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MASSACHUSETTS INSTITUTE OF TECHNOLOGY

PROJECT MAC

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Music Playing on the PDP-6

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This memo describes a process of converting coded music into auditory stimuli on the PDP-6. Attached is a copy of the original specifications for the coding (a PDP-1 memo by Peter Samson).

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I

Specifications

CLEF: Bass, Alto, Tenor, Treble

TIME: Multiply key signature by 32. Ex. UNITS 24 [= 3/4 time]

KEY:) = no sharps or flats; (= ♯; - = ♭; Ex. Key (3 [= 3 sharps]

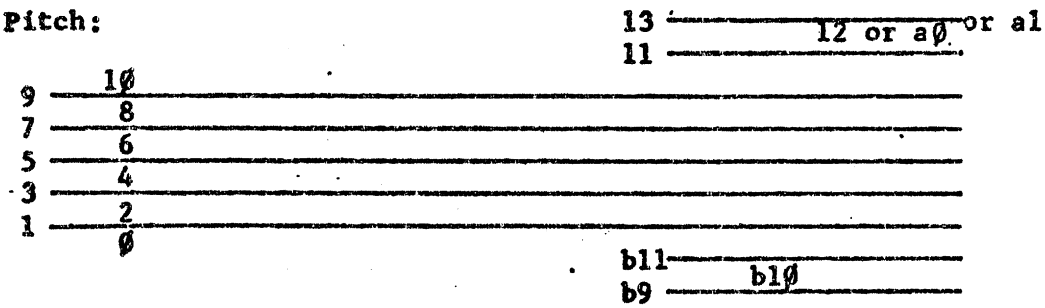
'Rest N' can be inserted anywhere between measures.

Highest note: C two octaves up from middle C.

Lowest note: C three octaves down from middle C.

Note Values: 1, 2, 4, 8, 16, 32, 64. ONLY

Pitch:



Specify Notes by: Pitch +(non-numeric char)+ duration

Ex. 3t8 4x4 5.8

Rests = R + duration Ex. Rt8 k.4

, = copy previous note

R, = R (copy duration only)

Dotted notes = . between pitch and duration Ex. 8.8

N.B. more than one '.' is possible. If . < 1/64 it is ignored.

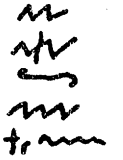
Ex. 4..4

Triplets: 'C' in note Ex. 9C8 8, 7, or 9C8 8C, 7C

Accidentals:) = ♮ (= ♯ - = ♭

Slurs: Specify all notes with 'L' except the last.

Embellishments:



Appoggiatura (grace): g anywhere in note.
If not specified, duration of g = 1/32nd note.

Comments: Anything enclosed in [ ] is totally ignored.

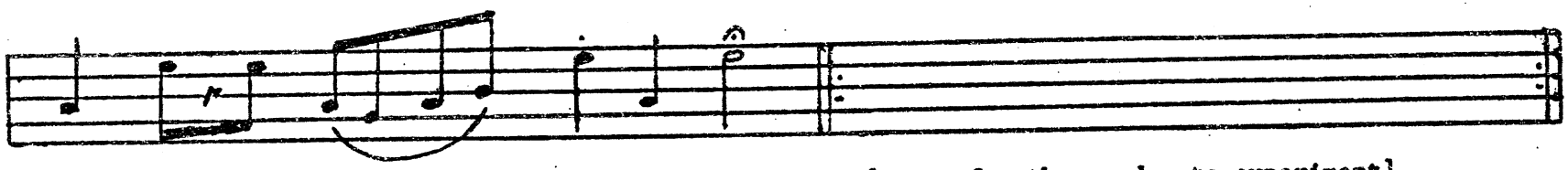
Articulation:

Note duration	Artic. duration	Letter	Use
1	∅	L	legato notes, slurs
7/8	1/8	E	notes not specificly marked (initial mode)
1/2	1/2	H	staccato for organ
3/4	1/4	Q	alternative to 'E'
3/8	5/8	S	alternative to 'H'

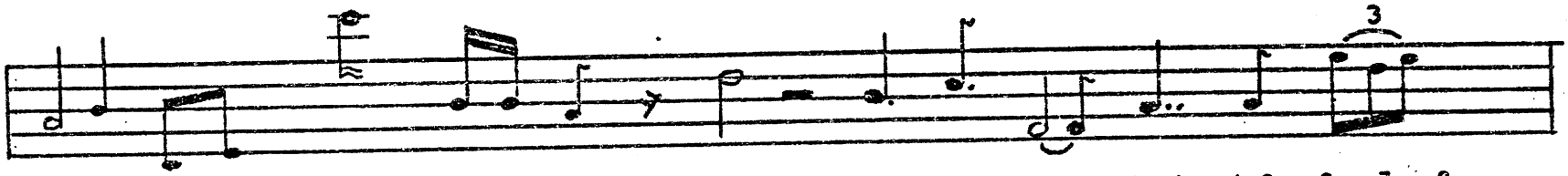
SAMPLE TAPE

VALHALLAL/	TREBLE	UNITS 24	KEY (1	TEMPO 670
Title	Clef (G)	Time (3/4)	Key (1♯)	Optional

```
1    1T4  3.4  5T8  /
2    8.8  1∅T16  A∅T4  1∅T4  /
3    8t4  5,  3T8  4T8/
.
.
.    REST 4
..
.
.
     Copy 3  6
     END
```



