

(12) STANDARD PATENT
(19) AUSTRALIAN PATENT OFFICE

(11) Application No. **AU 2007332121 B2**

(54) Title
Method for identifying blockages in sprinkler devices and apparatus for carrying out this method

(51) International Patent Classification(s)
E21C 35/22 (2006.01)

(21) Application No: **2007332121**

(22) Date of Filing: **2007.11.30**

(87) WIPO No: **WO08/070884**

(30) Priority Data

(31) Number
A 2058/2006

(32) Date
2006.12.13

(33) Country
AT

(43) Publication Date: **2008.06.19**

(44) Accepted Journal Date: **2014.01.23**

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(56) Related Art
EP 0188188
DE 2915176
US 4533180

(12) NACH DEM VERTRAG ÜBER DIE INTERNATIONALE ZUSAMMENARBEIT AUF DEM GEBIET DES
PATENTWESENS (PCT) VERÖFFENTLICHTE INTERNATIONALE ANMELDUNG

(19) Weltorganisation für geistiges Eigentum
Internationales Büro



(43) Internationales Veröffentlichungsdatum
19. Juni 2008 (19.06.2008)

PCT

(10) Internationale Veröffentlichungsnummer
WO 2008/070884 A1

(51) Internationale Patentklassifikation:
E21C 35/22 (2006.01)

(21) Internationales Aktenzeichen: PCT/AT2007/000541

(22) Internationales Anmeldedatum:
30. November 2007 (30.11.2007)

(25) Einreichungssprache: Deutsch

(26) Veröffentlichungssprache: Deutsch

(30) Angaben zur Priorität:
A 2058/2006 13. Dezember 2006 (13.12.2006) AT

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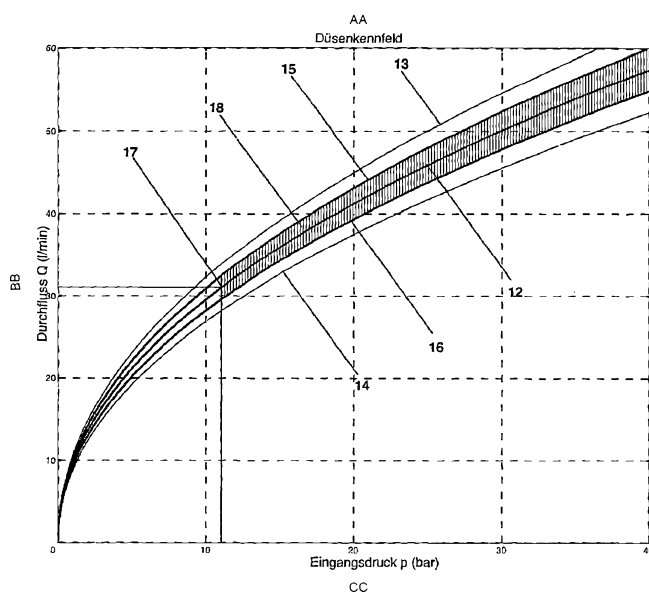
(81) Bestimmungsstaaten (soweit nicht anders angegeben, für jede verfügbare nationale Schutzrechtsart): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Bestimmungsstaaten (soweit nicht anders angegeben, für jede verfügbare regionale Schutzrechtsart): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), eurasisches (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), europäisches (AT, BE, BG, CH, CY, CZ, DE, DK,

[Fortsetzung auf der nächsten Seite]

(54) Title: METHOD FOR IDENTIFYING BLOCKAGES IN SPRINKLER DEVICES AND APPARATUS FOR CARRYING OUT THIS METHOD

(54) Bezeichnung: VERFAHREN ZUM ERKENNEN VON VERSTOPFUNGEN VON BEDÜSUNGSEINRICHTUNGEN SOWIE VORRICHTUNG ZUR DURCHFÜHRUNG DIESES VERFAHRENS



AA. Nozzle characteristic map
BB. Flow rate Q (l/min)
CC. Input pressure p (bar)

of the heading and mining machine.

