(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Veröffentlichungsnummer: **0 176 670**
**A2**

# (12) EUROPÄISCHE PATENTANMELDUNG

(21) Anmeldenummer: **85108252.9**

(22) Anmeldetag: **03.07.85**

(51) Int. Cl.⁴: **G 10 H 7/00**
G 10 H 1/057

(30) Priorität: **05.09.84 DE 3432582**

(43) Veröffentlichungstag der Anmeldung:
**09.04.86 Patentblatt 86/15**

(84) Benannte Vertragsstaaten:
**FR GB IT NL**

(71) Anmelder: **Matth. Hohner AG**
**Postfach 160**
**D-7218 Trossingen1(DE)**

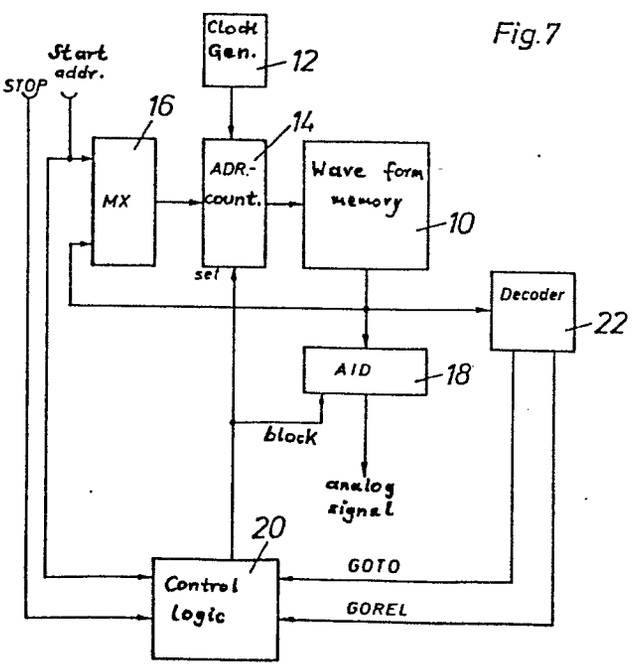
(72) Erfinder: **Deforeit, Christian, Dipl.-Ing.**
**6, rue de l'Hôpital**
**F-21140 Semur-en-Auxois(FR)**

(74) Vertreter: **Dipl.-Ing. H. Marsch Dipl.-Ing. K. Sparing**
**Dipl.-Phys.Dr. W.H. Röhl Patentanwälte**
**Rethelstrasse 123**
**D-4000 Düsseldorf(DE)**

## (54) Schaltung für ein elektronisches Musikinstrument.

(57) The invention concerns a circuit for an electronic musical instrument which comprises a clock generator whose clock rate is variable in accordance with sound frequencies to be generated. A wave form memory contains scanning values of a wave form indigital format and may be addressed by the clock generator output signals. Data retrieved from the memory are processed by a digital to analogue converter by means of which the read-out scanning values are converted into analogue signals and processed in following circuits so as to produce audio-signals to be sounded. The wave form memory holds the scanning values of several periods of a note including its release section, and under predetermined memory element addresses of the wave form memory command words are memorized and if these are read-out a command signal is passed to the clock generator so to set it onto an address under which in the wave form memory the same scanning value as prior to said command, however, in the release section of the envelope, is read while the digital analogue converter is disabled for the command words.

Fig.7



# A circuit for an electronic musical instrument

The present invention relates to a circuit for an electronic musical instrument, in particular to a circuit having the features set forth in the preamble of patent claim 1. Such a circuit is disclosed in German published patent application 27 15 510 based on Japanese priority application P 51-38466.

Hereinafter, individual sections of a wave form will be designated with the internationally used words "attack", "sustain", "release".

In accordance with the teaching of the publication referred to above, a complete wave form is memorized including attack, sustain and release if a percussion sound is to be simulated as, e.g., piano notes. If by striking a key on a manual of the instrument, such a note is called upon, the wave form memory is read-out completely even if the player will prematurely cease to strike the key. However, in this latter case, the wave form is modified in that data read-out after release of the key are multiplied by an attenuation function.

