

[54] HONING AND PLATING APPARATUS AND
METHOD EMBODYING BORE GAUGING
MEANS

[75] Inventors: Myron P. Ellis, Royal Oak; Karl H. Kaake, Detroit, both of Mich.

[73] Assignee: Micromatic Industries, Inc., Detroit, Mich.

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204/224, 225, 26, 129.2

[56] References Cited

UNITED STATES PATENTS

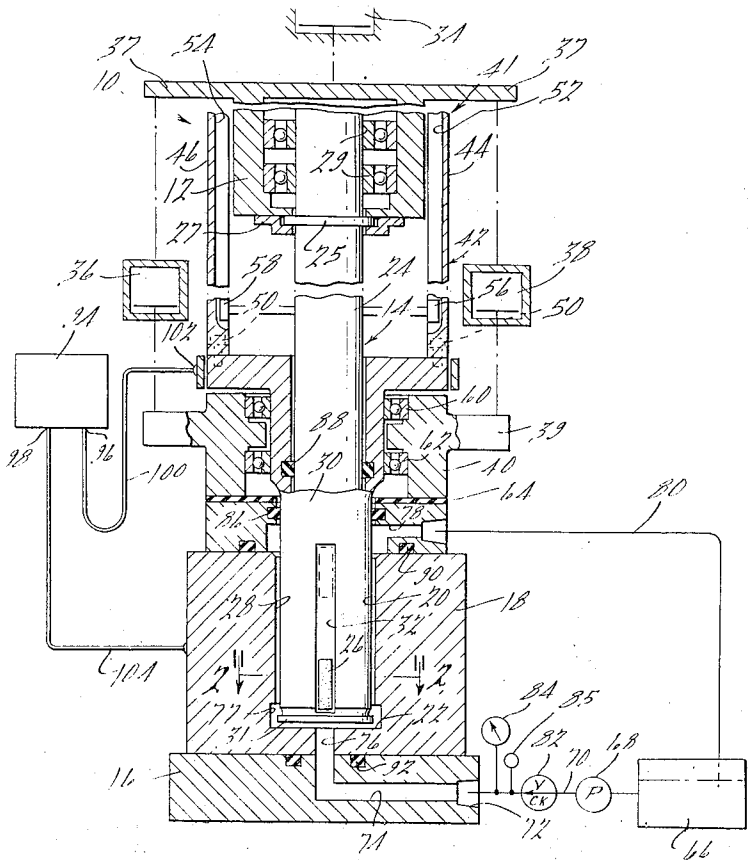
3,637,469	1/1972	Ellis et al.	204/26
3,650,922	3/1972	Augustin et al.	204/224
3,399,125	8/1968	Mikoshiba et al.	204/224

Primary Examiner—T. Tufariello
Attorney—Malcolm R. McKinnon et al.

