

The invention relates to a device for aligning the longitudinal axis of a machining tool with respect to the bore of a valve guide with a view to the precision-machining of the seat or any other bearing surface concentric with this bore.

It relates more specifically to devices comprising, on the one hand, a pilot rod for positioning, borne, together with the machining tool, by a spindle connected to means able to drive it in rotation and which is mounted so that it can rotate freely in a sheath which can be shifted axially and, on the other hand, a pre-adjustment support which can be shifted in the horizontal plane with respect to the slideways of a bed and in at least one longitudinal direction, or in two perpendicular directions and, in addition and between the sheath and the pre-adjustment support, a means for the angular orientation of the spindle with respect to the vertical, this means being composed of a spherical core through which the sheath passes, resting on the lower spherical seat of a sphere holder and interacting with a means for holding something firmly in the position for machining.

With this type of device, the alignment operation comprises:

- a pre-adjustment phase consisting in bringing the device above the seat, by shifting the pre-adjustment support on the bed,

- a phase of releasing the means for locking or clamping the elements of the device,

- a phase of lowering the sheath, with respect to the core, using motorized or manually-operated drive means with the pilot rod being guided manually, in order to facilitate the insertion of the pilot into the valve guide,

- a phase of alignment, taking place automatically using the rigidity of the rod between the pilot and the tool to bring the axis of the spindle into coincidence with the axis of the guide, by relative shifting of the elements of the alignment device,

- then finally, a phase of locking in position.

Depending on the embodiment, the spherical core is associated with pneumatic support means, as in WO-A-80/01365, with electromagnetic support means, as in EP-A-263766, or, more simply, rests on a layer of material
5 with a high coefficient of slip covering the spherical seat supporting it, and this is so that after its means for holding it firmly in position have been released, it can pivot freely in this seat to allow the sheath and therefore the longitudinal axis of the spindle to be
10 orientated.

In the case of devices mounted on machines for grinding valve seats requiring a high driving torque, an electric motor, fixed to the pre-adjustment support, is connected to the spindle by transmission means which,
15 even if it comprises an intermediate telescopic shaft with a Cardan joint at each end for following the angular movements involved in orientating the spindle, as in FR-A-2501094, impedes these movements and requires a substantial force, which does not favour accuracy of the
20 sought position, at the time of automatic alignment.

To this should be added the fact that when the pilot is inserted into the bore of the valve guide, and when the pilot rod, through its rigidity, adjusts the position of the spindle, orientating it angularly and
25 shifting it in the horizontal plane, this shifting takes place in an arbitrary direction with respect to the spindle, and requires all of the members and means borne by the device to be shifted. For top-of-the-range machines, the mass to be shifted is of the order of
30 140 kilograms. Owing to the inertia of this mass and to the friction between the guide means giving the crossed motion, this friction being amplified by the breakdown of forces when the shifts of the spindle are not parallel to the crossed motion, these shifts of the pilot rod are not
35 perfect, which means that the reaction force developed by the pilot rod is countered and that the rod may remain deflected and not bring the axis of the spindle into coincidence with that of the guide. The result of this is that it leads to concentricity inaccuracies which may be

as much as a few hundredths of a millimetre, which is thus unacceptable.

These drawbacks are all the more troublesome when a machine of this type is used to grind the valve seats of multi-valve cylinder heads, for example ones having four valves per cylinder, which have valve guides of a diameter smaller than or equal to 7 mm, because the pilot rod, which has a diameter of the order of 4 mm, is more flexible and more able to retain residual stresses with the risk of having a permanent deformation or when, as in EP-A-478478, the device for positioning the pilot rod is combined with means making it possible, by feeling, to determine the mean geometric position of the longitudinal axis of the housing for the valve.

Indeed, in these cases, and despite the freedom of movement given to the spherical core, the inertias and various resistances to shifting in the horizontal plane disrupt, respectively, the alignment of the spindle or the movements of feeling the ovalized internal face of the reference bore.

FR-A-2501094 discloses an alignment device in which the spherical articulation is borne by an adjustment body which, in the alignment phase, can slide in a horizontal plane with respect to a fixed clamp containing it and which, after alignment, is locked by actuator rods.

