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(54) **Multi-chamber ink jet recording head for color use.**

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Description

This invention relates to multi-chamber ink jet recording heads providing ink isolation and selective access to differing colors of ink in the respective chambers for printing text or graphics. More particularly, this invention is directed to a multichamber ink jet recording head having an improved nozzle plate employing nozzle formats in individual nozzle groups, corresponding to those of a single color recording head with which it is interchangeable.

Ink jet recording heads are used in printers and plotters. These include thermal and piezoelectric types for expelling ink. The term printer as used herein is used as a term of convenience and is not intended to exclude other types of recording such as plotting.

Black ink is used in most printing applications, but there is a developing need for the use of colored inks in printing text and graphics. Heretofore, printers having recording heads designed for single color printing have not been retrofitted with color recording heads which may be interchangeably fittable in the printer carriage designed for the single color recording head, because of differing requirements resulting from pen body configurations, usually larger for accommodating several colors of ink, nozzle spacing and grouping, and control requirements, to name a few. While multicolor recording heads can be provided with a chamber for black ink, where a printer is predominately used for black text or graphics, a supply of black ink in a multicolor recording head fitting an all black or other single color recording head carriage mount is limited in volume. Thus interchangeable single color/multicolor recording heads in a printer increase the utility of an otherwise single color printer or recorder.

Patents 4,511,907 ; 4,540,996 ; 4,611,219 ; 4,630,076 and 4,631,548 are related to this invention in the sense that they are all directed to multi-color ink jet printers. None of these, however, appear to teach or to suggest a configuration for a multicolor recording head which is interchangeable with a single color recording head in a single color printer.

Patent 4,511,907 describes a color printer having a plurality of recording heads arranged in a horizontal direction, the nozzles in each being arranged in a vertical direction. The signals for printing are delayed for the second and subsequent recording heads by the time required for the carriage to move the distance between the first recording head and the second or subsequent recording heads.

Patent 4,540,996 describes the positioning of a plurality of different color recording heads in the scan direction with respect to one another and the nozzles in each in terms of dot intervals for the purpose of defining an arrangement preventing double recording.

Patent 4,611,219 describes a liquid jetting printer comprising a plurality of perforated plates providing two channel isolation with alternate ink passages for thermal ink jet operation.

Patent 4,630,076 describes a multicolor recording head having horizontally spaced nozzle groups, each of which includes a row of nozzles inclined at an angle to the horizontal. An arrangement is described employing white or transparent dot over printing of a previously deposited color dot to cause color bleeding for achieving color tinting.

Patent 4,631,548 provides a plurality of ink reservoirs for different colors of ink in an ink jet printer. Multicolor images are printed using the dot matrix principle. Dot diameter is controlled, either by adjusting the volume of ink in each droplet inversely with a number of droplets in a matrix dot, or preselecting a constant volume for the droplets and using the same number of the same or different colors of droplets in forming each matrix dot.

All of the patents aforesaid are related to this invention in the use of individual nozzle groups for differing colors and in the employment of dot matrix techniques for printing. None, however, are concerned with the interchangeability of a multicolor recording head with a single color recording head in a single color printer, particularly as to the arrangement of the nozzle formats in the respective nozzle groups for each chamber in the multichamber reservoir of the pen.

U.S. 4540996 discloses a multicolor ink jet pen with a top and a bottom, having a plurality of nozzle groups each comprising a plurality of nozzles, each nozzle group having a predefined length and width and receiving a different colour of ink. This disclosure corresponds to the introductory portion of claim 1.

Each nozzle group is contained in a separate recording head. This makes the ink jet pen too large to be used on known single color ink jet pens.

According to the invention there is provided a multicolor ink jet pen with a top and a bottom, having a plurality of nozzle groups, each comprising a plurality of nozzles, each nozzle group having a predefined length and width and receiving a different color of ink, characterised in that the nozzle groups are arranged one above another, with each nozzle group laterally offset with respect to each adjacent nozzle group by at least a distance greater than said width to minimise the vertical separation between adjacent nozzle groups whilst providing a sealing surface area around each group for isolating the respective colors of ink at each nozzle group.

Minimising the vertical separation permits the inkjet pen to be made small enough to be interchangeable

with known single colour ink jet pens.

In a preferred arrangement the ink jet pen is multichambered and can be fitted to a recording apparatus which can be fitted either with the multichamber ink jet pen or a single color ink jet pen wherein the multichamber ink jet pen comprises a nozzle group of nozzles connected to each chamber by an ink path, the respective nozzles in each group arranged in a format corresponding to that of the single color ink jet pen.

Preferably, each nozzle group comprises two parallel columns of nozzles.

Preferably, each of said parallel columns of nozzles in a nozzle group has the same number of nozzles, one column of nozzles being displaced in a direction along the one column, one half of a nozzle space with respect to the other column of nozzles, defining an ink dot row space one dot row between corresponding nozzles in the two columns in a nozzle group, measured in a direction paralleling the columns of nozzles.

A multichamber ink jet recording head or pen for color use is provided which is retrofittable to a single color ink jet printer. A nozzle layout is provided such that even size paper steps in the paper feed direction allows full color printing with only about a 3% reduction in printable area. Color separation is provided by staggering the individual color groups of nozzles in the scan direction while maintaining the same dot per centimetre spacing of the nozzles within the groups and between the groups as in the single color printhead. Construction of the multicolor ink jet pen is essentially the same as that of the single color pen especially as to size and external configuration and as to the pen mounting details in the pen carriage. Only changes are made in the interior of the ink reservoir to provide for the isolated storing of four colors of ink and to the nozzle substrate to provide the separate color channels for printing.

By using the nozzle format of the single color pen in each of the color nozzle groups, all of the printer control characteristics for the standard single color pen are utilized in color printing, requiring only that firmware and software be provided with the capability for color printing. Formatting must include the color dot stagger offset.

The invention will be better understood by reference to the following specification when considered in conjunction with the accompanying drawings, in which :

Figure 1 is an exploded isometric view of a four color ink jet recording head or pen embodying the principles of this invention ;

Figure 2 is a cross sectional view of a sealing plate taken on the line II-II of Figure 1 ;

Figure 3 illustrates the layout or format of the nozzles of a single color printhead for a recording head or pen ;

Figure 4 is a resistor firing timing signal diagram for the nozzle format of Figure 3 ;

Figure 5 illustrates the layout of the printhead of one embodiment of the recording head or pen of this invention ;

Figure 6 is a cross sectional view of one nozzle of the printhead taken on the line VI-VI of Figure 5 ; and

Figure 7 illustrates the layout of the printhead of a second embodiment of the recording head or pen of this invention.

A disposable type thermal ink jet recording head or pen is employed in describing this invention. The invention, however, is not limited to a thermal ink jet type of pen, but is equally applicable to a piezoelectric type of ink jet pen. The printer or plotter in which the recording head or pen is mounted is not shown, it being understood that constant speed relative motion in one direction between the printing medium and the pen provides scanning for printing a line of text or graphics and that stepping relative motion between the printing medium and the pen in a direction orthogonal to the one direction positions the ink jet pen to print the next line of text or graphics.

In Figure 1, the recording head or pen illustrated comprises a printhead 60. The printhead comprises an orifice or nozzle plate 60a, containing nozzles 62 arranged in four nozzle groups 62a, 62b, 62c and 62d. The nozzle plate 60a is attached to a patterned substrate 61 having a thin film resistor array with an integral ink pathway which is in turn sealed in a cavity or recess 64 in a front plate 66 which is part of a plastic pen body 68 having individual ink chambers 68a, 68b, 68c and 68d which carry the ink supply. Each nozzle 62 supplies ink droplets on demand or command from the printer control system as the pen scans the print medium. In the thermal ink jet type of pen, the droplets of ink are ejected by instantaneously vaporizing a tiny volume of ink. The vapor bubble grows rapidly displacing and giving momentum to the ink between the bubble and the nozzle, which expels the ink through the selected nozzle onto the print medium. Ink is refilled automatically in the nozzle as the vapor bubble collapses. Blocks of foam 70a, 70b, 70c and 70d are compressed in the respective chambers of the ink reservoir. Advantageously, this foam material may be a reticulated polyurethane foam of the type disclosed in copending European patent application 87305776.4,publication No.0261764, entitled "Thermal Ink Jet Pen Body Construction Having Improved Ink Storage and Feed Capability and Multicolor Ink Dispensing Capability and Low Cost Construction", assigned to the present assignee and incorporated herein by reference. These blocks of foam are individually saturated with ink of the selected color, typically black, yellow, cyan and magenta. When the foam is installed in the respective chambers, the reservoirs are sealed by a rear cover plate 72 provided with individual vent holes 74 for venting the respective ink chambers to the atmosphere.