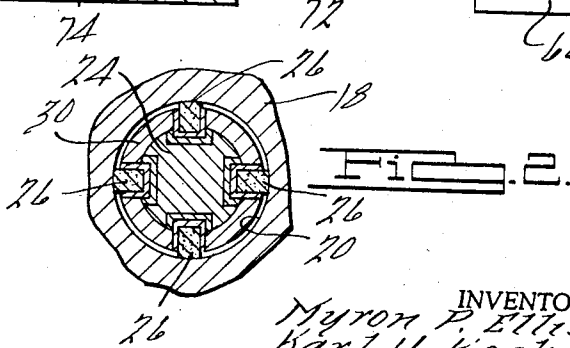
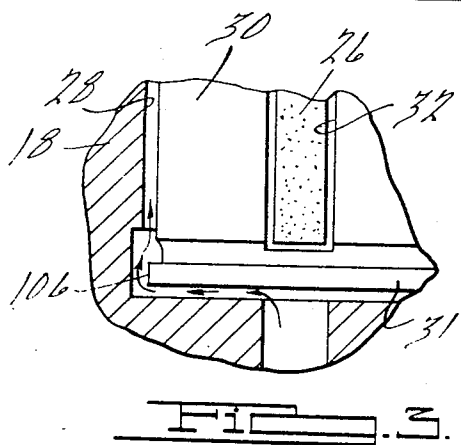
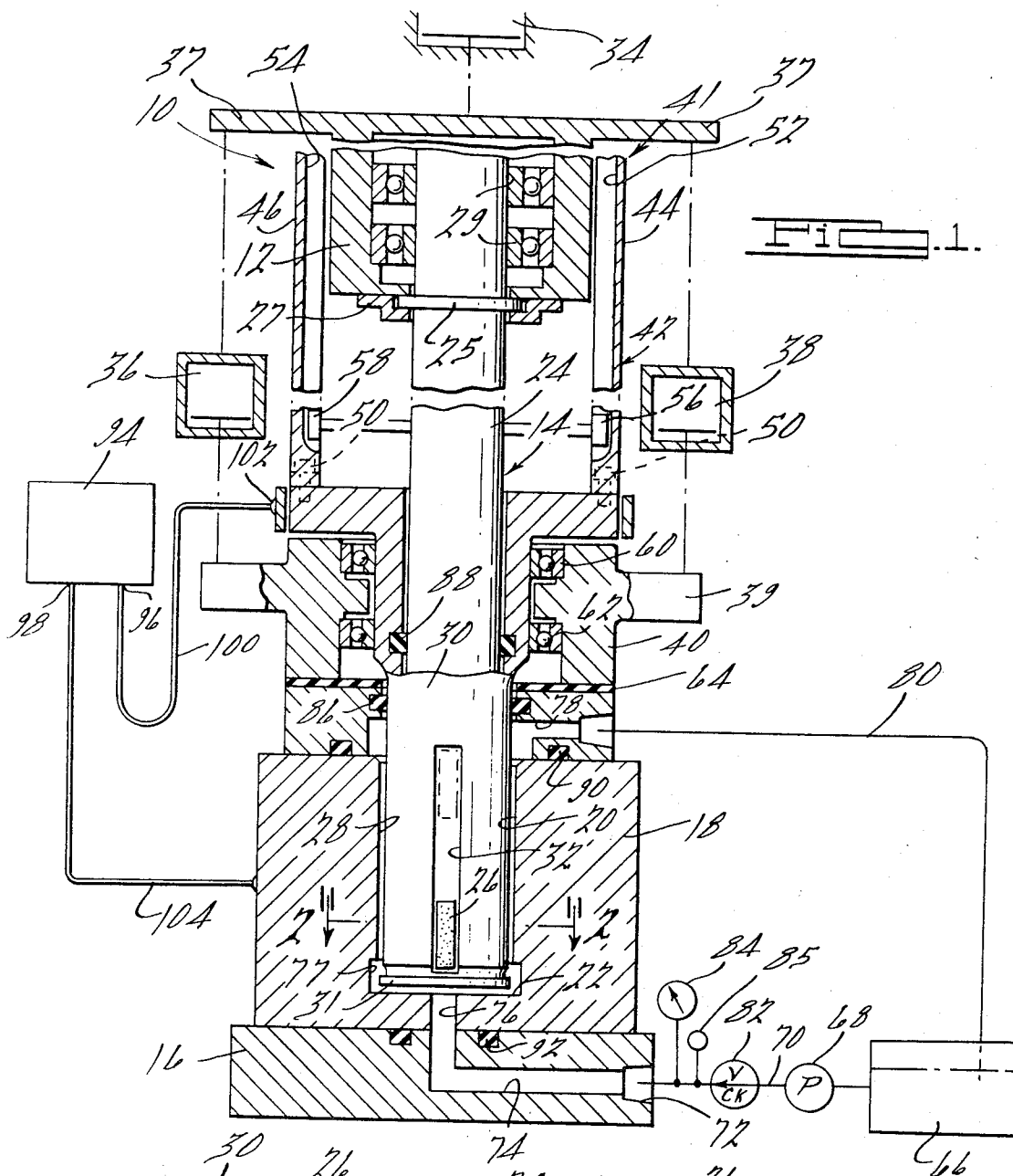
[57] ABSTRACT

A honing and plating apparatus and method utilizing the pressure of electrolytic solution to effect gauging of an internal dimension of a workpiece.

