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(54) Ink jet printer including a disengageable medium transport for jam clearance

(57) A liquid ink printing machine (10), for forming an image on a recording medium (30) moving along a path, including a jam clearance drive gear disengagement mechanism. The printing machine includes a transport roller (40), to move the medium along the path, a drive gear assembly (58,60,62,64,66,68,70,72) which is coupled to the transport roller, to drive the transport roller and which is disengageable to free the transport roller for movement to provide for removal of the medium in the event of a jam. A stepper motor (52), coupled to the gear assembly, moves the gear assembly for which in turn moves the transport roller for advance of the recording medium along the path. An actuating arm (44) is displaced by the liquid ink printhead carriage (20), in the event of a jam, to disengage the drive gear assembly, thereby freeing the transport roller for unrestricted movement in at least one direction for removal of the recording medium in the event of a jam or inadvertent sheet stoppage. A printer controller (54) moves the gears of the gear assembly to reengage the gears once the jam has been cleared.

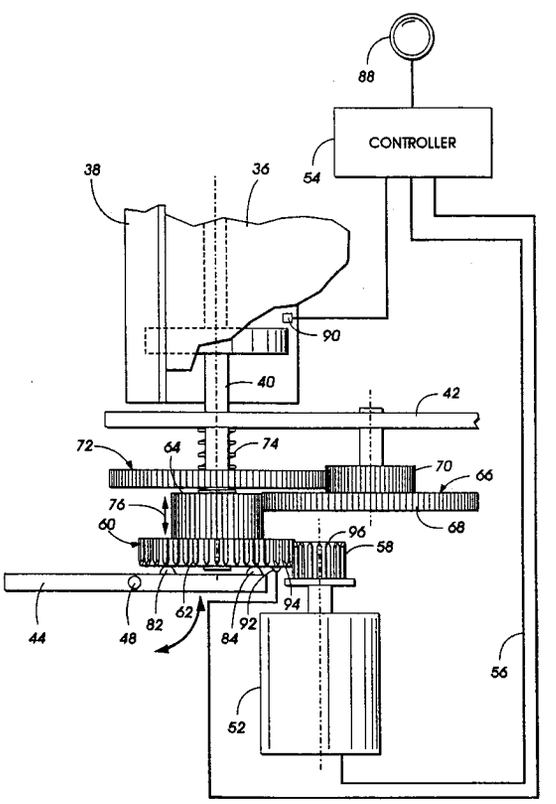

FIG. 3

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Description

This invention relates generally to liquid ink printers and more particularly to a medium transport being disengageable to provide for removal of the medium from the printer in the event of an inadvertent medium stoppage or jam.

Liquid ink printers of the type frequently referred to as continuous stream or as drop-on-demand, such as piezoelectric, acoustic, phase change wax-based or thermal, have at least one printhead having drop ejectors from which droplets of ink are directed towards a recording sheet. Within the printhead, the ink is contained in a plurality of channels. Power pulses cause the droplets of ink to be expelled as required from orifices or nozzles at the end of the channels.

In a thermal ink-jet printer, the power pulses are usually produced by resistors, each located in a respective one of the channels, which are individually addressable to heat and vaporize ink in the channels. As voltage is applied across a selected resistor, a vapor bubble grows in the associated channel and initially the ink bulges from the channel orifice. The bubble quickly collapses and the ink within the channel then retracts and separates from the bulging ink thereby forming a droplet moving in a direction away from the channel orifice and towards the recording medium whereupon hitting the recording medium a dot or spot of ink is deposited. The channel is then refilled by capillary action, which, in turn, draws ink from a supply container of liquid ink. Operation of a thermal ink-jet printer is described in, for example, U.S. Patent No. 4,849,774.

The ink jet printhead may be incorporated into either a carriage type printer, a partial width array type printer, or a page-width type printer. The carriage type printer typically has one or more relatively small printheads containing the ink channels and nozzles. The printheads can be sealingly attached to one or more disposable ink supply cartridges and the combined printheads and cartridge assembly is attached to a carriage which is reciprocated to print one swath of information (equal to the length of a column of nozzles), at a time, on a stationary recording medium, such as paper or a transparency. After the swath is printed, the paper can be stepped a distance equal to the height of the printed swath or a portion thereof, so that the next printed swath is contiguous or overlapping therewith. This procedure is repeated until the entire page is printed.

In a typical ink-jet printing machine, the carriage must transport the printhead assembly across the page for printing as the recording medium is held stationary. After the printhead has scanned across the medium, the medium is advanced by a transport which typically includes a transport roller driven by a gear assembly which is in turn driven by a motor. In one example of an ink jet printer, the motor is a stepper motor which provides for accurate control of the medium advance by being coupled to the gear assembly which includes a number of gears for reducing the advance of the motor by the appropriate amount to, for instance, print at 300 dots per inch (dpi) or 600 dpi. A one-way needle roller clutch is included in the gear assembly which provides for removing a medium from the transport in a direction opposite the advance direction in the event a jam occurs.

In contrast, the page width printer includes a stationary printhead having a length sufficient to print across the width or length of a sheet of recording medium at a time. The recording medium is continually moved past the page width printhead in a direction substantially normal to the printhead length and at a constant or varying speed during the printing process. A page width ink-jet printer is described, for instance, in U.S. Patent No. 5,192,959.

