

⑫

EUROPEAN PATENT APPLICATION

⑲ Application number: **89312882.7**

⑤① Int. Cl.⁵: **B41J 2/04**

⑳ Date of filing: **11.12.89**

③① Priority: **30.12.88 GB 8830398**

④③ Date of publication of application:
04.07.90 Bulletin 90/27

⑧④ Designated Contracting States:
AT CH DE ES FR GB GR IT LI NL SE

⑦① Applicant: **AM INTERNATIONAL
INCORPORATED**
333 West Wacker Drive Suite 900
Chicago Illinois 60606-1265(US)

⑦② Inventor: **Michaelis, Alan John,**
1800 Crest Road,
Itasca, Illinois 60143,(US)

⑦④ Representative: **Coleman, Stanley et al**
MATHYS & SQUIRE 10 Fleet Street
London EC4Y 1AY(GB)

⑤④ **Droplet deposition apparatus.**

⑤⑦ A pulsed droplet deposition apparatus comprises a high density array of parallel droplet ejection channels. Pressure cross-talk between the channels is diminished by selectively operating the channels in time successive groups, with the channels of the groups interleaved with one another such that one unoperated channel is disposed adjacent each operated channel. Pressure cross-talk is further diminished by providing a pressure signal for operating each selected channel whose magnitude is dependent upon the operational status of neighbouring channels.

EP 0 376 532 A1

Droplet Deposition Apparatus

This invention relates to pulsed droplet deposition apparatus and more particularly such apparatus of the kind comprising a high density array of parallel channels, respective nozzles communicating with said channels droplet liquid supply means connected to said channels and electrically operated means for imparting pressure signals to droplet liquid in said channels to effect droplet ejection therefrom. By, "a high density array" is meant one in which are present at least two channels per millimetre in the array direction i.e. in the direction normal to the channel axes. The most familiar form of apparatus of the kind set forth is the so-called "drop-on-demand" ink jet printer. As channel density is increased the compliance of the channel dividing walls is increased and the size and velocity of drop ejected by a channel is changed depending on whether a neighbouring channel is operated or not, this effect being known as "pressure cross-talk".

The present invention has for its principal object the provision of pulsed droplet deposition apparatus in which the effect of pressure cross-talk is diminished.

The present invention consists in a pulsed droplet deposition apparatus comprising a high density array of parallel channels of which adjacent channels are divided by respective inactive walls, respective nozzles communicating with said channels, droplet liquid supply means connected with said channels and electrically operated means for imparting pressure signals to droplet liquid in the channels to effect droplet ejection from the nozzles, characterised in that said channels are arranged in interleaved relationship in a plurality of groups and said electrically operated means are adapted to effect in each group of channels substantially simultaneous ejection of drops from respective selected channels thereof, the ejection of drops from said selected channels of the groups being effected group by group sequentially and the disposition of the channels of the groups being arranged so that when droplet ejection takes place from said selected channels of any one of said groups, there is disposed between any two of said selected channels at least one channel of another of said groups of channels.

Suitably, the channels of the groups are arranged with channels of the respective groups disposed in alternating sequence. In one form the channels are arranged in two groups.

Advantageously, the electrically operated means are adapted to impart pressure signals respectively to selected channels of the groups the magnitude of which depend in the case of each

selected channel on the selected or non-selected status of a plurality of channels on each side of each selected channel.

Preferably, where the channels are arranged in two groups, said electrically operated means are adapted to impart pressure signals respectively to selected channels of the groups of magnitudes which depend in the case of each selected channel on the selected or non-selected status of at least two channels of the same group as the selected channel on each side of the selected channel.

