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(54) **Audio synthesis method and electronic musical instrument for its implementation.**

(57) The invention concerns a method of audio synthesis wherein numerical samples memorized in a sample memory are reconstructed. The samples are memorized in the sample memory in the form of a plurality of sample packages, and each package corresponds to a distinct sound event. The sample packages are read out one after the other in accordance with a predetermined linking of the packages. The selection and linking of the sound events is determined in a dependence upon an audio signal to be produced. The invention is particularly suited for high quality musical instruments.

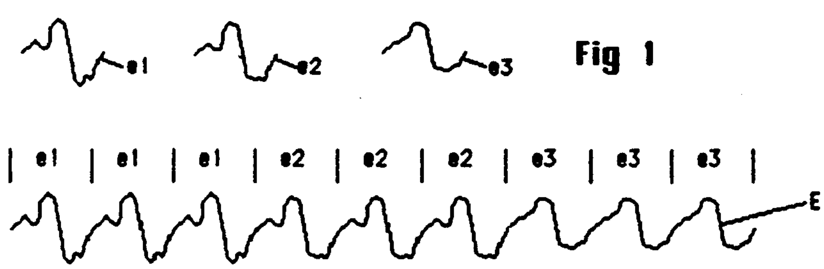
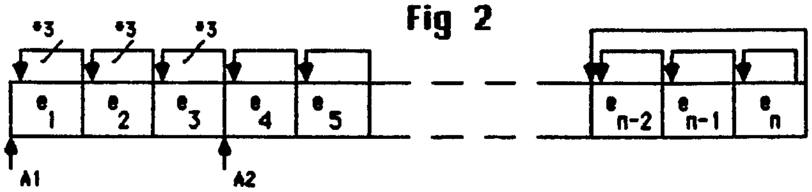


Fig 1

Fig 2



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Audio Synthesis Method and Electronic Musical Instrument for its Implementation

The present invention is related to a method of audio synthesis wherein numerical samples are reconstructed or converted into analog form, said numerical samples being combined in packages designated "macro-samples". The invention concerns also audio signal synthesizers and, more generally, musical instruments implementing the method according to the invention for the generation of musical sounds of high quality.

Numerous types of electronic musical instruments utilize memories containing numerical samples which represent the points of a registered wave form of real or artificial sound signals. These memories are designated sample memories. The sampling is the operation of registration which comprises conversion of an audio signal (for example) into a sequence of numerical values representing the amplitude values of the signal in regular temporal intervals. These samples are memorized in the sample memory. The synthesis includes the step to read out these memories and to reproduce the original signal by means of a numerical-to-analog converter and filter circuits so to restitute the continuous form of the signal. A musical instrument implements this synthesis at different frequencies, generally under the control of a keyboard, and is able to reproduce the initial sound registered at various frequencies which permits thus to play the instrument.

Such an audio synthesis device is described in the French patent specification published under number 2 476 888.

To obtain a good reproduction quality of the sounds, it is necessary to sample the initial sound with a high frequency generally in the order of magnitude of 40 KHz. Moreover, each sample must be encoded with a minimum of 12 bits to obtain an acceptable sound quality. Because of this fact the necessary capacity of sample memory becomes rapidly prohibitive. For example, for the complete reproduction of a base note of a piano having a duration of about 20 seconds, a sample memory of 20x40x12 =9600 kilobits is necessary which corresponds to 1,2 megaoctets. Moreover, the registration of one single note is insufficient because the sound color varies naturally over the extent of the keyboard and in dependence upon the force and speed of the player's key depressions. The problem becomes even more complex when the musical instrument is expected to reproduce the sounds of various instruments. There are thousands of memories of this size which would be necessary for this purpose.

For all these reasons only instruments have been marketed which are able to produce an only small number of sounds for nevertheless a very high price in case there is a complete sampling, or instruments having many more sound possibilities but which do not permit to produce sounds of high quality because of an extended simplification of the utilized sample memories.

EP-A-169 659 discloses an electronic musical instrument including a sample memory from which samples are selected in accordance with a bit combination supplied by the keyboard and a counter started by the player upon depression of a key. Only one type of sound may be produced because the addressing of the sample memory is hard-wired and thus not programmable.

GB-A-2,137,399 discloses a similar system. A sample memory is divided into blocks corresponding to three consecutive notes. Each block contains a first portion "attack", which is read only once, a second portion "sustain" which may be read out several times, and a third portion "decay" which is repeatedly read out until total extinction of the sound. The addresses for extraction of the samples are generated in response to key depression, and the respective logic unit is hard-wired so that the sample blocks can be combined only in one and the same manner. The ROM representing the hard-wiring delivers a start address which points to the first sample of a block. The address is then incremented by a counter. The linking cannot be modified nor programmed by a control unit.

WO-A-8 103 236 discloses a yet similar system where the sample memory is divided into an "attack portion", a "sustain portion" and a "decay portion". The retrieval of the samples can be implemented in a "pseudo-random" fashion in that sound portions to be repeated are read out either by incrementing or by decrementing an address counter, the address of inversion being shifted.

It is an object of the present invention to produce sounds by means of synthesis using sample memories of reasonable size without interfering with the quality of the reproduced sounds.

It is another object of the present invention to implement the memorizing of audio signal samples utilizing a novel method of information compression.

A further object of the present invention is the definition and exploitation of an internal organization of the sample memory corresponding to a physical reality in the domain of musical sounds.