4t4 8c8 r, 8, 4L8 3L, 4L, 5, 8s4 4s4 8L2 [Space for the reader to experiment]



4t2 5t4 Øt8 1t8 13t16 5t16 , 4, r, 7t2 r, 5.4 5.8 2x.2 4..4 4t8 8c, 7c, 8c,
or
8c8 7, 8,

II
How to Compile

Df: English Tape--the tape consisting of coded music which you prepared on the teletypewriter as per the specifications in Part I of this Memo.

1. Load the Program entitled "1phase compil", via Macdmp.
2. Set Test Address switches to 442_8
3. Put English Tape in reader, turn reader on.
4. For each voice press the 'Instruction Continue' switch. [The right half of the MI lights has the number of voices loaded if 442_8 is in the address switches.]
5. When all voices have been loaded, press 'start' and the machine will punch the 'Binary Tape'.

Notes:

If Data switches $=7\emptyset\emptyset_8$, the punchout is suppressed.

For loading more than one tape at a time (as in the case of large tapes), bits ∅ and 35 deal with leading blocks and trailing blocks respectively. When ∅ is down it punches leader, when 35 is down it punches trailer. To compile a sequence of types, put switch 35 up for all but the last tape and put zero up for all but the first tape.

III
Error Messages

Below is an alphabetical list of the 2∅-odd error messages in the compiler. The numbers in parentheses after the 3-letter mnemonic have the following significance:

(1) The error is ignored; it should not hurt you.

(2) The compiler makes an algorithmic decision concerning the error which is either what you wanted or 18∅ out.

(3) Any resemblance between the computer-generated music and what you had in mind is purely coincidental. Go back to Start, do not collect $2∅∅.

In the error printout, the offending word is enclosed in < >.

ERROR MESSAGES

AIR (1) An accidental appeared on a rest; it is ignored.

AOR (2) An accidental applied to a note caused it to exceed the pitch range.

BBL (3) Compilers measure count ≠ to one listed on tape

BLC (3) In a 'Copy' command first number not lower than present number measure.

BRC (3) In a 'Copy" command second number not lower than first number measure

DTU (1) A dot whose duration was less than 1/64 occurred; it is ignored

EIT (1) An Embellishment was imposed on too small a note.

EOR (2) A note generated by an embellishment was out of range.

ERT (3) Illegal duration number used.

ETR (1) Embellishment on triplet notes

ILC (3) 'Copy' command used when notes were already written in a measure

ILR (3) Illegal use of 'rest' command, i.e., a rest command was used when notes were already written in a measure.

ITG (2) Duration of appoggiatura too small.

MTL (3) A measure was too long

MTS (3) A measure was too short

MYK (3) Mysterious key. The statement 'key ∝' occurred where ∝≠ (,), or -

NOR (2) A natural appeared in a note with sharp or flat; the natural takes precedence.

TFF (3) Pitch duration missing from a note specification

TIC (3) A period occurred in the same note as a comma

TMC (1) More than one comma in a note

TME (1) Too many embellishments on a note; last one takes precedence

TMG (1) More than one g occurred in a note

TMR (1) More than one r occurred in a note

TMS (1) Too many articulation specifications; last one takes precedence

TS (3) Tempo number greater than 682

UAT (2) A note was specified above the upper limit of the compiler, i.e., above C two octaves up.

Number (3) The measure so numbered ended at different times in different parts

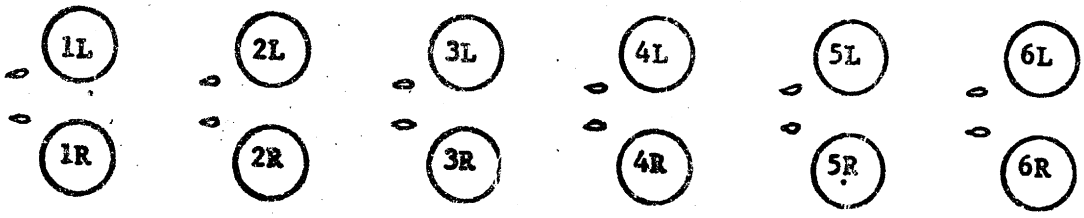
IV
How to Play Music

1. Load any of the current music programs. Since MACDMP dumps all non-zero core, and since loading a new piece does not flush all of the old one, it is best to use a short program such as MUSIC WINSTO.
2. Put Binary tape [output of Compiler] into reader; trun on reader.
3. Put up either switch 3 or 4:
   For 1-3 voices (parts), put up 3.
   For 4-6 voices (parts), put up 4.
4. Program is now loaded and ready to run.

