



**DEPARTMENT OF THE NAVY**  
OFFICE OF COUNSEL  
NAVAL UNDERSEA WARFARE CENTER DIVISION  
1176 HOWELL STREET  
NEWPORT RI 02841-1708

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PATENT COUNSEL  
NAVAL UNDERSEA WARFARE CENTER  
1176 HOWELL ST.  
CODE 000C, BLDG. 112T  
NEWPORT, RI 02841

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Inventor            Thomas J. Gieseke

If you have any questions please contact James M. Kasischke, Acting Deputy Counsel, at 401-832-4736.

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STOWABLE INTEGRATED MOTOR PROPULSOR FINS

TO ALL WHOM IT MAY CONCERN:

BE IT KNOWN THAT THOMAS J. GIESEKE, employee of the United States Government, citizen of the United States of America, and resident of Newport, County of Newport, State of Rhode Island, has invented certain new and useful improvements entitled as set forth above of which the following is a specification:

JAMES M. KASISCHKE ESQ.  
Reg. No. 36562  
Naval Undersea Warfare Center  
Division Newport  
Newport, Rhode Island 02841-1708  
TEL: 401-832-4736  
FAX: 401-832-1231

20030613 074



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PATENT TRADEMARK OFFICE

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STOWABLE INTEGRATED MOTOR PROPULSOR FINS

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STATEMENT OF GOVERNMENT INTEREST

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BACKGROUND OF THE INVENTION

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(1) Field of the Invention

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(2) Description of the Prior Art

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Elongate undersea vehicles, such as torpedoes are being used by many navies for offensive and defensive purposes. They are efficiently engineered to be compact, yet be able to carry heavy loads of ordnance or instrumentation packages over considerable distances. En route, they can be steered and maneuvered to intercept a distant moving target vessel or deliver the payload to a destination. Their propulsion systems have continued to improve over the years and one of these improvements is generally

1 referred to as the integrated motor propulsor (IMP). Some  
2 typical IMPs and improvements related thereto are shown in U.S.  
3 Patents Numbers 5,078,628, 5,205,653, 5,252,875, 5,220,231,  
4 5,607,329, 5,649,811, and 5,702,273. An IMP can integrate an  
5 electric motor with the moving parts of a ducted propeller.  
6 Control surfaces cannot be added that extend beyond the periphery  
7 of the annular duct because the diameter of the propulsor then  
8 exceeds the constraints of contemporary tube-shaped launchers.  
9 Control surfaces should not interfere with the propulsor inflow  
10 and not influence the maximum propulsor diameter. In accordance  
11 with this invention it was discovered that better control  
12 surfaces for contemporary IMP vehicles improve control surface  
13 performance.

14 Some concepts for improving control surfaces might meet the  
15 requirements for minimal inflow disturbance and maximum diameter  
16 of the propulsor. These concepts include, 1) vectoring thrust,  
17 2) mounting canard wings forward on the vehicle, 3) including  
18 wings which fold out from inside of the IMP duct, and 4) making a  
19 flexible vehicle (vehicle gimbaled in center). Although these  
20 concepts may meet some requirements for integration of control  
21 surfaces for an IMP, they do not completely eliminate inflow  
22 disturbances from the IMP, do not maximize available volume for  
23 the IMP, and do not lend themselves to simple control systems.

24 Thus, in accordance with this inventive concept, a need has  
25 been recognized in the state of the art for improved control

1 surfaces for an IMP that do not interfere with inflow and  
2 outflow, allow launch from contemporary tube diameters, and do  
3 not rely on complicated systems.  
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#### 5 OBJECTS AND SUMMARY OF THE INVENTION

6 The first object of the invention is to provide a control  
7 surface system for a torpedo-like undersea vehicle.

8 Another object is to provide a control surface system for an  
9 undersea vehicle propelled by an IMP.

10 Another object is to provide an improved control surface  
11 system for an IMP that does not interfere with inflow and  
12 outflow, allows launch from contemporary tube diameters, and does  
13 not rely on unduly complicating systems.

