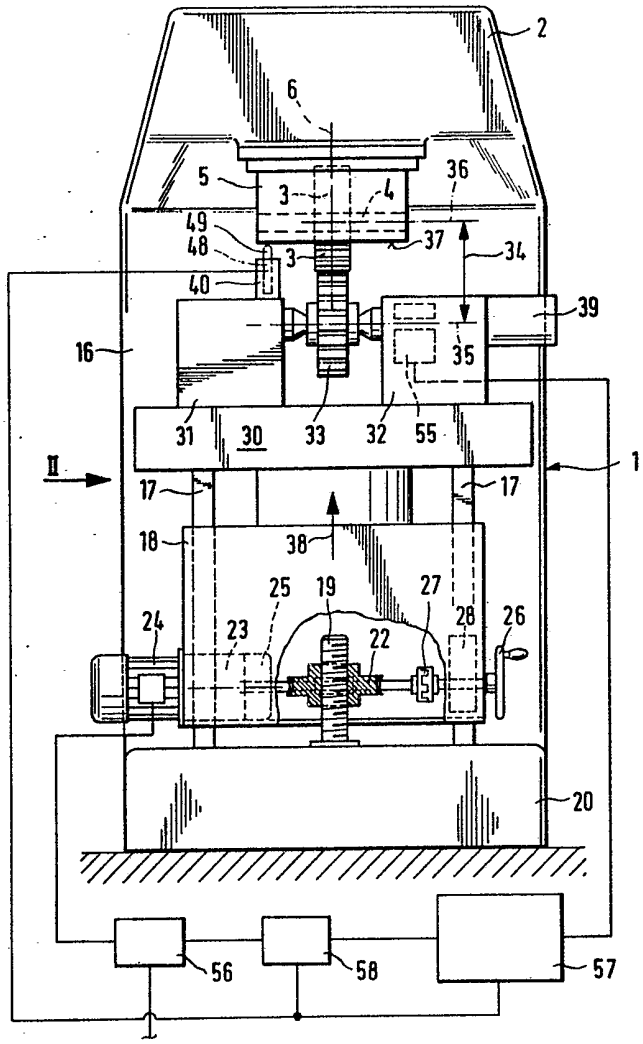
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(54) Method and apparatus for finish-machining of gearwheels

(57) In the finishing of gearwheels 33 by shaving or rolling using a toothed tool 3 in backlash-free mesh, depth infeed is controlled by measuring the distance 34 between the axis of the tool and gearwheel, and the infeed is stopped when the measured centre distance reaches a predetermined value. The device 40 for measuring the centre distance is mounted as close as possible to the tool and workpiece, to avoid errors due to mechanical deformation, temperature changes and other causes. For example it is mounted on a workpiece tailstock 31 and directly senses the tool holder 5. It comprises a probe 49 which is pressed back upon tool holder contact until it operates a contact at the predetermined position.

