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(54) **OPERATING A LED BASED LIGHTING MEANS**

(57) The invention relates to a method (100) for operating a LED based lighting means (202), wherein the method (100) comprises the steps of pulse width modulating (101), PWM, a current through the LED lighting means (202) by a driver unit (201) such that a long-time average value of the current through the LED based lighting means (202) corresponds to a value set by a feed-forward or a feedback control performed by the driver unit (201), and modulating (102), by the driver unit (201), this set long time average value by varying an on-time of the PWM modulation while maintaining a constant off-time of the PWM modulation, in case the PWM duty cycle is more than 50%, or an off-time of the PWM modulation while maintaining a constant on-time of the PWM modulation, in case the PWM duty cycle is less than 50%.

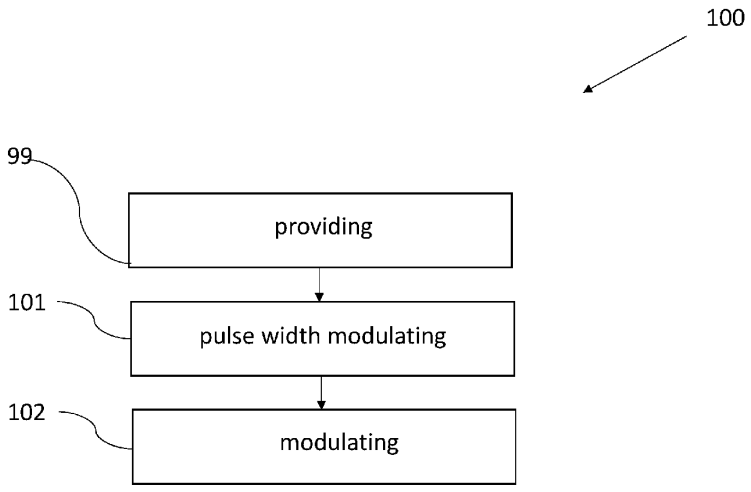

Fig. 1

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Description

TECHNICAL FIELD OF THE INVENTION

[0001] The invention relates to a method and driver unit for reducing the effect of bright and dark stripes, which occur when, for example, cameras of smartphones are used to take still pictures or videos inside an area which is illuminated by LED lighting means which are controlled using pulse-width-modulation (PWM).

BACKGROUND OF THE INVENTION

[0002] When, for example, cameras of smartphones are used to take still pictures or videos inside an area, which is illuminated by lighting means, which are controlled using PWM modulation, the disadvantageous effect may occur that the still pictures or videos taken will show bright and dark stripes both on the surfaces illuminated by the lighting means, but also when taking a photo-shot or video of the lighting means itself.

[0003] Thus, it is an objective to provide an improved method and driver unit which reduce this disadvantageous effect.

SUMMARY OF THE INVENTION

[0004] The object of the present invention is achieved by the solution provided in the enclosed independent claims. Advantageous implementations of the present invention are further defined in the dependent claims.

[0005] According to a first aspect of the invention, a method for operating a LED based lighting means is provided. The method comprises the steps of: pulse width modulating, PWM, a current through the LED lighting means by a driver unit, such that a long-time average value of a current through the LED based lighting means, as defined by the duty cycle of the PWM set by the driver unit, corresponds to a target value used by a feed-forward or a feedback control unit of the driver unit; and modulating, by the driver unit, this set long time average value by varying: an on-time of the PWM modulation while maintaining a constant off-time of the PWM modulation, in case the PWM duty cycle is more than a given threshold value, or an off-time of the PWM modulation while maintaining a constant on-time of the PWM modulation, in case the PWM duty cycle is less than a given threshold value.

[0006] The threshold value may be arranged between 25% and 75% PWM duty cycle.

[0007] This provides the advantage that bright and dark stripes on the surfaces illuminated by the lighting means are reduced.

[0008] In a preferred embodiment, the method further comprises: modulating, by the driver unit, the on-time or off-time such that a spectrum of the waveform of the current through the LED based lighting means comprises a DC component as well as an AC component having a frequency greater than 60 Hz, preferably greater than 80 Hz, more preferably greater than 100 Hz, but essentially no component in between.

