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(71) Applicant: **Exxon Research and Engineering Company**
P.O.Box 390 180 Park Avenue
Florham Park New Jersey 07932(US)

(72) Inventor: **De Young, Thomas William**
Overhill Road
Stormville New York(US)

(72) Inventor: **Mccormick, John Atwater**
14 Hunting Ridge Road
Brookfield Center Connecticut(US)

(74) Representative: **Field, Roger Norton et al,**
ESSO Engineering (Europe) Ltd. Patents & Licences
Apex Tower High Street
New Malden Surrey KT3 4DJ(GB)

(54) Ink jet array.

(57) An ink jet array comprises a plurality of elongate transducers (204) coupled to a plurality of ink jet chambers (200). The transducers (204) are supported at longitudinal extremities only so as to minimise cross-talk between jets within the array. The support at the extremity remote from the chamber (200) is provided by a compliant clamp (230) such that no substantial reaction force transverse to the axis of elongation of the transducers (204) occurs. The support at the other extremity includes bearings (224) precluding substantially lateral movement transverse to the axis of elongation but permitting longitudinal movement along the axis of elongation.

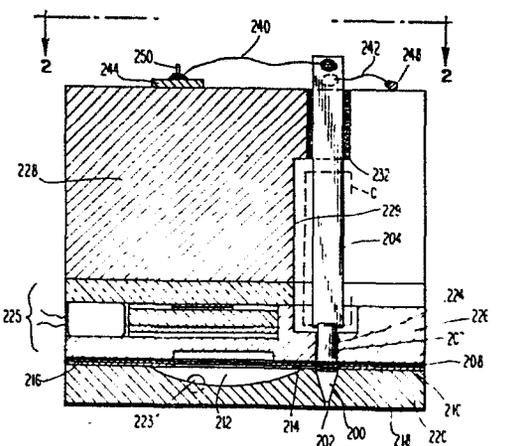

Fig. 1

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"INK JET ARRAY"

This invention relates to an ink jet array.

According to the invention there is provided an ink jet array characterised in that it comprises a plurality of chambers having ink jet droplet ejection orifices therein, a plurality of elongate transducers respectively coupled to said chambers for ejecting ink from said orifices in response to energisation thereof, and supporting means for said transducers comprising a rigid portion and a compliant clamping portion between said rigid portion and said transducers in an area along the axis of elongation of the transducers.

With embodiments of this invention, it is possible to provide improved transducer support in an ink jet array, and in particular such that cross-talk between ink jets in an array may be minimised.

The compliant clamping portion may comprise an elastomeric material. Silicone rubber has been found to be particularly suitable. The ink jet array may further comprise compliant electrical connections to the transducers. The electrical connections may comprise flexible wires or a flexible printed circuit.

The compliant clamping means may substantially surround a transverse cross-section of the transducers. As an alternative, the compliant clamping portion may only partially surround a transverse cross-section of the transducers.

The invention will be better understood from the following description given, by way of example, with reference to the accompanying drawings in which :

Fig. 1 is a sectional view of one form of ink jet apparatus in accordance with this invention;

Fig. 1a is an enlarged view of a portion of the ink jet apparatus of Fig. 1;

Fig. 2 is a top view of the ink jet apparatus shown in Fig. 1 taken along line 2-2;

Fig. 3 is a sectional view of the apparatus shown in Fig. 2 taken along line 3-3;

Fig. 4 is a view comparable to the view of Fig. 2 of another embodiment of the invention;

Fig. 5 is a view comparable to Fig. 2 of another embodiment of the invention; and

Fig. 6 is a sectional view of the apparatus shown in Fig. 5 taken along 6-6.

Referring to Figs. 1-3, an ink jet apparatus

comprises a plurality of chambers 200 having orifices 202 and an orifice plate 218 for ejecting droplets of ink in response to the state of energization of the transducers 204. The transducers 204 which are rectangular in cross-section transverse to the axis of elongation expand and contract along the axis of elongation as depicted by the arrowheads shown in Fig. 1a. The resulting movement of the transducers 204 along the axis of elongation is coupled into the chamber 200 by coupling means 206 including a foot 207, a viscoelastic material 208 juxtaposed to the foot 207 and a diaphragm 210 which is preloaded to a position best shown in Fig. 1a.

