

MINIATURIZED DIRECT CURRENT FAN

The invention relates to a miniaturized direct current fan, particularly for ventilating electrical or electronic equipment.

05 Numerous miniaturized direct current fans are known and these generally have a polygonal contour, usually that of a square in an axial plan view on the rotor axis. In such a standardized parallelepipedic casing, there are also standardized mounting holes,
10 quadratically spaced in the corner area of the square contour of the casing. Generally, such blowers are constructed as axial-flow blowers, i.e. the feed direction is parallel to the rotor axis of the drive motor arranged centrally in the casing area. It is
15 not only the square lateral length of the casing, but also the axial length of the square, i.e. the fan casing length in the feed direction, which is generally standardized.

Such fans, generally called electronic fans and
20 constructed in the form of axial-flow blowers, have been used for roughly two decades and are usually operated with alternating current. However, there has of late been an increasing demand for direct current operation of such fans. Alternating current drives
25 for such fans are already known in connection with very small dimensions, an improvement in efficiency being obtained by increasing the frequency. There are

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also already direct current drives for very small fans. However, such known solutions have the disadvantage of a relatively short service life, because they are driven with brush motors and external,
05 complicated electronics are required.

The present invention now provides a direct current fan for ventilating electrical and electronic equipment, comprising a casing containing a central, flange mounted, external rotor type drive motor with
10 an impeller fixed thereto, which drive motor is a brushless direct current motor for one or two-pulse operation having a cylindrical air gap between rotor and stator and a bearing member injection moulded in plastics in one piece with the flange holding the
15 motor and impeller and surrounding a bearing for a central rotor shaft of the motor, wherein a stator winding of the motor closely surrounds the bearing member.

Preferably, the fan further comprises a casing
20 defining a cylindrical flow duct surrounding the impeller, the diameter of the impeller essentially corresponding to the diameter of said duct, which duct on the outlet side, is widened to approach corners of the casing in such a way that said enlargements extend
25 radially beyond the impeller.

Alternatively, the fan may further comprise a

casing defining a flow duct about the impeller such that the cross-section of the flow duct decreases in the flow direction initially in the manner of a Venturi tube to a minimum circular cross-section and
 05 from there widens to the outlet cross-section, the radial outer edges of the impeller blades passing close to the inner wall of the duct.

The flow duct may be widened on the outlet side to approach the corners of the casing in such a way
 10 that the enlargements extend radially substantially beyond the impeller.

The smaller the blower, particularly the axial-flow fan, the more noticeable the advantages in the case of a solution of this type. (However, the
 15 arrangement is not limited to axial-flow blowers, because the same advantages, at least with respect to the compactness of the motor to be driven and the integration of the motor electronics in the mounting flange of the motor can be obtained in the case of a
 20 very small diameter radial blower). However, the two combination features of motor and such a casing configuration have a particularly advantageous effect in the case of a very small fan, e.g. less than 70 x 70 mm and with an axial length of 15 to 30 mm.

25 More preferably, the base area of casing is about 3844 mm² and the axial length of the fan is

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about 25 mm.

Thus, such a motor with one or two pulses per 360° can have very reduced electronics, which can be economically and advantageously housed in the motor, above all in the flange, particularly in the case of mass production so that, unlike in the case of known solutions, no external electronics are required.

In addition, the casing configuration with such a small fan and particularly with a ratio of the diameter of the central drive unit to the impeller diameter of approximately 1:2 (or greater than 0.5) is particularly advantageous, the latter applying equally to radial and axial-flow blowers.

The drive motor may be for two-pulse operation with a magnetic resistance of the stator which is variable over the rotation angle for producing an auxiliary reluctance moment, which is staggered in time with respect to the electrodynamic torque.

The fan casing surrounding the impeller may be injection moulded in one piece with the flange, so that casing, flange and bearing member systems form a single plastics part.

Preferably the fan is arranged as an axial flow blower.

Preferably electronic circuitry includes only two power transistors.

Preferably, said circuitry includes only one motor position sensor.

Preferably, said electronic circuitry includes a PTC resistor in the power feed to the motor close to
05 the voltage source.

Preferably, said motor includes a serially wound bifilar stator winding.

Said bearing member is preferably a tube.

The ratio of the diameter of the central
10 drive motor to the diameter of the impeller is preferably about 1:2.

Alternatively, the ratio of the diameter of the central drive motor to the diameter of the impeller may be greater than 0.5.

15 Embodiments of the invention are described hereinafter with reference to the drawings, in which:

Fig. 1 shows one example of an embodiment of a fan according to the invention in a full size plan view of the outlet side.

20 Fig. 2 shows a section along the line II-II of Fig. 1.

Fig. 3 shows a section along the line II-II of Fig. 1 through a fan according to the invention with a different blow duct configuration.

