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DESCRIPTION

Field of the Invention

[0001] The present invention relates to heat exchangers, and more particularly to closed circuit evaporative heat exchangers having a combination of direct and indirect closed circuit evaporative heat exchangers.

Background of the Invention

[0002] Waste heat may be rejected to the atmosphere by dry or sensible heat exchangers. In a dry or sensible heat exchanger, there are two fluids: an air stream and a process fluid stream. In a closed system, the process fluid stream is enclosed so that there is no direct contact between the air stream and the process fluid stream; the process fluid stream is not open to the atmosphere. The enclosing structure may be a coil of tubes. Sensible heat is exchanged as the air stream is passed over the structure enclosing the process fluid stream. In the art these structures are known as "compact heat exchangers."

[0003] In most climates, evaporative heat exchangers offer significant process efficiency improvements over dry heat exchangers. One type of evaporative heat exchanger is a direct evaporative heat exchanger, also known in the industry as an open cooling tower. In a direct heat exchanger, only an air stream and an evaporative liquid stream are involved; the evaporative liquid stream is usually water, and the two streams come into direct contact with each other.

[0004] Another type of evaporative heat exchanger is an indirect closed circuit evaporative heat exchanger, where three fluid streams are involved: an air stream, an evaporative liquid stream, and an enclosed process fluid stream. The enclosed fluid stream first exchanges sensible heat with the evaporative liquid through indirect heat transfer, since it does not directly contact the evaporative liquid and then the air stream and the evaporative liquid exchange heat and mass when they contact each other.

[0005] Another type of evaporative heat exchanger is a combined direct and indirect closed circuit evaporative heat exchanger. Examples of combined systems are disclosed in U.S. Pat. No. 5,435,382, U.S. Pat. No. 5,816,318 and U.S. Patent No. 6,142,219.

[0006] Both dry and evaporative heat exchangers are commonly used to reject heat as coolers or condensers. Evaporative coolers reject heat at temperatures approaching the lower ambient wet bulb temperatures, while dry coolers are limited to approaching the higher ambient dry bulb temperatures. In many climates the ambient wet bulb temperature is often 20° to 30° F. below the ambient design dry bulb temperature. Thus, in an evaporative cooler, the evaporative liquid stream may reach a temperature significantly lower than the ambient dry bulb temperature, offering the opportunity to increase the efficiency of the cooling process and to lower the overall process energy requirements. Evaporative condensers offer similar possibilities for increased efficiency and lower energy requirements. In spite of these opportunities to increase process efficiencies and lower overall process energy requirements, evaporative cooling and evaporative condensing are often not used due to concern about water consumption from evaporation of the evaporative liquid and freezing potentials during cold weather operation.

[0007] In addition, both sensible and evaporative heat exchangers are typically sized to perform their required heat rejection duty at times of greatest thermal difficulty. This design condition is typically expressed as the summer design wet bulb or dry bulb temperature. While it is often critical that the heat rejection equipment be able to reject the required amount of heat at these design conditions, the duration of these elevated atmospheric temperatures may account for as little as 1% of the hours of operation of the equipment. The remainder of the time, the equipment may have more capacity than required, resulting in unnecessary usage of additional evaporative liquid.

[0008] U.S. Patent No. 6,142,219 discloses a closed circuit heat exchanger having three heat exchange sections: a dry indirect contact heat exchange section; a second indirect contact heat exchange section that is operable in either a wet or dry mode; and a direct contact heat exchange section. As a fluid cooler, a connecting flow path connects the dry indirect contact heat exchange section to the second indirect contact heat exchange section. A bypass flow path extends from the dry indirect contact heat exchange section to the process fluid outlet. A modulating valve is at the outlet so that process fluid can be selectively drawn from the dry indirect contact heat exchange section alone, from the second indirect contact heat exchange section in series with the dry indirect contact heat exchange section, or from both the dry and second indirect contact heat exchange sections and mixed. Separate air streams pass through the second indirect and direct contact heat exchange sections before entering the dry indirect contact heat exchange section. As a condenser, process fluid is directed to the dry indirect contact heat exchange section alone or to the dry and second indirect contact heat exchange sections in parallel by valves in the process fluid supply lines. In another embodiment, the process fluid flows in series from the dry to the second indirect contact heat exchange section. The system is operable in different modes to extract heat from the process fluid in the most efficient way with respect to annual water consumption. At low temperatures, the system operates dry with primary heat extraction performed by the dry indirect contact heat exchange section. At higher temperatures, the air streams may be adiabatically saturated with evaporative liquid to pre-cool them below the dry bulb temperature before entering the dry indirect contact heat exchange section. At still higher temperatures, the apparatus may be operated in a wet mode with the primary heat extraction performed by the second indirect contact heat exchange section. Heat is extracted from the process fluid while selectively distributing or not distributing the evaporative liquid over the second indirect contact heat exchange section A heat exchanger system as defined in the preamble of claim 1 is disclosed for example in US 2011/100593 A1.

Summary of the Invention

[0009] The invention, and apparatus and processes, disclosed herein are improvements to the inventions disclosed in U.S. Patent No. 6,142,219 and corresponding European Patent No EP 1 035 396.

[0010] An apparatus disclosed herein relates to a hybrid closed circuit cooler for extracting heat from a process fluid having a dry indirect heat exchange portion or "section" in fluid connection with an evaporative indirect heat exchange section, in which the evaporative indirect heat exchange portion or "section" is divided into a plurality of evaporative indirect heat exchange flow paths or "sub-sections." Each of the plurality of evaporative indirect heat exchange flow paths may be contained in a separate evaporative indirect heat exchange coil bundle. An evaporative fluid distribution system is located and configured to controllably and selectively distribute evaporative fluid over all, part, or none of the evaporative indirect heat exchange sub-sections. In addition, a process fluid flow path control system is configured to controllably and selectively direct the process fluid through one or more of the evaporative indirect heat exchange sub-sections. The process fluid flow path control system may send all of the process fluid through a single evaporative indirect heat exchange sub-sections, through two or more evaporative indirect heat exchange sub-sections in equal amounts, or through two or more evaporative indirect heat exchange sub-sections in different amounts. There is preferably a process fluid flow path that does not pass through at least one evaporative indirect heat exchange sub section. That is, there is preferably no evaporative heat exchange section bypass flow path.

[0011] The evaporative fluid distribution system and the process fluid flow path control system may be configured so that the evaporative indirect heat exchange sub-sections may collectively, or individually and separately, be run in evaporative mode and/or in dry mode. In particular, the system of the invention may be configured so that one or more sub-sections of the evaporative indirect heat exchange section are run in dry mode, and another one or more sub-sections of the evaporative indirect heat exchange section are run in evaporative mode. Additionally, one or more-subsections of the evaporative indirect heat exchange sections may be run in "adiabatic mode" according to which evaporative fluid is distributed over an evaporative indirect heat exchange sub-section, but no process fluid is passed through that sub-section, providing adiabatic cooling of the air flow passing through the evaporative indirect heat exchange section. Accordingly, the system may be configured so that one or more sub-sections of the evaporative indirect heat exchange section is running in dry mode (process fluid running, but no evaporative fluid running), one or more subsections are running in evaporative mode (process fluid running and evaporative fluid running), and/or one or more subsections are running in adiabatic mode (evaporative fluid running, but no process fluid running).

[0012] Air moving systems may be arranged according to methods known in the art to move air through the dry indirect heat exchange portion and the evaporative indirect heat exchange portion according to induced draft arrangement, forced draft arrangement, or some combination thereof (e.g., induced draft for one section and forced draft for another section)

[0013] Relative direction of air flow and process fluid flow for each of the heat exchange sections, collectively, or individually and separately, may be concurrent, countercurrent, or cross current.

[0014] The device according to the invention may optionally include a direct contact heat exchange section for cooling the evaporative fluid. The direct contact heat exchange section may optionally contain fill material. Air may be directed through the direct contact heat exchange section in cross-current, concurrent, or countercurrent arrangement.

[0015] The invention is claimed in claim 1. There may be included one or more mechanisms for moving air through the heat exchangers.

[0016] The mechanism for moving air through the heat exchanger may be an induced draft system.

[0017] According to another embodiment, the mechanism for moving air through the heat exchanger is a forced draft system.

[0018] There may be no process fluid flow path that does not travel through the evaporative indirect heat exchange section (i.e., no evaporative indirect heat exchange section by-pass).

[0019] The process fluid flow path may be controlled so that it only flows through fewer than all of the evaporative heat exchanger sections, bypassing others.

[0020] The water distribution system may be two or more separate systems. The distribution system can be operated via separate flow means, such as pumps placed as separate systems, or it can be a single system separated with a valve or multiple valves in the main distribution pipe, or any other means to selectively shut of water flow to parts of the distribution system approximately corresponding to the internal flow divisions of the second evaporative heat exchanger section.. An evaporative fluid distribution system may be arranged to distribute evaporative fluid over fewer than all of the evaporative heat exchange sections. There may be one, two or more dry indirect sections, and two or more evaporative indirect sections, and the evaporative fluid distribution system is arranged over one or more evaporative indirect sections, and not present over one or more different evaporative indirect sections.

[0021] There may be multiple dry heat exchangers with additional piping to connect to the flow distribution valve. The dry heat exchanger may have an additional flow control means to selectively distribute process fluid flow between the multiple dry heat exchangers creating unequal flows between the two or more dry heat exchanger sections or shutting off one or multiple of the dry heat exchangers. There may be a mechanism for bypassing the process fluid around one or more of the dry heat exchanger sections.

[0022] The flow-divide in the dry heat exchange section can be equal or unequal and the dry heat exchanger can be two or more separate heat exchangers and the multiple dry heat exchangers may have a series process fluid flow path for the process fluid.

[0023] There may be provided series process fluid flow path for either or both the multiple dry heat exchangers and the multiple evaporative heat exchangers. This can also be accomplished with single heat exchangers for either or both the dry and evaporative heat exchangers by using partitions within the heat exchanger headers. According to the series arranged evaporative sections, one embodiment permits the bypass of one or more evaporative sections, wherein the process fluid flow travels through fewer than all of the evaporative sections..

[0024] There may be provided modulating valves, or operational equivalent, to control flow to the various sections, where the modulating valve, or operational equivalent, can be operated either manually or automatically

[0025] The amount of process fluid flow split between the two or more evaporative heat exchangers and the control of evaporative liquid flow over two or more evaporative heat exchangers may depend upon the process fluid temperature. There may be provided a mechanism for measuring the process fluid temperature and a means for controlling the modulating valve, or operational equivalent, and the distribution system flows (pumps) or valves.

[0026] According to an embodiment of the invention, a method is provided for extracting heat from a process fluid including the steps of: providing a process fluid inlet and outlet; providing an evaporative liquid; providing a distribution system for the evaporative liquid, a dry heat exchange section, and a second divided indirect heat exchange section; passing the process fluid through the dry indirect contact heat exchange section and selectively through the flow paths of the second divided indirect heat exchange section; and selectively distributing or not distributing the evaporative liquid over the divisions of the second evaporative indirect heat exchange section, characterized by: providing a process fluid flow path from the dry indirect contact heat exchanger through one or more or all of the divisions of the evaporative heat exchanger section; providing a mechanism for controlling the process fluid flow to the divided flow paths of the evaporative heat exchange section, and providing a mechanism for controlling the evaporative fluid (e.g., water) flow to the section of the distribution system.

[0027] The method may further include the step of selectively moving process fluid flow through the second evaporative indirect heat exchanger sections as a function of the process fluid temperature.

[0028] The method may include turning on the evaporative distribution flow sections as a function of the process fluid temperature.

[0029] The method may include selectively moving process fluid flow through the dry heat exchanger sections as a function of the process fluid temperature.

[0030] In the heat exchanger system the evaporative heat exchange section may comprise a plurality of separate evaporative heat exchange sections. Two or more of the plurality of separate evaporative heat exchange sections may be connected in a series flow path for the process fluid.

[0031] The heat exchanger system may comprise a plurality of evaporative fluid distribution systems, including a mechanism to selectively shut off water flow to parts of the evaporative fluid distribution system approximately corresponding to internal flow divisions of the evaporative heat exchanger section. The heat exchanger system may further comprise a partition separating the second heat exchanger section to further separate the flows from the water distribution system.

[0032] The heat exchanger system may comprise multiple dry heat exchangers with piping to connect to the flow distribution valve, wherein the dry heat exchanger may have an additional flow control means to selectively distribute process fluid flow between the multiple dry heat exchangers creating unequal flows between the two or more dry heat exchanger sections or shutting off one or multiple of the dry heat exchangers.

[0033] The heat exchanger system may further comprise a mechanism for bypassing the process fluid around one or more of the dry heat exchanger sections. The heat exchanger system according, wherein the flow-divide in the dry heat exchange section can be equal or unequal and the dry heat exchanger can be two or more separate heat exchangers and the multiple dry heat exchangers may have a series process fluid flow path for the process fluid. The heat exchanger system may further comprise a series process fluid flow path for both the multiple dry heat exchangers and also to the multiple evaporative heat exchangers.

[0034] The heat exchanger system may further comprise valves to control flow to the various sections. The heat exchanger system wherein the valves may be selected from the group consisting of three-way valves and modulated valves, and wherein said valves can be operated either manually or automatically.

[0035] According to another aspect of the invention there is provided a method of extracting heat from a process fluid by using the heat exchanger of claim 1, which comprises the steps of:

passing the process fluid through a dry indirect contact heat exchange section and selectively through one or more of a plurality of evaporative indirect heat exchange sections;

selectively distributing or not distributing the evaporative liquid over one or more of the plurality of evaporative indirect heat exchange sections;

controlling the flow of the process fluid to one or more of the plurality of evaporative indirect heat exchange sections, and controlling the evaporative fluid flow to the section of the distribution system.

Description of the Drawings

[0036] The subsequent description of the preferred embodiments of the present invention, as well as various apparatus, refers to the attached drawings, wherein:

Figure 1 is a representation of a heat exchange system having a dry indirect heat exchange section and an evaporative heat exchange section having subsections A and B, in which the evaporative fluid flow is set to "off and the process fluid is set to flow through both evaporative heat exchange subsections.

Figure 2 is a representation of a heat exchange system having a dry indirect heat exchange section and an evaporative heat exchange section having subsections A and B, in which the evaporative fluid flow is set to flow over both evaporative sub-sections, and in which the process fluid is set to flow only through one of the two evaporative subsections.

Figure 3 is a representation of a heat exchange system having a dry indirect heat exchange section and an evaporative heat exchange section having subsections A and B, in which the evaporative fluid flow is set to flow over both evaporative sub-sections, and in which the process fluid is set to a partial flow through one evaporative sub-section and to a full flow through a second evaporative sub-section.

Figure 4 is a representation of a heat exchange system having a dry indirect heat exchange section and an evaporative heat exchange section having subsections A and B, in which the evaporative fluid flow is set to flow over both evaporative sub-sections and the process fluid is set to full flow through both evaporative heat exchange subsections.

Figure 5 is a representation of a heat exchange system having a dry indirect heat exchange section, an evaporative heat exchange section having subsections A and B, and two evaporative fluid distribution systems, in which the evaporative fluid flow is set to "off and the process fluid is set to flow through both evaporative heat exchange subsections.

