

The present invention relates to a device for the position-defined clamping of a workpiece on a workpiece holder or of a tool on a tool holder according to the generic definition in patent claim 1.

In the broadest sense the term "position-defined clamping" is here taken to mean that the object, namely a workpiece to be machined or a tool for machining the workpiece, is attached in a precisely known and defined position within a machining device. In particular the device is primarily intended to achieve a precisely defined position of the object in two axes lying perpendicular to one another, the X and the Y axis, and in regard to a torsion in the X/Y plane. Finally a further embodiment of the object of the invention is intended to ensure defined positioning in the Z axis also which, while less critical, is nevertheless equally important.

Devices are known for the clamping of small workpieces or tools of generally relatively small dimensions, comprising a workpiece or tool holder to which a workpiece or tool carrier can be fastened. Location is achieved by projecting locating pins on the holder and correspondingly positioned locating holes in the carrier into which the locating pins engage. If one ignores the positioning in the direction of extension of the Z axis for the moment, it is sufficient to provide two interacting pairs of pins/holes, with one pair defining the position in the X and Y axes and the interaction of both pairs defining the angular position in respect of the Z axis.

One essential prerequisite for such known clamping devices is the fact that the locating pins on the one hand and the locating holes on the other are very precisely arranged in their positions relative to each other so as to ensure the perfect interplay of pins and holes and hence the desired positioning of the carrier relative to the holder (whose position is known). This entails complex manufacturing and hence a high level of cost, especially when unusually exacting demands are made on positional accuracy as is the case for example in the electrical discharge machining of workpieces. In addition such an arrangement is often geometrically overdefined, particularly when, as in most instances, tapered locating pins are used, since here theoretically both pairs of pins/holes determine the position in the X/Y axis independently of each other.

These disadvantages have an especially serious effect when relatively large workpieces are to be clamped. In the interests of achieving a stable position the individual locating pins and locating holes will be arranged as far apart from each other as possible. Even with distances of 20 to 40 cm between the individual pairs of pins/holes, variances caused as a result of thermal expansion and contraction make themselves felt by affecting the proper seating of one or the other locating pin in its corresponding locating hole. The consequence of this is that the extremely high positional accuracy required above all in the toolroom is no longer assured.

A further problem arises when a number of different carriers are supposed to be attached to one and the same holder, these carriers possibly originating from different production series and having dimensional variations which while small are nevertheless noticeable given extremely close tolerance requirements. Here again, exact positional accuracy will not be achieved for the reasons already stated.

DE 31 15 586 A1 discloses a pallet changing and locating device for a machine tool which comprises a feeder track upon which the pallets bearing the workpiece move to a pallet reception and workpiece machining station. Once the pallet has arrived at this station, the latter is lowered until the pallet is first supported on the surfaces on Z axis locating pins which do not have any locating function in the X, Y or angular direction however. When the station is lowered, tapered upper edges of locating pins then engage in correspondingly tapered sleeves. These sleeves are spring-loaded axially but held rigid radially. The purpose of this arrangement is to achieve a "precise alignment of the pallet on the locating pin".

With this arrangement it is not possible to achieve a precise location in the X/Y axis or as regards angular position when the centre to centre distances of the locating pins on the one hand and the sleeves on the other hand do not exactly coincide. If namely the distance between the locating pins on the one hand and the sleeves on the other does not exactly coincide, then the position of the pallet is undefined since depending on the initial position of the pallet before the pins engage in the sleeves either one or the other pair of pins/sleeves will engage each other in a defined position; however this must result in two different positions of the pallet which the invention is supposed to avoid.

DE-AS 10 08 966 discloses a sprung suspension or bearing of a first machine part in relation to a second machine part in order to achieve a precision positioning of the one machine part by means of controlled displacement efforts with little force and eliminating the effect of stiction. When the desired position is reached, e.g. by the manual or assisted displacement of the one machine part, the two machine parts that are movable relative to one another are clamped one against the other, e.g. by means of an electromagnet. This publication therefore does not even pose the problem of positively moving two parts into a certain position relative to one another, nor is any solution proposed to that problem.