The music program uses the sense switches as follows:

Switch	Meaning if Up
Ø	Stop playing; go into wait loop
1	'Take it from the top'
2	Detune. Look at switches 18-35, consider as six groups of three. Voice 1 is associated with 18-20; Voice 2 with 21-23; ... Voice 6 with 33-35. Each group of switches is set for some value between $Ø_8$--7_8. 7_8 indicates 44Ø cycles for "A". 6_8 --$Ø_8$ successively flatten the notes.
3 4	Load binary tape: 1--3 voices 4--6 voices
5	Tune. Program adjusts to current speed of machine.
6	Not used
7	Go to MACDMP when piece is over
13 14	Append Binary tape: 1-3 voices 4-6 voices
17	Tempo control: play piece as a function of bits 18-35.

In the bay to the right of the console are twelve pots and twelve switches laid out as follows:



The number refers to the voice with which the pot is associated. The top rows of pots govern the Left Hand Speaker; the bottom row the Right Hand one.

These can be considered as "balance" pots; that is, they control the relative volume of the music into a given speaker with respect to the total volume available.

Ex. Consider a two-part melody. We want voice one to be 'strong' and voice two to be in the background. One would set the pot for voice one all the way up, and the pot for voice two at 20-30 %.

N.B. If 'Stereo' is desired, both pots for each voice must be set or one channel will be random.

Each set of two switches can assume one of four configurations. In the discussion below, let '⊦' represent a switch in the Right Hand position and '┤' a switch in the Left Hand position.

The different configurations control the degree of filtering which, in turn, affects the sound of the music. There are four degrees:

1 (least filtering) 2 3 4 (most filtering)

Filtering cuts down the high-frequency components, i. e., "buzz" characteristics of a voice.

MUSIC COMPILER

I. A. 1. The first task when preparing a score for the Compiler is to arrange the music in a number of distinct lines (otherwise called parts or voices), fitting the restriction that each part may play only one note at a time. The Compiler will handle selections taking from one to eight parts. The complete specifications for a single line constitute a "logical tape".

2. For each voice one must supply: (1) a title, which is all material on the tape through the first slash "/"; (2) the clef, and key and time signatures; (3) a tempo (which needs to occur in only one of the parts); (4) one or more full measures of music; (5) the word "end" to terminate the logical tape.

B. Each and every note in a musical score conveys two pieces of information: (a) its pitch, indicated by the note's position on the staff; (b) its duration, signified by the form of the note symbol. Both these data must be supplied to the Compiler for each note [tff].

1. a. pitch. The pitch of a note may be indicated to the Compiler by a number representing the position on the staff which the note occupies: the correspondence between position and pitch number is shown in Fig. 1. The lowest possible pitch number is 0; the number may be as high as necessary. Notice that lines are odd-numbered, and spaces are even-numbered.

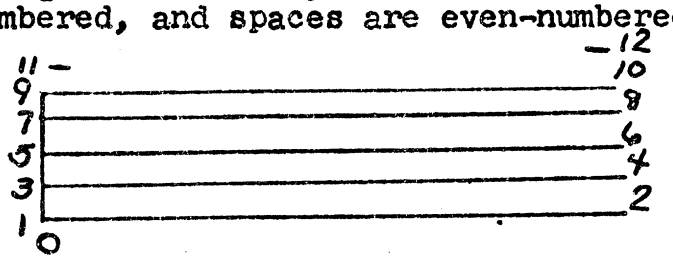


Figure 1. Pitch Numbers

b. duration. A note's duration can be specified by a number as demonstrated by Fig. 2. No duration number may be used except the seven listed [ert].

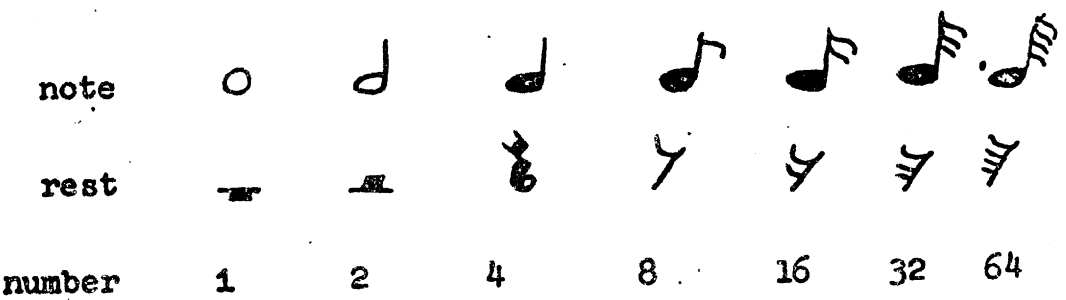


Figure 2. Duration Numbers

c. notes specified by two numbers. A pitch number and a duration number conjoined form a note. The numbers must be in the order "pitch--duration". To distinguish the two numbers, they must be separated by one or more non-numeric characters: the letter "t" is available especially for this purpose. Fig. 3 shows some notes and their Compiler representations as formed in this manner.

