# (12) UK Patent Application (19) GB (11) 2 184 245 (13) A

(43) Application published **17 Jun 1987**

(21) Application No **8629760**

(22) Date of filing **12 Dec 1986**

(30) Priority data

(31) **3543973** (32) **12 Dec 1985** (33) **DE**

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(51) INT CL[4]
**G01N 33/497**

(52) Domestic classification (Edition I)
**G1N** 1A3B 1D13 1F 3S1B 4C 7B1 7K AAG
**U1S** 1515 2159 G1N

(56) Documents cited
**None**

(58) Field of search
**G1N**
**G1A**
**Selected US specifications from IPC sub-class G01N**

(54) **Breath alcohol measuring appliance**

(57) In a breath alcohol measuring appliance which detects the alcohol concentration by means of an alcohol sensor (3) and is provided, preferably in a shunt passage (31) branching from the respiration passage (5), with a hot temperature-dependent resistor (33) acting as a flow sensor the output signal of which is integrated by components (57,59) for ascertaining that a minimum respiratory air volume has been exhaled, the integrator is controlled by a resetting circuit (71) and switch (75) responding to the direction of flow in the respiration passage, which circuit liberates the integrator for the integration when respiratory air is flowing in the exhalation direction and resets it, and keeps it reset for the duration of the inhalation action, when respiratory air is flowing in the inhalation direction. The resetting circuit (71) comprises a differentiating circuit (81) and an amplifier (83) which closes the switch (75) to discharge integrating capacitor (59) when resistor (33) is no longer cooled by exhaled air. The resistor is screened against inhaled air by a non-return valve (35).

