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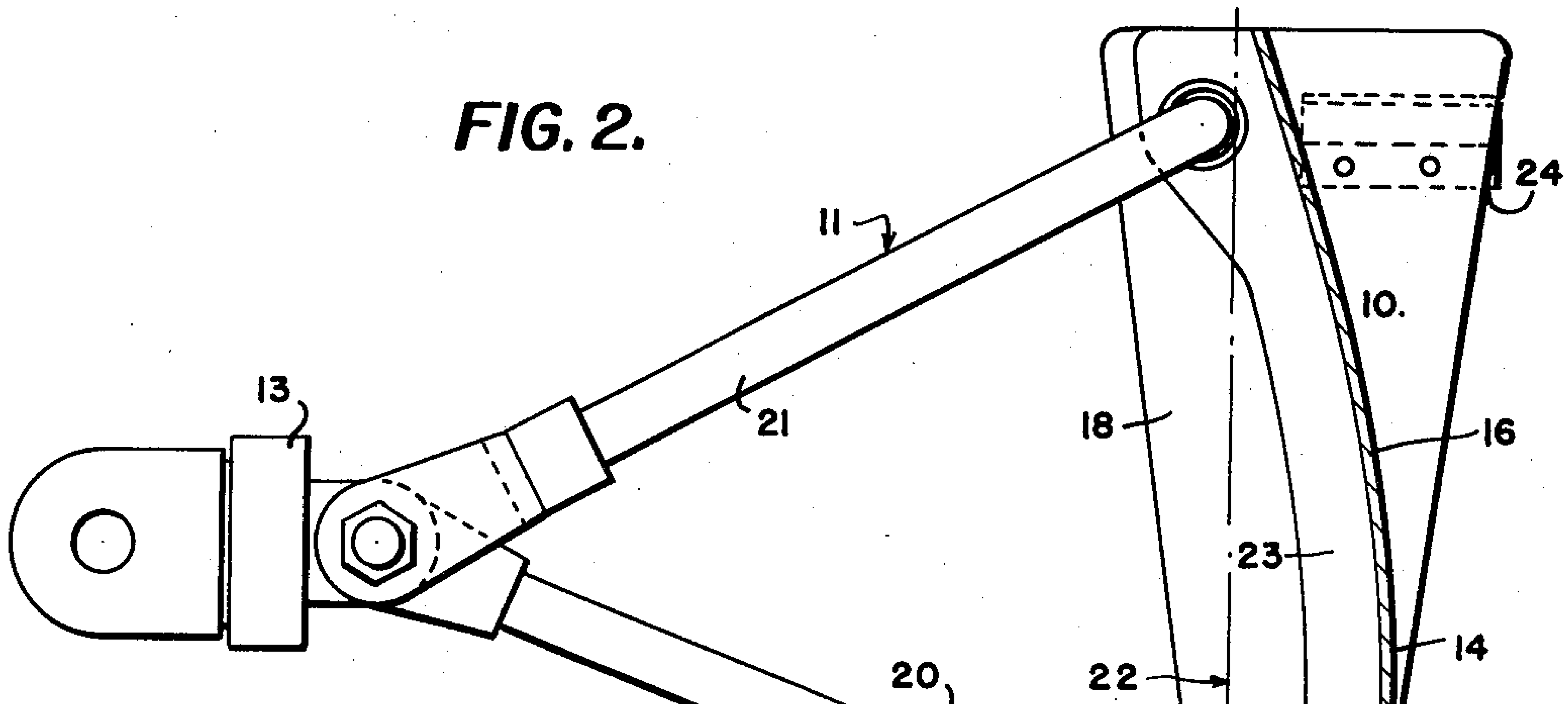
