



WIRE-TYPE BORE LAPPING APPARATUS

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a wire-type bore lapping apparatus.

5 Description of the Related Art

In recent years, parts requiring high-precision machining of a small-diameter bore have increased in number. As such parts, for example, ferrules for optical fiber and fuel injection valves for internal combustion engine can be cited.

Japanese Patent Application Publication No. 5-113523 has disclosed a bore lapping
10 apparatus 100 for a ceramic ferrule as shown in Fig. 10. The configuration of the apparatus 100 will be described briefly.

The bore lapping apparatus denoted by reference numeral 100 will be configured as described below. A lapping wire 104 is stretched between a right-hand side reel 102 and a left-hand side reel 103 provided on a drive base 101 so as to penetrate a blank holding device
15 106, and a plurality of ceramic blanks 105 are installed on the lapping wire 104 and held in a freely movable state. In order to perform lapping operation, one ceramic blank 105a selected from the aforementioned ceramic blanks 105 is turned, and at the same time, while applying lapping powder (not shown) from a lapping powder supply device 107 to the lapping wire 104, the lapping wire 104 is reciprocated transversely, by which the bore of the selected turning
20 ceramic blank 105a is subjected to lapping operation. Subsequently, the remaining other ceramic blanks 105 are selected one by one in sequence, and the bores thereof are subjected to lapping operation in the same way.

For the bore lapping apparatus 100 configured as described above, since the bores of the ceramic blanks 105 are subjected to lapping operation one by one, some results including
25 stable finished diameter and bore circularity of the ceramic blank 105 can be obtained.

However, the above-described conventional bore lapping apparatus 100 uses a configuration such that the ceramic blank 105, which is a workpiece subjected to bore lapping, is installed on the transversely stretched lapping wire 104, and thereby the bore thereof is lapped (see Fig. 10). As a result, the ceramic blank 105 is subjected to bore lapping in a state
30 in which the gravity is applied in the vertical direction, so that there is room for further



improvement in the accuracy of bore circularity.

Also, the bore lapping apparatus 100 has a configuration such that one stretched lapping wire 104 is used to perform bore lapping operation. Therefore, when the bore lapping operation of all of the ceramic blanks 105, workpieces, installed on the lapping wire 104 has been finished, preparatory work for shifting to the next bore lapping operation takes much time, so that it is difficult to continuously perform the bore lapping operation.

SUMMARY OF THE INVENTION

Accordingly, a principal object of the present invention is to provide a wire-type bore lapping apparatus in which the accuracy of bore circularity is high, and moreover continuous bore lapping operation can be performed.

To attain the above object, the present invention is directed to a wire-type bore lapping apparatus, comprising: a wire holding device which holds a lapping wire in a vertical direction, a workpiece to be subjected to bore lapping being installed on the lapping wire; a wire loading/unloading device which loads and unloads the lapping wire to and from the wire holding device; and a bore lapping device which holds the lapping wire loaded by the wire loading/unloading device in the vertical direction so as to perform bore lapping operation for the workpiece with the lapping wire.

This apparatus is configured so that the lapping wire held vertically by the wire holding device is captured and transferred by using an appropriate device, and the lapping of a bore in the workpiece such as a blank is performed in the state in which the lapping wire is held vertically. Therefore, in comparison with the conventional configuration in which bore lapping is performed for the workpiece installed on the lapping wire stretched transversely, bore lapping can be performed in the state in which there is no influence of the own weight of workpiece, so that the accuracy of bore circularity can be improved.

Preferably, the lapping wire comprises a plurality of lapping wires; the wire holding device locks the plurality of lapping wires at equal intervals in a circumferential direction on peripheral wall portions of a pair of disk-shaped or cylindrical wire holders disposed in upper and lower end regions of the plurality of lapping wires; and the locked plurality of lapping wires are transferred in sequence to the wire loading/unloading device by indexing the wire holders at predetermined positions.

According to the present invention, the wire holding device for vertically holding the

lapping wires is a device in which the lapping wires are locked at equal intervals in the circumferential direction on the peripheral wall portion of the pair of disk-shaped or cylindrical wire holders disposed in the upper and lower end regions of the lapping wires.