[0009] In a preferred embodiment, the method comprises: using a sigma-delta modulator for the PWM modulation by the driver unit.

[0010] In a preferred embodiment, the method comprises: performing the PWM modulation such that a long-time average value of the current is constant for a human eye temporal perception.

[0011] In a preferred embodiment, the method further comprises: performing the PWM modulation such that, when a photo or video is taken in an area which is illuminated by the LED based lighting means, no black/white stripes effect occurs in such photos or videos.

[0012] In a preferred embodiment, the method further comprises the step of feeding back a signal to the driver unit representing an actual long-time average value of the current through the LED based lighting means, and performing a feedback-control by comparing, in the driver unit, this actual value with a target (nominal) value, in order to set the duty cycle of the PWM.

[0013] According to a second aspect of the invention, a driver unit for LED based lighting means is provided. The driver unit comprises: a PWM modulator designed to PWM modulate a current supplied to output terminals for supplying the LED based lighting means; a feed-forward or feedback control unit for generating a long time average value of the PWM modulated current through the LED based lighting means; a modulating unit designed to modulate this given long time average value by cyclically varying: an on-time of the PWM modulation while maintaining a constant off-time of the PWM modulation, in case the PWM duty cycle is more than a given threshold value , or an off-time of the PWM modulation while maintaining a constant on-time of the PWM modulation, in case the PWM duty cycle is less than said given threshold value. The threshold value may be arranged between 25% and 75% PWM duty cycle.

[0014] In a preferred embodiment, the driver unit is configured to: modulate the on-time or off-time such that a spectrum of the current through the LED based lighting means comprises a DC component as well as an AC component having a frequency of greater than 60 Hz, preferably greater than 80 Hz, more preferably greater than 100 Hz.

[0015] In a preferred embodiment, the driver unit is configured to: use a sigma-delta modulator for the PWM modulation.

[0016] In a preferred embodiment, the driver unit is configured to: perform the PWM modulation such that a long-time average value of the current is constant for a human eye temporal perception.

[0017] In a preferred embodiment, the driver unit is configured to: perform the PWM modulation such that, when a photo or video is taken in an area which is illuminated by the LED based lighting means, no black/white stripes effect occurs in such photos or videos.

[0018] According to a third aspect, the invention relates to the use of a PWM modulation for varying a frequency of a LED based lighting means by varying the off-time or on-time of the PWM modulation for reducing a black/white stripes effect on photos or videos taken in areas illuminated by the LED based lighting means.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] The invention will be explained in the followings together with the figures.

Fig. 1 shows an embodiment of a method for operating a LED based lighting means; and

Fig. 2 shows an embodiment of a driver unit for LED based lighting means.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0020] Now referring to Fig. 1, a method 100 for operating a LED based lighting means 202 is shown, according to an embodiment.

[0021] The method 100 comprises the step of providing 99 a nominal or target value for a long-term average value of a current through the LED lighting means 202. "Long-term average" corresponds to the low pass filtering as effected by the human eye, i.e., a low-pass filtering in the order of 50Hz.

[0022] This nominal value is either translated, e.g., by mapping or by a function implemented in the diver unit 201, into a duty cycle of a PWM modulation of the current (in case of feedforward control), or it is compared to an actually measured long-term average value of the current through the LED means 202, wherein a feedback control in the driver unit 201 translates any deviation in the comparison to a duty cycle of the PWM modulation. Thus, in a first step, in both cases, a duty cycle and a set frequency for the PWM modulation are given.

[0023] In other words, in a further step, the method 100 further comprises pulse width modulating 101, PWM, the current through the LED lighting means 202 by a driver unit 201, such that a long-time average value of the current through the LED based lighting means 202 corresponds to a value set by a feed-forward or a feedback control performed by the driver unit 201.

