A Cyclone Generator for Simulating Tornados' Travel Path

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1 Background and Significance of the Invention

Tornadoes, characterized by fast moving speed and complicated traveling pattern, are cyclone storms with high intensity and small scale, which may cause serious damage to the floor area where they passes by. The formation and development of tornadoes relate to complicated meteorological conditions such as atmospheric temperature, humidity, and airflow disturbances. A tornado will travel on the ground under the effect of an external wind field when it becomes strong enough. The prediction of the tornado's trail has always been a difficulty for scientists to tackle. Theoretical analysis, numerical simulation, and field observation are major approaches for studying the tornado. However, there is not a complete set of cyclone generator that can be utilized in the laboratory to study the travel path of a tornado through simulation and quantitative observance. Therefore, the inventors attempted to explore relevant problems of the tornado's travel path through experiments, simulate the wind field of the tornado and observe its travel path under the wind tunnel condition in the laboratory through organically combining theoretical derivation with experiments, accumulating significant experimental data and theoretical basis for addressing practical problems of meteorological disasters.

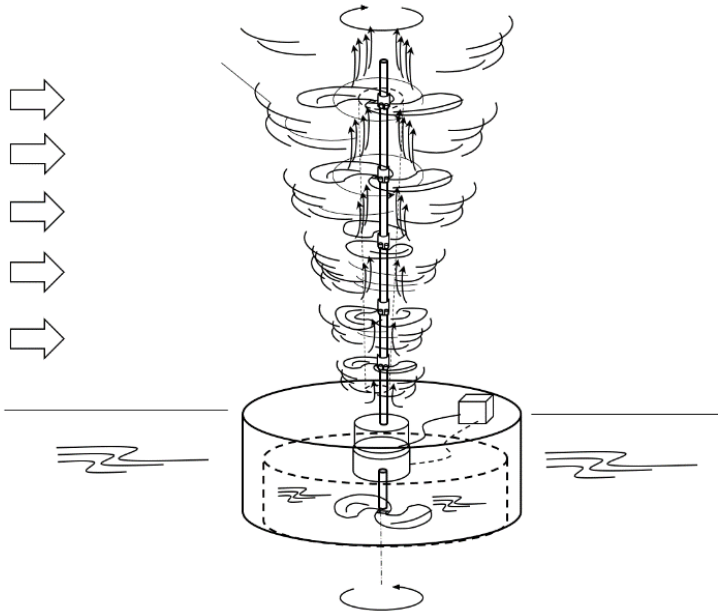
This invention is a cyclone generator for simulating a tornado, which can be utilized to study the variation law of a tornado's travel path. Consisting of an air impeller rotation system, a floating support base, an underwater impeller rotation system, and a power source and a controller, the invention can generate a funnel-shaped air cyclone and a hollow updraft, and be placed on the water surface and in a floating state, which can also simulate the travel path of tornado in the environment of the wind field under an ideal condition. When a variety of test parameters such as funnel-shaped dimension, rotational velocity, and wind velocity in the wind field, etc., are varied, the law of the tornado's travel path will be systematically tested or simulated with the present invention.

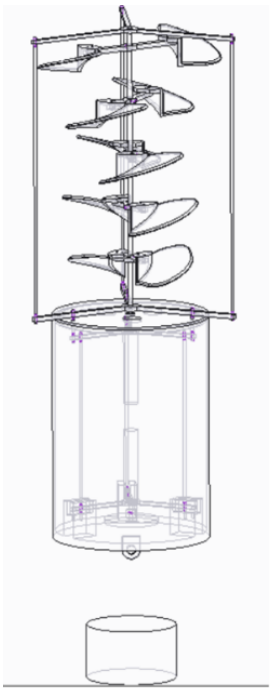
The invention can be operated in an open-loop mode and in a closed-loop mode. In the closed-loop mode, the wind field generated by the invention is stable and conforms to the preset values in the experiment. Apparatus operating data are sent to the host by means of a wireless device (or a wire) for real-time monitoring. A camera is installed on the top of the wind tunnel to record the travel trajectory of the invention in the experiment process. The travel trajectory recorded is then transferred to the host. Each frame of the returned video data is intercepted every second and analyzed with MATLAB to study the trajectory law of the real tornado on the basis of uncovering the trajectory law of the tornado simulator.

