

The present invention relates to a device for the detachable mounting of tools in a handling appliance in accordance with the introductory part of the patent claim 1 and to a use of the device as the interface for the exchangeable mounting of pneumatically and/or electrically actuated tools on an industrial robot.

Such automatic or computer controlled handling appliances are gaining increasing importance in the treatment and processing of workpieces in series, for example, in the mounting of implements and devices in the assembly of electric printed circuit boards etc. These handling appliances have a tool holder for receiving a tool which can be moved in several degrees of freedom within the design limits and by means of which the workpiece is worked on. The term "tool" is, in this context, to be deliberately understood in a broad sense; reference is here not only made to machine tools such as drilling machines, screwdrivers or the like, but also grippers, vacuum grippers, adhesive applicators, measurement and test devices, loading and unloading devices for workpiece pallets and the like.

As long as such a handling appliance only has to meet a single task, for example, the gripping of an individual component from a magazine and its insertion in a workpiece which is carried past a handling appliance, no problems are presented by the mounting of the tool suitable for this purpose on the arm of the handling appliance. However, if only relatively small series are to be worked on, or if a single handling appliance is to fulfil several functions, one should ensure that it is possible to effect a speedy and straightforward tool change that is as far as possible, fully automatic.

For this purpose, a device has been proposed, for example in the US-PS 4,636,135, which includes a coupling element mounted on a robot arm and a tool holder that is conjugately lockable and detachably mounted in the coupling element. Since some tools, for example, grippers are actuated pneumatically and electrically if required, provision was made for a compressed air connector which, when the tool holder is mounted, communicates with an air outlet provided thereon, and an electric plug connection engaging in a connector on the tool holder. This made it possible that the tool actuated for example, pneumatically and/or electrically could be premounted in the tool holder and be provided with the necessary compressed air connection for the air outlet on the tool holder and/or the electric connection.

However, two problems have not been solved, or only unsatisfactorily so, by the mounting devices known to date: for one thing, these devices cannot be used universally, but only just for such pneumatically operated tools requiring only a single air connection. Further connections, for example, additional compressed air or vacuum connections had to be established in addition, which of course precludes an automatic tool change.

Furthermore, the accuracy, and in particular the repetitive accuracy, of positioning the tool left much to be desired. Since modern handling appliances have a repetitive positioning accuracy of the order of 5/100 mm per se, increasingly high demands are placed on the accuracy of the tool position relative to the arm of the handling appliance. This particularly important when a handling appliance is to be used on a universal basis, that is to say, when there occurs a frequent change of tools.

From the FR-A-2 554 043, a handling appliance is known with a movable transporter arm which at its end, is provided with a first coupling element of a coupling device. A gripper is mounted on the second coupling element of the coupling device. The coupling device includes all the lines necessary for the operation of the gripper and is designed in such a way that these connections can be automatically coupled and uncoupled when the gripper is to be changed. Admittedly here there do exist a plurality of connection lines (for example, of an electric or pneumatic kind) but the problem of the exact centring of the tool coupling elements with respect to each other has not been solved.

It is the object of the present invention to avoid these drawbacks and to develop a device of the kind cited at the outset in such a way that it can be used for almost any tool to be mounted on the handling appliance without the need for establishing any pneumatic and/or electric connections, apart from the actual tool exchange and that it is thus suitable for a fully automatic tool change and that it has an exceedingly high positioning accuracy, in particular a repetitive accuracy.

In accordance with the invention, this problem is solved by the measures indicated in patent claim 1.

Thereby one ensures on the one hand that when the tool holder is inserted and locked, all electric and pneumatic connections are automatically established between the handling appliance and the tool, since the tool holder bears with one of its faces, from which the ducts and electric contacts emerge whereto the previously mounted tool is connected, on the free front face of the coupling element wherein the ducts on the side of the implement and electric contacts issue. On the other hand, the cooperation of the conically tapering centring pins and of the centring openings in the axially elastic centring plate ensures that the tool holder and hence the tool, is not only mounted accurately within minimum tolerances on the arm of the handling appliance, but that it is also mounted in the correct angular position.

