July 21, 1964 L. D. CATHERS ETAL 3 141,436

HYDROFOIL ASSISTED AIR CUSHION BOAT

Filed Nov. 25, 1960 4 Sheets-Sheet 1

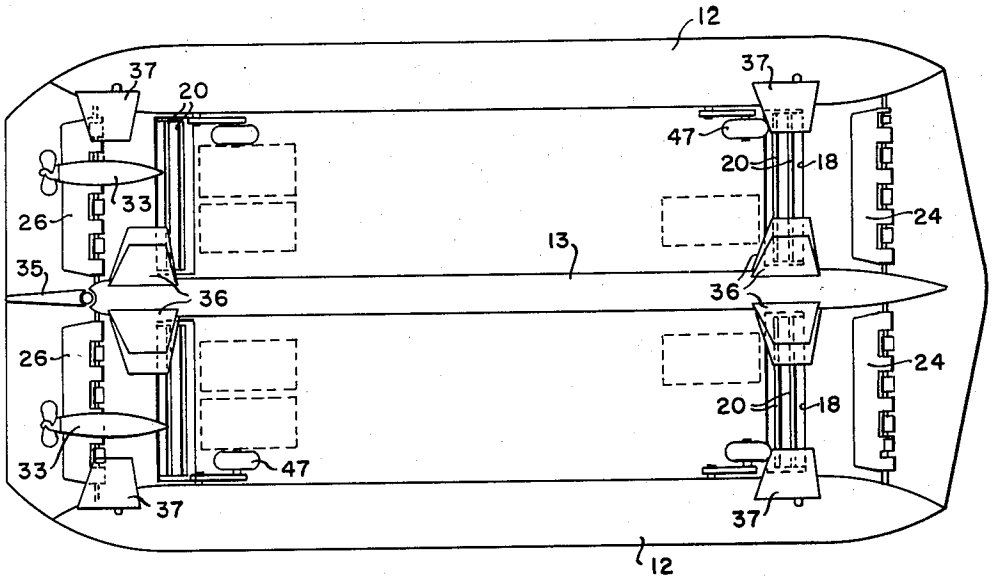

FIG. 4.

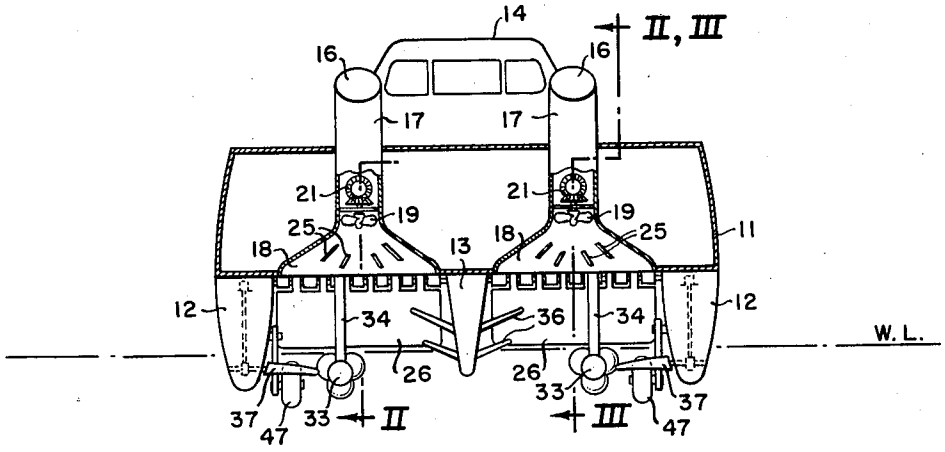

FIG. 1.

INVENTOR.
LINCOLN D. CATHERS
BY JOHN BADER
Howard W. Hermann
AGENT.