Figure 6 is a representation of a heat exchange system having a dry indirect heat exchange section, an evaporative heat exchange section having subsections A and B, and two evaporative fluid distribution systems, in which one evaporative fluid distribution system is set to "off and a second evaporative fluid distribution system is set to distribute evaporative fluid over one subsection of the evaporative heat exchange section, and the process fluid is set to flow through the evaporative subsection which is not receiving evaporative fluid, and does not flow through the evaporative subsection over which evaporative fluid is distributed.

Figure 7 is a representation of a heat exchange system having a dry indirect heat exchange section, an evaporative heat exchange section having subsections A and B, and two evaporative fluid distribution systems, in which one evaporative distribution system is set to "off' and a second evaporative fluid distribution system is set to distribute evaporative fluid over one subsection of the evaporative heat exchange section, and the process fluid is set to fully flow through the evaporative subsection which is not receiving evaporative fluid, and is set to partially flow through the evaporative subsection over which evaporative fluid is distributed.

Figure 8 is a representation of a heat exchange system having a dry indirect heat exchange section, an evaporative heat exchange section having subsections A and B, and two evaporative fluid distribution systems, in which the evaporative fluid flow is set to flow over both evaporative subsections, and the process fluid is set to flow through both evaporative subsections.

Figure 9 is a representation of a heat exchange system having a dry indirect heat exchange section having subsections C and D, an evaporative heat exchange section having subsections A and B, in which process fluid enters each dry indirect subsection in separate flow paths, in which, upon leaving the dry indirect subsections, the two process fluid paths are combined into a single process fluid flow path, which is then split into two process flow paths each of which flows through a different evaporative subsection. The embodiment of Figure 9 has a single evaporative fluid distribution system, which is shown as turned off.

Figure 10 is representation of a heat exchange system having a dry indirect heat exchange section having subsections C and D, an evaporative heat exchange section having subsections A and B, in which process fluid enters each dry indirect subsection in separate flow paths, in which, upon leaving the dry indirect subsections, the two process fluid paths can be optionally and selectively mixed and or re-directed prior to entering the evaporative subsections. The embodiment of Figure 10 has a single evaporative fluid distribution system, which is shown as turned off.

Figure 11 is a representation of a heat exchange system having a dry indirect heat exchange section, an evaporative heat exchange section having subsections A and B, in which process fluid can be optionally directed entirely or partially into the dry indirect section or optionally be directed to bypass the dry indirect section, and in which the process fluid flow may optionally be directed into one or both of the evaporative sub-sections. The embodiment of Figure 11 has a single evaporative fluid distribution system, which is shown as turned off.

Figure 12 is a representation of a heat exchange system having a dry indirect heat exchange section having subsections C and D, an evaporative heat exchange section having subsections A and B, in which process fluid enters each dry indirect subsection one after the other, then proceeds to the evaporative section, and in which the process fluid flow path may be selectively directed to one or the other or to both evaporative subsections. The embodiment of Figure 12 has a single evaporative fluid distribution system, which is shown as turned off.

Figure 13a is a representation of a heat exchange system having a dry indirect heat exchange section, an evaporative heat exchange section having subsections A and B, in which process fluid enters each evaporative subsection one after the other. The embodiment of Figure 13a has a single evaporative fluid distribution system, which is shown as turned off.

Figure 13b is a representation of an embodiment according to the invention having a dry indirect heat exchange section, an evaporative heat exchange section having subsections A and B, in which process fluid enters each evaporative subsection one after the other, but in which the process fluid flow path may be controlled to bypass a second evaporative section and only flow through a first evaporative section. The embodiment of Figure 13b has a single evaporative fluid distribution system, which is shown as turned off.

Figure 14a is a representation of a heat exchange system having a dry indirect heat exchange section having subsections C and D, an evaporative heat exchange section having subsections A and B, in which process fluid enters each evaporative subsection one after the other. The embodiment of Figure 14a has a single evaporative fluid distribution system, which is shown as turned off

Figure 14b is a representation of an embodiment according to the invention having a dry indirect heat exchange section having subsections C and D, an evaporative heat exchange section having subsections A and B, in which process fluid enters each evaporative subsection one after the other, but in which the process fluid flow path may be controlled to bypass a second evaporative section and only flow through a first evaporative section. The embodiment of Figure 14b has a single evaporative fluid distribution system, which is shown as turned off.

Figure 15a is a representation of a heat exchange system having a dry indirect heat exchange section (optionally having either a single section or a plurality of sections, arranged in either parallel or in series), an evaporative fluid distribution system, and an evaporative indirect heat exchange section having subsections A and B, with the process fluid flow path arranged to flow through the evaporative subsections in parallel. The evaporative fluid distribution system is located over fewer than all of the evaporative sections.

Figure 15b is a representation of an embodiment according to the invention having a dry indirect heat exchange section (optionally having either a single section or a plurality of sections, arranged in either parallel or in series), an evaporative fluid distribution system, and an evaporative indirect heat exchange section having subsections A and B, with the process fluid flow path arranged to flow through the evaporative subsections in series. The evaporative fluid distribution system is located over fewer than all of the evaporative sections.

Figure 16 is a side view schematic of a prior art (U.S. Patent No. 6,142,219) closed circuit heat exchange system having a unitary dry indirect heat exchange section, a unitary evaporative indirect heat exchange section, a direct heat exchange system, a single evaporative fluid distribution system, a single process fluid flow path through said dry indirect section, a single process fluid flow path through said evaporative indirect section, and a process fluid path that bypasses said evaporative indirect section.

Detailed Description of the Invention

[0037] A heat exchange system is shown in FIG.s 1-4. The system of FIG. s 1-4 includes a dry indirect heat exchange section **1,** an evaporative heat exchange section **3** having a plurality of subsections **5**, **7**, an evaporative fluid distribution system **9**, a dry indirect section process fluid inlet **11**, a dry indirect section process fluid outlet **13**, a process fluid intermediate flow path valve **15** which can be used to direct the process fluid to one or more of the evaporative subsection inlets **17**, **19**, and evaporative subsection outlets **21**, **23**.

[0038] In the heat exchange system shown in FIG.s 1-4, the evaporative fluid distribution system **9** may be set to on (see evaporative fluid **35**, FIG.s 2-4) or off (FIG. 1). The process fluid intermediate flow path valve **15** may be set to allow the process fluid to flow in roughly equal amounts through evaporative subsections **5**, **7** (FIG.s 1, 3), to flow only one evaporative subsections **17**, **19** (FIG. 2), or to flow through one evaporative subsection (e.g., 7, FIG. 3) in substantially greater volumes than through another evaporative subsection (e.g., **5**, FIG. 3).

[0039] A second heat exchange system is shown in FIG.s 5-8. This system is similar in structure to that shown in FIG.s 1-4, but has a plurality of evaporative fluid distribution systems **9a** and **9b**. Thus, the system of FIG.s 5-8 includes a dry indirect heat exchange section **1,** an evaporative heat exchange section **3** having subsections **5, 7,** evaporative fluid distribution systems **9a, 9b,** a dry indirect section process fluid inlet **11,** a dry indirect section process fluid outlet **13,** a process fluid intermediate flow path valve **15** which can be used to direct the process fluid to one or more of the evaporative subsection inlets **17,19,** and evaporative subsection outlets **21, 23.**

[0040] In the heat exchange system of FIG.s 5-8, the evaporative fluid distribution systems **9a** and **9b** may both be turned off (FIG. 5), may both be turned on (FIG. 8), or one evaporative fluid distribution system **9a, 9b** may be turned on and another turned off (FIG.s 6 and 7 show **9a** turned off, and **9b** turned on). Furthermore, the process fluid intermediate flow path valve **15** of the structural embodiment of FIG.s 5-8 may be set to allow the process fluid to flow in roughly equal amounts through multiple evaporative subsections **5, 7** (FIG.s 5, 8), to flow through only one evaporative subsections **17, 19** (FIG. 6), or to flow through one evaporative subsection (e.g., 7, FIG. 7) in substantially greater volumes than through another evaporative subsection (e.g., **5,** FIG. 7).

[0041] Yet another heat exchange system is shown in FIG. 9. The system of FIG. 9 includes a plurality of dry indirect heat exchange sections **1a,** and **1b,** an evaporative heat exchange section 3 having a plurality of subsections **5, 7,** an evaporative fluid distribution system **9,** dry indirect section process fluid inlets **11a, 11b,** dry indirect section process fluid outlets **13a, 13b,** a first and second process fluid intermediate flow path valves **15a, 15b,** evaporative subsection inlets **17, 19,** and evaporative subsection outlets **21, 23.**

[0042] In the heat exchange system of FIG. 9, process fluid may be directed to only one, to less than all, or to all of the plurality of dry indirect heat exchange sections **1a,** and **1b.** If process fluid is directed to only one of dry indirect heat exchange sections **1a, 1b,** valve **15a** may be used to prevent process fluid from flowing into another dry indirect heat exchange section. In the case the process fluid is directed to a plurality of dry indirect heat exchange sections **1a, 1b,** valve **15a** may be used to combine the process fluids exiting the dry indirect heat exchange sections. Valve **15b** may be used to split the process fluid flow into equal or unequal parts and direct each part to a different of the plurality of evaporative sections **5, 7,** or to direct the entire process fluid flow into only one of the plurality of evaporative sections **5, 7.** Figure 9 shows valve **15b** sending equal parts of the process fluid flow into each of the plurality of evaporative sections **5, 7.**

[0043] Another heat exchange system is shown in FIG. 10. The system of FIG. 10 includes a plurality of dry indirect heat exchange sections **1a,** and **1b,** an evaporative heat exchange section **3** having a plurality of subsections 5, 7, an evaporative fluid distribution system **9,** dry indirect section process fluid inlets **11a, 11b,** dry indirect section process fluid outlets **13a, 13b,** a first and second process fluid intermediate flow path valves **15c, 15d,** evaporative subsection inlets **17,19,** and evaporative subsection outlets **21, 23.**

[0044] In the heat exchange system of FIG. 10, process fluid may be directed to only one, to less than all, or to all of the plurality of dry indirect heat exchange sections **1a,** and **1b.** If process fluid is directed to only one of dry indirect heat exchange sections **1a, 1b,** valves **15c, 15d** may be used to direct process fluid exiting a dry indirect heat exchange section to one or more of the plurality of heat exchange sections. In the case the process fluid is directed to a plurality of dry indirect heat exchange sections **1a, 1b,** valves **15c, 15d** may be used to direct the process fluid from each dry indirect section to a separate evaporative section, or to combine the process fluids from a plurality of dry indirect sections and direct the combined process fluid to a plurality of the evaporative sections. The valving shown in the drawings may be multiple valves to accomplish the flow paths or may be three way valves as deemed appropriate and useful.

[0045] Yet another heat exchange system is shown in FIG. 11. The system of FIG. 11 includes a dry indirect heat exchange section **1,** an evaporative heat exchange section **3** having a plurality of subsections **5, 7,** an evaporative fluid distribution system **9,** a dry indirect section process fluid inlet **11,** dry indirect section process fluid outlet **13,** a process fluid intermediate flow path valve **15,** evaporative subsection inlets **17, 19,** evaporative subsection outlets **21, 23,** and a dry indirect section bypass valve **29.**

[0046] The system of FIG. 11 may be operated in all the same ways as the embodiments of FIG.s 1-4, with the additional ability of sending some or all of the process fluid directly to the evaporative section, bypassing the dry indirect section.

[0047] Yet another heat exchange system is shown in FIG. 12. The system of FIG. 129 includes a plurality of dry indirect heat exchange sections **1a,** and **1b,** an evaporative heat exchange section **3** having a plurality of subsections **5, 7,** an evaporative fluid distribution system **9,** dry indirect section process fluid inlets **11a, 11b,** dry indirect section process fluid outlets **13a, 13b,** a process fluid intermediate flow path valve **15,** evaporative subsection inlets **17,19,** and evaporative subsection outlets **21, 23.**

[0048] In the heat exchange system of FIG. 12, process fluid is directed through dry indirect section process fluid inlet **11a** to first dry indirect heat exchange section **1a,** and then through dry indirect section process fluid outlet **13a** and subsequently through dry indirect section process fluid inlet **11b** to second dry indirect heat exchange section **1b.** Process fluid then exits the second dry indirect section through dry indirect section outlet **13b.** Valve **15a** may be used to prevent process fluid from flowing into another dry indirect heat exchange section. In the case the process fluid is directed to a plurality of dry indirect heat exchange sections **1a, 1b.** Valve **15** may be used to split the process fluid flow into equal or unequal parts and direct each part to a different of the plurality of evaporative sections **5, 7,** or to direct the entire process fluid flow into only one of the plurality of evaporative sections **5, 7.**

[0049] In yet another heat exchange system, shown in FIG.s 13a and 13b, the system includes dry indirect heat exchange section **1,** an evaporative heat exchange section **3** having a plurality of subsections **5, 7,** an evaporative fluid distribution system **9,** dry indirect section process fluid inlet **11,** dry indirect section process fluid outlet **13,** evaporative subsection inlets **17,19,** and evaporative subsection outlets **21, 23.**

[0050] In the heat exchange system of FIG. 13a, process fluid enters dry indirect section **1** through dry indirect heat exchange inlet **11,** exits through dry indirect section outlet **13** and is directed to a first of said plurality of evaporative sections **5, 7** through evaporative section inlet **17.** The process fluid then exits said first of said plurality of evaporative sections through evaporative section outlet 21, and enters a second of said plurality of evaporative sections through evaporative section inlet 19. The process fluid then exits the second evaporative section through evaporative section outlet 23.

[0051] In the structural embodiment of FIG 13b, which is an embodiment of the invention, the process fluid can be optionally directed to bypass evaporative section B by operation of one or more valves 15.

[0052] The systems of FIG.s 14a and 14b represent a combination of multiple section dry heat exchange sections with a series process fluid flow path (for example, shown in Fig. 12), and multiple evaporative heat exchange sections with a series process fluid flow path (for example shown in FIG.s. 13a and 13b). Figure 14b is an embodiment of the invention.

[0053] Each of the embodiments shown in FIG.s 9-14 may have a plurality of evaporative fluid distribution systems, as shown in the embodiments of FIG.s 5-8.

[0054] Additional systems are shown in FIG.s 15a and 15b, in which the embodiment shown in Figure 15b is an embodiment of the invention. FIG.s. 15a and 15b include a dry indirect heat exchange section **1,** an evaporative heat exchange section **3** having a plurality of subsections **5, 7,** an evaporative fluid distribution system **9,** a dry indirect section process fluid inlet **11,** dry indirect section process fluid outlet **13,** a process fluid intermediate flow path valve **15,** evaporative subsection inlets **17, 19,** evaporative subsection outlets **21, 23,** and a dry indirect section bypass valve **29.** The dry indirect heat exchange section **1** may be a single unit, for example as shown in FIG. 11, or it may be a multiple section unit as shown, for example, in FIG. 12. In the system of FIG.s. 15a and 15b, the evaporative fluid distribution system is located over fewer than all of the evaporative indirect heat exchange systems.

[0055] FIG. 15a shows the process fluid flow path through the evaporative subsections as parallel flow, subject to the control of valve 15, which may be set to send all the flow through one or the other evaporative sections entirely, through one or more evaporative sections equally, or through multiple sections in different amounts.

[0056] FIG. 15b shows the process fluid flow path through the evaporative subsections as series flow, with the option to bypass an evaporative section by the action of the valve between outlet 21 and outlet 23.

[0057] According to a preferred aspect of each embodiment described herein, there is no process fluid bypass of the evaporative heat exchange system.

