Fig. 1 shows an inventive device 1 for determining the concentration of a predetermined gas in a sample 2. Device 1 comprises a light source 3 with a tunable diode laser 4 (see Fig. 2). The diode laser 4 comprises a DFB (distributed feedback) laser diode (not shown) for emitting substantially monochromatic light into the sample 2. The diode laser 4 is adapted to emit laser light of a wavelength between 1810 and 1850 nm, i.e. tunable between 1810 and 1850 nm.

Device 1 also includes a measuring unit 5 with a light sensor 6 to measure the intensity of the light emitted from sample 2. The device 1 also comprises a control unit 7 for controlling the pumping current of the laser diode of the diode laser 4. Finally, the device also comprises an evaluation unit 8. The control unit 7 is designed to vary the pumping current of the laser diode of the diode laser 4 over time, in particular to modulate it periodically. Specifically, it is designed to provide a substantially constant and non-zero base current 10 as the pump current of the laser diode of the diode laser 4 during a first time period 9 (cf. Fig. 4). In this example, this base current 10 corresponds to the laser threshold value of the diode laser 4. The control unit 7 is also set up, during a second time period 11, to specify a continuously increasing current ramp 12 starting from the base current 10 as the pump current of the laser diode of the diode laser 4. Furthermore, the control unit is set up to set a pump current I decreasing in three steps towards the base current 10 during a third time period 29. The evaluation unit 8 is connected to the light sensor 6 and to the control unit 7. It is also designed to calculate the concentration of the gas as a function of the pump current specified by control unit 7 and the intensity of the light transmitted through sample 2 measured by light sensor 6.

Sample 2 in Fig. 1 is a liquid empty head space of a sample container 13 in the form of a closed PET bottle containing a beverage 14 (mainly water). The relative humidity in the headspace is essentially 100 %, i.e. water vapour is present. The sample container 13 is essentially transparent to light in the infrared range. It is accommodated in an essentially U-shaped insert holder 15 and is supported by the insert holder 15 on a closure collar 16 of the sample container 13. An upper part 17 of device 1 is connected to a base 19 by two support elements 18 in the form of rods. A temperature measuring device 20 in the form of an infrared temperature measuring instrument is arranged on one of the support elements 18 below the upper part 17. The temperature measuring device 20 is set up to measure the temperature on an outer wall of the sample container 13. During operation of device 1, in addition to the absorption spectrum, the temperature on the outer wall of the sample container 13 is measured with the temperature measuring device 20 and taken into account when calculating the concentration of the gas. A display 21 is provided on the base 19 to indicate the determined concentration or the determined partial pressure.

Fig. 2 shows the optical system of the device 1 together with a simplified beam path 22 and the functional units 3, 5, 7, 8 of the device 1, which are only schematically drawn, as well as their connections to each other. The optical system of device 1 comprises two diffusion elements 23, 24. The diffusion elements 23, 24 are each designed for transmission and scattering of the light emitted by the laser diode of the diode laser 4. A first diffusion element 23 scatters the light before entering the sample 2. A second diffusion element 24 scatters the light after leaving the sample 2.

In addition, a collecting lens 25, 26 is provided in light source 3 and measuring unit 5. A first collecting lens 25 in the light source 3 is set up to focus the light emitted by the laser diode of the diode laser 4 before scattering at the first diffusion element 23. A second collecting lens 26 in measuring unit 5 is arranged to focus the light emitted from sample 2 before scattering at the second diffusion element 24. Thus during operation the light emitted by the diode laser 4 is focused before it is scattered in one of the diffusion elements 23, 24.

Using the device according to Fig. 1 and 2, the concentration of a predetermined gas, e.g. nitrogen, in sample 2 can be determined by the present method. The wavelength (actually the central wavelength of the emission spectrum) of the essentially monochromatic light emitted by the diode laser 4 into the sample 2 is varied in time and modulated by changing the pump current I of the laser diode of the diode laser 4 (see Fig. 4). The intensity of the light emitted from sample 2 is then measured with measurement unit 5 and the concentration of the gas in the sample is calculated as a function of the temporal course of the pump current I and the temporal course of the measured intensity in evaluation unit 8. In particular, the line widening in the absorption spectrum determined from the intensity distribution as a function of the pump current is determined and the partial pressure of water vapour in the sample is deduced from this line widening. The relationship between this partial pressure and the partial pressure of the gas sought (e.g. nitrogen) can be determined in advance by calibration and then used for measurement. Calibration can, for example, be carried out using one or more reference samples with a known nitrogen concentration.

Fig. 4 schematically shows the temporal course of a period 28 of the pump current I of the laser diode of the diode laser 4 of device 1 according to Fig. 1. The duration of a period 28 in this example is 100 ms. During operation, period 28 is repeated in a loop so that a pulse frequency of the pump current results corresponding to the inverse period duration, i.e. for example a pulse frequency of 10 Hz. To explain the temporal course of the pump current I, period 28 is divided into a first temporal section 9, a second temporal section 11 and a third temporal section 29. The duration of each time period is not proportional.

