

Driving and Control Device for a Multispindle Processing Machine

The present invention answers a need for perfection
5 and new development of multi-spindle processing machines.
Until now, when an indexing operation has had to be
carried out between two machining operations on a bar or
workpiece borne by a spindle situated in a predetermined
machining station, there has been provided on the barrel
10 support a device including an auxiliary motor capable of
engaging the spindle to be indexed at the moment when such
indexing is to be carried out, and means have likewise
been provided for uncoupling the spindle from its usual
drive shaft, stopping it, and putting it in free-wheeling
15 so that the auxiliary motor can rotate it through the
desired angle.

It is the object of this invention to provide
improved driving and control apparatus which is more
compact, simpler, and above all more flexible in
20 operation, and which allows not only spindle indexing but
also a number of other functions which increase the
operating ability of the multi-spindle processing
machines.

Certain multi-spindle processing machines are already
25 equipped with auxiliary apparatus comprising a chuck
capable of gripping a workpiece in a machining spindle in
order to transfer it to another spindle during a cycle.
Thus, West German Patent No. 3,204,886 describes a
processing machine having a multi-spindle indexable barrel
30 and two front-mounted work-station assemblies disposed in
front of and behind the barrel, respectively. The chuck of
the auxiliary apparatus can grip a workpiece in a spindle
of the barrel oriented toward one of the work-station
assemblies in order to transfer it to a spindle oriented
35 toward the other assembly. However, this chuck is not

capable of supporting the workpiece when it is driven rotatingly.

On the other hand, pneumatically controlled chucks per se have already been proposed in the art of processing machines, particularly in U.S. Patent No. 2,392,999 and U.K. Patent No. 860,927.

Nevertheless the teaching furnished by these documents does not permit a person skilled in the art to solve the problem cited above.

10 A solution to the problem can be found, according to the present invention, in a driving and control device for a multispindle processing machine itself comprising, within a frame, a barrel indexable about an axis and fitted with a plurality of spindles distributed about said axis and provided with rotary means, a plurality of work stations disposed opposite the barrel so as to carry out operations on the bars or workpieces borne by the spindles, and drive means actuating the work stations, said device comprising on the one hand in one of the said work stations an auxiliary unit constituting a chuck with controlled opening and closing and means for driving the chuck, connected to said drive means, and on the other hand programmable control means connected to the spindle situated opposite the said auxiliary unit, and connected to the auxiliary unit, and capable of controlling said means for rotating the spindle situated opposite the auxiliary unit and the chuck, and thus to carry out at least one indexing operation on the bar or workpiece borne by said spindle, this operation being carried out by means of said chuck.

A preferred embodiment of the invention will now be described in detail with reference to the accompanying drawings, in which:

Figure 1 is a diagrammatic elevation of a processing machine equipped with the inventive apparatus,

Figure 2 is a partial diagrammatic section thorough an autonomous unit forming part of the drive apparatus of the invention,

Figure 3 is a detailed axial section thorough a chuck
5 forming part of the autonomous unit,

Figure 4 is a seciton taken on the line IV-IV of Figure 3,

Figure 5 is a partial diagrammatic elevation illustrating the execution of work on axis C on a
10 processing machne equipped with the inventive apparatus, and

Figure 6 is a partial diagrammatic elevation of a spindle-locking mechanism.

A brief description of the essential elements of the
15 processing machine shown in Figure 1 will be given. This machine comprises a base 1 having an upright 2 which constitutes a barrel support in which a barrel 3 is rotatngly supported. Barrel 3 rotates about a horizontal axis and bears a series of spindles 4 having parallel axes
20 distributed about the central axis of barrel 3 and each comprising a chuck 5 intended to grip a bar (not shown) held in a spindle 4. The general operation of this machine need not be described in detail here. It is known that the chucks open periodically and that suitable means
25 cause the bars to advance by a predetermined length, after which tools, e.g., a radial tool mounted in a tool holder 6, and/or front-mounted tools such as a drill 7 or a tapper 8, carry out machining operations on the front ends of the bars. These bars are made integral by means of
30 chucks 5 with spindles 4 which rotate aobut their axes, each in one of the machining stations provided. Components 9 and 10 are scrolls which, when barrel 3 is indexed, are driven via a shaft 11 by an indexing motor 12, so that barrel 3 and the group of bars held in

spindles 4 rotate together in order for each bar to reach the following machining station.

