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**Control Device for an Incremental Numerical Axis  
in a Machining Station**

The subject of the present invention is a control device for an incremental numerical axis in a machining station.

Numerical control devices of machining stations generally include in their program a referencing sequence which takes place at the time of starting-up of the machine. This sequence consists, for each axis, in bringing the carriage subjected to the impulse of this axis into a reference position from which the movements to be effected during the working sequence will be counted.

In general, the reference position is determined on a fixed measuring instrument. The position of the mobile assembly is constantly detected, both in the course of the referencing sequence and in the course of the working sequences in relation to this instrument. Fixed rules bearing detection marks generally form said measuring instruments. They are fixed along the course of the moving assemblies and include several spaced-out reference marks in order to permit an adaptation to the particular conditions of each machine. It is therefore necessary, at the moment of putting into service, to "activate" that one of the reference marks which it is desired to use.

Until now, a sensor has been used for this purpose, in general a contact switch which is placed in the vicinity of the mark which it is desired to activate. During the referencing sequence which the program of the machine includes, the mobile assembly is moved until the moment when the switch is actuated. At this moment, the reference detector is activated, and at the moment when it detects the next reference mark,



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the mobile assembly is directed towards this reference, and the zero position is stored in the control device.

The measuring instruments are generally high-precision racks, in which a pinion meshes which drives a rotary encoder, or optical devices mounted on the mobile assembly and capable of reading marks borne by the rule.

These locating devices are adaptable both to linear axes and to rotary axes.

For permitting the referencing, it is therefore necessary, at the time of putting a machine into service, to place a switch on each axis, in a carefully predetermined position, and to connect this switch to the control unit, which, when the number of axes is large, represents extensive and delicate work. Patent US 4,757,458 describes a known device applied to a rotary axis. A deviation, variable with the number of revolutions, between the angular position given by a switch and an angular reference, gives the number of revolutions effected. The presence of a switch is necessary. The connections to be established manifestly represent a risk for the reliability in the known systems. Now, it has been noticed that it was possible to remedy these drawbacks in an extremely simple manner not needing any additional investment in the manufacture of the machines.

The present invention therefore aims to permit the improvement in reliability alluded to above and a reduction of the costs by replacing a switch by a simpler means. To this end, the subject of the present invention is a device for controlling an incremental numerical axis in a machining station including an assembly associated with the mobile axis and

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capable of travelling along a predetermined course, at least one reference disposed along this course in a predetermined position, means for driving the assembly capable of moving it in one direction and the other along the course, and activation means for activating the reference in the course of a locating movement effected by the assembly, characterized in that said activation means comprise action means localized on said course and capable of causing the transmission of a signal of deviation of position of the assembly between an instantaneous position value given by the drive means and a real position value of the assembly and means for processing said signal capable of initializing the locating movement when said signal corresponds to a predetermined critical position deviation.

It will be explained below, on the basis of an embodiment taken by way of example, how the invention can be implemented.

Reference will be made to the appended drawing, of which

Fig. 1 is a diagrammatic top plan view of a mobile assembly and of its control means, in a machining station,

Fig. 2 is a graph illustrating the position signals transmitted by the detector of the mobile assembly, and

Fig. 3 is a graph representing the processing in the device of Fig. 1 of the signals of Fig. 2 and the determination of the reference position.

Taken as an example is the movement of a carriage 1 on a slideway 2 in any kind of machining station. Mounted on the carriage 1 is a tool holder 3 which it is not necessary to specify in greater detail. The carriage 1 is actuated by a jack 4, the piston 5 of which

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is connected to the carriage by a rod 6 and the cylinder 7 of which is fed with pressurized oil from a system of valves 8, which it is also not necessary to describe in detail. The control of the valve 8 is effected from a control unit 9. A part P of the unit 9 symbolizes a stored program, and it is seen that the unit 9 is connected by a connection 10 to a signal converter 11.

The signal converter 11 is connected, in a manner known per se, to a sensor 12 which moves with the carriage above a series of marks 13 marked on a rule 14 associated with the slideway 2. The marks 13 permit determining, in the unit 9, the instantaneous position of the mobile assembly 1, as well as its speed and the direction of its movement, as will be seen below. Besides the marks 13, the rule 14 further bears a series of marks 15 which constitute references.

As has been said previously, the marks 13 and 15 may be of any known type. They are conceived according to the type of encoder and sensor used.