[0058] Each of the systems of FIG. s 1-15 may optionally be combined with a direct heat exchange section for cooling the evaporative fluid, in the case that one or more evaporative fluid distribution systems are operating. Such a direct heat exchange system may be located below the evaporative heat exchange section, or it may be located between the evaporative fluid distribution system nozzles and the evaporative heat exchange sections. A direct heat exchange system according to the invention may include fill, or it may not include fill.

[0059] Any combination of air flow direction, e.g., concurrent, countercurrent, cross-current, through each of the dry indirect section, the evaporative indirect section and the direct section is considered to fall within the scope of this invention. For example, the airflow through each of the sections may be concurrent; alternatively, the airflow through each of the sections may be countercurrent, or the airflow through each of the sections may be cross-current. The airflow may be concurrent through one section, two, or three sections. The airflow may be crosscurrent through one, two or three sections; and the airflow may be countercurrent through one, two or three sections. The airflow may be different in each section. Structures for creating and direction airflow through indirect and direct heat exchange sections are well known.

[0060] Independent of the direction of airflow for each section, each section may be part of the same airflow, or each section may have its own separate airflow, or each section may share a portion of the airflow from another section.

[0061] The systems of FIG.s 1-15 may be each used to modify and improve prior art heat exchange systems. An example of such a prior art system that may be improved with the features of the present invention is disclosed in U.S. Patent No. 6,142,219 ("Korenic"), the entirety of which is incorporated herein by reference. indirect section process fluid inlets **11a, 11b,** dry indirect section process fluid outlets **13a, 13b,** a first and second process fluid intermediate flow path valves **15c, 15d,** evaporative subsection inlets **17,19,** and evaporative subsection outlets **21, 23.**

[0062] In the structural embodiment of FIG. 10, process fluid may be directed to only one, to less than all, or to all of the plurality of dry indirect heat exchange sections **1a,** and **1b.** If process fluid is directed to only one of dry indirect heat exchange sections **1a, 1b,** valves **15c, 15d** may be used to direct process fluid exiting a dry indirect heat exchange section to one or more of the plurality of heat exchange sections. In the case the process fluid is directed to a plurality of dry indirect heat exchange sections **1a, 1b,** valves **15c, 15d** may be used to direct the process fluid from each dry indirect section to a separate evaporative section, or to combine the process fluids from a plurality of dry indirect sections and direct the combined process fluid to a plurality of the evaporative sections. The valving shown in the drawings may be multiple valves to accomplish the flow paths or may be three way valves as deemed appropriate and useful.

[0063] Yet another structural embodiment is shown in FIG. 11. The system of FIG. 11 includes a dry indirect heat exchange section **1,** an evaporative heat exchange section **3** having a plurality of subsections **5, 7,** an evaporative fluid distribution system **9,** a dry indirect section process fluid inlet **11,** dry indirect section process fluid outlet **13,** a process fluid intermediate flow path valve **15,** evaporative subsection inlets **17, 19,** evaporative subsection outlets **21, 23,** and a dry indirect section bypass valve **29.**

[0064] The embodiment of FIG. 11 may be operated in all the same ways as the embodiments of FIG.s 1-4, with the additional ability of sending some or all of the process fluid directly to the evaporative section, bypassing the dry indirect section.

[0065] Yet another structural embodiment is shown in FIG. 12. The system of FIG. 129 includes a plurality of dry indirect heat exchange sections **1a,** and **1b,** an evaporative heat exchange section 3 having a plurality of subsections **5, 7,** an evaporative fluid distribution system **9,** dry indirect section process fluid inlets **11a, 11b,** dry indirect section process fluid outlets **13a, 13b,** a process fluid intermediate flow path valve **15,** evaporative subsection inlets **17,19,** and evaporative subsection outlets **21, 23.**

[0066] In the structural embodiment of FIG. 12, process fluid is directed through dry indirect section process fluid inlet **11a** to first dry indirect heat exchange section **1a,** and then through dry indirect section process fluid outlet **13a** and subsequently through dry indirect section process fluid inlet **11b** to second dry indirect heat exchange section **1b.** Process fluid then exits the second dry indirect section through dry indirect section outlet **13b.** Valve **15a** may be used to prevent process fluid from flowing into another dry indirect heat exchange section. In the case the process fluid is directed to a plurality of dry indirect heat exchange sections **1a, 1b.** Valve **15** may be used to split the process fluid flow into equal or unequal parts and direct each part to a different of the plurality of evaporative sections **5, 7,** or to direct the entire process fluid flow into only one of the plurality of evaporative sections **5, 7.**

[0067] In yet another structural embodiment, shown in FIG.s 13a and 13b, the system includes dry indirect heat exchange section **1,** an evaporative heat exchange section **3** having a plurality of subsections **5, 7,** an evaporative fluid distribution system **9,** dry indirect section process fluid inlet **11,** dry indirect section process fluid outlet **13,** evaporative subsection inlets **17,19,** and evaporative subsection outlets **21, 23.**

[0068] In the structural embodiment of FIG. 13a, process fluid enters dry indirect section **1** through dry indirect heat exchange inlet **11,** exits through dry indirect section outlet **13** and is directed to a first of said plurality of evaporative sections **5, 7** through evaporative section inlet **17.** The process fluid then exits said first of said plurality of evaporative sections through evaporative section outlet 21, and enters a second of said plurality of evaporative sections through evaporative section inlet 19. The process fluid then exits the second evaporative section through evaporative section outlet 23.

[0069] In the structural embodiment of FIG 13b, the process fluid can be optionally directed to bypass evaporative section B by operation of one or more valves 15.

[0070] The structural embodiments of FIG.s 14a and 14b represent a combination of multiple section dry heat exchange sections with a series process fluid flow path (for example, shown in Fig. 12), and multiple evaporative heat exchange sections with a series process fluid flow path (for example shown in FIG.s. 13a and 13b).

[0071] Each of the embodiments shown in FIG.s 9-14 may have a plurality of evaporative fluid distribution systems, as shown in the embodiments of FIG.s 5-8.

[0072] Additional structural embodiments are shown in FIG.s 15a and 15b. FIG.s. 15a and 15b include a dry indirect heat exchange section **1,** an evaporative heat exchange section **3** having a plurality of subsections **5, 7,** an evaporative fluid distribution system **9,** a dry indirect section process fluid inlet **11,** dry indirect section process fluid outlet **13,** a process fluid intermediate flow path valve **15,** evaporative subsection inlets **17, 19,** evaporative subsection outlets **21, 23,** and a dry indirect section bypass valve **29.** The dry indirect heat exchange section **1** may be a single unit, for example as shown in FIG. 11, or it may be a multiple section unit as shown, for example, in FIG. 12. In the embodiments of FIG.s. 15a and 15b, the evaporative fluid distribution system is located over fewer than all of the evaporative indirect heat exchange systems.

[0073] FIG. 15a shows the process fluid flow path through the evaporative subsections as parallel flow, subject to the control of valve 15, which may be set to send all the flow through one or the other evaporative sections entirely, through one or more evaporative sections equally, or through multiple sections in different amounts.

[0074] FIG. 15b shows the process fluid flow path through the evaporative subsections as series flow, with the option to bypass an evaporative section by the action of the valve between outlet 21 and outlet 23.

[0075] According to a preferred aspect of each embodiment described herein, there is no process fluid bypass of the evaporative heat exchange system.

[0076] Each of the embodiments of FIG.s 1-15 may optionally be combined with a direct heat exchange section for cooling the evaporative fluid, in the case that one or more evaporative fluid distribution systems are operating. Such a direct heat exchange system may be located below the evaporative heat exchange section, or it may be located between the evaporative fluid distribution system nozzles and the evaporative heat exchange sections. A direct heat exchange system according to the invention may include fill, or it may not include fill.

[0077] Any combination of air flow direction, e.g., concurrent, countercurrent, cross-current, through each of the dry indirect section, the evaporative indirect section and the direct section is considered to fall within the scope of this invention. For example, the airflow through each of the sections may be concurrent; alternatively, the airflow through each of the sections may be countercurrent, or the airflow through each of the sections may be cross-current. The airflow may be concurrent through one section, two, or three sections. The airflow may be crosscurrent through one, two or three sections; and the airflow may be countercurrent through one, two or three sections. The airflow may be different in each section. Structures for creating and direction airflow through indirect and direct heat exchange sections are well known.

[0078] Independent of the direction of airflow for each section, each section may be part of the same airflow, or each section may have its own separate airflow, or each section may share a portion of the airflow from another section.

[0079] The embodiments of FIG.s 1-15 may be each used to modify and improve prior art heat exchange systems. An example of such a prior art system that may be improved with the features of the present invention is disclosed in U.S. Patent No. 6,142,219 2.

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- US5435382A [0005]
- US5816318A [0005]

- US6142219A [0005] [0008] [0009] [0036] [0061]
- US2011100593A1 [0008]
- EP1035396A [0009]
- US61422192B [0079]

Patentkrav

1. Varmevekslersystem til udtrækning af varme fra en procesvæske, som omfatter:

et procesvæskeindløb (11);

et procesvæskeudløb;

en tørvarmevekslingssektion med indirekte kontakt (1), der modtager procesvæske fra procesvæskeindløbet og har en luftindløbsside, en luftudløbsside og et procesvæskeindløb og et procesvæskeudløb;

en fordampningsvarmevekslersektion med indirekte kontakt (3), som er opdelt i mindst to procesvæskestrømningsvej, et procesvæskeindløb og et procesvæskeudløb til hver af de to procesvæskestrømningsveje, og en luftindløbsside og en luftudløbsside; en respektiv undersektion (5, 7) tilvejebragt til hver vej;

et luftflytningssystem til flytning af luft gennem varmevekslerne, som kan være sugetræk, trykluft eller andet,

et distributionssystem (9) til selektiv fordeling af en fordampningsvæske til fordampervarmevekslersektionen med indirekte kontakt (3);

en procesvæske, der forbinder væskevejen fra tørvarmevekslingssektionen med indirekte kontakt (1), som derefter forbindes til en første respektiv fordampningsundersektion med indirekte varmeveksling (5);

kendetegnet ved, at,

en mekanisme til at lede procesvæsken selektivt til procesvæskeindløbene på fordampningsundersektionerne med indirekte varmeveksling, så al procesvæsken først løber ind i en første fordampningsundersektion (5), og derefter kan ledes helt mod en anden undersektion (7), kan blive ledt helt ud af fordampningsvarmevekslersektionen med indirekte kontakt (3) gennem et første fordampningsundersektionsudløb (21); eller kan opdeles jævnt eller ujævnt mellem anden undersektion (7) og det første fordampningsundersektionsudløb (21); og

en procesvæskeudløbsstrømningsvej fra den anden varmevekslerundersektion med indirekte kontakt (7) til procesvæskeudløbet.

2. Varmevekslersystemet ifølge krav 1, som desuden omfatter inkludering af én eller flere mekanismer til at flytte luft gennem varmevekslerne.

3. Varmevekslersystemet ifølge krav 2, hvori mekanismen til at flytte luft gennem varmeveksleren er et sugetrækssystem eller et trykluftsystem.

4. Varmevekslersystemet ifølge krav 1, hvori der ikke er nogen procesvæskestrømningsvej, der ikke fører gennem fordampningsvarmevekslersektionen med indirekte kontakt (3).

5. Varmevekslersystemet ifølge krav 1, hvori fordampningsvarmevekslersektionen (3) omfatter en flerhed af separate fordampningsvarmevekslerundersektioner (5, 7).

6. Varmevekslersystemet ifølge krav 5, hvori to eller flere af flerheden af separate fordampningsvarmevekslerundersektioner (5, 7) er forbundet i en seriestrømningsvej til procesvæsken.

7. Varmevekslersystemet ifølge krav 1, som omfatter en flerhed af fordampningsvæskedistributionssystemer, herunder en mekanisme (15) til selektiv slukning af vandstrømmen til dele af fordampningsvæskedistributionssystemet, som svarer tilnærmelsesvist til interne strømningsopdelinger af fordampervarmevekslersektionen (3).

8. Varmevekslersystemet ifølge krav 7, som desuden omfatter en skilleanordning, der adskiller varmevekslersektionen for yderligere af adskille strømningerne fra vanddistributionssystemet.

9. Varmevekslersystemet ifølge krav 1, som omfatter flere tørvarmevekslere med rørføring til at forbinde til en strømningsdistributionsventil, hvori tørvarmeveksleren (1) kan have et yderligere strømningskontrolmiddel til selektiv distribution af procesvæskestrøm mellem de flere tørvarmevekslere, så der skabes ujævne strømninger mellem de flere tørvarmevekslersektioner, eller én eller flere af tørvarmevekslerne slukkes.

10. Varmevekslersystemet ifølge krav 9, som desuden omfatter en mekanisme til omgåelse af procesvæske omkring én eller flere af tørvarmevekslerundersektionerne.

11. Varmevekslersystemet ifølge krav 10, hvori strømningsopdelingen i tørvarmevekslingssektionen (1) kan være jævn eller ujævn, og tørvarmeveksleren kan være to eller flere separate varmevekslere, og de flere tørvarmevekslere kan arrangeres på en serieprocesvæskestrømningsvej til procesvæsken.

12. Varmevekslersystemet ifølge krav 11, som desuden omfatter en serieprocesvæskestrømningsvej til begge de flere tørvarmevekslere (1) og også til de flere fordampningsvarmevekslere (3).

13. Varmevekslersystemet ifølge krav 1, som desuden omfatter to ventiler til kontrol af strømningen til de forskellige sektioner (5, 7).

14. Varmevekslersystemet ifølge krav 13, hvori ventilerne er valgt fra den gruppe, der består af trevejsventiler og modulerede ventiler, og hvori nævnte ventiler kan betjenes enten manuelt eller automatisk.

15. Varmevekslersystemet ifølge krav 1, hvori mængden af procesvæskestrømning, der er opdelt mellem de to eller flere fordampningsvarmevekslere (5, 7), og kontrollen af fordampningsvæskestrøm over to eller flere fordampningsvarmevekslere afhænger af procesvæsketemperaturen.

16. Fremgangsmåden til udtrækning af varme fra en procesvæske ved at bruge varmevekslersystemet i ethvert af kravene 1 til 15, som omfatter trinnene:

føring af procesvæsken gennem tørvarmevekslersektionen med indirekte kontakt (1) og selektivt gennem den ene eller flere af en flerhed af fordampningsvarmevekslingsundersektioner med indirekte kontakt (5, 7);

selektiv distribution eller ikke distribution af fordampningsvæsken over én eller flere af flerheden af fordampningsvarmevekslingsundersektioner med indirekte kontakt (5, 7);

kontrol af strømningen af procesvæsken til én eller flere af flerheden af fordampningsvarmevekslingsundersektioner med indirekte kontakt (5, 7), og

kontrol af fordampningsvæskestrømmen til distributionssystemets (9) sektion.