Also, the configuration is such that by indexing the wire holder at predetermined positions (by
5 turning and stopping the wire holder at a predetermined position), the lapping wires locked to the wire holder are transferred in sequence to the adjacently provided wire loading/unloading device.

In this apparatus, the lapping wires held vertically in the state in which the workpieces are installed on the lapping wires are prepared in plural numbers in advance for the
10 wire holding device, and the lapping wires are transferred in sequence to the wire loading/unloading device. As a result, bore lapping operation can be performed continuously by transferring the lapping wires in sequence from the wire loading/unloading device to the bore lapping device.

The wire loading/unloading device arranged between the wire holding device and the
15 bore lapping device may be made to perform work for returning a lapping wire in which bore lapping of all of the workpieces installed thereon have been finished in the bore lapping device (hereinafter referred to as "a wire having finished lapping operation") again to the wire holding device.

Specifically, the wires having finished lapping operation are returned one after
20 another with predetermined timing from the bore lapping device to the paired wire holders having a wire locking function, by which the wires can be locked again to the peripheral wall portions of the wire holders, and thereby can be held vertically. In this case, the paired wire holders not only load lapping wire (not yet finished bore lapping) but also function as a stock device for the wires having finished bore lapping.

25 Preferably, the wire-type bore lapping apparatus further comprises a disk-shaped or cylindrical intermediate locking member interposed between the pair of wire holders, the intermediate locking member locking the plurality of lapping wires to prevent the plurality of lapping wires from swaying or oscillating during transfer.

According to the present invention, since the lapping wire does not sway during
30 transfer, there is no fear of the lapping wire coming off the wire holder of the wire holding device. Also, in the process in which the lapping wire is transferred to the wire loading/unloading device, the locking position of lapping wire does not shift, so that the

lapping wire is surely held vertically, and thus the lapping wire can surely be transferred to a predetermined position in which the lapping wire is transferred to the wire loading/unloading device.

Preferably, the wire-type bore lapping apparatus further comprises: a control device
5 which indexes the pair of wire holders at the predetermined positions; a device which controls the loading and unloading of the lapping wires; and a device which controls the bore lapping operation, wherein a series of wire holding process, wire loading/unloading process, and bore lapping process are carried out full-automatically.

According to the present invention, the wire holding process, wire loading/unloading
10 process, and bore lapping process can be carried out continuously in an unmanned mode.

Preferably, the bore lapping device comprises a mechanism for controlling a lapping pressure to be fixed, so that the bore lapping accuracy can further be improved. For example, the lapping pressure can be attained by the configuration such that the lapping wire is set
15 vertically between a pair of pulleys disposed in the upper and lower positions, and weights are installed to the lapping wire.

Preferably, the bore lapping device comprises a work holder which grasps the workpiece to perform bore lapping operation; and the work holder comprises a mechanism for automatically loading and unloading the lapping wire. Thereby, the loading and unloading work between the bore lapping device and the wire loading/unloading device can be made
20 unmanned.

Preferably, the wire holding device comprises a sensor which checks that one of the plurality of lapping wires to be transferred to the wire loading/unloading device is in a vertical state, the sensor being arranged nearby one of the pair of wire holders disposed at the lower end region of the one of the plurality of lapping wires.

Specifically, in the case where the lapping wire to be held vertically by being locked
25 at equal intervals in the circumferential direction on each peripheral wall portion of the paired opposed wire holders disposed in the upper and lower positions shifts from the wire locking position of the lower wire holder and is held obliquely, the lower end position of the lapping wire rises slightly upward. The configuration is such that the shift of the lower end position
30 of the lapping wire is detected by a position detecting sensor, by which the abnormality of the holding state of lapping wire can be found instantly.

In the wire-type bore lapping apparatus in accordance with the present invention,

regarding the lapping wire, either a wire with bonded abrasive in which lapping powder is caused to adhere to the lapping wire in advance or a wire with free abrasive in which lapping powder is supplied at the time of bore lapping operation can be used. Therefore, this apparatus is a versatile one in which the type of lapping wire is not subject to any special
 5 restriction.

