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(54) Method of and apparatus for making stencil

(57) A stencil is made by the use of a thermal head which has an array of resistance heater element arranged in a main scanning direction. The resistance heater elements are selectively driven while the stencil material is conveyed in a sub-scanning direction intersecting the main scanning direction so that perforations are formed in the stencil material in a predetermined size at a first pitch in the main scanning direction and a second pitch in the sub-scanning direction. The stencil material is perforated so that unperforated portions which continuously extend in one of the main scanning direction and the sub-scanning direction to separate perforations in the other of the main scanning direction and the sub-scanning direction are left in the stencil material.

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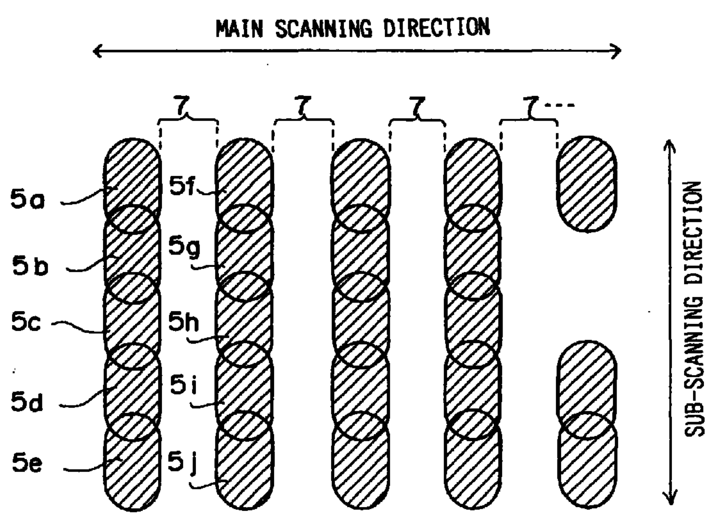

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Description

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] This invention relates to a method of and an apparatus for making a stencil.

Description of the Related Art

[0002] As the thermal head used in various image forming apparatuses, there have been known a thin film thermal head and a thick film thermal head. The former is formed by the use of thin film forming technique and the latter is formed by the use of technique other than the thin film forming technique. When perforating a heat-sensitive stencil material to make a stencil for a stencil printer by the use of such a thermal head, it is required in order to obtain a high printing quality that adjacent perforations are clearly separated with an unperforated portion left between the perforations. Further, in order to make feasible stencil printing in a large size, e.g., A2 size or larger sizes, it is required to make a thermal head in a large size. Further, since the manufacturing process and the manufacturing cost of the thermal head occupy a large part of the manufacturing process and the manufacturing cost of the stencil making apparatus for a stencil printer, there has been a demand for a thermal head which can be easily manufactured at low cost.

[0003] From the viewpoint of making smaller and discrete the perforations formed in the stencil material, the thin film thermal head is advantageous over the thick film thermal head. In the thin film thermal head, the width and/or shape of the heater elements can be controlled much more finely than in the thick film thermal head due to the difference in manufacturing process. However, the thin film thermal head is disadvantageous in that it is expensive and is difficult to produce in a large size. That is, since the thin film thermal head is manufactured by the use of semiconductor manufacturing apparatuses which are generally for making integral circuits and the like and are not able to produce a large size thermal head by one step. Accordingly, a large size thin film thermal head must be produced by incorporating a plurality of small thermal head segments, which gives rise to a problem that heat generation becomes unsatisfactory at junctions between the segments, which can result in white stripes on prints. Further, difference in heat generating characteristic between the small thermal head segments can result in fluctuation in the printing density and can adversely affect the image quality of the prints. Though these problems may be overcome by carefully joining the thermal head segments, this approach deteriorates the yield of the thermal head and further adds to the manufacturing cost of the thermal head.

[0004] To the contrast, the thick film thermal head can be produced, for instance, by screen printing, and can be easily produced at low cost and can be easily produced in a large size.

[0005] Accordingly, there has been a demand for use of a thick film thermal head in thermally making a stencil.

[0006] However, attempts to use a thick film thermal head in thermally making a stencil have encountered the following difficulties.

[0007] That is, the thick film thermal head generally comprises an electrical insulating substrate such as of ceramic, a plurality of stripe electrodes formed on the substrate and a linear resistance heater strip formed on the electrodes. In this thick film thermal head, the resistance heater strip extends across the electrodes and the parts of the resistance heater strip between the electrodes form resistance heater elements. That is, when power is supplied to the electrodes, the resistance heater strip generates heat at the parts between the electrodes. Since the heater strip is in contact with the electrodes at the lower surface thereof, heat is generated from the lower surface of each resistance heater element and propagates the resistance heater element to the upper surface thereof where the resistance heater element is brought into contact with a stencil material. In this thermal head, heat generated from the lower surface of each resistance heater element spreads in various directions while it propagates the resistance heater element to the upper surface thereof, and each perforation formed by the thermal head becomes larger than the heater element. That is, when the thick film thermal head, as it is, is used for making a stencil, each of the perforations becomes too large and the perforations cannot be discrete. Though the problem may be overcome by making smaller each resistance heater element, it is very difficult to make further smaller the resistance heater element of the thick film thermal head due to the manufacturing process of the thick film thermal head. Especially when the perforations are connected in both the main scanning direction and the sub-scanning direction (the thermal head generally has an array of resistance heater elements extending in the main scanning direction, and the stencil material is conveyed in the sub-scanning direction relative to the thermal head when making a stencil), parts of the stencil material encircled by connected perforations can separate from the stencil material leaving large holes. When such a large hole is formed in the stencil, an excessive amount of ink is transferred to the printing paper, which results in offset and/or strike through. Further, the separated fractions of the stencil material can adhere to the surface of the thermal head and deteriorate the performance of the thermal head. Further, the large holes left by the fractions of the stencil material and large holes formed by connected perforations deteriorate the tensile strength of the stencil, and the stencil is apt to be stretched or deformed at the portions of such large holes, which deteriorates the quality of printings.

SUMMARY OF THE INVENTION

[0008] In view of the foregoing observations and description, the primary object of the present invention is to provide a method of and an apparatus for making a stencil which can prevent separation of a fraction of stencil material and/or formation of a large hole, and deformation of the stencil due to formation of connected perforations even if a thick film thermal head is used.

[0009] In accordance with a first aspect of the present invention, there is provided a method of making a stencil by the use of a thermal head which has an array of resistance heater element arranged in a main scanning direction, the method comprising the step of selectively driving resistance heater elements while conveying the stencil material in a sub-scanning direction intersecting the main scanning direction, wherein the improvement comprises the step of

perforating the stencil material so that unperforated portions which continuously extend in one of the main scanning direction and the sub-scanning direction to separate perforations in the other of the main scanning direction and the sub-scanning direction are left in the stencil material.

[0010] With this arrangement, since perforations can be connected only in one of the main scanning direction and the sub-scanning direction and no part of the stencil material can be encircled by connected perforations even if a thick film thermal head is used. Accordingly, no fraction can be separated from the stencil material. Further, connected perforations can grow only in one of the main scanning direction and the sub-scanning direction and accordingly a large hole formed by connected perforations is limited in its area, whereby the amount of ink transferred to the printing paper through the hole formed by the connected perforations is limited to an acceptable level. It is very difficult to leave continuous unperforated portions in both the main scanning direction and the sub-scanning direction (to make discrete the perforations in both the main scanning direction and the sub-scanning direction) due to limitation in making small the resistance heater element and complication of control, and the difficulty increases as the resolution required to the stencil becomes higher. That is, the present invention is based on the discovery that to leave continuous unperforated portions only in one of the main scanning direction and the sub-scanning direction (to make discrete the perforations only in one of the main scanning direction and the sub-scanning direction) is much easier than to leave continuous unperforated portions in both the main scanning direction and the sub-scanning direction (to make discrete the perforations in both the main scanning direction and the sub-scanning direction) and an acceptable stencil can be obtained, even if the density of the perforations is increased to improve the resolution, by leaving continuous unperforated portions only in one of the main scanning direction and the sub-scanning direction.

[0011] To leave continuous unperforated portions in one of the main scanning direction and the sub-scanning direction can be realized in various ways as follows.

[0012] In the case where the stencil is made by the use of a thermal head in which a resistance heater strip extends in the main scanning direction, a plurality of electrodes are in contact with the resistance heater strip at intervals in the main scanning direction, and the portions of the resistance heater strip between the electrodes form resistance heater elements, continuous unperforated portions can be left in the sub-scanning direction by making the length in the main scanning direction of the electrodes of the thermal head larger than that of the resistance heater elements or by making perforating pitch in the sub-scanning direction shorter than the length in the sub-scanning direction of the resistance heater elements.

[0013] Further, continuous unperforated portions can be left in the main-scanning direction by making perforating pitch in the sub-scanning direction (the second pitch) longer than the length in the sub-scanning direction of the resistance heater elements.

[0014] Further, continuous unperforated portions can be left in the main scanning direction by controlling the output energy of the resistance heater elements so that the size of perforations formed along one or more main scanning lines every two or more main scanning lines becomes smaller than the regular size (the predetermined size) to such an extent that an unperforated portion is left between the perforations on the main scanning line(s) and those on the preceding main scanning line.

[0015] Continuous unperforated portions can be left in the sub-scanning direction by controlling the output energy of the resistance heater elements so that the size of perforations formed along one or more sub-scanning lines every two or more sub-scanning lines becomes smaller than the regular size to such an extent that an unperforated portion is left between the perforations on the sub-scanning line(s) and those on the sub-scanning lines on opposite sides of the sub-scanning line(s).

[0016] For example, perforations on every second or third main or sub-scanning line may be made smaller than the regular size. Further, perforations on every second or third main or sub-scanning line and the next main or sub-scanning line may be made smaller than the regular size.

[0017] The output energy of the resistance heater elements can be controlled, for instance, by changing the heat generation duty (energizing time) of the resistance heater elements and/or the electric voltage applied to the resistance heater elements.

[0018] Since the dimension and the position of the perforations in the sub-scanning direction depend upon the conveying speed of the stencil material, and the energizing timing, the energizing time and the output energy of the resistance heater elements, the output energy of the resistance heater elements should be controlled according to the conveying speed of the stencil material, and the energizing timing and the energizing time of the resistance heater elements.

[0019] For example, the perforations can be made smaller by shortening the heat generation duty (energizing time) of the resistance heater elements with the conveying speed of the stencil material fixed or by reducing the conveying speed of the stencil material with the heat generation duty (energizing time) of the resistance heater elements fixed.

[0020] Further continuous unperforated portions can be left in the main scanning direction by deviating the perforating pitch in the sub-scanning direction from the second pitch every two or more main scanning lines.

[0021] In the case where the resistance heater elements are energized to perforate the stencil material under the control of a heat generation timing control signal, the perforating pitch in the sub-scanning direction may be deviated from the second pitch every two or more sub-scanning lines by deviating the timing at which the heat generation timing control signal energizes the resistance heater elements from that corresponding to the second pitch.

[0022] Further, continuous unperforated portions can be left in the sub-scanning direction by deviating the perforating pitch in the main scanning direction from the first pitch every two or more sub-scanning lines.

[0023] The perforating pitch in the main scanning direction or the sub-scanning direction may be deviated according to any rule. For example, the perforating pitch in the sub-scanning direction may be deviated every other main scanning line, or may be alternately deviated every two main scanning lines and every four main scanning lines. Further, the perforating pitch in the sub-scanning direction may be deviated so that the perforations on the successive three main scanning lines are formed close to each other. In this case, even if the perforations on the successive three main scanning lines are connected to each other, unperforated portions which are wider than when the perforations on the successive three main scanning lines are discrete from each other can be formed on opposite sides of the successive three main scanning lines.

[0024] In accordance with a second aspect of the present invention, there is provided a stencil making apparatus which carries out the method of making a stencil in accordance with the first aspect of the present invention.

[0025] Thus, in accordance with the present invention, an acceptable stencil can be obtained even if a thick film thermal head is employed which can be manufactured at low cost and in a large size. At the same time, modification of the stencil making apparatus in accordance with the present invention hardly adds to the cost of the stencil making apparatus and complicates the structure of the stencil making apparatus since the modification involves only a simple rearrangement of the thermal head control circuit or the thermal head itself.