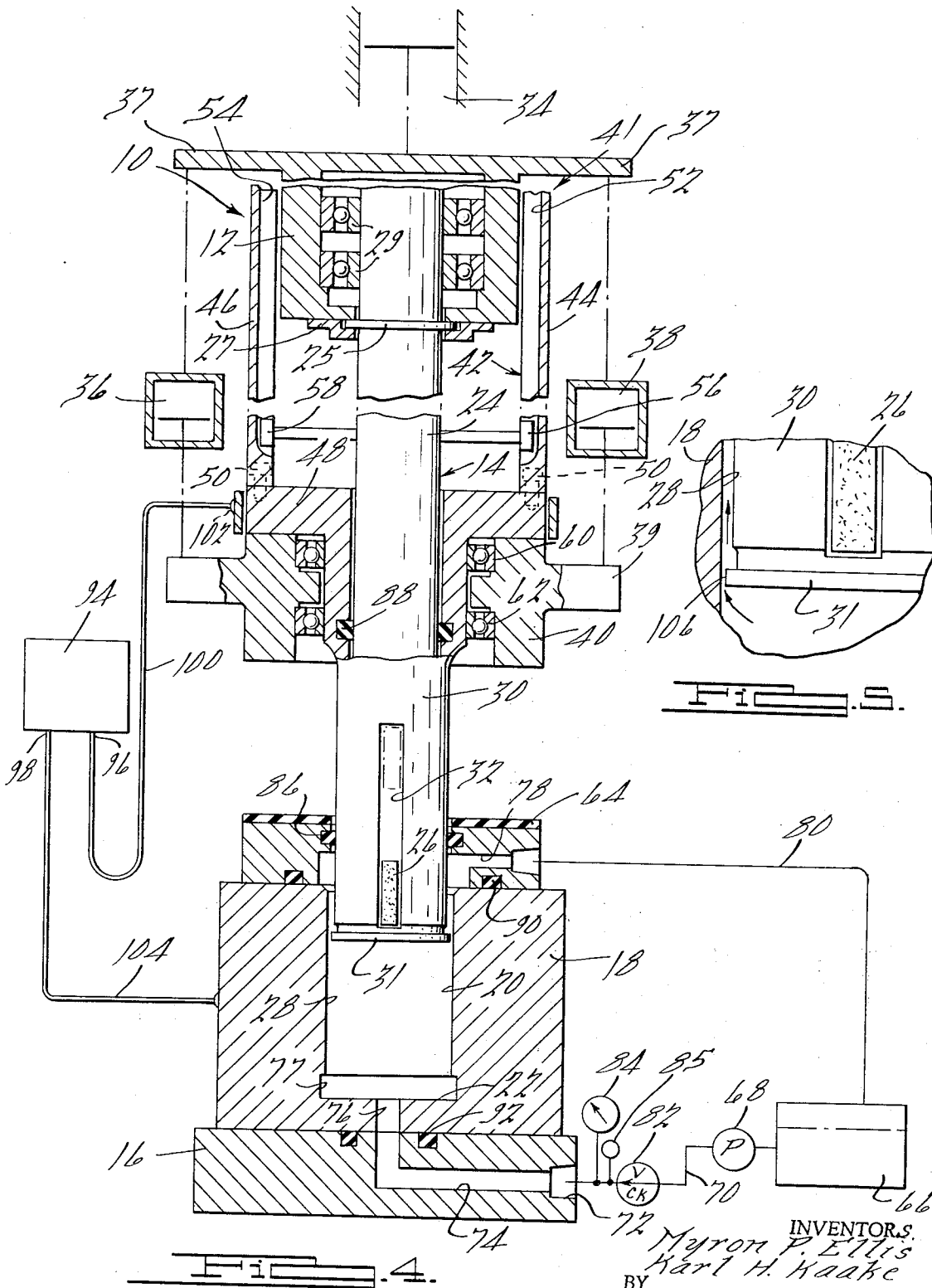
9 Claims, 5 Drawing Figures



2 Sheets-Sheet 1



INVENTORS
Myron P. Ellis
Karl H. Haake
BY
Malcolm R. McKinnon
Irvin L. Groh
ATTORNEYS



INVENTORS:
 Myron P. Ellis
 Karl H. Haake
 BY
 Malcolm R. McKinnon
 Irvin L. Groh

ATTORNEYS.

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BRIEF SUMMARY OF THE INVENTION

This invention relates to the honing and plating art and, more particularly, to an improved honing and plating apparatus and method embodying improved gauging means whereby internal dimensions of a honed or plated surface of a workpiece may be accurately gauged by means of fluid pressure.

