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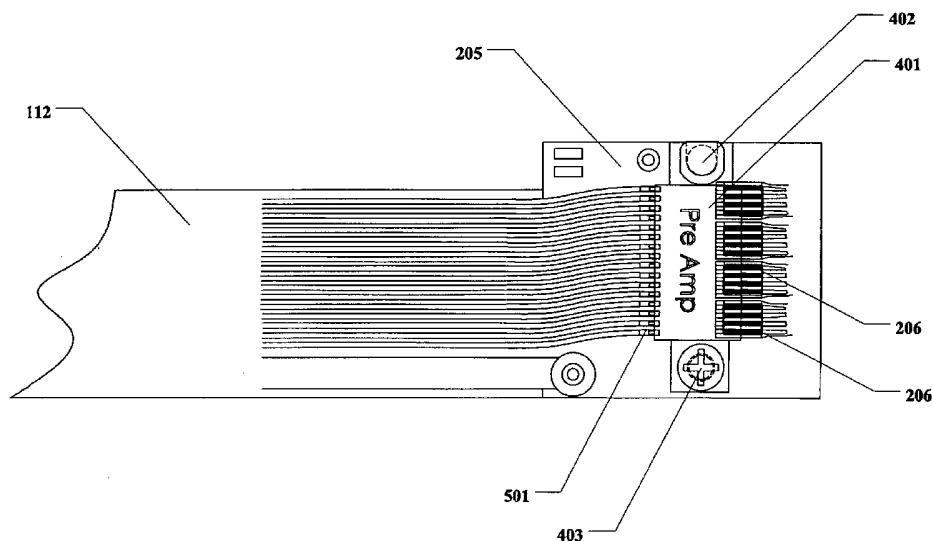
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(54) Title: AN IMPROVED ELECTRICAL CONNECTION BETWEEN A SUSPENSION FLEXURE CABLE AND A HEAD STACK ASSEMBLY FLEXIBLE CIRCUIT



(57) Abstract: A method and apparatus for electrically coupling a slider to a controller circuit are disclosed. In one embodiment, a pre-amplifier with an integrated electrical connector (I-connector) may be connected via an electrical trace to a slider and via a head stack assembly flexible circuit to a control circuit. The pre-amplifier may have two parallel series of spring probe claws, two parallel series of contact pegs, two slots, or a slot and a rotary cam.

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An Improved Electrical Connection Between a Suspension Flexure Cable and a Head Stack Assembly Flexible Circuit

Background Information

5 [0001] The present invention relates to magnetic hard disk drives. More specifically, the present invention relates to a method of electrically connecting the actuator and micro-actuator to a control circuit.

[0002] In the art today, different methods are utilized to improve recording density in hard disk drives. **Figure 1** provides an illustration of a typical disk drive. 10 The typical disk drive has a head gimbal assembly (HGA) configured to read from and write to a magnetic hard disk 101. The HGA and the magnetic hard disk 101 are mounted to the base 102 of a main board 103. The disk 101 is rotated relative to the base 102 by a spindle motor 104. The HGA typically includes an actuator arm 105 and a suspension 106. The HGA supports and positions a magnetic read/write slider 15 107 above the magnetic hard disk 101. The slider may contain transducers to perform the read/write function. The HGA is rotated relative to the base 102 along the axis of a pivot bearing assembly 108 by an actuator frame 109. The actuator frame 109 contains an actuator coil 110 driven by a magnet 111. A relay flexible printed circuit 112 connects a board unit 113 to the transducer of the magnetic 20 read/write slider 107. The signal from the transducer is amplified by the preamplifier 114 before being transmitted along the relay flexible printed circuit.

[0003] **Figure 2** provides one illustration of an actuator as practiced in the prior art. The suspension 106, which supports the slider 107, may include a flexure 201 attached to a base plate 202 that suspends a load beam 203 coupled to the slider 107. 25 The slider 107 may be electronically coupled by electrical traces 204 that run along the suspension 106 and actuator arm 105 to an actuator board 205. The actuator board 205 runs the signals from the slider 107 through a pre-amplifier 114 before sending them through the relay flexible printed circuit 112. The electrical traces 204

may be coupled to the actuator board 205 by a set of termination pads 206 at the end of the electrical traces 204.

[0004] Figure 3 provides one illustration of the electrical connection between the slider 107 and the relay flexible printed circuit 112 as practiced in the prior art. The electrical trace 204 coupled to the suspension 106 may electrically connect the slider 107 to the termination pads 206. The termination pads 206 may be coupled to a set of contact pads 301 on the actuator board 205. The signal is then sent through a pre-amplifier to the relay flexible printed circuit 112.

[0005] In order to carry out previous methods of establishing an electrical connection, the flex cable on the suspension must be aligned properly to the pads of the actuator board 205. If soldering is used to connect the pads, the solder bump must be preliminarily formed on the pads for solder bonding. Laser or ultrasonic bonding can be prohibitively expensive and time consuming due to the necessary calibration work.

Brief Description Of The Drawings

[0006] **Figure 1** provides an illustration of a typical disk drive.

[0007] **Figure 2** provides one illustration of an actuator as practiced in the prior art.

5 [0008] **Figure 3** provides one illustration of the electrical connection between the slider and the relay flexible printed circuit as practiced in the prior art.

[0009] **Figure 4** provides an illustration of one embodiment of an actuator with an electrical connection as constructed in the present invention.

10 [0010] **Figure 5** provides an illustration of one embodiment of the electrical connection as constructed in the present invention.

[0011] **Figure 6** provides an illustration one embodiment of a pre-amplifier with an I-connector.

[0012] **Figure 7** provides an illustration in a cross-section one embodiment of the pre-amplifier with I-connector as used in creating an electrical connection.

15 [0013] **Figure 8** provides an illustration in a side view of one embodiment of the electrical connection.

[0014] **Figure 9** provides an illustration in a top view of one embodiment of the electrical connection.

20 [0015] **Figures 10a-d** provide an illustration of alternate embodiments of the pre-amplifier with I-connector.

Detailed Description

[0016] A method and apparatus for electrically coupling a slider to a controller circuit are disclosed. In one embodiment, a pre-amplifier with an integrated electrical connector (I-connector) may be connected via an electrical trace to a slider and via a head stack assembly flexible circuit to a control circuit. The pre-amplifier may have two parallel series of spring probe claws, two parallel series of contact pegs, two slots, or a slot and a rotary cam.

[0017] **Figure 4** illustrates one embodiment of an actuator with an electrical connection as constructed in the present invention. The pre-amplifier 401 of the actuator board 205 may have a built in I-connector. The termination pads 206 of the electrical traces 204 may be directly connected to the pre-amplifier with I-connector 401. An alignment pin 402 extending up from the actuator board 205 may allow the pre-amplifier with I-connector 401 to be position. A screw 403 or other coupling device may be used to couple the I-connector to the actuator board 205.