DE 34 10 359 A1 merely discloses the concept that separate bearer rails are attached to a pallet and that their position can be adjusted relative to the pallet. The problem of location in the sense of the present invention is not touched on at all.

Finally US-A-3 381 554, which constitutes the closest state of the art, discloses a solution in which a pair of parallel pins/holes defines the position in the X and Y axes while a second pair of pins/holes comprises a parallel pin and a slot-like opening in order to define the torsional position. The second pin can be deflected along the line connecting the two pins. This is a constructionally very expensive solution and the accuracy of positioning depends in principle only on the accuracy of the machining of the pin, the accuracy of the machining of the slot and the precision with which the adjustable pin is guided.

It is the task of the present invention to avoid the stated disadvantages and to embody a device of the type stated in the generic definition in patent claim 1 such that the desired high degree of positional accuracy of the carrier on the holder is achieved and maintained even with reduced precision in the manufacture of the holder or the carrier, namely with regard to the reciprocal distances between locating pins and locating holes and under the influence of thermally-related dimensional changes in the carrier and/or holder.

This task is resolved by the measures stated in the characterization in patent claim 1. In particular they ensure that in the case of two pairs of pins/holes for example, one pair merely assumes the task of X/Y positioning and hence defines the datum for the Z axis, while the other pair of pins/holes positions the carrier in relation to its torsional orientation about the Z axis. The intervening distance between the two pairs of pins/holes is therefore made to be non-critical by the one pair being spring-movable in relation to the other pair in regard to distance. As a result, manufacturing tolerances, thermal dimensional changes and so forth can be offset and compensated and a geometrical overdefinition of the position of the carrier on the holder is avoided.

Although in principle any suitable type of spring-deflecting arrangement of the movable locating hole on the workpiece or tool holder is conceivable, it would nevertheless seem expedient to provide the movable locating hole in a section of the carrier that is spring-mounted on the carrier in relation to the fixed locating hole, especially since the deflection of the movable locating hole involves minimal distances of the order of perhaps several 1/100 mm or at most 1/10 mm.

For the purposes of the invention, in order to achieve the desired deflection in one direction and simultaneous rigidity in another direction perpendicular to that direction, the connection between the displaceable section which comprises the movable locating hole and the workpiece or tool carrier must be made by means of leaf-spring type elements that possess a virtually ideal linear flexural pattern and a high degree of rigidity in the direction of longitudinal extension, especially given the short spring travel that is involved here. In addition, these elements are only subjected to load when the carrier is clamped to the holder and then only to a slight mechanical load because they are merely required to provide elastic guidance for the movable section of the carrier while the comparatively high clamping forces are taken up by the workpiece or tool holder itself.

In order to make optimum use of the beneficial properties as already described of such spring-leaf type elements in the sense of the concept of the invention, it is expedient to arrange these elements perpendicular to the connecting line running between the movable locating hole and a further locating hole which is rigid in relation to the carrier.

Although it is possible to provide separate spring-leaf elements that can be attached to the movable section and to the carrier, it would seem expedient to configure these elements as webs of the carrier material integrally formed into it; this can be done by, for example, cutting a number of suitably arranged narrow slits preferably by wire-erosion into the carrier or into an auxiliary element connected to it, so as to kinematically delimit the movable section from the actual workpiece or tool carrier.

As has already been mentioned, one particularly beneficial solution of the task resolved by the invention is an embodiment in which the workpiece or tool carrier comprises a first rigid locating hole that receives a first locating pin on the holder and a second spring-deflected locating hole that receives a second locating pin on the holder. The first pin/hole pair serves as the X/Y datum for the machining of the workpiece, while the second pin/hole pair defines the angular position of the carrier about the Z axis.

While it is in principle possible for the workpiece or tool carrier itself to comprise two sections, with a first actual carrier part in which the rigid locating hole is comprised, and a second part that is spring-deflectable in the manner described above and which comprises the second movable locating hole, it would seem more expedient to arrange two locating rails spaced apart on the workpiece or tool carrier, one of which comprises the rigid and the other the spring-deflectable locating hole. This configuration allows considerably greater freedom in the design of the carrier, since always the same uniform locating rails can be used in conjunction with different designs of carrier.