Provision (not shown) is made for preventing ink leakage out of these ports.

In one application, the pen is mounted with the nozzle plate 60a pointed downwardly. Ink is delivered to the nozzle plate under the influence of capillary force supplied by the ink pathway and the nozzles themselves.

The end face 69 as seen, of each of the foam filled ink chambers is provided with an opening. These are designated 68e, 68f, 68g and 68h. These are the ink chamber exit ports through which ink is delivered to each of the respective nozzle groups 62a, 62b, 62c, 62d in the printhead 60.

The individual ink paths for ink delivery from the ink chambers to the respective nozzle groups in the printhead 60 are defined by a sealing plate 76 having respective openings 76a, 76b, 76c and 76d therethrough, which provide the respective isolated channels or ink flow paths between the individual ports 68e-68h and the individual ports 64a, 64b, 64c, 64d, respectively, opening through the front plate 66 into the recess 64 in which the printhead 60 is sealed. These ports, e.g. 64a-64d, are in the geometry of elongated slots herein, and such slot-feed ink flow techniques and related electrical interconnect methods are known in the art. These techniques and methods are described for example in U.S. patents 4,680,859 and 4,683,481 issued to S. A. Johnson and U.S. Patent 4,635,073 issued to Gary E. Hanson, all assigned to the present assignee and incorporated herein by reference. The pattern of the ports 64a-64d corresponds to the pattern of the nozzle groups 62a-62d in the plate 60. The sealing plate 76 is provided with a beaded peripheral edge and beaded edges around each of the openings 76a-76d to provided positive sealing when compressed between the end face of the reservoir of the pen body 68 and the back face of the front plate 66.

When the front plate 66 of the pen body 68 is sealed in position compressing the sealing plate 76, individual ink paths are established from the respective ports 68e-68h via respective openings 76a-76d to the respective ports 64a-64d thus providing separate ink paths from the individual chambers 68a-68d to the respective nozzle groups 62a-62d.

In a thermal ink jet type of printhead 60, the patterned substrate 61 is provided with electrical contact pads 62e along the side edges of its face which individually communicate through circuit traces with the resistors at the nozzles which fire the drops of ink. These contact pads are schematically seen in Fig. 1. One patterned substrate format, detailing the circuit connections with the resistors, is seen in Figure 5, which will be described at a later point. These contact pads are individually engaged by corresponding contact points on the back side of a flexible circuit 78 having flexible circuit traces 78a thereon. The flexible circuit 78 has an opening through its face which straddles the plate 60. The edges of this opening overlap the contact pads 62e and are indexed with contact pads on the patterned substrate 61 to make electrical connections. This type of flexible circuit interconnection is described in the Hewlett-Packard Journal, dated May 1985 on page 14, which is included herein by reference. When the flexible circuit 78 is positioned with its circuit traces 78a in contact with the contact pads 62e of the patterned substrate 61, its bottom extension extends beneath the pen body 68. Here it is attached to the bottom side of the ink reservoir by an adhesive pad 80 or other fastening means.

To illustrate the adaptability of this multichamber ink jet recording head to single color printers, reference is made to Figure 3 of the drawings and to Table I herebelow. Figure 3 illustrates a pattern or format of one type of single color nozzle or orifice plate. This nozzle plate comprises two columns of nozzles, there being 25 nozzles in each column. The nozzles in each column are arranged in staggered groups of 3 as seen. The nozzles in the right column which are the odd numbered nozzles, 1-49, are displaced vertically, as viewed, with respect to the nozzles in the left column which are the even numbered nozzles, 2-50, by one-half the distance between the nozzles in the columns. The distance between the nozzles in the right column and the left column measured in a direction parallel to the columns, as indicated, is identified as one dot row or logical print position. The distance between the nozzle center line and the top nozzle in each row measured horizontally for nozzle number 2 is 5 dot row minus 8 μm and for the nozzle number 1 is 5 dot rows plus 8 μm. In one practical embodiment of this single color nozzle format, a dot row or logical print position is 84 μm (.0033 inches) and the total distance between corresponding nozzles, such as nozzle 1 and nozzle 2, is typically 10 dot rows and thus 840 μm (0.033 inches). The nozzles are staggered in the columns, typically in groups of three (3).

TABLE I

FIRING SEQUENCE	SHIFT OFFSET (1PP) * 0	10	TIMING OFFSET (µM)
0	20,46	19,45	0.0
1	14,40	13,39	2.5
2	8,34	7,33	5.5
3	2,28	1,27	8.0
4	22,48	21,47	11.0
5	16,42	15,41	13.5
6	10,36	9,35	16.5
7	4,30	3,29	19.0
8	24,50	23,49	22.0
9	18,44	17,43	24.5
10	12,38	11,37	27.5
11	6,32	5,31	30.0
12	26	25	33.0

* Print position or dot row

Table I illustrates the firing sequence of the resistors associated with each of the nozzles of Fig. 3. The timing signal diagram for the nozzle array of Figure 3 is seen in Figure 4, identifying the resistors fired with each pulse. The resistors on the recording head must be fired in a particular order to minimize cross talk. The location of the orifices is set so that the dots will all be fired in the same vertical column when there is a constant scan or printing velocity, typically 0.3 m/s (12 in./sec.), with a 3.25 µsec. electrical pulse width TPW and a 5.75 µsec dead time TDT, or interval between pulses (see Figure 4). The dot firing sequence and relative nozzle locations in microns are specified in Table I. When printing left to right, the indicated sequence is used. When printing right to left, the resistors are fired in the reverse sequence.

In the single colour ink jet recording head, the printhead 60 comprises the 2 columns of nozzles as seen in Figure 3. A single opening is all that is required to provide communication between a single ink chamber 68 in the pen body and the plate 60. This opening is configured as a slot 64, as seen in Fig.3, at the point where it opens through the face of a recess in which the nozzle plate is mounted, such as the recess 64 of Figure 1.

The nozzle format of Figure 3 is retained in the individual nozzle groups of the printhead 60 as seen in Figure 5. In effect, the nozzle column of Figure 3 is divided by four. Each nozzle group 62a-62d comprises 12 nozzles arranged in 2 columns of 6 having the dot row spacing between corresponding nozzles of the respective rows and having the same column spacing. Thus within each nozzle group the ink drop firing sequence is the same as that of the single colour pen.

In the arrangement shown in Figure 5, the common contact pads are shown in the four corners of the substrate 61 of the printhead 60. A circuit trace from the common contact pad in the upper left corner of the substrate 61 connects to the resistors R of the even numbered nozzles of the nozzle groups 62a and 62c. The common contact pad in the upper right hand corner of the substrate 61 connects to the resistors R of the odd numbered nozzles of the nozzle group 62a and 62c. The common contact pad in the bottom left corner of the substrate 61 connects to the resistors R of the even numbered nozzles of the nozzle groups 62b and 62d and finally the common contact pad in the bottom right corner of the substrate 61 connects to the resistors R of the odd numbered nozzles of the nozzle groups 62b and 62d. The remaining contact pads numbered 1-48 are connected by circuit traces C to individual resistors R of correspondingly numbered nozzles in the individual nozzle groups.

Only 48 of the 50 nozzles of Figure 3 are needed in developing the nozzle and circuit format of the printhead 60 of Figure 5. Two nozzles must be eliminated from Figure 3. A factor to be considered in the resistor firing sequence in the arrangement of Figure 5 is the need to avoid firing resistors together which are coupled by a common ground circuit trace. For example, the resistors R at nozzles 45 and 31 should not be fired together since they are coupled to the same common or ground circuit trace, the reason being that resistor firing voltages

are critical. Some voltage overdrive is required to guarantee ink drop development. But excessive overdrive shortens resistor life. Thus the firing voltages are kept as low as possible while still guaranteeing firing. The voltage drop in a ground circuit trace when two resistors in that circuit are fired simultaneously may result in uncertain ink drop formation.