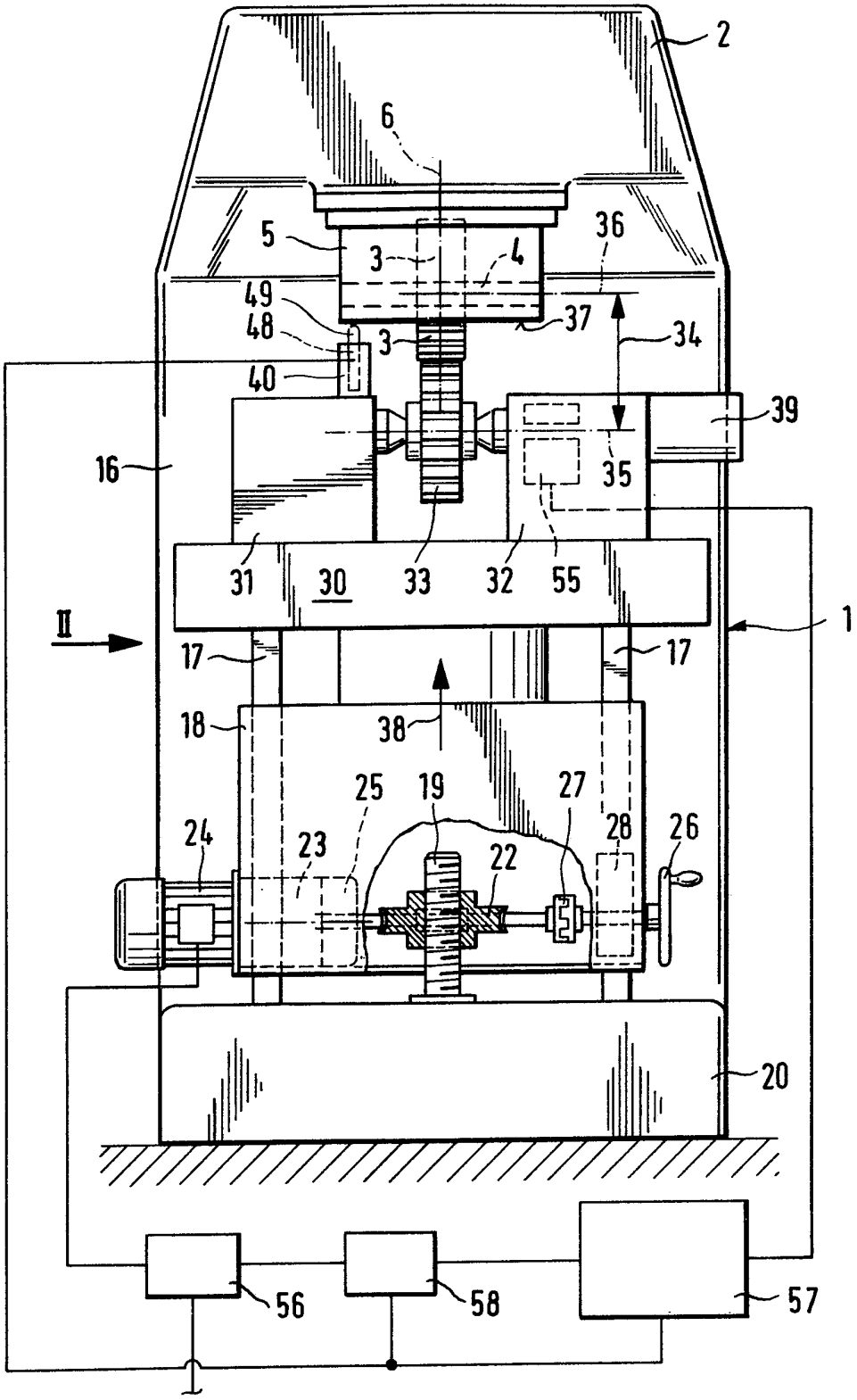
Fig. 1



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Fig. 1



