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(54) METHOD OF GENERATING MANIPULATED IMAGES WITH DIGITAL CAMERA

(75) Inventor: Kia Silverbrook, Balmain (AU)

Correspondence Address:
SILVERBROOK RESEARCH PTY LTD
393 DARLING STREET
BALMAIN 2041 (AU)

(73) Assignee: Silverbrook Research Pty Ltd

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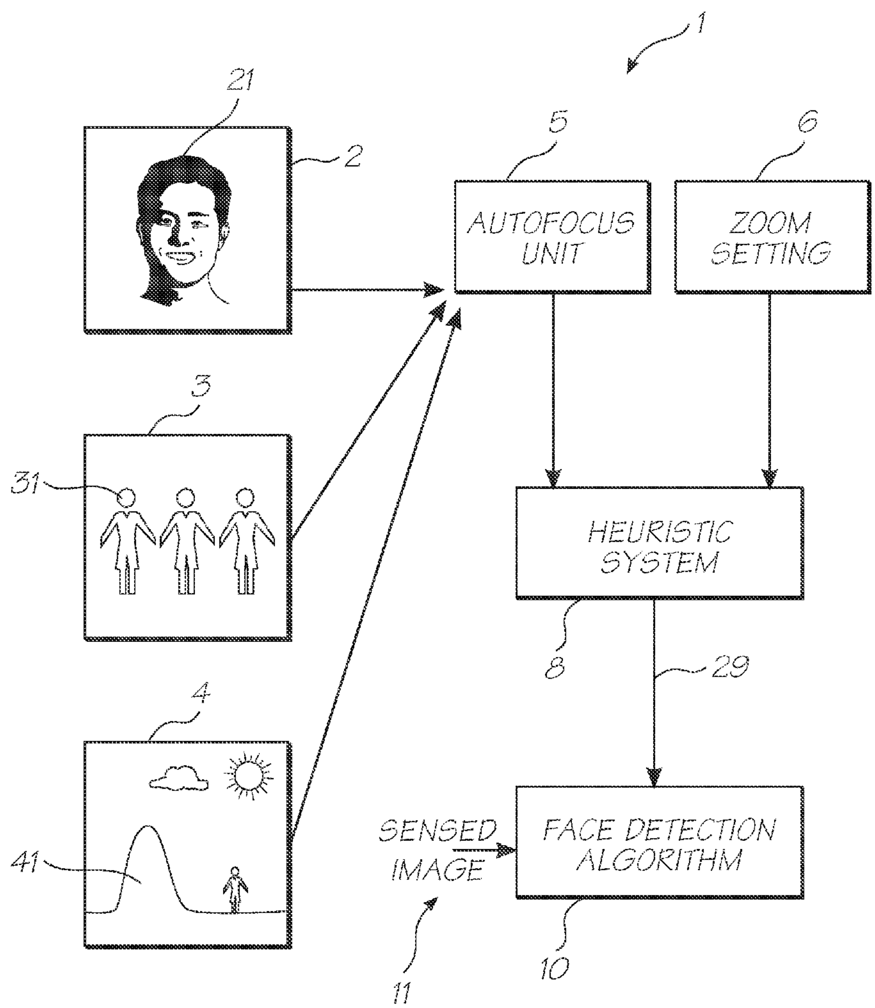
(57) ABSTRACT

A method of generating manipulated images with a digital camera is provided in which objects within a digital image produced by the digital camera utilising an autofocus unit of the digital camera are detected by processing the digital image with a processor of the digital camera utilising focusing settings of the autofocus unit as an indicator of positions of said objects, and a manipulated image is generated by applying a digital image manipulating process of the processor to the detected objects.



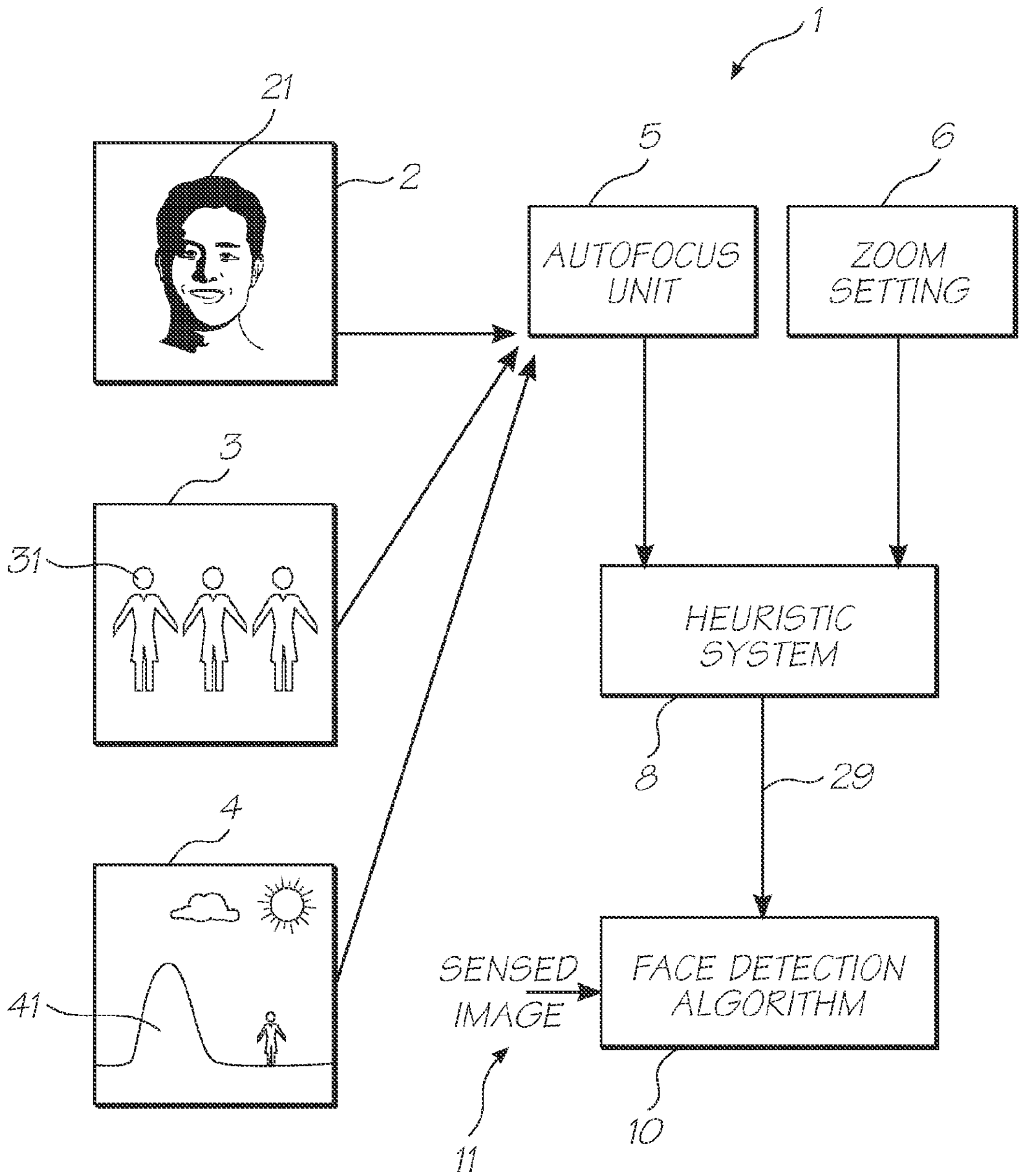

1
21
2
5
6
AUTOFOCUS UNIT
ZOOM SETTING
3
31
HEURISTIC SYSTEM
8
29
4
41
SENSED IMAGE
FACE DETECTION ALGORITHM
11
10

FIG. 1

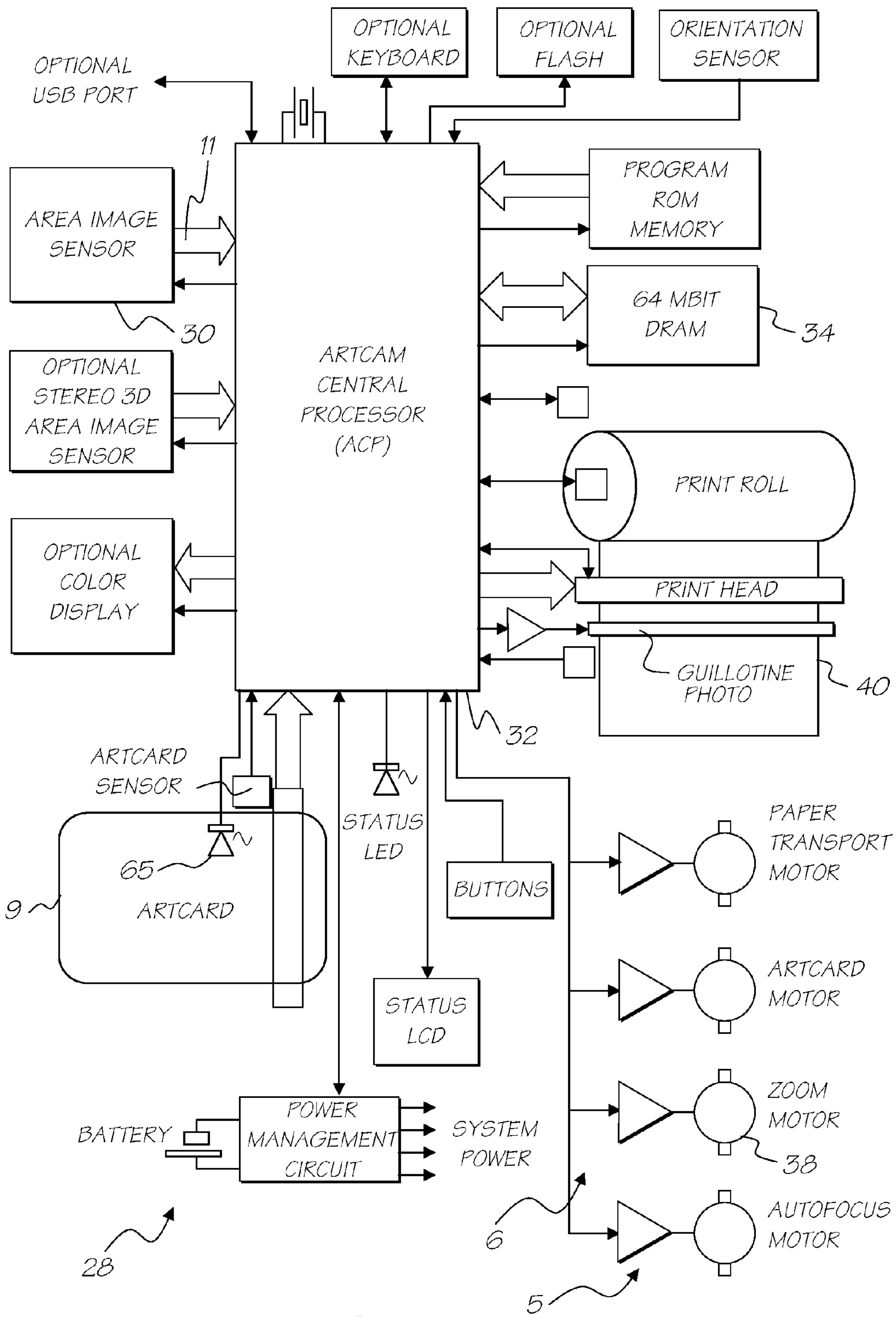

OPTIONAL USB PORT
OPTIONAL KEYBOARD
OPTIONAL FLASH
ORIENTATION SENSOR
11
AREA IMAGE SENSOR
30
PROGRAM ROM MEMORY
64 MBIT DRAM
34
OPTIONAL STEREO 3D AREA IMAGE SENSOR
ARTCAM CENTRAL PROCESSOR (ACP)
PRINT ROLL
OPTIONAL COLOR DISPLAY
PRINT HEAD
GUILLOTINE PHOTO
40
32
ARTCARD SENSOR
STATUS LED
65
9
ARTCARD
BUTTONS
PAPER TRANSPORT MOTOR
ARTCARD MOTOR
STATUS LCD
ZOOM MOTOR
38
BATTERY
POWER MANAGEMENT CIRCUIT
SYSTEM POWER
AUTOFOCUS MOTOR
6
28
5

FIG. 2

METHOD OF GENERATING MANIPULATED IMAGES WITH DIGITAL CAMERA

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This is a Continuation of U.S. application Ser. No. 10/831,237 filed Apr. 26, 2004, which is a Continuation Application of U.S. application Ser. No. 09/112,750, filed on Jul. 10, 1998, now issued U.S. Pat. No. 6,727,948, all of which are herein incorporated by reference.

