United States Patent

Murray et al.

[15] **3,682,185**

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[54] **PLATED WIRE MANUFACTURING CELL**

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[51] **Int. Cl.** **B08b 3/02**

[58] **Field of Search** 134/9, 15, 64, 122; 118/405; 134/199

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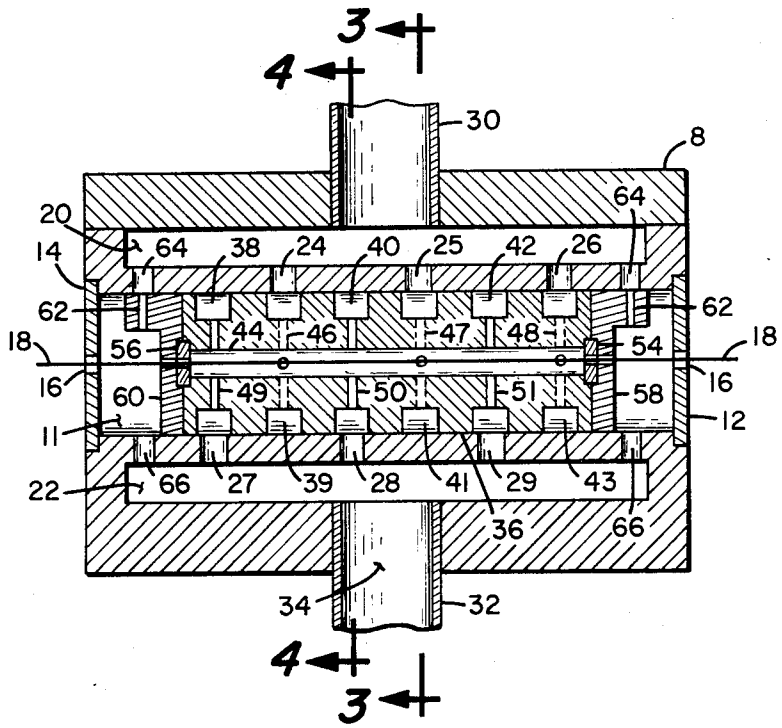
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[57] **ABSTRACT**

A cell suitable for plating, etching, rinsing, or cleaning a wire in a continuous wire plating operation. A fluid contacts the wire in the central bore of a diffuser which has several distinct groups of fluid inlet ducts and several distinct groups of fluid outlet ducts longitudinally offset in an interlaced sequence along the longitudinal axis of the bore. The individual ducts of the groups of inlet ducts are angularly offset with respect to the individual ducts of the groups of outlet ducts. The angular offset provides the necessary fluid swirling action for uniform plating and the longitudinal offset provides a directional fluid flow which assists the wire through the cell. A fluid stream having a directional component transverse to the longitudinal axis of the bore prevents leakage of fluid from the cell.

