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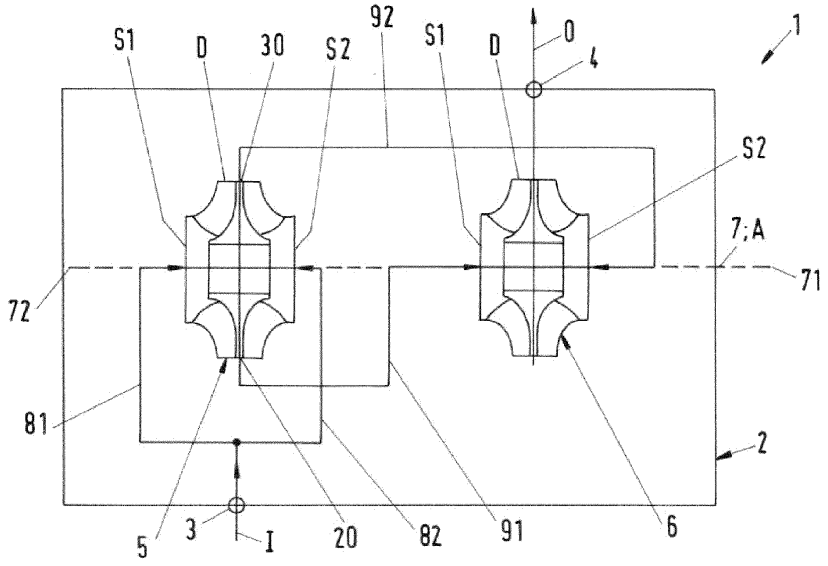
(54) MULTISTAGE CENTRIFUGAL PUMP FOR CONVEYING A FLUID

(57) A multistage centrifugal pump for conveying a fluid is proposed, comprising a pump housing (2) with an inlet (3) and an outlet (4) for the fluid, a first stage impeller (5) and a second stage impeller (6) for conveying the fluid from the inlet (3) to the outlet (4), and a shaft (7) for rotating each impeller (5, 6) about an axial direction (A), wherein each impeller (5, 6) is configured as a double suction impeller (6), having a first suction side (S1), a second suction side (S2) for receiving the fluid and a discharge side (D) for discharging the fluid, wherein the discharge side (D) of the first stage impeller comprises two separate exits, namely a first exit (20) for discharging the fluid into a first crossover line (91), and a second exit (30) for discharging the fluid into a second crossover line (92), wherein the first crossover line (91) is in fluid communication with the first suction side (S1) of the second stage impeller (6), and the second crossover line (92) is in fluid communication with the second suction side (S2) of the second stage impeller (6).

Fig.1



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Description

[0001] The invention relates to a multistage centrifugal pump for conveying a fluid in accordance with the preamble of the independent claim.

[0002] Centrifugal pumps for conveying a fluid, for example a liquid such as water, are used in many different industries. Examples are the oil and gas industry, the power generation industry, the chemical industry, the water industry or the pulp and paper industry. Multistage centrifugal pumps have at least two impellers and a shaft for rotating the impellers. The impellers may be configured for example as radial impellers or as axial or semi-axial impellers or as helicoaxial impellers. Furthermore, the impellers may be configured as open impellers or as a closed impellers, where a shroud is provided on the impeller, said shroud at least partially covering the vanes of the impeller, or as a semi-open impeller.

[0003] Furthermore, it is known to configure an impeller as a single suction impeller or as a double suction impeller. In the case of a single suction impeller the fluid approaches the impeller only from one side, i.e. the impeller has only one suction side. In the case of a double suction impeller the fluid approaches the impeller from both sides, i.e. the impeller has two suction sides. It is also known to design centrifugal pumps with a combination of single suction impeller(s) and double suction impellers.

[0004] In a multistage centrifugal pump a plurality of impellers is mounted to the shaft in a torque proof manner, wherein the impellers are arranged in series on the shaft.

[0005] Many multistage centrifugal pumps are provided with at least one balancing arrangement for at least partially balancing the axial thrust that is generated by the impellers during operation of the pump. The balancing arrangement shall reduce the total axial thrust generated by the rotating impellers (hydraulic forces) and acting on the axial bearing or the thrust bearing. The residual thrust needs to be absorbed by the bearing, whose size, weight and cost is proportional to the magnitude of said residual thrust, hence there is a need of reducing the residual thrust as much as possible. Besides this, high forces are associated with higher mechanical losses that ultimately reduce the efficiency of the pump.

