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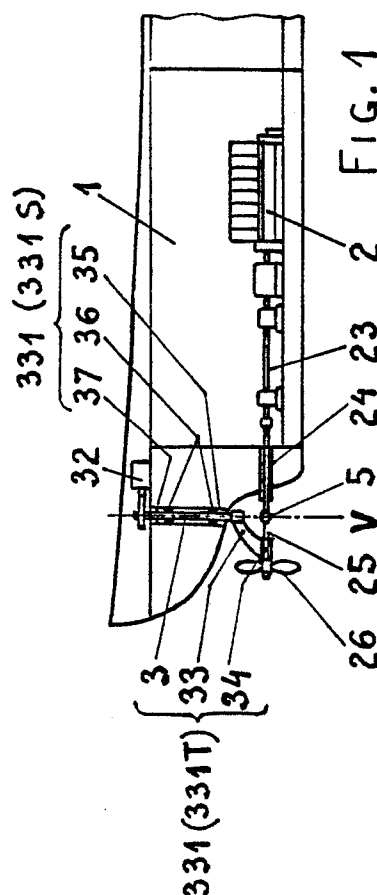
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Ship installation with the rudder propeller driven by a generally horizontal shaft line together with specific joints and propeller-shaft carriers thereto.

The shaft line includes a joint (5) before the propeller shaft (25) whereby the angularity of the latter is enabled with respect to the driving shaft (23). Besides the standard universal joints to be applied, a series of special gearbox and hydraulic joints have also been developed for the installation proposed. All of a multitude of propeller-shaft carriers (331) consist of the turning assembly (331T) and stationary assembly (331S) whose connecting and thus pivoting vertical axis coincides with the angularity axis V of the joint.

Whereas the existing systems of ship steering with the rudder propeller (Schottel, etc.) have the shaft line "broken" several times in the elevation plan, the proposed installation is a "direct drive" with complete shafting lying in a horizontal line which makes the installation generally simpler, more reliable and capable of transmitting greater power ratings.

In a series of cases the installation is a capsuled reducing-steering-propelling "compact" to be simply attached to or inserted into the ship's stern even while the ship is afloat.



SHIP INSTALLATION WITH THE RUDDER PROPELLER DRIVEN BY A GENERALLY HORIZONTAL SHAFT LINE TOGETHER WITH SPECIFIC JOINTS AND PROPELLER-SHAFT CARRIERS THERETO

1. Technical field to which the invention relates

The invention relates to the field of ship propulsion and steering installations and it is particularly appropriate for the ships having need of an increased steering capability.

2. Definition of the technical problem

The problem solved is that of ship steering by means of the "rudder propeller" which, in the case considered, is applied to the direct drive of ship implying that the shaft line is generally horizontal, i. e. that the usual vertical "stem" of the Z-drive is eliminated and substituted by an adequately sealed joint.

3. Background art

There is a general need to improve the steering of ships. This requirement is, however, particularly acute with pushboats, tugs, trawlers and other workboats.

Lately, to increase the steering capability, there has been introduced the Z-drive (Schottel, etc.) with the engine mounted on the deck and the shaft line "broken" twice at right angles - firstly at the upper and secondly at the lower bevel-gear reduction gearboxes; Hook (Cardan) joints, splines, etc. are also built in the shaft line.

The steering of the Z-drive is very good ("positive" steering by the "rudder propeller", no rudders proper are necessary) and the high-speed engines are applicable which both is useful, - but the shaft line has become complicated and rather vulnerable (instead of in the eliminated rudders, the complexity and vulnerability exist now in the shafting). Besides, only relatively small and light engines can be installed on the ship's deck.

When installing a heavier engine in the machinery room, then the transmission is first conveyed on the deck (or below it) by a belt drive or by an obliquely positioned joint shaft and then there ensues the "leg" of the Z-drive (vertical shaft in the "stem" (tube) between the two gearboxes followed by the horizontal propeller shaft in its gondola) - which all is again complicated.

For a better comparison and discussion, some additional features of the state of the art will be presented only after the present invention has been disclosed.

4. Disclosure of the invention

With the reference to the drawings, the invention will be described hereinbelow.

4.1. List and brief description of the drawings

Fig. 1 -General lay-out of the installation proposed with the joint 5 in the shaft line before the propeller shaft 25 ("first variant" for 5 being a universal joint).

Fig. 2 -a = side view at the joint 5, propeller shaft bearing 34, curved lever 33 and stock 3; b = plan view, propeller shaft 25 deflected by the turning (steering) angle

Fig. 3 -A general presentation of the propeller-shaft carrier 331 with its axis of turning (pivoting) $v_{331} = v = v$.

Figs. 4, 5, 6, 7 -Various kinds of the carrier 331.

Fig. 8 -Rudder 31 as the carrier 331.

Fig. 9 -The universal joint 5 shielded by the boot seal 555 and its protectors 571, 572.

Fig. 10 -Gear joint 5 in the one-part stationary housing 55 with the aft "window" 550A ("second variant").

Fig. 11 -Gear joint 5 in the two-part housing (part 551 stationary, part 552 turning) with the vertical seals 62M ("third variant").

Fig. 12 -Gear joint 5 in the one-part turning housing with the forward "window" 550F ("fourth variant").

Fig. 13 -Review of variants: a - 1st var. (universal joint 5); b - 2nd var.; c, d, e - 3rd variants, versions forward-aft, lower-upper and upper-lower, resp.; f - 4th var. [b, c, d, e, f with gear joint 5]; g - 5th var. (hydraulic joint 5); h, i - 3rd and 4th variants with the joint protector 151, resp.

Fig. 14 -Arced plate 6 with spring 61 and seal 62 in guides 56i, 56e.

Fig. 15 -Angular widths of the aft window 550A, guides 56, etc., IGA = inter-guide access.

Fig. 16 -Sealing of the aft window 550A by the riding band 6BR.

Fig. 17 -a = equatorial seals 62E of the riding band 6BR with chamber 62i filled with header-tank oil; b, c = entry seals ES.

[Next Figs. 18-24, 2nd var.]

Fig. 18 -An embodiment; sealing by the arced plate 6 and boot seals 660, access tube 165 oblique.

Fig. 19 -Tunnel 55T with the quasi stern tube 24Q; curved levers 33, 33L connected to the housing-born pins 541, 541L, RSPC.

Fig. 20 -As in Fig. 19 but with engine 2 on the forward extension FE, semi-MRSPC.

Fig. 21 -Ways of sealing tunnel 55T.

Fig. 22 -An embodiment; curved lever 33 connected to the riding band 6BR which carries also the gear wheel G_n , vertical access.

Fig. 23 -Horizontal ring RG in the guides GRG carrying the shaft 25i, access oblique.

Fig. 24 -Arm 3A of the joint stock 51 carrying the hollow shaft 25.

[Next Figs. 25-38, 3rd var.; Figs. 25-35, version forward-aft]

Figs. 25, 26, 27 -External, medium and internal supporting of G_n , resp.

Fig. 28 -Bearing 52 connected to the turning part 552; part connecting pins 5512, 5512L.

Fig. 29 -Inter-part chamber 55i filled with oil from the header tank HT.

Fig. 30 -Entry boot seal 555 and its protector 571 with the seal 517s.

Figs. 31, 32 -Sealing of the joint protector 151.

Figs. 33, 34 -Two embodiments of the 3rd variant; sealing near MMP, joint protector 151, flexible coupling 292, oblique access, etc. (extensive description in text).

Fig. 35 -Stationary calotte 551 tunneled, no axis displacement, RSPC.

Figs. 36, 37 -Versions upper-lower, access oblique.

Fig. 38 -Version lower-upper, no access.

Fig. 39 -"fourth variant"; forward window 550F, window protector 171F, boot seal 174F.

Fig. 40 -3rd variant, version lower-upper; horizontal ring RG, lowering tube connection, access vertical, RSPC.

[Next Figs. 41-43, 52, 54,56 hermafrodite designs of RSPCs]

Fig. 41 -Stationary vertical tube 55V (part 551) and riding band 6BR (part 552) extended upward, stern tube 24 in guide 24G.

Fig. 42 -As in Fig. 41 but with the stern tube 24 structural (outside-hull case).

Fig. 43 -Vertical tube 552 turning in the short tube 551 in the stool ST.

Fig. 44 -Hydraulic centrifugal joint.

Figs. 45, 46 -Hydraulic multisphere friction joint.

Fig. 47 -Cylinder hydraulic whirl coupling.

Fig. 48 -Sphere hydraulic whirl joint.

Fig. 49 -V-drive with horizontal propeller shaft 25.

Fig. 50 -Gear joint 5 with the secondary set of gears $G_1, \dots, G_n$.

Fig. 51 -System protectors 191F and 191A (forward outer and aft inner, resp.).

Fig. 52 -Version for larger ships, inner and outer housings (55V and 55D, resp.), riding band 6BR, tunnel 55T, etc.

Fig. 53 -Easily substitutable gearbox joint in cage CG.

Fig. 54 -"Capsular variant" of the joint.

Fig. 55, 56 -Two embodiments of the capsular variant (reversibility, flexible couplings both at input and output of the joint).

Fig. 57 -Satellite gears cylindrical.

Fig. 58,a,b,c -Substitution of RSPC while the ship is afloat (for compacts with horizontal tunnel).

Fig. 59 -General substitution of RSPC when the ship is afloat (cone-shaped connecting element 55E, etc.).

Fig. 60 -An embodiment, substitution of RSPC as in Fig. 59.

Fig. 61 -Strut bearing 244 arrangement.

Fig. 62 -Substitution of RSPC while the ship is afloat in the case of the strut bearing.

4.2. Abbreviations used

CP = central plane (of ship); CPP = controllable pitch propeller; EP = equatorial plane (of joint); PSC = propeller-shaft carrier; MMP = main meridional plane (of joint); MRSPC = motoring-reducing-steering-propelling compact; RSPC = reducing-steering-propelling compact. --
x --

The Z-drive is fundamentally opposed to the "elementary rule" of the ship drive which is based on the fact that the engine crankshaft is generally horizontal, that the propeller shaft is also horizontal and that therefore the intermediate shafting connecting them (in fact, the whole shaft line) should be horizontal as well.

It is exactly the "leg" of the Z-drive (in fact, its vertical "stem" only) that, on one hand, "hurts" the "elementary rule" and that, on the other one, provides very good steering with the Z-drive.

Therefore, the technical problem and engineering task posed are as follows:

How to avoid the vertical "leg" (its "stem") and thus meet the "elementary rule" and thereby still achieve as good a steering as with the Z-drive?

The answer reads:

As shown in Fig.1, the engine 2 is put on the floor of the machinery room of ship 1 and then a normal generally horizontal shaft line is installed and let, as usual, to pass through the stern tube 24 but - which is essential -with a joint 5 being built into it just after the stern tube 24 (or just after the strut bearing) and a specific carrier 331 of the

propeller shaft 25 being fitted to the ship's stern 11 (in one embodiment, in Figs. 1 and 2, that carrier consists of the propeller-shaft bearing 34, curved lever 33 and stock 3 in bearings 36, 37 in the structural tube 35). The specifics of the carrier 331 lies in the fact that, on one hand, it holds firmly (in an unyielding way) the propeller shaft 25 and propeller 26 and, on the other one, enables their turning by the steering angle α owing to the fact that - which is also essential - the carrier's 331 axis v_{331} (stock's 3 axis v_3) of pivoting coincides with the joint's 5 pivoting axis v_5 , $v_{331} = v_3 = v_5 = v =$ common axis.

[To note is also that the propeller-shaft bearing 34 is provided with the thrust collar 342 and that the stock 3 is turned by the steering gear 32; skeg 121 and fins 122, 122L are useful but not essential for the "answer".]

This basic "answer" (solution proposed) belongs to the class of simple "classical direct drives" of ship (where the whole shaft line is horizontal) - but now, which is novel to that class, with the propeller being a "rudder" propeller ("active" steering).

As a matter of course, this basic solution can be elaborated in a multitude of ways regarding both the joint 5 and propeller-shaft carrier (PSC) 331.

Thus, the joint 5 may be a universal mechanical (commercially available) joint (as in Figs. 1 and 2), a gearbox joint (to be proposed here), a hydraulic joint (to be proposed here), an electro-magnetic joint, etc. while the PSCs 331 can be designed in a multitude of ways.

In general, the propeller-shaft carrier 331 consists (see general Fig. 3) of its turning (pivoting) assembly 331T (34, 33 and 3 in Figs. 1 and 2) and stationary assembly 331S (bearings 36, 37, tube 35 in Figs. 1 and 2) with its axis v_{331} of pivoting necessarily coinciding with the joint's axis v_5 .

Another implementation of the PSC 331 is shown in Fig. 4 where it consists of the curved lever 33 that is provided with the hub 330 pivoting around the pin 111 fixed in the stern 11 (pin 111 may be extended and have the upper bearing 1191 which is represented by dotted lines: 33, 330 and 111, 1191 belong to the 331T and 331S, respectively). The pin 111 and steering gear 32 (M is the meshing of the steering gear 32 with hub 330) are located in the well 116 provided with the window 110 through which the curved lever 33 gets out of the well.

Next step is the pin 111 supported by the strong cantilever beam 119 protruding from the stern 11, cf. Fig. 5 (the tiller 3301 and ran 321 are in the well 116 but there is the protector 1162 with seal 1163 that closes the well 116 and keeps it dry; dotted lines present the extension of the pin 111

and its upper bearing 1191).

Note: Generally, since consisting of several elements, the propeller-shaft carrier 331 is not particularly denoted in the figures to follow; exceptions to this are made only in Figs. 1, 2, 4 and 8. Textual comments regarding 331 (331T and 331S) are, however, given for a number of figures.]

A further example of the PSC 331 is given in Fig. 6 where besides the curved lever 33 and its hub 330 there is the pin 241 fixed to the arm 242 which is just an extension of the stern tube 24 (the arm 242 is shrunk on the stern tube). The near-by steering gear 32 is fitted also to the stationary arm 242 (or to the pin 241 itself).

Further on, in Fig. 7 there are the lower curved lever 33L, its hub 330L, pin 241L and arm 242L which are "parallel" to the upper ones 33, 330, 241, 242, respectively. The steering gear 32, located in the dry compartment 116, is connected to the hub 330 of the upper pin 241 by a short vertical stock 3 and a double slider or similar coupling 513 (311 is the seal of the stock 3).

It will be seen later that there are also the designs with pins 541 (for hubs 330) on the joint's housing 55, whereby the housing is included into the PSC 331. However, the discussion of the multitude of PSCs 331 will be temporarily interrupted here by noting only the fact that also the usual rudder 31 with its stock 3 can be transformed into the carrier 331 of the propeller shaft 25 inasmuch as it accommodates the joint 5 in its lower forward corner and "receives" within itself the generally horizontal propeller-shaft bearing 34, cf. Fig. 8.

[To note is that the pins 111, 241,... and hubs 330,... - as well as their equivalents to appear in the further discussion - can exchange their carriers. For example, the pins may be fixed to the curved levers 33, 33L,... (and thus belong to the 331T) while hubs, turned into bearings, may be fixed to the (earlier pins') stationary carriers (and thus belong to the 331S).]