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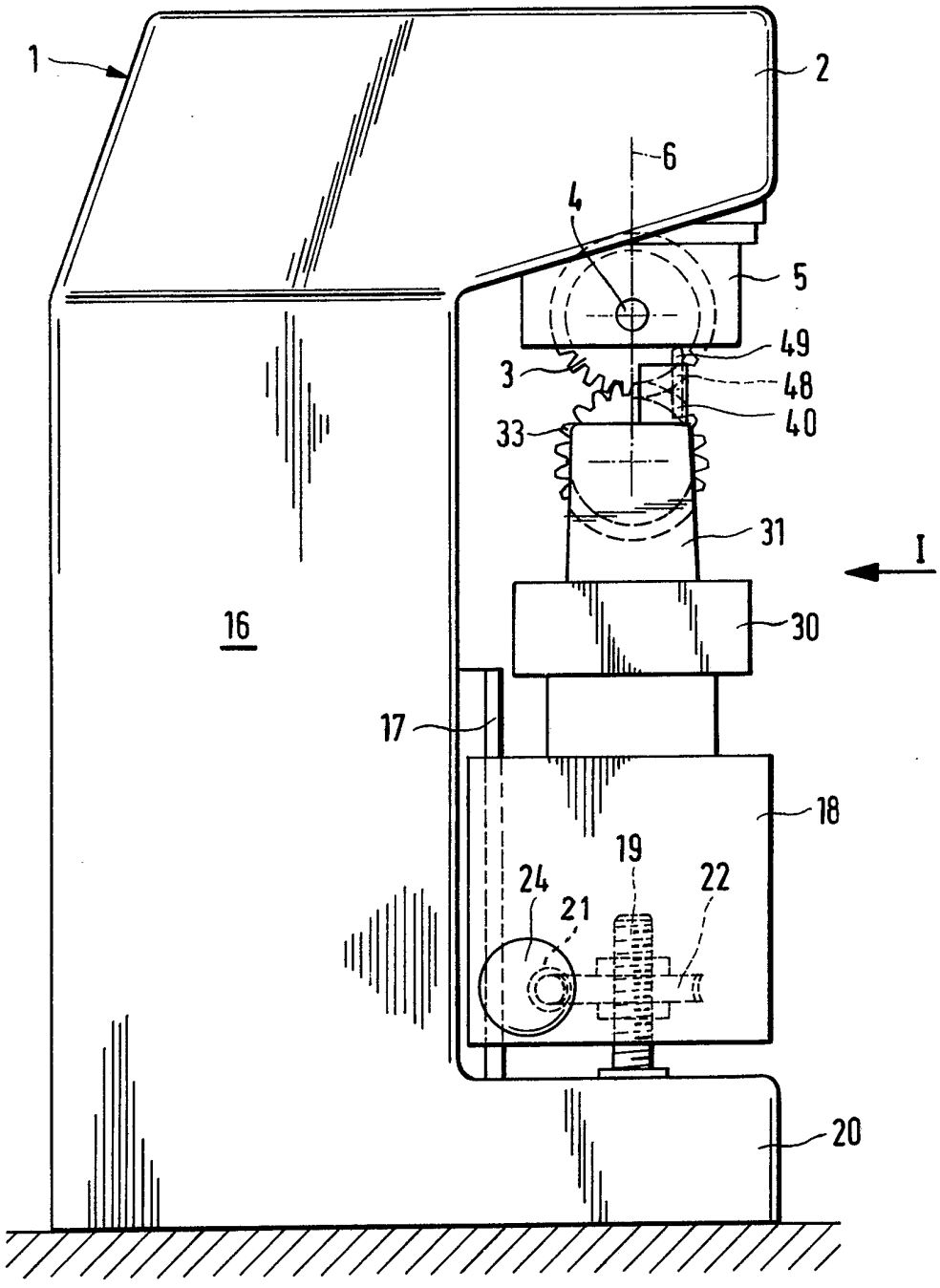


