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(71) Applicant: **NEDERLANDSE ORGANISATIE VOOR TOEGEPAST-NATUURWETENSCHAPPELIJK ONDERZOEK TNO**
Laan van Westenenk 501
NL-7334 DT Apeldoorn(NL)

(72) Inventor: **Knoll, Bastiaan**
Lange Broekweg 2
NL-2671 PR Naaldwijk(NL)

(74) Representative: **Flamman, Han**
LIOC Patents and Licensing P.O. Box 85096
NL-3508 AB Utrecht(NL)

(54) Self-regulating ventilation grate.

(57) Self-regulating ventilation grate with an inlet opening (1), an exhaust opening (13) and in between a variable passage opening (A). The passage opening (A) is determined by the distance between the edge of a valve (3) and an adjustable bottom sheet (6). In case of an increasing overpressure the valve (3) will rotate, so that that distance becomes smaller. During the turning, the valve (3) rolls over a spherical bearing surface (5). This makes the grate fit, i.e. self-regulating, for pressure differences up to about 40 Pa.

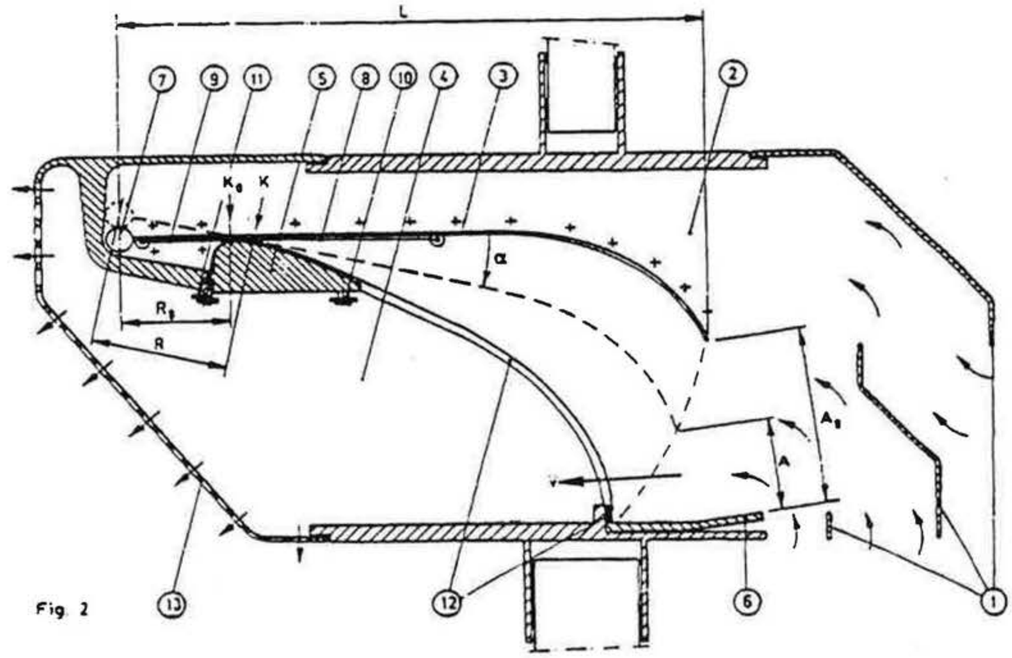

Fig. 2

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The invention relates to a self-regulating ventilation grate with an inlet opening, an exhaust opening and in between a variable passage opening, of which the opening is determined by the distance between an edge of an end of a valve, at the opposite end provided with a counter weight, being between inlet and exhaust opening and a bottom sheet positioned approximately parallel to that edge, which edge in case of an increasing overpressure at the wall-surface of the valve, moves towards that bottom sheet because the valve rotates around an axis at or near that opposite end.

A self-regulating ventilation grate is for instance used in rooms in houses etc. occupied by people. It is exposed to varying pressure differences as a consequence of wind, of temperature differences between in- and outside, of ventilation fans (if present) and of a number of other factors. Regulation only makes sense, if air is supplied through the grate. The pressure differences over the grate (upon supply) during 90% of the time amount to between 1 and 20 Pa in an average house.

