[0044] In a particularly exemplary embodiment of the invention, the dispersant is introduced into each of chambers **40**_b_, **42**_b_, and **44**_b_. The dispersant may be anionic, cationic, non-ionic, and/or a bile salt, for example. Anionic dispersants include sodium dodecyl sulfate (SDS), benzylated SDS, dodecylbenzenesulfonic acid (DBS), and/or lithium dodecyl sulfate (LDS). SDS is available from various suppliers, including Sigma-Aldrich of St. Louis Mo. TCI America of Portland Oreg. is a supplier of DBS. Cationic dispersants include trimethylhexadecylammonium chloride supplied by, e.g., Sigma-Aldrich. Triton™-X100 of Sigma-Aldrich is an example of a non-ionic dispersant, while sodium cholate and deoxycholate (also supplied by Sigma-Adrich) are examples of bile salt dispersants. Commercial detergent blends such as NanoSperse AQ™ (of Nanolab Inc. of Boston, Mass.) also may be used. Other useful dispersants are described in U.S. Pat. No. 7,074,310, which is incorporated herein by reference for its list of dispersants.

[0045] In an exemplary embodiment, a 10 percent weight/volume solution of SDS in water has been found to be particularly useful for the tumbler **32**. According to one useful embodiment, a 35:1 volume/weight ratio of 10% SDS to CNTs was used.

[0046] Dispersants are capable of readily dispersing CNTs in aqueous media to provide colloidal CNTs. WO 2004/024428 explains that many dispersants when used with an ultrasonication process are capable of providing stable dispersions of carbon nanotubes which are less breakable in processing operations such as sonification. The dispersant coating stabilizes the CNTs by forming a "double layer" or a micellular arrangement of dispersant molecules around CNTs in aqueous phase. The dispersant coating has also been reported to prevent re-aggregation or re-bundling of the CNTs. See U.S. Pat. No. 7,074,310.

[0047] While not wishing to necessarily be bound by any theory, in the context of exemplary embodiments of the present invention it is believed that dispersants such as SDS encapsulate the grit particles and the CNTs by either bonding via van der Waals forces or forming a micelle, and that the encapsulate softens or cushions the shearing blow of the grit particles against the CNT bundles. It is believed that this phenomenon largely contributes to the high yields achievable by practicing embodiments of the present invention. Generally, increasing the ratio of dispersant in the aqueous medium will increase viscosity and softening or cushioning effect on the grit particles. High dispersant concentrations may require that the tumbler **32** be operated for longer processing times to attain adequate shearing.

[0048] The CNT bundles, aqueous medium, and grit particles may be introduced through the port **40**_a_ into compartment **40**_b_ in any sequence, or combined together in any combination before being introduced through the port **40**_a_. The compartments **40**_b_, **42**_b_, **44**_b_ of the cylindrical segments **40**, **42**, and **44** may be partially filled with the aqueous medium and/or detergent (e.g., SDS) before introducing the CNT bundles.

[0049] The rotating mechanism or system **34** operates to rotate the tumbler **32** about its longitudinal axis. In the illustrated embodiment, rotating mechanism **34** includes a platform **60** that may be made of rubber, metal, plastic, or any other suitable material. The rotating mechanism **34** includes a pair of shafts **62** and a motor **64** or motors for rotating the shafts **62** about their longitudinal axes. The motor **64** may be a conventional electric motor or any other suitable motor. A plurality of rollers **66** are spaced along the length of each shaft **62** and support or otherwise contact the tumbler **32**. In the illustrated embodiment, a roller **66** is provided for each of the cylindrical segments **40**, **42**, **44**. The rollers **66** rotate with the shafts **62**. The rollers **66** may be made of rubber materials capable of transmitting the rotational movement of the shafts **62** to the tumbler **32**, causing the tumbler **32** to rotate about its cylindrical axis.

[0050] The pump assembly **36** includes a conduit **37** connecting the upstream and downstream ends of **32**_a_, **32**_b_ of the tumbler **32**. A pump **38** is situated along the conduit **37**. Electrical connections between stationary and rotating parts of apparatus described herein can be implemented using rotating electrical connectors, such as supplied by Mercotac, Inc. of Carlsbad, Calif. According to an experimental embodiment, the fluid connections between the conduit **37** and ends **32**A, **32**B of tumbler **32** are made through threaded reducing coupling port with ¼ inch NPT, such as supplied by US Plastics of Lima, Ohio which connect to ⅛ inch Tygonm tubing at the end of the tumblers and to an in-line small re-circulating pump to create a close loop system that rotates with the tumbler **32**. In-line pumping can be implemented using a model TCS M200 micro pump, such as supplied by TCS Micro Pumps Limited of Kent, England. A rotating electrical connector using a rotating electrical connector, such as supplied by Mercotac, Inc. of Carlsbad, Calif. provides power to the internal micro-pumps within the tumbler assembly.

[0051] The pump system **36** exerts a force perpendicular to the mesh surface to help drive smaller particles such as CNTs through the mesh. The pumped liquid flow along the long-axis of the tumbler tube and external tubing connecting the pump and ported end caps of the tumbler core represent a closed-loop system. All liquids and dispersed particles are confined within the tumbler device and pump/tubing assembly. It should be understood that alternative systems and set-ups may be used in place of the pump assembly **36** for driving flow through the meshes. For example, the pump assembly may be replaced with an Archemedes screw. Gravitational force created by tilting the tumbler **32** at an angle, e.g., 4-10 degrees from horizontal, may be used instead of or in combination with the pump assembly and/or Archemedes screw for micron-scale particle (CNT) size separation.

[0052] Rotation of the tumbler **32** causes the grit particles, which are believed to be encapsulated with SDS or other dispersant, to impact against the CNT bundles. The grit particles shear the CNTs of the bundles from one another in an operation known as debundling. The grit particles also removes the amorphous carbon shells in an operation known as descaling, and shorten the carbon nanotubes in an operation known as shearing. Generally, carbon nanotubes in the CNT bundles may have lengths on the order of 1 to 10 microns in length when introduced into tumbler **32**. These CNT lengths may be shortened to, for example, lengths of 10 to 1,000 nm during descaling/shearing in the tumbler depending on the processing time (number of rotations of tumbler **32**), and the diameter and type of grit particle. In general, larger grit shearing particles and those with a reduced hardness factor (silicon carbide reduced hardness compared to diamond) will result in longer CNT tube lengths when the number of rotations and weight ratios of CNTs vs shearing particles remain constant. In addition to hardness, grit particle morphology can also result in differences in processing outcomes. For example, diamond powder is considered much