25 Fig. 4 shows a circuit diagram for the drive motor.

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Fig. 5 shows an alternative circuit diagram of the drive motor.

Fig. 6 shows a diagram of the feed characteristic of the fan according to the invention.

05 A fan 1 (Figs. 1 and 2) comprises a casing 2, whose webs 3 connect said casing 2 to a centrally arranged motor 5, via a flange 4. These webs 3 are positioned on the outlet side, so that the noise produced by the air movement is reduced. Casing 2,
10 webs 3 and flange 4 are preferably constructed in one piece.

Motor 5 is an external rotor-type motor, which will be described in greater detail hereinafter. An impeller 6 is fixed (bonded or shrunk-on) to the outer
15 casing of motor 5. Impeller 6 preferably has seven fan blades 7, which are distributed in irregular manner around the periphery, thereby damping annoying pure tones.

Between the fan blade 7 and the inner wall 8 of
20 casing 2 is formed a substantially cylindrical flow duct. The external diameter of impeller 6 (outer fan blade diameter) is to be only slightly smaller than the diameter of the inner wall 8 of casing 2, in order to optimize the air flow (Fig. 2). Very good results
25 are obtained if casing 2 and impeller 6, including its fan blade 7, are produced from glass fibre-reinforced

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plastic by the injection moulding process.

The feed capacity of the fan is further increased if, at least on the outlet side of the flow duct, widening takes place in contour corners 9 of casing 2 in such a way that the widened or enlarged portions 10 extend significantly beyond the diameter of impeller 6,7. This corner widening particularly helps to improve the efficiency in the case of fans of this type (base area 62 x 62 mm, axial length 25 mm). On the inlet and/or outlet side of contour corners 9 are also provided mounting holes 11.

Ball bearings 12 are used for mounting the rotor of motor 5, which rotates at a speed of approximately 5000 r.p.m. Cheaper sliding bearings, which are used in the case of larger fans, are not suitable here, particularly due to the high speeds.

The ball bearings 12 are placed in a bearing tube 99, whose external diameter is reduced in the vicinity of the stator laminations, in order to obtain an adequate iron cross-section for the magnetic circuit there by means of the slot bottom in the stator, which should be as close as possible to rotor shaft 19. Bearing tube 99 is injection moulded in one piece with flange 4. Surprisingly, this has adequate precision and thermal stability for continuous operation in

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conjunction with a brushless D.C. motor operated in a one-pulse or two-pulse manner. The casing, flange, webs and bearing tube form a single plastics moulding. Bearing tube 99 has injection moulded shoulders 99A, 99B and 99C for the engagement of bearings and stator. the flow direction is indicated by arrows 13 and 14.

Fig. 3 shows another embodiment according to the invention. A fan 21 comprises a casing 22, which has webs 23, which pass over into a flange 24, provided centrally with respect to the square base area of casing 22 (corresponding to Fig. 1). Casing 22, webs 23 and flange 24 are in one piece and a motor 25 is fixed to flange 24. An impeller 26 with fan blades 27 are fitted to the outer casing of the motor. In this case, the flow duct 28 is in the form of a Venturi tube and on the outlet side, in accordance with the embodiment of Figs. 1 and 2 of flow duct 18, enlargements 30 are provided into the contour corners 9 of casing 22. On the inlet and outlet sides of contour corners 29, there are mounting holes 31 (spacing 50 x 50 mm).

Motor 5, 25 is a commutatorless d.c. motor for one or two-pulse operation with a so-called auxiliary reluctance moment, which is brought about in that the electrodynamic moment from the stator winding only has an a.c. field and the magnetic resistance of the

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magnetic circuit in the stator region is so modified over the rotation position of the impeller, that magnetic energy is stored for as long as the electrodynamic moment drives in pulsewise manner and
05 in the pulse gaps, the stored magnetic energy is freed again by the cooperation of the rotor permanent magnets with the stator iron accompanied by torque formation. Such motors are described in detail in GB Patent Specification 1392582. The electronics for
10 controlling such a motor (described in British Patent Application 8108534) require fewer components than conventional d.c. motors of this type, so that it is possible to house within the external dimensions of casing 2, 22 of fan 1, 21 the electronics for
15 commutating the motor, in fact within the motor, above all in the vicinity of the flange 4. The European Patent Application 82111882.5 (published specification 0084156) discloses a commutation unit with few elements, which can be used to good effect here.

20 In principle, it is also possible to use advantageously for this purpose, the commutation circuit according to US Patent Specification 3873898 or DE OS 2263242 and 2460419.

