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Bradley et al.

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[54] **APPARATUS FOR BLENDING SMALL PARTICLES**

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[52] **U.S. Cl.** **222/145**; 141/105; 259/2

[51] **Int. Cl.**[2] **B67D 5/60**

[58] **Field of Search** 222/49, 50, 47, 145, 426, 222/428, 429, 430, 438, 439, 450, 484, 485, 486, 459, 564; 141/100, 105; 259/2

[56] **References Cited**

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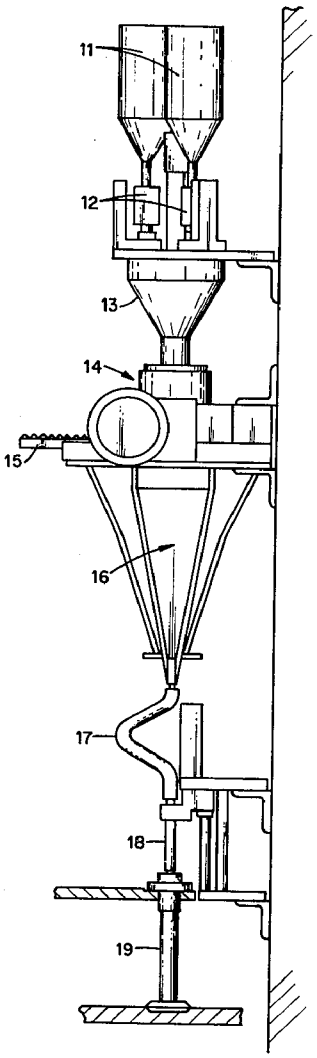
[57] **ABSTRACT**

Apparatus is described for blending small particles and uniformly loading the blended particles in a receptacle. Measured volumes of various particles are simultaneously fed into a funnel to accomplish radial blending and then directed onto the apex of a conical splitter which collects the blended particles in a multiplicity of equal subvolumes. Thereafter the apparatus sequentially discharges the subvolumes for loading in a receptacle. A system for blending nuclear fuel particles and loading them into fuel rod molds is described in a preferred embodiment.

