11	8	6
37	15	6	1	208	13	8	6
121	11	4	4	209	15	8	6
122	13	4	4	223	11	8	8
123	15	4	4	224	13	8	8
136	11	6	6	225	15	8	8
137	13	6	6				

A = 11

Chord #	S	T	B	Chord #	S	T	B
4	13	6	4	132	18	6	6
5	15	6	4	139	13	8	8
6	18	6	4	140	15	8	8
10	13	8	4	141	18	8	8
11	15	8	4	149	11	8	6
12	18	8	4	177	11	11	11
32	13	4	1	182	11	11	1
33	15	4	1	183	13	11	1
34	18	4	1	184	15	11	1
38	13	6	1	185	18	11	1
39	15	6	1	186	11	4	4
40	18	6	1	193	11	11	4
41	13	8	1	194	13	11	4
42	15	8	1	195	15	11	4
43	18	8	1	196	18	11	4
50	13	8	6	205	11	6	6
51	15	8	6	210	11	11	6
52	18	8	6	211	13	11	6
108	11	4	1	212	15	11	6
109	11	6	1	213	18	11	6
111	11	8	1	226	11	8	8
117	11	6	4	229	11	11	8
119	11	8	4	230	13	11	8
124	13	4	4	231	15	11	8
125	15	4	4	232	18	11	8
126	18	4	4	243	13	11	11
130	13	6	6	244	15	11	11
131	15	6	6	245	18	11	11

A = 13

Chord #	S	T	B	Chord #	S	T	B
7	15	6	4	142	15	8	8
8	18	6	4	143	18	8	8
9	20	6	4	144	20	8	8
13	15	8	4	146	13	11	4
14	18	8	4	150	13	8	6
15	20	8	4	152	13	11	6
16	15	11	4	158	13	11	8
17	18	11	4	167	15	6	1
18	20	11	4	168	18	6	1
44	15	11	1	169	20	6	1
45	18	11	1	170	15	8	1
46	20	11	1	171	18	8	1
53	15	8	6	172	20	8	1
54	18	8	6	197	13	13	4
55	20	8	6	198	15	13	4
61	15	11	6	199	18	13	4
62	18	11	6	200	20	13	4
63	20	11	6	206	13	6	6
77	15	11	8	214	13	13	6
78	18	11	8	215	15	13	6
79	20	11	8	216	18	13	6
100	15	11	11	217	20	13	6
101	18	11	11	227	13	8	8
102	20	11	11	233	13	13	8
110	13	6	1	234	15	13	8
112	13	8	1	235	18	13	8
114	13	11	1	236	20	13	8
118	13	6	4	246	13	11	11
120	13	8	4	249	13	13	11
133	15	6	6	250	15	13	11
134	18	6	6	251	18	13	11
135	20	6	6	252	20	13	11

A = 15

Chord #	S	T	B	Chord #	S	T	B
19	18	11	4	49	22	11	1
20	20	11	4	56	18	8	6
21	22	11	4	59	20	8	6
22	18	13	4	64	18	11	6
23	20	13	4	65	20	11	6
24	22	13	4	66	22	11	6
47	18	11	1	69	18	13	6
48	20	11	1	70	20	13	6

Chord #	S	T	B	Chord #	S	T	B
71	22	13	6	161	15	13	11
80	18	11	8	164	15	13	8
81	20	11	8	173	18	8	1
82	22	11	8	174	20	8	1
85	18	13	8	175	22	8	1
86	20	13	8	190	18	8	4
87	22	13	8	191	20	8	4
92	18	13	11	192	22	8	4
93	20	13	11	201	15	13	4
94	22	13	11	219	15	15	6
97	18	8	8	220	18	15	6
98	20	8	8	221	20	15	6
99	22	8	8	222	22	15	6
103	18	11	11	228	15	8	8
104	20	11	11	239	15	15	8
105	22	11	11	240	18	15	8
113	15	8	1	241	20	15	8
115	15	11	1	242	22	15	8
145	15	8	4	247	15	11	11
147	15	11	4	255	15	15	11
151	15	8	6	256	18	15	11
153	15	11	6	257	20	15	11
155	15	13	6	258	22	15	11
159	15	11	8				

A = 18

Chord #	S	T	B	Chord #	S	T	B
25	20	13	4	95	20	13	11
26	22	13	4	96	22	13	11
27	20	11	4	106	20	11	11
28	22	11	4	107	22	11	11
57	20	11	1	116	18	11	1
58	22	11	1	148	18	11	4
67	20	11	6	154	18	11	6
68	22	11	6	156	18	13	6
72	20	13	6	157	18	15	6
73	22	13	6	160	18	11	8
75	20	15	6	162	18	13	11
76	22	15	6	163	18	15	11
83	20	11	8	165	18	13	8
84	22	11	8	166	18	15	8
88	20	13	8	202	18	13	4
89	22	13	8	248	18	11	11
90	20	15	8	259	20	15	11
91	22	15	8	260	22	15	11