14 These and other objects of the invention will become more  
15 readily apparent from the ensuing specification when taken in  
16 conjunction with the appended claims.

17 Accordingly, the present invention is a control surface  
18 system particularly well suited to provide improved control for  
19 undersea vehicles having integrated motor propulsors (IMP). The  
20 control surface system is deployable beyond lateral peripheral  
21 dimensions of the IMP and undersea vehicle. Arc-shaped control  
22 elements are disposed in a stowed position in an annular intake  
23 recess inside of an annular duct on the undersea vehicle. Struts  
24 connect each of the control elements to the annular duct. A  
25 deployment device rotates each of the control elements and the

1 struts radially outwardly beyond lateral peripheral dimensions of  
2 the vehicle to a fully deployed position. A latching mechanism  
3 selectively engages and disengages the struts to hold the control  
4 elements in the stowed position and the fully deployed position,  
5 respectively.

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#### BRIEF DESCRIPTION OF THE DRAWINGS

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A more complete understanding of the invention and many of the attendant advantages thereto will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in conjunction with the accompanying drawings wherein like reference numerals refer to like parts and wherein:

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FIG. 1 is an isometric drawing showing the arc-shaped control elements of the invention in a stowed position in an annular recess of an undersea vehicle during launch of the vehicle;

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FIG. 2 is a partial cross-sectional view taken generally along line 2-2 in FIG. 1 schematically showing details of an upper strut and stowed control element of the invention;

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FIG. 3 is a cross-sectional top view of an arc-shaped control element in the deployed position schematically showing details of exemplary articulating modules of a steering assembly;

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FIG. 4 is a cross-sectional front view taken generally along line 4-4 in FIG. 3 schematically showing details of the exemplary

1 actuation mechanism of the arc-shaped control element in the  
2 deployed position;

3 FIG. 5 is a schematic, isometric showing of the stowable  
4 control elements of the invention in a position deployed radially  
5 outwardly beyond the lateral peripheral dimensions of the  
6 undersea vehicle; and

7 FIG. 6 is a cross-sectional view taken generally along line  
8 6-6 in FIG. 5 schematically showing details of a deployed upper  
9 strut and control element of the invention.

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#### 11 DESCRIPTION OF THE PREFERRED EMBODIMENTS

12 Referring to FIGS. 1 and 2 of the drawings, control surface  
13 system 10 of the invention is mounted aft on a torpedo, or  
14 similar undersea vehicle 60 launchable from a standard launch  
15 tube 70 into ambient water 80. Control surface system 10 of the  
16 invention is shown in a retracted, or stowed position in an  
17 annular intake recess 61 adjacent to intake contour 62 on vehicle  
18 60. This stowed position permits fitting and being retained in  
19 launch tube 70 prior to and during launch of vehicle 60 from  
20 launch tube 70.

21 Control surface system 10 is particularly well suited for  
22 vehicle 60 having an integrated motor propulsor (IMP) 90. IMP 90  
23 can be any one of many well-known designs having a rotor, or  
24 propeller 92 in an annular chamber 94 adjacent to annular intake  
25 recess 61 and inside of an annular duct 95. Annular duct 95 is

1 mounted on vehicle 60 by at least one hydrofoil-shaped structural  
2 member 96, although four such structural members 96 are included  
3 in this embodiment. This design can achieve maximum propulsor  
4 performance and motor power density inside of duct 95 that can  
5 have a hydrofoil shape if the duct is as large as possible and  
6 its outer surface 95A equals the outer diameter (lateral  
7 peripheral dimensions) of vehicle 60.

