PDP-1 COMPUTER
ELECTRICAL ENGINEERING DEPARTMENT
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
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PDP 43-2

MUSIC PROGRAMS

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Music Compiler

Music to be coded for the compiler must be arranged in one or more "sections" (e.g. movements), each with up to six parts or voices. Each part may play only one note at a time. The last part of the last section should end with the word "stop"; the last part of other sections should end with "append"; other parts should end with "end".

Each part has a number of measures, separated by slashes ("/"), numbered starting with 1. A number alone (not part of a note) is considered a bar label, and is checked against the compiler's measure count. 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.

The total duration of a measure is specified by the word "units" followed by the number of thirty-second notes in a measure. This number is the time signature (taken as a fraction) times 32. The "units" command may appear anywhere, and takes effect for all subsequent measures (until the next use of "units"). For each measure, the compiler checks the total duration of the notes in the measure against the expected total given in the "units" command.

There are four commands to inform the compiler of the clef in which the notes appear; these may appear anywhere in the music.

treble   alto   tenor   bass
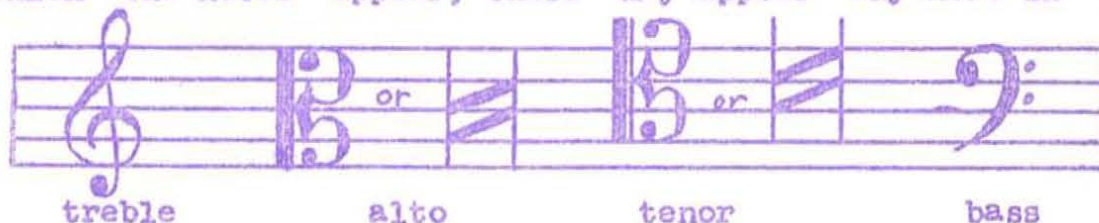
The pitch of a note is indicated by a number representing the position of the note on the staff. Lines are odd-numbered, and spaces are even-numbered.
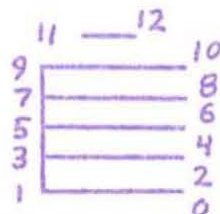
The number may be as high as necessary, and as low as 0. Including the letter "a" (above) in a note adds 12 to the pitch number; "b" (below) subtracts 12, so notes below the staff may be coded. Note that if the current clef is "treble", "b" makes pitch numbers relative to a bass clef, and vice versa for "a". "a" and "b" may occur more than once in a note, and their effect is cumulative.

Accidental signs, and the characters to signify them to the compiler, are shown below. These characters may be placed anywhere in the note that they affect. In accord with standard music notation, an accidental affects all subsequent notes in the measure on the same position in the staff.

natural	sharp	flat	double sharp	double flat
)	(	-	((	--

A key signature can be stated at any time, and applies to all subsequent notes. The word "key" is followed by a letter "(", "_", or ")" for sharps, flats, and no sharps or flats respectively. The number of sharps or flats can be specified either by a number with the letter, or by using one "(" or "_" for each sharp or flat. For example, three sharps could be specified either by "key (3" or "key (((".

A note's duration is specified by a number as indicated below. Only these seven numbers may be used.

note	o	d	♩	♪	♪	♪	♪
rest							
number	1	2	4	8	16	32	64

Including a dot (".") in a note adds an amount to its 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. 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.

Notes in triplets are indicated as such by including the letter "c" anywhere in the note. The "c" makes the note two-thirds its usual duration. Dots and x's may be included.

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. No character may be placed between the digits of a pitch number or duration number. Notes are separated by space, tab, carriage return, or slash.

A rest is expressed by the letter "r" and a duration number. Dots, x's, and c's may be included.

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. A comma will copy a "c" only if the note in which the "c" occurs did not contain a comma.

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. The effect of these letters is not copied by comma, unless the comma is used alone.

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

The articulation of notes not containing an explicit articulation letter is governed by the default articulation mode. This mode is set by the single letters "l", "e", "h", "q", and "s". At the beginning of each part the compiler is in the "e" mode. Any note which immediately precedes a rest in the same measure is automatic- ally made legato unless it contains an explicit articulation letter.

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. Below 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 letter used to signify that embellishment in a note; (d) the name of the embellishment.