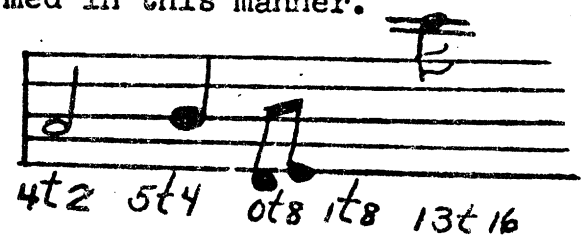


Figure 3. Notes Specified by two Numbers

Hereafter, it will be stated that certain characters may be placed "anywhere" in a note: actually, there is the one restriction that no character may be placed between the digits of a pitch number or duration number.

2. A rest may be expressed by the letter "r" and a duration number.aThe number and the "r" may be put in either order, although practice has favored putting the duration number last. A pitch number may not occur in the same note as an "r" [tmf]. A note should not contain more than one "r" [tmr]. Examples are in Fig. 4.

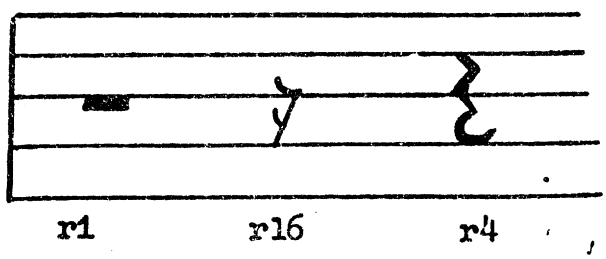


Figure 4. Rests

3. A comma may be used alone as a note, meaning to copy the previous note exactly. Also, the comma may be used with R or a pitch number to form a note; the comma in this case indicates to copy only the duration from the previous note. The comma and the pitch indicator may come in either order. There should be no more than one comma in a note [tmc]; there should never be a duration number in the same note with a comma [tmf]. Fig. 5 demonstrates the use of the comma.

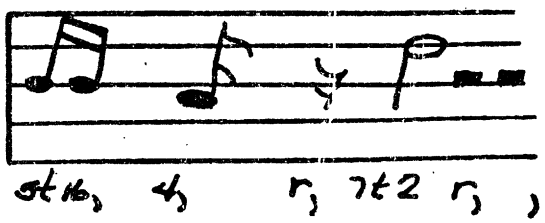


Figure 5. Use of Comma

4. a. dotted notes. Often one or more dots occur directly after a note indicating that the duration of the note is to be lengthened. This notation is carried over into the Compiler, using the character "." (period). Each dot adds an amount to the duration: the first dot in a note adds one-half the duration of the note; each succeeding dot adds half the duration of the dot before it. A dot whose duration is less than that of a sixty-fourth note is ignored [dtu]. It is occasionally convenient to add a smaller fraction than half the note's duration. To enable this, the Compiler interprets the letter "x" in a note to mean, "halve the value of the dot". Periods and x's may be used anywhere in the note, and need not be contiguous. Their order is significant only among themselves. Either character will suffice to separate the pitch number from the duration number. The period may not occur in the same note as a comma [tic]. Fig. 6 shows some dotted notes and their translations for the Compiler.

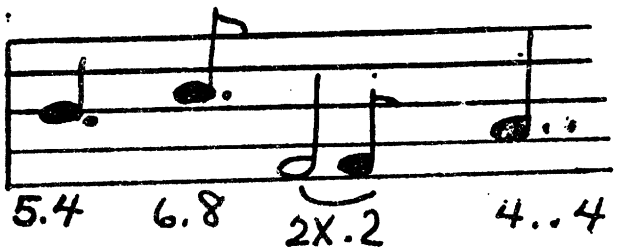


Figure 6. Dots

b. triplets. Sometimes three notes are to be played in the time intended for two; musical notation indicates this with numeral "3" above the notes, directing that each note be played for two-thirds its usual duration. This is indicated to the Compiler by including the letter "c" anywhere in each note so affected. Dots and x's may be included. It is not necessary to the Compiler that the notes in a triplet be adjacent. A comma in the following note will copy the "c" only if the note in which the "c" occurs does not contain a comma. (A note with a comma may contain a "c".) For instances of use, see Fig. 7.