According to a characteristic feature of the invention the samples are organized in blocks or packages in the sample memory, and each package corresponds to an element or distinct elementary audio or sound event (that is a portion of a sound over the time or a period this being however not obligatory). In each sample package the samples are read out sequentially during the reconstruction of the audio or sound event and the ultimate sound to be produced is obtained by a linkage of the reconstructions of a plurality of sound events of which some may be repeated. The choice and linking of the audio events thus is determined in dependence upon the signal to be reproduced (real or synthetic instrument, attack, dynamics, effect, duration, etc.).

For a piano, for example, the ultimate sound signal for a played note will thus be constituted by the temporal juxtaposition of a plurality of sound portions (audio or sound events): A portion corresponds to the attack (depression of the key) during which the spectral richness is extremely great and which has a duration of a fraction of a second. Thereafter follows a series of portions corresponding to the rapid decreasing of the sound during which the color develops even more rapidly. Thereafter follows a long series of portions corresponding to the end or extinction of the sound during which the sound color shows little development. Such a sound may be generated with only some tenths of sound events: one sound event corresponding to the attack, a series of sound events covers the rapid decrease of the sound with repetitions of the events near the termination of this portion and then a small number of sound events which are numerous times repeated so to reproduce the last portion of the sound (extinction). Of course, different sound events are allocated to different notes and octaves but under all of them a great number of them may be common to a plurality of sounds.

Accordingly the invention permits to obtain simultaneously a high audio reproduction quality because of a very great number of samples read out during the restitution and an important economy of the memory for stocking the samples in that the latter are organized in packages which are read out, as the case may be, a plurality of times in accordance with a predetermined linking. Moreover, one obtains thanks to this method a great reality of reproduced sounds because of the real transition effects procured by the linking between sound or audio events.

According to another feature of the invention a musical instrument implementing the audio synthesis process described above, comprises

-a numerical sample memory which is divided in memory blocks each containing at least one sample package corresponding to a sound event (a plurality of packages in one and the same block belong to the same event but define subevents for example the different octaves of the event);

-addressing means for the sample memory, said means comprising a phase counter for addressing the successive samples of one and the same sample package, a linking memory for the addressing of the sample packages and synchronizing means for commanding the linking to another memory block upon termination of the read out of the last sample in each package;

-and a central control unit for piloting the entirety of the musical instrument and in particular for writing into the linking memory at least one list of sample packages corresponding to the audio restitution of a predetermined audio signal.

Further features and advantages of the invention will become apparent from the following description of preferred embodiments, reference being made to the attached drawings:

Fig. 1 shows three different types of audio events and their combination in accordance with a predetermined enchainment;

Fig. 2 shows an enchainment of audio events forming a complete sound;

Fig. 3 shows a block of samples with its audio subevents;

Fig. 4 shows a principle scheme of a musical synthesizer according to the invention;

Fig. 5 shows an embodiment of a monophone synthesizer;

Fig. 6 shows an example of the organization of given data in a linking means;

Fig. 7 shows another example of an addressing apparatus and synchronization of sample packages and

Fig. 8 shows an example for the implementation of a polyphonic musical instrument.

For a better comprehension of the description the following de finitions will apply throughout the entire specification:

An "audio event" is a portion of a sound over the time represented in the sample memory by a collection of successive samples. This collection is designated "sample package". An audio event, materialized by a sample package is treated as an entity. For a periodic sound it is practical to define an audio event coincident with a period of the sound but this is not obligatory. The size of a sample package can be fixed for a given sound (for example 128 octects), but it may change from one sound to another. One may define also sample packages of variable size under the condition that to each package is associated its information of size or an indication of the termination of the package. One may associate to a given audio or sound event a plurality of sample packages as for example the different octaves of one and the same sound. In this case it may be said that the sound event is decomposed into "subevents". From a practical standpoint, the sample packages of one of the same family of subevents are regrouped in one and the same "memory block". To simplify the description, the term "audio event" or "sound event" may designate either a sample package or a sample block or the abstract notion of the portion of sound as defined above.

In Fig. 1 there are illustrated three sound events e1, e2 and e3 and their combination E which is the sound product (in an time interval limited for the comprehension of the figure).

Each sound event is memorized in a sample memory in the form of numerical successive sample packages which are read out with a fixed frequency or a variable frequency, thereafter transmited to digital-to-analog conversion circuits, thereafter to amplifiers and filter circuits and thereafter distributed by a loudspeaker.

According to the invention the final sound results from a small quantity of informations, memorized in the sample memory. The three sample packages e1, e2 and e3 are sufficient to product the sound E which is comprised of e1, three times read out, thereafter e2, also read out three times, and e3 read out three times.

The notion of the amplitude of the sound signal is here not discussed because it is treated by separate means and the sound signal generated in accordance with the invention is of course modulated by an "envelope" but this is not described either because it is of no importance for the present invention.

Figure 2 represents an example of a complete sound obtained by the association of n sound events each repeated several times and enchained with one another. To fix the ideas the sound portion represented in figure 1 is taken again in its entirety in a schematic format which clearly makes apparent the loopings of the sound events. The sound is formed of sound event e1 which is three times repeated, thereafter by e2, three times repeated, thereafter by e3, repeated three times, etc. then by events e_{n-2}, e_{n-1}, e_n each thereof being several times repeated. Moreover, there is a looping back of the termination of event e_n to the start of event e_{n-2} and so on just to the disappearance of the sound, determined otherwise in the complete process of sound synthesis. It will be understood that the linkages of the sound event may consist of passages of one event to another, in loopings of the events with themselves and/or loopings of one or several groups of events, all these combinations being possible, and the loopings may be overlapping.

