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Ellis et al.

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[54] **FLUID SYSTEM FOR HONING AND PLATING APPARATUS**

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Related U.S. Application Data

[63] Continuation of Ser. No. 172,007, Aug. 16, 1971, abandoned.

[52] **U.S. Cl.**..... **204/212**, 51/5, 204/217, 204/224 R, 204/275, 204/DIG. 10

[51] **Int. Cl.**..... **C23b 5/68**

[58] **Field of Search**..... 204/212, 217, 224 R, 275, 204/DIG. 10, 224 M; 51/5, 34 R

[56] **References Cited**

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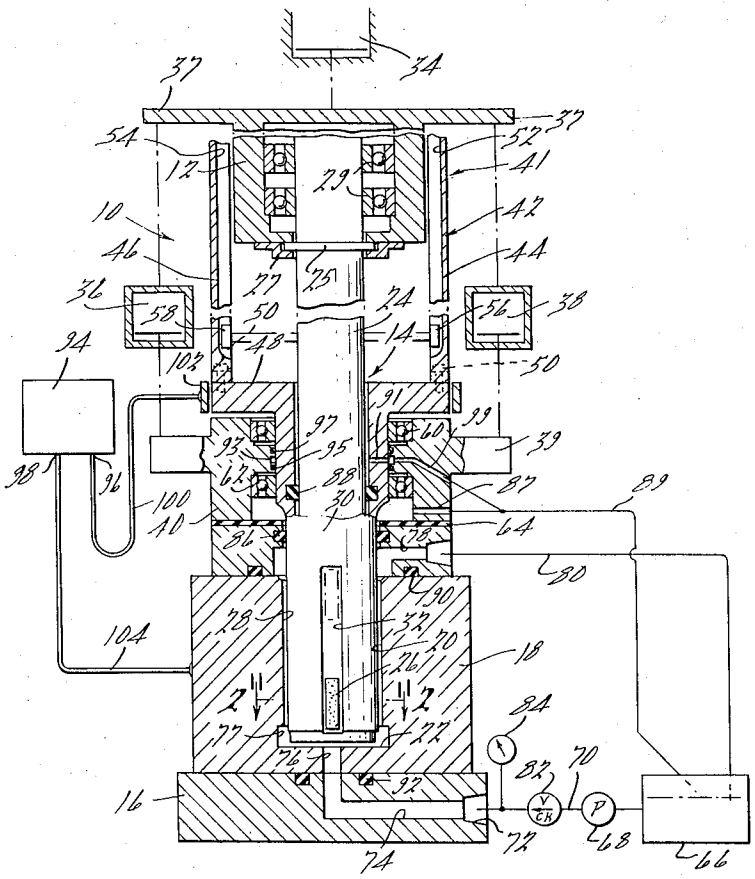
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[57] **ABSTRACT**

Plating and honing apparatus embodying a closed fluid circuit for the circulation of liquid electrolyte and/or coolant during plating and/or honing.