BRIEF DESCRIPTION OF THE DRAWINGS

[0026]

Figure 1 is a schematic view for illustrating the structure of a stencil making apparatus in accordance with a first embodiment of the present invention,

Figure 2 is a fragmentary plan view of the thermal head employed in the stencil making apparatus shown in Figure 1,

Figure 3 is a cross-sectional view taken along line A-A in Figure 2,

Figure 4 is a cross-sectional view taken along line B-B in Figure 2,

Figure 5 is a view showing an example of a stencil made by the stencil making apparatus shown in Figure 1,

Figures 6A and 6B are views for illustrating the effect of the continuous unperforated portions in preventing an excessive amount of ink from being transferred to the printing paper,

Figure 7 is a view showing an example of a stencil made by the stencil making apparatus in accordance with a second embodiment of the present invention,

Figure 8 is a view showing an example of a stencil made by a conventional stencil making apparatus,

Figure 9 is a schematic view for illustrating the structure of a stencil making apparatus in accordance with a third embodiment of the present invention,

Figure 10 is a view showing an example of a stencil made by the stencil making apparatus shown in Figure 9,

Figure 11 is a view showing an example of waveforms of signals employed for control of the stencil making apparatus shown in Figure 9,

Figure 12 is a view showing an example of a stencil made by a modification of the stencil making apparatus shown in Figure 9,

Figure 13 is a view for illustrating imperfect perforations,

Figure 14 is a view showing an example of waveforms of signals employed for control of the stencil making apparatus in the fourth embodiment of the present invention,

Figure 15 is a view showing an example of a stencil made by the stencil making apparatus of the fourth embodiment of the present invention,

Figure 16 is a view showing an example of a stencil made by a modification of the stencil making apparatus of the fourth embodiment,

Figure 17 is a view showing an example of a stencil made by the stencil making apparatus of the fifth embodiment of the present invention, and

Figure 18 is a view showing an example of waveforms of signals employed for control of the stencil making apparatus in the fifth embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

First embodiment

[0027] In Figures 1 to 4, a stencil making apparatus in accordance with a first embodiment of the present invention comprises a thermal head 100 having an array of resistance heater elements 1 arranged in a main scanning direction, a thermal head control circuit 200 which selectively drives the resistance heater elements 1, a sub-scanning section 300 which conveys a stencil material (not shown) in a sub-scanning direction relative to the thermal head 100, and a power source circuit 400 which supplies a line voltage to the thermal head 100, the thermal head control circuit 200 and the sub-scanning section 300.

[0028] The thermal head 100 comprises a ceramic substrate 101, a heat insulating layer 102 formed substantially over the entire area of the surface of the substrate 101, a plurality of electrodes 103 formed on the heat insulating layer 102 and arranged in the main scanning direction at predetermined intervals, and a resistance heater strip 104 is formed to extend across the electrodes 103 in perpendicular thereto. Thus the resistance heater elements 1 are formed between adjacent electrodes 103. A protective layer 105 is formed to cover substantially the entire area of the surface of the heat insulating layer 102 including the electrodes 103 and the resistance heater strip 104. The heat insulating layer 102 is of glass 40 to 100μm thick and is a typical one. The electrodes 103 are typical electrodes formed by solidifying silver paste or gold paste in a thickness of 0.5 to 4μm or formed of aluminum or the like. The resistance heater strip 104 is formed, for instance, by forming a layer of material, obtained by mixing ruthenium oxide (RuO_2), glass powder and solvent, in a predetermined pattern by screen printing or the like and curing the layer, and semicircular in cross-section. The resistance heater strip 104 continuously extends in the longitudinal direction of the thermal head 100 or in the main scanning direction. The resistance heater elements 1 are not thermally independent of each other but thermally continuous in the main scanning direction by way of the resistance heater strip 104. The protective layer 105 is formed of wear-resistance glass and 1 to 20μm in thickness.

[0029] As can be understood from the description above, the thermal head 100 is basically the same as the conventional thick film thermal head but differs from the conventional thick film thermal head in that the length (width) in the main scanning direction of each electrode 103 is larger than that of the space between adjacent electrodes 103 (i.e., the length in the main scanning direction of each resistance heater element 1). As the length in the main scanning direction of each electrode 103 is increased in the pitch at which the resistance heater elements 1 are arranged in the main scanning direction (will be referred to as "the main scanning pitch", hereinbelow), the length in the main scanning direction of each resistance heater element 1 is reduced. Specifically, the thermal head 100 in this particular embodiment is for making a stencil at a dot density of 400dpi, and the length in the main scanning direction of each resistance heater element 1 is 23.5μm and the length in the main scanning direction of each electrode 103 is 40μm.

[0030] The length in the sub-scanning direction of each resistance heater element 1 depends on the width of the resistance heater strip 104, which is 100μm. That is, the width of the resistance heater strip 104 cannot be smaller than 100μm so long as it is formed at a practical accuracy by screen printing or the like which can form the resistance heater strip at low cost.

[0031] The sub-scanning section 300 is for conveying the stencil material in the sub-scanning direction at a constant speed in synchronization with perforation of the stencil material according to an image signal representing an original, and comprises a system control circuit 301 which controls timings of actions of the overall thermal head, an image processing/sub-scanning control section 302 having an image processing circuit for processing the image signal and a sub-scanning motor drive circuit which controls a sub-scanning motor (not shown) of a sub-scanning mechanism 303 in synchronization with image processing by the image processing circuit, and the sub-scanning mechanism 303 which conveys the stencil material in the sub-scanning direction at a constant speed by driving force supplied from the sub-scanning motor. The sub-scanning section 300 conveys the stencil material in the sub-scanning direction in synchronization with the timing at which the resistance heater elements 1 are selectively energized (energizing timing) and the period for which the selected resistance heater elements 1 are kept energized (heat generation duty) so that the stencil material is perforated at a pitch of 63.5μm (corresponding to a dot density of 400dpi.

[0032] The thermal head control circuit 200 comprises a sub-scanning control circuit 201, a timing generation circuit 202 and a main scanning control circuit 203, and controls energizing of the resistance heater elements 1 according to various signal and data such as clocks, latches, strobe signals and image data. The timing generation circuit 202 outputs latches and strobe signals for setting an image signal to a thermal head drive register provided on the thermal head 100 and clocks. The main scanning control circuit 203 supplies information on the perforating timing and the image signal to the sub-scanning control circuit 201 and the timing generation circuit 202, and generates a waveform for selectively energizing the resistance heater elements 1 on the basis of the image signal and supplies the waveform to the thermal head 100. The sub-scanning control circuit 201 controls the perforation timing in the sub-scanning direction and controls the energizing timing and the heat generation duty so that the perforating pitch in the sub-scanning direction becomes 63.5μm.

[0033] When the length in the main scanning direction of each resistance heater element 1 is sufficiently small as compared with the pitch at which the resistance heater elements 1 are arranged in the main scanning direction (the main scanning pitch), perforations can be surely separated from each other in the main scanning direction with continuous unperforated portions extending in the sub-scanning direction left between adjacent columns of perforations as will be described in more detail later with reference to Figure 5, even if heat generated by each resistance heater element 1 spreads in the main scanning direction while it propagates to the upper surface of the resistance heater strip 104. Further, this is realized by only increasing the widths of the electrodes 103, which is very simple and inexpensive. In the case of a dot density of 400dpi, it is preferred that the width of each electrode 103 be in the range of 30 to 50μm.

[0034] Further, since the resistance heater elements 1 are not thermally independent of each other but thermally continuous in the main scanning direction by way of the resistance heater strip 104 as described above, perforations can be connected to each other in the main scanning direction when each resistance heater element 1 is kept energized for an excessively long time (when the heat generation duty is too long) and/or when the heat capacity of each resistance heater element 1 is too large. Accordingly, it is preferred that the amount of heat generated by each resistance heater element 1 be controlled so that perforations cannot be connected to each other in the main scanning direction in addition to making the length in the main scanning direction of each resistance heater element 1 sufficiently smaller than the main scanning pitch.

[0035] Figure 5 shows an example of a stencil made by the stencil making apparatus of this embodiment. In this example, a stencil material comprising a support sheet of Japanese paper coated with PFT (polyethylene terephthalate) in a thickness of 1 to 3μm was used.

[0036] As shown in Figure 5, in the stencil made by the stencil making apparatus of this embodiment, perforations adjacent to each other in the main scanning direction (such as those indicated 5a and 5f) were clearly separated from each other by continuous unperforated portions 7 continuously extending in the sub-scanning direction though perforations adjacent to each other in the sub-scanning direction (such as those indicated at 5a to 5e or 5f to 5i) were connected to each other, whereby formation of a defective large hole formed by a plurality of perforations connected in both the main scanning direction and the sub-scanning direction was prevented.

[0037] To the contrast, when the same stencil material was perforated on the basis of the same image signal by the use of a conventional stencil making apparatus, a defective large hole 702 was formed by a plurality of perforations connected in both the main scanning direction and the sub-scanning direction as shown in Figure 8.

[0038] By leaving the continuous unperforated portion 7 in the stencil, an excessive amount of ink is prevented from being transferred to the printing paper and deformation and/or damage of the stencil material can be prevented. This will be described with reference to Figures 6A and 6B, hereinbelow. That is, when the stencil 700 has a defective large hole 702 formed by a plurality of perforations connected in both the main scanning direction and the sub-scanning direction, ink 701 passes through the large hole 702 substantially without interference and an excessive amount of ink 701 is transferred to the printing paper as shown in Figure 6B. Further, it is apparent that such a large hole 702 greatly reduces the mechanical strength of the stencil 700.

[0039] To the contrast, when a continuous unperforated portion 7 is left between rows of connected perforations 5, the continuous unperforated portion 7 enhances the mechanical strength of the stencil 700 and at the same time, properly controls the amount of ink 701 passing through the stencil 700.

<u>Second embodiment</u>

[0040] A stencil making apparatus in accordance with a second embodiment of the present invention will be described, hereinbelow. The stencil making apparatus of this embodiment is basically the same as that of the first embodiment except that the perforating pitch in the sub-scanning direction is set to be larger than the length in the sub-scanning direction of the resistance heater elements 1.

[0041] That is, in the stencil making apparatus of the second embodiment, the stencil material is conveyed in the sub-scanning direction in synchronization with the timing at which the resistance heater elements 1 are selectively energized (energizing timing) and the period for which the selected resistance heater elements 1 are kept energized (heat generation duty) so that the perforating pitch in the sub-scanning direction becomes larger than the length in the sub-scanning direction of the resistance heater elements 1. In other words, the speed at which the stencil material is conveyed in the sub-scanning direction during one sub-scanning period is adjusted so that the perforating pitch in the sub-scanning direction becomes larger than the length in the sub-scanning direction of the resistance heater elements 1. When the perforating pitch in the sub-scanning direction is larger than the length in the sub-scanning direction of the resistance heater elements 1, perforations can be surely separated from each other in the sub-scanning direction with continuous unperforated portions extending in the main scanning direction left between adjacent lines of perforations as will be described in more detail later with reference to Figure 7, even if heat generated by each resistance heater element 1 spreads in the main scanning direction while it propagates to the upper surface of the resistance heater strip 104. Figure 7 shows an example of a stencil made by the stencil making apparatus of this embodiment. As shown in Figure 7, perforations adjacent to each other in the sub-scanning direction (such as those indicated 5a to 5c, 5f to 5h, and 5k to 5m) were clearly separated from each other by continuous unperforated portions 6 continuously extending in the main scanning direction though perforations adjacent to each other in the main scanning direction (such as those indicated at 5a-5f-5k, 5b-5g-5i and 5c-5h-5m) were connected to each other, whereby formation of a defective large hole formed by a plurality of perforations connected in both the main scanning direction and the sub-scanning direction was prevented. Further, this is realized by simply adjusting the speed at which the stencil material is conveyed in the sub-scanning direction.

Third embodiment

[0042] Figure 9 shows a stencil making apparatus in accordance with a third embodiment of the present invention. The stencil making apparatus shown in Figure 9 is substantially the same as that shown in Figure 1 and, accordingly, in Figure 9, the elements analogous to those shown in Figure 1 are given the same reference numerals and will not be described here. The stencil making apparatus of the third embodiment differs from that of the first embodiment in that the thermal head control circuit 200 is provided with a hysteretic control circuit 203' in place of the main scanning control circuit 203. The thermal head control circuit 200 controls heat generation of the resistance heater elements 1 on the basis of the signals shown in Figure 11. The hysteretic control circuit 203' supplies information for controlling the heat generation duty and the image signal to the sub-scanning control circuit 201 and the timing generation circuit 202, and generates a pulse shape for selectively energizing the resistance heater elements 1 on the basis of the image signal and supplies the pulse shape to the thermal head 100. The timing generation circuit 202 outputs latches (Figure 11-(c)) and strobe signals (Figure 11-(e)) for setting an image signal (Figure 11-(b)) to a thermal head drive register (not shown) provided on the thermal head 100 and clocks (Figure 11-(a)).