The invention also consists in a pulsed droplet deposition apparatus comprising a high density array of parallel channels of which adjacent channels are divided by respective inactive walls, respective nozzles communicating with said channels, droplet liquid supply means connected with said channels and electrically operated means for imparting pressure signals to droplet liquid in the channels to effect droplet ejection from the nozzles, and in which said channels are formed at corresponding longitudinally extending edges of the channel inactive dividing walls thereof with respective displaceable wall parts of poled piezo-electric material and said electrically operated means comprise first electrodes at respective edges of each of said displaceable wall parts adjacent and parallel to said channel dividing walls and second electrodes engaging said displaceable wall parts and respectively disposed between said first electrodes to form therewith and with said piezo-electric material shear mode actuators for effecting drop expulsion from said channels, each such actuator providing two capacitors formed respectively at opposite sides of the second electrode thereof between that electrode and the first electrodes adjacent thereto, characterised in that said channels are arranged in interleaved relationship in a plurality of groups and said electrically operated means are adapted to effect in each group of channels substantially simultaneous ejection of drops from respective selected channels thereof, the ejection of drops from said selected channels of the groups being effected group by group sequentially and the disposition of the channels of the groups being arranged so that when droplet ejection takes place from said selected channels of any one of said groups, there is disposed between any two of said selected channels at least one channel of another of said groups of channels.

The invention further consists in a pulsed droplet deposition apparatus comprising a high density array of parallel channels, respective nozzles communicating with said channels, droplet liquid supply means connected with said channels

and electrically operated droplet liquid heating means for imparting pressure signals to said droplet liquid in said channels by formation of vapour bubbles therein to cause droplet ejection from said nozzles, characterised in that said channels are arranged in interleaved relationship in a plurality of groups and said electrically operated means are adapted to effect in each group of channels substantially simultaneous ejection of drops from respective selected channels thereof, the ejection of drops from said selected channels of the groups being effected group by group sequentially and the disposition of the channels of the groups being arranged so that when droplet ejection takes place from said selected channels of any one of said groups, there is disposed between any two of said selected channels at least one channel of another of said groups of channels.

The invention additionally consists in a pulsed droplet deposition apparatus comprising a high density array of parallel channels, respective nozzles communicating with said channels, droplet liquid supply means connected to said channels and electrically operated means for imparting pressure signals to droplet liquid in said channels to effect droplet ejection from said nozzles, characterised in that the electrically operated means are adapted to impart pressure signals to selected channels of the array of magnitude respectively which depend in the case of each selected channel on the selected or non-selected status of at least one channel on each side of and adjacent to said selected channel.

The invention will now be described by way of example with reference to the accompanying drawings, in which:-

FIGURE 1 is a circuit diagram of a fragment of electrically operated means employed in accordance with this invention in a pulsed droplet deposition apparatus of the form illustrated in the drawings of United States Patent 4,584,590, the contents of which are incorporated herein by reference; and

FIGURE 2 is a circuit diagram of a fragment of electrically operated means employed in accordance with this invention in a pulsed droplet deposition apparatus of the form illustrated in the drawings of U.S. Patent 4,296,421, the contents of which are incorporated herein by reference.

Referring to the embodiment of the invention illustrated in Figure 1, pulsed drop deposition apparatus is provided as a series of butted modules each of the form described with reference to, and as shown in the drawings of U.S. patent 4,584,590, that is to say, (see Fig. 4 of said U.S. Patent) having a channel body 15 formed with a high density array of parallel channels 21 connected to respective drop ejection nozzles closed by an isolating layer 17 and a piezo-electric layer 3 flanked

by first electrodes 5, 7 at the sides of each channel and second electrodes 9a, b, c and 11a, b, and c disposed centrally in the part of the layer 3 spanning each channel. The first electrodes and second electrodes form a pair of parallel connected capacitors 100 of each channel which at a common side thereof (i.e. the electrodes 5, 7) are connected to a bus 102, which is grounded, of an integrated circuit chip 104 which comprises electrically operated means for imparting pressure signals to droplet liquid in the channels for droplet ejection therefrom by way of the associated nozzles. Each pair of capacitors extends in the layer 3 from the electrodes 9,11 at the centre of the corresponding channel to the electrodes 5,7 at edges of that channel. The electrodes 9,11 of the capacitors 100 are common connected to field effect transistors 106 108 of which transistor 106 is a charging transistor and has its source/drain path connected to a charging bus 110 of the chip 104 and the transistor 108 is a discharging transistor and has its source/drain path connected to a discharging bus 112 of the chip. A signal generator 114 of the chip is connected between the grounded bus 102 and each of the buses 110 and 112. The gate electrodes 116 and 118 respectively of transistors 106 and 108 are connected to a register 120 in a logic block 122, the register supplying to and removing from transistors 106 and 108 logic signals for effecting and terminating conduction thereof.