[0006] It is known to balance the axial thrust to a good extent by a proper disposition of the impellers, for example by an back-to-back arrangement, whereby the thrust generated by one impeller is at least partially compensated by an equivalent but opposite force acting on another impeller fitted symmetrically on the shaft.

[0007] Problems occur with this kind of balancing the axial thrust for example in two stage pumps, when the first stage impeller is configured as a double suction impeller because in such configurations the second stage impeller is usually configured as a single suction impeller. In such a combination of a double suction first stage impeller and a single suction second stage impeller the rotor of the pump (comprising both impellers) is inherently unbalanced regarding the axial thrust, because the single suction impeller of the second stage is unbalanced. This asymmetry generates a considerable residual axial thrust on the rotor, which should be reduced for example by means of a balancing device such as a balance drum or a center bush. However, such balance devices have a negative impact on the efficiency of the pump. Another means for handling the residual axial thrust is to provide strong or properly sized bearings, which can absorb the residual thrust. However, this measure, too, may have a negative impact on the overall efficiency of the pump, because of higher mechanical losses associated with higher bearing loading.

[0008] Starting from this state of the art, it is therefore an object of the invention to propose a multistage centrifugal pump for conveying a fluid, providing a better balancing of the axial thrust and avoiding said drawbacks of prior art embodiments.

[0009] The subject matter of the invention satisfying this object is characterized by the features of the independent claim.

[0010] Thus, according to the invention, a multistage centrifugal pump for conveying a fluid is proposed, comprising a pump housing with an inlet and an outlet for the fluid, a first stage impeller and a second stage impeller for conveying the fluid from the inlet to the outlet, and a shaft for rotating each impeller about an axial direction, wherein each impeller is configured as a double suction impeller, having a first suction side, a second suction side for receiving the fluid, and a discharge side for discharging the fluid, wherein the discharge side of the first stage impeller comprises two separate exits, namely a first exit for discharging the fluid into a first crossover line, and a second exit for discharging the fluid into a second crossover line, wherein the first crossover line is in fluid communication with the first suction side of the second stage impeller, and the second crossover line is in fluid communication with the second suction side of the second stage impeller.

[0011] The configuration according to the invention enables a fully symmetric design of the hydraulics of the multistage pump, thus providing a balancing of the axial thrust generated by the rotating impellers. At the discharge side of the first stage impeller the fluid discharged from the discharge side is divided by the two separate exits. A part of the fluid flows through the first exit into the first crossover line and is supplied to the first suction side of the second stage impeller, and another part of the fluid flows through the second exit into the second crossover line and is supplied to the second suction side of the second stage impeller.

[0012] This fully symmetric design results - at least approximately - to a complete balancing of the axial thrust so that the residual thrust equals zero.

[0013] Preferably, the first crossover line and the second crossover line are arranged within the pump housing. Each crossover line may be configured as a channel, for example as a channel delimited by the pump housing,

wherein said channel guides the fluid from the discharge side of the first stage impeller to the first or the second suction side of the second stage impeller. Arranging the crossover lines inside the pump housing has the advantage that bulky and heavy external pipes may be avoided which considerably reduces the weight of the pump and also the manufacturing costs.

[0014] According to a preferred configuration the pump has a first volute for guiding a first stream of the fluid from the discharge side of the first stage impeller into the first crossover line, and a second volute for guiding a second stream of the fluid into the second crossover line. Since the first and the second volute transform kinetic energy of the fluid into pressure the efficiency of the pump is enhanced.

[0015] In order to minimize the radial hydraulic force acting on the first stage impeller it is preferred that the first exit and the second exit are displaced by 180° with respect to each other, when viewed in a circumferential direction of the first stage impeller.

[0016] Furthermore it is a preferred design that the first suction side of the first stage impeller is in fluid communication with the inlet by means of a first suction line, and the second suction side of the first stage impeller is in fluid communication with the inlet by means of a second suction line, wherein the first suction line and the second suction line are arranged within the pump housing. Each suction line may be configured as a channel, for example as a channel delimited by the pump housing, wherein said channel guides the fluid entering through the inlet to the first or the second suction side of the first stage impellers.