5 Claims, 8 Drawing Figures



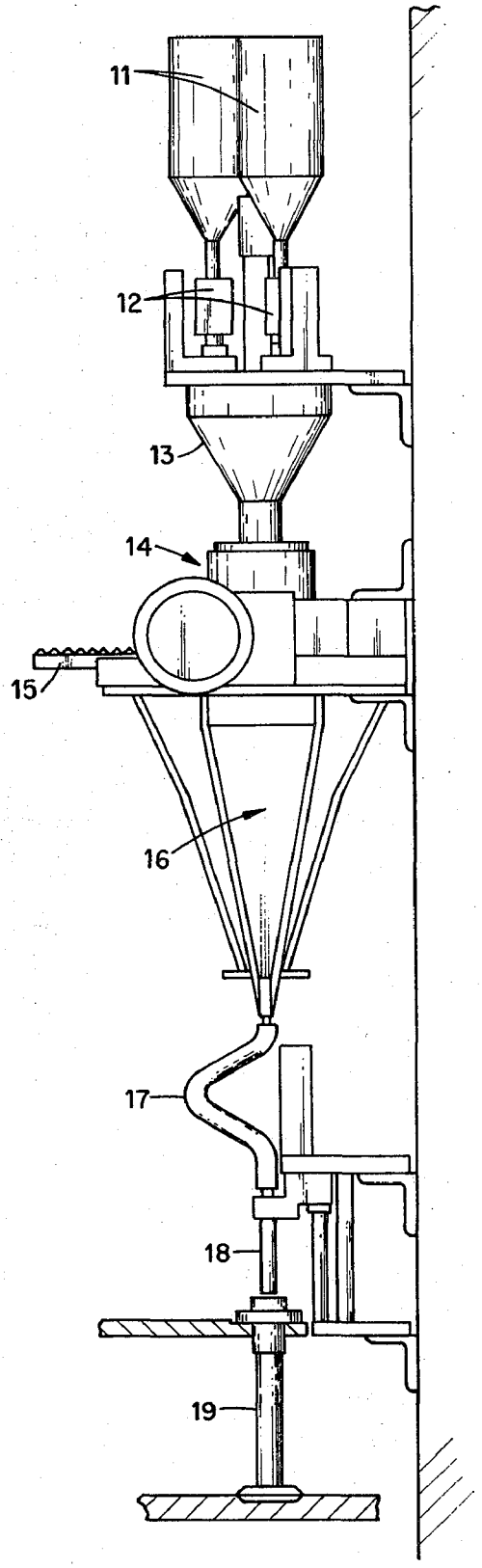


Fig. 1

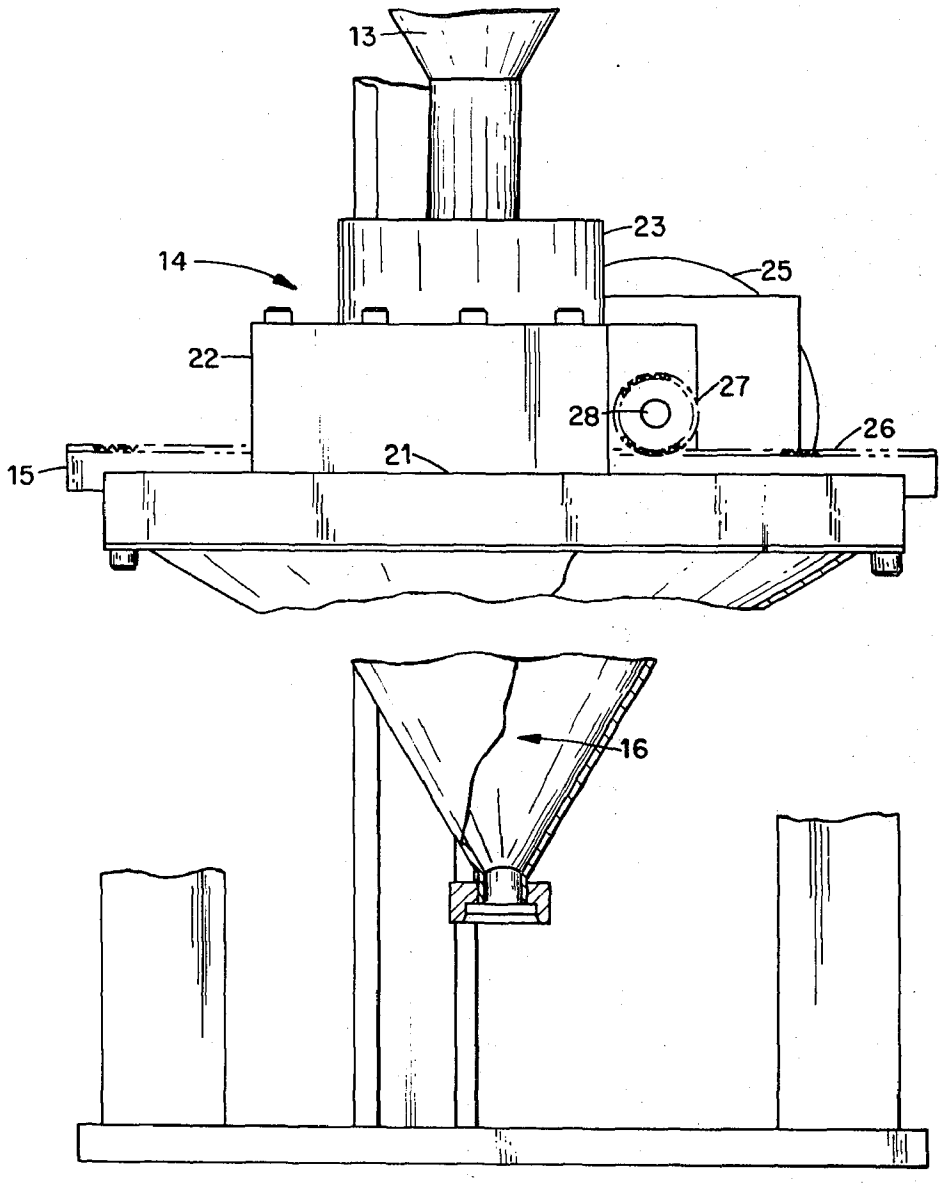


Fig. 2

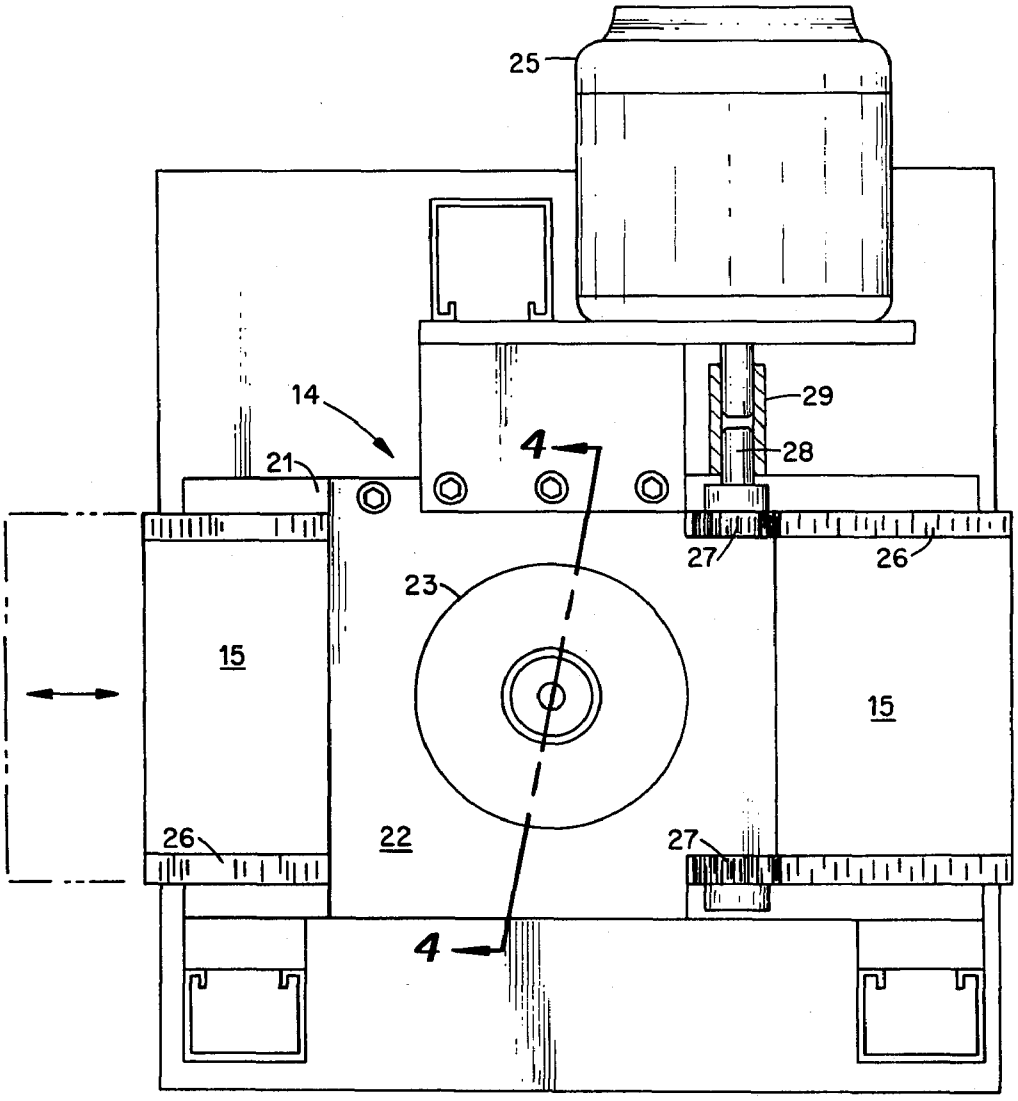


Fig. 3

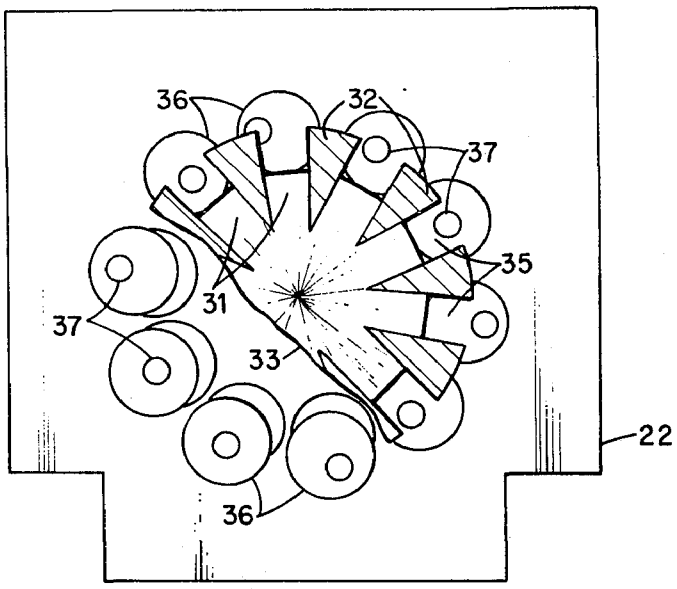


Fig. 5

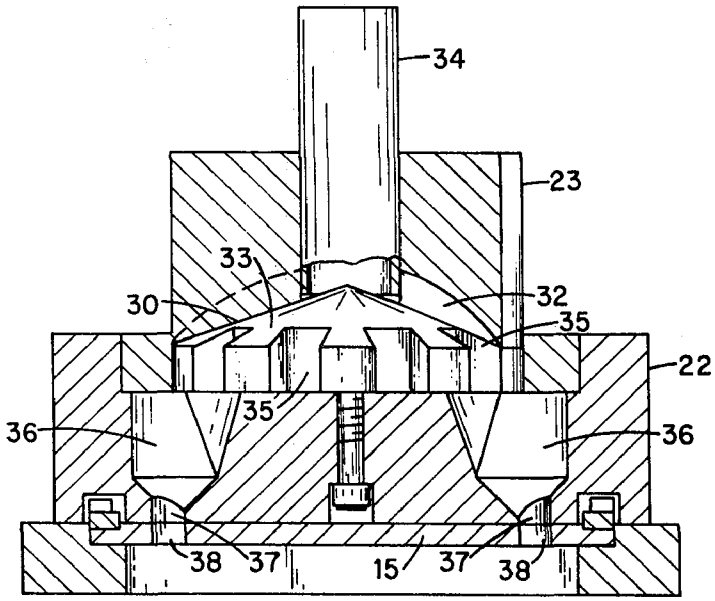


Fig. 4

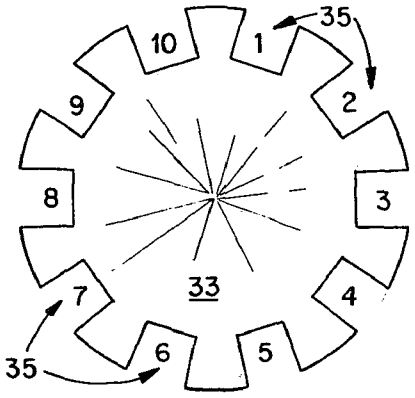


Fig. 7

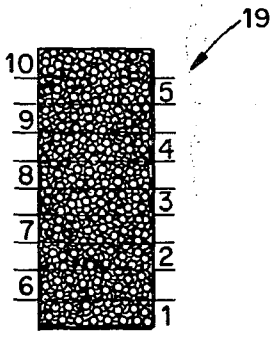


Fig. 8

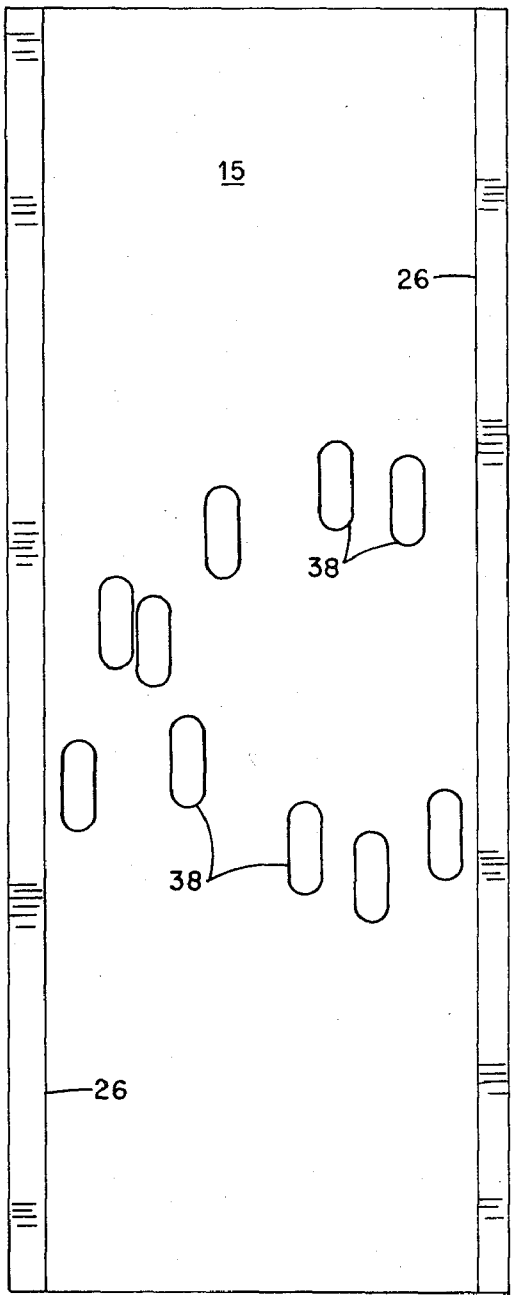


Fig. 6

APPARATUS FOR BLENDING SMALL PARTICLES

BACKGROUND OF THE INVENTION

The invention described herein relates generally to particle blenders and more particularly to a particle blender for small spherical or spheroidal particles such as the coated nuclear fuel particles used in the manufacture of bonded-particle carbon-matrix nuclear fuel composites. It was made in the course of, or under, a contract with the U.S. Atomic Energy Commission.

Particulate nuclear fuels have been widely investigated for use in high-temperature gas-cooled reactors. Generally, individual fuel particles comprise a central core of fissile or fertile material surrounded by one or more layers of refractory material, such as pyrolytic carbon, silicon carbide, etc., which serves as an outer, protective, gas-impermeable coating. Individual fuel particles are about the size of grains of common table salt. One such coated fuel particle, commonly referred