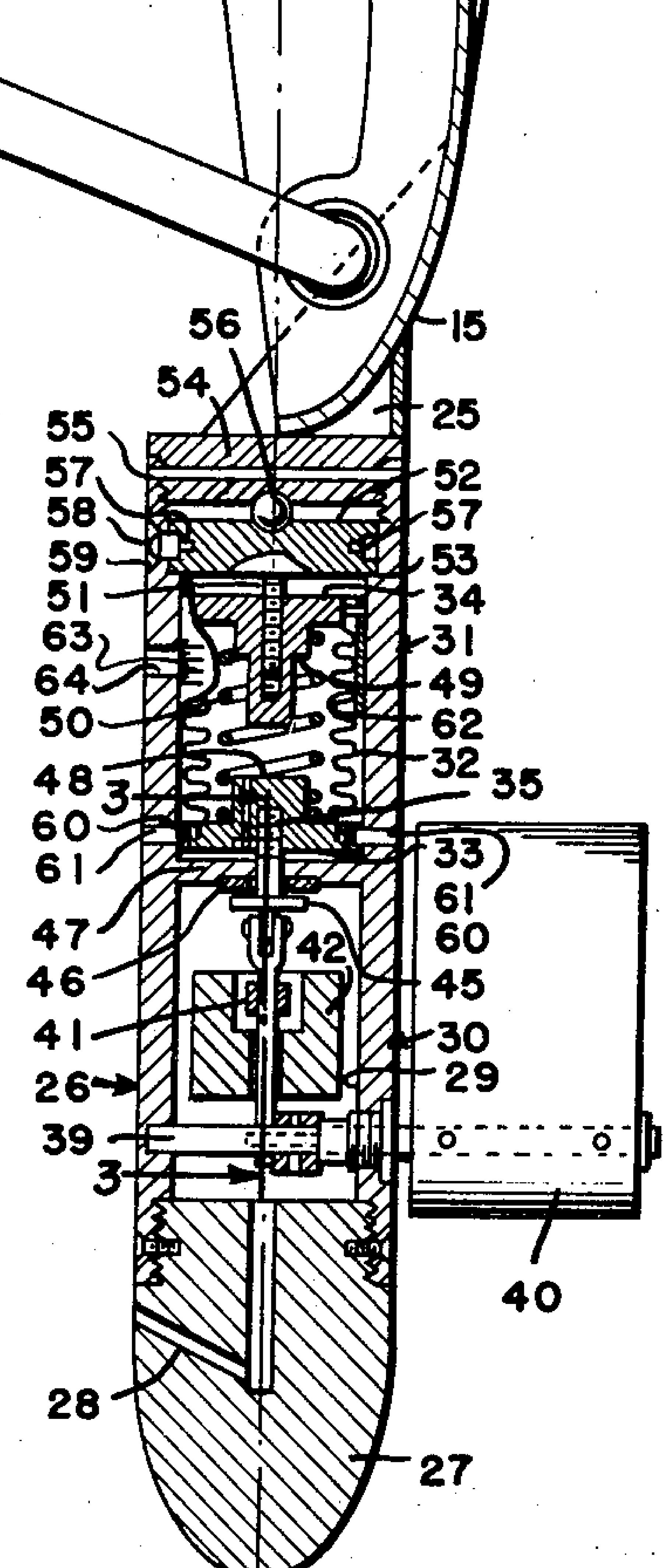
K. H. WILCOXON