DRAWINGS

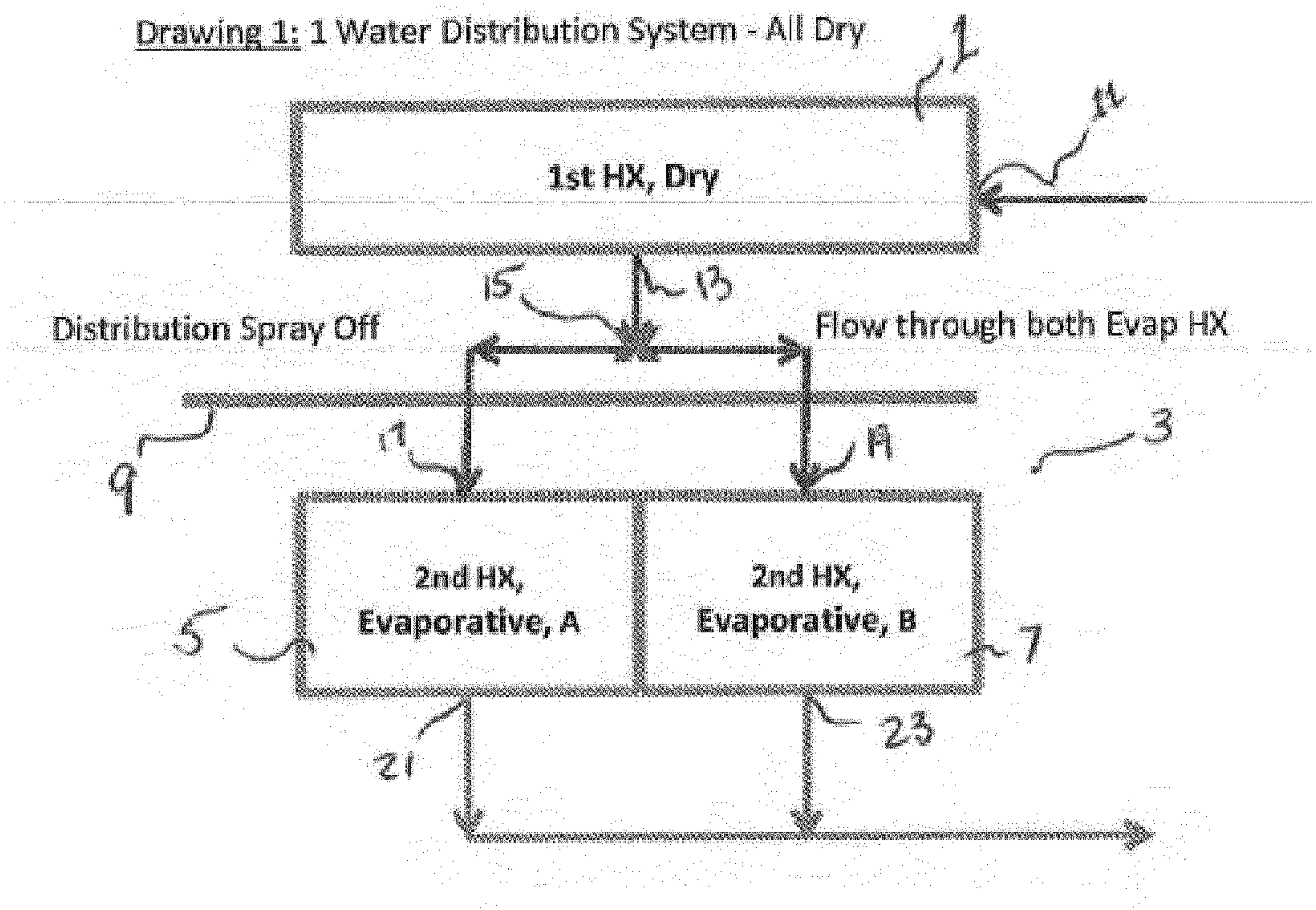


FIG. 1

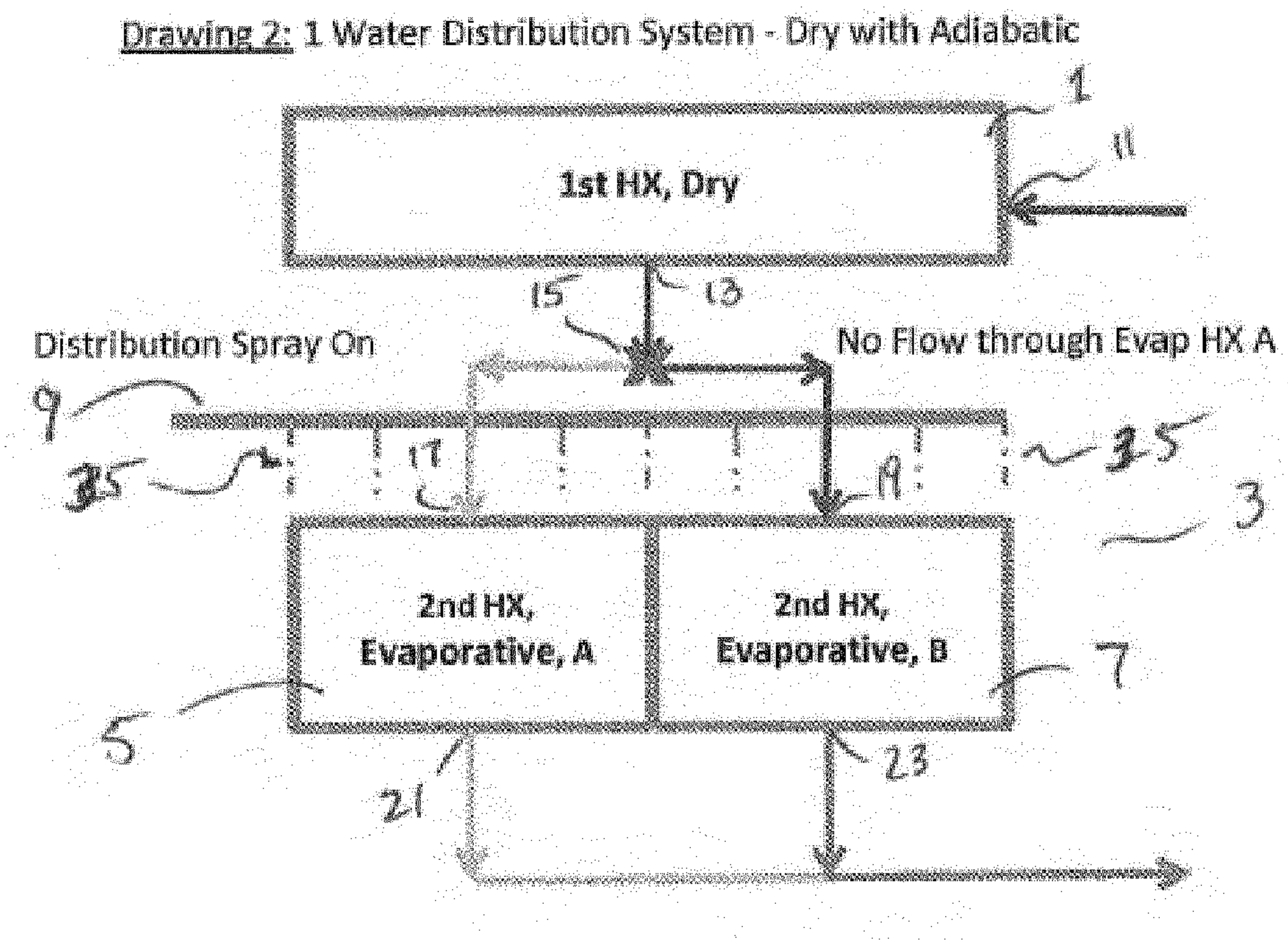

Drawing 2: 1 Water Distribution System - Dry with Adiabatic
1
11
1st HX, Dry
15
13
Distribution Spray On
No Flow through Evap HX A
9
35
17
19
35
3
2nd HX, Evaporative, A
2nd HX, Evaporative, B
5
7
21
23

FIG. 2

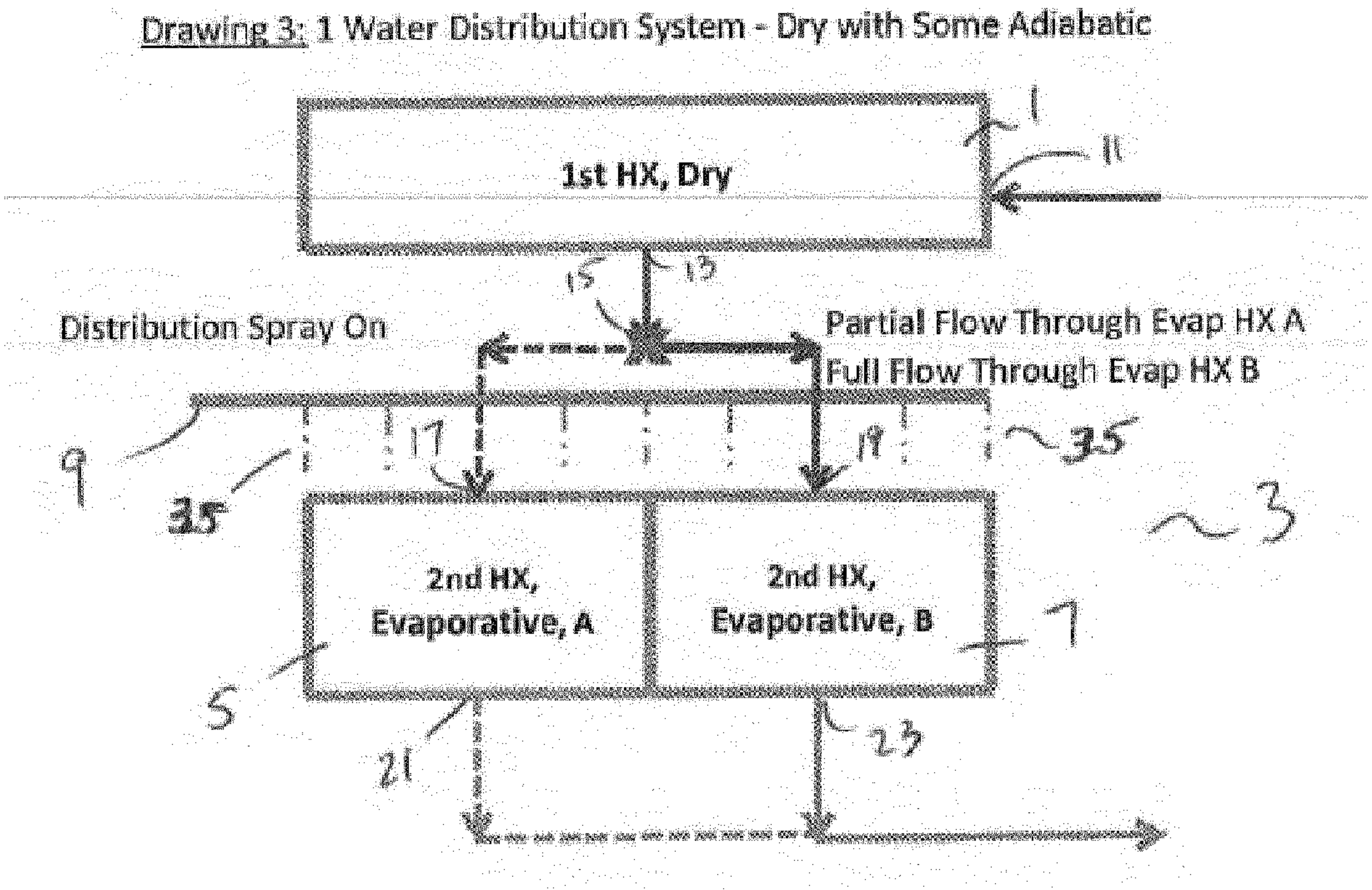

Drawing 3: 1 Water Distribution System - Dry with Some Adiabatic
1st HX, Dry
1
11
15
13
Distribution Spray On
Partial Flow Through Evap HX A
Full Flow Through Evap HX B
9
35
17
19
35
3
2nd HX, Evaporative, A
2nd HX, Evaporative, B
5
7
21
23

FIG. 3

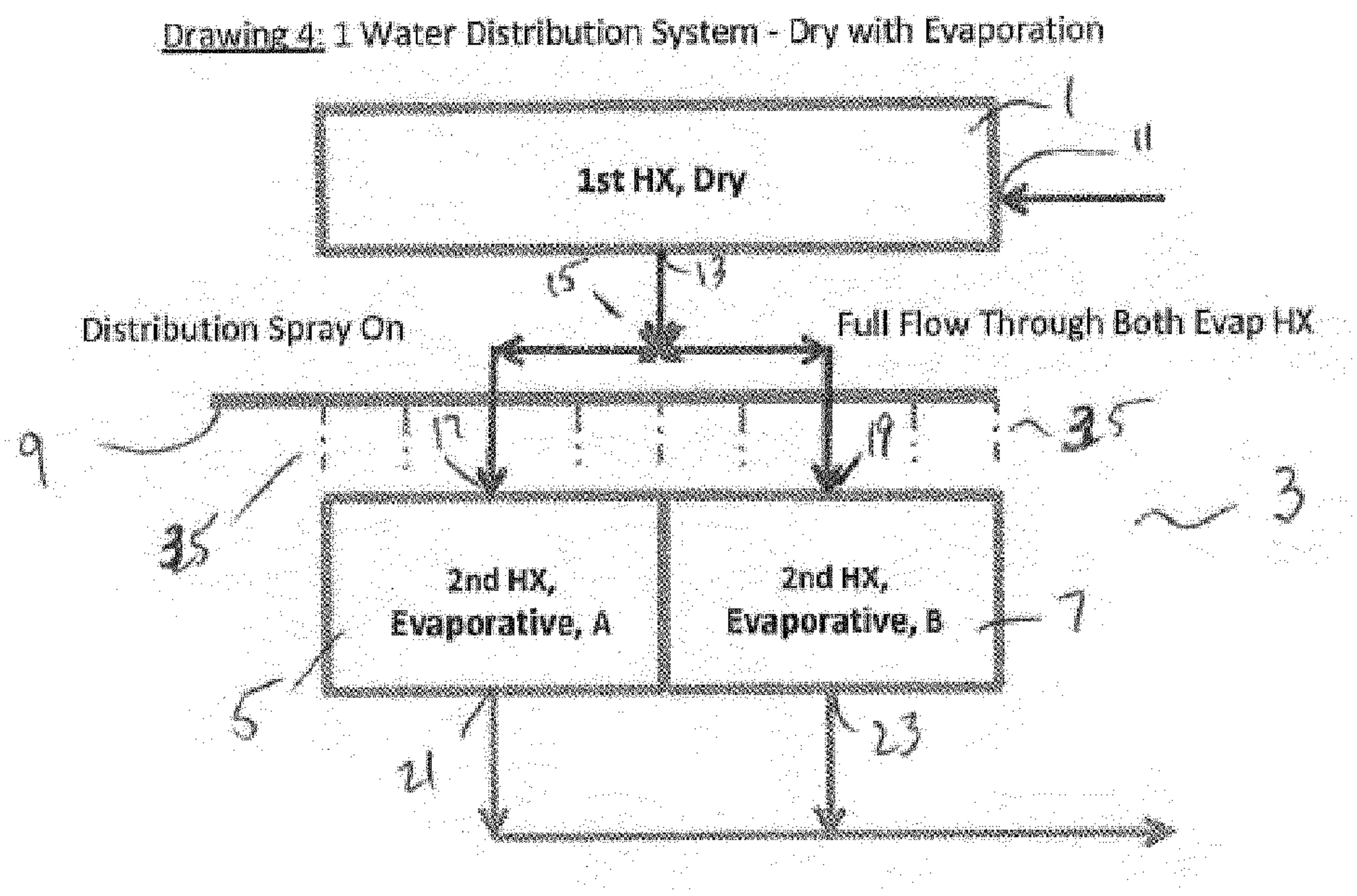

Drawing 4: 1 Water Distribution System - Dry with Evaporation
1st HX, Dry
Distribution Spray On
Full Flow Through Both Evap HX
2nd HX, Evaporative, A
2nd HX, Evaporative, B
1
11
13
15
17
19
9
35
3
5
7
21
23

