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(54) **Integrated spindle and motor rotor**

(57) A single-motor spindle or motor spindle (20) for textile machines, comprising a synchronous motor, fed by an individual three-phase generator with variable voltage and frequency, wherein the design of the spindle (20) and of the actuation motor are conceived as a single entity and the support part, comprising the bearings and dampers (10, 12), is foreseen in the lower part of the motor spindle (20).

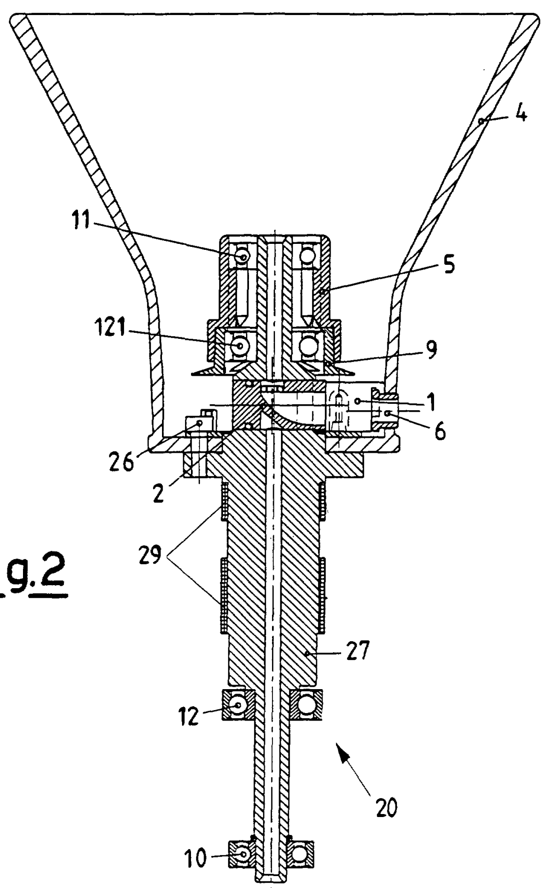

Fig.2

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Description

[0001] The present invention refers to a single-motor spindle or motor spindle for textile machines. For many years a way has been sought for introducing single-motor spindles onto textile machinery, to replace the traditional tangential belt controls for transferring motion from a central unit to the base of each spindle.

[0002] Such a tendency is justified basically for a few decisive advantages, with respect to the tangential belt solutions, amongst which can be noted reduced noise pollution, constructive simplicity, the possibility of carrying out more than one operation on the same machine and the possibility of overcoming the technical limitations to power transmission.

[0003] Further potential advantages, such as greater energy efficiency and the possibility of quickly changing the working conditions, are yet to be carefully evaluated.

[0004] However, the adoption of single-motor spindles has some drawbacks such as the total cost of the machine which is certainly high, the need to have highly qualified maintenance personnel, problems of electromagnetic compatibility which may arise, the high cost of replacement parts and the difficulty of operating such a solution in certain countries, such as those of the Third World.

[0005] Based upon what has previously been reported one immediately understands the reasons why the sectors which first introduced this application are those in which the application of motor spindles solves serious operational problems, like, for example, those relative to the manufacture of stretch yarn covering (where the levels of noise pollution are extremely high) or to applications of double twist spindles of a large size (in which there are power transmission problems).

[0006] In both of these sectors, the technical solution which has been adopted up to now is that of foreseeing many small asynchronous motors, such as individual actuation means for each spindle, connected to a single large frequency converter or inverter.

[0007] This solution, has up to now represented the most cost-effective solution which could be realised.

[0008] Even in this case, however, if, on the one hand, costs are kept to a minimum, on the other hand there are further drawbacks represented mainly by the technical difficulty of obtaining high yields from small asynchronous motors, together with the rapid fall in the same yield particularly in working conditions which are far removed from the design conditions; such problems are the cause of the fact that individual actuation spindles have not yet managed widespread distribution.

[0009] It is indeed the case that the normal working operation of a double twist textile spindle ranges from full speed to a value equal to around half of the aforementioned full speed.

[0010] Indeed, a halving of the speed corresponds indicatively to a four times greater mechanical power necessary for the rotation of the spindle; it can, therefore, be immediately understood how it is easy to work in the low zone of the input/output characteristic of asynchronous motors and how, moreover, the asynchronous motor, from a point of view energy consumption, poorly runs the operation in conditions far removed from the design conditions.

