Dec. 15, 1959 W. H. A. BOYD 2,917,255

SELF-REGULATING ROTOCHUTE

Filed Aug. 1, 1958 2 Sheets-Sheet 1

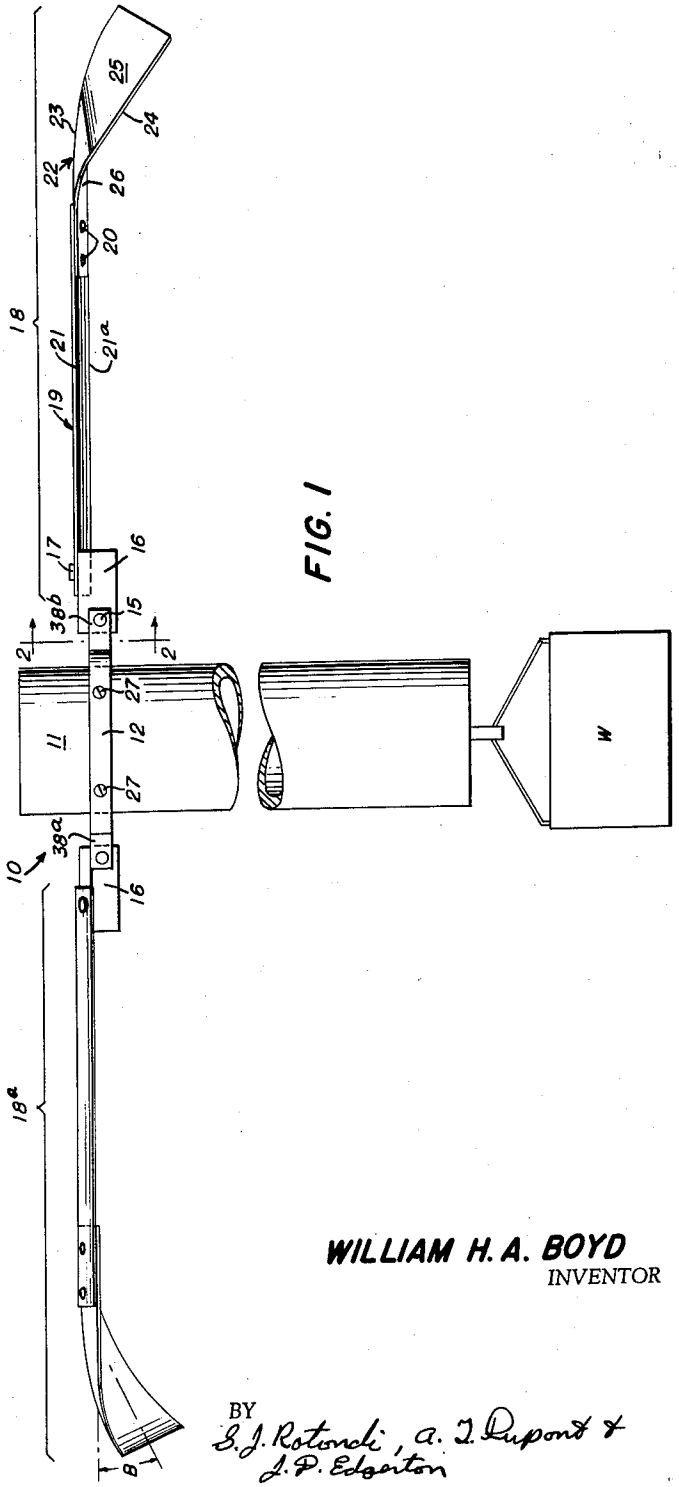


FIG. 1

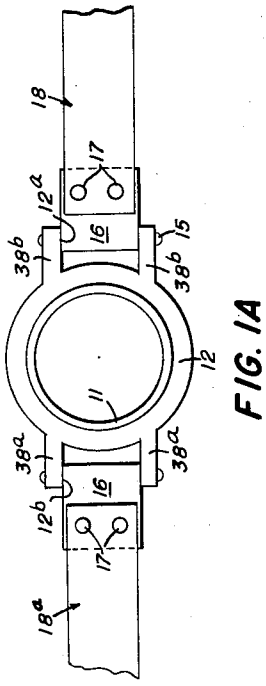


FIG. 1A

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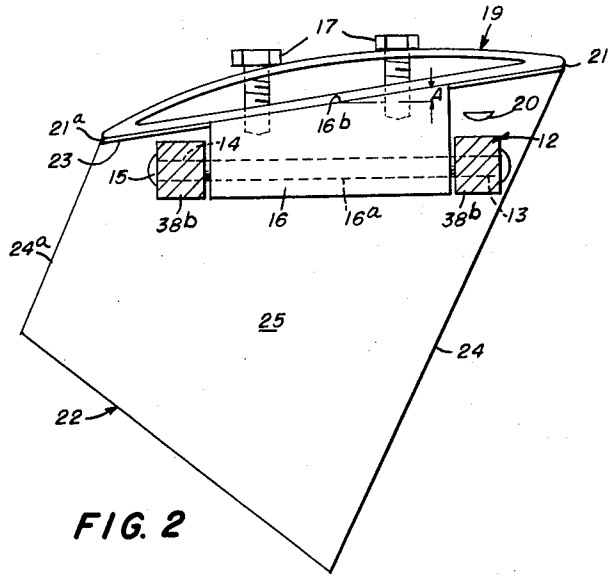


