(12) UK Patent Application (19) GB (11) 2 240 656 (13) A

(43) Date of A publication 07.08.1991

(21) Application No 9000850.9

(22) Date of filing 15.01.1990

(51) INT CL[5]
G11B 20/10 27/30

(52) UK CL (Edition K)
G5R RB347 RB35 RB476 RB784 RB788 RHX

(56) Documents cited
EP 0152142 A2

(58) Field of search
UK CL (Edition K) G5R RB35 RHD RHX RJB
INT CL[5] G11B

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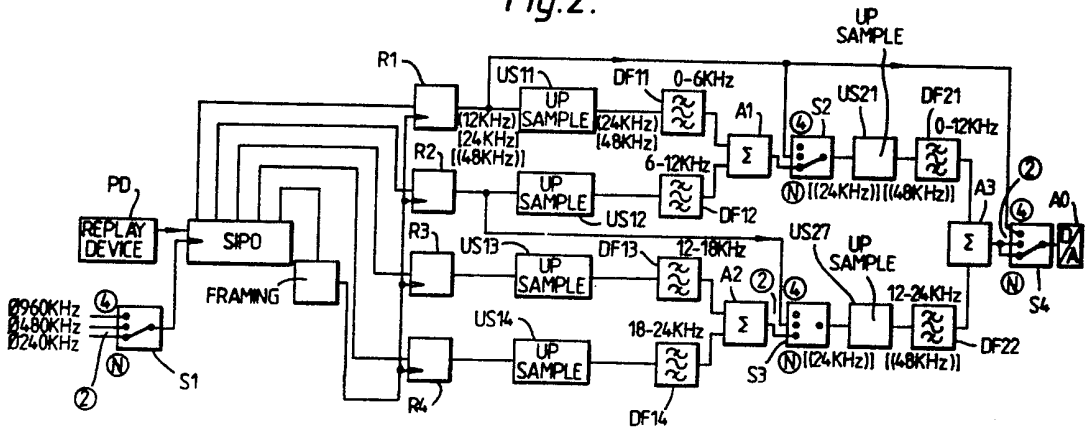
(54) Audio recording/replay

(57) Audio signals are digitally coded onto a compact disc or other digital medium using sub-band coding. During normal play signals from a replay device PD are passed through a four-band sub-band decoder having two stages of filtering recombination (DF, A). During double-speed fast forward operation the two upper sub-bands are discarded and the two lower sub-bands are routed directly from registers R1, R2 via switches S2, S3 to the second decoding stage (US21, US22, DF21, DF22, A3).

During quadruple-speed play, only the lowest sub-band is used, signals from register R1 being routed directly (via switch S4) to an output digital-to-analogue converter D/A, without being combined with other sub-bands.

Fig.2.



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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

Fig.1.