[0018] **Figure 5** illustrates one embodiment of the electrical connection. The pre-amplifier with I-connector 401 may be coupled to an actuator board 205 by using an alignment pin 402 and a screw 403 or other coupling device. The termination pads 206 of the electrical traces 204 may be directly coupled to the pre-amplifier with I-connector 401. The head stack assembly flexible circuit 112 may be coupled to the pre-amplifier with I-connector 401 by a direct connection 501 or by terminating in a controller connection tab that connects to the pre-amplifier with I-connector.

[0019] **Figure 6** illustrates one embodiment of a pre-amplifier with an I-connector 401. Two parallel rows of spring probe claws 601 may line the bottom of the pre-amplifier with I-connector 401. The spring probe claws 601 may bend inwards towards the center of the pre-amplifier with I-connector 401. An alignment slot 602 may be used to align the pre-amplifier with I-connector 401 with the alignment pin 402. A screw hole 603 may allow the pre-amplifier with I-connector 401 to be coupled to the actuator board by a screw 403 or other coupling device.

[0020] **Figure 7** illustrates in a cross-section one embodiment of the pre-amplifier

with I-connector 401 as used in creating an electrical connection. The pre-amplifier with I-connector 401 may be aligned to the actuator board 205 by an alignment pin extending up from the actuator arm 105 through the actuator board 205 and the alignment slot 602 of the pre-amplifier with I-connector 401. The pre-amplifier with I-connector 401 may then be coupled to the actuator board 205 and arm 105 by a screw 403 or other coupling device. The screw 403 or other coupling device may cause the spring probe claws 601 to be in contact with the contact pads 301 of the actuator board 205. The contact pads 301 may be electrically coupled to the head stack assembly flexible circuit 112.

10 [0021] Figure 8 illustrates in a side view one embodiment of the electrical connection. One series of spring probe claws 601 may be in contact with the contact pads 301 of the actuator board 205. The other series of spring probe claws 601 may be in contact with the termination pads 206 of the electrical traces 204. The termination pads 206 may be affixed to the actuator board 205 by adhesive or other coupling methods. Alternatively, the termination pads 206 may be held in place by the pressure generated by coupling the pre-amplifier with I-connector 401 to the actuator board 205.

[0022] Figure 9 illustrates in a top view the same embodiment of the electrical connection. The alignment pin 402 may keep the spring probe claws 601 aligned with the termination pads 206 and the contact pads 301. The screw 403 or other coupling device may be adjusted to create the proper amount of pressure to keep the termination pads 206 in contact with the spring probe claws 601.

25 [0023] Figures 10a-d illustrate alternate embodiments of the pre-amplifier with I-connector 401. Figure 10a shows an embodiment of the pre-amplifier with I-connector 401 with spring probe claws 1001 that bend toward the outside of the pre-amplifier with I-connector 401. Figure 10b shows an embodiment of the pre-amplifier with I-connector 401 with two parallel series of contact pegs 1002 instead of two series of spring probe claws 601. Figure 10c shows an embodiment of the pre-amplifier with I-connector 401 with a slot 1003 on each side. The head stack

assembly flexible circuit 112 may be inserted into one of the slots 1003 and the electrical trace 204 may be inserted into the other slot. **Figure 10d** shows an embodiment of the pre-amplifier with I-connector 401 with a slot 1003 on one side and a rotary cam 1004 on the other side. The head stack assembly flexible circuit
5 112 may be inserted into the slot 1003. The termination pads 206 of the electrical traces 204 are coupled to the rotary cam 1004.

(0224) Although several embodiments are specifically illustrated and described herein, it will be appreciated that modifications and variations of the present invention are covered by the above teachings and within the purview of the appended claims
10 without departing from the spirit and intended scope of the invention.

What is claimed is

1. An actuator circuit assembly, comprising:
 - at least one electrical trace termination pad electrically coupled to a slider;
 - 5 a head stack assembly flexible circuit electrically coupled to a control circuit; and
 - a pre-amplifier with an integrated connector to electrically connect the at least one electrical trace termination pad to the head stack assembly flexible circuit.
2. The actuator circuit assembly of claim 1, wherein the pre-amplifier is coupled to an
10 actuator circuit board mounted on an actuator arm.
3. The actuator circuit assembly of claim 2, wherein the pre-amplifier is coupled to the actuator circuit board by a fastener.
- 15 4. The actuator circuit assembly of claim 2, further comprising:
 - at least one slider spring probe claw protruding from the pre-amplifier and pressure coupled to the at least one electrical trace termination pad; and
 - at least one controller spring probe claw protruding from the pre-amplifier and pressure coupled to an electrical actuator controller connection tab of the head stack
20 assembly flexible circuit.
5. The actuator circuit assembly of claim 4, wherein the at least one slider spring probe claw and the at least one controller spring probe claw curve inward.
- 25 6. The actuator circuit assembly of claim 4, wherein the at least one slider spring probe claw and the at least one controller spring probe claw extend outward.
7. The actuator circuit assembly of claim 2, further comprising:
 - at least one slider contact peg protruding downward from the pre-amplifier and

pressure coupled to the at least one electrical trace termination pad; and

at least one controller contact peg protruding downward from the pre-amplifier and pressure coupled to an electrical actuator controller connection tab of the head stack assembly flexible circuit.

5

8. The actuator circuit assembly of claim 1, further comprising:

a slider slot into which the at least one electrical trace termination pad is inserted; and

a controller slot into which the head stack assembly flexible circuit is inserted.

10

9. The actuator circuit assembly of claim 1, further comprising:

a slider rotary cam into which the at least one electrical trace termination pad is inserted; and

a controller slot into which the head stack assembly flexible circuit is inserted.

15

10. A head stack assembly, comprising:

an actuator arm to place a slider above a magnetic storage medium;

a control circuit to control the slider and the actuator arm;

at least one electrical trace termination pad electrically coupled to the slider;

20 a head stack assembly flexible circuit electrically coupled to the control circuit;

and

a pre-amplifier with an integrated connector to electrically connect the at least one electrical trace termination pad to the head stack assembly flexible circuit.

25 11. The head stack assembly of claim 10, wherein the pre-amplifier is coupled to an actuator circuit board mounted on an actuator arm.

12. The head stack assembly of claim 11, wherein the pre-amplifier is coupled to the actuator circuit board by a fastener.

13. The head stack assembly of claim 11, further comprising:

at least one slider spring probe claw protruding from the pre-amplifier and pressure coupled to the at least one electrical trace termination pad; and

at least one controller spring probe claw protruding from the pre-amplifier and pressure coupled to an at least one electrical actuator controller connection tab of the head stack assembly flexible circuit.

14. The head stack assembly of claim 13, wherein the at least one slider spring probe claw and the at least one controller spring probe claw curve inward.