FIG. 2

FIG. 3

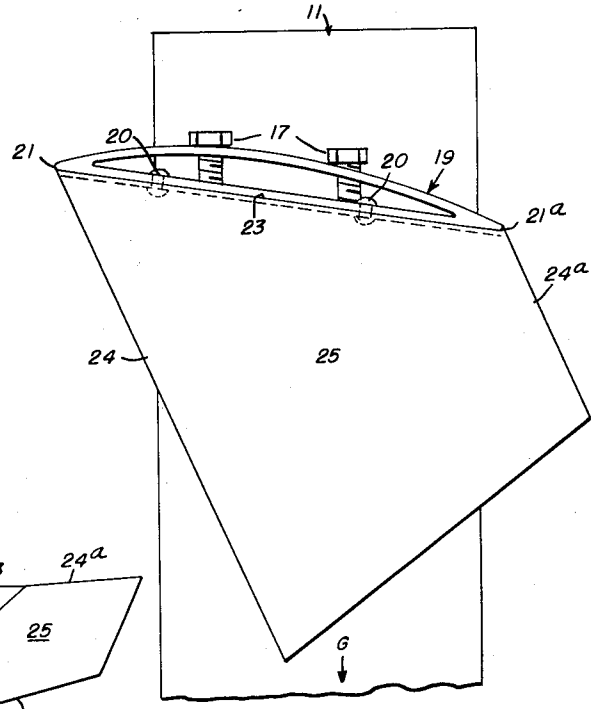
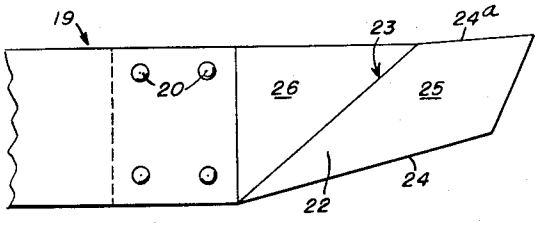


FIG. 4



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SELF-REGULATING ROTOCHUTE

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Application August 1, 1958, Serial No. 752,676

3 Claims. (Cl. 244—138)

(Granted under Title 35, U.S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the Government for governmental purposes without the payment to me of any royalty thereon.

This invention relates to an improved rotochute having blades with self-regulating speed characteristics.

In general, rotochutes have found extensive use in air-dropping supplies, bombs and other objects. This is because rotochutes fall almost vertically from the point of air drop, thereby making possible accurate aiming of the object to be dropped.

Rotochutes incorporate a plurality of blades which are adapted to rotate and provide lift as the rotochute falls through the air, thus slowing the rate of descent. It is of considerable importance that the blades reach a high rotational speed as soon as possible after the rotochute is dropped so that an immediate lift can be created by the blades. This will prevent the rotochute from attaining a high initial speed of descent which is hard to reduce.

It is also important that the blades not be permitted to reach excessively high rotational speeds during the drop which would damage or break-up the rotochute because of the severe centrifugal forces developed.

Prior art rotochutes ordinarily incorporate a high blade pitch to produce a relatively high initial blade rotational speed. To prevent this relatively high pitch from producing excessive blade rotational speeds, governor-type devices responsive to the centrifugal forces produced by the blades have been used to keep the blade rotational speeds at a safe value. These devices add undesirable weight to the rotochute and greatly increase the cost and complexity of the resulting rotochute.

Accordingly, it is a principal object of this invention to provide an improved rotochute which is cheap, simple, and easy to manufacture.

It is a further object to provide an improved rotochute having blades with self-regulating speed characteristics adapted to rapidly achieve a high initial rotational speed, and at the same time being self-regulating so that the blades do not attain excessive rotational speeds during the drop.

The rotochute in accordance with this invention achieves the above objects by the use of blades having a variable pitch produced by a flexible bent strip of material provided at the end portion of the blade. The flexible strip is adapted to provide a high initial blade pitch for producing a large initial torque so as to rapidly bring the blades up to speed. As the blades speed up, the centrifugal forces produced by blade rotation act on the flexible strip reducing blade pitch. By suitable design of the flexible strip, therefore, the blades may be prevented from reaching an excessive speed.