One approach to solving this problem, while still retaining the firing sequence of the single color head, when the nozzle array of Figure 3 is divided in developing the nozzle and circuit format of Figure 5, is to eliminate the resistors and nozzles 25 and 26. When this is done, the resistors and nozzles 27 to 50 are moved up in the columns to maintain the 1 dot row spacing. Thus resistors and nozzles 27 and 28 move up into the positions occupied by resistors and nozzles 25 and 26 and those that follow shift correspondingly. Thus nozzles and resistors 27 and 28, occupying positions 25 and 26 must now be fired in the 25 and 26 position sequences, although they are still fired in the old 27 and 28 timing sequences, thus allowing for the same driver electronics. Similar considerations apply to the remainder of the higher numbered resistors and nozzles.

Table IIA below is the firing sequence for the nozzles and resistors based upon this development approach for the printhead 60 of Figure 5, showing the shift offset required in dot rows or logical print positions in firing the individual resistors.

TABLE IIA

FIRING SEQUENCE	0		10		16		26		TIMING OFFSET (μM)
0					20	44	19	43	0
1					14	38	13	37	2.5
2	8	32	7	31					5.5
3	2	26	1	25					8.0
4					22	46	21	45	11.0
5					16	40	15	39	13.5
6	10	34	9	33					16.5
7	4	28	3	27					19.0
8					24	48	23	47	22.0
9					18	42	17	41	24.5
10	12	36	11	35					27.5
11	6	30	5	29					30.0
12									33.0

An alternative and presently preferred approach to selecting 48 of the 50 nozzles of Figure 3 while avoiding firing two resistors in a single ground trace, is to eliminate nozzles and resistors 49 and 50. The resistor firing sequence for this arrangement is shown in Table IIB below.

TABLE IIB

FIRING SEQUENCE	0		10		16		26		TIMING OFFSET (µM)
0					20	46	19	45	0
1					14	40	13	39	2.5
2	8	34	7	33					5.5
3	2	28	1	27					8.0
4					22	48	21	47	11.0
5					16	42	15	41	13.5
6	10	36	9	35					16.5
7	4	30	3	29					19.0
8					24		23		22.0
9					18	44	17	43	24.5
10	12		11			38		37	27.5
11	6	32	5	31					30.0
12		26		25					33.0

The printhead 60 of Figure 5 is arranged as four groups of 12 nozzles with each group associated with one of the four ink colors. Each 12 nozzle group is arranged as two columns of 6 nozzles separated by 10 logical print positions or dot rows. The four nozzle groups are arranged such that the columns of groups are offset from each other by 16 logical print or dot row positions. When firing the nozzles, data for nozzle groups 62c, 62d is shifted 16 dot rows from the rest of the nozzle data to adjust for the group offset. With the nozzle group data shifted, the multicolor nozzle format or pattern is the same as two columns of 25 nozzles separated by 10 dot rows, the format of Figure 3. The resistors are fired in a specific order to minimize internozzle crosstalk. The location of the nozzles has been set (Timing Offset) so that the dots in one of the 25 nozzle equivalent columns (after stagger correction of the nozzle groups) will all be fired in the same vertical column when the head is moving at 30.48 cm/sec (12 in/sec) horizontally (with a 3.25 µsec pulse width and 5.75 µsec dead time). The dead time is adjusted to suit a selected carriage constant velocity.

The dot firing sequence and relative orifice locations are shown in Tables IIA and IIB. When printing left to right, the indicated sequence should be used with the Shift Offset being data delay units. When printing right to left, the resistors should be fired in the reverse sequence with the Shift Offset being data advance units. The resultant print will be a vertical column of dots as though all nozzles were located in a line at the physical position of the first nozzle to fire when the sequence started.

The location of individual nozzles 62 in Figure 5 is shown only as a small circle over the individual resistors. The nozzle or orifice plate 60a detail is not shown in this figure to minimize confusion in an already highly detailed drawing. By way of explanation with regard to the nozzle plate 60a, reference is made to Figure 6 depicting an enlarged cross sectional view through a section of the printhead 60 taken on the line VI-VI of Figure 5. This section line is shown at the top left side of the nozzle group 62b and is a section through nozzle 28. Other even numbered nozzles are the same. Odd numbered nozzles are reversed.

As described in the Hewlett-Packard Journal, referenced hereinabove, particularly in the article entitled "Development of the Thin-Film Structure for the ThinkJet Printhead" beginning on page 27 of that journal, the printhead 60 comprises a glass substrate 82 on which a silicon dioxide barrier, SiO_2, 84, is deposited. The individual resistors are tantalum aluminum, TaAl. The circuit traces C for the individual resistors R are next deposited to connect the resistors to the respective contact pads. A passivation layer P is next deposited to protect the resistor R from reacting directly with the ink. The ink being an effective electrolyte, isolation is required. The passivation layer permits heat transfer from the resistor to the ink while providing physical, chemical and electrical isolation from the ink.

A nozzle plate 60a is electroformed over a mandrel. Usually this nozzle plate is electroformed of nickel. It comprises a body defining individual ink cavities, or priming cavities 86a into which the ink is admitted. This cavity opens into the nozzle 62. The ink meniscus line is shown bridging the nozzle opening. The ink cavities for the even and odd numbered nozzles in each nozzle group are joined by a manifold, defining a manifold cavity 86b extending between the nozzles, which bridges an opening 64b' in the glass substrate 82 and the layers deposited thereon. This opening 64b' registers with the opening 64b at the location of the section line VI-VI as

seen in Figure 5. The separately electroformed nozzle plate 60a is bonded to the laminated substrate structure by means of a polyimide or polymer material 88, such as RISTON or VACREL, which are trade name polymer materials of the E.I. Dupont Company of Wilmington, Delaware. The polymer material 88 is disposed on the laminated substrate over the area covered by the nozzle plate 60a around and between the nozzle groups, as seen in Figure 5, and outlines the cavities 86a and the manifold 86b therebetween in the nozzle groups. The staggering of the nozzle groups provides adequate polymer sealing between the nozzle plate and the substrate to achieve ink isolation and improves the substrate strength around the ink feed holes 64a-64d.

Another design of the nozzle plate structure is provided in U.S. Patent 4,694,308, to C.S. Chan, et al, filed November 22, 1985, entitled "Barrier Layer and Orifice Plate for Thermal Ink Jet Printhead Assembly ; assigned to the assignee of this invention and incorporated herein by reference.

As seen in Figure 5, the individual nozzles 62 in a group of nozzles are 1 dot row apart and the nozzles between the four nozzle groups are preferably, but not limited to, 1 dot row apart, in the paper motion or stepping direction, there being 12 nozzles in each nozzle group. In the example described herein, each nozzle group can print a nozzle stripe which is 0.1 cm (0.04 inches) wide. Thus a paper step of 0.1 cm (0.04 inches) permits colour overlaying on subsequent passes. In the scan direction, the nozzle groups are staggered by 8 dot rows off the center line indicated in Figure 5. This provides for an effective stagger of 16 dot rows between the centers of the colour groups. In the embodiment of this invention which is being described, this stagger allows approximately 0.51 mm (20 mils) between the ink cavities for sealing with the polymer material. This sealing line is roughly equivalent to the ink cavity to the outside seal.

The ink supply from the pen body is also eased by the increasing clearance due to the stagger. Adequate sealing and separation on the back side of the glass substrate in the recess 64 of the front plate 66 is possible with this increased clearance.

The division of the ink reservoir of the single color pen into four cavities results in a total volume of ink, that is the volume of all of the colors, which is somewhat less than an all black or single color pen.

Since 1 dot row spacing can be maintained between the nozzles in the individual nozzle groups and the nozzles between the nozzle groups, this multichamber recording head or pen has the same continuous dot per centimetre dot spacing with four color capability as the single color printhead. This utilizes all of the single color printer system text and graphics control characteristics and requires only that firmware and software have the color capability. Formatting must be provided to provide the 16 dot stagger offset between the nozzle groups.

