A further problem with manual operation of known machines as described above is that the operator is required to be in close contact with the machine, posing a safety hazard to the operator.

A similar problem exists during boring operations using portable boring bars which are used for both refurbishment and new construction. A mechanically driven facing arm (typically positioned at right angles to the axial line of the bore) and used to machine faces has the same mechanical complexity as described above, is typically limited to one feed rate per revolution of the bar and again there is difficulty in providing precise control regarding spigot face diameters and the like.

It would be desirable to provide apparatus that overcomes or alleviates one or more of the above problems, or at least provides a useful alternative.

Prior art document EP 0 493 020 A2 discloses a machining apparatus having a boom rotatable about a pivot support. At the end of the boom a milling cutter machine is located, which is movable along the boom by manual or driven means.

SUMMARY OF THE INVENTION

According to one aspect of the present invention, there is provided a facing arm ~~for machining a surface of a workpiece, including:~~

~~a machining element which is movable along an axis of the facing arm thereby to position the machining element relative to the surface of the workpiece; and~~

~~electrically powered drive means for moving the machining element along the axis of the facing arm~~according to claim 1.

The facing arm includes a computerised control module for the powered drive means, such as a CNC module. Computer control of the drive means allows a desired sequence of precise cutting operations for the cutting tool to be programmed, for example.

By ~~this~~ the powered means for the feeding of the machining element there is provided a much larger range of control than is possible for a mechanically driven machining element.

Continuous motion (infinitely variable feed) of the machining element is possible, allowing for a large range of surface finishes, and a cutting tool of the machining element can be stopped at very precise locations. Furthermore, the direction of motion of the machining element along the axis may easily be reversed.

~~A battery can be used to power the drive means. Alternatively, a slip ring system or any other suitable power source can be used to provide electrical power to the drive means.~~

~~In some embodiments the powered drive means is housed within an arm casing. This provides for a compact arrangement which is easily assembled. It is also possible to mount the drive outside the body of the arm, which might be desirable for small arm assemblies which have space limitations.~~

~~In a presently preferred embodiment, the facing arm further includes a computerised control module for the powered drive means, such as a CNC module. Computer control of the drive means allows a desired sequence of precise cutting operations for the cutting tool to be programmed, for example.~~

The computerised control module ~~may be~~is operably couplable to a remote control module for wirelessly receiving instructions to operate the drive means. This may be in the form of a hand held wireless device such as a mobile computing device with wireless communication capabilities, for example.

The use of a remote control enables the operator to stop and start the machining element and hence the cutting action at will. The feed rate may be infinitely varied between zero and maximum feed rate. In general, the maximum feed rate would be used only for returning the tool, not for carrying out a machining operation. In addition it would be possible to stop the machining element at any desired preset position, either on the internal diameter or the external diameter of the cut.

A particular advantage of wireless operation of the controller is that the operator can be located remotely of the apparatus, perhaps tens or even hundreds of metres depending on the range of the wireless receiver of the control module. A flange facing machine having a rotating arm can be hazardous to the operator and it is much preferred that the operator not

be standing in close proximity while the machine is operational.

A further advantage of wireless operation is that the operator may reprogram the controller on the fly, rather than connecting and disconnecting a computer in order to issue different sets of instructions to the controller.

A battery can be used to power the drive means. Alternatively, a slip ring system or any other suitable power source can be used to provide electrical power to the drive means.

In some embodiments the powered drive means is housed within an arm casing. This provides for a compact arrangement which is easily assembled. It is also possible to mount the drive outside the body of the arm, which might be desirable for small arm assemblies which have space limitations.

In certain embodiments, the computerised control module is located within an internal cavity of the arm casing.

The drive means may include a lead screw, preferably coupled to a servo motor.

In a second aspect, the present invention provides an apparatus ~~for machining a surface of a workpiece, the apparatus including a support structure and a facing arm according to the first aspect of the invention, the facing arm being mounted to the support structure for motion relative to the support structure~~according to claim 8.