(a)

(b)

(c)	p	d	u	k	f
(d)	short trill	mordent	turn	three note trill	full turn

(a)   or tr   or tr

(b)
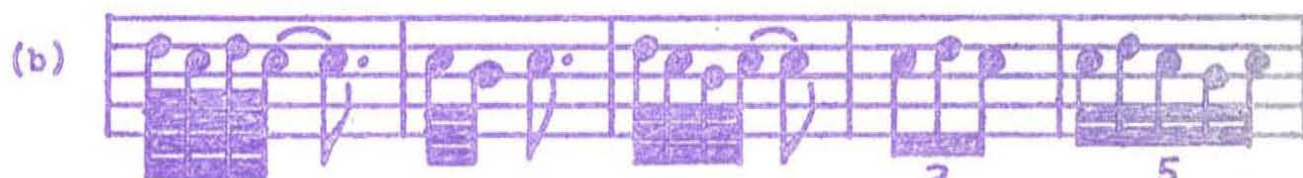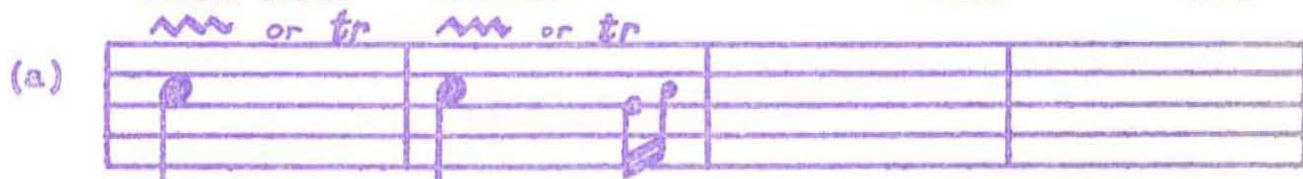
(c)	m	n	o	w
(d)	trill	trill with grace notes	odd numbered trill	inverted trill

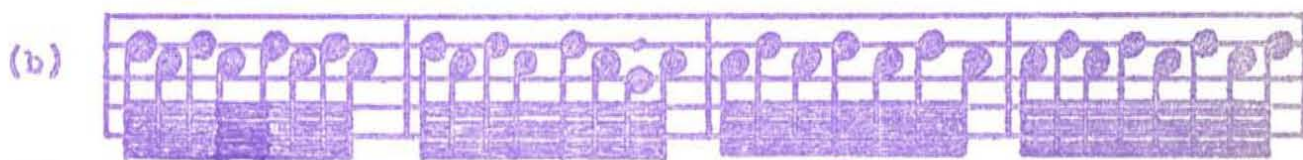The speed at which trills and other embellishments are played depends on the trill time. The trill time is set by the command "trill" followed by a note duration. It is initially 32. Notes marked above as thirty-second notes in embellishments "d", "u", "m", "n", "o", and "w" are given the trill time duration; notes marked as sixty-fourth notes in "p" are given half the trill time duration. The trill time will be stretched or compressed slightly to make "m", "n", and "o" come out with the right number of notes (even or odd). For "k" and "f", the note duration is evenly divided by 3 and 5, respectively. Comma does not copy embellishments.

An accidental on the principal note of an embellishment can be indicated by a "(", "-", or ")" in the note. Accidentals on other notes can be specified by the following letters. These do not affect subsequent notes the way accidentals do.

    i - raise upper tone
    j - depress upper tone
    y - raise lower tone
    z - depress lower tone

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. A duration may be specified in a grace note, either by a number or by a 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.

The volume of a part can be specified by the word "vol" followed by a number from 0 to 15. These volume commands may be given as often as necessary, and apply only to the part in which they appear. While the compiler allows for 16 different volume levels, the present music hardware has only 8 different levels; thus, "vol 0" and "vol 1" will play at the same loudness. One of these may be preferred, however, for special effects with "cresc" (q.v.). The following words are also available for the most common vol commands, and are almost always used instead of "vol":

```
ppp    vol 0
pp     vol 2
p      vol 4
mp     vol 6
mf     vol 9
f      vol 11
ff     vol 13
fff    vol 15
```

The words "cresc" or "dim" direct the compiler to gradually increase or decrease the volume from its value where the "cresc" or "dim" occurred to the next occurrence of a volume command. The number of volume steps from the starting volume to the final volume is evenly divided within the intervening time.

An example of the action of cresc:

mp cresc 511 f

becomes
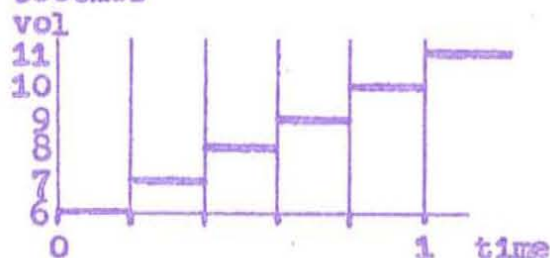
Accented notes may be coded by including the letter "v" anywhere in the note. This causes the volume of the note to be raised two volume levels for a duration depending on the note duration as shown in the following table:

duration of note	duration of accent
note < 1/64	note
1/64 ≤ note < 1/8	1/64
1/8 ≤ note < 1/4	note/8
1/4 ≤ note	1/32

Two v's in a note will raise the volume four levels, etc. The word "accent" followed by a number from 0 to 15 causes all succeeding notes (until the next "accent") to be accented that number of volume levels. "v" may still be used, and its effect will be added to the standard accent.