Such a device does away with the reactions resulting from the break-down of forces by the movements of the crossed slides, but adds friction which, adding to the stresses exerted on the spindle by the Cardan joint connecting it to its drive means, generate alignment inaccuracies which do not allow this device to be used for machining multi-valve cylinder head valve seats.

Furthermore, after alignment, actuation of the means for locking the adjustment body may shift this body not parallel to itself thus, as shown in Fig. 8, causing it to rest on the support off-centred with respect to the axis of the spindle and causing a flexing of the spindle, by the latter tilting about its pilot set in the valve

guide. An inaccuracy at the time of locking is hence added to the inaccuracy in automatic alignment.

These various drawbacks are worsened in the alignment devices in which the sphere holder is supported
5 by a flat cushion of air in the alignment phase.

This is because it has proved that, during the alignment phase, the various masses of the device and particularly those of the means for driving the rotation of the spindle, but also and above all those for driving
10 the translation of this spindle, create tilting movements on the spindle/sphere/sphere holder assembly, which tend to give the flat cushion a wedge shape causing the sphere holder to tilt in the clamping phase. The result of this, as shown in Figure 8, is that the axis of the spindle
15 becomes misaligned with respect to the position defined in the alignment phase, which finally leads to inaccuracies.

The object of the present invention is to provide an alignment device which overcomes these drawbacks by
20 reducing the inertia and eliminating most of the physical and mechanical stresses which result from the transmission of the movement for driving the spindle and from the guiding of the translational movement of this spindle in its sphere with respect to the sphere holder and with
25 respect to the support.

To this end, in the device according to the invention, the spherical core carries masses which, balancing the mass of the means for driving the sheath in translation and the mass of this sheath and of the
30 spindle when these are in the lowered alignment position, bring the centre of gravity of the assembly substantially onto the axis of the sheath, while the electric means for powering the spindle are arranged in the sheath and in such a manner that when this sheath is in the lowered
35 alignment position, the centre of gravity of this sheath is on the axis and close to the centre of the spherical core, that the means for generating the flat cushion between the support and the sphere holder comprise nozzles arranged in the support facing the sphere holder

and able to deliver a film of uniform thickness and that the clamping means comprise tubes distinct from the lift nozzles and able to be connected to a source of vacuum.

By virtue of this arrangement, when the means for
5 holding the core firmly release this core to allow the spindle to be aligned with the valve guide, the angular orientation of the spindle is no longer hampered by a mechanical transmission creating a directional force. What is more, doing away with this mechanical trans-
10 mission considerably reduces the value of the mass to be shifted and reduces the inertia. In addition, the organization of the masses in the sheath, the balancing of the masses of the whole assembly, the positioning of the centre of gravity on the axis of the sheath then at the
15 centre of the core, and the supporting of the sphere holder using a uniform film of air, eliminate all the external stresses so that the sphere holder is completely free to shift in the horizontal plane and generates no stresses at the time of automatic alignment of the
20 spindle, by reaction to the pilot fitting into the guide.

Likewise, this arrangement favours the shifting of the device and does away with all parasitic stresses during the operation of the pilot feeling for a bore.

Finally, the balancing of the sheath/sphere/
25 sphere holder assembly, combined with the production of a flat film of uniform thickness, guarantees parallelism between the lower face of the sphere holder and the upper one of the support and, at the time of clamping by partial vacuum, avoids any inclination of the sphere
30 holder and therefore any change in the accurate alignment achieved in the previous phase.

It is thus clear that the positioning of the centre of gravity of the head, the layout of the means for powering the spindle motor, the formation of a flat
35 support film of constant thickness, and the vacuum clamping work together towards a common goal which is that of obtaining perfect alignment of the spindle with the valve guide.

In one embodiment of the invention, the unlocking

travel of the piston which locks the spherical core by interaction with the lower spherical seat of the sphere holder is limited by three adjustable stops screwed into a fixed wall of the sphere holder at 120° from one another.

Thus, in the alignment phase, the cushion of air which is formed between the lower spherical seat and the spherical core is sized by the cushion formed between the core and the upper seat, because this seat is itself perfectly to position [sic] by the resting of the back of the locking piston on the three stops. The result of this is that any transverse shift of the spherical core is prevented and that the alignment operation gains in accuracy.