FIG. 4

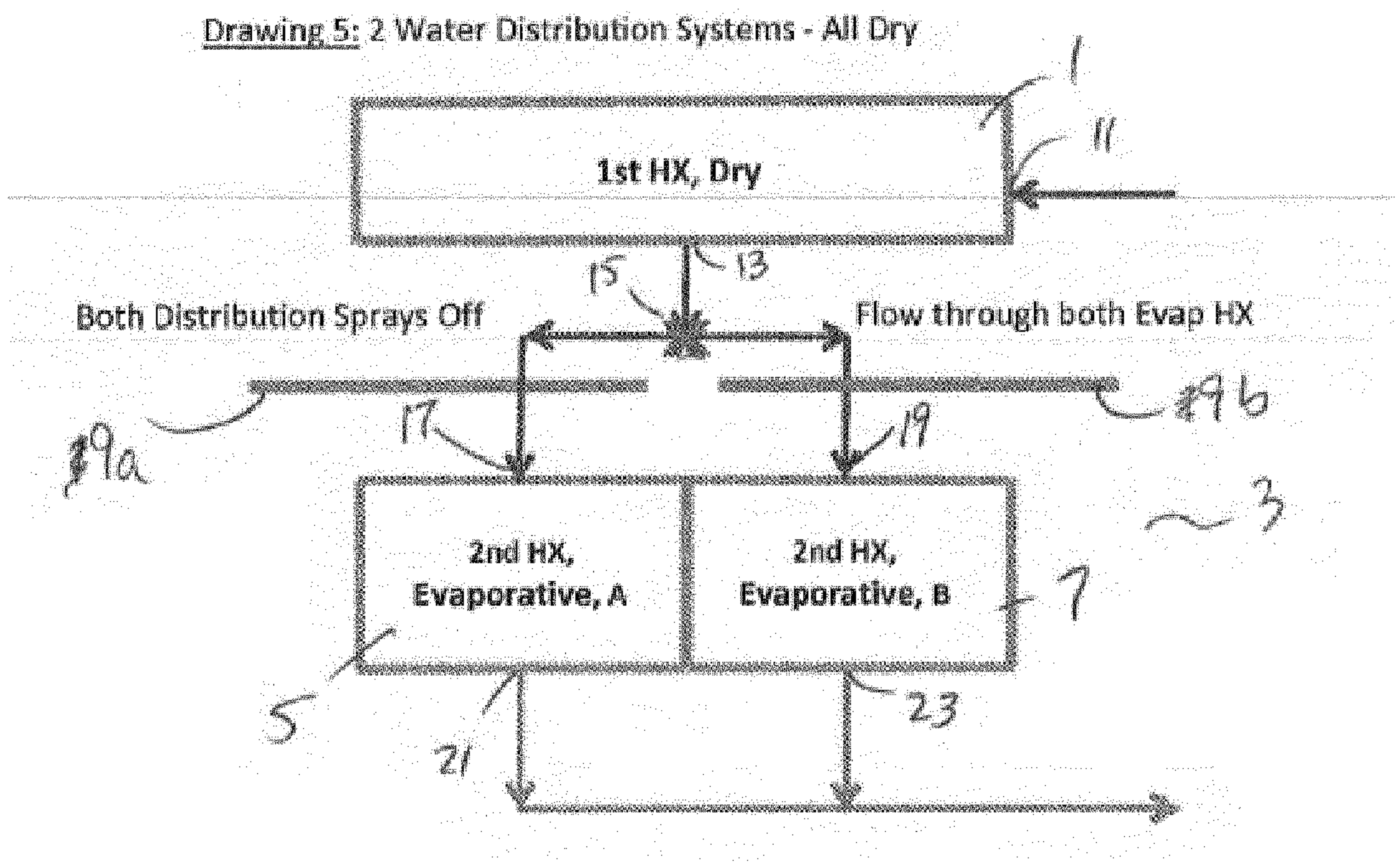

Drawing 5: 2 Water Distribution Systems - All Dry
1
11
1st HX, Dry
15
13
Both Distribution Sprays Off
Flow through both Evap HX
#9a
17
19
#9b
3
2nd HX, Evaporative, A
2nd HX, Evaporative, B
7
5
21
23

FIG. 5

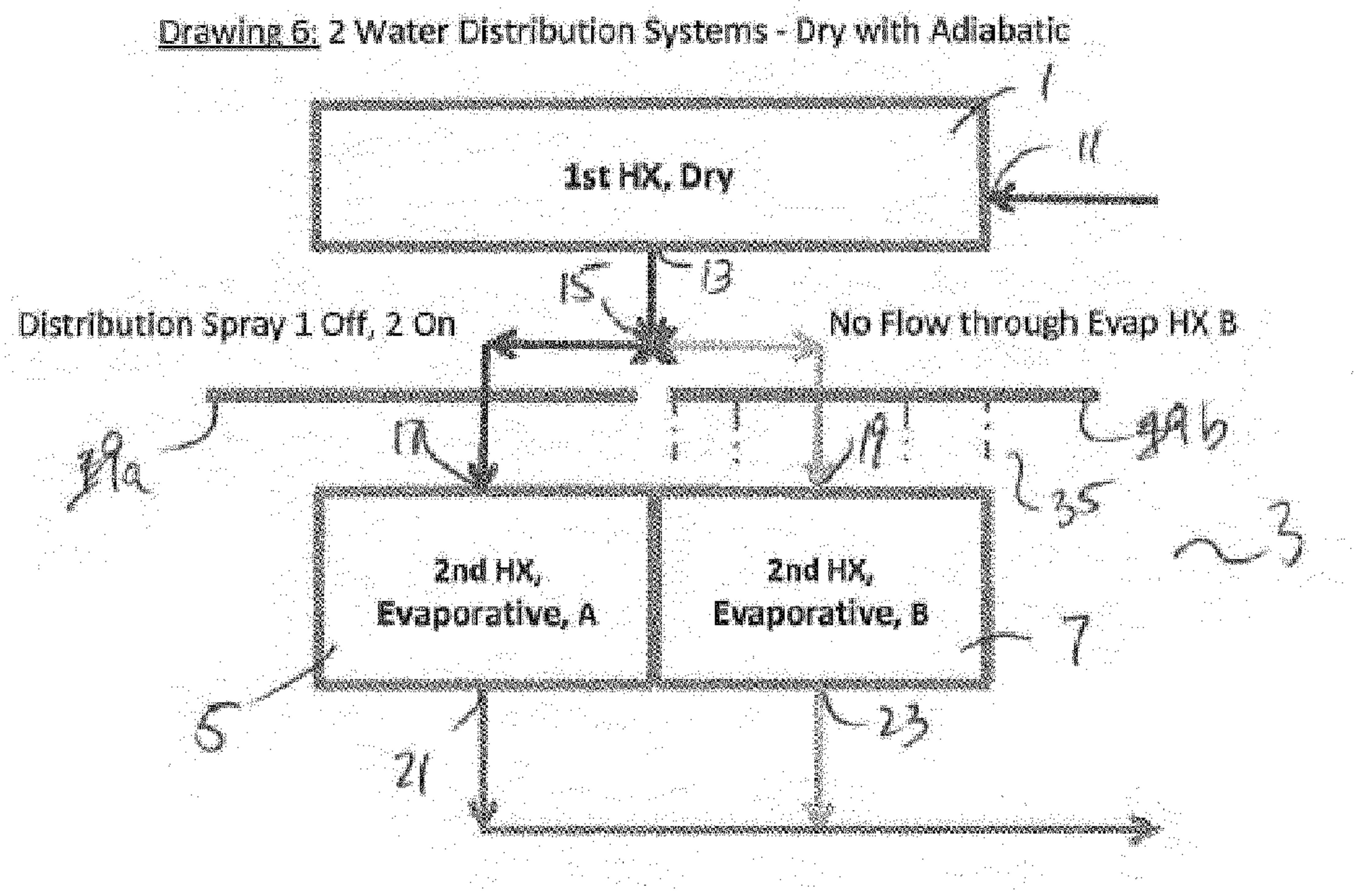

Drawing 6: 2 Water Distribution Systems - Dry with Adiabatic
1st HX, Dry
1
11
15
13
Distribution Spray 1 Off, 2 On
No Flow through Evap HX B
19a
17
19
19b
35
3
2nd HX, Evaporative, A
2nd HX, Evaporative, B
7
5
21
23

FIG. 6

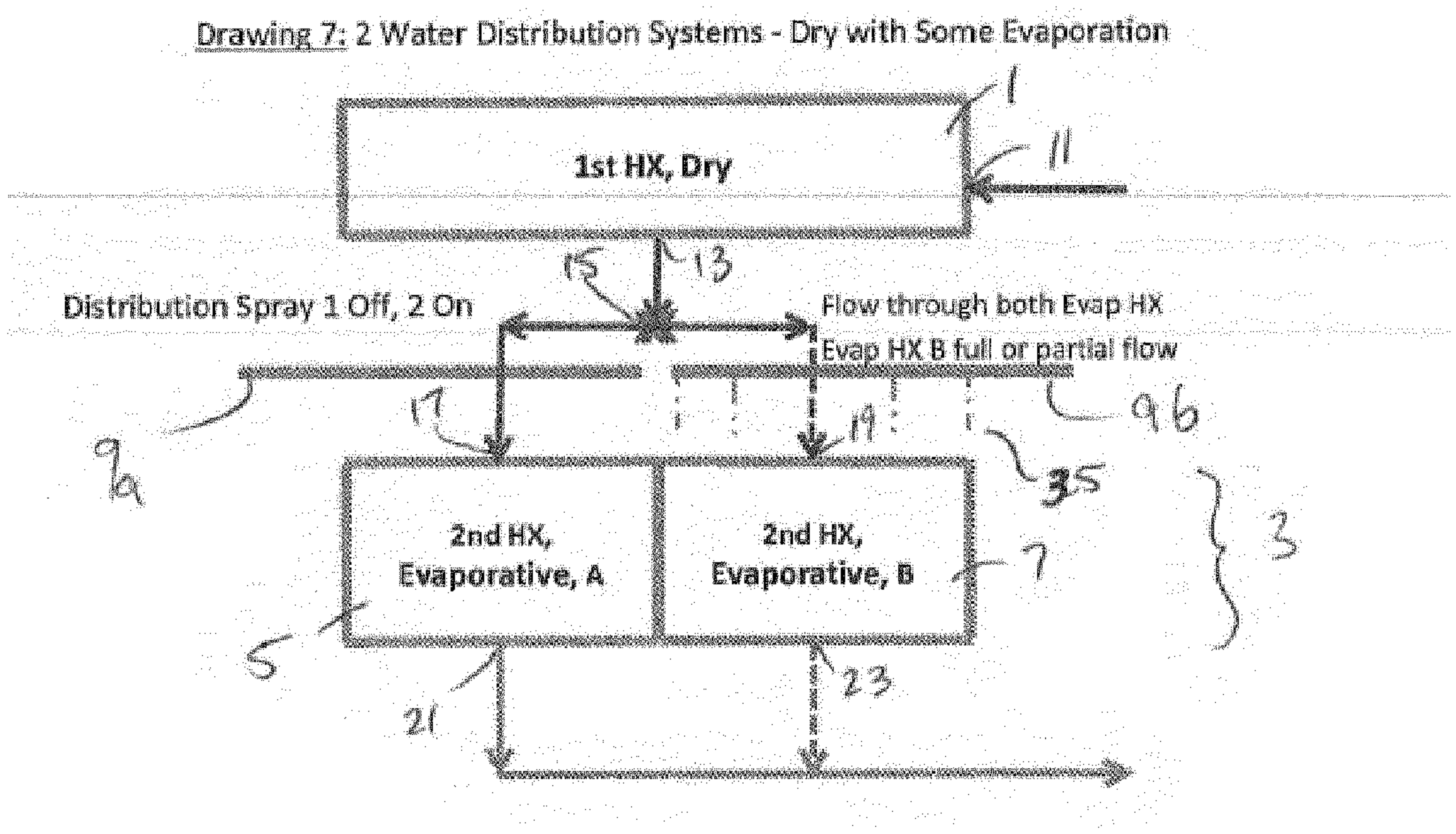

Drawing 7: 2 Water Distribution Systems - Dry with Some Evaporation
1st HX, Dry
1
11
13
15
Distribution Spray 1 Off, 2 On
Flow through both Evap HX
Evap HX B full or partial flow
9a
9b
17
19
35
2nd HX, Evaporative, A
2nd HX, Evaporative, B
7
3
5
21
23