Further developments of the object of the invention and particular modes of embodiment will emerge from the dependent claims 2 to 10. An example of the embodiment of the device

in accordance with the invention will be explained in greater detail below with reference to the attached drawings. In the drawings there are shown in:

- 5 Fig. 1 a schematic, general side view, partly in section of the device in an extracted state;
- Fig. 2 a top view of the coupling element, the cover cap having been removed;
- 10 Fig. 3 a section along line III-III in Figure 2;
- Fig. 4 a section along line IV-IV in Figure 2;
- 15 Fig. 5 a section along line V-V in Figure 2;
- Fig. 6 a side view of the tool holder;
- Fig. 7 a top view of the tool holder; and
- 20 Fig. 8 a section through the tool holder along line VIII-VIII in Figure 7.

25 According to Figure 1, the device consists in general of a coupling element 1 and a tool holder 2. The tool holder 1 is designed for being mounted on a shaft 3 at the arm end 5 of the robot; the shaft 3 has an air duct 4 by means of which the coupling element 1 is provided with compressed air. The tool holder 2 has a mounting plate 6 whereon a tool (not shown) for example, a pneumatically actuated gripper or the like can be mounted.

35 The mounting plate 6 has a centrally arranged locking pin 7 projecting at right angles which serves to secure the plate 6 in the coupling element 1. For this purpose, the locking pin 7 is provided with a head 8 which is accommodated in a corresponding bore in the coupling element 1; relevant further details will be explained below in conjunction with Figure 3.

40 The coupling element 1 has an edge zone 9 in which there issue on the one hand air ducts 10 and on the other hand, electric contacts 11. Four projecting centring pins 12 are symmetrically arranged at the centre of the free front face of the coupling element 1, which pins cooperate with a centring plate 13 on the tool holder 2. The mounting plate 6 of the tool holder 2 is provided along its edge, on the one hand, with electric contacts 14 leading to connector terminals 15 and on the other hand, with air ducts 16. The position of the contacts 14 and of the air ducts 16 is such that they correspond to the contacts 11 and the air ducts 10 when the tool holder 2 is connected to the coupling device 1.

In Figure 2, the coupling element 1 is represented in a top view with the cover 17 having been removed and in Figure 3 in

a cross section along line III-III in Figure 2. The coupling element 1 includes, in essence, a coupling body 18 and a connecting body 19 which, in the case of this example, are both round in shape and firmly interconnected by means of screws 20. The coupling body 18 has a central bore 21 for receiving the locking pins 7 and the head 8 of the tool holder 2. Concentrically with the bore 21, an annular piston 22 is mounted for axial displacement which is urged into its upper end position under the action of springs 23. In this action, slanting side faces 24 of the annular piston 22 displace balls 25 towards the bore 21, which balls are mounted in the wall 27 of the bore 21. Therewith the head 8 of the locking pin 7 is gripped from below and hence the pin 7 is prestressed and held in the bore 21, and the mounting plate 6 of the tool holder 2 is pressed against the free front face 9 of the coupling element 1. This locked position is represented in Figure 3 on the left hand side.

To detach the tool holder 2 from the coupling element 1, compressed air is introduced into the annular space above the piston 22 so that the latter moves downwards towards the position shown in Figure 3 on the right hand side; thereby the balls 25 are released and the locking pins 7 can be pulled out of the bore 21.

The connecting body 19 of the coupling element 1 has a base plate 28 provided with a central air connector pipe 29. The coupling element 1 is mounted on the shaft 3 of the arm end 5 of the robot by means of a clamp 30. A number of electromagnetically actuable pneumatic valves 31a - 31g are arranged on the base plate 28 round the connector pipe 29 in a star configuration. In the case of the example, there are the following valves: two valves 31a and 31b for the supply of air under reduced pressure, two valves 31c and 31d for the supply of air under normal excess pressure, two valves 31e and 31f for actuating the locking of the tool holder 2 and a valve 31g for the low pressure supply.

At the inlet side, the valves 31c, 31d, 31e and 31f communicate via radial ducts 32 and axial ducts 33 with the main air connector, that is to say, with the connector pipe 29, roughly as shown in Figure 3 for the valve 31e. At the outlet side, the valves 31e and 31f are connected via axial ducts 34 to the annular space 26, whilst the valves 31c and 31d communicate at the outlet side via axial ducts 35 passing through the base plate 28 with air ducts 36 which extend through the whole coupling body 18 as far as its front face edge zone 9 and terminate thereat. Expediently, provision is made for an O-ring 37 for sealing purposes when the tool holder 2 is mounted.