DEPTH CONTROL DEVICE WITH A MOVABLE SURFACE CONTROLLED THEREBY

Original Filed July 6, 1948

2,709,981

FIG. 2.

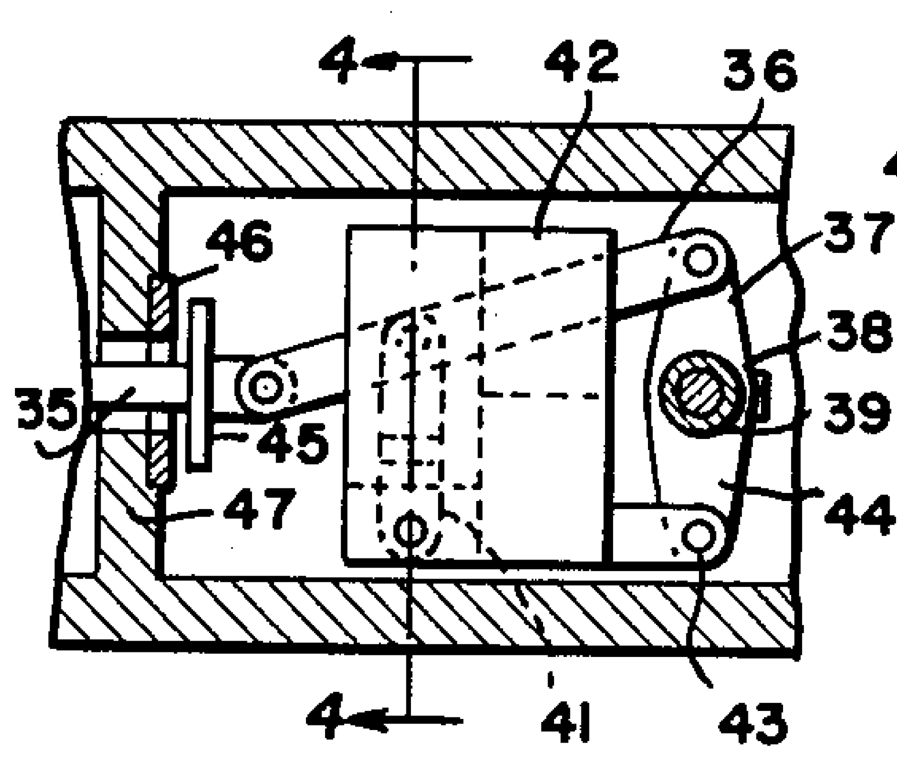


FIG. 3.

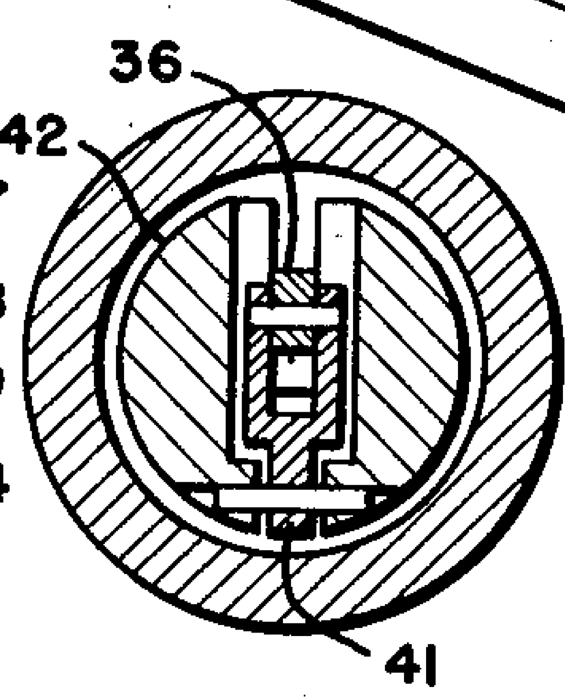


FIG. 4.