[0043] The sub-scanning control circuit 201 controls the heat generation duty so that perforations formed along even-numberth (e.g., second, fourth, sixth • • •) main scanning lines become smaller than perforations formed in the regular size along odd-numberth (e.g., first, third, fifth • • •) main scanning lines as schematically shown in Figure 11-(f) on the basis of the information for controlling the heat generation duty and the image signal supplied from the hysteretic control circuit 203' and the clocks supplied from the timing generation circuit 202. That is, in this particular embodiment, the size of the perforations formed is governed by the heat generation duty DL or DS which is governed by the pulse duty of the pulse shape of the strobe tb1, tb2, tb3, tb4, • • •. The sub-scanning control circuit 201 alternately generates a strobe (tb1, tb3, • • •) whose pulse duty is TdL (corresponding to a perforation of the regular size) and a strobe (tb2, tb4, • • •) whose pulse duty is TdS (corresponding to a perforation of the smaller size) as shown in Figure 11-(e). (Figure 11-(d) shows the pulse shape of the strobes in the conventional stencil making apparatus.) Thus, the heat generation duty is made to be alternately DL and DS, whereby perforations formed along odd-numberth (e.g., first, third, fifth • • •) main scanning lines become regular in size and those formed along even-numberth (e.g., second, fourth, sixth • • •) main scanning lines become smaller than the regular size. By thus making smaller the perforations formed along alternate main scanning lines, as shown in Figure 10, perforations adjacent to each other in the sub-scanning direction (such as those indicated 5a to 5e) are clearly separated from each other by continuous unperforated portions 6 continuously extending in the main scanning direction, whereby formation of a defective large hole formed by a plurality of perforations connected in both the main scanning direction and the sub-scanning direction was prevented. Further, this is realized by simply changing the pulse shape of the strobe at predetermined intervals, which is very simple and inexpensive. Further, in this particular embodiment, since the length in the main scanning direction of the resistance heater elements 1 is smaller than the main scanning pitch, also perforations adjacent to each other in the main scanning direction (such as those indicated 5a and 5f) are clearly separated from each other by continuous unperforated portions 7 continuously extending in the sub-scanning direction. However, even if the length in the main scanning direction of the resistance heater elements 1 is not smaller than the main scanning pitch and perforations adjacent to each other in the main scanning direction (such as those indicated at 5a and 5f) are connected to each other as shown in Figure 12, formation of a defective large hole formed by a plurality of perforations connected in both the main scanning direction and the sub-scanning direction can be prevented as in the first embodiment.

[0044] The specific value of the heat generation duty DS for the smaller perforations can be set on the basis of the dimension in the sub-scanning direction of the resistance heater element 1, the amount of heat generated from the resistance heater element 1, the area over which the heat generated from the resistance heater element 1 spreads until it propagates to the surface of the resistance heater strip 104, and the sub-scanning speed (the speed at which the stencil material is conveyed in the sub-scanning direction). For instance, in the case of resolution (dot density) in the sub-scanning direction of 400dpi, the perforating pitch in the sub-scanning direction is 63.5μm when a sub-scanning cycle is 2ms. It has been empirically found that, when a stencil material of a common material is used, reduction of the heat generation duty by at least 30% of one sub-scanning cycle (equal to about 600μs) is required to obtain continuous unperforated portions 6 of a sufficient width. That is, continuous unperforated portions 6 of a sufficient width can be obtained by reducing the on-pulse duty of the even-numberth strobes by about 600μs.

[0045] As can be understood from the description above, in the stencil making apparatus of this embodiment, formation of a defective large hole formed by a plurality of perforations connected in both the main scanning direction and the sub-scanning direction can be prevented without adding to the manufacturing cost of the stencil making apparatus and complicating the manufacturing process of the same.

[0046] Though, in the third embodiment, the perforations are made smaller in size by reducing the output energy of the resistance heater elements, the perforations may be made smaller by other various methods, e.g., by slowing the speed at which the stencil material is conveyed in the sub-scanning direction.

<u>Fourth embodiment</u>

[0047] When smaller perforations are to be formed by reducing the output energy of the resistance heater elements 1, there is fear that imperfect perforations 500 can be sometimes formed as shown in Figure 13. In a such an imperfect perforation 500, only a part of the perforation indicated at 5' (will be referred to as "the penetration 5'", hereinbelow) pierces through the stencil material and the major part of the imperfect perforation 500 is covered with thin film 600 of the stencil material. Substantially no ink can pass through such imperfect perforations 500 and defective printings can be made.

[0048] In order to overcome the problem of imperfect perforations, a plurality of small size perforations are formed to partly overlap with each other in the fourth embodiment of the present invention. For example, as shown in Figure 15, a plurality of pairs of small size perforations 500a and 500b are formed along alternate main scanning lines between a pair of lines of regular size perforations 5a and 5c so that each pair of small size perforations 500a and 500b partly overlap with each other. With this arrangement, the penetrations 5' of the small size perforations 500a and 500b are incorporated with each other to a penetration of a size sufficient to permit ink to pass through. The stencil making apparatus of this embodiment is substantially the same as that of the third embodiment and only differs from the third embodiment in control, i.e., the pulse shape of the strobes. That is, as shown in Figure 14-(e), for instance, the on-pulse shapes of second and third strobes ta2 and ta3 are changed so that the on-pulse duty of each strobe is shortened and the on-pulse periods of the second and third strobes ta2 and ta3 approach each other, whereby the small size perforations formed in response to the second and third strobes ta2 and ta3 partly overlap each other.

[0049] The stencil making apparatus of the fourth embodiment may be modified so that regular size perforations 5 and the small size perforations 500 are alternately formed in both the main scanning direction and the sub-scanning direction as shown in Figure 16. This can be realized by reducing the heat generation duty of alternate resistance heater elements in the main scanning direction and alternating the resistance heater elements reduced with the heat generation duty main scanning line by main scanning line.

[0050] Though, in the fourth embodiment, perforations are made smaller along alternate main scanning lines, perforations may be made smaller every three main scanning lines, or may be made smaller along two adjacent main scanning lines every five main scanning lines.

<u>Fifth embodiment</u>

[0051] A stencil making apparatus in accordance with a fifth embodiment of the present invention will be described, hereinbelow. The stencil making apparatus of this embodiment is basically the same as that of the third embodiment except control of the thermal head 100.

[0052] The thermal head control circuit 200 controls heat generation of the resistance heater elements 1 on the basis of the signals shown in Figure 18. The timing generation circuit 202 outputs latches (Figure 18-(c)) and strobe signals (Figure 18-(e)) for setting an image signal (Figure 18-(b)) to a thermal head drive register (not shown) provided on the thermal head 100 and clocks (Figure 18-(a)). The hysteretic control circuit 203' supplies information on the way of deviating the perforations and the image signal to the sub-scanning control circuit 201 and the timing generation circuit 202, and generates a pulse shape for selectively energizing the resistance heater elements 1 on the basis of the image signal and supplies the pulse shape to the thermal head 100.

[0053] The sub-scanning control circuit 201 controls the perforating timing in the sub-scanning direction as schematically shown in Figure 18-(f) on the basis of the information on the way of deviating the perforations and the image signal supplied from the hysteretic control circuit 203' and the clocks supplied from the timing generation circuit 202. That is, the sub-scanning control circuit 201 delays the perforating timing by Δt from the regular timing for even-numberth main scanning lines by delaying the on-pulse timing of the pulse shape of the strobe as shown in Figure 18-(e). The regular timing is a perforating timing of a constant cycle T (=ta1=ta2=ta3=ta4=• • •) controlled on the basis of a strobe which is turned on at a constant cycle as shown in Figure 11-(d).

[0054] With this arrangement, time pitches tb1, tb3, • • • between each odd-numberth perforating timing and the following even-numberth perforating timing is elongated and accordingly, a continuous unperforated portion 6 can be surely left in the main scanning direction between the perforations along each odd-numberth main scanning line and the following even-numberth main scanning line (e.g., between perforations 5a and 5b in Figure 17), though time pitches tb2, tb4, • • • between each even-numberth perforating timing and the following odd-numberth perforating timing is shortened and accordingly, the space between the perforations along each even-numberth main scanning line and the following odd-numberth main scanning line (e.g., between perforations 5b and 5c in Figure 17) is narrowed and the perforations along each even-numberth main scanning line and the following odd-numberth main scanning line can be connected to each other.

[0055] The specific value of the delay $\triangle t$, that is, the amount by which the perforating timing is to be deviated from the regular (predetermined) timing can be set on the basis of the dimension in the sub-scanning direction of the resistance heater element 1, the amount of heat generated from the resistance heater element 1, the area over which the heat generated from the resistance heater element 1 spreads until it propagates to the surface of the resistance heater strip 104, and the sub-scanning speed (the speed at which the stencil material is conveyed in the sub-scanning direction). For instance, in the case of resolution (dot density) in the sub-scanning direction of 400dpi, the regular perforating pitch in the sub-scanning direction is 63.5μm when a sub-scanning cycle is 2ms. It has been empirically found that, when a stencil material of a common material is used, the width of the continuous unperforated portions 6 should be at least 15% (about 9.5μm) of the regular perforating pitch in the sub-scanning direction (63.5μm). That is, $\Delta t \geqq 2\text{ms} \times 15\% = 300\text{ms}$.

[0056] As can be understood from the description above, in the stencil making apparatus of this embodiment, formation of a defective large hole formed by a plurality of perforations connected in both the main scanning direction and the sub-scanning direction can be prevented without adding to the manufacturing cost of the stencil making apparatus and complicating the manufacturing process of the same.

[0057] Though, in the fifth embodiment, the perforating pitch in the sub-scanning direction is deviated by the timing at which the resistance heater elements 1 are energized with the sub-scanning speed or the speed at which the stencil material is conveyed in the sub-scanning direction fixed, the perforating pitch in the sub-scanning direction may be deviated in any suitable manner. For example, the perforating pitch in the sub-scanning direction may be deviated by changing the sub-scanning speed with the timing at which the resistance heater elements 1 are energized fixed.

[0058] The technique described above in conjunction with the fifth embodiment may be applied to other methods of perforating a stencil material to make a stencil, e.g., a laser stencil making system in which the stencil material is perforated by energy of a laser beam or an ink jet stencil making system in which jets of solvent (e.g., aliphatic hydrocarbon solvent, aromatic hydrocarbon solvent, alcohol solvent or the like) are selectively applied to a stencil material comprising a solvent-soluble resin layer and the portions of the resin layer applied with the jets of the solvent are dissolved to form perforations.

[0059] The sub-scanning of the stencil material may be effected either by conveying the stencil material in the sub-scanning direction with the thermal head 100 kept stationary or by moving the thermal head 100 in the sub-scanning direction with the stencil material kept stationary.

[0060] Further, though in the embodiments described above, a thick thermal head 100 of a typical conventional structure in which a resistance heater strip is formed above a plurality of electrodes 103 to be in contact with the upper surfaces of the electrodes is employed, a thick thermal head of other structure, for instance, a thermal head in which a resistance heater strip is embedded in a linear groove formed on the surface of a substrate and a plurality of electrodes are formed above the resistance heater strip so that the resistance heater strip is to be in contact with the lower surfaces of the electrodes may be employed. Further, even a thin film thermal head may be employed.

[0061] In addition, all of the contents of Japanese Patent Application Nos. 11(1999)-245839, 11(1999)-245840 and 11(1999)-246230 are incorporated into this specification by reference.

Claims

1. A method of making a stencil by the use of a thermal head which has an array of resistance heater element arranged in a main scanning direction, the method comprising the step of selectively driving the resistance heater elements while conveying the stencil material in a sub-scanning direction inter-

secting the main scanning direction so that perforations are formed in the stencil material in a predetermined size at a first pitch in the main scanning direction and a second pitch in the sub-scanning direction, wherein the improvement comprises the step of

perforating the stencil material so that unperforated portions which continuously extend in one of the main scanning direction and the sub-scanning direction to separate perforations in the other of the main scanning direction and the sub-scanning direction are left in the stencil material.

2. A method of making a stencil as defined in Claim 1 in which continuous unperforated portions are left in the sub-scanning direction by using a thermal head which comprises a resistance heater strip extending in the main scanning direction and a plurality of electrodes in contact with the resistance heater strip at intervals in the main scanning direction, the portions of the resistance heater strip between the electrodes forming resistance heater elements, and in which the length in the main scanning direction of the electrodes is larger than that of the resistance heater elements.

3. A method of making a stencil as defined in Claim 1 in which continuous unperforated portions are left in the main-scanning direction by making the second pitch longer than the length in the sub-scanning direction of the resistance heater elements.

4. A method of making a stencil as defined in Claim 1 in which continuous unperforated portions are left in the main scanning direction by controlling the output energy of the resistance heater elements so that the size of perforations formed along one or more main scanning lines every two or more main scanning lines becomes smaller than the predetermined size to such an extent that an unperforated portion is left between the perforations on the main scanning line(s) and those on the preceding main scanning line.