In one embodiment of the invention, the electric motor arranged in the sheath is powered by means of an external circuit including a retractable wiper interacting with contact members borne by the core on either side of its diametral plane, and forming part of a circuit internal to the core.

Thus, in the alignment or feeling phase, the wiper is brought into a retracted position to leave the spherical core completely free to move. The result of this is that this core is freed of all the stresses, even minimal ones, resulting from the means for powering the electric motor of the spindle. After positioning, the wiper is brought into the operating position, that is to say is shifted radially towards the core in order to power the electric motor.

Advantageously, each of the nozzles formed in the support for forming the film of air supporting the sphere holder includes, on its compressed-air supply circuit, a member for adjusting its flow.

This arrangement makes it possible, in a simple way, to adjust the delivery of the various nozzles in order to obtain a film of air of constant thickness guaranteeing, between the alignment phase and the locking phase, and by virtue of the centre of gravity of the head being positioned in the bore thereof, that the sphere

holder drops down parallel to the support.

Further features and advantages will emerge from the description which follows with reference to the attached diagrammatic drawings representing, by way of example, several embodiments of the device according to the invention.

Figure 1 is a partial view in perspective diagrammatically showing a tool-holder device according to the invention in the positioning phase.

Figure 2 is a side view in transverse section showing one embodiment of the device when it is equipped with a handwheel for shifting the sheath.

Figure 3 is a front elevation of the device represented in Figure 2.

Figure 4 is a side view in section of another embodiment of the device.

Figure 5 is a view in longitudinal section of one embodiment of the sheath containing the motorized spindle.

Figure 6 is a partial view in section, showing, on a larger scale, an alternative form of the means for powering the spindle motor.

Figure 7 is a side view in section showing an alternative form of the clamping means.

Figure 8 is a diagrammatic side view illustrating, on a very much larger scale, the error in alignment which results from mechanical clamping acting on a support film of uneven thickness.

In this drawing, the numerical reference 1 denotes a cylinder head (Fig. 1), and the reference 2 denotes, in general, the bed of the machine provided with longitudinal slideways 3 for a pre-adjustment support 4, which is guided by rolling elements 5. The spindle 6 is provided with a tool holder 7, in which a tool 8 can be engaged with its pilot rod 9. This spindle is mounted so that it can rotate freely in a sheath 10. The latter is held firmly against rotation and mounted so that it can slide in the internal bore 12 of a spherical core 13, with the possibility of shifting, under the control of a

device of the motorized or mechanical type. In Figure 2, this device consists of a gearwheel 11a driven by a handwheel 11b and interacting with a rack 11c formed on the sheath 10. The translational guidance of the sheath
5 10 is supplemented by a lower bearing 14 secured to the spherical core 13 and through which the shaft 11d connecting the handwheel 11b to the gearwheel 11a passes.

The reference 73 denotes a gas strut for balancing which, interposed between the spherical core 13 and
10 a support 74 connected to the sheath 10, has the objective of storing up energy as the sheath is lowered, in order to restore it as it rises again, and also of holding the sheath in position when the handwheel 11b is not actuated.

15 The spherical core 13 is held firmly against rotation about the axis of the sheath 10 by means which have not been represented and includes a lower spherical bearing surface 15 which rests on a seat 16 in the shape of a spherical cup secured to a sphere holder 17 borne by
20 the support 4. An upper spherical bearing surface 18 of the core 13 is intended to interact with the corresponding concave bearing surface of a holding means here consisting of a piston 19 which can be shifted vertically in the sphere holder 17. In the embodiments represented,
25 the piston 19 is shifted in the direction of clamping the spherical core 13 by a compressed air circuit, the air reaching the chamber 20 formed between the upper face of this piston and a fixed annular wall 22 of the sphere holder 17.