[0017] According to a preferred embodiment the centrifugal pump has exactly two impellers, namely the first stage impeller and the second stage impeller. However, it has to be noted that the centrifugal pump according to the invention may also be configured with more than two stages

[0018] Preferably the multistage centrifugal pump is configured as a between-bearing pump.

[0019] Further advantageous measures and embodiments of the invention will become apparent from the dependent claims.

[0020] The invention will be explained in more detail hereinafter with reference to an embodiment of the invention and with reference to the drawings. There are shown in a schematic representation:

Fig. 1: a first embodiment of a multistage centrifugal pump according to the invention, and

Fig. 2: a cross-sectional view of the first stage impeller in a section perpendicular to the axial direction.

[0021] Fig. 1 shows a schematic representation of an embodiment of a multistage centrifugal pump according to the invention, which is designated in its entity with reference numeral 1. The pump 1 is designed as a centrifugal pump for conveying a fluid, for example a liquid such as water.

[0022] The multistage centrifugal pump 1 comprises a pump housing 2 having an inlet 3 and an outlet 4 for the fluid to be conveyed. The centrifugal pump 1 further comprises a first stage impellers 5 and second stage impeller 6, as well as a shaft 7 for rotating the impellers 5, 6 about an axial direction A. The axial direction A is defined by the axis of the shaft 7. Each impeller 5, 6 is mounted to the shaft 7 in a torque proof manner. The shaft 7 has a drive end 71, which may be connected to a drive unit (not shown) for driving the rotation of the shaft 7 about the axial direction A. The drive unit may comprise, for example, an electric motor. The other end of the shaft 7 is referred to as non-drive end 72.

[0023] In this embodiment the multistage centrifugal pump 1 is configured as a two stage pump with the first stage impeller 5 and the second stage impeller 6. In other embodiments the multistage centrifugal pump according to the invention may be configured with more than two stages.

[0024] Both the first stage impeller 5 and the second stage impeller 6 are configured as a double suction impeller, i.e. the fluid approaches the particular impeller 5 or 6 from both sides regarding the axial direction A. Thus, both the first stage impeller 5 and the second stage impeller 6 have a first suction side S1 on the left side in Fig. 1 and a second suction side S2 at the right side in Fig. 1. In addition, each impeller 5 and 6 has a discharge side D at the radially outer region of the particular impeller 5 or 6, where the fluid exits the impeller 5 or 6.

[0025] Generally speaking the suction sides S1, S2 are these sides where the eyes of the impellers 5 or 6 are arranged, i.e. the sides, from which the fluid approaches the impeller 5 or 6. The discharge side D is the side where the fluid is discharged from the impeller 5 or 6.

[0026] The discharge side D of the second stage impeller 6 is in fluid communication with the outlet 4 of the pump 1. The outflow of the fluid discharged through the outlet 4 is indicated by the arrow O in Fig. 1. Each of the suction sides S1 and S2 of the first stage impeller 5 is in fluid communication with the inlet 3. A first suction line 81 constitutes the fluid communication between the inlet 3 and the first suction side S1 of the first stage impeller 5, and a second suction line 82 constitutes the fluid communication between the inlet 3 and the second suction side S2 of the first stage impeller 5. Each suction line 81, 82 may be configured as a channel which is delimited by the pump housing 2 or an inlet housing (not shown) that is part of the pump housing 2. The inflow I of the fluid to be conveyed enters the pump housing 2 through the inlet 3 and is then divided in a first stream passing through the first suction line 81 and a second stream passing through the second suction line 82.

[0027] For a better understanding Fig. 2 shows a cross-sectional view of the first stage impeller 5in a section perpendicular to the axial direction A.

[0028] The discharge side D of the first stage impeller

5 comprises two separate exits, namely a first exit 20 and a second exit 30. Through the first exit 20 a part of the fluid is discharged into a first crossover line 91 (see Fig. 1). Through the second exit 30 a part of the fluid is discharged into a second crossover line 92. The first crossover line 91 is connected to the first suction side S1 of the second stage impeller 6 and the second crossover line 92 is connected to the second suction side S2 of the second stage impeller 6. Thus, during operation the flow of the fluid leaving the discharge side D of the first stage impeller 5 is divided in a first stream leaving the discharge side D of the first stage impeller 5 through the first exit 20 and a second stream leaving the discharge side D of the first stage impeller 5 through the second exit 30. By means of the first crossover line 91 the first stream is guided to the first suction side S1 of the second stage impeller 6. By means of the second crossover line 92 the second stream is guided to the second suction side S2 of the second stage impeller 6.