FIG. 7

Drawing 8: 2 Water Distribution Systems – Dry with Evaporation

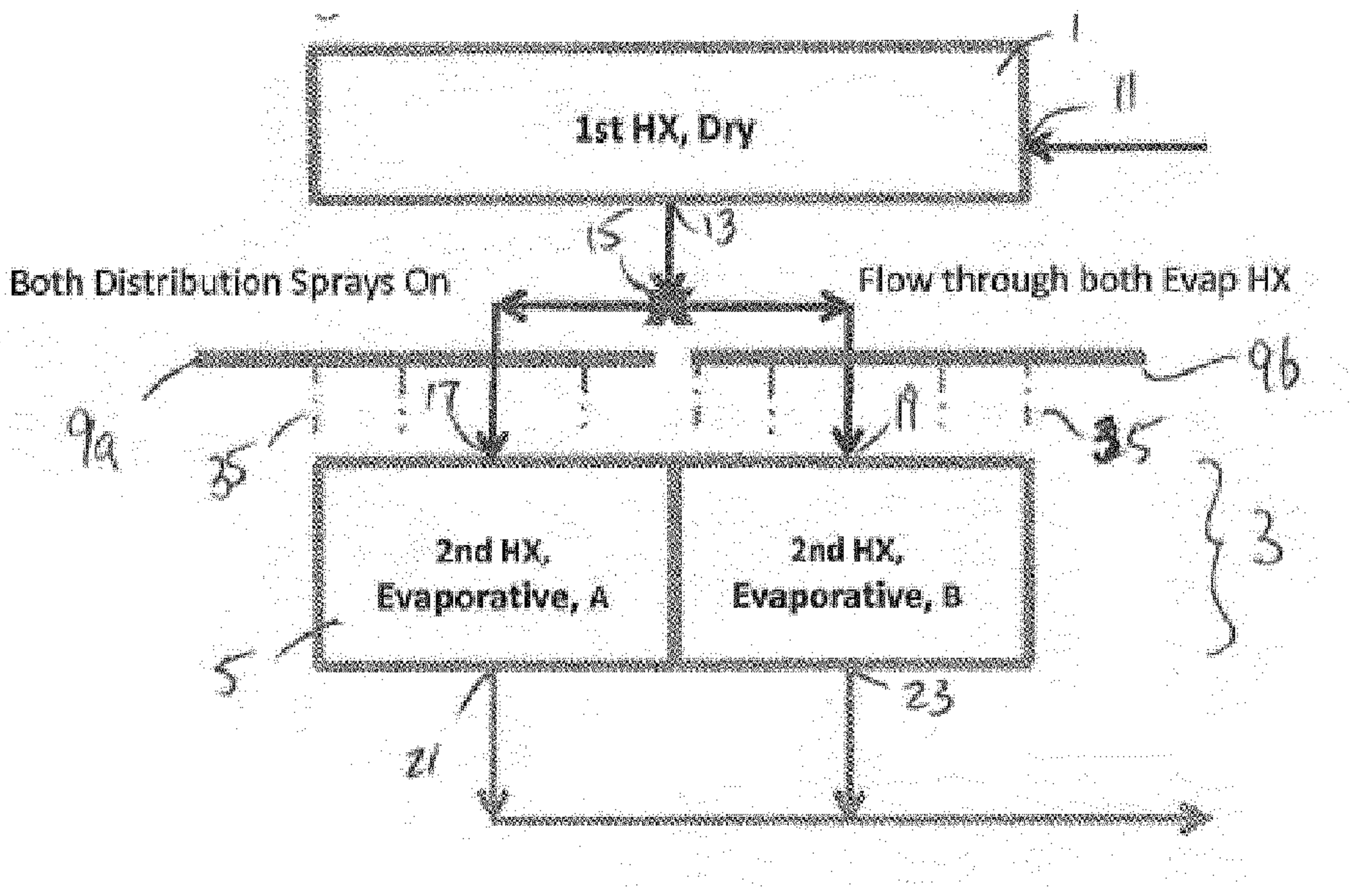


FIG. 8

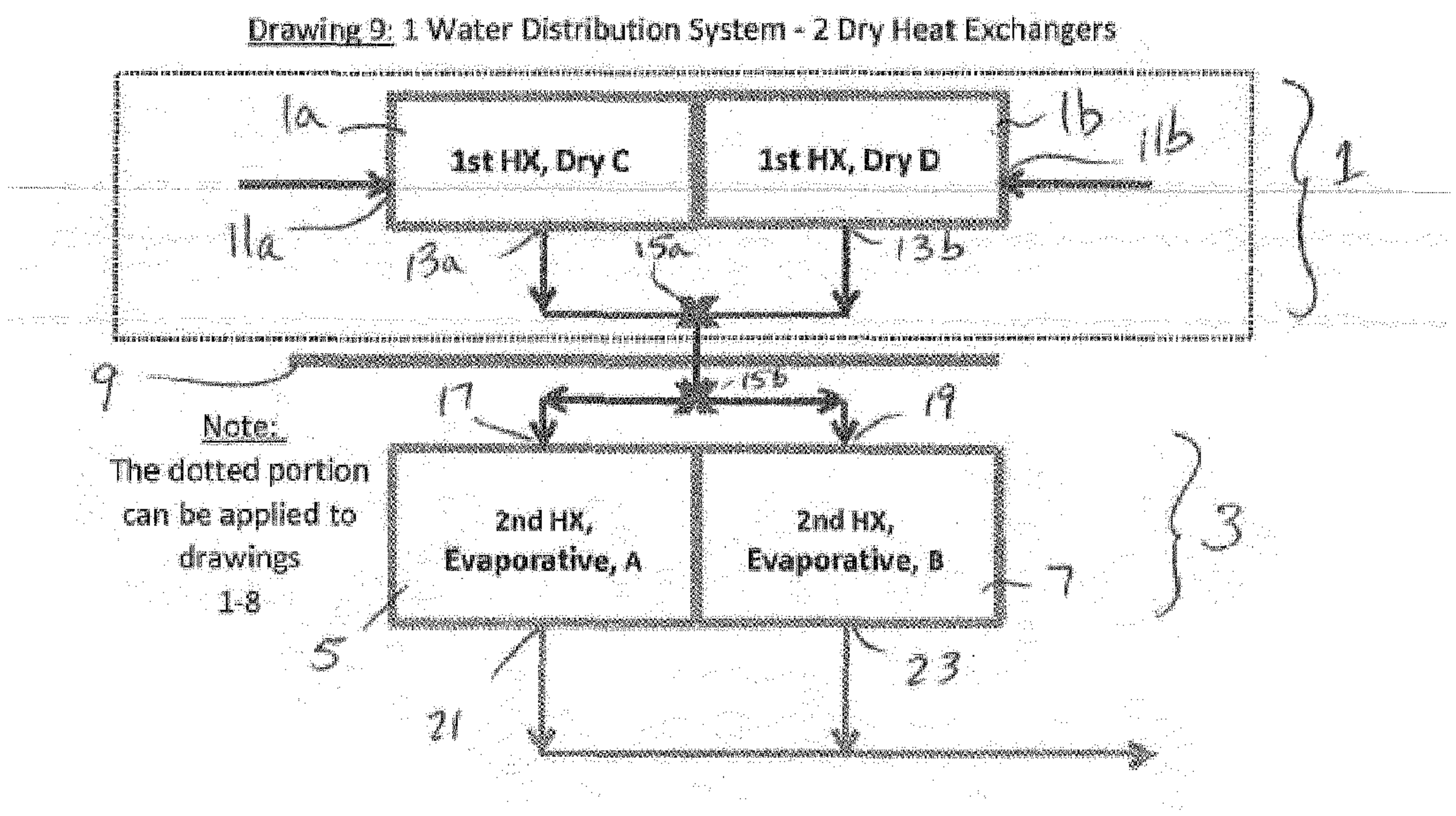

Drawing 9: 1 Water Distribution System - 2 Dry Heat Exchangers
1a
1st HX, Dry C
1st HX, Dry D
1b
11b
1
11a
13a
15a
13b
9
15b
17
19
Note:
The dotted portion can be applied to drawings 1-8
2nd HX, Evaporative, A
2nd HX, Evaporative, B
3
7
5
23
21

FIG. 9

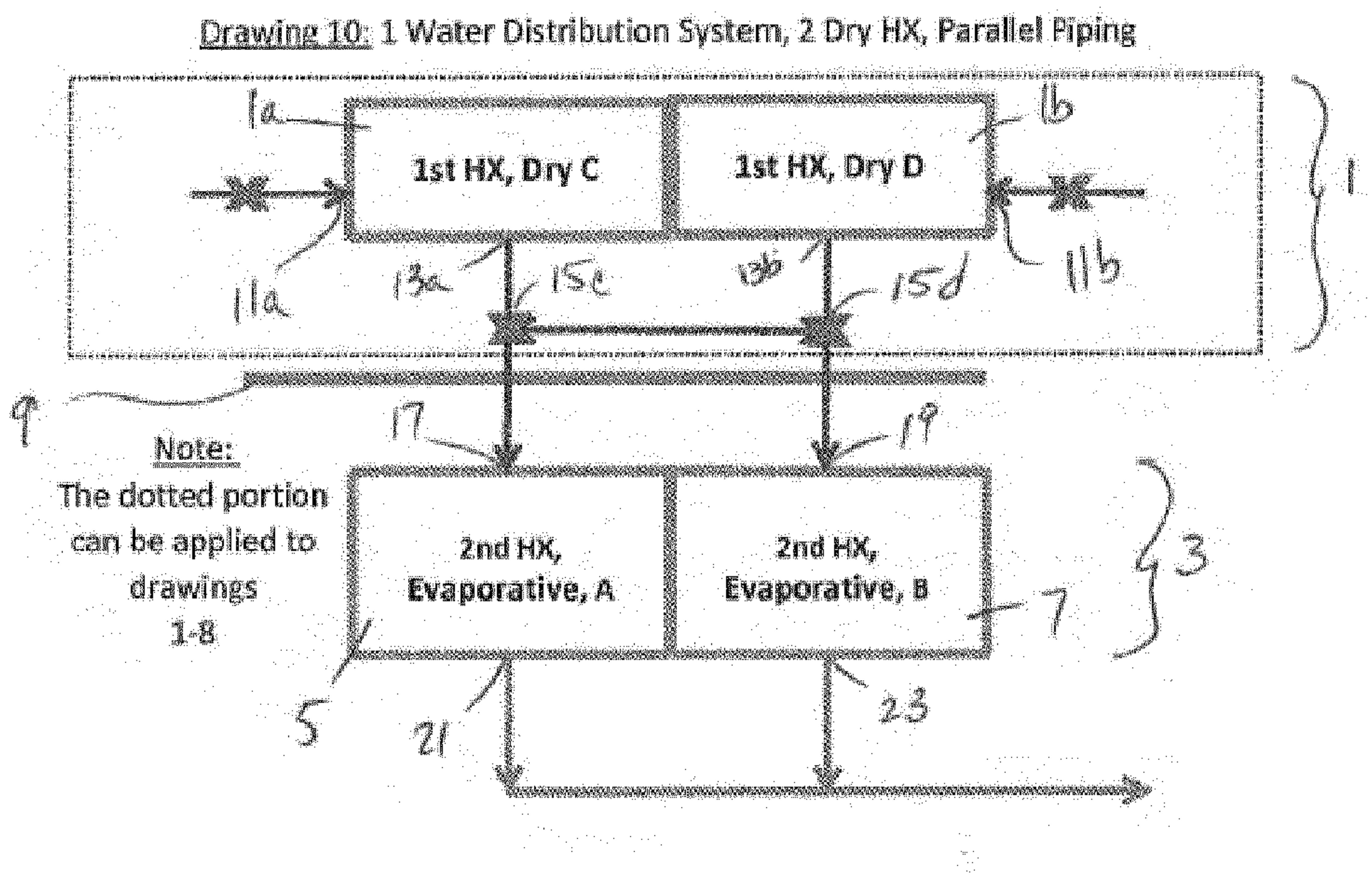

Drawing 10: 1 Water Distribution System, 2 Dry HX, Parallel Piping
1a
1b
1st HX, Dry C
1st HX, Dry D
1
11a
13a
15c
13b
15d
11b
9
17
19
Note:
The dotted portion can be applied to drawings 1-8
2nd HX, Evaporative, A
2nd HX, Evaporative, B
3
7
5
21
23

FIG. 10

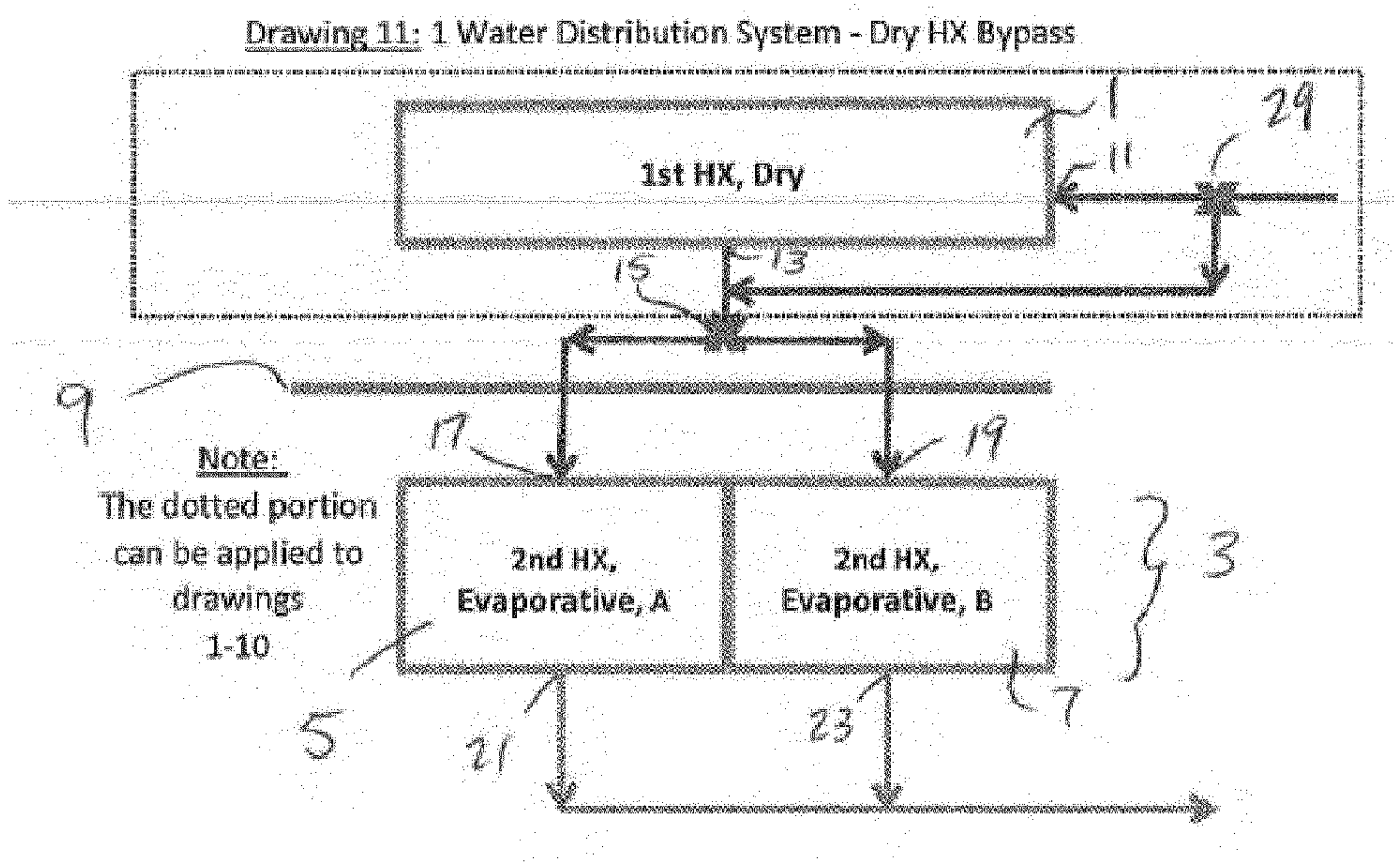
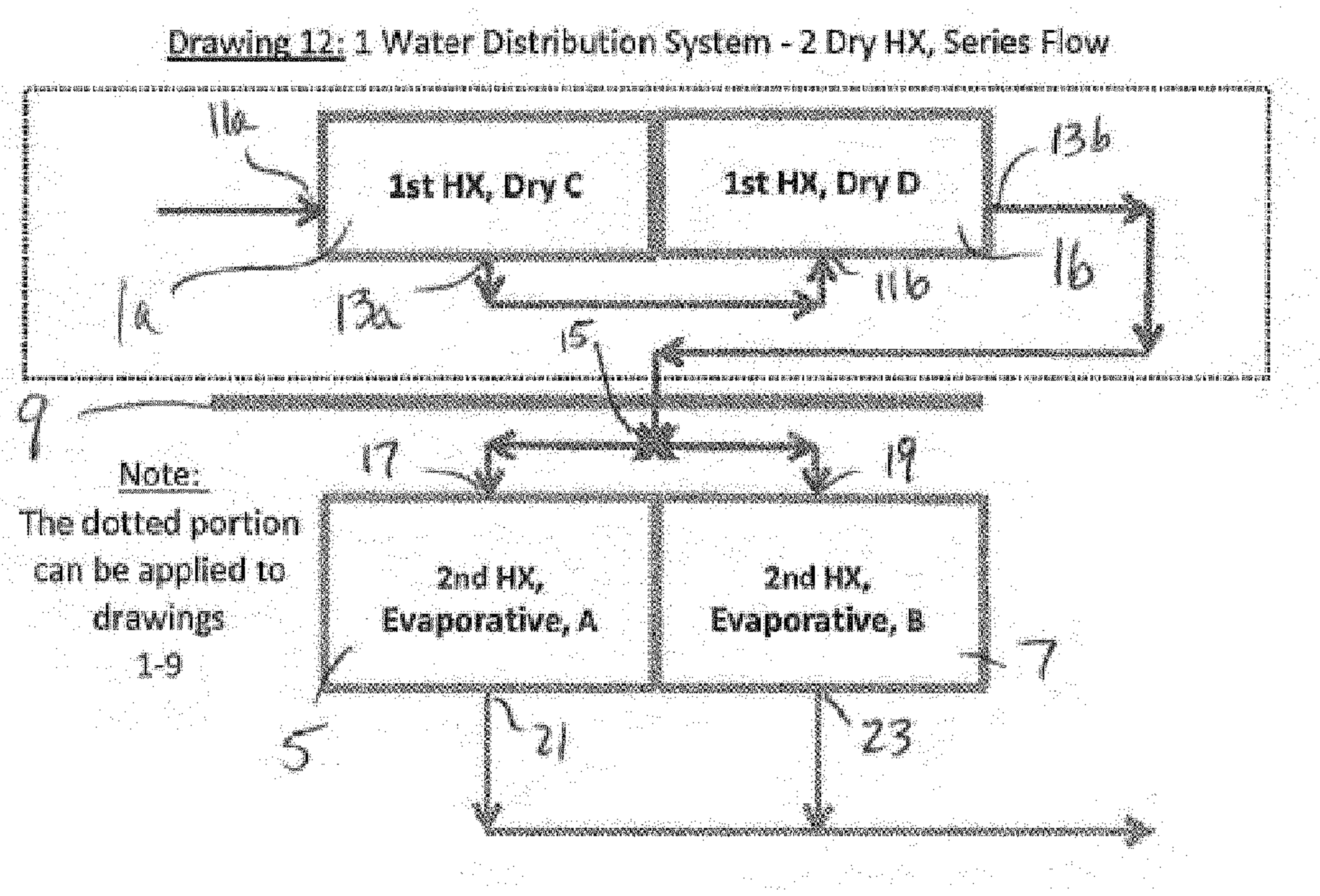