At the time of starting-up the axis depicted in Fig. 1, it is a question of bringing the carriage 1 onto a reference position, or zero position, which is determined by one of the marks 15 chosen beforehand.

Fig. 2 shows the mark 15 which has been chosen, or more exactly, the signal transmitted by the sensor 12 at the moment when the carriage 1 is opposite this mark. The signals 16 and 17 composed of trains of square pulses, of the same frequency and of the same width, represent the signals transmitted by the encoder 11 at the time of the movement of the carriage 1 along the rule 14. The phase-shift  $\Delta$  of  $90^\circ$  between the corresponding signals of the series of signals 16 and of the series of



signals 17 permits determining the direction of the movement, while the calculation of the number of signals transmitted per the unit of time permits determining the relative position and the speed.

In the device described, one completely avoids the use of an additional signal transmitted to the unit 9 for permitting locating that one of the marks 15 which has been selected as position zero. The means provided for that follows from the graph of Fig. 3. This graph depicts four parameters which vary as a function of time. On the upper line, the parameter  $V$  is seen, which represents the speed of the mobile assembly as a function of time. On the second line, the parameter  $\Delta P$  is seen, which represents the deviation between the instantaneous position of the mobile assembly, given by the signals of the encoder 11, and the position which this mobile assembly should theoretically occupy according to the program contained in the unit 9, at the moment considered. As will be seen, this position deviation assumes an abnormal value at a certain moment.

The third line represents, as a function of time and synchronously with the first two lines, a signal of activation  $E$  of the referencing function, thus of activation of the corresponding function in the sensor 12.

As for the fourth line, it represents the transmission of the reference signal  $R$  upon passage of the carriage over the mark 15 which has been activated.

To understand the operation of the system thus programmed, the device is considered to be situated, at the time of starting, in an initial position which corresponds, for example, to that of Fig. 1. At the time of putting into service, the jack 4 is actuated so that the piston moves from right to left. As is seen on the first line of Fig. 3, the



speed of the carriage 1 increases up to a first limiting value  $V_{ref1}$ , and the movement of the carriage continues thus until the moment when its slide comes in contact with a stop 18 which limits its course. At this moment, marked by the letter A on the first line of Fig. 3, there occurs a halt of the movement, and the position deviation  $\Delta P$ , which until then had a very low value corresponding to the determination of the speed of movement according to the program, assumes an increasing value, the deviation between the theoretical position and the real position augmenting proportionately to the time. When the deviation attains the value  $\Delta P_{ref}$ , the program P controls, on the one hand, the reversal of the direction of movement of the piston 5 in the jack 4 and, on the other hand, the activation of the referencing function, as indicated above. The speed curve of the carriage therefore has the appearance depicted in the first line of Fig. 3 and, after a certain lag, rapidly increases to attain a limiting value  $V_{ref2}$ . The carriage 1 thus moves from left to right at the speed  $V_{ref2}$  until the moment when, the sensor 12 being activated, it records the signal of passage over that one of the marks 15 which has been preselected. It can, in fact, easily be determined that, the movement starting from the stop, it will be the first reference signal 15 or the second, or the third, etc., which will be recorded as reference zero, so that only this reference signal will be operational.

If need be, the position of the rule 14 might be adjusted in relation to that of the stop 18 in such a way that the position of the carriage corresponding to the halt A (Fig. 3) directly constitutes the reference position. It is necessary for that purpose that the halt position, determined by the stop, be sufficiently precise.



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Of course, it is not necessary that the stop 18 be a part situated at the end of the slideway. Any element capable of causing, at the time of the movement of the carriage 1, a position deviation attaining a predetermined critical value, may be used for carrying out the referencing. What is essential is that it is no longer necessary to connect a detection element electrically to the electronic circuit of the control unit, as has been the case until now.

It should be noted on the other hand that, in the case where the control of the axis is a motorized control, cases might arise where causing the position deviation by means of a stop, such as the stop 18, would not be acceptable. However, in such a case, one might also, in lieu of a stop, place on the course of the carriage 1, at the proper location, an element which, instead of blocking the movement, causes braking, for example, thus a slowing of its speed such that a position deviation attaining the critical value  $\Delta Pref$  may be caused.