To avoid unnecessary length, reference is made to
25 the aforementioned publications (eg GB Patent Specification 1456546) and particularly to Figs. 6 and 7 of

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GB Patent Application 8108534. Due to lack of space, the relatively large capacitors 68, 74 (Fig. 6 of GB Patent Application 8108534) used for blocking purposes are omitted and replaced by a PTC-resistor 78 in the
05 positive line 33.

Fig. 4 shows such a circuit, in which there is a matching network 65 comprising three resistors. From output 50 of Hall-IC's 55, a resistor 66 leads to the positive line 33, a resistor 67 to the base of a pnp-
10 transistor 69, said base being connected across a bleeder resistor 70 to the positive line 33 to which is also applied the emitter of transistor 69. The Hall IC 55 serving as a rotor position-dependent sensor is connected with one terminal to the negative
15 line 35 and with the other terminal, across a resistor 48 to the positive lines 33. Parallel thereto is provided a Zener diode 49, which regulates the voltage at Hall IC 55. In addition, from output 50, a resistor 73 leads to the base of an npn transistor 75,
20 which is also connected across a bleeder resistor 76 to the negative line 35, to which is also applied the emitter of said transistor. The collector of transistor 69 is connected to terminal a1 of winding strand W1, whilst the collector of transistor 75 is
25 connected to terminal a2 of winding strand W2. The free-running diodes 49 and 60 are connected in

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antiparallel to the associated transistors 69 or 75. Coupling capacitor 47 is positioned between terminals a1 and a2.

If on starting, a north pole e.g. faces Hall IC
05 55, its output potential becomes low and it approximately assumes the potential of negative line 35. Thus, a charging current flows across the emitter-base junction of transistor 69 and makes the latter conductive, so that a current flows in winding
10 strand W1. If this current is subsequently switched off, the energy from winding strand W1 is recovered by coupling capacitor 47 and diode 60 via the transformer coupling. Transistor 75 is then conductively controlled. If the rotor is blocked, the conductive
15 transistor 69 or 75 still receives part of the relatively high starting current, but very rapidly heats the PTC-resistor 78 located at the input, so that its resistance rises sharply in accordance with its characteristic curve and consequently the actual
20 current in the blocked state is reduced to 10 to 20% of the "normal" short-circuit current value. Thus, the current acting on transistor 69, 75 is so low that they are not thermally endangered.

The circuit according to Fig. 4 represents an
25 economically advantageous solution for such a miniaturized fan, because the relatively few

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components have to be housed in space-saving manner in the flange of the very small drive motor, despite fulfilling the requirements of blocking protection and protection against wrong poles (by means of the PTC-resistor 78 located at the input and which is also housed in this flange).

A further reduction of the components is achieved with a circuit according to Fig. 5. A parallel-wire winding (so-called bifilar winding) makes it possible to use smaller capacitors, whilst the number of capacitors can be reduced. Through the use of the PTC-resistor 78 and the bifilar windings (W_1', W_2'), there is no need for the capacitors 45, 47, 68, 74 used in GB Patent Application 8108534 (Fig. 6).

In place of the simple transistors 69, 75 according to Fig. 4, in this case complementary Darlington transistors 80, 81 are used and preferably those types already contained in the bleeder resistors 80', 81' and the free-running diodes 80'', 81''. As the Darlington transistors have a much greater current amplification than ordinary transistors, they can also be controlled with higher impedance RC-elements.

The Hall IC is constituted by a type having integrated voltage stabilization (e.g. UGN 3016 "Sprague"), so that diode 49 (Fig. 4) is rendered

superfluous.

The resistance network 82 serving as a matching element can in principle be constructed here in the same way as network 65 of Fig. 4. Junction 83 is
 05 connected across a resistor 85 to the positive line 33, across a resistor 86 to the base of the transistor 80 and across a resistor 88 to the base of transistor 81. The arrangement of capacitors 16, 17 between the bases of transistors 80, 81 and lines 33, 35 improves
 10 the switching behaviour.

The emitter of the pnp-transistor 80 is here again connected to the positive line 33, its collector is connected to terminal a1 of a winding strand W₁', and the emitter of the npn-transistor 81 is connected
 15 to the negative line 35, whilst its collector is connected to terminal a2 of winding strand W₂'.

Fig. 6 shows the feed characteristic of a fan according to the invention with external dimensions 62 x 62 x 25 mm and with a speed of 5000/6000 r.p.m.
 20 for 12/13V d.c.