FIG. 1

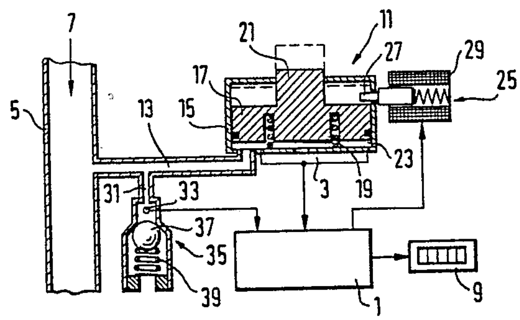


FIG. 2

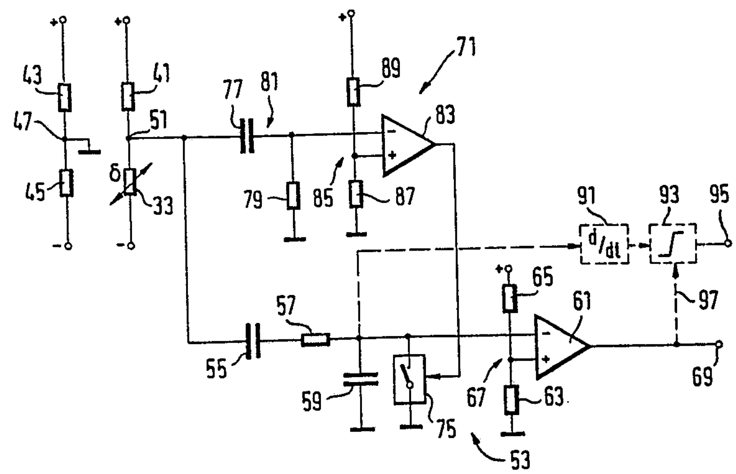


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FIG. 1

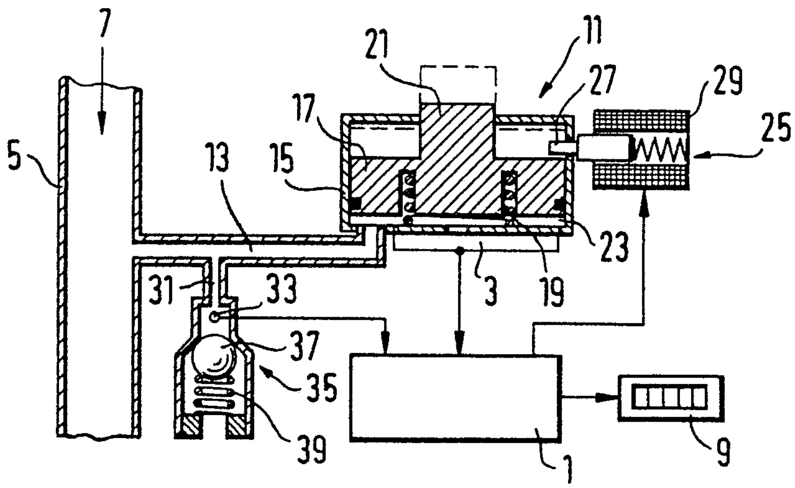



FIG. 2

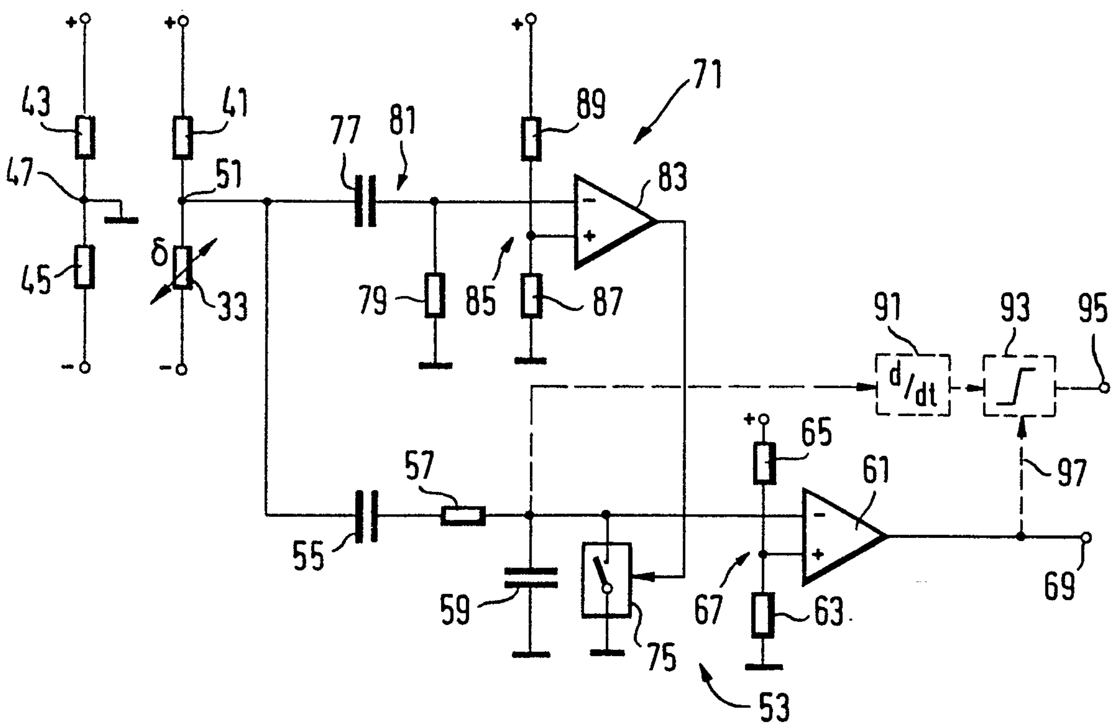
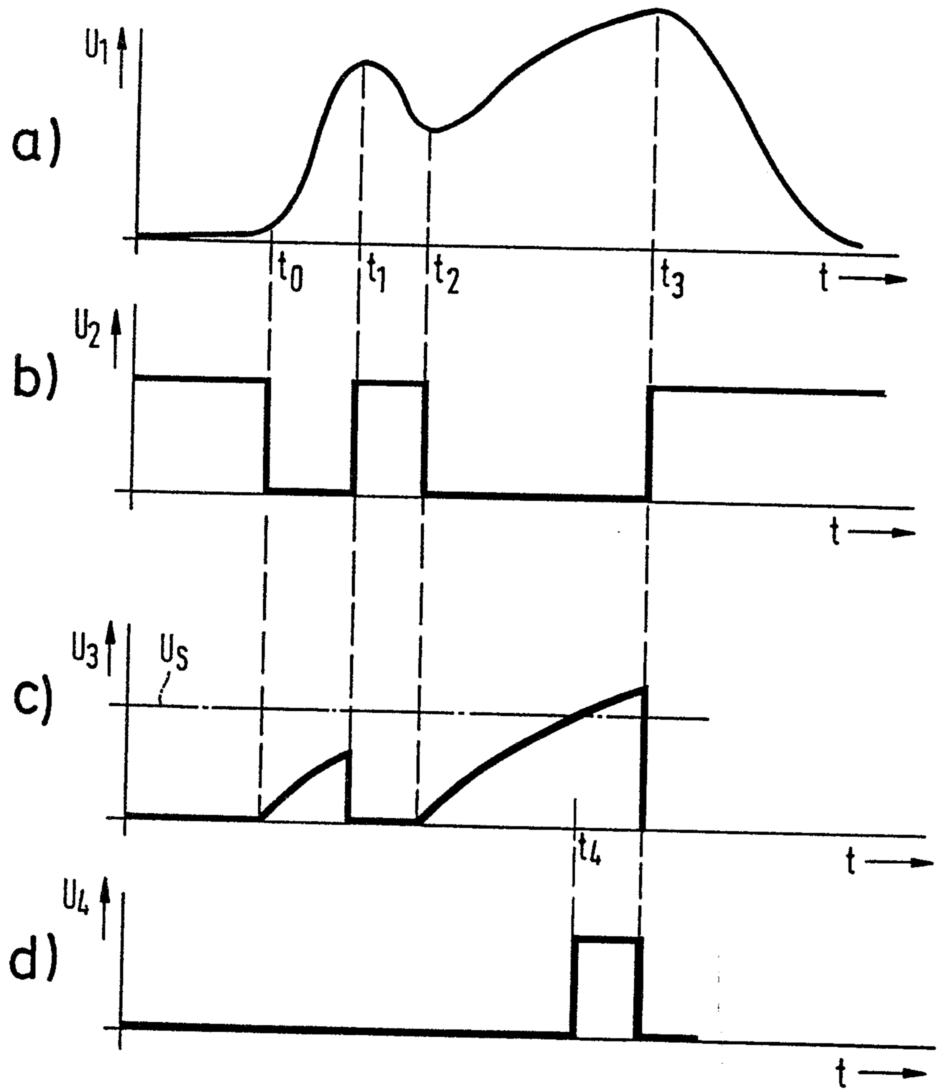