If it is necessary to permit production of a sound of arbitrary sustain duration, as e.g. organ notes, the publication referred to above suggests to use, as the release portion of the note, quickly or slowly attenuated data of the sustain period.

It is an object of the present invention to improve the circuit as defined in the preamble of patent claim 1 such that always the complete wave form including the release section is read-out wherein the transition from sustain to release can be provided at any point of the sustain section, without the necessity to complete reading-out of the entire sustain wave form before release can commence. In fact, this permits to memorize relatively long periods of a natural sound and to thereby

improve the simulation while nevertheless the reading of the sustain may be interrupted with only negligible delay in order to commence release data reading upon cessation of a key stroke.

The characterizing portion of patent claim 1 defines the means which, in accordance with the present invention, are provided to achieve the object defined above.

Accordingly, during the memorization of scanning data, certain memory elements - preferably regularly spaced - are preserved for the command words. Upon their reading, a decoder detects whether in the time period since the reading of the previous command word a signal "sound off" has occurred (which would e.g. mean in case of an electronic organ that the respective key had been released by the player). Only under these conditions, the command words will cause a "jump" to the memorized release section which will then be read-out.

Preferred additional features are defined in the subclaims, and the results of their features will become apparent upon reading of the following detailed description of embodiments.

Reference is made to the accompanying drawings.

Fig. 1 shows the envelope of a sound, for example, a trumpet note.

Fig. 2 illustrates schematically how such a sound is reproduced by means of the circuit of the invention.

Fig. 3 illustrates with a temporal scale considerably increased over that of Fig. 2 the interspersing of the command words into the scanning values.

Fig. 4 illustrates the envelope of a percussion sound (e.g. piano), in one case with the key held depressed and in the other case with the key briefly struck.

Fig. 5 shows the reproduction of such sound.

Fig. 6 shows in analogy to Fig. 3 the interspersing of the command words.

Fig. 7 is a considerably simplified block circuit diagram according to the invention.

Fig. 1 shows the temporal events of a sound generated by means of an instrument permitting to "hold" a note, as e.g. a trumpet note. The amplitudes show three characteristic sections: Attack A, Sustain S, and Release R.

Fig. 2 shows the envelope plot as reproduced for such a note by means of the circuit of the invention. The sections A and R are memorized in their entirety while of the section S, only a portion S' is memorized and will be repeated in case of a duration of a "sound on"-signal with a duration exceeding that of the memorized portion S'. It will be appreciated that the reproduction will sound the more natural the longer subsection S' is chosen, however, there is the inherent limit of memory capacity and access time. A duration of subsection S' should have a minimum reading duration of about 100 milliseconds, and 500 milliseconds would be preferable.

On the other hand, when already a "sound off"-signal is present, occurring somewhere within S', it is undesirable to complete the actual reading of S' before the sound is continued with the R section. For this reason, under predetermined addresses of the wave form memory holding the amplitude scanning values, command words GOREL are written in. Upon presence of a "sound off" instruction ( i.e. in case of an organ, release of the respective key), at first the reading of subsection S' will continue but only until an address holding a GOREL is met. From then on, a jump is made to continue with section R. The GOREL commands may be addressed with a temporal spacing of about 10 or, as a maximum, 20 milliseconds - depending on the clock frequency - while their minimum spacing is one period of the sound oscillation. This has the consequence that a certain wave form memory is suitable for a limited range of clock frequencies only; higher or lower clock frequencies are handled by other memories which are loaded in a commensurate manner. For example, one memory may be provided for each octave to be playable by the instrument.

As illustrated in Fig. 3, it is preferred to select the addresses of the GOREL such that they are at amplitude zero crossings of the memorized sound because under this condition, noise is reduced to a minimum.

Fig. 4 is analog to Fig. 1 but shows percussion sounds, e.g. of a piano.