(57) Abstract: In a method for identifying blockages in sprinkler devices (2) on heading and mining machines, the pressure and the flow rate of the medium to be fed to the sprinkler device are measured, the measured values are fed to an evaluation circuit and compared with the desired characteristic curve (12), which is measured for the sprinkler device, for the dependence of its flow rates on the operating pressure of a fault-free sprinkler device. Deviations from the desired characteristic curve of a fault-free sprinkler device are displayed and/or used as control signals for driving the heading and/or mining machine. The apparatus for carrying out the method is characterized in that a pressure sensor (4) and a flow rate sensor (7) for the medium which is to be fed to the sprinkler device are provided, the measured values from these sensors being passed to an evaluation circuit via signal lines; in that the evaluation circuit contains a memory for desired characteristic curves (12, 18) of the pressure-dependent profile of the flow rates of a fault-free sprinkler device and provides characteristic maps for the permissible deviation from the desired characteristic curve, and in that the evaluation circuit is connected to a display apparatus and/or a control element of the drive

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EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC,
MT, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF,
CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD,
TG).

Veröffentlicht:

— mit internationalem Recherchenbericht

(57) Zusammenfassung: Bei einem Verfahren zum Erkennen von Verstopfungen von Bedüsungseinrichtungen (2) an Vortriebs- oder Gewinnungsmaschinen werden der Druck und die Durchflussmenge des der Bedüsungseinrichtung zuzuführenden Mediums gemessen, die Messwerte einer Auswerteschaltung zugeführt und mit der für die Bedüsungseinrichtung gemessenen Sollkennlinie (12) für die Abhängigkeit ihrer Durchflussmengen vom Betriebsdruck einer fehlerfreien Bedüsungseinrichtung verglichen. Abweichungen von der Sollkennlinie einer fehlerfreien Bedüsungseinrichtung werden angezeigt und/oder als Steuersignale für einen Antrieb der Vortriebs- und/oder Gewinnungsmaschine herangezogen. Die Vorrichtung zur Durchführung des Verfahrens ist dadurch gekennzeichnet, dass ein Drucksensor (4) und ein Durchflussmengensensor (7) für das der Bedüsungseinrichtung zuzuführende Medium vorgesehen sind, deren Messwerte über Signalleitungen zu einer Auswerteschaltung geführt sind; dass die Auswerteschaltung einen Speicher für Sollkennlinien (12, 18) des druckabhängigen Verlaufs der Durchflussmengen einer fehlerfreien Bedüsungseinrichtung enthält und Kennlinienfelder für die zulässige Abweichung von der Sollkennlinie bereitstellt und dass die Auswerteschaltung mit einer Anzeigevorrichtung und/oder einem Steuerglied des Antriebs der Vortriebs- und Gewinnungsmaschine verbunden ist.

Method for identifying blockages in sprinkler devices and apparatus for carrying out this method

The invention relates to a method for detecting blockages in nozzling devices on advance working or mining machines, and a device for carrying out the method.

In advance working or mining machines it is known to conduct cooling liquid through nozzles to the mine face or to the cutters, the aim of such spraying of cooling liquid being to prevent inadmissibly high temperatures at the mine face and hence rendering impossible the formation of sparks and explosions. Depending on the type of medium supplied, it is also feasible to use such spray nozzles for spraying a liquid to avoid excessive dust formation. Yet, when using such nozzles, contaminations of the cooling liquid may cause blockages in the nozzles, which blockages may in turn result in the supply of insufficient cooling liquid, and the formation of sparks and explosions can no longer be effectively avoided. From EP 188188, a device of this type has become known for spraying cooling liquid from nozzles of a cutter head, in which valves are actuated by the cutters of the cutter head themselves, for which reason the spraying of cooling liquid will only be effected if the respective cutter, to which the nozzle is associated, is engaged. In order to enable the detection of a nozzle blockage also in those cases, the nozzle is preceded by a throttle, with sensors using the pressure difference of the space in front of the throttle relative to the space following the throttle as an indication whether a nozzle blockage has occurred or not. At the occurrence of a blockage, the pressure in the space following the throttle will, in fact, rise relative to the pressure in front of the throttle such that a major blockage of the nozzle

can be concluded from a pregiven, sufficiently small pressure difference.

