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(54) **Wear resistant port plate for a fluid transfer device**

(57) In a fluid transfer device (10) that includes a housing (12), a rotor (16) rotatably mounted in the housing (12) and having a bore (24) and at least one piston (30) slidably mounted in the bore (24), a port plate (42) that includes a body portion (44) mountable in the hous-

ing (12) and formed from a first material and a wear layer (56) formed of a second material, different from the first material, attached to the body portion (44) and adapted to contact the rotor (16). Also a fluid transfer device (10) including such a port plate (42).

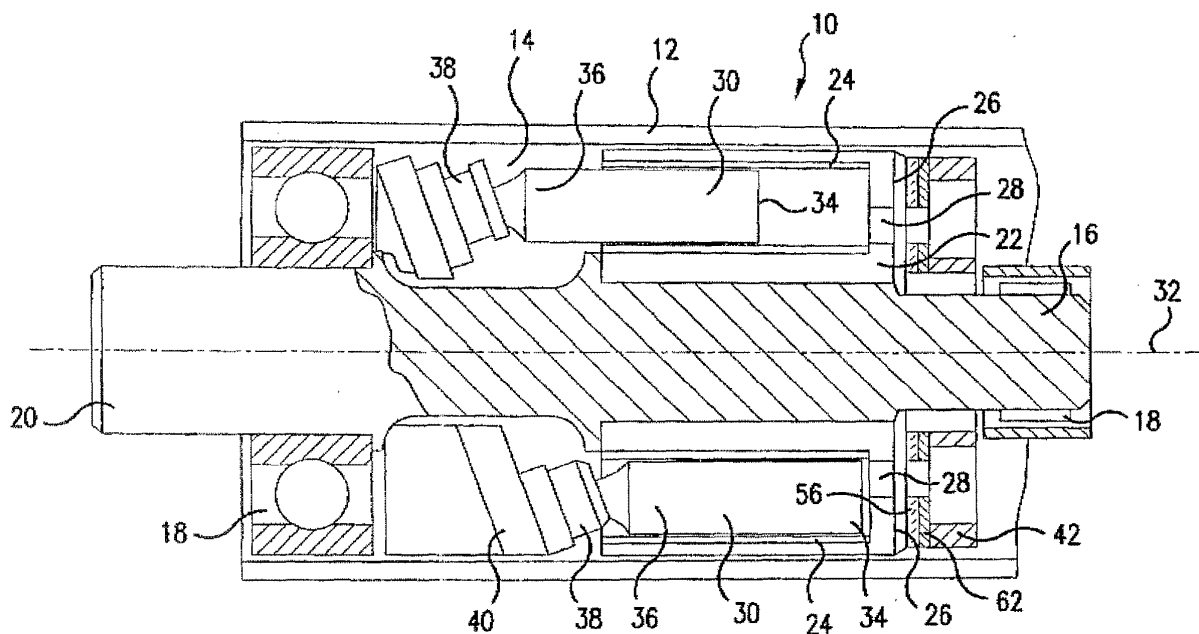


FIG. 1

Description

[0001] The present invention is directed to a port plate having a wear layer formed from a wear resistant material and a body portion formed from a second material and to a fluid transfer device including such a port plate, and, more specifically, toward a port plate having a ceramic or cermet wear layer connected to a metallic body portion and to a fluid transfer device including such a port plate.

[0002] Fluid transfer devices are known that can be operated in a first direction as a pump and in a second direction as a motor. These devices may comprise a housing within which a rotor rotates with respect to a port plate and a cam plate angled with respect to the rotor's axis of rotation. The rotor includes a bore or bores for receiving one or more (generally an odd number) of pistons. One end of each piston is held against the cam plate. As the rotor rotates with respect to the housing, each piston moves axially with respect to the rotor and the port plate.

[0003] The port plate includes a fluid inlet through which a fluid enters the housing when a piston aligned with the fluid inlet moves away from the port plate and a fluid outlet through which fluid exits the housing when a piston aligned with the fluid outlet moves toward the port plate. When the rotor is connected to a source of power, it causes the pistons to draw fluid from the inlet and expel fluid through the outlet; when operated in this manner, the fluid transfer device is referred to as an axial piston pump. When fluid is applied under pressure to the fluid inlet and drawn from the fluid outlet at a lower pressure, the rotor is caused to turn by the pressure difference, and the fluid transfer device is referred to as a hydraulic motor. Thus "axial piston pump" and "hydraulic motor" may refer to the same fluid transfer device, depending on the what is causing the rotation of the rotor.