As can be seen from Fig. 4, the pump current I in the first time period 9 corresponds to an essentially constant and non-zero base current 10. The base current 10 corresponds approximately to the laser threshold value of the laser diode of the diode laser 4. Thus, the laser diode is constantly controlled in laser operation and at the same time the temperature development in this operating mode is as low as possible. In this example, the base current is 5 mA. The duration of the first time section 9 in this example is about 84.9 ms.

In the second time section 11, which immediately follows the first time section 9, the pump current I is changed or increased by the control unit 7 according to a continuously increasing current ramp 12 starting from the base current 10 up to a limit current 30. The duration of the second time section 11 in this example is exactly 15 ms. In this example, the limit current is about 100 mA.

After the second time period 11, the third time period 29 immediately follows, in which the pump current I is changed or shut down in three stages 31 towards the base current 10. The duration of the individual stages is a maximum of 35 µs (microseconds), so that the total duration of the third time section 29 is a maximum of about 100 µs (i.e. about 0.1 ms).

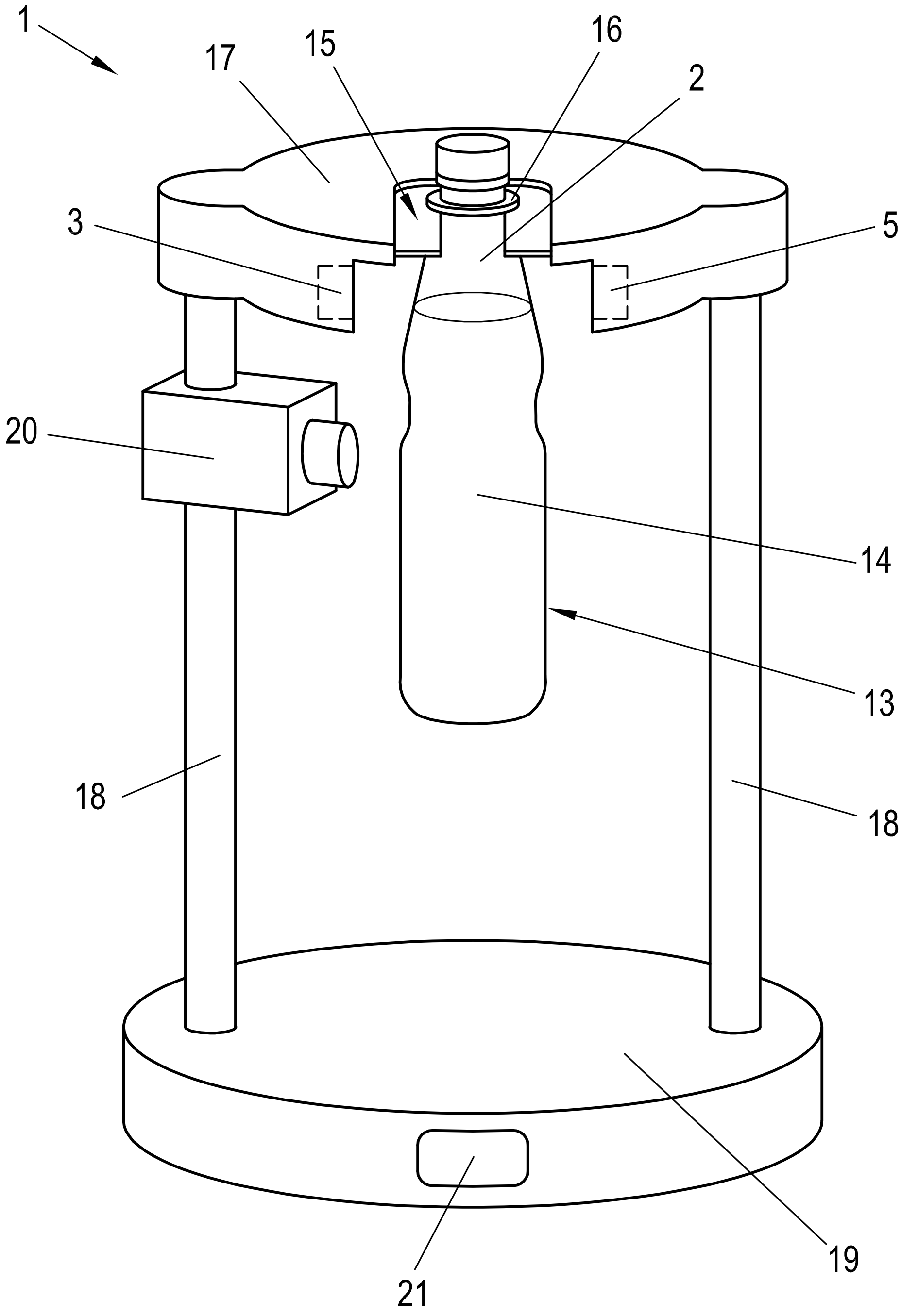

Fig. 1

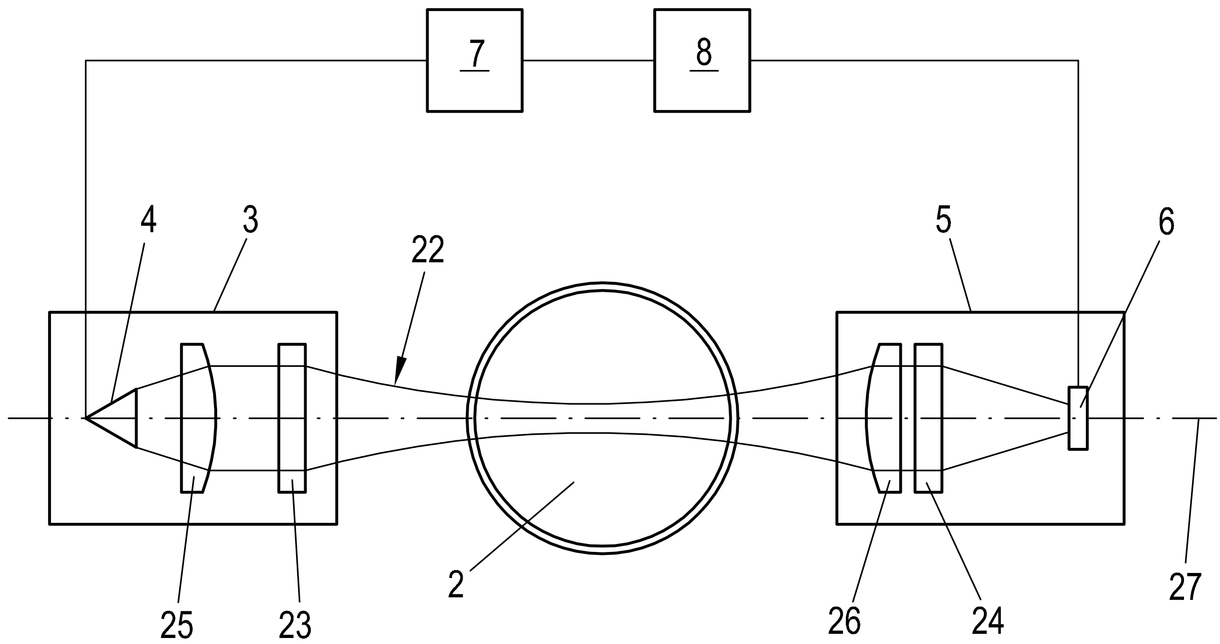

Fig. 2

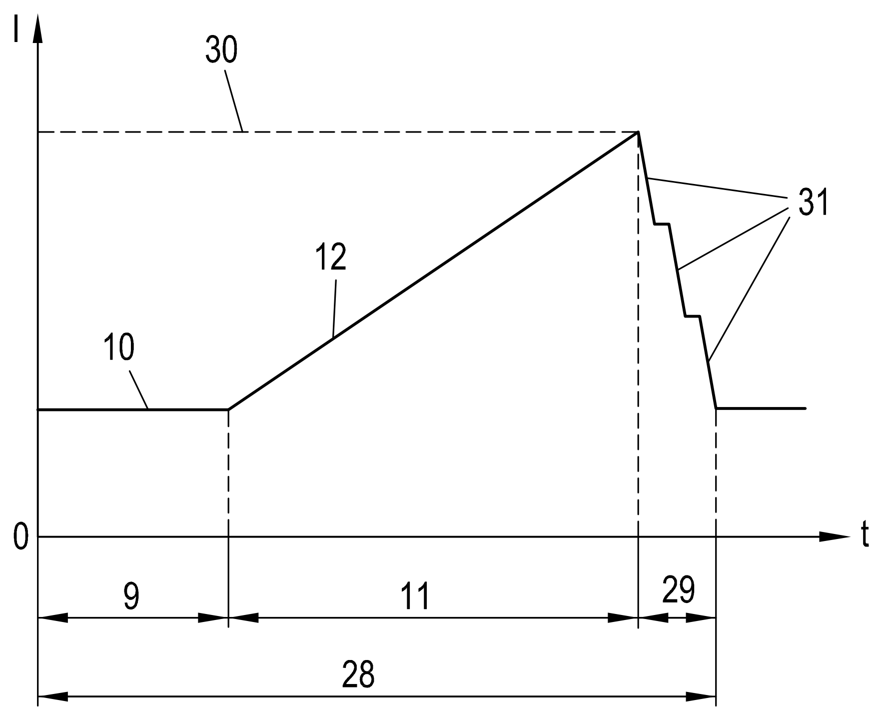

Fig. 4