8 Control surface system 10 has a set of four streamlined  
9 hydrofoil-shaped struts 20 orthogonally disposed about vehicle  
10 60. Each strut 20 is secured to a lateral pin 22 which is  
11 pivotally connected to annular duct 95 extending across a slot 97  
12 formed in annular duct 95. The other end of each strut 20 is  
13 secured to a lateral pin 24 and is pivotally connected to the  
14 middle of a separate arc-shaped control element 30. Lateral pin  
15 24 extends through a separate slot 31 formed in each control  
16 element 30. The four curved, or arc-shaped control elements 30  
17 have first and second surfaces 30A, 30B on their opposite sides.  
18 These arc-shaped control elements 30 make up segments or sections  
19 of a streamlined segmented duct 32 that occupies annular intake  
20 recess 61 when control elements 30 are stowed in a retracted  
21 position. When stowed, each control element 30 is secured by a  
22 separate latching mechanism 91 located in annular duct 95. Arc-  
23 shaped control elements 30 are curved allowing conformance of  
24 their outer first surfaces 30A to the outermost radius of vehicle  
25 60. This sizing and fitting of control elements 30 allows



1 control elements 30 to be large to enhance control capabilities  
2 when they are deployed without affecting the outer diameter of  
3 undersea vehicle 60.

4 Referring additionally to FIGS. 3 and 4 each control element  
5 30 has a steering assembly 40 therein for responsively  
6 articulating, or rotating control element 30 to steer and  
7 maneuver vehicle 60 after control element 30 has been fully  
8 deployed beyond the lateral peripheral dimensions of vehicle 60.  
9 Each steering assembly 40 has a pair of articulation modules 50A,  
10 50B that each includes an actuator unit 52 connected to batteries  
11 54. Actuator unit 52 preferably includes a motor and gearbox;  
12 however, other devices such as solenoids, smart materials or the  
13 like could be used. Although only one articulation module 50A or  
14 50B might be selected, two modules 50A, 50B are more likely to be  
15 used to overcome the forceful resistance created by flowing fluid  
16 80' on control elements 30 as vehicle 60 travels through water  
17 80.

18 Articulation modules 50A, 50B are completely contained  
19 within each control element 30. Both actuator units 52 from both  
20 articulation modules 50A, 50B of each steering assembly 40 can be  
21 connected to engage lateral pin 24 and/or strut 20. These units  
22 52 can selectively and responsively rotate each interconnected  
23 control element 30 in opposite directions as shown by arrows 99  
24 (FIG. 6) to steer and maneuver vehicle 60. Such rotation is  
25 imparted in response to control signals shown as arrows 52A

1 transmitted over control leads 52B extending to units 52 through  
2 strut 20, annular duct 95 and structural member 96 from a control  
3 module (not shown) in vehicle 60.

4 In a first embodiment, steering assemblies 40 can be used to  
5 deploy control elements 30 to the fully deployed position  
6 radially outwardly from vehicle 60 as shown in FIG. 5. Steering  
7 assemblies 40 can rotate edges 30' of control elements 30  
8 counter-clockwise out of the stowed position as shown in FIG. 1  
9 and away from vehicle 60. This rotational displacement causes  
10 edge 30' and second control surface 30B of control elements 30 to  
11 be exposed to a force created by flowing water 80' as vehicle 60  
12 is propelled through water 80 by rotor 92 of IMP 90. The pushing  
13 force exerted on control surfaces 30B by flowing water 80' can be  
14 used to complete rotation of control elements 30 from the stowed  
15 position shown in FIGS. 1 and 2 to the fully deployed position of  
16 FIG. 5

17 In a second embodiment, an extending mechanism 98 can be  
18 provided in contact with each strut 20 and in combination with  
19 steering assembly 40 for deployment. Extending mechanisms 98  
20 (only one of which is schematically shown in FIG. 6) can be small  
21 electric motor-gear-box combinations in annular duct 95 that each  
22 engage a separate strut 20 and/or lateral pin 22. This mechanism  
23 98 can hold each control element 30 in its stowed position in  
24 annular intake recess 61, see FIGS. 1 and 2. In addition, each  
25 extending mechanism 98 can rotate a separate strut 20 in response

1 to control signals shown as arrow 98A over control lead 98B  
2 extending to the control module. Rotation of all of struts 20  
3 around the longitudinal axis of lateral pins 22 in response  
4 control signals 98A will deploy control elements 30 radially  
5 outwardly from longitudinal axis 60A of vehicle 60 to fully  
6 deployed positions shown. Steering assembly 40 can orient  
7 control element 30. Instead of a motor, extending mechanism 98  
8 can also include a coiled biasing spring selectively released by  
9 appropriate control signals to use its biasing force to rotate a  
10 separate strut 20 and control element 30 to the fully deployed  
11 position of FIGS. 5 and 6.