At a constant passage opening the volume flow through the grate then varies by a factor 5. By closing down the passage opening, starting from an initial pressure difference of approximately 0.5 Pa with an increasing pressure difference, the volume flow may be kept constant at a desired standard value (Figure 1). Leaks in the housing shell, however, also permit an air volume flow, which increases in case of an increasing pressure difference. The grate should compensate this in order to keep the total volume flow through the grate plus leaks constant.

It is known to construct such ventilation grates in such a way that the volume flow through the passage opening is regulated with the help of a moveable valve. The valve is then steered by the air flow on a wall thereof. The higher the pressure on that wall, the more the valve is pushed into a position, in which it increasingly closes off the passage opening, until it possibly entirely even closes it off. The movement of the valve is: hinging around an axis at the end. The resistance of the valve against movement is for instance caused by counter weights that work at the utmost end of the valve, hence as it were behind the hinge pin.

These known constructions of ventilation grates have disadvantages: the hinge friction causes the starting point of the regulation section - at which a pressure difference of 0.5 Pa already leads to a significant change of angle of the valve - to be negatively influenced. That friction also causes a hysteresis effect. Furthermore, at a relatively low overpressure the maximum deflection of a valve is already reached, which means that the grate could no longer be regulated for pressure differences of 20 up to 40 Pa.

The ventilation grate according to the invention does not show said disadvantages. It is thereto characterized in that the valve at the spot at which it turns, touching via a line contact, is adjacent to a spherical bearing surface and that when turning, it rolls along that bearing surface.

The working of a ventilation grate according to the invention will be further explained by means of Figure 2.

Under the influence of overpressure for instance on a front of a building, air comes into the front room (2) through the so-called external grate (1). This builds overpressure at the entry side of the valve (3) compared to the space (4) behind the valve. The pressure difference between the rooms 2 and 4 (Δ_{P2-4}) causes a deflection (α) of valve (3), which is put on the bearing surface (5). The crossover point thereby moves from K_0 to K. This causes the flow-through area between valve (3) and the bottom sheet (6) to narrow from A_0 to A. At the same time the pressure difference (Δ_{P2-4}) causes a flow velocity (v) in the cross section (A).

The higher the pressure difference across the grate and hence also across the valve (Δ_{P2-4}), the more the flow-through area (A) decreases and the flow velocity (v) increases. The product A.v, multiplied by a contraction factor (μ) depending on the design is the volume flow rate let through (q_v).

The air let through enters the room through the openings in the inner hood (13).

It is strived for to have the valve deflection (α) run in such a way with the pressure difference (Δ_{P2-4}) that the volume flow (q_v) allowed to pass in case of increasing pressure difference runs through the grate according to similar curves as in Figure 1. It turned out that a high sensitivity of the valve (3) was required, or a small counteracting moment at the deflection. This can be achieved by making the valve of a thin and light material. The objection then is, however, that insufficient damping of the pressure fluctuations appearing in practice occurs and that the dimensional stability of the valve is rather small. This is a disadvantage for amongst others the regulation accuracy, the life span and the own noise production. In order to overcome these objections the valve (3) is made of an aluminum sheet being 0.5 mm thick, reinforced by the curve at one end and provided with a counter weight (7) at the other end. The mass inertia of this composition then provides the necessary damping qualities.

Valve (3) and counter weight (7) are balanced in such a way that from pressure differences of 0.5 Pa across the grate already a deflection (α) arises. If the valve - according to the state of the art - had been hanged in a hinging manner at bearing point K_0, the hinge friction would unfavourably influence that starting point of the regulation route and also cause a hysteresis effect. A further disadvantage then is, that in case of insufficient damping the valve (3) would already have its maximum deflection (α = 25°) at a much lower pressure difference than the desired 20 to 40 Pa (dependent on the flow-compensation required in view of for instance the air tightness of the housing).

All these disadvantages are prevented according to the invention by putting the valve (3) on the unwinding surface of support (5).

By unwinding the valve along this surface, any sliding along each other (friction) is avoided.