The specific nature of the invention, as well as other objects, uses and advantages thereof, will clearly appear from the following description and from the accompanying drawing, in which:

Figure 1 shows a side elevation of the rotochute in accordance with this invention.

Figure 1A is a partial plan view of the center portion of Figure 1.

Figure 2 is a sectional view taken along lines 2—2 of Figure 1.

Figure 3 is an end view of the upper portion of the rotochute shown in Figure 1.

Figure 4 is a plan view of a portion of the end of a blade showing the flexible impeller.

In Figure 1, a rotochute **10**, is in substantially the position it assumes when dropped from a height. The object W which is to be supported in descent is fastened to cylindrical tube **11** in any convenient manner. A generally cylindrical collar **12** is coaxially and rotatably connected to tube **11** and may be locked to tube **11** by set screws **27**. Ball or roller bearings (not shown), seated in grooves in collar **12** and tube **11**, may be used to permit rotation of collar **12** when set screws **27** are removed. Tube **11** can thereby remain substantially stationary when the collar **12** is rotated if so desired. The collar **12** has flange member **38***a* and **38***b* forming cutout portions **12***a* and **12***b*, respectively. These cutout portions are adapted to pivotably receive blocks **16** having blades **18** and **18***a* affixed thereto.

While two blades **18**, **18***a* are shown in Figure 1, it is evident that any number of blades can be used. All blades are preferably of the same size and shape, and are preferably symmetrical to collar **12**. Since all blades are constructed the same, reference in this description will be made only to one blade **18** and its connection to collar **12** at cutout portion **12***a*.

The block **16**, to which the blade **18** is affixed by screws **17**, extends into the cutout portion **12***a* of collar **12**. The block **16** has a bore **16***a* therethrough which is coaxial with bores **13** and **14** in flange members **38***b*. Pin **15** passes through the bores **13**, **14** and **16***a* so as to pivotably connect the block **16** to the collar **12**. Pin **15** is perpendicular to the axis of rotation of collar **12** and permits block **16** to pivot at the ends of collar **12**. This permits the blades **18** and **18***a* to be folded down against the tube **11** during storage and transportation.

The blade **18** comprises two membres, an inflexible relatively long inner blade member **19** and a flexible relatively short outer blade member or impeller **22**. Block **16** is provided with an inclined flat surface **16***b* which is at a small positive angle with respect to the axis of rotation of the collar **12**. This angle is the angle of attack and is referred to by the letter A in Figure 2. Since inner blade **19** is affixed to block **16** at one end by screws **17**, the inclination of surface **16***b* determines the pitch of inner blade **19** relative to its axis of rotation. Thus when the rotochute is dropped from a height, it ordinarily will turn in the direction from its leading edge **21** to its trailing edge **21***a* as a result of the positive angle of attack of inner blade **19**.

At the outermost end of inner blade **19** is outer blade or impeller **22**. Outer blade **22** is fixedly connected to the end of inner blade **19** by rivets **20** or other suitable means. Outer blade **22** is flexible and is made of considerably thinner material than inner blade **19**. Thus, while inner blade **19** is substantially inflexible, outer blade **22** is relatively flexible. Inner blade **19** and outer blade **22** can be composed of any suitable material, such as copper beryllium, aluminum or plastic.

As shown in Figure 4, impeller **22** is bent along line **23** to form a first part **26** and a second part **25**. First part **26** is substantially coplanar with inner blade **19** while second part **25** is bent at a substantial angle with respect to the planes of blade **19** and first part **26**, thereby forming a negative angle of attack. Line **23**, which defines the line of bend, extends from the leading surface **24** of outer blade **22** at a substantial angle to the longitudinal axis of the inner blade **19** and outer blade **22**, and across the sur-

face of blade **22** to the trailing edge 24. It is important that the line of bend be at a substantial angle to the longitudinal axis of the inner blade **19** and the outer blade **22** so that centrifugal forces produced by blade rotation will act to reduce the angle of bend. The action of these centrifugal forces on the flexible impeller will be described later.

The operation of the rotochute **10** may be described as follows. Initially blades **18** and **18***a* are folded down so that their longitudinal axes are substantially parallel to the longitudinal axis of tube **11**. The blades 18 and **18***a* are held locked in this position by any suitable means (not shown) until the rotochute **10** is dropped. Air striking outer blade **22** causes outer blade **22** to open the blades **18** and **18***a* to the position shown in Figure 1 immediately after the rotochute **10** is dropped. As explained previously, it is important that the blades **18** and **18***a* reach a high initial speed as soon as possible so that an immediate lift can be produced to slow the descent of weight W. Outer blade **22** accomplishes this by adapting the bend of the impeller to provide a high initial pitch, thereby developing a large starting torque to turn the blade **18**. The pitch of the impeller **22** which drives the blade **18** must therefore necessarily be opposite to the pitch of the inner blade member **19** which provides lift. Also, it is evident that the initial driving pitch of the impeller **22** must be considerably greater than that of the inner blade **19** to provide the desired operation.