12 The latching mechanism 91 associated with each strut 20 also  
13 acts as a stop to prevent further rotation of each strut 20 and  
14 engages each strut 20 to secure, or fix it at the fully deployed  
15 position. Latching mechanism 91 can be any of many such  
16 mechanisms freely available in the art. As mentioned above,  
17 latching mechanism 91 can also engage each strut 20 when each  
18 control element 30 is in the stowed position of FIGS. 1 and 2.  
19 Appropriate control signals 91A over a lead 91B extending to a  
20 control module in vehicle 60 can actuate latch mechanism 91 to  
21 selectively disengage or engage strut 20. Steering assemblies 40  
22 and flowing ambient water 80' over vehicle 60 and through annular  
23 chamber 94 can both be used to displace control elements 30 to  
24 the fully deployed position. Extending mechanisms 98 can act as  
25 a damper to prevent control elements 30 from being too rapidly

1 extended, or deployed. This damping assures that they will not  
2 be damaged as they otherwise might forcefully impact the stop  
3 created by latching mechanism 91.

4 Four struts 20 and control elements 30 with associated  
5 modules have been described. It is understood that different  
6 numbers of differently shaped struts and control elements could  
7 be made in accordance with this invention to allow large control  
8 elements 30 to be deployed and stowed in a relatively small  
9 volume within the dimensions of undersea vehicle 60. In  
10 addition, other mechanisms, controls, and actuation approaches  
11 could be selected by one skilled in the art to which this  
12 invention applies without departing from the scope of this  
13 invention herein described. The invention disclosed herein can  
14 be applied to more conventional undersea vehicles having long  
15 proven conventional propulsion systems instead of IMP 90. Having  
16 this disclosure in mind, selection of suitable components from  
17 among many proven contemporary designs and compactly interfacing  
18 them on vehicle 60 can be readily done without requiring anything  
19 beyond ordinary skill.

20 The disclosed components and their arrangements as disclosed  
21 herein contribute to the novel features of this invention.  
22 Control surface system 10 of this invention provides a reliable  
23 and cost-effective means to improve the reliability and  
24 responsive operation of many different undersea vehicles 60.  
25 Therefore, control surface system 10 as disclosed herein is not

1 to be construed as limiting, but rather, is intended to be  
2 demonstrative of this inventive concept.

3       It will be understood that many additional changes in the  
4 details, materials, steps and arrangement of parts, which have  
5 been herein described and illustrated in order to explain the  
6 nature of the invention, may be made by those skilled in the art  
7 within the principle and scope of the invention as expressed in  
8 the appended claims.

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STOWABLE INTEGRATED MOTOR PROPULSOR FINS

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ABSTRACT OF THE DISCLOSURE

6 A control surface system is particularly well suited to  
7 provide improved control for undersea vehicles having integrated  
8 motor propulsors (IMP). The control surface system is  
9 deployable beyond lateral peripheral dimensions of the IMP and  
10 undersea vehicle. A plurality of arc-shaped control elements is  
11 disposed in a stowed position in an annular intake recess inside  
12 of an annular duct on the undersea vehicle. Struts connect each  
13 of the control elements to the annular duct. A deployment  
14 device rotates each of the control elements and the struts  
15 radially outwardly beyond lateral peripheral dimensions of the  
16 vehicle to a fully deployed position. A latching mechanism  
17 selectively engages and disengages the struts to hold the  
18 control elements in the stowed position and the fully deployed  
19 position, respectively. Launch tubes sized for the undersea  
20 vehicles can launch undersea vehicles provided with control  
21 surface system.