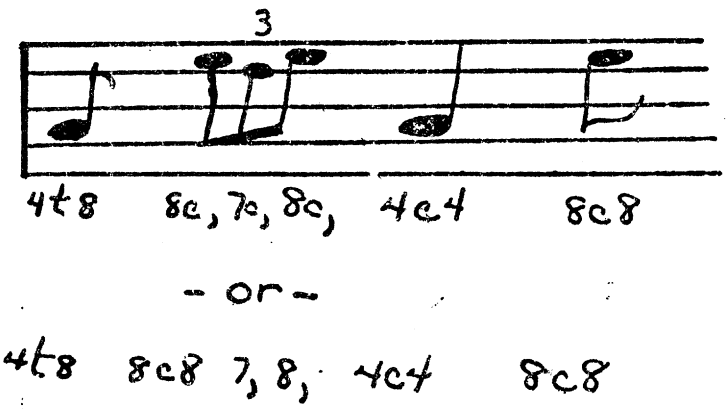


Figure 7. Triplets

5. a. tone relocation. Occasional notes will be found which are either above or below the staff. The Compiler assumes staves to exist above and below the staff in use, as per Fig. 8. To refer an individual note to either adjoining staff, include the letter "a" (above) or "b" (below) anywhere in the note. These letters may occur more than once in a note, and their effect is cumulative: e.g. "aa" refers to the second staff above. The highest pitch available is the treble clef's "a1"; the lowest is the bass clef's "b2" [uat] [aor].

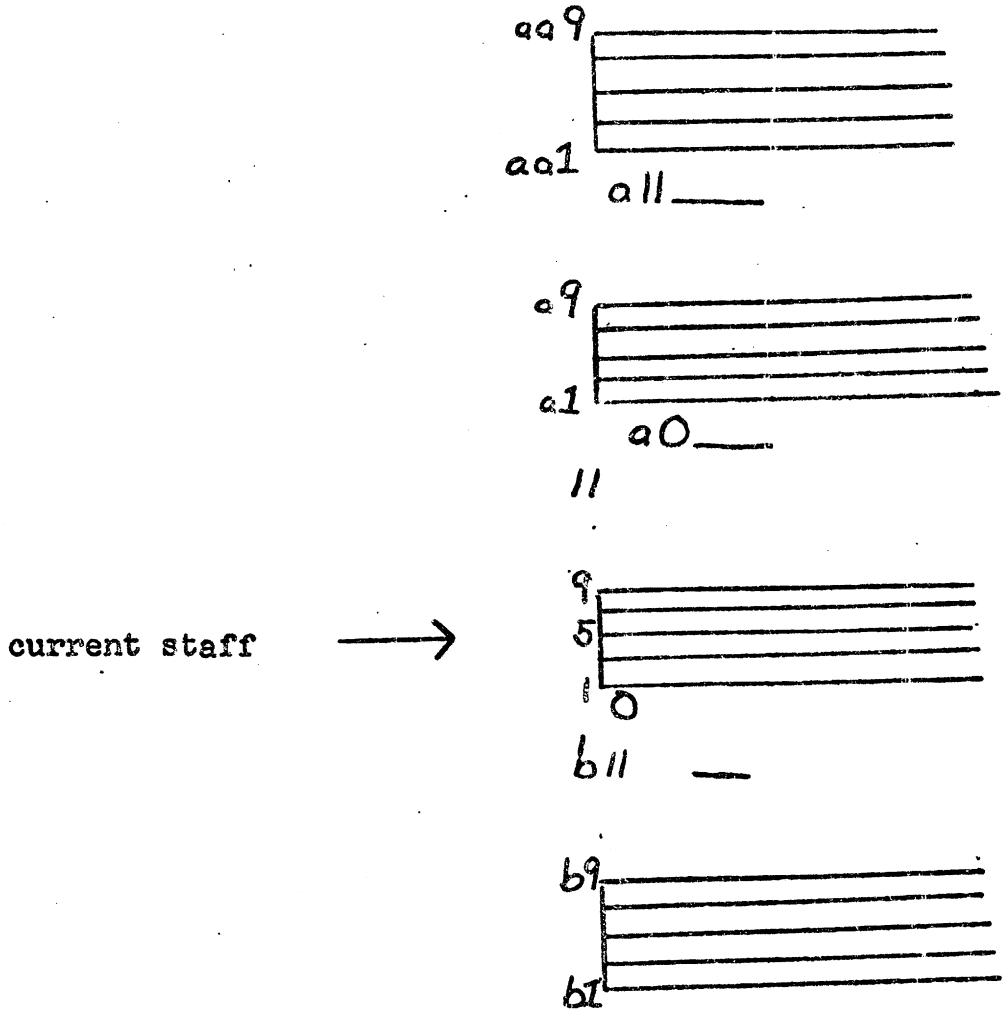


Figure 8. Adjacent Staves

b. accidentals. Accidental signs, and the characters to signify them to the Compiler, are shown in Fig. 9. The appropriate characters may be placed anywhere in the note that they affect. An accidental appearing on a rest is ignored [air]. If ")" appears in the same note with "-" or "(", the ")" takes precedence [nor].