One preferred embodiment of such locating rails to be attached to the actual workpiece or tool carrier is described in claims 7 to 10.

The locating pins consist preferably of hard metal alloy and with ends that are provided with at least one, but preferably with two tapered surface areas, namely a first slightly tapered surface area used for the actual locating and a second more markedly tapered adjoining tip area which facilitates the engagement of the locating pin in its corresponding locating hole.

By providing the locating pins with a central bore right through them which is connected to a compressed air supply, it is possible to achieve a very efficient cleaning effect by blowing compressed air into these bores while the pin is entering the locating hole, thereby removing any contamination. This is especially effective when the locating holes are formed by hard metal alloy sleeves that are open at one end, since the entry of the pins into the sleeves causes a gradual reduction in the size of the annular gap through which the compressed air must escape; the decreasing annular gap section increases the flow velocity of the compressed air and thus enhances the cleaning effect.

A particularly precise and reliable positioning can be achieved in conjunction with the locating pins referred to above when a section of the inner wall of the hard metal alloy sleeves around the rim facing the pin is chamfered, and especially when this chamfer angle is greater than that of the first slightly tapered area at the extremity of the locating pin. This results in virtually annular line contact between pin and sleeve without any risk of jamming and achieves a further self-cleaning effect additional to compressed air injection by scraping off any particles of dirt.

If positional locating is also desired in the direction of extension of the Z axis, as is required in most cases, this can be done by means of a plurality of support pins that project out from the workpiece or tool holder beyond the locating rails referred to above and which are in contact with support faces on the workpiece or tool holder; the latter can also be provided for cleaning purposes and against-datum checks with compressed air holes that are sealed when the support pins are hard on.

The following description gives a more detailed explanation of an embodiment example of the device according to the invention for the position-defined clamping of workpieces by reference to the attached drawings. In the drawings:

- Fig. 1 shows a view from below of a workpiece carrier of the clamping device according to the invention;
- Fig. 2 shows an enlarged diagrammatic detail view of a part of a locating rail with sections pushed against each other;
- Fig. 3 is a section on line III-III in Fig. 1;
- Fig. 4 is a much enlarged and partly cutaway view of a locating pin and a locating sleeve;
- Fig. 5 is a diagrammatic, partly cutaway side view of the clamping device according to the invention in the unclamped condition; and
- Fig. 6 is a diagrammatic, partly cutaway side view of the clamping device according to the invention in the clamped condition.

The embodiment example which will be explained in more detail below is a clamping device for a workpiece that is to be attached within a machining equipment in a precisely specified position in the X/Y axis, in relation to a torsional position about the Z axis and in the direction of longitudinal extension on the Z axis. It goes without saying however that the principle according to the invention can just as well be used for clamping tools given such appropriate design modifications to the device as should be familiar to any engineer well versed in the subject.

The totality of the clamping device in accordance with the invention is best viewed by considering the diagrammatic representations of Fig. 5 and 6. According to these the device comprises a workpiece holder 1 which can for example be the machine table of a machining device (not shown) or a separate holder element anchored to the machining device. There is also provided a workpiece carrier 2 which in the case of the example is plate-like in form and can be provided with bores, slots, clamping means etc. (not shown) to receive and support a workpiece 3 which is to be machined. In special cases the workpiece carrier 2 can be constituted by the workpiece 3 itself.

The workpiece carrier 2 is attached to the workpiece holder 1 by means of an attachment device which in the case of the example is a diagrammatically indicated inverse-Tee section connecting rail 4 that is attached to the underside of the workpiece carrier 2, and comprises an anchoring piston 5 the upper end of which encasps the connecting rail 4 with clearance such that the desired locating process can attain its full effect. By the downward motion of the anchoring piston 5 the entire workpiece carrier 2 is drawn against the holder 1 and held in position, as shall be explained hereinafter.