FIELD OF THE INVENTION

[0002] The present invention relates to an image processing method and apparatus and, in particular, discloses a process for utilising autofocus information in a digital image camera.

BACKGROUND OF THE INVENTION

[0003] Recently, digital cameras have become increasingly popular. These cameras normally operate by means of imaging a desired image utilizing a charge coupled device (CCD) array and storing the imaged scene on an electronic storage medium for later down loading onto a computer system for subsequent manipulation and printing out. Normally, when utilizing a computer system to print out an image, sophisticated software may be available to manipulate the image in accordance with requirements.

[0004] Unfortunately such systems require significant post processing of a captured image and normally present the image in an orientation in which is was taken, relying on the post processing process to perform any necessary or required modifications of the captured image.

SUMMARY OF THE INVENTION

[0005] It is an object of the present invention to provide a method for enhanced processing of images captured by a digital camera utilising autofocus settings.

[0006] In accordance with a first aspect of the present invention there is provided a method of generating a manipulated output image by means of a digital camera, the method comprising the steps of:

[0007] capturing a focused image using an automatic focusing technique generating focus settings;

[0008] generating a manipulated output image by applying a digital image manipulating process to the focused image, the digital image manipulating process utilizing the focus settings.

[0009] Preferably the focus settings include a current position of a zoom motor of the digital camera.

[0010] In a preferred embodiment the digital image manipulating process includes a step of locating an object within the focused image utilizing the focus settings.

[0011] The method may include the step of printing out the manipulated image by means of a printing mechanism incorporated into the digital camera.

[0012] It is preferred that the digital image manipulating process selectively applies techniques to the focused image on the basis of the focus settings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] Notwithstanding any other forms which may fall within the scope of the present invention, preferred forms of the invention will now be described, by way of example only, with reference to the accompanying drawings in which:

[0014] FIG. **1** illustrates the method of the preferred embodiment; and

[0015] FIG. **2** illustrates a block diagram of the ARTCAM type camera.

DESCRIPTION OF PREFERRED EMBODIMENTS

[0016] The preferred embodiment is preferably implemented through suitable programming of a hand held camera device such as that described in the concurrently filed application, Applicant's reference ART01, U.S. Ser. No. 09/113,060 entitled "A Digital Camera with Image Processing Capability" filed concurrently herewith by the present applicant the content of which is hereby specifically incorporated by cross reference and the details of which, and other related applications are set out in the tables below. FIG. **2** shows a block diagram thereof.

[0017] The aforementioned patent specification discloses a camera system, hereinafter known as an "Artcam" type camera, wherein sensed images can be directly printed out by an Artcam portable camera unit such as illustrated in FIG. **2**. Further, the aforementioned specification discloses means and methods for performing various manipulations on images captured by the camera sensing device **30** leading to the production of various effects in any output image **40**. The manipulations are disclosed to be highly flexible in nature and can be implemented through the insertion into the Artcam of cards having encoded thereon various instructions for the manipulation of images, the cards **9** hereinafter being known as Artcards. The Artcam further has significant onboard processing power by an Artcam Central Processor unit (ACP) **32** which is interconnected to a memory device **34** for the storage of important data and images.

[0018] In the preferred embodiment, autofocus is achieved by processing of a CCD data stream to ensure maximum contrast. Techniques for determining a focus position based on a CCD data stream are known. For example, reference is made to "The Encyclopedia of Photography" editors Leslie Stroebel and Richard Zakia, published 1993 by Butterworth-Heinemann and "Applied Photographic Optics" by London & Boston, Focal Press, 1988. These techniques primarily rely on measurements of contrast between adjacent pixels over portions of an input image. The image is initially processed by the ACP in order to determine a correct autofocus setting.

[0019] This autofocus information is then utilized by the ACP **32** in certain modes, for example, when attempting to locate faces within the image, as a guide to the likely size of any face within the image, thereby simplifying the face location process.

[0020] Turning now to FIG. **1**, there is illustrated an example of the method utilized to determine likely image characteristics for examination by a face detection algorithm **10**.

[0021] Various images eg. **2**, **3** and **4** are imaged by the camera device **28**. As a by product of the operation of the auto-focusing the details of the focusing settings of the autofocus unit **5** are stored by the ACP **32**. Additionally, a current position of the zoom motor **38** is also utilized as zoom setting **6**. Both of these settings are determined by the ACP **32**. Subsequently, the ACP **32** applies analysis techniques in heuristic system **8** to the detected values before producing an output **29** having a magnitude corresponding to the likely depth location of objects of interest **21**, **31** or **41** within the image **2**, **3** or **4** respectively.

[0022] Next, the depth value is utilised in a face detection algorithm **10** running on the ACP **31** in addition to the inputted sensed image **11** so as to locate objects within the image. A close output **29** corresponding to a range value 9 indicates a high probability of a portrait image, a medium range indicates a high probability of a group photograph and a further range indicates a higher probability of a landscape image. This probability information can be utilized as an aid for the face detection algorithm and also can be utilised for selecting between various parameters when producing "painting" effects within the image or painting the image with clip arts or the like, with different techniques or clip arts being applied depending on the distance to an object.

[0023] It would be appreciated by a person skilled in the art that numerous variations and/or modifications may be made to the present invention as shown in the specific embodiment without departing from the spirit or scope of the invention as broadly described. The present embodiment is, therefore, to be considered in all respects to be illustrative and not restrictive.

[0024] The present invention is further best utilized in the Artcam device, the details of which are set out in the following paragraphs although it is not restricted thereto.

Ink Jet Technologies

[0025] The embodiments of the invention use an ink jet printer type device. Of course many different devices could be used. However presently popular ink jet printing technologies are unlikely to be suitable.

[0026] The most significant problem with thermal inkjet is power consumption. This is approximately 100 times that required for high speed, and stems from the energy-inefficient means of drop ejection. This involves the rapid boiling of water to produce a vapor bubble which expels the ink. Water has a very high heat capacity, and must be superheated in thermal inkjet applications. This leads to an efficiency of around 0.02%, from electricity input to drop momentum (and increased surface area) out.

[0027] The most significant problem with piezoelectric inkjet is size and cost. Piezoelectric crystals have a very small deflection at reasonable drive voltages, and therefore require a large area for each nozzle. Also, each piezoelectric actuator must be connected to its drive circuit on a separate substrate. This is not a significant problem at the current limit of around 300 nozzles per print head, but is a major impediment to the fabrication of pagewidth print heads with 19,200 nozzles.

[0028] Ideally, the inkjet technologies used meet the stringent requirements of in-camera digital color printing and other high quality, high speed, low cost printing applications. To meet the requirements of digital photography, new inkjet technologies have been created. The target features include:

[0029] low power (less than 10 Watts)

[0030] high resolution capability (1,600 dpi or more)

[0031] photographic quality output

[0032] low manufacturing cost

[0033] small size (pagewidth times minimum cross section)

[0034] high speed (<2 seconds per page).

[0035] All of these features can be met or exceeded by the inkjet systems described below with differing levels of difficulty. Fortyfive different inkjet technologies have been developed by the Assignee to give a wide range of choices for high volume manufacture. These technologies form part of separate applications assigned to the present Assignee as set out in the table below.

[0036] The inkjet designs shown here are suitable for a wide range of digital printing systems, from battery powered one-time use digital cameras, through to desktop and network printers, and through to commercial printing systems

[0037] For ease of manufacture using standard process equipment, the print head is designed to be a monolithic 0.5 micron CMOS chip with MEMS post processing. For color photographic applications, the print head is 100 mm long, with a width which depends upon the inkjet type. The smallest print head designed is IJ38, which is 0.35 mm wide, giving a chip area of 35 square mm. The print heads each contain 19,200 nozzles plus data and control circuitry.

[0038] Ink is supplied to the back of the print head by injection molded plastic ink channels. The molding requires 50 micron features, which can be created using a lithographically micromachined insert in a standard injection molding tool. Ink flows through holes etched through the wafer to the nozzle chambers fabricated on the front surface of the wafer. The print head is connected to the camera circuitry by tape automated bonding.

CROSS-REFERENCED APPLICATIONS

[0039] The following table is a guide to cross-referenced patent applications filed concurrently herewith and discussed hereinafter with the reference being utilized in subsequent tables when referring to a particular case:

Docket No	Reference	Title
IJ01US	6,227,652	Radiant Plunger Ink Jet Printer
IJ02US	6,213,588	Electrostatic Ink Jet Printer
IJ03US	6,213,589	Planar Thermoelastic Bend Actuator Ink Jet
IJ04US	6,231,163	Stacked Electrostatic Ink Jet Printer
IJ05US	6,247,795	Reverse Spring Lever Ink Jet Printer
IJ06US	6,394,581	Paddle Type Ink Jet Printer
IJ07US	6,244,691	Permanent Magnet Electromagnetic Ink Jet Printer
IJ08US	6,257,704	Planar Swing Grill Electromagnetic Ink Jet Printer
IJ09US	6,416,168	Pump Action Refill Ink Jet Printer
IJ10US	6,220,694	Pulsed Magnetic Field Ink Jet Printer
IJ11US	6,257,705	Two Plate Reverse Firing Electromagnetic Ink Jet Printer
IJ12US	6,247,794	Linear Stepper Actuator Ink Jet Printer
IJ13US	6,234,610	Gear Driven Shutter Ink Jet Printer

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Docket No	Reference	Title
IJ14US	6,247,793	Tapered Magnetic Pole Electromagnetic Ink Jet Printer
IJ15US	6,264,306	Linear Spring Electromagnetic Grill Ink Jet Printer
IJ16US	6,241,342	Lorenz Diaphragm Electromagnetic Ink Jet Printer
IJ17US	6,247,792	PTFE Surface Shooting Shuttered Oscillating Pressure Ink Jet Printer
IJ18US	6,264,307	Buckle Grip Oscillating Pressure Ink Jet Printer
IJ19US	6,254,220	Shutter Based Ink Jet Printer
IJ20US	6,234,611	Curling Calyx Thermoelastic Ink Jet Printer
IJ21US	6,302,528	Thermal Actuated Ink Jet Printer
IJ22US	6,283,582	Iris Motion Ink Jet Printer
IJ23US	6,239,821	Direct Firing Thermal Bend Actuator Ink Jet Printer
IJ24US	6,338,547	Conductive PTFE Ben Activator Vented Ink Jet Printer
IJ25US	6,247,796	Magnetostrictive Ink Jet Printer
IJ26US	6,557,977	Shape Memory Alloy Ink Jet Printer
IJ27US	6,390,603	Buckle Plate Ink Jet Printer
IJ28US	6,362,843	Thermal Elastic Rotary Impeller Ink Jet Printer
IJ29US	6,293,653	Thermoelastic Bend Actuator Ink Jet Printer
IJ30US	6,312,107	Thermoelastic Bend Actuator Using PTFE and Corrugated Copper Ink Jet Printer
IJ31US	6,227,653	Bend Actuator Direct Ink Supply Ink Jet Printer
IJ32US	6,234,609	A High Young's Modulus Thermoelastic Ink Jet Printer
IJ33US	6,238,040	Thermally actuated slotted chamber wall ink jet printer
IJ34US	6,188,415	Ink Jet Printer having a thermal actuator comprising an external coiled spring
IJ35US	6,227,654	Trough Container Ink Jet Printer
IJ36US	6,209,989	Dual Chamber Single Vertical Actuator Ink Jet
IJ37US	6,247,791	Dual Nozzle Single Horizontal Fulcrum Actuator Ink Jet
IJ38US	6,336,710	Dual Nozzle Single Horizontal Actuator Ink Jet
IJ39US	6,217,153	A single bend actuator cupped paddle ink jet printing device
IJ40US	6,416,167	A thermally actuated ink jet printer having a series of thermal actuator units
IJ41US	6,243,113	A thermally actuated ink jet printer including a tapered heater element
IJ42US	6,283,581	Radial Back-Curling Thermoelastic Ink Jet
IJ43US	6,247,790	Inverted Radial Back-Curling Thermoelastic Ink Jet
IJ44US	6,260,953	Surface bend actuator vented ink supply ink jet printer
IJ45US	6,267,469	Coil Acutuated Magnetic Plate Ink Jet Printer

Tables of Drop-on-Demand Inkjets

[0040] Eleven important characteristics of the fundamental operation of individual inkjet nozzles have been identified. These characteristics are largely orthogonal, and so can be elucidated as an eleven dimensional matrix. Most of the eleven axes of this matrix include entries developed by the present assignee.

[0041] The following tables form the axes of an eleven dimensional table of inkjet types.