Fig. 2

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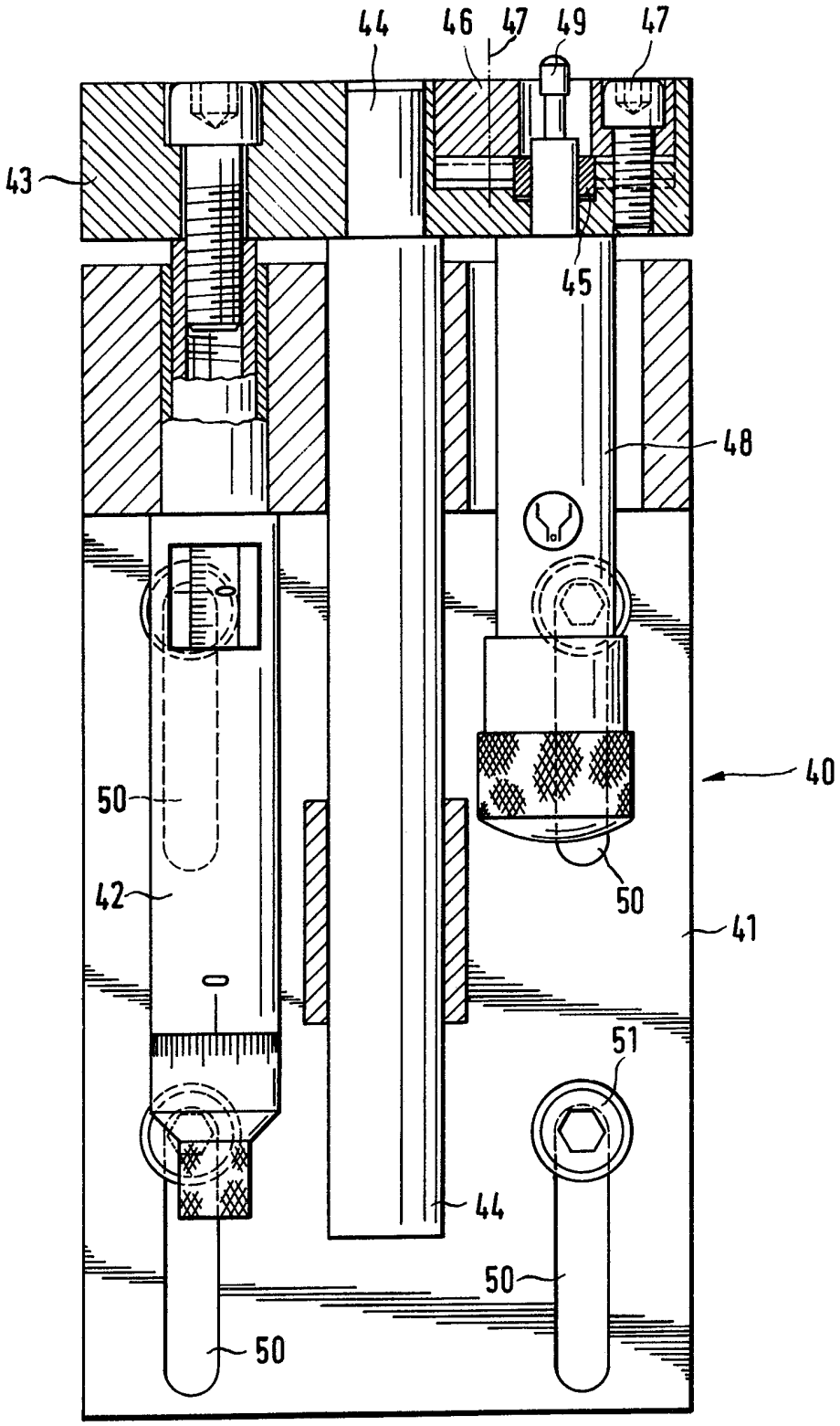


Fig. 3

SPECIFICATION

Method and apparatus for finish-machining of gearwheels

The invention relates to a method for the finish-machining of gearwheels by running these in backlash-free mesh with gear-like toothed tools, with parallel or crossed axes.

Different elastic flexure and deformation, affecting the finished dimension of machined workpieces, occurs in practically all machine tools during operation. Especially in finish-machining procedures, for example in rolling or shaving of gearwheels, such different finishing dimensions frequently cannot be reconciled with present-day accuracy requirements. There is an entire series of causes resulting in different finishing dimensions with a constant machine setting, i.e. with the same minimum centre distance set between tool and workpiece in rolling and shaving. This includes the tolerances in the machining allowance for the workpieces which are to be produced, that is to say, the workpieces which are rough-machined with different tooth width dimensions give rise to different machining pressures in finish-machining and therefore result in different finishing dimensions of the workpieces. Different material conditions or structural conditions of the individual loads have the same effect. A diminishing cutting performance of the tool within its tool life also affects the machine pressure and therefore the finishing dimensions. The effects of different temperatures during the day on the thermal expansion of machine components must also be mentioned.

It is the object of the invention to provide a method and apparatus by which the effects of machine deformations, leading to different workpiece dimensions, can be eliminated.

The problem is solved by measuring the set or desired centre distance, directly on the working axes of the tool and workpiece in the machine. The tool is advanced (depth in-feed) until the measured centre distance corresponds to the set or desired centre distance.

Conveniently, operation is performed with a preselectably adjusted working pressure which is reduced when the set centre distance is reached or after a delay, and the tool as well as the workpiece dwell in this position before they are disengaged. This method results in very clean tooth flanks of the workpiece.