With the designs in Figs. 1, 2, 4, 5 and 8 the propeller 26 is - through the PSC 331 - supported by the stern 11 of ship ("stern-supported" propellers).

With the designs in Figs. 6 and 7 the PSC 331 is such (it includes the pin 241 on the arm 242 of the stern tube 24) that the propeller is supported by the stern tube 24 ("stern-tube supported" propellers; most of the announced designs where the housing 55 is included into the PSC 331 belong to this group, too).

Mixed solutions are possible as well.

Stern-tube supported propellers are very convenient regarding the alignment of the shaft line.

Note should be made that the propeller shaft 25 in Figs. 1 through 8 is relatively short, that it is almost completely situated in the propeller shaft

bearing 34 held by the curved levers 33, 33L and that therefore it is well protected. A substitution of the levers 33, 33L by the strong cone-shaped jacket 33J to be made later (Figs. 23, 38, 42, etc.) will improve that protection.

To note is here that this is not for the first time that the universal joints would be fitted into the horizontal ship shaft lines.

Namely (and here is where we extend our previous presentation of the background art), such joints have been fitted into the shaft lines just aft of the "elastically mounted" engines in order to bring into accord the "freely moving" engine with the "stationary" shaft line.

Then the Swedish firm Scatra AB (Box 2001, S-14900 Nynäshamn, Sweden) fits the universal joints into the shaft lines of boats mainly to avoid alignment problems and to reduce noise and vibration.

There are, however, the cases of the joints installed within the ship's hull so that, consequently, nor application of the joint is made for the steering purposes.

In contrast, in the case of the "Arneson drive" (Arneson Marine Engineering, Inc., 15 E Koch Road, Corte Madera, California 94925, USA), the joint has been taken out of the hull and the propeller shaft 25 (its bearing) is supported by two obliquely aftward positioned hydraulic cylinders fixed to the stern (transom) 11 of boat whereby the joint is used exactly for the steering purposes (the very steering is performed by extending and contracting the cylinders).

The hydraulic cylinders with the Arneson drive make it, however, that the supporting/suspension system of the propeller shaft is both

-elastic (due to the axial yielding or compliance ['Nachgiebigkeit' in German] of cylinders - which, indeed, damps vibration); and

-vulnerable (since the obliquely aftward positioned cylinders require pretty long unprotected and therefore very exposed propeller shafts).

For this reason the Arneson drive is suitable for smaller (pleasure, patrol and similar) boats only while the proposed installation

-owing to its "rigid" propeller-shaft support (due to both the assemblies 331T, 331S of the 331 and their connection being uncompliant ['unnachgiebig'];

-and also to its relatively short and protected propeller shaft (which, as such, is not unduly exposed and therefore is not unduly vulnerable) is appropriate generally, that is, both for the heavier boats (push boats, work boats, etc.) as well as for smaller boats including the smallest ones where the turning of the rudder stock 3 (generally, of the PSC's 331 turning assembly 331T) is performed manually.

After the above additional discussion of the background art and comparison of the proposed installation with it, let us turn to the said installation again.

The existing universal joints applicable in the installation proposed are the homokinetic universal joints such as the well-known double Cardan universal joint, Tracta, tripot, Rzeppa, Weiss, cross groove universal joints, etc.

The only additional requirement for the universal joints when applied in the proposed ship installation refers to a better sealing (surrounding water should not enter the joint) and this is a requirement that can be met in a satisfactory fashion (a similar situation is met in sealing the hubs of controllable pitch propellers (CPP) where the problem of sealing has been satisfactorily solved).

A simple sealing of the universal joint in our application is presented in Fig. 9 where the joint 5 is embraced by the boot seal 555 which is fixed to the driving and propeller shafts 23 and 25, respectively. Besides, there are the spheric protectors 571 and 572 which are fixed to the same shafts and which protect the boot seal 555 from the streaming surrounding water, floating debris, etc.

To note is that the universal joint 5 is completely carried by the driving and propeller shafts (and thus revolves with them).

The application of the universal joint will be called the first variant of the installation proposed.

An overview of variants is given in Fig. 13 where Fig. 13,a relates to the 1st variant.

However, the universal joints possess an infinity of axes with respect to which the two shafts connected can be "broken" (angularity or pivoting axes). This is much more than necessary in our application where basically only one (vertical) axis of angularity is needed.

The above fact induces us to design "simple" (nonuniversal) joints possessing only one (vertical) axis of angularity.

Two groups of such simple joints will be proposed here. The first group consists of mechanical gear joints (the second, third and fourth variants of the installation, Figs. 10, 11, 12, resp., and 13,b-f) while the second one includes hydraulic joints (the fifth variant of the installation), Fig. 13,g).

The basic version of the mechanical simple gear joint consists of the following:

The first gear in a train of gears is bevel pinion G_1 fixed to the driving shaft 23 getting out of the stern tube 24, cf. Fig. 10. Then, there follows a train of bevel (and eventually spur or worm or planet) gears reducing, but not necessarily so, the speed of revolution. The last but one gear G_{n-1} is a bevel gear and its axis v_{n-1} , around which the joint stock 51 is built up ($v_{n-1} = v_{51}$), is vertical and coincides with the axis v_3 of the vertical stock 3 (of

the PSC 331) and thus with the common axis v ($v_{n-1} = v_{51} = v_3 = v_{331} = v$).

The axis of the least gear G_n , which is also a bevel gear, is horizontal ($n_{\min} = 3$) and it coincides with the axis of the propeller shaft 25 supported by the propeller-shaft bearing 34 that is linked (by the curved lever 33) to the stock 3. The bearing 52 of the last gear G_n (in fact, of the last-gear shaft 25i to be called the intermediate propeller shaft) is supported by the joint stock 51 by means of the curved arm 53 and bearing 54 (or otherwise) in the way that it can be turned (pivoted) around the joint stock. (The propeller shaft 25 and intermediate propeller shaft 25i are connected either directly or through a spline 255, etc. so that they are coaxial and therefore will be jointly called the "propeller shafting".)

The train of gears described is necessarily enclosed in the housing (casing) 55 shrunk on the stern tube 24. The problem of the propeller shafting 25,25i getting out of that housing (in a sealed way) to perform its steering turning will be discussed at a later stage.

The gear complex presented is a simple "joint" acceptable in our application. For, the axis v_{51} of the joint stock 51 is actually the vertical axis v_5 of the joint 5 with respect to which the axes of the incoming driving shaft 23 and outgoing propeller shafting 25,25i realize the joint angle when, in the steering turning, the propeller shafting travels (gets deflected) in its horizontal plane by pivoting with respect to the axis v_{51} of the joint stock 51.

Let us, however, note the following. The meshing points of gears $G_1, \dots, G_{n-3}, G_{n-2}$ of the train of gears are invariable while the meshing point of the last but one gear G_{n-1} and the last gear G_n travels in the steering turning on the pitch diameter circumference of the last but one gear G_{n-1} . In other words, in the steering turning the last gear G_n undergoes an additional rotation (positive or negative - depending on the direction of α) as against the gear G_{n-1} which is superimposed on the regular (driving) rotation (to note is that the same phenomenon exists in the lower gearbox of the Z-drive). However, this additional (steering) rotation is less than 0.5% of the regular (driving) rotation so that it may be neglected.

[Notes: (a) While the theoretical ratio of the (mean) speeds of the incoming and outgoing shafts with the universal joints is 1:1, with the simple gear joint proposed it is 1:b where $b \geq 1$ (with b being a constant or, if need be for a greater flexibility of operation, several constants); (b) Depending on the design, the angularity with the universal joints is theoretically limited to $15^\circ - 40^\circ$ and, besides, with an (operationally) increasing angularity the driven shaft undergoes an increasing nonuniformity as against the driving shaft revolving

uniformly; in contrast, with the simple gear joint proposed there is no (theoretical) limit to the angularity (in the horizontal plane) and, in addition, the driven shaft follows exactly (in a constant speed ratio) the driving one.]

Needless to say, besides their function as joints, the gear joints described are also reduction gears or gearboxes (and even, if need be, the reverse reduction gears).

To point to both of the said functions, they might be called the reduction gear joints or the gearbox joints.

As already noted, the gear joint variants are necessarily the "housing variants". Basically, there are three ways to design the housing 55 and thus to fit the gearbox joint into the ship installation:

-The housing 55 is a unique (one part) housing that is shrunk on the stern tube 24 and possibly connected to the stern 11 of ship (by attachment 159) so that it is stationary, see Figs. 10, 13,b, 18. In this case the housing must be provided with a sealed aft horizontal slot or port or "window" 550A to allow the propeller shafting 25,25i to get out of it and perform its steering turning by pivoting around the common axis v . Hence, this is the case of the "stationary one part housing with the sealed aft window" - to be referred to as the second variant of the installation.

-The housing is a two-part casing with the dividing plane being either the medium vertical transverse plane (main meridional plane, MMP) or one of the horizontal planes, preferably the medium one (equatorial plane, EP). The part that is fixed to the stern tube 24 (in general, to the ship's stern 11) is the stationary part 551, the other part is riding on it and that is the turning (pivoting) part 552 (its turning axis v_{552} coincides with the common axis v) while the propeller shafting 25,25i is passed "normally" (without a "window") through it since they turn (pivot) together; thus, by naming first the stationary part 551, there are either the versions forward-aft (MMP-sealed versions, vertical seals 62M), Figs. 11, 13,c, 25-28, 33-35, or the versions lower-upper, Figs. 13,d 38, 40, or upper-lower, Figs. 13,e, 36, 37, which are the EP-sealed versions (horizontal seals 62E). Hence, this is the case of the 'two-part housing with the part sealing in or near the dividing plane (and no window sealing of the propeller shafting)" - to be called the third variant of the installation.

[Notes: (1) Under circumstances, the dividing plane may also be an oblique plane more or less close to either MMP or EP or it may be just in between; (2) Generally, the stationary part 551 and pivoting part 552 may be either the inner and outer parts or vice versa.]

-The housing 55 is again a unique (one part) housing which, however, is connected (by attach-

ment 335) to the curved lever 33 (in general, to the PSC's 331 turning assembly 331T) and thus pivots with it around the common axis v , see Figs. 12, 13.f, 39. In this case the housing is provided with a horizontal sealed forward "window" .550F to be able to ride (in the steering turning) across the incoming driving shaft 23 which is revolving but stationary in space. Hence, this is the case of the "turning one part housing with the sealed forward window" - to be denoted as the fourth variant of the installation.

Let us first discuss the 2nd variant.

The only real problem with the 2nd variant (Figs. 10, 13.b, 18) is the sealing of its aft window 550A.

By allowing for the radius of the propeller shafting plus the window seal the angular width $\pm\alpha_w$ of the window 550A should be by a small amount (by $\pm\beta_1 \approx \pm 15^\circ$, say) greater than $\pm\alpha_m = \pm\alpha_{max} =$ steering angle of the propeller shafting (which amounts to $\approx \pm(30^\circ - 50^\circ)$), $\pm\alpha_w = \pm(\alpha_m + \beta_1)$, Fig. 15.

One of a multitude of ways to seal the window 550A of such an angular width is by the stiff vertical plate formed (in the horizontal plane) as a circular arc (the center of the circle is in the joint stock axis $v_{51} = v_5 = v$), to be called the arced plate 6, Fig. 14, which plate embraces (by its collar 60) the propeller shafting 25,25i and travels with it in the circular guides 56 (56i = internal guide, 56e = external guide or housing wall) by the steering (turning, deflection, pivoting) angle $\pm\alpha_m$. The angle widths $\pm\alpha_6$ of the circular-arc plate 6 and $\pm\alpha_{56}$ of the guides 56 are by $\pm\beta_1$ greater than $\pm\alpha_m$ and $\pm\alpha_3$, hence $\pm\alpha_6 = \pm(2\alpha_m + \beta_1)$ and $\pm\alpha_{56} = \pm(3\alpha_m + \beta_1)$, respectively, Fig. 15. (β_1 is by $\Delta\beta$ greater than β_1 to allow for the width $\Delta\beta = \beta_1 - \beta_1$ of the seal around the vertical rim of the window 550A.)

The arced plate 6 is pressed by the stationary spring 61 against the seal 62 fixed to the housing wall 56e, which wall - while being in the equatorial region of the housing - is, just as the plate 6, circular in plan and vertical in elevation. The seal 62 circumvents the window 550A.

In a variation, the springs may be fixed to the arced plate 6 and travel with it. In general, there is a number of seals and "springs" that may be applied here (including the inflated hoses, the Newark seals, radial face mechanical seals, etc., which are both at the same time - hence, "springy" seals - and as such are self-adjustable). If necessary, more than one seal or springy seal may be on both sides of the arced plate 6 with the chambers between the seals filled with the overhead tank oil. Also, there may be two or more arced plates 6, etc.

If the guides are made a complete horizontal circle then a full-circle riding band (short vertical

turning tube) 6BR is used instead of the arced plate 6 and also the full-circle standard Simmer rings (lip rings), O-rings, etc. 62E are used instead of the seal 62, cf. Fig. 16; in this case, the "seal range" consisting of the upper and lower riding-band seats 6SU and 6SL and one or more upper and lower horizontal seal rings 62EU and 62EL located above and below the propeller shafting 25,25i, resp., together with the riding-band 6BR and guides, - should not interfere with the range of the driving shaft 23, that is, there should be an either positive or negative axis displacement a (axis of the shafting 25,25i should be either above or below the axis of the shaft 23, $a > 0$ or $a < 0$, respectively).

The arced plate 6 or riding band (tube) 6BR are actually covers to the window 550A and therefore will be jointly called the window covers WC.

In Fig. 17,a there is presented the lower end of the riding band 6BR with its seat 6SL and two seal rings 62E in their chamber 62SC (by conduit 6CB, the inter-seal chamber 62i is filled with header tank oil). For the sealing of the very entry to the seal chamber 62SC there is the collar ES of polymer, hard rubber or similar material, which collar is radially slightly elastic so that the spring 6S tightens it to the housing 55. Thus, the sealing is quadruple: by the collar ES, by seal rings 62E, by the header-tank oil (conduit 6CB) and by the very seat 6SL.

The collar ES as an entry seal may be applied generally. If the stationary and turning parts 551 and 552, respectively, are close to one another, then the entry seals ES may be made as in Figs. 17,b,c or in any other appropriate way.

In Fig. 18 there is presented one of a multitude of embodiments of the 2nd variant.

The one-part housing 55 is shrunk on the stern tube 24 and, by the oblique access tube 165, connected also (by attachment 159) to the stern 11 of ship.

Its aft window 550A is sealed with the arced plate 6; there are also seal 62, spring 61 and collar 60. Besides, there are two sets of internal boot seals 68 with collars 660 and plates 606 and 607.

The joint 5 consists of the joint stock 51 and bevel gears G_1 , (G_2 , G_3) and G_4 supported by the driving shaft 23, joint stock 51 and intermediate propeller shaft 25i, resp., so that there is a double reduction of the speed of revolution. The axes of the joint stock 51 and stock 3 necessarily coincide with the common axis v .