July 21, 1964 L. D. CATHERS ETAL 3,141,436

HYDROFOIL ASSISTED AIR CUSHION BOAT

Filed Nov. 25, 1960 4 Sheets-Sheet 2

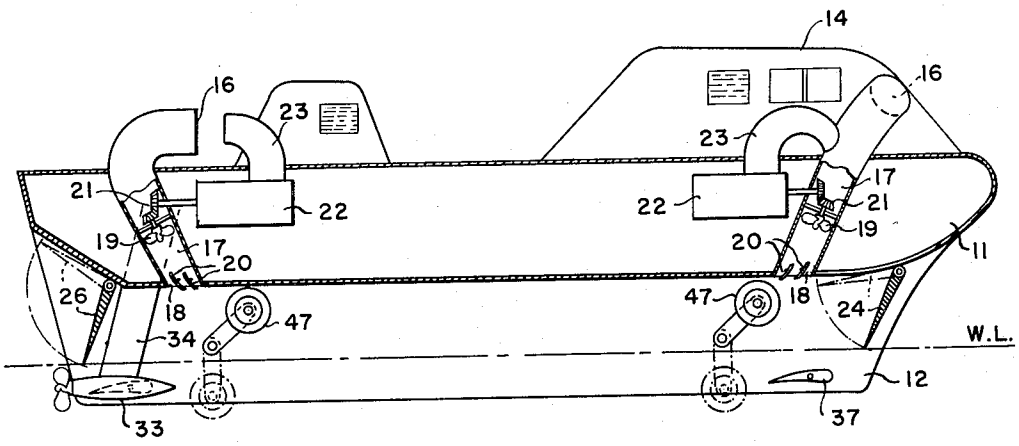

FIG. 2.

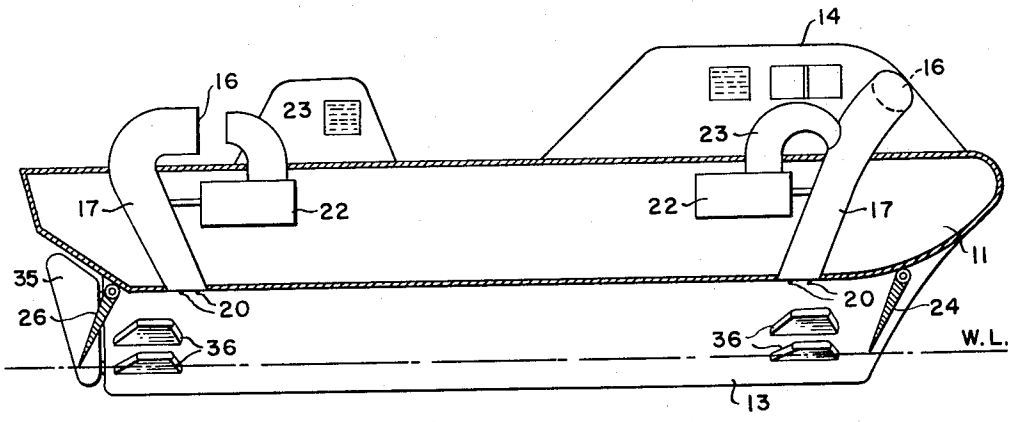

FIG. 3.

INVENTOR.
LINCOLN D. CATHERS
BY JOHN BADER
Howard W. Hermann
AGENT.