In this manner a very important reduction of the sample quantity to be memorized in a memory is obtained while ensuring a very great quality of reproduction by properly choosing the sound events which must make up the ultimate sound. For example for most of the traditional instruments as the piano, the "attack", i.e. the start of the sound is frequently very rich in harmonics and has a spectral composition which varies very rapidly. This portion of the sound which has a duration of only a fraction of a second may be completely memorized in the form of a unique sample, package representing an individual sound event. Just after the attack the natural variations of the sound color become more and more slow which permits to cut this portion to produce a plurality of events which are then repeated, at first only a few times and thereafter more and more frequently in dependence upon the time. The sustaining and the termination of the sound are generally characterized by a sound color which is more stable and permits reproduction based on a small number of sound events repeated a great number of times.

The invention permits all the intermediates between the sound synthesis methods which are known up today: The synthesis of the wave form by calculation and the restitution of a sound completely memorized. For the loopings of the events and the sequence of events looped themselves the invention permits a considerable reduction of the memory size necessary for memorizing the samples.

Numerous amendments of this method permit its application to different types of synthesis.

Generally the loopings are realized in a dynamic manner in dependence upon the characteristics of the sound: the portions of the sound having a rapid color variation are treated without looping (pure sampling) and with the evolution of the color becoming more slow the loopings may become longer and longer.

The generation of aperiodic sounds is produced accordingly without looping with the exception of the termination of the sound(for example cymbal), but fortunately these are sounds of short duration. In the case of aperiodic sounds which nevertheless are cyclic (roll of drums), a global looping over a great portion of the sound reproduces the rolling.

The invention permits also to take care of the sound color variations in dependence upon the dynamics for one and the same sound (the force with which a key is depressed or the force of blowing into a wind-instrument, for example). Accordingly it is sufficient to provide linkages of different sound events in dependence of the dynamics wherein a sound of great dynamics generally has an evolution of the spectrum which is more rapid than the same sound with a more feeble dynamics.

In figure 2 for example an attack of powerful dynamic is reproduced by starting the linking at A1 with the start of the event e1. In the contrary for a more feeble dynamics the sound starts only at A2 at the start of event e4. Of course, all intermediate possibilities are given under the condition that the necessary linkings are provided.

Figure 3 shows an example of a sound event in correspondence with e2 of figure 1. Its representation in the form of the plot amplitude over time is more convenient for the explications. In the sample memory, the function is represented in the form of a sequence of binary encoded numbers, each number corresponding to a point of the curve, either by its direct value ("absolute" coding) or by the amplitude difference relative to the preceding point ("delta" coding or relative coding).

The illustrated sound event is composed of five subevents which correspond to a period of the same sound at five different octaves. The octave o1 occupies one half of the memory block utilized for the memorizing the complete sound event. The octave o2 occupies a quarter of the block, the octave o3 one eighth, the octave o4 one sixteenth, the octave o5 a thirty-secondth, etc.

The octave o2 represente the same wave form as 01, but comprises two times less samples etc. for 03, 04 and 05. The disposition of the sample packages corresponding to subevents is such that it permits the addressing of the latter in simple manner in the interior of the memory block by utilizing the bits representing the number of the octave in the address of the sample (equivalent dispositions are possible).

Figure 4 represents a simplified embodiment of a sound synthesizer implementing the method of the invention.

The numerical samples of the sounds to be produced are memorized in a sound event memory 2. These samples are regrouped in blocks corresponding to events as indicated above, each block being able to hold, as the case may be, a plurality of sample packages corresponding to subevents or one single package. The constitution of this sample memory is implemented on the basis of records of sounds, digitized and analyzed thereafter by an apparatus which is external with respect to the synthesizer which in dependence upon predetermined criteria, has extracted portions of the digitized signal and formed libraries of sound events which are then transferred into memory 2. The latter may be a programmed read only memory or a random access memory, the contents thereof being charged prior by a central control unit 5 prior to the generation of sounds; or a combination of the two types which permits to have a library of reprogrammed sounds (frequently used sounds) and a series of sounds to be charged upon request from an external mass memory (not illustrated).

The addressing of memory 2 is implemented by two devices: A phase counter and comparator 3 which permits the extraction of samples in one and the same memory block, and a linking device 1 which ensures the linking of the blocks and their repetition, as the case may be, upon the reading of the last sample of each block. the address to be applied to memory 2 is thus a composite address having as more significant weight the number of the block p1 and for the less significant weight the value of the phase counter p2.

The assembly counter and comparator 3 comprises a counter which is automatically incremented by clock signals produced by a clock device of the central control unit 5. An internal comparator detects the termination of the reading of a block either by overflow of the counter (for blocks having all the same size) or by comparison of the contents of the counter with a maximum value which may be constant or variable (the value is for example read in the sample memory at a place reserved for the size of the respective block). The comparator is not necessary if the indication of the block end is furnished by the sample memory. In all cases a block termination signal is accordingly emitted to the linking device 1 which searches for the following block (or the same in the case of a looping), and the phase counter is reset to zero.

The linking device 1 comprises essentially a linking memory, charged by the central control unit in dependence upon the sounds to be produced with lists of sound events (and their addresses) and their linking (number of repetitions, number of following event after last repetition). An example for the organization of data in the linking device is described later (figure 6).