T = 4

Chord #	S	A	B	Chord #	S	A	B
29	11	8	1	121	11	8	4
30	13	8	1	122	13	8	4
31	15	8	1	123	15	8	4
32	13	11	1	124	13	11	4
33	15	11	1	125	15	11	4
34	18	11	1	126	18	11	4
108	11	11	1	186	11	11	4

T = 6

Chord #	S	A	B	Chord #	S	A	B
1	11	8	4	117	11	11	4
2	13	8	4	118	13	13	4
3	15	8	4	130	13	11	6
4	13	11	4	131	15	11	6
5	15	11	4	132	18	11	6
6	18	11	4	133	15	13	6
7	15	13	4	134	18	13	6
8	18	13	4	135	20	13	6
9	20	13	4	136	11	8	6
35	11	8	1	137	13	8	6
36	13	8	1	138	15	8	6
37	15	8	1	167	15	13	1
38	13	11	1	168	18	13	1
39	15	11	1	169	20	13	1
40	18	11	1	205	11	11	6
109	11	11	1	206	13	13	6
110	13	13	1				

T = 8

Chord #	S	A	B	Chord #	S	A	B
10	13	11	4	50	13	11	6
11	15	11	4	51	15	11	6
12	18	11	4	52	18	11	6
13	15	13	4	53	15	13	6
14	18	13	4	54	18	13	6
15	20	13	4	55	20	13	6
41	13	11	1	56	18	15	6
42	15	11	1	59	20	15	6
43	18	11	1	60	22	15	6

Chord #	S	A	B	Chord #	S	A	B
97	18	15	8	173	18	15	1
98	20	15	8	174	20	15	1
99	22	15	8	175	22	15	1
111	11	11	1	179	11	8	1
112	13	13	1	180	13	8	1
113	15	15	1	181	15	8	1
119	11	11	4	187	11	8	4
120	13	13	4	188	13	8	4
139	13	11	8	189	15	8	4
140	15	11	8	190	18	15	4
141	18	11	8	191	20	15	4
142	15	13	8	192	22	15	4
143	18	13	8	207	11	8	6
144	20	13	8	208	13	8	6
145	15	15	4	209	15	8	6
149	11	11	6	223	11	8	8
150	13	13	6	224	13	8	8
151	15	15	6	225	15	8	8
170	15	13	1	226	11	11	8
171	18	13	1	227	13	13	8
172	20	13	1	228	15	15	8

T = 11

Chord #	S	A	B	Chord #	S	A	B
16	15	13	4	66	22	15	6
17	18	13	4	67	20	18	6
18	20	13	4	68	22	18	6
19	18	15	4	77	15	13	8
20	20	15	4	78	18	13	8
21	22	15	4	79	20	13	8
27	20	18	4	80	18	15	8
28	22	18	4	81	20	15	8
44	15	13	1	82	22	15	8
45	18	13	1	83	20	18	8
46	20	13	1	84	22	18	8
47	18	15	1	100	15	13	11
48	20	15	1	101	18	13	11
49	22	15	1	102	20	13	11
57	20	18	1	103	18	15	11
58	22	18	1	104	20	15	11
61	15	13	6	105	22	15	11
62	18	13	6	106	20	18	11
63	20	13	6	107	22	18	11
64	18	15	6	114	13	13	1
65	20	15	6	115	15	15	1

Chord #	S	A	B	Chord #	S	A	B
116	18	18	1	195	15	11	4
146	13	13	4	196	18	11	4
147	15	15	4	210	11	11	6
148	18	18	4	211	13	11	6
152	13	13	6	212	15	11	6
153	15	15	6	213	18	11	6
154	18	18	6	229	11	11	8
158	13	13	8	230	13	11	8
159	15	15	8	231	15	11	8
160	18	18	8	232	18	11	8
177	11	11	11	243	13	11	11
182	11	11	1	244	15	11	11
183	13	11	1	245	18	11	11
184	15	11	1	246	13	13	11
185	18	11	1	247	15	15	11
193	11	11	4	248	18	18	11
194	13	11	4				

