[0034] The exhaust tube 52 includes a first end 63 that is co-planar with the floor 73 of the gas plenum housing 71. The exhaust tube 52 is connected to the bottom 30 of the ingot puller housing 12. The exhaust tube 52 includes a second, distal end 67 that includes a flanged portion 78 for connection to a vacuum system.

[0035] Referring now to FIGS. 3-4, the exhaust tube 52 includes a radial inner wall 82 and a radial outer wall 84 each extending from the first end 63 to the second end 67. The exhaust tube 52 includes baffles 91 between the inner wall 82 and outer wall 84. The inner wall 82, outer wall 84 and baffles 91 define a flow channel 88. The flow channel 88 defines a flow path 92 along which fluid circulates within the exhaust tube 52. The fluid channel 88 is configured to receive fluid, such as water, for cooling exhaust gas within the exhaust flow path 70. Cooling fluid generally moves upward toward the first end 63 of the tube 52 and back down toward the second end 67. The fluid that circulates within the fluid channel 88 may be water which may be at a temperature significantly less than the hot zone of the puller (e.g., 30°C to 40°C compared to about 1700°C or more).

[0036] The inner wall 82 of the exhaust tube 52 is constructed of suitable thermally conductive materials to facilitate heat exchange between the cooling fluid and exhaust gas within the exhaust flow path 70. Suitable materials from which the inner wall 82 may be constructed include, for example and without limitation, stainless steel. In some embodiments, the inner wall 82 is constructed of the same materials as the housing 12. The outer wall 84 and/or baffles 91 may be constructed of the

same materials as the inner wall 82, or may be constructed of materials different than the inner wall 82.

[0037] The fluid channel 88 is fluidly connected with a fluid supply source 90 at a fluid supply inlet 86 for supplying cooling fluid to the fluid channel 88. The cooling fluid may be any suitable fluid that enables the system 10 to function as described herein, including, for example and without limitation, water and any cooling fluid (e.g., refrigerated water or ethylene glycol). The flow rate of cooling fluid through the fluid channel 88 may be controlled to increase or decrease the cooling rate of exhaust gas within the exhaust flow path. In some embodiments, the flow rate of the cooling fluid through the first fluid channel 88 is between about 5 liters per minute (L/min) and about 60 L/min, and, more suitably, is about 40 L/min. The fluid supply source 90 may be connected to suitable flow control components, such as pumps and flow controllers (not shown) for controlling the flow rate of fluid through the fluid channel 88.

[0038] From the fluid supply source 90, the cooling fluid moves through the inlet 86 and into the fluid channel 88. The cooling fluid travels around the baffles 91 and along the flow path 92. The cooling fluid moves toward the first end 63 of the tube 52 within the fluid channel and then travels back down the tube toward the second end 67 and the fluid supply outlet 93. The cooling fluid moves through the fluid supply outlet 93 and enters a cooling fluid treatment system 96 (e.g., cooling and disposal or recycle).

[0039] In the illustrated embodiment, the cooling fluid inlet 86 and outlet 93 are fluidly connected

to the exhaust tube 52 at the flange portion 78 of the exhaust tube 52. The inlets 86 and outlets 93 may be disposed at other positions along the tube 52 that allow the exhaust tube 52 to function as described herein.

[0040] As shown in FIG. 2, the exhaust tube 52 extends a length L below the bottom 30 of the housing 12. In the illustrated embodiment, the exhaust tube 52 is fluid-cooled over the entire length L, although in other embodiments, the exhaust tube 52 may be fluid-cooled over only a portion of the length L.

[0041] In the embodiment shown in FIG. 1, the crystal pulling system 10 includes a single exhaust tube 52 and port 56. In other embodiments, the system includes two, three or more exhaust tubes 52 and ports 56 (e.g., three exhaust tubes 52 and ports 56 which are symmetrically spaced about the crystal pulling system bottom 30).

[0042] The crystal pulling system 10 is suitably used to grow monocrystalline ingots from the melt 46 according to the Czochralski method. More specifically, a melt 46 is prepared in the crucible 44 by charging the crucible 44 with polycrystalline silicon feedstock material. The feedstock material is melted in the crucible 44 using heaters 19, 62, 65 to form the melt 46 of semiconductor or solar-grade material. Once the feedstock material is sufficiently melted, the seed crystal 37 is lowered into contact with the melt 46 by the pulling mechanism 47 to initiate crystal growth, and a monocrystalline ingot 48 is grown from the melt 46 by