[0042] Actuator mechanism (18 types)

[0043] Basic operation mode (7 types)

[0044] Auxiliary mechanism (8 types)

[0045] Actuator amplification or modification method (17 types)

[0046] Actuator motion (19 types)

[0047] Nozzle refill method (4 types)

[0048] Method of restricting back-flow through inlet (10 types)

[0049] Nozzle clearing method (9 types)

[0050] Nozzle plate construction (9 types)

[0051] Drop ejection direction (5 types)

[0052] Ink type (7 types)

[0053] The complete eleven dimensional table represented by these axes contains 36.9 billion possible configurations of inkjet nozzle. While not all of the possible combinations result in a viable inkjet technology, many million configurations are viable. It is clearly impractical to elucidate all of the possible configurations. Instead, certain inkjet types have been investigated in detail. These are designated IJ01 to IJ45 above.

[0054] Other inkjet configurations can readily be derived from these fortyfive examples by substituting alternative configurations along one or more of the 11 axes. Most of the IJ01 to IJ45 examples can be made into inkjet print heads with characteristics superior to any currently available inkjet technology.

[0055] Where there are prior art examples known to the inventor, one or more of these examples are listed in the examples column of the tables below. The IJ01 to IJ45 series are also listed in the examples column. In some cases, a print technology may be listed more than once in a table, where it shares characteristics with more than one entry.

[0056] Suitable applications include: Home printers, Office network printers, Short run digital printers, Commercial print systems, Fabric printers, Pocket printers, Internet WWW printers, Video printers, Medical imaging, Wide format printers, Notebook PC printers, Fax machines, Industrial printing systems, Photocopiers, Photographic minilabs etc.

[0057] The information associated with the aforementioned **11** dimensional matrix are set out in the following tables.

ACTUATOR MECHANISM (APPLIED ONLY TO SELECTED INK DROPS)

Actuator Mechanism	Description	Advantages	Disadvantages	Examples
Thermal bubble	An electrothermal heater heats the ink to above boiling point, transferring significant heat to the aqueous ink. A bubble nucleates and quickly forms, expelling the ink. The efficiency of the process is low, with typically less than 0.05% of the electrical energy being transformed into kinetic energy of the drop.	Large force generated Simple construction No moving parts Fast operation Small chip area required for actuator	High power Ink carrier limited to water Low efficiency High temperatures required High mechanical stress Unusual materials required Large drive transistors Cavitation causes actuator failure Kogation reduces bubble formation Large print heads are difficult to fabricate	Canon Bubblejet 1979 Endo et al GB patent 2,007,162 Xerox heater-in-pit 1990 Hawkins et al U.S. Pat. No. 4,899,181 Hewlett-Packard TIJ 1982 Vaught et al U.S. Pat. No. 4,490,728
Piezoelectric	A piezoelectric crystal such as lead lanthanum zirconate (PZT) is electrically activated, and either expands, shears, or bends to apply pressure to the ink, ejecting drops.	Low power consumption Many ink types can be used Fast operation High efficiency	Very large area required for actuator Difficult to integrate with electronics High voltage drive transistors required Full pagewidth print heads impractical due to actuator size Requires electrical poling in high field strengths during manufacture	Kyser et al U.S. Pat. No. 3,946,398 Zoltan U.S. Pat. No. 3,683,212 1973 Stemme U.S. Pat. No. 3,747,120 Epson Stylus Tektronix IJ04
Electro-strictive	An electric field is used to activate electrostriction in relaxor materials such as lead lanthanum zirconate titanate (PLZT) or lead magnesium niobate (PMN).	Low power consumption Many ink types can be used Low thermal expansion Electric field strength required (approx. 3.5 V/μm) can be generated without difficulty Does not require electrical poling	Low maximum strain (approx. 0.01%) Large area required for actuator due to low strain Response speed is marginal (~10 μs) High voltage drive transistors required Full pagewidth print heads impractical due to actuator size	Seiko Epson, Usui et all JP 253401/96 IJ04
Ferroelectric	An electric field is used to induce a phase transition between the antiferroelectric (AFE) and ferroelectric (FE) phase. Perovskite materials such as tin modified lead lanthanum zirconate titanate (PLZSnT) exhibit large strains of up to 1% associated with the AFE to FE phase transition.	Low power consumption Many ink types can be used Fast operation (<1 μs) Relatively high longitudinal strain High efficiency Electric field strength of around 3 V/μm can be readily provided	Difficult to integrate with electronics Unusual materials such as PLZSnT are required Actuators require a large area	IJ04
Electrostatic plates	Conductive plates are separated by a compressible or fluid dielectric (usually air). Upon application of a voltage, the plates attract each other and displace ink, causing drop ejection. The conductive plates may be in a comb or honeycomb structure, or stacked to increase the surface area and therefore the force.	Low power consumption Many ink types can be used Fast operation	Difficult to operate electrostatic devices in an aqueous environment The electrostatic actuator will normally need to be separated from the ink Very large area required to achieve high forces High voltage drive transistors may be required Full pagewidth print heads are not competitive due to actuator size	IJ02, IJ04
Electrostatic pull on ink	A strong electric field is applied to the ink, whereupon electrostatic attraction accelerates the ink towards the print medium.	Low current consumption Low temperature	High voltage required May be damaged by sparks due to air breakdown Required field strength increases as the drop size decreases High voltage drive transistors required Electrostatic field attracts dust	1989 Saito et al, U.S. Pat. No. 4,799,068 1989 Miura et al, U.S. Pat. No. 4,810,954 Tone-jet
Permanent magnet electro-magnetic	An electromagnet directly attracts a permanent magnet, displacing ink and causing drop ejection. Rare earth magnets with a field strength around 1 Tesla can be used. Examples are: Samarium Cobalt (SaCo) and magnetic materials in the neodymium iron boron family (NdFeB, NdDyFeBNb, NdDyFeB, etc)	Low power consumption Many ink types can be used Fast operation High efficiency Easy extension from single nozzles to pagewidth print heads	Complex fabrication Permanent magnetic material such as Neodymium Iron Boron (NdFeB) required. High local currents required Copper metalization should be used for long electromigration lifetime and low resistivity Pigmented inks are usually infeasible Operating temperature limited to the Curie temperature (around 540 K)	IJ07, IJ10

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ACTUATOR MECHANISM (APPLIED ONLY TO SELECTED INK DROPS)

Actuator Mechanism	Description	Advantages	Disadvantages	Examples
Soft magnetic core electro-magnetic	A solenoid induced a magnetic field in a soft magnetic core or yoke fabricated from a ferrous material such as electroplated iron alloys such as CoNiFe [1], CoFe, or NiFe alloys. Typically, the soft magnetic material is in two parts, which are normally held apart by a spring. When the solenoid is actuated, the two parts attract, displacing the ink.	Low power consumption Many ink types can be used Fast operation High efficiency Easy extension from single nozzles to pagewidth print heads	Complex fabrication Materials not usually present in a CMOS fab such as NiFe, CoNiFe, or CoFe are required High local currents required Copper metalization should be used for long electromigration lifetime and low resistivity Electroplating is required High saturation flux density is required (2.0-2.1 T is achievable with CoNiFe [1])	IJ01, IJ05, IJ08, IJ10 IJ12, IJ14, IJ15, IJ17
Magnetic Lorenz force	The Lorenz force acting on a current carrying wire in a magnetic field is utilized. This allows the magnetic field to be supplied externally to the print head, for example with rare earth permanent magnets. Only the current carrying wire need be fabricated on the print-head, simplifying materials requirements.	Low power consumption Many ink types can be used Fast operation High efficiency Easy extension from single nozzles to pagewidth print heads	Force acts as a twisting motion Typically, only a quarter of the solenoid length provides force in a useful direction High local currents required Copper metalization should be used for long electromigration lifetime and low resistivity Pigmented inks are usually infeasible	IJ06, IJ11, IJ13, IJ16
Magneto-striction	The actuator uses the giant magnetostrictive effect of materials such as Terfenol-D (an alloy of terbium, dysprosium and iron developed at the Naval Ordnance Laboratory, hence Ter-Fe-NOL). For best efficiency, the actuator should be pre-stressed to approx. 8 MPa.	Many ink types can be used Fast operation Easy extension from single nozzles to pagewidth print heads High force is available	Force acts as a twisting motion Unusual materials such as Terfenol-D are required High local currents required Copper metalization should be used for long electromigration lifetime and low resistivity Pre-stressing may be required	Fischenbeck, U.S. Pat. No. 4,032,929 IJ25
Surface tension reduction	Ink under positive pressure is held in a nozzle by surface tension. The surface tension of the ink is reduced below the bubble threshold, causing the ink to egress from the nozzle.	Low power consumption Simple construction No unusual materials required in fabrication High efficiency Easy extension from single nozzles to pagewidth print heads	Requires supplementary force to effect drop separation Requires special ink surfactants Speed may be limited by surfactant properties	Silverbrook, EP 0771 658 A2 and related patent applications
Viscosity reduction	The ink viscosity is locally reduced to select which drops are to be ejected. A viscosity reduction can be achieved electrothermally with most inks, but special inks can be engineered for a 100:1 viscosity reduction.	Simple construction No unusual materials required in fabrication Easy extension from single nozzles to pagewidth print heads	Requires supplementary force to effect drop separation Requires special ink viscosity properties High speed is difficult to achieve Requires oscillating ink pressure A high temperature difference (typically 80 degrees) is required	Silverbrook, EP 0771 658 A2 and related patent applications
Acoustic	An acoustic wave is generated and focussed upon the drop ejection region.	Can operate without a nozzle plate	Complex drive circuitry Complex fabrication Low efficiency Poor control of drop position Poor control of drop volume	1993 Hadimioglu et al, EUP 550,192 1993 Elrod et al, EUP 572,220
Thermoelastic bend actuator	An actuator which relies upon differential thermal expansion upon Joule heating is used.	Low power consumption Many ink types can be used Simple planar fabrication Small chip area required for each actuator Fast operation High efficiency CMOS compatible voltages and currents Standard MEMS processes can be used Easy extension from single nozzles to pagewidth print heads	Efficient aqueous operation requires a thermal insulator on the hot side Corrosion prevention can be difficult Pigmented inks may be infeasible, as pigment particles may jam the bend actuator	IJ03, IJ09, IJ17, IJ18 IJ19, IJ20, IJ21, IJ22 IJ23, IJ24, IJ27, IJ28 IJ29, IJ30, IJ31, IJ32 IJ33, IJ34, IJ35, IJ36 IJ37, IJ38, IJ39, IJ40 IJ41
High CTE thermoelastic	A material with a very high coefficient of thermal expansion	High force can be generated	Requires special material (e.g. PTFE)	IJ09, IJ17, IJ18, IJ20

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ACTUATOR MECHANISM (APPLIED ONLY TO SELECTED INK DROPS)

Actuator Mechanism	Description	Advantages	Disadvantages	Examples
actuator	(CTE) such as polytetrafluoroethylene (PTFE) is used. As high CTE materials are usually non-conductive, a heater fabricated from a conductive material is incorporated. A 50 μm long PTFE bend actuator with polysilicon heater and 15 mW power input can provide 180 μN force and 10 μm deflection. Actuator motions include: 1) Bend 2) Push 3) Buckle 4) Rotate	PTFE is a candidate for low dielectric constant insulation in ULSI Very low power consumption Many ink types can be used Simple planar fabrication Small chip area required for each actuator Fast operation High efficiency CMOS compatible voltages and currents Easy extension from single nozzles to pagewidth print heads	Requires a PTFE deposition process, which is not yet standard in ULSI fabs PTFE deposition cannot be followed with high temperature (above 350° C.) processing Pigmented inks may be infeasible, as pigment particles may jam the bend actuator	IJ21, IJ22, IJ23, IJ24 IJ27, IJ28, IJ29, IJ30 IJ31, IJ42, IJ43, IJ44
Conductive polymer thermoelastic actuator	A polymer with a high coefficient of thermal expansion (such as PTFE) is doped with conducting substances to increase its conductivity to about 3 orders of magnitude below that of copper. The conducting polymer expands when resistively heated. Examples of conducting dopants include: 1) Carbon nanotubes 2) Metal fibers 3) Conductive polymers such as doped polythiophene 4) Carbon granules	High force can be generated Very low power consumption Many ink types can be used Simple planar fabrication Small chip area required for each actuator Fast operation High efficiency CMOS compatible voltages and currents Easy extension from single nozzles to pagewidth print heads	Requires special materials development (High CTE conductive polymer) Requires a PTFE deposition process, which is not yet standard in ULSI fabs PTFE deposition cannot be followed with high temperature (above 350° C.) processing Evaporation and CVD deposition techniques cannot be used Pigmented inks may be infeasible, as pigment particles may jam the bend actuator	IJ24
Shape memory alloy	A shape memory alloy such as TiNi (also known as Nitinol - Nickel Titanium alloy developed at the Naval Ordnance Laboratory) is thermally switched between its weak martensitic state and its high stiffness austenic state. The shape of the actuator in its martensitic state is deformed relative to the austenic shape. The shape change causes ejection of a drop.	High force is available (stresses of hundreds of MPa) Large strain is available (more than 3%) High corrosion resistance Simple construction Easy extension from single nozzles to pagewidth print heads Low voltage operation	Fatigue limits maximum number of cycles Low strain (1%) is required to extend fatigue resistance Cycle rate limited by heat removal Requires unusual materials (TiNi) The latent heat of transformation must be provided High current operation Requires pre-stressing to distort the martensitic state	IJ26
Linear Magnetic Actuator	Linear magnetic actuators include the Linear Induction Actuator (LIA), Linear Permanent Magnet Synchronous Actuator (LPMSA), Linear Reluctance Synchronous Actuator (LRSA), Linear Switched Reluctance Actuator (LSRA), and the Linear Stepper Actuator (LSA).	Linear Magnetic actuators can be constructed with high thrust, long travel, and high efficiency using planar semiconductor fabrication techniques Long actuator travel is available Medium force is available Low voltage operation	Requires unusual semiconductor materials such as soft magnetic alloys (e.g. CoNiFe [1]) Some varieties also require permanent magnetic materials such as Neodymium iron boron (NdFeB) Requires complex multi-phase drive circuitry High current operation	IJ12