Drawing 11: 1 Water Distribution System - Dry HX Bypass
1st HX, Dry
1
11
29
15
13
9
17
19
Note:
The dotted portion can be applied to drawings 1-10
2nd HX, Evaporative, A
2nd HX, Evaporative, B
3
5
7
21
23

FIG. 11


Drawing 12: 1 Water Distribution System - 2 Dry HX, Series Flow
11a
1st HX, Dry C
1st HX, Dry D
13b
1a
13a
11b
1b
15
9
17
19
Note:
The dotted portion can be applied to drawings 1-9
2nd HX, Evaporative, A
2nd HX, Evaporative, B
7
5
21
23

FIG/ 12

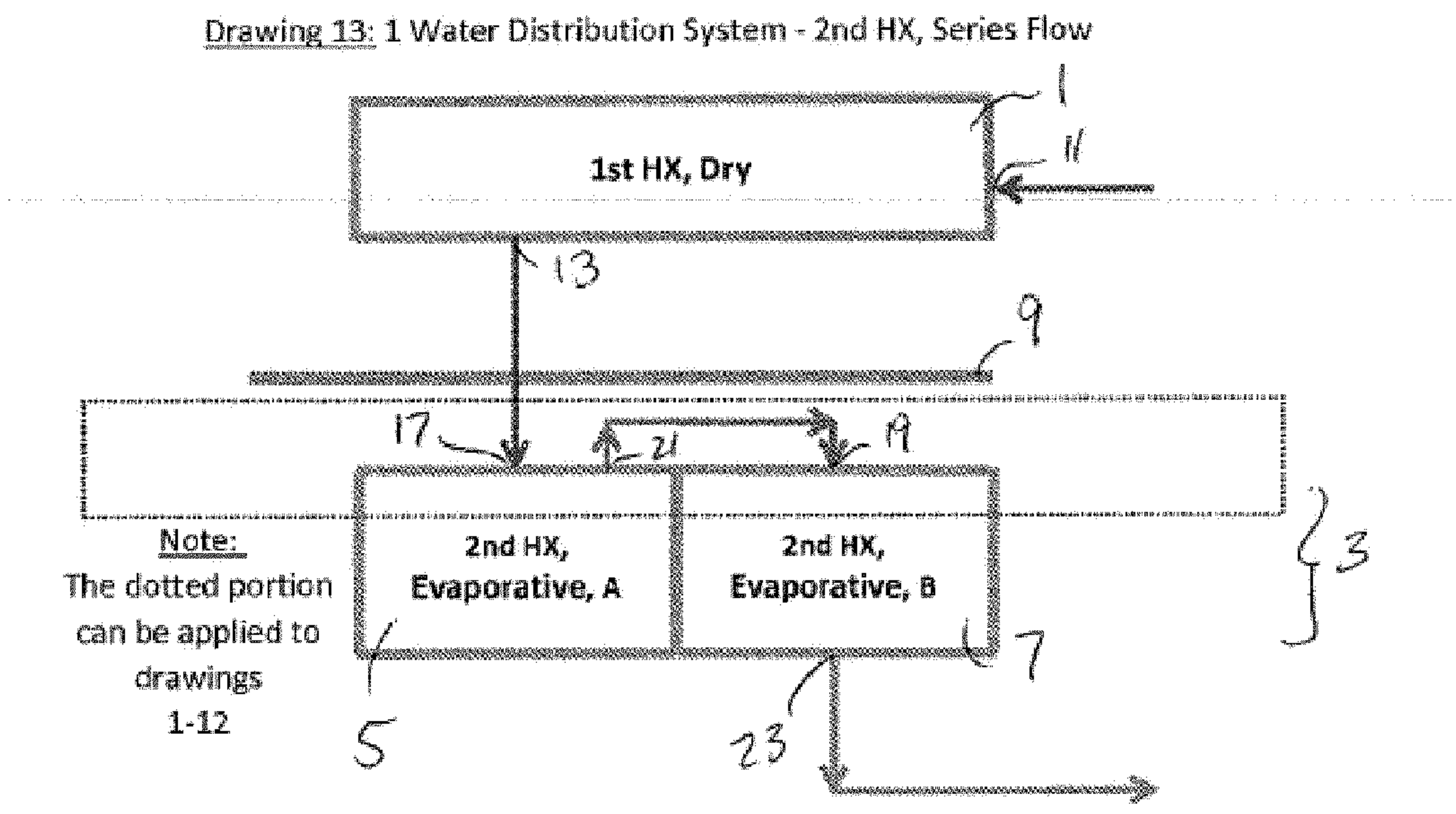

Drawing 13: 1 Water Distribution System - 2nd HX, Series Flow
1st HX, Dry
1
11
13
9
17
21
19
2nd HX,
Evaporative, A
2nd HX,
Evaporative, B
3
Note:
The dotted portion can be applied to drawings 1-12
5
7
23

FIG. 13a

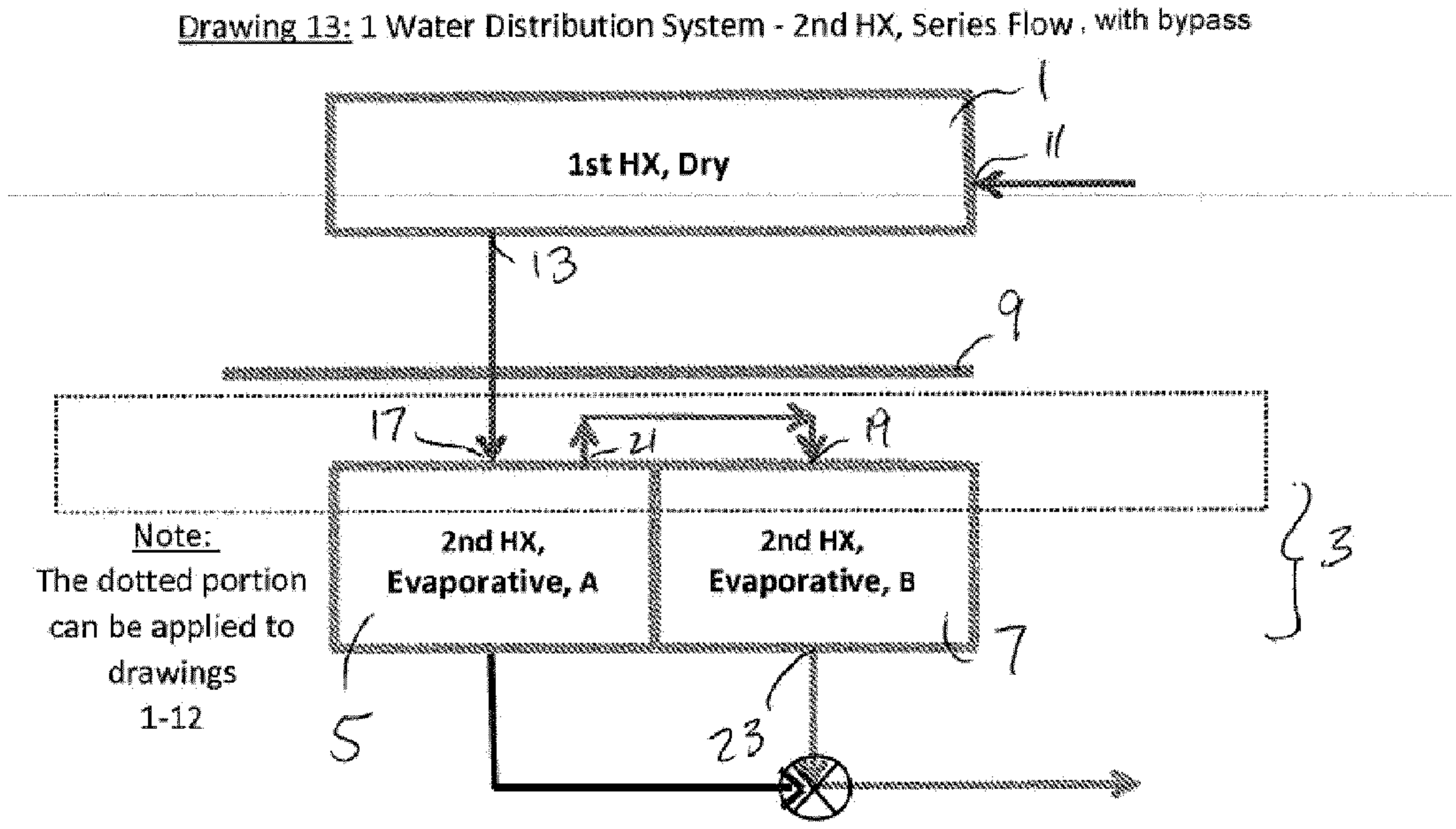

Drawing 13: 1 Water Distribution System - 2nd HX, Series Flow, with bypass
1st HX, Dry
1
11
13
9
17
21
19
2nd HX, Evaporative, A
2nd HX, Evaporative, B
3
Note:
The dotted portion can be applied to drawings 1-12
5
7
23

FIG. 13b

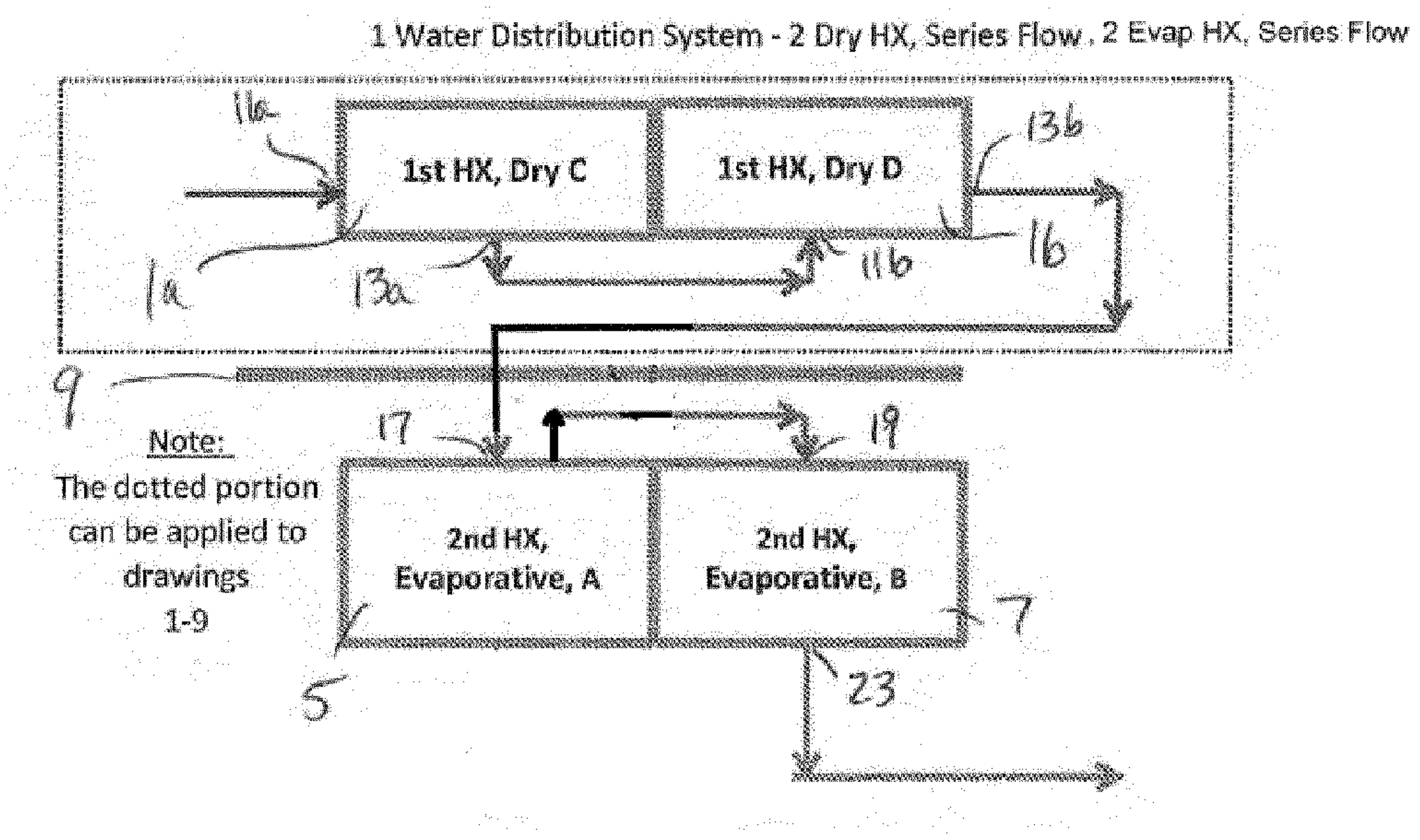

1 Water Distribution System - 2 Dry HX, Series Flow , 2 Evap HX, Series Flow
11a
1st HX, Dry C
1st HX, Dry D
13b
1a
13a
11b
1b
9
Note:
The dotted portion can be applied to drawings 1-9
17
19
2nd HX, Evaporative, A
2nd HX, Evaporative, B
7
5
23

