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(54) MICROCARRIER FORMING APPARATUS

(71) Applicant: **METAL INDUSTRIES RESEARCH & DEVELOPMENT CENTRE**, Kaohsiung City (TW)

(72) Inventors: **Zong-Hsin Liu**, Kaohsiung City (TW); **Cheng-Han Hung**, Kaohsiung City (TW); **Ying-Chieh Lin**, Kaohsiung City (TW); **Cheng-Tang Pan**, Kaohsiung City (TW); **Shiao-Wei Kuo**, Kaohsiung City (TW); **Yao-Kun Huang**, Kaohsiung City (TW)

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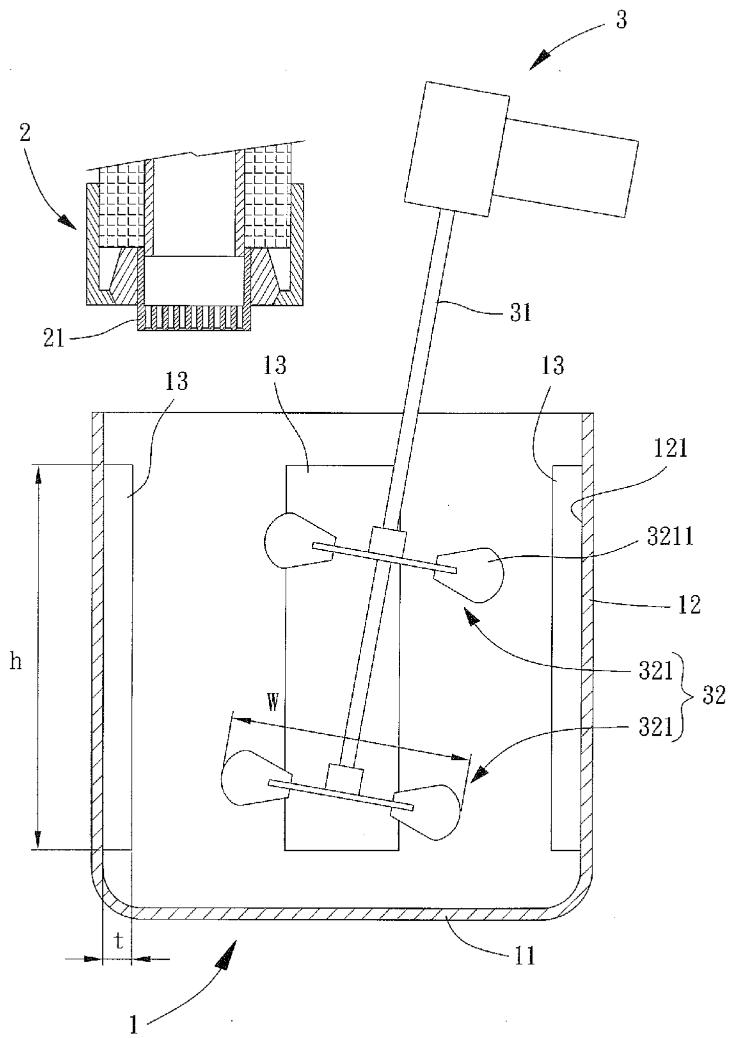
(57) **ABSTRACT**

A microcarrier forming apparatus includes a tank having an inner periphery. A plurality of spoilers is disposed on the inner periphery of the tank. A spray generator includes a spraying end facing an interior of the tank. A stirrer includes a shaft and a fluid driving member. The shaft includes a central axis inclined from a horizontal plane. The fluid driving member is coupled to the shaft and is disposed in the interior of the tank.