The machine therefore comprises, on base 1, a frame 13 in the top part of which work stations 14 are mounted, distributed so that each one faces one of the machining stations defined by the stopping positions of barrel 3. Base 1 bears a main motor 15 which, via belts 16, drives a shaft 17, the rotation of which is communicated by suitable gearing to spindles 4. On the other hand, via a system of rotary driving means 18 comprising various pinions, transmissions, and couplings, which need not be described here, various motors, e.g., a motor 19 and an adjustable-speed motor 20, rotate work spindles (not shown) which are mounted in work stations 14 and drive rotary tools such as 7 and 8.

The driving apparatus which will now be described uses one of the work stations 14. It comprises, on the one hand, an autonomous unit 21 and, on the other hand, control means 22. These two parts of the apparatus are shown diagrammatically in Figure 2 and in more detail in Figures 3 and 4. Unit 21 is mounted on a support 23 intended to be fixed against frame 13 at the location of one of the work stations 14. Mounted within support 23 is a sliding sleeve 24. As may be seen in Figure 2, unit 21 comprises a cylinder 25; and sliding sleeve 24 comprises, approximately halfway along its length, a collar 26 which will be provided with a gasket and functions as a piston. The two ends of cylinder 25 are fed by ducts 27 and 28 so that an axial movement toward the left or the right, as viewed in Figure 2, can be controlled and cause displacement of sleeve 24. Disposed within sleeve 24 is a rotary assembly 29 supported within sleeve 24 by bearings and comprising in particular a grooved hollow shaft 30, the rearward end of which is seen in Figure 2. This grooved end of hollow shaft 30 is coupled by means of one

or more keys 31 to a hub 32, the central part of which surrounds the rearward end of sleeve 24 and is supported by bearings 33 and 34 in frame 13. Mounted on hub 32 is a multiple pinion 35 which can be displaced axially, in a manner known per se, and co-operate with a gear element 36 to drive rotary assembly 29 at variable speeds while allowing hollow shaft 30 and the elements integral therewith to move axially in response to the movement of piston 26 controlled by the hydraulic device.

10 Figure 3 again shows part of support 23, cylinder 25, and the front end of sleeve 24. It also shows the front end of hollow shaft 30 supported within sleeve 24 by a bearing 37.

Sleeve 24 bears at its front end a chuck, designated 15 as a whole by reference numeral 38 and shown in more detail in Figures 3 and 4. Chuck 38 comprises a generally cylindrical chuck body having a rear extension 41 connected by a locking means 40 to the end of sleeve 24. Rear extension 41 bears a rear bearing 42 coaxial with a 20 front bearing 43 of large diameter. These two bearings support the rotary part of the chuck, which in turn comprises a spindle 44 ending at the rear in a rocket shape 45 with grooves allowing spindle 44 to be connected to hollow shaft 30 by means of a coupling sleeve 46.

25 Spindle 44 guides in a recess in its front end an axially movable collet 47 and a chuck element 48 of conventional design. Collet 47 co-operates with three radially disposed levers 49 and with an axially movable piston 50 in response to air pressure injected through an inlet 30 connection 51. By moving axially forward, piston 50 prompts levers 49 which press against a shoulder of spindle 44 and cause collet 47 to back up toward the rear against the bias of chucking spring 52. Hence chuck element 48, which is held in place by a secondary spring 35 53, is released and can open, whereas it is kept closed

when collet 47 is urged forward by spring 52 in the absence of air pressure in the chamber contrived between piston 50 and the back of the cylinder formed within chuck body 41.