The samples extracted from the sound event memory 2 are applied to an assembly 4 comprising a digital-to-analog converter, filters and amplifiers and receiving also control signals for the conversion from the counter 3 (for the synchronization of the synthesizer) and amplitude commands from the central control unit 5 so to produce the combination of variations of color and amplitude as necessary.

The central control unit 5 comprises for example a microprocessor which pilots the entirety of the instrument under control of a programme in dependence upon the actions on the keyboard(s), buttons and drawers for the control of the instrument whereby also all the auxiliary means of the instrument are affected. The details of the central control unit and these auxiliary means are not represented and not described either because they do not form a portion of the invention and are not necessary for its comprehension.

Figure 5 illustrates an example of the implementation of a monophone synthesizer according to the invention.

The linking device (1 in figure 4) is composed of a pointer register of the linking memory 11, a linking memory 12 and an address selection table 13.

The phase counter and comparator device (3 in figure 4) is comprised of a programmable clock 31, a phase counter 32 and a comparator 33 for the audio synthesis at variable frequency. The frequency is commanded (signal fv) by the central control unit 5 which also furnishes the list (signal pi) of the linking pointers to memory 11.

The composite address p1-p2 furnished respectively by the address selection table 13 and the phase counter 32 is applied to the sound event memory 2 which delivers its numerical samples to the digital-to-analog converter 41. The reconstruction of the audio signals is then continued by the assembly filter and amplifier 42.

Upon the start of the synthesizing process the phase counter 32 is initiated at a value $\phi 0$ (equal to zero or a value non zero which permits the access to subevents for example) and an initial pointer pi is furnished to register 11 by the central control unit 5. The phase counter 32 furnishes now an initial address p2 (less significant) to the sample memory 2. The initial pointer pi points in the linking memory 12 to a pointer pi + 1 which points in turn in the address selection table 13 to the address (more significant p1) of a block of the sample memory allocated to the first sound event to be generated.

The clock signals increment the counter 32 and the sample memory delivers successively the samples of the first sound event. Upon the comparator 33 having detected the phase ϕmax. it transmits a command of reinitiation to counter 32 which reinitiates itself to the value $\phi 0$, and a linking command to pointer register 11. The latter replaces accordingly the pointer which it holds by the poniter pi + 1 which prior thereto has been read in the linking memory. This new pointer addresses a new pointer pi + 2 in the linking memory and the latter is associated in the address selection table with a sound event which may be either the same as the preceding one or a new sound event.

Figure 6 permits the comprehension of the sequence of linkings which are produced at each detection of the termination of an event by the comparator 33.

The left column represents the contents of pointer register 11 (in the example of figure 5 this register holds only one single value at a time) the central column represents the contents of the linking memory 12 (this time it is a list); the right column represents the contents of the address selection table 13 (also a list). The different lines of the table represent the evolution of the linking.

Upon start (first line) the linking pointer has the value "1"; it points to the linking "2" which points to the sound event "e1".

The phase counter is initiated and the samples of the audio event "e1" commence to be produced.

Upon termination of the audio event the comparator 33 emits a command of reinitiation to counter 32 and a command of linking to the pointer register 11. The linking "2" of memory 12 is accordingly recopied in the register 11 (second line of the table). It points accordingly to linking "3" which points to event "e1". Event e1 thus is played a second time.

The sequence of the table shows what happens after each termination of a sound event. The linkings "2", "3" and "4" repeat the sound or audio event "e1". The linking "5", "6" and "7" repeat the sound event "e2". The linking "8" points to the sound event "e3". But as the linking "8" is recopied in register 11, the latter points again to linking "8" and there is a permanent repetition of event "e3" up to the instant when the central control unit terminates this process.

The linking memory may hold preprogrammed linkings which corresponds to a library of preexisting sound signals. It may also hold a variable portion produced by the central control unit for generation of special sounds not contained in the library.

A variation of the device phase counter plus comparator is represented in figure 7 for the sound synthesis with fixed frequency. In this case the phase is not incremented at each clock signal but it is augmented by a value $\Delta\phi$.

Clock 31 is commanded via input 311, by the central control unit 5 and delivers reading pulses to phase register 32. The running phase ϕ contained in the phase register 32 before the pulse and a constant value $\Delta\phi$ are applied to an adding device 34. The running phase is furnished via the connection 342 from register 32 and value $\Delta\phi$ is furnished via connection 341 by the central control unit 5. The result of the addition is returned to register 32 via connection 343.

The phase comparator 33 compares the current phase value ϕ with a value ϕ max. Upon this value being achieved or passed, the comparator emits a linking command to the linking circuits 1 (fig. 4) or 11 (fig. 5) and the contents of the phase register 32 is reinitiated to value ϕ-ϕmax. (circuits and connections of the reinitiation are not illustrated in an attempt to amintain clarity).

Figure 8 represents an example of implementation of a polyphonic synthesizer wherein use is made of the method according to the invention.

It comprises a memory designated "virtual keyboard" which contains all the information necessary to generate all the audio signals at each instant. This technique is described in detail in the French patent published under registration no. 2 476 888. The virtual keyboard is composed of 6 memory blocks for each signal to be generated, each memory being able to be accessible by the central control unit 50 which comprises one or a plurality of microprocessors, as indicated above. These memory blocks are:

-A following block register 53 which contains the linking to another block with respect to another signal to be generated. As soon as there is no sample anymore to be generated for the signal associated to the running block, this memory permits addressing of the registers associated to other signals and thus to treat only the signals for which a treatment is to be made (no "idling" treatment). A circular linking is implemented with a current block register 54 under control of a clock 52.