FIG. 3



SPECIFICATION

**Breath alcohol measuring appliance**

The invention relates to a breath alcohol measuring appliance having a measuring arrangement which detects the alcohol concentration of the respiratory air exhaled through a respiration passage by means of an alcohol sensor, having a flow sensor including at least one temperature-dependent resistor exposed to the respiratory air current, which flow sensor delivers at least one throughput signal representing the respiratory air throughput through the respiration passage, having an integrator arrangement which time-dependently integrates the throughput signal for the ascertaining of the respiratory air volume breathed out by way of the respiration passage and liberating the measuring arrangement for the measurement of the alcohol concentration on or after the reaching of a pre-determined minimum breath volume, and having a control arrangement connected to the flow sensor and detecting the direction of flow of the respiratory air in the respiration passage, which blocks the measurement of the alcohol concentration if inhalation is effected before the liberation of the measurement by the integrator arrangement.

A breath alcohol measuring appliance of the above kind is known from German Patent No. 2,428,352. In this measuring appliance monitoring is effected as to whether within a pre-determined time interval exhalation is effected at least with a minimum respiratory air throughput, in order to ensure that the measurement of the alcohol concentration is carried out on alveolar air. If during the minimum time period the minimum respiratory air throughput is understepped, the measurement of the alcohol concentration does not take place, or its invalidity is indicated. For the measurement of the minimum throughput a temperature-dependent resistor is provided in the respiration passage, which is arranged in the feedback branch of a sum-and-difference amplifier and determines the amplification thereof in dependence upon the respiratory air cooling. The sum-and-difference amplifier delivers a signal representing the respiratory air throughput to a threshold value stage which in turn, in the case of falling short of the minimum throughput fixed for the exhaling of alveolar air, generates a fault signal indicating the invalidity of the alcohol measurement.