July 21, 1964 L. D. CATHERS ETAL 3,141,436

HYDROFOIL ASSISTED AIR CUSHION BOAT

Filed Nov. 25, 1960 4 Sheets-Sheet 3

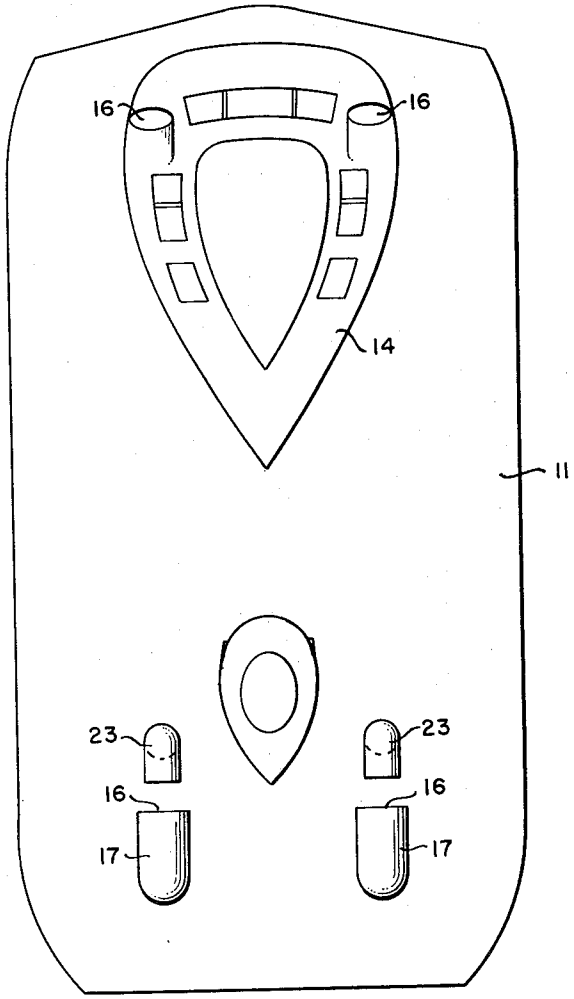

FIG. 5.

INVENTOR.
LINCOLN D. CATHERS
JOHN BADER
BY Howard W. Hermann
AGENT.

July 21, 1964 L. D. CATHERS ETAL 3,141,436

HYDROFOIL ASSISTED AIR CUSHION BOAT

Filed Nov. 25, 1960 4 Sheets-Sheet 4

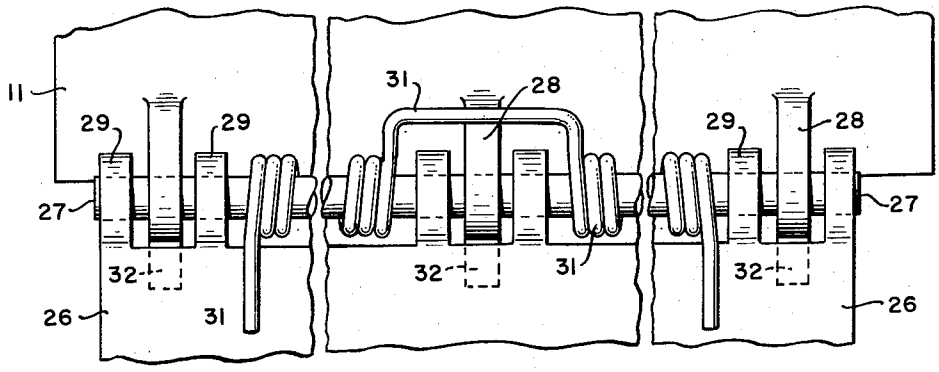

FIG. 6.

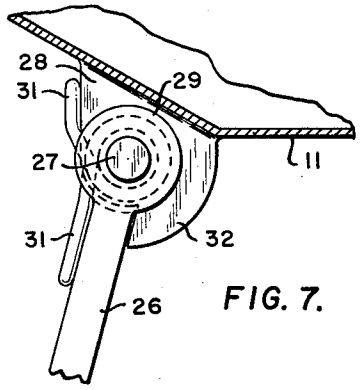

FIG. 7.