-A time-of-happening register 56 which contains the instant te from which on a new sample must be generated. A time counter 55 is periodically incremented by clock 52. The time represented by this counter may be designated t. A comparator 57 compares the contents t of time counter 55 with that,te, of register 56. As long as t is smaller than te, there is nothing to be done and the following block register 53 indicates the linking to another sound signal.

-A sampling period register 59 which contains the period T of the generation of signal samples. As long as the comparator 57 detects t greater or equal to te, this means that there is time to produce a new sample. This happening represented by reference 88, is distributed in the entirety of the synthesizer. The time-of-happening register 56 is accordingly activated thanks to a summing circuit 58 which receives T and te and which permits to replace te by te + T.

-A phase register 32 contains the phase ϕ which serves to select a sample in the interior of a package in the sound event memory 2. Each happening 88 increments the phase ϕ of the corresponding signal by means of an adder 34. A comparator 33 indicates whether the phase has reached its maximum value, and initiates thus the addressing of a new sound event.

-A linking pointer register 11 contains the current pointer to a linking memory 12 which contains a pointer to an address selection table for sound events 13 (as described in the preceding example). This table furnishes the complement of the address to the sound event memory 2 for access by phase ϕ to a sample of the selected event.

-A current amplitude register 60 of the concerned signal. This amplitude serves to modulate the obtained signal to obtain slow effects like sustain, tremolo, extinction, etc.

A digital-to-analog converter 411 reconstitutes in analog form the samples read in memory 2. A second converter 412 used as a multiplier modulates the amplitude of the analog sample by the value contained in the register 60. The resulting signal is thereafter formed and amplified by a filter and amplifier circuit 42 and then reproduced by a loudspeaker 43.

The operation of the device is the following:

Clock 52 increments, normally at a constant frequency (in the order of magnitude of 8 MHz) the time counter 55 (time t) and selects a new block in the virtual keyboard (register 53) at each pulse. The treatment concerning a sample and its digital-to-analog conversion occur in one period of the clock.

The time t is compared with te (register 56). If t is smaller than te, one goes directly to the following generator (following block 53). If t is greater or equal te, a new value of te is calculated and memorized in register 56 (te = te + T). The phase is incremented ($\phi = \phi + 1$) in phase register 32. The sample selected by ϕ and the contents of the selection table 13 is transmitted to converter 411. The amplitude read in register 60 is transmitted to converter 412 which multiplies the amplitude of the output signal of converter 411 with this value. The result is filtered, amplified and reproduced by the loudspeaker 43.

If the phase ϕ has reached its value ϕ max., a new pointer is extracted from the linking memory 12 which permits access to the first sample of a new sound event.

The polyphonic operation is obtained by the linking of blocks in register 53, samples of different signals to be produced being multiplexed at the input of converter 411.

Numerous variations of implementation are possible.

For example the linking memory 12 may contain the number of executions of a sound event instead of a list comprising several times the same events. Some supplementary bits in each information of the pointer may permit this implementation.

It is also possible to combine the linking pointer 11 and the linking memory 12 by reserving a small portion of the memory 12 for containing the pointer 11. This possibility permits to economize on memory circuits in particular in a polyphonic instrument.

The invention is applicable in electronic musical instruments of the organ type or research synthesizer or stage synthesizer. Each instrument may comprise one or several of such synthesizers and powerful commanding means as one or several microprocessors allocated to certain objects of the instrument as for example the scrutinizing of keys, keyboard, buttons as well as the reading of synthesis data of sounds in the virtual keyboard in dependence upon a predetermined programme.

Claims

1. A method of audio synthesis including the step of successive reading of numerical samples memorized in a sample memory and the step of restituting said samples in analog format, wherein

-said samples are memorized in said sample memory in a plurality of sample packages, each sample package corresponding to a distinct sound event,

-said sample packages are read successively in accordance with a predetermined package linking,

-said package linking is written into a linking table containing a list of sound events to be successively produced,

-selection and linking of sound events are written into said linking table in dependence upon a sound signal to be produced.

2. The method of claim 1 wherein said linking table comprises a plurality of entries corresponding to a plurality of restitution types of a sound to be produced.

3. An electronic musical instrument for implementation of the method defined in claim1 or 2, comprising:

-a numerical sample memory, divided into memory blocks, each block adapted to memorize at least one sample package corresponding to a respective sound event,

-means for reading and numerical-to-analog converting of samples read out of said sample memory, said means including a phase counter for addressing successive samples of a sample package,

-a linking memory for global addressing of sample packages,

-synchronizing means for pointing said linking to another memory block after reading of a last sample in each block, and

-a central control unit for writing into said linking memory at least a list of sample packages and for control of the successive reading of samples and production of predetermined sounds.

4. The instrument of claim 3 wherein said linking device comprises an address selection table containing at least a common address portion of samples of each sample block, and a linking memory containing at least a list of sample blocks which constitute a linking, each element of said list serving the addressing of said selection table, and each address portion delivered by said address selection table being combined with the count of said phase counter for addressing each sample.