Heretofore, various means have been provided for gauging the finished surface of a workpiece which has been plated and honed. In particular, U.S. Pat. No. 3,390,068 issued June 25, 1968 to M.P. Ellis discloses gauging means by which the size of a workpiece is sensed mechanically.

An object of the present invention is to overcome disadvantages inherent in prior gauging methods and apparatus of the indicated character and to provide an improved method and improved apparatus for automatically gauging a plated and/or honed surface during a plating and/or honing operation.

Another object of the invention is to provide an improved method and improved apparatus for gauging the finished surface of a bore defined by a workpiece wherein the pressure of fluid employed during the honing and/or plating operations is utilized to effect a measurement of the internal dimensions of a bore defined by a workpiece.

The above as well as other objects and advantages of the present invention will become apparent from the following description, the appended claims and the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic, elevational view, with portions in cross-section, of a honing and plating machine embodying the present invention;

FIG. 2 is a cross-sectional view of the structure illustrated in FIG. 1, taken on the line 2—2 thereof;

FIG. 3 is a fragmentary, enlarged elevational view of a portion of the structure illustrated in FIG. 1;

FIG. 4 is a schematic, elevational view similar to FIG. 1 but showing the position of the honing and plating tool during the gauging operation; and

FIG. 5 is a fragmentary sectional view of an enlarged scale of the structure illustrated in FIG. 4.

DETAILED DESCRIPTION

Referring to the drawings, the present invention is illustrated embodied in apparatus for honing and plating stepped or semi-blind end and straight cylindrical bores of a workpiece although it will be understood that the present invention is applicable to other uses. For example, the present invention may be embodied in machines for honing only as well as in other machine tools, as will be understood by those skilled in the art. FIG. 1 illustrates a honing machine, generally designated 10, having a reciprocating quill 12 to which a honing and plating tool, generally designated 14, is drivably connected for reciprocation with the quill 12 and rotation relative to the quill 12. A work holding fixture 16 is provided which is mounted beneath the tool 14 is illustrated in FIG. 1 and supports a workpiece 18 in axial alignment with the tool 14.

Details of an electrochemical honing machine of a type in which the present invention may be incorpo-

rated are more fully disclosed in U.S. Pat. No. 3,390,068 issued to M.P. Ellis et al. on June 25, 1968. It will be understood that a wide variety of honing tools may be mounted to the reciprocating quill 12 for both reciprocating and rotational movement in any manner well known in the art.

As shown in FIG. 1, the honing and plating tool 14 is positioned relative to the workpiece 18 for combined plating and honing, the workpiece 18 being disposed in a fixed position relative to the fixture 16 forming a part of the machine 10. The illustrated workpiece 18 has a stepped bore 20 in which the lower portion of the bore is partially closed, as at 22. Such a bore may be described generally as a modified blind bore but it will be understood that the present invention may also be utilized with straight cylindrical bores.

The combined honing and plating tool 14 comprises a tool support 24 which includes a plurality of honing stones 26, four of such stones 26 being illustrated although any desired number of such honing stones may be utilized. The stones 26 are mounted relative to the tool support 24 so that they may be adjusted radially outwardly or inwardly relative to the axis of rotation of the tool support in any manner well known in the art whereby the stones may be moved toward and away from the bore surface which is to be plated and honed. One means for moving the honing stones 26 and for supporting them on the tool support 24 is more fully disclosed in the aforementioned Ellis patent and in U.S. Pat. No. Re26,499 issued to J.H. Greening on Dec. 3, 1968. It will be understood that any other suitable means may be employed to support and move the honing stones.

In the embodiment of the invention illustrated, the tool support 24 includes an integral flange 25 which is secured to the quill 12 by a retaining ring 27 whereby the tool support reciprocates with the quill 12, and the tool support 24 is supported for rotation within the quill 12 by bearings such as 29.

Surrounding the honing tool support 24 is a sleeve member 30 which is closed at its lower end by a gauging plug 31, the sleeve member 30 and gauging plug 31 also being adapted to project into the bore 20. The sleeve 30 is provided with longitudinally extending slots 32 adapted to receive the honing stones 26 so that upon radial adjustment, the stones may protrude through the slots 32 and into engagement with the bore surface 28 with any desired surface pressure or they may be retracted out of engagement with the surface 28. The inside diameter of the sleeve member 30 affords sufficient clearance between the sleeve and the honing tool support 24 to permit reciprocation or relative movement of the tool support relative to the sleeve member 30. The outside diameter of the sleeve member is of a selected size to afford a small clearance with the wall surface 28 of the bore 20 in the workpiece 18.