[0004] The position of either the rotor or the port plate should generally be adjustable to control the clearance therebetween. If the position of the rotor is adjustable, the fluid transfer device is referred to as a "floating rotor" fluid transfer device. However, it may be difficult to dynamically control the position of a rotor in such a device. In floating rotor devices a constant force is generally applied against a port plate under all operating conditions. This can lead to excessive drag between the rotor and port plate at low pressures and to excessive leakage at higher pressures.

[0005] When the position of the port plate is variable, the device is referred to as a "floating port plate" fluid transfer device. Such devices generally include one or more balance pistons for dynamically adjusting the position of the port plate as the device operates. Such floating port plates can thus be adjusted to minimize drag at low pressures and control leakage at higher pressures. However, these port plates, with their various openings for accommodating balance pistons and flow channels for carrying fluids to and from the port plate, are more complex than the port plates used with floating rotor de-

vices.

[0006] Significant wear occurs at the interface of the rotor and the port plate. For some combinations of pressures and temperatures, it is highly desirable to use a ceramic or cermet port plate which resists wear significantly better than a metal port plate. However, ceramics and cermets are generally more expensive than metals. Using solid ceramic or cermet port plates increases the cost of fluid transfer devices. In addition, these materials are more brittle than metals and can be difficult to machine. Thus the formation of blind openings for fluid inlets and outlets, internal fluid passageways, and openings for accommodating balance pistons becomes difficult. And, because port plates are often exposed to significant pressures during use, ceramic port plates, lacking the strength of metal port plates, may be more likely to crack during use.

[0007] It would therefore be desirable to provide a port plate and fluid transfer device including same that has the wear resistance of a ceramic port plate but that does not suffer from the aforementioned shortcomings.

[0008] These problems are addressed by various embodiments of the present invention, which comprises, in a first aspect, a fluid transfer device that includes a housing having an interior, a cam surface in the interior and a port plate in the interior opposite the cam surface. The port plate includes a body portion formed from a first material and a wear layer formed from a second material. The fluid transfer device further includes a rotor mounted in the housing for rotation relative to the housing and the port plate. The rotor includes at least one axial opening and has a surface contacting the port plate wear layer. At least one piston is mounted in the at least one opening that has a first end contacting the cam surface, the piston reciprocating in the at least one opening as the rotor rotates relative to the port plate.

[0009] Another aspect of the invention comprises a fluid transfer device that includes a housing having an interior, a cam surface in the interior and a port plate in the interior opposite the cam surface. The port plate has a body portion formed from a first material and a wear layer formed of a second material. A rotor is mounted in the housing for rotation relative to the housing and the port plate and includes at least one axial opening and a surface contacting the port plate wear layer. Pistons are mounted in the axial openings and each has a first end contacting the cam surface so that the piston reciprocates in the opening as the rotor rotates relative to the port plate.

[0010] An additional aspect of the invention comprises a fluid transfer device that includes a housing having an interior and a cam plate in the interior. A floating port plate is mounted in the interior opposite the cam surface and includes a body portion formed from a first material and having a fluid inlet and a fluid outlet and a wear layer formed of a second material and having a first through-opening aligned with the fluid inlet and a second through-opening aligned with the fluid outlet. A brazed interlayer,

which may include a silver alloy, connects the wear layer to the body portion. A rotor is mounted in the housing for rotation relative to the housing and the port plate and includes at least one axial opening and a surface contacting the port plate wear surface. Pistons are mounted in the openings, each having a first end contacting the cam surface, the pistons reciprocating in the openings as the rotor rotates relative to the cam surface. A biasing device biases the port plate against the rotor.