At the inlet side, the valves 31a and 31b communicate with a separate air connector 38 to which compressed air is supplied via a line (not shown) at a lower pressure than that of the main air supply. At the outlet side, the valves 31a and 31b

join the front face edge zone of the coupling element 1 via corresponding ducts 35 and 36, as shown in Figure 5, in connection with the valve 31c. Finally, the valve 31g is connected at the inlet side to a connector pipe 39 that communicates with a vacuum line not shown. At the outlet side, the valve 39g is again connected via similar ducts 35 and 36 as shown in Figure 5, to the front face edge zone 9.

As has already been mentioned, the coupling element 1 is, moreover, provided with a number of electric contacts 11. Two contact pins 11a and 11b extend axially between the valves 31b and 31c, two contact pins 11c and 11d between the valves 31d and 31e and two contact pins 11e and 11f between the valves 31f and 31g through the base plate 28 and through the coupling body 18 and again terminate in the front face edge zone 9. The contact pins are accommodated in an insulating sleeve 42 and have an upper fixed part 44 communicating with a connector part 41, and a lower axially movable part 45 that passes into the actual contact pin 11 and rests on a spring 43.

Finally, the coupling element is provided with a centring body 46 which is arranged centrally in the zone of the free front face and is slightly recessed round the opening 21. In the case of the example, the centring body has four centring pins 47 mounted in central symmetry and projecting slightly beyond the front face edge zone 9 of the coupling element 1, which pins have a conically tapering tip 48. The centring pins 47 cooperate in a way still remaining to be explained with the centring plate 13 fixed to the mounting plate 6 of the tool holder 2.

Firstly, it may be noted in summary that the coupling element 1 is formed by a compact block connected at one of its sides to the arm end 5 of the robot, the main air connection being effected directly through the robot arm via the air duct 4 in its shaft 3 and from which all additional pneumatic and electric connections are led out, for example through a connector 49 (Figure 1). At the other end, there are available a freely accessible front face 9 with freely accessible pneumatic and electric connectors as well as the centring body 46 and the receiving bore 47 for the locking pins 7.

According to Figures 6 to 8, the mounting plate 6 of the tool holder 2 has a centring plate 13 which is mounted, for example by screws 51, secured against rotation and is rigid in the peripheral direction. The centring plate 13 is preferably made of spring steel and has a number of centring openings 52 which correspond to the centring pins 47 with respect to their size, shape and position. When the tool holder 2 is mounted on the coupling element 1, the head of the locking pin is drawn by the bolt 25 into the opening 21 and the centring pins 47 penetrate with their tapered tips into the centring openings 52, so that the latter are at least partly covered. The centring plate 13 is thereby deformed in the axial direction;

5 this is made possible by the cavities 53 in the mounting plate 6. In this way, one ensures an extremely accurate positioning of the mounting plate 6 on the coupling element 1, in which arrangement, inaccuracies or considerable play or wear phenomena between the locking pin 7 and the bore 21 are completely insignificant as far as the positioning accuracy is concerned.

10 The mounting plate 6 is, moreover, provided with air ducts 16 and with electric contacts 14. In this arrangement, the position of the ducts 16 correspond to the position of the ducts 36 in the coupling element and the position of the contacts 14 correspond to the position of the contacts 11 in the coupling element. At the free surface of the mounting plate 6, the
15 ducts 16 are expediently provided with connector pipes 54 from which the required pneumatic connections are effected to one of the tools mounted on the mounting plate 6. Similarly, the electric contacts 14 are connected to connector terminals 15 to allow provision to be made for any kind of connection to a tool.

20 The device proposed and described above by way of example allows provision to be made for a plurality of premounted tools each mounted on one tool holder 2 and in which all required pneumatic and electric connections between the tool holder 2
25 and the tool are already established. When a tool holder 2 prepared in this way is then inserted into the coupling element 1, these pneumatic and electric connections are automatically completed to the coupling element, and hence to the control device of the robot, since the mounting plate 6 of the
30 tool holder 2 is applied to the free front face zone 9 of the coupling element 1 with a close fit as soon as the tool holder 2 is locked on the coupling element 1. Thereby, a fully automatic tool change is ensured without the assistance of an operator.