10

15. The head stack assembly of claim 13, wherein the at least one slider spring probe claw and the at least one controller spring probe claw extend outward.

16. The head stack assembly of claim 11, further comprising:

at least one slider contact peg protruding downward from the pre-amplifier and pressure coupled to the at least one electrical trace termination pad; and

at least one controller contact peg protruding downward from the pre-amplifier and pressure coupled to at least one electrical actuator controller connection tab of the head stack assembly flexible circuit.

20

17. The head stack assembly of claim 10, further comprising:

a slider slot into which the at least one electrical trace termination pad is inserted; and

a controller slot into which the head stack assembly flexible circuit is inserted.

25

18. The head stack assembly of claim 10, further comprising:

a slider rotary cam into which the at least one electrical trace termination pad is inserted; and

a controller slot into which the head stack assembly flexible circuit is inserted.

19. A hard disk drive, comprising:

a magnetic storage medium to store data;

a base to support the magnetic storage medium;

an actuator arm to place a slider above a magnetic storage medium;

5 a pivot to move the actuator arm in relation to the magnetic storage medium;

a printed circuit board to control the slider and the actuator arm;

at least one electrical trace termination pad electrically coupled to the slider;

a head stack assembly flexible circuit electrically coupled to the control circuit;

and

10 a pre-amplifier with an integrated connector to electrically connect the at least one electrical trace termination pad to the head stack assembly flexible circuit.

20. The hard disk drive of claim 19, wherein the pre-amplifier is coupled to an actuator circuit board mounted on an actuator arm.

15

21. The hard disk drive of claim 20, wherein the pre-amplifier is coupled to the actuator circuit board by a fastener.

22. The hard disk drive of claim 20, further comprising:

20 at least one slider spring probe claw protruding from the pre-amplifier and pressure coupled to the at least one electrical trace termination pad; and

at least one controller spring probe claw protruding from the pre-amplifier and pressure coupled to at least one electrical actuator controller connection tab of the head stack assembly flexible circuit.

25

23. The hard disk drive of claim 22, wherein the at least one slider spring probe claw and the at least one controller spring probe claw curve inward.

24. The hard disk drive of claim 22, wherein the at least one slider spring probe claw

and the at least one controller spring probe claw extend outward.

25. The hard disk drive of claim 20, further comprising:

at least one slider contact peg protruding downward from the pre-amplifier and
5 pressure coupled to the at least one electrical trace termination pad; and

at least one controller contact peg protruding downward from the pre-amplifier
and pressure coupled to at least one electrical actuator controller connection tab of the
head stack assembly flexible circuit.

10 26. The hard disk drive of claim 19, further comprising:

a slider slot into which the at least one electrical trace termination pad is inserted;
and

a controller slot into which the head stack assembly flexible circuit is inserted.

15 27. The hard disk drive of claim 19, further comprising:

a slider rotary cam into which the at least one electrical trace termination pad is
inserted; and

a controller slot into which the head stack assembly flexible circuit is inserted.

20 28. A method, comprising:

electrically coupling at least one electrical trace termination pad to a slider;

electrically coupling a head stack assembly flexible circuit to a control circuit;

and

electrically coupling the at least one electrical trace termination pad to the head
25 stack assembly flexible circuit with a pre-amplifier with an integrated connector.

29. The method of claim 28, further comprising coupling the pre-amplifier to an
actuator circuit board mounted on an actuator arm.

30. The method of claim 29, further comprising coupling the pre-amplifier to the actuator circuit board by a fastener.

31. The method of claim 29, further comprising:

- 5 pressure coupling the pre-amplifier to the at least one electrical trace termination pad using at least one slider spring probe claw protruding from the pre-amplifier; and
 pressure coupling the pre-amplifier to at least one electrical actuator controller connection tab of the head stack assembly flexible circuit using at least one controller spring probe claw protruding from the pre-amplifier.

10

32. The method of claim 31, wherein the at least one slider spring probe claw and the at least one controller spring probe claw curve inward.

15

33. The method of claim 31, wherein the at least one slider spring probe claw and the at least one controller spring probe claw extend outward.

34. The method of claim 29, further comprising:

20

- pressure coupling the pre-amplifier to the at least one electrical trace termination pad using at least one slider contact peg protruding downward from the pre-amplifier;
and
 pressure coupling the pre-amplifier to at least one electrical actuator controller connection tab of the head stack assembly flexible circuit using at least one controller contact peg protruding downward from the pre-amplifier.

25

35. The method of claim 28, further comprising:

- inserting the at least one electrical trace termination pad into a slider slot; and
 inserting the head stack assembly flexible circuit into a controller slot.

36. The method of claim 28, further comprising:

inserting the at least one electrical trace termination pad into a slider rotary cam;
and
inserting the head stack assembly flexible circuit into a controller slot.