As schematically shown in FIG. 1, the quill 12 is adapted to be reciprocated by a conventional piston and cylinder unit 34 mounted on the machine 10 while the sleeve member 30 is adapted to be releasably clamped to the quill 12 through the agency of conventional piston and cylinder units 36 and 38 for selective reciprocation with the tool support 24. The pistons of the piston and cylinder units are connected to a flange 39 provided on a bearing collar 40 which supports the sleeve 30 while the cylinders of the piston and cylinder units 36 and 38 are connected to the opposite ends of

an outwardly projecting arm 37 fixed to the quill 12. A rotatable drive mechanism, generally designated 41, is also provided for simultaneously rotating the tool support 24 and the sleeve 30. The rotatable drive mechanism 41 is comprised of a driving cage 42 which may be rotated about the axis of the quill 12 by any suitable rotating driving mechanism such as a splined gear drive (not shown). The cage 42 includes angularly spaced, vertically extending driving members, such as 44 and 46, the lower end portions of which are fixed to an integral flange 48 provided on the sleeve 30, as by bolts 50, while the upper end portions of the driving members 44 and 46 are driven by the aforementioned driving mechanism. The driving members 44 and 46 define longitudinally extending slots 52 and 54, respectively, in which are mounted rollers, such as 56 and 58, the rollers 56 and 58 in turn being fixed to the tool support 24. With such a construction, rotation of the drive members 44 and 46 imparts simultaneous rotation to both the tool support 24 and the sleeve 30, the sleeve 30 being supported for rotation by bearings 60 and 62 carried by the bearing collar 40. In addition, the tool support 24 is permitted to be reciprocated independently of the sleeve 30 through the agency of the piston and cylinder unit 34 and the sleeve 30 is permitted to be reciprocated with the tool support 24 by actuating the piston and cylinder units 36 and 38 so that the arm 37, the flange 48 of the sleeve 30 and the bearing collar 40 are clamped together for reciprocation with the quill 12. Thus, such a construction either permits the rotating tool support 24 to move vertically relative to the simultaneously rotating but longitudinally stationary sleeve 30 within the range afforded by the length of the slots 32 or both the tool support and sleeve 30 may be simultaneously reciprocated.

The lower end of the collar 40 is insulated from the fixture 16 by an insulator 64 made of any suitable electrically non-conductive material, the insulator 64 remaining stationary relative to the fixture 16 while permitting rotational and reciprocable movement of the sleeve member 30.

As is well known, it is necessary during plating to provide an electrolyte or plating solution in the area between the tool and the work surface to be plated. As shown in FIG. 1, the flow path or circuit by which plating solution may be circulated, includes a reservoir 66 of electrolytic solution which is pumped by means of a pump 68 through a conduit 70 to a port 72 in the fixture 16 and thereafter through passage 74 into the lower end 76 at the semi-blind bore 20. The plating solution is free to flow through the enlarged radial bore portion 77 and through the annular space formed by the outer diameter of the sleeve member 30 and the bore surface 28 of the workpiece to a passageway 78 provided at the upper end of the fixture 16. The plating solution flows from the passageway 78 through a conduit 80 which returns the plating solution to the reservoir 66. In order to prevent reverse flow through the system, a check valve 82 is provided in the conduit 70 and a pressure gauge 84 and pressure switch 85 are also provided for purposes which will be described hereinafter in greater detail.

In order to seal the plating solution within the system, a seal 86 is provided at the upper end of the fixture 16 for engagement with the outside diameter of the rotating sleeve member 30. Another seal 88 is provided which is located between the inner diameter of the

sleeve member and the outer diameter of the tool support 24. A static seal 90 is also provided between the stationary fixture 16 and the upper surface of the workpiece 18 while the lower portion of the workpiece is sealed relative to the supporting fixture by means of the seal 92.