Also connected to the register 120 of each pair of channel capacitors 100 is a line 124 by way of which a data stream of N bits which defines the print pattern of the array of channels is supplied to the register 120. A further line 126 which also connects with the signal generator 114, supplies high frequency, suitably about 10MHertz, clock pulses to each of the registers 120. A further lower frequency clock line 128 supplies clock pulses to the signal generator to cause initiation of a charging and discharging voltage waveform having a relative slow initial rising voltage ramp portion, an intermediate portion during which the voltage attained in the ramp portion of the waveform is not allowed to fall, and, a final portion in which the voltage falls rapidly to zero. The capacitors 100 of the channels selected by the data stream N are charged during the initial portion of this waveform by reason of the corresponding registers 120 sending logic signals to the gate electrodes 116 of the associated transistors 106. At the end of the ramp portion of the voltage waveform the logic signals to the gate electrodes of the selected channels are removed and this state is maintained during the intermediate portion of the waveform at the end of which the data stored in the registers 120 sends to each of the gate electrodes 118 of the transistors 108 of the selected channels a logic signal to

render those transistors conducting. Before conduction of the transistor 108 of the selected channels takes place, a voltage waveform is applied to the bus 112 to raise its voltage to near that of the charged voltage of the capacitors 100 and when the transistors 108 concerned are made conducting, the voltage on the bus 112 is lowered to discharge the capacitors at a rapid rate but one which prevents damage by surge currents to the discharge transistors 108.

During the charging of the capacitors 100 of the selected channels, the corresponding portions of the piezo-electric layer 3 spanning those channels move outwards causing flow into the selected channels of droplet liquid at a rate which is insufficient to cause droplet ejection from adjoining channels. In the intermediate portion of the applied waveform from the signal generator the liquid in the channels settles and in the final portion of the waveform, the portions of the layer 3 that were moved outwards in the first portion of the waveform are rapidly returned to their initial positions thereby imparting a pressure signal to the selected channels so causing droplet expulsion therefrom.

As the demand grows in droplet deposition apparatus for higher density of channels so the compliance of the channel dividing side walls increases and the effects of cross-talk become of greater significance. In the apparatus described in relation to Figure 1, the rapid return of the actuated parts of the piezo-electric layer 3 during the discharge phase of the capacitors 100 is resisted by the liquid in the selected channels to the end that bending moments are imparted to the actuated parts of the layer 3 which deflect the channel dividing side walls so that any particular selected channel may be expected to generate a pressure different from that which would obtain were the channel walls rigid and which depends on whether or not the neighbouring channels are selected or not for actuation with the result that the drop ejected from the channel is not of desired size or velocity.

This effect is that of pressure cross-talk and in the apparatus described is reduced by arranging the channels in groups with the channels of the groups interleaved. Where the arrangement is that of two groups of channels the channels of one group alternate with those of the other group and alternating channels would usually be employed where there are more than two groups. For convenience, the description of Figure 1 now proceeds on the footing that the channels are arranged in two groups of alternating channels.

The data stream of N bits determines in one cycle of the waveform applied by the signal generator 114 the selection for actuation of the channels in one of the groups and, in the next cycle of that

5 waveform, the selection for actuation of the channels in the other of the groups. This is accomplished by loading the registers 120 with the print pattern data in the stream of N bits prior to printing of each line of droplets. The data stream addresses the channel registers 120 of the channel group concerned in series and so selects some or all of the channels of that group for actuation and loads data into the registers 120 of those channels. The next print line is initiated by a clock pulse on the line 128 which causes a cycle of the charging/discharging voltage waveform from the generator 114 to commence. At the time of commencement of this waveform, the data in the register 120 of each selected channel applies a logic signal to the gates 116 of the transistor 106 of the relevant channels so that the corresponding capacitors 100 are charged and discharged as described earlier to effect droplet ejection from the nozzles of the selected channels. Thereafter the data stream of N bits selects the channels of the other group which are to be actuated before the appearance on the line 128 of the next pulse so that when that pulse appears the selected channels are actuated to effect droplet ejection.