Also the moving of the crossover or bearing point (K) in case of an increasing deflection (α) causes an increasing counteracting moment, because the arm (R) on which the counter weight (7) has been applied, increases from R_0 to R. In combination with the accompanying reduction of the valve surface (from $\{L - R_0\}B$ to $\{L - R\}B$, in which L is total valve length from counter weight to curved valve tip and B is the valve width) and the reduction of the average arm length (from $\frac{1}{2}\{L - R_0\}$ to $\frac{1}{2}\{L - R\}$ to which the pressure difference ($\Delta_{P2\text{-}4}$) applies, this leads to an increased regulation range up to the desired 20 to 40 Pa.

The exact regulation range and the resulting regulation curve are to a large extent determined by the form of the unwinding surface of support (5). In principle an ample variation on the regulation characteristics is possible by adapting the form of this unwinding surface, possibly in combination with the weight of valve (3), the counter weight (7), the valve length L, the tilting arm R_0 and the position and form of bottom sheet (6). According to a further characteristic of the ventilation grate according to the invention it applies that the unwinding surface of support (5) - the bearing surface - is the most curved at the spot of crossover point K_0 - when there is no pressure difference -, while the curving radius gradually increases with the increasing movement of the crossover point K - hence in case of an increasing pressure difference -. High demands are put on the processing accuracy of the unwinding surface.

Another possible alternative for the unwinding surface is to build the surface from a series of parallel bearing combs. To position the valve (3) on the bearing surface of support (5) in a preferred embodiment of the invention the locking wires (8) and (9) are stretched with the help of the stretching screws (10) and (11) in such a way from valve (3) towards support (5) that the angle (α) of valve (3) with the horizontal surface amounts to nil degrees, at a pressure difference ($\Delta_{P2\text{-}4}$) across the valve of O Pa. The valve (3) possibly becoming oblique widthwise is prevented by a double execution of the locking wires (8) and (9) and the stretching screws (10) and (11) widthwise.

The locking wire 8 prevents the valve (3) to slide downwards along the unwinding surface of support (5) at a larger angle of rotation (α). The locking wire (9) prevents the valve from being pushed up in case of possible gusts or blasts of wind. The two locking wires (8) and (9) together prevent the valve (3) to break loose from the unwinding surface of support (5) in case of possible gusts of wind, thus preventing rattling noises.

The locking wires have been attached in such a way across the unwinding surface that they do not hinder the valve in its movement, because the locking wires do not undergo any change in length. The locking wires to that end run according to the invention through narrow, shallow grooves in the unwinding surface, so that the valve (3) remains resting on the unwinding surface of support (5). As a possible alternative for the locking wires the bottom side of the valve (3) may be provided with gear racks that grip on toothings on the unwinding surface. In order to absorb any stretch of the locking wires usually little springs are adapted between the locking wires and the stretching screws.

The line contact, which exists at the crossover point (K) across the full valve width (B), functions as a sealing between the space (2) above the valve (3) and the space (4) underneath.

When the valve is closed (α = maximum), it seals itself, because apart from the line contact at K, the valve is all around pressed at a stop surface with seat (12). The sealing material on seat (12) is preferably flexible and then damps possible extreme pressure fluctuations, insofar as these are not already damped by the mass inertia of the valve. Annoying sound production such as for instance occurs in case of storm is avoided therewith.

In figure 3 it is indicated how by rotating the bottom sheet (6) around hinge point (14) by means of a control mechanism (not drawn), the passage (A_2) under valve (3) in case of a constant valve deflection (α) can be changed into (A_1). Thus the need for ventilation in principle can be adjusted stepless within a certain range. By fitting a scale division at the control mechanism or by marking preferential positions (for instance ventilation for 1 person, 2 persons etc.) an univocal, reproducible ventilation adjustment may be obtained, dependent on the current need, but independent of weather influences and other pressure influencing factors.

In a somewhat adapted form, the bottom sheet (6) is also preferably used to entirely seal off the grate.

For this purpose the valve (3) should be taken along, from any arbitrary position, by the (prolonged and in its hinge point adapted) bottom sheet surface (6), in order to be pushed against the seat (12).