The plating solution acts to form an electrically conductive path between the electrically conductive sleeve member 30 and the electrically conductive workpiece 18. As shown in FIG. 1, a power supply 94 of direct current is provided adjacent the honing machine 10 and is provided with positive and negative output terminals 96 and 98. The power supply unit functions to supply direct electric current of a selected magnitude to the work environment. The positive output terminal 96 is connected by a conductor 100 to a brush take-off unit 102 by means of which the electric current may be transmitted between the power source and the sleeve member 30 during rotation of the latter. From the sleeve member, the current flows through the electrolyte to the workpiece 18 which is of electrically conductive material. A conductor 104 between the workpiece and the negative terminal of the power supply unit completes the electrical circuit.

The actual abrading or cleaning of the surface of the workpiece and the plating thereof will be described later in greater detail. However, it will be appreciated that it is often necessary to measure accurately the inside diameter of the bore 20 to determine the amount or degree of plating and/or honing that may be required before the bore is brought to the desired size. It also is desirable to measure the inside diameter of the honed bore after a plating operation to determine if the bore is of a size ready for honing only, and after plating and honing, remeasurement may be required to determine if the proper degree of plating and/or honing has been accomplished. Heretofore, various means have been provided to gauge or measure the surface of workpieces. For example, the aforementioned patent to Ellis provides mechanical means to engage the work surface for this purpose. In the present embodiment of the invention, however, gauging is afforded by employing the pressure of electrolytic fluid in the flow circuit previously described. For the purpose of gauging, the lower portion of the sleeve member 30 is provided with the gauging plug 31 which is made of a non-conductive, non-wearing material such as a ceramic. The gauging plug 31 is very carefully and accurately made to reflect within extremely close tolerances the desired dimensions of the finished bore of the workpiece and the gauging plug 31 is rigidly connected to the lower end of the sleeve member 30 in any well known manner.

As will be noted from an examination of FIGS. 1, 3, 4 and 5, the gauging plug 31 has an outer circumferential surface 106 the diameter of which is larger than the outside diameter of the sleeve member 30. During honing and plating operations, the gauging plug 31 is positioned as shown in FIGS. 1 and 3. It will be noted that the lower end of the bore 20 in the workpiece 18 is provided with the enlarged bore portion 77, and with the gauging plug 31 positioned as shown, an enlarged annular cavity is formed which permits the unrestricted flow of electrolyte in the circuit.

To gauge the size of the bore, reciprocation of the tool support 24 relative to the sleeve member 30 is stopped and the supply of electric current is terminated. While rotation of the tool support 24 and sleeve

member 30 continues, the piston and cylinder units 36 and 38 are actuated to clamp the sleeve in the manner previously described and the tool support 24 and the sleeve member 30 are then raised vertically through the agency of the piston and cylinder unit 34 to position the gauging plug 31 approximately one-fourth the distance from the upper end of the bore as shown in FIG. 4. The tool support 24 and sleeve member 30 including the gauging plug 31 are then plunged downwardly by activating the piston and cylinder unit 34 and because of the very close proximity of the outer circumferential edge 106 of the gauging plug 31 relative to the bore surface 28 as shown in FIG. 5, pressure will result in the electrolyte circuit between the gauging plug 31 and the check valve 82. This pressure can be measured by means of the pressure gauge 84. A pressure higher than some predetermined pressure indicates that the bore is smaller than desired and a pressure less than the predetermined pressure indicates that the bore is larger than desired. Thus, during the gauging operation illustrated in FIGS. 4 and 5, it will be apparent that the pressure of the electrolyte fluid measured at the gauge 84 will be a function of the minute annular clearance between the gauging plug 31 and the surface 28 of the bore of the workpiece and the pressure switch 85 may be utilized to automatically stop the cycle when the bore reaches a predetermined size.

Thus far the invention has been described in connection with operations on a workpiece with a modified blind bore. It will be understood, however, that the invention may be employed to hone and plate an open ended or straight cylindrical bore in a workpiece. In this instance, the fixture may be provided with an enlarged inlet passageway to eliminate any restriction to the free flow of plating solution into the bore of the workpiece during the plating and honing process. It will also be understood that the present invention may be embodied in machines for honing only by fixing the gauging plug 31 to the end of the tool support if a sleeve, such as the sleeve 30, is not utilized.