T = 13

Chord #	S	A	B	Chord #	S	A	B
22	18	15	4	165	18	18	8
23	20	15	4	197	13	13	4
24	22	15	4	198	15	13	4
25	20	18	4	199	18	13	4
26	22	18	4	200	20	13	4
69	18	15	6	201	15	15	4
70	20	15	6	202	18	18	4
71	22	15	6	203	20	20	4
72	20	18	6	204	22	20	4
73	22	18	6	214	13	13	6
74	22	20	6	215	15	13	6
85	18	15	8	216	18	13	6
86	20	15	8	217	20	13	6
87	22	15	8	218	20	20	6
88	20	18	8	233	13	13	8
89	22	18	8	234	15	13	8
92	18	15	11	235	18	13	8
93	20	15	11	236	20	13	8
94	22	15	11	237	20	20	8
95	20	18	11	238	22	20	8
96	22	18	11	249	13	13	11
155	15	15	6	250	15	13	11
156	18	18	6	251	18	13	11
161	15	15	11	252	20	13	11
162	18	18	11	253	20	20	11
164	15	15	8	254	22	20	11

T = 15

Chord #	S	A	B	Chord #	S	A	B
75	20	18	6	239	15	15	8
76	22	18	6	240	18	15	8
90	20	18	8	241	20	15	8
91	22	18	8	242	22	15	8
157	18	18	6	255	15	15	11
163	18	18	11	256	18	15	11
166	18	18	8	257	20	15	11
219	15	15	6	258	22	15	11
220	18	15	6	259	20	18	11
221	20	15	6	260	22	18	11
222	22	15	6				

B = 1

Chord #	S	A	T	Chord #	S	A	T
29	11	8	4	109	11	11	6
30	13	8	4	110	13	13	6
31	15	8	4	111	11	11	8
32	13	11	4	112	13	13	8
33	15	11	4	113	15	15	8
34	18	11	4	114	13	13	11
35	11	8	6	115	15	15	11
36	13	8	6	116	18	18	11
37	15	8	6	167	15	13	6
38	13	11	6	168	18	13	6
39	15	11	6	169	20	13	6
40	18	11	6	170	15	13	8
41	13	11	8	171	18	13	8
42	15	11	8	172	20	13	8
43	18	11	8	173	18	15	8
44	15	13	11	174	20	15	8
45	18	13	11	175	22	15	8
46	20	13	11	179	11	8	8
47	18	15	11	180	13	8	8
48	20	15	11	181	15	8	8
49	22	15	11	182	11	11	11
57	20	18	11	183	13	11	11
58	22	18	11	184	15	11	11
108	11	11	4	185	18	11	11

B = 4

Chord #	S	A	T	Chord #	S	A	T
1	11	8	6	15	20	13	8
2	13	8	6	16	15	13	11
3	15	8	6	17	18	13	11
4	13	11	6	18	20	13	11
5	15	11	6	19	18	15	11
6	18	11	6	20	20	15	11
7	15	13	6	21	22	15	11
8	18	13	6	22	18	15	13
9	20	13	6	23	20	15	13
10	13	11	8	24	22	15	13
11	15	11	8	25	20	18	13
12	18	11	8	26	22	18	13
13	15	13	8	27	20	18	11
14	18	13	8	28	22	18	11

Chord #	S	A	T	Chord #	S	A	T
117	11	11	6	189	15	8	8
118	13	13	6	190	18	15	8
119	11	11	8	191	20	15	8
120	13	13	8	192	22	15	8
121	11	8	4	193	11	11	11
122	13	8	4	194	13	11	11
123	15	8	4	195	15	11	11
124	13	11	4	196	18	11	11
125	15	11	4	197	13	13	13
126	18	11	4	198	15	13	13
145	15	15	8	199	18	13	13
146	13	13	11	200	20	13	13
147	15	15	11	201	15	15	13
148	18	18	11	202	18	18	13
186	11	11	4	203	20	20	13
187	11	8	8	204	22	20	13
188	13	8	8				

B = 6

Chord #	S	A	T	Chord #	S	A	T
50	13	11	8	130	13	11	6
51	15	11	8	131	15	11	6
52	18	11	8	132	18	11	6
53	15	13	8	133	15	13	6
54	18	13	8	134	18	13	6
55	20	13	8	135	20	13	6
56	18	15	8	136	11	8	6
59	20	15	8	137	13	8	6
60	22	15	8	138	15	8	6
61	15	13	11	149	11	11	8
62	18	13	11	150	13	13	8
63	20	13	11	151	15	15	8
64	18	15	11	152	13	13	11
65	20	15	11	153	15	15	11
66	22	15	11	154	18	18	11
67	20	18	11	155	15	15	13
68	22	18	11	156	18	18	13
69	18	15	13	157	18	18	15
70	20	15	13	205	11	11	6
71	22	15	13	206	13	13	6
72	20	18	13	207	11	8	8
73	22	18	13	208	13	8	8
74	22	20	13	209	15	8	8
75	20	18	15	210	11	11	11
76	22	18	15	211	13	11	11