The level of the workpiece carrier 2 in relation to workpiece holder 1 and hence the position on the Z axis is determined in the case of the example by four support pins 6 attached at one end to the workpiece carrier 2 and whose other end rests on support faces 7 of the workpiece holder 1. In fact however three support pins 6 are sufficient to position the carrier 2 in defined relation to the holder 1 and clearly defined on the Z axis. The workpiece holder 1 is provided with bores 8 that are connected to a compressed air supply and that open into the support faces 7 and which are used first to blow away any dirt collecting on the support faces 7 when the support pins 6 approach the support faces 7; second the mouths of the bores 8 are sealed as soon as the support pins 6 come to rest on the support faces 7, a fact that can be evaluated as an against-datum check for a workpiece carrier.

To achieve positional location of the workpiece carrier 2 on the holder 1 the latter has two locating pins 9a and 9b, which in the case of the example are let into the face of the workpiece holder 1 and whose tapered upper ends project beyond the surface of the holder. The configuration of the locating pins will be explained in greater detail below. The locating pins 9 engage in locating holes 10a and 10b which are basically situated on the workpiece holder 2, to be more precise each in a locating rail 11a and 11b both of these being attached to the lower face of the workpiece carrier 2 and at a distance away from it.

The configuration of the locating rails 11a and 11b will also be explained more fully below.

The locating pins 9a and 9b each possess a central straight-through bore 12 (cf. Fig. 4) that communicates with compressed air channels 14 in the workpiece holder 1 and are also used to remove contamination when the locating pin 9 is introduced into the corresponding hole 10.

The configuration of the locating rails 11a and 11b is shown in Fig. 1 to 3. Each of the two locating rails 11a and 11b has a generally rectangular form and is attached by its two end sections 15a and 15b to the lower face of the workpiece carrier 2, e.g. by means of bolts 16. In the middle of locating rails 11a and 11b is a middle section 18a and 18b with a central area 17a and 17b that is thicker than the intermediate sections 19a and 19b of the middle section 18a and 18b which are adjacent to the end sections 15a and 15b. By this means, the middle section 18a and 18b is able to spring in relation to the end sections 15a and 15b and hence in relation to the workpiece carrier 2, but only on the Z axis, that is to say towards and away from the workpiece carrier 2 as indicated by the double-headed arrow P₁ in Fig. 3.

The locating holes 10a and 10b are arranged in the middle sections 18a and 18b and are formed by hard metal alloy sleeves 20a and 20b let into corresponding holes in the middle sections 18a and 18b. A more detailed explanation of the configuration of sleeves 20a and 20b will be given below by reference to Fig. 4.

Except for the ability of its middle section 18b to spring on the Z axis, the locating rail 11b is rigid, that is to say rigid on both the X and the Y axis. The middle section 18a including its intermediate sections 19a of locating rail 11a on the other hand is movable in the direction indicated by the double-headed arrow P₂ in Fig. 1, i.e. in a direction that lies on the connecting line between the locating hole 10a and the locating hole 10b. A displacement of the middle section 18a perpendicular to that direction is not possible on the other hand. This can be achieved in accordance with the illustrated example as follows:

Both the end sections 15a of locating rail 11a are provided with an essentially U-shaped continuous slot that consists of the slot sides 21, 21' and 21". The two slot sides 21' and 21" run parallel to the outer side edges of the end sections 15a, while the slot side 21 that interconnects those two slot sides runs parallel and adjacent to the boundary between end section 15a and intermediate section 19a of the middle section 18a. Two leaf-spring type elements 22' and 22" are thereby formed per end section 15a, running perpendicular to the direction of movement of the middle section 18a, i.e. perpendicular to arrow P₂, and connecting the end sections 15a to the middle section 18a, and in particular to its intermediate sections 19a. In the case of the example these leaf-spring type elements 22' and 22" are formed by webs of material between slot sides 21' and 21" and the side edge of the end sections 15a and because of their configuration and arrangement are very rigid in the direction of longitudinal extension yet very flexible perpendicular thereto, especially since the required deflections are minimal amounts of several 1/100 mm to perhaps 1/10 mm.