To the sum-and-difference amplifier there is further connected an integrator which in inhaling integrates the respiratory air throughput for the ascertaining of the entire inhaled respiratory air volume. The value of the entire inhaled respiratory air volume is stored and in exhaling is compared with the exhaled air volume, likewise ascertained by the integrator. A comparator ascertains when the minimum respiratory air volume which renders possible the alcohol measurement on alveolar air has been exhaled.

In the respiration passage of the known measuring appliance there is arranged a second temperature-dependent resistor which is screened off in the exhalation direction by a restrictor. Thus the second temperature-dependent resistor is cooled by different amounts in inhaling and exhaling. The resultant different resistances are detected by means of a threshold value stage which generates a fault signal representing the direction of flow in inhaling. In order to preclude faulty measurements by reason of breath manipulations the alcohol measurement is rejected as invalid if within the ascertaining of the minimum respiratory air volume which ensures measurement on alveolar air the fault signal representing the inhaling direction was generated.

The known measuring appliance already delivers an invalid alcohol measurement if during the determination of the minimum respiratory air volume inhaling occurs, even if only briefly, or breathing is halted only briefly. Since the measurement of the alcohol concentration, including in police use, is to take place even with unwilling or nervously excited persons, operating errors can occur which lead to an invalid measurement.

From German Patent No. 2,522,932 a further breath alcohol measuring appliance is known in which the temperature-dependent resistor arranged in the respiration passage for the ascertaining of the direction of flow of the respiratory air is connected between a voltage source and a differentiating member. The differentiation member responds to the speed of variation of the current flowing through the temperature-dependent resistor, which in turn is a measure for the direction of flow of the respiratory air.

It is the problem of the invention to improve a measuring appliance of the initially explained kind so that valid alcohol concentration measurements can be carried out on alveolar air even in the case of respiration faults.

On the basis of the breath alcohol measuring appliance as initially explained, this problem is solved in accordance with the invention in that the control arrangement resets the integrator arrangement on detecting air flowing in the inhalation direction and blocks it for the duration of the inhalation condition for the integration of the throughput signal. Delaying or briefly ceasing exhalation thus does not lead to invalidity of the measurement, since the minimum breath volume is ascertained by time integration of the respiratory air throughput and the time period until the reaching of the minimum breath volume is not limited. Even if inhaling is effected briefly, this does not necessarily lead to invalidity of the alcohol concentration measurement. The volume value ascertained by the integrator arrangement is set to zero and in the same breath integration is begun anew in the subsequent inhalation. The alcohol concentration measurement takes place in every case only after uninterrupted exhaling of the predetermined minimum breath volume. The integrator arrangement and/or the control arrangement for detecting the direction of flow, also further components of the measuring appliance, can also be realised by a microprocessor.

In the known breath alcohol measuring appliance several temperature-dependent resistors are arranged in the respiration passage containing the alcohol sensor. In a preferred form of embodiment of the invention it is provided that the flow sensor comprises one single temperature-dependent resistor which is arranged in a shunt passage branching off from the respiration passage and leading separately to atmosphere and that the shunt passage contains, on the side placed to atmosphere in the direction of flow, a screening device which screens the temperature-dependent resistor in the inhalation direction. In this way it is possible to reduce the current consumption of the measuring appliances, which are usually transportable and fed mains-independently from batteries. Not only is the number reduced of the temperature-dependent resistors, which are formed for example as hot conductors and heated in the rest condition to a temperature of at least 70° C., preferably about 100° C., but it is also possible to set the speed of flow in the shunt passage to suitable measurement values, independently of the flow cross-section of the respiration passage.