FIG. 14a

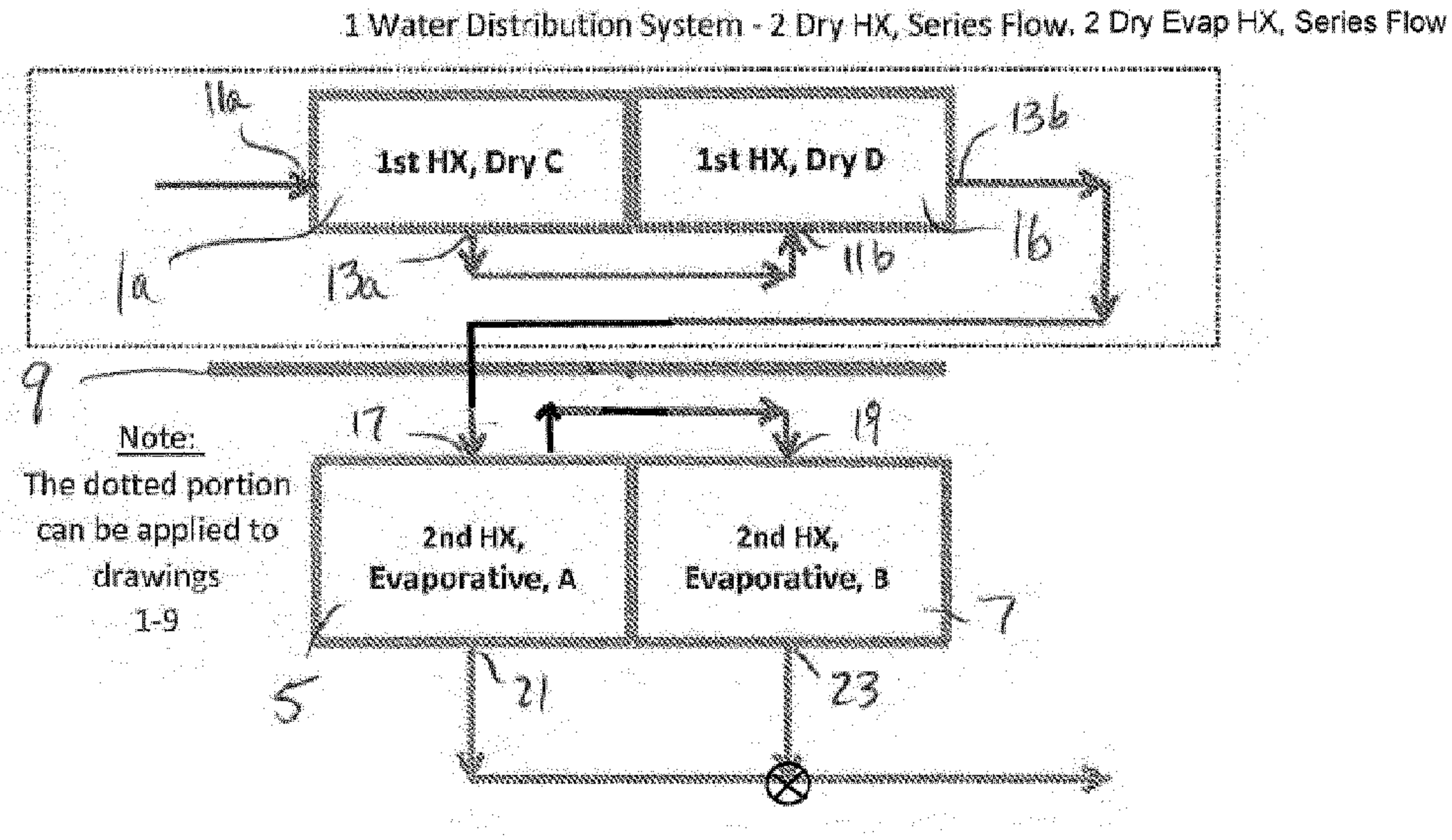

1 Water Distribution System - 2 Dry HX, Series Flow, 2 Dry Evap HX, Series Flow
11a
1st HX, Dry C
1st HX, Dry D
13b
1a
13a
11b
1b
9
Note:
The dotted portion can be applied to drawings 1-9
17
19
2nd HX, Evaporative, A
2nd HX, Evaporative, B
7
5
21
23

FIG. 14b

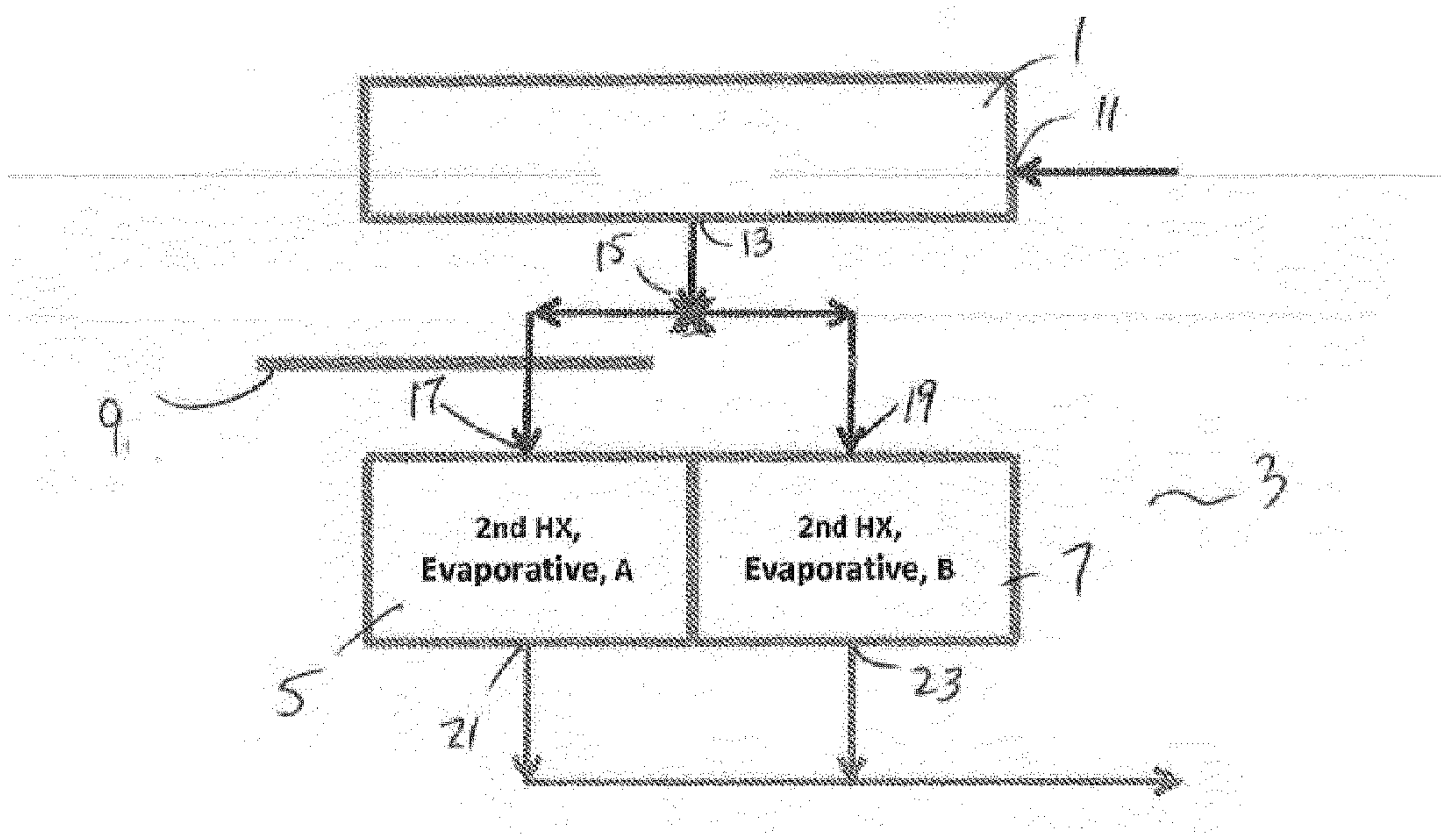

1
11
13
15
9
17
19
3
2nd HX,
Evaporative, A
2nd HX,
Evaporative, B
7
5
23
21

FIG. 15a

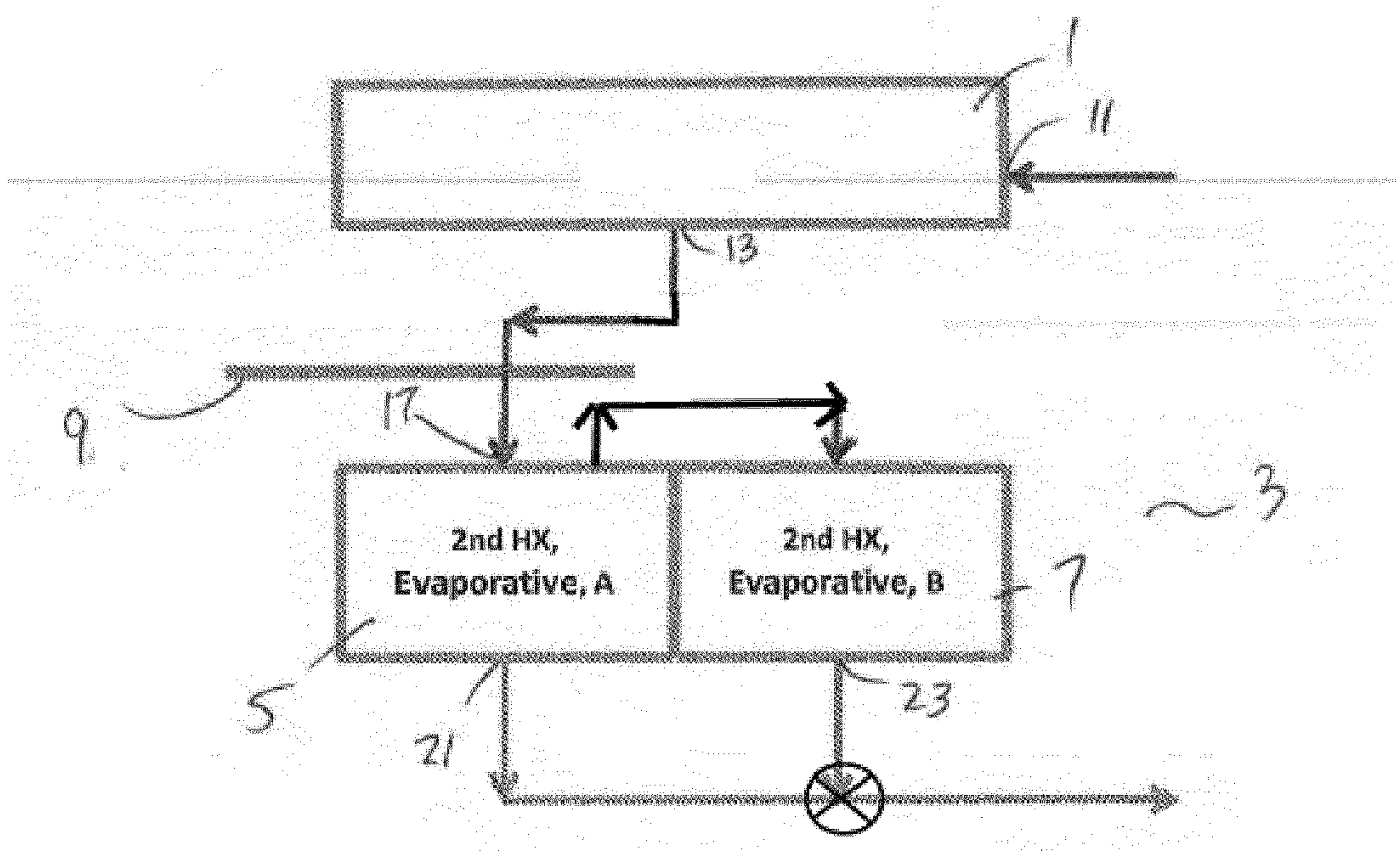


FIG. 15b

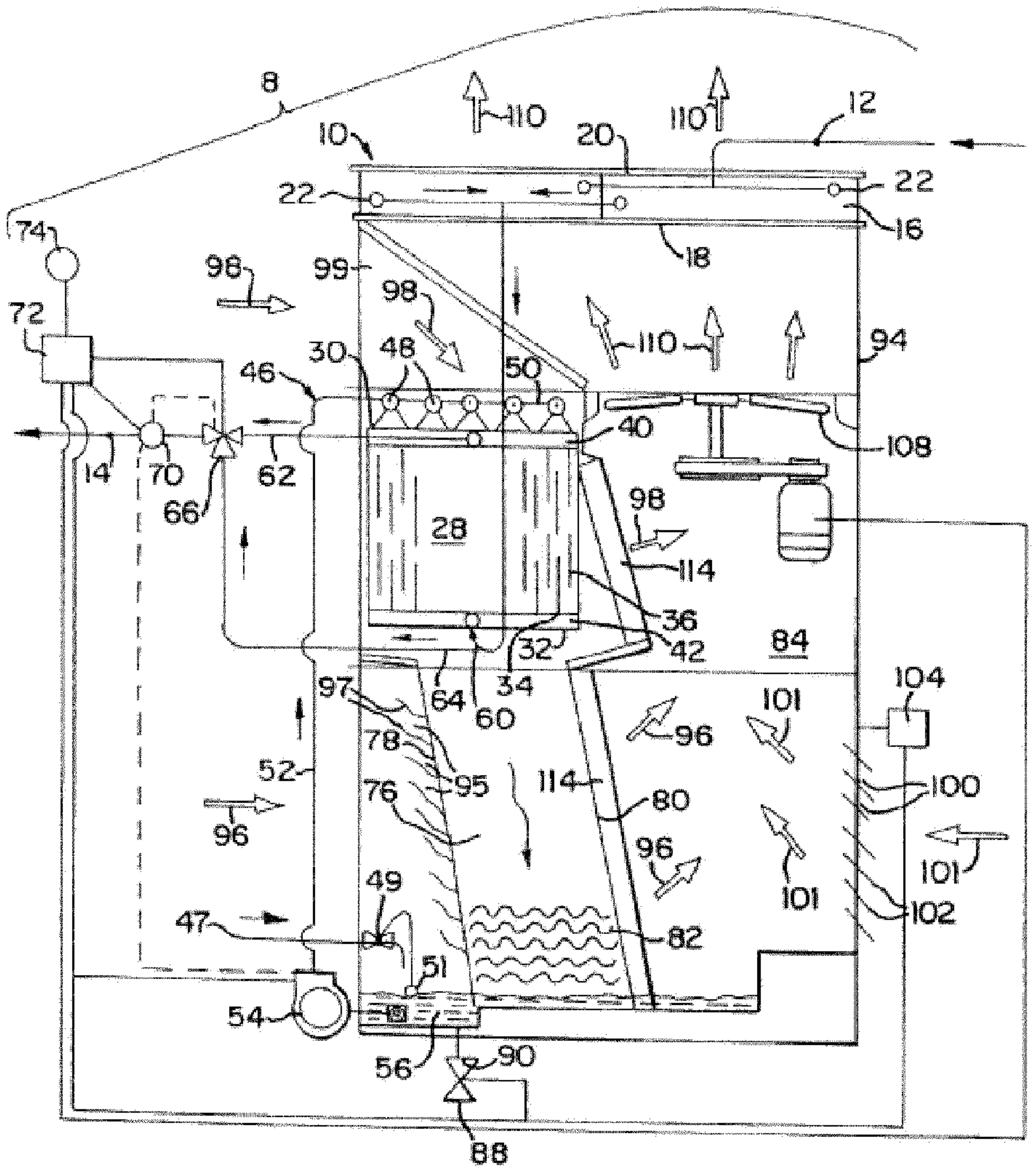

8
10
110
110
12
20
22
22
16
18
74
72
98
99
98
110
94
30
48
50
46
40
108
14
70
66
62
28
98
114
36
42
32
34
84
64
60
97
78
95
76
114
80
101
96
104
100
52
96
96
101
101
49
47
82
102
51
54
56
90
88

FIG. 16