Means which measure the centre distance and cause the depth feed motion to be switched off when the set centre distance is reached are required on the finishing machine. Since measurement is to be performed as closely as possible to the tool and workpiece axis, the measuring device is preferably disposed on means adapted to retain the workpiece so as to act against one of the devices which retain the tool. The measuring reaction is unaffected by the angle between the tool and workpiece axes, if the aforementioned device is appropriately shaped. To obtain reliable machining results it is convenient to operate with a specific selectable working pressure and a suitable measuring device is preferably provided to this end.

The invention will be further explained hereinbelow with reference to the accompanying drawings in which:

Fig. 1 is a simplified view of a machine according to the invention, partially in section,

Fig. 2 shows a simplified form of the machine according to Fig. 1 from another side, also partially in section, and

Fig. 3 shows in simplified form the arrangement of the device for measuring the centre distance.

Figs. 1 and 2 show a gearwheel finishing machine without a longitudinal feed facility and which therefore operates by the plunge method. A tool carrier 5 is supported on the top overhang 2 of a C-shaped machine frame 1 so as to be pivotable about the vertical axis 6 and lockable in position. The tool 3 is retained on a rotatably drivable tool spindle 4 in the tool carrier. The drive for the tool is known and is therefore not shown. A bracket 18 is supported by a guideway 17 on the middle part 16 of the machine frame so as to be slidable in the direction which is perpendicular to the pivoting plane of the tool carrier, i.e. vertically, and lockable. A work table 30 is disposed on the bracket. The workpiece 33, adapted to mesh with the tool 3 and to be driven thereby, is retained between tailstocks 31, 32 on the work table. In the basic position of the tool carrier 5, the axis 35 of the workpiece 33 is parallel with the axis 36 of the tool 3 i.e. of the tool spindles 4. One of the tailstocks, for example 31, is provided with a hydraulic, pneumatic or electric clamping device 39 to actuate the quill for automatic clamping.

The bracket 18 is driven by an electric motor 24 via a change-gear transmission 35 and a worm gear. The worm wheel 22 of the said transmission has a screw-threaded bore which engages with a feed spindle 19, mounted in the bottom member 20 of the machine frame. The worm 21 of the worm gear transmission is concealed by the worm wheel 22 in Fig. 1. A slip clutch is provided in the transmission chain between the electric motor 24 and the worm wheel 22. The worm wheel 22 can also be driven by means of a hand crank 26 via a clutch 27 and via a gear transmission 28 which can also be of the shift gear kind. Steplessly variable transmissions can be provided in place of the shift gear transmission 25, 28.

A so-called measuring slide 40, shown in detail in Fig. 3, is mounted on one of the tailstocks, for example 31. A micrometer screw 42 by means of which a plate 43 is adjustably moved towards or away from the tool carrier 5, is retained by a carrier 41. The plate 43 is guided by the carrier 41 by means of guide rods 44 and is prevented from rotating. An electric precision tracer 48 is mounted on the plate 43, for example by means of tapered clamping collars 45 which are compressed by means of a compression plate 46 and screw fasteners 47 so as to clampingly surround the flank of the precision tracer. The tracer head 49 of the precision tracer projects

from the plate 43. The tracer 48 is adjusted as follows. By suitable vertical adjustment of the bracket 18 with the work table 30, the centre distance 34 between the workpiece axis 35 and the tool axis 36 is set to the required value. The plate 43 is moved by means of the micrometer screw 42 towards the tool carrier 5 until the tracer head 49 bears on the underside 37 of the tool carrier 5 and movement is continued until the contact point of the precision tracer 48 is reached. Coarse adjustment can be obtained by adjusting the carrier 41, since the micrometer screw 42 has only a narrow adjustment range. To this end, the carrier is provided with slots 50 through which the mounting screws 51 extend.

The quill of one of the two tailstocks, for example 32, yields to the operating pressure and bears upon a load cell 55. Such cells are known and therefore need not be described in detail. The load cell is connected to a switching device 57 which, inter alia, permits the setting of different operating pressures.