5. A method of making a stencil as defined in Claim 4 in which the output energy of the resistance heater elements is controlled by changing the heat generation duty of the resistance heater elements.

6. A method of making a stencil as defined in Claim 4 in which the thermal head comprises a resistance heater strip extending in the main scanning direction and a plurality of electrodes in contact with the resistance heater strip at intervals in the main scanning direction, and the portions of the resistance heater strip between the electrodes form resistance heater elements and the length in the main scanning direction of the electrodes is larger than that of the resistance heater elements.

7. A method of making a stencil as defined in Claim 4 in which the second pitch is made shorter than the length in the sub-scanning direction of the resistance heater elements.

8. A method of making a stencil as defined in Claim 1 in which continuous unperforated portions are left in the sub-scanning direction by controlling the output energy of the resistance heater elements so that the size of perforations formed along one or more sub-scanning lines every two or more sub-scanning lines becomes smaller than the predetermined size to such an extent that unperforated portions are left between the perforations on the sub-scanning line(s) and those on the sub-scanning lines on opposite sides of the sub-scanning line(s).

9. A method of making a stencil as defined in Claim 8 in which the output energy of the resistance heater elements is controlled by changing the heat generation duty of the resistance heater elements.

10. A method of making a stencil as defined in Claim 8 in which the thermal head comprises a resistance heater strip extending in the main scanning direction and a plurality of electrodes in contact with the resistance heater strip at intervals in the main scanning direction, and the portions of the resistance heater strip between the electrodes form resistance heater elements and the length in the main scanning direction of the electrodes is larger than that of the resistance heater elements.

11. A method of making a stencil as defined in Claim 1 in which continuous unperforated portions are left in the main scanning direction by deviating the perforating pitch in the sub-scanning direction from the second pitch every two or more main scanning lines.

12. A method of making a stencil as defined in Claim 11 in which the resistance heater elements are energized to perforate the stencil material under the control of a heat generation timing control signal and the perforating pitch in the sub-scanning direction is deviated from the second pitch every two or more sub-scanning lines by deviating the timing at which the heat generation timing control signal energizes the resistance heater elements from that corresponding to the second pitch.

13. A method of making a stencil as defined in Claim 11 in which continuous unperforated portions are left also in the sub-scanning direction to separate per-

forations in the main scanning direction.

14. A method of making a stencil as defined in Claim 11 in which the thermal head comprises a resistance heater strip extending in the main scanning direction and a plurality of electrodes in contact with the resistance heater strip at intervals in the main scanning direction, and the portions of the resistance heater strip between the electrodes form resistance heater elements and the length in the main scanning direction of the electrodes is larger than that of the resistance heater elements.

15. A method of making a stencil as defined in Claim 1 in which continuous unperforated portions are left in the sub-scanning direction by deviating the perforating pitch in the main scanning direction from the first pitch every two or more sub-scanning lines.

16. An apparatus for making a stencil comprising a thermal head which has an array of resistance heater element arranged in a main scanning direction, a thermal head control means which selectively drives the resistance heater elements and a sub-scanning means which conveys the stencil material in a sub-scanning direction intersecting the main scanning direction so that perforations are formed in the stencil material in a predetermined size at a first pitch in the main scanning direction and a second pitch in the sub-scanning direction, wherein the improvement comprises that

the thermal head control means controls the thermal head and the sub-scanning means conveys the stencil material in the sub-scanning direction so that unperforated portions which continuously extend in one of the main scanning direction and the sub-scanning direction to separate perforations in the other of the main scanning direction and the sub-scanning direction are left in the stencil material.

17. An apparatus for making a stencil as defined in Claim 16 in which the thermal head comprises a resistance heater strip extending in the main scanning direction and a plurality of electrodes in contact with the resistance heater strip at intervals in the main scanning direction, and the portions of the resistance heater strip between the electrodes form resistance heater elements, and the length in the main scanning direction of the electrodes is larger than that of the resistance heater elements.

18. An apparatus for making a stencil as defined in Claim 16 in which the thermal head control means controls the thermal head and the sub-scanning means conveys the stencil material in the sub-scanning direction so that unperforated portions which continuously extend in the main scanning direction to separate perforations in the sub-scanning direction are left in the stencil material.

19. An apparatus for making a stencil as defined in Claim 16 in which the sub-scanning means conveys the stencil material in the sub-scanning direction so that the second pitch becomes longer than the length in the sub-scanning direction of the resistance heater elements.

20. An apparatus for making a stencil as defined in Claim 16 in which the thermal head control means controls the output energy of the resistance heater elements in association with the sub-scanning means so that the size of perforations formed along one or more main scanning lines every two or more main scanning lines becomes smaller than the predetermined size to such an extent that an unperforated portion is left between the perforations on the main scanning line(s) and those on the preceding main scanning line.

21. An apparatus for making a stencil as defined in Claim 20 in which the thermal head control means controls the output energy of the resistance heater elements by changing the heat generation duty of the resistance heater elements.

22. An apparatus for making a stencil as defined in Claim 20 in which the thermal head comprises a resistance heater strip extending in the main scanning direction and a plurality of electrodes in contact with the resistance heater strip at intervals in the main scanning direction, and the portions of the resistance heater strip between the electrodes form resistance heater elements and the length in the main scanning direction of the electrodes is larger than that of the resistance heater elements.

23. An apparatus for making a stencil as defined in Claim 20 in which the sub-scanning means conveys the stencil material in association with the thermal head control means so that the second pitch becomes shorter than the length in the sub-scanning direction of the resistance heater elements.

24. An apparatus for making a stencil as defined in Claim 16 in which the thermal head control means controls the output energy of the resistance heater elements in association with the sub-scanning means so that the size of perforations formed along one or more sub-scanning lines every two or more sub-scanning lines becomes smaller than the predetermined size to such an extent that unperforated portions are left between the perforations on the sub-scanning line(s) and those on the sub-scanning lines on opposite sides of the sub-scanning line(s).

25. An apparatus for making a stencil as defined in Claim 24 in which the thermal head control means controls the output energy of the resistance heater elements by changing the heat generation duty of the resistance heater elements.

26. An apparatus for making a stencil as defined in Claim 24 in which the thermal head comprises a resistance heater strip extending in the main scanning direction and a plurality of electrodes in contact with the resistance heater strip at intervals in the main scanning direction, and the portions of the resistance heater strip between the electrodes form resistance heater elements and the length in the main scanning direction of the electrodes is larger than that of the resistance heater elements.

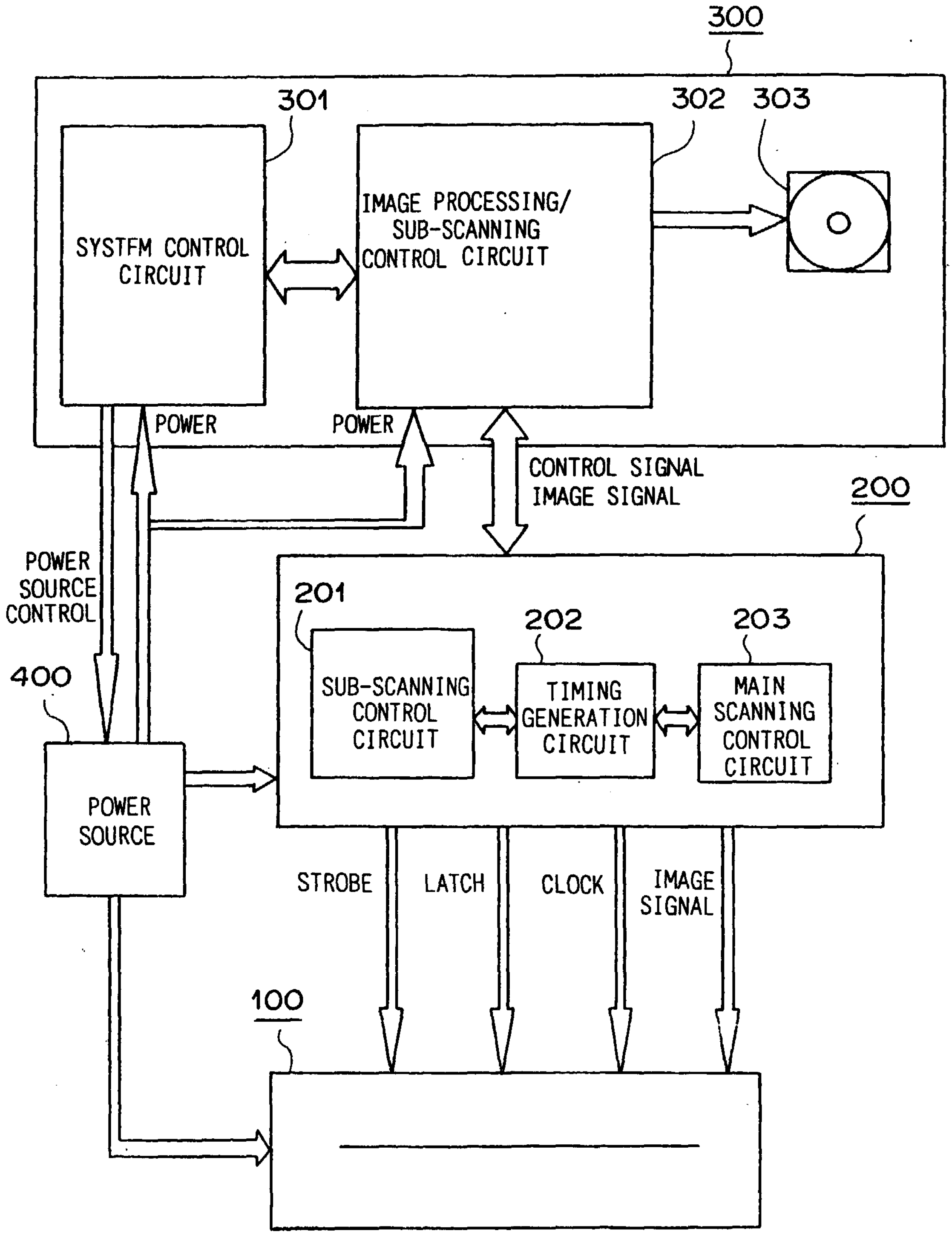
27. An apparatus for making a stencil as defined in Claim 16 in which the sub-scanning means conveys the stencil material in association with the thermal head control means so that the perforating pitch in the sub-scanning direction is deviated from the second pitch every two or more main scanning lines.

28. An apparatus for making a stencil as defined in Claim 27 in which the resistance heater elements are energized to perforate the stencil material under the control of a heat generation timing control signal and the thermal head control means deviates the perforating pitch in the sub-scanning direction from the second pitch every two or more sub-scanning lines by deviating the timing at which the heat generation timing control signal energizes the resistance heater elements from that corresponding to the second pitch.

29. An apparatus for making a stencil as defined in Claim 27 in which the thermal head control means controls the output energy of the resistance heater elements in association with the sub-scanning means so that continuous unperforated portions are left also in the sub-scanning direction to separate perforations in the main scanning direction.

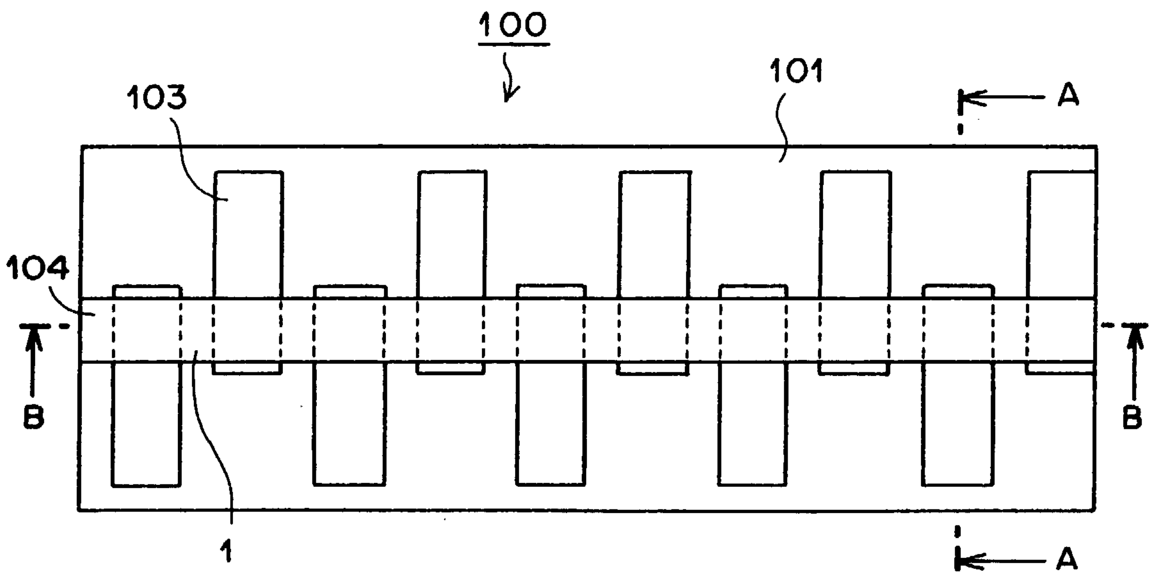
30. An apparatus for making a stencil as defined in Claim 27 in which the thermal head comprises a resistance heater strip extending in the main scanning direction and a plurality of electrodes in contact with the resistance heater strip at intervals in the main scanning direction, and the portions of the resistance heater strip between the electrodes form resistance heater elements and the length in the main scanning direction of the electrodes is larger than that of the resistance heater elements.