Chord #	S	A	T	Chord #	S	A	T
212	15	11	11	218	20	20	13
213	18	11	11	219	15	15	15
214	13	13	13	220	18	15	15
215	15	13	13	221	20	15	15
216	18	13	13	222	22	15	15
217	20	13	13				

B = 8

Chord #	S	A	T	Chord #	S	A	T
77	15	13	11	159	15	15	11
78	18	13	11	160	18	18	11
79	20	13	11	164	15	15	13
80	18	15	11	165	18	18	13
81	20	15	11	166	18	18	15
82	22	15	11	223	11	8	8
83	20	18	11	224	13	8	8
84	22	18	11	225	15	8	8
85	18	15	13	226	11	11	8
86	20	15	13	227	13	13	8
87	22	15	13	228	15	15	8
88	20	18	13	229	11	11	11
89	22	18	13	230	13	11	11
90	20	18	15	231	15	11	11
91	22	18	15	232	18	11	11
97	18	15	8	233	13	13	13
98	20	15	8	234	15	13	13
99	22	15	8	235	18	13	13
139	13	11	8	236	20	13	13
140	15	11	8	237	20	20	13
141	18	11	8	238	22	20	13
142	15	13	8	239	15	15	15
143	18	13	8	240	18	15	15
144	20	13	8	241	20	15	15
158	13	13	11	242	22	15	15

B = 11

Chord #	S	A	T	Chord #	S	A	T
92	18	15	13	100	15	13	11
93	20	15	13	101	18	13	11
94	22	15	13	102	20	13	11
95	20	18	13	103	18	15	11
96	22	18	13	104	20	15	11

Chord #	S	A	T	Chord #	S	A	T
105	22	15	11	249	13	13	13
106	20	18	11	250	15	13	13
107	22	18	11	251	18	13	13
161	15	15	13	252	20	13	13
162	18	18	13	253	20	20	13
163	18	18	15	254	22	20	13
177	11	11	11	255	15	15	15
243	13	11	11	256	18	15	15
244	15	11	11	257	20	15	15
245	18	11	11	258	22	15	15
246	13	13	11	259	20	18	15
247	15	15	11	260	22	18	15
248	18	18	11				

Short Catalog

S	Chord #	A	T	B
11	1	8	6	4
	35	8	6	1
13	2	8	6	4
	10	11	8	4
	30	8	4	1
	32	11	4	1
	38	11	6	1
	41	11	8	1
	50	11	8	6
15	3	8	6	4
	5	11	6	4
	7	13	6	4
	13	13	8	4
	16	13	11	4
	39	11	6	1
	44	13	11	1
	51	11	8	6
	61	13	11	6
	77	13	11	8
18	14	13	8	4
	22	15	13	4
	40	11	6	1
	45	13	11	1
	52	11	8	6
	54	13	8	6
	56	15	8	6
	64	15	11	6
	69	15	13	6
	78	13	11	8
	85	15	13	8
	92	15	13	11
	168	13	6	1
	171	13	8	1
20	15	13	8	4
	20	15	11	4
	23	15	13	4
	46	13	11	1
	48	15	11	1
	57	18	11	1
	65	15	11	6
	75	18	15	6
	79	13	11	8
	81	15	11	8
	83	18	11	8
	88	18	13	8
	90	18	15	8
	93	15	13	11
	191	15	8	4
	259	18	15	11
22	24	15	13	4
	26	18	13	4
	66	15	11	6
	68	18	11	6
	73	18	13	6
	76	18	15	6
	89	18	13	8
	94	15	13	11
	96	18	13	11
	204	20	13	4
	254	20	13	11