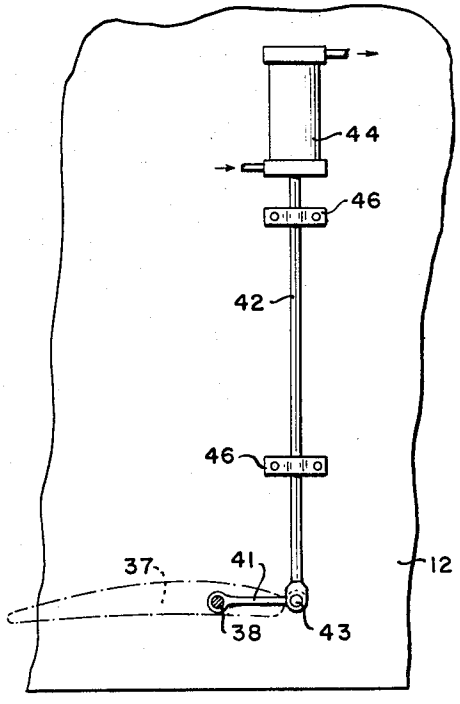

FIG. 8.

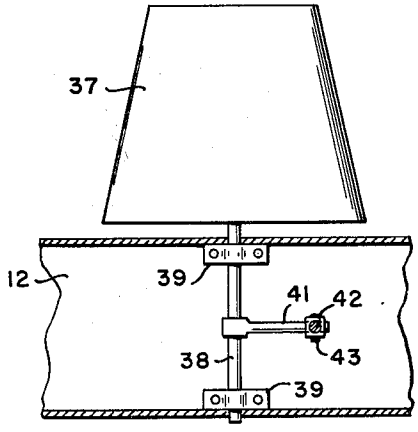

FIG. 9.

INVENTOR.
LINCOLN D. CATHERS
BY JOHN BADER
Howard W. Hermann
AGENT.

United States Patent Office 3,141,436 Patented July 21, 1964

3,141,436

HYDROFOIL ASSISTED AIR CUSHION BOAT

Lincoln D. Cathers, 5117 Brentford Drive, Rockville, Md., and John Bader, 1835 Crandall Drive, San Diego, Calif.

Filed Nov. 25, 1960, Ser. No. 71,838
2 Claims. (Cl. 114—66.5)
(Granted under Title 35, U.S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

The present invention relates to high speed watercraft and more particularly to high speed amphibious craft wherein the craft is principally supported by a cushion of air.

In the field of naval architecture, many types of configurations have been suggested to allow watercraft to travel economically at high speeds. Among these suggested configurations is the type of craft wherein an air cushion is provided between the hull and the water surface so that the hull friction is greatly reduced from conventional craft and a minimum of wave motion is transmitted to the hull. However, up until the present time, such craft, which have been built to operate over water have been plagued by problems caused by waves. Large waves on the water allow air to escape from beneath the hull, thus reducing pressure and causing a decrease in lift. Waves contacting the hull of the craft have caused severe rolling and pitching motions which at high speeds have been disastrous.

By the present invention the advantages of earlier craft have been retained but the aforedescribed disadvantages have been obviated. This is accomplished by the addition of auxiliary hydrofoils to add stability and help to negotiate a wave system.

As used in this application it is to be understood that the term "an air cushion craft" refers to a craft which is principally supported both at rest and in motion by a cushion of air. This air cushion is established beneath the craft by pumping air into the spaces between the craft and the surface over which it rests until the craft is raised sufficiently above the surface for the air to escape peripherally around the edges of the craft at the same rate as it is pumped in.

It is therefore an object of this invention to provide a stabilized air cushion craft.

Another object is the provision of an air cushion craft which is able to negotiate large waves.

A further object is the provision of an air cushion craft which has both calm and rough water capability and is capable of safely obtaining higher speeds than known craft of this type.

Other objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

FIG. 1 is an end view, partly in section of an embodiment of the invention;

FIG. 2 is a section of the embodiment taken on the line II—II of FIG. 1 looking in the direction of the arrows;

FIG. 3 is a section of the embodiment taken on the line III—III of FIG. 1 looking in the direction of the arrows;

FIG. 4 is a bottom plan view of the embodiment shown in FIG. 1;

FIG. 5 is a top plan view of the device;

FIG. 6 is a detail plan view of the flap bias and stop arrangement;

FIG. 7 is an end view of FIGURE 6;

FIG. 8 is a detail plan view of the hydrofoil adjusting system; and

FIG. 9 is a top view partly in section of the hydrofoil adjusting system.