31. An apparatus for making a stencil as defined in Claim 16 in which the thermal head control means controls the output energy of the resistance heater elements in association with the sub-scanning means so that the perforating pitch in the main scanning direction is deviated from the first pitch every two or more sub-scanning lines.

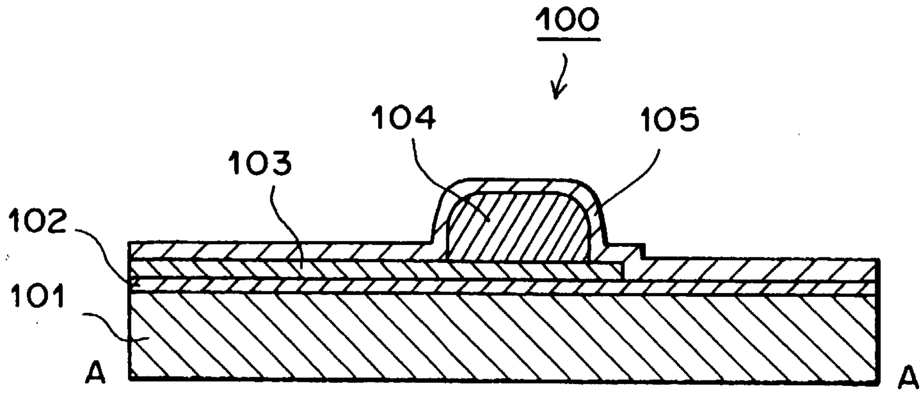

300
301
302
303
SYSTFM CONTROL CIRCUIT
IMAGE PROCESSING/ SUB-SCANNING CONTROL CIRCUIT
POWER
POWER
CONTROL SIGNAL
IMAGE SIGNAL
200
POWER SOURCE CONTROL
201
202
203
SUB-SCANNING CONTROL CIRCUIT
TIMING GENERATION CIRCUIT
MAIN SCANNING CONTROL CIRCUIT
400
POWER SOURCE
STROBE
LATCH
CLOCK
IMAGE SIGNAL
100

F I G. 1

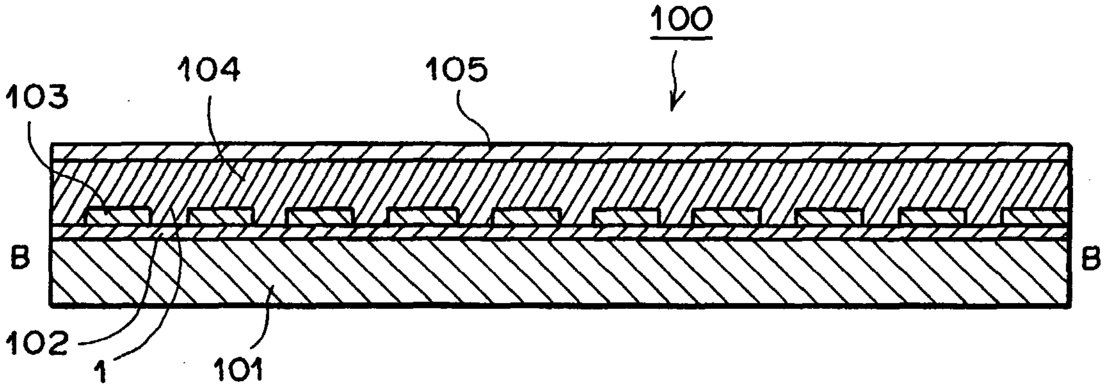
F I G . 2



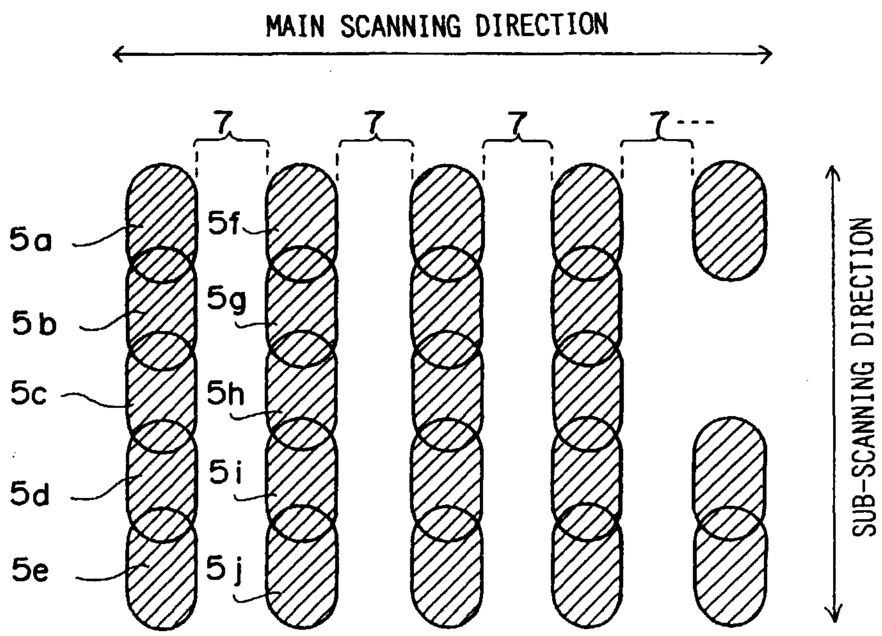
F I G . 3



F I G . 4


100
104
105
103
B
B
102
1
101

F I G . 5


MAIN SCANNING DIRECTION
7
7
7
7 ---
5a
5f
5b
5g
5c
5h
5d
5i
5e
5j
SUB-SCANNING DIRECTION

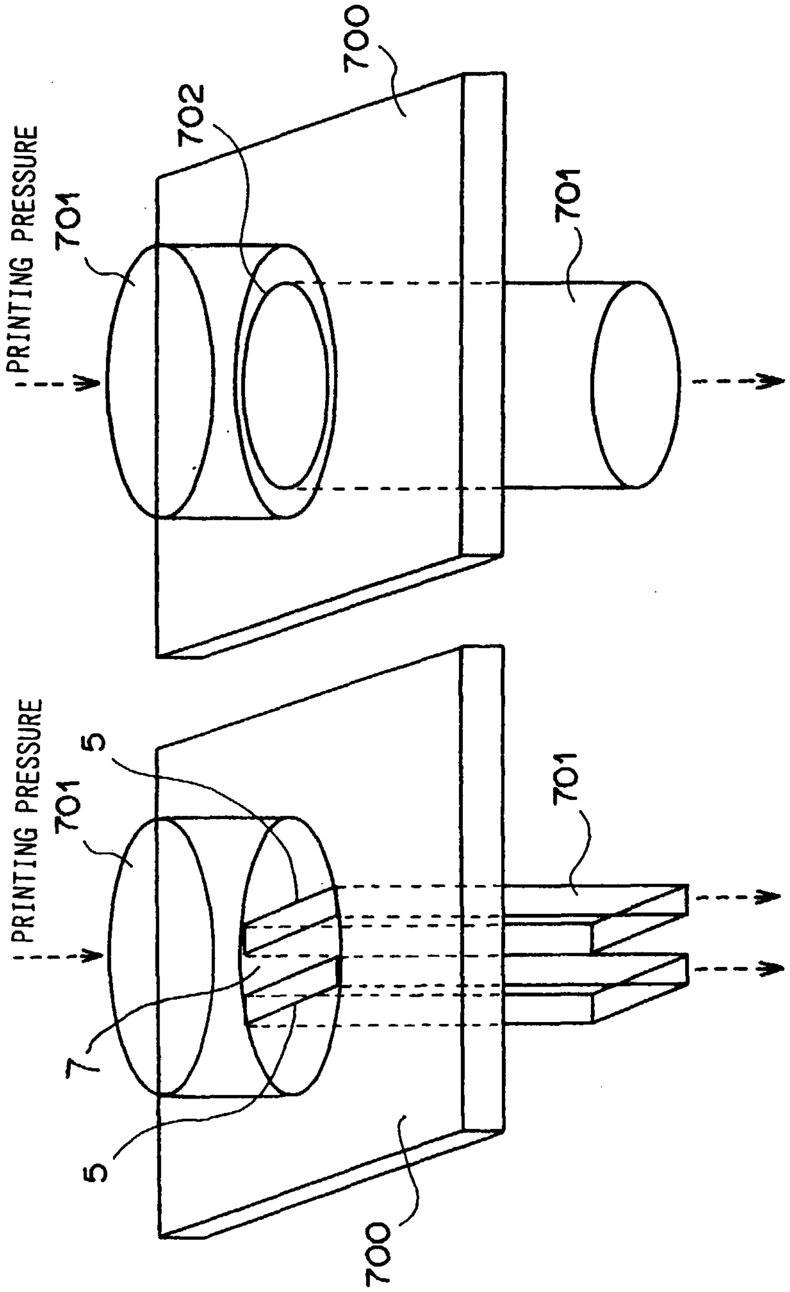
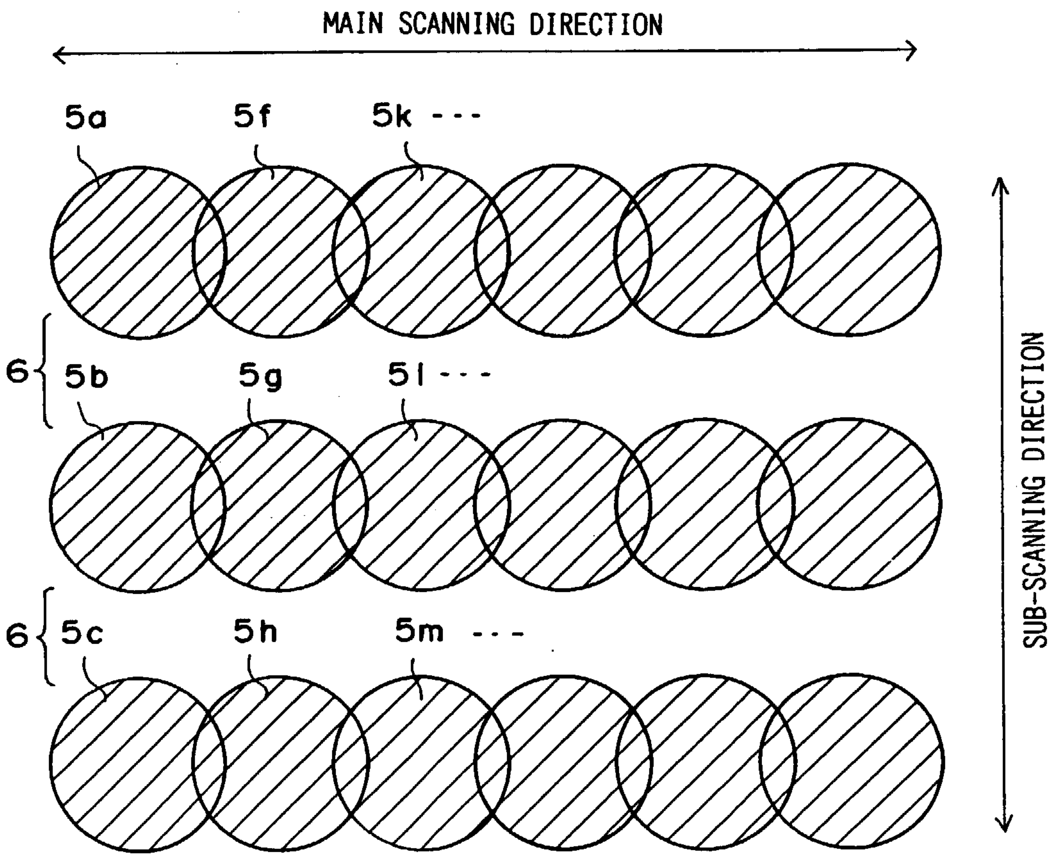
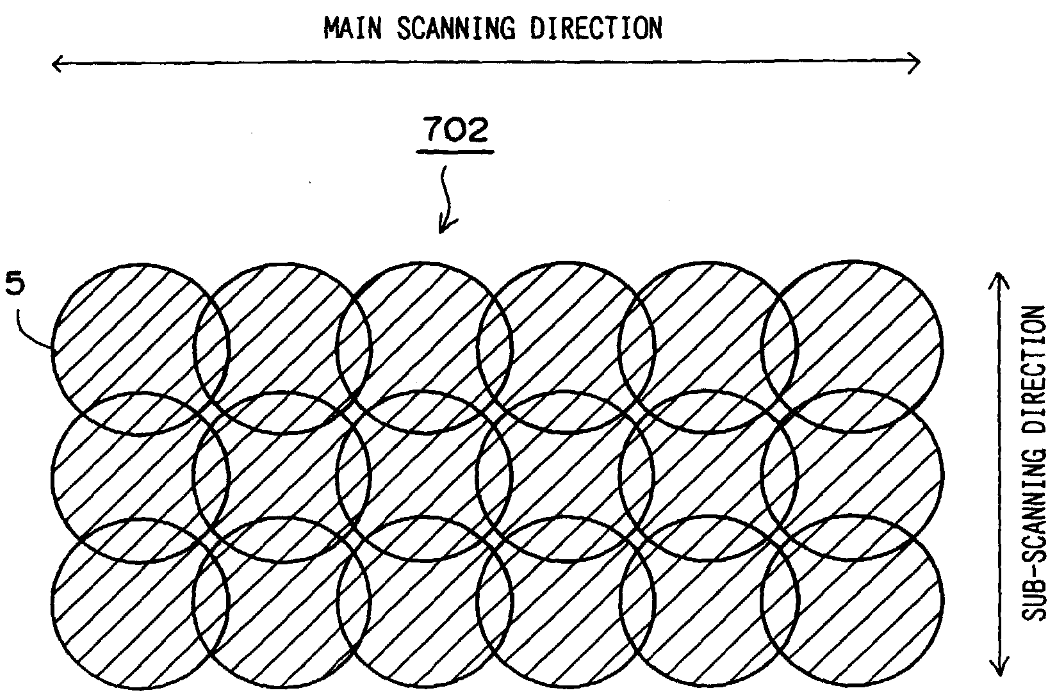