BASIC OPERATION MODE

Operational mode	Description	Advantages	Disadvantages	Examples
Actuator directly pushes ink	This is the simplest mode of operation: the actuator directly supplies sufficient kinetic energy to expel the drop. The drop must	Simple operation No external fields required Satellite drops can be	Drop repetition rate is usually limited to less than 10 KHz. However, this is not fundamental to the method, but is related to the	Thermal inkjet Piezoelectric inkjet IJ01, IJ02, IJ03, IJ04

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BASIC OPERATION MODE

Operational mode	Description	Advantages	Disadvantages	Examples
	have a sufficient velocity to overcome the surface tension.	avoided if drop velocity is less than 4 m/s Can be efficient, depending upon the actuator used	refill method normally used All of the drop kinetic energy must be provided by the actuator Satellite drops usually form if drop velocity is greater than 4.5 m/s	IJ05, IJ06, IJ07, IJ09 IJ11, IJ12, IJ14, IJ16 IJ20, IJ22, IJ23, IJ24 IJ25, IJ26, IJ27, IJ28 IJ29, IJ30, IJ31, IJ32 IJ33, IJ34, IJ35, IJ36 IJ37, IJ38, IJ39, IJ40 IJ41, IJ42, IJ43, IJ44
Proximity	The drops to be printed are selected by some manner (e.g. thermally induced surface tension reduction of pressurized ink). Selected drops are separated from the ink in the nozzle by contact with the print medium or a transfer roller.	Very simple print head fabrication can be used The drop selection means does not need to provide the energy required to separate the drop from the nozzle	Requires close proximity between the print head and the print media or transfer roller May require two print heads printing alternate rows of the image Monolithic color print heads are difficult	Silverbrook, EP 0771 658 A2 and related patent applications
Electrostatic pull on ink	The drops to be printed are selected by some manner (e.g. thermally induced surface tension reduction of pressurized ink). Selected drops are separated from the ink in the nozzle by a strong electric field.	Very simple print head fabrication can be used The drop selection means does not need to provide the energy required to separate the drop from the nozzle	Requires very high electrostatic field Electrostatic field for small nozzle sizes is above air breakdown Electrostatic field may attract dust	Silverbrook, EP 0771 658 A2 and related patent applications Tone-Jet
Magnetic pull on ink	The drops to be printed are selected by some manner (e.g. thermally induced surface tension reduction of pressurized ink). Selected drops are separated from the ink in the nozzle by a strong magnetic field acting on the magnetic ink.	Very simple print head fabrication can be used The drop selection means does not need to provide the energy required to separate the drop from the nozzle	Requires magnetic ink Ink colors other than black are difficult Requires very high magnetic fields	Silverbrook, EP 0771 658 A2 and related patent applications
Shutter	The actuator moves a shutter to block ink flow to the nozzle. The ink pressure is pulsed at a multiple of the drop ejection frequency.	High speed (>50 KHz) operation can be achieved due to reduced refill time Drop timing can be very accurate The actuator energy can be very low	Moving parts are required Requires ink pressure modulator Friction and wear must be considered Stiction is possible	IJ13, IJ17, IJ21
Shuttered grill	The actuator moves a shutter to block ink flow through a grill to the nozzle. The shutter movement need only be equal to the width of the grill holes.	Actuators with small travel can be used Actuators with small force can be used High speed (>50 KHz) operation can be achieved	Moving parts are required Requires ink pressure modulator Friction and wear must be considered Stiction is possible	IJ08, IJ15, IJ18, IJ19
Pulsed magnetic pull on ink pusher	A pulsed magnetic field attracts an 'ink pusher' at the drop ejection frequency. An actuator controls a catch, which prevents the ink pusher from moving when a drop is not to be ejected.	Extremely low energy operation is possible No heat dissipation problems	Requires an external pulsed magnetic field Requires special materials for both the actuator and the ink pusher Complex construction	IJ10

AUXILIARY MECHANISM (APPLIED TO ALL NOZZLES)

Auxiliary Mechanism	Description	Advantages	Disadvantages	Examples
None	The actuator directly fires the ink drop, and there is no external field or other mechanism required.	Simplicity of construction Simplicity of operation Small physical size	Drop ejection energy must be supplied by individual nozzle actuator	Most inkjets, including piezoelectric and thermal bubble. IJ01-IJ07, IJ09, IJ11 IJ12, IJ14, IJ20, IJ22 IJ23-IJ45
Oscillating ink pressure (including acoustic stimulation)	The ink pressure oscillates, providing much of the drop ejection energy. The actuator selects which drops are to be fired by selectively blocking or enabling nozzles. The ink pressure oscillation may be achieved by vibrating the print head, or preferably by an actuator in the ink supply.	Oscillating ink pressure can provide a refill pulse, allowing higher operating speed The actuators may operate with much lower energy Acoustic lenses can be used to focus the sound on the nozzles	Requires external ink pressure oscillator Ink pressure phase and amplitude must be carefully controlled Acoustic reflections in the ink chamber must be designed for	Silverbrook, EP 0771 658 A2 and related patent applications IJ08, IJ13, IJ15, IJ17 IJ18, IJ19, IJ21
Media proximity	The print head is placed in close proximity to the print medium. Selected drops protrude from the print head further than unselected drops, and contact the print medium. The drop soaks into the medium fast enough to cause drop separation.	Low power High accuracy Simple print head construction	Precision assembly required Paper fibers may cause problems Cannot print on rough substrates	Silverbrook, EP 0771 658 A2 and related patent applications
Transfer roller	Drops are printed to a transfer roller instead of straight to the print medium. A transfer roller can also be used for proximity drop separation.	High accuracy Wide range of print substrates can be used Ink can be dried on the transfer roller	Bulky Expensive Complex construction	Silverbrook, EP 0771 658 A2 and related patent applications Tektronix hot melt piezoelectric inkjet Any of the IJ series
Electrostatic	An electric field is used to accelerate selected drops towards the print medium.	Low power Simple print head construction	Field strength required for separation of small drops is near or above air breakdown	Silverbrook, EP 0771 658 A2 and related patent applications Tone-Jet
Direct magnetic field	A magnetic field is used to accelerate selected drops of magnetic ink towards the print medium.	Low power Simple print head construction	Requires magnetic ink Requires strong magnetic field	Silverbrook, EP 0771 658 A2 and related patent applications
Cross magnetic field	The print head is placed in a constant magnetic field. The Lorenz force in a current carrying wire is used to move the actuator.	Does not require magnetic materials to be integrated in the print head manufacturing process	Requires external magnet Current densities may be high, resulting in electromigration problems	IJ06, IJ16
Pulsed magnetic field	A pulsed magnetic field is used to cyclically attract a paddle, which pushes on the ink. A small actuator moves a catch, which selectively prevents the paddle from moving.	Very low power operation is possible Small print head size	Complex print head construction Magnetic materials required in print head	IJ10

ACTUATOR AMPLIFICATION OR MODIFICATION METHOD

Actuator amplification	Description	Advantages	Disadvantages	Examples
None	No actuator mechanical amplification is used. The actuator directly drives the drop ejection process.	Operational simplicity	Many actuator mechanisms have insufficient travel, or insufficient force, to efficiently drive the drop ejection process	Thermal Bubble Inkjet IJ01, IJ02, IJ06, IJ07 IJ16, IJ25, IJ26

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ACTUATOR AMPLIFICATION OR MODIFICATION METHOD

Actuator amplification	Description	Advantages	Disadvantages	Examples
Differential expansion bend actuator	An actuator material expands more on one side than on the other. The expansion may be thermal, piezoelectric, magnetostrictive, or other mechanism.	Provides greater travel in a reduced print head area The bend actuator converts a high force low travel actuator mechanism to high travel, lower force mechanism.	High stresses are involved Care must be taken that the materials do not delaminate Residual bend resulting from high temperature or high stress during formation	Piezoelectric IJ03, IJ09, IJ17-IJ24 IJ27, IJ29-IJ39, IJ42, IJ43, IJ44
Transient bend actuator	A trilayer bend actuator where the two outside layers are identical. This cancels bend due to ambient temperature and residual stress. The actuator only responds to transient heating of one side or the other.	Very good temperature stability High speed, as a new drop can be fired before heat dissipates Cancels residual stress of formation	High stresses are involved Care must be taken that the materials do not delaminate	IJ40, IJ41
Actuator stack	A series of thin actuators are stacked. This can be appropriate where actuators require high electric field strength, such as electrostatic and piezoelectric actuators.	Increased travel Reduced drive voltage	Increased fabrication complexity Increased possibility of short circuits due to pinholes	Some piezoelectric ink jets IJ04
Multiple actuators	Multiple smaller actuators are used simultaneously to move the ink. Each actuator need provide only a portion of the force required.	Increases the force available from an actuator Multiple actuators can be positioned to control ink flow accurately	Actuator forces may not add linearly, reducing efficiency	IJ12, IJ13, IJ18, IJ20 IJ22, IJ28, IJ42, IJ43
Linear Spring	A linear spring is used to transform a motion with small travel and high force into a longer travel, lower force motion.	Matches low travel actuator with higher travel requirements Non-contact method of motion transformation	Requires print head area for the spring	IJ15
Reverse spring	The actuator loads a spring. When the actuator is turned off, the spring releases. This can reverse the force/distance curve of the actuator to make it compatible with the force/time requirements of the drop ejection.	Better coupling to the ink	Fabrication complexity High stress in the spring	IJ05, IJ11
Coiled actuator	A bend actuator is coiled to provide greater travel in a reduced chip area.	Increases travel Reduces chip area Planar implementations are relatively easy to fabricate.	Generally restricted to planar implementations due to extreme fabrication difficulty in other orientations.	IJ17, IJ21, IJ34, IJ35
Flexure bend actuator	A bend actuator has a small region near the fixture point, which flexes much more readily than the remainder of the actuator. The actuator flexing is effectively converted from an even coiling to an angular bend, resulting in greater travel of the actuator tip.	Simple means of increasing travel of a bend actuator	Care must be taken not to exceed the elastic limit in the flexure area Stress distribution is very uneven Difficult to accurately model with finite element analysis	IJ10, IJ19, IJ33
Gears	Gears can be used to increase travel at the expense of duration. Circular gears, rack and pinion, ratchets, and other gearing methods can be used.	Low force, low travel actuators can be used Can be fabricated using standard surface MEMS processes	Moving parts are required Several actuator cycles are required More complex drive electronics Complex construction Friction, friction, and wear are possible	IJ13
Catch	The actuator controls a small catch. The catch either enables or disables movement of an ink pusher that is controlled in a bulk manner.	Very low actuator energy Very small actuator size	Complex construction Requires external force Unsuitable for pigmented inks	IJ10
Buckle plate	A buckle plate can be used to change a slow actuator into a fast motion. It can also convert a high force, low travel actuator into a high travel, medium force motion.	Very fast movement achievable	Must stay within elastic limits of the materials for long device life High stresses involved Generally high power requirement	S. Hirata et al, "An Ink-jet Head ...", Proc. IEEE MEMS, February 1996, pp 418-423. IJ18, IJ27
Tapered magnetic pole	A tapered magnetic pole can increase travel at the expense of force.	Linearizes the magnetic force/distance curve	Complex construction	IJ14
Lever	A lever and fulcrum is used to transform a motion with small	Matches low travel actuator with higher	High stress around the fulcrum	IJ32, IJ36, IJ37