Ink flows into the chamber 200 from a reservoir 212 through a restricted inlet means provided by a restricted opening 214 best shown in Fig. 3. The opening 214 is located in a restrictor plate 216 best shown in Fig. 2.

The reservoir 212 is formed by a concave region in a chamber plate 220 which is covered by the restrictor plate 216 so as to form an acute angle along one side of the reservoir 212 leading to the inlet 214. A feeder input tube 223 communicates with the reservoir 212 at one end thereof as shown in Fig. 1. A heater assembly 225 is also shown in Fig. 1.

Each of the transducers 204 are supported at the extremities thereof with intermediate portions being essentially unsupported as best shown in Fig. 1. More specifically, Fig 1 discloses a transducer support means including a plate 226 and a plate 228. The plate 226 of the transducer support means includes bearing means in the form of a hole 224 which receives the foot 207 attached to an extremity of the transducer 204.

It will be appreciated that the foot 207 is free to move longitudinally within the hole 224 thereby permitting longitudinal motion of the transducer along the axis of elongation of the transducer while substantially preventing lateral motion of the transducer.

Mounting means for the transducer 204 provided by the plate 228 includes slots 232 best shown in Fig. 2. Compliant mounting means 230 as shown in Figs. 21 and 3 clamp the transducers 204 adjacent the extremities of the transducers 204 remote from the chambers 200. It will be appreciated that the compliant mounting means 230 provides a shear bond with the transducer 204.

The compliant mounting means 230 provide a sufficient clamping action with respect to the transducers 204 so as to substantially prevent any longitudinal motion of the transducers along the axis of elongation at the compliant clamping means 230 such that expansion and contraction of the transducer 204 is translated along the transducer 204 and into the movement of the foot 207 through the bearing holes 224 in the plate 226. At the same time, the stiffness (which is low) of the compliant mounting means 230 is nevertheless sufficient in the direction of elongation of the transducers 204 so as to achieve substantial movement of the transducer extremity adjacent the foot 207 in the direction of expansion and contraction. The low mechanical stiffness minimises the reaction force that one transducer 204 transmits laterally to other transducers 204 in the array when driven or energised.

The plate 228 includes a recessed area 229 shown in Fig. 1 below the slots 232 which is spaced from the transducers 204. Thus, there is no contact along the area 229. Moreover, it will be appreciated that

portions of the plate 228 including the slots 232 in conjunction with the area 229 and the portion of the plate 226 extending toward the holes 224 forms a C-shape cross-section designated with broken lines identified with the character C where the region 229 forms the center of the C. Note that the space between the region 229 and the transducer permits the transducer to have a substantially larger dimension than the foot 207 while still avoiding contact with the plate 228. Moreover, the foot 207 extends sufficiently far upwardly toward the slots 232 so as to assure that the transducer 204 may expand and contract without contacting any portion of the plate 226. Thus, the transducer 204 may be rectangular in cross-section having a substantially greater dimension in the direction shown in the plane of Fig. 1 as compared with the direction shown in the plane of Fig. 2.

As shown in Fig. 1, the overall length of the longitudinal bearing surface represented by the hole 224 in the direction of the axis of elongation of the transducer 204 is substantially less than the overall length of the transducer 204 along that axis. Preferably, the overall length of the bearing surface 224 along the axis is less than twice the maximum cross-sectional dimension of the transducer as also shown in Fig. 1.

Referring to Figs. 1-3, it will be observed that the compliant material 230 surround all four sides of the transducers 204 and the slots 232. However, it will be appreciated that the compliant material 230 need not surround all four sides. In the embodiment as shown in Fig. 4, the compliant material 330 is located between a single side of the transducers 204 in one wall of the slots 232. It will be appreciated that any

number of walls of the transducers 204 may be surrounded by the compliant material. Therefore, it will be appreciated that regardless of the amount of compliant material utilized to clamp the transducers 204 in place, the magnitude of the mechanical disturbance from one transducer to another is substantially minimized. As a consequence, the erroneous ejection of a droplet from a neighboring channel or ink jet chamber is minimized.