PRINTING PRESSURE
701
5
7
5
700
701
PRINTING PRESSURE
701
702
700
701

FIG.6A

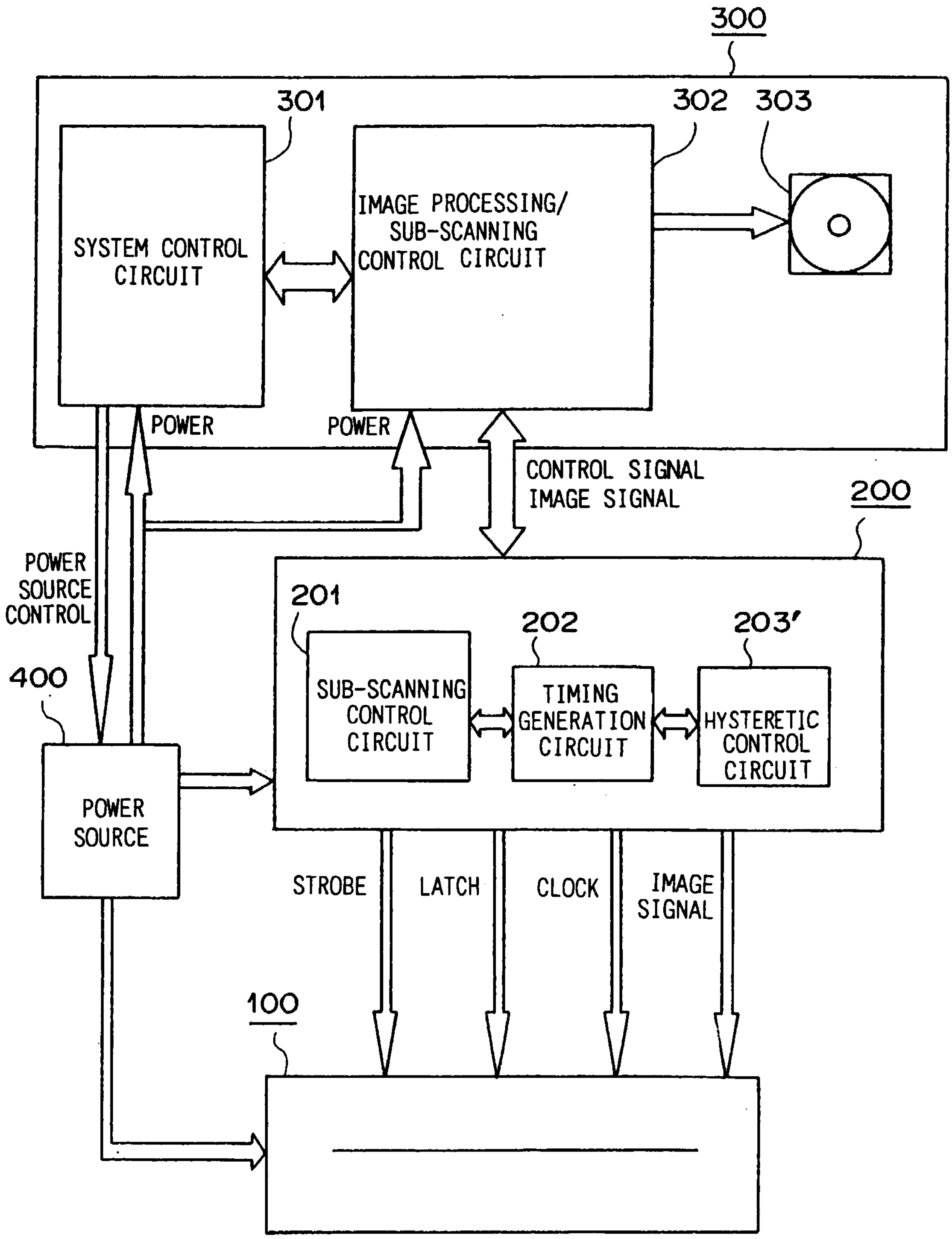
FIG.6B


MAIN SCANNING DIRECTION
5a
5f
5k ---
6
5b
5g
5l ---
6
5c
5h
5m ---
SUB-SCANNING DIRECTION

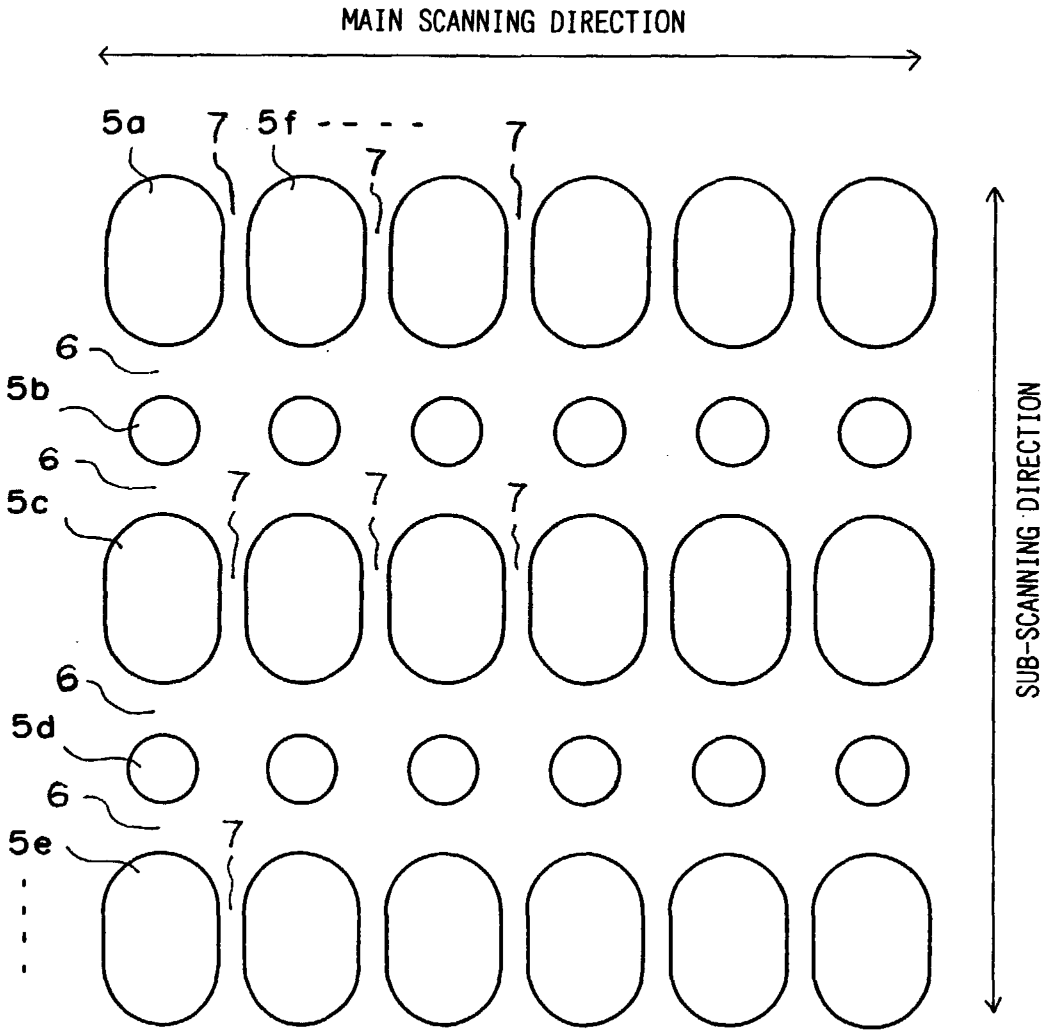
F I G. 7



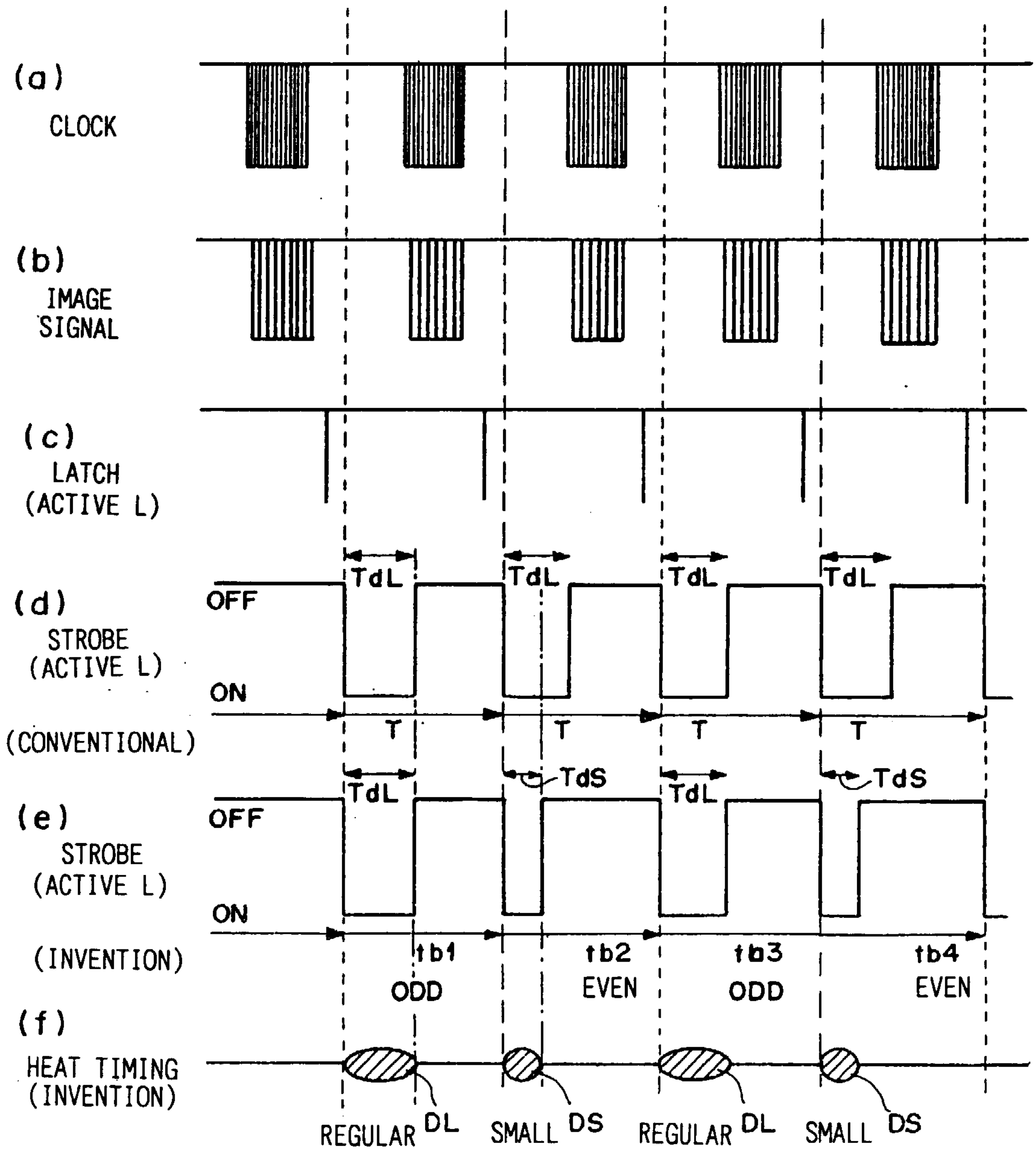
F I G . 8


300
301
SYSTEM CONTROL CIRCUIT
302
303
IMAGE PROCESSING/ SUB-SCANNING CONTROL CIRCUIT
POWER
POWER
CONTROL SIGNAL
IMAGE SIGNAL
200
POWER SOURCE CONTROL
201
SUB-SCANNING CONTROL CIRCUIT
202
TIMING GENERATION CIRCUIT
203'
HYSTERETIC CONTROL CIRCUIT
400
POWER SOURCE
STROBE
LATCH
CLOCK
IMAGE SIGNAL
100