In the preferred embodiment of a grate according to the invention, as described in figure 3, the sealing of the grate can be executed independent from the adjustment of the ventilation need by pushing the valve (3) downwards with the carrying pins (15) that hinge around point (16) through an operable arm.

Another possibility to seal off the grate is to adapt a separate locking plate. This then hinges from the bottom of the grate casing upwards, as far as against the bottom of the bearing surface.

Measurements have been performed on an embodiment of a grate according to the invention. To that end the grate was placed in the side wall of a large wind tunnel. The wind flowing alongside it generated a pressure difference across the grate, without the regulating characteristics of the grate showing any interaction with the working point of the ventilation fan of the wind tunnel. The volume flow let through to the grate has been measured with the help of a specially calibrated measuring cassette placed on the grate. The pressure difference across the grate minus the measuring cassette has been measured with a device for measuring a pressure difference.

The regulating curve thus determined is shown in figure 4. It concerns the curve for the ventilation need of two persons. The ideal, desired curve has also been drawn in figure 4 for the sake of comparison. It appears from comparison of the measured curve and the desired curve that at the trial model concerned of the grate the yield is accurately regulated within 20% up to a pressure difference of 30 Pa. The occurring inaccuracies can be explained because small adjusting screws were adapted to create the unwinding surface of support (3). The valve (3) thereby tilted across the protruding tips of the screws concerned. Since the number of screws was limited, there occurred some discontinuity, which explains the oscillations in the measuring curve between 10 and 30 Pa.

The space around the protruding screw tips caused an extra leak at the spot of the crossover point (K).

In addition to measurements to determine the adjustment of the grate and the grate curve, tests have been performed at the damping characteristics of the grate. The pressure differences in practice show considerable fluctuations of various frequencies. It should be prevented that the moving valve reacts too strongly hereto, which causes a fast wear and sound production (rattling). To test the damping the grate has been exposed to the most extreme, in practice occurring, pressure fluctuations. The pressure fluctuations have been generated with the help of a lockable opening in the casing in which the grate was mounted for testing. The pressure fluctuations arise by opening and locking said opening more or less fastly, entirely or partially. The pressure fluctuations across the grate have been recorded with an electrical pressure recorder.

The reactions of the valve on extreme pressure fluctuations, as may occur in practice, turn out to be good. There was not observed any fast movement of the valve nor any sound production.

Claims

1. Self-regulating ventilation grate with an inlet opening, an exhaust opening and in between a variable passage opening, of which the opening is determined by the distance between an edge of an end of a valve, provided at the opposite end by a counter weight and situated between inlet and exhaust opening, and a bottom sheet positioned about parallel to that edge, which edge in case of an increasing overpressure at a wall-surface of the valve, moves towards that bottom sheet because the valve turns around an axis at or near that opposite end,
characterised in that the valve at the spot where it turns, touching through a line contact lies adjacent to a spherical bearing surface and that when turning, it rolls along that bearing surface.

2. Self-regulating ventilation grate according to claim 1,
characterised in that the bearing surface is the most curved there where the valve lies in contact with it when there is no pressure difference and that that curve is gradually increasing in the direction, in which the tangent with the valve moves, in case of an increasing pressure difference.

3. Self-regulating ventilation grate according to claim 1 or 2,
characterised in that the system of valve and bearing surface is provided with locking wires and stretching screws belonging thereto, which make the valve always lying against the bearing surface, preventing the valve from gliding along the bearing surface and with which the tuning of the position of the valve in case of absence of a pressure difference, may be realised.

4. Self-regulating ventilation grate according to claim 3,
characterised in that the locking wires run in grooves in the bearing surface.

5. Self-regulating ventilation grate according to one or more of the preceding claims, characterised in that the passage opening is provided with a stop surface against which in case of a sufficiently high pressure difference, the valve is stopped, such, that in that position the entire passage opening is closed.

6. Self-regulating ventilation grate according to claim 3, characterised in that there where the valve stops against the seat, the latter is covered with, or consists of a resilient material.

7. Self-regulating ventilation grate according to one or more of the preceding claims, characterised in that the position of the bottom sheet is adjustable.