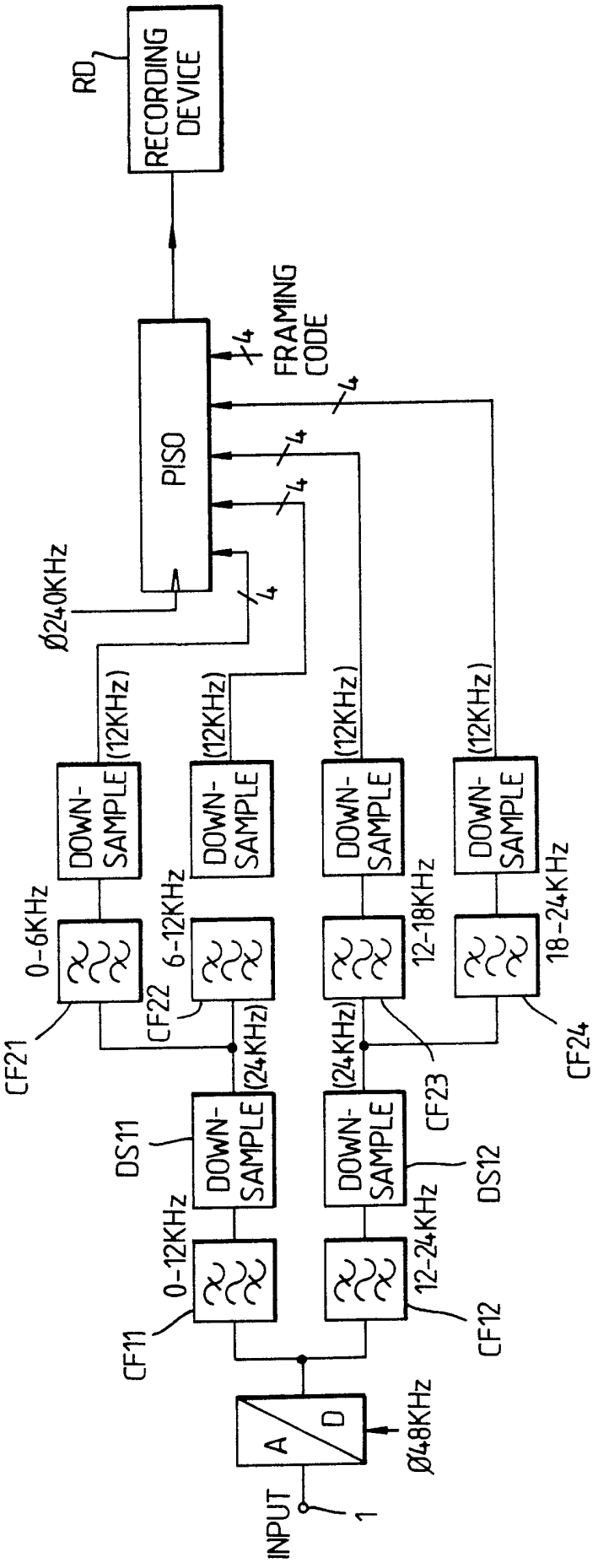
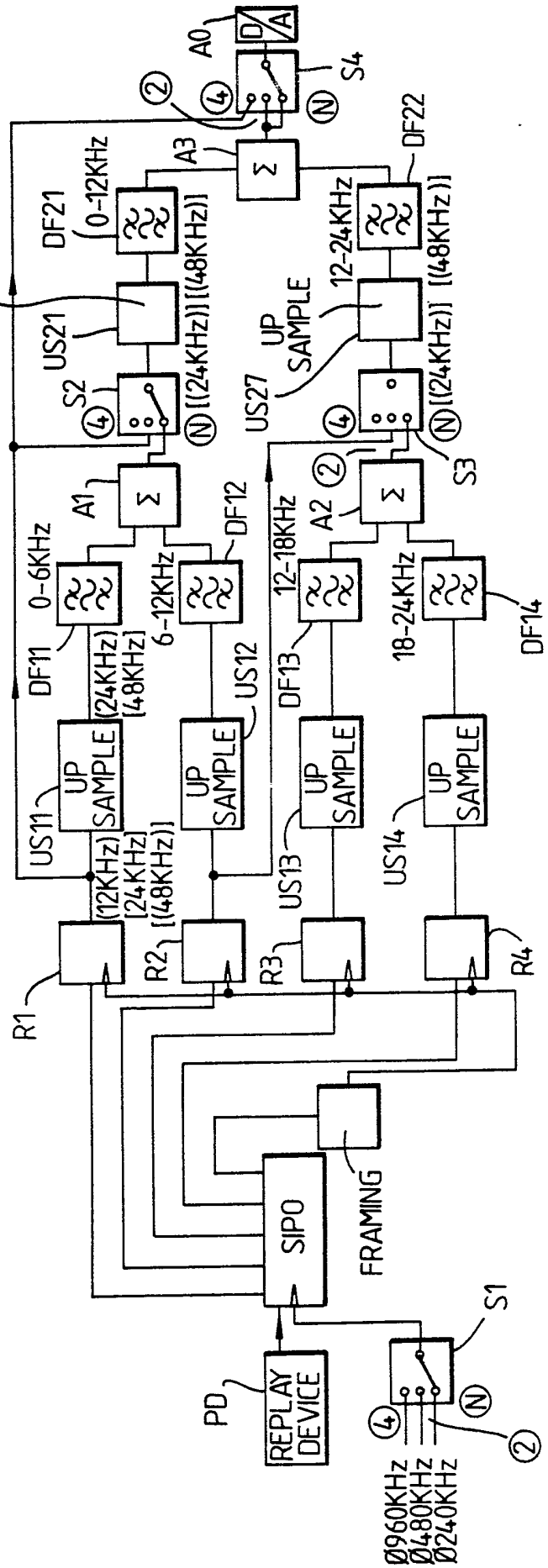

RD
RECORDING DEVICE
PISO
FRAMING CODE
4
Ø240KHz
(12KHz)
DOWN-SAMPLE
0-6KHz
6-12KHz
12-18KHz
18-24KHz
CF21
CF22
CF23
CF24
(24KHz)
DS11
DS12
0-12KHz
12-24KHz
CF11
CF12
A
D
Ø48KHz
INPUT
1

Fig.2.