30 The means represented here correspond to those described in International Application WO-A-80/1365 and need not be described further in detail. It should, however, be pointed out that when the device is in the alignment-adjustment or feeling position, the chamber 20
35 is vented to atmosphere in order to free the piston 19 and compressed air is introduced via a duct 21 into the central chamber 23 formed between the core 13 and the body 17 in order, on the one hand, to support the core vertically and, on the other hand, to form two cushions

of air between the spherical bearing surfaces 15 and 18 of this core and, respectively, the seat 16 and the piston 19.

5 The assembly which has just been described constitutes a means for angularly orientating the core 13 and the spindle 6 making it possible, as shown in Figure 1, to align the axis $x'x$ of the spindle with the longitudinal axis of a valve guide 24 coaxial with the valve seat 25 which is to be re-machined, in which guide the pilot 9 is set.

10 As shown in greater detail in Figure 5, the sheath 10 containing bearings 26 and 27 for guiding the rotation of the spindle 6 also constitutes a housing for an electric motor 28 and for the means 29 transmitting the movement between its output shaft 30 and the end of the spindle 6. In the embodiment represented, the means 15 29 consist of a reduction gear, but they may adopt any other form, without departing from the scope of the invention.

20 As a result of this, the centre of gravity G of the head formed by the sheath and the elements which it contains, which terminate there and which it bears, is arranged on the axis $x'x$ of the spindle 6.

25 What is more, and according to another feature of the invention, the spherical core 13 bears masses 13a and 13b which balance the mass of the means 11a to 11d for driving the translation of the sheath 10, and also the mass of this sheath 10 and of the spindle 6 when the latter two elements are in the alignment position, that is to say lowered. This balancing is intended to bring 30 the centre of gravity of this assembly onto the axis $x'x$ of the sheath 10 and to eliminate the parasitic torque at the time of shifting of the spindle in the alignment phase. What is more, these various elements are arranged 35 with respect to one another in such a way that when the sheath is in the alignment position, that is to say is lowered to allow the pilot 9 to be inserted into the valve guide 24, the centre of gravity G is close to the centre C of the spherical core 13, as shown in Figure 1.

In Figures 2 to 5, the electric motor 28 is powered by an axial connector 32 terminating a flex 33 which is wound into a helix, and the upper end of which is fastened to a bracket 34 secured to the sphere holder 17. By virtue of this arrangement, the flex exerts a very small stress on the machining head, this stress being incapable of hampering the various movements during the alignment phase.

Figure 2 clearly shows that by virtue of this particular layout, the head of the machine is not encumbered with any transmission devices and that as a result of this the angular orientation of the spindle 6 is freed of all the stresses inherent to such a transmission. The same is true of the shifting movements in the horizontal plane, which movements, unencumbered by the inertia of the motor and of the intermediate transmission, take place without a substantial initiating force, and then take place very freely.

The sphere holder 17, which has a cylindrical overall shape, is secured to a cylindrical flange 35, the lower face 35a of which rests directly on the upper face of the pre-adjustment support 4. It may be used on its own or be arranged in a cylindrical casing 36 fixed to the support 4 and including an interior bore 37 having a larger diameter than the outside diameter of the flange 35, so as to leave a radial clearance with this flange. Likewise, the upper wall 38 of the casing is some distance from the upper face of the flange 35, so as to allow the latter to shift freely. This upper wall has an axial opening 39, the diameter of which is larger than the outside diameter of the cylindrical body 17, and the support 4 has an opening 40 of larger diameter than the outside diameter of the lower bearing 14 secured to the core 13 passing through it.

It will be readily understood that by virtue of this structure, the sphere holder 17, and therefore the core 13, the sheath 10, and the spindle 6, can be shifted radially in all directions starting from the longitudinal axis of the body, as shown by the arrows 31 in Figure 1,

and also in translation on either side of the theoretical longitudinal axis of the casing 36, and that this is true within the limits permitted by the radial clearance between the flange 35 and the internal bore 37 of the casing 36.

This arrangement does away with all the drawbacks inherent to the use of crossed-motion slides, or slides with other motions having one direction fixed by constraint of mechanical nature and makes it possible, in the case of a machine for machining valve seats, to use the movements of the support 4 only for prepositioning the head with respect to the area of work on the cylinder head 1 (Figure 1).