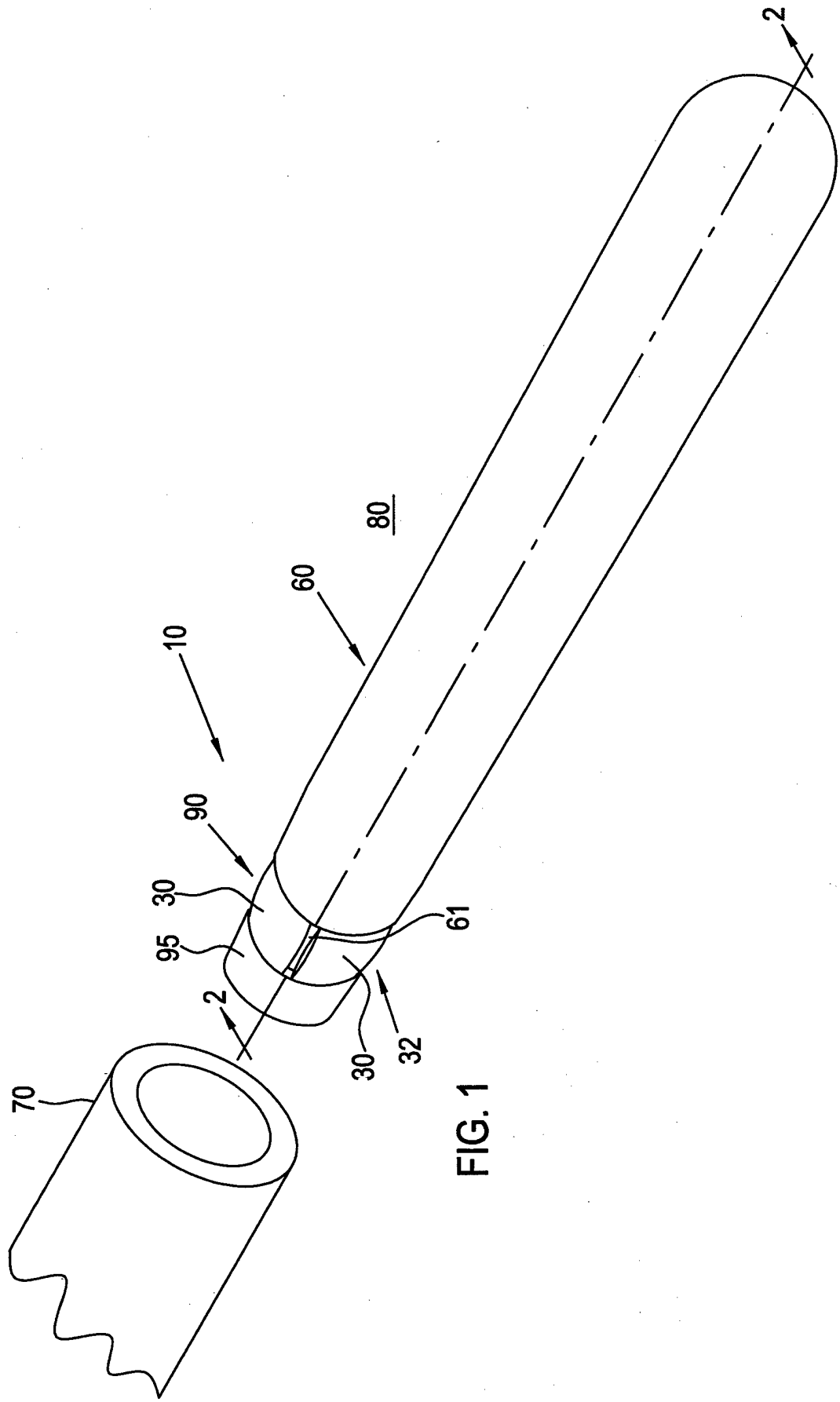


FIG. 1

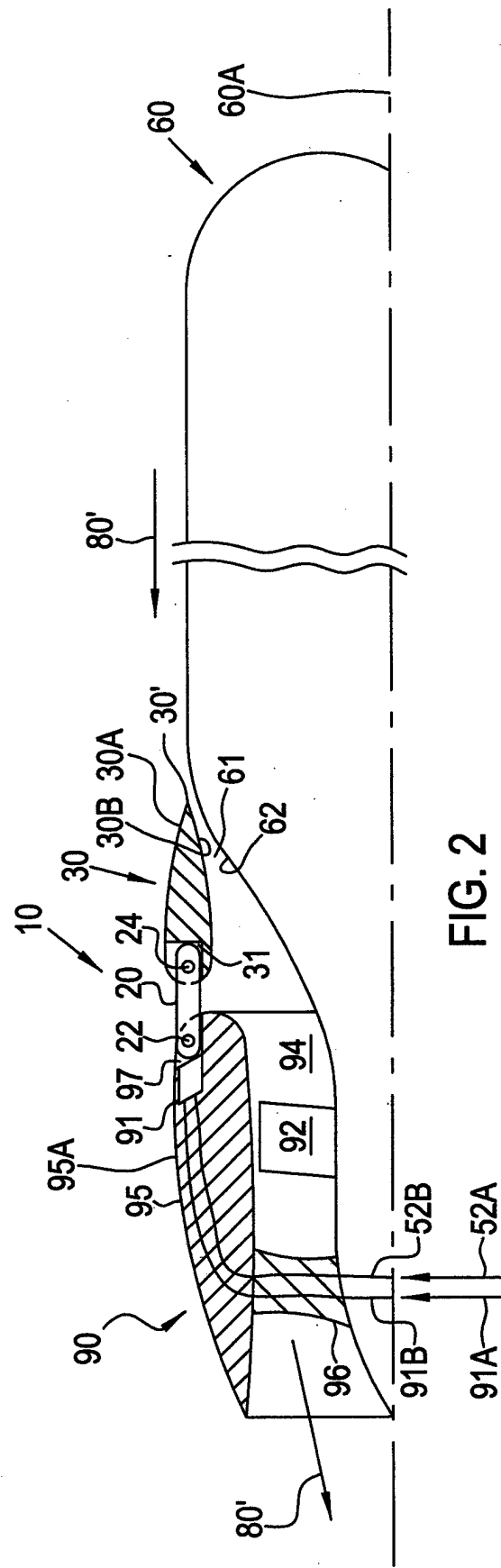