Various methods and apparatus of printing with liquid ink printers having an advance mechanism including a transport are described in the following disclosure which may be relevant to certain aspects of the present invention.

In U.S. Patent No. 4,491,854 to Habelt et al., a printer with a guide ruler for flattening a record carrier is described. The record carrier is fed around a transport roller and over and elongated flat supporting surface extending alongside the roller, with a printing head displaceable along that surface. The transport roller can be rotated either by means of a handwheel connected thereto or by means of a motor, via a gearwheel drive.

In accordance with one aspect of the present invention, there is provided a printing machine, for forming an image on a recording medium moving along a path. The printing machine includes a transport roller, to move the medium along the path, a gear assembly, coupled to the transport roller, to drive the transport roller, being disengageable to free the transport roller for movement to provide for removal of the medium in the event of a jam, and an electromover, coupled to the gear assembly, to move the gear assembly.

Pursuant to another aspect of the invention, there is provided a method of returning a printing machine to normal operation when printing fails due to an inadvertent recording medium stoppage occurring in a nip of a transport roller being driven by a gear assembly coupled thereto. The method includes the steps of detecting the inadvertent medium stoppage, disengaging the gear assembly to free the transport roller for movement to enable removal of the medium from the nip, and engaging the gear assembly to return the printing machine to normal operation.

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

FIG. 1 illustrates a perspective view of a color ink jet printer incorporating the present invention.

FIG. 2. illustrates a side view of a disengageable medium transport of the present invention including an actuating arm for disengaging the gear assembly to pro-

vide for jam clearance.

FIG. 3. illustrates a plan view of the medium transport including a gear assembly engaged to a transport roller of the described printer.

FIG. 4 illustrates a plan view of the gear assembly being disengaged from the transport roller through actuation of the actuation arm by the printhead carriage.

FIG. 5 illustrates a flow chart of one embodiment of disengaging the gear assembly after the detection of a jam and the reengagement of the gear assembly.

FIG. 1 illustrates a perspective view of a color thermal ink jet printer 10 which incorporates a preferred embodiment of the present invention. Printer 10 is exemplary only. The invention can be practiced in other types of thermal ink jet printers, as well as other reproduction devices including liquid ink printers driven by signals from a document raster input scanner or signals received from a computing device, such as a personal computer. Printer 10 includes four ink jet ink containers 12, 14, 16, and 18 mounted in a print cartridge 19 on a carriage 20 supported by carriage rails 22. The carriage rails 22 are supported by a frame 24 of the ink jet printer 10. The printhead cartridge which comprises the ink containers contain ink for supply to a thermal ink jet printhead 26 which selectively expels droplets of ink under control of electrical signals received from a controller (not shown) of the printer 10 through an electrical cable (not shown). The printhead 26 contains a plurality of ink channels (not shown) which carry ink from one or more of the ink containers 12, 14, 16, and 18 to respective ink ejecting orifices or nozzles of the printhead 26.

When printing, the carriage 20 reciprocates or scans back and forth along the carriage rails 22 in the direction of an arrow 28. As the printhead 26 reciprocates back and forth across a recording medium 30, fed from an input stack 32 containing, for instance, sheets of paper or transparencies, droplets of ink are expelled from selected ones of the printhead nozzles towards the recording medium 30. The ink ejecting orifices or nozzles are typically arranged in a linear array perpendicular to the scanning direction 28. During each pass of the carriage 20, the recording medium 30 is held in a stationary position. At the end of each pass, the recording medium is stepped in the direction of an arrow 34. For a more detailed explanation of the printhead and printing thereby refer to U.S. Patent No. 4,571,599 and U.S. Patent No. Re. 32,572, the relevant portions of which are incorporated herein by reference.

The single recording sheet 30 is fed from the input stack through the printer along a path defined by a curved platen 36 and a guide member 38. The sheet 30 is driven along the path by a transport roller 40 as is understood by those skilled in the art or, for instance, as illustrated in U.S. Patent No. 5,534,902, herein incorporated by reference. As the recording medium 30 exits the slot between the platen 36 and guide member 38, the sheet 30 is caused to reverse bow such that the sheet is supported by the platen 36 at a flat portion thereof for printing by the printhead 26.

At one side of the printer 10 is a frame 42 for supporting the transport roller 40 as well as a gear assembly and motor therefore shown in more detail in FIGS. 2-4. In addition, outside the printing zone, which encompasses the width of the recording medium 30, is an actuator arm 44 pivotally mounted to a support 46 through a spindle 48. When the carriage 20 is moved into a jam clearance position adjacent the actuator arm 44, a butting member 50 contacts the actuator arm 44 causing the actuator to rotate about the spindle 48. Movement of the actuator arm 44 towards the frame 42 provides for disengagement of the gear assembly such that the transport roller 40 freely rotates to enable the removal of a recording sheet in the event of an inadvertent medium stoppage or jam.

As illustrated in the side view of FIG. 2 and the plan view of FIG. 3, the present invention includes an electromover 52, such as a stepper motor, connected to a controller 54 through a cable 56. The controller 54 resides in the printer 10 and can include a variety of control functions, for instance, controlling the stepper motor 52 for paper advance as well as controlling the motion of the carriage 20 for accurate control of the deposition of ink upon the recording medium 30. It is well known and commonplace to program and execute imaging, printing, document and/or paper handling control functions and logic with software instructions for conventional or general purpose microprocessors typically used as a controller. This is taught by various prior patents and commercial products. Such programming or software may, of course, vary depending on the particular functions, software type, and microprocessor or other computer system utilized, but will be available to, or readily programmable without undue experimentation from, functional descriptions such as those provided herein, or prior knowledge or functions which are conventional, together with general knowledge in the software and computer arts. This can include object oriented software development environments, such as C++. Alternatively, the disclosed system or method may be implemented partially or fully in hardware, using standard logic circuits, or a single chip using VLSI designs.