Compliance is also provided in the electrical connection to electrodes 236 and 238 of the transducers 204 as shown in Figs. 2 and 3. This compliant electrical coupling is provided by flexible wire leads 240 and 242. The wire leads 240 and 242 are connected to pins 250 extending into a planar insulator 244 extending across the top of the plate 228. Each of the pins 250 is capable of coupling an electrical signal to a particular transducer 204 for selectively ejecting a droplet on demand. The flexible wire leads 242 are connected to a bus 248 which in turn is connected to ground as shown in Fig. 2.

It will be appreciated that the compliant electrical connection to the transducer 204 minimizes the possibility of any mechanical disturbances being transmitted from one channel or one chamber to another channel or chamber by means of the electrical connection. Therefore, compliance is provided in both the mechanical mounting through means of the compliant material 230 as well as the electrical connection by means of the flexible or compliant leads 240 and 242. It will be appreciated that various types of electrical connections may be made at the electrodes 236 and 238 as well as at the pins 250 as shown in Figs. 2, 3 and 4, e.g., solder. The same compliant electrical connection is achieved in

the embodiment of Fig. 4 utilizing flexible wire leads 240 and 242.

Referring now to Figs. 5 and 6, an embodiment of the invention is shown wherein another compliant electrical connection is utilized. More specifically, in this connection, a flexible printed circuit board having a flexible substrate 300 is unsecured and free to move with respect to the top of the plate 228. The substrate 300 includes a series of slots 302 which generally correspond and are aligned with the slots 232 in the plate 228 which are filled with the compliant material 230. The printed circuit board also includes planar conductive portions 304 mounted on the substrate 300 which are coupled to the electrodes 236 of the transducers 204 by solder points 308. These planar conductive members 304 are selectively energized so as to produce drops on demand from the various chambers associated with the ink jets. Additional planar conductive members 306 are connected to the electrodes 238 and a flexible ground bus bar 248 by solder points 308 to complete the electrical connection between the planar conductive members 304 and 306 and the electrodes 236 and 238. Other techniques may be employed to minimize cross-talk including the slitting of the substrate 300 between transducers. It may also be desirable to employ other conductive patterns so as to permit a planar ground bus bar to be utilized.

It will be appreciated that the compliant clamping material may comprise a variety of elastomeric materials. For example, silicone rubber has been found to be particularly suitable for use. Other elastomeric materials suitable for use include latex and Neoprene. In general, it is desirable to have a compliant material characterized by a stiffness at least an order of

magnitude less than the compressive stiffness of the transducer along the transducer axis.

As described in the foregoing, the electrical coupling may comprise wire leads or a flexible printed circuit board. In general, flexible leads having a lesser diameter than the thickness of the transducers 204 (e.g., less than .25 mm) have been found to provide the necessary compliance. The thickness of the flexible circuit board substrate 300 should also be less than the thickness of the transducers 204 (e.g., less than .25 mm).

Finally, reference is directed in particular to our co-pending European patent application 823071985, corresponding with U.S. patent application 336,672, which relates to the manner in which the transducer is supported at both end regions, and also to our European patent applications 82307117 and 82307185 corresponding respectively with U.S. patent applications 336,601 and 336,602, which are concerned with other aspects of ink jet apparatus such as of the kind disclosed herein.

CLAIMS:

1. An ink jet array characterised in that it comprises a plurality of chambers (200) having ink jet droplet ejection orifices (202) therein, a plurality of elongate transducers (204) respectively coupled to said chambers for ejecting ink from said orifices in response to energisation thereof, and supporting means (228, 230) for said transducers comprising a rigid portion (228) and a compliant clamping portion between said rigid portion and said transducers (204) in an area along the axis of elongation of the transducers.

2. An ink jet array according to claim 1, characterised in that the compliant clamping portion (230) comprises an elastomeric material.

3. An ink jet array according to claim 2, characterised in that said elastomeric material comprises silicone rubber.

4. An ink jet array according to claim 2 or 3, characterised in that said elastomeric material is characterised by a stiffness at least an order of magnitude less than the stiffness of the corresponding transducer (204).

5. An ink jet array according to any preceding claim, characterised in that a transverse cross-section through each of said transducers (204) is substantially surrounded by said compliant clamping portion (230).