As described above, the present invention can have a technical meaning such that a wire-type bore lapping apparatus in which the whole of the apparatus is made small in size by holding the lapping wire vertically, the holding, loading, and unloading of workpiece and bore lapping operation are accomplished by automatic control, and the lapping time can be
 10 shortened is supplied to the industrial field.

BRIEF DESCRIPTION OF THE DRAWINGS

The nature of this invention, as well as other objects and advantages thereof, will be explained in the following with reference to the accompanying drawings, in which like reference characters designate the same or similar parts throughout the figures and wherein:

15 Fig. 1 is a general front view of a wire-type bore lapping apparatus (1) in accordance with the present invention, in which the apparatus (1) is viewed from a front;

Fig. 2 is a plan view of the apparatus (1), in which the apparatus (1) is viewed from the top;

20 Fig. 3 is a partially omitted side view of the apparatus (1), in which the apparatus (1) is viewed from a bore lapping device (5) side;

Fig. 4(A) is an enlarged side view of a portion of a locking concave portion (31b) of an upper wire holder (31) in which a lapping wire (2a) is held vertically;

25 Fig. 4(B) is a partially enlarged plan view of a portion of a locked locking end portion (21), in which the locking end portion (21) is viewed from the top (in the direction of an arrow U_1 in Fig. 4(A));

Fig. 5(A) is an enlarged side view of a portion of a locking concave portion (32b) of a lower wire holder (32) in which a lapping wire (2a) is held vertically;

30 Fig. 5(B) is a partially enlarged plan view of a portion of a locking end portion (22), in which the locking end portion (22) is viewed from the top (in the direction of an arrow U_2 in Fig. 5(A));

Fig. 6 is a partially enlarged side view showing a state in which a locking end portion

(22) of a lapping wire (2a) comes off a locking concave portion (32b);

Fig. 7 is an enlarged side view showing a configuration of one embodiment of an intermediate locking member (33);

Fig. 8 is an enlarged sectional view showing a state of bore lapping in a simplified manner;

Fig. 9(A) is a view showing a state in which a wire loading/unloading device (4) receives a lapping wire (2a) from a wire holding device (3);

Fig. 9(B) is a view showing a state in which a wire loading/unloading device (4) slidably moves upward together with a lapping wire (2a);

Fig. 9(C) is a view showing a state in which a wire loading/unloading device (4) begins to transfer a lapping wire (2a) to a bore lapping device (5);

Fig. 9(D) is a view showing a state in which a lapping wire (2a) is inserted in a work holder (53);

Fig. 9(E) is a view showing a state in which a lapping wire (2a) is engaged with pulleys (51, 52);

Fig. 9(F) is a view showing a state in which a work holder (53) of a bore lapping device (5) moves upward to capture a workpiece (W_1) at a lowest end, by which bore lapping is started;

Fig. 9(G) is a view showing a state in which workpieces (w) having been subjected to bore lapping are collected in a lower portion of a work holder (53);

Fig. 9(H) is a view showing a state in which a wire (2b) having finished lapping operation is locked to a wire holding device (3); and

Fig. 10 is a view showing a configuration of a related art.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Hereunder preferred embodiments will be described in detail for a wire-type bore lapping apparatus 1 in accordance with the present invention with reference to the accompanying drawings. First, a general configuration of the wire-type bore lapping apparatus 1 in accordance with the present invention will be described briefly with reference to Fig. 1, which is a general front view of the wire-type bore lapping apparatus 1, the apparatus 1 being viewed from the front, Fig. 2, which is a plan view of the apparatus 1, the apparatus 1 being viewed from the top, and Fig. 3, which is a partially omitted side view of the

apparatus 1, the apparatus 1 being viewed from the bore lapping device 5 side.

The wire-type bore lapping apparatus 1 in accordance with the present invention includes a wire holding device 3, a wire loading/unloading device 4, and a bore lapping device 5. The wire holding device 3 is a device which holds a plurality of lapping wires 2a in the vertical direction, the lapping wire 2a being inserted in a plurality of cylindrical workpieces W to be subjected to bore lapping. The wire loading/unloading device 4 is a device that receives the lapping wire 2a from the wire holding device 3 and transfers it to the bore lapping device 5. The bore lapping device 5 is a device which holds one lapping wire 2a having transferred from the wire loading/unloading device 4 in the vertical direction and performs bore lapping operation for the workpieces W. The devices 3, 4 and 5 are disposed on a base member 6 (see Figs. 2 and 3) erected vertically in a casing C.