The stepper motor 52 drives or rotates the transport roller 40 through a gear assembly including a brass pinion 58, which engages a positionable gear 60 which includes an outer gear 62 and an inner gear 64. The inner gear 64 engages an idler gear 66 which likewise includes an outer gear 68 and an inner gear 70. The inner gear 70 engages a main drive gear 72 which is fixedly attached to the transport roller 40. While the gears 58, 60, 66, and 72 are illustrated to provide for accurate control of the transport roller 40 to print at the desired resolution, other configurations of gears are also possible and depend in part on the type of stepper motor used to drive the gear assembly.

The positionable gear 60 is supported in the frame 42 by a support shaft (not shown). A compression spring

74 is disposed between the inner gear 64 and the frame 42 to provide for movement of the gear 60 in the direction 76 along the shaft. The end of the shaft includes a stop to prevent the gear from falling from the shaft. Movement of the gear 60 in the direction 76 allows for disengagement of the outer gear 62 from the brass pinion 58 such that the stepper motor 52 is disengaged from the transport roller providing for removal of the recording medium 30 in the event of a jam.

The imaging transport, which includes the motor 52, as well as the gears 58, 60, 66, and 72, plus the transport roller 40 is disengageable for removing the recording medium or substrate from the transport in the event of a jam. Jams can occur for a number of reasons which include the transport of the recording medium along the U shaped path which can be prone to jams. Likewise, the beam strength of the recording medium can cause slippage along the transport. Jams also can result from a loss of traction or low frictional coefficients. In addition, jams result from a power failure to the printer itself, software malfunctions, as well as other interruptions to the transport roller occurring from other mechanical failures. Because of these reasons and the need to use a stepper motor whose cost is constrained due to the overall price of the printer itself, the gear assembly provides for a cost reduced apparatus to achieve a higher feed resolution. Consequently, it is desirable to use a gear assembly in such situations which not only provides for accurate feeding of the recording medium past the printhead but also for removal of the recording medium in the event of a jam.

While it is possible to use a one-way needle roller clutch in the gear assembly, it has been found that such a device is a major contributor to excessive understitch due to slippage as well as due to inertial causes. Consequently, it has been found that disengagement of the gear assembly provides for complete removal of a recording sheet in the event of a jam.

To cause disengagement of the positionable gear 60 from the gear 58, the carriage 20 is moved to the far side of the printer such that the butting member 50 contacts the actuating arm 44 rotating the arm about the spindle 48 whereby the distal end of the actuating arm comes into contact with the positionable gear 60 forcing the gear towards the paper path, compressing the spring 74 and ultimately disengaging the outer gear of the positionable gear 60 from the gear 58. The inner gear 64 is sufficiently long in the axial direction such that when the positionable gear 60 is forced inward towards the transport roller, the outer gear 68 of the idler gear 66 remains engaged with the inner gear 64. To provide for adequate contact between the actuating arm 44 and the gear 60, the actuating arm includes a U shaped portion 80, the arms of which include a first projection 82 and a second projection 84. The first and second projections 82 and 84 provide for adequate contact between the actuating arm 44 and the gear 60 for movement thereof.

In one embodiment of the present invention, when the user sees that a jam has occurred, the user presses a button or user interface 88 on the printer 10, coupled to the controller 54, which causes the carriage 20 to move and force the actuating arm 44 into contact with the gear 60 for disengagement. Once the jam is corrected, the user presses the button 88 again to indicate that printing can be resumed once a sheet of paper is advanced to the printhead.

In another embodiment of the present invention, a medium sensor 90, coupled to a controller 54, senses whether or not a jam has occurred. The occurrence of a jam can be determined by a single point sensor such that once the lead edge of the recording medium passes the sensor 90, a signal transmitted from the sensor 90 to the controller 54 causes the controller to begin a count based on when printing of the sheet should be completed. If the count exceeds the predetermined time period, a jam has occurred. At this time, the controller 54 causes the carriage 20 to move into position for actuating the actuating arm 44. When the gear 60 is disengaged from the gear 58, a gear sensor 92 coupled to the controller 54 indicates that the gear assembly has been disengaged for removal of the recording medium. A light or audible warning could be activated by the controller 54 indicating to the user that the recording medium needs to be removed from the paper path due to the occurrence of a jam. Once the medium is removed, the sensor 90 indicates that the path has been cleared. The controller then causes the carriage 20 to move back to a position for printing which would allow the actuating arm 44 to rotate back to its original position thereby allowing the gear 60 to reengage with the gear 58. Reengagement is facilitated by having a taper 94 included in the teeth of the gear 60 as well as a taper 96 included in the teeth of the pinion. If space is at a premium in the gear assembly, it is possible that the tapers can be removed from the teeth of one of the gears 58 or 60. It has been found, for instance, that a 4-5 millimeter inward gear movement of the gear 60 is sufficient for engagement and reengagement.