6 Claims, 4 Drawing Figures



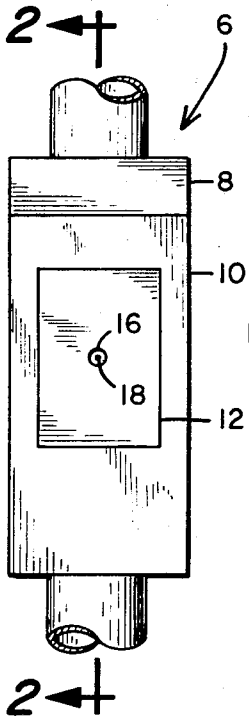


Fig. 1

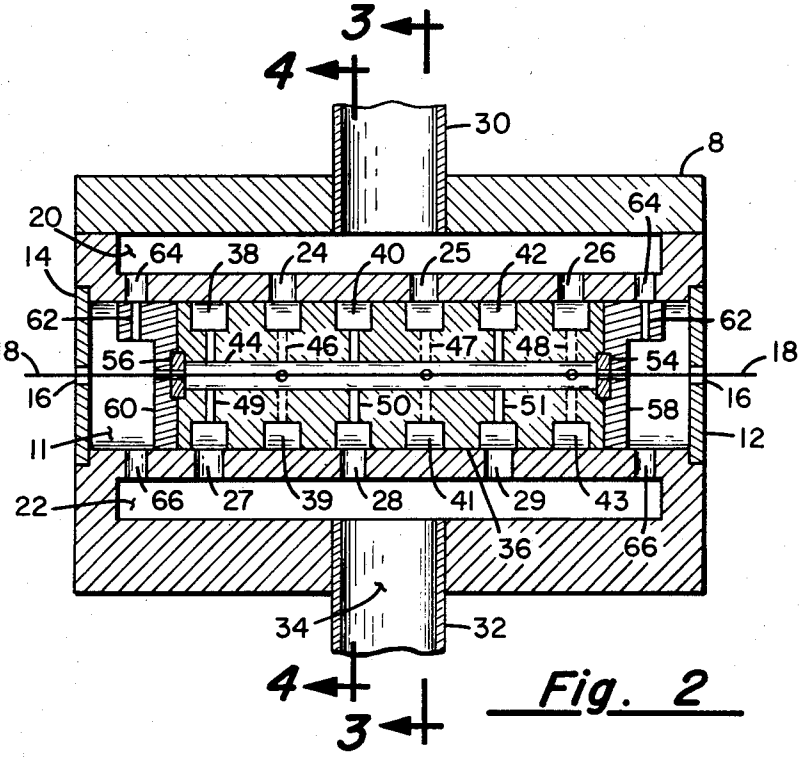


Fig. 2

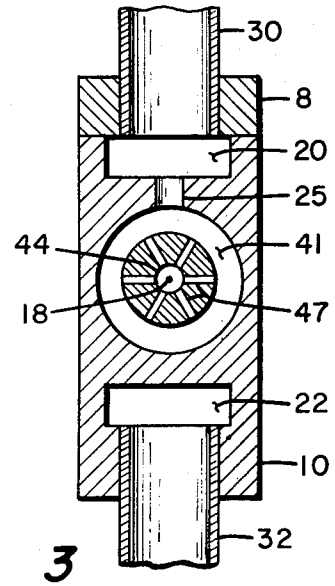


Fig. 3

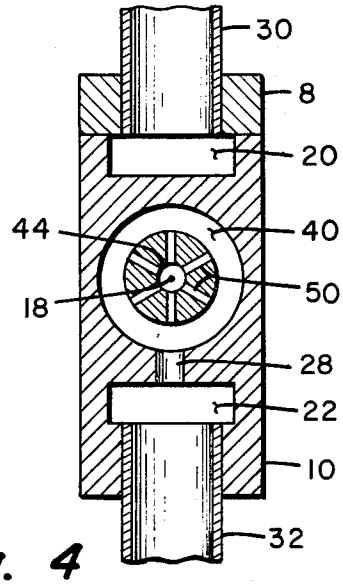


Fig. 4

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PLATED WIRE MANUFACTURING CELL

In U.S. Pat. No. 3,370,929 entitled "Magnetic Wire Of Iron And Nickel On A Copper Base" issued Feb. 27, 1968, and assigned to the assignee of this application, there is described a method of producing magnetic wire having improved reproducible physical and magnetic properties which make it suitable for computer use. The method includes the steps of electro-cleaning, rinsing, acid etching, rinsing, copper plating, rinsing, and nickel-iron plating. In particular, non-magnetic beryllium-copper wire is etched for the removal of oxides from its surface by immersing or passing the wire through a nitric acid etchant bath. The etched wire then is passed through a water rinse and subsequently is subjected to a copper plating operation. Next, the copper-plated wire is passed through a water rinse. Subsequently, the wire is subjected to an electroplating operation, producing a coating of magnetic material thereon, such as a coating consisting essentially of nickel, about 81 percent by weight; iron, about 19 percent by weight; and a trace of cobalt, about 0.1 percent by weight.

Cleaning, rinsing, etching, rinsing, copper-plating, rinsing, nickel-iron plating, etc., desirably are performed continuously in a manner which minimizes bending and dragging of the wire. Desirably, the wire is pulled off a reel by suitable means such that the wire passes therefrom, through the cleaning, rinsing, etching, rinsing and plating steps, under substantially zero stress with a minimum of bending.