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ACTUATOR AMPLIFICATION OR MODIFICATION METHOD

Actuator amplification	Description	Advantages	Disadvantages	Examples
	travel and high force into a motion with longer travel and lower force. The lever can also reverse the direction of travel.	travel requirements Fulcrum area has no linear movement, and can be used for a fluid seal		
Rotary impeller	The actuator is connected to a rotary impeller. A small angular deflection of the actuator results in a rotation of the impeller vanes, which push the ink against stationary vanes and out of the nozzle.	High mechanical advantage The ratio of force to travel of the actuator can be matched to the nozzle requirements by varying the number of impeller vanes	Complex construction Unsuitable for pigmented inks	IJ28
Acoustic lens	A refractive or diffractive (e.g. zone plate) acoustic lens is used to concentrate sound waves.	No moving parts	Large area required Only relevant for acoustic ink jets	1993 Hadimioglu et al, EUP 550,192 1993 Elrod et al, EUP 572,220
Sharp conductive point	A sharp point is used to concentrate an electrostatic field.	Simple construction	Difficult to fabricate using standard VLSI processes for a surface ejecting ink-jet Only relevant for electrostatic ink jets	Tone-jet

ACTUATOR MOTION

Actuator motion	Description	Advantages	Disadvantages	Examples
Volume expansion	The volume of the actuator changes, pushing the ink in all directions.	Simple construction in the case of thermal ink jet	High energy is typically required to achieve volume expansion. This leads to thermal stress, cavitation, and kogation in thermal ink jet implementations	Hewlett-Packard Thermal Inkjet Canon Bubblejet
Linear, normal to chip surface	The actuator moves in a direction normal to the print head surface. The nozzle is typically in the line of movement.	Efficient coupling to ink drops ejected normal to the surface	High fabrication complexity may be required to achieve perpendicular motion	IJ01, IJ02, IJ04, IJ07 IJ11, IJ14
Linear, parallel to chip surface	The actuator moves parallel to the print head surface. Drop ejection may still be normal to the surface.	Suitable for planar fabrication	Fabrication complexity Friction Stiction	IJ12, IJ13, IJ15, IJ33, IJ34, IJ35, IJ36
Membrane push	An actuator with a high force but small area is used to push a stiff membrane that is in contact with the ink.	The effective area of the actuator becomes the membrane area	Fabrication complexity Actuator size Difficulty of integration in a VLSI process	1982 Howkins U.S. Pat. No. 4,459,601
Rotary	The actuator causes the rotation of some element, such a grill or impeller	Rotary levers may be used to increase travel Small chip area requirements	Device complexity May have friction at a pivot point	IJ05, IJ08, IJ13, IJ28
Bend	The actuator bends when energized. This may be due to differential thermal expansion, piezoelectric expansion, magnetostriction, or other form of relative dimensional change.	A very small change in dimensions can be converted to a large motion.	Requires the actuator to be made from at least two distinct layers, or to have a thermal difference across the actuator	1970 Kyser et al U.S. Pat. No. 3,946,398 1973 Stemme U.S. Pat. No. 3,747,120 IJ03, IJ09, IJ10, IJ19 IJ23, IJ24, IJ25, IJ29 IJ30, IJ31, IJ33, IJ34 IJ35
Swivel	The actuator swivels around a central pivot. This motion is suitable where there are opposite forces applied to opposite sides of the paddle, e.g. Lorenz force.	Allows operation where the net linear force on the paddle is zero Small chip area requirements	Inefficient coupling to the ink motion	IJ06
Straighten	The actuator is normally bent, and straightens when energized.	Can be used with shape memory alloys where the austenic phase is planar	Requires careful balance of stresses to ensure that the quiescent bend is accurate	IJ26, IJ32

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ACTUATOR MOTION

Actuator motion	Description	Advantages	Disadvantages	Examples
Double bend	The actuator bends in one direction when one element is energized, and bends the other way when another element is energized.	One actuator can be used to power two nozzles. Reduced chip size. Not sensitive to ambient temperature	Difficult to make the drops ejected by both bend directions identical. A small efficiency loss compared to equivalent single bend actuators.	IJ36, IJ37, IJ38
Shear	Energizing the actuator causes a shear motion in the actuator material.	Can increase the effective travel of piezoelectric actuators	Not readily applicable to other actuator mechanisms	1985 Fishbeck U.S. Pat. No. 4,584,590
Radial constriction	The actuator squeezes an ink reservoir, forcing ink from a constricted nozzle.	Relatively easy to fabricate single nozzles from glass tubing as macroscopic structures	High force required Inefficient Difficult to integrate with VLSI processes	1970 Zoltan U.S. Pat. No. 3,683,212
Coil/uncoil	A coiled actuator uncoils or coils more tightly. The motion of the free end of the actuator ejects the ink.	Easy to fabricate as a planar VLSI process Small area required, therefore low cost	Difficult to fabricate for non-planar devices Poor out-of-plane stiffness	IJ17, IJ21, IJ34, IJ35
Bow	The actuator bows (or buckles) in the middle when energized.	Can increase the speed of travel Mechanically rigid	Maximum travel is constrained High force required	IJ16, IJ18, IJ27
Push-Pull	Two actuators control a shutter. One actuator pulls the shutter, and the other pushes it.	The structure is pinned at both ends, so has a high out-of-plane rigidity	Not readily suitable for inkjets which directly push the ink	IJ18
Curl inwards	A set of actuators curl inwards to reduce the volume of ink that they enclose.	Good fluid flow to the region behind the actuator increases efficiency	Design complexity	IJ20, IJ42
Curl outwards	A set of actuators curl outwards, pressurizing ink in a chamber surrounding the actuators, and expelling ink from a nozzle in the chamber.	Relatively simple construction	Relatively large chip area	IJ43
Iris	Multiple vanes enclose a volume of ink. These simultaneously rotate, reducing the volume between the vanes.	High efficiency Small chip area	High fabrication complexity Not suitable for pigmented inks	IJ22
Acoustic vibration	The actuator vibrates at a high frequency.	The actuator can be physically distant from the ink	Large area required for efficient operation at useful frequencies Acoustic coupling and crosstalk Complex drive circuitry Poor control of drop volume and position	1993 Hadimioglu et al, EUP 550,192 1993 Elrod et al, EUP 572,220
None	In various ink jet designs the actuator does not move.	No moving parts	Various other tradeoffs are required to eliminate moving parts	Silverbrook, EP 0771 658 A2 and related patent applications Tone-jet

NOZZLE REFILL METHOD

Nozzle refill method	Description	Advantages	Disadvantages	Examples
Surface tension	After the actuator is energized, it typically returns rapidly to its normal position. This rapid return sucks in air through the nozzle opening. The ink surface tension at the nozzle then exerts a small force restoring the meniscus to a minimum area.	Fabrication simplicity Operational simplicity	Low speed Surface tension force relatively small compared to actuator force Long refill time usually dominates the total repetition rate	Thermal inkjet Piezoelectric inkjet IJ01-IJ07, IJ10-IJ14 IJ16, IJ20, IJ22-IJ45
Shuttered oscillating ink pressure	Ink to the nozzle chamber is provided at a pressure that oscillates at twice the drop ejection frequency. When a drop	High speed Low actuator energy, as the actuator need only open or close the shutter,	Requires common ink pressure oscillator May not be suitable for pigmented inks	IJ08, IJ13, IJ15, IJ17 IJ18, IJ19, IJ21

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NOZZLE REFILL METHOD

Nozzle refill method	Description	Advantages	Disadvantages	Examples
	is to be ejected, the shutter is opened for 3 half cycles: drop ejection, actuator return, and refill.	instead of ejecting the ink drop		
Refill actuator	After the main actuator has ejected a drop a second (refill) actuator is energized. The refill actuator pushes ink into the nozzle chamber. The refill actuator returns slowly, to prevent its return from emptying the chamber again.	High speed, as the nozzle is actively refilled	Requires two independent actuators per nozzle	IJ09
Positive ink pressure	The ink is held a slight positive pressure. After the ink drop is ejected, the nozzle chamber fills quickly as surface tension and ink pressure both operate to refill the nozzle.	High refill rate, therefore a high drop repetition rate is possible	Surface spill must be prevented Highly hydrophobic print head surfaces are required	Silverbrook, EP 0771 658 A2 and related patent applications Alternative for: IJ01-IJ07, IJ10-IJ14 IJ16, IJ20, IJ22-IJ45

METHOD OF RESTRICTING BACK-FLOW THROUGH INLET

Inlet back-flow restriction method	Description	Advantages	Disadvantages	Examples
Long inlet channel	The ink inlet channel to the nozzle chamber is made long and relatively narrow, relying on viscous drag to reduce inlet back-flow.	Design simplicity Operational simplicity Reduces crosstalk	Restricts refill rate May result in a relatively large chip area Only partially effective	Thermal inkjet Piezoelectric inkjet IJ42, IJ43
Positive ink pressure	The ink is under a positive pressure, so that in the quiescent state some of the ink drop already protrudes from the nozzle. This reduces the pressure in the nozzle chamber which is required to eject a certain volume of ink. The reduction in chamber pressure results in a reduction in ink pushed out through the inlet.	Drop selection and separation forces can be reduced Fast refill time	Requires a method (such as a nozzle rim or effective hydrophobizing, or both) to prevent flooding of the ejection surface of the print head.	Silverbrook, EP 0771 658 A2 and related patent applications Possible operation of the following: IJ01-IJ07, IJ09-IJ12 IJ14, IJ16, IJ20, IJ22, IJ23-IJ34, IJ36-IJ41 IJ44
Baffle	One or more baffles are placed in the inlet ink flow. When the actuator is energized, the rapid ink movement creates eddies which restrict the flow through the inlet. The slower refill process is unrestricted, and does not result in eddies.	The refill rate is not as restricted as the long inlet method. Reduces crosstalk	Design complexity May increase fabrication complexity (e.g. Tektronix hot melt Piezoelectric print heads).	HP Thermal Ink Jet Tektronix piezoelectric ink jet
Flexible flap restricts inlet	In this method recently disclosed by Canon, the expanding actuator (bubble) pushes on a flexible flap that restricts the inlet.	Significantly reduces back-flow for edge-shooter thermal ink jet devices	Not applicable to most inkjet configurations Increased fabrication complexity Inelastic deformation of polymer flap results in creep over extended use	Canon
Inlet filter	A filter is located between the ink inlet and the nozzle chamber. The filter has a multitude of small holes or slots, restricting ink flow. The filter also removes particles which may block the nozzle.	Additional advantage of ink filtration Ink filter may be fabricated with no additional process steps	Restricts refill rate May result in complex construction	IJ04, IJ12, IJ24, IJ27 IJ29, IJ30
Small inlet compared to nozzle	The ink inlet channel to the nozzle chamber has a substantially smaller cross section than that of	Design simplicity	Restricts refill rate May result in a relatively large chip area	IJ02, IJ37, IJ44

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METHOD OF RESTRICTING BACK-FLOW THROUGH INLET

Inlet back-flow restriction method	Description	Advantages	Disadvantages	Examples
	the nozzle, resulting in easier ink egress out of the nozzle than out of the inlet.		Only partially effective	
Inlet shutter	A secondary actuator controls the position of a shutter, closing off the ink inlet when the main actuator is energized.	Increases speed of the ink-jet print head operation	Requires separate refill actuator and drive circuit	IJ09
The inlet is located behind the ink-pushing surface	The method avoids the problem of inlet back-flow by arranging the ink-pushing surface of the actuator between the inlet and the nozzle.	Back-flow problem is eliminated	Requires careful design to minimize the negative pressure behind the paddle	IJ01, IJ03, IJ05, IJ06 IJ07, IJ10, IJ11, IJ14 IJ16, IJ22, IJ23, IJ25 IJ28, IJ31, IJ32, IJ33 IJ34, IJ35, IJ36, IJ39 IJ40, IJ41
Part of the actuator moves to shut off the inlet	The actuator and a wall of the ink chamber are arranged so that the motion of the actuator closes off the inlet.	Significant reductions in back-flow can be achieved Compact designs possible	Small increase in fabrication complexity	IJ07, IJ20, IJ26, IJ38
Nozzle actuator does not result in ink back-flow	In some configurations of ink jet, there is no expansion or movement of an actuator which may cause ink back-flow through the inlet.	Ink back-flow problem is eliminated	None related to ink back-flow on actuation	Silverbrook, EP 0771 658 A2 and related patent applications Valve-jet Tone-jet IJ08, IJ13, IJ15, IJ17 IJ18, IJ19, IJ21