Since removal of the recording medium from the paper path in the event of a jam may cause the transport roller and consequently the gear 60 to rotate, the present invention includes a motor step control procedure that reengages the gear teeth of the positionable gear 60 with the pinion gear 58 after the carriage 20 is returned to a position for printing.

One example of reengaging the gear teeth after the carriage is moved back to the position of printing is illustrated in FIG. 5. Where the printer includes the jam sensor 90, for instance, at step 100 the jam sensor is continuously monitored by the controller 54. If there is no occurrence of a jam, the jam sensor 90 continues to be monitored. If, however, it is determined that a jam has occurred at step 102, then the controller causes the carriage to move to the jam clearance position at step 104. At this point, as previously described, the printer

indicates to the user that the jammed medium needs to be removed from the paper path. A step 106 the controller determines whether or not the sensor detects the absence of the medium, that is, the medium has been removed. If there is no absence of the medium, the controller continues its monitoring function. Otherwise, if the medium has been removed as sensed by the sensor 90, then at step 108 the carriage 20 is moved away from the jam clearance position such that the positionable gear 60 moves towards the pinion gear 58 for engagement. In the event that the gear 60 properly engages the gear 58 as sensed by the gear sensor 92, as determined at step 110, the controller returns to a condition of monitoring the jam sensor once a printing operation begins. If, however, the gear sensor 92 determines that the gears have not properly seated, then at step 112, the motor 52 is cause to rotate by the controller such that the rotation of the gear 58 with respect to the gear 60 causes teeth of each of the gears to mesh. In one embodiment of the present invention, the motor 52 is rotated two and one-half steps in each direction, that is clockwise and counterclockwise to ensure engagement. Other number of steps in each direction are also possible, of course, and can be related to the number of teeth in the positionable gear 60 to the number of teeth in the pinion gear 58 which in the present embodiment is a 5-1 ratio. It is also possible to avoid the use of the gear sensor 92 and always bidirectionally rotate the motor to reseat the gears such that step 110 is not performed.

It has also been determined, that by using the bidirectional rotation of the pinion gear 58, that the teeth of the pinion gear 58 as well as the teeth of the positionable gear 60 need not include tapers. This is especially important when the gear assembly is constrained according to space.

In recapitulation, there has been described an ink jet printer including a disengageable medium transport for jam clearance. It is, therefore, apparent that there has been provided in accordance with the present invention a disengageable medium transport that fully satisfies the aims and advantages hereinbefore setforth. While this invention has been described in conjunction with a specific embodiment thereof, in an ink jet environment, it is evident that many alternatives, modifications, and variations will be apparent to those skilled in the art. For instance, the present invention is not limited to ink jet printers, however, but is equally applicable to any printer having a motor driving a gear train where jams occur in the paper path. Likewise, the customer button used to disengage and to reengage the gears, need not appear on the printer itself, but can be shown on a user interface depicted as a screen on a personal computer. It is possible that a signal indicating the jam has occurred may be transmitted to the user's personal computer where the user will at that time take action to clear the jam.

Accordingly, it is intended to embrace all such alternatives, modifications and variations that fall within the spirit and broad scope of the appended claims.

Claims

1. A printing machine, for forming an image on a recording medium (30) moving along a path (34), comprising:

   a transport roller (40), to move the medium (30) along the path (34);
   a gear assembly, coupled to said transport roller (40), to drive the transport roller (40), being disengageable to free said transport roller (40) for movement to provide for removal of the medium (30) in the event of a jam; and
   an electromover (52), coupled to said gear assembly, to move said gear assembly.

2. A printing machine according to claim 1, comprising an actuator (44) disposed adjacent said gear assembly, said actuator (44) being actuable to cause said gear assembly to disengage from said transport roller (40).

3. A printing machine according to claim 2, wherein said gear assembly includes a first gear (60) and a second gear (58), said first gear (60) being disengageable from said second gear (58) upon actuation of said actuator (44).

4. A printing machine according to claim 3 wherein said first gear (60) includes a plurality of teeth, each of said teeth including a tapered portion (94), providing for engagement with said second gear (58).

5. A printing machine according to claim 4 wherein said second gear (58) includes a plurality of teeth, each of said teeth including a tapered portion (96), providing for engagement with said first gear (60).

6. A printing machine according to claim 4 or 5, comprising a resilient member (74), operatively coupled to said first gear (60), said resilient member (74) biasing said first gear (60) in a position of engagement with said second gear (58).

7. A printing machine according to any of claims 2 to 6, comprising a user actuable control device (54), coupled to said actuator (44), to provide actuation thereof.

8. A printing machine according to claim 7, wherein said user actuable control device includes a button (88).

9. A printing machine according to any of claims 2 to 6, comprising a sheet detector (90), disposed along

the path, to generate a signal in response to the occurrence of the jam.

10. A printing machine according to claim 9, comprising a controller (54), coupled to said sheet detector, said controller including an input, to receive the generated signal, and an output, to transmit an actuator signal to actuate said actuator (44).

11. A printing machine according to claim 10, comprising an engagement sensor (92), coupled to said controller (54), to generate a signal indicating said first gear (60)is engaged with said second gear (58).

12. A printing machine according to any of claims 2 to 9, comprising a printhead carriage (20), disposed adjacent the medium path (34), adapted for movement in a direction substantially transverse to the medium path (34).

13. A printing machine according to claim 12, wherein said printhead carriage (20) comprises an actuating member (50), being located thereon to contact said actuator (44).