The screening device can be a restrictor placed to atmosphere in the exhalation direction. Such a restrictor permits a flow cooling of the temperature-dependent resistor for the measurement of the throughput, but prevents flow cooling in the inhalation direction and thus permits the detection of the direction of flow. In a preferred form of embodiment however the screening device is a non-return valve blocking in the inhalation direction. The non-return valve mechanically blocks the flow of respiratory air in the inhalation direction through the shunt passage, whereby a relatively simple recognition of direction of flow is rendered possible, preferably by means of a differentiating arrangement.

The integrator arrangement can liberate the measuring arrangement for alcohol measurement directly on reaching of the minimum breath volume. Since however the measurement accuracy of the measuring arrangement is the greater, the greater is the proportion of alveolar air in the respiratory air, in a preferred form of embodiment it is provided that a delay arrangement delays the liberation of the measuring arrangement beyond the reaching of the minimum respiratory air volume. The delay arrangement responds to the throughput signal or a signal derived from it and liberates the measuring arrangement for the measurement of the alcohol concentration before the end of the breath is reached or before the next-succeeding inhaling action. Due to the delay of the liberation it is possible to increase the accuracy of the alcohol measurement without detriment to the security against manipulation. The delay arrangement expediently responds to the speed of variation of the integrated throughput signal and liberates the measuring arrangement for the measurement of the alcohol concentration when the speed of variation drops below a pre-determined threshold value which indicates the end of the breath. In order to preclude faults the delay arrangement is liberated for its operation, through the integrator arrangement, only when the minimum respiratory air volume is reached.

The alcohol sensor is expediently a fuel cell responding specifically to alcohol vapour in the air of the breath and delivering an output signal proportional to the alcohol concentration. Since fuel cells inherently possess a certain response time and a certain recovery time, they are expediently not lastingly exposed to the current of respiratory air. In a preferred form of embodiment of the measuring appliance the measuring arrangement includes a piston suction pump the suction chamber of which is connected with the respiration passage through a connecting passage which branches off from the respiration passage and the piston of which, which limits the suction chamber, is movable manually against the force of a return spring into its minimum suction chamber volume position and by the return spring into its maximum suction chamber volume position. The piston is arrestable in the minimum position by means of an electro-magnetically unlockable locking device which is controlled by the integration arrangement. The locking device is unlocked when the minimum breath volume is reached, whereby the piston suction pump sucks a breath air sample from the respiration passage. The alcohol concentration measurement takes place by reference to this breath air sample. Although the above piston suction pump is preferred, other forms of embodiment are also usable within the scope of the invention. By way of example the pump can be equipped with a drive magnet to stress the return spring,or the piston can be movable to and fro between the minimum position and the maximum position by means of a drive device which can be set in action in two drive directions, for example a two-way magnet.

An example of embodiment of the invention is to be explained in greater detail below by reference to drawings, wherein: -

*Figure 1* shows a diagrammatic representation of the breath alcohol measuring appliance;

*Figure 2* shows a circuit diagram of a control circuit of the measuring appliance which determines the time moment of measurement and

*Figures 3a - d* show time diagrams of signals occurring in the circuit according to Figure 2.

In Figure 1 a control and measuring circuit of a breath alcohol measuring appliance is designated by 1 which, by means of an alcohol sensor 3, measures the alcohol concentration of the breathed air exhaled through a respiration passage 5 in the direction of the arrow 7 and, calibrated in values of blood alcohol concentration, displays it in a measured value indicator device 9. The alcohol sensor 3 which expediently is a fuel cell responding specifically to alcohol vapour, measures the alcohol concentration in a breath air sample sucked in by a piston suction pump 11 through a connection passage 13 branching off from the respiration passage 5. The measurement moment when the piston suction pump 11 takes the breath air sample is fixed by the control and measurement circuit 1.

The piston suction pump 11 has a housing 15 in which a piston 17 is displaceable against the force of a return spring 19 by means of a press knob 21 in the direction of the reduction of the volume of a suction chamber 23 limited by the housing 15 and the piston 17. By means of an electro-magnetically unlockable locking device, represented diagrammatically at 25, the piston 17 can be arrested in its position determining the minimum volume of the suction chamber 23 by means of a bolt 27 initially stressed resiliently into the locking position. The locking device 25 is unlocked by energisation of an electro-magnet 29 controlled by the control and measuring circuit 1, whereby the return spring 19 moves the piston into the position determining the maximum volume of the suction chamber 23 and the breath air sample is sucked out of the respiration passage 5.