[0029] Due to this symmetric arrangement the resulting axial thrust acting upon the pump shaft and the bearing is at least considerably reduced.

[0030] The residual thrust generated by the first stage impellers 5 is at least approximately zero due to the double suction design. Since the second stage impeller 6 is also configured as a double suction impeller 6 with the first suction side S1 and the second suction side S2, the residual axial thrust generated by the second stage impeller 6 is also at least approximately zero.

[0031] It has to be noted that each of the crossover lines 91, 92 is preferably configured as an internal line completely arranged inside the pump housing 2.

[0032] The centrifugal pump 1 comprises bearings (not shown) on both ends of the shaft 7, namely at or near the non-drive end 72 of the shaft, and near the drive end 71 of the shaft 7, i.e. the centrifugal pump 1 is designed as a between-bearing pump.

[0033] During operation of the multistage pump 1 the inflow I of the fluid enters the pump housing 2 through the inlet 3 and is then divided into a part passing through the first suction line 81 to the first suction side S1 of the first stage impeller 5 and another part passing through the second suction line 82 to the second suction side S2 of the first stage impeller 5.

[0034] At the discharge side D of the first stage impeller 5 the first stream is discharged through the first exit 20 in the first crossover line 91 and guided to the first suction side S1 of the second stage impeller 6. The second stream is discharged at the discharge side D of the first stage impeller 5 through the second exit 30 in the second crossover line 92 and guided to the second suction side S2 of the second stage impeller 6. At the second stage impeller 6 the first stream and the second stream are reunited with each other and leave the pump 1 through the outlet 4 as outflow O.

[0035] According to a preferred embodiment and as it is shown in Fig. 2 the multistage pump 1 has a first volute 21 for guiding the first stream of the fluid from the discharge side D of the first stage impeller 5 into the first crossover line 91, and a second volute 31 for guiding the second stream of the fluid from the discharge side D of the first stage impeller 5 into the second crossover line 92.

[0036] Furthermore, in view of a very symmetric design it is a preferred measure that the first exit 20 and the second exit 30 are displaced by 180° with respect to each other, when viewed in a circumferential direction of the first stage impeller 5.

Claims

1. A multistage centrifugal pump for conveying a fluid, comprising a pump housing (2) with an inlet (3) and an outlet (4) for the fluid, a first stage impeller (5) and a second stage impeller (6) for conveying the fluid from the inlet (3) to the outlet (4), and a shaft (7) for rotating each impeller (5, 6) about an axial direction (A), wherein each impeller (5, 6) is configured as a double suction impeller (6), having a first suction side (S1), a second suction side (S2) for receiving the fluid and a discharge side (D) for discharging the fluid, **characterized in that** the discharge side (D) of the first stage impeller comprises two separate exits, namely a first exit (20) for discharging the fluid into a first crossover line (91), and a second exit (30) for discharging the fluid into a second crossover line (92), wherein the first crossover line (91) is in fluid communication with the first suction side (S1) of the second stage impeller (6), and the second crossover line (92) is in fluid communication with the second suction side (S2) of the second stage impeller (6).

2. A multistage centrifugal pump in accordance with claim 1 ,wherein the first crossover line (91) and the second crossover line (92) are arranged within the pump housing (2).

3. A multistage centrifugal pump in accordance with anyone of the preceding claims, having a first volute (21) for guiding a first stream of the fluid from the discharge side (D) of the first stage impeller (5) into the first crossover line (91), and a second volute (31) for guiding a second stream of the fluid into the second crossover line (92).

4. A multistage centrifugal pump in accordance with anyone of the preceding claims, wherein the first exit (20) and the second exit (30) are displaced by 180° with respect to each other, when viewed in a circumferential direction of the first stage impeller (5).

5. A multistage centrifugal pump in accordance with anyone of the preceding claims, wherein the first suction side (S1) of the first stage impeller (5) is in fluid communication with the inlet (3) by means of a first suction line (81), wherein the second suction side

(S2) of the first stage impeller (5) is in fluid communication with the inlet (3) by means of a second suction line (82), and wherein the first suction line (81) and the second suction line (82) are arranged within the pump housing (2).