[0011] In figure 1 attached to the present description, in a single Cartesian graph, are shown the trends of the characteristics of yield in function of the load on the shaft of asynchronous bi-polar motors at the projected speed of 3000 revs/minute (curve PMA), of large asynchronous motors (curve GMA) and of motor spindles constructed for high velocities and each actuated by an asynchronous motor (curve MFA); on the same graph of figure 1 are also represented the indicative and exemplifying trends of a yield curve in function of the load on the shaft of a motor spindle with a synchronous motor (curve MFS).

[0012] Moreover, normally, the mechanical basis of the motor spindle follows that of the electric motor, in the sense that two bearings are foreseen at the ends of the rotor; outside of one of the aforementioned bearings then extends the technological part of the spindle.

[0013] The following critical remarks can be made about this: one of the two bearings remains trapped between the rotor and the technological part of the spindle and, therefore, for it to be replaced it is necessary to disassemble the spindle itself and proceed to a readjustment thereof; moreover, the bearings are normally a short distance from the stator and feel the effects of the heat generated by its presence: the low yield of asynchronous motors, which generates greater heat loss, only exasperates the situation.

[0014] In the case of the operation of asynchronous motors, finally, the electromotive forces induced, which generate the rotor's magnetic field, create eddy currents, which can cause damage to the balls and the rings of the bearings.

[0015] A purpose of the present invention is, therefore, to disclose a single-motor spindle for textile machines which avoids the drawbacks quoted above, or rather to realise a single-motor spindle which allows a higher energy or yield efficiency to be obtained, with respect to the known solutions, in as wide a range of functional loads on the shaft as possible.

[0016] Another purpose of the present invention is to realise a single-motor spindle for textile machines which is extremely reliable and which, moreover, simplifies the mechanical structure of the whole textile machine, so that it is not necessary to employ highly specialised personnel for its maintenance and operation.

[0017] Another purpose of the invention is to disclose a single-motor spindle for textile machines which, with respect to the state of the art, allows a reduction in electrical energy consumption, increasing, at the same time, the service life and not neglecting, moreover, to solve the problems caused by unexpected power cuts.

[0018] A further purpose of the present invention is that of disclosing a single-motor spindle or motor spindle for textile machines which allows relatively simple replacement of mechanical parts and which does not require further adjustment operations.

[0019] These and other purposes are achieved by a single-motor spindle for textile machines according to claim 1, to which we refer for the sake of brevity.

[0020] Advantageously, according to the present invention, it is foreseen to mount a synchronous motor on each spindle since, from the conceptual point of view, a synchronous motor exhibits a characteristic of yield as a function of the speed and, thus, of yield as a function of the load (assuming there is a roughly quadratic relationship between load and speed), which is extremely regular and constant with respect to the corresponding characteristic of an asynchronous motor (regarding this, see the graph of figure 1 and compare the trends of the curves MFA and MFS).

[0021] This means that in the field of use of between 50% and 100% load, a synchronous motor exhibits higher energy efficiency with respect to a corresponding asynchronous motor.

[0022] Moreover, the modular conception of the spindle's assembly allows rapid adjustment to the different configurations for the desired applications.

[0023] Further purposes and advantages of the present invention will become clear from the description which follows and from the appended drawings, given only as an illustrative and indicative example and not for limiting purposes, wherein:

- figure 1 shows a Cartesian graph wherein the trends for the yield of asynchronous motors and motor spindles as a function of the load on the shaft are represented;
- figure 2 shows a sectioned view of a first portion of a single-motor spindle for textile machines, according to the present invention;
- figure 3 shows a sectioned view, enlarged with respect to figure 2, of a second portion of the single-motor spindle for textile machines, according to the present invention;
- figure 4 is a partial and sectioned view of the mounted spindle, according to the present invention.

[0024] With reference to the figures mentioned, a single-motor spindle for textile machines or motor spindle, according to the present invention is wholly indicated with 20.