8. Self-regulating ventilation grate according to claims 5, 6 or 7, characterised in that it is provided with a mechanism, with which the valve can be pushed against the stop surface.

9. Self-regulating ventilation grate according to one or more claims 1-4, characterised in that the passage opening can be sealed off by means of a hinging locking plate.

Fig. 1

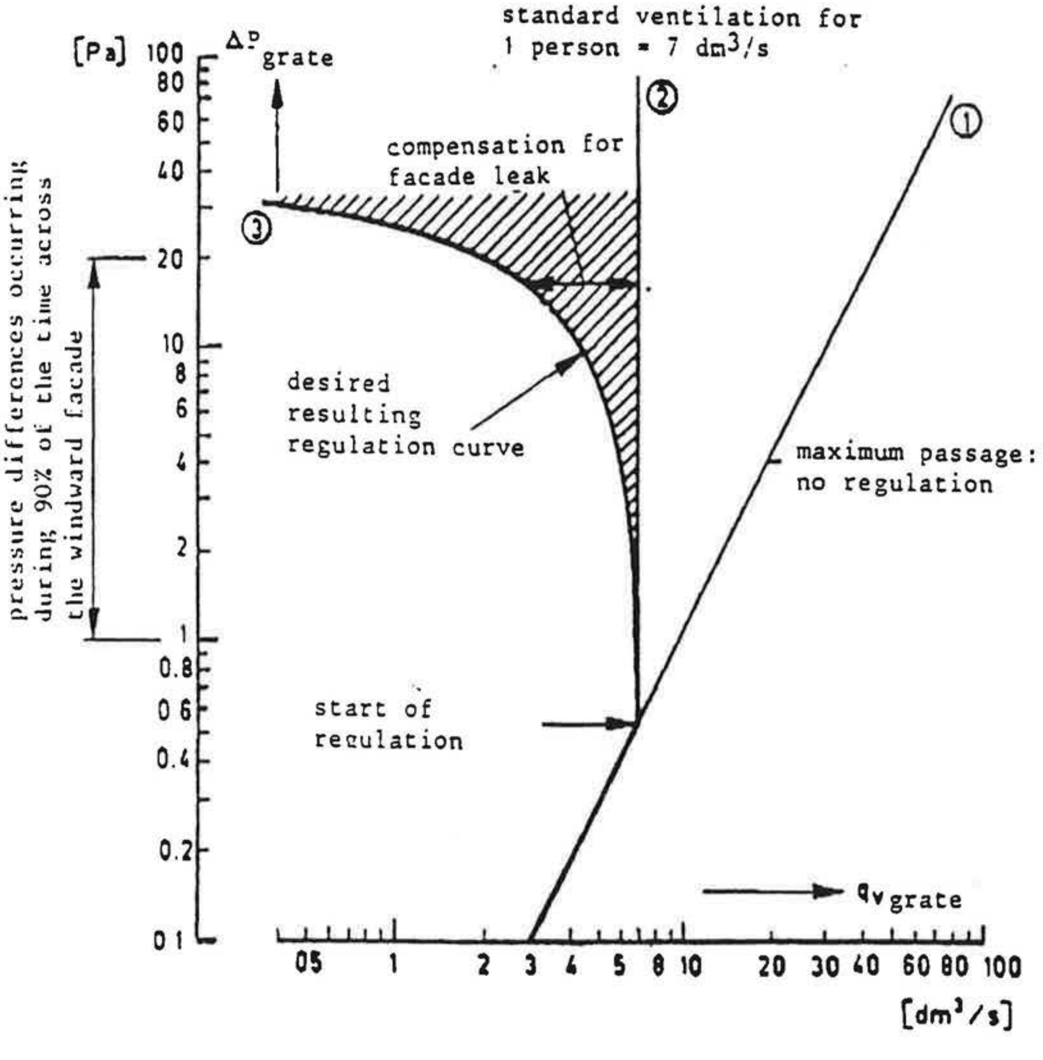

[Pa]
100
80
60
40
20
10
8
6
4
2
1
0.8
0 6
0.4
0.2
0 1
Δp grate
pressure differences occurring during 90% of the time across the windward facade
standard ventilation for 1 person = 7 dm³/s
②
①
compensation for facade leak
③
desired resulting regulation curve
maximum passage: no regulation
start of regulation
qv grate
05
1
2
3
4
5
8
10
20
30
40
60
80
100
[dm³/s]