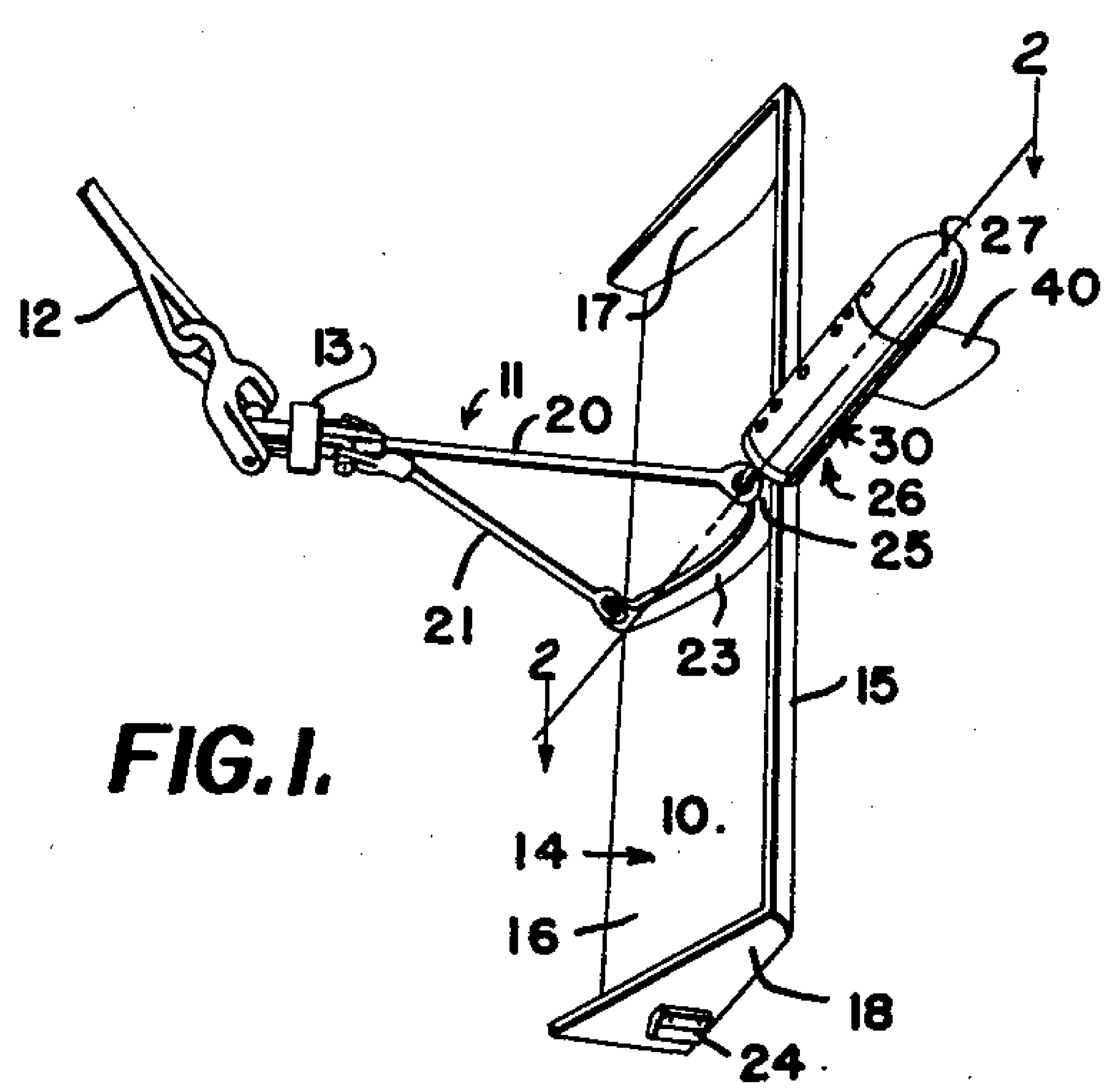


FIG. 1.

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ATTORNEYS

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DEPTH CONTROL DEVICE WITH A MOVABLE SURFACE CONTROLLED THEREBY

Kenneth H. Wilcoxon, Cabin John, Md.

Original application July 6, 1948, Serial No. 37,177, now Patent No. 2,589,312, dated March 18, 1952. Divided and this application October 10, 1950, Serial No. 189,463

6 Claims. (Cl. 114—235)

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

This is a division of my co-pending application Serial Number 37,177, filed July 6, 1948, for Non-Buoyant Paravanes, now Patent 2,589,312.

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 improvements in paravanes and more particularly to a depth control device.

The primary object of the present invention is to provide a depth control device having a bellows sensitive to static pressure changes but protected against explosion pressures.

A further object is to provide a depth control device having a bellows sensitive to small static pressure changes but protected against excessive static pressure of a magnitude sufficient to injure the bellows.

A still further object is to provide a depth control device with counterbalancing means compensating for the weight of the bellows and control linkage when the depth control device is tilted forwardly or backwardly.

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 drawing wherein:

Fig. 1 is a perspective view of the paravane looking at it from a point forwardly of and slightly below the paravane.

Fig. 2 is a view of the paravane partly in top plan and partly in central horizontal section taken substantially on the line 2—2 of Fig. 1.

Fig. 3 is a fragmentary central vertical longitudinal sectional view taken substantially on the line 3—3 of Fig. 2.

Fig. 4 is a central vertical transverse sectional view taken substantially on the line 4—4 of Fig. 3.

In the drawing which for the purpose of illustration shows only a preferred embodiment of the invention, and wherein similar reference characters denote corresponding parts throughout the several views, the numeral **10** generally designates a water kite including a bridle **11** connected to a tow cable **12** by a swivel **13**.

The water kite **10** is in some respects similar to the type shown and described in Patent 2,403,036 granted to K. Wilcoxon and L. Landweber in that it includes a rectangular sheet metal shear plate **14** with an elliptically-curved leading marginal portion **15** and a cylindrically-curved after portion **16**, upper and lower stabilizing side plates, **17**, **18**, rigidly affixed to opposite side edges of the shear plate, and a bridle having rigid forward and aft links **20**, **21** which permit limited rolling movement of the kite about an axis in the vicinity of the central chord line **22**. The links **20**, **21** are connected at spaced points to a central rib **23** fixed to the concave side of the shear plate **14**. In the example shown the shear plate has an aspect ratio of approximately 2.4. Fixed to the lower surface of the stabilizer plate **18** at its trailing end portion is a yaw plate **24** creating hydrodynamic drag sufficient to maintain a slight downward yaw of the kite during forward travel.

The swivel **13** may be of the ball-bearing type shown and described in my co-pending patent application Serial No. 789,008 filed December 1, 1947, now Patent 2,633,375.