to as a duplex-coated particle, consists of a dense actinide oxide core, a first highly porous, pyrolytic carbon coating, and an outer, gas-impermeable, protective coating of high density, isotropic, pyrolytic carbon. Another coated fuel particle described in U.S. Pat. No. 3,298,921, issued to Jack C. Borkos on Jan. 17, 1967, for "Pyrolytic Carbon Coated Particles for Nuclear Applications," comprised a central fuel core surrounded by a single protective coating of isotropic carbon.

Of recent interest in the incorporation or consolidation of such coated particles into a carbon-containing matrix fuel composite useful, for example, in a high-temperature gas-cooled reactor such as the Fort St. Vrain reactor designed by General Atomic Company for the Public Services Corporation of Colorado. That particular reactor has a graphite core containing approximately 210 elongated fuel cavities per fuel element each of which is loaded with coated-particle carbonized-matrix fuel composites commonly referred to as fuel sticks or fuel rods.

Depending upon the size of the fuel stick used, it is presently contemplated that a single, large (1000 MWE), high-temperature, gas-cooled nuclear reactor will require a loading of from four to ten million fuel sticks. In normal operation, about one-fourth of the fuel sticks will be replaced each year. Assuming that fifty such reactors are eventually built, hundreds of millions of fuel sticks meeting stringent nuclear standards will have to be fabricated. Fuel recycle will complicate this massive fabrication need by adding a remote operation requirement since the recycled fuel will be radioactive.

Another complication occurs due to the mixture of different particles required in each fuel stick. Present plans call for three different kinds of particles to be loaded in each fuel stick: particles containing fissile material, particles containing fertile material, and shim particles which are unloaded carbon blanks used to regulate the concentration of fissile and fertile material in the fuel stick. Each particle type, which may differ in size and density from the others, must be accurately dispensed and uniformly blended in each fuel stick to ensure its satisfactory nuclear performance.

It is, accordingly, a general object of the invention to provide apparatus for rapidly and uniformly blending two or more kinds of small particles and loading the blended particles in a receptacle.

Another object of the invention is to provide apparatus for rapidly and uniformly blending measured volumes of two or more kinds of small particles wherein the apparatus is amendable to remote operation as in a hot cell.

Other objects of the invention will be apparent to those skilled in the art upon examination of the following written description of the preferred embodiment and the appended drawings.

SUMMARY OF THE INVENTION

In accordance with the invention, apparatus is provided for rapidly and uniformly blending measured volumes of two or more kinds of small particles and loading the blended particles in a receptacle. The apparatus includes: a funnel-shaped radial mixing member; a splitter cone having a base portion with a slotted periphery and an upwardly extending apex portion disposed below and in axial alignment with the radial mixing member; a base supporting the splitter cone and defining a multiplicity of collection cavities spaced in a circular array in gravimetric communication with respective slots in the splitter cone and discharge ports open to the bottom surface of the base and in gravimetric communication with respective collection cavities; a perforated valve plate slidably engaging the bottom surface of the base to sequentially open each discharge port and empty the contents of the respective collection cavities; and means for passing blended particles discharged from the collection cavities to a receptacle.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic front elevation view of an automatic multistation particle loading system incorporating particle blending apparatus made in accordance with the invention.