It will be appreciated that in the printing operation described, as any channel selected for printing has on opposite sides thereof at least one inactive channel, the incidence of cross-talk for any given density of channels is substantially reduced. If the channels were arranged in three groups there would be two inactive channels at least present on each side of any actuated channel reducing further, for the particular density of channels, the incidence of cross-talk.

Another way of reducing pressure cross-talk which can be used with or without the grouping of channels as described involves including in the data stream of N bits subsets each of n bits which are representative of the selected or non-selected status of at least one channel on opposite sides of each selected channel. In the case where the channels are arranged in two groups with the channels of one group alternating with those of the other group, typically each subset n comprises a four bit word representative of the selected or non-selected status of two channels of the same group as the selected channels on each side of each selected channel. If a six bit set is employed, the print status of three channels of the same group of channels on each side of each selected channel would thereby be taken into account. When, after completion of a printline, data from the N bit data stream is loaded into the registers 120 of the channels selected for the next cycle of the signal generator waveform, the subsets of n bits are sent to a look-up table in a ROM (not shown) which sends digital signals to the registers 120 which are

stored therein and which determine the level on the ramp of the first portion of the voltage waveform of the signal generator that the capacitors 100 of each selected channel are charged to take account of the selected or non-selected status of a number of channels of the same group as the selected channels on either side of each selected channel.

Referring now to Figure 2, in which like parts as those of Figure 1 have been accorded the same reference numerals, and which depicts the electrically operated means for driving a pulsed droplet deposition apparatus consisting of butted modules of the form described and illustrated in U.S. Patent 4,296,421, for example in Figures 16 to 19 thereof. The modules comprise a high density array of parallel channels formed at corresponding ends thereof with respective nozzles remotely from which the channels are connected to a common droplet liquid supply. Adjacent the nozzles, the respective channels are provided with resistive heating elements to which pulses of electrical energy are supplied which cause droplet ejection from the channels by reason of the heat energy transmitted by the heating elements to the droplet liquid in the channels causing formation in any individual channel of a vapour bubble which increases the pressure of liquid in the channel resulting in the expulsion from the channel nozzle of a droplet.

In Figure 2, the heating element of each channel is represented by a resistor 130 which is connected in series with the source/drain path of a field effect transistor 132, the gate electrode 134 of which connects with the corresponding register 120 in the logic box 122.

Operation of the circuit of Figure 2 is similar to that described for the circuit of Figure 1. Thus the data stream of N bits after a printing of a line of droplets from selected channels loads the registers 120 serially with data at the frequency - 10 mHertz approximately - of the clock pulses on line 126. When the next pulse on line 128 initiates the application of a voltage which in this case is of uniform magnitude to all transistors 132, between the buses 110 and 102, the registers 120 of the selected channels apply a logic signal to the transistor gates 134 so that heating current passes through the corresponding resistors which is terminated after a predetermined period by removal from the gates 134 of the applied logic signals. A current pulse of predetermined duration thus passes through the resistors 130 of the selected channels to effect droplet expulsion from those channels.

The compliance of the materials used for the channel modules of the apparatus for which the chip circuit of Figure 2 is employed is substantially greater than the piezo-electric channel body ma-

terials employed in the apparatus in which the chip circuit of Figure 1 is employed so that the need for cross-talk reduction is all the more important. Such reduction is effected in the same ways as described in relation to the apparatus in which the circuit of Figure 1 is used, that is to say by grouping of the channels and/or by compensating for the effect on each selected channel of the array or group within the array of channels of the selected or non-selected status of channels on opposite sides of each selected channel. In the case where grouping of channels is present compensation takes place for the effect on each of the channels selected of a group for the selected or non-selected status of a number of channels of the same group on each side of each selected channel. Where grouping is not resorted to, compensation takes place for the effect on each selected channel of the selected or non-selected status of a number of channels on each side of the selected channel. Compensation is effected by the ROM signals determined by the subsets of n bits within the data stream of N bits which give rise to signals from the ROM which are stored in the registers 120 and which determine the duration of the application of the voltage applied by the signal generator between the buses 110 and 102 to the resistors 130.