The method of operation of the machine is as follows: initially the bracket 18 is sufficiently lowered to enable the workpiece 33 to be clamped. To start the actual machine operation the motor 24 is started by closing a switch 56 and the feed motion, i.e. the depth feed 38, is initiated. The switching device 57 remains inoperative at the beginning of the operation. A relay 58, which maintains the switch 56 in the closed condition, is actuated only after the full operating pressure between the tool 3 and the workpiece 33 has been reached. The preset working pressure leads to elastic deformation of the machine and of the parts which retain the tool and the workpiece, so that the centre distance 34 is increased relative to that obtained under the conditions without operating pressure. The feed motion 38 is therefore continued until the centre distance which exists under stress corresponds to the desired centre distance. This condition is obtained when the tracer head 49 of the precision tracer reaches the contact point after having touched the underside 37 of the tool carrier and having been pushed back in the course of the continued feed motion. The contact thus triggered causes the motor 24 to be switched off and the depth feed 38 is thus completed. Machining is then continued as a finishing operation without depth feed. In shaving, this operation is also known as run-out shaving. Either simultaneously with completion of the depth feed or after a delay, the preset operating pressure is reduced and the finishing operation is continued. After a preselected time has elapsed the relay 58 is switched over and the motor 24 is switched to reverse operation. The bracket 18 is lowered until it regains the starting position. At this position, a limit switch, not shown, causes the relay 58 and the motor 24 to be switched off and the original operating pressure to be set in the switching device 57. The machine is then ready for machining the next workpiece.

In the described embodiment, the measured distance is that between the tool and workpiece holders, which differs by a constant amount from the distance between the tool and workpiece axes.

CLAIMS

1. A method of finishing a gear wheel, in which a workpiece gear wheel is run in backlash-free mesh with a toothed rotating tool and the centre distance between the workpiece and the tool axes is reduced by a relative depth feed motion, and in which the centre distance is monitored and the depth feed is discontinued when the centre distance reaches a predetermined value.

2. A method for the finish-machining of gearwheels by means of a gear-like tool which is in slack-free mesh with the workpiece, with parallel or intersecting axes, in which method a depth feed motion is made between the tool and the workpiece in the sense of reducing the centre distance therebetween, the change of distance between the workpiece axis and the tool axis is measured, and the depth feed is continued until a preselectably adjusted centre distance is obtained.

3. A method according to claim 2, characterised in that in the course of machining the tool acts with a preselectably adjustable working pressure on the workpiece and that after reaching the preset centre distance the tool and the workpiece continue to rotate and dwell, the working pressure being reduced on completion of the depth feed or after a delay, before the tool and workpiece are disengaged by a fast return motion.

4. Apparatus for finishing gear wheels by rotating a workpiece gear wheel and a toothed tool in backlash-free mesh, comprising means for holding a workpiece rotatably, means for holding a tool rotatably, driving means for rotating the workpiece and/or tool, feeding means arranged to effect relative depth feed of the tool and workpiece, measuring means for monitoring the centre distance between the axes of rotation of the tool and workpiece, and control means for the feeding means, responsive to the measuring means and arranged to end the depth in-feed when the centre distance reaches a predetermined value.

5. Apparatus for performing the method according to claim 2 or 3, characterised by the provision of means for measuring the centre distance, which means are associated with control devices for an automatic operating cycle of the machine and in operation supply a signal to stop the depth feed motion and where appropriate provide a signal for dwelling in this position and/or for a return motion when the preselectably adjustable centre distance is reached.

6. Apparatus according to claim 5, characterised in that the means for measuring the centre distance is an electric tracer which is adjustable in the direction towards the tool and is disposed on a device, such as a tailstock, for holding the workpiece acts on a device for receiving the tool or a part fixedly connected thereto.

7. Apparatus according to claim 5 or 6

characterised in that additional means for adjusting and measuring the working pressure between the tool and the workpiece are provided.

8. Apparatus for finishing gear wheels, substantially as herein described with reference to the accompanying drawings.

9. A method of finishing gear wheels, substantially as herein described with reference to the accompanying drawings.

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