In addition to such relatively complex devices, it is known to arrange spray nozzles in nozzle assemblies and to constantly eject cooling liquid via a plurality of such nozzles during the operation of an advance working or mining machine. To monitor the appropriate sprinkling effect, DE 2915176 has already proposed to arrange a temperature-dependent resistance after the water spray nozzles. The jet of water emerging from the nozzles affects the temperature-dependent resistance, whereby a signal of that temperature-dependent resistance is subsequently used to shutdown the machine, if required. That document, however, also refers to safety problems, which consist in that the machine might nevertheless be started up while avoiding such simple control measures, thus causing maloperation. Such maloperation might occur not least if the permissible operation of the machine were exclusively dependent on whether the water supply had been turned on. Such an arrangement might in fact permit operation even if one or several of the water nozzles were blocked or if one or several of the valves associated with the water nozzles remained closed, since its control is merely based on the sensed pressure and, even if the flow rate were sensed instead of the pressure, a pipe break could lead to a failure of the arrangement.

The invention now aims to provide a method of the initially defined kind, which enables the effective monitoring of an entire nozzle beam and the avoidance of maloperations. The invention, in particular, also aims to avoid malfunctions and/or shutdowns of the machine if the water supply does not occur at a constant pressure. Monitoring systems in which

merely a flow regulator is manually adjusted to a critical flow rate indicative of the blockage of a nozzle are extremely prone to errors at fluctuating water pressures and will result in an uncontrolled control behavior, which will in turn implicate relatively complex maintenance and adjustment operations in order to avoid undesired machine shutdowns during operation.

To solve this object, the invention provides a monitoring method and a monitoring system for a nozzling device of, for instance, a nozzle beam for a cutting tool or broken material on the loading table, which will automatically adjust to the actual on-site conditions and ensure higher safety in the detection of a failure of an individual nozzle.

To this end, the method of the initially defined kind according to the invention is characterized in that the pressure and the flow rate of the medium to be supplied to the nozzling device are measured, that the measured values are fed to an evaluation circuit and compared with the target characteristic curve measured for the nozzling device, for the dependence of its flow rates on the operating pressure of an error-free nozzling device, and that deviations from the target characteristic curve of an error-free nozzling device are displayed and/or used as control signals for a drive of the advance working and/or mining machine. Due to the fact that not only flow rate measurements but also pressure measurements enter into the evaluation or control according to the invention, and that a respective characteristic curve which takes into account pressure-dependent changes in the flow rate is determined according to the invention, it has become possible to specify such characteristic curves in the form of target characteristic curves and compare with the

behavior of the characteristic curve the respectively measured actual values corresponding to a defined point on this characteristic curve in a comparator or an evaluation circuit. Hence results that, in the event the pressure is subject to fluctuations, the respective change in the flow rate in the time unit will not yet necessarily result in a shutdown as long as the measured change remains within what would have to be denoted as pressure-dependent change in the flow rate per time unit. Thus, in order to ensure a certain tolerance relative to an unambiguous target characteristic curve that is not yet to be classified as critical, it is advantageously proceeded according to the invention in a manner that the permissible deviations from the target characteristic curve are stored in the evaluation circuit as a field of characteristics, which field of characteristics is preferably delimited by characteristic curves corresponding to a measurement deviation at less than a defective nozzle. This will ensure reliable operation unless a predetermined threshold value is exceeded, wherein an especially high degree of accuracy will be achieved if the characteristic curves of the individual nozzles are actually known, such characteristic curves usually falling within the ex-factory nozzle specifications. The method is, therefore, advantageously carried out such that the characteristic curves, for the determination of the fields of characteristics, are identified as pressure-dependent flow rate characteristic curves for individual nozzles and computationally determined for the actual number of nozzles of the nozzling device, wherein, in a preferred manner, the threshold value is set to turn off a drive upon achievement of a characteristic curve corresponding to a deviation of the characteristic curve of the nozzling device relative to the value of the characteristic curve of ± 0.5 nozzle. A shutdown is, thus, safely initiated in case a

nozzle fails, so that a high degree of operating safety is provided at simultaneously substantially reduced options of unintentionally influencing the operation-related shutdown of the cutting motor.

In order to monitor, during operation, the safe functioning of the respective sensors, it may advantageously be proceeded in a manner that the sensors are checked by plotting characteristic curves at reduced operating pressures and comparing these measurements with previously measured target values.