5. The instrument of claim 4 comprising further a linking pointer register connected to said linking memory for obtaining repeated readings of sample blocks or of sample block groups in response to said linking list contained in said linking memory.

6. The instrument of claim 5 for generation of polyphonic sounds wherein said phase counter comprises a phase register and an adding circuit, and wherein the instrument comprises an assembly of memory blocks for each signal to be generated, each assembly including said phase register, said linking pointer register and further an amplitude register, a period register, an instant-of-happening register and a block linking register, and means for counting the time and means for comparing the elapsed time with the contents of the instant-of-happening register of each assembly so as to produce the samples of each signal in multiplexed format by linking the read-out of block assemblies.

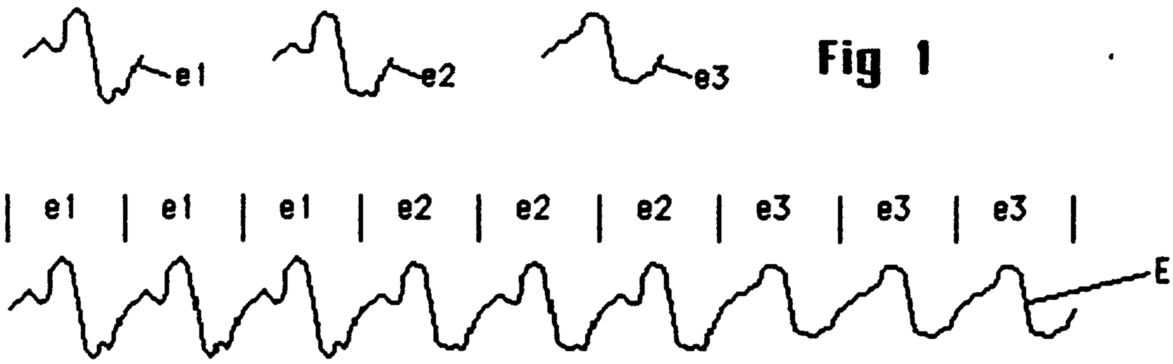
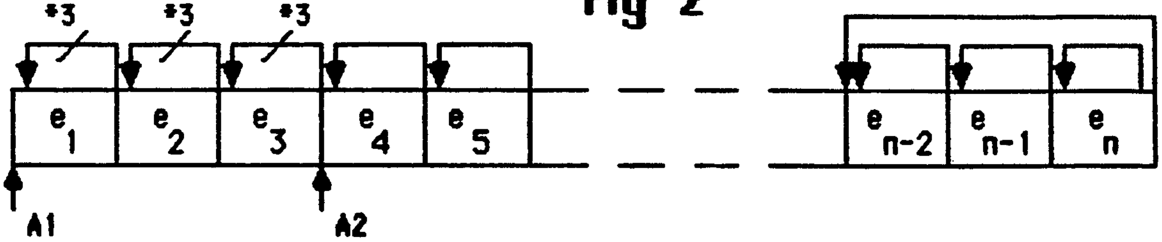