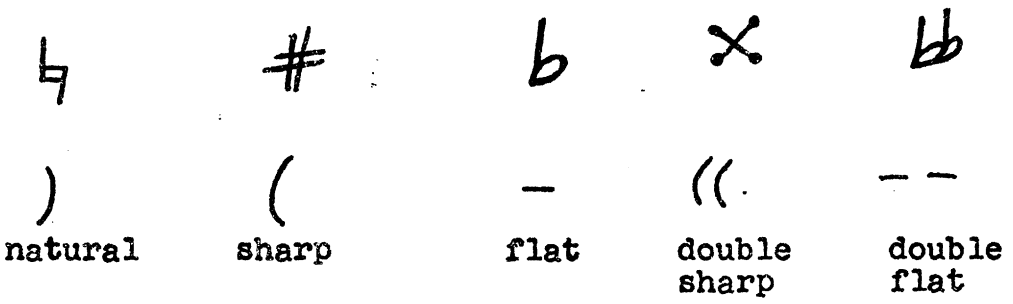


Figure 9. Accidentals

6. Two notes played in succession are made distinct to the ear by articulation: the effect of a short duration of silence between them. The duration of the preceding note is shortened by the amount taken for the period of articulation. The articulation following a note can be expressed to the Compiler by including an identifying letter anywhere in the note: the five letters available are explained in the following table.

letter	name	duration of note	duration of articulation	used for
l	legator	1	0	slurs, legato notes
e	eighth	7/8	1/8	notes not specially marked
h	half	1/2	1/2	staccato for organ works
q	quarter	3/4	1/4	alternative to "e"
s	staccato	~3/8	~5/8	alternative to "h"

The articulation of notes not containing "e", "h", "l", "q", or "s" is explained in I.D.5. The effect of these letters in a note is not copied by a comma in subsequent note. If more than one of these letters should occur in a note, the last one will prevail [tms]. A slur is expressed to the Compiler by making legator all notes in the slur except the last. A few examples are shown in Fig. 10.

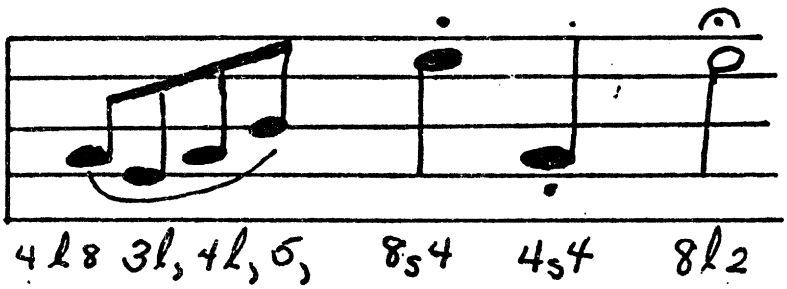


Figure 10. Articulation Examples

7. Various embellishment signs may appear on a note in a piece of music, indicating that the note is to be performed more elaborately than written. In Fig. 11 are (a) the symbols (as used by C. P. E. Bach in his "Essay on the True Art of Playing Keyboard Instruments"); (b) the patterns compiled; (c) the minimum duration on which the Compiler will perform that embellishment [eit]; (d) the letter used to signify that embellishment in a note.