Fig. 2

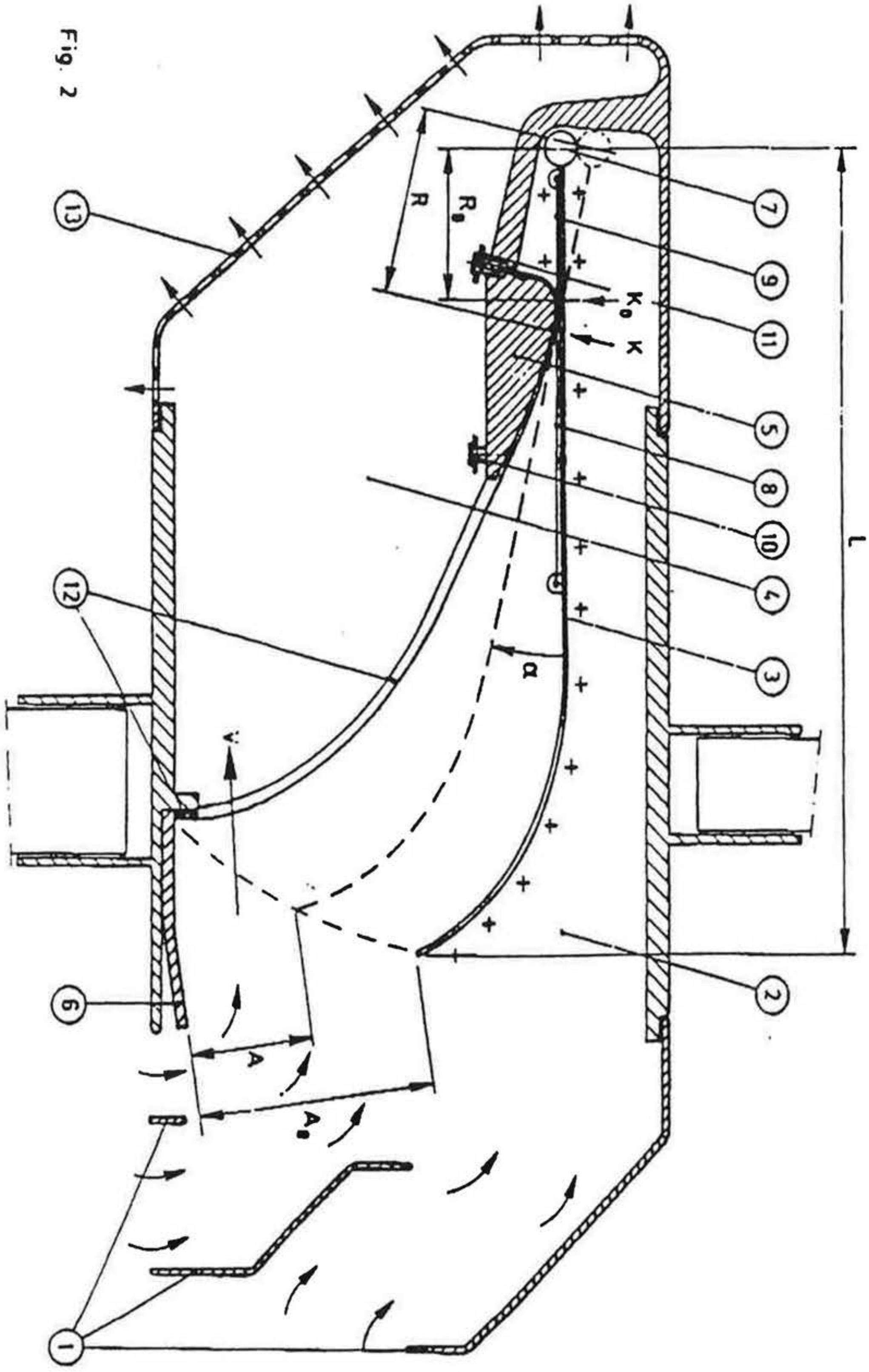