6. A multistage centrifugal pump in accordance with anyone of the preceding claims, having exactly two impellers (5, 6), namely the first stage impeller (5) and the second stage impeller (6).

7. A multistage centrifugal pump in accordance with anyone of the preceding claims, configured as a between-bearing pump.

Fig.1

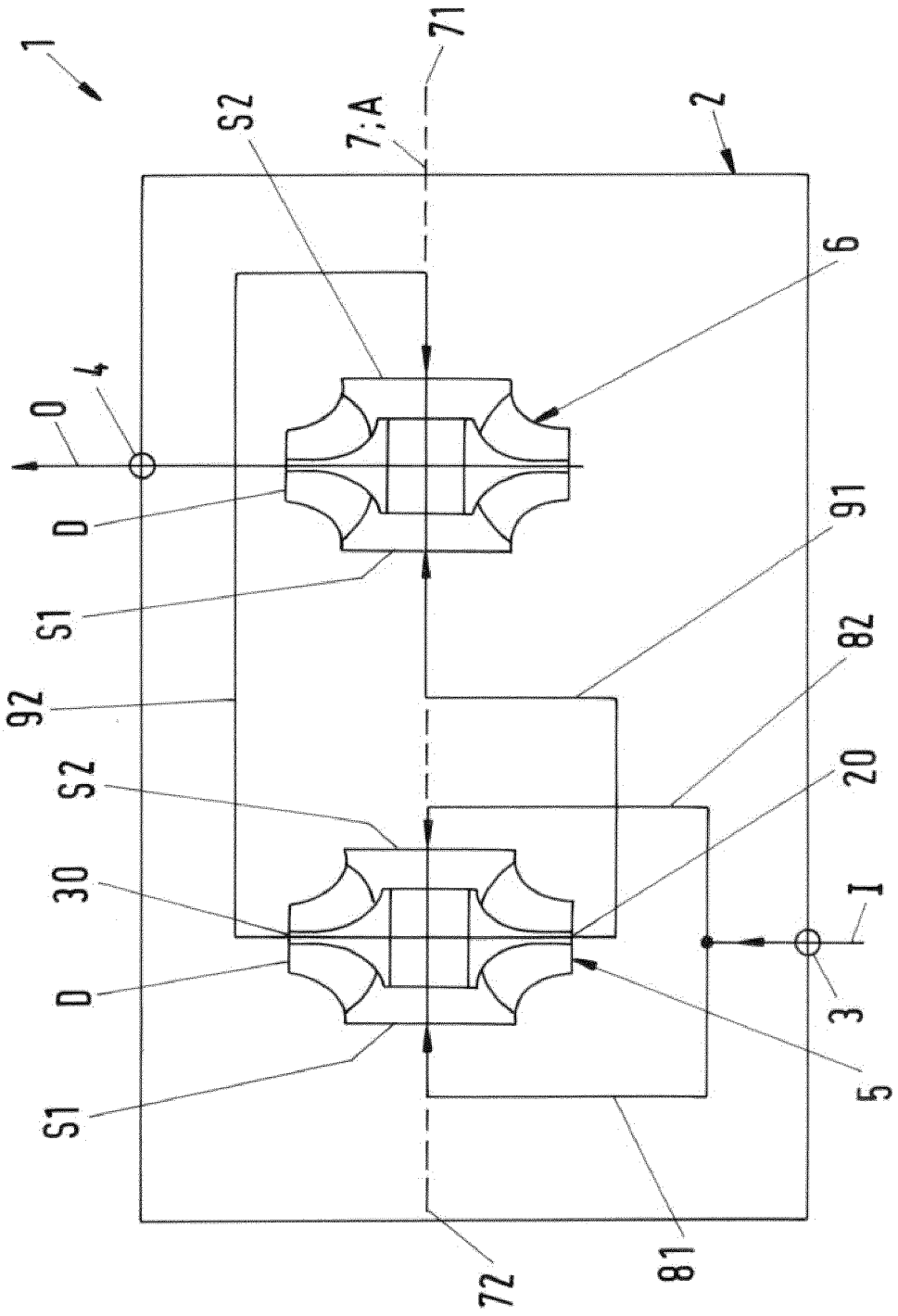
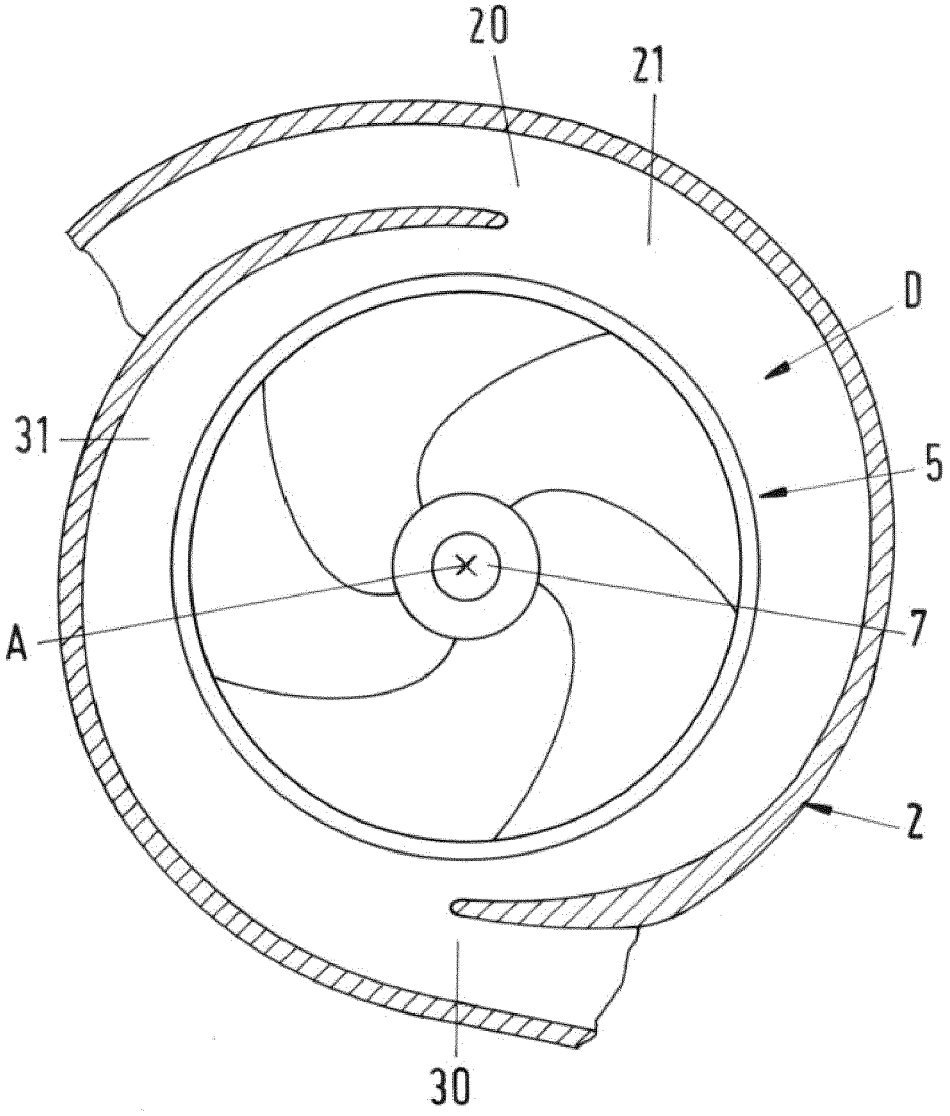


Fig.2



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EUROPEAN SEARCH REPORT

Application Number
EP 21 19 0198

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	CN 208 169 136 U (SHENYANG BLOWER GROUP PETROCHEMICAL PUMP CO LTD) 30 November 2018 (2018-11-30) * figures 1,2 *	1-7	INV. F04D1/00 F04D1/06 F04D29/42
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A	* column 9, lines 45-60 * * figure 10 *	3,7	
A	GB 2 072 748 A (KLEIN SCHANZLIN & BECKER AG) 7 October 1981 (1981-10-07) * page 1, lines 86-129 * * figures 1,2 *	1,4	

TECHNICAL FIELDS SEARCHED (IPC)
F04D

1 The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	6 January 2022	Gombert, Ralf

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 21 19 0198

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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06-01-2022

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82