NOZZLE CLEARING METHOD

Nozzle Clearing method	Description	Advantages	Disadvantages	Examples
Normal nozzle firing	All of the nozzles are fired periodically, before the ink has a chance to dry. When not in use the nozzles are sealed (capped) against air. The nozzle firing is usually performed during a special clearing cycle, after first moving the print head to a cleaning station.	No added complexity on the print head	May not be sufficient to displace dried ink	Most ink jet systems IJ01-IJ07, IJ09-IJ12 IJ14, IJ16, IJ20, IJ22 IJ23-IJ34, IJ36-IJ45
Extra power to ink heater	In systems which heat the ink, but do not boil it under normal situations, nozzle clearing can be achieved by over-powering the heater and boiling ink at the nozzle.	Can be highly effective if the heater is adjacent to the nozzle	Requires higher drive voltage for clearing May require larger drive transistors	Silverbrook, EP 0771 658 A2 and related patent applications
Rapid succession of actuator pulses	The actuator is fired in rapid succession. In some configurations, this may cause heat build-up at the nozzle which boils the ink, clearing the nozzle. In other situations, it may cause sufficient vibrations to dislodge clogged nozzles.	Does not require extra drive circuits on the print head Can be readily controlled and initiated by digital logic	Effectiveness depends substantially upon the configuration of the inkjet nozzle	May be used with: IJ01-IJ07, IJ09-IJ11 IJ14, IJ16, IJ20, IJ22 IJ23-IJ25, IJ27-IJ34 IJ36-IJ45

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NOZZLE CLEARING METHOD

Nozzle Clearing method	Description	Advantages	Disadvantages	Examples
Extra power to ink pushing actuator	Where an actuator is not normally driven to the limit of its motion, nozzle clearing may be assisted by providing an enhanced drive signal to the actuator.	A simple solution where applicable	Not suitable where there is a hard limit to actuator movement	May be used with: IJ03, IJ09, IJ16, IJ20 IJ23, IJ24, IJ25, IJ27 IJ29, IJ30, IJ31, IJ32 IJ39, IJ40, IJ41, IJ42 IJ43, IJ44, IJ45
Acoustic resonance	An ultrasonic wave is applied to the ink chamber. This wave is of an appropriate amplitude and frequency to cause sufficient force at the nozzle to clear blockages. This is easiest to achieve if the ultrasonic wave is at a resonant frequency of the ink cavity.	A high nozzle clearing capability can be achieved May be implemented at very low cost in systems which already include acoustic actuators	High implementation cost if system does not already include an acoustic actuator	IJ08, IJ13, IJ15, IJ17 IJ18, IJ19, IJ21
Nozzle clearing plate	A microfabricated plate is pushed against the nozzles. The plate has a post for every nozzle. The array of posts	Can clear severely clogged nozzles	Accurate mechanical alignment is required Moving parts are required There is risk of damage to the nozzles Accurate fabrication is required	Silverbrook, EP 0771 658 A2 and related patent applications
Ink pressure pulse	The pressure of the ink is temporarily increased so that ink streams from all of the nozzles. This may be used in conjunction with actuator energizing.	May be effective where other methods cannot be used	Requires pressure pump or other pressure actuator Expensive Wasteful of ink	May be used with all IJ series ink jets
Print head wiper	A flexible 'blade' is wiped across the print head surface. The blade is usually fabricated from a flexible polymer, e.g. rubber or synthetic elastomer.	Effective for planar print head surfaces Low cost	Difficult to use if print head surface is non-planar or very fragile Requires mechanical parts Blade can wear out in high volume print systems	Many ink jet systems
Separate ink boiling heater	A separate heater is provided at the nozzle although the normal drop e-ection mechanism does not require it. The heaters do not require individual drive circuits, as many nozzles can be cleared simultaneously, and no imaging is required.	Can be effective where other nozzle clearing methods cannot be used Can be implemented at no additional cost in some inkjet configurations	Fabrication complexity	Can be used with many IJ series ink jets

NOZZLE PLATE CONSTRUCTION

Nozzle plate construction	Description	Advantages	Disadvantages	Examples
Electroformed nickel	A nozzle plate is separately fabricated from electroformed nickel, and bonded to the print head chip.	Fabrication simplicity	High temperatures and pressures are required to bond nozzle plate Minimum thickness constraints Differential thermal expansion	Hewlett Packard Thermal Inkjet
Laser ablated or drilled polymer	Individual nozzle holes are ablated by an intense UV laser in a nozzle plate, which is typically a polymer such as polyimide or polysulphone	No masks required Can be quite fast Some control over nozzle profile is possible Equipment required is relatively low cost	Each hole must be individually formed Special equipment required Slow where there are many thousands of nozzles per print head May produce thin burrs at exit holes	Canon Bubblejet 1988 Sercel et al., SPIE, Vol. 998 Excimer Beam Applications, pp. 76-83 1993 Watanabe et al., U.S. Pat. No. 5,208,604
Silicon micro-machined	A separate nozzle plate is micromachined from single crystal silicon, and bonded to the print head wafer.	High accuracy is attainable	Two part construction High cost Requires precision alignment Nozzles may be clogged by adhesive	K. Bean, IEEE Transactions on Electron Devices, Vol. ED-25, No. 10, 1978, pp 1185-1195

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NOZZLE PLATE CONSTRUCTION

Nozzle plate construction	Description	Advantages	Disadvantages	Examples
				Xerox 1990 Hawkins et al., U.S. Pat. No. 4,899,181
Glass capillaries	Fine glass capillaries are drawn from glass tubing. This method has been used for making individual nozzles, but is difficult to use for bulk manufacturing of print heads with thousands of nozzles.	No expensive equipment required Simple to make single nozzles	Very small nozzle sizes are difficult to form Not suited for mass production	1970 Zoltan U.S. Pat. No. 3,683,212
Monolithic, surface micro-machined using VLSI lithographic processes	The nozzle plate is deposited as a layer using standard VLSI deposition techniques. Nozzles are etched in the nozzle plate using VLSI lithography and etching.	High accuracy (<1 μm) Monolithic Low cost Existing processes can be used	Requires sacrificial layer under the nozzle plate to form the nozzle chamber Surface may be fragile to the touch	Silverbrook, EP 0771 658 A2 and related patent applications IJ01, IJ02, IJ04, IJ11 IJ12, IJ17, IJ18, IJ20 IJ22, IJ24, IJ27, IJ28 IJ29, IJ30, IJ31, IJ32 IJ33, IJ34, IJ36, IJ37 IJ38, IJ39, IJ40, IJ41 IJ42, IJ43, IJ44
Monolithic, etched through substrate	The nozzle plate is a buried etch stop in the wafer. Nozzle chambers are etched in the front of the wafer, and the wafer is thinned from the back side. Nozzles are then etched in the etch stop layer.	High accuracy (<1 μm) Monolithic Low cost No differential expansion	Requires long etch times Requires a support wafer	IJ03, IJ05, IJ06, IJ07 IJ08, IJ09, IJ10, IJ13 IJ14, IJ15, IJ16, IJ19 IJ21, IJ23, IJ25, IJ26
No nozzle plate	Various methods have been tried to eliminate the nozzles entirely, to prevent nozzle clogging. These include thermal bubble mechanisms and acoustic lens mechanisms	No nozzles to become clogged	Difficult to control drop position accurately Crosstalk problems	Ricoh 1995 Sekiya et al U.S. Pat. No. 5,412,413 1993 Hadimioglu et al EUP 550,192 1993 Elrod et al EUP 572,220
Trough	Each drop ejector has a trough through which a paddle moves. There is no nozzle plate.	Reduced manufacturing complexity Monolithic	Drop firing direction is sensitive to wicking.	IJ35
Nozzle slit instead of individual nozzles	The elimination of nozzle holes and replacement by a slit encompassing many actuator positions reduces nozzle clogging, but increases crosstalk due to ink surface waves	No nozzles to become clogged	Difficult to control drop position accurately Crosstalk problems	1989 Saito et al U.S. Pat. No. 4,799,068

DROP EJECTION DIRECTION

Ejection direction	Description	Advantages	Disadvantages	Examples
Edge (‘edge shooter’)	Ink flow is along the surface of the chip, and ink drops are ejected from the chip edge.	Simple construction No silicon etching required Good heat sinking via substrate Mechanically strong Ease of chip handing	Nozzles limited to edge High resolution is difficult Fast color printing requires one print head per color	Canon Bubblejet 1979 Endo et al GB patent 2,007,162 Xerox heater-in-pit 1990 Hawkins et al U.S. Pat. No. 4,899,181 Tone-jet

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DROP EJECTION DIRECTION

Ejection direction	Description	Advantages	Disadvantages	Examples
Surface ('roof shooter')	Ink flow is along the surface of the chip, and ink drops are ejected from the chip surface, normal to the plane of the chip.	No bulk silicon etching required Silicon can make an effective heat sink Mechanical strength	Maximum ink flow is severely restricted	Hewlett-Packard TIJ 1982 Vaught et al U.S. Pat. No. 4,490,728 IJ02, IJ11, IJ12, IJ20 IJ22
Through chip, forward ('up shooter')	Ink flow is through the chip, and ink drops are ejected from the front surface of the chip.	High ink flow Suitable for pagewidth print High nozzle packing density therefore low manufacturing cost	Requires bulk silicon etching	Silverbrook, EP 0771 658 A2 and related patent applications IJ04, IJ17, IJ18, IJ24 IJ27-IJ45
Through chip, reverse ('down shooter')	Ink flow is through the chip, and ink drops are ejected from the rear surface of the chip.	High ink flow Suitable for pagewidth print High nozzle packing density therefore low manufacturing cost	Requires wafer thinning Requires special handling during manufacture	IJ01, IJ03, IJ05, IJ06 IJ07, IJ08, IJ09, IJ10 IJ13, IJ14, IJ15, IJ16 IJ19, IJ21, IJ23, IJ25 IJ26
Through actuator	Ink flow is through the actuator, which is not fabricated as part of the same substrate as the drive transistors.	Suitable for piezoelectric print heads	Pagewidth print heads require several thousand connections to drive circuits Cannot be manufactured in standard CMOS fabs Complex assembly required	Epson Stylus Tektronix hot melt piezoelectric ink jets

INK TYPE

Ink type	Description	Advantages	Disadvantages	Examples
Aqueous, dye	Water based ink which typically contains: water, dye, surfactant, humectant, and biocide. Modern ink dyes have high water-fastness, light fastness	Environmentally friendly No odor	Slow drying Corrosive Bleeds on paper May strikethrough Cockles paper	Most existing inkjets All IJ series ink jets Silverbrook, EP 0771 658 A2 and related patent applications
Aqueous, pigment	Water based ink which typically contains: water, pigment, surfactant, humectant, and biocide. Pigments have an advantage in reduced bleed, wicking and strikethrough.	Environmentally friendly No odor Reduced bleed Reduced wicking Reduced strikethrough	Slow drying Corrosive Pigment may clog nozzles Pigment may clog actuator mechanisms Cockles paper	IJ02, IJ04, IJ21, IJ26 IJ27, IJ30 Silverbrook, EP 0771 658 A2 and related patent applications Piezoelectric ink-jets Thermal ink jets (with significant restrictions)
Methyl Ethyl Ketone (MEK)	MEK is a highly volatile solvent used for industrial printing on difficult surfaces such as aluminum cans.	Very fast drying Prints on various substrates such as metals and plastics	Odorous Flammable	All IJ series ink jets
Alcohol (ethanol, 2-butanol, and others)	Alcohol based inks can be used where the printer must operate at temperatures below the freezing point of water. An example of this is in-camera consumer photographic printing.	Fast drying Operates at sub-freezing temperatures Reduced paper cockle Low cost	Slight odor Flammable	All IJ series ink jets
Phase change (hot melt)	The ink is solid at room temperature, and is melted in the print head before jetting. Hot melt inks are usually wax based, with a	No drying time-ink instantly freezes on the print medium Almost any print medium	High viscosity Printed ink typically has a 'waxy' feel Printed pages may 'block'	Tektronix hot melt piezoelectric ink jets 1989 Nowak U.S. Pat. No.