The intermediate propeller shaft 25i is supported by two roller bearings in the bush 514 whereby the bearing 522 is formed that is built in the joint stock 51 (which means that the matter is about the "internally supported" gear wheel G_4 , cf. Fig. 27 and the relevant text). The aft end of the

intermediate shaft 25i supports the flexible coupling 292 that connects it to the propeller shaft 25.

The PSC's turning assembly 331T consists of the curved lever 33 and stock 3. While in the steering turning the turning assembly of the joint (consisting of 51, 514 (522), 25i, 522, G₄, 292) is basically turned (deflected) by the propeller shaft 25 through the flexible coupling 292, a more direct turning is performed by the joint stock arm 517 which is coupled to the curved lever 33 by the plate 531 in the guides 532 whereby the lagging of the turning assembly of the joint due to the compliance angle of the flexible coupling 292 is forestalled.

The oil bath in the bottom of the housing serves for lubrication of gears and bearings (forced lubrication may be applied as well). Partition 293 protects the flexible coupling 292 from oil splashing. The fan 294 cools the rubber parts of the flexible coupling 292 (the heat is transmitted to the surrounding water). Bilge 7 is drained by the bilge pipe.

Another version of the 2nd variant is presented in Fig. 19 where the housing 55 is provided with the forward tunnel 55T that is inserted in the tunnel guide 55TG in the stern (transom) 11 and fixed there. In the lower portion of the tunnel there is the quasi "stern tube" 24Q with its bearings BA and BF (or, instead, two "open" bearings without the tube) supporting the driving shaft 23. (The tube 24Q is located within the tunnel 55T so that it is not, as usual, a structural part of the stern 11 directly wherefrom we call it the "quasi" stern tube).

If the tunnel guide 55TG and the engine foundation are well aligned then the driving shaft 23 and the forward part of the shaft line are connected by an ordinary coupling (or by a spline). Otherwise, for alignment reasons, they may be connected by either a flexible coupling or a joint (working practically with a zero angularity) or, as in Fig. 19, a short shaft 23S with fast gear couplings GC at its ends.

In Fig. 19, the housing 55 and its tunnel 55T belong to the stationary assembly 331S of the PSC 331 since the pins 541, 541L on the very housing support the curved levers 33, 33L and thus receive the propeller's both weight and thrust force and transmit them through the housing 55 to the ship's stern 11. To note is that this version is very practical since the whole installation (both the gearbox joint and the propeller with the complete PSC 331) is a compact unit to be simply (horizontally, axially) inserted (slid like a drawer) into the ship's stern (substitution of a damaged unit by a new one is very quick). Besides, there is an ample horizontal access 160 enabling major repairs of the gearbox to be done with the ship afloat.

Besides bringing forth the easiness of mounting and dismounting, the compactness mentioned implies also that the whole unit is produced, adjusted and aligned in works with very little to be done aboard the ship. Such compact units emerge as soon as the housing 55 gets included in the stationary assembly 331S of the PSC 331 (by introducing the pins 541, 541L fixed onto the housing 55 or otherwise). Since the compact units in hand include a reduction gear, a steering gear (basically, the joint-stock turning assembly) and a propeller - they will be called the reducing-steering-propelling compacts (RSPC). Besides the very compactness, the main characteristic of the RSPCs is their easiness of mounting and dismounting.

For smaller ships with high-speed engines (which are both small and light), the RSPC may contain also the engine itself that is fitted on the lower tunnel plate in front of the quasi stern tube 24Q or, if the latter is omitted, in front of the gearbox joint. In this case, evidently, there is no problem of shaft alignment within the ship since the whole shaft line including the engine is contained in the compact (in its tunnel 55T), which compact - since performing also the motoring - will be called the motoring-reducing-steering-propelling compact (MRSPC). (The motor may be an internal combustion engine, an electric or hydraulic motor, etc.).

Hence, the RSPCs and MRSPCs with the horizontal tunnel 55T are actually some kind of "capsules" (or "cartridges") to be inserted into the ship's stern to perform the functions indicated. (It will be seen soon that there are the RSPCs with the oblique and vertical access tubes as well.)

If the engine - even though being a high-speed one and thus generally small and light - is still too large to be located within the tunnel 55T (horizontal tube 165), then it may be fitted on the "open" forward extension (platform) FE of the lower side of the tunnel and mounted there only after the compact has been inserted into the hull (and dismounted before it is pulled out from the hull), Fig. 20. The concept that the whole shaft line including the engine and propeller at its ends is carried by a single structure (which is the structure of the compact) so that the ship's hull is not involved in shaft alignment - is preserved here.

Since this compact is an RSPC before being inserted into the stern to become an MRSPC only thereafter, it may be called the semi-MRSPC.

The tunnel guide 55TG and other fixation should be standardized for a wide interchangeability of RSPCs or MRSPCs.

The sealing of the tunneled compacts can be made in a number of ways: by seals SL (packings, inflatable hoses, etc.) below the outward and inward attachments 159, Fig. 21,a; by the plate ring

PR lightly welded to both the tunnel 55T (tube 165) and stern 11, Fig. 21,b; by seal SL at the forward end of the guide 55TG, Fig. 21,c; by some stuffing boxes by filling the "chamber" between the tunnel and its guide with the header tank fluid, etc.

The next group of versions of the 2nd variant is to make the stationary housing 55 as a strong vertical tube 55V protruding from the ship's stern 11 and possessing the aft window 5510 while the curved levers 33, 33L (or their substitutes such as a cone, sleeve, etc. carrying the bearing 34 and embracing the shaft 25) are fixed to the strong window cover WC riding the tube 55V. Thus in Fig. 22 the WC is the riding band 6BR that lies by its foot 6F on the circular foothold (seat) 6FH offered by the inner stationary tube 55V. The band carries a strong horizontal bush 55BS whose forward end enters the tube (housing) 55V through its window 5510 and yields there the bearing 52 to the shaft 25i and gear G_4 while its aft end yields the bearing 52A to the shaft 25i and the forward half of the flexible coupling 292. The propeller-shaft bearing 34 and curved lever 33 carry the bush 34B which is shrunk on the aft end of the bush 55BS while the curved lever 33 itself is also fixed to the band (tube) 6BR which rides on the stationary tube 55V that is shrunk (by its bush 55B) on the stern tube 24 (33, 6BR, 55BS and 55V, 55B, 55t belong to the 331T and 331S, resp.)

Thus, the stern tube 24 carries the weight of the cantilevered complex "gearbox joint plus propeller" while the clamping moment is offered both by the stern tube 24 and the structural tube 55S of the stern 11. Namely, the complex is horizontally shrunk on the stern tube 24 (the stern 11 is slightly sunk so as to receive thereby the forward upper end of the tube 55V) and then the intermediate tube 55t within the tube 55S is lowered down ("lowering tube connection") by being either screwed or shrunk or splined, etc. onto the tube 55V (so that, in some cases, the weight is partially born by the tube 55S, too). Thus, the vertical tube (housing) 55V is not strictly a structural part of the stern and therefore the mounting of the whole unit is easy - such that this is an RSPC with the vertical (upper) access 160.

The gear wheels G_2 and G_2' in Fig. 22 are by their claws and sliding dog SD (which is actuated by the lever LV and hydraulic cylinder HC) intermittently coupled to the sleeve SLV whereby the reversing is performed. The steering gear 32 is fixed to the tube 55V and it meshes with the horizontal arced rack AR which is, through the upper window 550U, connected with the band 6BR (or, alternatively, which is through the pillar PL (dashed lines) connected with the forward end of the bush 55BS in which case there is no upper window 550U).

The seals 62EL and 62EU are O-rings (other seals are possible, too). The upper seal 62EU is additionally sealed with the entry seal ES.

The hose 261 and distributing box 262 fitted to the face of the shaft 25i serve the mechanism of the controllable pitch propeller. (CP propeller is an alternative to the reversing mechanism by G_2 , G_2' .)

The version in Fig. 22 differs basically from the previous versions in the following: it is only the stationary housing 55 or 55V (belonging to 331S) that has been supporting all the gears $G_1, \dots, G_n$ in the previous versions while in Fig. 22 the last gear G_4 is being supported by the riding band 6BR (belonging to 331T). This implies that the dimensions a_1 and a_2 should be made very precisely since they affect directly the meshing of G_4 with G_3 ($a_1 + a_2 = a$ = displacement of axes of shafts 23 and 25i). Also, the gliding surfaces of the foothold 6FH and foot 6F should be well both made and protected.

A somewhat different interior of the housing 55 (55V) than in the previous designs is presented in Fig. 23 where the horizontal ring RG is fitted in the circular guides GRG fixed to the inside of the cylindric housing 55 (the centers of the guides lie in the joint stock axis $v_{51} = v$) while the ring contains the bearings BRF and BRA supporting the shafting 25,25i that is passed through the arced plate 6 (or band 6BR). The propeller-shaft bearing 34 is fixed to the arced plate 6 (or band 6BR) by the stiff streamlining cone-shaped jacket 33J which is strong enough to receive and transmit to the housing 55 both the propeller's weight and thrust and which also turns out to be a good protection to the propeller shaft 25 (while the shafts 25i and 25 are connected by the flexible coupling 292). The steering gear 32 is matched with the sector SC fixed to the ring RG.

For reversing, the two gears G_4 and G_4' freely revolve on the shaft 25i and are intermittently matched to it by the multidisk clutches MDC (claw and other clutches can also be applied). The joint stock 51 is short (it carries only the gears G_2 and G_3).

By its bush 55B, the cylindric housing 55 is shrunk on the stern tube 24. Besides, its top is fixed (by a flange or similar coupling - to be generally called the "face connection" and designated by 158) to the stationary oblique tube 165 (with access 160) protruding from the stern 11 so that the whole unit is mounted very simply (bell-and-spigot and some other couplings may be used here, too). Hence, this is an RSPC with the oblique (forward upper) access.

[Connections as by the vertical intermediate tube 55t in Fig. 22 ("lowering tube connection") or by the oblique (or other) tube as in Fig. 23 ("face connection" 158) can also be applied to a number

of other gearbox joints in order to achieve an RSPC.]

In Fig. 24 the strong vertical joint stock 51 is provided with the horizontal arm (cantilever) 3A which carries the hollow propeller shaft 25 with the gear wheel G_4 and propeller 26. The shaft passes in the usual way through the arced plate 6 (or riding band 6BR). The joint stock 51 is supported by the strong bearings 5BL and 5BU in the housing 55 that is shrunk on the stern tube 24 and attached to the stern 11 by the tube 165. The steering gear 32 fitted in the housing turns the stock 51 by the quadrant SC. The bearing 52H in the propeller's hub is both axial and radial such that the thrust is transmitted through the arm 3A to the joint stock 51 and the housing 55 (thus, 3A, 51 and 55, 24, 165 belong to the 331T and 331S, resp.). The gear G_4 is splined to the shaft 25 so that the thrust does not affect the meshing point of G_4 with G_3 .

If the housing is connected to the tube 165 by a flange or similar face coupling 158 (as in Fig. 23) then the arrangement is an RSPC. The joint stock 51 may be extended into the stock 3 supported by the structural tube 35, the stock 3 being provided with the curved lever 33 carrying the propeller shaft bearing 34 (dashed lines). (In the latter case the arrangement ceases to be an RSPC.)

Now, let us discuss the case of the third (or two-part housing) variant of the installation.

Here, the discussion of the 3rd variant will at first be conducted for the forward-aft (MMP-sealed) versions of the variant with the housing parts 551 and 552 being the inner stationary and outer pivoting calottes, respectively, cf. Figs. 11, 13, c, 33, 34, but it will generally hold for the other versions, too.

Before tackling the basic problem of the 3rd variant - which is that of sealing the two housing parts - let us discuss the problem of supporting the last gear wheel G_n (which problem is general but is emphasised here because of the relative motion of the two housing parts).

As for the supporting of G_n , it has already been shown that its bearing 52 is supported by the joint stock 51 by means of the curved arm 53 and bearing 54 so that it can pivot either around or with the joint stock, cf. Fig. 11.

There are, however, some additional solutions, too.

Thus, first of all, there may be two curved arms and their bearings, the upper ones 53 and 54 and the lower ones 53L and 54L, resp., cf. Fig. 25 (in Figs. 25-28, $G_n = G_4$). The joint stock 51 is the basic supporter of all of them.

Then, the hub 520 of the gear wheel G_n may be supported by the pin 521 that is carried by the joint stock 51, cf. Fig. 26 (so that the hub-520

complex plays the role of the bearing 52).

Thereupon, the bearing 52 of G_n may be built in the very joint stock 51, cf. Fig. 27, in which case it is denoted by 522.

Considering the distance of the bearing 52 (or 522) from the joint stock 51 (which is the final supporter of G_n in all of the above cases), one may say that Figs. 25, 26 and 27 present the cases of external, medium and internal supporting of G_n , respectively.

To note in Figs. 25-27 is also that the stationary forward part (calotte) 551 of the housing bears the whole of the joint 5 (gears $G_1, G_2, \dots, G_n$ and stock 51) while the aft part 552 serves only as a (turning) cover to it (and is also born by it).

However, if the aft calotte (part) lies precisely on the forward one, then one may dispense with the curved arm(s) 53, 53L or the other means for the bearing 52 to be directly supported by the joint stock 51. Namely, in this case the bearing 52 of G_n may be fixed to the aft calotte (part) 552, cf. Fig. 28. Pins 5512 and 5512L connect the two parts 551 and 552 (part-connecting pins) and thus yield the counter-moment to the moment of weight taken by the bearing 52; they also align the axes of the two parts, which axes coincide with the joint stock's 51 axis $v_{51} = v$ (so that the bearing 52 is now indirectly - through 552 and 5512, 5512L - again connected to the joint stock 51). The latter property makes the part-connecting pins generally recommendable.

Pins 5512 and 5512L may be external (Fig. 28) or internal. Mixed cases are possible as well.

Functionally, each housing part is single but for production and mounting reasons the parts may be made of several subparts.

The stationary forward part 551 should in any case be provided with the aft window 5510 to allow for the steering turning of the outgoing propeller shafting. However, that window is not sealed since it is covered by the turning aft part 552 so that the general inter-part sealing is responsible for that window, too.

There may be only one seal between the parts in the MMP or two such seals 62M (standard Simmer or lip rings, O-rings, rings with grooves, etc.) may be fitted near the MMP, Fig. 29; in the latter case the inter-calotte chamber 55i (space between the two seals) is filled with oil from the header tank HT (so that the oil pressure in the chamber 55i is somewhat higher than that of the surrounding water).

To note is, however, the following. In the case of the vertical MMP-seal 62M and with the axis v of pivoting being vertical, the points of the seal move perpendicularly to the seal's plane so that there are the surfaces on the stationary part (calotte) 551 which are intermittently covered by the turning

(pivoting) part 552 and thereafter exposed to the external water. Therefore, some cleaning of these surfaces should be provided (brush ring 552R in Fig. 29) in order to reduce their fouling. (There is, however, no such phenomenon with the horizontal EP-seals where the points of the seal keep moving in the plane of the seal only.)