14. A printing machine according to claim 13, comprising a liquid ink printhead (19), disposed on said printhead carriage (20), depositing liquid ink on the recording medium.

15. A printing machine according to any preceding claim, comprising a U-shaped transport path, said transport roller (40) moving the medium through the U-shaped transport path.

16. A method of returning a printing machine to normal operation when printing fails due to an inadvertent recording medium stoppage occurring in a nip of a transport roller being driven by a gear assembly coupled thereto, comprising:

detecting the inadvertent medium stoppage;
disengaging the gear assembly to free the transport roller for movement to enable removal of the medium from the nip; and
engaging the gear assembly to return the printing machine to normal operation.

17. A method according to claim 16, wherein said disengaging step comprises disengaging the gear assembly by disengaging a first gear from a second gear of the gear assembly.

18. A method according to claim 17, wherein said engaging step comprises engaging the gear assembly by rotating one of the first gear or the second gear to enable engagement of the gear assembly.

19. A method according to claim 17 or 18, wherein said disengaging step comprises disengaging the first gear from the second gear by moving an actuator into contact with the first gear or the second gear.

20. A method according to claim 19, wherein said disengaging step comprises disengaging the first gear from the second gear by moving a printhead carriage into contact with the actuator.

21. A method according to claim 20, wherein said engaging step comprises engaging the gear assembly by moving the printhead carriage out of contact with the actuator.

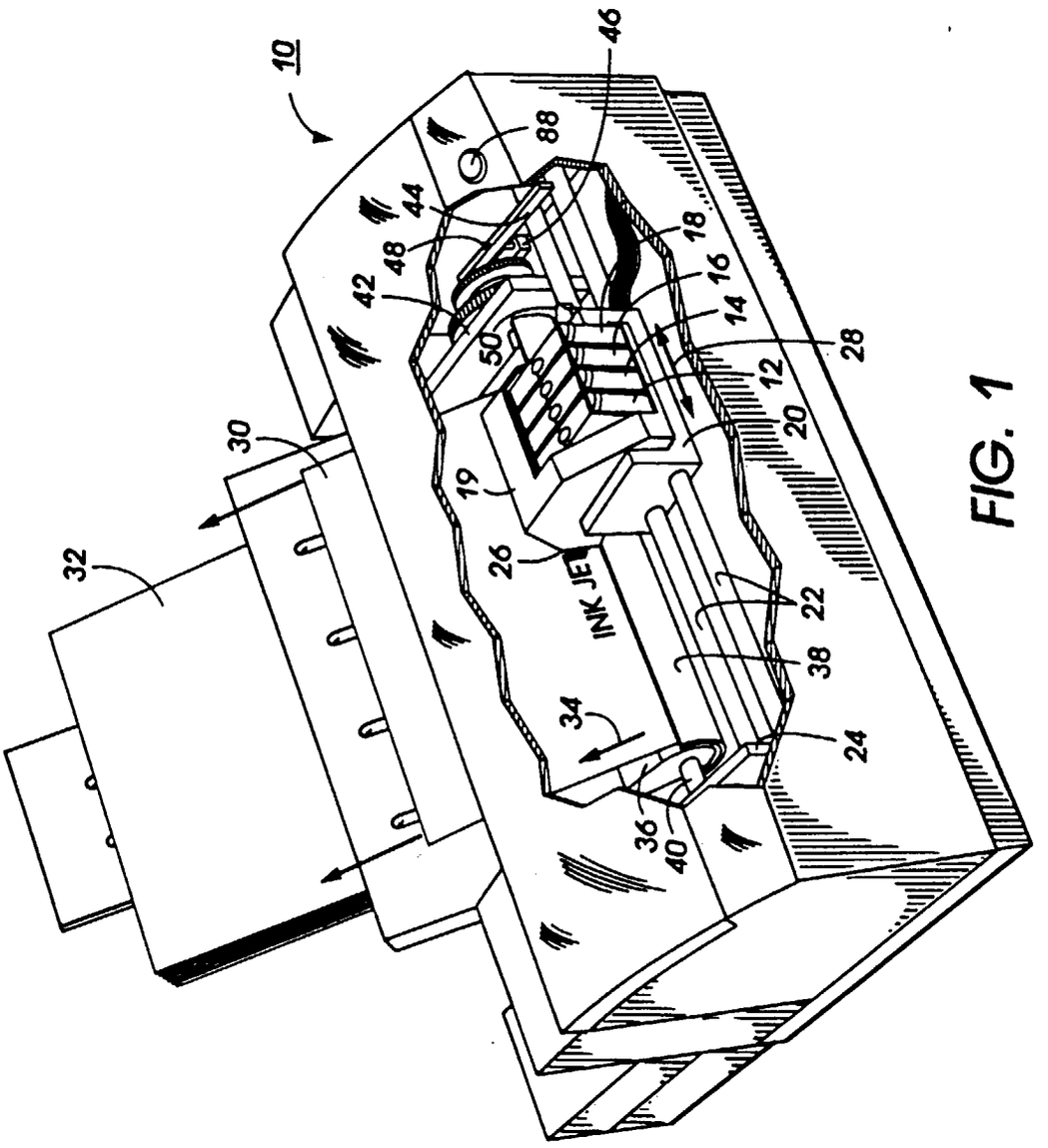
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FIG. 1