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INK TYPE

Ink type	Description	Advantages	Disadvantages	Examples
	melting point around 80° C.. After jetting the ink freezes almost instantly upon contacting the print medium or a transfer roller.	can be used No paper cockle occurs No wicking occurs No bleed occurs No strikethrough occurs	Ink temperature may be above the curie point of permanent magnets Ink heaters consume power Long warm-up time	4,820,346 All IJ series ink jets
Oil	Oil based inks are extensively used in offset printing. They have advantages in improved characteristics on paper (especially no wicking or cockle). Oil soluble dies and pigments are required.	High solubility medium for some dyes Does not cockle paper Does not wick through paper	High viscosity: this is a significant limitation for use in inkjets, which usually require a low viscosity. Some short chain and multi-branched oils have a sufficiently low viscosity. Slow drying	All IJ series ink jets
Microemulsion	A microemulsion is a stable, self forming emulsion of oil, water, and surfactant. The characteristic drop size is less than 100 nm, and is determined by the preferred curvature of the surfactant.	Stops ink bleed High dye solubility Water, oil, and amphiphilic soluble dies can be used Can stabilize pigment suspensions	Viscosity higher than water Cost is slightly higher than water based ink High surfactant concentration required (around 5%)	All IJ series ink jets

Ink Jet Printing

[0058] A large number of new forms of ink jet printers have been developed to facilitate alternative ink jet technologies for the image processing and data distribution system. Various combinations of ink jet devices can be included in printer devices incorporated as part of the present invention. Australian Provisional Patent Applications relating to these ink jets which are specifically incorporated by cross reference. The serial numbers of respective corresponding US patent applications are also provided for the sake of convenience.

Australian Provisional Number	Filing Date	Title	U.S. Pat./Patent Application and Filing Date
PO8066	Jul. 17, 1997	Image Creation Method and Apparatus (IJ01)	6,227,652 (Jul. 10, 1998)
PO8072	Jul. 17, 1997	Image Creation Method and Apparatus (IJ02)	6,213,588 (Jul. 10, 1998)
PO8040	Jul. 17, 1997	Image Creation Method and Apparatus (IJ03)	6,213,589 (Jul. 10, 1998)
PO8071	Jul. 17, 1997	Image Creation Method and Apparatus (IJ04)	6,231,163 (Jul. 10, 1998)
PO8047	Jul. 17, 1997	Image Creation Method and Apparatus (IJ05)	6,247,795 (Jul. 10, 1998)
PO8035	Jul. 17, 1997	Image Creation Method and Apparatus (IJ06)	6,394,581 (Jul. 10, 1998)
PO8044	Jul. 17, 1997	Image Creation Method and Apparatus (IJ07)	6,244,691 (Jul. 10, 1998)
PO8063	Jul. 17, 1997	Image Creation Method and Apparatus (IJ08)	6,257,704 (Jul. 10, 1998)
PO8057	Jul. 17, 1997	Image Creation Method and Apparatus (IJ09)	6,416,168 (Jul. 10, 1998)

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Australian Provisional Number	Filing Date	Title	U.S. Pat./Patent Application and Filing Date
PO8056	Jul. 17, 1997	Image Creation Method and Apparatus (IJ10)	6,220,694 (Jul. 10, 1998)
PO8069	Jul. 17, 1997	Image Creation Method and Apparatus (IJ11)	6,257,705 (Jul. 10, 1998)
PO8049	Jul. 17, 1997	Image Creation Method and Apparatus (IJ12)	6,247,794 (Jul. 10, 1998)
PO8036	Jul. 17, 1997	Image Creation Method and Apparatus (IJ13)	6,234,610 (Jul. 10, 1998)
PO8048	Jul. 17, 1997	Image Creation Method and Apparatus (IJ14)	6,247,793 (Jul. 10, 1998)
PO8070	Jul. 17, 1997	Image Creation Method and Apparatus (IJ15)	6,264,306 (Jul. 10, 1998)
PO8067	Jul. 17, 1997	Image Creation Method and Apparatus (IJ16)	6,241,342 (Jul. 10, 1998)
PO8001	Jul. 17, 1997	Image Creation Method and Apparatus (IJ17)	6,247,792 (Jul. 10, 1998)
PO8038	Jul. 17, 1997	Image Creation Method and Apparatus (IJ18)	6,264,307 (Jul. 10, 1998)
PO8033	Jul. 17, 1997	Image Creation Method and Apparatus (IJ19)	6,254,220 (Jul. 10, 1998)
PO8002	Jul. 17, 1997	Image Creation Method and Apparatus (IJ20)	6,234,611 (Jul. 10, 1998)
PO8068	Jul. 17, 1997	Image Creation Method and Apparatus (IJ21)	6,302,528 (Jul. 10, 1998)
PO8062	Jul. 17, 1997	Image Creation Method and Apparatus (IJ22)	6,283,582 (Jul. 10, 1998)
PO8034	Jul. 17, 1997	Image Creation Method and Apparatus (IJ23)	6,239,821 (Jul. 10, 1998)

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Australian Provisional Number	Filing Date	Title	U.S. Pat./Patent Application and Filing Date
PO8039	Jul. 17, 1997	Image Creation Method and Apparatus (IJ24)	6,338,547 (Jul. 10, 1998)
PO8041	Jul. 17, 1997	Image Creation Method and Apparatus (IJ25)	6,247,796 (Jul. 10, 1998)
PO8004	Jul. 17, 1997	Image Creation Method and Apparatus (IJ26)	09/113,122 (Jul. 10, 1998)
PO8037	Jul. 17, 1997	Image Creation Method and Apparatus (IJ27)	6,390,603 (Jul. 10, 1998)
PO8043	Jul. 17, 1997	Image Creation Method and Apparatus (IJ28)	6,362,843 (Jul. 10, 1998)
PO8042	Jul. 17, 1997	Image Creation Method and Apparatus (IJ29)	6,293,653 (Jul. 10, 1998)
PO8064	Jul. 17, 1997	Image Creation Method and Apparatus (IJ30)	6,312,107 (Jul. 10, 1998)
PO9389	Sep. 23, 1997	Image Creation Method and Apparatus (IJ31)	6,227,653 (Jul. 10, 1998)
PO9391	Sep. 23, 1997	Image Creation Method and Apparatus (IJ32)	6,234,609 (Jul. 10, 1998)
PP0888	Dec. 12, 1997	Image Creation Method and Apparatus (IJ33)	6,238,040 (Jul. 10, 1998)
PP0891	Dec. 12, 1997	Image Creation Method and Apparatus (IJ34)	6,188,415 (Jul. 10, 1998)
PP0890	Dec. 12, 1997	Image Creation Method and Apparatus (IJ35)	6,227,654 (Jul. 10, 1998)
PP0873	Dec. 12, 1997	Image Creation Method and Apparatus (IJ36)	6,209,989 (Jul. 10, 1998)

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Australian Provisional Number	Filing Date	Title	U.S. Pat./Patent Application and Filing Date
PP0993	Dec. 12, 1997	Image Creation Method and Apparatus (IJ37)	6,247,791 (Jul. 10, 1998)
PP0890	Dec. 12, 1997	Image Creation Method and Apparatus (IJ38)	6,336,710 (Jul. 10, 1998)
PP1398	Jan. 19, 1998	An Image Creation Method and Apparatus (IJ39)	6,217,153 (Jul. 10, 1998)
PP2592	Mar. 25, 1998	An Image Creation Method and Apparatus (IJ40)	6,416,167 (Jul. 10, 1998)
PP2593	Mar. 25, 1998	Image Creation Method and Apparatus (IJ41)	6,243,113 (Jul. 10, 1998)
PP3991	Jun. 9, 1998	Image Creation Method and Apparatus (IJ42)	6,283,581 (Jul. 10, 1998)
PP3987	Jun. 9, 1998	Image Creation Method and Apparatus (IJ43)	6,247,790 (Jul. 10, 1998)
PP3985	Jun. 9, 1998	Image Creation Method and Apparatus (IJ44)	6,260,953 (Jul. 10, 1998)
PP3983	Jun. 9, 1998	Image Creation Method and Apparatus (IJ45)	6,267,469 (Jul. 10, 1998)

Ink Jet Manufacturing

[0059] Further, the present application may utilize advanced semiconductor fabrication techniques in the construction of large arrays of ink jet printers. Suitable manufacturing techniques are described in the following Australian provisional patent specifications incorporated here by cross-reference. The serial numbers of respective corresponding US patent applications are also provided for the sake of convenience.

Australian Provisional Number	Filing Date	Title	U.S. Pat./Patent Application and Filing Date
PO7935	Jul. 15, 1997	A Method of Manufacture of an Image Creation Apparatus (IJM01)	6,224,780 (Jul. 10, 1998)
PO7936	Jul. 15, 1997	A Method of Manufacture of an Image Creation Apparatus (IJM02)	6,235,212 (Jul. 10, 1998)
PO7937	Jul. 15, 1997	A Method of Manufacture of an Image Creation Apparatus (IJM03)	6,280,643 (Jul. 10, 1998)
PO8061	Jul. 15, 1997	A Method of Manufacture of an Image Creation Apparatus (IJM04)	6,284,147 (Jul. 10, 1998)
PO8054	Jul. 15, 1997	A Method of Manufacture of an Image Creation Apparatus (IJM05)	6,214,244 (Jul. 10, 1998)
PO8065	Jul. 15, 1997	A Method of Manufacture of an Image Creation Apparatus (IJM06)	6,071,750 (Jul. 10, 1998)
PO8055	Jul. 15, 1997	A Method of Manufacture of an Image Creation Apparatus (IJM07)	6,267,905 (Jul. 10, 1998)
PO8053	Jul. 15, 1997	A Method of Manufacture of an Image Creation Apparatus (IJM08)	6,251,298 (Jul. 10, 1998)

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Australian Provisional Number	Filing Date	Title	U.S. Pat./Patent Application and Filing Date
PO8078	Jul. 15, 1997	A Method of Manufacture of an Image Creation Apparatus (IJM09)	6,258,285 (Jul. 10, 1998)
PO7933	Jul. 15, 1997	A Method of Manufacture of an Image Creation Apparatus (IJM10)	6,225,138 (Jul. 10, 1998)
PO7950	Jul. 15, 1997	A Method of Manufacture of an Image Creation Apparatus (IJM11)	6,241,904 (Jul. 10, 1998)
PO7949	Jul. 15, 1997	A Method of Manufacture of an Image Creation Apparatus (IJM12)	6,299,786 (Jul. 10, 1998)
PO8060	Jul. 15, 1997	A Method of Manufacture of an Image Creation Apparatus (IJM13)	09/113,124 (Jul. 10, 1998)
PO8059	Jul. 15, 1997	A Method of Manufacture of an Image Creation Apparatus (IJM14)	6,231,773 (Jul. 10, 1998)
PO8073	Jul. 15, 1997	A Method of Manufacture of an Image Creation Apparatus (IJM15)	6,190,931 (Jul. 10, 1998)
PO8076	Jul. 15, 1997	A Method of Manufacture of an Image Creation Apparatus (IJM16)	6,248,249 (Jul. 10, 1998)
PO8075	Jul. 15, 1997	A Method of Manufacture of an Image Creation Apparatus (IJM17)	6,290,862 (Jul. 10, 1998)
PO8079	Jul. 15, 1997	A Method of Manufacture of an Image Creation Apparatus (IJM18)	6,241,906 (Jul. 10, 1998)
PO8050	Jul. 15, 1997	A Method of Manufacture of an Image Creation Apparatus (IJM19)	09/113,116 (Jul. 10, 1998)
PO8052	Jul. 15, 1997	A Method of Manufacture of an Image Creation Apparatus (IJM20)	6,241,905 (Jul. 10, 1998)
PO7948	Jul. 15, 1997	A Method of Manufacture of an Image Creation Apparatus (IJM21)	6,451,216 (Jul. 10, 1998)
PO7951	Jul. 15, 1997	A Method of Manufacture of an Image Creation Apparatus (IJM22)	6,231,772 (Jul. 10, 1998)
PO8074	Jul. 15, 1997	A Method of Manufacture of an Image Creation Apparatus (IJM23)	6,274,056 (Jul. 10, 1998)
PO7941	Jul. 15, 1997	A Method of Manufacture of an Image Creation Apparatus (IJM24)	6,290,861 (Jul. 10, 1998)
PO8077	Jul. 15, 1997	A Method of Manufacture of an Image Creation Apparatus (IJM25)	6,248,248 (Jul. 10, 1998)
PO8058	Jul. 15, 1997	A Method of Manufacture of an Image Creation Apparatus (IJM26)	6,306,671 (Jul. 10, 1998)
PO8051	Jul. 15, 1997	A Method of Manufacture of an Image Creation Apparatus (IJM27)	6,331,258 (Jul. 10, 1998)
PO8045	Jul. 15, 1997	A Method of Manufacture of an Image Creation Apparatus (IJM28)	6,110,754 (Jul. 10, 1998)
PO7952	Jul. 15, 1997	A Method of Manufacture of an Image Creation Apparatus (IJM29)	6,294,101 (Jul. 10, 1998)
PO8046	Jul. 15, 1997	A Method of Manufacture of an Image Creation Apparatus (IJM30)	6,416,679 (Jul. 10, 1998)
PO8503	Aug. 11, 1997	A Method of Manufacture of an Image Creation Apparatus (IJM30a)	6,264,849 (Jul. 10, 1998)
PO9390	Sep. 23, 1997	A Method of Manufacture of an Image Creation Apparatus (IJM31)	6,254,793 (Jul. 10, 1998)