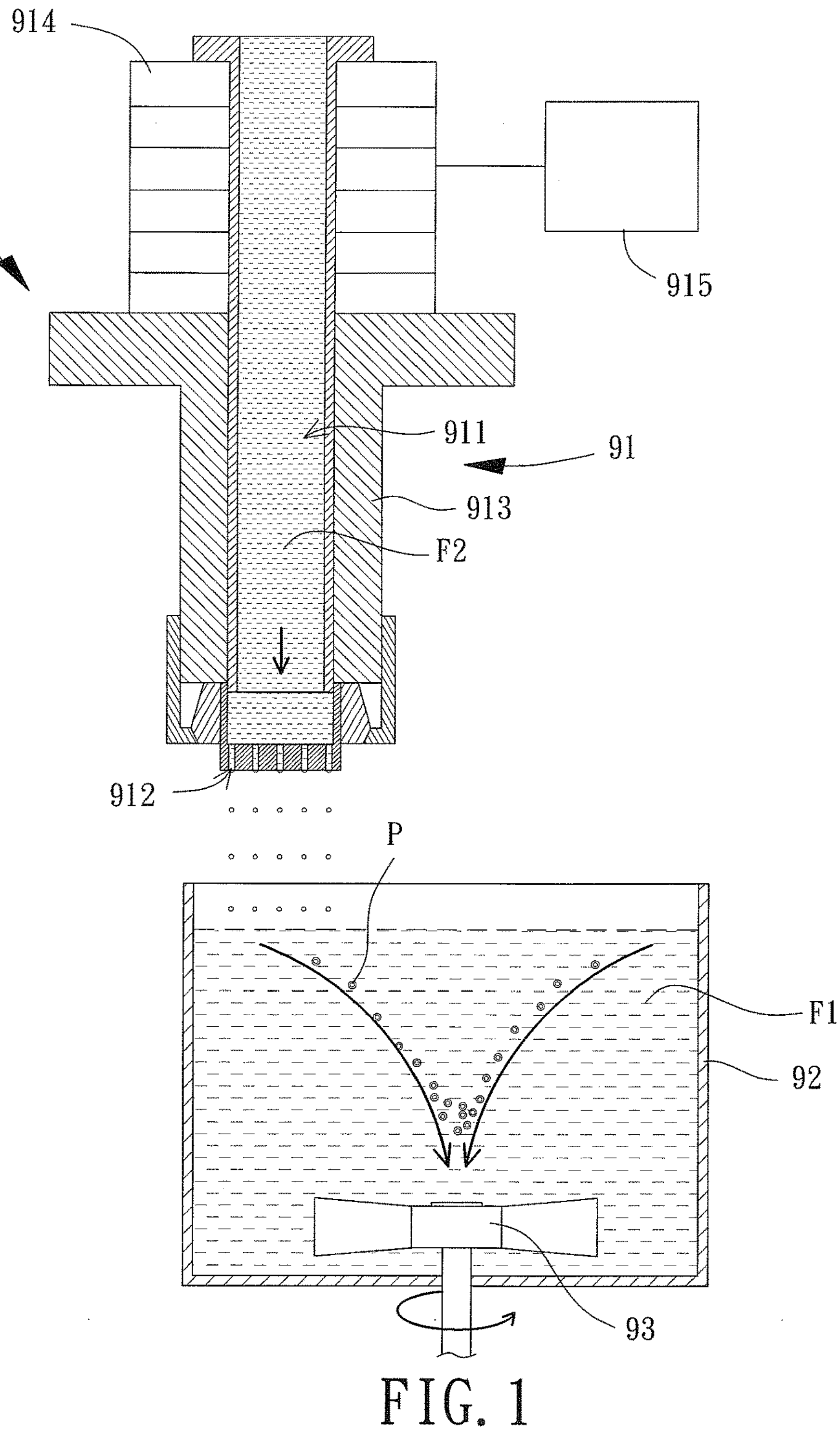



FIG. 1
PRIOR ART

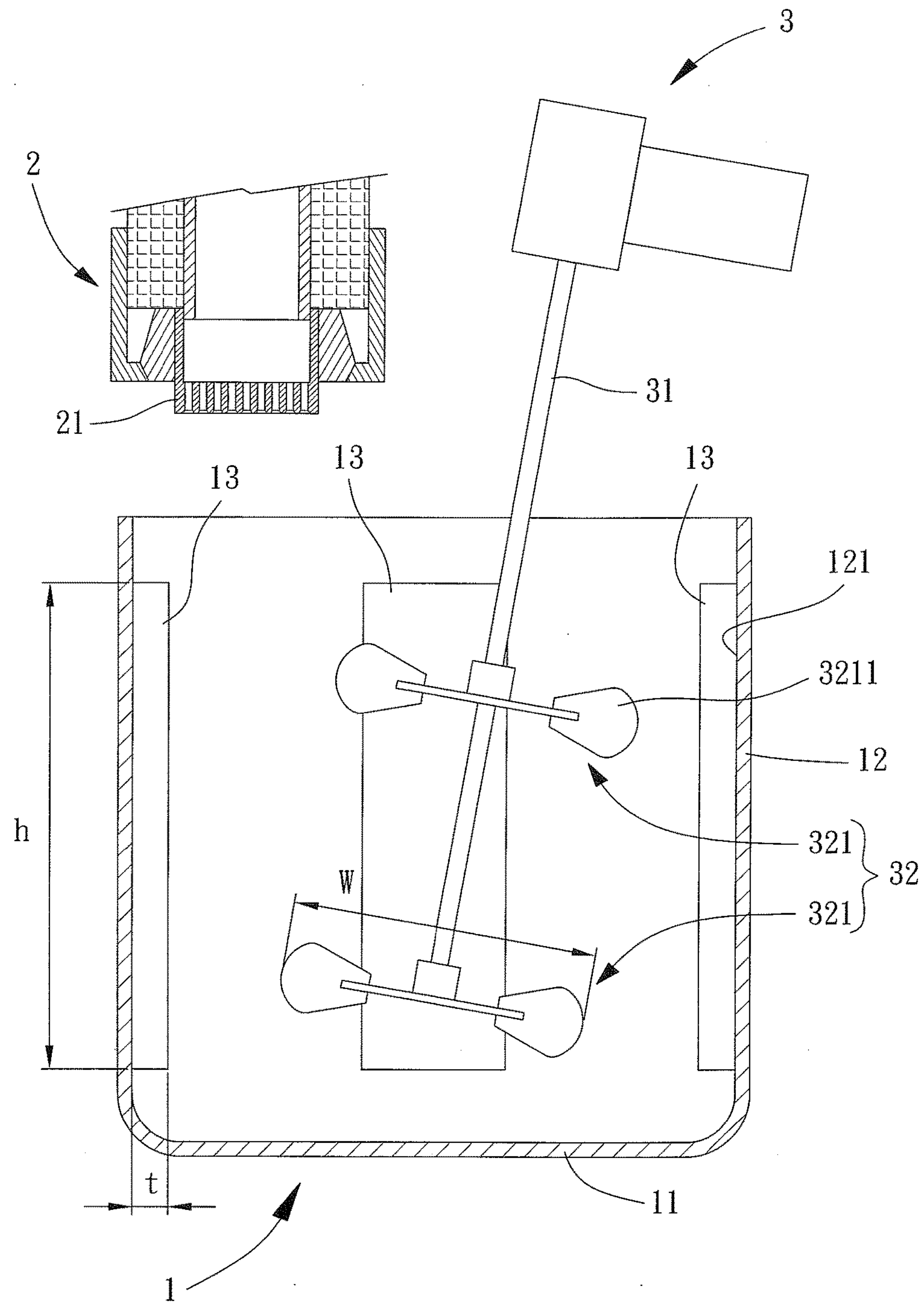



FIG. 2

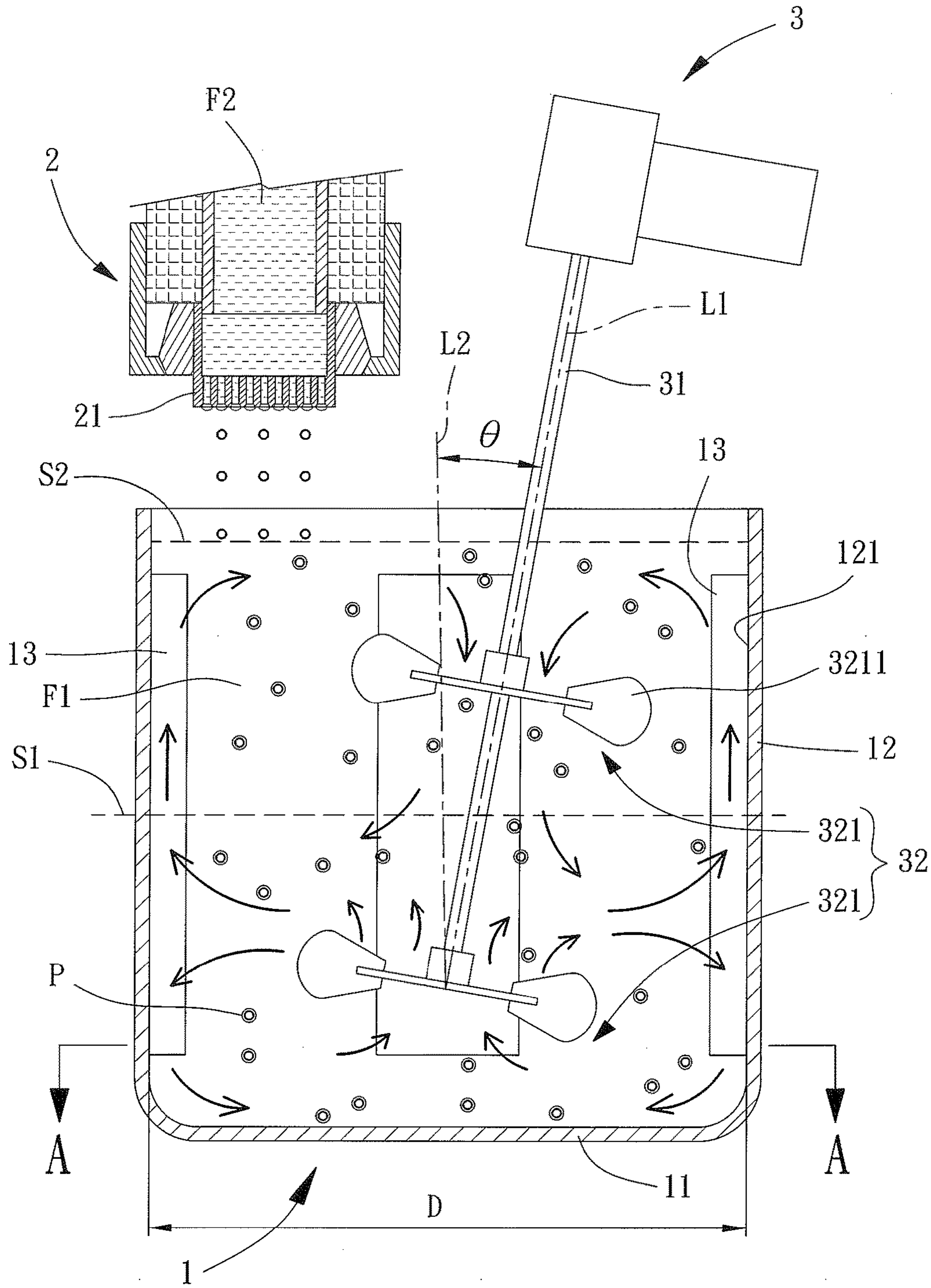