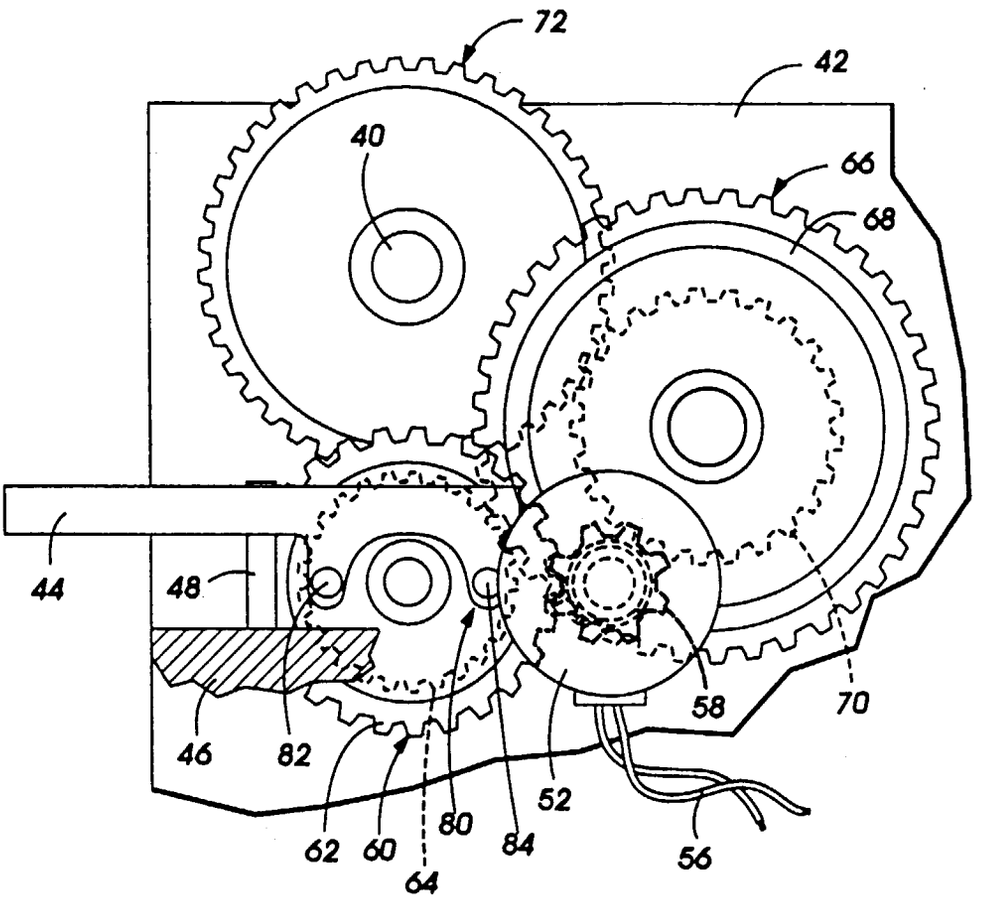

FIG. 2

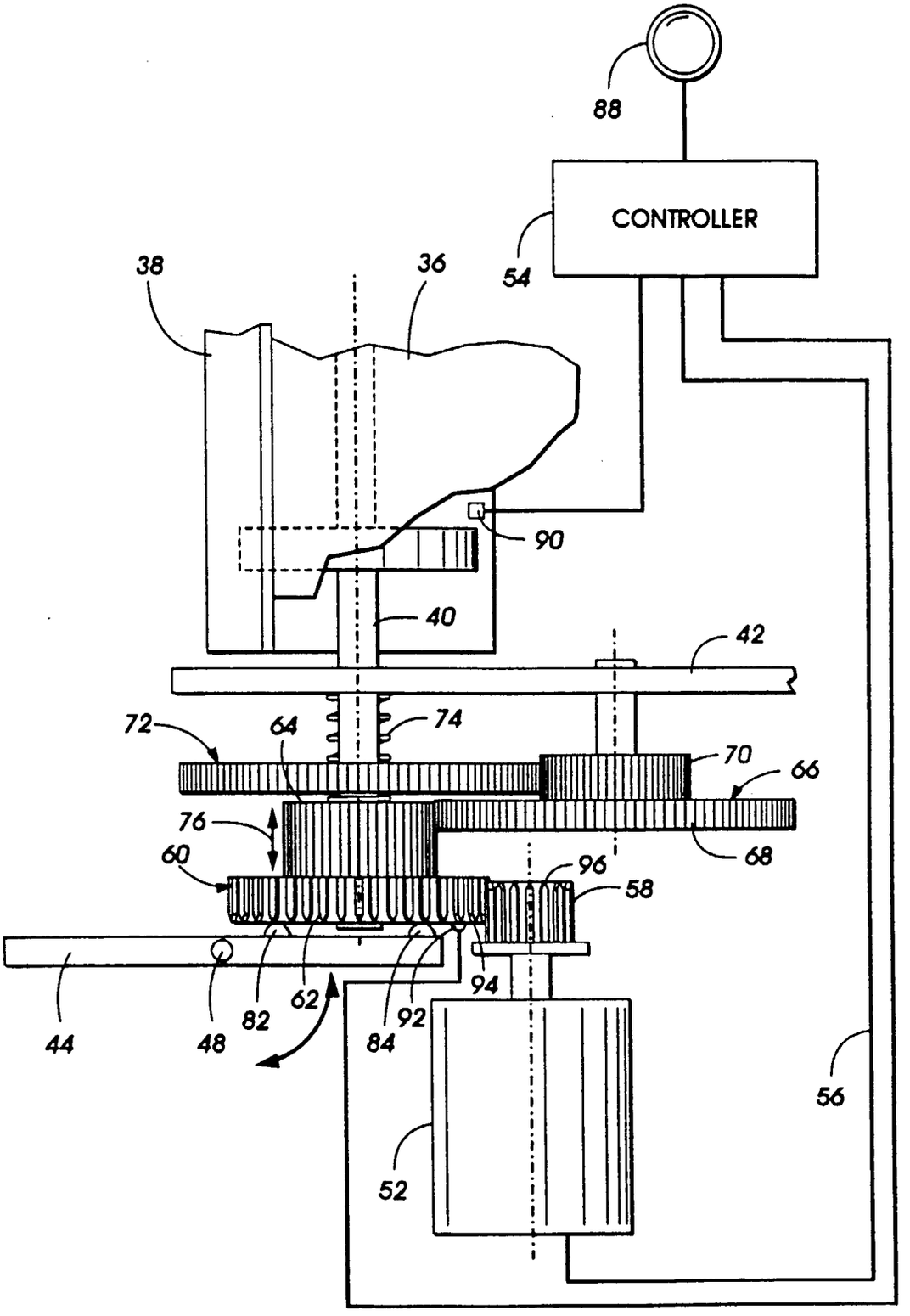
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FIG. 3