In the method according to the invention, it is a general rule that too low a supply pressure will not guarantee a sufficient minimum pressure for the flaming security of methane evolutions and, therefore, will not comply with the pertinent safety regulations. It is, thus, possible to select an accordingly low limit value for the supply pressure as one of the limit values, a rapid decrease of the supply pressure being, for instance, observable in the event of a hose break or with a closed supply duct. Other events of damage to be recognized are related to the fact that nozzles may be lost from the beam due to mechanical vibrations and a hose break may, for instance, occur after the flow sensor. A leakage in the pressure line downstream of the flow sensor as well as strongly washed-out nozzles having spray patterns that are no longer correct will require an exchange of the set of nozzles.

The mode of procedure according to the invention, however, also enables the particularly simple detection of a possible nozzle blockage. In such cases it will frequently do to clean the nozzles, wherein the entire set of nozzles will have to be replaced if several nozzles exhibit reduced flow rates due to

deposits. In the main, this complex overall scheme of events implies that a field of characteristics can be defined as a permissible field of characteristics in the context of the plotted characteristic curves, and that merely the permissible field of characteristics need to be stored in the evaluation circuit and it has to be verified whether the actual measurements range within said permissible field of characteristics. Within the permissible range, the required minimum pressure and the minimum flow rate at said minimum pressure are monitored, while the calculation of the characteristic curve is continuously performed. If the following conditions apply:

- a) a minimum pressure of, for instance, 11 bar
- b) the flow rate sensor measures an amount larger than the minimum permissible flow rate
- c) the flow rate sensor measures a value smaller than the maximum permissible flow rate,

and it is, at the same time, ensured that the flow rate is larger than the minimum flow at the minimum pressure, correct nozzling can be assumed. The mutual check of the sensors by varying the water pressure may likewise be performed during operation. If the pressure and flow rate sensors behave in conformity with the characteristic curve at a reduction of the water pressure, correct functioning may be anticipated. If the machine shuts down in such a case, this means that a sensor would be defective.

The device according to the invention for carrying out the method is essentially characterized in that a pressure sensor and a flow rate sensor for the medium to be supplied to the nozzling device are provided, whose measurements are fed to an evaluation circuit via signal lines, that the evaluation circuit comprises a memory for target characteristic curves of the pressure-dependent behavior of the flow rates of an error-

free nozzling device and provides characteristic fields for the permissible deviation from the target characteristic curve, and that the evaluation circuit is connected with a display device and/or a control member of the drive of the advance working and winning machine.

Overall, the device according to the invention and the method according to the invention offer the advantage that manual adjustment operations can be obviated and machine shutdowns merely based on pressure deviations supply line and influences causing pressure decreases are largely avoided. It is also beneficial that the nozzling system can be operated at different pressures and the water consumption and dust deposition can be influenced in this manner without causing malfunctions of the device. In the main, the number of electronic monitoring elements can be markedly reduced and the risk of manipulations of the monitoring system by the operating personnel can be minimized.

In the following, the invention will be explained in more detail by way of an exemplary embodiment schematically illustrated in the drawing. Therein, Fig. 1 is a schematic view of the circuit arrangement according to the invention for nozzling; Fig. 2 depicts a typical characteristic field of a nozzle, as it is used according to the invention; and Fig. 3 is a diagrammatic illustration of the switching logic.

Fig. 1 schematically depicts a nozzle assembly 1 for nozzling a cutting cylinder, wherein the individual nozzles are denoted by 2. The pressure in the supply line of such a nozzle is detected via the control line 3 and the pressure sensor 4. The medium is supplied to the nozzle assemblies 1 and the nozzles 2 via a pressure reduction valve 5 and a line 6 comprising a

flow rate sensor 7. However, the medium is now not only supplied to the nozzle assemblies 1 via line 8, but also to the nozzles of the loading table via line 9 in order to sprinkle and cool the broken material. The motors to be controlled and, in particular, the cutting motor are schematically indicated by 10, with the two loading motors being denoted by 11. By the evaluation of the values of the flow rate sensor and of the pressure sensor, which is going to be described in more detail below, the cutting motor or the loading motors can be directly influenced.