[0024] In a second, consecutive step, the method 100 comprises modulating 102, by the driver unit 201, this set long-time average value, as expressed by the duty cycle of the PWM, by cyclically varying, with a frequency higher than 50 or 60Hz:

- an on-time of the PWM modulation while maintaining a constant off-time of the PWM modulation, in case the PWM duty cycle is more than a given threshold value, or
- an off-time of the PWM modulation while maintaining a constant on-time of the PWM modulation, in case the PWM duty cycle is less than said given threshold value.

[0025] The threshold value may be arranged between 25% and 75% PWM duty cycle.

[0026] Thus, in this second step, both the duty cycle and the frequency of the PWM modulated current through the LED lighting means 202 are cyclically varied.

[0027] In general, the PWM control of the lighting means 202 is effected with a modulation of the PWM period. In other words, it is no longer a fixed frequency PWM, but a PWM modulation with variable frequency.

[0028] Preferably, the period is modulated by varying the on-time of the PWM while maintaining a constant off-time, provided that the PWM duty cycle is greater than a given threshold which is preferably within the range of between 25% to 75%. Otherwise, i.e. if the PWM duty cycle is lower than said given threshold, a varying off-time and a constant on-time comes is applied.

[0029] This can result in a modulation of the total period of the PWM modulation.

[0030] The modulation can be made such that in a long-time average the duty cycle of the PWM modulation is constant. Especially, the duty cycle should be constant in view of the time resolution of the human eye. Therefore, "long-time average" is meant to be within range of human eye temporal perception, while "short-time fluctuations" are those beyond the speed of human eye.

[0031] In order to avoid flickering effects visible to the human eye and caused by said PWM modulation period modulation, the resulting spectrum of the modulation should be such that there is no spectrum contribution in a non-zero frequency area, which is resolvable to the human eye. In other words, the modulation is done such that the resulting frequency spectrum has only the DC components as well as AC components higher than for example 100 Hz.

[0032] The method 100 may further comprise the step of using a sigma-delta modulator for the PWM modulation by the driver unit 201.

[0033] The method 100 may comprise the step of feeding back a signal 203 to the driver unit 201 representing an actual long time average value of the current through the LED based lighting means 202 (see also Fig. 2).

[0034] Fig. 2 shows an embodiment of a driver unit 201 for LED based lighting means 202.

[0035] The driver unit 201 for LED based lighting means 202, comprises:

- a PWM modulator 201c designed to PWM modulate a current supplied to output terminals 201a, 201b for supplying the LED based lighting means 202;
- a feed-forward or feedback control unit 201d for generating a long-time average value of the PWM modulated current through the LED based lighting means 202;
- a modulating unit 201e designed to modulate this given long-time average value by cyclically varying:

- (preferably in a first PMW duty cycle range higher than a threshold value) an on-time of the PWM modulation while maintaining a constant off-time of the PWM modulation, or
- (preferably in a first PMW duty cycle range lower than said threshold value) an off-time of the PWM modulation while maintaining a constant on-time of the PWM modulation.

[0036] The LED based lighting means 202 can be a device which comprises one or more LEDs.

[0037] In an embodiment, the driver unit 201 can be configured to provide a nominal or target value for the long-term average value of the current through the LED lighting means 202.

[0038] The driver unit 201 can be configured to translate this nominal value, e.g., by mapping or by a function implemented in the diver unit 201, into a duty cycle of a PWM modulation of the current (in case of feedforward control). Alternatively or additionally, the driver unit 201 can be configured to compare the nominal value to an actually measured long-term average value of the current through the LED lighting means 202. The driver unit 201 can further comprise a feedback control unit configured to translate any deviation in this comparison to a duty cycle of the PWM modulation. Thus, in both cases, a duty cycle and a set frequency for the PWM modulation are given.

[0039] For example, the driver unit 201, in particular the modulating unit 201e, can be configured to modulate the on-time or off-time such that a spectrum of the current through the LED based lighting means 202 comprises both a DC and an AC component. The AC component can have a frequency of greater than 60 Hz, preferably greater than 80 Hz, more preferably greater than 100 Hz. In this way, flickering effects visible to the human eye can be avoided, as explained above.