Ø960KHz
Ø480KHz
Ø240KHz
PD
REPLAY DEVICE
S1
SIPO
FRAMING
R1
R2
R3
R4
(12KHz) [24KHz] [(48KHz)]
US11
US12
US13
US14
UP SAMPLE
DF11
DF12
DF13
DF14
0-6KHz
6-12KHz
12-18KHz
18-24KHz
A1
A2
A3
Σ
S2
S3
S4
US21
US27
DF21
DF22
0-12KHz
12-24KHz
[(24KHz)] [(48KHz)]
A0
D/A

AUDIO RECORDING/REPLAY

The present invention is concerned with audio recording, and is particularly concerned with replay apparatus for such recordings. Conventional digital audio recordings such as the standardised compact disc or digital audio tape formats record the audio signals in PCM format. Often it is required that the replay apparatus be provided with additional replay speeds (fast forward) for indexing purposes, and generally the digital signals obtained from the drive mechanism are, during fast operation, sub-sampled prior to processing by a digital-to-analogue converter. This sub-sampling process reduces the sampling rate of the signal to a level considerably less than required by the Nyquist criterion, and results in considerable aliasing which makes the resulting signal, in extremis, difficult to interpret.

The present invention proposes a modified format and structure of replay apparatus in order to alleviate this difficulty.

According to the present invention there is provided an audio replay apparatus, comprising means for scanning, at a first and at least one second speed exceeding the first by a factor, a recording medium having digital information recorded thereon to produce digital signals, the recorded information being in the form of a plurality of channels representing respective portions of the frequency spectrum of the recorded signal; means for providing separate digital signals corresponding to the respective channels; and
decoding means operable in a first mode corresponding to the said first speed to combine the channels into a single audio signal having a frequency range corresponding to the

said spectrum, and operable in at least one second mode to combine into a single audio signal such lesser number of channels as together represent a frequency range not exceeding the said spectrum divided by the respective speed factor.

Preferably the channels are the sub-bands of a sub-band coding scheme. However, other methods of dividing a coded signal into a plurality of discrete channels which represent respective portions of the frequency spectrum of the signal may also be used, for example transform coding.

One embodiment of the present invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a block diagram of an audio recording apparatus; and

Figure 2 is a block diagram of a replay apparatus in accordance with the present invention.

Figure 1 shows a block diagram of an audio recording apparatus. The recording apparatus is not part of the present invention, but is described here in order to clarify the recorded format, upon which the operation of the replay apparatus to be described below is contingent. An audio input signal is received at an input 1 and is converted into digital form by an analogue-to-digital converter A/D having a sampling rate of 48kHz. Each output sample is assumed to be represented by 16 bits. The digitalised signal is then supplied to the first stage of a sub-band coder, which comprises a pair of band-pass

filters CF11, CF12 which pass, respectively, the frequency bands 0-12kHz and 12-24kHz. The outputs of the two filters are, as is conventional, downsampled by downsampling units DS11, DS12, to an output sampling rate of 24kHz. These outputs are fed to respective second stages of the sub-band coder, the first having band-pass filters CF21, CF22 covering 0-6 and 6-12kHz respectively, and the second having band-pass filters CF23, CF24 with pass bands of 12-18 and 18-24kHz. The outputs of the four filters are further downsampled to a sampling rate of 12kHz and also quantized to 4 bits. The four 4-bit outputs are assembled, along with a 4-bit framing code in a parallel-in/serial-out shift register PISO. The contents of this register are clocked out with a 240kHz clock to form a 240 kbit/s bit stream forming the input to a recording device RD which may be a Digital Audio Tape (DAT) recorder, or a Compact Disc (CD) mastering unit.

Figure 2 shows a block diagram of a replay apparatus suitable for playing recordings made using the apparatus of figure 1. A replay device PD is shown, and is of conventional construction, such as a DAT player or CD player, and produces in play mode, a serial bit stream at 240 kbit/s. This is converted into parallel form by a serial-in/parallel-out register SIPO, which is clocked at 240kHz during normal play. If, however, a fast-forward mode is invoked, in which the replay device operates at twice-or four time-speed, a 480kHz or 960kHz clock is used as appropriate. Selection of the appropriate clock rate from a master clock generator (not shown) is achieved by an electronic switch, shown schematically as a three position switch S1. Other three-position switches S2, S3

and S4 are controlled in tandem with this switch S1, so that, at any time, all switches are in the same one of the three possible positions "N", "2" or "4".