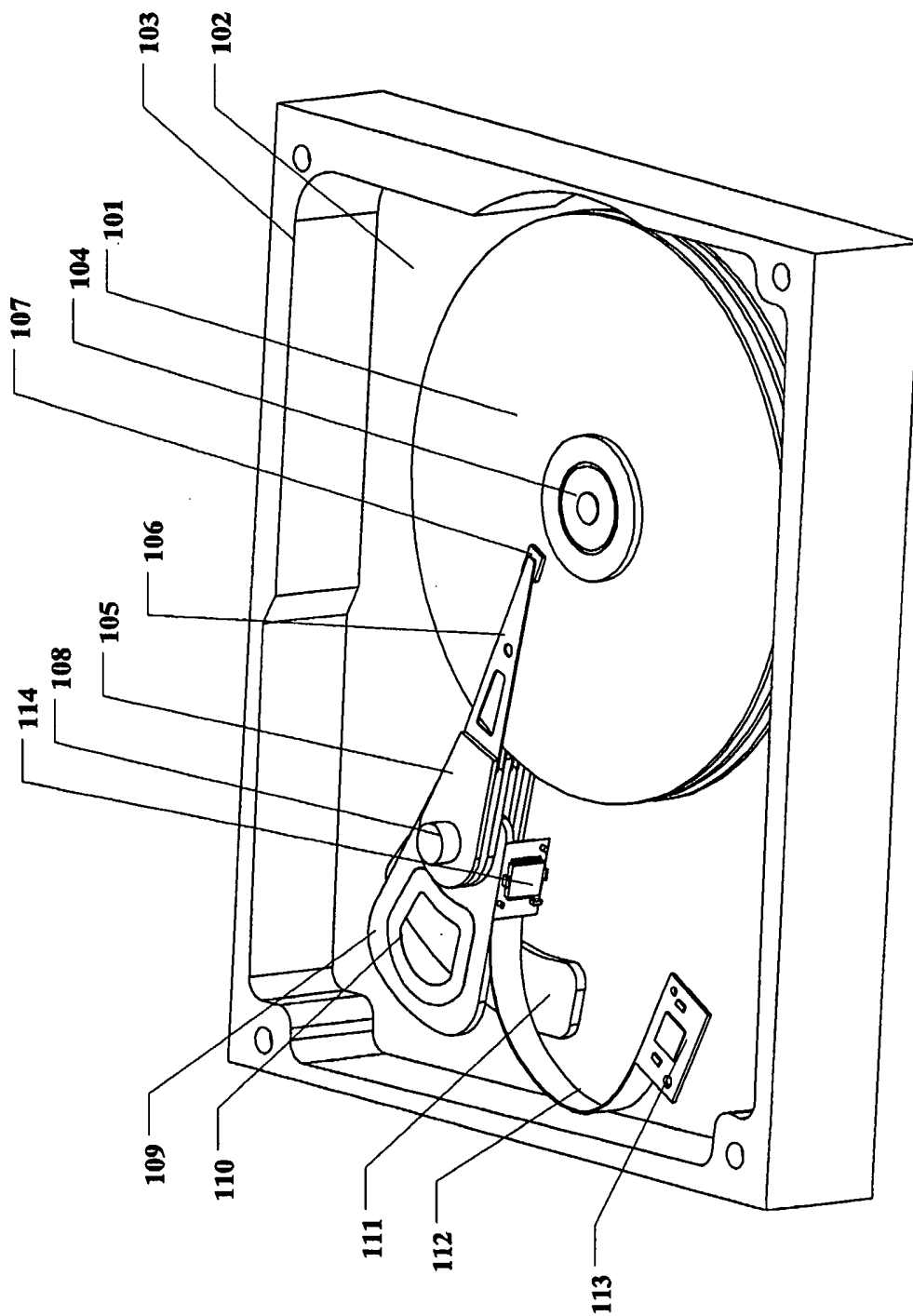


FIG. 1
(Prior Art)