6. An ink jet array according to any one of claim 1 to 4, wherein a transverse cross-section through each of said transducers (204) is only partially surrounded by said compliant clamping portion (230).

7. An ink jet array according to any preceding claim, characterised in that it further comprises a compliant electrical connection (240, 242) to said transducers.

8. An ink jet array according to claim 7, characterised in that said compliant electrical connection (240, 242) comprises a flexible substrate (300) and planar conductors (304) thereon.

9. An ink jet array according to claim 7, characterised in that said compliant electrical connection comprises a flexible arrangement (300, 304, 306, 248) including planar conductors (304, 306).

10. An ink jet array according to claim 7, characterised in that said compliant electrical connection comprises wire leads (240, 242).

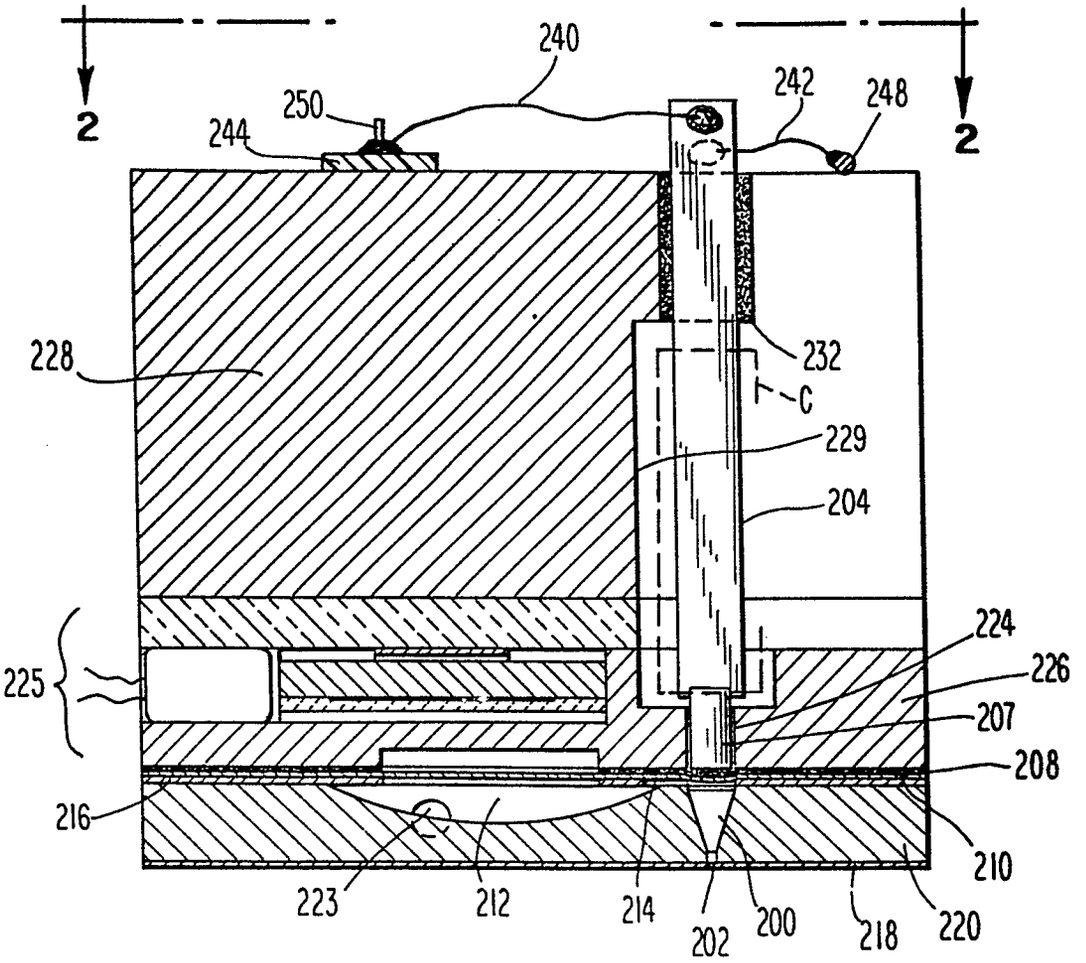
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Fig. 1