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### CLAIMS

1. Device for controlling an incremental numerical axis in a machining station including an assembly associated with the mobile assembly and capable of travelling along a predetermined course, at least one reference disposed along this course in a predetermined position, means for driving the assembly capable of moving it in one direction and the other along the course and activation means for activating the reference in the course of a locating movement effected by the assembly, characterized in that said activation means comprise action means localized on said course and capable of causing the transmission of a signal of deviation of position of the assembly between an instantaneous position value given by the drive means and a real position value of the assembly and means for processing said signal capable of initializing the locating movement when said signal corresponds to a predetermined critical position deviation.

2. Device according to claim 1, characterized in that the action means consist of a stop capable of blocking the movement of the mobile assembly under the influence of its drive means, in a predetermined region of the course.

3. Device according to claim 1, characterized in that the action means consist of a braking means capable of braking the movement of the mobile assembly under the influence of its drive means, in a predetermined region of the course.

4. Device according to claim 1,

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comprising a series of references associated with a fixed measuring instrument, disposed along the course, characterized in that the processing means are made up in such a way that a preselected reference in said series is activated when the locating movement is initialized.

5. Device according to claim 4, characterized in that the action means consist of a stop capable of blocking the movement of the mobile assembly under the influence of its drive means, in a predetermined region of the course, and in that the processing means are made up in such a way that the stop physically represents the reference position.

6. Device according to claim 1, characterized in that the drive means are hydraulic means and the mobile assembly bears a cutting tool.

7. Device according to claim 1, characterized in that the drive means comprise an electric motor and the mobile assembly bears a cutting tool.

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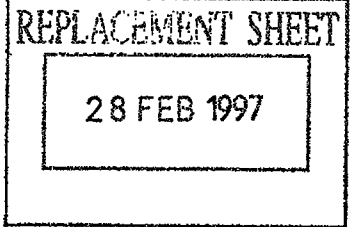
**ABSTRACT:**

The instantaneous position of the carriage (1) is made explicit in the form of a datum transmitted by the connection (10) to the circuit (9) by the signal converter (11) and the sensor (12) reading the marks (13) on the rule (14). One of the marks (15) acts as a reference mark. During the referencing sequence, the carriage (1) is moved towards the left until it reaches the stop (18). The circuit (9) then causes a position error to appear which attains a critical value, which causes the reversal of the direction of movement of the carriage (1) and the activation of the detection of the reference (15) which has been preselected.

(Fig. 1)

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**Control Device for an Incremental Numerical Axis  
in a Machining Station**

The subject of the present invention is a control device for an incremental numerical axis in a machining station.

Numerical control devices of machining stations generally include in their program a referencing sequence which takes place at the time of starting-up of the machine. This sequence consists, for each axis, in bringing the carriage subjected to the impulse of this axis into a reference position from which the movements to be effected during the working sequence will be counted.

In general, the reference position is determined on a fixed measuring instrument. The position of the mobile assembly is constantly detected, both in the course of the referencing sequence and in the course of the working sequences in relation to this instrument. Fixed rules bearing detection marks generally form said measuring instruments. They are fixed along the course of the moving assemblies and include several spaced-out reference marks in order to permit an adaptation to the particular conditions of each machine. It is therefore necessary, at the moment of putting into service, to "activate" that one of the reference marks which it is desired to use.

Until now, a sensor has been used for this purpose, in general a contact switch which is placed in the vicinity of the mark which it is desired to activate. During the referencing sequence which the program of the machine includes, the mobile assembly is moved until the moment when the switch is actuated. At this moment, the reference detector is activated, and at the moment when it detects the next reference mark,

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the mobile assembly is directed towards this reference, and the zero position is stored in the control device.

The measuring instruments are generally high-precision racks, in which a pinion meshes which drives a rotary encoder, or optical devices mounted on the mobile assembly and capable of reading marks borne by the rule.

These locating devices are adaptable both to linear axes and to rotary axes.

For permitting the referencing, it is therefore necessary, at the time of putting a machine into service, to place a switch on each axis, in a carefully predetermined position, and to connect this switch to the control unit, which, when the number of axes is large, represents extensive and delicate work. Patent US 4,757,458 describes a known device applied to a rotary axis. A deviation, variable with the number of revolutions, between the angular position given by a switch and an angular reference, gives the number of revolutions effected. The presence of a switch is necessary. The connections to be established manifestly represent a risk for the reliability in the known systems. Now, it has been noticed that it was possible to remedy these drawbacks in an extremely simple manner not needing any additional investment in the manufacture of the machines.