Fig 1

Fig 2



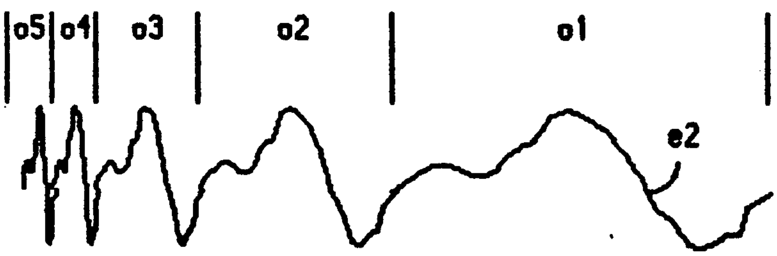


Fig 3

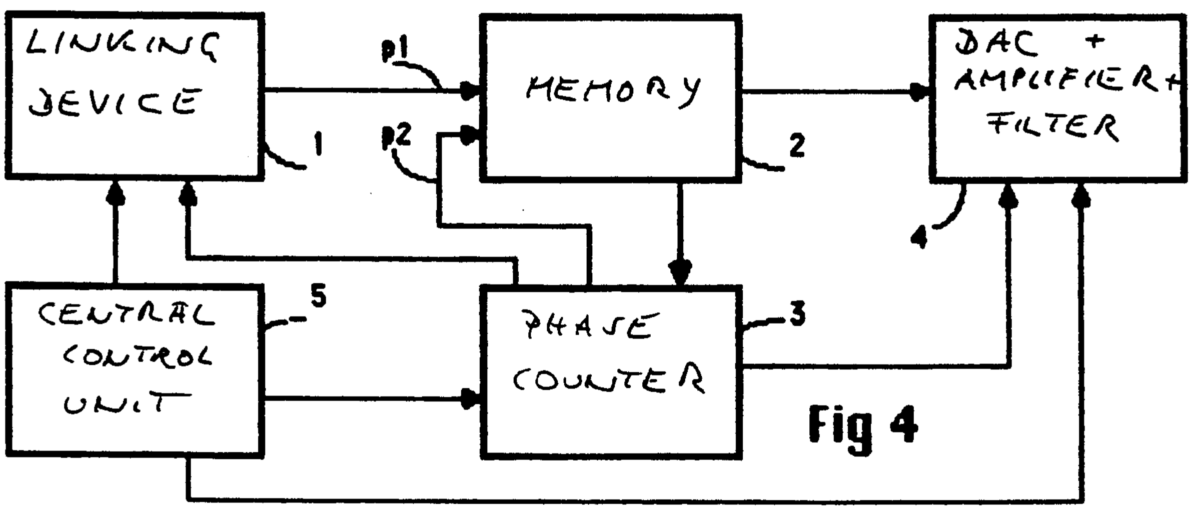


Fig 4

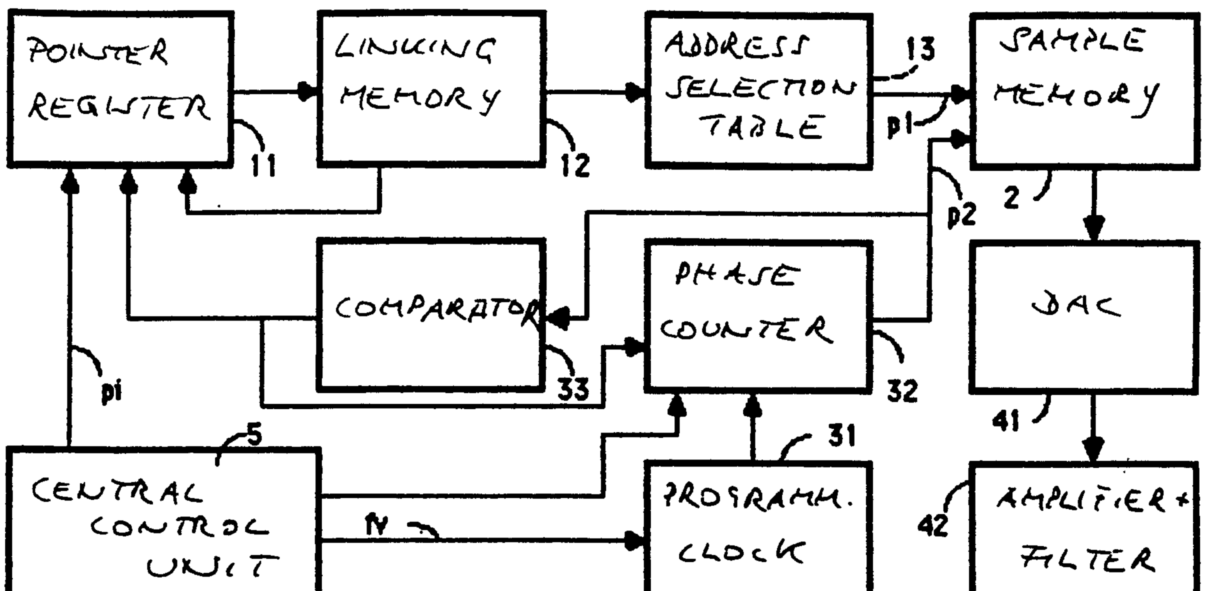
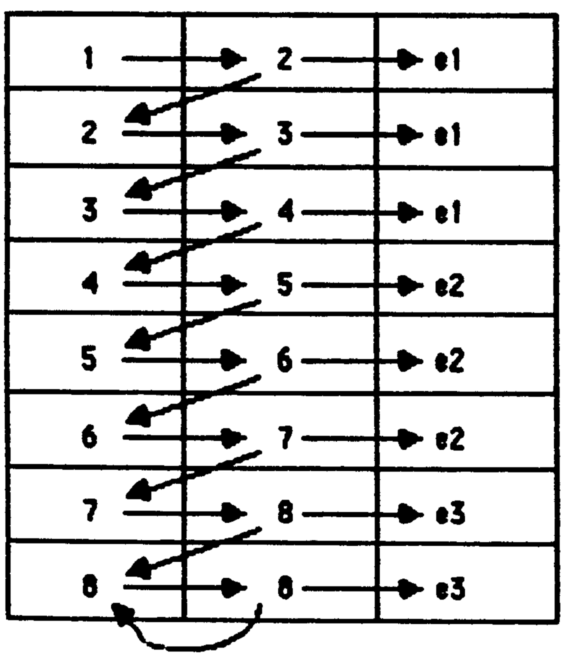
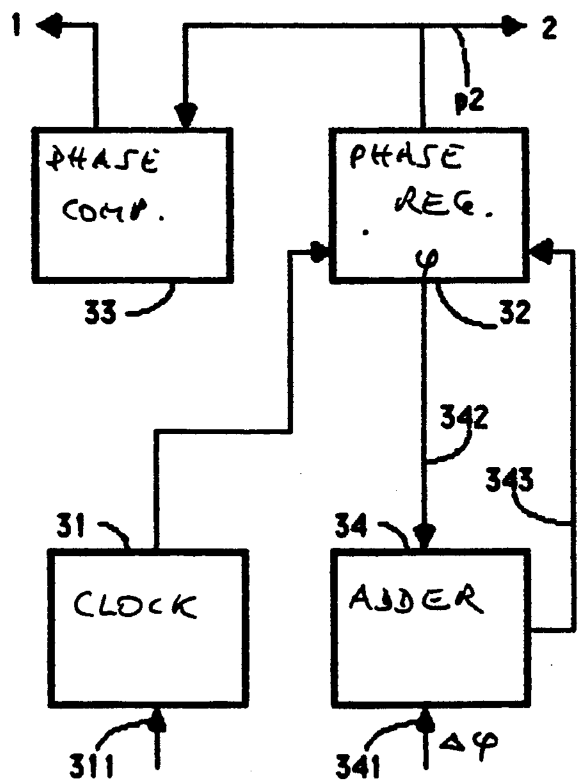