[0025] In particular, in the specific case of the attached figures, a double twist spindle with thread feeding packages of the "cops" type is referred to; however, it should be noted that the technical characteristics described in the present invention are equally applicable to any other textile application, relative, for example, to roving frames, covering machines and two-for-one twisters for technical threads, as well as two-for-one twisters for textile threads, which use feed packages with cylindrical bobbins, or "cheeses" (for medium and low twists).

[0026] With particular reference to figures 3-6, a sleeve for supporting the stator of the motor spindle 20, which constitutes furthermore a lower closing shield for the motor, is indicated with 22, while two guide bushes, which are forced inside the support sleeve 22 are respectively indicated with 23 and 24; the bushes 23, 24 support a rotor stem 27 with the relative support bearings 10, 12, while, around the rotor stem 27 and in a determined position, two permanent ring-shaped magnets 29 are foreseen which surround a magnetic crown 3 of a Hall wave encoder, on which the magnetic poles are impressed: preferably, the ring magnets 29 are realised in plastoneodymium.

[0027] The rotating part 4 of the spindle 20 is attached to the rotor shaft 27 through the screw 26, while, in a position facing the ring magnets 29 and with a diameter slightly greater than said magnets, in compatibility with the mechanical tolerance of the spindle 20, a magnetic circuit of the stator 28 is foreseen, consisting, essentially, of a pack of small magnetic plates with low losses.

[0028] In the hollow areas of the aforementioned pack of small plates, a three-phase electric winding 21 is positioned, which generates a rotating magnetic field; such a pack of small plates is housed inside the sleeve 22, which constitutes the whole structural casing of the motor spindle 20.

[0029] The sleeve 22, which is fixed to a generic base of a textile machine in correspondence with the fastening elements 291, is constructed in one single piece and is shaped so as to stop the penetration of particles of dirt or metallic dust inside the circuit of the stator 28.

[0030] The bearings 11, 121, contained inside the sheath 5, which, in turn, is supported by the containing element 9, represent the containing elements of the static structure of the spindle 20, which is kept immobile through a pair of magnets installed outside the structure, according to technical solutions of the known type.

[0031] Finally, with particular reference to figure 2, a ring for blocking the rotating part 4, a switch element for spindles 20 of the universal type, and a bushed thread guide are indicated with 1, 2 and 6 respectively.

[0032] The "brushless" synchronous motor mounted on each spindle 20, having control of the angular position on its own axis, allows, when the spindle 20 stops, the bush 6 to be positioned so that it is turned towards the operator, in order to ease the threading operations.

[0033] Each spindle 20 has an electronic generator of the three-phase type, with variable voltage and frequency (not illustrated in the figures for the sake of simplicity), which can be installed outside or inside the spindle itself 20.

[0034] All the electronic generators are fed in parallel from a common bus, the voltage level of which is chosen so as to optimise the yield of the whole motor spindle 20.

[0035] Even if one does not exclude the possibility of feeding the generators in alternating current (single-phase or three-phase), the use of direct current is preferable in that it allows an energy reserve to be stored, using suitable condenser elements and/or storage batteries, and, in particular, partly exploiting the recovery of kinetic energy deriving from the motion of the spindles 20; this makes it possible to supply current even when there is no supply coming from the electrical equipment, so as to avoid the unwanted halting of the spindles 20 and the collection cylinders during the operation of the textile machines.

[0036] Suitable serial inlet and outlet lines, generically indicated with 30 in figure 4, allow the management of control means suitable, for example, for controlling the operation of the spindle 20 in the presence of thread (through signals originating from electrical or electronic sensors of the presence of thread) or for bringing the other accessories of the textile machine into line with the operational or rest state of the spindle 20.

[0037] It is possible, moreover, to manage externally and from a central position a whole series of operational parameters both of the spindle 20 and the whole textile machine, such as the speed, the starting method, the starting and stopping of each motor spindle 20, as well as to foresee an alarm signal for determined critical conditions of the machine, such as those relative to the moving of the collection cylinders, as already highlighted before.

[0038] The proposed solution allows many of the problems deriving from mechanical bases of the motor spindle of the traditional type to be solved.

[0039] In particular, according to the present invention, it has been chosen to foresee the spindle and motor as a single entity, whereas the mechanics are based in three distinct and sequential zones: one support part, comprising bearings and dampers 10, 12, which is arranged in the lower portion of the motor spindle 20; an electric part, consisting of the two permanent magnets 29 of the rotor itself 27 and the magnetic crown 3 of the Hall wave encoder; a technological part, completely similar to that of a traditional spindle and arranged in the upper portion of the motor spindle 20.