Furthermore a shunt passage 31 opening to atmosphere independently of the respiration passage 5 branches off from the respiration passage 5. In the shunt passage 31 there is arranged a temperature-dependent resistor 33 on the side of which facing to atmosphere in the exhalation direction there is arranged a non-return valve 35 opening in the exhalation direction and closing in the inhalation direction. The non-return valve 35 comprises a ball 37 which is pressed by a spring 39 with very slight spring force which merely ensures a closure position of the ball 37 independent of the position of installation. The force of the spring 39 is preferably so small that the back pressure occurring in the exhalation direction in the shunt passage 31 is negligible. The temperature-dependent resistor 33 is cooled in dependence upon the respiratory air throughput in the shunt passage and thus in predetermined manner in dependence upon the respiratory air throughput in the respiration passage 5. The resistance variation caused by the cooling is exploited by means of the control and measuring circuit 1 for the control of the time moment for the taking of the breath air sample and for the recognition of breath manipulations which can lead to measurement errors.

Figure 2 shows a control circuit suitable for the control of the locking device 25 in combination with a temperature-dependent resistor 33 formed as hot conductor. The hot conductor 33 is connected in series with a resistor 41 in the form of a voltage-divider circuit between working voltage terminals designated by + and −. A voltage divider circuit consisting of resistors 43 and 45 is further connected to the working voltage terminals + and −, the voltage divider tapping 47 of which circuit is connected with the circuit earth 49 and keeps the circuit earth at a pre-determined potential. The current flowing through the hot conductor 33 heats the hot conductor 33 to a temperature of at least 70° C., preferably about 100° C. The voltage related to a reference potential, for example earth, occurring at the voltage divider tapping 51 between the hot conductor 33 and the resitor 41, is a measure for the respiratory air throughput in the shunt passage 31 and thus a measure for the respiratory air throughput of the respiration passage 5 in the exhalation direction 7. With growing respiration air throughput the hot conductor 33 is cooled to an increasing extent, whereby its resistance grows and the voltage on the voltage divider tapping 51 increases.

A controllable integrator 53 is connected to the voltage divider tapping 51 through a direct-current break capacitor 55 and a series coupling resistor 57. The integrator 53 comprises an integration capacitor 59 connected by way of the capacitor 55 and the series resistor 57 between the voltage divider tapping 51 and earth, to the terminal of which remote from earth the inverting input of a sum-and-difference amplifier 61, working as threshold value switch, is connected. The non-inverting input of the sum-and-difference amplifier 61 is connected with a reference voltage souce 67, here positive, formed by resistors 63, 65.

The integrator 53 integrates the voltage on the voltage divider tapping 51, representing the respiratory air throughput of the respiration passage 5, and delivers a signal corresponding to the exhaled breath air volume at the terminal of the integration capacitor 59 remote from earth. The reference voltage of the reference voltage source 67 is set so that the signal energising the electromagnet 29 of the locking device 25 is generated on the output 69 of the sum-and-difference amplifier 61 when a minimum volume of respiratory air has been breathed out, which ensures that the respiratory air available for the respiratory air sample comes from the alveoles of the lungs.

The integrator 53 is controlled by a resetting circuit 71 responding to the direction of flow of the respiratory air and comprises a controllable switch 75 which is connected in parallel with the capacitor 59 and is opened and closed in alternation by the resetting circuit 71. During the integration action the switch 75 connected in parallel with the integration capacitor 59 is opened. In resetting the switch 75 is closed.