The wire moves through the etching, plating, and rinsing stations, at a substantially constant rate of about 3 inches per minute, concurrently with the passage of about 800 milliamperes bias current through the wire. Higher processing rates are possible, for example, in excess of 9 inches per minute, depending upon the results desired. The bias current continuously passes through the wire during processing and serves to set up a magnetic field around the wire which circumferentially orients the easy direction of the electrodeposited magnetic nickel-iron coating. During the electrodeposition of the magnetic coating on the wire, current of about 15 milliamperes is passed through a set of coils encompassing the plating cell. This current serves to set up a field which cancels the earth's magnetic field at the plating location and any stray magnetic fields.

In U.S. Pat. No. 3,399,685, issued Sept. 3, 1968, and entitled "Modular System For A Continuous Electrolytic Deposition Process For Wire," and assigned to the same assignee as this application, there is described a cellular system for performing the aforedescribed wire-plating method. Each cell of the system includes a fluid diffuser having (1) a central bore through which the wire to be plated is passed, (2) two rows of angularly offset fluid inlet ducts, and (3) two rows of fluid outlet ducts. Each inlet duct is aligned longitudinally with an outlet duct and offset angularly with respect to that outlet duct.

In an assembled cellular system, a plurality of cells are pinned together so that the central bores or passageways of adjacent cells are abutted against each other, thereby forming a continuous line. Plugs, which fit into recesses in the ends of each cell, support and guide the wire to be plated and, in addition, align the overall system.

The plated wire produced by the cell of the aforedescribed system possess a small non-uniformity of magnetic field composition around the circumference. This small non-uniformity, which is termed the "roll effect" and is believed due to a non-uniform flow of solution around the wire, results in a relatively large non-uniformity in the coefficient of magnetostriction around the circumference of the wire. Non-uniformity in the coefficient of magnetostriction around the circumference of the wire produces undesirable stresses in the wire and undesirable changes in the anisotropy field of the wire.

It is an object of the present invention to provide a novel fluid diffuser useful in the treatment of solid objects.

It is an object of the present invention to provide a novel cell which is useful in the treating, plating, rinsing, or electrochemical treatment of wire.

Another object of the invention is to provide a novel cell for a cellular system which is relatively compact and useful for the continuous multi-stage process of electroplating wire, and, in particular, for the electrodeposition of a magnetic alloy onto a wire for use in computer memories, which cellular system produces plated wire having a substantial uniformity of magnetic field composition around its circumference.

In accordance with the invention, the cell includes a block of a non-magnetic material having, in a central passageway extending therethrough, a fluid diffuser with a central bore. Several distinct groups of fluid inlet ducts and several distinct groups of fluid outlet ducts extend radially from the central bore in a longitudinally-interlaced sequence. The individual ducts of the groups of inlet ducts are angularly offset with respect to the individual ducts of the groups of outlet ducts. The angular offset of the inlet and outlet ducts provides the necessary fluid swirling action for uniform electroplating and the longitudinal offset-interlace sequence of the inlet and outlet ducts provides a direction of fluid flow which assists a wire through the cell. The cell also generates a fluid stream which prevents fluid leakage from the cell.

Other objects and advantages of this invention together with construction and mode of operation will become more apparent from the following description when read in conjunction with the accompanying drawings, in which:

FIG. 1 is a front view of a plating cell in accordance with one embodiment of the invention;

FIG. 2 is a cross-sectional view taken along the line 2—2 of FIG. 1, illustrating, inter alia, a sectional view of the diffuser of the cell of FIG. 1.

FIG. 3 is a cross-sectional view taken along line 3—3 of FIG. 2; and

FIG. 4 is a cross-sectional view taken along the line 4—4 of FIG. 2.

Referring now to the drawings, the exterior housing 6 of the plating cell includes top and bottom sections 8 and 10, respectively, which can be machined from blocks of a plastic material, for example, plexiglas. Section 10 of housing 6 is provided with a substantially cylindrical horizontal fluid passageway 11 which is closed substantially at the right and left ends by plugs 12 and 14, respectively, which fit tightly into recessed portions of housing section 10. Plugs 12 and 14 have

apertures 16 therein, for the passage, support, and guidance of a wire 18, which has a cross-sectional area slightly smaller than the cross-sectional area of apertures 16.