[0040] The PWM modulator 201c of the driver unit 201 can be a sigma-delta modulator.

[0041] Preferably, as a consequence of the driver unit 201 performing the PWM modulation, black/white stripes or similar effects can be avoided in photos or videos which are captured in an area which is illuminated by the LED based lighting means 202. The photos or videos can be captured by a camera of a smartphone. The LED based lighting means 202 can be installed in the area, e.g. to provide an ambient illumination of the area.

Claims

1. A method (100) for operating a LED based lighting means (202), wherein the method (100) comprises the steps of:

   - pulse width modulating (101), PWM, a current through the LED based lighting means (202) by a driver unit (201),

   such that a long-time average value of the current through the LED based lighting means (202) corresponds to a value set by a feed-forward or a feedback control performed by the driver unit (201); and

   - modulating (102), by the driver unit (201), this set long time average value by varying:
   - preferably in a first PMW duty cycle range higher than a threshold value, an on-time of the PWM modulation while maintaining a constant off-time of the PWM modulation, or
   - preferably in a first PMW duty cycle range lower than a threshold value, an off-time of the PWM modulation while maintaining a constant on-time of the PWM modulation.

2. The method of claim 1,
wherein said threshold value is within a range of 25% and 75% of the PW; duty cycle.

3. The method (100) of any of the preceding claims, wherein the method (100) further comprises:

   - modulating, by the driver unit (201), the on-time or off-time such that a spectrum of the current through the LED based lighting means comprises a DC component as well as an AC component having a frequency greater than 60 Hz, preferably greater than 80 Hz, more preferably greater than 100 Hz.

4. The method (100) of any one of the preceding claims, wherein the method (100) comprises:

   - using a sigma-delta modulator for the PWM modulation by the driver unit (201).

5. The method (100) of any one of the preceding claims, wherein the method (100) comprises:

   - performing the PWM modulation such that a long-time average value of the current is constant for a human eye temporal perception.

6. The method (100) of any one of the preceding claims, wherein the method (100) further comprises:

   - performing the PWM modulation such that, when a photo or video is taken in an area which is illuminated by the LED based lighting means, no black/white stripes effect occurs in such photos or videos.

7. The method (100) according to any of the preceding claims, comprising the step of feeding back a signal (203) to the driver unit (201) representing an actual long time average value of the current through the LED based lighting means (202) .

8. A driver unit (201) for LED based lighting means (202), comprising:

- a PWM modulator (201c) designed to PWM modulate a current supplied to output terminals (201a, 201b) for supplying the LED based lighting means (202);
- a feed-forward or feedback control unit (201d) for generating a long-time average value of the PWM modulated current through the LED based lighting means (202);
- a modulating unit (201e) designed to modulate this given long time average value by cyclically varying:
- preferably in a first PMW duty cycle range higher than a threshold value, an on-time of the PWM modulation while maintaining a constant off-time of the PWM modulation, or
- preferably in a first PMW duty cycle range lower than a threshold value, an off-time of the PWM modulation while maintaining a constant on-time of the PWM modulation.

9. The driver unit (201) of claim 8, wherein the driver unit (201) is configured to:

- modulate the on-time or off-time such that a spectrum of the current through the LED based lighting means (202) comprises a DC component as well as an AC component having a frequency of greater than 60 Hz, preferably greater than 80 Hz, more preferably greater than 100 Hz.

10. The driver unit (201) of claim 8 or 9, wherein the driver unit (201) is configured to:

- use a sigma-delta modulator for the PWM modulation.

11. The driver unit (201) of any of claims 8 to 10, wherein the driver unit (201) is configured to:

- perform the PWM modulation such that a long-time average value of the current is constant for a human eye temporal perception.

12. The driver unit (201) of any one of the preceding claims 8 to 11, wherein the driver unit (201) is configured to:

- perform the PWM modulation such that, when a photo or video is taken in an area which is illuminated by the LED based lighting means, no black/white stripes effect occurs in such photos or videos.