The resetting circuit 71 includes a differentiating member, designated by 81 and consisting of a series capacitor 77 and a parallel resistor 79 connected for one part to earth and for the other part through the series capacitor 77 with the voltage divider tappings 51, to which member a sum-and-difference amplifier 83 working as threshold value switch is connected with its inverting input. The sum-and-difference amplifier 83 is connected with its non-inverting input to a voltage divider circuit formed from resistors 87, 89 and serving as reference voltage source 85, and controls the switch 75. The differentiating member 81 and the reference voltage source 85 are so dimensioned that the resetting circuit 71 liberates the integrator 53 for the integration of the voltage on the voltage divider tapping 51, representing the throughput, when respiratory air is flowing in the exhalation direction and thus cooling the hot conductor 33, and resets it and keeps it reset for the duration of inhalation when respiratory air is flowing in the inhalation direction in the respiration passage 5. For the duration of inhalation the non-return valve 35 is closed, so that the hot conductor 33 heats up in stationary ambient air with pre-determined temperature variation rate. The rate of variation is detected by means of the differentiating member 81 and the series-connected sum-and-difference amplifier 83, working as threshold value switch.

Details of the manner of working appear from Figures 3a - 3d, which show the course of the voltage at different points of the circuit according to Figure 2, in dependence upon the time t. Figure 3a shows the voltage $U_1$, representing the respiratory air throughput, on the voltage divider tapping 51 for an exhalation beginning at the time moment $t_0$, where inhalation takes place briefly between the time moments $t_1$ and $t_2$. and ending at the moment $t_3$. When subjected to breath in the exhalation direction the hot conductor 33 is cooled and the voltage $U_1$ rises. Between $t_1$ and $t_2$ inhaling takes place, whereby the hot conductor 33 heats up with pre-determined variation rate in the shunt passage 31 blocked by the non-return valve 35, while the voltage $U_1$ drops. In the following exhalation between $t_1$ and $t_3$ the voltage $U_1$ rises again as a result of the cooling of the hot conductor 33. After the end of the breath application at the moment $t_3$ the hot conductor 33 can heat up again, whereby the voltage $U_1$ decreases.

Figure 3b shows the voltage $U_2$ at the output of the sum-and-difference amplifier 83. In the case of a high level of the voltage $U_2$ the integrator 53 is set back and in the case of a low level of the voltage $U_2$ it is liberated for the integration of the voltage $U_1$.

Figure 3c shows the output voltage $U_3$ of the integrator 53 at the terminal of the integration capacitor 59 remote from earth. In Figure 3c the threshold voltage level $U_s$ pre-determined by the reference voltage source 67 and determining the minimum breath air volume is entered in dot-and-dash lines. In the period $t_0$ to $t_1$ the integral does not reach the value of the threshold voltage $U_s$ before it is set back to zero at the moment $t_1$. The integration action begins afresh at the moment $t_2$ on renewed exhalation and at the moment $t_4$ reaches the threshold voltage $U_s$. The integral voltage $U_3$ rises further and is set back at the moment $t_3$ at the end of the breath application. Figure 3d shows the voltage $U_4$ at the output 69 of the sum-and-difference amplifier 61, that is the control voltage for the locking device 25. A circuit connected to the output 69 here utilises only the here rising front flank of the voltage pulse.

Figure 2 shows in chain lines a variant of the control circuit in which the measuring arrangement is liberated for the measurement of the alcohol concentration with delay after the reaching of the minimum respiratory air volume. Due to the delay of the measurement moment the alveolar air proportion in the respiratory air sample and thus the accuracy of measurement of the alcohol meter are increased. The delay arrangement comprises a differentiating member 91 connected with the integrator output, which delivers a signal corresponding to the speed of variation of the integral of the throughput signal to a threshold value stage 93. The locking device 25 is connected to the output 95 of the threshold value stage 93 instead of to the output 69, and is unlocked through this stage when the speed of variation drops below a predetermined threshold value denoting the end of the breath. In order to prevent the unlocking before the predetermined minimum respiratory air volume is reached, the threshold value stage 93 has a release input 97, to which the sum-and-difference amplifier 61 is connected and by way of which it is liberated for the monitoring of the speed of variation only after the minimum respiratory air volume is reached.

The differentiating member 91 can be omitted if the threshold value stage 93 is coupled directly to the voltage divider tapping 51 and monitors the dropping of the throughput signal at the end of the breath. This variant is distinguished by relatively low circuitry expense. The monitoring of the speed of variation of the integral of the throughput signal has however the advantage that momentary fluctuations of the throughput signal cannot lead prematurely to the unlocking of the locking device 25.