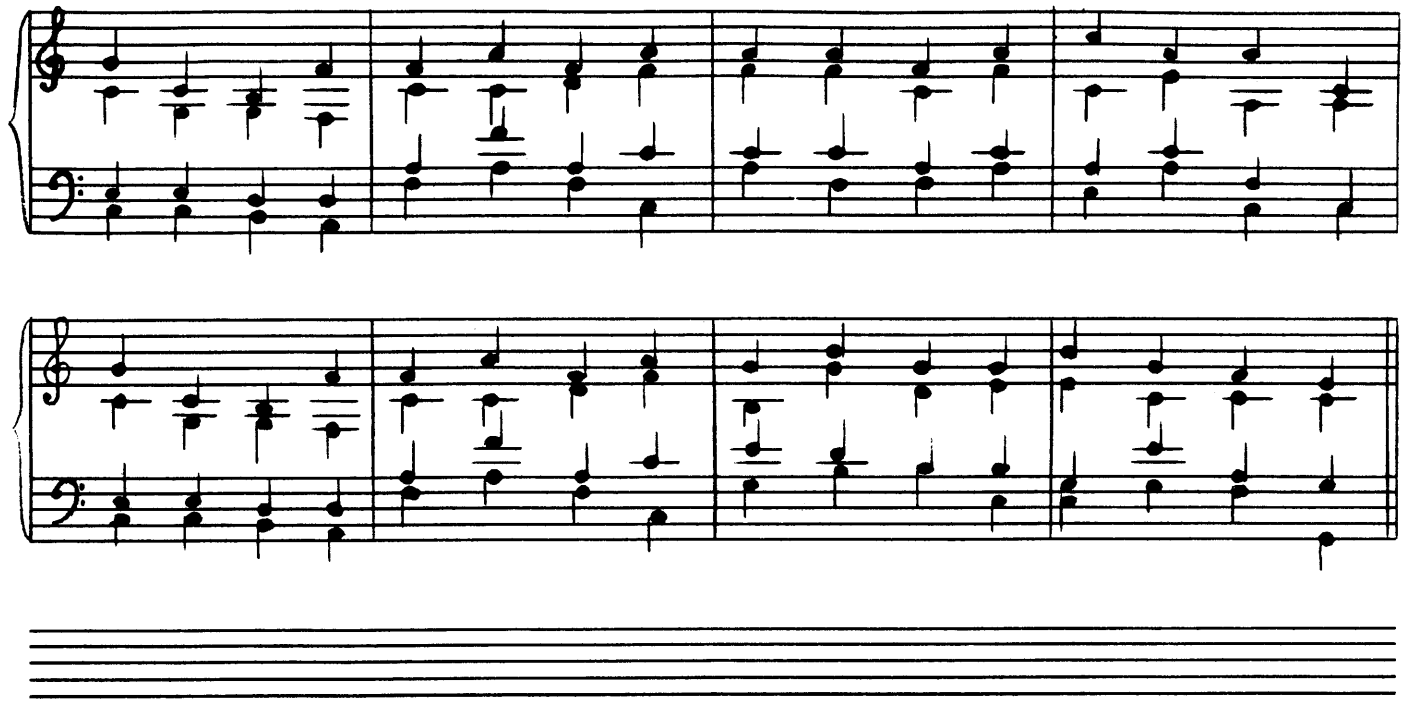
A	Chord #	S	T	B
8	1	11	6	4
	2	13	6	4
	3	15	6	4
	30	13	4	1
	35	11	6	1
11	32	13	4	1
	38	13	6	1
	39	15	6	1
	40	18	6	1
13	7	15	6	4
	13	15	8	4
	14	18	8	4
	15	20	8	4
	16	15	11	4
	44	15	11	1
	45	18	11	1
	46	20	11	1
	54	18	8	6
	61	15	11	6
	77	15	11	8
	78	18	11	8
	79	20	11	8
	168	18	6	1
	171	18	8	1
15	20	20	11	4
	22	18	13	4
	23	20	13	4
	24	22	13	4
	48	20	11	1
	56	18	8	6
	64	18	11	6
	65	20	11	6
	66	22	11	6
	69	18	13	6
	81	20	11	8
	85	18	13	8
	92	18	13	11
	93	20	13	11
	94	22	13	11
	191	20	8	4
11	10	13	8	4
	41	13	8	1
	50	13	8	6
	5	15	6	4
	51	15	8	6
	52	18	8	6
18	26	22	13	4
	57	20	11	1
	68	22	11	6
	73	22	13	6
	75	20	15	6
	76	22	15	6
	83	20	11	8
	88	20	13	8
	89	22	13	8
	90	20	15	8
	96	22	13	11
	259	20	15	11
20	204	22	13	4
	254	22	13	11