Figure 7 illustrates another embodiment of this invention in which the single color nozzle plate of Figure 3 is modified in a printhead to accommodate three nozzle groups in a three chamber ink jet pen or recording head. Each nozzle group comprises 16 nozzles in two columns of 8 occupying the same positions in the individual columns as the correspondingly numbered nozzles in Figure 3.

The nozzles of this printhead are arranged as three groups of 16 nozzles each, each group being associated with one of the three ink colors. The nozzles of each of the 16 nozzle groups are arranged as two columns of 8 nozzles separated by 10 logical print positions or dot rows. The three nozzle groups are arranged such that the middle group 62c is offset from the other two groups by 16 logical print or dot row positions. When firing the printhead, data for nozzles 17-32 should be shifted 16 logical print positions or dot rows from the rest of the nozzle data to adjust for the middle group offset. With the middle nozzle group data shifted, the nozzle arrangement is the same as that of two columns of 25 nozzles separated by 10 dot rows, as seen in Figure 3. The nozzle resistors R are fired in a specific order to minimize internozzle crosstalk. The location of the nozzles has been set (Timing Offset) so that the dots in one of the 25 nozzle equivalent columns (after stagger correction of the middle nozzle group) will all be fired in the same vertical column when the head is moving at 30.48 cm/sec (12 in/sec) horizontally (with a 3.25 μsec pulse width and 5.75 μsec dead time). The dead time is adjusted to suit a selected carriage velocity.

The dot firing sequence and relative orifice locations are shown in Table III. When printing left to right, the indicated sequence should be used with the Shift Offset being data delay units. When printing right-to-left, the resistors should be fired in the reverse sequence with the Shift Offset being data advance units. The resultant print will be a vertical column of dots as though all nozzles were located in a line at the physical position of nozzle 46 when the sequence started.

TABLE III

FIRING SEQUENCE	0	10	16	26	TIMING OFFSET (UM)
0	46	45	20	19	0.0
1	14 40	13 39			2.5
2	8 34	7 33			5.5
3	2	1	28	27	8.0
4	48	47	22	21	11.0
5	16 42	15 41			13.5
6	10 36	9 35			16.5
7	4	3	30	29	19.0
8			24	23	22.0
9	44	43	18	17	24.5
10	12 38	11 37			27.5
11	6	5	32	31	30.0
12			26	25	33.0

Claims

1. A multi-color ink jet pen with a top and a bottom, having a plurality of nozzle groups (62a-62d) each comprising a plurality of nozzles, each nozzle group having a predefined length and width and receiving a different color of ink, characterised in that the nozzle groups are arranged one above another, with each nozzle group laterally offset with respect to each adjacent nozzle group by at least a distance greater than said width to minimise the vertical separation between adjacent nozzle groups whilst providing a sealing surface area around each group for isolating the respective colors of ink at each nozzle group.

2. An ink jet pen according to claim 1 for a recording apparatus which can be fitted either with the multi-chamber ink jet pen or a single color jet pen, wherein the multi-chamber ink jet pen comprises a group (62a-62d) of nozzles (1,2,3,4 etc.) connected to each chamber (68a-68d) by an ink path 68e-68h, 76a-76d, 64a-64d), the respective nozzles in each group arranged in a format corresponding to that of the single color ink jet pen.

3. An ink jet pen according to claims 1 or 2, in which each nozzle group (62a-62d) comprises two parallel columns of nozzles (1-11, 2-12 ; 13-23, 14-24 ; 25-35, 26-36 ; 37-47, 38-48).

4. An ink jet pen according to claim 3, in which each of said parallel columns of nozzles (1-11, 2-12 ; 13-23, 14-24 ; 25-35, 26-36 ; 37-47, 38-48) in a nozzle group (62a-62d) has the same number of nozzles, one column of nozzles being displaced in a direction along the one column, one half of a nozzle space with respect to the other column of nozzles, defining an ink dot row space one dot row between corresponding nozzles (11, 12) in the two columns in a nozzle group measured in a direction paralleling the columns of nozzles.

5. An ink jet pen according to claims 3 or 4, in which : each ink path (68e-68h, 76a-76d, 64a-64d) has an opening (64a', 64b', 64c', 64d') at each nozzle group (62a-62c) in a position between said two parallel columns of nozzles, said opening extending substantially along the length of said columns of nozzles in the nozzle group (62a-62d).

6. An ink jet pen according to any of claims 3 to 5 for recording apparatus, further comprising a pen body (68) having a plurality of ink chambers (68a, 68b, 68c, 68d) ; a printhead (60, 66) having a plurality of spaced openings (64a', 64b', 64c', 64d') therein and a nozzle group (62a, 62b, 62c, 62d), at each opening (64a'-64d'); means (76) for mounting said printhead on said pen body ; and a manifold (86b) between each two parallel columns of nozzles in each nozzle group, said manifold comprising part of said ink path and being disposed at said opening (64a' or 64b' or 64c' or 64d') and providing communication of said opening to each nozzle of said two parallel columns of nozzles.

7. An ink jet pen according to claim 6, wherein said pen body comprises : an end plate common to all of

said ink chambers and having respective openings (68e-68h) therethrough into said ink chambers ; a front plate (66) on said pen body adjacent said end plate, on which said printhead is mounted and having openings (64a-64d) therethrough communicating respectively with each opening of said plurality of spaced openings ; and a sealing plate (76) disposed and compressed between said end plate and said front plate and having openings therethrough (76a-76d) defining individual passages between each opening in said end plate and a corresponding opening in said front plate, to provide an ink path from each ink chamber (68a-68d) to a corresponding nozzle group (62a-62d).

8. A method of operating an ink jet pen according to any preceding claim, wherein the nozzles (1, 2, 3, 4 etc) making up the nozzle group (62a-62d) are fired in an order corresponding to the firing order for the nozzles of a single colour ink jet pen containing the same number of nozzles.

Patentansprüche

1. Mehrfarb-Tintenstrahlstift mit einem Kopfende und einem Boden und mit mehreren Düsengruppen (62a-62d), von denen jede mehrere Düsen umfaßt, eine festgelegte Länge und Breite hat und eine andere Tintenfarbe aufnimmt, dadurch **gekennzeichnet**, daß die Düsengruppen übereinander angeordnet sind, jede Düsengruppe bezüglich jeder benachbarten Gruppe einen seitlichen Mindestversatz aufweist, der größer als die Breite ist, um den vertikalen Abstand zwischen benachbarten Düsengruppen zu minimieren und gleichzeitig einen abdichtenden Oberflächenbereich um jede Gruppe zu bilden, um die entsprechenden Tintenfarben jeder Düsengruppe zu isolieren.

2. Tintenstrahlstift nach Anspruch 1 für ein Aufzeichnungsgerät, das entweder mit dem Mehrkammer-Tintenstrahlstift oder mit einem Einfarb-Tintenstrahlstift bestückt sein kann, bei dem der Mehrkammer-Tintenstrahlstift eine mit jeder Kammer (68a-68d) über einen Tintenpfad (68e-68h, 76a-76d, 64a-64d) verbundene Gruppe (62a-62d) von Düsen (1, 2, 3, 4 etc.) aufweist, wobei die entsprechenden Düsen jeder Gruppe in einem dem Format des Einfarb-Tintenstrahlstiftes entsprechenden Format angeordnet sind.

3. Tintenstrahlstift nach Anspruch 1 oder 2, bei dem jede Düsengruppe (62a-62d) zwei parallele Düsenreihen (1-11, 2-12 ; 13-23, 14-24 ; 25-35, 26-36 ; 37-47, 38-48) aufweist.

4. Tintenstrahlstift nach Anspruch 3, bei dem jede der parallelen Düsenreihen (1-11, 2-12 ; 13-23, 14-24; 25-35, 26-36 ; 37-47, 38-48) einer Düsengruppe (62a-62d) dieselbe Anzahl von Düsen aufweist, wobei eine Düsenreihe in Richtung längs dieser einen Düsenreihe um einen halben Düsenabstand gegenüber den anderen Düsenreihen versetzt ist, wodurch ein Tintenpunktreihen-Zwischenraum einer Punktreihe zwischen entsprechenden Düsen (11, 12) in den zwei senkrechten Düsenreihen einer Düsengruppe, gemessen in Richtung parallel zu den Düsenreihen, definiert wird.