The wire holding device 3 plays a role in holding the lapping wires 2a, on which the workpieces W to be subjected to bore lapping are installed in a freely movable state, in a detachably locked state, and transferring the lapping wire 2a in sequence to the wire loading/unloading device 4.

The number of lapping wires 2a to be held by the wire holding device 3 is not limited by the example shown in Fig. 1 etc., and can be determined appropriately.

The wire loading/unloading device 4 plays a role in holding a lapping wire 2a, having been transferred to a predetermined position by the wire holding device 3, by hand members 41 and 42, turning the lapping wire 2a after receiving it from the wire holding device 3, and transferring the lapping wire 2a to the bore lapping device 5 disposed on the right side of Fig. 1.

The bore lapping device 5 plays a role in capturing and grasping the lowest one workpiece W_1 of the workpieces W installed on one lapping wire 2a transferred from the wire loading/unloading device 4 by using a work holder 53, and performs bore lapping operation while supplying lapping powder (lapping diamond powder D having a predetermined grain size, see Fig. 8). The use of a wire with bonded abrasive in place of the lapping wire 2a is convenient because a process for supplying lapping powder is unnecessary.

The lapping wire 2b in the state in which all workpieces W installed thereon have been subjected to bore lapping is grasped again by the hand members 41 and 42 of the wire loading/unloading device 4, being rotationally transferred to the wire holding device 3, and is held again by the wire holding device 3 in a locked state.

The following will be a detailed description of the configuration and function of the wire holding device 3.

This wire holding device 3 has a wire holder 31 disposed in an upper position in the casing C (hereinafter referred to as an “upper wire holder 31”) and a wire holder 32 disposed
 5 at a lower position at a predetermined distance from the upper wire holder 31 in such a manner as to be opposed to the upper wire holder 31, which has the same diameter as that of the upper wire holder 31 and the center position of which coincides with the center position of the upper wire holder 31 (hereinafter referred to as a “lower wire holder 32”).

Above the upper wire holder 31, there is arranged a motor 34, and a rotating shaft 35
 10 (see Fig. 1) extending downward from the motor 34 is fixed to the upper wire holder 31. Specifically, the upper wire holder 31 is turned to and stopped at a predetermined position by the operation of the motor 34. As the motor 34, a stepping motor, a servomotor, or the like is suitably used. On the other hand, the rotating shaft 35, which penetrates the upper wire holder 31 and extends downward, is penetratingly fixed to the lower wire holder 32 so that the
 15 lower wire holder 32 is turned and stopped integrally with the upper wire holder 31. The lower end of the rotating shaft 35 is pivotally supported by a bearing 36.

According to the above-described configuration, the upper wire holder 31 and the lower wire holder 32 are turned and stopped integrally, and thereby transfer the lapping wires
 20 2a, which are held as described below, in sequence to a predetermined position in which the hand members 41 and 42 of the wire loading/unloading device 4 are on standby.

Next, the configuration of the upper wire holder 31 and the lower wire holder 32 for holding the lapping wire 2a will be described in detail with reference to Figs. 4 and 5. First, in peripheral walls 31a and 32a of the upper wire holder 31 and the lower wire holder 32, respectively, a plurality of locking concave portions 31b and 32b, each of which is provided so
 25 as to be concave toward the inside in the radial direction, are provided at equal intervals in the circumferential direction.

Fig. 4(A) is a partially enlarged side view showing a state in which a cylindrical locking end portion 21 provided in the upper end portion of the lapping wire 2a (or a wire 2b having finished lapping operation, hereinafter being omitted) is locked to one of the locking
 30 concave portions 31b of the upper wire holder 31, by which the lapping wire 2a is held vertically. Fig. 4(B) is a partially enlarged plan view of a portion of the locked locking end portion 21, in which the locking end portion 21 is viewed from the top (in the direction of

arrow U_1 in Fig. 4(A)).