[0040] This modular conception of spindle construction exhibits the principle advantage of allowing a rapid adjustment to the different configurations of spindles 20; since the support part is outside of the rotor stem 27, it is possible to equip the spindle 20 with different bearings without having to interfere with the rotor.

[0041] It is moreover possible to easily replace the bearings 10, 12 at the end of their life, in that they are canty-levered and not trapped by the motor's rotor; finally, it is not necessary to readjust the spindle 20 after the replacement of the bearings 10, 12.

[0042] The canty-levered position of the bearing allows the temperature of the casing of the stator 22 to be kept to contained levels, since it is not positioned near to the windings 21; this guarantees a greater lifetime of the support bearings 10, 12.

[0043] Furthermore, the presence of a permanent magnet on the rotor and the absence of eddy currents on it avoids the problems of damaging the races and rings of the bearings 10, 12.

[0044] The operation of the single-motor spindle for textile machines, according to the present invention, is substantially the following.

[0045] Sending three-phase current into the electric windings 21 of the stator 28 through the electronic generator of variable frequencies and voltages, a rotating magnetic field of velocity which varies according to the frequency is generated, which drags, in synchronous rotation with the frequency itself, the magnetic crown 3 and the rotor stem 27, solidly connected to it.

[0046] The single-motor of each spindle 20 allows a synchronous motor which is integrated in the spindle itself 20 to be used; this allows a rotation speed which is very precise and substantially independent from variations in load to be obtained.

[0047] In practice, from the energy consumption point of view, the solution of the synchronous motor for the development of a motor spindle is that which most resembles traditional solutions; as a further advantage it has a very good yield even when the shaft holds a small load.

[0048] On the other hand, in actuation systems of the traditional type, the parallel operation of many self-starting asynchronous motors which are attached to a single inverter causes an imprecision in the rotation speed value of around 3-4%, whereas with the described system according to the invention the speed error is only caused by the imprecisions of the electronic circuits connected to the textile machine and is, in operation, less than 0.1%.

[0049] From the description which has been made the characteristics of the single-motor spindle or motor spindle for textile machines, according to the present invention are clear, just as its advantages are also clear.

[0050] In particular, the most important characteristics and advantages are summarised as the following:

- rapid adjustment to the different spindle configurations, without interfering with the various rotors;
- rapid and simple replacement of bearings, without readjustment operations of each spindle;
- keeping the temperature built up in the casing of the motor-spindle to low levels and consequent longer lifetime of the support bearings, with respect to the solutions of the traditional type;
- absence of further problems of damage to the races and rings of the bearings;
- relatively simple readjustment of the motor spindle.

Claims

1. Single-motor spindle or motor spindle (20) for textile machines, **characterised in that** it comprises at least one synchronous motor which is integrated in

the spindle (20) and fed from an individual generator with variable voltage and frequency.

2. Single-motor spindle or motor spindle (20) according to claim 1, **characterised in that** it also comprises a support part, which includes a plurality of first bearings and dampers (10, 12), foreseen in a lower portion of the motor spindle (20) and outside of an electrical actuation part, and a technological part arranged in an upper part of said motor spindle (20).

3. Single-motor spindle or motor spindle (20) according to claim 2, **characterised in that** said synchronous motor includes at least one support element (22) of a stator of the motor spindle (20) and at least one rotor element (27), which carries said first bearings and dampers (10, 12), mounted canty-levered, and to which a rotating part (4) is connected.

4. Single-motor spindle or motor spindle (20) according to claim 3, **characterised in that**, on said rotor element (27) and in a determined position, at least one permanent magnet (29) which surrounds at least one magnetic crown (3) of an encoder, upon which the magnetic poles are impressed, is foreseen.

5. Single-motor spindle or motor spindle (20) according to claim 4, **characterised in that**, in a position facing said permanent magnet (29), magnetic circuits of the stator (28) are foreseen, each of which is composed of a pack of small magnetic plates with low losses, housed inside said support element (22), in the hollow areas between which is positioned an electric three-phase winding (21), which generates a rotating magnetic field.