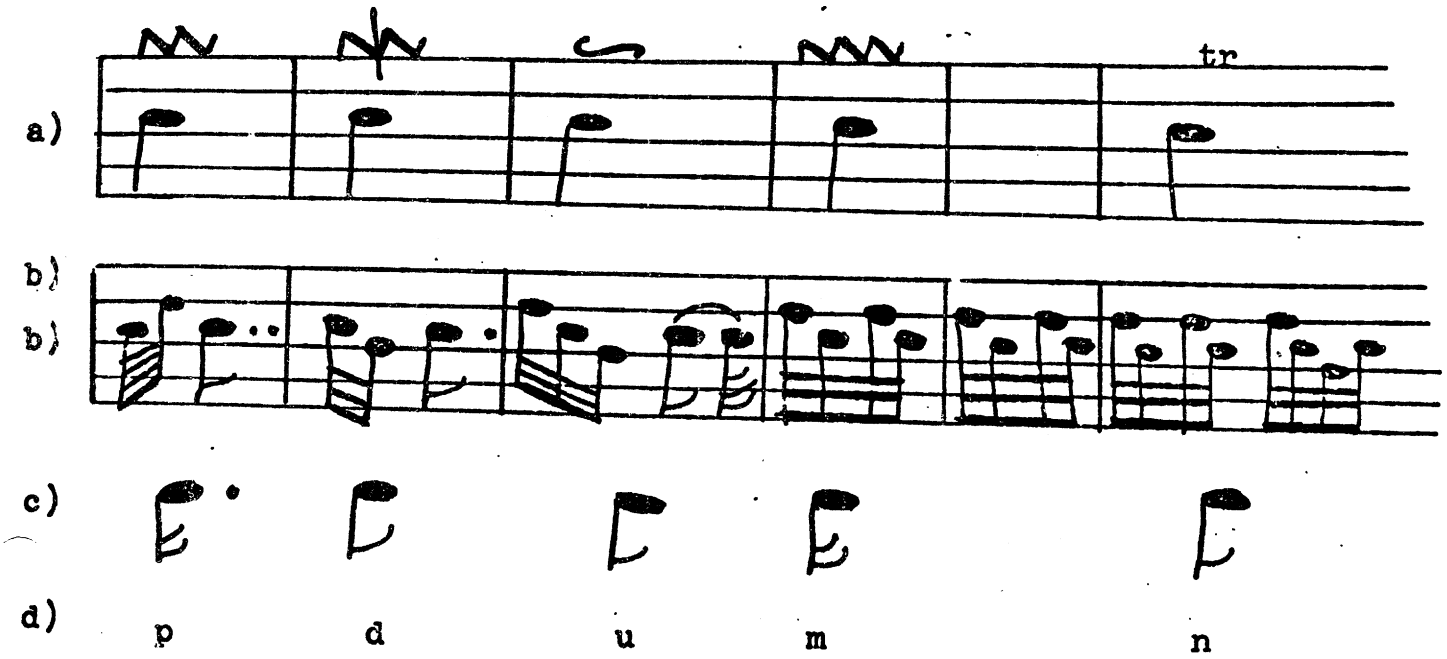


Figure 11. Embellishments (see I.B.7)

If more than one embellishment is chosen for one note, the last one will be taken [tme]. Embellishments may not be called for on triplet notes [etr]. Comma does not copy embellishments. An embellishment will be illegal if any note it generates is out of range [eor].

8. A grace note (appoggiatura) steals its playing time from the first non-grace note to follow: such a note should have sufficient duration to sound itself as well [itg]. A duration may be specified in a grace note, either by a number or by the comma; if a time is not specified, a thirty-second note will be compiled. The letter "g" anywhere in a note marks it a grace note. Only one "g" should be used in a note [tmg].

C1 In score, measures are separated by a bar; for the Compiler, the bar is represented by the slash "/".

1. The Compiler assigns successive numbers 1,2,3,...etc. to successive measures of the music. If a number alone (not part of a note) occurs in the input to the Compiler, it is checked against the Compiler's measure-count [bb1]. It is wise to use such bar labels frequently; they warn of missing or duplicated measures, and also serve to identify the measures they appear in.

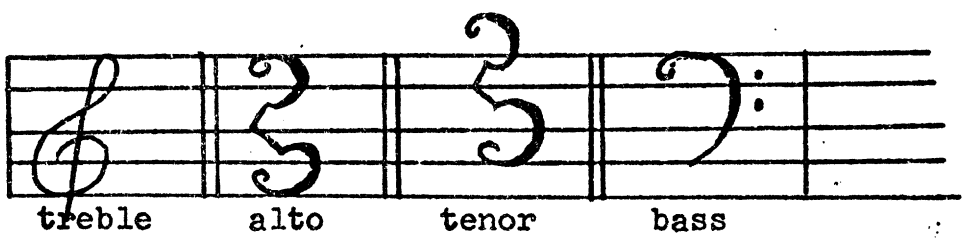
2. When the Compiler encounters a slash, it adds up the duration of all notes since the last slash, and checks their total duration against the expected length of the measure [mt1] [mts].

D. Certain instructions must be supplied to the Compiler on an infrequent basis: this is accomplished by including in the Compiler input certain special words called commands. Also some commands are provided merely to make the Compiler input more compact or easier to prepare.

1. The command "end" signifies the end of a line of music. When this command, followed by a space, tab, or carriage return, is encountered, the Compiler stops reading tape.

2. The total duration of a measure should be stated to the Compiler before any notes or rests occur. To do this, the command "units" should appear, followed directly by a number indicating the number of thirty-second notes in a measure. This number may be computed by multiplying the time signature (as a fraction) by 32. The "units" command may occur anywhere in the text, and takes effect immediately, referring to the measure where it occurs and to all following measures (until the next use of "units").

3. Prior to the appearance of any notes in the text, the Compiler should be informed of the clef which heads the staff being read. There are four commands, representing four clefs shown in Fig. 12.



F1
Figure 12. Clefs

A clef command may occur anywhere in the text, in order to follow changes of clef in the music or simply for the convenience where a long run of notes is above or below the staff in use.