Section 10 of housing 6 is provided also with fluid transport channels 20 and 22. Channel 20 communicates with horizontal passageway 11 through fluid inlet ports 24, 25, and 26 and channel 22 communicates with horizontal passageway 11 through fluid outlet ports 27, 28, and 29. Ports 27, 28, and 29 are longitudinally interlaced with ports 24, 25, and 26. Channels 20 and 22, and ports 24 through 29 constitute, together with hose adaptors 30 and 32 fitted respectively into opening in housing sections 8 and 10, a portion of a vertical fluid passageway 34.

A substantially cylindrical fluid diffuser 36 is positioned tightly within horizontal passageway 11 intermediate plugs 12 and 14. As clearly shown in FIG. 2, diffuser 36 has a plurality of longitudinally offset annular channels 38 through 43 positioned along its exterior surface. Channels 38 through 43 are spaced such that, when diffuser 36 is positioned properly within passageway 11, each one of these channels will be aligned with a different one of the ports 24 through 29. In addition to channels 38 through 43, diffuser 36 is provided with a central bore 44 which has its longitudinal axis along the path followed by wire 18.

Channels 39, 41, and 43 communicate with central bore 44 by groups of fluid input ducts 46, 47, and 48, respectively, and channels 38, 40, and 42 communicate with central bore 44 by groups of fluid output ducts 49, 50, and 51, respectively. As shown in FIGS. 3 and 4, each group of ducts 46 through 51 has six individual ducts evenly spaced around the circumference of central bore 44. The individual duct of groups of ducts 46, 47, and 48 are angularly aligned and the individual ducts of groups of ducts 49, 50, and 51 are angularly aligned. However, the individual ducts of groups of ducts 46, 47, and 48 are angularly offset with respect to the individual ducts of groups of ducts 49, 50, and 51. For example, if the individual ducts of groups of ducts 46, 47, and 48 form angles of 30°, 90°, 150°, 210°, 270° and 330° with a plane perpendicular to the face of the drawings, the individual ducts of groups of ducts 49, 50, and 51 form angles of 0°, 60°, 120°, 180°, 240° and 300° with that plane.

Apertured plugs 54 and 56 are fitted tightly within the right and left ends, respectively, of central bore 44. The apertures of plugs 54 and 56 are coaxial with the path of wire 18 and are made just slightly larger than the diameter of wire 18 such that seepage of fluid from diffuser 36 is minimized. Additional fluid seepage control is provided, as explained hereinafter, by members 58 and 60 which are keyed in proper alignment with plugs 54 and 56, respectively, and have central apertures coaxial with the aperture of plugs 54 and 56, respectively. Each of the members 58 and 60 has a conduit 62 which communicate with channel 20 by way of ports 64 in housing section 10. Ports 66 connect the sections of horizontal passageway 11 between plug 12 and member 58 and between plug 14 and member 60 to channel 22.

In operation, a segment of wire 18 passes in turn through plug 12, member 58, plug 54, fluid diffuser 36, plug 56, member 60 and plug 14. Meanwhile, the solution passes from a solution source (not shown), through adaptor 30, through channel 20, through ports 24, 25, and 26, through channels 39, 41, and 43, through groups of ducts 46, 47, and 48, through central bore 44, through groups of ducts 49, 50, 51, through channels 38, 40, and 42, through ports 27, 28, and 29, through channel 22, and through adaptor 32, following which, the solution, if desired, can be recirculated by suitable pumping means. The angular offset of the individual ducts of the groups of ducts 46, 47, and 48, with respect to the individual ducts of the groups of ducts 49, 50, and 51, provides a swirling action which results in the uniform plating of wire 18 and thereby plated wire having a more uniform coefficient of magnetostriction than plated wire produced by conventional cells. The longitudinal offset of groups of ducts 46, 47, and 48, with respect to the groups of ducts 49, 50, and 51 provides a directional flow which assists wire 18 through the cell. This assistance provides a negative friction effect and thereby allows high speed plating.