Where grouping of channels is involved the nozzles of the groups are spatially offset to compensate for the time interval between the successive actuation of the channels group by group to the end of ensuring that the drops of a complete printline are deposited collinearly.

Claims

1. A pulsed droplet deposition apparatus comprising a high density array of parallel channels of which adjacent channels are divided by respective inactive walls, respective nozzles communicating with said channels, droplet liquid supply means connected with said channels and electrically operated means for imparting pressure signals to droplet liquid in the channels to effect droplet ejection from the nozzles, characterised in that said channels are arranged in interleaved relationship in a plurality of groups and said electrically operated means are adapted to effect in each group of channels substantially simultaneous ejection of drops from respective selected channels thereof, the ejection of drops from said selected channels of the groups being effected group by group sequentially and the disposition of the channels of the groups being arranged so that when droplet ejection takes place from said selected channels of any one of said groups, there is disposed between any two of said selected channels at least one channel

of another of said groups of channels.

2. A pulsed droplet deposition apparatus as claimed in Claim 1, characterised in that the channels of the groups are arranged with channels of the respective groups disposed in alternating sequence.

3. A pulsed droplet deposition apparatus as claimed in Claim 2, characterised in that the channels are arranged in two groups.

4. A pulsed droplet deposition apparatus as claimed in any preceding claim, characterised in that the electrically operated means are adapted to impart pressure signals respectively to selected channels of the groups the magnitude of which depend in the case of each selected channel on the selected or non-selected status of a plurality of channels on each side of each selected channel.

5. A pulsed droplet deposition apparatus as claimed in Claim 4 and in which the channels are arranged in two groups, characterised in that said electrically operated means are adapted to impart pressure signals respectively to selected channels of the groups of magnitudes which depend in the case of each selected channel on the selected or non-selected status of at least two channels of the same group as the selected channel on each side of the selected channel.

6. A pulsed droplet deposition apparatus comprising a high density array of parallel channels of which adjacent channels are divided by respective inactive walls, respective nozzles communicating with said channels, droplet liquid supply means connected with said channels and electrically operated means for imparting pressure signals to droplet liquid in the channels to effect droplet ejection from the nozzles, and in which said channels are formed at corresponding longitudinally extending edges of the channel inactive dividing walls thereof with respective displaceable wall parts of poled piezo-electric material and said electrically operated means comprise first electrodes at respective edges of each of said displaceable wall parts adjacent and parallel to said channel dividing walls and second electrodes engaging said displaceable wall parts and respectively disposed between said first electrodes to form therewith and with said piezo-electric material shear mode actuators for effecting drop expulsion from said channels, each such actuator providing two capacitors formed respectively at opposite sides of the second electrode thereof between that electrode and the first electrodes adjacent thereto, characterised in that said channels are arranged in interleaved relationship in a plurality of groups and said electrically operated means are adapted to effect in each group of channels substantially simultaneous ejection of drops from respective selected channels thereof, the ejection of drops from said selected

channels of the groups being effected group by group sequentially and the disposition of the channels of the groups being arranged so that when droplet ejection takes place from said selected channels of any one of said groups, there is disposed between any two of said selected channels at least one channel of another of said groups of channels.

7. A pulsed droplet deposition apparatus as claimed in Claim 6, characterised in that the channels of the groups are arranged with channels of the respective groups disposed in alternating sequence.

8. A pulsed droplet deposition apparatus as claimed in Claim 7, characterised in that the channels are arranged in two groups.

9. A pulsed droplet deposition apparatus as claimed in any one of Claims 6 to 8, characterised in that the electrically operated means are adapted to impart pressure signals respectively to selected channels of the groups the magnitude of which depend in the case of each selected channel on the selected or non-selected status of a plurality of channels on each side of each selected channel.