FIG. 2



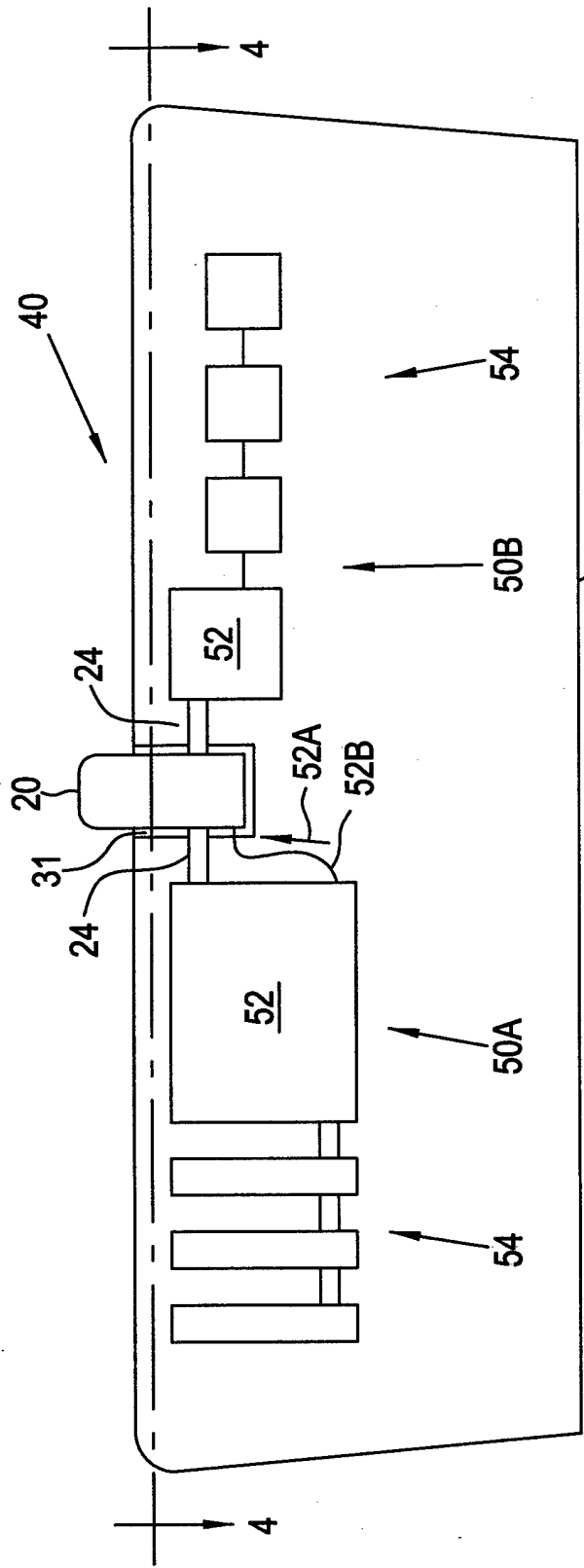


FIG. 3

