ASU college of technology & innovation
ARIZONA STATE UNIVERSITY

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Dear Mr. Montgomery,

Please find the quarterly progress report on the project "Suction Stabilized Floats" with this letter. This report summarizes the activities done so far.

I have reviewed your patent #13/242,489, which is currently pending with USPTO, in detail. My background investigation has not revealed any prior research or utilization of this unique concept to stabilize floating devices.

Suction stabilization is similar to anti-roll bars that are used in cars to increase roll stability. As discussed in the report, it increases the effective metacentric height due to "closed surface effect".

This concept has wide range of potential commercial and military applications and I think USPTO will acknowledge the innovation and uniqueness of this application. If you have any questions, I can be reached at sredkar@asu.edu via email or 480-727-1129 via phone.

Thank you and best wishes,

S Redkar

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Suction Stabilized Float (SSF) Progress Report (12/21/2012)

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Abstract: In this report, the concept of SSF, principle of operation and applications are briefly discussed. A simple float example is also included to demonstrate the effect of suction stabilization on metacentric height and float stability. It can be seen that the suction stabilization results in an increased "effective metacentric height" and stability margin.

Introduction: SSFs are floats with an internal chamber completely filled with liquid as shown in Figure 1 [1]. The cross sectional view of the SSF is shown in Figure 2 [1]. The liquid in the inner chamber acts as a ballast that improves the stability characteristics of the float. It is noted that traditionally, water ballast tanks, anti-roll tanks and roll fins have been used by ship builders to improve the marine vessel stability.

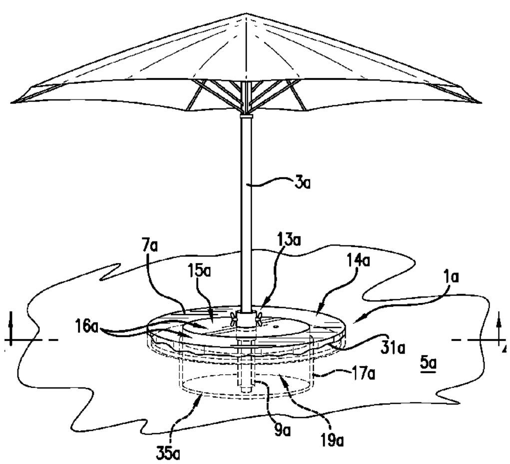


Figure 1: SSF with an Umbrella [1]

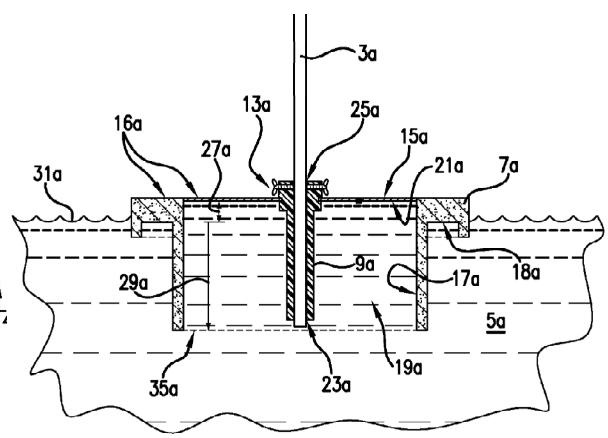


Figure 2: Cross-sectional view of SSF [1]

The SSFs concept is different than the methods traditionally used to improve roll or heel stability and can be considered as a "torsion bar" or anti roll bars used in cars. When the float heels, the liquid in the inner chamber (29-a) on the heeling side is raised and increases the "righting moment". If the "righting moment" is greater than the "heeling moment" then the float returns to its equilibrium position (shown in Figure 1). Unlike anti-roll tanks, it's a passive stability enhancement device and does not depend upon external energy sources. For the detailed working of SSFs, the reader is referred to reference 1.

Suction Stabilization and effective Metacentric Height:

Metacenter (M) is the point where the lines of action of buoyancy forces interact before and after a particular heel (or roll). The distance between the centre of gravity (G) and metacenter (M) is known as the metacentric height (GM). For statical stability, metacentric height should be positive ie. M should be above G. For the details, the reader is referred to reference 2. The metacentric height (GM) is given by [2]

$$GM = \frac{I}{V} - BG$$

where I is the moment of inertia of the cross sectional area at the liquid surface about its longitudinal axis and V is the displaced volume. BG is the distance between center of buoyancy (B) and centre of gravity (G). For floating bodies containing liquid tank (as shown in Figure 3), “free surface effect” plays an important role in stability. The metacentric height is reduced due to movement of the liquid in tank decreasing the “righting moment”. This reduced metacentric height is called effective metacentric height (GMe) and is given by [2].

$$GMe = GM - \frac{I_1}{V}$$

Where I_1 is the moment of inertia of the area of the free surface in the tank. Suction stabilization “closed surface” (as shown in Figure 4) can be viewed as the opposite of the “free surface effect” and the fluid in the inner “closed” chamber of SSFs increases the metacentric height by $\frac{I_s}{V}$

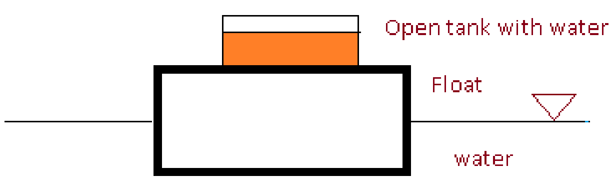


Figure 3: Float with free surface

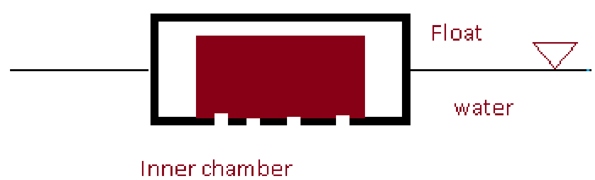


Figure 4: Float with closed surface (SSFs)

Thus, effective metacentric height (GMs) for SSF is given by

$$GMs = GM + \frac{I_s}{V}$$

Where I_s is the moment of inertia of the area of the closed surface in the inner chamber. Assuming an air tight seal is maintained, the GMs for SSF for small (up to 15 degrees) angles of heel is increased by $\frac{I_s}{V}$. For a symmetric float suction stabilization increases metacentric height in pitch as well by same amount.