5. Tintenstrahlstift nach Anspruch 3 oder 4, bei dem jeder Tintenpfad (68e-68h, 76a-76d, 64a-64d) eine Öffnung (64a', 64b', 64c', 64d') an jeder Düsengruppe (62a-62c) aufweist, die zwischen den zwei parallelen Düsenreihen gelegen ist, und sich diese Öffnung im wesentlichen entlang der Länge dieser Düsenreihen der Düsengruppe (62a-62d) erstreckt.

6. Tintenstrahlstift nach einem der Ansprüche 3 bis 5 für ein Aufzeichnungsgerät mit weiterhin einem Stiftkörper (68) mit mehreren Tintenkammern (68a, 68b, 68c, 68d) ; einem Druckkopf (60, 66) mit mehreren voneinander entfernten Öffnungen darin, und mit einer Düsengruppe (62a, 62b, 62c, 62d) an jeder Öffnung (64a'-64d') ; einer Vorrichtung (76) zum Befestigen des Druckkopfes am Stiftkörper ; und mit einem Verteiler (86b) zwischen jeder der zwei parallelen Düsenreihen jeder Düsengruppe, wobei der Verteiler einen Teil des Tintenpfades umfaßt und an der Öffnung (64a' oder 64b' oder 64c' oder 64d') angeordnet ist und die Verbindung dieser Öffnung zu jeder Düse der zwei parallelen Düsenreihen gewährleistet.

7. Tintenstrahlstift nach Anspruch 6, bei dem der Stiftkörper aufweist : eine allen Tintenkammern gemeinsame Abdeckplatte mit entsprechenden, in die Tintenkammern führenden Öffnungen (68e-68h) ; eine der Abdeckplatte benachbarte Frontplatte (66) an dem Tintenkörper, auf die der Druckkopf montiert ist und die Öffnungen (64a-64d) aufweist, über welche jeweils die entsprechende Öffnung der mehreren voneinander entfernten Öffnungen (64a', 64b', 64c', 64d') kommuniziert ; und eine Dichtplatte (76), die zwischen der Abschlußplatte und der Frontplatte angeordnet und eingepresst ist und Öffnungen (76a-76d) aufweist, die einzelne Durchlässe zwischen jeder Öffnung in der Abschlußplatte und der entsprechenden Öffnung in der Frontplatte definiert, um einen Tintenpfad von jeder Tintenkammer (68a-68d) zu jeder entsprechenden Düsengruppe (62a-62d) zu schaffen.

8. Verfahren zum Betreiben eines Tintenstrahlstiftes nach einem der vorangehenden Ansprüche, bei dem die eine Düsengruppe (62a-62d) bildenden Düsen (1, 2, 3, 4 etc.) in einer der Schußreihenfolge der Düsen eines Einfarb-Tintenstrahlstiftes mit derselben Anzahl von Düsen entsprechenden Reihenfolge abgefeuert werden.

Revendications

1. Une plume à jet d'encre multicolore avec un haut et un bas, ayant une pluralité de groupes de buses (62a-62d), chacun d'entre eux comprenant une pluralité de buses, chaque groupe de buses ayant une longueur et une largeur prédéterminées et recevant une encre de couleur différente, caractérisée par le fait que les groupes de buses sont disposés les uns au-dessus des autres, chaque groupe de buses étant décalé latéralement par rapport à chaque groupe adjacent d'une distance au moins supérieure à ladite largeur pour minimiser la séparation verticale entre les groupes de buses adjacents tout en constituant une surface d'étanchéité autour de chaque groupe afin d'isoler les encres de couleurs respectives de chaque groupe de buses.

2. Une plume à jet d'encre selon la revendication 1 pour un appareil d'enregistrement pouvant être équipé soit d'une plume à jet d'encre à plusieurs chambres ou d'une plume à jet d'encre à une seule couleur, dans lequel la plume à jet d'encre à plusieurs chambres comporte un groupe (62a-62d) de buses (1, 2, 3, 4, etc.) connecté à chaque chambre (68a-68d) par un canal d'acheminement d'encre (68e-68h, 76a-76d, 64a-64d), les buses respectives de chaque groupe étant disposées selon un format correspondant à celui de la plume à jet d'encre à une seule couleur.

3. Une plume à jet d'encre selon les revendications 1 ou 2, dans laquelle chaque groupe de buses (62a-62d) comporte deux colonnes parallèles de buses (1-11, 2-12 ; 13-23, 14-24 ; 25-35, 26-36 ; 37-47, 38-48).

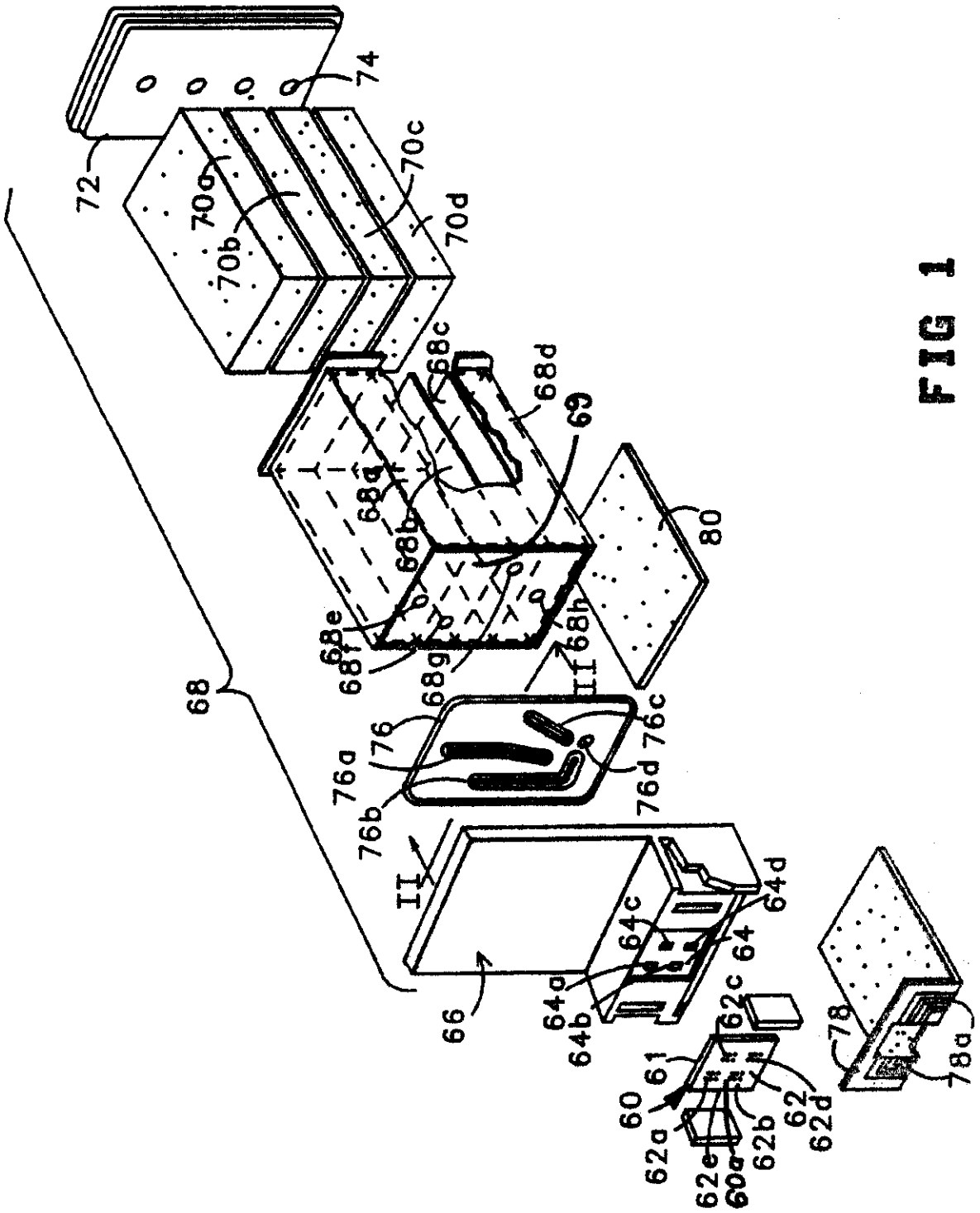
4. Une plume à jet d'encre selon la revendication 3, dans laquelle chacune desdites colonnes parallèles de buses (1-11, 2-12 ; 13-23, 14-24 ; 25-35, 26-36 ; 37-47, 38-48) dans un groupe de buses (62a-62d) a le même nombre de buses, une colonne de buses étant déplacée dans une direction le long de la colonne d'un demi espace de buse par rapport à l'autre colonne de buses, définissant un espace de ligne de points d'encre d'une rangée de points entre les buses correspondantes (11, 12) dans les deux colonnes d'un groupe de buses mesuré dans une direction parallèle aux deux colonnes de buses.