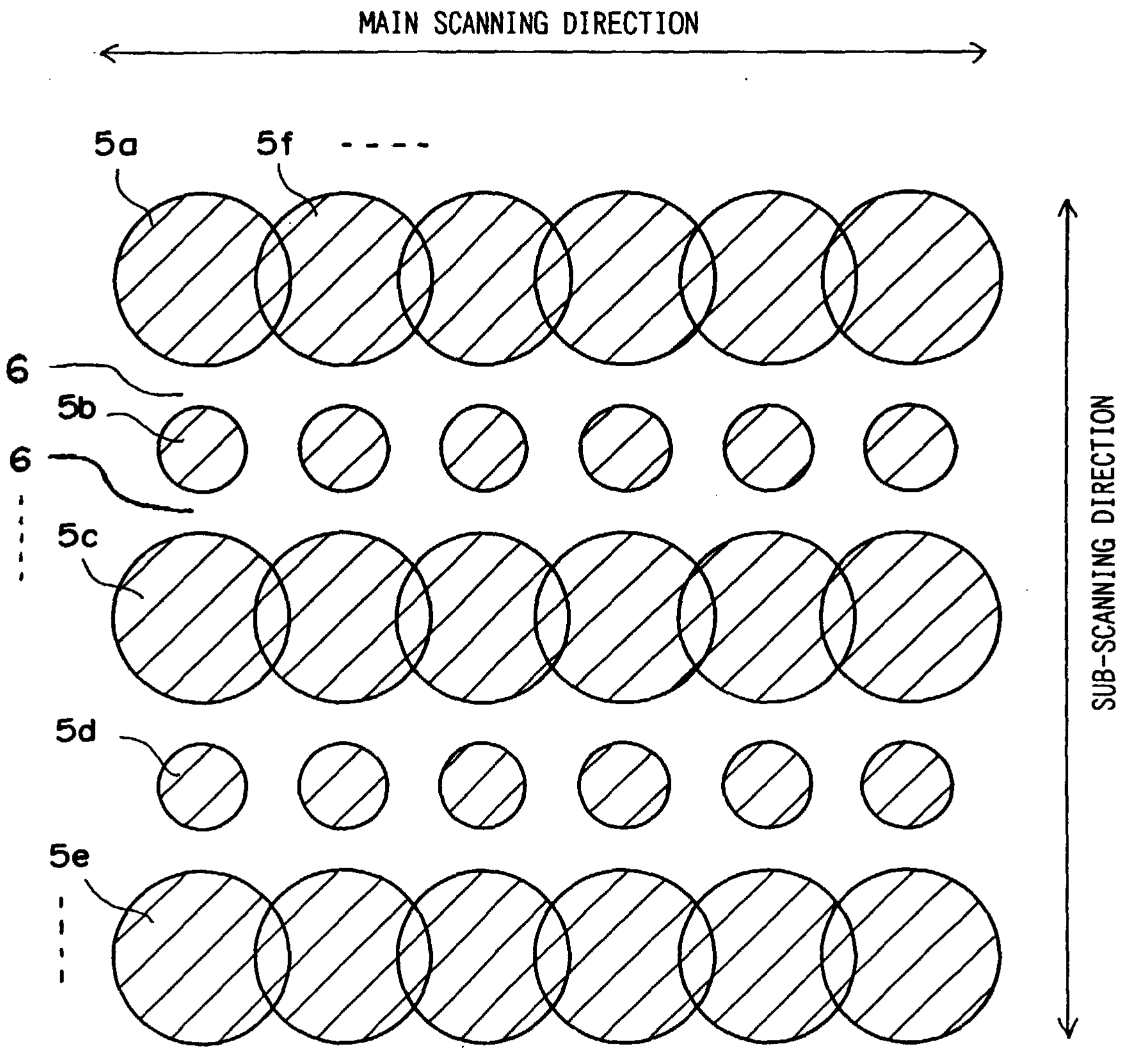
F I G . 9


MAIN SCANNING DIRECTION
5a
7
5f
7
7
6
5b
6
5c
7
7
7
6
5d
6
5e
7
SUB-SCANNING DIRECTION

F I G.10

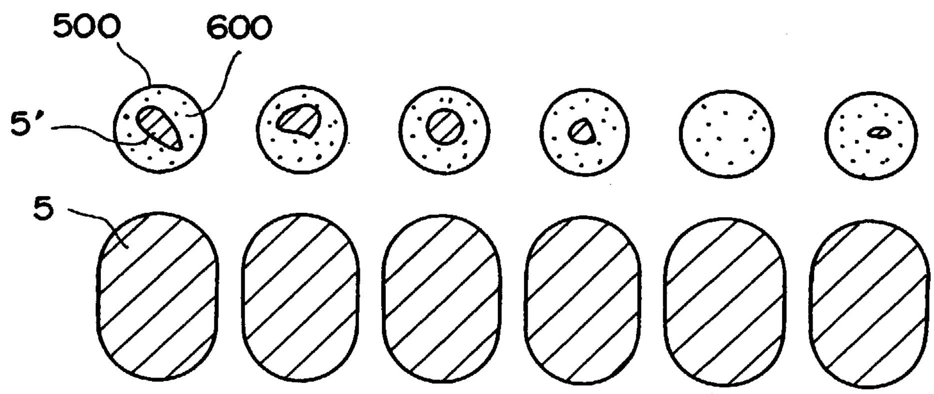

(a)
CLOCK
(b)
IMAGE
SIGNAL
(c)
LATCH
(ACTIVE L)
(d)
STROBE
(ACTIVE L)
(CONVENTIONAL)
OFF
ON
TdL
T
(e)
STROBE
(ACTIVE L)
(INVENTION)
TdS
tb1
ODD
tb2
EVEN
tb3
ODD
tb4
EVEN
(f)
HEAT TIMING
(INVENTION)
REGULAR
DL
SMALL
DS