In place of the aforementioned two-pulse, commutatorless d.c. motor with an auxiliary reluctance moment, which is advantageously constructed in accordance with GB Patent Specification 1392582 which
 25 is hereby incorporated into the present application, it is also possible to operate with a two-pulse

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commutatorless d.c. motor without an auxiliary reluctance moment, e.g. in accordance with GB Patent Specification 2000646 which is also incorporated into the present application. In conjunction with said
05 motor, the central bearing tube can also be made from plastic material and is moulded in one piece with the flange, webs and outer casing. However, particular advantages are obtained with a two-pulse, auxiliary reluctance moment motor, because its efficiency is
10 particularly high (particularly if in accordance with GB Patent Specification 1392582) and its heating is correspondingly low, whereby a relatively high stability of the bearing tube is ensured. It is evident that the outer contour of the fan casing does
15 not affect the stability of the bearing support tube nor the accommodation of the commutating electrics within the motor. A so-called onepulse motor is described in GB Patent Specification 1456546.

It can be seen that there has been described with
20 reference to the drawings a very small axial flow fan, with dimensions of less than 80 x 80 x 35 mm, a blower unit which can be produced economically and advantageously and which has a very long service life, low consumption, a compact overall arrangement (i.e.
25 the complete drive electronics for the fan can be housed in the square area), a higher blower efficiency, a good feed characteristic (volume per second under variable pressure) and a moderate power consumption (approximately constant with variable speed).

CLAIMS

1. A direct current fan for ventilating electrical and electronic equipment, comprising a casing containing a central, flange mounted, external rotor
05 type drive motor with an impeller fixed thereto, which drive motor is a brushless direct current motor for one or two-pulse operation having a cylindrical air gap between rotor and stator and a bearing member injection moulded in plastics in one piece with the
10 flange holding the motor and impeller and surrounding a bearing for a central rotor shaft of the motor, wherein a stator winding of the motor closely surrounds the bearing member.

2. A direct current fan as claimed in Claim 1
15 further comprising a casing defining a cylindrical flow duct surrounding the impeller, the diameter of the impeller essentially corresponding to the diameter of said duct, which duct on the outlet side, is widened to approach corners of the casing in such a
20 way that said enlargements extend radially beyond the impeller.

3. A direct current fan as claimed in Claim 1, further comprising a casing defining a flow duct about the impeller such that the cross-section of the flow
25 duct decreases in the flow direction initially in the manner of a Venturi tube to a minimum circular cross-section and from there widens to the outlet



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cross-section, the radial outer edges of the impeller blades passing close to the inner wall of the duct.

4. A direct current fan as claimed in Claim 3 wherein the flow duct is widened on the outlet side to
05 approach the corners of the casing in such a way that the enlargements extend radially substantially beyond the impeller.

5. A direct current fan as claimed in any preceding claim, wherein the base area of the casing is no
10 greater than 4900 mm^2 and the axial length of the fan is in the range 15 to 30 mm.

6. A direct current fan as claimed in Claim 5, wherein the base area of casing is about 3844 mm^2 and the axial length of the fan is about 25 mm.

15 7. A direct current fan as claimed in any preceding claim, wherein the drive motor is for two-pulse operation with a magnetic resistance of the stator which is variable over the rotation angle for producing an auxiliary reluctance moment, which is
20 staggered in time with respect to the electrodynamic torque.

8. A direct current fan as claimed in any preceding claim, wherein the fan casing surrounding the impeller is injection moulded in one piece with the flange, so
25 that casing, flange and bearing member systems form a single plastics part.



9. A direct current fan as claimed in any preceding claim arranged as an axial flow blower.
10. A direct current fan as claimed in any one of Claims 1 to 8, arranged as a radial flow blower.
- 05 11. A direct current fan as claimed in any preceding claim further including electronic circuitry for control thereof.
12. A direct current fan as claimed in Claim 11, wherein said circuitry is mounted on said flange.
- 10 13. A direct current fan as claimed in Claim 11 or Claim 12, wherein the said electronic circuitry includes only two power transistors.
14. A direct current fan as claimed in any one of Claims 11 to 13, wherein said circuitry includes only
- 15 one motor position sensor.
15. A direct current fan as claimed in any one of Claims 11 to 14, wherein said electronic circuitry includes a PTC resistor in the power feed to the motor close to the voltage source.
- 20 16. A direct current fan as claimed in any preceding claim, wherein said motor includes a serially wound bifilar stator winding.
17. A direct current fan as claimed in any preceding claim, wherein said bearing member is a tube.
- 25 18. A direct current fan as claimed in any preceding claim wherein the ratio of the diameter of the central



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drive motor to the diameter of the impeller is about 1:2.

19. A direct current fan as claimed in any one of Claims 1 to 18 wherein the ratio of the diameter of
05 the central drive motor to the diameter of the impeller is greater than 0.5.

20. A fan substantially as hereinbefore described with reference to and as illustrated in Figures 1 and 2, or Figure 3 of the accompanying drawings,
10 optionally including electronic circuitry substantially as described with reference to and illustrated in Figure 4 or Figure 5.

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