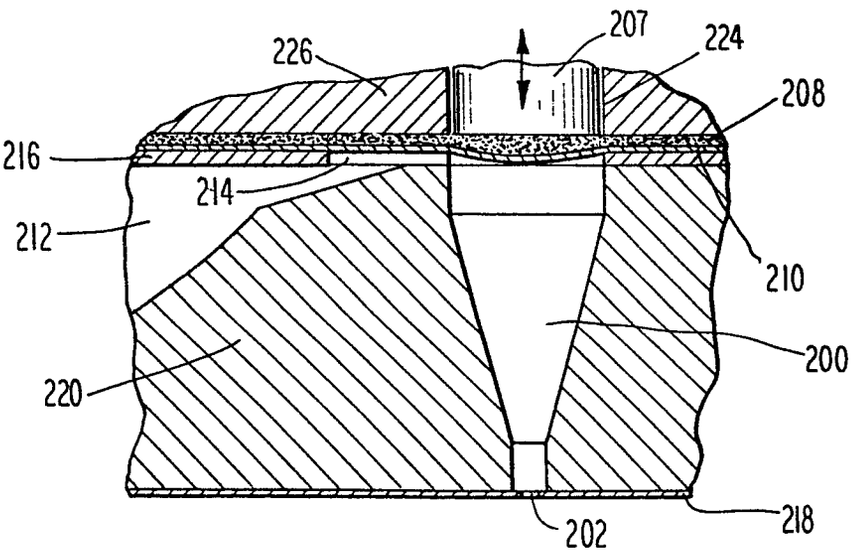
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Fig. 1A

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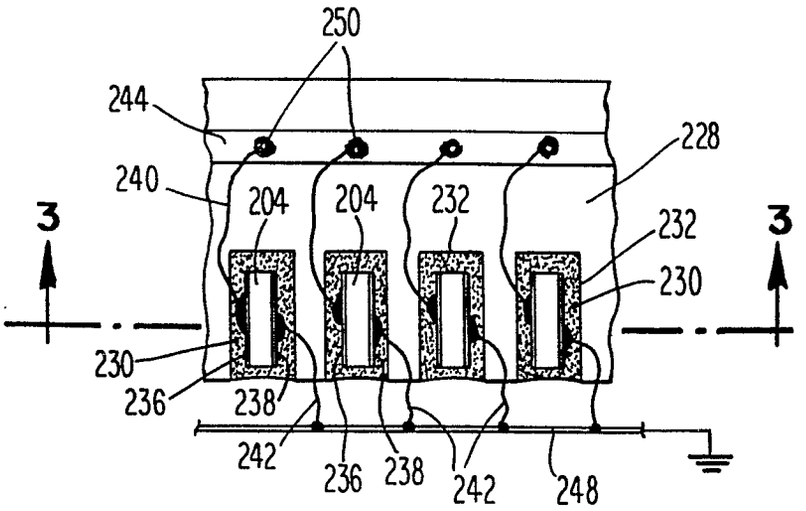