5. Une plume à jet d'encre selon les revendications 3 ou 4, dans laquelle : chaque canal d'acheminement d'encre (68e-68h, 76a-76d, 64a-64d) est doté d'une ouverture (64a', 64b', 64c', 64d') à chaque groupe de buses (62a-62c) dans une position située entre lesdites deux colonnes parallèles de buses, ladite ouverture se projetant de manière substantielle le long de la longueur desdites colonnes de buses à l'intérieur du groupe de buses (62a-62d).

6. Une plume à jet d'encre selon l'une ou l'autre des revendications 3 à 5 pour l'appareil d'enregistrement, comprenant en outre un corps de plume (68) ayant une pluralité de chambres à encre (68a, 68b, 68c, 68d) ; une tête d'impression (60,66) ayant une pluralité d'orifices espacés (64a', 64b', 64c', 64d') à l'intérieur et un groupe de buses (62a, 62b, 62c, 62d), à chaque ouverture (64a'-64d') ; un moyen (76) de montage de ladite tête d'impression sur ledit corps de plume ; et un cavité de distribution (86b) entre chacune des deux colonnes parallèles de buses dans chaque groupe de buses, ladite cavité de distribution comportant une partie dudit canal d'acheminement d'encre et aboutissant à ladite ouverture (64a' ou 64b' ou 64c' ou 64d') et servant de moyen de communication entre ladite ouverture rt chaque buse desdites deux colonnes parallèles de buses.

7. Une plume à jet d'encre selon la revendication 6, dans laquelle le corps de ladite plume comprend : une plaque arrière commune à toutes lesdites chambres et dotées d'ouvertures respectives (68e-68h) la traversant pour déboucher dans les chambres à encre ; une plaque frontale (66) sur ledit corps de plume adjacente à ladite plaque arrière, sur laquelle ladite tête d'impression est montée et dotée d'ouvertures (64a-64d) la traversant et communiquant respectivement avec chacun de ladite pluralité d'ouvertures espacées ; et une plaque d'étanchéité (76) disposée et comprimée entre ladite plaque arrière et ladite plaque avant et dotée d'ouvertures la traversant (76a-76d) définissant des canaux individuels entre chaque ouverture et ladite plaque arrière et une ouverture correspondante dans ladite plaque avant, pour établir un canal d'acheminement entre chacune des chambres à encre (68a-68d) et le groupe de buses correspondant (62a-62d).

8. Une méthode d'utilisation d'une plume à jet d'encre selon toute revendication précédente, dans laquelle les buses (1, 2, 3, 4, etc..) constituant le groupe de buses (62a-62d) sont allumées dans un ordre correspondant à l'ordre d'allumage des buses d'une plume à jet d'encre à une seule couleur contenant le même nombre de buses.


74
72
70a
70b
70c
70d
68c
68d
69
68a
68b
80
68e
68f
68g
68h
II
68
76
76a
76b
76c
76d
II
64d
64c
64
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62c
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60
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62d
62a
62b
62e
60a
78
78a

FIG 1

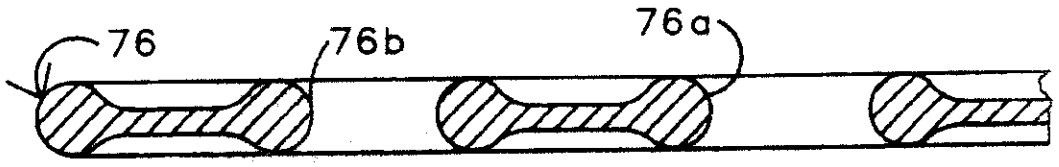
76
76b
76a

FIG 2

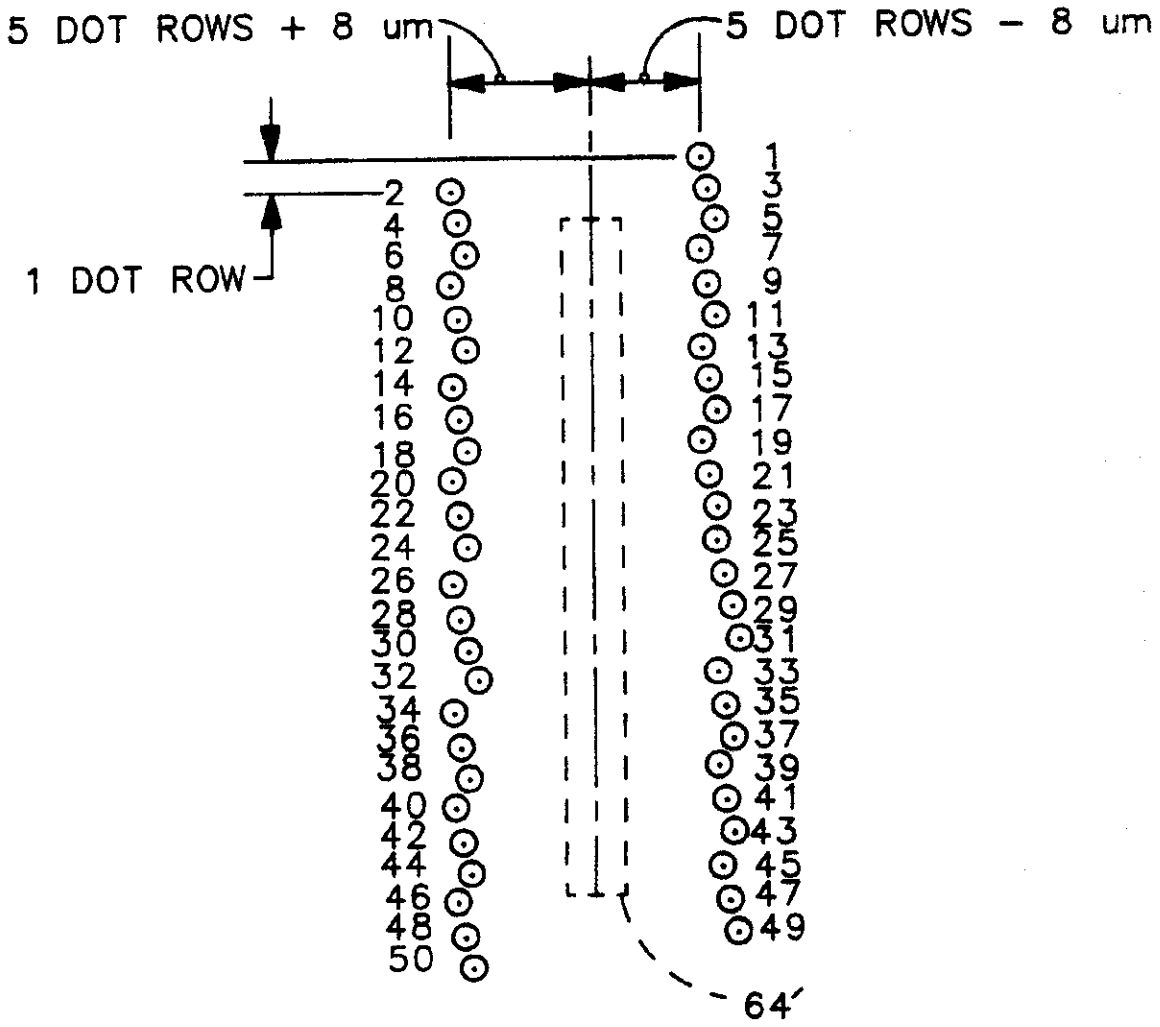
5 DOT ROWS + 8 um
5 DOT ROWS − 8 um
1 DOT ROW
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
64'