Besides the inter-part seals 62M, there may be fitted to the joint 5 a boot seal 555 fixed to the forward part (calotte) 551 in the range of its shrinking on the stern tube 24 and to the forward rim of the aft part (calotte) 552 so that it covers the very entry to the inter-part space 55i, Fig. 30. Therefore, it will be called the entry boot seal. (Let us note that the entry boot seal 555 has already been used with the universal joints, that is, with the 1st variant, cf. Fig. 9.) Needless to say, the simple entry seals ES, Fig. 17, may also be applied here.

The entry boot seal 555 may be protected by the stationary spheric protector 571 fixed to the forward calotte 551 in the range of its shrinking on the stern tube 24, cf. Fig. 30.

This protector is extended aft beyond the MMP so that it covers the entry boot seal 555 even at the maximum steering angle $\pm\alpha_{\max} = \pm\alpha_m$ and thus does so permanently. The gap between its opening and the aft calotte 552 may also be sealed (stationary seal 571s that rubs against the turning aft calotte 552, cf. Fig. 30).

The (partly or completely) turnable joint housing 55 with the 3rd and 4th variants may be protected by a protrusion 151 of the ship's stern 11 that embraces the joint housing 55 (cf. Figs. 13,h, 33, 34 and 13,i, 39 for the 3rd and 4th variants, resp.) and lets (through the gap in between) the external water enter the space 153 of the protector and stand there as "dead" (almost immovable) water (ballast). This protector (protrusion) 151 may be either permanently fixed to or dismountable from the ship's stern 11. Since in the final account it protects the joint 5, it will be called the joint protector.

To note is that, by the way, the joint protector 151 may serve as a good stern bulb for a better induction of water by the propeller - which is a property to be only welcomed.

Now, once the joint protector 151 having come close to the joint housing 55, the gap 150 between its opening and the joint housing may be sealed and thereby the joint 5 may virtually be "introduced" into the ship's hull.

For a spheric (two-calotte or the like) housing 55 the said gap 150 is circular and then the standard ring seals are readily applicable for the joint protector seal 152. These are reliable seals and they make it that the space 153 within the protector (stern protrusion) turns out to be dry.

Some of a multitude of variations of seals 152

are presented in Fig. 31 (a ring with grooves) and Fig. 32 (three Simmer rings; by pipe and channel 154 the chamber 151i between the forward rings 152F and 152M is filled with the header tank oil while the aft ring 152A is responsible for the gap 150). Designs with one seal active and with a special device for the stand-by seal ring to be engaged after the first one has yielded are also possible.

With the unsealed or sealed joint protectors the interior of the joint 5 or of space 153, respectively, may eventually be held under a slight air overpressure.

One of a multitude of embodiments of the forward-aft (MMP-sealed) version of the 3rd variant of the installation is presented in Fig. 33. Two parts 551 and 552 of the two-part housing 55 are calottes. The forward (inner) calotte 551 is shrunk (by its bush 55B) on the stern tube 24 and the two calottes are aligned by internal part-connecting pins 5512 and 5512L. The aft (outer) calotte 552 is extended forward beyond the MMP (its dividing plane is in the EP - see the shading of 552).

The gearbox joint consists of four bevel gears G_1, G_2, G_3, G_4 (G_4') and there is the joint stock 51.

The intermediate propeller shaft 25i is supported by the bearing 52 (that is carried by the curved arm 53 and bearing 54, hence by the joint stock 51) and the bearing 522 within the joint stock 51 whereby the external and internal supports, resp., of the gear wheel G_4 are realized (cf. Figs. 25 and 27).

The gear wheel G_2 has a platelike form to conform better to the spherical housing and also to make free room between the pinion G_1 and the wheel G_4' (which room is necessary for the free turning of the turning assembly of the joint).

The aft calotte 552 is connected to the propellershaft bearing 34 by the elastic jacket 57 enveloping the flexible (rubber) coupling 292 between the shafts 25i and 25.

The inter-calotte sealing is provided for by the seals 62M. In addition, there is the entry boot seal 555 with its stationary spherical protector 571 (cf. Fig. 30) that is fixed to the stern tube 24 (to the bush 55B). Finally, there is the joint protector 151 with its seal 152 and brush ring 152R. The joint protector space 153 is provided with the bilge system 71.

The steering turning to the turning assembly of the joint is transmitted from the curved lever 33 through the coupling 532, 531 to the outer calotte 552 to whose pin 5512 is keyed the joint stock 51 and then through the bearing 54 (that is also keyed to the joint stock 51) and curved arm 53 to the bearing 52 of the gear wheel G_4 .

Clutches MDC (of any design) mesh either G_4 or G_4' with the intermediate shaft 25i whereby the

reverse reduction gear joint is achieved. Oil or air or else to control the clutches is conducted through the oblique access tube 165, collar 51c and joint stock 51.

An embodiment similar to that of Fig. 33 is shown in Fig. 34.

However, the flexible coupling 292 is now located in the very joint 5 (it is a metallic rather than rubber coupling). Then the aft calotte 552 has the forward subpart 552S connected to it by screw thread. Since there is no external bearing 52 to the shaft 25i (otherwise held by the now nonexistent arm 53), the internal bearing 522 (within the bush 514 in the joint stock 51) is pretty long and the shaft 25i is splined there (spline 515) while the gear wheels G_4 , G_4' revolve on the spline's bush 514.

The joint stock 51 is passed upward through both calottes and then connected with the rudder stock 3 by the double slider coupling 513 whereby a direct steering-turning transmission to the turning assembly of the joint is performed.

The propeller 26 is shrouded by the Kort nozzle that is fixed to the curved lever 33.

In Fig. 35 there is presented a forward-aft two-calotte version of the 3rd variant where the shafts 23 and 25i are coaxial ($\alpha = 0$). Owing to the multidisk (or other) clutches MDC and gear G_1 this gearbox joint is reversible. Besides the MMP seals 62M there is also the entry seal ES. The steering gear 32 turns (by quadrant SC) the joint stock 51 and thereby also the propeller supporting system 33, 33L, 34. Due to the tunnel 55T, quasi stern tube 24Q and housing-born pins 541, 541L (which may be merged with the part-connecting pins 5512, 5512L) this is an RSPC (or an MRSPC) within the 3rd variant.

A presentation of the EP-sealed versions of the 3rd variant is given in Figs. 13.d, 38 (version lower-upper) and 13.e, 36, 37 (version upper-lower). The housing parts 551 (stationary, shrunk on the stern tube 24, provided with the window 5510 for the shaft 25 or 25i) and 552 (pivotal, with the shaft 25 or 25i passing through it normally) are cylindrical vessels ("pots") there but they might also be calottes, etc.

Since the inter-part EP-seals are necessarily located in the horizontal planes between the driving and driven shafts, there is an appreciable axis displacement a in this case (with the lower-upper and upper-lower versions the axis displacement is positive and negative, resp.).

The version upper-lower in Fig. 36 can receive a broad vertical or oblique access tube 265 but there is little use of it since it meets horizontal wheels G_2 and G_3 which block the entry to the joint. However, the configuration in Fig. 37 offers a broad and free access on account of the horizontal

wheels G_2 , G_3 being in the bottom of the housing owing to the spur gears G_a and G_b .

To note is that the top of the stationary upper part 551 in Figs. 36 and 37 is not closed, the upper bearing 5BU of the joint stock 51 being carried by the brackets 51BR.

In Fig. 38 there is presented a lower-upper version of the 3rd variant where both parts of the two-part housing 55 are cylindrical "pots" (note should be taken that the cylindrical surfaces of "pots" are easier to produce and fit than the spherical ones of calottes). The EP-seals 62E (with the chamber 55i between them filled with overhead-tank oil) lie now in the horizontal planes (which are necessarily between the driving and driven shafts) and thus all the rubbing is made only in the seal planes.

The propeller-shaft bearing 34 is by the thick cone-shaped jacket 33J connected to the turning upper housing part 552 which, through bearings 55U, 55L and 55A (or directly), is supported by the stationary lower part 551 that is (by its bush 55B) shrunk on the stern tube 24. Thus, the turning assembly 331T and the stationary one 331S of the carrier 331 consist of 34, 33J, 552 and 55A, 55U, 55L, 551, 55B, 24, resp. (steering gear 32 fitted on the stern tube 24 turns directly the turning part 552; alternatively, a special steering gear may be fitted in the cylindrical chamber between the parts 551 and 552). This is a specific kind of the PSC 331 where, in a sense, the lower "pot" 551 as a whole stands for the stern-tube supported pin 241 while both housing parts 551 and 552 are carrying elements (with, in the final account, both of them being carried by the stern tube 24). To note is that the propeller shaft is well protected by the jacket 33J.

This version (lower-upper) has no access (vertical or oblique access tubes would hit the turning pot 552).

In the case of the fourth variant of the installation, Fig. 13.f, the sealing of the forward window 550F may in principle be made in completely the same way as the sealing of the aft window 550A with the 2nd variant (see Fig. 14 where for this reason there are double designations 25(23) and 550A(550F)).

The vicinity of the forward window to the stern 11 of ship offers, however, the other ways to seal it.

The basic of them is as follows. The forward wall of the housing 55 containing the forward window 550F is either made as a horizontal circular arc or is simply formed spherically (the latter may also refer to the housing 55 as a whole). Then the stationary protrusion 171F from the stern 11 - to be called the forward-window protector - holds and presses to the housing (providing a face) the face

(mechanical or other) seal 172F of any appropriate design and thus seals the forward window (cf. Fig. 39 presenting an embodiment of the 4th variant).

In addition, the window 550F itself is closed by the boot seal 174F that is fixed to the forward wall of the housing 55 (within the window protector) and to the boot seal collar 175F that rides on the driving shaft 23 (and that is analogous to the collar 660 in Fig. 18). (Instead of to the collar 175F, the forward end of the boot seal 174F may also be fixed either to the inside of the forward window protector 171F or to the very stern 11 of ship within the protector.)

The bearing 521 of the pinion G_1 is carried by the curved arms 561 and 561L which are freely supported by the joint stock 51 by means of the bearings 541 and 541L, respectively (external support of G_1). The gear wheel $G_n = G_4$ is supported by the bearing 522 within the joint stock (internal support of G_n).

The driving shaft 23 (which is supported by the bearing 521, hence by the joint stock 51) and the intermediate driving shaft 23F (which is supported by the stern tube 24) are connected by the flexible coupling 292F where misalignment and other assembly errors are compensated for.

The rods 176 connect (by springs 176S) the collar 175F to the stationary window protector 171F whereby the assembly 521, 561, 561L is kept in the central plane (CP) without the aid of the flexible coupling 292F to that effect (connections 176, 176S are by far stiffer than the compliance of the flexible coupling and thus they transmit the reaction to the matching force of G_1 with G_2 to the window protector). In addition, the said connections prevent the collar 175F to revolve (due to the friction torque imparted to it by the shaft 23).

In the forward housing space there may be fitted the boot seals closing the forward window 550F from inside (in the same way as such seals have been applied to close the aft window 550A with the 2nd variant - see the internal boot seals 68 in Fig. 18).

In the window protector space 173F and joint protector space 153 there are bilges 7 with bilge systems 71.

So far, the window protector 171F and the face to its seal 171F on the housing have been stationary and turning, respectively. The reverse case is obtained if the window protector is fixed to the housing 55 and thus gets to be turning with it while the face to its seal is provided by the stationary stern which yields a sealing surface for that purpose that should be concave to the protector.

The access to the gearbox joint in the case of the 4th variant may be provided by and through a vertical turnable tube which is fitted instead of the massive stock 3.

Generally, the sealing of the forward window by the window protector 171F - which thus yields the 4th variant with protector sealing of the forward window - seems to be very efficient. This being the case, the protector window sealing may be applied also to the aft window 550A with the 2nd variant. In this case, instead of 550F and 171F there are 550A and 171A, respectively, and the support to the protector 171A of the window 550A should be provided by the turning propeller shaft bearing 34 (or some other part of 331T) with the housing 55 being stationary while all the rest should, in an analogous way, be as with the 4th variant with protector sealing of the window (hence, just as already mentioned 171A, there should also be 172A, 174A, 175A, etc.).

To note is that by some transformations a lot of designs belonging to the 2nd, 3rd and 4th variants containing the gearbox joint ("housing variants") can change their variant classification. This holds generally but is particularly feasible in the case of transforming from the 2nd to the 3rd variant.

In doing so, on reducing the earlier one-part housing to the stationary housing part 551 and introducing the turning housing part 552 - the arced plate 6 with its guides 56 or band 6BR are cancelled and substituted by either the 62M or 62E seals located near the MMP or in (parallel to) the EP (between the shafts 23 and 25,25i) with the forward-aft or lower-upper (or upper-lower) versions, respectively. Thereby, a lot of combinations of the versions are possible, too.

One of a multitude of such transformations and combinations is shown in Fig. 40 that derives from Fig. 23 (horizontal ring RG, etc.) but is also combined with Fig. 38 (two cylindrical pots, etc.) so that a lower-upper version of the 3rd variant is obtained. However, in Fig. 40 there is also the vertical tube 55t (within the structural tube 55S) the lower portion of which is splined with both the hub 330 and turning housing part 552 while its upper end is turned by the steering gear 32 and worm wheel 32W. This turning tube substitutes for the (stationary) access tube 165 and thus it is through it that the necessary piping and cabling are led to the multidisk or other clutches MDC, etc.

The tube 55t is lowered down (and thereby splined, keyed, etc. with 330 and 552) only after the bush 55B has been shrunk on the stern tube 24 ("lowering tube connection"). (The curved levers 33, 33L may be substituted by the cone 33J fixed directly to 552 in which case the hubs 330, 330L are omitted.) Hence, this is an RSPC even though the steering gear 32 is outside the compact ("S" in RSPC refers to the property of steering as such rather than to the very steering gear 32).

In some cases the transformation brings forth "hermafrodite" solutions.

One of a multitude of such solutions is presented in Fig. 4.1 that derives from Fig. 22 (2nd variant with band 6BR) where the inner tube 55V (housing) has been extended upward to pass through the structural tube 35. The upper rim of the riding band (outer tube) 6BR has also been raised above the water level WL and therefore the upper seal 62EU has been omitted. Now, with only the lower seal 62E (and possibly an entry seal ES) existing, and by hanging on the foothold 6FH of the inner tube 55V, the riding band 6BR may also be considered as the turning part 552 of the two-part housing 55 riding on the stationary part 551 (tube 55V) - which turns out to be the 3rd variant (version lower-upper, but with the part 551 extending upward beyond part 552).

The mounting is performed by a vertical insertion of the tube 55V into tube 35 which is followed by an axial aftward shifting of the stern tube 24 (in its guide 24G) to fit it into the tube 55V or its possible bush 55B (55V, 35, 24 make 331S). The turning of 6BR or 552 (and thereby of the propeller supporting system 33, 33L, 34 which is fixed to 6BR and which all make 331T) is performed by the steering gear 32 and quadrant SC fixed to 6BR; the stationary part 55V or 551 is provided with the aft window 5510 to pass through it the shaft 25i and curved arm 53; extension 582 of the band 6BR (part 552) rides the curved arm 53 whereby the turning of the joint assembly is performed.