35 The centring by means of the pins 47 and the plate 13 provides the desired high accuracy of the order of plus/minus 0.01 mm which is distinguished in particular by a high repetitive accuracy, imperviousness to wear and fouling and by its simplicity. Thereby one ensures a continuous operation free of
40 problems even with frequent tool changes with short cycle times.

45 In the example herein described, provision is made for seven valves, six electric through connections and five pneumatic through connections which would probably be enough for most of the tools to be used in this generic context. Accordingly, the device is eminently suitable for universal use. However,
50 it goes without saying that provision can be made for a greater or smaller number of the electric and/or pneumatic connections.

PATENT CLAIMS

- 5 1. A device for the detachable mounting of tools in a
handling appliance, with a tool holder (2) and, arranged on
the handling appliance, a coupling element (1) wherein the
tool holder is conjugately locked and detachably mounted, the
coupling element (1) having a compressed air connector which,
10 when the tool holder is mounted, communicates with an air
outlet provided thereon, and electric connectors which, when
the tool holder is mounted, cooperate with electric connector
elements provided thereon, with the following features:
- 15 a) the coupling element has a free front face (9) whereon
there bears the mounted tool holder (2), as well as a plu-
rality of ducts (36) and electric contacts (11) issuing in
the free front face (9),
- 20 b) in the zone of the free front face (9) of the coupling ele-
ment (1), provision is made for a plurality of projecting
centring pins (47) conically tapering towards their tips,
- 25 c) the tool holder (2) has a surface sector designed for
bearing on the free front face (9) of the coupling element
(1), which sector is provided with correspondingly arranged
ducts (16) and electric contacts (14),
- characterized by the following feature:
- 30 d) in the zone of the above mentioned surface sector of the
tool holder (2), a rigid centring plate (13) is arranged
having openings (52) disposed to correspond to the centring
pins (47) of the coupling element (1), which openings cover
35 the conically tapered part (48) of the centring pins (47)
when the tool holder is mounted, in such a way that the
centring plate (13) is elastically deformed in the axial
direction in the zone of its openings (52).
- 40 2. A device according to claim 1, characterized in that the
coupling element (1) is, moreover, provided with a plurality
of electromagnetic valves (31) assigned to the individual
ducts (36).
- 45 3. A device according to claim 2, characterized in that at
least some of the electromagnetic valves (31c, 31d, 31e, 31f)
communicates on the inlet side with the compressed air
connector (29).
- 50 4. A device according to claim 2, characterized in that the
coupling element (1) is provided with a further compressed air
connector (38) communicating on the inlet side with at least
one of the electromagnetic valves (31a, 31b).



5. A device according to claim 2, characterized in that the coupling element (1) is moreover provided with a vacuum line connector (39) which communicates on the inlet side with at least one of the electromagnetic valves (31g).

6. A device according to one of the preceding claims, characterized in that the electric contacts (11) of the coupling element have pins (45) sprung in the axial direction whose tip (11) on the side of the front face is slightly offset rearwards in relation to the free front face (9) of the coupling element.

7. A device according to one of the preceding claims, characterized in that the electric contacts (14) of the tool holder (2) project beyond its surface sector designed for bearing on the free front face (9) of the coupling element (1).

8. A device according to one of the preceding claims, characterized in that the coupling element (1) is provided with four centring pins (47), disposed with central symmetry on a sector of the front face offset in relation to the free front face (9) of the coupling element.

9. A device according to one of the preceding claims, characterized in that the tool holder (2) has a centrally symmetrical plate-type body (6) along whose periphery the duct (16) and the electric contacts (14) are disposed, and in that the centring plate (13) is centrally fixed at the centre of the plate-type body (6).

10. A device according to claim 9 characterized in that the plate-type body (6) of the tool holder (2) is provided in the zone of the openings (52) of the centring plate (13) with cavities (53) recessed into the surface of the plate-type body (6).

11. Use of the device according to one or more of the preceding claims as interface for the interchangeable mounting in pneumatically and/or electrically actuated tools in an industrial robot.

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