FIG. 3

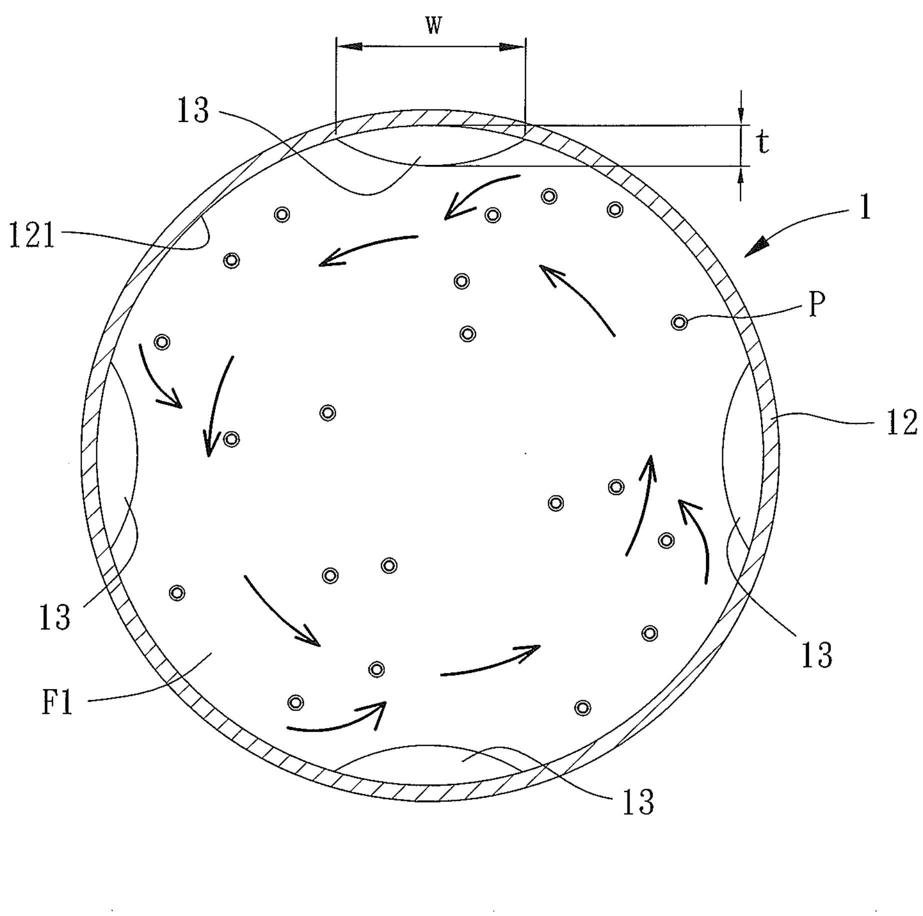



FIG. 4

# MICROCARRIER FORMING APPARATUS

## CROSS REFERENCE TO RELATED APPLICATION

**[0001]** The application claims the benefit of Taiwan application serial No. 106138153, filed on Nov. 3, 2017, and the entire contents of which are incorporated herein by reference.