An Example[1]:

For a simple SSF design, it is possible to compute GM and GMs with simple calculations as shown here. For a complex float design, computer software should be used to compute moment of inertias and other hydrostatic parameters.

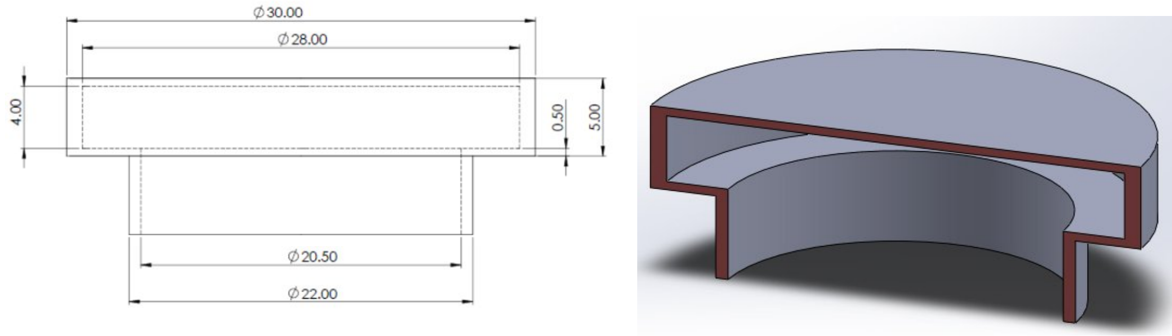


Figure 5: Urethane SSF with cylindrical inner chamber

Consider the SSF shown in Figure 5.

Weight of the float = Weight of float + weight of water inner chamber= 62 lb

Combined Centre of Gravity of the Float and water in inner chamber is at 2 inches from O.

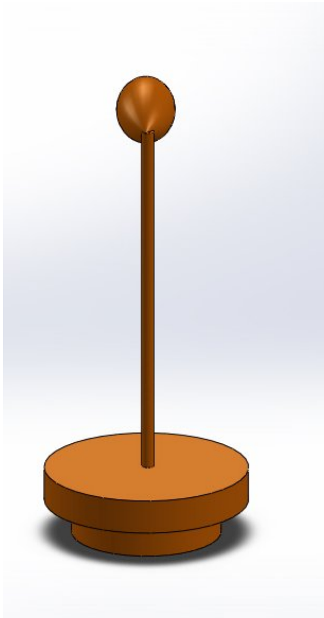
The Metacentric height $GM = \frac{I}{V} - BG = 17.11in$

The Effective Metacentric Height due to Suction stabilization =

$$GMs = GM + \frac{I_s}{V} = 17.11 + 16.25 = 33.36in$$

Thus, suction stabilization adds 16.25 in to GM.

[1] Detailed calculations are omitted for brevity



Mass = 1.97 pounds

Volume = 1156.60 cubic inches

Surface area = 3507.98 square inches

Center of mass: (inches)

X = 0.00
Y = -3.26
Z = 0.00

Principal axes of inertia and principal moments of inertia:
Taken at the center of mass.

Ix = (0.00, 0.00, 1.00)	Px = 165.38
Iy = (1.00, 0.00, 0.00)	Py = 165.38
Iz = (0.00, 1.00, 0.00)	Pz = 298.96

Figure 6: Float with a payload of 10 lb at 52 inch and float propoeries.

Consider Figure 6, where a payload (eg. an umbrella) of 10 lb is added at 52 inches. The centre of buoyancy, centre of gravity and depth of immersion changes due to this added mass. The combined CG of float and payload is calculated at 5 inches above the float surface along centerline of float.

The new metacentric height

$$GM = \frac{I}{V} - BG = 9.74 \text{ inch}$$

Note: The metacentric height is decreased compared to 17.11 inch earlier.

The effective metacentric height

$$GMs = GM + \frac{I_s}{V} = 9.74 + 16.25 = 25.97 in$$

Thus, the **suction stabilization increases the statical stability of the float**.

Applications: Suction stabilization can be utilized in **variety of commercial and military applications**. Some commercial applications such as floats and mobile platforms are discussed in reference 1. Additional applications would be military/ commercial buoy, floating beacons, stabilized platforms for cargo/ crew landing, floating stabilized helipads for helicopters. Also applications like floating stabilized trampoline, and slides are possible with this concept. For a backyard pool platform with low wind or wave loading a statical stability analysis may be sufficient. But for an offshore application or under heavy wind and/or traveling loads the dynamic stability should be studied. This study is currently in progress.

Conclusion:

The author's study of the pending patent (reference 1) and back ground investigation did not reveal similar application of suction stabilization concept. The suction stabilization increases effective metacentric height. It has wide commercial and military applications ranging from backyard pool umbrella float to offshore platforms for wind turbines.

References:

1. Montgomery James, "Suction Stabilized Floats" US Patent Application number: 13/242,489
Publication number: US 2012/0090525 A1 Filing date: Sep 23, 2011

2. A.B. Biran, 2003, Ship Hydrostatics and Stability, Butterworth-Heinemann