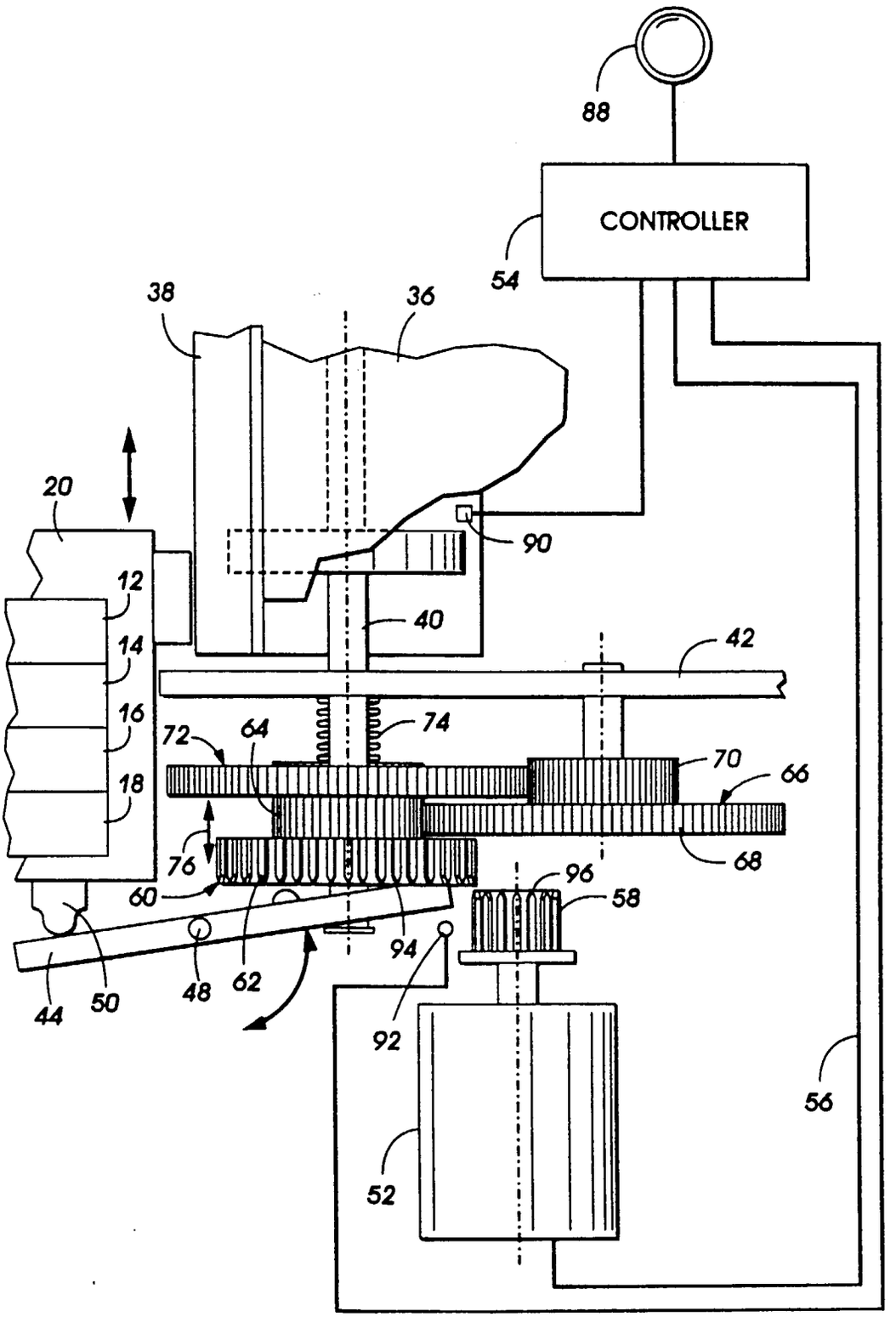
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FIG. 4