## BACKGROUND

### 1. Technical Field

**[0002]** The present invention relates to a microcarrier forming apparatus and, more particularly, to a microcarrier forming apparatus for producing microcarriers.

### 2. Description of the Related Art

**[0003]** One of the emerging drug delivery technologies uses microparticles having a diameter ranging from 1 μm to 1000 μm as microcarriers. Since the diameters of the microcarriers are small, the first aim is to form microcarriers of uniform diameters to make each microcarrier have the same drug releasing effect.

**[0004]** Current microcarrier formation techniques for producing microcarriers mainly include emulsification, micro fluid passageways, thermospray, and electrospray. The emulsification technique includes dissolving a polymer in an organic solvent to serve as an oil-phase solution. Then, a water-phase solution is added. After proper stirring, semi-cured spherical microcarriers are formed. However, the microcarriers have diverse diameters after taking shape, and a large quantity of waste material is generated due to poor uniformity in the diameters. The micro fluid passageway technique uses a water-phase solution to shear the oil-phase solution. Although microcarriers of good diameter uniformity are produced, disadvantages including easy formation of a clod of semi-cured microcarriers due to aggregation and adherence, slow formation speed of microcarriers, difficulties in processing the micro fluid passageways, and easy blockage of the micro fluid passageways. The thermospray technique includes heating a polymer into a liquid state which is ejected by high pressure spraying and then cooled by liquefied nitrogen. The liquid phase solution has a high viscosity and, thus, cannot easily form uniform spheres during the high pressure spraying procedure. The electrospray technique uses an electrostatic force, and a capillary nozzle is used to create uniform electrostatic atomization on charged polymer droplets. However, the distance between the semi-cured microcarriers and a collection board is often insufficient, such that the microcarriers hit the collection board at a high speed and cause damage to a surface of the collection board. Furthermore, the high pressure electric field between the conductive capillary tube and the collection board is apt to be interfered by the ambience.

**[0005]** FIG. **1** shows a conventional microcarrier forming apparatus **9** including a spray generator **91**, a tank **92**, and a stirrer **93**. The spray generator **91** includes a fluid passageway **911** having an end with a plurality of fluid outlets **912**. The spray generator **91** further includes an amplifying portion **913**, a piezoelectric portion **914**, and a supersonic wave generator **915**. The amplifying portion **913** and the piezoelectric portion **914** are contiguous to each other and are mounted around the fluid passageway **911**. Furthermore, the amplifying portion **913** is adjacent to the plurality of fluid outlets **912**, and the supersonic wave generator **915** is connected to the piezoelectric portion **914**. The plurality of fluid outlets **912** faces a top opening of the tank **92**. The stirrer **93** is rotatably mounted in the tank **92**. An example of such a microcarrier forming apparatus **9** is disclosed in Taiwan Patent Application No. 105132934 entitled "MICROPARTICLE NOZZLE".

**[0006]** The tank **92** receives a water-phase fluid F**1**. An oil-phase fluid F**2** is filled into the fluid passageway **911** and forms a liquid film at each of the plurality of fluid outlets **912** by the surface tension. Then, the supersonic wave generator **915** is activated to transmit the high frequency electric energy to the piezoelectric portion **914** that coverts the high frequency electric energy into vibrational energy. The vibrational energy is transmitted and amplified by the amplifying portion **913** connected to the piezoelectric portion **914**. The liquid films at the plurality of fluid outlets **912** absorb the vibrational energy until the surface tension is overcome, forming a plurality of microdroplets that falls into the tank **92** and that is enveloped by the water-phase fluid F**1**, thereby forming a plurality of microcarrier semi-product P. After a number of microcarrier semi-products P are accumulated in the tank **92**, the microcarrier semi-products P are collected and dried to evaporate the water-phase fluid F**1** forming the outer layer of each microcarrier semi-product P, obtaining a plurality of microcarrier products merely formed by the oil-phase fluid F**2**. Thus, the conventional microcarrier forming apparatus **9** can mass produce microcarriers of uniform diameters and having an intact appearance.

**[0007]** However, the axis of the stirrer **93** is orthogonal to the liquid surface of the water-phase fluid F**1** in the tank **92** that has a smooth inner periphery. When the stirrer **93** operates, the water-phase fluid F**1** in the tank **91** is apt to create a swirling flow field, such that a number of microcarrier semi-products P are apt to accumulate in a position adjacent to the axis of the stirrer **93**, causing formation of a clod of semi-cured microcarriers due to aggregation and adherence.