Fig. 2 is a partial and for the sake of clarity somewhat exaggerated illustration of what happens when the middle section 18a is deflected to an extreme in the direction of arrow P₃. In practice on the other hand the required deflections are only minimal. As can be seen from this drawing, slot side 21" has fully closed at its end adjacent to slot side 21 and the lower end of the leaf-spring type element 22" is hard up against end section 15a, while slot side 21' has opened up by a corresponding amount at its end adjacent to slot side 21. At the opposing end of locating rail 11a the relationships are naturally symmetrical to its centre such that a parallel deflection of the middle section 18a in the direction indicated by arrow P₃ is the result. A deflection of middle section 18a perpendicular to that direction is impossible however, since the leaf-spring type elements 22' and 22" are sufficiently rigid in the direction of longitudinal extension to counteract such deflection.

When the force causing the deflection of the middle section 18a ceases to act the middle section 18a automatically returns to its initial position as shown in Fig. 1 due to the spring action of material webs 22' and 22".

The configuration of the locating pins 9 and the locating sleeves 20 and their interaction is shown in Fig. 4. The locating pins 9 are preferably manufactured from hard metal alloy and possess a parallel cylindrical main section 23 and two tapered end sections 24 and 25. The one tapered end section 24 which performs the actual locating task is only relatively slightly tapered, e.g. to an angle α of approximately 8° , while the other tapered terminal end section that primarily serves to facilitate the introduction of locating pin 9 into the corresponding locating hole is more sharply tapered to an angle β of approximately 45° . As already mentioned the locating pin 9 possesses a central straight-through bore 12 for the supply of compressed air.

Locating sleeve 20 possesses an outer lip section 26 in which the edge of the sleeve 20 is chamfered. The chamfer angle (γ) is approximately 15° and is in any event greater than the angle of the tapered end section 24 of locating pin 9. The diameters of pin 9 and sleeve 20 are selected in such a way that when pin 9 is introduced into sleeve 20 the tapered end section 24 of pin 9 comes to rest against the rim 27 that forms the boundary between the chamfered area 26 of sleeve 20 and its parallel cylindrical inner wall surface.

Since the sleeve 20a and 20b mounted in the middle section 18a and 18b of the locating rail 11a and 11b is blind at one end (cf. Fig. 4), an ever-decreasing annular gap is created as the sole opening as the pin 9 is inserted into the sleeve 20. Compressed air flowing in through bore 12 escapes across this annular gap at an increasing velocity, blowing away any contamination that might be deposited on the mentioned rim 27 and the tapered end section 24 of the pin 9.

Fig. 5 illustrates the situation in which the workpiece carrier 2 has been introduced with its connecting rail 4 into anchoring cylinder 5 just prior to being pulled down against the workpiece holder 1. Here the dimension a between the centres of the two locating pins 9a and 9b does not correspond with dimension b between the centres of the two locating holes 10a and 10b, e.g. as a result of manufacturing tolerances or because of temperature differences between workpiece carrier 2 and workpiece holder 1. This is reflected in a differential dimension x which is very small in practice and is shown much exaggerated in the drawing in Fig. 5.

If now the workpiece carrier 2 is lowered further from its position as shown in Fig. 5 and is finally clamped in the position shown in Fig. 6, this differential dimension x must be compensated. This is done by the one rigid locating rail 11b precisely adjusting itself under the influence of pin 9b and sleeve 20b to a defined X/Y position that serves as the datum position for the machine tool. In the other locating rail 11a on the other hand, the middle section 18a will deflect by the amount of the differential dimension x along the connecting line between the two locating holes 10a and 10b, as has been described above, until the pin 9a locates exactly in sleeve 20a. As the locating rail 11a is rigid perpendicular to this direction of deflection, the entire workpiece carrier 2 will turn about the centreline of pin 9b/sleeve 20b, i.e. the X/Y axis of reference, until the desired angular position of the workpiece carrier 2 and hence of the workpiece 3 is attained. Finally the position according to Fig. 6 is attained in which the support pins 6 rest against the support faces 7 such that a defined position is also achieved on the Z axis.

During the locating process described above the middle sections 18a and 18b of the two locating rails 11a and 11b deflect slightly towards the workpiece carrier 2, i.e. along the Z axis. This does not affect accuracy and encourages the close fit of the tapered end section 24 of pin 9 against the rim 27 of sleeve 20. As Fig. 2 clearly illustrates, the two locating rails 11a and 11b are arranged at a distance from the lower face of the workpiece holder 2 to allow this spring deflection to take place. It goes without saying however that the same effect could be achieved by providing recesses in the lower face of workpiece holder 2.