Fig. 4.2 is the previous design for the case of a vertical stern (transom) 11. The stern tube 24 is immovable (structural) in this case so that the inner tube or part 551 (specifically, its bush 55B) is in its horizontal shifting shrunk onto it whereupon the radial bearing 36H is fastened. The outer tube (part 552) hangs by its foot 6F on the upper foothold 6FH. (Alternatively, the foothold 6FH and foot 6F may be put near the lower edge of the tube 552 - so that the latter tube is supported by the tube 551 rather than hung on it - in which case, as in Fig. 17.a, also its very seating 6SL gets to support the sealing action of the seal 62S; if the tube 552 is short, there may exist also the upper seals 62EU just above the propeller shafting). The steering gear 32 is fixed either to the stern 11 or to the bearing 36H or to the inner tube (part 551) in which case it is meshed with the outer tube through the window 550U (alternatives 32, (32), [32], respectively). The propeller-shaft bearing 34 is supported by the cone-shaped jacket 33J fixed to the turning tube 552 whereby a stern bulb is formed before the propeller. Summarizing, the design in Fig. 4.2 turns out to be a very simple and straightforward solution.

Another hermafrodite design is presented in Fig. 4.3. The heel of the stern 11 is formed as a stool ST holding the stationary part (short vertical

tube) 551 into which is entered the stern tube 24 and shaft 23 with pinion G_1 . Then the turning part (long vertical tube) 552 (holding the joint stock 51 with its gear assembly G_2-G_n and also the propeller supporting system 33, 33L, 34, etc.) is inserted vertically till its end (bottom) lies on the bottom of the tube 551 (and thereby G_2 meshes with G_1 and also seals 62E get tight). The clamp, buckle or similar radial bearings 36H are then fastened around the tube 552. Now, following the action of the steering gear 32 through the quadrant SC the tube 552 is turned together with the propeller supporting system and the joint stock assembly within it (34, 33, 33L, 552 and 551, 36H belong to 331T and 331S, resp.).

Hence, by its two-part housing (551 and 552) this is the 3rd variant. However, since the tube 552 is necessarily provided with the forward window 5520 to ride (in its steering turning) over the stationary stern tube 24 this may be considered also as the 4th variant (where the one-part housing is necessarily provided with the forward window 550F). For, after all, the stationary stool ST and short tube 551 may be considered as some "extensions" of the stern 11 and then what remains is the turning "one-part" housing 552 (however, the forward window 5520 is not sealed directly since "its" sealing is relinquished to the inter-part seals 62E). The design may also be viewed as that of Fig. 12 where the housing and stock 3 have been transformed and merged into the vertical tube 552 calling for the horizontal seal 62E.

If the access is dispensed with, then the tube 552 may be shortened and closed with some cover (just above the lower bearing 36H) and then continued (through a double slider or similar coupling) into the vertical stock 3 with the steering gear 32 still on (or near) the deck (if the tube 552 is ended somewhat above the water level, then an emergency access to its interior (joint 5) is still possible upon removing the stock 3 and the tube cover). Or, after the tube shortening, the steering gear 32 may be put on (or near) the bottom of the tube 552 and then, through a window, meshed with the stationary tube 551. Or, it may be fitted to the sternpost below the bearing 36H or on the stern tube 24 and meshed with the tube 552 from outside.

Now, let us present the hydraulic simple joints whose application presents the fifth variant of the installation, Fig. 13.g.

Four of a multitude of such joints will be presented here.

The first one is as follows (Fig. 4.4):

The driving shaft 23 bears a set of longitudinal (radial) plates with semicircular external contours to be called the inner blades IB.

The driven (propeller) shaft 25 bears the hollow sphere SH with inner longitudinal (radial) ribs to be

called the peripheral blades PB the internal contours of which are also semicircular. The said sphere and peripheral blades have the opening OP (they do not exist) in the forward spherical angle slightly greater than $\theta_{op} = 2\alpha_m + \theta$ (θ = angle to allow for the diameter of shaft).

Both the blades IB and PB may be connected with transverse vanes TVI and TVP, respectively (the TVIs should not go till the shaft 23). As a rule, the number of blades IB and PB is unequal.

The sphere SH with peripheral blades PB and the imaginary sphere enveloping the inner blades IB are concentric with point C being their common center. The gap between the mentioned contours of the inner and peripheral blades is small.

The system is enveloped by the two-calotte housing 55, the forward calotte 551 being fixed to the stern tube 24 and thus stationary while the aft one 552 is pivotal together with the propeller shaft 25 and sphere SH around the vertical pivoting axis $v_5 = v$ passing through C (but, since fixed to the bearing B25 of the shaft 25 rather than to the shaft itself, it is not revolving). The stationary calotte 551 has the aft horizontal window 5510 to allow for the steering turning (pivoting) of the propeller shaft 25. The two calottes are sealed in the usual way (seals 62M with entry seal ES, boot seal, etc.).

The housing 55 is either partially or completely filled with some heavy fluid or fluidized and graphitized powder or powder with balls, etc. - to be generally called the (heavy) "fluid".

In the case $\alpha = 0$ the shafts 23 and 25 are coaxial. Then, the rotation of the driving shaft 23 with the angular velocity ω_{23} is imparted to the fluid which, due to the ensuing centrifugal force, is thrown to the periphery, that is, to the sphere SH. Therefore, a rotating either ring RI or ball of fluid for the housing being filled with fluid partially or completely, respectively, is built up in the plane perpendicular to the common axis of rotation of shafts.

The thickness of the fluid ring RI is such that the fluid, while being strongly pressed by the centrifugal force to the sphere SH, is present within both the inner and peripheral blades and therefore the torque of the driving shaft 23 is transmitted (through IB, fluid, PB and SH) to the driven (propeller) shaft 25.

Since some slipping is inherent to the fluid transmission (in the case in hand, it occurs mostly in the fluid in the gap between IB and PB), the angular velocity of the driven shaft ω_{25} is slightly less than ω_{23} , $\omega_{25}(\alpha=0) < \omega_{23}$, but the transmission (torque, velocity, efficiency) should in general be good.

Now, with the propeller shaft 25 being deflected in the horizontal plane by the steering angle α_m , Fig. 44,c, the process of transmission will ba-

sically be the same. However, since the fluid cannot simultaneously rotate in two different planes (planes perpendicular to the two shafts with the angle α_m between them) it will generally rotate in a "compromise" or medium plane m which is at the angle $\alpha_m/2$ to the said planes. In this case the particles of fluid will have a first order (one period per one revolution) back and forth (axial) motion along the blades and also a first order "deformation of fluid chamber forms" within the blades and vanes will ensue due to the change of angles between the inner and peripheral blades and vanes (the angles are zero and in a maximum for the blades being in horizontal and vertical positions, respectively, a period of change of angles reading $0, \alpha_m/2, 0, -\alpha_m/2, 0$) - whilst neither of these effects was existing in the case of $\alpha = 0$. This means an additional loss of energy followed by an increase of slip, $\omega_{25}(\alpha = \alpha_m) < \omega_{25}(\alpha = 0)$, and decrease of efficiency but with the transmission in general should still be acceptable.

[The additional loss of energy may be reduced by making the blades IB and PB pivotal around their radial pins on shaft 23 and sphere SH, respectively. The deformation of fluid and its friction are then substituted by the friction in the blade-pin bearings in the first order pivoting of blades around their pins.]

Hence, it is due to the slip that the driven shaft velocity is always less than the driving shaft one (the greater α the greater the velocity difference) but for a uniform ω_{23} the velocity ω_{25} is also uniform (for α being constant).

Since based mainly on the action of the centrifugal force, this joint will be called the hydraulic centrifugal joint. This joint has two versions: version with fixed blades and version with pivoting blades. The blades are in general plane in which case the joint works equally well in both directions of rotation. If they are curved, then one may achieve a better efficiency in the ahead running than in the astern one.

[In principle, the "reverse" version is feasible as well whereby the sphere SH (with PBs) is fixed to the driving shaft 23 (for which reason it is provided with the aft opening OP) while the inner blades IB are carried by the driven (propeller) shaft 25.]

The second hydraulic joint is as follows (Fig. 45): The driving shaft 23 bears a set of concentric spheres B23 slightly separated from each other. The spheres have the opening OP (they do not exist) in the aft spheric angle 0_{op} .

Similarly, the driven (propeller) shaft 25 bears a set of concentric spheres B25 which have the opening OP in the forward spheric angle 0_{op} .

Point C is the common center of the two sets of spheres B23 and B25. The driving and driven

shafts end and begin somewhat before and behind the point C, respectively, so that they are in no contact.

The diameters of the two sets of spheres are such that in the space between two successive spheres of one set there is one sphere of the other set (the spheres are "intermingled"). The spheres of the two sets are in no (mechanical) contact but the gaps between them are small.

The system of the two sets of concentric spheres is enveloped by the two-calotte housing (stationary calotte 551 and turning calotte 552) in the usual way. The housing is filled with some viscous fluid.

Now, for $\alpha = 0$ the shafts 23 and 25 are coaxial and the spheres B23 of the driving shaft 23 (driving spheres) rotate with that shaft (angular velocity ω_{23}). But, since the gaps between two sets of spheres are small with the coverage angle of (slightly coarse) spheres amounting to $\pi - \theta_{OP}$, cf. Fig. 46,a, the friction of the viscous fluid will make it that the spheres of the driven shaft 25 (driven spheres) and thus also the shaft 25 will rotate as well (angular velocity $\omega_{25}(\omega = 0)$). Due to the friction losses, heating, etc. there will be some slip between the two sets of blades yielding $\omega_{25}(\alpha = 0) < \omega_{23}$ but the transmission will generally be good. The particles of the fluid will rotate in planes perpendicular to the common axis of the shafts 23 and 25.

For $\alpha = \alpha_m$ there will be the "inner" and "outer" ranges (in the horizontal plane) where the angle between the shafts is decreased and increased resulting in the coverage angle of spheres being increased and decreased and amounting to $\pi - \theta_{OP} + \alpha_m$ and $\pi - \theta_{OP} - \alpha_m$, respectively, cf. Fig. 46, b (plan view). The torque and speed will be transmitted in this case, too, but the fluid particles will rotate in planes which are generally parallel to the "medium" plane (plane at the angle $(\pi - \alpha_m)/2$ to the axes of the shafts in the inner range). This and the different sphere coverages in the two ranges will result in the fluid particles also having a first order axial motion along the blades which, all together, will yield a greater slip than before, $\omega_{25}(\alpha = \alpha_m) < \omega_{25}(\alpha = 0) < \omega_{23}$, but the transmission in general (torque, velocity, efficiency) will still be acceptable. For $\alpha = \text{const}$ a uniform rotation of the driving shaft will be followed by a uniform rotation of the driven shaft, too.

This joint is based on the friction of fluid between the closely adjoining (concentric) spheres and therefore it will be called the hydraulic multisphere friction joint. The heat generated by this friction joint can easily be transferred to the surrounding water.

[Hydraulic couplings for $\alpha \neq 0$ (for general mechanical engineering) based on fluid friction can be made as "intermingled" either disks or cylinders.]

The third hydraulic device will first be presented in its cylindrical version (coupling) and then in the spherical one (joint).

There is the inner cylinder C23 with axial external grooves G23 and coaxial outer (hollow) cylinder C25 with axial internal grooves G25 (both cylinders may also have transverse vanes across the grooves), which cylinders are connected to the shafts 23 and 25, respectively, Fig. 47. The set of cylinders is enveloped by the sealed stationary cylindrical housing filled with fluid or, simply, the outer cylinder is sealed and filled with fluid serving thus as a (revolving) housing.

Now, the rotation of the inner or driving cylinder C23 makes it that the fluid in its grooves G23 gets both peripheral velocity (due to rotation) and radial outward velocity (due to the centrifugal force) whereby it is thrown into the grooves G25 of the outer cylinder C25 which is thereby rotated in the same direction as the inner cylinder. The process is continuous whereby the "new" masses of fluid keep being whirled into the outer grooves G25 while the "old" masses found there (which have already delivered their energy to the outer cylinder) keep being expelled therefrom and returned to some successive inner grooves G23, etc. Thus, during one revolution of the cylinder C23 a considered mass of fluid gets to be several times whirled to and returned from the external grooves G25 which means that rather high torques can be transmitted by this coupling. This coupling can be generally applied in mechanical engineering.

To make a simple joint out of this coupling, all that should be done is to transform the cylinders C23 and C25 into the inner sphere S23 with external "meridional" grooves SG23 and outer (hollow) sphere S25 with internal meridional grooves SG25, resp. ("poles" of meridians lie on the horizontal axes of shafts), with the outer sphere being pivotal around the vertical axis $v = v_s$ through the common center C of spheres for which reason it is provided with the opening OP in the forward spherical angle θ_{OP} , Fig. 50. The housing is made of two calottes 551 and 552 in the usual way.

Owing to the above modifications, the coupling has become a joint that can be used both for $\alpha = 0$ and $\alpha > 0$. It will be called the sphere hydraulic whirl joint.

For $\alpha = 0$ the meridional internal and external grooves SG23 and SG25, resp., are "parallel" and the situation is basically the same as with the cylinder hydraulic whirl coupling.

For $\alpha > 0$ the said grooves are, however, at the angles α and $-\alpha$ in the zenith and antizenith positions, resp., and zero in horizontal positions so that a given groove SG23 imparts a changing amount of torque to the sphere S25 during one shaft revolution but since there is a number of active grooves

SG23 at different positions the total amount of torque received by the sphere S25 is constant (for $\alpha = \text{const}$) and thus for a uniform ω_{23} there is also a uniform ω_{25} (with $\omega_{25} < \omega_{23}$ due to the slip).

To increase the torque transmitted by the hydraulic multisphere friction joint one may artificially increase the roughness of its spheres by providing them with ribs transverse to the fluid flow. This actually yields the (meridional) "grooves" on the surfaces of spheres and thereby the fourth hydraulic joint is obtained which is a combination of the second (friction) and third (whirl) ones. Namely, by letting the centrifugal force to whirl the fluid from the driving to the driven spheres only, it is but the external surfaces of the driving spheres and internal surfaces of the driven ones that are ribbed or grooved (whirling) while the internal surfaces of the driving spheres and external surfaces of the driven ones are ribless or grooveless (friction). Since the whirling is preponderant this joint will be called the multisphere hydraulic whirl joint.

Since with the hydraulic joints described the driving and driven shafts are in no direct (mechanical) contact (the contact is only hydraulic) - these joints are self-adjustable to some slight misalignments of the "systems" of the driving and driven shafts. For the same reason they also easily endure all kinds of vibration (axial, transverse, torsional) and even act as a damper to them (or divide the system in two subsystems). Therefore, generally no flexible coupling 292 is necessary between these joints and the propeller-shaft bearing 34.

Besides, due to their slip the hydraulic couplings act also as some relief elements in the case of overload.