Such sounds have an A section which is immediately followed by a R section. The envelope is shown in Fig. 4 for the case of a steadily depressed key causing a steady decrease of the amplitude, and also for the case of a sudden key strike.

As shown in Fig. 5, both these envelopes are memorized without, of course, provision of a sustain section.

Fig. 6 shows that at the GOREL commands, there is always the possibility to jump to the address of the same amplitude but in the R section of the memory which results in an excellent simulation of natural sounds. This jump is performed under the condition that the depressed key is released.

Fig. 7 shows in block form and reduced to the components which are of importance for the implementation of the invention a circuit according to the principles of the present invention.

Scanning values of the desired wave form are memorized in wave form memories of which only one is shown and designated with 10. The data may be absolute values, differential values or other digital representations of the amplitude variations. As a memory, either ROM or RAM type memories may be used, in the latter case external loading means are provided, preferably a microprocessor.

At certain memory addresses, command words GOREL and GOTO, respectively, are memorized.

If it is e.g. desired that a maximum 20 milliseconds delay after release of a key be permitted before the A section or S' section (as the case may be) is quitted and the sound is continued with the R section, for a basic frequency of the sound of, say, 250 cps one GOREL should be

memorized after each fifth sound period. If the reading frequency is doubled, the temporal spacing between two succeeding GOREL commands will be reduced to 10 milliseconds only. In order to maintain this 10..20 milliseconds spacing, thus one envelope memory is to be provided for each octave.

GOTO commands are provided only if the memory contains a S' section, too, said subsection S' being simply repeated if the respective key is held depressed long enough. The reading duration of S' is at least 100 milliseconds. This means that for the example given above, for a sound frequency of 500 cps at least fifty periods of a natural sound are to be memorized to form S'. (With 250 cps, of course, the S' duration will be doubled to 200 milliseconds).

The reading clock is supplied by clock generator 12 which addresses an address counter 14. The latter receives, via multiplexer 16, the start address (upon depression of a key), and data retrieved under the read-out addresses are passed to a digital-to-analog converter 18 which generates a respective analog signal to be further processed by components as filters, amplifiers and the like, as is common practice in electronic musical instruments. In addition, the data are fed to a decoder 22 which detects whether a GOREL or GOTO has been read. The following possibilities are to be considered:

- key still depressed: Ignore GOREL.
- key still depressed: GOTO will set address counter to the start address of subsection S' (if any).
- key released (symbolized by STOP line): Ignore GOTO.
- key released: GOREL will set address counter 14 to the "homologue" address of the R section of the memorized sound, i.e. that address where
  (i) with a preceding S' subsection, the R section begins, or
  (ii) with a preceding A section (or portion thereof) the same or most similar amplitude value of the R section is memorized.

In any such event, the digital-to-analog converter is disabled, and for this purpose a disabling input is supplied to its BLOCK input.

The processing described above is implemented by means of a control logic 20 which may be a ROM or a gate array logic and which supplies the respective control signal SET. Such a control logic may be easily implemented by an expert skilled in the art based on the following truth table:

| Start address | GOTO | GOREL | STOP | SET | Remarks |
|---|---|---|---|---|---|
| no | no | no | no | no | normal sound generation |
| yes | no | no | no | yes | input start address into counter 14 |
| no | yes | no | no | yes | input of S' start address into counter 14 |
| no | no | yes | no | no | ignore GOREL |
| no | no | yes | yes | yes | input of R address into counter 14. |

It will be understood that the circuit embodiment as described above may be modified in order to produce a polyphonic instrument. In this connection, reference is made to European Patent 36074 which discloses a circuit arrangement operating with variable clock rate.