FIG. 2 is an enlarged front elevation view of the particle blending apparatus used in the system of FIG. 1.

FIG. 3 is a top elevation view of the apparatus of FIG. 2.

FIG. 4 is a vertical section view of particle blending apparatus showing internal details.

FIG. 5 is a plan view, partly cut away and sectioned, of the base member, housing, and splitter cone used in the apparatus of FIG. 4 further illustrating the relationship between the housing, splitter cone, and base.

FIG. 6 is a top plan view of the valve plate used to sequentially discharge blended particle subvolumes from the blending apparatus of FIGS. 2 through 4.

FIG. 7 is a top plan view of the splitter cone used in the blending apparatus of FIG. 4.

FIG. 8 is a schematic vertical-section view of a fuel rod mold loaded using the apparatus of FIGS. 1 through 4.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings, initially to FIG. 1, an automatic particle dispensing and blending system using blending apparatus made in accordance with the invention is shown in a schematic front elevation view. Particulate materials to be dispensed and blended are stored in supply hoppers 11 with one hopper being provided for each type of particulate material. Adjustable volumetric dispensers 12, which are described in detail in copending application of common assignee Ser. No. (481,422), dispense measured volumes of particulate

material from the respective supply hoppers into funnel **13.** Radial mixing occurs as the respective particles pass through the funnel into blending apparatus **14** made in accordance with the invention. Subvolumes of blended particles are retained in blending apparatus **14** until the dispensing operation is completed and then sequentially discharged through the action of slide valve plate **15.** The subvolumes of blended particles are discharged into a second funnel **16** which is connected, by means of delivery tube **17,** with fill tube **18.** Fill tube **18,** shown in its non-filling or "up" position, is normally fully lowered into a fuel rod mold **19** during a filling operation. The fill tube is made retractable to facilitate rapid removal and replacement of fuel rod mold **19** as might be required where a plurality of molds are mounted on a turntable and sequentially loaded using a turntable indexing mechanism. Following the particle loading operation, the loaded fuel rod mold may be moved to an infiltration station for the injection of carbonaceous filler material in accordance with prior-art procedures.

Turning now to FIGS. **2** and **3** where front and top elevation views of blending apparatus **14** made in accordance with the invention are shown, frame **21** is shown supporting a base **22** which in turn supports a housing **23.** Additional base and housing details are described in later reference to FIG. **4.** As shown, slide valve plate **15** passes between base **22** and frame **21** under the urging of drive motor **25.** Lateral motion of plate **15** is accomplished by means of racks **26** attached to both sides of the plate and a mating set of pinions **27** keyed to shaft **28** which extends through base **22.** Coupling **29** transmits power from drive motor **25** to shaft **28** when it is desired to displace plate **15.** Also shown in FIG. **2** is collection funnel **16** for catching blended particles released from blending apparatus **14.**

FIG. **4** is a vertical-section view of the blending apparatus of FIGS. **2** and **3** showing internal details of base **22** and housing **23.** Positioned within housing **23** is a splitter cone **33** having a base portion with a slotted cylindrical periphery and an upwardly extending apex disposed below and in axial alignment with discharge tube **34** attached to the lower end of funnel **13** (see FIG. **1**). In the preferred embodiment shown, ten slots **35** are equally spaced about the periphery of cone **33** in order to subdivide particles passing through discharge tube **34** into ten equal subvolumes. More of fewer slots could be provided in cone **33** without departing from the scope of the invention, however. As shown, the sloping conical surface **30** of splitter cone **33** mates with wedge-shaped splitter vanes **32** to define a multiplicity of particle flow passageways **31** (see FIG. **5**) of equal size uniformly spaced about said cone.