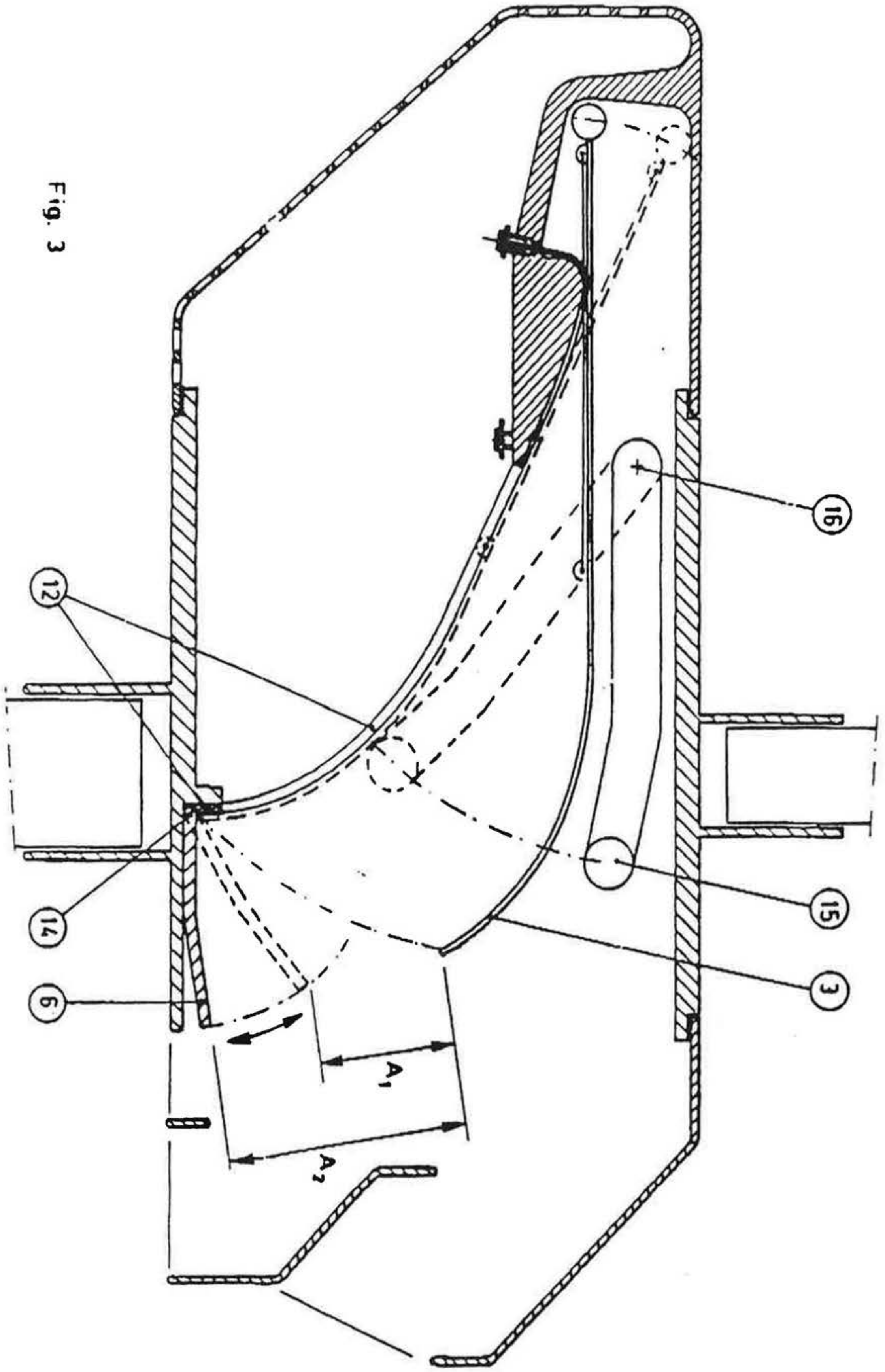