While it is important that the blades **18** and **18***a* be driven at a high speed as soon as possible to create lift, it is also important that the blades **18** and **18***a* not reach a speed where excessive centrifugal forces would be developed, as would be the case if the high pitch of the outer blade **22** remained constant. This problem is overcome by means of the flexible impeller **22**. Centrifugal forces acting on the bent second part **25** of the impeller **22** reduce the angle of bend, thereby decreasing the driving pitch. It can be seen, therefore, that the blades **18** and **18***a* will thus rapidly be driven to a high predetermined speed and will maintain this predetermined speed because of the speed-regulating action of the flexible impeller **22**. It will be understood that this predetermined blade speed and the resulting rate of descent is determined by the pitch of the rigid inner blade **19**, the initial pitch of the impeller **22**, the bend angle and flexibility of the impeller **22** and the load W carried.

When the rotochute **10** is dropped, air resistance acting against blades **18** and **18***a* may cause these blades to pivot around pin **15** through an angle which is greater than ninety degrees. Thereafter, centrifugal forces developed by rotation of blades **18** and **18***a* will restore the blades to substantially the horizontal plane, as shown in Figure 1.

In one embodiment of a rotochute in accordance with this invention, the blade **18** is composed of aluminum. Inner blade **19** is 16 inches long, 4½ inches wide, ½ inch thick and has a positive angle of attack A, of four degrees. Outer blade **22** is 8 inches long, 3 inches wide, 1/32 inch thick and has a negative angle of attack B of 25 degrees. The angle formed between line **23** and edge **24** is 45 degrees. The outside diameter of the cylindrical portion of collar **12** is 3 inches. When a rotochute having four opposed, equi-spaced blades designed as above, was dropped from an elevation of approximately 3,000 feet, the blades rapidly attained a constant speed of 700 revolutions per minute and supported a load of 40 pounds in descent at the rate of 55 feet per second.

It will be apparent that the embodiments shown are only exemplary and that various modifications can be made in construction and arrangement within the scope of the invention as defined in the appended claims.

I claim as my invention:

1. An improved rotochute having self-regulating blade speed characteristics comprising: means to which objects to be dropped can be attached, a plurality of blades connected to said means for rotation about a common axis, each rotatable blade comprising an inner blade member and an outer blade member, said inner blade member being substantially inflexible and connected at its innermost end to said means, said inner blade member having a pitch so that said inner blade member develops forces of lift when driven in a predetermined direction around said means, said outer blade member affixed to the outermost end of said inner blade member, said outer blade member being flexible relative to said inner blade member and having a pitch opposite to, and substantially larger than that of said inner blade member, the size and pitch of said outer blade member being such that said outer blade member develops a torque which drives said inner blade member in said predetermined direction when said rotochute is falling through air, each outer blade member being flexible enough to reduce its pitch in response to centrifugal forces produced by the rotation of said blades, the reduced pitch decreasing the driving torque on said blades, thereby self-regulating the speed of said blades.

2. An improved rotochute having self-regulating blade speed characteristics comprising: means to which the object to be air-dropped can be attached; a generally cylindrical collar connected to said means, the longitudinal axis of said collar being the axis of rotation of said rotochute, a plurality of blocks pivotally connected to the outermost extremities of said collar, said blocks having surfaces inclined transversely to the axis of rotation of said collar, each of said blocks pivoting about an axis perpendicular to said axis of rotation, a plurality of blade members, each of said blade members comprising a substantially inflexible inner blade member and a flexible outer blade member, the inner blade members connected at their innermost ends to said inclined surfaces, the angle of inclination of the inclined surfaces of said blocks determining the pitch of said inner blade members, said inner blade members developing forces of lift when driven in a predetermined direction around said axis of rotation, each of the flexible outer blade members affixed to the outermost end of each inner blade member, said outer blade members having a pitch opposite to that of said inner blade members, said outer blade members being of such a size and pitch as to drive said inner blade members in said predetermined direction when said rotochute is falling through air, each outer blade member being flexible enough to reduce its pitch in response to centrifugal forces produced by the rotation of said blades, the reduced pitch decreasing the driving torque on said blades, thereby self-regulating the speed of said blades.

3. The invention as defined by claim 2, wherein a first part of each outer blade member nearest said inner blade member is coplanar therewith, and a second part of said outer blade member is bent with respect to said first part, the line of bend being at a substantial angle to the longitudinal axis of said first part of each outer blade member.

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