13. Use of a PWM modulation for varying a frequency of a LED based lighting means (202) by varying the off-time or on-time of the PWM modulation for reducing a black/white stripes effect on photos or videos taken in areas illuminated by the LED based lighting means (202).

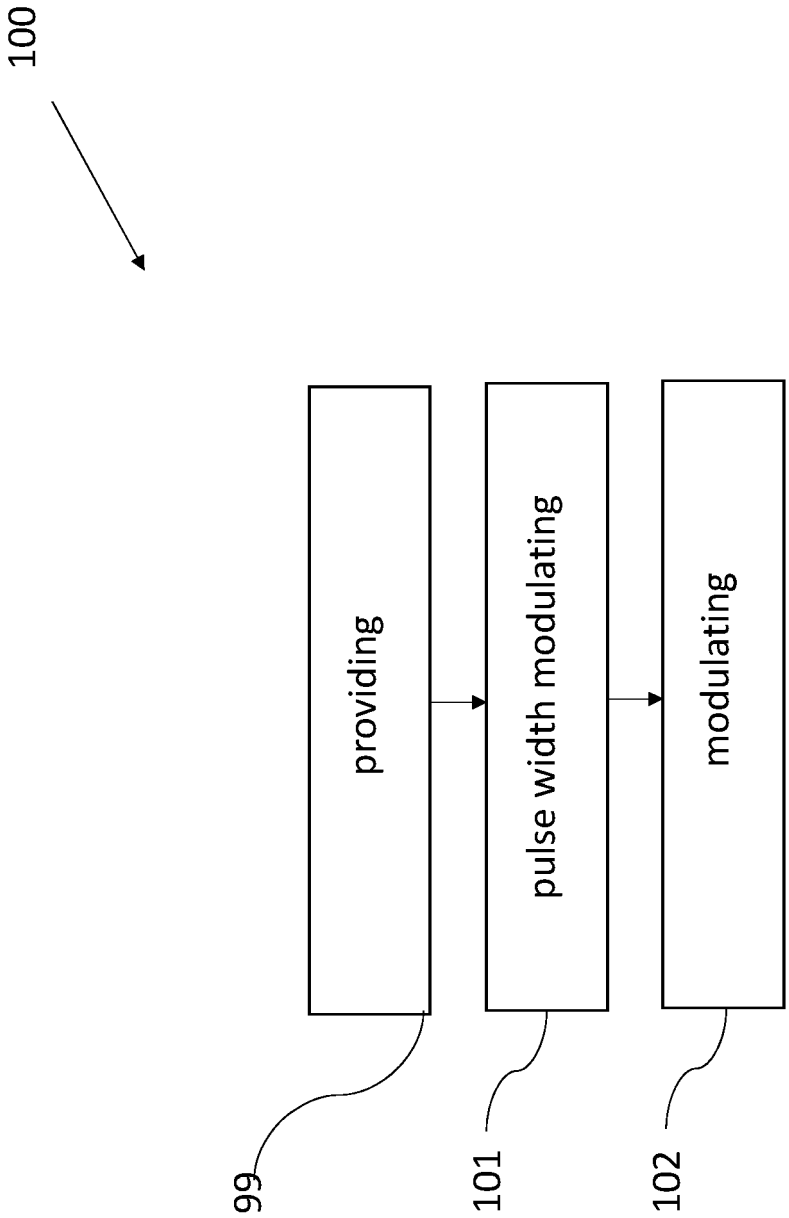
100
providing
pulse width modulating
modulating
99
101
102