2 Brief Summary of the Invention

The cyclone generator is comprised of an air impeller rotation system, a floating support base, an underwater impeller rotation system and a controller; each pair of impellers of an air impeller assembly includes two blades, whose radius are increased linearly along the height and fixed at different height positions of the rotating main shaft of the air impeller. An angle difference to be initially disposed can be found between each pair of impellers. Moreover, an installation interstice is set between the root of the impeller and the rotating main shaft, forming an updraft channel centered at the rotating main shaft. Meanwhile, the underwater rotating part is connected to the rotating main shaft and the drive motor of the underwater impeller; and rotating main shafts of the air impeller rotation system and the underwater impeller rotation system are rotated reversely along the same axis, resulting in the overall rotational momentum of the device approaching zero, that is, no rotation occurs at the cavity. Therefore, the cyclone generator herein can generate a funnel-shaped cyclone and updraft and simulate the tornado's travel path upon being placed on the water surface under the effect of the wind field.

3 Schematic Pictures of the Invention





Air impeller rotation system

Control system

Floating support base

Balance rotation system

Bob-weight

4 Technical Scheme and Innovation Highlights of the Invention

Based on the experimental study of the tornado’s travel path in a certain wind field, this invention illustrates a cyclone generator that simulates the travel path of a tornado in motion.

The technical scheme of the invention is presented as follows:

The cyclone generator herein for simulating the tornado's travel path is advantageous because the cyclone simulator consists of an air impeller rotation system, a floating support base, an underwater impeller rotation system, and a controller; the air impeller rotation system is composed of an air impeller assembly and a rotation driving motor of the air impeller, and a rotating main shaft of the air impeller; each pair of impellers of the air impeller assembly is fixed at different height positions of the rotating main shaft of the air impeller; and an updraft can be generated by the blade of the air impeller under rotation; the lower end of the rotating main shaft of the air impeller is fixed to the rotating driving motor of the air impeller. The underwater impeller rotation system includes an underwater impeller, a rotation driving motor of the underwater impeller, a rotating main shaft of the underwater impeller; the underwater impeller is fixed to the lower end of the rotating main shaft of the underwater impeller, while the upper end of the rotating main shaft of the underwater impeller is fixed to the rotating shaft of the motor driven by the rotation of the underwater impeller. And drive motors of the air impeller and the underwater impeller in the enclosed cavity of the base are fixed on the upper and lower surfaces of the enclosed cavity of the base, respectively. Rotating main shafts of the air impeller and the underwater impeller are along the same axis. Drive motors rotated by the air impeller and by the underwater impeller are connected to the power and the controller by means of wires.

The present invention is technically characterized by each pair of impellers of the air impeller assembly including and arranging two blades symmetrically, the radius of each pair of impellers increasing linearly along the height direction, and the angular difference between the initial installation angle of the last pair and the next pair of impellers being linearly related.

The present invention is technically characterized by each pair of impellers of the air impeller assembly being connected to the rotating main shaft through a connecting rod at the root of the impeller, and the installation interstice at the root of the impeller increasing linearly along the height

direction, forming an upward airflow channel along the rotating main shaft.

Theoretical analysis, numerical simulation, and field observation are major approaches for studying the tornado. Whereas, there isn't a complete set of cyclone generator that can be utilized in the laboratory to study the travel path of a tornado through simulation and quantitative observance. Researches are incapable of carrying out quantitative experiments under the circumstance, hindering the research process to some extent. Thereby, in comparison to the existing method of tornado study, the present invention is characterized and highlighted as follows: ①It is a complete set of inventions for physical simulation test to simulate, observed, and measure the travel path of a tornado in an ideal wind field. ②The invention is provided with a funnel-shaped air cyclone and updrafts along the central axis area, which is close to the airflow state of a real tornado. ③The invention herein is provided with a reverse rotation system of the underwater impeller to balance the rotating torque generated by the air impeller rotation system, maintaining the whole cyclone simulator in a self-balancing state. ④The generator that is placed on the water surface in the test can move freely on the water surface under the effect of the wind field, which can show the tornado's travel path.⑤Adjusting parameters, such as the impeller dimension, the impeller deflection angle, the dimension of the updraft channel, and the rotation speed of the generator can systematically study the tornado's travel law. ⑥Production, installation and operation of the invention are user-friendly with high reliability in the test system.