5 The air pressure reaches connection 51 thorough a tube 54, monitored by a solenoid valve 55 (Figure 2) which operates in co-operation with a solenoid valve 58 directly or inversely feeding tubes 27 and 28 which admit oil pressure to cylinder 25. Thus control device 22, acting
10 upon solenoid valves 55 and 58, makes it possible to control monitored axial movements of sleeve 24, as well as the opening and closing of chuck 38. Control device 22 will likewise be connected to whichever of motors 19 and 20 is used to rotate shaft 30 via pinion 35. This
15 electronic unit will likewise be connected to detectors, one of which, for example, designated by reference numeral 61, is shown in Figure 1. This is a detector intended for taking the angular reference of the spindle 4 situated opposite the work station equipped with autonomous unit
20 21. Detector 61 is, for example, a proximity detector co-operating with a stud 56 fixed to spindle 4. It transmits a signal when this spindle is so oriented that stud 56 coincides with the detector. For instance, in the case where the bar supported by spindle 4 is a sectional bar,
25 this detector ensures that spindle 4 is locked with the section of the bar in a predetermined orientation. Once this maneuver has been carried out, control unit 22 may, for example, control a maneuver of chuck 38 so that this chuck moves to grip the end of the bar opposite which it
30 is situated. It will be noted that this operation can be carried out without making any change either in the design of the chuck holding the bar or in the arrangement of the corresponding spindle or in the arrangement of barrel 3. This operation having been effected, control unit 22 is in
35 a position to control various work programs, not only on

the elements of autonomous unit 21 or on the motor driving the corresponding work station, but also on other components of the processing machine.

To clarify these ideas, there will be indicated below, by way of example and in summary, a program of a number of stages which in turn comprises different variations as regards some of these stages.

Description of the Cycle

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1. (Preliminary operation). Indexing of the barrel. During this movement, spindle 4 is braked and passes from speed N to speed zero. Locking of the barrel. Locking of the spindle once stopped. This operation can be carried out by disposing (see Figure 6) within barrel 3, coaxially with spindle 4, a locking cone 62 co-operating with a sliding clutch part 63 which slides on the spindle and can be moved, starting from an intermediate position (0), either (1) into a clutching position with a pinion 64 rotated by shaft 17, or (2), into a locking position in contact with locking cone 62. The sliding part 63 will be keyed on the shaft of spindle 4.

2. Control of spindle 38. Gripping of chuck 39 on the end of the bar or on the workpiece.

25 3. Release of sliding part 63 from its locking position.

4. Control of indexing of the bar or of the workpiece and stopping of rotation by means of drive motor 20 or 19 upon the signal supplied by detector 61.

30 5. Control of a machining operation (drilling, radial milling, slicing, etc.).

6. - Rotation of spindle 38 through a predetermined angle with a view to a second radial machining operation or

-placing of an auxiliary machining part, with spindle 38 remaining fixed, or

-C-axis machining operation, making it possible to machine, for example through milling, a helical groove, the control unit then simultaneously controlling a rotational movement of spindle 38 and an axial movement of the machining tool, the bar or the workpiece still being gripped in chuck 39.

7. Return of spindle 38 to its starting position.

8. Unclamping of chuck 39 and retraction of spindle 38.

9. Indexing of barrel 3. During this movement, the spindle will again be driven so as to pass from speed zero to speed N. The new spindle which comes into place in the machining station where unit 21 is situated undergoes the operation described in 1 above, so that the cycle is complete.

Thus, as may be seen on the basis of this example, control unit 22 may comprise the inputs and outputs necessary for controlling all these different operations.

Figure 5 further illustrates diagrammatically the arrangement corresponding to the carrying out of a machining operation forming a helical groove on the lateral surface of a cylindrical workpiece 57. This drawing shows body 39 of the chuck and spindle 38, as well as support 23 fixed to frame 13. Mounted at the top of upright 2, used for pivoting barrel 3, is a tool support 58 bearing a milling tool 59 supported by a slide so as to move radially relative to the axis of spindle 38. Chuck 5 of the corresponding spindle of barrel 3 is likewise shown in Figure 5. It is seen that a slicing operation has been carried out on the end of the bar gripped in chuck 5, so that workpiece 57 has been moved away from chuck 5 by an axial displacement of spindle 38. The radial movement of milling cutter 60 is a movement whose control meets

criterion X, whereas the rotation of spindle 38 is a movement meeting the criterion called C-axis. The axial displacement of spindle 38 meets the criterion called Z2. Thus, the production of a helical groove in the

- 5 cylindrical side surface of workpiece 57 is an operation necessitating a control XCZ2. Such a control is easily programmable when the processing machine is equipped with a numeric control. This naturally means that the auxiliary motor used to drive shaft 30 must be C-axis
10 guidable by the numeric control device of the machine.