The circuit of Fig. 7 may be implemented by using integrated circuits available on the market.

| | |
|---|---|
| Wave form memory: | IC 27256 of the company INTEL |
| Digital-analog-converter: | IC DAC 08 NS or<br>IC DAC 16 PCM of company Burr-Brown |
| Control logic: | Gate array PAL Series MMI of company Monolithic Memories Inc. |

## Claims

1. A circuit for an electronic musical instrument, comprising a clock generator producing a variable clock rate commensurate with sound frequencies to be generated, comprising further a wave form memory readable by means of clock generator output signals and holding scanning values of several periods of a note including its release section, said values being digitally memorized, and comprising further a digital to analogue converter by means of which the read-out scanning values are converted into analogue signals to be processed by succeeding circuits so to produce audio-signals to be sounded in analogue form characterized in that predetermined memory element addresses of said wave form memory hold command words controlling, when read-out, transmission of a command signal to said clock generator so to set the latter to an address under which in said wave form memory the same scanning value as prior to said command but in the release section of the envelope is read, and that the digital analogue converter is disabled for said command words.

2. A circuit as set forth in claim 1, characterized in that between succeedingly readable command words at least one period of a wave form is memorized.

3. A circuit as set forth in claim 2, characterized in that the clock generator frequency and the number of scanning values memorized between succeeding command words are adapted to each other such that the temporal spacing between succeedingly readable command words will be 20 milliseconds mostly.

4. A circuit as set forth in claim 3, characterized in that a plurality of wave form memories are provided each allocated to a range of clock generator frequencies.

5. A circuit as set forth in claim 4, characterized in that each wave form memory has a memory capacity for a reading duration of at least 100 milliseconds.

6. A circuit as set forth in one of claims 1 to 5, characterized in that under second predetermined memory element addresses of said wave form memory and in the order of reading behind a predetermined number of scanning values of a sustained note, second command words are memorized which enable upon being read, transmission of a second command signal to said clock generator so to set the latter onto an address under which in said wave form memory the first scanning value of the sustained note just sounded is read-out again, and that said digital to analogue converter is disabled for said second command words, too.