In the drawings:

[0011] These and other aspects and features of the invention will be better understood after a reading of the following detailed description together with the following drawings, wherein:

Figure 1 is an elevational view, partly in section, of a fluid transfer device including a rotor, first and second pistons, and a port plate;

Figure 2 is a top plan view of the port plate of Figure 1;

Figure 3 is a bottom plan view of the port plate of Figure 1;

Figure 4 is a sectional elevational view taken along line IV-IV of Figure 3; and

Figure 5 is a sectional elevational view taken along line V-V of Figure 3.

[0012] Referring now to the drawings, wherein the showings are for purposes of illustrating presently preferred embodiments of the invention only and not for the purpose of limiting same. Figure 1 illustrates a fluid transfer device 10 according to an embodiment of the present invention comprising a housing 12 having an interior 14 in which a rotor 16 is mounted for rotation. Rotor 16 is supported by first and second sets of bearings 18 and comprises a rotor shaft 20 and a rotor body 22. Rotor body 22 includes a plurality of cylinders 24, two of which are illustrated in Figure 1. Generally, an odd number of cylinders will be provided. Rotor body 22 includes a balance land or front face 26 having first and second openings 28 communicating with cylinders 24. First and second pistons 30 are mounted for sliding movement in cylinders 24 in an axial direction generally parallel to the axis 32 of rotor shaft 20. Each of pistons 30 includes a first end 34 facing openings 28 and a second end 36 projecting from rotor body 22 and terminating in a shoe assembly 38. A cam plate 40 (also known as a swash plate) is mounted in interior 14 of housing 12, and shoe assembly 38 are slidably mounted thereagainst.

[0013] A port plate 42 is mounted at the end of housing 12 opposite cam plate 40. Port plate 42 includes a body portion 44 formed from a metal or alloy such as, for example, titanium or a titanium alloy or steel such as a stainless steel. Body portion 44 includes an inlet 46 having a first portion 48 with a first diameter and a second portion 50 having a second diameter smaller than the diameter of the first portion 48 and an outlet 45 having a first portion

47 with a first diameter and a second portion 49 having a second diameter smaller than the diameter of the first portion 47. Body portion 44 further includes an opening 52 for receiving a balance piston 54 illustrated in Figure 4. Port plate 42 further includes a wear layer 56 including a first arcuate inlet opening 58 communicating with inlet 46 of body portion 44 and a second arcuate outlet opening 60 communicating with outlet 45 of body portion 44. Wear layer 56 is preferably formed from a ceramic or cermet and is approximately 0.1 inch thick. Suitable wear layer materials include, for example, silicon nitride, silicon carbide, aluminum oxide, tungsten-carbide cobalt, ceramic matrix composites, metal matrix composites and titanium carbide particulate-silicon carbide whisker-reinforced aluminum oxide.

[0014] The coefficient of thermal expansion of metal is significantly greater than that of most ceramics and cermets. The operating temperature range of the fluid transfer device can range from well below 0° F to many hundreds of degrees. Thus, joints between such material can be severely stressed and may fail if not formed in an appropriate manner.

[0015] To address this problem, an interlayer 62, illustrated in detail in Figure 5, is provided between wear layer 56 and body portion 44. This interlayer 62 helps compensate for the different thermal expansion coefficients of the two materials and to distribute stresses and strains in a manner that allows the port plate to survive the extreme variations in temperature that it encounters in normal use and during manufacturing. Stresses are controlled in interlayer 62 by allowing for creep, plasticity, and yielding of the interlayer materials. In addition, the interlayer 62 provides a thermal expansion gradient between the low expansion ceramic and high expansion metal. The brazed interlayer structure must also act as a seal to prevent leakage. When used in an environment where jet fuel is present, braze materials and metals must be carefully selected so as not to react with the jet fuel.

[0016] In a preferred embodiment interlayer 62 includes a first layer of braze 70 on body portion 44, a first layer of nickel 72, a second layer of braze 74, a layer of molybdenum 76, a third layer of braze 78, a second layer of nickel 80, and fourth layer of braze 82 connecting wear layer 56 to body portion 44. A suitable brazing alloy containing silver, copper and titanium (95% Ag, 5% copper and titanium) is available from Wesgo Metals of Hayward, California as part of their Active Brazing Alloy line under the trade name "Silver ABA." It is believed that gold- and palladium-containing alloys would also be suitable, but these tend to be more expensive than Silver ABA. The use of interlayer structures for joining ceramics and metals is discussed in U.S. Patent 6,131,797 to Gasdaska and in U.S. Patent 6,655,695 to Sund which patents are both hereby incorporated by reference in their entireties.