As shown in Figs. 4(A) and 4(B), a lower end portion 21a of the locking end portion 21 provided at the upper end of the lapping wire 2a abuts on the upper face of a step portion 31c provided in the locking concave portion 31b. The lapping wire 2a is seated on and
 5 locked to the step portion 31c by the own weight of the lapping wire 2a.

On the other hand, Fig. 5(A) is a partially enlarged side view showing a state in which a cylindrical locking end portion 22 provided in the lower end portion of the lapping wire 2a is locked to one of the locking concave portions 32b of the lower wire holder 32, by which the lapping wire 2a is held vertically. Fig. 5(B) is a partially enlarged plan view of a portion of
 10 the locking end portion 22, in which the locking end portion 22 is viewed from the top (in the direction of arrow U_2 in Fig. 5(A)).

As shown in Figs. 5(A) and 5(B), the locking end portion 22 of the lapping wire 2a is locked to the locking concave portion 32b, which is provided concavely in a semicylindrical form toward the inside in the radial direction on the peripheral wall 32a of the lower wire
 15 holder 32, in a state of entering substantially by half.

According to the above-described configuration, the lapping wire 2a is locked to both of the upper wire holder 31 and the lower wire holder 32, and is held vertically. Specifically, the upper wire holder 31 and the lower wire holder 32 function as stock members for the lapping wire 2a.

20 A case can be assumed in which the locking end portion 22 of the lapping wire 2a comes off the locking concave portion 32b provided in the lower wire holder 32 by means of a centrifugal force produced in a process in which the lapping wire 2a is transferred. For this reason, a sensor S is provided in the vicinity of the lower wire holder 32 to quickly detect the locking end portion 22 coming off the locking concave portion 32b.

25 A detailed explanation will be given with reference to Fig. 6. Fig. 6 is a partially enlarged side view showing a state in which the locking end portion 22 of the lapping wire 2a comes off the locking concave portion 32b. As shown in Fig. 6, the height differs between a lower end position P_1 of the locking end portion 22 held vertically and a lower end position P_2 of the locking end portion 22 coming off the locking concave portion 32b to a degree indicated
 30 by reference character H in Fig. 6.

Therefore, the lower end of the locking end portion 22 lying higher than the lower end position P_1 is detected by the sensor S. Thereby, it can be judged easily that the locking

end portion 22 has come off the locking concave portion 32b and the lapping wire 2a is in a state of not being held vertically (a state of being oblique). As the sensor S, an optical sensor or other sensors that can detect the lower end position of the locking end portion 22 can be used appropriately.

5 In this embodiment, the lapping wire 2a is locked between the paired wire holders 31 and 32, and a disk-shaped or cylindrical intermediate locking member 33 is provided to perform function of preventing the lapping wire 2a from swaying (oscillating) during transfer (see Fig. 1).

Fig. 7 is an enlarged side view showing a configuration of one embodiment of the
10 intermediate locking member 33. As shown in Fig. 7, in a peripheral wall 33a of the intermediate locking member 33, which is formed into a substantially cylindrical shape having the same diameter as those of the upper wire holder 31 and the lower wire holder 32, a plurality of locking concave portions 33b are provided in the same positions in the peripheral direction as those of the locking concave portions 31b and 32b provided in the peripheral walls
15 31a and 32a of the upper and lower wire holders 31 and 32, respectively.

The provision of the intermediate locking member 33 eliminates the swaying (oscillation) of the lapping wire 2a during transfer, so that there is no fear that the lapping wire 2a comes off the wire holder 31, 32 (especially, the lower wire holder 32). Also, since the lapping wire 2a does not come off or shift in a process in which the lapping wire 2a is
20 transferred to the wire loading/unloading device 4, the lapping wire 2a can surely be held vertically and can surely be transferred to the wire loading/unloading device 4.

Next, the configuration and function of the aforementioned wire loading/unloading device 4 will be described in detail.