Referring now to the drawings wherein like reference numerals designate like or corresponding parts throughout the several views, there is shown in FIG. 1 a hull **11** illustrated as a trimaran having two outboard skegs **12** and a center line skeg **13**. It will be realized, however, that the trimaran type craft is chosen for illustrative purposes only and that the invention could also be practiced on other types of hulls. A deckhouse **14** from which the craft is operated is provided above the hull.

A plurality of air intakes **16** in connection with air supply ducts **17** carry air from outside the craft to nozzles **18** opening into the spaces between skegs **12** and **13**. Air pumping means **19**, driven through a gear system **21** from a power source **22** cause the air to be forced through the ducts **17** and nozzle **18** into the space defined by skegs **12** and **13**, hull **11** and the water surface illustrated by water line W.L.

In order to distribute the air evenly at the nozzles, a plurality of transversely and longitudinally mounted vanes **20** and **25**, which may be pivotably mounted or alternatively, fixed, are mounted within nozzles **18**. Power sources **22**, as illustrated in FIGS. 2 and 3, are shown as gas turbines having exhaust ducts **23** which discharge exhaust gases into either air intakes **16** or air supply ducts **17**, thus adding efficiency to the air supply system. Since the exhaust gases form only a small portion of the total gas flow, no adverse heat problems are encountered.

In order to gain still more efficiency a bow flap **24** and a stern flap **26** are provided at the ends of each of the spaces defined by skegs **12** and **13**. As shown in FIGS. 6 and 7 a hinge pin **27** passes through a series of projections **28** of hull **11** and through a series of projections **29** of the flap **26**. A bias spring **31** urges flap **26** downwardly against shoulders **32** leaving the flap free to swing rearwardly against the tension of the spring whenever a wave hits the flap, thus allowing the wave to pass. Forward flaps **24** are mounted in the same manner although the bias spring may be omitted since the air pressure under the craft acts to bias the flap in the forward direction.

Referring again to FIGS. 1–4, forward water propulsion means are provided by propulsion nacelles **33** mounted on struts **34** which may be made retractable in the manner shown in copending application of John Bader, Serial No. 834,899, filed August 19, 1959. Although as shown the propulsion is by means of a water propeller, it will be realized that other types of propulsion, air propellers for example, could be utilized without departing from the spirit of the invention.

Steering is accomplished by means of a rudder **35** mounted at the aft end of centerline skeg **13**. Again it will be realized that other known steering systems could be utilized without departing from the spirit of the invention.

It should be noted that the use of the trimaran arrangement provides some transverse stability to the craft by separating the air cushion into two transverse parts. As the craft begins to roll, a higher pressure is built upon the lower side thus providing a restoring moment.

To enhance both lateral and transverse stability a plurality of hydrofoils are also provided on the craft. As shown in FIGS. 1–4, a series of fixed hydrofoils **36** are cantilevered from the centerline skeg **13** and a pair of adjustable hydrofoils **37** are mounted on each end of the outboard skegs **12**. As shown in FIGS. 8 and 9, wherein one type of adjusting means is illustrated, hydrofoils **37** are each fixedly mounted on a pivot pin **38**. Pivot pin

38 is rotatably mounted on skeg 12 by means of bearings 39 and has a crank 41 having one end fixedly mounted thereon between bearings 39. To the opposite end of crank 41 an operating rod 42 is attached by means of a second pivot pin 43. Operating rod 42 is adapted for axial motion derived from controllable hydraulic cylinder 44 which may be actuated either manually or automatically, by any suitable known control system. As operating rod moves up and down sliding through bearings 46, crank 41 causes pivot pin 38 and hydrofoil 37 to rotate. This system can be operated by an autopilot system such as that used on present hydrofoil craft to give automatic roll and pitch control when the craft is in operation. It can be easily seen that by operating hydrofoils 37 in opposite directions a rolling moment can be accomplished to counteract the rolling moment given the craft by wave action. The operation of the forward foils in the opposite direction from the after foils results in a pitching moment. By activating all foils in the same direction an upward or downward motion may be produced. Fixed foils 36 are normally at least partially above the water line and act only when the craft encounters waves. The fixed foils then provide added lift to prevent diving and leaping in the seaway.