**[0008]** In view of the above, improvement to the conventional microcarrier forming apparatuses is necessary.

## SUMMARY

**[0009]** To solve the above problem, the present invention provides a microcarrier forming apparatus that effectively avoids the water-phase fluid from creating the swirling flow field, such that the microcarrier semi-products in the tank can be more uniformly dispersed in the water-phase fluid and is less likely to form a clod of microcarriers due to aggregation and adherence.

**[0010]** A microcarrier forming apparatus according to the present invention includes a tank having an inner periphery. A plurality of spoilers is disposed on the inner periphery of the tank. A spray generator includes a spraying end facing an interior of the tank. A stirrer includes a shaft and a fluid driving member. The shaft includes a central axis inclined from a horizontal plane. The fluid driving member is coupled to the shaft and is disposed in the interior of the tank.

**[0011]** Thus, the microcarrier forming apparatus according to the present invention can effectively avoid the water-phase fluid from creating a swirling flow field, such that the plurality of microcarrier semi-products can be more uniformly dispersed in the water-phase fluid and is less likely

to form a clod due to aggregation and adherence. This assures that the plurality of microcarrier products has more uniform diameters and has an integral appearance, increasing the yield of the microcarriers.

**[0012]** In an example, the plurality of spoilers includes an even number of spoilers that are symmetrically disposed to increase stirring uniformity of the water-phase fluid.

**[0013]** In an example, the spray generator includes an equipment using supersonic wave energy to create a standing wave effect to thereby induce an oriented microdroplet spray. Thus, the oil-phase fluid can be ejected by the spray generator as microdroplets in a soft spray at a low speed towards the water-phase fluid in the tank, increasing the integrity of the appearance of the microcarriers.

**[0014]** In an example, the tank includes a bottom board, each of the plurality of spoilers has a vertical height, and a reference plane passes through a half of the vertical height of each of the plurality of spoilers. The fluid driving member includes two blade units. One of the two blade units is disposed between the bottom board and the reference plane, and another of the two blade units is disposed above the reference plane, increasing the stirring uniformity of the water-phase fluid.

**[0015]** In an example, each of the plurality of spoilers has a maximum thickness in a radial direction toward a central axis of the tank, and a ratio of the vertical height of each of the plurality of spoilers to the maximum thickness is in a range between 6.5 and 7.5, increasing the stirring uniformity of the water-phase fluid.

**[0016]** In an example, a ratio of a maximum width of each of the plurality of spoilers to the maximum thickness is in a range between 3 and 5 to increase the stirring uniformity of the water-phase fluid.

**[0017]** In an example, each of the two blade units includes a central portion coupled to the shaft and a plurality of blades disposed on an outer periphery of the shaft at regular angular intervals, increasing the stirring uniformity of the water-phase fluid.

**[0018]** In an example, the tank has an inner diameter, each of the two blade units has a maximum span, and a ratio of the maximum span to the inner diameter is in a range between 0.35 and 0.45, increasing the stirring uniformity of the water-phase fluid.

**[0019]** In an example, the shaft rotates at a speed of 100-500 rpm, increasing the stirring uniformity of the water-phase fluid.

**[0020]** In an example, the tank includes a vertical axis coplanar to the central axis of the shaft, the vertical axis is at an angle to the central axis, and the angle is not equal to 0°. This avoids the water-phase fluid from creating a swirling flow field.

**[0021]** In an example, the angle is between 5° and 45° to increase the stirring uniformity of the water-phase fluid

**[0022]** The present invention will become clearer in light of the following detailed description of illustrative embodiments of this invention described in connection with the drawings.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0023]** FIG. **1** is a diagrammatic view of a conventional microcarrier forming apparatus.

**[0024]** FIG. **2** is a diagrammatic view of a microcarrier forming apparatus of an embodiment according to the present invention.

**[0025]** FIG. **3** is a diagrammatic view illustrating operation of the microcarrier forming apparatus of FIG. **2**.

**[0026]** FIG. **4** is a cross sectional view taken along section line A-A of FIG. **3**.

## DETAILED DESCRIPTION

**[0027]** With reference to FIGS. **2** and **3**, a microcarrier forming apparatus of an embodiment according to the present invention includes a tank **1**, a spray generator **2**, and a stirrer **3**. The tank **1** receives a water-phase fluid F**1**. The spray generator **2** ejects an oil-phase fluid F**2** into the water-phase fluid F**1** in the tank **1**. The stirrer **3** stirs the water-phase fluid F**1** in the tank **1**.