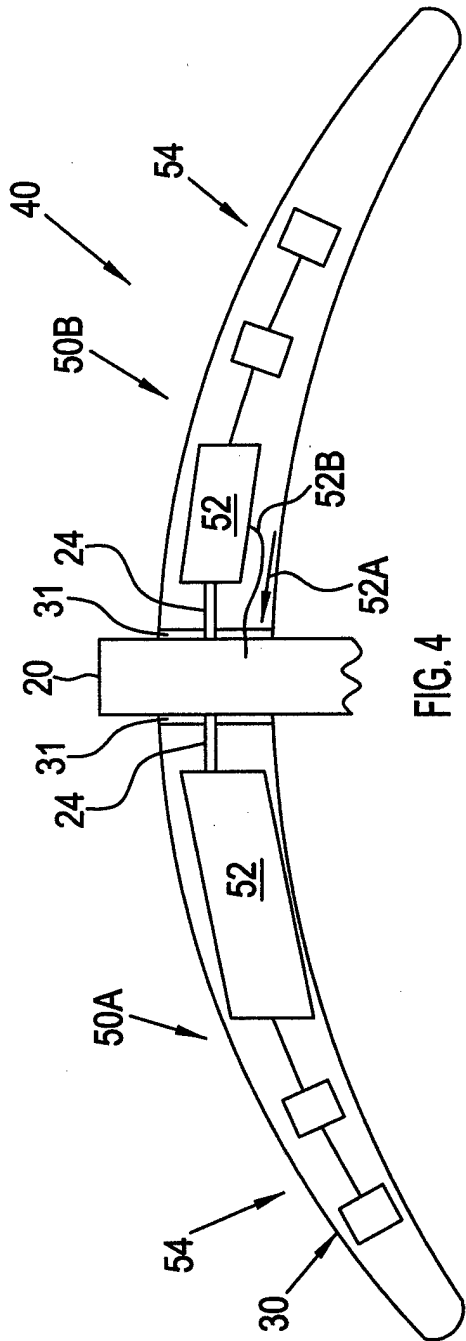


FIG. 4

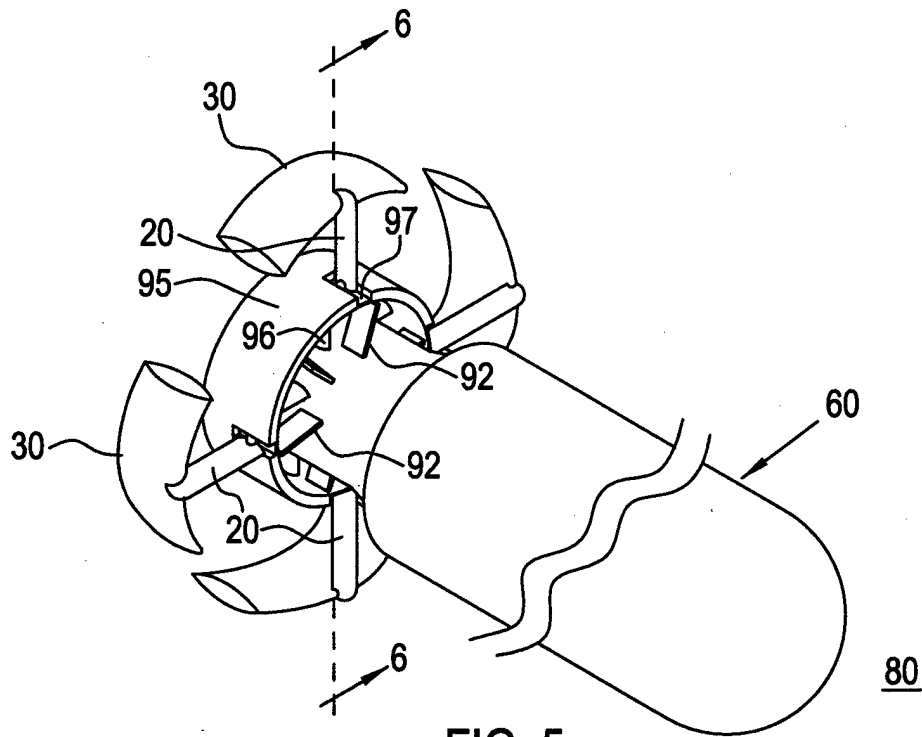