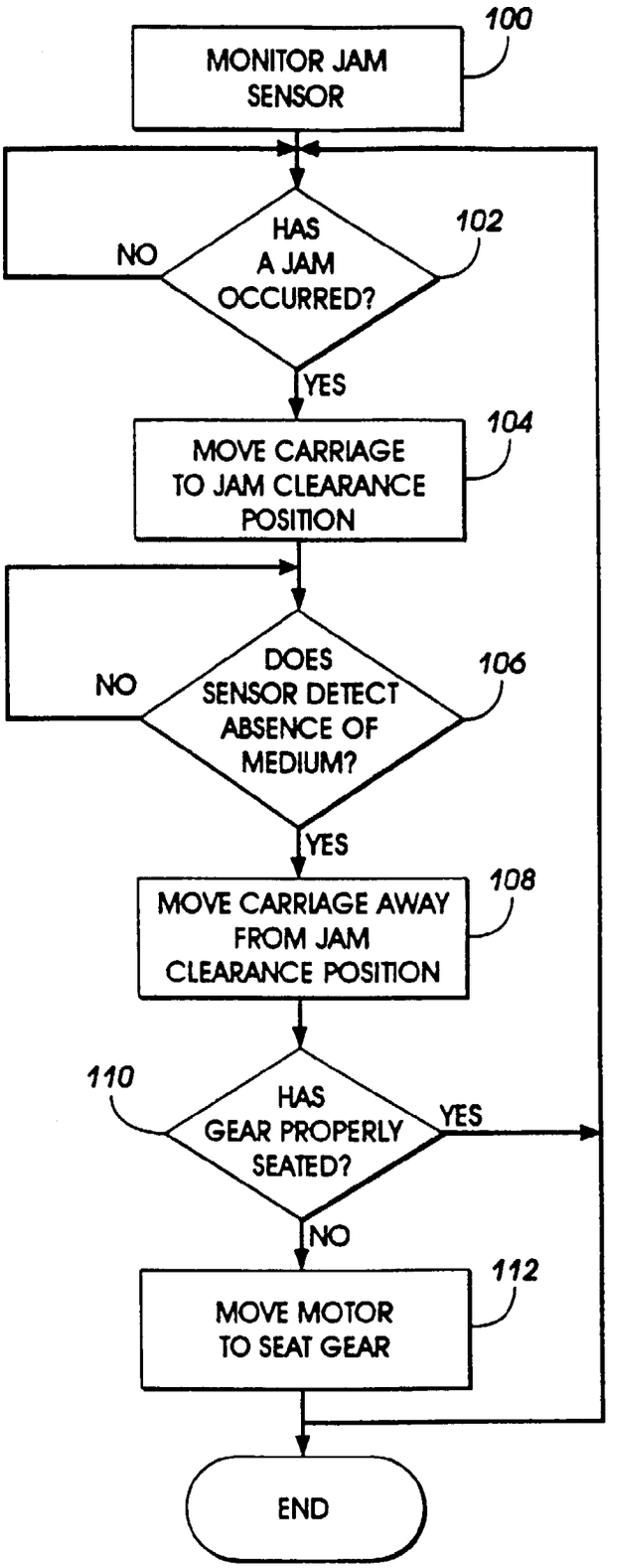
100
MONITOR JAM SENSOR
HAS A JAM OCCURRED?
102
NO
YES
MOVE CARRIAGE TO JAM CLEARANCE POSITION
104
DOES SENSOR DETECT ABSENCE OF MEDIUM?
106
NO
YES
MOVE CARRIAGE AWAY FROM JAM CLEARANCE POSITION
108
110
HAS GEAR PROPERLY SEATED?
YES
NO
MOVE MOTOR TO SEAT GEAR
112
END

FIG. 5

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 98 30 1583

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	EP 0 257 527 A (HITACHI LTD) 2 March 1988 * column 9, line 5-28; figures 1,4-6 *	1-12, 15-20	B41J11/24
X	PATENT ABSTRACTS OF JAPAN vol. 015, no. 253 (M-1129), 27 June 1991 & JP 03 083667 A (MITSUBISHI ELECTRIC CORP), 9 April 1991, * abstract *	1-8, 15-19	
X	PATENT ABSTRACTS OF JAPAN vol. 018, no. 207 (M-1592), 13 April 1994 & JP 06 009099 A (RICOH CO LTD), 18 January 1994, * abstract *	1-5,7,8, 16-19	
X	PATENT ABSTRACTS OF JAPAN vol. 007, no. 064 (P-183), 17 March 1983 & JP 57 208580 A (RICOH KK), 21 December 1982, * abstract *	1-3,6,7, 9,10, 16-19	
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
MUNICH	15 June 1998	Widmeier, W

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

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EUROPEAN SEARCH REPORT

Application Number
EP 98 30 1583

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	PATENT ABSTRACTS OF JAPAN vol. 017, no. 240 (M-1409), 14 May 1993 & JP 04 365736 A (CANON INC), 17 December 1992, * abstract *	1-21	
A	PATENT ABSTRACTS OF JAPAN vol. 018, no. 098 (M-1562), 17 February 1994 & JP 05 301656 A (MATSUSHITA ELECTRIC IND CO LTD), 16 November 1993, * abstract *	9-11	
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)

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MUNICH	15 June 1998	Widmeier, W

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A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

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