10. A pulsed droplet deposition apparatus as claimed in Claim 9 and in which the channels are arranged in two groups, characterised in that said electrically operated means are adapted to impart pressure signals respectively to selected channels of the groups of magnitudes which depend in the case of each selected channel on the selected or non-selected status of at least two channels of the same group as the selected channel on each side of the selected channel.

11. A pulsed droplet deposition apparatus comprising a high density array of parallel channels, respective nozzles communicating with said channels, droplet liquid supply means connected with said channels and electrically operated droplet liquid heating means for imparting pressure signals to said droplet liquid in said channels by formation of vapour bubbles therein to cause droplet ejection from said nozzles, characterised in that said channels are arranged in interleaved relationship in a plurality of groups and said electrically operated means are adapted to effect in each group of channels substantially simultaneous ejection of drops from respective selected channels thereof, the ejection of drops from said selected channels of the groups being effected group by group sequentially and the disposition of the channels of the groups being arranged so that when droplet ejection takes place from said selected channels of any one of said groups, there is disposed between any two of said selected channels at least one channel of another of said groups of channels.

12. A pulsed droplet deposition apparatus, as claimed in Claim 11, characterised in that the chan-

nels of the groups are arranged with channels of the respective groups disposed in alternating sequence.

13. A pulsed droplet deposition apparatus, as claimed in Claim 12, characterised in that the channels are arranged in two groups.

14. A pulsed droplet deposition apparatus, as claimed in any one of Claims 11 to 13, characterised in that the electrically operated means are adapted to impart pressure signals respectively to selected channels of the groups the magnitude of which depend in the case of each selected channel on the selected or non-selected status of a plurality of channels on each side of each selected channel.

15. A pulsed droplet deposition apparatus, as claimed in Claim 14 and in which the channels are arranged in two groups, characterised in that said electrically operated means are adapted to impart pressure signals respectively to selected channels of the groups of magnitudes which depend in the case of each selected channel on the selected or non-selected status of at least two channels of the same group as the selected channel on each side of the selected channel.

16. A pulsed droplet deposition apparatus comprising a high density array of parallel channels, respective nozzles communicating with said channels, droplet liquid supply means connected to said channels and electrically operated means for imparting pressure signals to droplet liquid in said channels to effect droplet ejection from said nozzles, characterised in that the electrically operated means are adapted to impart pressure signals to selected channels of the array of magnitude respectively which depend in the case of each selected channel on the selected or non-selected status of at least one channel on each side of and adjacent to said selected channel.

17. A pulsed droplet deposition apparatus as claimed in Claim 16, characterised in that said electrically operated means are adapted to impart pressure signals to selected channels of the array of magnitudes which depend in the case of each selected channel on the selected or non-selected status of two channels on each side of said selected channel and next in the array direction thereto.

18. A pulsed droplet deposition apparatus as claimed in Claim 16 or 17, characterised in that said array of parallel channels is arranged in a plurality of groups of interleaved channels and said electrically operated means are adapted to effect selection of channels for actuation group by group in sequence, the disposition of the channels of the groups being arranged so that when droplet ejection takes place from said selected channels of any one of said groups, there is disposed between any two of said selected channels at least one channel

of another of said groups of channels.

19. A pulsed droplet deposition apparatus as claimed in Claim 17, characterised in that the channels of the groups are arranged with channels of the respective groups disposed in alternating sequence.

20. A pulsed drop droplet deposition apparatus as claimed in Claim 19, characterised in that the channels are arranged in two groups.

21. A pulsed droplet deposition apparatus as claimed in any one of Claims 1, 6, 11 and 18, characterised in that the nozzles of the respective groups are spatially offset to compensate for the time interval between actuation group by group of the selected channels of each group so that the deposited drops in each printline are collinearly disposed.