In order to add land capability to the craft a plurality of wheels 47 are retractibly mounted on outboard skegs 12. Normally the wheels are kept retracted but when land operation is required the wheels are dropped into operative position for travel over land and the propulsion nacelles 33 are retracted.

In operation the craft is given forward speed by means of propulsion nacelles 33 and air pumping means 19 are started to provide air pressure under the craft. Air intakes 16 are positioned to aid air inflow at forward speeds. The exit angle of the air jets from nozzle 18 is adjusted by rotating vanes 20 about their axes. The speed of the fore and aft air pumping means can be regulated to give proper trim to the craft for the sea conditions encountered, i.e. it may be desirable to provide more power to the bow jet than the stern jet.

The use of hydrofoils permits the air cushion boat to provide a smoother ride on waves and a greater degree of stability in the water than is possible with known air cushion craft. The use of bow and stern flaps and discharging the turbine exhaust into the air intake help to reduce the power requirements of the craft. The use of marine propellers and water rudders results in smaller, cheaper and lighter installation.

It will be realized that the shape of the boat, number, shape, and location of foils, air pumping means, and engines, as well as the propulsion and steering means may all be varied somewhat without departing from the spirit of the invention. It will also be realized that the foils may in some instances be attached directly to the hull as is presently done on hydrofoil boats.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within

the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. An air cushion craft comprising:
a hull member;
a plurality of open faced compartments formed in said hull for providing an air cushion between said hull and the surface over which said craft is designed to move;
a gas turbine engine;
a plurality of ducts connecting the exhaust of said engine with each of said compartments respectively;
means mounted on said hull for producing translatory motion of said craft;
means mounted on selected side walls of said compartments adjacent the open face thereof for stabilizing said craft when traveling over an irregular surface.

2. An air cushion craft comprising:
a hull member;
a plurality of open faced compartments formed in said hull for providing an air cushion between said hull and the surface over which said craft is designed to move;
a gas turbine engine;
a plurality of ducts connecting the exhaust of said engine with each of said compartments respectively;
said compartments are formed by a plurality of at least three logitudinally mounted skegs and a plurality of hinged flaps, at least one at each end of said body to normally close the spaces between the ends of the skegs;
means mounted on said hull for producing translatory motion of said craft;
means mounted on selected side walls of said compartments adjacent the open face thereof for stabilizing said craft when traveling over an irregular surface.

References Cited in the file of this patent

UNITED STATES PATENTS

920,849	Fauber	May 4, 1909
1,081,489	Currie	Dec. 16, 1913
1,307,135	Lake	June 17, 1919
1,412,848	Dunajeff	Apr. 18, 1922
1,750,959	Lake	Mar. 18, 1930
1,815,303	Kloen	July 21, 1931
1,819,216	Warner	Aug. 18, 1931
2,348,106	Brian	May 2, 1944
2,356,349	Persson	Aug. 22, 1944
2,444,318	Warner	June 29, 1948
2,708,894	Hook	May 24, 1955
3,016,864	Woodfield	Jan. 16, 1962
3,027,862	Votre	Apr. 3, 1962
3,031,999	Bader	May 1, 1962

FOREIGN PATENTS

518,878	Great Britain	Mar. 11, 1940
657,488	Great Britain	Sept. 19, 1951
4,270	France	Aug. 22, 1905
1,222,805	France	Jan. 25, 1960