The tempo of a piece of music is expressed to the compiler by the command "tempo" followed by the number of quarter notes per minute. A "tempo" command appearing in any voice will be applied to all voices; hence only one part need contain tempo information.

The words "accel" or "ritard" direct the compiler to gradually increase or decrease the tempo from its value where the "accel" or "ritard" occurred to the next occurrence of a tempo command.

The command "copy" may be used to duplicate previous measures in the same part. "Copy" should be followed by the number of the measure to start copying from, and the number of the last measure to be copied. The second number may be omitted if only one measure is to be copied; in this case, the first number should be immediately followed by a carriage return. The second number may be higher than the current measure number. "Copy" need not be followed by a slash. The measures are copied exactly; they are not modified by change in the mode of articulation, accent, transposition, 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. The copied measures will begin with the volume that was current when "copy" was given, and if they contain volume changes, subsequent measures will be affected.

In addition to "copy, "open" and "close" are available for coding repeats. Measures between "open" and "close" will be repeated. "Open" and "close" need not coincide with ends of measures, but must be in corresponding places. After "close", the bar numbering must be advanced to skip over the repeated measures.

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. There need not be a slash directly after the "rest" command.

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 "down 0". The compiler starts each part at 0 transposition.

Because the frequencies generated by the music player are exact, parts which play notes in unison or an octave apart may exactly or nearly cancel each other, depending on the relative phase of the two notes. To counteract this, there is a provision for detuning parts. The command "tune" followed by a number from 0 to 7 directs the player to slightly alter the normal frequencies of all notes in the part. Normal tuning is 4; a higher number raises the pitch, and a lower number lowers the pitch. If no tuning is specified, 4 is assumed. Normally, parts are left at tuning 4 unless phase proves to be a problem.

A vertical bar ("|") begins a comment; everything up to the next carriage return is ignored. In addition, anything in upper case is ignored.

The compiler allows great flexibility in the arrangement of the input 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) After the title the clef, time, key, tuning, and tempo are specified in any order.

(b) Each line represents one measure; the measure number is put at the beginning, and "space" is used to separate notes; the line is ended with a slash.

(c) 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 measure ends with a slash.

(d) The commands "copy" and "rest" get a line to themselves, with no slash at the end.

A short example follows.
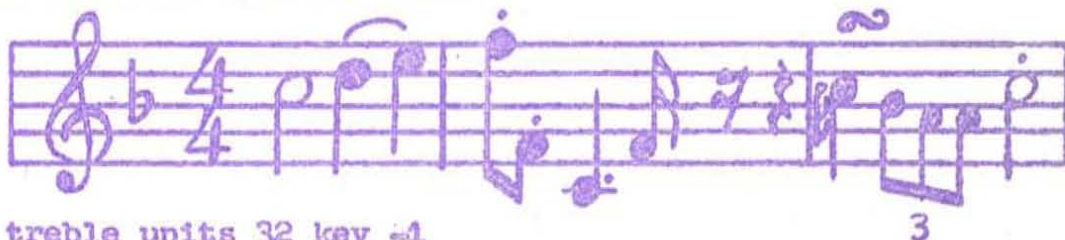

```
treble units 32 key -1
1 6t2 714 8,/
2 9s8 2s, 11b4, 2t16 r4x./
3 6r4 5c8 4, , 6h2/
stop
```

To run the compiler, load a copy of "mcomp" from Dectape 0 and start it at 0 or 102. The compiler expects the input text in Expensive Typewriter's text buffer. It places the output on the drum, where it should be saved on a Dectape using a standard file system.

When the compiler detects an error, it prints the page, line, and measure number at which the error was found, the line in error, and a three-letter error code. Following is a list of the error codes.

mts   Measure too short. Total duration does not match duration specified in units command.

mtl   Measure too long. Ditto.

nst   Text ends without "stop" command.

cnt   Cresc or accel still pending at end of part.

ncl   Repeat still pending at end of part, i.e. missing close.

itg   Illegal time in grace note. Following note must be in same measure.