Neu eingereicht / New
Nouvellement déposé

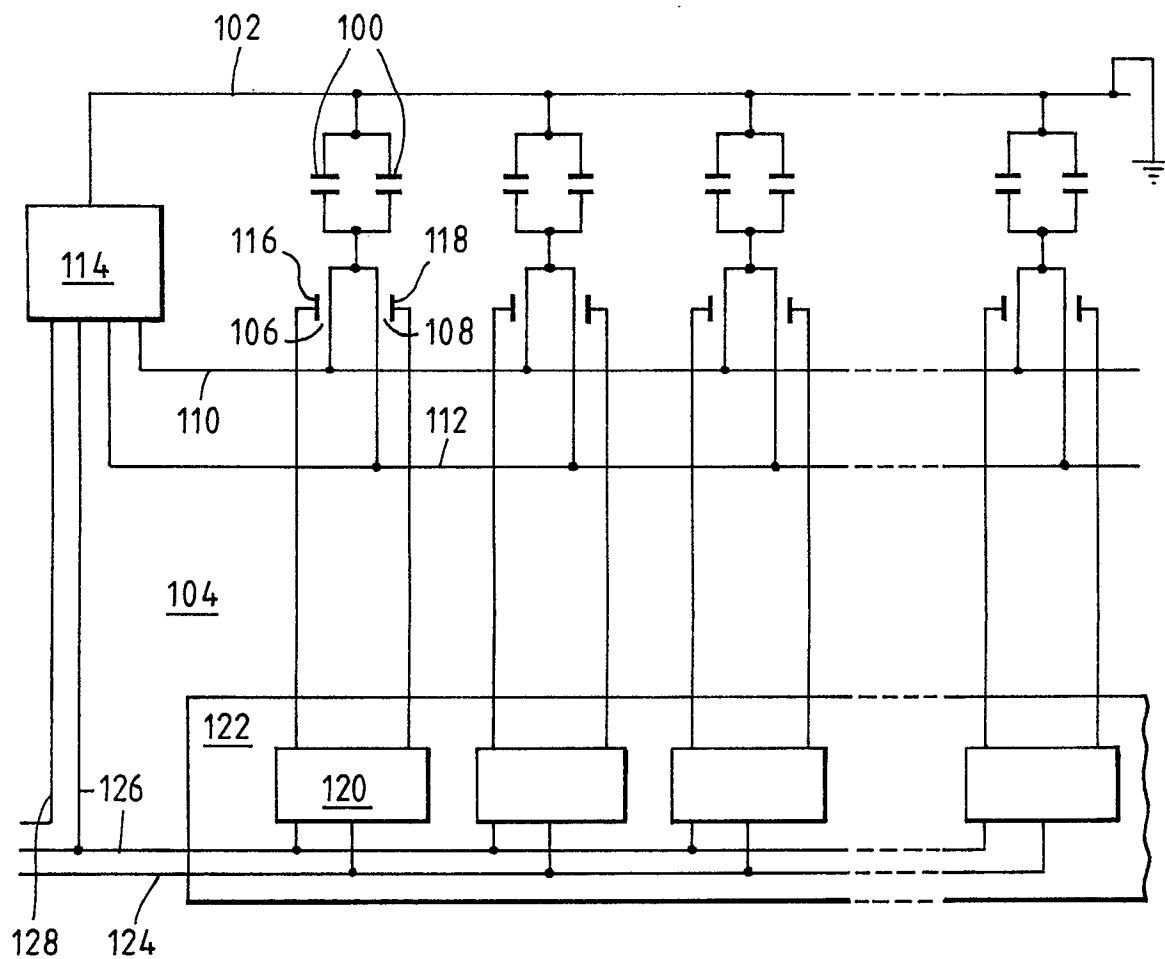


FIG. 1

Neu eingereicht / Newly filed
Nouvellement déposé

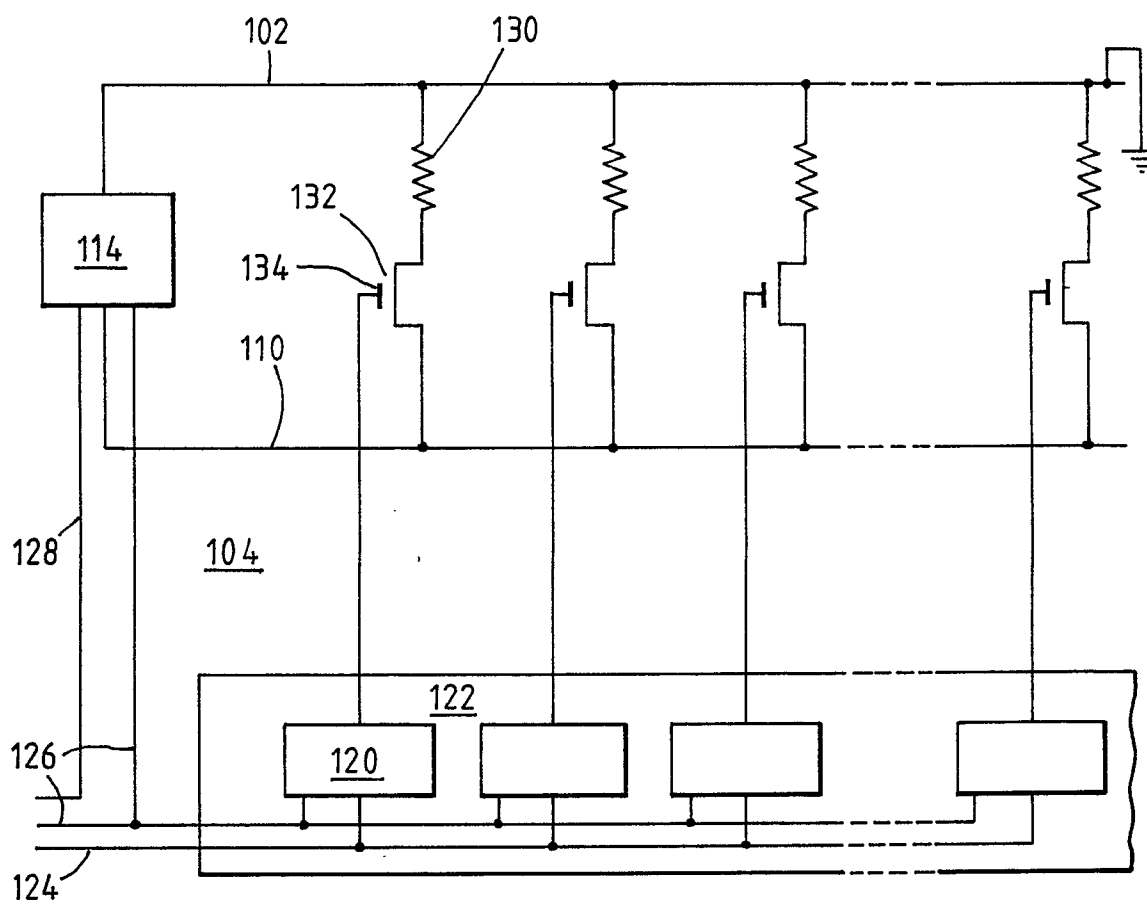


FIG. 2



DOCUMENTS CONSIDERED TO BE RELEVANT			EP 89312882.7
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int Cl ³)
Y	<u>EP - A1 - 0 278 590</u> (AM INTERNATIONAL INCORPORATED) * Totality *	1, 6	B 41 J 2/04
A	--	2, 3, 7, 8	
Y	<u>US - A - 4 395 146</u> (ARAI) * Totality *	1, 6	
A	--		
A	<u>EP - A2 - 0 103 943</u> (HEWLETT-PACKARD COMP.) * Totality *	1, 11, 16	
D, A	<u>US - A - 4 584 590</u> (FISCHBECK) * Fig. 4 *	6	

The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (Int Cl ³)
			B 41 J G 01 D
Place of search		Date of completion of the search	Examiner
VIENNA		02-04-1990	WITTMANN
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone		T : theory or principle underlying the invention	
Y : particularly relevant if combined with another document of the same category		E : earlier patent document, but published on, or after the filing date	
A : technological background		D : document cited in the application	
O : non-written disclosure		L : document cited for other reasons	
P : intermediate document		& : member of the same patent family, corresponding document	