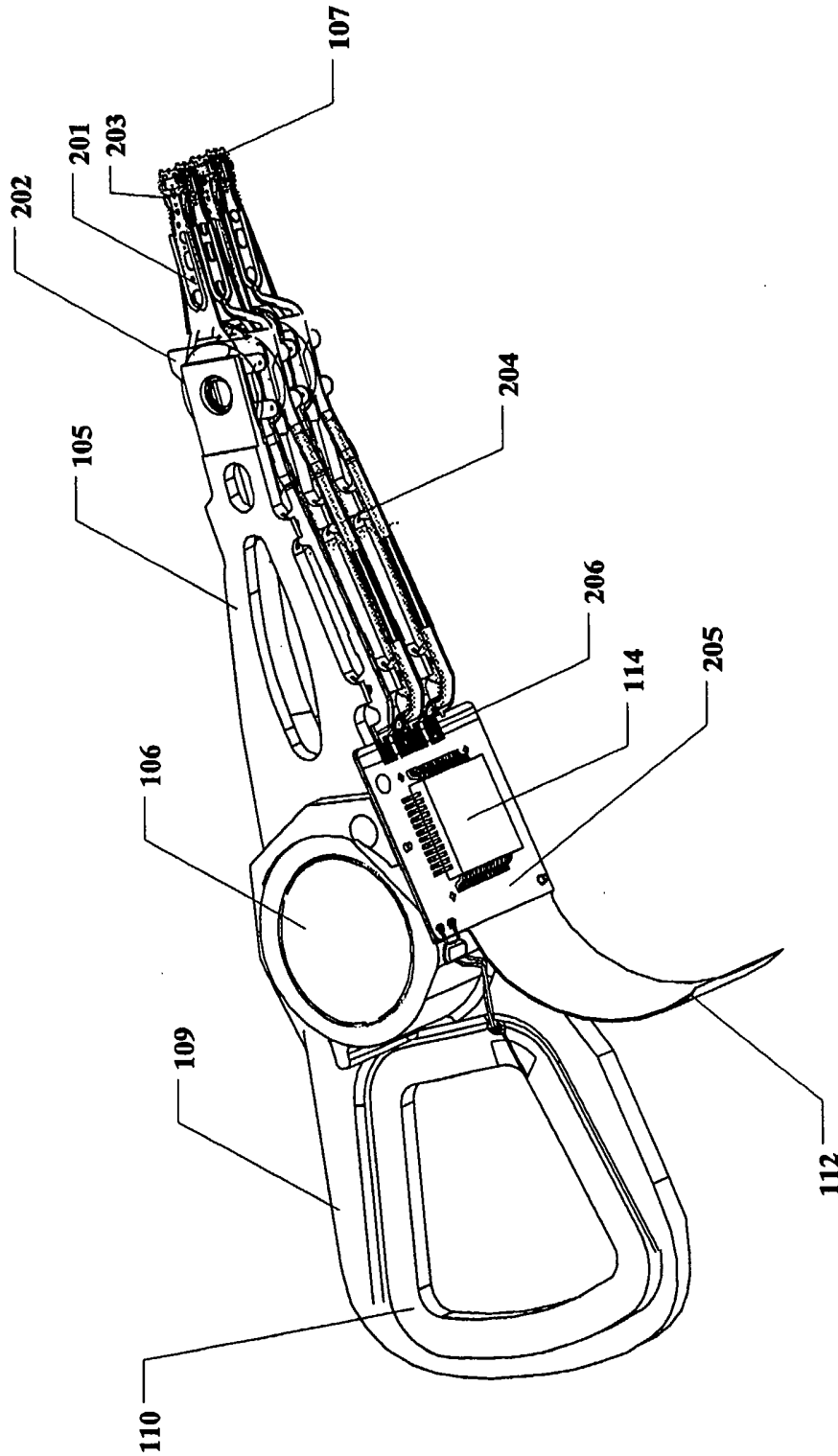


FIG. 2

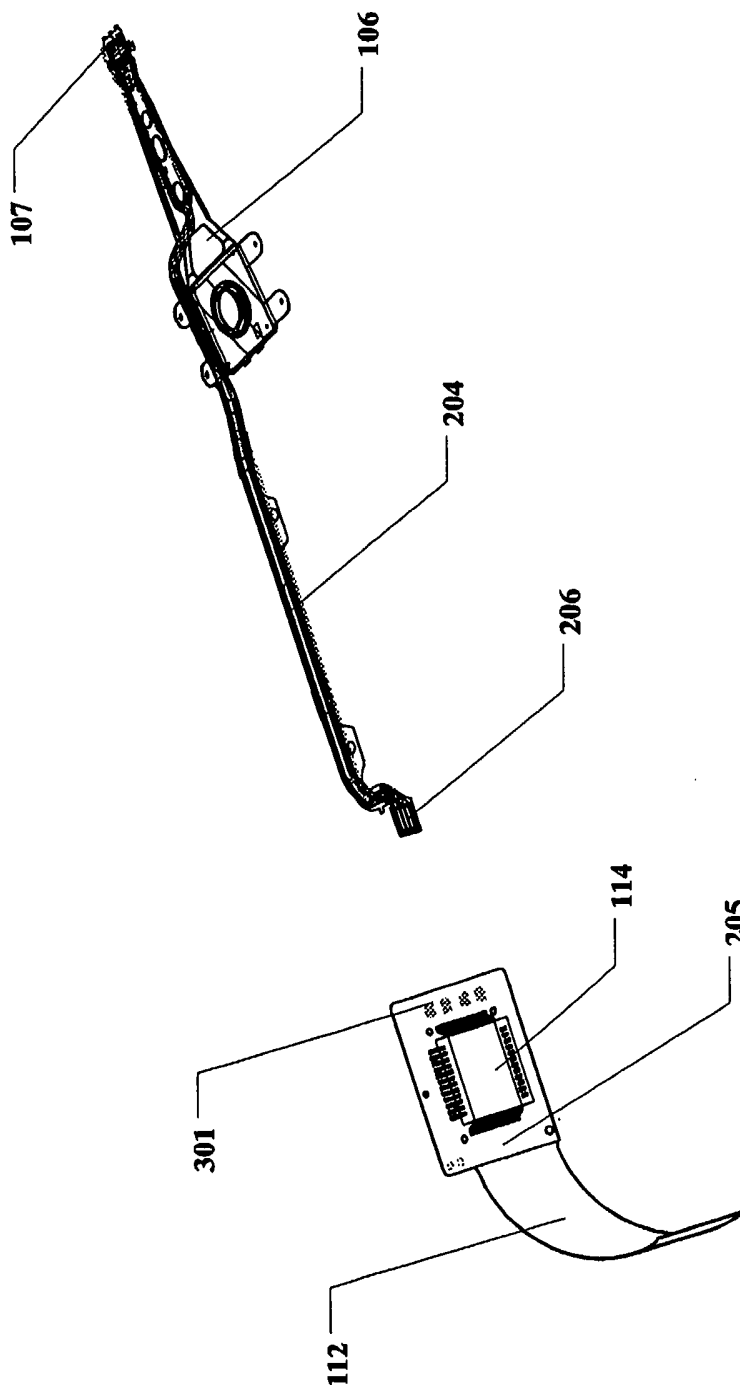


FIG. 3
(Prior Art)