## CLAIMS

1. Breath alcohol measuring appliance, having a measuring arrangement (1) detecting the alcohol concentration of the respiratory air exhaled through a respiration passage (5) by means of an alcohol sensor (3), having a flow sensor (33, 41) comprising at least one temperature-dependent resistor (33) exposed to the flow of respiratory air and delivering at least one throughput signal representing te respiratory air throughput through the respiration passsage, having an integrator arrangement (53, 61) time-dependently integrating the throughput signal for ascertaining the respiratory air volume exhaled through the respiration passage and liberating the measuring arrangement (1) for the measurement of the alcohol concentration on or after the reaching of a pre-determined minimum breath volume, and having a control arrangement (71) connected to the flow sensor (33, 41) and detecting the direction of flow of the respiratory air in the respiration passage, which control arrangement blocks the measurement of the alcohol concentration if inhalation occurs before the liberation of the measurement by the integrator arrangement (53, 61), characterised in that the control arrangement (71) resets the integrator arrangement (53, 61) on detection of air flowing in the inhalation direction and blocks it for the integration of the throughput signal for the duration of the inhalation condition.

2. Alcohol-measuring appliance according to Claim 1, characterised in that the flow sensor comprises one single temperature-dependent resistor (33) which is arranged in a shunt passage (31) branching off from the respiration passage (5) and leading separately to atmosphere, and in that the shunt passage (31) contains, on the side placed to atmosphere in the exhalation direction, a screening device (35) which screens off the temperature-dependent resistor (33) in the inhalation direction.

3. Alcohol-measuring appliance according to Claim 2, characterised in that the screening device is formed as non-return valve (35) blocking in the inhalation direction.

4. Alcohol-measuring appliance according to Claim 2 or 3, characterised in that the

temperature-dependent resistor is formed as a hot conductor (33) connected to a current source and is kept by current heating at a temperature higher than the temperature of the respired air and in that the control arrangement for detecting the direction of flow comprises a differentiating arrangement (81).

5. Alcohol-measuring appliance according to Claim 4, characterised in that the hot conductor (33) in the state of rest is heated to a temperature of at least 70° C.

6. Alcohol-measuring appliance according to one of Claims 1 to 5, characterised in that a delay arrangement (91, 93) delays the liberation of the measuring arrangement for the measurement of the alcohol concentration after reaching of the pre-determined minimum breath volume.

7. Alcohol-measuring appliance according to Claim 6, characterised in that the delay arrangement (91, 93) includes a threshold value device (93) controllable in dependence upon the throughput signal, which liberates the measuring arrangement for the measurement of the alcohol concentration when the respiratory air throughput falls short of a pre-determined threshold value, and in that the integrator arrangement (53, 61) blocks the threshold value device (93) before the pre-determined minimum breath volume is reached and liberates it after this volume is reached.

8. Alcohol-measuring appliance according to Claim 7, characterised in that the threshold value device (93) includes a differentiating arrangement (91) and responds to the integral ascertained by the integrator arrangement (53, 61).

9. Alcohol-measuring appliance according to one of Claims 1 to 8, characterised in that the measuring arrangement comprises a piston suction pump (11) the suction chamber (23) of which is connected with the respiration passage (5) by way of a connection passage (13) branching off from the respiration passage (5) and the piston (17) of which, limiting the suction chamber (23), is manually movable against the force of a return spring (19) into its minimum suction chamber volume position and by the return spring (19) into its maximum suction chamber volume position, in that the piston (17) is arrestable in the minimum position by means of an electro-magnetically unlockable locking device (25), in that the alcohol sensor (3) detects the alcohol concentration in the suction chamber (23) and in that the integration arrangement (53, 61) controls the locking device (25).

10. Breath alcohol measuring appliance as claimed in Claim 1 substantially as described with reference to the accompanying drawings.

Printed for Her Majesty's Stationery Office by
Croydon Printing Company (UK) Ltd, 4/87, D8991685.
Published by The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.