[0017] The thickness of each layer will depend on the particular application. Testing and computer simulations suggest that titanium alloy (Ti-6-4) for body portion 44, and 0.01 inch layers Silver ABA for the braze provide

satisfactory results. The nickel layers were also selected to be 0.01 inch thick while a molybdenum layer 0.09 inches thick was used. Nickel thicknesses ranging from 0.01 to 0.03 inches and Molybdenum thicknesses of about 0.05 to 0.09 were also contemplated and simulated. These thicknesses appear to provide adequate, but not superior, results.

[0018] As will be appreciated from the foregoing discussion, body portion 44 of port plate 42 may include a relatively complex passageways and chambers. However, because body portion 44 is formed from a metal or metal alloy, it is relatively easy to cast, machine, or otherwise work into a suitable configuration using common metalworking techniques. The metal or metal alloy also possesses great strength and is relatively unlikely to crack or rupture even when exposed to high pressures over a wide range of operating temperatures during use. The ceramic or cermet of wear layer 56 includes first and second arcuate openings 58, 60. These are formed as through openings, however, and therefore can be formed relatively easily in the ceramic material (as opposed to the blind bores that would be required in a solid ceramic port plate). In this manner, a port plate is provided with a highly wear resistant layer that does not require complex and expensive machining and a body portion 44 that is strong and easy to machine. It is believed that, even though the addition of interlayer 62 adds to the complexity of port plate 42 as compared to a solid ceramic port plate, the reduced use of expensive ceramic material and simplified machining and greater reliability provided by the inventive design will provide an overall cost savings.

[0019] The present invention has been described herein in terms of a preferred embodiment. Various modifications and additions to this embodiment will become apparent to those skilled in the relevant arts upon a reading of the foregoing description. It is intended that all such obvious modifications and additions comprises a part of the present invention to the extent they fall within the scope of the several claims appended hereto.

Claims

1. A port plate (42) for a fluid transfer device (10) comprising a housing (12), a rotor (16) rotatably mounted in the housing (12) and having a bore (24) and at least one piston (30) slidably mounted in the bore (24), the port plate (42) comprising:

a body portion (44) mountable in the housing (12) and formed from a first material; and
a wear layer (56) formed from a second material, different from said first material, attached to said body portion (44) and adapted to contact the rotor (16).

2. The port plate (42) of claim 1 wherein said first material comprises a metal and said second material is

selected from the group consisting of a ceramic, a cermet, ceramic matrix composites and metal matrix composites.

3. The port plate (42) of claim 2 wherein said body portion (44) includes a fluid inlet (46) and a fluid outlet (45) and the wear layer (56) includes a first through-opening (58) aligned with said fluid inlet (46) and a second through-opening (60) aligned with said fluid outlet (45).

4. The port plate of claim 2 further comprising an interlayer (62) including a layer of braze (70) comprising a silver alloy, a layer of nickel (72) and a layer of molybdenum (76) between said wear layer (56) and said body portion (44).

5. The port plate of claim 2 wherein said wear layer (56) has a thickness of about 0.1 inches and is selected from the group consisting of silicon nitride, tungsten-carbide cobalt, silicon carbide, aluminum oxide and titanium carbide particulate-silicon carbide whisker-reinforced aluminum oxide.

6. A fluid transfer device (10) comprising:

a housing (12) having an interior (14);
a cam surface (40) in said interior (14);
a port plate (42) in said interior (14) opposite said cam surface (40) comprising a body portion (44) formed from a first material and a wear layer (56) formed from a second material;
a rotor (16) mounted in said housing (12) for rotation relative to said housing (12) and said port plate (42), said rotor (16) including at least one axial opening (24) and having a surface (26) contacting said port plate wear layer (56); and
at least one piston (30) mounted in said at least one opening (24) and having a first end (38) contacting said cam surface (40), said piston (30) reciprocating in said at least one opening (24) as said rotor (16) rotates relative to said port plate (42).