T	Chord #	S	A	B
4	30	13	8	1
	32	13	11	1
6	1	11	8	4
	2	13	8	4
	3	15	8	4
	5	15	11	4
	7	15	13	4
	35	11	8	1
	38	13	11	1
	39	15	11	1
	40	18	11	1
	168	18	13	1
8	10	13	11	4
	13	15	13	4
	14	18	13	4
	15	20	13	4
	41	13	11	1
	50	13	11	6
	51	15	11	6
	52	18	11	6
	54	18	13	6
	56	18	15	6
	171	18	13	1
	188	13	8	4
	191	20	15	4
11	16	15	13	4
	20	20	15	4
	44	15	13	1
	45	18	13	1
	46	20	13	1
	48	20	15	1
	57	20	18	1
	61	15	13	6
	64	18	15	6
	65	20	15	6
	66	22	15	6
	77	15	13	8
	78	18	13	8
	79	20	13	8
	81	20	15	8
	83	20	18	8
13	22	18	15	4
	23	20	15	4
	24	22	15	4
	26	22	18	4
	69	18	15	6
	73	22	18	6
	85	18	15	8
	88	20	18	8
	89	22	18	8
	92	18	15	11
	93	20	15	11
	94	22	15	11
	96	22	18	11
	204	22	20	4
	254	22	20	11
15	75	20	18	6
	76	22	18	6
	90	20	18	8
	259	20	18	11

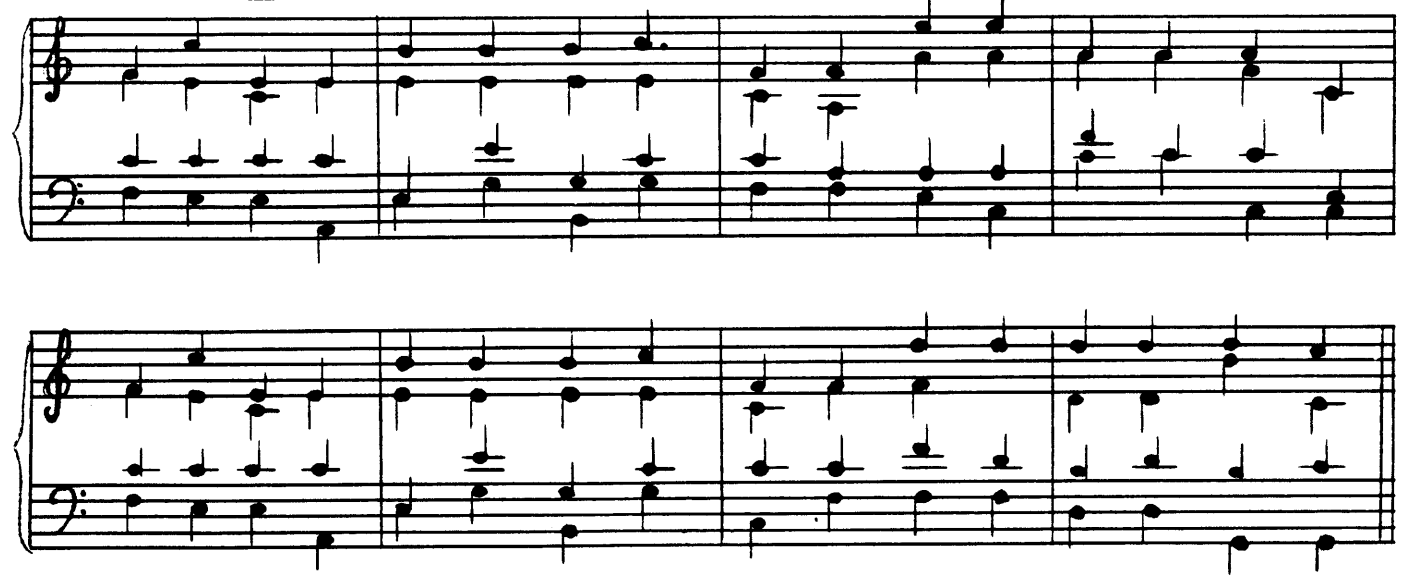
B	Chord #	S	A	T
1	30	13	8	4
	32	13	11	4
	35	11	8	6
	38	13	11	6
	39	15	11	6
	40	18	11	6
	41	13	11	8
	44	15	13	11
	45	18	13	11
	46	20	13	11
	48	20	15	11
	57	20	18	11
	168	18	13	6
	171	18	13	8
4	1	11	8	6
	2	13	8	6
	3	15	8	6
	5	15	11	6
	7	15	13	6
	10	13	11	8
	13	15	13	8
	14	18	13	8
	15	20	13	8
	16	15	13	11
	20	20	15	11
	22	18	15	13
	23	20	15	13
	24	22	15	13
	26	22	18	13
	191	20	15	8
	204	22	20	13

B	Chord #	S	A	T
6	50	13	11	8
	51	15	11	8
	52	18	11	8
	54	18	13	8
	56	18	15	8
	61	15	13	11
	64	18	15	11
	65	20	15	11
	66	22	15	11
	68	22	18	11
	69	18	15	13
	73	22	18	13
	75	20	18	15
	76	22	18	15
8	77	15	13	11
	78	18	13	11
	79	20	13	11
	81	20	15	11
	83	20	18	11
	85	18	15	13
	88	20	18	13
	89	22	18	13
	90	20	18	15
11	92	18	15	13
	93	20	15	13
	94	22	15	13
	96	22	18	13
	254	22	20	13
	259	20	18	15