The present invention therefore aims to permit the improvement in reliability alluded to above and a reduction of the costs by replacing a switch by a simpler means. To this end, the subject of the present invention is a device for controlling an incremental numerical axis in a machining station including an assembly associated with the mobile axis and

capable of travelling along a predetermined course, at least one reference disposed along this course in a predetermined position, means for driving the assembly capable of moving it in one direction and the other along the course, and activation means for activating the reference in the course of a locating movement effected by the assembly, characterized in that said activation means comprise action means localized on said course and capable of causing the transmission of a signal of deviation of position of the assembly between an instantaneous position value given by the drive means and a real position value of the assembly and means for processing said signal capable of initializing the locating movement when said signal corresponds to a predetermined critical position deviation.

It will be explained below, on the basis of an embodiment taken by way of example, how the invention can be implemented.

Reference will be made to the appended drawing, of which

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Fig. 2 is a graph illustrating the position signals transmitted by the detector of the mobile assembly, and

Fig. 3 is a graph representing the processing in the device of Fig. 1 of the signals of Fig. 2 and the determination of the reference position.

Taken as an example is the movement of a carriage 1 on a slideway 2 in any kind of machining station. Mounted on the carriage 1 is a tool holder 3 which it is not necessary to specify in greater detail. The carriage 1 is actuated by a jack 4, the piston 5 of which

is connected to the carriage by a rod 6 and the cylinder 7 of which is fed with pressurized oil from a system of valves 8, which it is also not necessary to describe in detail. The control of the valve 8 is effected from a control unit 9. A part P of the unit 9 symbolizes a stored program, and it is seen that the unit 9 is connected by a connection 10 to a signal converter 11.

The signal converter 11 is connected, in a manner known per se, to a sensor 12 which moves with the carriage above a series of marks 13 marked on a rule 14 associated with the slideway 2. The marks 13 permit determining, in the unit 9, the instantaneous position of the mobile assembly 1, as well as its speed and the direction of its movement, as will be seen below. Besides the marks 13, the rule 14 further bears a series of marks 15 which constitute references.

As has been said previously, the marks 13 and 15 may be of any known type. They are conceived according to the type of encoder and sensor used.

At the time of starting-up the axis depicted in Fig. 1, it is a question of bringing the carriage 1 onto a reference position, or zero position, which is determined by one of the marks 15 chosen beforehand.

Fig. 2 shows the mark 15 which has been chosen, or more exactly, the signal transmitted by the sensor 12 at the moment when the carriage 1 is opposite this mark. The signals 16 and 17 composed of trains of square pulses, of the same frequency and of the same width, represent the signals transmitted by the encoder 11 at the time of the movement of the carriage 1 along the rule 14. The phase-shift  $\Delta$  of  $90^\circ$  between the corresponding signals of the series of signals 16 and of the series of

signals 17 permits determining the direction of the movement, while the calculation of the number of signals transmitted per the unit of time permits determining the relative position and the speed.

In the device described, one completely avoids the use of an additional signal transmitted to the unit 9 for permitting locating that one of the marks 15 which has been selected as position zero. The means provided for that follows from the graph of Fig. 3. This graph depicts four parameters which vary as a function of time. On the upper line, the parameter V is seen, which represents the speed of the mobile assembly as a function of time. On the second line, the parameter  $\Delta P$  is seen, which represents the deviation between the instantaneous position of the mobile assembly, given by the signals of the encoder 11, and the position which this mobile assembly should theoretically occupy according to the program contained in the unit 9, at the moment considered. As will be seen, this position deviation assumes an abnormal value at a certain moment.

The third line represents, as a function of time and synchronously with the first two lines, a signal of activation E of the referencing function, thus of activation of the corresponding function in the sensor 12.

As for the fourth line, it represents the transmission of the reference signal R upon passage of the carriage over the mark 15 which has been activated.

To understand the operation of the system thus programmed, the device is considered to be situated, at the time of starting, in an initial position which corresponds, for example, to that of Fig. 1. At the time of putting into service, the jack 4 is actuated so that the piston moves from right to left. As is seen on the first line of Fig. 3, the