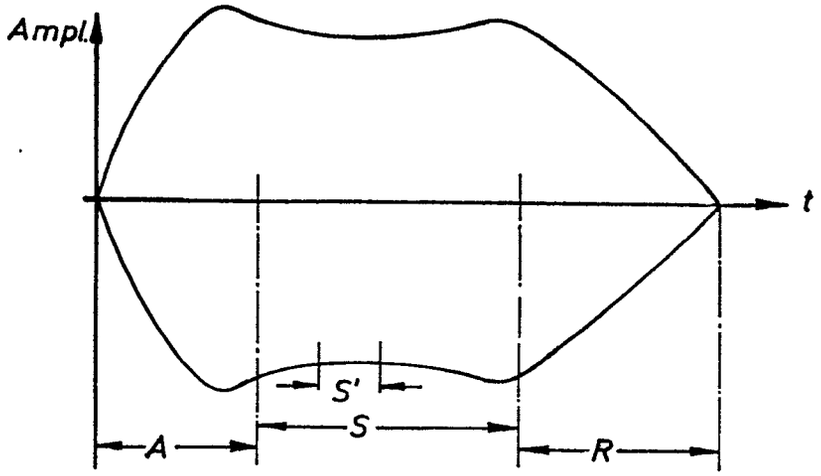



Fig. 1

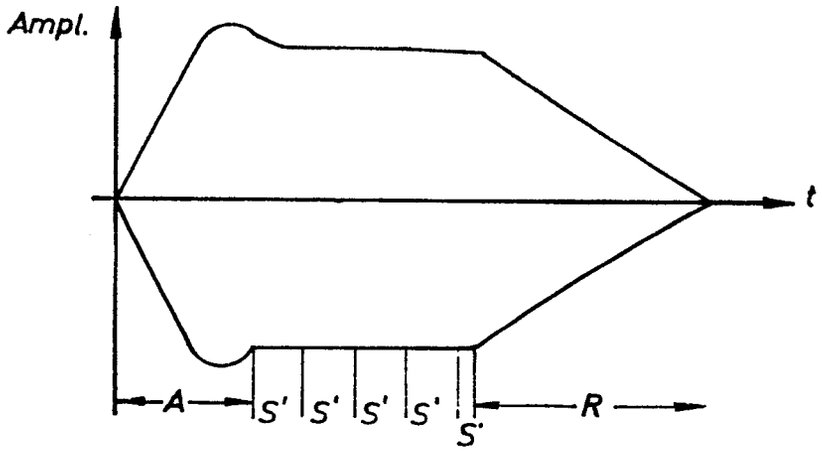



Fig. 2

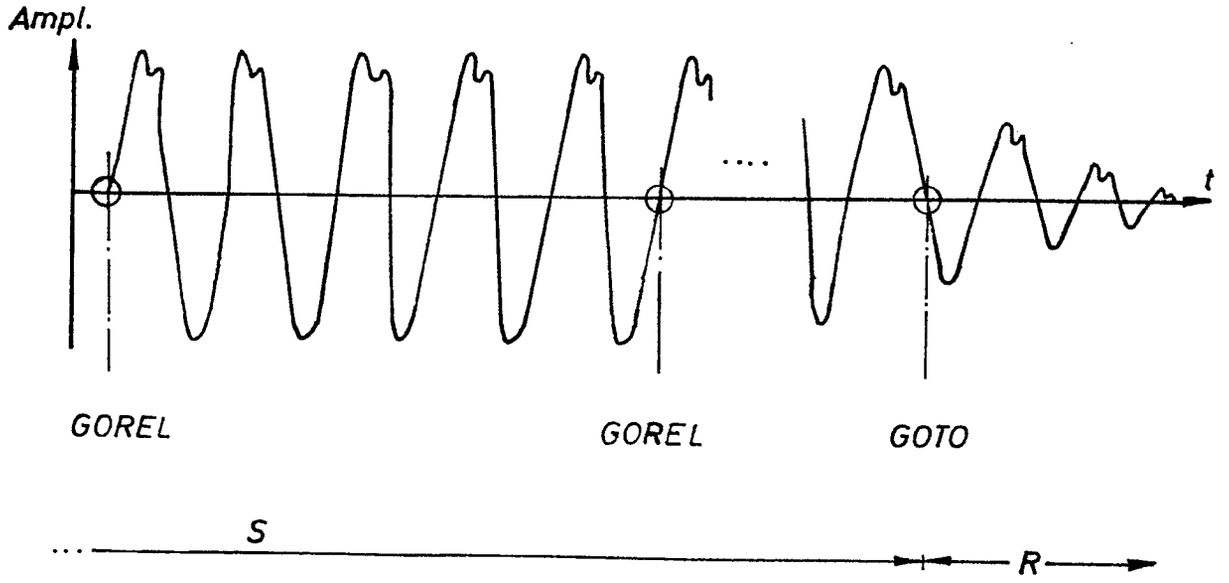



Fig.3