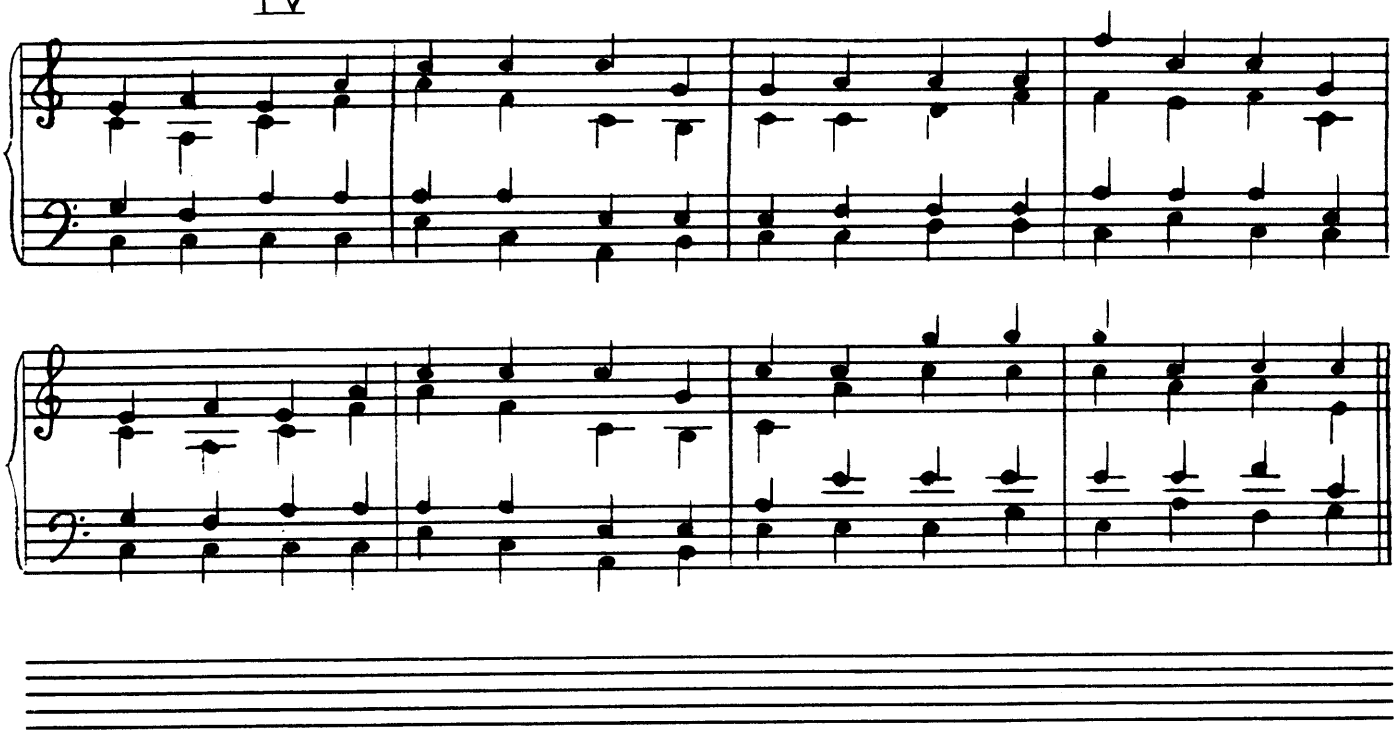
RANDOM I



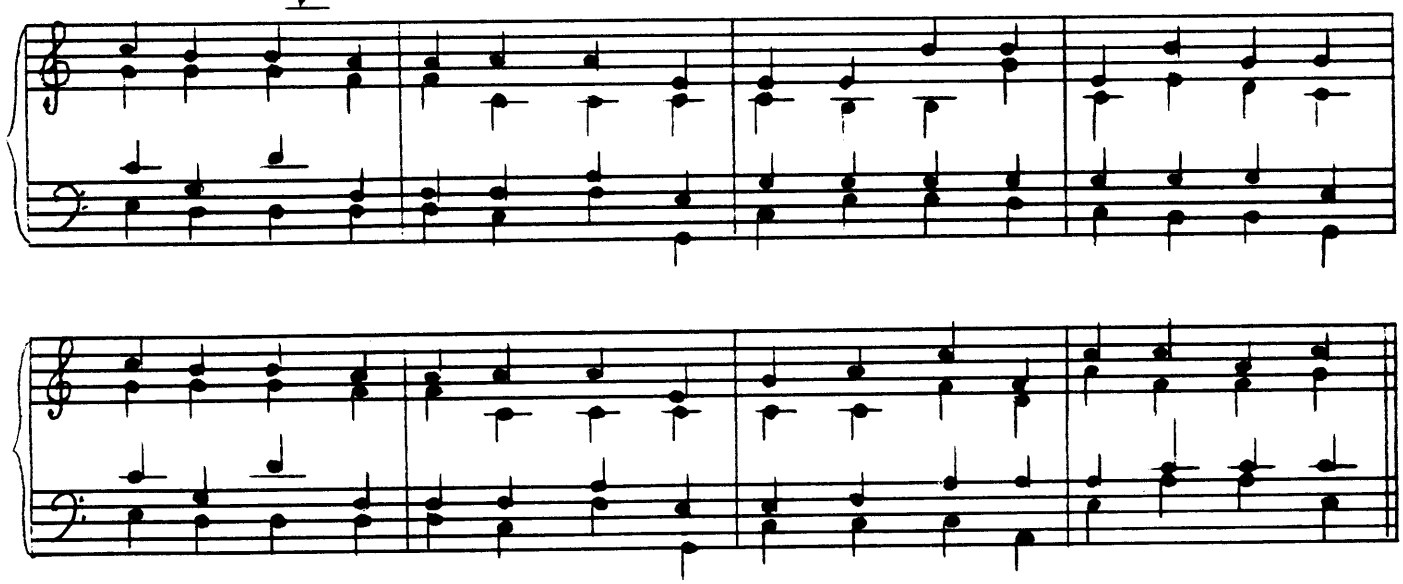