The characteristic field for the determination of correct operating parameters is illustrated in Fig. 2 as a nozzle characteristic field. From Fig. 2, a characteristic curve 12 is apparent, which indicates the change in the flow rate per time unit from the input pressure for the entirety of the respective nozzles. This characteristic curve 12 thus corresponds to the overall nozzling target value. If a nozzle is added or removed, the respective characteristic curve will be displaced upwards or downwards, the characteristic curve 13 corresponding to the conditions for $n+1$ nozzles and the characteristic curve 14 corresponding to the conditions for $n-1$ nozzles. Between these two limit values, a fictitious characteristic curve 15 and 16, respectively, is each computationally or graphically respectively determined, each corresponding to the deviation by half a nozzle. The area delimited by the characteristic curves 15 and 16 is to be denoted as permissible nozzle characteristic field, and correct functioning can be assumed as long as the measured values lie within said area. At the same time, also a lower limit value must, however, be defined, which is determined by the coordinates of point 17 in the illustration according to Fig. 2. This point corresponds to the minimum flow rate and

the minimum pressure for safe functioning, with a shutdown of the motor(s) being also effected if these values are fallen short of. The permissible characteristic field is thus defined by the hatchedly shown area 18.

Fig. 3 elucidates the switching logic. The signals of the sensor inputs are denoted as P_{Sensor} and Q_{Sensor} and serve to control the minimum pressure and minimum flow rate, respectively, in the time unit, on the one hand, and to calculate the respective target value which takes into account the pressure dependence of the flow rate, on the other hand. This calculation of Q_{Target} is done according to the relation

$$Q_{\text{Target}} = Q_0 \times \left(\frac{P_{\text{Sensor}}}{P_0} \right)^{0.48}$$

flow value with the actual flow value detected by the sensor will result in a logic retrieval of the characteristic field. The measured value of the flow rate sensor Q_{Sensor} is to be

$$\leq Q_{\text{Target}} \times \left(n + \frac{i}{2} \right) \text{ or } \geq Q_{\text{Target}} \times \left(n - \frac{i}{2} \right), \text{ wherein } i = 1 \text{ and } n = \text{number of}$$

nozzles, whereby the respectively upper or lower limitation of the characteristic field is retrieved. As long as Q_{Sensor} remains within the required area, nozzling is correct and the machine can be operated further. In case the value is exceeded or fallen short of, a shutdown will be triggered and an error message will be emitted.

At the same time, the initially mentioned checks of the minimum pressure and minimum flow rate will cause the respective retrieval of the characteristic fields. If

$$Q_{\text{Sensor}} \geq Q_0 \times n \times \left(\frac{P_{\text{min}}}{P_0} \right)^{0.48} \text{ and the pressure value } P_{\text{Sensor}} \geq P_{\text{min}}, \text{ the}$$

machine may continue to operate and nozzling is correct. In case the sensor value for the flow rate per time unit and the

minimum pressure are fallen short of, a shutdown will be triggered and an error will be emitted.

It will be appreciated by those skilled in the art that the invention is not restricted in its use to the particular application described. Neither is the present invention restricted in its preferred embodiment with regard to the particular elements and/or features described or depicted herein. It will be appreciated that various modifications can be made without departing from the principles of the invention. Therefore, the invention should be understood to include all such modifications in its scope.

The reference to any prior art in this specification is not, and should not be taken as, an acknowledgement of any form of suggestion that such prior art forms part of the common general knowledge.

It will be understood that the term "comprise" and any of its derivatives (eg comprises, comprising) as used in this specification is to be taken to be inclusive of features to which it refers, and is not meant to exclude the presence of any additional features unless otherwise stated or implied.

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Claims:

1. A method for identifying blockages in a nozzling device of advance working or mining machines, wherein a pressure and a flow rate of a medium to be supplied to the nozzling device are measured by a pressure sensor and a flow rate sensor respectively, that the measured values are fed to an evaluation circuit and compared with a target characteristic curve, for a flow rate for a given operating pressure of an error-free nozzling device, and that any deviations from the target characteristic curve of the error-free nozzling device are displayed and/or used as control signals for a drive of the advance working and/or mining machine.
2. The method of claim 1, wherein permissible deviations from the target characteristic curve are stored in an evaluation circuit as a field of characteristics.
3. The method of claim 2, wherein the field of characteristics is delimited by characteristic curves corresponding to a measurement deviation of less than a defective nozzle.
4. The method according to any one of the preceding claims, wherein the characteristic curves, are computationally determined for an actual number of nozzles of the nozzling device.
5. The method according to any one of the preceding claims, wherein a threshold value is set to turn off the drive upon achievement of a characteristic curve corresponding to a deviation of the characteristic curve of the nozzling device relative to the value of a characteristic curve of ± 0.5 nozzles.
6. The method according to any one of claims 1 to 4, wherein the sensors are checked by plotting characteristic curves at

reduced operating pressures and comparing these measurements with previously measured target values.