In order to facilitate this movement, and as shown in Figure 2, that region of the support 4 which lies beneath the casing 36 and more particularly underneath the region in which the flange 35 shifts, has, passing through it, ducts 41 connected to a circuit 42 of pressurized gas 49, especially compressed air, controlled by directional control valves 61. In these conditions, supplying the ducts 41 with pressurized air creates a film 71 of air between the flange 35 and the support 4, this film supporting the sphere holder 17 and all the members it contains, and making it easier for this body to shift with respect to the support 4.

This arrangement reduces friction and, in combination with the two cushions of air favouring orientation of the spherical core 13 allows, in the alignment phase, the head to be freed of any stress and, at the time of feeling, allows the feeler assembly to be freed of any force, making this operation easier.

It is emphasized that the readings taken during the feeling operation are recorded by mechanical or electronic means which have not been described here because they have nothing to do with the subject-matter of the invention.

Advantageously, and as shown in Figure 6, passing through the fixed annular wall 22 of the sphere holder 17 are three screws 75 parallel to the axis $x'x$, spaced 120°

apart and constituting stops for the piston 19. Thus, when the chamber 20 is vented to atmosphere and compressed air is introduced into the chamber 23, the retreating of the piston 19 brings its back to rest perfectly against the three stops 75 so that it remains perfectly positioned. The same is true for its spherical seat 19a which thus sizes the film of air passing between it and the upper bearing surface 18 of the core 13. This sizing provides self-centring of the spherical core 13 and sizes the film of air passing between its lower bearing surface 15 and the seat 16 of the sphere holder. This arrangement avoids any off-centring of the spherical core 13 which may influence the accuracy of the alignment operation and subsequently the accuracy of the clamping.

When the alignment or feeling operation is over, and the position of the spindle is definitive, it is locked in position. The spherical core is held firmly by pneumatic shifting of the piston 19 then the sphere holder 17 is clamped.

In order to prevent the flange 35 coming to rest on the support 4 at 35d, that is to say with eccentricity, during this clamping operation, as shown in Figure 8, causing the sphere holder 17 to tilt off centre and the axis $x'x$ of the spindle 6 to tilt about the point where the pilot 9 is set in the guide 24, at an angle α , and consequently disturbing the setting of this axis with respect to its position defined by the operation of alignment with the axis of the guide, means are provided for forming a film of air of constant thickness between the support 4 and the sphere holder 17, and other means organize the removal of this film.

The means which give the film of air a constant thickness consist of nozzles 47 which, arranged at the outlet of the ducts 41 are each associated with a member 48 for adjusting their delivery, as Figure 6 shows. It is by virtue of the positioning of the centre of gravity on the axis $x'x$ of the assembly comprising the sphere holder, the spherical core and the sheath, and of the setting of the nozzles that it is possible to obtain a

flat film 71 of air of uniform thickness and to obtain, during clamping, a shifting of the sphere holder parallel to itself.

5 The means which organize the removal of the film 71 of air and therefore of the clamping consist, as shown in Fig. 2 and 6, of ducts with tubes 62 which, distinct from the ducts 41 with nozzles 47, are connected by pipes 63 to a directional control valve 64 which can either isolate them or place them in communication with a source
10 of vacuum 60.

With this arrangement, when the alignment operation is over, the manually or electromagnetically controlled directional control valve 61 is actuated in order to cut off the compressed air supply 49 and place the
15 film 71 of air in communication with the atmosphere 59. Owing to the even thickness of the film and its small thickness, of the order of a few hundredths of a millimetre, the sphere holder 17 drops down parallel to itself, following the axis of the spindle, by virtue of
20 the guidance provided by the sliding of the pilot 9 in the valve guide 24. As soon as the sphere holder 17 is resting on the support 4, the directional control valve 64 is actuated and places the ducts 41 with tubes 62 in communication with the source of vacuum 60 in order to
25 create a partial vacuum for locking the sphere holder 17 on the support 4 and clamping the position obtained.

This clamping is generally sufficient to withstand the cutting forces generally encountered. It may, however, be supplemented by mechanical clamping.