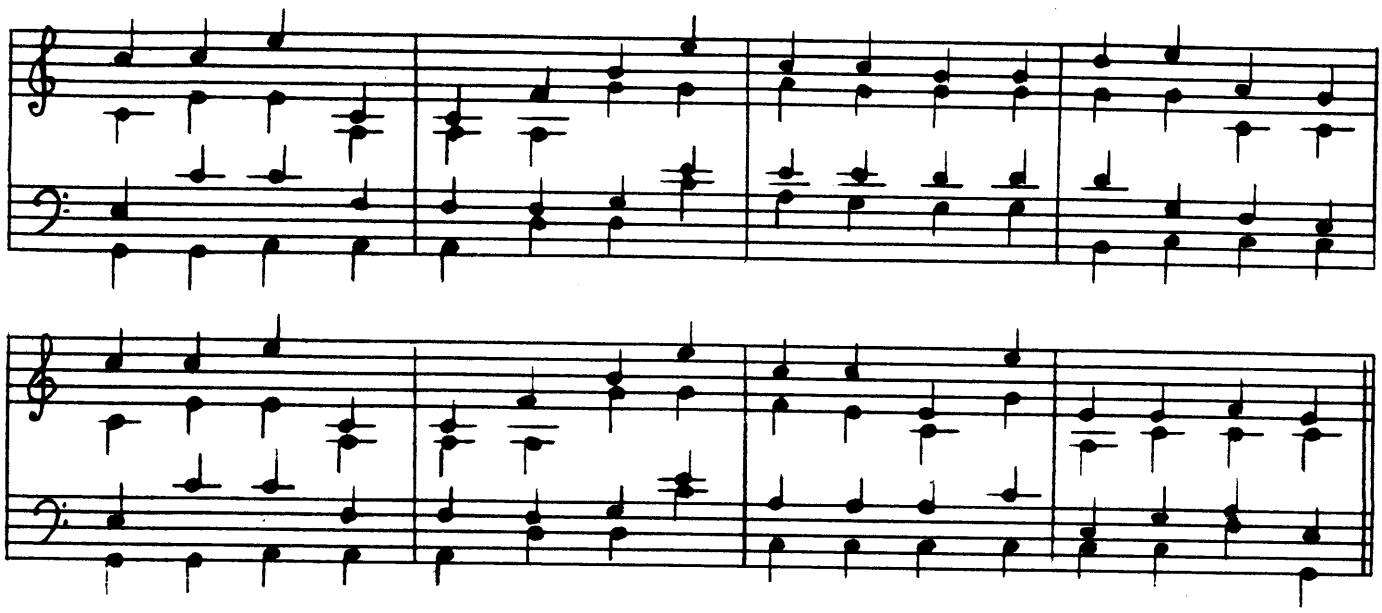
II



IV



V



VI