**[0028]** The type of the tank **1** receiving the water-phase fluid F**1** is not limited. In this embodiment, the tank **1** includes a bottom board **11** and an annular wall **12** connected to the bottom board **11**, with the bottom board **11** and the annular wall **12** together defining a space for receiving the water-phase fluid F**1**. A plurality of spoilers **13** is mounted in the tank **1** and can be disposed on the inner periphery of the tank **1**. Preferably, an even number of spoilers **13** is symmetrically disposed.

**[0029]** The spray generator **2** can be an equipment that uses a standing wave effect (capillary waves) to induce an oriented microdroplet spray. In a non-restrictive example, the spray generator **2** uses supersonic wave energy to provide the standing wave effect. The spray generator **2** receives the oil-phase fluid F**2** and includes a spraying end **21** facing an interior of the tank **1**. Namely, the spraying end **21** of the spray generator **2** and the fluid level of the water-phase fluid F**1** in the tank **1** can have a fixed spacing therebetween to permit spraying of oil-phase microdroplets into the water-phase fluid F**1**. Alternatively, the spraying end **21** of the spray generator **2** extends into water-phase fluid F**1** and is immersed in the water-phase fluid F**1**, such that the oil-phase microdroplets can be directly ejected in the water-phase fluid F**1**.

**[0030]** It is particularly noted that the number of the nozzles of the spraying end **21** of the spray generator **2** is not limited in the present invention, and the spraying end **21** can be of a planar type permitting installation of a number of nozzles or a conic type permitting installation of a single nozzle. Thus, the spraying end **21** is not limited to the type illustrated in the drawings.

**[0031]** The stirrer **3** includes a shaft **31** and a fluid driving member **32**. The fluid driving member **32** is coupled to the shaft **31** and is mounted in the tank **1**. The shaft **31** drives the fluid driving member **32** to rotate to thereby stir the water-phase fluid F**1** in the tank **1**. The type of the fluid driving member **32** is not limited in the present invention. For example, the fluid driving member **32** includes two blade units **321**. Each of the two blade units **321** includes a central portion coupled to the shaft **31** and a plurality of blades **3211** disposed on an outer periphery of the shaft **31**. Preferably, each of the two blade units **321** includes 2-4 blades disposed on the outer periphery of the shaft **31** at regular angular intervals. Furthermore, each of the plurality of spoilers **13** has a vertical height h. A reference plane S**1** passes through a half of the vertical height h of each of the plurality of spoilers **13**. One of the two blade units **321** is disposed between the bottom board **11** and the reference plane S**1**, and the other blade unit **321** is disposed above the reference plane S**1**, increasing stirring uniformity of the water-phase fluid F**1**.

[0032] Furthermore, the shaft **31** includes a central axis L**1** inclined from a horizontal plane S**2**. Namely, the tank **1** includes numerous vertical axes L**2**. After the shaft **31** of the stirrer **3** is inserted into to the interior of the tank **1**, the central axis L**1** of the shaft **31** is coplanar to one of the vertical axes L**2**. When installing or operating the stirrer **3**, the central axis L**1** should be an angle θ to the vertical axes L**2** to obliquely extend the shaft **31** through the water-phase fluid F**1**, with the angle θ being not equal to 0°.

[0033] With reference to FIGS. **3** and **4**, in use of the microcarrier forming apparatus of the embodiment, the oil-phase fluid F**2** is ejected by the spray generator **2** as microdroplets in a soft spray at a low speed towards the water-phase fluid F**1** in the tank **1**. The water-phase fluid F**1** envelops the microdroplets of the oil-phase fluid F**2** to form a plurality of microcarrier semi-products P in the tank **1**. Each of the plurality of microcarrier semi-products P includes an inner layer formed by the oil-phase fluid F**2** and an outer layer formed by the water-phase fluid F**1**.

[0034] By using the shaft **31** inclinedly disposed in the water-phase fluid F**1** to drive the fluid driving member **32** to rotate, the water-phase fluid F**1** can be continuously stirred without creating a swirling flow field. Furthermore, the plurality of spoilers **13** in the tank **1** creates a stir to the whole flow field, guides the water-phase fluid F**1** to form a plurality of vertical flow fields, and guides the ambient water-phase fluid F**1** to flow towards the center. Thus, the plurality of microcarrier semi-products P can be more uniformly dispersed in the water-phase fluid F**1** and is less likely to form a clod due to aggregation and adherence.

[0035] Finally, the plurality of microcarrier semi-products P is collected and dried by hot air and/or other provisions to evaporate the outer layers formed by the water-phase fluid F**1**, forming a plurality of microcarrier products merely formed by the oil-phase fluid F**2**. The plurality of microcarrier products has more uniform diameters and has an integral appearance.