The following print the offending syllable in red.

nps   No pseudo-instruction. The compiler doesn't recognize the syllable.

tmo   Too many opens, i.e. close is missing.

nop   No open corresponding to this close.

rtc   Close in same measure as open.

rtl   Repeat too long, i.e. position of close doesn't match position of open.

rts   Repeat too short, i.e. ditto.

vor   Volume out of range. Must be $0 \leq vol \leq 15$.

tur   Tune out of range. Must be $0 \leq tune \leq 7$.

cbv   Cresc before any volume command, or accel before tempo.

cic   Cresc in cresc, without intervening volume command, or accel in accel.

acr   Accent out of range. Must be $0 \leq accent \leq 15$.

tor   Tempo out of range. Must be $1 \leq tempo \leq 1023$.

atf   Accel or ritard too fast.

blc   Bad bar label in copy.

brc   Bad range in copy.

bbl   Bad bar label.

tmc	Too many commas. Only one should be used.
tmg	Too many g's. Ditto.
tmr	Too many r's. Ditto.
tme	Too many embellishments. Ditto.
tms	Too many articulations. Ditto.
tma	Too many accidentals.
tmf	Too many fields. Pitch and duration are overspecified.
tff	Too few fields. Pitch and duration must both be specified.
itg	Illegal time in grace note. Following note is too short.
air	Articulation, accidental, accent, or embellishment in rest.
eit	Note too short for embellishment. This can be fixed by making the trill time shorter.
uat	Pitch too high or too low.
unc	Comma used before any duration has been given.
tic	Comma used with dot.
nna	Non-numeric argument to a command.
ert	Duration field is not 1, 2, 4, 8, 16, 32, or 64.
dtu	Dot time underflow. Too many dots and x's.

Music Player

There are two versions of the music player; one for use in timesharing, and one for non-timesharing. Since the non-timesharing version has complete control of timing, the quality of music is somewhat higher; however, running it requires that no other users be on the computer.

To run the timesharing music player, load a copy of "tsmplay" from Dectape 0 and start it at 0. To run the non-timesharing player, load "ntsmplay" from Dectape 0, start at 0, and follow the printed directions. The player accepts the following commands, of which only as many characters as are necessary to distinguish the command from other commands need be typed.

tape n   Specifies the tape unit for loading music. The player loads music from files which are the saved output of the compiler.

untape   Rewinds the tape.

load filename
    Reads the music on file "filename". The music is stored in an internal buffer.

append filename
    Appends the music in file filename" to music previously loaded into the buffer.

go   Plays the music which has been loaded.

play filename
    Loads "filename" and plays it.

wait   In timesharing, waits for a key to be struck on the typewriter, then plays the music in the buffer. Out of timesharing, waits for the continue switch to be depressed, then plays. Used to start playing without the clatter of typewriters.

tempo n
    Multiplies the overall speed of playing by n/1000 (decimal). Used for debugging music without having to recompile. Music must be reloaded for the change in tempo to take effect.

tune n,m,...
    Overrides the tuning numbers specified to the compiler. Used for debugging music without having to recompile. It takes effect immediately.

back   Rewinds the tape, if any. In timesharing, dismisses to ID. Out of timesharing, restarts the timesharing system.

directory filename
    Prints all subfiles of file "filename". If no name is given, prints all files on the tape.

Commands "load", "append", and "play" may be used to load only one section of a music file, or a part of one section. If, after all subfile names are given, a number is typed, only that section number will be loaded (sections are numbered starting with 1). If a second number is given, only that measure number and succeeding measures of the section will be loaded. This feature is useful for debugging specific sections of a piece of music.

Both versions may be stopped in the middle of playing and restarted at location 4.

The controls on the amplifier on top of bay 7 may be adjusted for volume and tone. In addition, the switches inside bay 10 can be used to switch parts from one speaker to the other, and to change the degree of filtering.

WARNING - In timesharing as well as out, the music player stores music on drum fields used by Expensive Typewriter for text. Therefore, always file the text of the music on Dectape before running the player.

Frotz

There is a program to facilitate the task of preparing the input text for the music compiler from a musical score. It enables notes to be inserted in Expensive Typewriter's text buffer under control of buttons and knobs.

Frotz displays a staff with a note on it. The leftmost knob moves the note up and down. The middle two knobs control the position of the staff on the scope face.

There is an overlay to the button console which indicates which buttons correspond to the functions described below. Two buttons are used to calibrate the leftmost knob, by forcing the current knob position to correspond to the top or bottom of the staff. Five buttons are used to generate specifications for half, quarter, eighth, sixteenth, and thirty-second notes. Another button specifies a dot. Three buttons are used for accidentals, four for articulation, one for rests. Another button generates a slash, carriage return, and a measure number; typed corrections to the measure number will be reflected in subsequent measure numbers. There is a button to stop the display.

"Underneath" Frotz is an Expensive Typewriter, and all of its editing features may be used. Commands may be typed in the normal way; the typewriter may also be used to enter music.

Frotz is still under development, so this description may be inaccurate or incomplete by the time you read it.

Frotz may be found on Dectape 0, under "frotz".