4. At the beginning of the music the key signature should be stated: in the text this is done by use of the command "key" followed by: ")" meaning no sharps or flats; "-" for flats; or "(" for sharps. In case of sharps or flats, the symbol should be instantly followed by a number which tells how many sharps or flats are in the key signature. Samples are in Fig. 13.

Figure 13. Key Signatures

5. One often encounters runs of several notes which have the same degree of articulation. To facilitate expressing this to the Compiler, one may use the single letters "s", "l", "e", "h", and "q", with the exception of any note which immediately precedes a rest in the same measure; such a note is automatically made legato unless it contains an articulation letter. The articulation commands may occur anywhere in the text. At the beginning of each line of music the Compiler is in the "e" mode. Fig. 14 demonstrates articulation commands.

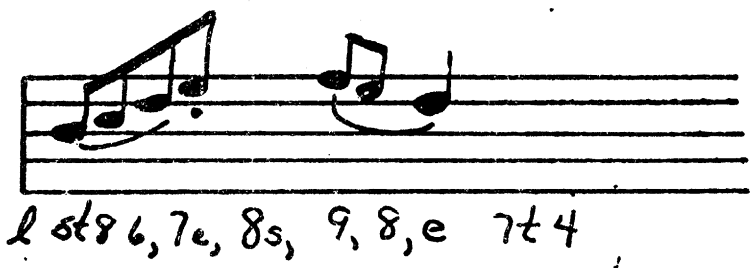


Figure 14. Examples of Articulation Commands

6. A given line may be silent for one or more measures. This should be expressed to the Compiler by the command "rest" followed by the number of inactive measures. (They will all be given the current measure length.) The rest command may not be used when notes have already been written in a measure [ilr]. Since it adds no duration to any measure, there must not be a slash directly after use of the "rest" command.

7. One or more measures may be identical to measures that have gone before. It is advised in this case to use the command "copy" to duplicate previously written measure. "Copy" should be followed by two numbers: the number of the measure to start copying from, and the number of the number of the last measure to be copied. The first number must be lower than the present measure number [blc], and the second number must not be lower than the first [brc]. The second number may be higher than the present measure number; thus a section may be copied more than once. Like "rest", "copy" may not be used when some notes are already written in a measure [ilc]: copied measuresdo not affect the current measure's duration count, so "copy" should not be followed by a slash. The measures are copied exactly; they are not modified by change in the mode of articulation, or clef, or measure length; nor do they change any of these for non-copied measures to follow. They will be performed at a different tempo if that has been changed, however.

8. The Compiler is able to transpose music with the commands "up" and "down"; a number follows the transposition command to indicate the number of semitones that the compiled music will be above or below the music as written in the text. These commands may occur at any point in the text and take effect immediately. To restore the compiled music to no transposition, say "up 0" or "down00". The compiler starts tape at 0 transposition.

9. tempo. The tempo of a piece may be expressed to the Compiler by the command "tempo", followed by a number n computed as follows:

$$n = \frac{1126}{mf}$$

where m is Maezel's metronome count for a f note: i.e. if ♩=60, then m=60 and f=1/4; or ♪.=110 means m=110, f=3/16. The number n may not be larger than 682 [ts]. The tempo may be changed at any point in the music; it will be taken equal to 170 if none is given. A "tempo" command appearing in any voice will be applied to all voices; hence only one line need contain tempo information.

E. The Compiler expects the text punched on 8-channel paper tape in FIO-DEC code. The tape may be prepared away from the Computer, on a FIO-DEC Flexowriter or similar machine; or it may be prepared on the Computer via some editing program.

1. The characters "space", "tab", and "carriage return" are treated identically by the Compiler. Two or more of these characters in a row are treated the same as one. These facts allow great flexibility in the appearance of the printed page of text, but usually it proves worthwhile to follow a format which is stricter than necessary. One such format, which has proven satisfactory, is described below.

   a. the title is as long as desired (using any number of lines) and is ended by a slash.

   b. after the title the clef, time, key and tempo are specified in any order.

   c. each line represents one measure: the measure number is put at the beginning, and the "space" is used to separate notes; the line is ended with a slash.

   d. if a measure is too long to fit on one line, it is continued on the next line, indented by a tab. Only the last line of a measure is ended with a slash.

   e. the commands "copy" and "rest" get a line to themselves, with no slash at the end.

   f. "end" is followed by a carriage return.

2. Any material (not in the title) that is typed in upper case is ignored by the Compiler. Comments may thereby be entered in the text at any point.

3. The text for each line of the music may be punched on a sepa separate tape; for convenience in tape handling, several lines may be punched, one after the other, on one piece of tape: each part must have its own title, "key", "units", clef, "tempo", and "end".

Peter Samson

CS-TR Scanning Project
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