reboiler space **691** wherein part or all of the liquid phase may be vaporized and the remainder remains in liquid form. The part that remains in liquid form, which may be referred to as bottoms product B, flows out of microchannel reboiler **690** through liquid outlet **694**, as indicated by arrow **697**. The part of the liquid product that is vaporized flows through vapor outlet **693**, as indicated by arrow **611**, into microdistillation section **670**. From that point, the vapor phase flows through the process microchannel **610** and the series of microchannel sections **670** to **670*n*** towards the microchannel condenser **680**.

[**0117**] In one embodiment, the microchannel distillation column or apparatus (e.g., microchannel distillation column or apparatus **110** or **210**) may contain one or more microchannel distillation units having the construction of microchannel distillation unit **1100** illustrated in **FIG. 45**. Referring to **FIG. 45**, microchannel distillation unit **1100** comprises process microchannel **1110** which includes liquid region **1120** and vapor region **1130**. The liquid region **1120** and vapor region **1130** are separated by wicking layer **1140**. A heat exchange channel may be positioned on one or both sides of the process microchannel **1110**. The overall height or gap of the process microchannel from wall **1112** to wall **1114** may be in the range from about 0.05 to about 10 mm, and in one embodiment about 0.1 to about 5 mm. The height or gap between the wall **1114** and the wicking layer **1140** may be in the range up to about 5 mm, and in one embodiment in the range up to about 1 mm. The wicking layer **1140** may float on the surface of the liquid in the liquid region **1120** and may have a thickness in the range from about 0.01 to about 5 mm, and in one embodiment in the range from about 0.05 to about 2 mm. The wicking layer **1140** may be made of any of the wicking materials discussed below. Examples include sintered metals, metal screens, metal foams, or polymer fibers such as cellulosic fibers. The wicking layer may comprise a metal shim or foil that is stacked and laminated. In one embodiment, structures in the wicking layer may be through features in the shim, or partially etched into the shim, or a combination thereof.

[**0118**] The liquid may flow horizontally and countercurrent to the vapor. The flow of the liquid may be at a velocity in the range from about 0.001 to about 10 meters per second (m/s), and in one embodiment in the range from about 0.01 to about 1 m/s. The Reynolds number for the flow of the liquid may be in the range from about 10 to about 4000, and in one embodiment in the range from about 50 to about 2000. The flow of the vapor may be at a velocity in the range from about 0.01 to about 100 m/s, and in one embodiment in the range from about 0.1 to about 10 m/s. The Reynolds number for the flow of the vapor may be in the range from about 10 to about 4000, and in one embodiment in the range from about 100 to about 2000. Heat and mass transfer between the liquid and vapor. The mass is transferred from vapor to liquid via interface and vice-versa. The wicking layer **1140** may reduce or eliminate drag on the flow of the liquid by the flow of the vapor. The wicking layer **1140** may help promote contact between the vapor and the liquid. In one embodiment, the liquid flow is not constrained to occur within the wicking layer **1140**, but rather convective mixing induced by surface features on the walls adjacent to the wall in the vapor region, or adjacent to the heat transfer wall, or between the liquid and vapor interface, or a combination of any of the foregoing. The surface features may be used to overcome mass transport resistance in both the liquid and vapor phases. This is shown in **FIG. 46**.

[**0119**] Referring to **FIG. 46**, microchannel distillation unit **1100A** is the same as the microchannel distillation unit **1100** illustrated in **FIG. 45** except that the microchannel distillation unit **1100A** includes surface features **1150** and **1160** on opposing walls **1112** and **1114**, respectively, of process microchannel **1110**. The surface features **1160** improve the mixing of liquid while surface features **1150** improve the mixing of vapor. The surface features **1150** and **1160** may be in the form of grooves or protrusions in the microchannel walls **1112** and **1114**. The grooves may have depths in the range from about 1 to about 5000 microns, and in one embodiment in the range from about 10 to about 1000 microns. The protrusions may have heights in the range from about 1 to about 5000 microns, and in one embodiment in the range from about 10 to about 1000 microns. The grooves in wall **1112** may be positioned opposite protrusions in wall **1114**, and vice versa, so as to complement each other. The grooves and opposite protrusions may be used to promote continuous and well-dispersed mixing in the process microchannel **1110**. The grooves and protrusions divert the liquid in a direction towards the vapor region **1130**. Similarly, the grooves and protrusions divert the vapor in a direction towards the liquid region **1120**. This reduces the mass transfer resistance for both the liquid and the vapor. Different surface feature geometries may be required for the liquid and vapor regions. **FIG. 47** shows an example of surface features that may enable convective flow in a direction perpendicular to the direction of flow and thereby improve mass transfer. Alternate surface feature geometries are illustrated in **FIGS. 48-51**.

[**0120**] Alternatively, surface features may be used to churn, rotate, or otherwise create a non-traditional parabolic laminar flow profile within the liquid and/or vapor phase while maintaining a relatively calm interface between the two phases. The liquid phase may be held adjacent the heat transfer or other microchannel wall by the use of vertically aligned or diagonally weaving capillary features, wherein the surface features are recessed or protruding within the capillary features or protrude to a shorter height than the height of the capillary features. By this method, the flow capacity per channel or rate of the liquid film may be maintained at a higher level than that of a thin film on a wall or that which uses capillary features alone because the surface features create transverse and perpendicular advection within the otherwise thick liquid film such that the otherwise large liquid mass transfer limitation is reduced. Mass within the liquid film may be moved throughout the film predominantly by advection rather than the slow diffusion found in a laminar liquid film.

[**0121**] **FIGS. 52-55** illustrate various microchannel distillation units that employ surface features on their side walls to enhance mixing of the vapor and liquid. **FIGS. 53-55** illustrate embodiments wherein a fine pore size wicking material (that is, with thru features) is used behind vapor channel surface features to keep the surface features from filling with condensing liquid. Liquids in the system may include slurries of very fine particles. **FIG. 52** shows vertically oriented distillation channels, and **FIG. 53** shows the same with adjacent heat exchange channels. In this embodiment the cooling channel is not adjacent to the vapor channel. This is to prevent condensation inside the vapor