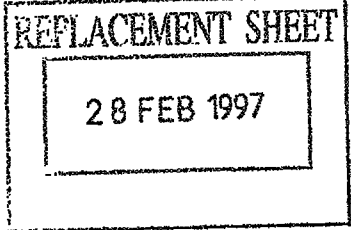
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speed of the carriage 1 increases up to a first limiting value  $V_{ref1}$ , and the movement of the carriage continues thus until the moment when its slide comes in contact with a stop 18 which limits its course. At this moment, marked by the letter A on the first line of Fig. 3, there occurs a halt of the movement, and the position deviation  $\Delta P$ , which until then had a very low value corresponding to the determination of the speed of movement according to the program, assumes an increasing value, the deviation between the theoretical position and the real position augmenting proportionately to the time. When the deviation attains the value  $\Delta P_{ref}$ , the program P controls, on the one hand, the reversal of the direction of movement of the piston 5 in the jack 4 and, on the other hand, the activation of the referencing function, as indicated above. The speed curve of the carriage therefore has the appearance depicted in the first line of Fig. 3 and, after a certain lag, rapidly increases to attain a limiting value  $V_{ref2}$ . The carriage 1 thus moves from left to right at the speed  $V_{ref2}$  until the moment when, the sensor 12 being activated, it records the signal of passage over that one of the marks 15 which has been preselected. It can, in fact, easily be determined that, the movement starting from the stop, it will be the first reference signal 15 or the second, or the third, etc., which will be recorded as reference zero, so that only this reference signal will be operational.

If need be, the position of the rule 14 might be adjusted in relation to that of the stop 18 in such a way that the position of the carriage corresponding to the halt A (Fig. 3) directly constitutes the reference position. It is necessary for that purpose that the halt position, determined by the stop, be sufficiently precise.

(cont'd.)



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Of course, it is not necessary that the stop 18 be a part situated at the end of the slideway. Any element capable of causing, at the time of the movement of the carriage 1, a position deviation attaining a predetermined critical value, may be used for carrying out the referencing. What is essential is that it is no longer necessary to connect a detection element electrically to the electronic circuit of the control unit, as has been the case until now.

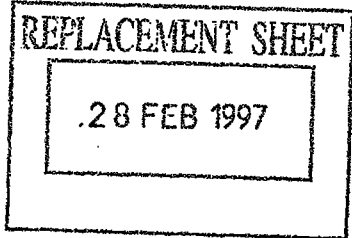
It should be noted on the other hand that, in the case where the control of the axis is a motorized control, cases might arise where causing the position deviation by means of a stop, such as the stop 18, would not be acceptable. However, in such a case, one might also, in lieu of a stop, place on the course of the carriage 1, at the proper location, an element which, instead of blocking the movement, causes braking, for example, thus a slowing of its speed such that a position deviation attaining the critical value  $\Delta Pref$  may be caused.



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CLAIMS



1. Device for controlling an incremental numerical axis in a machining station including an assembly associated with the mobile assembly and capable of travelling along a predetermined course, at least one reference disposed along this course in a predetermined position, means for driving the assembly capable of moving it in one direction and the other along the course and activation means for activating the reference in the course of a locating movement effected by the assembly, characterized in that said activation means comprise action means localized on said course and capable of causing the transmission of a signal of deviation of position of the assembly between an instantaneous position value given by the drive means and a real position value of the assembly and means for processing said signal capable of initializing the locating movement when said signal corresponds to a predetermined critical position deviation.

2. Device according to claim 1, characterized in that the action means consist of a stop capable of blocking the movement of the mobile assembly under the influence of its drive means, in a predetermined region of the course.

3. Device according to claim 1, characterized in that the action means consist of a braking means capable of braking the movement of the mobile assembly under the influence of its drive means, in a predetermined region of the course.

4. Device according to claim 1,

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comprising a series of references associated with a fixed measuring instrument, disposed along the course, characterized in that the processing means are made up in such a way that a preselected reference in said series is activated when the locating movement is initialized.

5. Device according to claim 4, characterized in that the action means consist of a stop capable of blocking the movement of the mobile assembly under the influence of its drive means, in a predetermined region of the course, and in that the processing means are made up in such a way that the stop physically represents the reference position.

6. Device according to claim 1, characterized in that the drive means are hydraulic means and the mobile assembly bears a cutting tool.

7. Device according to claim 1, characterized in that the drive means comprise an electric motor and the mobile assembly bears a cutting tool.

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CONTROL DEVICE FOR AN INCREMENTAL NUMERICAL  
AXIS IN A MACHINING STATION

**ABSTRACT:**

The instantaneous position of the carriage (1) is made explicit in the form of a datum transmitted by the connection (10) to the circuit (9) by the signal converter (11) and the sensor (12) reading the marks (13) on the rule (14). One of the marks (15) acts as a reference mark. During the referencing sequence, the carriage (1) is moved towards the left until it reaches the stop (18). The circuit (9) then causes a position error to appear which attains a critical value, which causes the reversal of the direction of movement of the carriage (1) and the activation of the detection of the reference (15) which has been preselected.