FIG 3

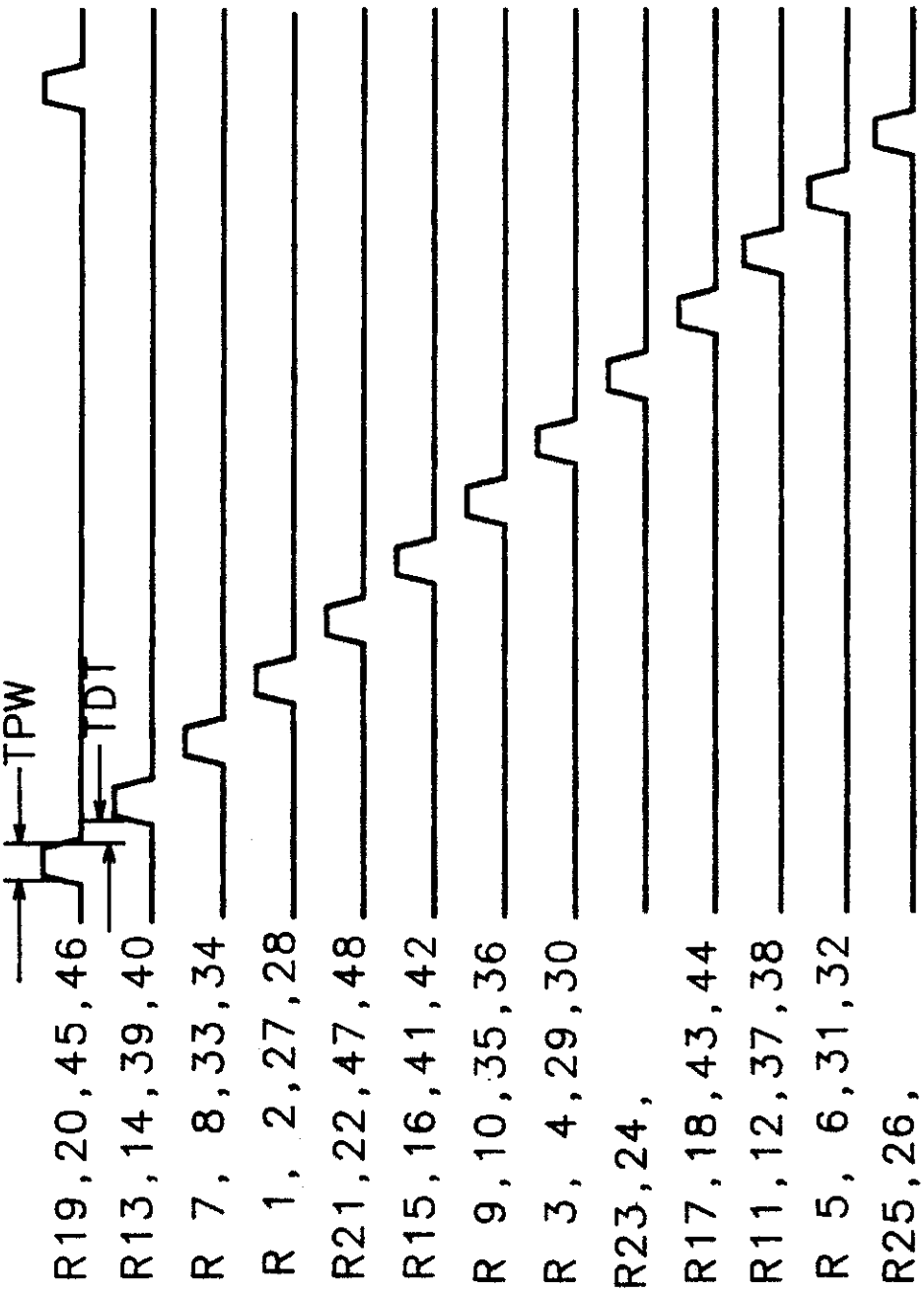
TPW
TDT
R19,20,45,46
R13,14,39,40
R 7, 8,33,34
R 1, 2,27,28
R21,22,47,48
R15,16,41,42
R 9,10,35,36
R 3, 4,29,30
R23,24,
R17,18,43,44
R11,12,37,38
R 5, 6,31,32
R25,26,

FIG 4

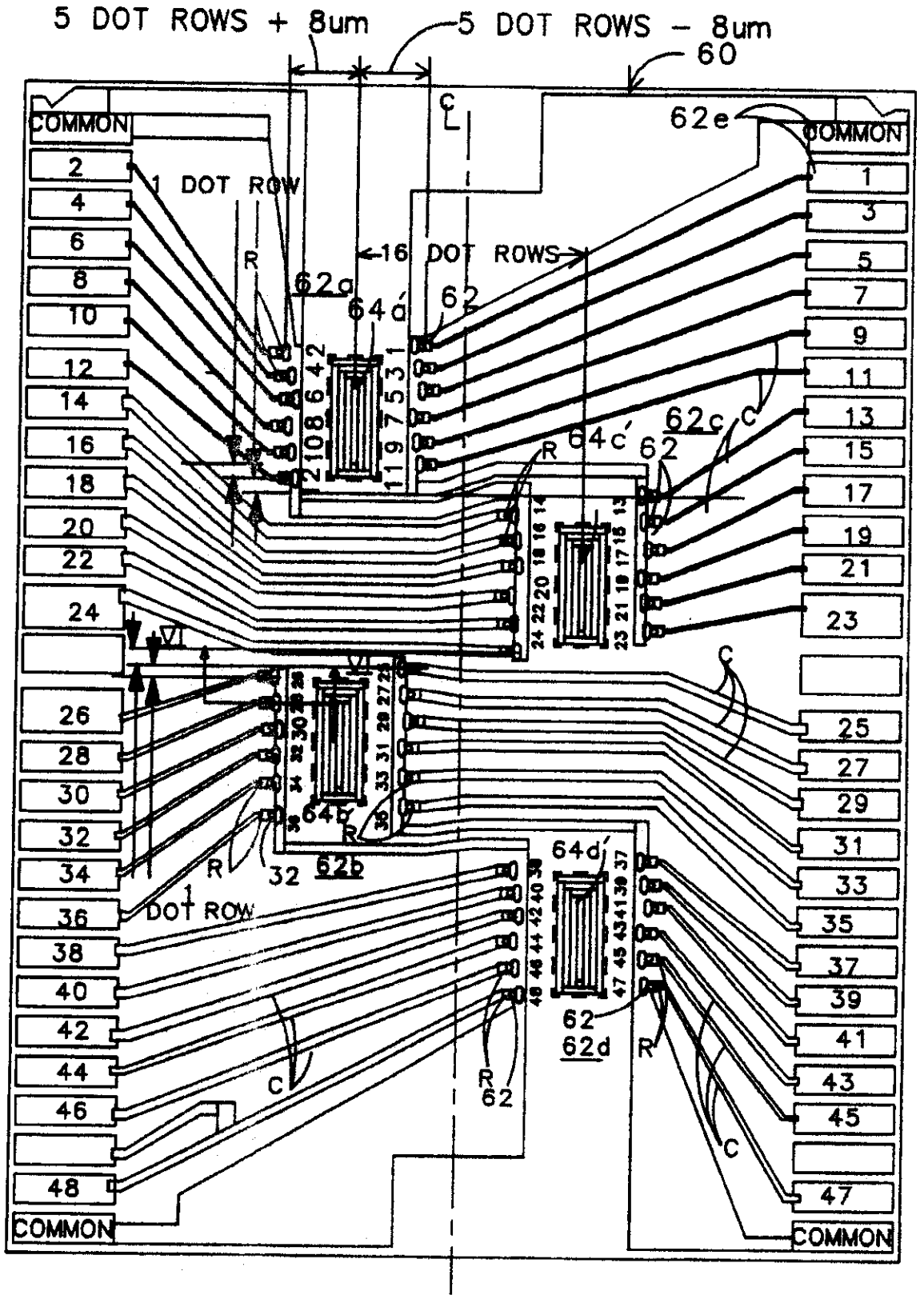
5 DOT ROWS + 8um
5 DOT ROWS − 8um
60
COMMON
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
46
48
COMMON
1 DOT ROW
R
62a
64a
62
16 DOT ROWS
62e
COMMON
1
3
5
7
9
11
13
15
17
19
21
23
25
27
29
31
33
35
37
39
41
43
45
47
COMMON
64c
62c
64b
32
62b
64d
62d
C
1 DOT ROW