Base **22** defines a plurality of collection cavities **36,** each of which is in gravimetric communication with a single respective slot **35** so that particles falling into slots **35** continue downward into the collection cavities. FIG. **5,** which is a plan view of the housing, base, and splitter cone with the housing sectioned and cut away and the splitter cone partly cut away for clarity, shows the alignment of splitter vanes **32,** slots **35,** and respective collection cavities **36.** Also shown in FIGS. **4** and **5** are discharge ports **37** extending between each collection cavity and the bottom surface of base **22.** Slide valve plate **15** blocks discharge ports **37** during a particle dispensing operation and then sequentially opens them through the selective alignment of slots **38** with the discharge ports through lateral displacement of the plate. FIG. **6** is a top plan view of slide valve plate **15** showing an arrangement of slots **38** which, using a ten-station splitter cone as shown in FIG. **7,** will sequentially load a fuel rod mold **19** with particle subvolumes as schematically shown in FIG. **8.** Slots **1-10** identified in FIG. **7** distribute particles to respective collection cavities **36** as described earlier in reference to FIGS. **4** and **5.** The particle subvolumes thus collected are sequentially released through discharge ports **37** and slots **38** as slide valve plate **15** is advanced in close sliding contact along base **22.** Those skilled in the art will recognize that any desired fuel rod mold loading sequence could be achieved through a suitable arrangement of slots **38.** However, an additional factor of random distribution is achieved by discharging collection cavities on opposite sides of the splitter cone in sequence; e.g., No. **1,** No. **6,** No. **2,** No. **7,** etc., as may be seen by comparing FIGS. **7** and **8.**

The above description of one embodiment of the invention is offered for illustrative purposes only and should not be interpreted in a limiting sense. For example, more or less than ten pairs of slots and collection cavities could be used without departing from the scope of the invention. Also, blending apparatus made in accordance with the invention is not restricted to blending nuclear fuel particles but is also useful in other unrelated areas of technology where uniform blending of small particles is necessary. It is intended, rather, that the invention be limited only by the scope of the appended claims.

What is claimed is:

1. Apparatus for blending particles and uniformly loading the blended particles in a receptacle comprising:

a. a funnel-shaped radial mixing member having a larger particle-receiving end and a smaller particle-discharge end, said mixing member having its axis vertically oriented with its larger end disposed above the smaller end;

b. a particle splitter cone having an upwardly extending apex disposed coaxially with and immediately below said radial mixing member;

c. a housing defining a multiplicity of wedge-shaped vanes, said vanes engaging the surface of said cone to define a multiplicity of particle flow passageways spaced about said cone;

d. a base disposed below said cone defining

i. a multiplicity of open collection cavities spaced in a circular array, each of said collection cavities being open to and in gravimetric flow communication with said particle flow passageways;

ii. a multiplicity of discharge ports open to the bottom surface of said base, said discharge ports each being in communication with respective collection cavities in said multiplicity of collection cavities;

e. means for closing and sequentially opening said discharge ports whereby only one of said collection cavities can be unloaded at a time, and whereby the contents of said collection cavities can be unloaded in a sequential order; and

f. means for passing blended particles discharged from said collection cavities to a receptacle.

2. The apparatus of claim **1** wherein said means for closing and sequentially opening said discharge ports comprises a valve plate disposed in sliding contact with

the bottom surface of said base, said valve plate defining a multiplicity of apertures positioned to sequentially align with said discharge ports as said valve plate is displaced laterally.

3. The apparatus of claim **1** wherein said particle flow passageways are of equal size and are uniformly spaced about said cone.

4. The apparatus of claim **2** wherein the apertures in said valve plate are positioned to sequentially align with discharge ports on opposite sides of said splitter cone.

5. Apparatus for blending particles and uniformly loading the blended particles in a receptacle comprising:

a. a funnel-shaped radial mixing member having a larger particle-receiving end and a smaller particle-discharge end, said mixing member having its axis vertically oriented with its larger end disposed above its smaller end;

b. a particle splitter cone having an upwardly extending apex disposed coaxially with and immediately below said radial mixing member, the base portion of said cone having a slotted cylindrical periphery comprising a multiplicity of uniformly spaced slots of equal size;

c. a base disposed below and supporting said cone defining:

i. a multiplicity of collection cavities spaced in a circular array, each of said collection cavities being open to and in gravimetric flow communication with respective slots in the base portion of said splitter cone; and

ii. a multiplicity of discharge ports open to the bottom surface of said base, said discharge ports each being in communication with respective collection cavities in said multiplicity of collection cavities;

d. a valve plate disposed in sliding contact with the bottom surface of said base, said valve plate defining a multiplicity of apertures positioned to sequentially align with said discharge ports as said valve plate is displaced laterally whereby only one of said collection cavities can be unloaded at a time, and whereby the contents of said collection cavities can be unloaded in a sequential order; and

e. means for passing blended particles discharged from said collection cavities to a receptacle.

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