The pressure within bore 44 and the lack of a tight seal between bore 44 and plugs 54 and 56 may result in solution being projected from plugs 54 and 56 toward plugs 12 and 14, respectively. This solution is deflected downward from its path toward plugs 12 and 14 by solution flowing through ports 64 and conduits 62 such that substantially all solution between plugs 12 and 54 and between plugs 14 and 56 is caused to flow into ports 66 and then into channel 22.

By way of example, the components of the cell 6 may have the following dimensions:

Length of diffuser 36 – 1 inch
Diameter of each port 24 through 29 – .116 inch
Width of channels 38 through 42 – .08 inch
Diameter of bore 44 – .125 inch
Diameter of each individual duct of groups of ducts 46 through 51 – .0465 inch

Although the invention has been described with reference to a particular embodiment thereof, various modifications can be made without departing from the invention. For example, the number of groups of ducts can be more or less than six and the number of individual ducts of each group of ducts can be more or less than six. In addition, the angular orientation of the ducts can be other than that exemplified, provided, however, that the individual ducts of the groups of input ducts and individual ducts of the groups of output ducts are angularly offset.

Furthermore, the diameter of ports 24, 25, and 26 can be made larger than the diameter of ports 27, 28, and 29 to decrease the cell's sensitivity to pressure changes. Still further, ports 64 can be inclined such that the solution flowing through them is directed toward plugs 54 and 56. This inclination of ports 64 will ensure that any solution seeping through plugs 54 and 56 will be directed toward and into channel 22. Still further, diffuser 36 could be formed with parts which correspond to ports 24 through 29 such that the diffuser 36 would communicate directionally with channels 20 and 22.

We claim:

1. A fluid diffuser having an interior lengthwise cavity, distinct groups of fluid inlet ducts communicating with said cavity and disposed along the length of said

cavity, and distinct groups of fluid outlet ducts communicating with said cavity and disposed along the length of said cavity in an interlaced sequence with said groups of fluid inlet ducts, the individual ducts of said groups of inlet ducts are angularly offset with respect to the individual ducts of said groups of outlet ducts, and a group of annular channels formed in the exterior surface of said diffuser, said group of channels being equal in number to the additive number of said groups of inlet ducts and said groups of outlet ducts, each one of said groups of fluid inlet ducts and said groups of fluid outlet ducts communicates with a different one of said channels.

2. A diffuser according to claim 1 in which said cavity has a substantially cylindrical wall and said individual ducts of both said groups of inlet ducts and said groups of outlet ducts are spaced evenly around said wall.

3. A diffuser according to claim 2 in which means are provided at the ends of said cavity both for allowing a solid member to pass through said cavity and for preventing a fluid from exiting said cavity at said ends.

4. A diffuser according to claim 3 in which said individual ducts of each one of said groups of inlet ducts and said groups of outlet ducts are six in number, said groups of inlet ducts are three in number and said groups of outlet ducts are three in number.

5. A diffuser according to claim 4 in which said individual ducts are cylindrical and the diameter of said ducts is less than the width of said channels.

6. A cell, suitable for working upon a solid material passing continuously therethrough, comprising

a. a housing having a bore extending therethrough, a group of fluid inlet ports communicating with said bore, and a group of fluid outlet ports communicating with said bore; and

b. a fluid diffuser disposed tightly within said bore, said diffuser having an interior lengthwise cavity, distinct groups of fluid inlet ducts communicating with said cavity and disposed along the length of said cavity, distinct groups of fluid outlet ducts communicating with said cavity and disposed along the length of said cavity in an interlaced sequence with said groups of fluid inlet ducts, and a group of angular channels formed in the exterior surface of said diffuser, said group of channels being equal in number to both the additive number of both said groups of inlet and outlet ducts and the additive number of said groups of inlet and outlet ports, said channels are positioned such that each one of said group of inlet ports communicates with a different one of said group of inlet ducts and each one of said group of outlet ports communicates with a different one of said group of outlet ducts.

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