Rigidly affixed to the kite forwardly of its leading edge as by a welded bracket **25** is a tubular streamlined depth control housing **26** having its longitudinal axis aligning with the central chord line **22** of the wing. Arranging the depth control wing forwardly of the main lift wing of the kite is preferred because the depth control wing will establish the depth and the main lift wing will follow, thus permitting quicker response and compensation for deviations in the set depth. Formed in the streamlined nose **27** of the depth control housing is a static pressure passageway **28** connecting an annular region in the flow around the exterior of the housing where the dynamic pressure is zero, with a static pressure chamber **29** in the central housing portion **30**. It is to be noted that dynamic pressures due to flow are unequal at different positions around the nose **27** and housing portion **30**. In order to maintain a reasonably constant depth over a range of speed, it is necessary to have constant pressure in the depth control, therefore the opening for receiving the static head for depth control is placed in the nose of the housing at a point where the dynamic pressure due to flow is at a minimum or zero.

Disposed coaxially within the after portion **31** of the housing is a cylindrical bellows **32** mounted between forward and after end plates **33**, **34**. Compression of air by the static head of water is the common method of depth control for comparable towed objects. The air-filled bellows **32** was selected rather than a diaphragm or air chamber because its effective area is greater for a given overall diameter, its spring rate is constant and can be varied over a wide range without serious effect. Also the bellows can be made from more durable material than the usual rubber diaphragm. Threaded into engagement with the forward end plate **33** is a stem **35** connected as by a link **36** to one arm **37** of a lever **38**. This lever **38** is affixed intermediate its ends to the inner end portion of a shaft **39** extending through and mounted for rotation in the central housing portion **30** at a right angle to the longitudinal axis of the housing. Affixed to the outer end portion of the shaft **39** is a symmetrically-shaped depth control wing **40**, disposed at zero angle of attack when the bellows plate **33** is forward. The amount of force the bellows is able to exert with a small change in depth is relatively small, therefore a symmetrical depth control wing was chosen because the center of pressure of the wing remains nearly in the same position through the small angles of attack.

Disposed in the static pressure chamber **29** and pendantly connected at its after end portion to the link **36** as by a shackle **41** is a counterbalancing weight **42** having its forward end portion pivotally connected at **43** to the lever **38** at its end **44** opposite the depth control arm **37**. The weights of the bellows end plate **33** and the connecting linkage are counterbalanced because as the paravane noses down or up these weights tend to fall forward or backward, working against the bellows in both cases.

Fixed on the stem **35** is a valve disc **45** adapted upon predetermined compression of the bellows **32** to seat against a washer **46** carried by an internal annular flange portion **47** of the housing surrounding the stem **35**. This valve arrangement protects the bellows against crushing at extreme depths by sealing itself from high static pressure upon predetermined compression of the bellows.

Supported on axial boss portions **48**, **49** of the bellows end plates **33**, **34** is an expansion coil spring **50** helping to resist static water pressure on the bellows when the paravane is operating in the sea at depths of the order of thirty feet.

Threaded into engagement with the boss 49 is a stem 51 extending axially from a disc 52 seated in an annular recess defining a shoulder 53 within the after end portion of the housing. Formed integrally with the bracket 25 is a plug 54 releasably secured in threaded engagement with the after end of the housing as by a taper pin 55. Interposed between the disc 52 and plug 54 is a ball thrust bearing 56 seated in shallow concavities centrally of the disc and plug. Formed in the rim of the disc 52 is a plurality of circumferentially-spaced radially-extending holes 57 having threaded walls for selective engagement with a locking screw 58 passing through an aperture 59 in the housing. The forward end plate 33 of the bellows is longitudinally grooved to receive the inwardly projecting ends 60 of pins 61 permitting longitudinal movement of the end plate 33.

Fastened on the after end plate 34 is a forwardly-extending sleeve 62 carrying indicia 63 visible through a sight opening 64 in the housing wall. In order to set the depth control for a selected depth, it is only necessary to remove screw 58, turn disc 52 until indicia 63 corresponding to the selected depth becomes visible through the sight opening 64, and then replace screw 58 in the nearest threaded rim-hole 57.