FIG. 5

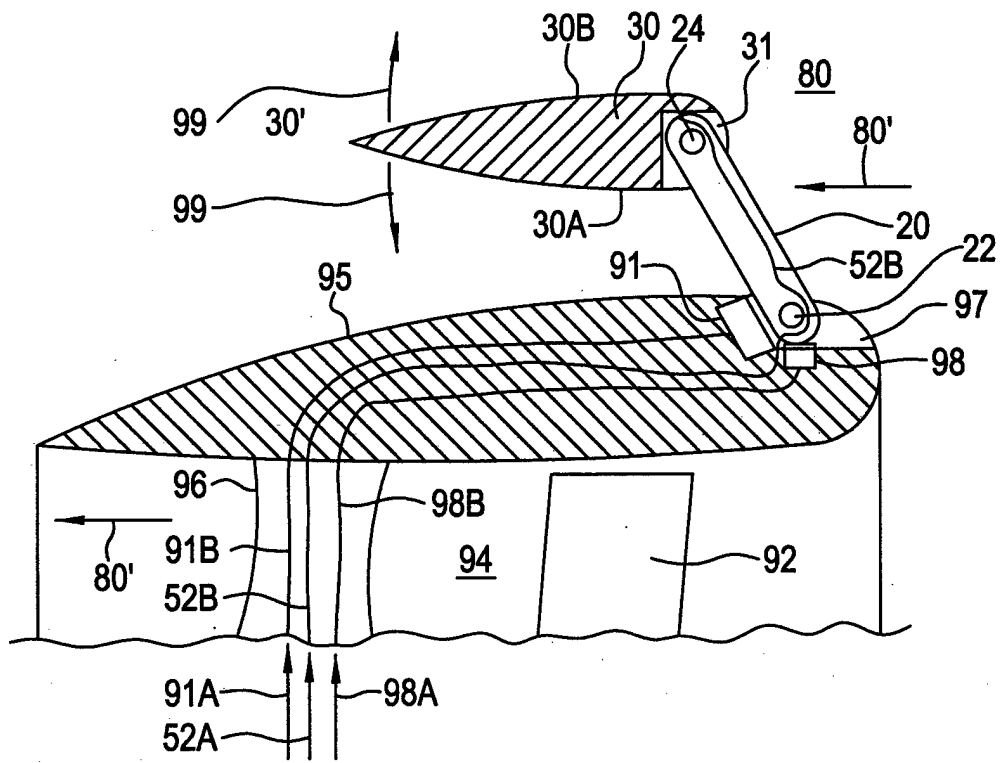


FIG. 6