7. A device for carrying out the method according to any one of claims 1 to 6, wherein a pressure sensor and a flow rate sensor for the medium to be supplied to the nozzling device are provided, whose measurements are fed to an evaluation circuit via signal lines, and wherein the evaluation circuit comprises a memory for target characteristic curves of pressure-dependent behavior of flow rates of an error free nozzling device and provides fields of characteristics for the permissible deviation from the target characteristic curve, and that the evaluation circuit is connected with a display device and/or a control member of a drive of the advance working and mining machine.

8. A method substantially as herein described with reference to the accompanying drawings.

9. A device substantially as herein described with reference to the accompanying drawings.

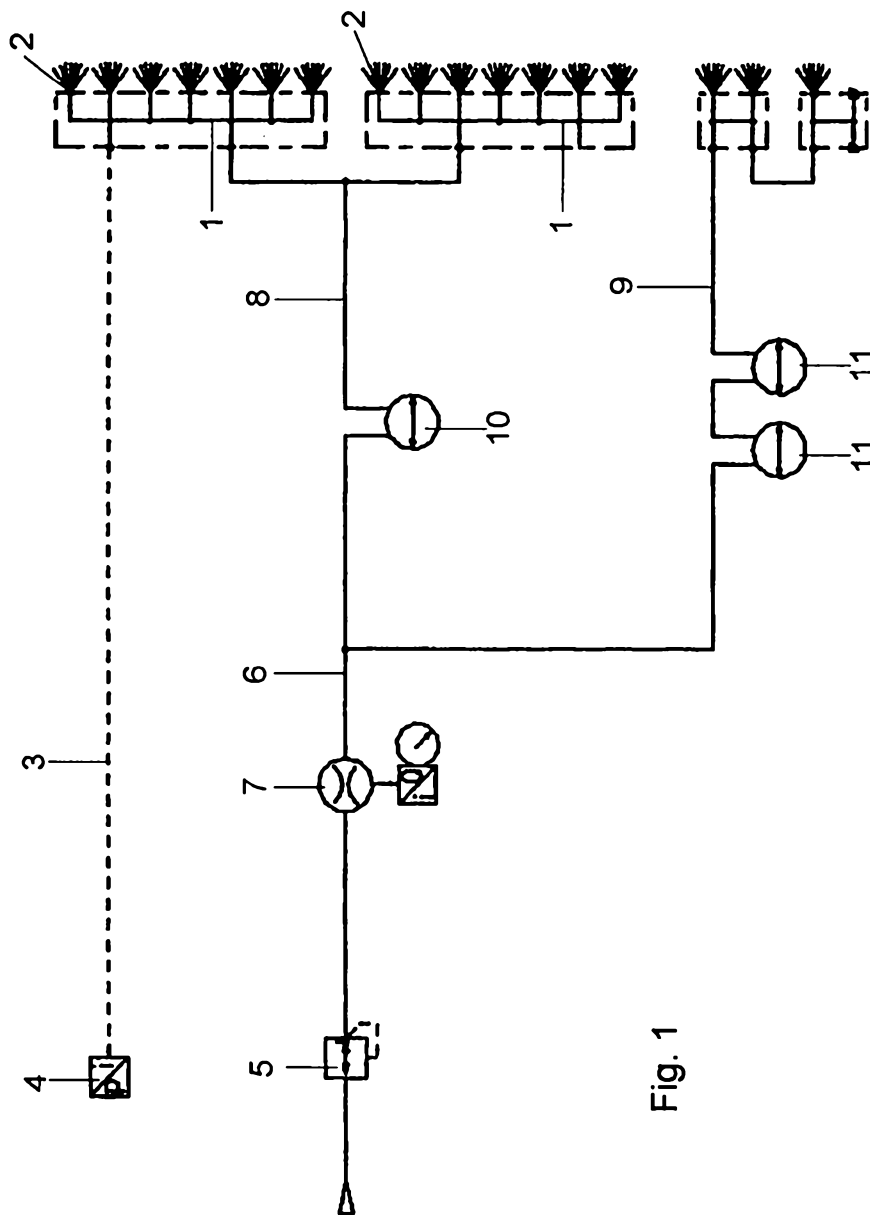
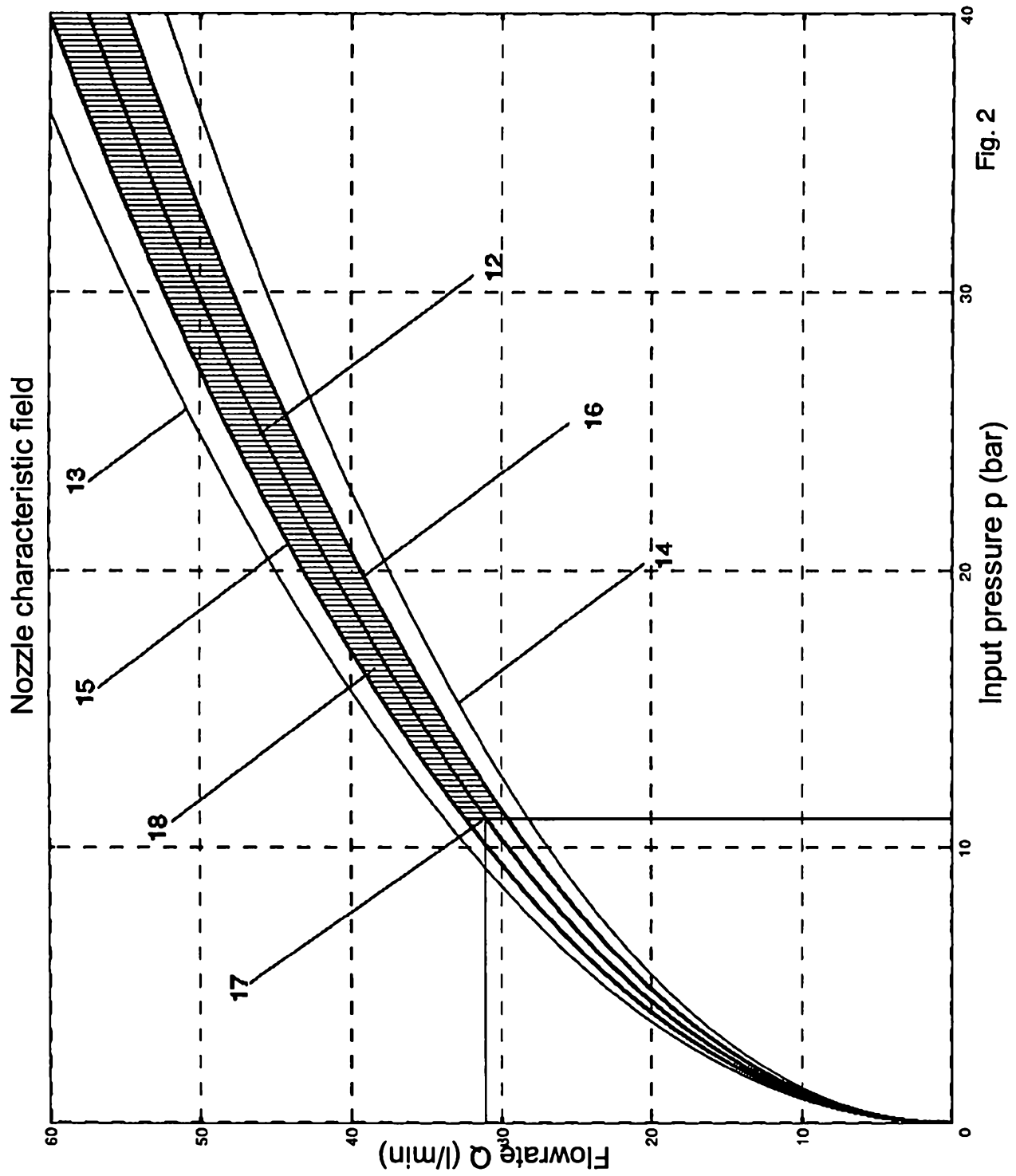