5 Detailed Description of the Mechanical Device

The present invention will now be described by referring to the attached illustration below that shows the preferred embodiment of the invention:

FIG 1 in part 6 shows a front view of a cyclone generator that can simulate the travel path of a tornado, which is provided by the present invention. The said invention comprises an air impeller rotation system **1**, a floating support base **2**, an underwater impeller rotation system **3**, and a controller **2a**. The air impeller rotation system **1** includes an air impeller assembly **6**, an air impeller rotation driving motor **4**, and an air impeller rotating main shaft **5**. Each pair of impellers of the air impeller

assembly **6** is fixed at different height positions of the air impeller rotating main shaft **5**, and an updraft can be generated by the blade of the impeller during rotating. The lower end of the air impeller rotating main shaft **5** is fixed to the rotating shaft of the air impeller rotation driving motor **4**. The underwater impeller rotation system **3** is composed of an underwater impeller **9**, an underwater impeller rotation driving motor **7**, and an underwater impeller rotating main shaft **8**. The underwater impeller **9** is fixed to the lower end of the underwater impeller rotating main shaft **8**, and the upper end of the underwater impeller rotating main shaft **8** is fixed to the rotating shaft of the underwater impeller rotation driving motor **7**.

FIG. 2 is a cutaway view of the floating support base of the cyclone generator. The air impeller driving motor **4** and the underwater impeller drive motor **7** in the enclosed cavity **2b** of the base are fixed on the upper and lower surfaces of the enclosed cavity **2b** of the base, respectively. The air impeller rotating main shaft **5** and the underwater impeller rotating main shaft **8** are along the same axis; and the air impeller rotation driving motor **4** and the underwater impeller rotation driving motor **7** are connected to the controller **2a** through wires.

FIG. 3 is a schematic diagram of the air impeller rotation system of the cyclone generator. Each pair of impellers of the air impeller assembly **6** includes two symmetrically-arranged blades. The deflection angle **19** of the impeller at the first stage is equivalent to the angle of the baseline **18** arranged in the impeller, being α_1, while the initial installation angle **20** of the ith pair of impellers is linearly associated with the angle difference between the next pair of impellers, i.e., $\alpha_i = \lambda \omega H_i$, thereof, H_i is the distance between the ith pair of impellers and the next pair; ω is the rotating angular velocity; λ is the impeller rotation vertical airflow coefficient. The outer diameter envelope **17** of the impeller can be formed after the impeller rotation.

FIG. 4 is a schematic diagram presenting the dimension of the ith-stage impeller of a cyclone generator and its root connection. The radius of each pair of impellers of the air impeller assembly **6** is increased linearly along the height direction, that is, the radius of the ith pair of impellers is $R_i = kH_i + R_{i-1}$, thereof, k is the slope of the funnel-shaped air cyclone; H_i is the distance between the ith pair and the next pair of impellers; and R_{i-1} is the radius of the next pair of impellers. Each pair of impellers of the air impeller assembly **6** is connected to the rotating main shaft **5** via the connecting rod **23** at the impeller root. Moreover, the installation distance **22** of the impeller root increases linearly along the height direction, that is, $r_i = kH_i + r_{i-1}$, thereof, r_i is the installation distance between

the roots of the impellers, and r_{i-1} is the installation distance between the roots of the next pair of impellers. The cyclone generator is rotated, forming a funnel-shaped air cyclone that rotates along the impeller rotation direction **10**, and an updraft channel **16** along the rotating main shaft **5** in the middle of the rotation axis.