As shown in Figs. 1 to 3, the wire loading/unloading device 4 is vertically disposed in
25 a position between the wire holding device 3 and the bore lapping device 5 (described later in detail). The wire loading/unloading device 4 has the hand members 41 and 42 which move in the direction indicated by an arrow Y in Fig. 2 while grasping the lapping wire 2a, and turn the lapping wire 2a in the direction indicated by an arrow Z (see Fig. 2), and a sliding mechanism 43 for sliding the hand members 41 and 42 integrally in the vertical direction
30 (direction indicated by an arrow X in Fig. 1).

According to this configuration, the wire loading/unloading device 4 grasps the lapping wire 2a, which has been transferred to the predetermined position while being locked

by the wire holding device 3, and after sliding upward (in the direction indicated by arrow X in Fig. 1), the whole of the wire loading/unloading device 4 slides toward the bore lapping device 5 (in the direction indicated by arrow Y in Fig. 1) along guides 44, 44. Then, the grasped lapping wire 2a is turned toward the bore lapping device 5 (in the direction indicated by arrow Z in Fig. 2), and is engaged with a pair of pulleys 51 and 52 disposed in the bore lapping device 5. The engagement of the lapping wire 2a with the pulleys 51 and 52 is carried out by locking the locking end portions 21 and 22 to notch portions 51a and 52a (see Fig. 1) provided in the pulleys 51 and 52, respectively.

Also, the wire loading/unloading device 4 receives, from the bore lapping device 5, the wire 2b having finished lapping operation, on which workpieces w having been subjected to bore lapping are installed, by grasping it using the hand members 41 and 42. Subsequently, the whole of the wire loading/unloading device 4 slides toward the wire holding device 3 (see the direction indicated by arrow Y in Fig. 1) along the guides 44, 44 (see Figs. 1 and 2). Then, the wire 2b having finished lapping operation is turned toward the wire holding device 3 (in the direction indicated by arrow Z in Fig. 2), and is lowered as it is (see the direction indicated by arrow X in Fig. 1), by which the wire 2b having finished lapping operation is transferred again to the wire holding device 3.

Next, the configuration and function of the aforementioned bore lapping device 5 will be described in detail.

The bore lapping device 5 captures and grasps the lowest workpiece W_1 of the workpieces W installed on the lapping wire 2a held vertically by being engaged with the pulleys 51 and 52 by sliding a work holder 53, which is on standby on the lower side, upward (in the direction indicated by arrow T in Figs. 1 and 3) along a guide 54. The workpiece grasping device of the work holder 53 may be of any type that can hold the workpiece surely, for example, a chuck type.

Fig. 8 is an enlarged view showing a state of bore lapping in a simplified manner. As shown in Fig. 8, when the workpiece W_1 is captured by and fixed to a holder hole 53a in a chuck portion 53b of the work holder 53, the work holder 53 turns via a belt 56 for transmitting the drive of a motor 55, by which the bore W_a in the workpiece W_1 (the bore in which the lapping wire 2a is inserted) is lapped.

This bore lapping operation is performed by supplying lapping powder (for example, diamond powder) D with a uniform grain size of about 0.5 micron from a powder supply

device (not shown) and by causing it to adhere to an outer peripheral surface 23 of the lapping wire 2a. Specifically, the lapping powder D is interposed between the outer peripheral surface 23 of the lapping wire 2a and an inner peripheral wall surface Wb of the bore Wa in the workpiece W₁ (see Fig. 8), and the inner peripheral wall surface Wb of the workpiece W₁ is gradually lapped so that the bore Wa is widened to a predetermined bore size by the lapping operation of the diamond powder D.

More particularly, for the inner peripheral wall surface Wb in the workpiece W₁, the work holder 53 turning while grasping the workpiece W₁ is moved downward under a fixed pressure with respect to a lapping portion 24 (see Fig. 8) formed in a predetermined position of the lapping wire 2a so that the diameter thereof increases gradually, by which the bore Wa is gradually widened from the downside thereof, and finally a cylindrical bore with a predetermined inside diameter is formed. After the bore with the predetermined inside diameter has been formed, the workpiece W₁ slides down on a cylindrical portion 25 on the downside of the lapping portion 24 and is collected in the lower portion.

In the vicinity of the chuck portion 53b of the work holder 53, a sensor (not shown) for detecting the presence of the workpiece W₁ is provided. This not illustrated sensor detects the position of the lowest workpiece W₁ installed on the lapping wire 2a, so that continuous bore lapping operation can be performed quickly.