7. The fluid transfer device (10) of claim 6 wherein said rotor (16) is axially fixed relative to said housing (12) and said port plate (42) is movable in a direction normal to said wear layer (56) and including at least one balance piston (54) biasing said port plate (42) against said rotor (16).

8. The fluid transfer device (10) of claim 6 wherein said first material comprises a metal and said second material is selected from the group consisting of a ceramic, a cermet ceramic matrix composite and a metal matrix composite.

9. The fluid transfer device. (10) of claim 6 including an

interlayer (62) connecting said wear layer (56) to said body portion (44), said interlayer (62) comprising a layer (70) of braze comprising a silver alloy, a layer (72) of nickel and a layer (76) of molybdenum between said wear layer (56) and said body portion (44). 5

10. A fluid transfer device (10) comprising:

a housing (12) having an interior (14); 10
 a cam plate (40) in said interior (14);
 a floating port plate (42) in said interior (14) opposite said cam surface (40) comprising a body portion (44) formed from a first material and having a fluid inlet (46) and a fluid outlet (45), a wear 15
 layer (56) formed from a second material having a first through-opening (58) aligned with said fluid inlet (46) and a second through-opening (60) aligned with said fluid outlet (45), and an interlayer (62) including a silver alloy connecting said 20
 wear layer (56) to said body portion (44);
 a rotor (16) mounted in said housing (12) for rotation relative to said housing (12) and said port plate (42), said rotor (16) including at least one axial opening (24) and having a surface (26) 25
 contacting said port plate wear layer (56);
 at least one piston (30) mounted in said at least one opening (24) and having a first end (38) contacting said cam surface (40), said piston (30) reciprocating in said at least one opening (24) 30
 as said rotor (16) rotates relative to said cam surface (40); and
 biasing means (54) biasing said port plate (42) against said rotor (16). 35

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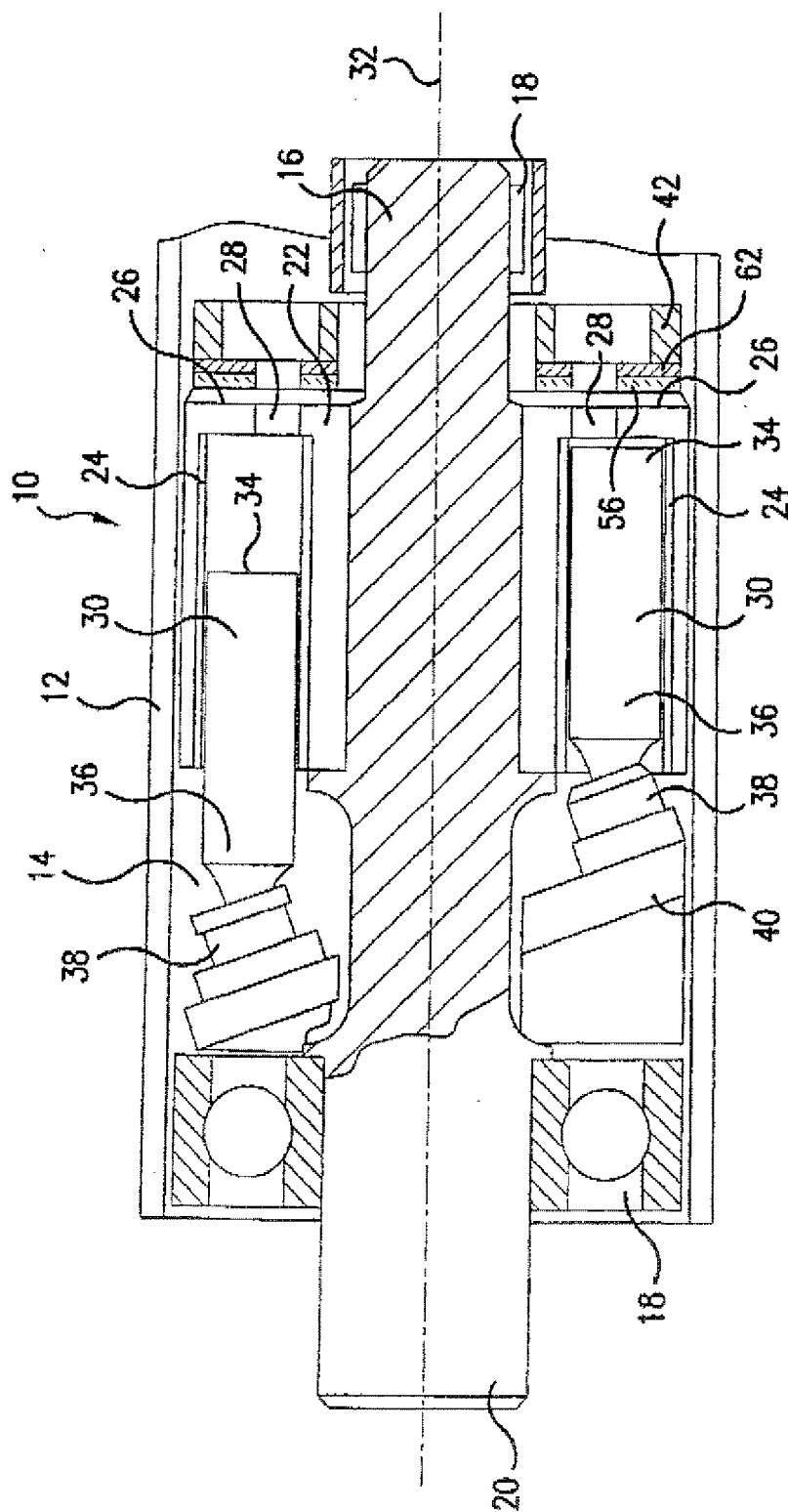