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Australian Provisional Number	Filing Date	Title	U.S. Pat./Patent Application and Filing Date
PO9392	Sep. 23, 1997	A Method of Manufacture of an Image Creation Apparatus (IJM32)	6,235,211 (Jul. 10, 1998)
PP0889	Dec. 12, 1997	A Method of Manufacture of an Image Creation Apparatus (IJM35)	6,235,211 (Jul. 10, 1998)
PP0887	Dec. 12, 1997	A Method of Manufacture of an Image Creation Apparatus (IJM36)	6,264,850 (Jul. 10, 1998)
PP0882	Dec. 12, 1997	A Method of Manufacture of an Image Creation Apparatus (IJM37)	6,258,284 (Jul. 10, 1998)
PP0874	Dec. 12, 1997	A Method of Manufacture of an Image Creation Apparatus (IJM38)	6,258,284 (Jul. 10, 1998)
PP1396	Jan. 19, 1998	A Method of Manufacture of an Image Creation Apparatus (IJM39)	6,228,668 (Jul. 10, 1998)
PP2591	Mar. 25, 1998	A Method of Manufacture of an Image Creation Apparatus (IJM41)	6,180,427 (Jul. 10, 1998)
PP3989	Jun. 9, 1998	A Method of Manufacture of an Image Creation Apparatus (IJM40)	6,171,875 (Jul. 10, 1998)
PP3990	Jun. 9, 1998	A Method of Manufacture of an Image Creation Apparatus (IJM42)	6,267,904 (Jul. 10, 1998)
PP3986	Jun. 9, 1998	A Method of Manufacture of an Image Creation Apparatus (IJM43)	6,245,247 (Jul. 10, 1998)
PP3984	Jun. 9, 1998	A Method of Manufacture of an Image Creation Apparatus (IJM44)	6,245,247 (Jul. 10, 1998)
PP3982	Jun. 9, 1998	A Method of Manufacture of an Image Creation Apparatus (IJM45)	6,231,148 (Jul. 10, 1998)

Fluid Supply

[0060] Further, the present application may utilize an ink delivery system to the ink jet head. Delivery systems relating to the supply of ink to a series of ink jet nozzles are described in the following Australian provisional patent specifications, the disclosure of which are hereby incorporated by cross-reference. The serial numbers of respective corresponding US patent applications are also provided for the sake of convenience.

Australian Provisional Number	Filing Date	Title	U.S. Pat./Patent Application and Filing Date
PO8003	Jul. 15, 1997	Supply Method and Apparatus (F1)	6,350,023 (Jul. 10, 1998)
PO8005	Jul. 15, 1997	Supply Method and Apparatus (F2)	6,318,849 (Jul. 10, 1998)
PO9404	Sep. 23, 1997	A Device and Method (F3)	09/113,101 (Jul. 10, 1998)

[0061] MEMS Technology

[0062] Further, the present application may utilize advanced semiconductor microelectromechanical techniques in the construction of large arrays of ink jet printers. Suitable microelectromechanical techniques are described in the following Australian provisional patent specifications incorporated here by cross-reference. The serial numbers of respective corresponding US patent applications are also provided for the sake of convenience.

Australian Provisional Number	Filing Date	Title	U.S. Pat./Patent Application and Filing Date
PO7943	Jul. 15, 1997	A device (MEMS01)	
PO8006	Jul. 15, 1997	A device (MEMS02)	6,087,638 (Jul. 10, 1998)
PO8007	Jul. 15, 1997	A device (MEMS03)	09/113,093 (Jul. 10, 1998)
PO8008	Jul. 15, 1997	A device (MEMS04)	6,340,222 (Jul. 10, 1998)
PO8010	Jul. 15, 1997	A device (MEMS05)	6,041,600 (Jul. 10, 1998)
PO8011	Jul. 15, 1997	A device (MEMS06)	6,299,300 (Jul. 10, 1998)
PO7947	Jul. 15, 1997	A device (MEMS07)	6,067,797 (Jul. 10, 1998)
PO7945	Jul. 15, 1997	A device (MEMS08)	09/113,081 (Jul. 10, 1998)
PO7944	Jul. 15, 1997	A device (MEMS09)	6,286,935 (Jul. 10, 1998)
PO7946	Jul. 15, 1997	A device (MEMS10)	6,044,646 (Jul. 10, 1998)

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Australian Provisional Number	Filing Date	Title	U.S. Pat./Patent Application and Filing Date
PO9393	Sep. 23, 1997	A Device and Method (MEMS11)	09/113,065 (Jul. 10, 1998)
PP0875	Dec. 12, 1997	A Device (MEMS12)	09/113,078 (Jul. 10, 1998)
PP0894	Dec. 12, 1997	A Device and Method (MEMS13)	09/113,075 (Jul. 10, 1998)

[0063] IR Technologies

[0064] Further, the present application may include the utilization of a disposable camera system such as those described in the following Australian provisional patent specifications incorporated here by cross-reference. The serial numbers of respective corresponding US patent applications are also provided for the sake of convenience.

Australian Provisional Number	Filing Date	Title	U.S. Pat./Patent Application and Filing Date
PP0895	Dec. 12, 1997	An Image Creation Method and Apparatus (IR01)	6,231,148 (Jul. 10, 1998)
PP0870	Dec. 12, 1997	A Device and Method (IR02)	09/113,106 (Jul. 10, 1998)
PP0869	Dec. 12, 1997	A Device and Method (IR04)	6,293,658 (Jul. 10, 1998)
PP0887	Dec. 12, 1997	Image Creation Method and Apparatus (IR05)	09/113,104 (Jul. 10, 1998)
PP0885	Dec. 12, 1997	An Image Production System (IR06)	6,238,033 (Jul. 10, 1998)
PP0884	Dec. 12, 1997	Image Creation Method and Apparatus (IR10)	6,312,070 (Jul. 10, 1998)
PP0886	Dec. 12, 1997	Image Creation Method and Apparatus (IR12)	6,238,111 (Jul. 10, 1998)
PP0871	Dec. 12, 1997	A Device and Method (IR13)	09/113,086 (Jul. 10, 1998)
PP0876	Dec. 12, 1997	An Image Processing Method and Apparatus (IR14)	09/113,094 (Jul. 10, 1998)

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Australian Provisional Number	Filing Date	Title	U.S. Pat./Patent Application and Filing Date
PP0877	Dec. 12, 1997	A Device and Method (IR16)	6,378,970 (Jul. 10, 1998)
PP0878	Dec. 12, 1997	A Device and Method (IR17)	6,196,739 (Jul. 10, 1998)
PP0879	Dec. 12, 1997	A Device and Method (IR18)	09/112,774 (Jul. 10, 1998)
PP0883	Dec. 12, 1997	A Device and Method (IR19)	6,270,182 (Jul. 10, 1998)
PP0880	Dec. 12, 1997	A Device and Method (IR20)	6,152,619 (Jul. 10, 1998)
PP0881	Dec. 12, 1997	A Device and Method (IR21)	09/113,092 (Jul. 10, 1998)

[0065] DotCard Technologies

[0066] Further, the present application may include the utilization of a data distribution system such as that described in the following Australian provisional patent specifications incorporated here by cross-reference. The serial numbers of respective corresponding US patent applications are also provided for the sake of convenience.

Australian Provisional Number	Filing Date	Title	US Patent/Patent Application and Filing Date
PP2370	Mar. 16, 1998	Data Processing Method and Apparatus (Dot01)	09/112,781 (Jul. 10, 1998)
PP2371	Mar. 16, 1998	Data Processing Method and Apparatus (Dot02)	09/113,052 (Jul. 10, 1998)

Artcam Technologies

[0067] Further, the present application may include the utilization of camera and data processing techniques such as an Artcam type device as described in the following Australian provisional patent specifications incorporated here by cross-reference. The serial numbers of respective corresponding US patent applications are also provided for the sake of convenience.

Australian Provisional Number	Filing Date	Title	U.S. Pat./Patent Application and Filing Date
PO7991	Jul. 15, 1997	Image Processing Method and Apparatus (ART01)	09/113,060 (Jul. 10, 1998)
PO7988	Jul. 15, 1997	Image Processing Method and Apparatus (ART02)	6,476,863 (Jul. 10, 1998)
PO7993	Jul. 15, 1997	Image Processing Method and Apparatus (ART03)	09/113,073 (Jul. 10, 1998)
PO9395	Sep. 23, 1997	Data Processing Method and Apparatus (ART04)	6,322,181 (Jul. 10, 1998)
PO8017	Jul. 15, 1997	Image Processing Method and Apparatus (ART06)	09/112,747 (Jul. 10, 1998)
PO8014	Jul. 15, 1997	Media Device (ART07)	6,227,648 (Jul. 10, 1998)
PO8025	Jul. 15, 1997	Image Processing Method and Apparatus (ART08)	09/112,750 (Jul. 10, 1998)

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Australian Provisional Number	Filing Date	Title	U.S. Pat./Patent Application and Filing Date
PO8032	Jul. 15, 1997	Image Processing Method and Apparatus (ART09)	09/112,746 (Jul. 10, 1998)
PO7999	Jul. 15, 1997	Image Processing Method and Apparatus (ART10)	09/112,743 (Jul. 10, 1998)
PO7998	Jul. 15, 1997	Image Processing Method and Apparatus (ART11)	09/112,742 (Jul. 10, 1998)
PO8031	Jul. 15, 1997	Image Processing Method and Apparatus (ART12)	09/112,741 (Jul. 10, 1998)
PO8030	Jul. 15, 1997	Media Device (ART13)	6,196,541 (Jul. 10, 1998)
PO7997	Jul. 15, 1997	Media Device (ART15)	6,195,150 (Jul. 10, 1998)
PO7979	Jul. 15, 1997	Media Device (ART16)	6,362,868 (Jul. 10, 1998)
PO8015	Jul. 15, 1997	Media Device (ART17)	09/112,738 (Jul. 10, 1998)
PO7978	Jul. 15, 1997	Media Device (ART18)	09/113, 067 (Jul. 10, 1998)
PO7982	Jul. 15, 1997	Data Processing Method and Apparatus (ART19)	6,431,669 (Jul. 10, 1998)
PO7989	Jul. 15, 1997	Data Processing Method and Apparatus (ART20)	6,362,869 (Jul. 10, 1998)
PO8019	Jul. 15, 1997	Media Processing Method and Apparatus (ART21)	6,472,052 (Jul. 10, 1998)
PO7980	Jul. 15, 1997	Image Processing Method and Apparatus (ART22)	6,356,715 (Jul. 10, 1998)
PO8018	Jul. 15, 1997	Image Processing Method and Apparatus (ART24)	09/112,777 (Jul. 10, 1998)
PO7938	Jul. 15, 1997	Image Processing Method and Apparatus (ART25)	09/113,224 (Jul. 10, 1998)
PO8016	Jul. 15, 1997	Image Processing Method and Apparatus (ART26)	6,366,693 (Jul. 10, 1998)
PO8024	Jul. 15, 1997	Image Processing Method and Apparatus (ART27)	6,329,990 (Jul. 10, 1998)
PO7940	Jul. 15, 1997	Data Processing Method and Apparatus (ART28)	09/113,072 (Jul. 10, 1998)
PO7939	Jul. 15, 1997	Data Processing Method and Apparatus (ART29)	09/112,785 (Jul. 10, 1998)
PO8501	Aug. 11, 1997	Image Processing Method and Apparatus (ART30)	6,137,500 (Jul. 10, 1998)
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1. A method of generating manipulated images with a digital camera, comprising the steps of:

detecting objects within a digital image produced by the digital camera utilising an autofocus unit of the digital camera by processing the digital image with a processor of the digital camera utilising focusing settings of the autofocus unit as an indicator of positions of said objects; and

generating a manipulated image by applying a digital image manipulating process of the processor to the detected objects.

2. A method according to claim **1**, wherein the focus settings include a current position of a zoom motor of the digital camera.

3. A method according to claim **2**, further comprising the step of printing the manipulated image with a printing mechanism of the digital camera.

4. A method according to claim **1**, wherein the digital image manipulating process selectively applies techniques to the digital image utilizing the focus settings.

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