Fig. 3



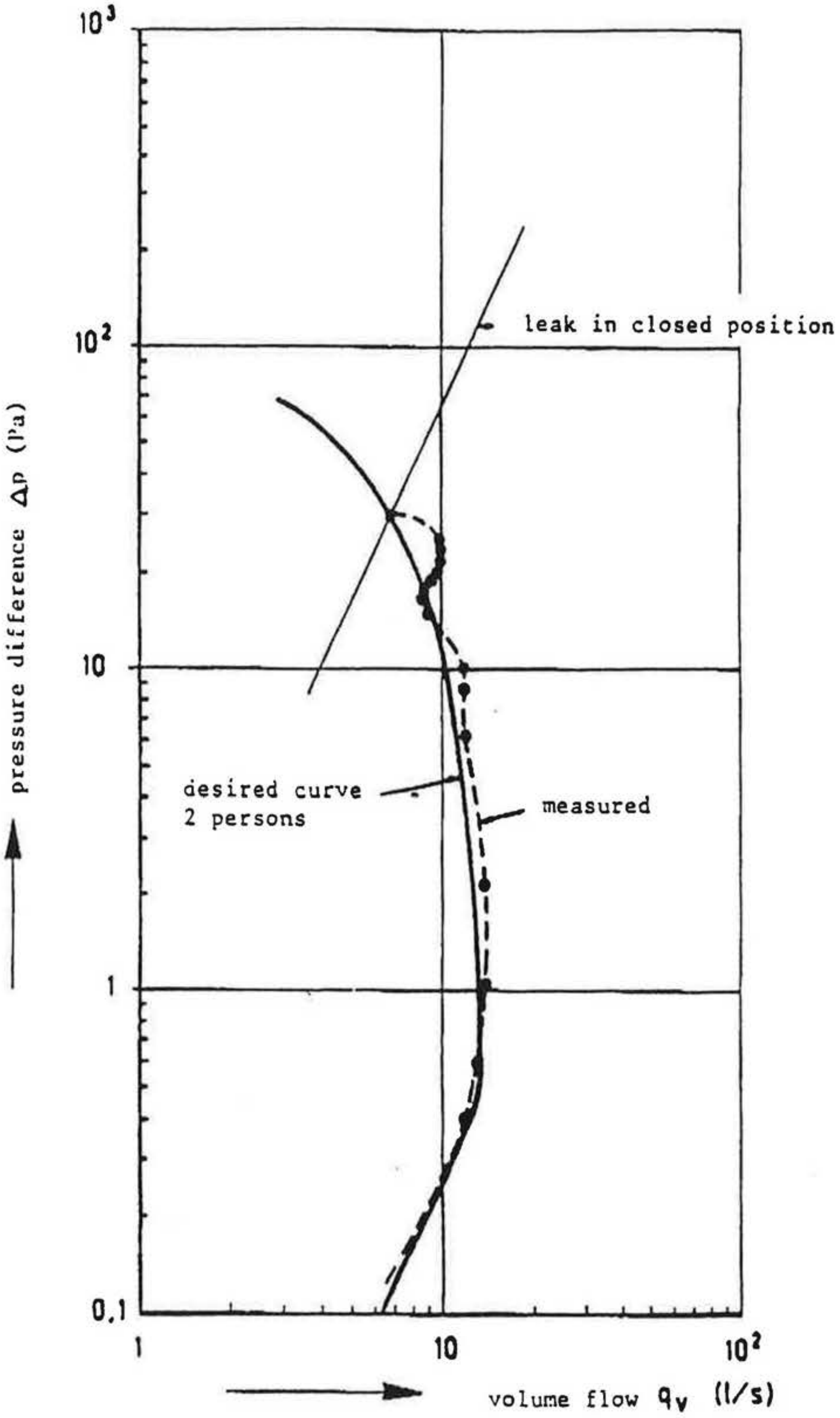


Fig. 4 Measured and desired curve for self regulating grate with unwinding hinge (unwinding surface adjusted with small screws)