However, the above good properties of the hydraulic joints are considerably reduced by a relatively poor efficiency of theirs (due to the slip, etc.) which is in particular emphasized for $\alpha = \alpha_m$. Still, if the efficiency is more or less acceptable for $\alpha = 0$, then it may be acceptable generally since the running at $\alpha = \alpha_m$ gets to be occasional only.

To note is here that, on the contrary, the efficiency of the gear joints is not only high but is also invariable with α (while the efficiency of the universal joint is also slightly less at α_m than at $\alpha = 0$).

By proceeding the comparison, let us note that it is only the gear joint that allows the driven-shaft (output) velocity ω_{25} to be greatly different from the driving-shaft (input) velocity ω_{23} , $\omega_{25} \neq \omega_{23}$, which is established simply by the gear ratio. With the universal joint the average output velocity is the same as the input one. With the hydraulic joint the output velocity is slightly lower than the input one (slip). However, for a uniform input velocity and for $\alpha = \text{const} > 0$ the output velocity is uniform, non-uniform and uniform for the gear, universal and

hydraulic joints, respectively.

Besides, it is only the gear joint that enables the reversibility within the joint itself.

The shafts 23 and 25 are necessarily coaxial with the universal and hydraulic joints. The gear joint may, however, have the shafts either coaxial or displaced.

General notes:

(a) When sailing in very shallow waters it is convenient to raise somewhat the propeller in order to prevent its hitting the ground. Considering Figs. 1 and 2, this can be achieved by inclining forward the stock 3 (around the joint 5) by some angle and thereby by inclining forward also the curved lever 33, propeller-shaft bearing 34 and propeller 26 by the same angle (and thereby by raising the latter). This can be done with the universal joints 5 (1st variant) and hydraulic joints if made universal (5th variant).

(b) Considering the gearbox joint 5, the axes v_{23} of the driving shaft 23 and v_{25} of the propeller shaft 25 are parallel (or coaxial) and generally horizontal while the axis v_{51} ($= v_5 = v_{331}$) of the joint stock 51 is perpendicular to them, $\beta_{51\ 23} = 90^\circ$. This, however, is by no means necessary since the said angles affect only the cone angles of the bevel gears $G_1, \dots, G_n$ so that no particular difficulties should be met in producing the gearbox joints with the shaft line inflected in them. This may be applied to the V-drive, Fig. 49 ($h = \text{horizontal}$), where, among other things, the gearbox joint in hand makes it that the propeller shaft 25 is now horizontal so that the full propeller's thrust force F_p is used for propulsion (rather than its horizontal projection only - which is the case of the usual layout where the propeller shaft 25 is a straight extension of the inclined driving shaft 23).

(c) The gears of the gearbox joint are $G_1, G_2, \dots, G_n$ ($n_{\min} = 3, n_{\max} = \text{unlimited}$; in steering, the meshing point G_{n-1}, G_n "walks" on the circumference of the pitch diameter of G_{n-1}). If necessary, however, this set may be followed by the secondary set of (spur, bevel, planetary, etc.) gears $G_1', G_2', \dots, G_n'$. An example is given in Fig. 50.

(d) As a rule, the thrust force is taken by the thrust collar 342 and transmitted through the PSC 331 to the ship's stern 11. Still, a small ("parasitic") amount of thrust gets to be imparted through the propeller shaft 25 to the joint 5. The gearbox joints (and also some of the universal joints) are, however, very susceptible to axial loads. Therefore, between the propeller-shaft bearing 34 and the joint 5 there is fitted either a flexible coupling or a spline or a ball-and-trunion universal joint (working with practically a zero angularity),

etc. which makes it that the joint 5 does not suffer from that thrust force. Misalignment and vibration are alleviated thereby, too.

Similar elements may be built in the very joint 5. For example, the spline 515 within the bearing 522 (held by the bush 514 in the joint stock 51) in Fig. 34 not only reduces the parasitic thrust imparted to the joint but also makes it that the said thrust is passed around the meshing point of the wheels $G_n = G_4$ and $G_{n-1} = G_3$.

(e) Two protectors (shields) have been met so far: joint protector 151 and window protector 171. For the good of a general protection, however, the whole system of the joint housing 55 together with the PSC 331 may be protected as well.

There is a number of ways to build these "system protectors".

One of them is to conceive the system protector 191 as a "housing" to the PSC 331. Thus, in Fig. 51 there is the forward stationary outer part (calotte) 191F of the system protector which is fixed to the tunnel 55T in the guide 55TG (the design is otherwise an RSPC similar to that in Fig. 35) while the aft turning inner one (calotte) 191A is so to the propeller-shaft bearing 34 and curved levers. The two calottes 191F, 191A are sealed (seals 62M', ES'). The joint 5 may possibly have the same kind of housing (parts 551, 552) of smaller dimensions (not shown in Fig. 51). The joint in Fig. 51 may be of any kind (universal, gear, hydraulic).

For a further illustration, in Fig. 12 there is a simple one-part system protector 191 (dashed lines) which is a stationary streamlined protrusion (hood) from the stern 11 of ship that is provided with the window 191W to allow the propeller-shaft bearing 34 to perform its steering turning. Then, in Fig. 44 there is the aft turnable protector 191A fixed to the jacket 33J. Similar protectors may be applied to the other designs as well.

A further hermafrodite design of our "straight shaft line rudder propeller ship installation" is obtained by the following consideration.

The designs in Figs. 19 and 20 are the 2nd variant RSPCs with horizontal access 160 (tunnel 55T). In this case the inter-guide access (IGA) from forward to the joint 5 is necessary ($\alpha_{IGA} > 0$, see Fig. 15) and therefore the circular plate 6 with the guides 56 has been applied there since a horizontal access is not feasible with the riding band 6BR.

Therefore, to apply the riding band 6BR in this case, too, there is the design in Fig. 52 which holds for larger ships and where the cone-shaped thick jacket 33J (substituting for the curved levers 33, 33L) is fixed to the band (tube) 6BR riding on the stationary tube 55V (or inner housing) that is fixed to the enlarged outer housing 55D which is extended into the horizontal tunnel 55T (access

160D) carried by the structural tunnel guide 55TG. Besides, there is the lower stern extension or stool ST to support the outer housing 55D.

The upper portion of 55D provides enough room for the access 160 (from above) to the inner housing (vertical tube) 55V (namely, the general access 160D to 55D (through the tunnel 55T) is horizontal while the access 160 to 55V is vertical). Besides, the outer housing 55D yields (together with ST) a streamlining form which is continued into the jacket-33J supported system protector (shield) 191A down to the propeller 26.

The steering gear 32 turns the joint stock 51 by the quadrant SC and then, by the arm ASC passing through the window W55 in the tube 55V, the riding band 6BR itself; the tube 55V has also the usual window 5510 for the arm 53 (33J, 6BR and 55V, 55D, 55T belong to the 331T and 331S, respectively).

The riding band 6BR with its seals 62EU and 62EL (which are responsible for the windows W55 and 5510) is not just a sealing element here since the propeller-supporting jacket 33J is fixed to it whereby it is involved in the 331T and therefore is built as a strong unit supported by the foothold 6FH of the stationary tube 55V. Therefore, this band may also be considered as the turning part 552 of the housing (6BR = 552) while the tube 55V itself is its stationary part (55V = 551) whereby a transformation into the 3rd variant is obtained.

The tunnel guide 55TG may be provided with the cover 55TC for the substitution of the RSPC afloat (see Fig. 58,a and related text).

Designs with vertical tubes in Figs. 40-43 are the RSPCs with vertical access 160 (ladder LD).

While Figs. 40, 41 are the "through-hull" cases, Figs. 42, 43, 52 are the "outside-hull" ones.

The through-hull case as in Fig. 41 can be made also with a stationary stern tube 24 if the structural tubes 35 and 35L are wide enough (or if they are elliptic with the greater axis being longitudinal) to allow horizontal shifting of the tube 551 in them for its bush 55B to be shrunk on the stern tube 24 after which a radial (and radially adjustable) bearing to 551 is fitted in the tube 35. Another way is to have "normal" tubes 35 and 35L and two-part tubes 551 and 552 with their upper parts being inserted (from above) through the tube 35 and connected to the lower parts (which are generally outside the tube 35) only after the bush 55B of 551 has been shrunk on the stationary stern tube. The above ways are applicable also when the outside-hull cases (such as that in Fig. 42) are transformed into the inside-hull ones.

To note is that the gearbox joint 5 as a whole can be easily substituted with the vertical-access compacts. For this, the joint stock 51 should not be fixed to the ambient tube (551 or 552 in Figs. 42 or

43. resp.) directly. Rather than that, it should be (together with the gear complex $G_2, G_3, \dots, G_n$) put in a "cage" CG. Fig. 53, that is slid downward in the vertical guides GCG in the ambient tube (by overriding the ladder LD); when on the bottom of the tube and fixed, its input gear wheel G_2 meshes with the (waiting) input gear G_1 ; then the (preferably flexible) coupling C25 of the output gear wheel G_n and the (waiting) output (propeller) shaft 25 are connected; if G_1 is contained in the cage complex, then a similar coupling should be between it and the (waiting) input shaft 23. The guides GCG and the seating of the cage should be precise.

An additional hermafrodite design of the gearbox joint is presented in Figs. 54 (sketch) and 55 (embodiment) where the stationary part 551 of the joint housing is a short vertical tube closed with the upper and lower covers (a sphere or similar element may be applied, too); for the propeller shafting 25i,25 to pivot by $\pm\alpha_m$, this housing part is provided with the usual after window 5510; at its forward side it is provided with the bush 55B whereby it is shrunk on the stern tube 24. The external turning (pivoting) housing part 552 is generally of the same shape but is somewhat larger and is provided with the forward window 552W so that it embraces completely the stationary part 551 except for the said window 552W whereby it rides (in its pivoting by $\pm\alpha_m$) over the bush 55B. The parts 551 and 552 are aligned by the joint stock 51.

The window 552W is covered by the arced plate 6F that is fixed to the bush 55B and therefore is stationary. The guides 56F of the arced plate 6F are fixed to the turning part 552. The angular widths of the window 552W, arced plate 6F and guides 56F are $\pm\alpha_w = \pm(\alpha_m + \beta_1)$, $\pm\alpha_{6F} = \pm(2\alpha_m + \beta_1)$ and $\pm\alpha_{56F} = \pm(3\alpha_m + \beta_1)$, resp., so that the arced plate 6F covers the window 552W in all of its positions.

There are the window seals S1, S2, S3 (for 552W) and S4 (for 5510) which circumvent the respective windows and thus have both horizontal and vertical stretches (the angular distance of vertical stretches is $\pm(2\alpha_m + \beta_1)$).

The seals S3 (between 551 and 552) and S2 (between 552 Lnd 6F) are fixed to the turning part 552, the seal S1 (between 6F and guides 56F) is so to the guides 56F. Hence, all of these seals turn with the turning part 552 and thus also with the window 552W (S3 rubs against 551, S2 and S1 do so against 6F).

The seal S4 (between 552 and 551) is fixed to the stationary part 551 and rubs against the turning part 552.

For the external water to penetrate into the joint 5, it should pass through S1, S2, 552W, S3, S4, 5510 so that the joint housing is practically water-

proof.

The chambers between the seals S3-S4, S2-S3 and S1-S2 may be filled with oils from respectively three header tanks with pressures $p_{3,4} > p_{2,3} > p_{1,2} > p_{s.w.}$ = pressure of surrounding water.

A simpler case is with 56F, S1 and S2 omitted and only chamber S3-S4 filled with header tank oil. The other both simplified and more elaborated designs are possible as well.

It is seen that this is the 3rd variant of the installation (since there are two parts of the housing) but with the forward window 552W of the turning part 552 which reminds of the 4th variant. To note is, however, that the turning part 552 embraces completely the stationary part 551 (no dividing plane has been applied to the housing to obtain the two housing parts; except for their windows the two housing "parts" are two complete housings) and it is exactly for that reason that the arced plate 6F covers (within the window 552W) the solid wall of the stationary housing part 551 rather than a hollow entrance to the joint - which presents the main difference (and a very convenient one) between this hermafrodite "3rd & 4th" or "capsular" variant and the pure 4th variant.

The relationship to the 4th variant makes it that the turning-part window 552W may also be protected by the forward-window protector 171F with face seal 172F and boot seal 174F (cf. Fig. 39); the protector 171F may be fixed either to the stern 11 (strut STR) or to the bush 55B. In addition, there may be applied also the joint protector 151.

Fig. 56 is an embodiment of the capsular variant with the protector 171F fixed to the bush 55B (which is shrunk on the tube 24 extending from the strut bearing 244).

With the "capsular" variant, the shafts 23 and 25i,25 may be either coaxial ($a = 0$) or non-coaxial (either $a > 0$ or $a < 0$) since there is no horizontal seal 62E to be located between shaft 23 and shafting 25i,25 (requiring $a > 0$ - as with the lower-upper versions of the 3rd variant, cf. Fig. 38).

As a matter of course, with the capsular variant the bush 55B may be substituted by the connecting element 55E as well.

In general, the reversibility can be provided

-either by the engine 2 being reversible;

-or by fitting a reverse gearbox after the engine;

-or by applying the CP propeller (Fig. 22);

-or by making the gearbox joint reversible (Figs. 22, 23, 33-35, 40-44, 53).

In the first three cases the gearbox joint is not reversible and therefore is simple. In the latter case it is more complex (additional gears, clutches, actuators, etc.).

Some additional reversible gearbox joints are shown in Figs. 55-57.

In Fig. 55, the gears G_1 and G_1' are supported

by the arm A1 carried by the joint stock 51 (A1 and 51 are not keyed; A1 is also connected to the housing part 551 - which connection is not shown in the figure - and therefore is stationary). Gears G_2 and G_3 freely revolve on the joint stock 51 and can be mutually connected/disconnected by the clutch MDC.

Generally, the gear G_1' (that is freely revolvable and - by the actuator ACT - axially movable on its supporting pin) is not matched with the gears G_1 and G_2' (dashed lines) while the gears G_2 and G_3 are connected (clutch MDC engaged) - which means the run ahead. The clutch MDC disengaged and gear G_1' matched with G_1 and G_2' - means the run astern.

In Fig. 56, the gears G_2 and G_3 revolve freely on the sleeve SL1 on the joint stock 51. The gear G_2 can be connected with the sleeve by the multidisk (or other) clutch MDC (AMDC, not shown in the figure, is the actuator of MDC). Drum DR is carried by the stocks SS of the satellite bevel gears SG fixed in the sleeve SL1 and thus revolves with the sleeve SL1. It can be blocked by band BD (ABD is hydraulic or other actuator of BD). Satellite gears SG are matched with the bevel gears GG_2 and GG_3 fixed to G_2 and G_3 , respectively.

Now the neutral position, ahead run and astern run are obtained for AMDC-ABD being idle-idle, active-idle and idle-active, respectively.

To note is that the bevel gears SG, GG_2 , GG_3 may be substituted by spur gears, cf. Fig. 57. In this case the astern drive speed is reduced to $n - (G_3) = n(G_2) D(GG_2)/D(GG_3) = n(G_2) z(GG_2)/z(GG_3)$ (where n = RPM, D = diameter, z = number of teeth).