The apparatus may ~~further~~ include a second electrically powered drive means for moving the facing arm along the axis of the spindle. In certain embodiments, the apparatus further includes a second computerised control module for the second electrically powered drive means, wherein the second computerised control module is operably couplable to the remote control module.

In a third aspect, the present invention provides a system ~~for machining a surface of a workpiece, including a support structure, a facing arm mountable to the support structure for motion relative to the support structure, and a remote control module, wherein the facing arm includes: a machining element which is movable along an axis of the facing~~

~~arm thereby to position the machining element relative to the surface of the workpiece, and electrically powered drive means for moving the machining element along the axis of the facing arm; and wherein the facing arm is operably couplable to the remote control module for wirelessly receiving instructions to operate the drive means~~according to claim 12.

Preferred embodiments are also detailed in the dependent claims.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the invention will now be described, by way of non-limiting example

CLAIMS:

1. A facing arm (14) for machining a surface (32) of a workpiece, including:

a machining element (4) which is movable along an axis of the facing arm (14) thereby to position the machining element (4) relative to the surface (32) of the workpiece; and

electrically powered drive means (9, 10, 11, 12, 13) for moving the machining element (4) along the axis of the facing arm (14),

characterised by a computerised control module (7) coupled to the electrically powered drive means (9, 10, 11, 12, 13) and operably couplable to a remote control module (1) for wirelessly receiving instructions to operate the drive means.

2. A facing arm (14) according to claim 1, including an arm casing (14a) for housing the electrically powered drive means (9, 10, 11, 12, 13).

~~3. A facing arm according to claim 1 or claim 2, further including a computerised control module coupled to the electrically powered drive means.~~

43. A facing arm according to claim ~~3~~1 or 2, wherein the computerised control module (7) is a CNC module.

~~5. A facing arm according to any one of claims 1 to 4, wherein the facing arm is operably couplable to a remote control module for wirelessly receiving instructions to operate the drive means.~~

~~6. A facing arm according to claim 5, wherein the computerised control module is operably couplable to the remote control module.~~

~~7~~4. A facing arm (14) according to claim ~~3~~ 2 or claim ~~4~~ 3 when appended to claim 2, wherein the computerised control module (7) is located within an internal cavity of the arm casing (14a).

~~8~~5. A facing arm (14) according to any one of the preceding claims, wherein the drive means includes a lead screw (13).

~~9~~6. A facing arm (14) according to any one of the preceding claims, wherein the drive means includes a servo motor or a stepper motor (9).

~~10~~7. A facing arm (14) according to any one of the preceding claims, further including a clamp (2) for mounting the arm to a support structure (18).

~~11~~8. Apparatus (100) for machining a surface (32) of a workpiece, including a support structure (18), and a facing arm (14) according to any one of claims 1 to ~~10~~7, the facing arm (14) being mounted to the support structure (18) for motion relative to the support structure.

~~12~~9. Apparatus (100) according to claim ~~11~~8, wherein the facing arm (14) is mounted to a spindle (22) of the support structure (18) for rotational motion about the spindle.

~~13~~10. Apparatus (100) according to claim ~~12~~9, further including a second electrically powered drive means (204, 213, 215, 216) for moving the facing arm (14) along the axis of the spindle (22).

~~14~~11. Apparatus (100) according to claim ~~13~~ 10~~when appended to any one of claims 4 to 9~~, further~~,~~ including a second computerised control module (217) for the second electrically powered drive means (204, 213, 215, 216), wherein the second computerised control module (217) is operably ~~coupled~~ couplable to the remote control (1).

~~15~~12. A system (1, 100) for machining a surface (32) of a workpiece, including a support structure (18), a facing arm (14) according to any one of claims 1 to 7 mountable to the support structure for motion relative to the support structure (18), and ~~a~~ the remote control module (1)~~, wherein the facing arm includes: a machining element which is movable along an axis of the facing arm thereby to position the machining element relative to the surface of the workpiece, and electrically powered drive means for moving the machining element along the axis of the facing arm; and wherein the facing arm is operably couplable to the remote control module for wirelessly receiving instructions to operate the drive means~~.