- As concerns Figure 5, it may also be indicated that, in another variation, if workpiece 57 were not separated from the bar, the program for carrying out the operations might comprise an opening of chuck 5 in order to permit an
15 axial displacement of the whole bar at the time of the machining operation by means of milling cutter 60, then the return of the bar to its normal position and reclamping of chuck 5. Next, chuck 39 would be opened, and spindle 38 would retract in order to permit indexing
20 of the barrel and repetition of the operation on the following bar. If workpiece 57 had been sliced or were a separate piece, it would obviously be ejected into a receptacle at the end of the operation, i.e., upon opening of chuck 39.

- 25 Another variation would be that the movement 22 would not be carried out by machining unit 21 but rather by an axial movement of milling tool 59.

Patent Claims

1. Driving and control device for a multispindle processing machine itself comprising within a frame (1, 2, 13) a barrel (3) indexable about an axis and fitted with a plurality of spindles (4) distributed about said axis and provided with rotary means (63, 64, 17), a plurality of work stations (14) disposed opposite the barrel so as to carry out operations on the bars or workpieces borne by the spindles, and drive means (18, 35, 36) actuating the work stations, characterized in that the said device comprises on the one hand in one of the said work stations (14) an auxiliary unit (21) constituting a chuck (38) with controlled opening and closing and means (24-35) for driving the chuck, connected to said drive means (18, 36), and on the other hand programmable control means (22, 55, 58) connected to the spindle (4) situated opposite the said auxiliary unit (21), and to the auxiliary unit (21), and capable of controlling said means (63, 64, 17) for rotating the spindle situated opposite the auxiliary unit and the chuck (38), and thus to carry out at least one indexing operation on the bar or workpiece borne by said spindle (4), this operation being carried out by means of said chuck (38).

2. The device of claim 1, characterized in that the unit (21) comprises a shaft element (24) bearing said chuck, in that the drive means comprise a hydraulic or hydro-pneumatic control (54, 50, 49) for opening and closing the chuck (38) and an axial drive monitored (25, 26) by the shaft element (24), and in that the control means (22, 55, 58) are arranged to control repetitive opening, closing, and axial displacement operations of said chuck.



3. The device of claim 2, characterized in that the control means comprise an output intended to be connected to a said rotary driving means (18, 36) so as to control and monitor rotation thereof when it is connected to the auxiliary unit.

4. The device of one of claims 1 to 3, characterized in that the control means comprise an input intended to be connected to a detector (61) mounted on the barrel (3) and capable of emitting a signal for at least one predetermined orientation of the spindle (4) which is opposite the auxiliary unit (21).

5. The device of any one of claims 1 to 4, characterized in that the control means comprise an output intended to be connected to a spindle coupling unit (63, 64) associated in the barrel to said spindle located opposite the auxiliary unit (21).

6. The device of any one of claims 1 to 5, characterized in that the control means are arranged so as to be able to control a pick-up of angular reference of the bar or the workpiece fixed in the spindle located opposite the auxiliary unit (21), then one or other of the following operations:

- a machine operations;
- indexing through a certain angle with a view to a second machining operation;
- a machining operation and an operation of rotation of said bar or of said workpiece, these two operations being combined and constituting a C-axis operation.

7. The device of any one of the preceding claims, characterized in that the chuck (38) and the drive means (24-35) are mounted in an auxiliary apparatus comprising a



shaft (32) and a support (23), this apparatus being designed to be fixed to the frame at the location of any one of the work stations (14).



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