The arrangement of the satellite gears SG with the drum DR braked by band BD and the rest is met in a number of gearboxes. Likewise, the other "borrowings" (to implement the neutral-ahead-astern run) may be applied to our gearbox joint as well.

It is worthwhile to note in Figs. 55 and 56 that the gear G_1 is held by the stationary arm A1 carried by the joint stock 51 while the driving shaft 23 is connected to it by the flexible coupling CG_1 . This, together with the flexible coupling 292 between the shafts 25i and 25 makes it that the gearbox joint 5 as a whole is well protected (vibration, misalignment, etc.) both at the input (CG_1) and output (292) - which may be set forward as a generally advisable measure.

The shaft 25i is hollow in both of the mentioned figures. This shaft, together with the gear $G_n = G_4$ and the forward "half" of the flexible coupling 292, is carried by the axle A4 that is held (cf. arm A2 in Fig. 55) by the joint stock 51. (This is similar to the case of Fig. 24 except that the arm 3A is forged there with the joint stock 51.)

Thus, the joint stock 51 carries all the gears $G_1, \dots, G_n$.

The turning of the joint turning assembly is performed through the bearing LZ and wedges WD, W1 in Figs. 55 and 56, respectively.

To note is that some compacts can be substituted with the ship afloat.

For example, in the case of the horizontal-tunnel compacts, the shaft line is first disconnected for the tunnel guide 55TG to be closed with the cover 55TC, Fig. 58,a, and then the old compact is pulled out and the new one inserted. With the new compact in and the cover 55TC off (in order to connect the shaft line) there is a slight leakage around the tunnel 55T only until the seals in the stuffing boxes 55SB are tightened (or until the other sealing devices applied are fixed). The leakage may be greatly reduced if the tunnel 55T and its guide 55TG are made slightly coned (so that the leakage practically vanishes when the tunnel has been completely inserted). The coning may relate either to the whole length (Fig. 58,b) or only to the forward end of the tunnel and guide (Fig. 58,c).

Then, the compacts with tunnelless housings can also be substituted while the ship is afloat.

For this reason, the (full or hollow) connecting element 55E of the housing in Fig. 59 (which element substitutes for the housing bush 55B and carries the driving shaft 23) is ended with cone CN that, in mounting the compact (by its horizontal shifting), is firmly seated in its coned bearing CNB (in the ship's stern) by tightening the nut NT (which is done from the inside of the hull).

In dismantling the compact with the ship afloat, the (preferably flexible) coupling 292F is first dismantled, then the protective nylon (or other) bag NB is fitted (to protect the fore end and bearing B23 of the shaft 23 when in water), the cover CTN (put in the gap GP between the shafts) is fixed to the tunnel TN whereupon the compact is shifted horizontally backward (dismantling) while the tunnel TN is getting filled with external water. (The cover CTN may have some screws whereby the initial push is given to the connecting element 55E if its cone has stuck in the bearing CNB.)

In mounting, the (new) compact is shifted horizontally forward till its cone CN sits (like a cork) in its bearing CNB (the cover CNT may have a viewing glass for inspection), then the tunnel is drained (opening DR) and the cover removed, whereupon the nut NT is put in its place and tightened, the nylon bag NB removed and the coupling 292F fixed.

[When not used, the tunnel TN may be shifted backward (dashed lines). Depending on the type of the coupling 292F, the shaft 23A may or may not be shifted axially.]

Fig. 60 shows an RSPC (similar to that of Fig.

38) with the connecting element 55E provided with the channels CLB for lube oil, for oil (air) to actuate the clutches MDC, etc. (the nut NT is provided with "sprockets" SPR with sufficient room in between to connect the hoses HS to the channels CLB; the axes of the cone CN and driving shaft 23 are displaced).

The tube 552T (fixed to the turning part 552) is as long as to make it that, on an unloaded draught (and possibly with the ship trimmed by the head) the radial bearing 36H and double slider coupling 513 are near the water level so that they can be manipulated (opening/closing the buckle bearing 36H, disconnecting/connecting the double slider coupling 513 and pulling up/down the steering stock 3) from a raft (without the aid of a diver).

The wedge WD connects the turning part 552 with the joint stock 51 so that the joint turning assembly and the propeller supporting elements (bearing 34, jacket 33J, etc.) turn together.

[The steering gear 32 (that turns the steering stock 3, not shown in Fig. 60) is on (or near) the stern deck; 33CV is cover to 33J to mount the flexible coupling 292; 33FL and 55FL are "filling bodies" fixed to 33J and 551, resp.]

Full lines and full lines plus dashed lines present the outside-hull and through-hull cases, resp. (in the latter case it is only the stock 3 that is passed through the tube 35 so that the said tube may be quite narrow).

If, for a good access of water to the propeller, a well 120 is formed before it, Fig. 61, for which purpose the driving shaft 23 is let to stretch considerably behind the stern tube 24 making it necessary to provide the strut bearing 244 just in front of the propeller 26, then the situation is generally as follows:

(a) Strong strut bearing 244 substitutes for the stern tube 24 and thus the bush 55B of the joint's housing 55 is shrunk on it (or on its aftward extension); or, the stern tube 24 is extended from the stern 11 and passed through the strut bearing 244 so that its end carries the bush 55B - as in Fig. 56. In both cases the bush 55B may be substituted by the connecting element 55E.

(b) Strong strut STR provides supports to the rudder stock 3, attachment 159 of the housing 55, etc. and yields some general protection to the joint 5 (in ahead running) substituting thus for the stern (transom) 11 (additionally, it may be used also as an access to the joint 5).

Points (a) and (b) indicate that a number of the previous designs can be mounted on the strut bearing 244 and to the strut STR.

For example, in Fig. 61 there is the design of Fig. 42 fitted to them. If the aftermost part 11A of the stern is bolted (or otherwise dismountably connected) to the main portion of the stern, then this is

an "outside-hull" case. If not, then the solutions for the "through-hull" cases are applicable (tubes 551, 552 inserted from above through the tube 35 and then fixed to the joint; elliptical tube 35; etc.).

For course stability, the well 120 may be parted by a skeg whose lower edge may (dashed line) or may not involve the shaft 23 (yielding thus a good shaft protection in the former case).

A wide but hollow skeg may merge with both the strut STR and just mentioned shaft protection and thus provide an access chamber to the joint (access horizontal or oblique).

In general, all the vertical and oblique access tubes 165 may be used as (or merged with) the strut STR.

If, instead of the bush 55B, there is the cone-shaped connection element 55E (for the purpose of substituting the compact while the ship is afloat), then the arrangement is as in Figs. 62,a,b,c where the tube 24E connects the strut bearing 244 and the standard stern tube 24 (the forward end of 24E is inserted into 24). The tube 24E contains the inner tube 24I with bearings BR1, BR2, BR3, BR4 and driving shaft 23A. By the thread screws TS1 and TS2, the inner tube 24I is connected, at its aft and fore ends, with the forward extension 55EX of the cone-shaped connecting element 55E and stationary tube 24E, Figs. 62,b and 62,c, respectively.

When dismantling the compact, the tube 24I is first turned (by the nut NT and counter-nut CNT blocked to it or otherwise) and thus shifted (together with the shaft 23A and its bearings BR1-BR4) forward (on the threads TS1 and TS2) whereby 24I and 55EX and also the spline SPL get disconnected (the short shaft 23B has been previously taken out of the shaft line). Then, while the spline SPL and its chamber CSP are being well greased (through pipes and channels PCH), the old compact is taken out.

When the new compact, provided with a protector on its female spline-SPL part, has been put in the cone-shaped bearing CNB, then the tube 24I is turned in the opposite direction and thus shifted (together with the shaft 23A and its bearings) aftward (on the thread ST2) whereby 24I and 55EX get connected (thread ST1) while also the said protector is pierced and spline SPL gets connected which is followed by the cone-shaped connecting element 55E getting tightened in its bearing CNB (by tightening the nut NT against 24E so that the tubes 24I and 24E get to be extended and compressed, resp.)

Pipes and channels PCH serve for greasing, flushing, etc. the spline SPL and its chamber CSP; SHO is a streamlining hood; stock 3 is connected with the turning part 552 by a double slider clutch or otherwise; strut STR and housing 55 (and also stock 3) may form a streamlined assembly.

Considering the connection of the joint 5 with the ship's stern, there is a general remark to the case of the joint's housing 55 being only shrunk (by its bush 55B) on the stern tube 24 (Figs. 6, 24, 38, etc.). Namely, the housing 55, jacket 33J and propeller 26, taken together, appear then as a cantilever (Grimm's shaft) with some deflection at its free end.

A general solution to this problem is to provide the housing 55 with respectively the lower and upper bearings 55L and 55U around the common axis v - as in Fig. 56 where the strut STR holds the housing 55 like a "wrench" (55L and 55U are "radial" housing bearings providing the counter-tumbling moment, the cantilever's weight is still mainly transmitted by the bush 55B to the stern tube 24). If the housing is close to the stern (no strut case) then the lower and upper housing bearings are held by the lower skeg and stern stem, respectively. The other solutions are possible as well (for example, the buckle bearing 36H in Fig. 60 substitutes for 55U).

The "wrenchlike" holding of the housing 55 is generally recommendable.

Let us conclude by giving a bird's eye view of this patent application (referring mostly but not necessarily to the gearbox joint variants):

(a) The fact is that the Z-drive is rid of the usual (horizontal) stern tube (the fixing of the upper part of its vertical cantilever "stem" (tube) is what stands in lieu of the stern tube);

Then, even though our actual approach had been quite different, what in the final account has been done here may be described as follows:

(b) First, the upper gearbox of the Z-drive has, say, been lowered to (merged with) the lower one cancelling thus the vertical "stem" (main part of the "leg") of the Z-drive and yielding thereby both our gearbox joint and a practically horizontal shaft line;

(c) Then, the resulting horizontal shaft line has been "put back" into the usual stern tube - yielding thus the drive proposed.

Hence, historically, State (a) may be considered as an "excursion" of the shaft line from the "standard" stern tube (a deviation from the classical "direct drive" involving the stern tube) in order to reach the "rudder propeller" drive that inherently calls for a vertical pivoting element ("stem"). Step (b) (cancelling the "stem" by introducing the "joint" as its substitute) enables us to make Step (c) (to "get back into the stern tube") and thus to restore the "classical" direct drive - but still retaining the "modern" achievement of the "rudder propeller" steering (which now appears as a novelty to the direct drive).

Once the shaft line firmly back in the stern tube, the installation obtained is inherently able to

transmit greater power ratings than the Z-drive whose shaft line (its vertical cantilever that, at its lower end, receives the horizontal thrust) is literally "hanging" in the water where, in addition, it is heavily exposed to the floating debris, etc. (while the closeness of our gearbox joint to and its connection with the stern tube and stern of the ship in general - yields a "natural" protection to it).

Therefore, at this stage we may disregard the Z-drive (and thus discontinue its comparison with the drive obtained). We may simply state that we now have the classical direct drive (horizontal shaft line, stern tube, etc.) plus the rudder propeller eliminating thus the rudders which have been unavoidable with that drive so far - hence, that we have a drive that is only to be wished for push-boats, tugs and other vessels requiring an increased steering capability.

Claims

1. Ship installation with the rudder propeller driven by a generally horizontal shaft line together with specific joints and propeller-shaft carriers thereto, characterized by

the engine (2) being installed in its usual place on the floor of the machine room and then the straight shaft line being conducted generally horizontally with the joint (5) being fitted in it just after either the stern tube (24) or the strut bearing or their equivalents, the joint (5) with the incoming driving shaft (23) and outgoing propeller shafting (25,25i) being such that it has at least one axis of angularity (v_5) which is generally vertical so that it enables the steering angle (α) in the horizontal plane between the pivoting propeller shaft (25) carrying the rudder propeller (26) one one hand and the stationary driving shaft (23) on the other one

as well as by the propeller shaft (25) being supported by the propeller-shaft bearing (34) held by the propeller-shaft carrier (331) consisting of its turning assembly (331T) that holds the propeller-shaft bearing (34) in an unyielding way and of its stationary assembly (331S) fixed to the ship's stern (11) either directly or through the stern tube (24) or through the stationary part (551) of the joint's housing (55), etc., and by the said turning and stationary assemblies, while themselves uncompliant, being connected pivotally around the propeller-shaft carrier's (331) generally vertical axis of pivoting (v_{331}) that is coincident with the axis of angularity (v_5) of the joint (5)

while the turning assembly (331T) is for steering purposes turned either manually or by the steering gear (32) fitted in a number of places, such as on or below the deck, on the stern tube (24), on or in the housing (55) of the joint (5), etc.

which all, inasmuch as a universal joint (5) is applied that has an infinity of axes of angularity and that is supported by and revolving with the shafts - is denoted as the first variant of the installation

whilst, in the case of the simple gear joint (5) with only one axis of angularity (v_s), which joint is enclosed in the housing (55) that is either wholly stationary or partly stationary and partly turning or wholly turning around the joint's generally vertical axis of angularity - is denoted as the second, third and fourth variant of the installation, respectively,

and, in the case of the hydraulic joint (5), - is denoted as the fifth variant of the installation.

2. Ship rudder-propeller installation together with specific joints and propeller-shaft carriers after claim 1, characterized by

the turning assembly (331T) of the propeller-shaft carrier (331) consisting of one or more curved, straight or similar lever(s) (33, 33L) or other rigid carrying means which are

either fixed to the vertical rudder stock (3) supported by and pivoting in the radial and axial bearings (36) and (37), respectively, in the ship's stern (11), which bearings belong to the stationary assembly (331S) of the propeller-shaft carrier (331)

or the said lever(s) or carrying means are by their hub(s) (330, 330L) or otherwise made pivotal around the stationary vertical pin(s) belonging to the stationary assembly (331S) which are

either pin(s) (111, 111L) fixed to the stern (11) directly or through the cantilever beam(s) (119), 119L) or

pin(s) (241, 241L) fixed to the arm(s) (242, 242L) carried by the stern tube (24)

or pin(s) (541, 541L) fixed on the housing (55) of the joint (5) or its stationary part (551)

or in a mixed way

or in the way that the mentioned pins are fixed to the said levers and carrying means and thus belong to the turning assembly (331T) while instead of the hubs there are bearings of the said pins belonging to corresponding elements of the stationary assembly (331S).