30 In Figures 2 and 4 the mechanical clamping means consist of several pneumatic actuators 45 distributed around the sphere holder 17, and the bodies of which are fixed to the upper face 38 of the casing 36, while their rod passes through this wall 38 to come into contact with
35 the upper face of the said flange.

In the alternative form represented in Figure 7, the actuators 65, for example three of them arranged at 120° about a longitudinal and vertical axis of the casing 36, are arranged below the support 4 against which their

bodies 66 are fixed. Their pistons 67 are equipped with a tubular hub 68 through which an axial rod 69 passes. Each rod, the upper end of which is screwed into the flange 35c of the body 17, passes through a bore 70 in the support 4 and the tubular hub 68, with a clearance which corresponds to the clearance for the shifting of the flange 35c inside the casing 36. Finally its lower end protruding beyond the hub is secured to a washer 72 capable of taking the thrust of the hub 68 of the piston 67.

Thus, when the flange 35c is supported by a cushion 71 of air, the clamping actuators 65 do not oppose its shifting and, during clamping, the force of the actuators is transmitted directly via the rods 69 to the flange 35c.

In the embodiment represented in Figure 4, the device can be differentiated from the previous one in that the centre C of the spherical core 13 is arranged substantially in the horizontal plane H of the upper face of the support 4. The result of this is that the cylindrical body 17a stretches on either side of the flange 35b and, in its lower part, passes through an opening 46 in the support 4.

By virtue of this arrangement, the angular orientation of the spindle is independent of its position in the horizontal plane, which further improves the alignment or feeling conditions.

Finally, in order to do away with the very slight hindrance which may be caused by the flex 33 for powering the electric motor 28, it is possible to replace this type of power supply by the one represented in Figure 6 which takes place substantially in a horizontal mid-plane of the spherical core 13. This power supply is composed of an interior circuit comprising:

- longitudinal strips 50 made of an electrically-conductive material, lying flush with the exterior face of the sheath 10 and connected electrically to the electric motor supply circuit arranged inside this sheath,
- contact pads 52 emerging from the axial bore 12

of the core 13 and able to come into contact with the strips 50,

- and portions of circular strips 53 projecting on the outside of the core, distributed on either side of its horizontal diametral plane and connected electrically to the pads 52 by circuits 54,

- and an external circuit ending at a contact wiper 55.

This wiper bears sprung contact pads 56, connected electrically to the external supply circuit. The wiper 55 is mounted so that it floats on a means able to shift it between an operating position in which its contacts 56 come into contact with the strips 53, and a retracted position in which its contacts are away from these strips. In the embodiment represented, this means consists of an actuator 57, the body of which is fixed to the exterior part of the sphere holder 17, and the rod of which passes through this sphere holder in order to bear on the wiper via a ball joint 72.

It will be readily understood that in the adjustment phase the wiper 55 is brought into the retracted position in order to release the core 13 completely and that after the position of the tool has been adjusted it is brought into the operating position with its contacts 56 in contact against the strips 53. It is emphasized that owing to the slight angle of angular orientation of the core 13 in the adjustment phase, which angle is of the order of 1 to 5°, the variations in position of the contact faces of the strips 53 are easily compensated for by the fact that the wiper 55 is mounted floating and also by the fact that its contacts are mounted floating and elastically.

It is clear from the foregoing that the device according to the invention, by freeing the means for adjusting the inclination and for adjusting the vertical position of the longitudinal axis of the spindle from any external stresses, does away with jerks, reduces forces, and makes adjustment more accurate because a concentricity of the order of 0.02 mm can be obtained

regularly. This device also favours feeling which can become manual.

Moreover, it will be noted that dispensing with the external transmission of the type having a telescopic
5 shaft and two Cardan joints between the motor and the spindle, makes it possible to increase the rotational speed of the spindle to obtain the speeds necessary for machining the seats and guides of valves of small dimensions.