7 Claims, 3 Drawing Figures



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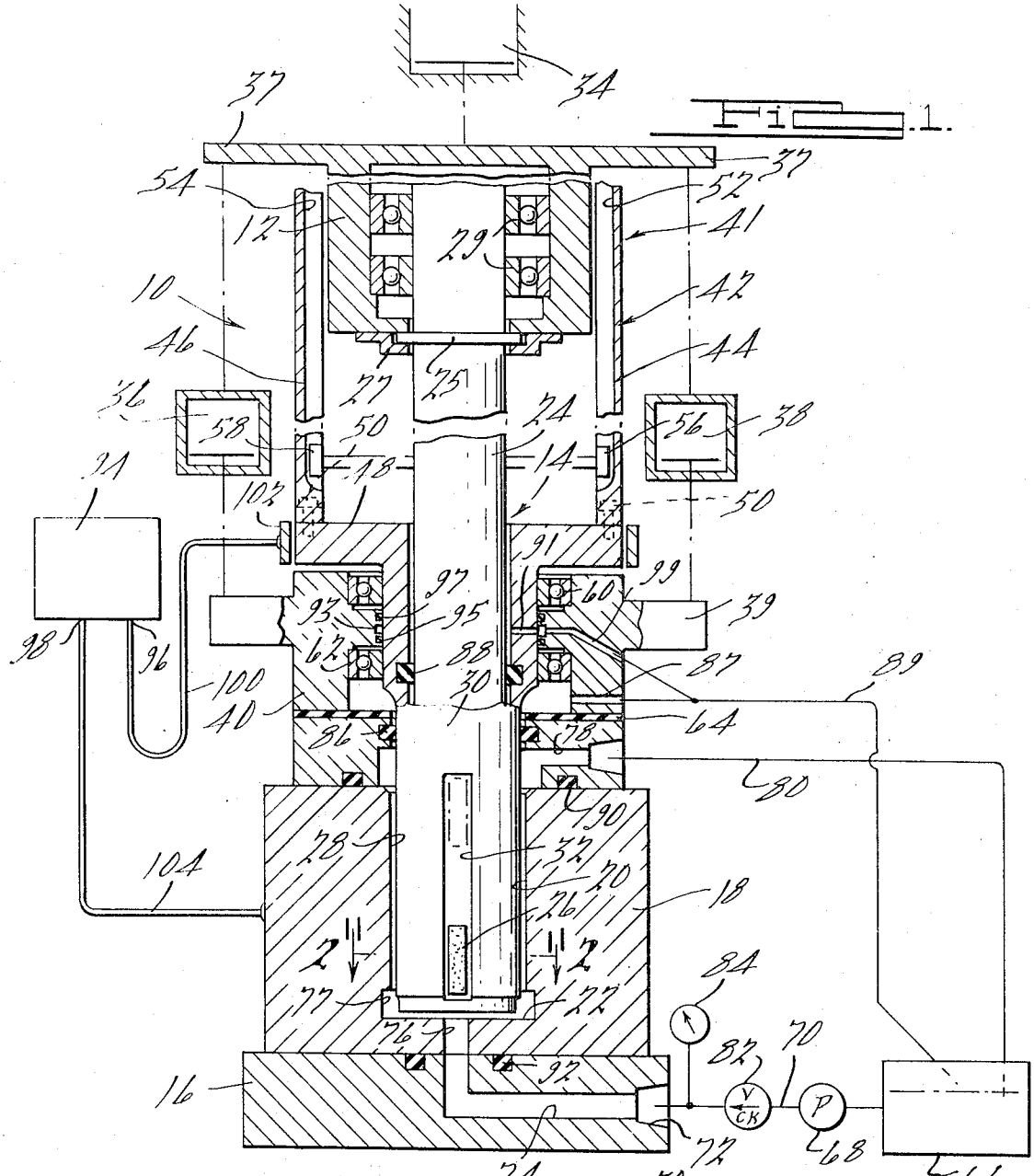


FIG. 1.

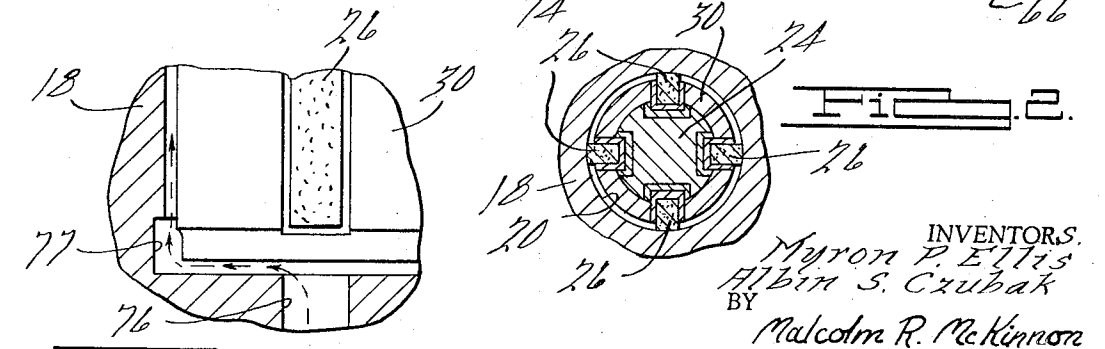


FIG. 2.