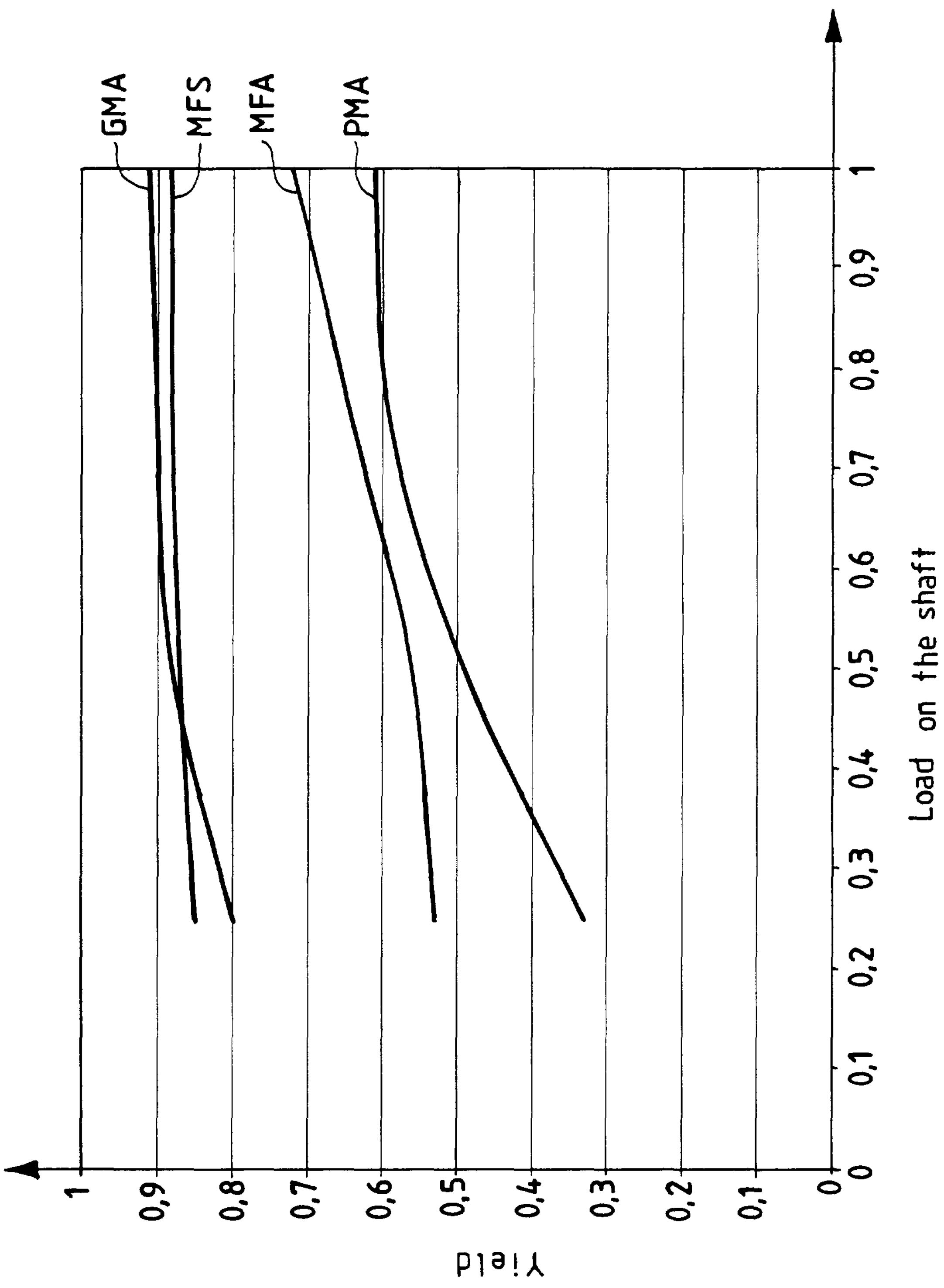
6. Single-motor spindle or motor spindle (20) according to claim 2, **characterised in that** said technological part comprises a series of second bearings (11, 121), contained inside a sheath (5), which, in turn, is supported by a containing element (9) of the static structure of the spindle (20), which is kept immobile through a series of magnets installed outside of said structure.