CLAIMS

1. Device for aligning the longitudinal axis of a tool with the axis of a valve guide, in which device, on the one hand, the tool which is held firmly in a spindle
5 (6) is secured to a pilot rod (9) coaxial with it and, on the other hand, the alignment means comprise:

- a pre-adjustment support (4) which can be shifted in the horizontal plane and at least longitudinally on a fixed bed (2),

10 - a sphere holder (17) placed on the support (4) with the possibility, in the phase of positioning the spindle and after the clamping means have been released, of it shifting in all directions of the horizontal plane by virtue of a flat cushion of air formed between it and
15 the support (4),

- a spherical core (13) mounted in a seat (16) of the adjustment body (17) with the possibility of rotating freely, in the phase of positioning the spindle, and after the holding means have been released,

20 - a substantially vertical sheath (10) which can be shifted axially in the core (13) and carries the spindle (6) for driving the tool,

characterized in that the spherical core carries masses which, balancing the mass of the means for driving
25 the sheath in translation and the mass of this sheath and of the spindle when these are in the lowered alignment position, bring the centre of gravity (G) of the assembly substantially onto the axis (x,x') of the sheath (10), while the electric means (28,29) for powering the spindle
30 (6) are arranged in the sheath (10) and in such a manner that when this sheath is in the lowered alignment position, the centre of gravity of this sheath is on the axis (x',x) and close to the centre (C) of the spherical core (13), that the means for generating the flat cushion
35 between the support (4) and the sphere holder (17) comprise nozzles arranged in the support (4) facing the sphere holder (17) and able to deliver a film of uniform thickness and that the clamping means comprise tubes (62) distinct from the lift nozzles (47) and able to be



connected to a source of vacuum.

2. Device according to Claim 1, characterized in that the unlocking travel of the piston (19) which locks the spherical core (13) by interaction with the lower
5 spherical seat (16) of the sphere holder (17) is limited by three adjustable stops (75) screwed into a fixed wall (22) of the sphere holder at 120° from one another.

3. Device according to Claim 1, characterized in that the electric motor (28) arranged in the sheath (10)
10 is powered by means of an electric flex (33) wound in a helix, the upper end of which is fastened to a bracket (34) connected to the body, and the lower end of which is secured to a connector (32) arranged substantially on the longitudinal axis of this sheath.

15 4. Device according to Claim 1, characterized in that the electric motor (28) arranged in the sheath (10) is powered by means of an external circuit including a retractable wiper (55) interacting with contact members borne by the core (13) on either side of its diametral
20 plane, and forming part of a circuit internal to the core.

5. Device according to Claim 4, characterized in that the electric motor (28) is powered, on the one hand, by means of electrically-conductive longitudinal strips
25 (50) lying flush with the exterior face of the sheath (10) and coming into contact with pads (52) emerging from the axial bore (12) of the core, these pads themselves being electrically connected by a circuit (54) arranged inside the core, to portions (53) of circular strips
30 projecting on the outside of the core and distributed on either side of its horizontal diametral plane and, on the other hand, by means of a wiper (55) which, carrying sprung contacts (56) able to interact with the portions (53) of circular strips, is borne by the sphere holder
35 (17) and by means able to shift it between an operating position in which its contacts (56) are in contact with the strips (53), and a retracted position in which its contacts are away from the strips.

6. Device according to Claims 4 and 5, characterized



in that the wiper (55) is mounted so that it floats at the free end of the rod of a fluid actuator (57), the body of which is fixed to the sphere holder (17) containing the spherical core (13).

5 7. Device according to Claim 1, characterized in that each of the nozzles (41) formed in the support (4) for forming the film of air supporting the sphere holder (17) includes, on its compressed-air supply circuit, a member for adjusting its flow rate (48) in order to
10 obtain a film of air of constant thickness.

8. Device according to Claim 1, characterized in that the sphere holder (17) is secured to a peripheral flange (35c) via which it comes into contact with the support (4) and this flange is associated with mechanical
15 clamping means consisting of actuators (55) arranged below the support (4) against which their bodies (66) are fixed, and of rods (69) connected to the flange (35c), each rod passing with clearance through a bore (70) in the support (4) and the tubular hub (68) of the piston
20 (67) of the corresponding actuator and including, at its lower free end, a washer (72) able to receive the thrust of the hub (68) in the clamping phase.

9. Device according to Claim 1, characterized in that the centre of rotation C of the spherical core (13)
25 is defined, in the horizontal plane H, by the face of the sphere holder (17) resting on the support (4).