[0036] With reference to FIGS. **2** and **4**, to assure an excellent stirring effect of the water-phase fluid F**1**, the tank **1**, the spray generator **2**, and the stirrer **3** of this embodiment are arranged as follows: the angle θ is between 5° and 45°, the rotating speed of the shaft **31** is 100-500 rpm, the tank **1** receives about 1-100 liters of water-phase fluid F**1** and has an inner diameter D, each of the two blade units **321** has a maximum span W, and a ratio (W/D) of the maximum span W to the inner diameter D is in a range between 0.35 and 0.45. The number of the spoilers **13** is four (4), and the spoilers **13** are disposed on the inner periphery **121** of the annular wall **12** at regular angular intervals. Each spoiler **13** has a maximum thickness t in a radial direction toward a central axis of the tank **1**, a ratio (h/t) of the vertical height h of each of the plurality of spoilers **13** to the maximum thickness t is in a range between 6.5 and 7.5, and a ratio of a maximum width w of each of the plurality of spoilers **13** to the maximum thickness is in a range between 3 and 5.

[0037] In view of the foregoing, by using the shaft **31** inclinedly disposed in the water-phase fluid F**1** and cooperating the spoilers **13** stirring the flow field, the microcarrier forming apparatus according to the present invention can effectively avoid the water-phase fluid F**1** from creating a swirling flow field, such that the plurality of microcarrier semi-products P can be more uniformly dispersed in the water-phase fluid F**1** and is less likely to form a clod due to aggregation and adherence. This assures that the plurality of microcarrier products has more uniform diameters and has an integral appearance, increasing the yield of the microcarriers.

[0038] Thus since the invention disclosed herein may be embodied in other specific forms without departing from the spirit or general characteristics thereof, some of which forms have been indicated, the embodiments described herein are to be considered in all respects illustrative and not restrictive. The scope of the invention is to be indicated by the appended claims, rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are intended to be embraced therein.

What is claimed is:

**1**. A microcarrier forming apparatus comprising:

a tank including an inner periphery, wherein a plurality of spoilers is disposed on the inner periphery of the tank;

a spray generator including a spraying end facing an interior of the tank; and

a stirrer including a shaft and a fluid driving member, wherein the shaft includes a central axis inclined from a horizontal plane, and wherein the fluid driving member is coupled to the shaft and is disposed in the interior of the tank.

**2**. The microcarrier forming apparatus as claimed in claim **1**, wherein the plurality of spoilers includes an even number of spoilers, and wherein the even number of spoilers are symmetrically disposed.

**3**. The microcarrier forming apparatus as claimed in claim **1**, wherein the spray generator includes an equipment using supersonic wave energy to create a standing wave effect to thereby induce an oriented microdroplet spray.

**4**. The microcarrier forming apparatus as claimed in claim **1**, wherein the tank includes a bottom board, wherein each of the plurality of spoilers has a vertical height, wherein a reference plane passes through a half of the vertical height of each of the plurality of spoilers, wherein the fluid driving member includes two blade units, wherein one of the two blade units is disposed between the bottom board and the reference plane, and wherein another of the two blade units is disposed above the reference plane.

**5**. The microcarrier forming apparatus as claimed in claim **4**, wherein each of the plurality of spoilers has a maximum thickness in a radial direction toward a central axis of the tank, and wherein a ratio of the vertical height of each of the plurality of spoilers to the maximum thickness is in a range between 6.5 and 7.5.

**6**. The microcarrier forming apparatus as claimed in claim **5**, wherein a ratio of a maximum width of each of the plurality of spoilers to the maximum thickness is in a range between 3 and 5.

**7**. The microcarrier forming apparatus as claimed in claim **4**, wherein each of the two blade units includes a central portion coupled to the shaft and a plurality of blades disposed on an outer periphery of the shaft at regular angular intervals.

**8**. The microcarrier forming apparatus as claimed in claim **4**, wherein the tank has an inner diameter, wherein each of the two blade units has a maximum span, and wherein a ratio of the maximum span to the inner diameter is in a range between 0.35 and 0.45.

**9**. The microcarrier forming apparatus as claimed in claim **1**, wherein the shaft rotates at a speed of 100-500 rpm.

**10**. The microcarrier forming apparatus as claimed in claim **1**, wherein the tank includes a vertical axis coplanar to the central axis of the shaft, wherein the vertical axis is at an angle to the central axis, and wherein the angle is not equal to 0°.

**11**. The microcarrier forming apparatus as claimed in claim **10**, wherein the angle is between 5° and 45°.

* * * * *