7. Single-motor spindle or motor spindle (20) according to claim 3, **characterised in that** said technological part comprises at least one ring for blocking said rotating part (4) and a switch element (2) for spindles (20) of the universal type.

8. Single-motor spindle or motor spindle (20) according to claim 1, **characterised in that** said individual generator is composed of a three-phase electronic generator, with variable voltage and frequency, connected to the power supply using single-phase or three-phase alternating current or direct current.

9. Single-motor spindle or motor spindle (20) according to claim 1, **characterised in that** serial inlet and outlet lines (30) are foreseen for the management of control means, suitable for controlling the operation of said spindle (20) in the presence of thread and for bringing accessories of said textile machine into line with the operational or rest state of the spindle (20), for the management of operational parameters of said spindle (20) and of said textile machine and for the intervention of alarm signals for determined critical conditions of the machine.

Fig.1


GMA
MFS
MFA
PMA
Yield
Load on the shaft
1
0,9
0,8
0,7
0,6
0,5
0,4
0,3
0,2
0,1
0

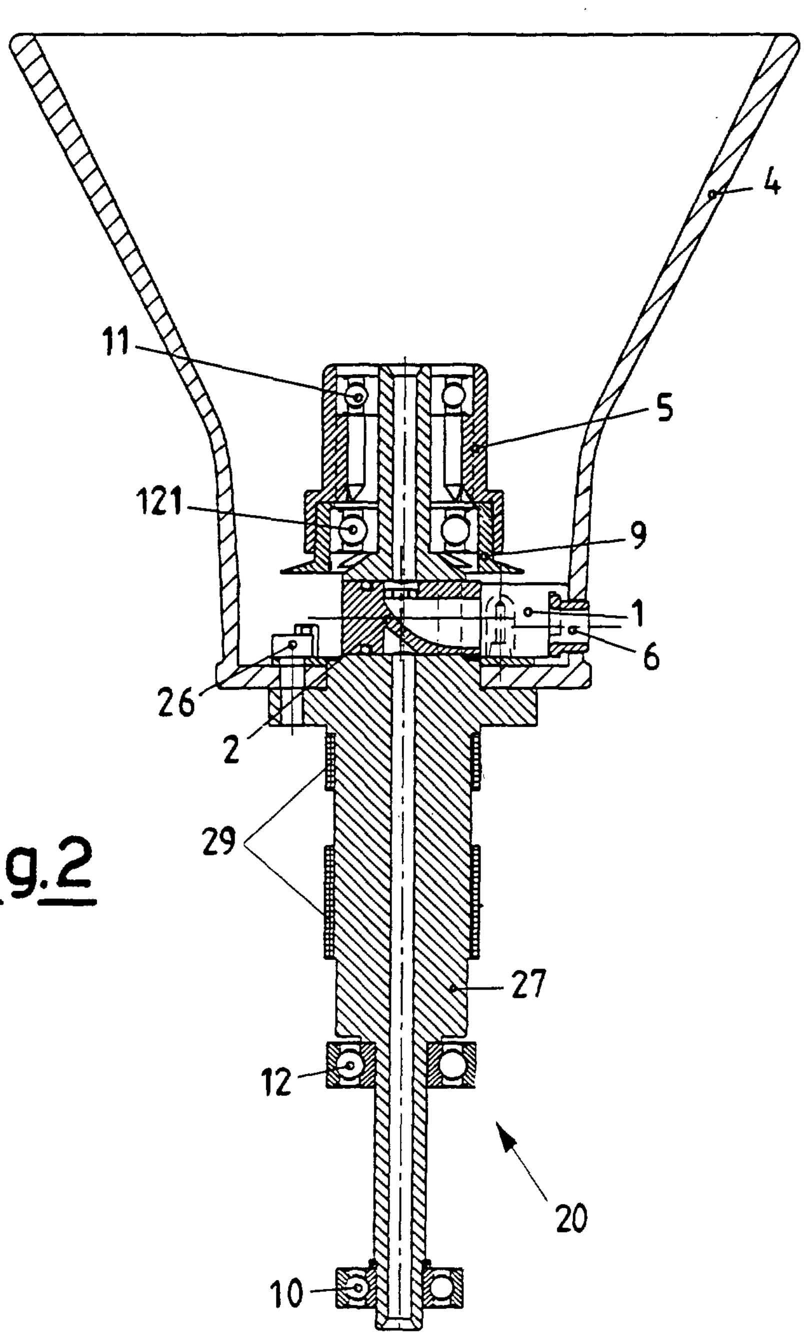


Fig.2

Fig.3

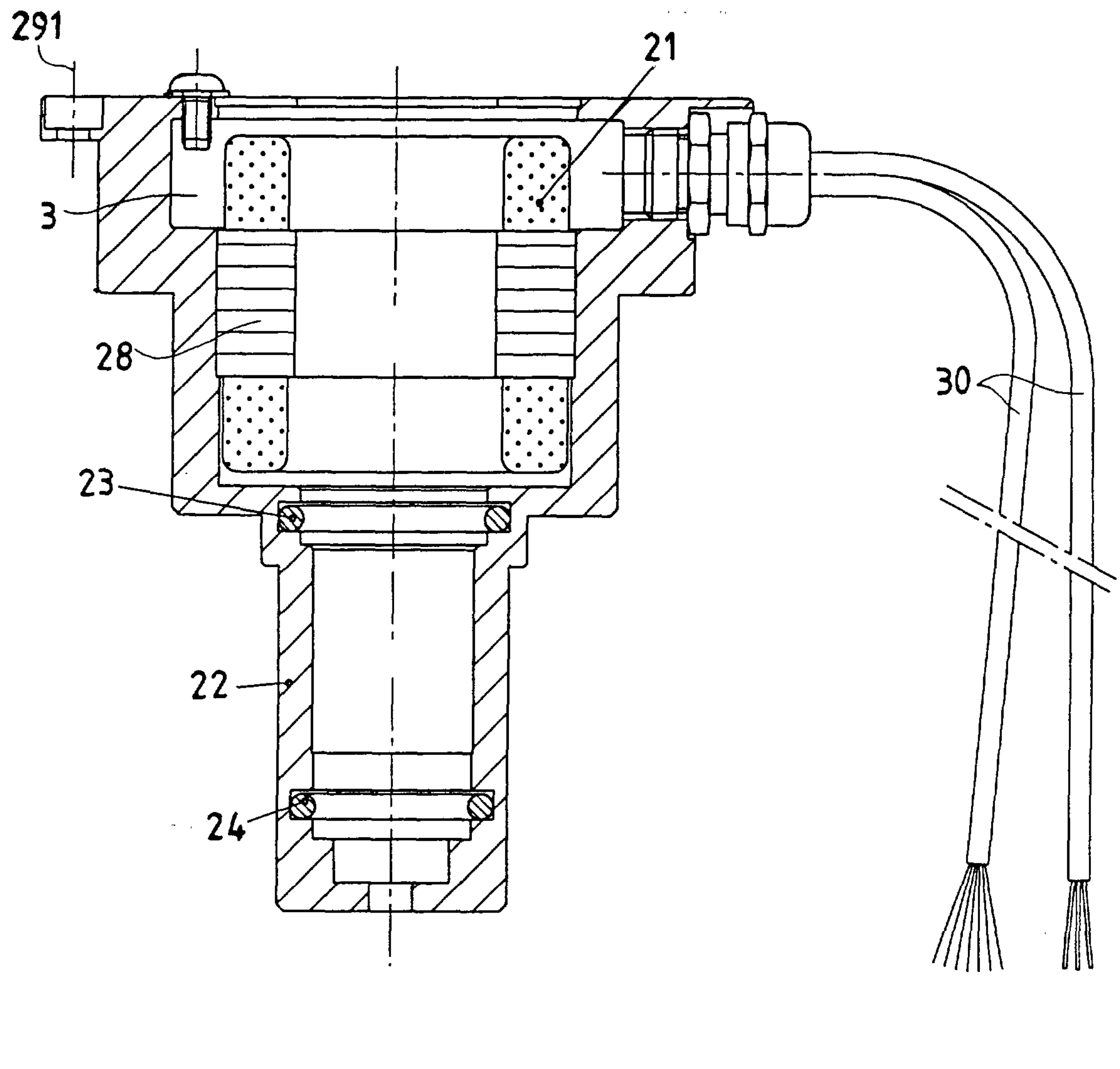


Fig.4