(Fig. 1)

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What is claimed is:

1. A device for controlling an incremental numerical axis in a machining station, comprising:

a movable carriage capable of moving along a predetermined path;

drive means for moving said carriage incrementally in either direction along said path; ,

at least one preselected reference mark disposed in a preselected position along said path;

deviation means, disposed along said path of said carriage, for causing an instantaneous position of said carriage to deviate from a programmed position to which said drive means attempts to move said carriage;

a position detector mounted to said carriage for detecting said at least one preselected reference mark; and

a control unit for controlling movement of said carriage and including:

first means for causing said drive means to move said carriage toward said deviation means until said carriage reaches said deviation means;

determining means for determining when a deviation between the instantaneous position of said carriage and the programmed position to which said drive means attempts to move said carriage reaches a preset limit value due to interaction between said carriage and said deviation means; and

second means for causing said drive means to move said carriage away from said deviation means until said position detector outputs a reference signal when said position detector detects said at least one preselected reference mark.

2. The device of claim 1, wherein said at least one preselected reference mark is a first mark over which said carriage passes when said second means causes said drive means to move said carriage away from said deviation means.

3. The device of claim 2, wherein said deviation means causes said carriage to stop moving when said carriage contacts said deviation means.

4. The device of claim 3, wherein said deviation means is located at the position of said at least one reference mark.



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5. The device of claim 2, wherein said deviation means causes said carriage to slow down when said carriage contacts said deviation means.

6. The device of claim 1, wherein said drive means includes hydraulic means for driving said carriage with fluid pressure, and further comprising a cutting tool located on said carriage.

7. The device of claim 1, wherein said drive means includes an electric motor, and further comprising a cutting tool located on said carriage.

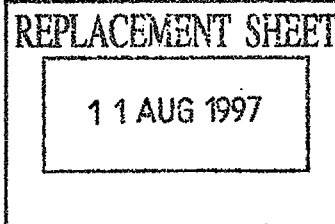
8. The device of claim 1, further comprising a signal converter, coupled between said position detector and said control unit, capable of transmitting to said control unit a series of signals output by said position detector when said carriage passes over a series of marks disposed along said path, and said reference signal when said position detector passes over said at least one preselected reference mark.

9. A process for controlling an incremental numerical axis in a machining station, of the type having an assembly associated with said axis for movement along a predetermined path, at least one preselected reference mark disposed in a predetermined position along said path, drive means capable of incrementally moving said assembly in either direction along said path, deviation means located along said path for causing an instantaneous position of the assembly to deviate from a programmed position, a control unit for controlling the drive means, and a position sensor connected to a signal converter for detecting a position of the assembly along said path, comprising the following steps:

moving said assembly along said path towards said deviation means with said drive means;

when said assembly interacts with said deviation means, determining a deviation in position between a programmed position of said assembly and the instantaneous position of the assembly given by signals output by said signal converter, and comparing the determined deviation to a predetermined limit value with said control unit;

when said determined deviation equals said predetermined limit value, causing said drive means to reverse the moving direction of said assembly with said control unit; and



when said position sensor passes over said at least one preselected reference mark, transmitting a reference signal with said signal converter to said control unit.

10. The method of claim 9, wherein said at least one preselected reference mark is a first mark over which said position sensor passes.

11. The method of claim 9, wherein said deviation means causes said assembly to stop moving when said assembly contacts said deviation means.

12. The method of claim 11, wherein said deviation means is located at the position of said at least one reference mark.

13. The method of claim 9, wherein said deviation means causes said assembly to slow down when said assembly interacts with said deviation means.

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AXIS IN A MACHINING STATION**ABSTRACT:**

The instantaneous position of the carriage (1) is made explicit in the form of a datum transmitted by the connection (10) to the circuit (9) by the signal converter (11) and the sensor (12) reading the marks (13) on the rule (14). One of the marks (15) acts as a reference mark. During the referencing sequence, the carriage (1) is moved towards the left until it reaches the stop (18). The circuit (9) then causes a position error to appear which attains a critical value, which causes the reversal of the direction of movement of the carriage (1) and the activation of the detection of the reference (15) which has been preselected.

(Fig. 1)