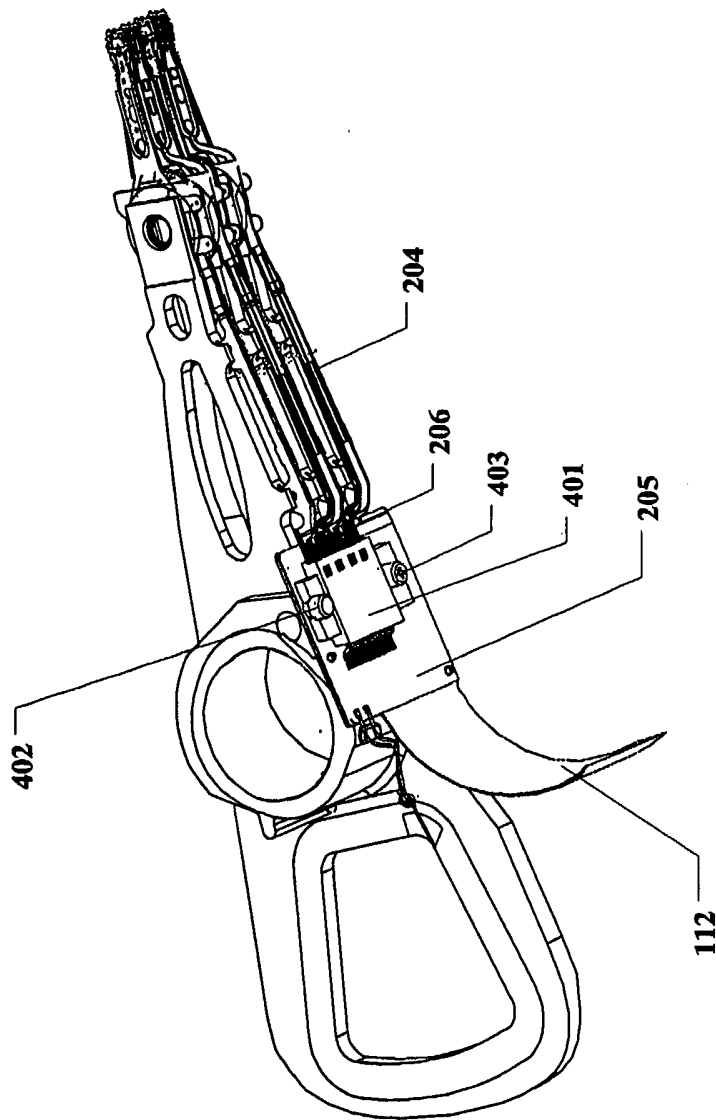


FIG. 4

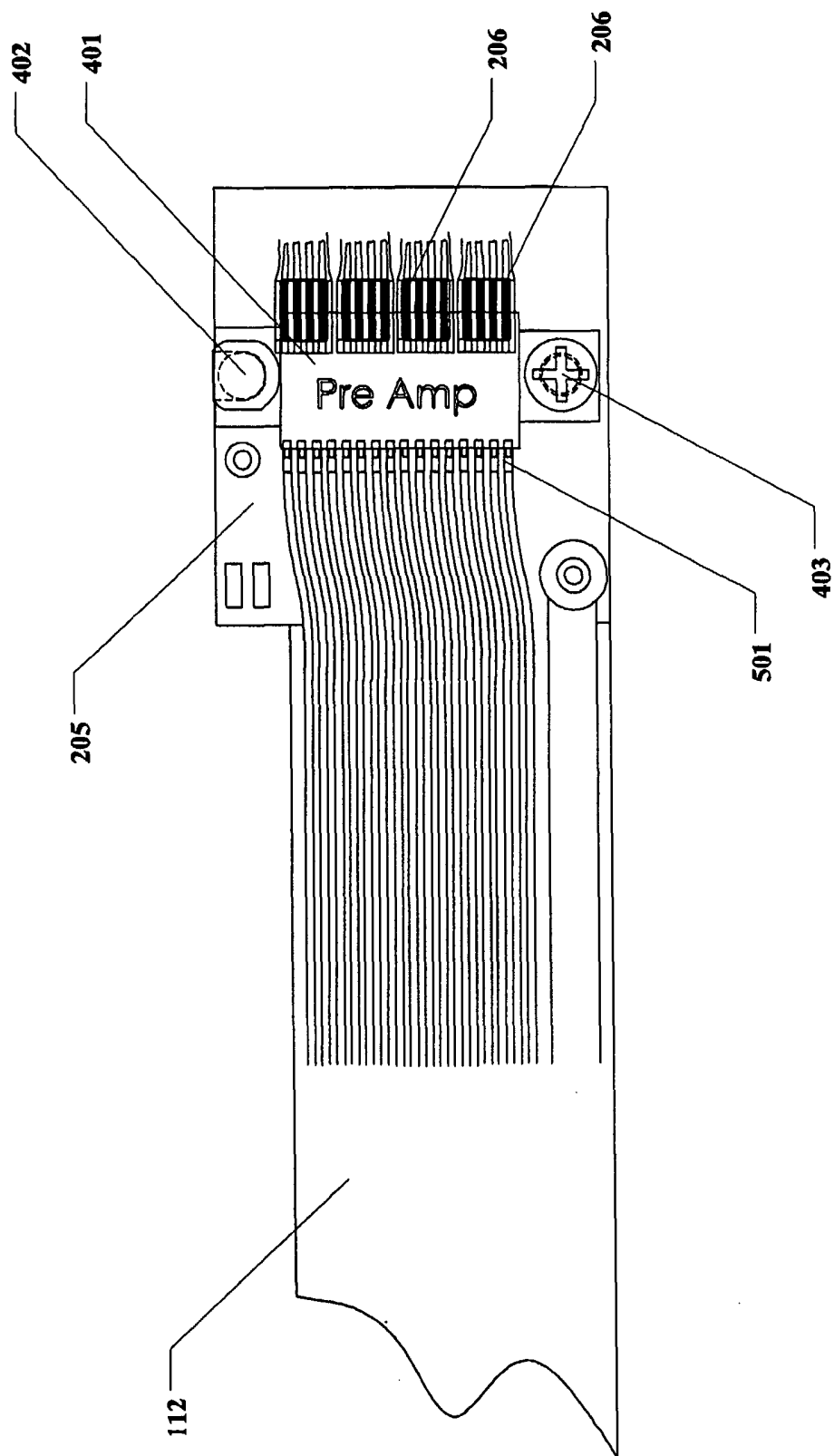


FIG. 5

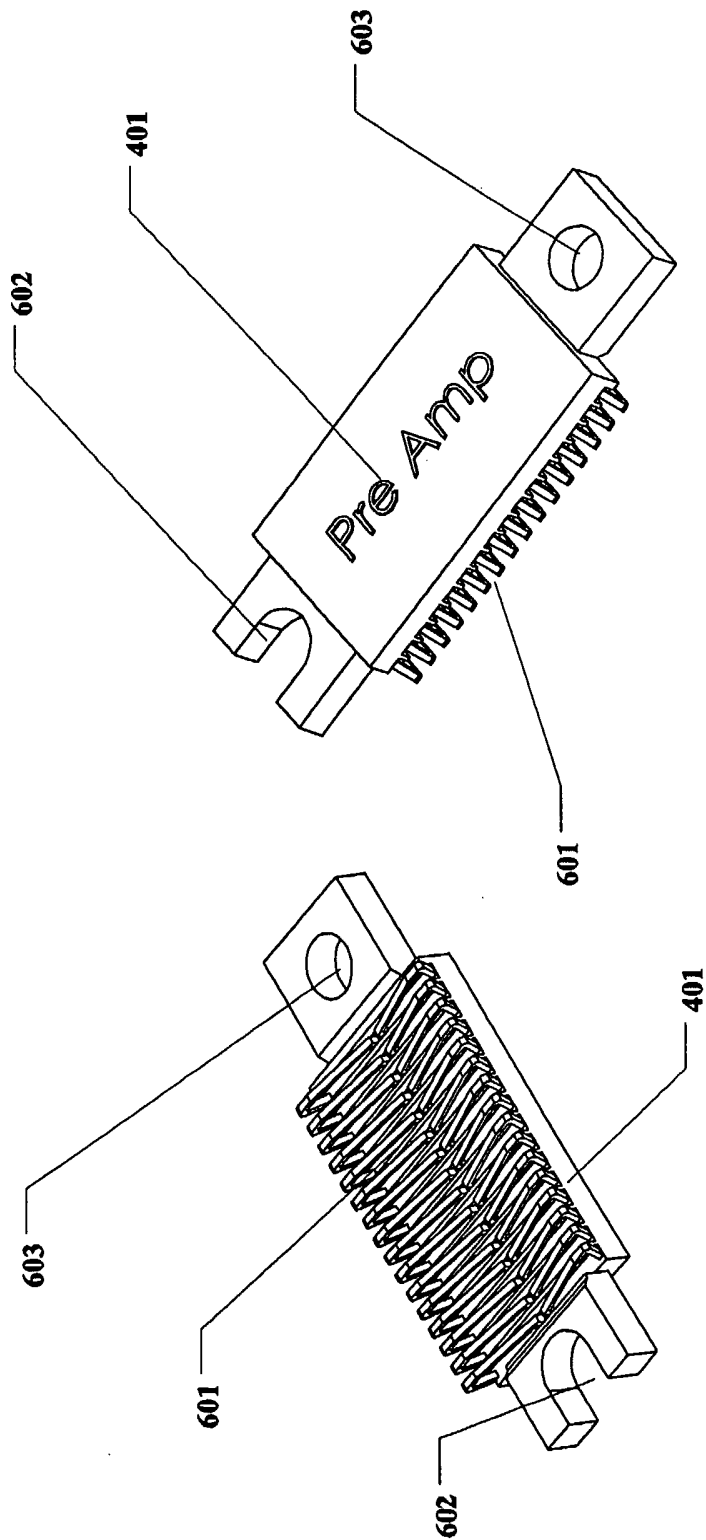


FIG. 6

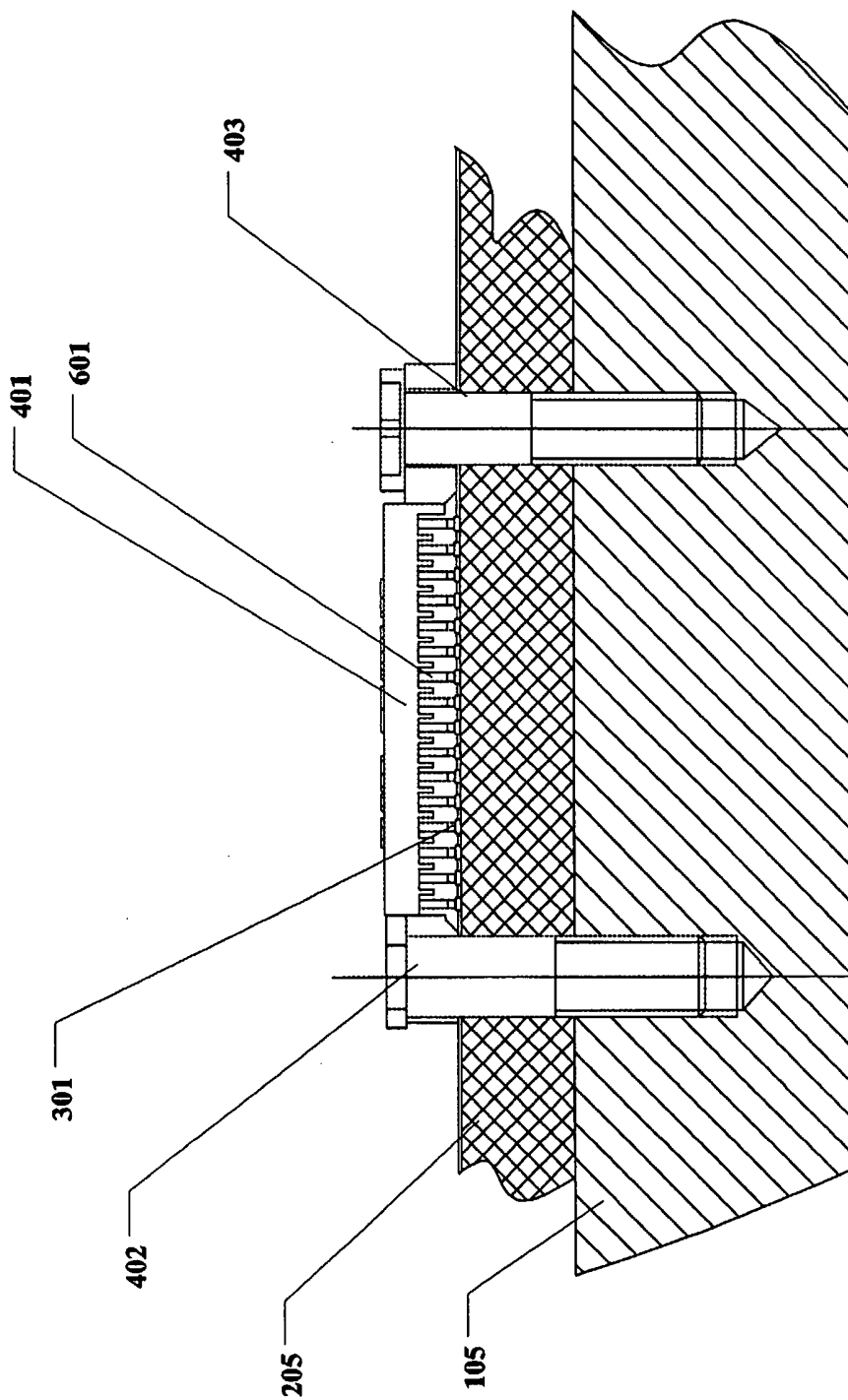


FIG. 7

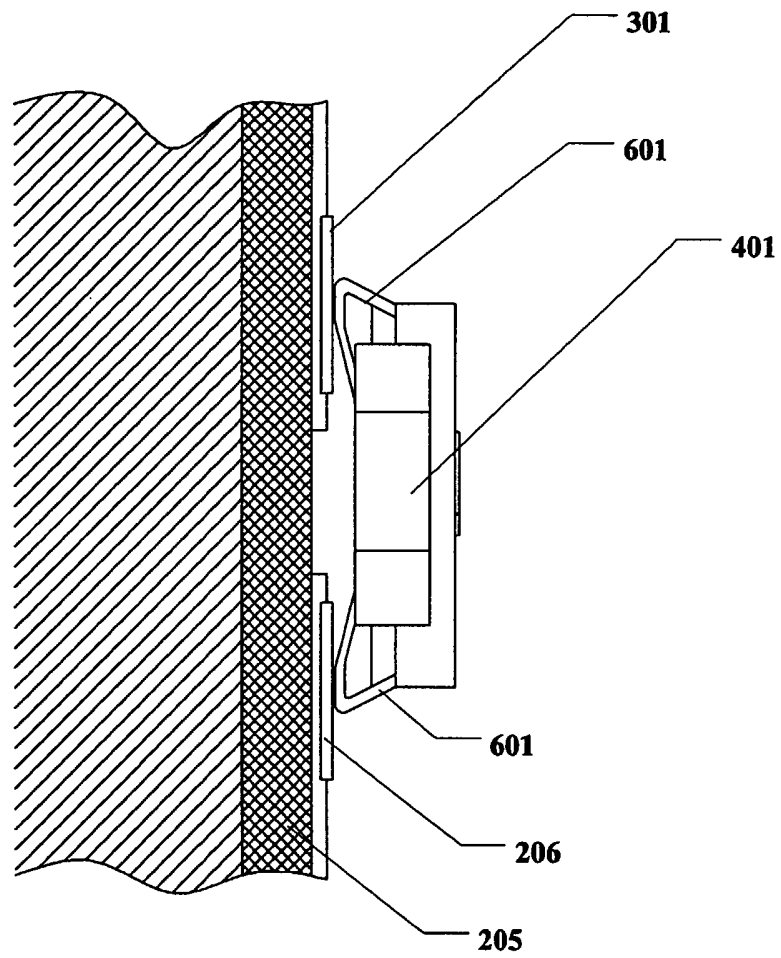