In the bore lapping device 5 constructed as described above, the lapping wire 2a is hung vertically by the paired pulleys 51 and 52 disposed in the upper and lower positions (see Fig. 1), and weights 58a and 58b are installed at the ends of the lapping wire 2a, by which the lapping pressure is made fixed. In Fig. 1, reference numerals 57a and 57b denote cylinders for adjusting the turning of the pulleys 51 and 52, respectively. In Figs. 2 and 3, reference character E denotes an encoder for detecting the load of the pulleys 51 and 52.

Figs. 9(A) to 9(H) show the flow of the bore lapping process using the wire-type bore lapping apparatus 1 in accordance with the present invention. The whole of a series of bore lapping steps performed by using the wire-type bore lapping apparatus 1 will be described briefly with reference to Figs. 9(A) to 9(H).

Fig. 9(A): First, the upper hand member 41 of the wire loading/unloading device 4 grasps and receives the lapping wire 2a from the wire holding device 3. At this time, the lower hand member 42 is in an open state.

Fig. 9(B): The wire loading/unloading device 4 slides upward while the hand member

41 grasps the lapping wire 2a.

Fig. 9(C): The wire loading/unloading device 4 slides toward the bore lapping device 5 while the hand members 41 and 42 grasp the lapping wire 2a. Subsequently, the hand members 41 and 42 are turned toward the bore lapping device 5.

5 Fig. 9(D): The wire loading/unloading device 4 is lowered, and the lower hand member 42 is opened. The lapping wire 2a is automatically inserted in the work holder 53 from the lower end thereof.

Fig. 9(E): The wire loading/unloading device 4 slides and retreats toward the wire holding device 3. The lapping wire 2a is engaged with the pulleys 51 and 52.

10 Fig. 9(F): The work holder 53 of the bore lapping device 5 moves upward and captures the lowest workpiece W_1 installed on the lapping wire 2a, by which the bore lapping operation for the workpiece W_1 is started.

Fig. 9(G): This bore lapping operation is performed for all of the workpieces W . All of the workpieces w having been subjected to bore lapping slide down by gravity along the lapping wire 2a (see Fig. 8), and are collected in the lower portion of the work holder 53. By
15 this configuration, the completion of bore lapping can be visually checked easily.

Fig. 9(H): The wire 2b having finished lapping operation is received by the wire loading/unloading device 4 (the hand members 41 and 42 thereof) by reversing the procedure for loading the lapping wire 2a to the work holder 53, and is locked to the empty locking
20 concave portions 31b and 32b of the paired wire holders 31 and 32 provided in the wire holding device 3.

In the wire-type bore lapping apparatus 1 in accordance with the present invention, as shown in Figs. 9(A) to 9(H), the lapping wires 2a are transferred in sequence from the wire holding device 3 to the bore lapping device 5 via the wire loading/unloading device 4, and the
25 wires 2b having finished lapping operation, on which the workpieces w having been subjected to bore lapping are installed, are returned to and stocked in the wire holding device 3 in sequence.

In the wire-type bore lapping apparatus 1 in accordance with the present invention, there are provided a control device which indexes the wire holders 31 and 32 at the
30 predetermined positions (device which controls the turning to and stoppage in the predetermined position), a device which controls the loading and unloading of the lapping wire 2a, and a device which controls the bore lapping operation, so that the above-described

series of wire holding process, wire loading/unloading process, and bore lapping process can be carried out full-automatically.

The main effects achieved by the wire-type bore lapping apparatus in accordance with the present invention are as follows:

5 (1) The lapping wire held vertically by the wire holding device is captured and transferred by using an appropriate device, and the lapping wire is vertically reciprocated in a state of being held vertically. Therefore, bore lapping operation can be performed in the state in which there is no influence of the own weight of workpiece, so that the accuracy of bore circularity can be improved. That is to say, the accuracy of bore lapping operation can be
10 enhanced.

(2) The lapping wires held vertically in the state in which the workpieces are installed in the wire holding device are stocked in plural numbers, and the lapping wires are transferred in sequence to the wire loading/unloading device. Therefore, the bore lapping operation can be performed continuously by transferring the lapping wires in sequence from the wire
15 loading/unloading device to the bore lapping device, so that a series of operations can be made unmanned by automatic control.