Fig. 1

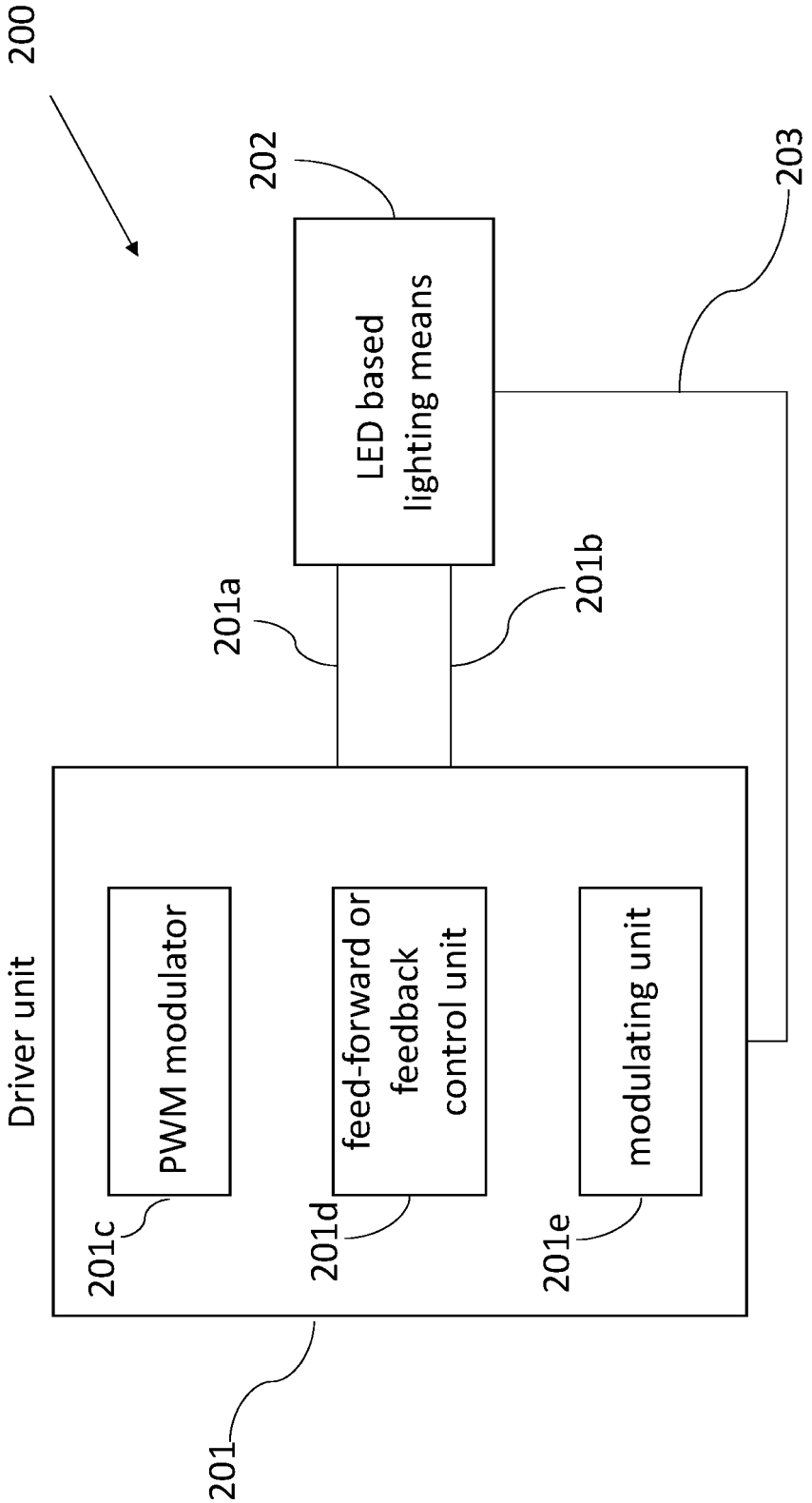
200
202
203
LED based lighting means
201a
201b
Driver unit
PWM modulator
feed-forward or feedback control unit
modulating unit
201c
201d
201e
201

Fig. 2

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EUROPEAN SEARCH REPORT

Application Number
EP 22 18 8455

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2018/084616 A1 (KOBER STEVEN J [US]) 22 March 2018 (2018-03-22) * paragraphs [0004], [0005], [0023] - [0031], [0061] - [0076]; figures 1, 2, 12, 13 *	1-13	INV. H05B45/335 ADD. H05B45/325

TECHNICAL FIELDS SEARCHED (IPC)

H05B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	13 January 2023	Waters, Duncan

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 22 18 8455

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13-01-2023

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