In operation, the apparatus 10 is employed for honing and electroplating by first retracting the quill 12 together with the honing-plating tool 14 to its uppermost position. A workpiece 18 is then positioned in the fixture 16 so that the workpiece bore 20 is in axial alignment with the axis of rotation of the tool 14. With the honing stones 26 retracted within the slots 32 of the sleeve member 30, the tool support 24 and sleeve member 30 are moved as a unit vertically downward until the lower end of the sleeve 30 is located at a position near the lower end of the modified stepped bore as shown in FIGS. 1 and 3 after which the sleeve 30 is unclamped from the quill 12 by releasing the piston and cylinder units 36 and 38. With the combined honing and plating tool 14 in this position, the flow of plating solution is initiated to cause fluid flow between the outer surface of the sleeve member 30 and the bore surface 28 of the workpiece. Thereafter, the honing stones are brought into engagement with the surface 28 and the tool support 24 is reciprocated by the piston and cylinder unit 34 and both the tool support 24 and sleeve 30 are rotated through the agency of the drive mechanism 41 to cause an abrading action to take place between the honing stones and the work surface. After a desired degree of abrading has taken place, the work surface will be sufficiently clean and be prepared for the subsequent plating cycle.

Thereafter, the electrical current is initiated so that the sleeve 30 acts as an anode and the workpiece acts as a cathode and a plating cycle is accomplished during continued rotation of the sleeve member 30 but with the honing stones 26 retracted slightly to relieve the pressure on the work surface of the workpiece. Under these conditions and with the continued flow of plating solution, plating of the surface 28 is effected. It will be understood that the D.C. current flows in the electrical circuit previously described and particularly between the sleeve member 30 which acts as an anode, through the electrolyte to the workpiece which acts as a cathode. As is well known, this causes a depositing of the plating material on the surface 28 of the workpiece. After a sufficient period of time and sufficient depositing and honing of plating material on the work surface 28 of the workpiece, the electrical current flow is terminated.

In order to determine if a sufficient degree of plating material has been deposited, the size of the bore may be gauged by retracting the tool support 24 and the sleeve 30 in the manner previously described. As mentioned previously, the dimensions of the gauging plug 31 are very carefully controlled and as best seen in FIG. 5 a restricted annular passage will be formed between the circumferential surface 106 of the gauging plug 31 and the bore surface 28. This annular passage will be of smaller dimension than the annular space between the sleeve member and the bore surface so that a pressure will result as the tool support 24, sleeve 30 and the gauging plug 31 are plunged downwardly. The pressure may readily be measured by any conventional pressure gauge 84. If the pressure is higher than some predetermined pressure, the plating surface will be thicker than desired and the abrading cycle previously described may be resumed to remove some of the plated material. On the other hand, if the pressure is less than the predetermined selected pressure, the plating and/or plating and simultaneous abrading operations are resumed to deposit additional material on the surface of the workpiece until the bore is of the desired size at which time the pressure switch 85 automatically terminates the cycle.

From the foregoing description, it will be seen that there has been provided a novel means for gauging very accurately the internal surface of a bore by employing the pressure of fluid within the bore and measuring the relative increase or decrease of pressure upon retracting and thereafter advancing a gauging plug within the bore of the workpiece.

While preferred embodiments of the invention have been illustrated and described, it will be understood that various changes and modifications may be made without departing from the spirit of the invention.

What is claimed is:

1. A method of finishing and gauging a surface defining a bore in a metallic workpiece with a tool including an electrically conductive sleeve having a gauging portion thereon and at least one abrasive member adjustable outwardly relative to said sleeve comprising the steps of providing relative movement between the abrasive member and the workpiece surface, maintaining said electrically conductive sleeve in spaced relationship to said surface, flowing a plating solution under pressure between said surface and said electrically conductive sleeve, passing a direct electric current between said surface and said electrically conductive

sleeve through said plating solution to plate metal onto said surface, terminating the supply of direct electric current, advancing said sleeve including said gauging portion into said bore, and measuring the fluid pressure in said bore created by said gauging portion as said sleeve is advanced into said bore.

2. The method as set forth in claim 1 including the step of advancing said abrasive member into increasing pressure with said surface to remove metal mechanically from said surface after said fluid pressure has reached a predetermined value.