FIG. 3.

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FLUID SYSTEM FOR HONING AND PLATING APPARATUS

This is a continuation of application Ser. No. 172,007, filed Aug. 16, 1971, and now-abandoned.

BRIEF SUMMARY OF THE INVENTION

This invention relates generally to the plating and honing arts and, more particularly, to an improved plating and honing apparatus wherein the electrolytic solution is maintained in a closed circuit during the electroplating and/or the honing operations.

Heretofore, various methods and apparatus have been employed for plating and honing workpieces, such methods and apparatus employing electrolytic solutions which may be of a corrosive and potentially dangerous nature if the solution are permitted to contact unprotected machinery and/or the human operators thereof. U.S. Pat. No. 3,390,068 issued to M. P. Ellis on June 25, 1968 discloses a workpiece fixture enclosure by which the splash and spray of electrolytic solution may be kept from contacting surrounding equipment and from contacting the human operators of plating and honing equipment.

An object of the present invention is to overcome disadvantages inherent in prior plating and honing apparatus of the indicated character and to provide improved apparatus for circulating honing and plating solutions in a closed circuit during honing and/or plating operations.

Another object of the present invention is to provide an improved fluid circuit for plating and honing solutions which permits the use of a minimum of fluid and which affords improved distribution and/or controlled distribution of the solution both during the honing operations and/or plating operations.

Another object of the invention is to provide improved plating and honing apparatus incorporating improved fluid circuitry which is economical and commercially feasible to manufacture and assemble, durable, efficient, reliable in operation, and which functions to protect the operators of the apparatus and nearby machinery from adverse effects generated by contact with plating and honing solutions.

Another object of the invention is to provide improved plating and honing apparatus embodying improved fluid circuitry effective to maintain the plating and/or honing solution in a closed circuit which includes the honing and/or plating tooling, the workpiece and the supporting fixtures.

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 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; and

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

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. 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** as 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 incorporated 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 **28** 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. 26,499 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 also 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 36 and 38 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 are connected to 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 at 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 a 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 may be provided if desired.

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. As previously mentioned, the tool support 24 reciprocates relative to the sleeve 30 during operation of the machine 10. In the preferred embodiment of the invention illustrated, the internal diameter of the seal 86 is slightly larger than the outside diameter of the sleeve 30 and the inside diameter of the seal 88 is slightly larger than the outside diameter of the tool support 24 whereby a slight clearance is provided between the inner surface of the seal 86 and the outer surface of the sleeve 30 and a slight clearance is also provided between the inner surface of the seal 88 and the outer surface of the tool support 24 so that a small amount of liquid is permitted to flow past the seals, such liquid acting as a fluid bearing thereby greatly increasing the life of the seals 86 and 88. By way of example, 0.001 to 0.002 inches clearance may be provided between the inside surface of the seal 86 and the outside surface of the sleeve 30 and the same amount of clearance may be provided between the inside surface of the seal 88 and the outside surface of the tool holder 24. Such a construction provides a controlled flow of liquid past the seals 86 and 88, the liquid flowing past the seal 86 being returned to the reservoir 66 through a passageway 87 provided in the collar 40 and communicating with a conduit 89 leading to the reservoir 66, while the fluid flowing past the seal 88 is returned to the reservoir 66 through a passageway 91 provided in the sleeve 30, the passageway 91 communicating with an internal annular groove 93 provided in the collar 40 and having conventional O-ring seals 95 and 97 on opposite sides thereof. The groove 93 communicates with a passageway 99 defined by the collar 40, the passageway 99 in turn being connected to the conduit 89 leading to the reservoir 66. It will be understood that the seals 86 and 88 may be fluid tight, if desired, thereby eliminating the necessity of providing the secondary return passageways 87, 89, 91, 93 and 99 and the O-ring seals 95 and 97. It will also be understood that the seals 86 and 88 may be carried by the sleeve 30 and tool support 24, respectively, rather than the collar 40 and sleeve 30, respectively. A static seal 90 also is 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 fluid circuit above described for the circulation of electrolytic fluid makes it possible to use a minimum amount of fluid to achieve its working purpose. Moreover, as is well known in the art, it is often necessary to use electrolytic solutions containing chemicals which can be extremely corrosive and detrimental to surrounding apparatus and dangerous to the operators of honing machines. By utilizing the closed circuit, possible exposure to the electrolytic solution is reduced to a minimum thereby materially increasing the safety factors incorporated in the apparatus and reducing the