In the embodiment of the cyclone generator provided hereof, first of all, the generator is placed into the water, which can be floated on the water surface **13** due to the buoyancy generated by the hollow and enclosed structure of the floating support base **2**. The weight of the entire cyclone generator should be matched with the buoyancy of the floating support base, so that the upper surface of the floating support base is awash. Hereupon, the air impeller rotation driving motor **4** is turned on to drive the air impeller rotation system **1**, forming a cyclone in accordance with the rotation direction **10**. Meanwhile, the underwater impeller rotation driving motor **7** is also turned to form a reverse rotation system in accordance with the rotation direction **11**. The speed of the driving motor **7** is adjusted to balance the torque generated by the rotation of the air impeller rotation system **1**. Heretofore, the floating support base **2** remains stationary on the water surface. Next, a constant wind field is turned on to obtain a stable atmospheric wind direction **12**. The travel path of the generator can be observed and measured when the atmospheric wind field acts on the rotated generator. Modifying parameters such as the dimension, the deflection angle of the impeller, the dimension of the updraft channel, and the rotation speed, etc. can systematically study the travel law of tornado.

6 Attached Illustrations

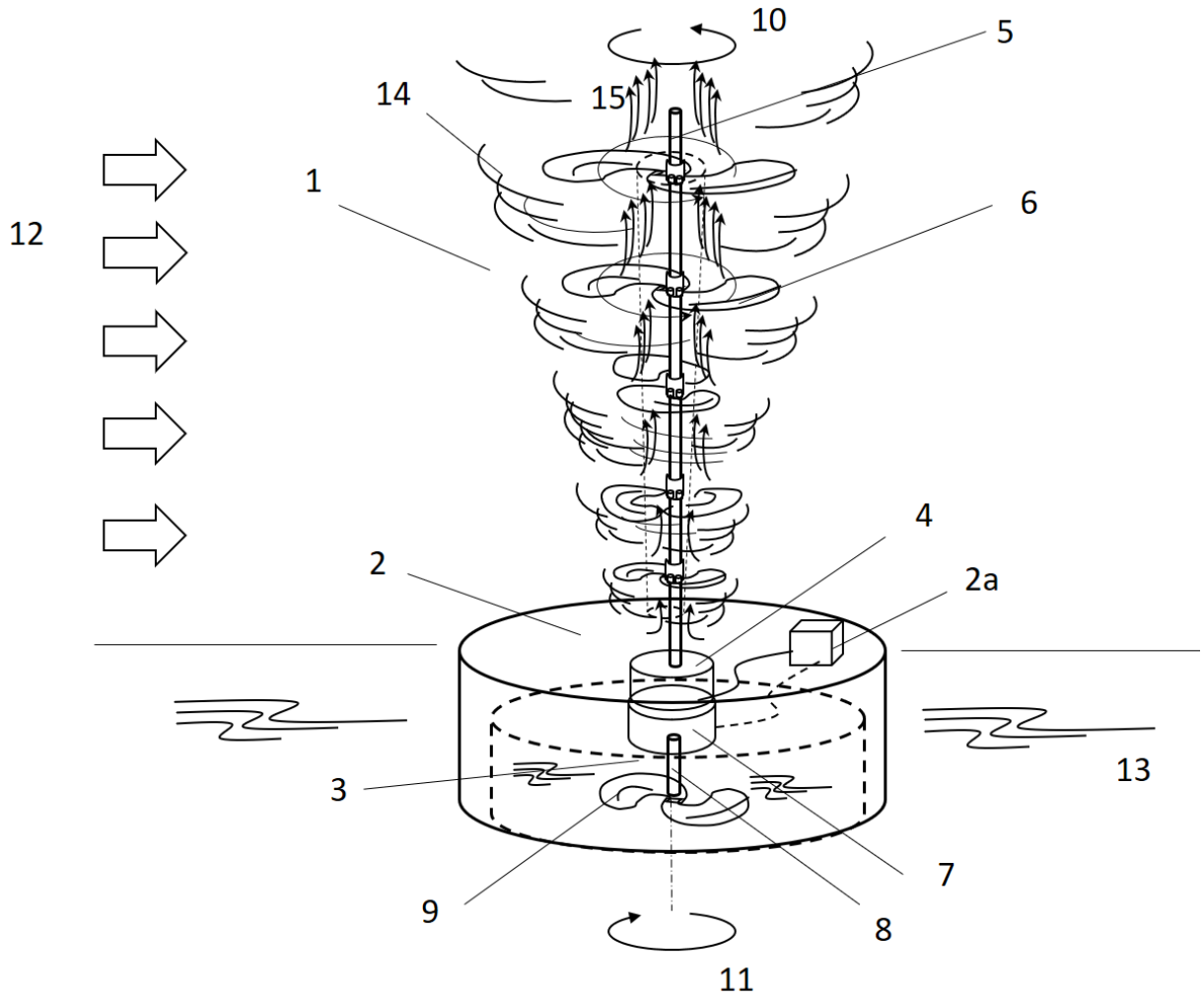


FIG. 1

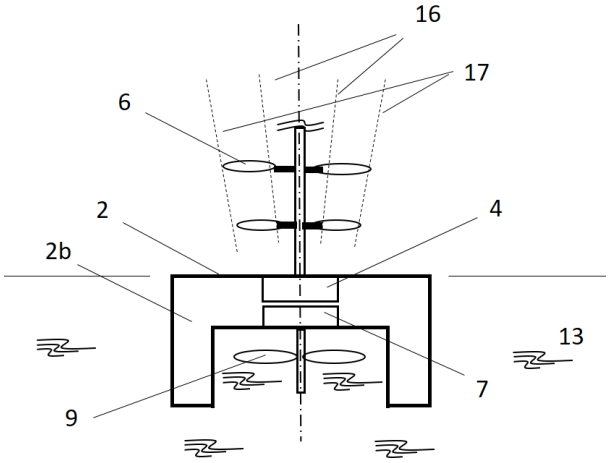


FIG. 2

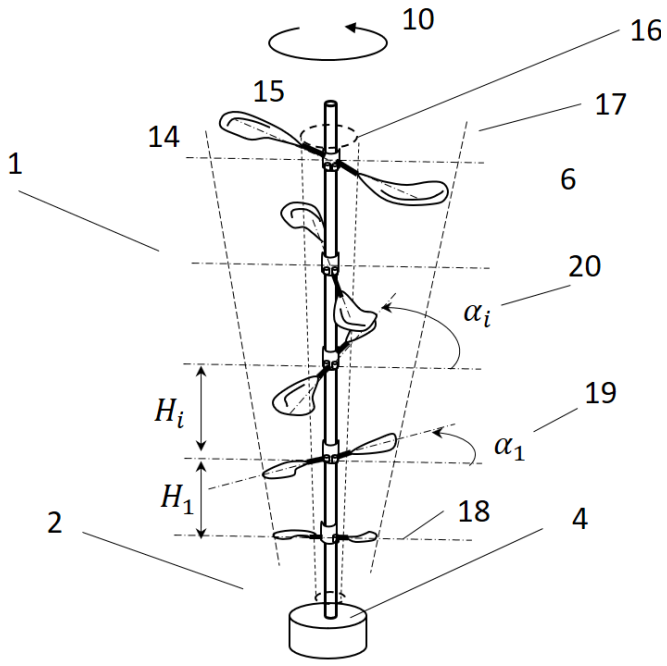


FIG. 3

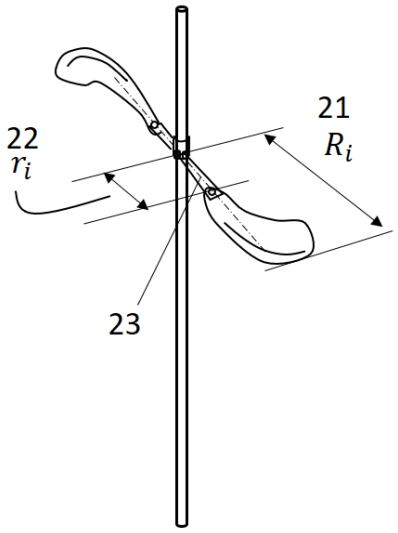


FIG. 4