3. A method for finishing and sequentially gauging a surface defining a bore in a metallic workpiece with a tool including an electrically conductive sleeve having a gauging plug at one end thereof and at least one abrasive member adjustable outwardly relative to said sleeve comprising the steps of providing relative rotational and longitudinal movement between said abrasive member and said workpiece surface, maintaining said electrically conductive sleeve and said gauging plug in spaced relationship to said surface with said gauging plug disposed outside of said bore, flowing a plating solution under pressure between said surface and said electrically conductive sleeve, passing a direct electric current between said surface and said electrically conductive sleeve through said plating solution to plate metal onto said surface, terminating the supply of direct electric current, moving said gauging plug into said bore, advancing said gauging plug in said bore, and measuring the fluid pressure in said bore created by said gauging plug.

4. A method of plating, honing and gauging a metallic work surface defining a bore with a tool having a tool body portion, an electrically conductive sleeve portion having a gauging plug at one end thereof, and at least one abrasive member extending through said sleeve portion and supported by and adjustable outwardly relative to said tool body portion and said sleeve portion, comprising the steps of providing relative movement between said tool and said work surface, maintaining said electrically conductive sleeve portion and said gauging plug in spaced relationship to said work surface, advancing said abrasive member into abrasive engagement with said work surface to remove metal mechanically from said work surface, flowing a plating electrolyte between said work surface and said sleeve portion, passing a direct electric current between the work surface and the electrically conductive sleeve portion through said plating electrolyte to plate metal on the work surface, applying abrasive pressure against said work surface as said work surface is being plated, terminating the supply of direct electric current and the relative movement between said abrasive member and said work surface, advancing said gauging plug in said bore, and measuring the fluid pressure in said bore created by said gauging plug as said plug is advanced in said bore.

5. A method of honing, plating, and gauging a metallic work surface defining a bore with a tool including an electrically conductive sleeve having an enlarged end portion and at least one abrasive member adjustable outwardly relative to said sleeve, comprising the steps of rotating and reciprocating said abrasive member over said work surface, maintaining said electrically conductive sleeve in a spaced relationship to said

work surface with said enlarged end portion disposed remotely from said work surface, flowing a plating solution under pressure between said work surface and said sleeve, passing a direct electric current between the work surface and said sleeve through the plating solution to plate metal on said work surface while maintaining said abrasive member in honing engagement with said work surface, terminating the supply of direct electric current, moving said enlarged portion into said bore, and measuring the fluid pressure in said bore created by said enlarged portion while said enlarged portion is advanced in said bore.

6. In a honing and plating apparatus for honing and plating material on an internal surface of an electrically conductive workpiece defining a bore, the combination comprising a honing tool means including an electrically conductive sleeve having a gauging portion thereon, means for supporting an electrically conductive workpiece with said internal surface in a position whereby the longitudinal axis of the bore defined thereby is coaxially aligned with the longitudinal axis of said sleeve, abrasive means movably mounted on said tool means for abrading engagement with said internal surface, means for flowing an electrolytic fluid under pressure between said sleeve and said internal surface, means for passing a direct electric current between said internal surface and said sleeve through said electrolytic fluid, means for moving said abrasive means relative to said bore surface in a combined reciprocating and rotating motion to remove metal mechanically from said surface, means for advancing and retracting said abrasive means and said sleeve, and means for measuring the fluid pressure in said bore created by said gauging portion as said sleeve including said gauging portion is advanced in said bore.

7. Apparatus as defined in claim 6 wherein said gauging portion is carried by said sleeve at one end thereof.

8. Apparatus as defined in claim 7 wherein said gauging portion is in the form of a ceramic gauging plug.

9. Apparatus for honing and plating metal on a surface defining a bore in an electrically conductive workpiece comprising, in combination, honing tool means including an electrically conductive sleeve having an electrically non-conductive gauging plug at one end thereof, means for supporting an electrically conductive workpiece with said bore surface in a position with the longitudinal axis of the bore coaxially aligned with the longitudinal axis of said sleeve, abrasive means movably mounted on said tool means for abrading engagement with said bore surface, means for flowing an electrolytic plating solution under pressure between said sleeve and said bore surface, means for passing a direct electric current between said bore surface and said sleeve through said electrolytic solution, means for moving said abrasive means relative to said bore surface in a combined reciprocating and rotating motion to remove metal mechanically from said bore surface while moving said sleeve in a rotating motion to effect plating of said bore surface while said gauging plug is disposed remotely from said bore surface, means for advancing said gauging plug through said bore, and means for measuring the fluid pressure in said bore created by said gauging plug while said gauging plug is advanced in said bore.

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