Fig. 2

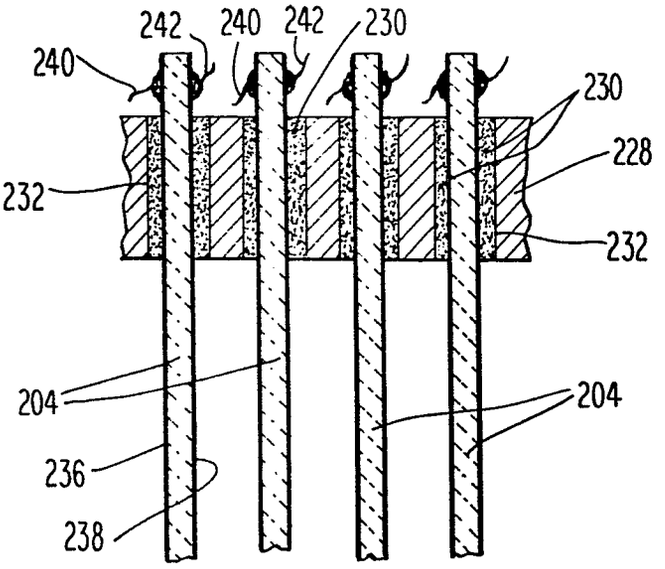

Fig. 3

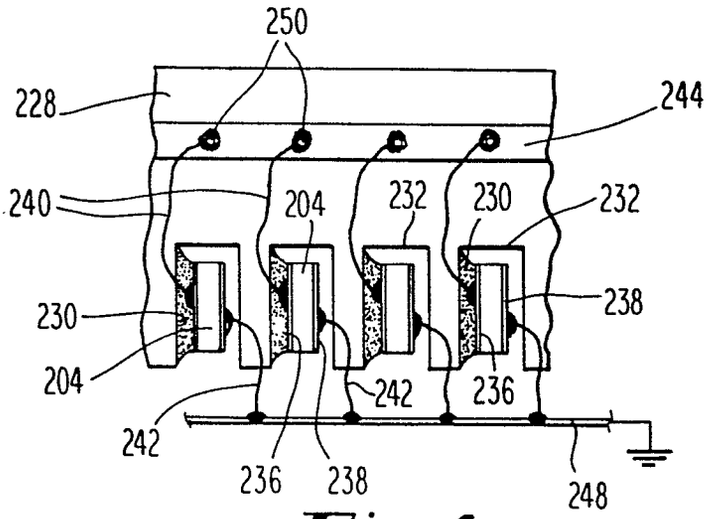

Fig. 4

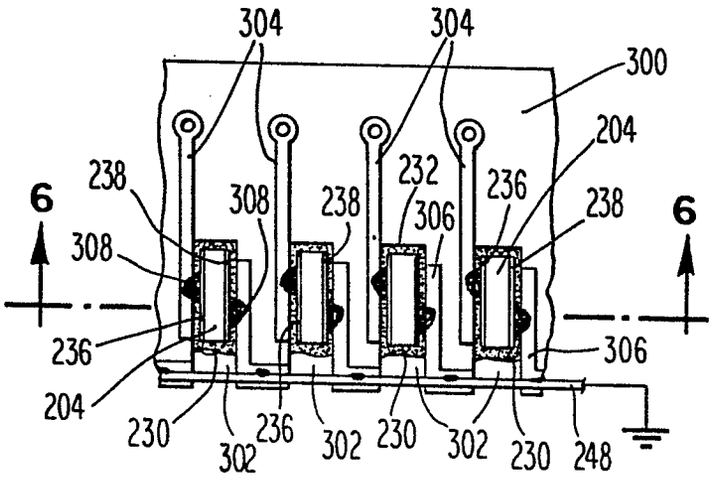
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Fig. 5

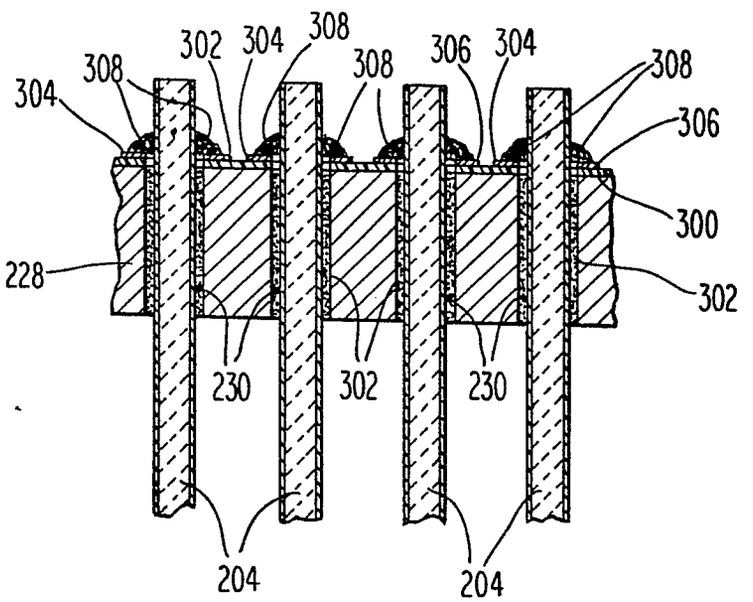
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Fig. 6