A framing code recognition unit FR examines constantly the upper four bits of the register SIPO, and when the framing code is recognised, provides a framing signal to initiate loading of four registers R1, R2, R3, R4 with respective 4-bit words representing four sub-bands. The outputs of these registers (at a sampling rate of 12kHz) are upsampled to 24kHz (upsamplers US11, US12, US13, US14), and filtered by respective band-pass filters DF11, DF12, DF13, DF14 analogous to the filters CF11, 12 etc of the coder. The responses of the decoder filters must be appropriately matched to those of the coder filters, in order to avoid aliasing effects, as described in works on sub-band coding.. - See for example R.E. Crochiere, S.A. Webber and J.L. Flanagan, "Digital Coding of Speech in Sub-bands," Bell System Tech. J., pp. 1069-1085, October 1976.

The outputs of the lower two first stage sub-band filters DF11 and DF12 are added in adder A1, and similarly the upper sub-bands added in adder A2. The respective adder outputs are upsampled (US21, US22) to 48kHz and filtered by filters DF21, DF22 having pass-bands 0-12kHz and 12-24kHz, before final combination in an adder A3. the output of the adder is fed via a digital-to-analogue converter D/A to an audio output A0.

The above description assumes that the switches S1, S2, S3, S4 are all in the "N" position, for normal replay operation.

Assume now that the replay device PD is set to play at four times normal speed, with the result that the lowest sub-band, previously representing a frequency spectrum

from 0-6kHz, will now represent, in the finally reproduced audio signal, the full range of 0-24kHz. In this case, it is simply necessary to feed the output of register R1 (with a sampling rate of 48kHz) directly via the switch S4 to the output digital-to-analogue converter D/A.

In the event that twice-speed replay is selected (position "2" of the switches), the contents of registers R1 and R2 respectively represent frequency ranges 0-12kHz and 12-24kHz of the finally output signal, and are therefore routed by switches S2, S3 directly to the upsamplers US21, 22 and thence via filters DF21, 22 and adder A3 to the output digital-to-analogue converter D/A. It will be seen that, by this means, the higher-frequency components of the recorded signal, which, when replayed at the higher speeds, would result in signals outside the audible range are simply discarded.

CLAIMS

1. An audio replay apparatus comprising means for scanning, at a first and at least one second speed exceeding the first by a factor, a recording medium having digital information recorded thereon to produce digital signals, the recorded information being in the form of a plurality of channels representing respective portions of the frequency spectrum of the recorded signal; means for providing separate digital signals corresponding to the respective channels; and decoding means operable in a first mode corresponding to the said first speed to combine the channels into a single audio signal having a frequency range corresponding to the said spectrum, and operable in at least one second mode to combine into a single audio signal such lesser number of channels as together represent a frequency range not exceeding the said spectrum divided by the respective speed factor.

2. An apparatus according to claim 1 in which the channels represent sub-bands of a sub-band coded signal and the decoding means is a sub-band decoder, the or a factor is equal to the number of sub-bands, and the decoding means, in the second mode corresponding to this factor, is operable to enable a bypass path by which signals corresponding to the lowest sub-band only are routed to an output without sub-band decoding.

3. An apparatus according to claim 1 or 2 in which the channels represent sub-bands of a sub-band coded signal and the decoding means is a sub-band decoder having a first stage in which the plurality of sub-bands is

combined into a smaller plurality of sub-bands and a second stage in which the smaller plurality of sub-bands is combined into a single audio signal, and in which in a second mode, a plurality of sub-bands corresponding to the said lesser number of channels are routed directly to the second stage.

4. An audio replay apparatus substantially as herein described with reference to figure 2 of the accompanying drawings.

5. A method of replaying, at an accelerated speed, audio signals from a recording medium on which digital information is recorded to produce digital signals, the recorded information being in the form of a plurality of channels representing respective portions of the frequency spectrum of the recorded signal, comprising the step of replaying at said accelerated speed a subset comprising at least one of the said channels representing lower frequency portions of the frequency spectrum of the signal.

Published 1991 at The Patent Office, State House, 66/71 High Holborn, London WC1R 4TP. Further copies may be obtained from Sales Branch, Unit 6, Nine Mile Point, Cwmfelinfach, Cross Keys, Newport, NP1 7HZ. Printed by Multiplex techniques ltd, St Mary Cray, Kent.