PATENT CLAIMS:

1. A device for the position-defined clamping of a workpiece (3) on a workpiece holder (1) or of a tool on a tool holder, in which the workpiece or tool holder (1) is provided with at least two projecting locating pins (9a, 9b) intended to engage in corresponding locating holes (10a, 10b) arranged in a workpiece or tool carrier (2) and further provided with connecting means (4, 5) for attaching the workpiece or tool carrier (2) to the workpiece or tool holder (1), characterized in that at least one element of the workpiece or tool carrier (2) bears a locating hole which in relation to at least one other locating hole (10b) spaced apart from it and fixed to the workpiece or tool carrier is spring-deflectable in a direction extending essentially along the connecting line between the said two locating holes (10a, 10b) or parallel thereto but is rigid perpendicular to those directions, and the connection between the fixed locating hole (10b) and the element bearing the deflectable locating hole (10a) is achieved by leaf-spring type elements (22', 22").
2. A device according to Claim 1 characterized in that the leaf-spring type elements (22', 22") extend perpendicular to the connecting line between the locating hole (10a) of the deflectable element and another locating hole (10b).
3. A device according to Claim 2 characterized in that the leaf-spring type elements (22', 22") are formed by webs of material integral both to the deflecting part (17a) and to the workpiece or tool carrier (2).
4. A device according to one of the preceding claims characterized in that the workpiece or tool holder (2) comprises a first rigid element with a locating hole (10b) interacting with a first locating pin (9b) and a second deflectable element with a locating hole (10a) interacting with a second locating pin (9a).
5. A device according to Claim 4 characterized in that the first locating hole (10b) is arranged in a first locating rail (11b) of the workpiece or tool carrier (2) and the second locating hole (10a) is arranged in a second locating rail (11a) of the workpiece or tool carrier (2).
6. A device according to Claim 5 characterized in that the two locating rails (11a, 11b) are attached to the workpiece or tool carrier (2) at a distance from it and from each other.



7. A device according to Claim 6 characterized in that one of the two locating rails (11a) comprises two end sections (15a) rigidly attached to the workpiece or tool carrier (2) and a middle section (18a, 18b) that is spring-deflectable in relation to the workpiece or tool carrier (2).
8. A device according to Claim 7 characterized in that the first and the second locating hole (10b, 10a) are each situated in a middle section (18b, 18a) of the first and second locating rail (11b, 11a) respectively.
9. A device according to Claim 8 characterized in that the middle section (18a) of the second locating rail (11a) is spring-deflectable in relation to its two end sections (15a) on a line towards the middle section (18b) of the first locating rail (11b) and away from it.
10. A device according to Claims 5 to 9 characterized in that the middle sections (18a, 18b) of the two locating rails (11a, 11b) each comprise a central area (17a, 17b) thicker than the intermediate sections (19a, 19b) adjacent to the end sections (15a, 15b) and in which the respective locating hole (10a, 10b) is arranged.
11. A device according to Claim 10 characterized in that the locating pins (9a, 9b) are made of hard metal alloy and have a slightly tapered end section (24) at their head and an adjoining, more sharply tapered end section (25) at their extreme tip.
12. A device according to Claim 11 characterized in that the locating pins (9a, 9b) have a centre straight-through bore (12) that is connected to a compressed air supply.
13. A device according to any one of the preceding claims characterized in that the locating holes (10a, 10b) are formed by hard metal alloy sleeves (20a, 20b) that are open at one end at least and which are let into each of the thickened central areas (17a, 17b) of the locating rails (11a, 11b).
14. A device according to Claim 12 characterized in that a part (26) of the inner wall of the hard metal alloy sleeves is chamfered at the lip facing the locating pin (9a, 9b) and that the taper angle of the chamfered part (26) of the inner wall of the hard metal alloy sleeves is greater than that of the slightly tapered end section (24) at the head of the locating pins (9a, 9b).