FIG.1

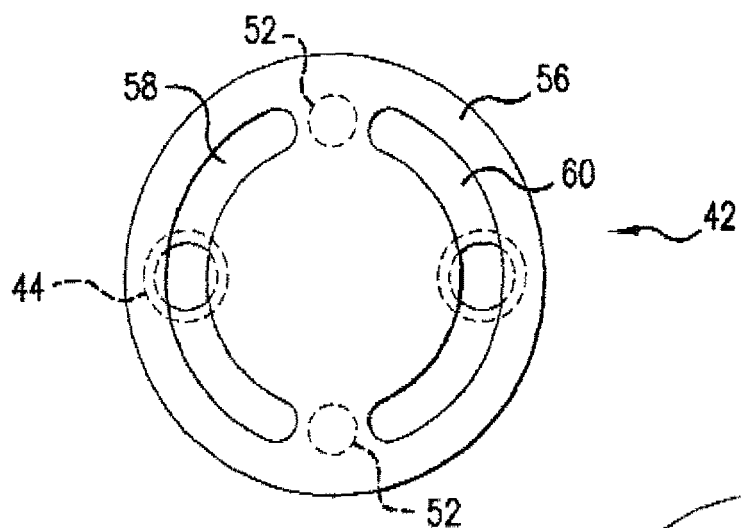


FIG. 2

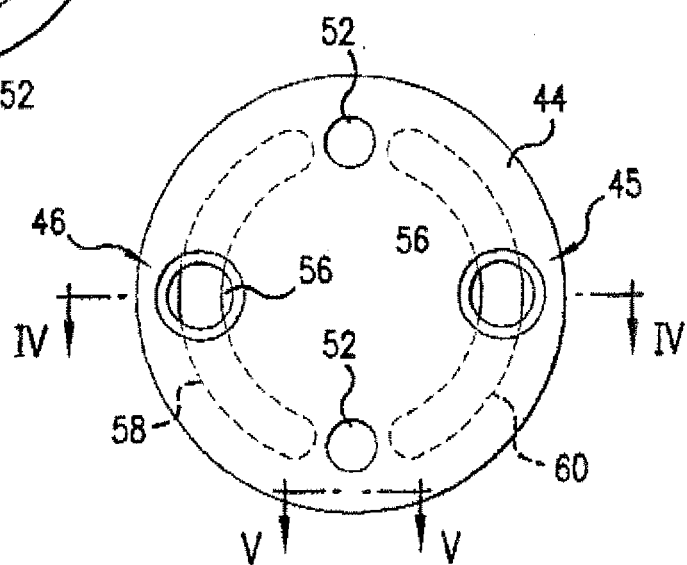


FIG. 3

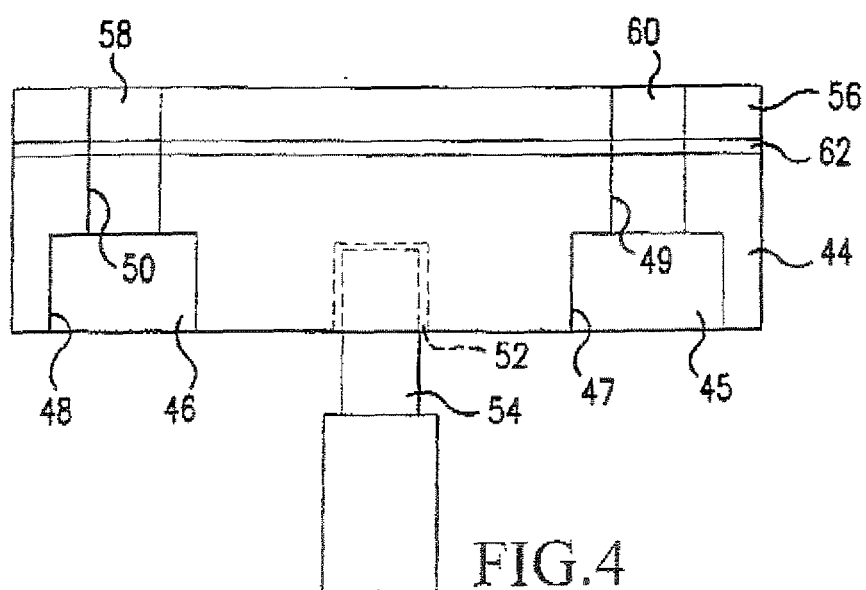