FIG. 8

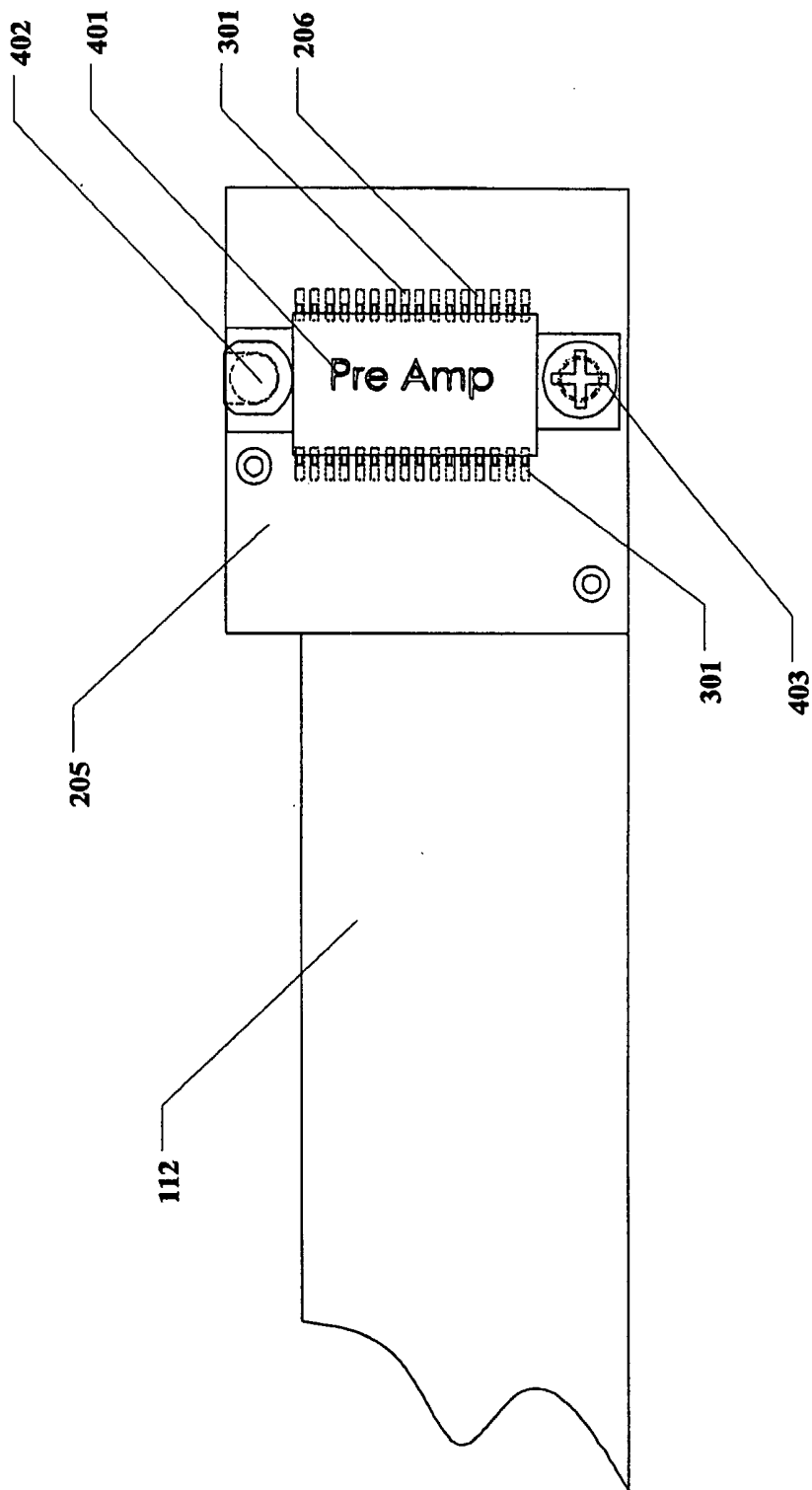


FIG. 9

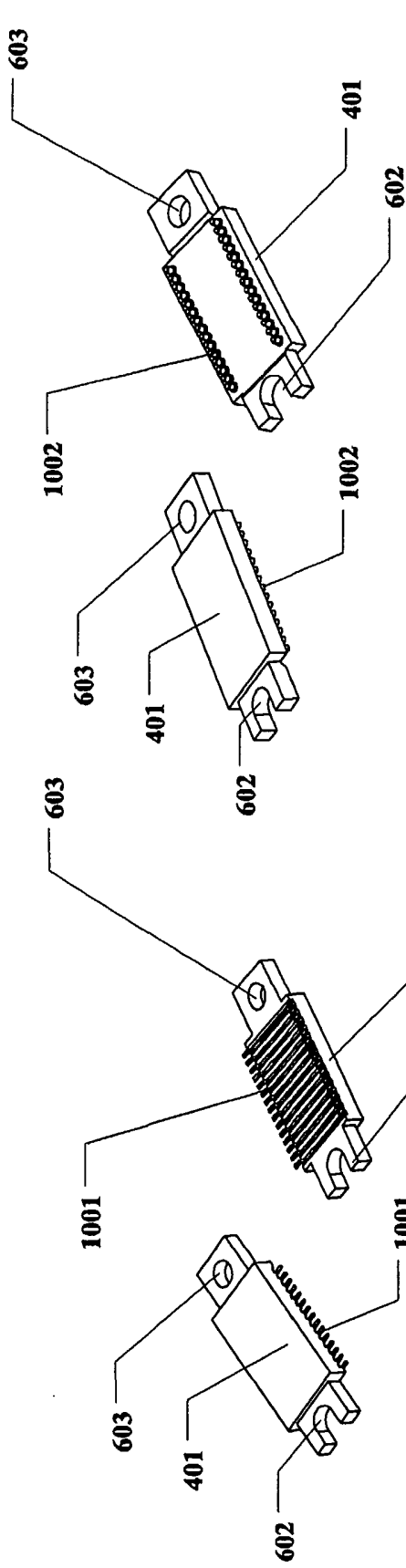


FIG. 10a

FIG. 10b

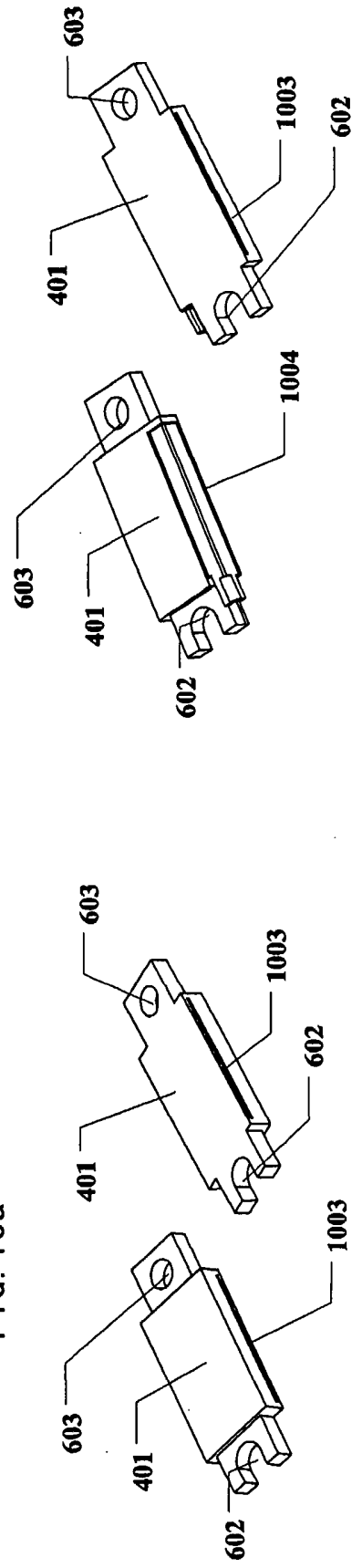


FIG. 10c

FIG. 10d

FIG. 10a

FIG. 10b

FIG. 10c

FIG. 10d

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN03/00341

Patent document	Publication	Patent family	Publication
Cited search report	Date	member	Date
US,A,5708541	13.01.98	US,A,5631786	20.05.97
		SG,A,47168	20.03.98
		US,B,6477014	05.11.02