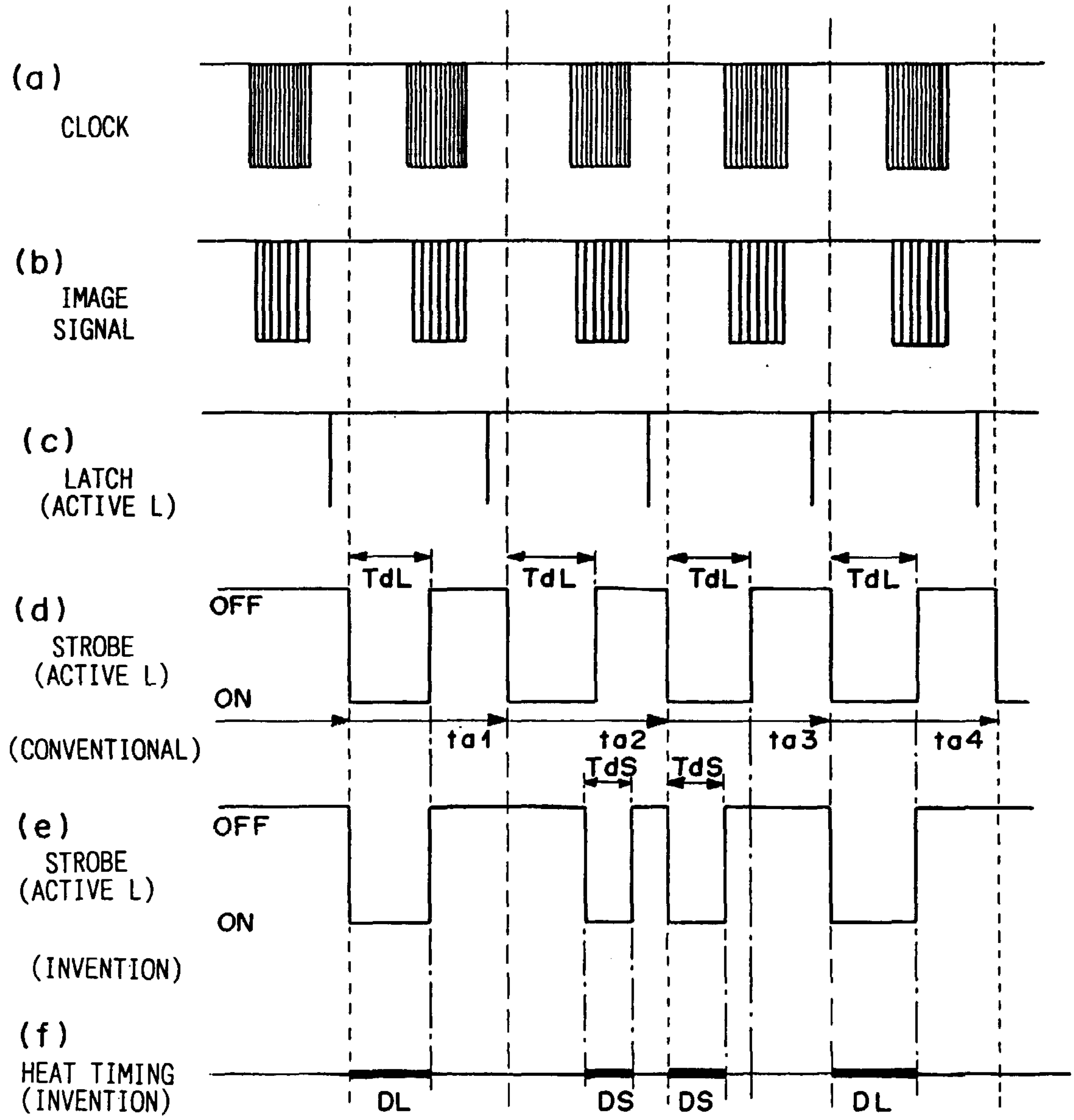
F I G. 11


MAIN SCANNING DIRECTION
5a
5f
6
5b
6
5c
5d
5e
SUB-SCANNING DIRECTION

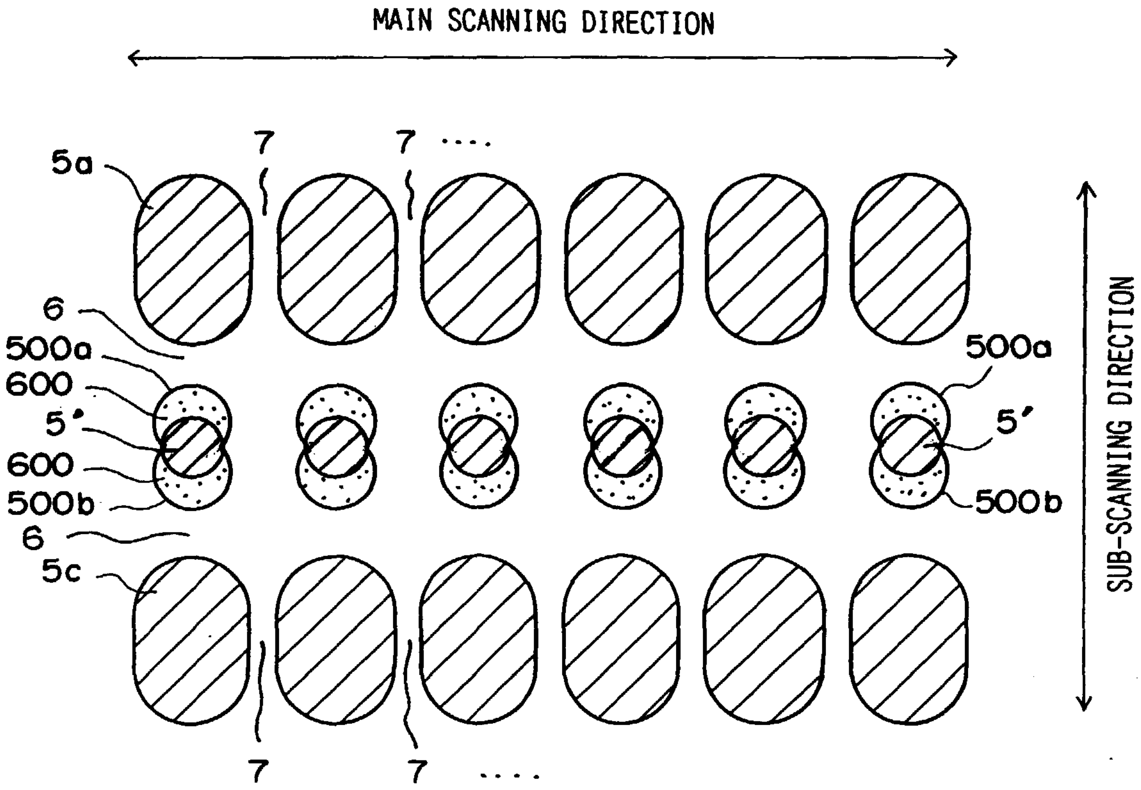
F I G .12

FIG.13



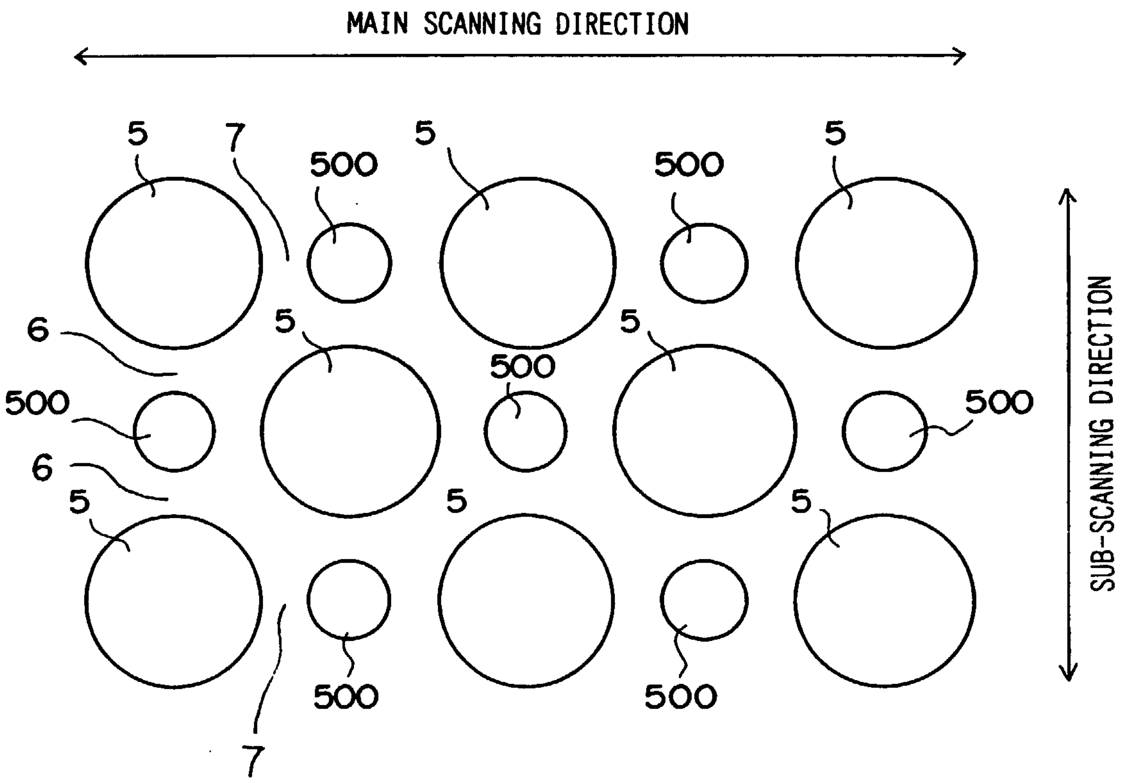

(a)
CLOCK
(b)
IMAGE
SIGNAL
(c)
LATCH
(ACTIVE L)
(d)
STROBE
(ACTIVE L)
(CONVENTIONAL)
OFF
ON
TdL
TdL
TdL
TdL
ta1
ta2
ta3
ta4
TdS
TdS
(e)
STROBE
(ACTIVE L)
(INVENTION)
OFF
ON
(f)
HEAT TIMING
(INVENTION)
DL
DS
DS
DL

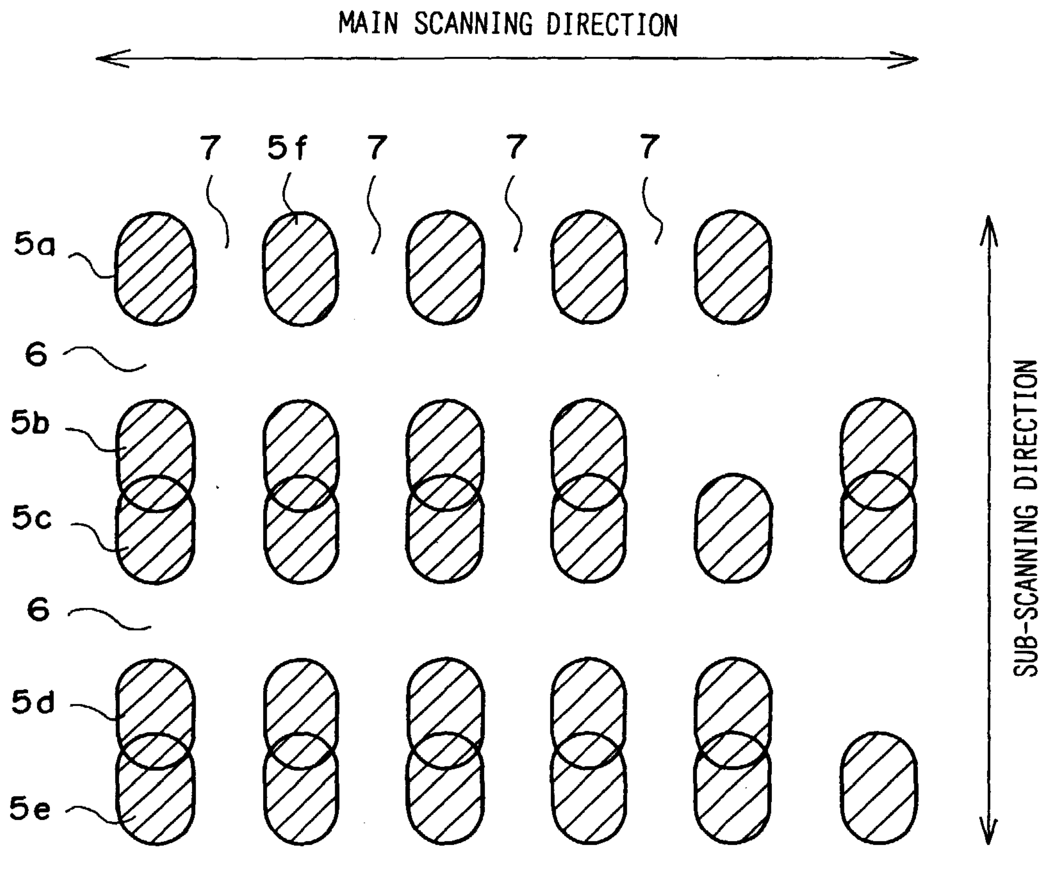
F I G . 14


MAIN SCANNING DIRECTION
SUB-SCANNING DIRECTION
5a
7
7 ....
6
500a
600
5'
600
500b
6
5c
7
7 ....
500a
5'
500b

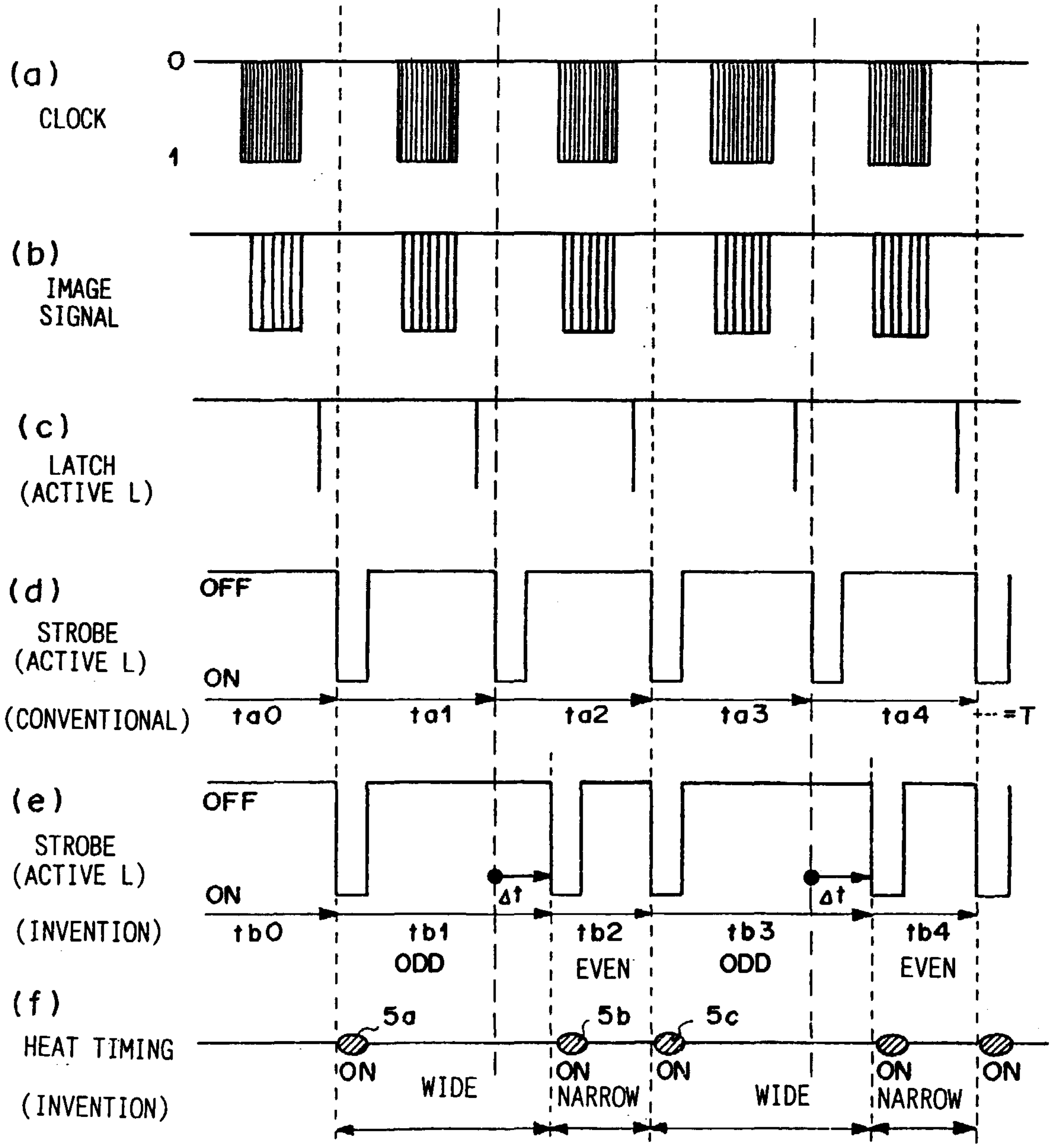
F I G . 15

F I G . 16




MAIN SCANNING DIRECTION
7
5f
7
7
7
5a
6
5b
5c
6
5d
5e
SUB-SCANNING DIRECTION

F I G. 17


(a)
CLOCK
0
1
(b)
IMAGE SIGNAL
(c)
LATCH (ACTIVE L)
(d)
STROBE (ACTIVE L)
OFF
ON
(CONVENTIONAL)
ta0
ta1
ta2
ta3
ta4
=T
(e)
STROBE (ACTIVE L)
OFF
ON
(INVENTION)
Δt
Δt
tb0
tb1
ODD
tb2
EVEN
tb3
ODD
tb4
EVEN
(f)
HEAT TIMING
(INVENTION)
5a
5b
5c
ON
WIDE
ON
NARROW
ON
WIDE
ON
NARROW
ON

F I G . 18