Before the yaw plate 24 was used, the paravane would operate properly at speeds up to sixteen or twenty knots at which time it would begin to oscillate. The cause of this oscillation at the higher speeds may be explained by the following statement of the theoretical operation of the paravane. The center of gravity of the paravane is forward of its center of pressure. At zero speed the non-buoyant paravane hangs down on the tow-line; as it begins to move forward, the paravane first acts as a depressor. The abnormally high static pressure at paravane depth maintains the valve seated with the bellows partly compressed and with the depth control wing disposed at a positive angle of attack. As the speed of the paravane increases, the hydrodynamic lift of the depth control wing causes the paravane to run to the side, and at eight knots is sufficient to lift the nose of the paravane to the set depth. As the speed is increased beyond eight knots the depth of the paravane tends to decrease slightly, the angle of attack of the depth control wing is decreased by the bellows to maintain the required constant amount of lift and the wing approaches zero angle of attack. At zero angle of attack the center of pressure of the depth control wing is forward of the pivot axis thus tending to keep the wing at an angle of attack. Therefore as the wing is urged into zero angle of attack from a positive angle by the bellows, it immediately shifts to a negative angle which causes the paravane to run deeper. In order for the depth control unit to gain force to move the wing across zero position the paravane must change depth, hence causing oscillation.

The towline effect adds to the oscillation. As the paravane noses down, the tow cable bows up due to its hydrodynamic drag thus causing the paravane to roll which in turn produces downward yaw. When the change in depth is great enough for the depth control device to start the paravane up again all the effects reverse and the paravane will overshoot the desired level. The longer the tow cable the greater the towline effect will be. The yaw plate 24 when added to the bottom side plate of the main lift wing creates sufficient hydrodynamic drag to tip the paravane down slightly so that the depth control wing can always operate at a positive angle of attack.

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.

I claim:

1. In a depth control device, a housing including a flexible wall defining a compression chamber, a static pressure chamber adjacent said compression chamber, said static pressure chamber communicating with the exterior of the housing, said flexible wall being normally exposed to said static pressure and being adapted to flex responsive to changes in said static pressure, a depth control surface pivotally supported by the housing, means transmitting motion from said flexible wall to said control surface, and valve means coupled to said motion transmitting means to prevent said flexible wall from being exposed to said static pressure when said static pressure reaches a predetermined magnitude.

2. In a depth control device, a housing including a wall adapted to flex responsive to changes in static pressure within the housing, a depth control surface pivotally supported by the housing, linkage means transmitting motion from said flexible wall to said control surface, a weight within said housing arranged to counterbalance at least a portion of the weight of said linkage means for various positions of the housing, a valve disc fixed to said linkage means and adapted upon a predetermined flexing of said wall to seal said wall from high static pressure.

3. In a depth control device, a housing including a wall adapted to flex responsive to changes in static pressure within the housing, a shaft pivotally supported by the housing, a depth control surface fixed to said shaft, two opposed arms fixed on the shaft, linkage connected between one of said opposed arms and said flexible wall for transmitting motion therebetween, a weight pivotally connected to the other of said opposed arms for counterbalancing at least part of the weight of said linkage, and a tie rod connecting the weight to said linkage.

4. In a depth control device, a cylindrical housing having a first end portion provided with a wall and a second end portion provided with a static pressure inlet, a resilient cylindrical bellows coaxially disposed within the housing and having first and second end members, said first end member being exposed to static pressure in said second end portion of the housing, a rotatable element disposed between said housing wall and said second end member and provided with a thrust bearing surface engaging said housing wall and a screw-threaded connection between said element and said second end member for adjusting said second end member axially of the housing upon rotation of said element, and means releasably fixing said element against rotation relative to the housing.

5. In a depth control device, a cylindrical housing having a first end portion provided with a wall and a second end portion provided with a static pressure inlet, a cylindrical bellows coaxially disposed within the housing and having first and second end members, an expansion coil spring coaxially disposed within the bellows between said first and second end members, said first end member being exposed to static pressure in said second end portion of the housing, a rotatable element disposed between said housing wall and said second end member and provided with a thrust bearing surface engaging said housing wall and a screw-threaded connection between said element and said second end member for adjusting said second end member axially of the housing upon rotation of said element, and means releasably fixing said element against rotation relative to the housing.

6. In a depth control device, a housing including a flexible wall defining a compression chamber, a static pressure chamber adjacent said compression chamber, a first passage leading from said compression chamber to said flexible wall, a second passage between said static pressure chamber and the exterior of said housing, said flexible wall being normally exposed to static pressure and being adapted to flex in a manner responsive to changes in said static pressure, a depth control surfacce pivotally supported by the housing, means transmitting motion

from said flexible wall to said control surface, and valve means operatively coupled to said motion transmitting means to close off said first passage when said static pressure is of a predetermined magnitude.

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