chances that the operators will come in contact with the electrolytic solution.

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 electrically conductive material. A conductor **104** between the workpiece and the negative terminal of the power supply unit completes the electrical circuit.

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 either hone or 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.

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 **2,** 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 may be terminated. If desired, honing may be continued after the flow of electrical current is terminated.

From the foregoing description, it will be seen there has been provided a closed circuit system for directing and containing the flow of electrolytic solution which system protects not only the surrounding surfaces of the apparatus and nearby equipment but also the operators of honing and plating equipment without requiring special guards or covers for protection against splash and spray.

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. In plating and honing apparatus for plating metal on and removing metal from the surface defining a bore in an electrically conductive workpiece, the combination comprising first means adapted to hold a workpiece in a stationary position, a plating and honing tool including a tool support and a sleeve surrounding said tool support, said tool support and said sleeve being adapted to be inserted in the bore defined by said surface, sealing means between said tool support and said sleeve means mounting said plating and honing tool for reciprocation and rotation relative to said surface, a reservoir for electrolytic fluid, fluid pressure generating means, and fluid conduit means for moving electrolytic fluid under pressure from said reservoir through said bore and to and from said first means and said sealing means and back to said reservoir through a closed passage defined by said surface and said tool.

2. In a honing and plating apparatus for removing and plating metal on a surface defining a bore in an electrically conducting workpiece, the combination comprising fixture means adapted to engage and hold a workpiece, plating and honing tool means including a tool support and a sleeve surrounding said tool support, said tool support and said sleeve being adapted to be inserted in said bore, sealing means between said tool support and said sleeve, means holding said plating and honing tool means for reciprocation and rotation relative to said workpiece, fluid passage means in said fixture means and in said holding means, a reservoir for electrolytic fluid, liquid pressure generating means, and fluid conduit means for delivering liquid from said reservoir to one of said passages and to said bore and from said bore to the other end of said passage and back to said reservoir whereby such liquid is maintained in a closed fluid circuit under pressure.

3. In a honing and plating apparatus for removing and plating metal on a surface defining a bore in an electrically conducting workpiece the combination comprising fixture means adapted to engage and hold a workpiece, said fixture means having a passage in communication with the bore defined by said workpiece, a combined plating and honing tool including a tool support and a sleeve surrounding said tool support, means for holding said plating and honing tool for selective reciprocation and rotation relative to said workpiece sur-

face, said holding means having a passage in communication with the bore defined by said workpiece, a reservoir for electrolytic liquid, and means including a pump for delivering liquid from said reservoir to one of said passages and to said bore and from said bore to the other of said passages and back to said reservoir whereby such liquid is maintained in a closed fluid circuit under pressure.

4. The combination as set forth in claim **3** including sealing means between said fixture means and said sleeve.

5. The combination as set forth in claim **3** including sealing means between said tool support sleeve.

6. The combination as set forth in claim **3** including first sealing means between said fixture means and said sleeve and second sealing means between said tool support and said sleeve.

7. The combination as set forth in claim **3** including first sealing means between said fixture means and said sleeve and second sealing means between said tool support and said sleeve, said second sealing means adapted to permit a controlled amount of liquid to flow between said tool support and said sleeve to provide a fluid bearing, and closed fluid circuit means for delivering liquid flowing past said second sealing means to said reservoir.

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