FIG 5

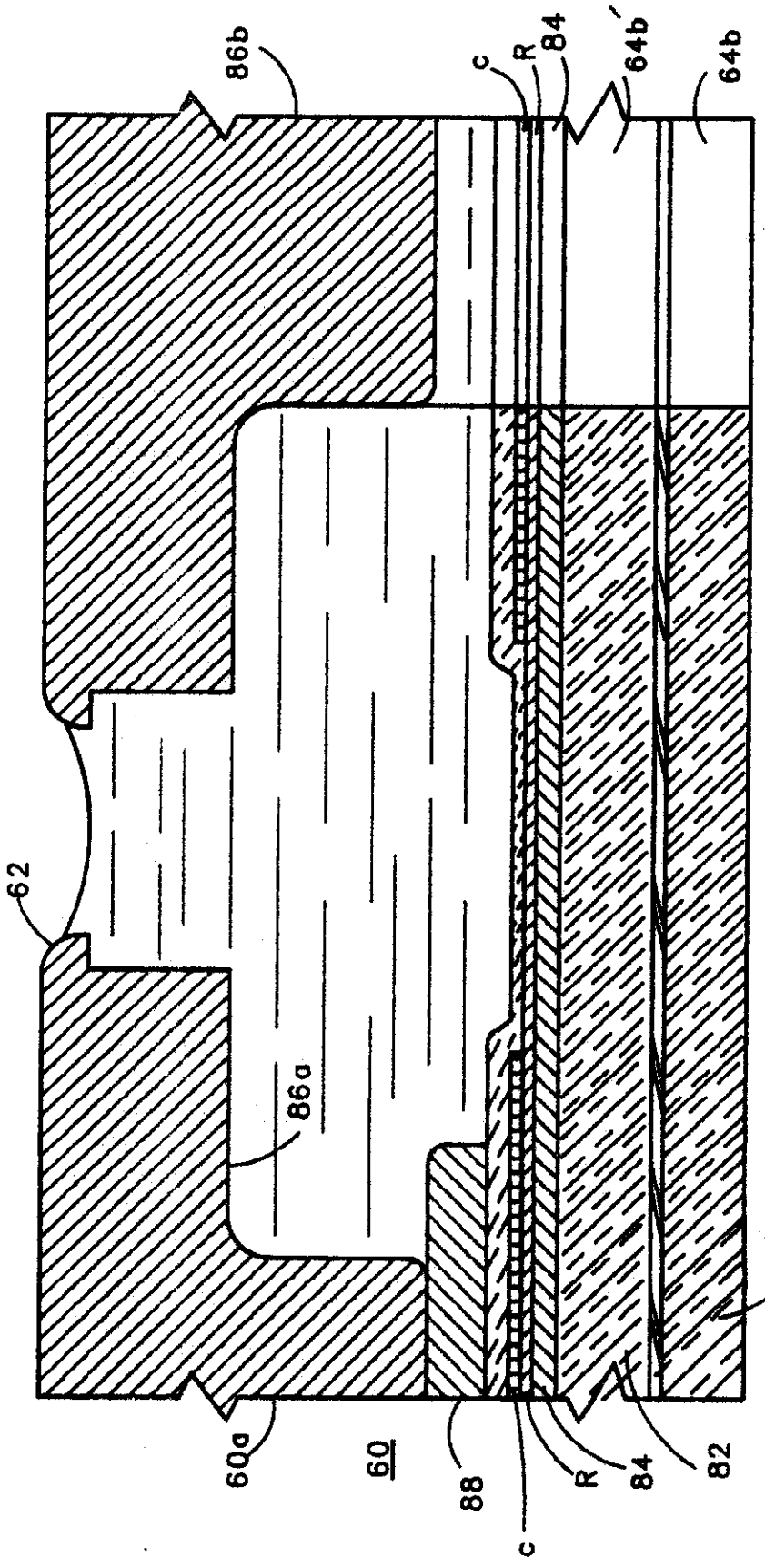

FIG 6

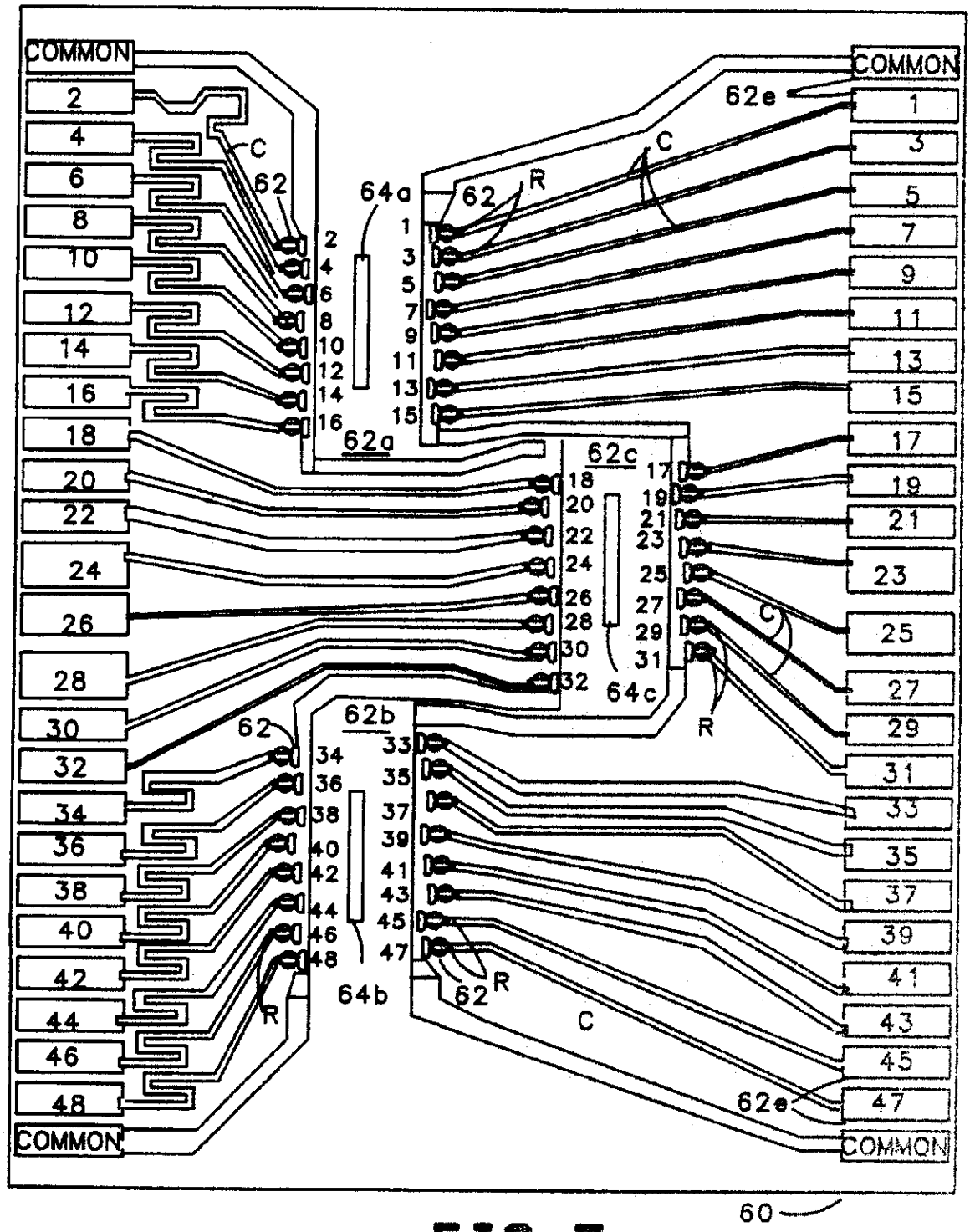
COMMON
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
46
48
COMMON
C
62
64a
62a
62b
64b
62c
64c
R
62e
60

FIG 7

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