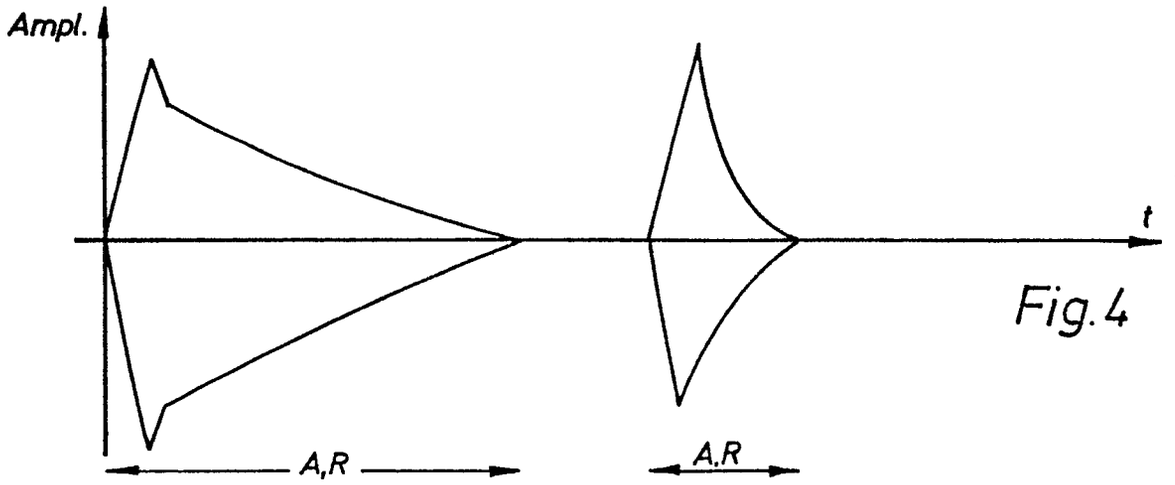



Fig.4

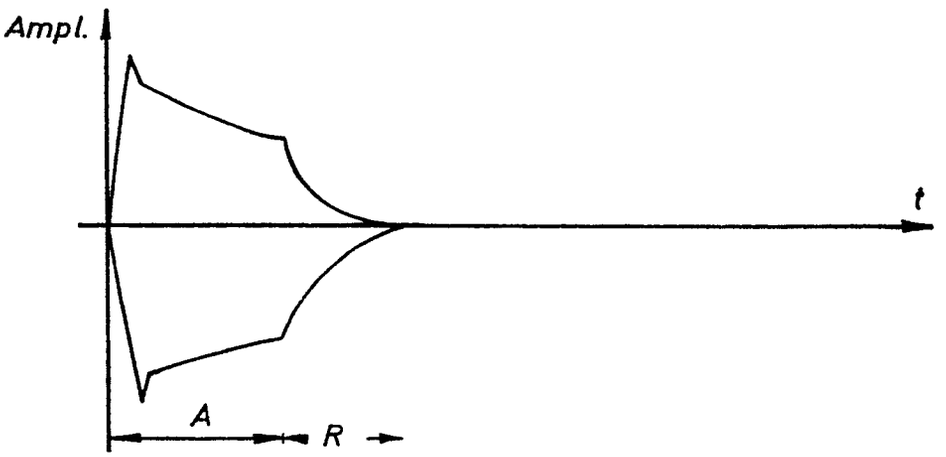



Fig.5

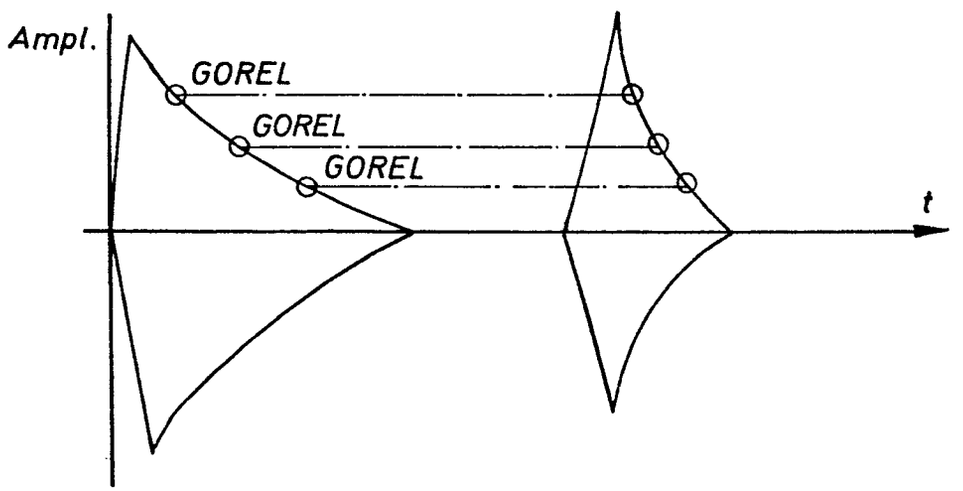



Fig.6

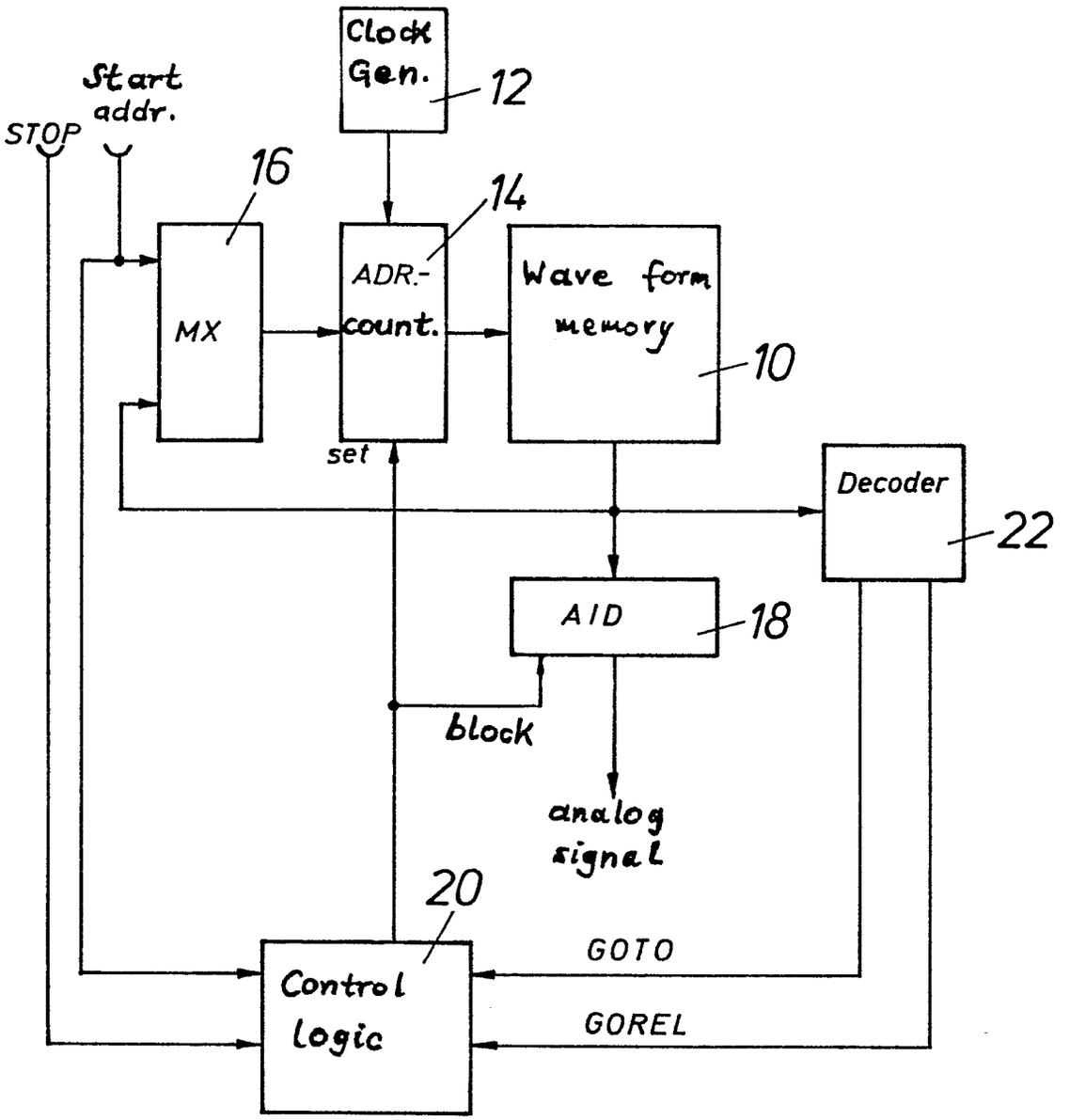

Clock Gen.
12
Start addr.
STOP
16
14
MX
ADR.-count.
Wave form memory
10
set
Decoder
22
AID
18
block
analog signal
20
GOTO
Control logic
GOREL

Fig. 7