Fig. 1



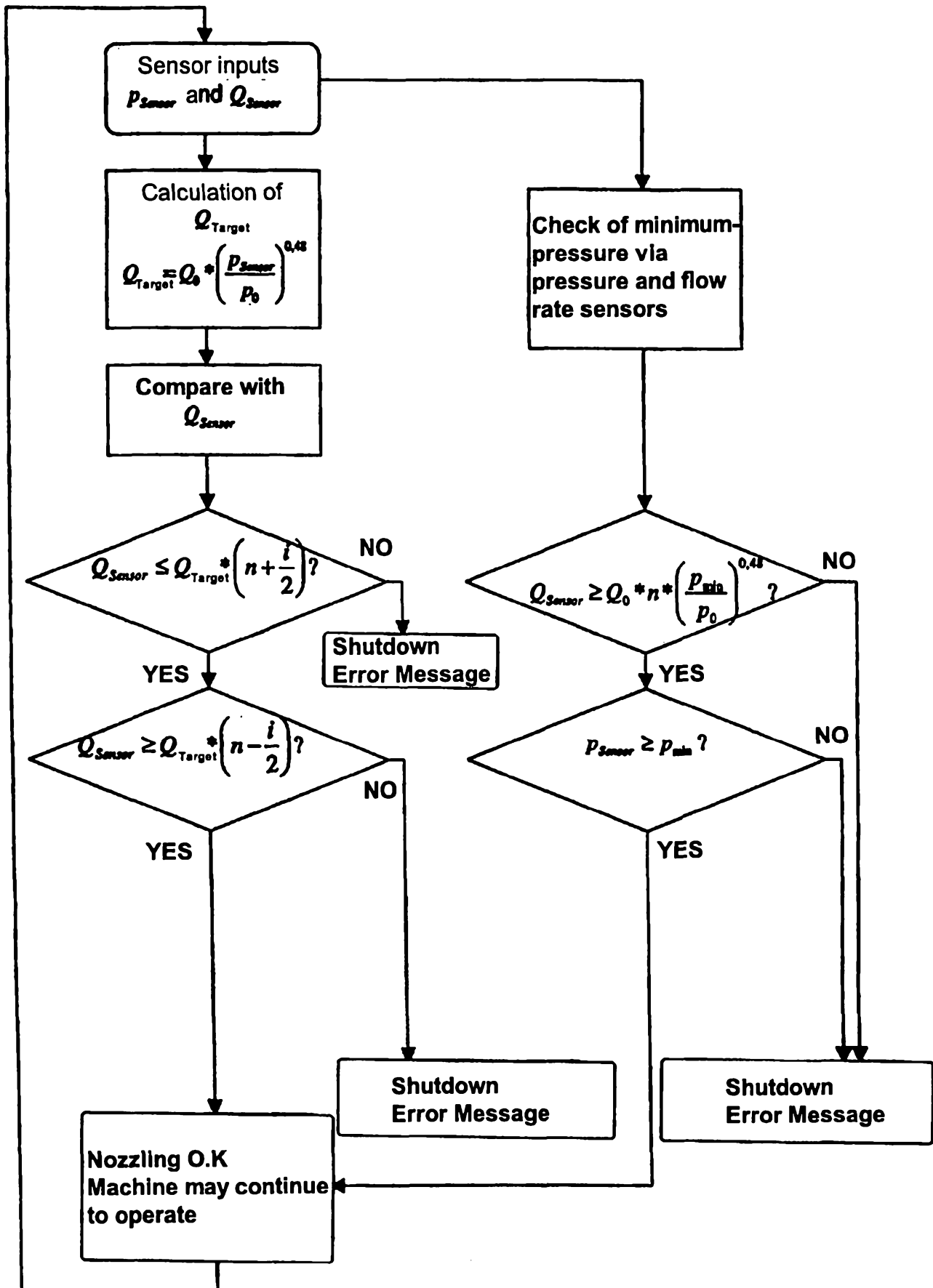


Fig. 3