Fig 5

Fig 7

Fig 6





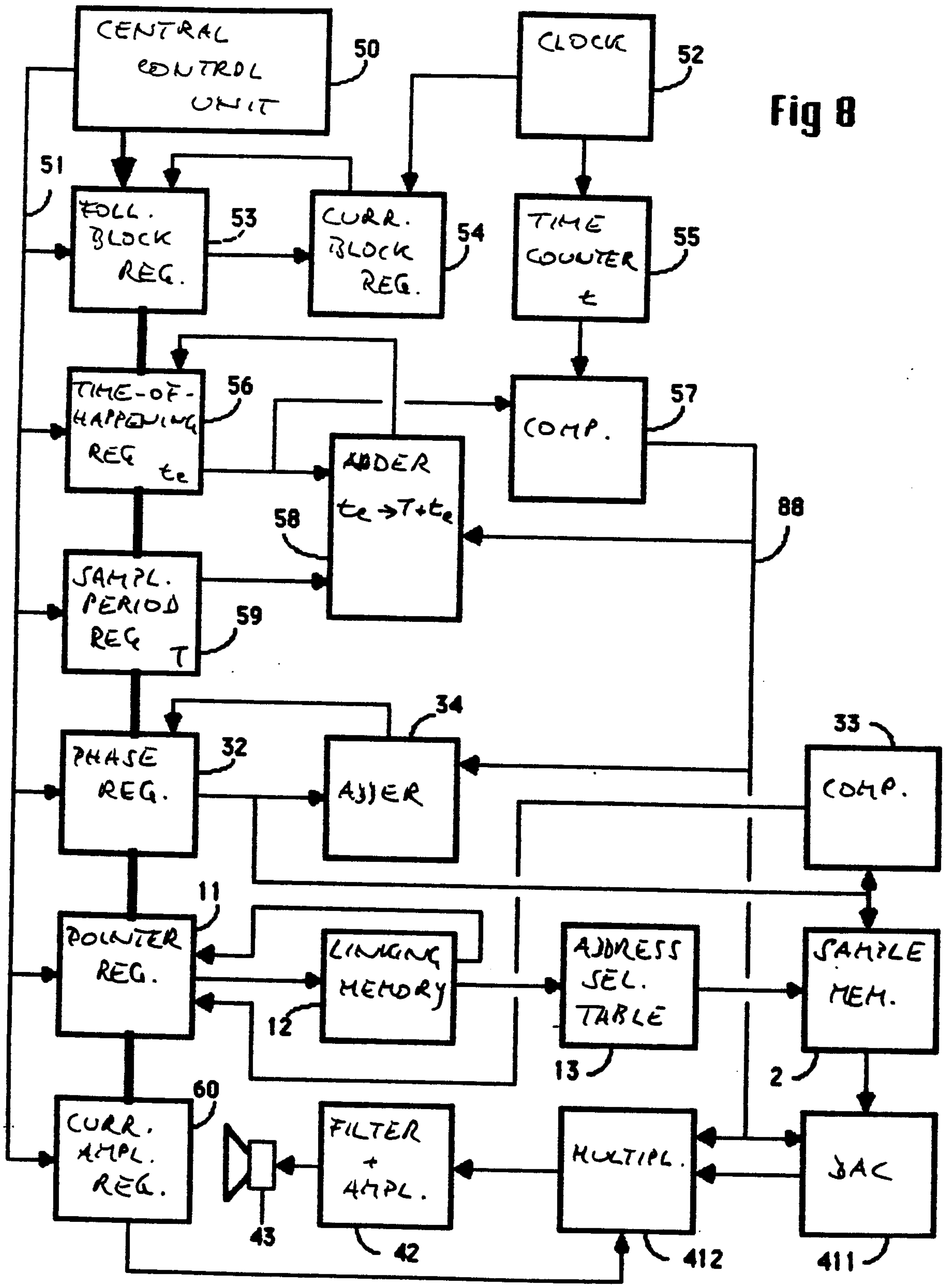

CENTRAL CONTROL UNIT
50
CLOCK
52
51
FOLL. BLOCK REG.
53
CURR. BLOCK REG.
54
TIME COUNTER t
55
TIME-OF-HAPPENING REG te
56
COMP.
57
ADDER te→T+te
58
88
SAMPL. PERIOD REG T
59
34
33
PHASE REG.
32
ADDER
COMP.
11
POINTER REG.
LINKING MEMORY
12
ADDRESS SEL. TABLE
13
SAMPLE MEM.
2
60
CURR. AMPL. REG.
43
FILTER + AMPL.
42
MULTIPL.
412
DAC
411

Fig 8

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 88 10 1416

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
D,A	GB-A-2 137 399 (NIPPON GAKKI SEIZO K.K.) * Page 1, lines 48-58; page 2, lines 16-24; page 4, lines 21-30; page 5, lines 63-65; page 6, lines 1-8; figures 2,4 * ---	1-6	G 10 H 7/00
D,A	WO-A-8 103 236 (NORLIN INDUSTRIES INC.) * Page 4, lines 4-26; page 5; page 6, line 1; figures 1-4 * -----	1	

TECHNICAL FIELDS SEARCHED (Int. Cl.4)

G 10 H

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	18-05-1988	PULLUARD R.J.P.A.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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A : technological background
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& : member of the same patent family, corresponding document