FIG. 4

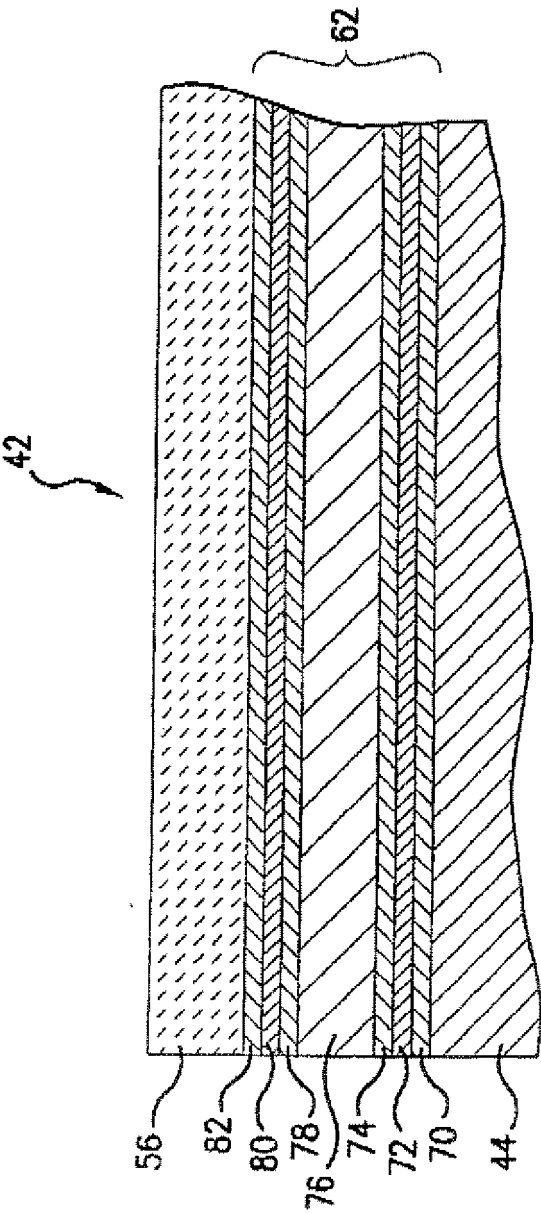


FIG.5

REFERENCES CITED IN THE DESCRIPTION

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