(3) The disk-shaped or cylindrical intermediate locking member, which locks the lapping wires and thereby performs a function of preventing the lapping wire from swaying (oscillating) during transfer, is interposed between the paired wire holders. Therefore, the
20 lapping wire does not sway during transfer, and thus there is no fear of the lapping wire coming off the wire holder of the wire holding device, so that continuous bore lapping operation can be performed smoothly.

(4) The sensor is provided to check that the lapping wire is in a vertical state. This configuration is convenient because an abnormal wire holding state can be found instantly, so
25 that measures can quickly be taken against the abnormality.

(5) The wire-type bore lapping apparatus of space-saving design, in which the lapping wires are held vertically, can be supplied to the industrial field.

It should be understood, however, that there is no intention to limit the invention to the specific forms disclosed, but on the contrary, the invention is to cover all modifications,
30 alternate constructions and equivalents falling within the spirit and scope of the invention as expressed in the appended claims.

WHAT IS CLAIMED IS:

1. A wire-type bore lapping apparatus (1), comprising:
 - a wire holding device (3) which holds a lapping wire (2a) in a vertical direction, a workpiece (W) to be subjected to bore lapping being installed on the lapping wire (2a);
 - a wire loading/unloading device (4) which loads and unloads the lapping wire (2a) to and from the wire holding device (3); and
 - a bore lapping device (5) which holds the lapping wire (2a) loaded by the wire loading/unloading device (4) in the vertical direction so as to perform bore lapping operation for the workpiece (W) with the lapping wire (2a).
2. The wire-type bore lapping apparatus (1) according to claim 1, wherein:
 - the lapping wire comprises a plurality of lapping wires (2a);
 - the wire holding device (3) locks the plurality of lapping wires (2a) at equal intervals in a circumferential direction on peripheral wall portions (31a, 32a) of a pair of disk-shaped or cylindrical wire holders (31, 32) disposed in upper and lower end regions of the plurality of lapping wires (2a); and
 - the locked plurality of lapping wires (2a) are transferred in sequence to the wire loading/unloading device (4) by indexing the wire holders (31, 32) at predetermined positions.
3. The wire-type bore lapping apparatus (1) according to claim 2, further comprising a disk-shaped or cylindrical intermediate locking member (33) interposed between the pair of wire holders (31, 32), the intermediate locking member (33) locking the plurality of lapping wires (2a) to prevent the plurality of lapping wires (2a) from swaying during transfer.
4. The wire-type bore lapping apparatus (1) according to claim 2 or 3, wherein the wire holding device (3) comprises a sensor (S) which checks that one of the plurality of lapping wires (2a) to be transferred to the wire loading/unloading device (4) is in a vertical state, the sensor (S) being arranged nearby one of the pair of wire holders (32) disposed at the lower end region of the one of the plurality of lapping wires (2a).
5. The wire-type bore lapping apparatus (1) according to any one of claims 2 to 4,

further comprising:

a control device which indexes the pair of wire holders at the predetermined positions;
a device which controls the loading and unloading of the lapping wires; and
a device which controls the bore lapping operation,
wherein a series of wire holding process, wire loading/unloading process, and bore lapping process are carried out full-automatically.

6. The wire-type bore lapping apparatus (1) according to any one of claims 1 to 5, wherein the bore lapping device (5) comprises a mechanism (51, 52, 58a, 58b) for controlling a lapping pressure to be fixed.

7. The wire-type bore lapping apparatus (1) according to any one of claims 1 to 6, wherein:

the bore lapping device (5) comprises a work holder (53) which grasps the workpiece (W) to perform bore lapping operation; and

the work holder (53) comprises a mechanism for automatically loading and unloading the lapping wire (2a).

8. The wire-type bore lapping apparatus according to any one of claims 1 to 7, wherein the lapping wire (2a) is a wire with bonded abrasive.

9. The wire-type bore lapping apparatus according to any one of claims 1 to 7, wherein the lapping wire (2a) is a wire with free abrasive.