3. Ship rudder-propeller installation with specific joints and propeller-shaft carriers after claims 1 and 2, characterized by

applying the simple gear joint (5) to be also called the gearbox joint consisting of the first pinion (G_1), fixed to the driving shaft (23) that is followed by a train of bevel and eventually also spur or worm or planetary gears with the last but one gear (G_{n-1}) being a bevel gear with the vertical axis (v_{n-1}) around which the joint stock (51) is built up and which axis, now both the joint-stock axis (v_{s1}) and axis of angularity (v_s) of the joint (5) itself, coincides with the axis (v_{331}) of pivoting of the propeller-shaft carrier's (331) turning assembly

(331T) and thus with the common axis (v) while the intermediate propeller shaft (25i) carrying the last bevel gear wheel (G_n) has generally horizontal axis coinciding with the axis of the propeller shaft (25) since these shafts are connected either directly or by a spline (255), etc.

so that in the steering turning the meshing point of the last and the last but one bevel gears travels on the circumference of the last but one gear (G_{n-1}) for which purpose the external bearing (52) of the intermediate propeller shaft (25i) is supported by the joint stock (51) by means of the curved arm(s) (53, 53L) and bearing(s) (54, 54L) on the joint stock (51) or in another way which enables the propeller shafting (25,25i) to perform the steering turning with respect to the joint stock axis (v_{s1}),

while the housing (55) of the gear joint (5) is either stationary by being fixed to the stern (11) of ship and therefore is provided with a sealed horizontal aft slot or "window" (550A) to allow the outgoing propeller shafting (25,25i) to perform its steering turning - which corresponds to the second variant of the installation;

or is made of two parts (551) and (552), that is, two calottes, two cylindrical vessels, tubes or so, whereby in the steering turning the turning part (552) turns on or in the stationary part (551) provided with the aft window (5510) and lets the outgoing propeller shafting (25,25i) pass aft through it normally while the two parts of the housing are sealed against one another - which relates to the third variant of the installation;

or it is a one-part housing that is fixed to the propeller-shaft carrier's (331) turning assembly (331T) so that it performs the steering turning with it and is therefore provided with a sealed horizontal forward "window" (550F) to enable its riding in the steering turning over the revolving driving shaft (23) that is stationary in space - which corresponds to the fourth variant of the installation.

4. Ship rudder-propeller installation with specific joints and propeller-shaft carriers after claims 1, 2 and 3 and according to the second variant, characterized by

the joint (5) being in a stationary one-part housing (55) fixed to the ship's stern, which housing is provided with the aft horizontal slot or "window" (550A) that is sealed

either with one or more arced plates (6) which by their collars (60) ride on the propeller shafting (25,25i) and travel with it by the steering angle while being either pressed by the mechanical or similar spring(s) (61) against the seals (62) or acted on by the elastic selfadjustable seals or inflatable hoses or the like, all of the said elements being located in the circular-arc guides (56)

or with a full-circle band (6BR) which rides on the propeller shafting (25,25i) and travels with it by

the steering angle while being sealed against the stationary housing (55) above and below the propeller shafting with the horizontal lip rings, O-rings, rings with grooves, Newark seals or any similar elastic rings or packings (62E) being fitted in the horizontal or "equatorial" full-circle guides

or, additionally or alternatively, with the face seal (172A) which encompasses the window (550A) from outside and is supported and pressed against the housing (55) by the window protector (171A) which is a closed structure protruding from the near-by propeller-shaft carrier's (331) turning assembly (331T)

as well as with one or more boot seals (174A) in the said window protector which are fixed to the rim of the window on one hand and, on the other one, are so either to the collar (175A) on the propeller shafting (25,25i) or to the inside of the window protector or to the turning assembly (331T) within the window protector

while there may be one or more boot seals (68) in the housing (55) fixed both to the housing and collars (660) on the propeller shafting so that they close the window from inside.

5. Ship rudder-propeller installation together with specific joints and propeller-shaft carriers after claims 1, 2 and 3 and according to the third variant, characterized by

the joint (5) being in a two part housing (55), such as two calottes, two cylindrical vessels, tubes or the like so that

the forward or lower/upper one (551), i.e. the stationary part is fixed to the ship's stern (11) while

the aft or upper/lower one (552), respectively, i.e. the turning part lies on or is located in the stationary one (551) and,

in the version forward-aft, is stretched somewhat forward beyond the main meridional plane which is the transversal vertical plane in the joint stock (51) axis (v_{51}), which axis coincides both with the common vertical axis of both housing parts and the propeller-shaft carrier's (331) axis of pivoting (v_{331}), that is, with the common axis (v), the two housing parts (551, 552) being sealed with the vertical ring or similar seals (62M) fitted between the housing parts near or in the main meridional plane and also by either the entry seal (ES) or the boot seal (555) connecting the forward rim of the aft housing part (552) with the stern tube (24) and thus sealing the very entrance in between the housing parts (551, 552), which boot seal is protected by the boot seal protector (571) fixed to the stern tube (24) and stretched aft beyond the main meridional plane where it carries the seal (571s) rubbing against the aft part (552) while,

in the versions lower/upper or upper/lower, the two housing parts are sealed with the horizontal ring or similar seals (62E) and entry seals (ES)

fitted between the driving shaft and propeller shafting which holds also for the two housing parts (551, 552) being vertical tubes with the turning tube (552) with its foot (6F) either hanging on the upper foothold (6FH) of the stationary tube (551) or being supported by its lower foothold (6FH) where besides the said lower seals (62E, 62EL) there may be exist also the seals (62EU) above the propeller shafting

as well as by the propeller shaft (25) or intermediate propeller shaft (25i) passing regularly aft through the turning housing part (552)

with the propeller shaft space (570) between the turning part (552) and the propeller-shaft bearing (34) being possibly closed by the jacket (57) so that

in the steering turning there turn together the propeller-shaft carrier's (331) turning assembly (331T) with propeller-shaft bearing (34), then the propeller shafting (25,25i) with propeller (26), jacket (57) and the turning housing part (552).

6. Ship rudder-propeller installation with specific joints and propeller-shaft carriers after claims 1 through 5, characterized by

the horizontal ring (RG) being fitted in the circular horizontal guides (GRG) fixed to the inside of the joint's housing (55) or its stationary part (551) and containing the forward and aft bearings (BRF) and (BRA), resp., of the propeller shaft (25) or intermediate propeller shaft (25i), which shaft bears the last gearwheels (G_n , G_n) of the gear joint (5) whereby the steering turning is enabled of the said shaft (25,25i) and gearwheels (G_n , G_n) around the vertical axis ($v_{51} = v_5 = v$) of the joint stock (51) since the axes of the horizontal ring (RG) and its guides (GRG) coincide with that axis.

7. Ship rudder-propeller installations with specific joints and propeller-shaft carriers after claims 1 through 4 and according to the fourth variant, characterized by

the joint (5) being in the one-part housing (55) fixed by attachment (335) to the curved or other levers (33, 33L) or the propeller-shaft carrier's turning assembly (331T) in general so that it undergoes the steering turning and therefore is provided with the forward horizontal slot or window (550F) whereby it rides in the steering turning over the rotating but in space stationary driving shaft (23)

while the said window (550F) is sealed

either with one or more arced plates (6) or a full-circle riding band (6BR) as in the case of the aft window (550A) with the second variant

or, in addition or alternatively, with the face seal (172F) encompassing from outside the window (550F) in all of its positions, which seal is supported and pressed against the housing by the window protector (171F) which is a closed structure protruding from the near stern (11) of the ship or its

extension

as well as with one or more boot seals (174F) in the window protector which are fixed to the rim of the window on one hand and, on the other one, either to the collar (175F) on the driving shaft (23) or intermediate driving shaft (23i) or to the inside of the window protector (171F) or to the ship's stern (11) within the protector

while there may be one or more boot seals (68) in the housing (55) which are fixed both to the housing and the collars (660) on the driving shaft or intermediate driving shaft so that they close the window from inside.

8. Ship rudder-propeller installation together with specific joints and propeller-shaft carriers after claims 1 through 7, characterized by

the stationary housing (55) of the joint (5) or its stationary part (551) being fixed to the ship's stern (11)

either by being shrunk by its bush (55B) on the stern tube (24) and/or fixed to the stern (11) by the joint's access tube (165) and attachment (159)

or by being by its horizontal tubular extension or tunnel (55T) inserted and fixed in the sealed structural tunnel guide (55TG) in which case the tunnel may contain the quasi stern tube (24Q) or one or more bearings of the "open" driving shaft (23) and even the engine (2) itself which may also be mounted on an open forward extension (FE) of the lower side of the tunnel

or, if there is an oblique or other access tube (165) protruding from the stern (11), then by being shrunk on the stern tube (24) and fixed to the said access tube by some flange, face or similar connection (158)

or, if there is a vertical structural tube (55S) in the stern (11), then by the "lowering tube connection" where the intermediate tube (55t) fitted in the structural tube (55S) is, after the joint housing or its part has been shrunk on the stern tube (24), lowered down into the housing (55) or its parts (551, 552) or hub (330), etc. and then screwed, splined, keyed, etc. there, as the case may be,

or, if the stern or transom (11) is vertical, then by being either shrunk on the stern tube (24) or supported by the stool (ST) that is an extension of the stern and then, if of a tubular or similar form, by being held by one or more radial horizontal bearings (36H) which may hold both stationary and turning parts (551, 552) or only one of them

so that, in the described and similar fixing arrangements, a reducing-steering-propelling compact or, in the case of tunneled or similar horizontal-access arrangements, a motoring-reducing-steering-propelling compact is obtained, which compact, besides performing the said func-

tions, can - as a complete self-contained unit - be easily mounted into or onto and dismantled from the ship's stern.

9. Ship rudder-propeller installation together with specific joints and propeller-shaft carriers after claims 1, 3 and 8, characterized by

the vertical stationary tube (551) being by its bush (55B) shrunk on the stern tube (24) and held by the clamp, buckle or similar radial bearing (36H) fixed to the stern (11) above the water level

as well as by that tube being embraced by the turning vertical tube (552) extending from just above the bush (55B) to just below the radial bearing (36H), to which tube is fixed either the cone-shaped jacket (33J) or the curved or other levers (33, 33L) carrying the propeller-shaft bearing (34)

while the turning tube (552) is either hung on the foothold (6FH) of the stationary tube (551) located just below the radial bearing (36H) or supported by such a foothold located just above the bush (55B)

with, in any case, a horizontal seal (62E) or a set of such seals at the lower end of the outer turning tube (552) blocking the access of external water in between the tubes

and with the gearbox or other joint (5) being located on the bottom of the stationary tube (551) and thus connecting the driving shaft (23) with the driven propeller shafting (25, 25i) for which reason the said tube is provided with the horizontal window (5510) and also the ladder (LD) with access (160) to the joint (5)

while the steering gear (32) that turns the outer tube (552) is fixed either to the stern (11) or to the radial bearing (36H) or to the stationary inner tube (551) in which case it is meshed with the outer turning tube through the window (550U).

10. Ship rudder-propeller installation with specific joints and propeller-shaft carriers after claims 1, 2 and 8 and according to the fifth variant, characterized by

applying the hydraulic centrifugal joint (5) consisting of the driving shaft (23) carrying a set of inner blades (IB) which are longitudinal radial plates with external semicircular contours and the driven or propeller shaft (25) carrying the hollow sphere (SH) with longitudinal radial, to be called peripheral blades (PB) the internal contours of which are also semicircular, the sphere (SH) and peripheral blades (PB) possessing the forward opening (OP) and the two sets of blades being concentric in the center (C) while having a small radial gap between their semicircular contours

as well as by the whole system being put in a two-part sealed spherical housing consisting of the pivotal aft part (552) fixed to the propeller-shaft system and nonpivotal forward part (551) so that

the propeller shaft (25) and the aft part (552) can pivot by the steering angle (α) around the vertical axis (v, v_s) through the center (C)

while the housing is filled with some heavy fluid so that in rotation of the driving shaft (23) and its inner blades (IB) the fluid is thrown by the centrifugal force into the sphere (SH) with its peripheral blades (PB) whereby a forced hydraulic coupling of the two sets of blades is established so that the torque is transmitted from the driving to the driven shaft.

11. Ship rudder-propeller installation together with specific joints and propeller-shaft carriers after claims 1, 2, 8 and 10 and according to the fifth variant, characterized by

applying the hydraulic multisphere friction joint (5) consisting of a set of concentric spheres (B23) fixed to the driving shaft (23) possessing the aft opening (OP) and a set of concentric spheres (B25) fixed to the driven or propeller shaft (25) possessing the forward opening (OP), both sets of spheres being concentric in the center (C) and the spheres being intermingled in the way that in the space between two successive spheres of one set there is one sphere of the other set with the spheres being close to each other

as well as by the whole system being put in a two-part sealed spherical housing as with the hydraulic centrifugal joint of claim 10

while the housing is filled with some viscous fluid so that in rotation of the driving shaft (23) and its spheres (B23) the torque is transmitted by the fluid friction from the driving-shaft spheres (B23) to the driven-shaft spheres (B25) and thus to the driven shaft itself.

12. Ship rudder-propeller installation together with specific joints and propeller-shaft carriers after claims 1, 2, 8 and 10 and according to the fifth variant, characterized by

applying the sphere or multisphere hydraulic whirl joint (5) consisting of one or more inner spheres (S23) on the driving shaft (23), which spheres are provided with external meridional grooves (SG23) and of one or more, resp., outer hollow spheres (S25) connected to the driven or propeller shaft (25), which spheres are provided with the internal meridional grooves (SG25), the "poles" of meridians lying in both cases in the axes of the respective horizontal shafts, while the outer spheres (S25) are pivotal around the vertical axis (v, v_s) through the common center of spheres (C) for which reason they are provided with the forward opening (OP)

as well as by the whole system being put in a two-part sealed spherical housing as with the hydraulic centrifugal joint of claim 10

while the housing is filled with some fluid so that in rotation of the driving shaft (23) and its

spheres (S23) the fluid is thrown from the inner-sphere external grooves (SH23) into the outer-sphere internal grooves (SG25) and returned therefrom several times during one revolution of shafts, hence it is being whirled, whereby the torque is transmitted from the driving to the driven shaft.

13. Ship rudder-propeller installation together with specific joints and propeller-shaft carriers after claims 3 and 8, characterized by

the gearbox joint (5) being easily substitutable due to the fact that it is, as a whole, put in a cage (CG) that, in the precise vertical guides (GCG), is slid down to the bottom of the ambient vertical-access tube (165) or housing (55, 551, 552) and fixed there

whereby its input gear wheel (G_2) gets meshed with the waiting input pinion (G_1)

and after which the coupling (C25) is fixed connecting the output gear wheel (G_n) with the output shaft (25i)

so that, to take out the gearbox, it is only the said coupling (C25) to be disconnected.

14. Ship rudder-propeller installation together with specific joints and propeller-shaft carriers after claim 8, characterized by

the possibility to substitute the horizontally tunneled compacts while the ship is afloat

for which purpose the shaft line is disconnected and then the cover (55TC) fixed to the stationary tunnel guide (55TG) that is flooded during the substitution of the horizontally shifted compacts whilst otherwise the cover (55TG) is removed and the shaft line connected

with, upon removing the cover (55TC), a slight leakage of external water between the tunnel and its guide only until the stuffing boxes (55SB) or other tunnel seals are tightened

and with, to reduce the said leakage, both the tunnel and its guide being slightly coned either all along their lengths or only at their forward ends.

15. Ship rudder-propeller installation together with specific joints and propeller-shaft carriers after claim 8, characterized by

the possibility to substitute, while the ship is afloat, the compacts that are shifted horizontally in mounting/dismounting

for which purpose the compact's connecting element (55E) is provided with the forward cone (CN) to be seated in the coned bearing (CNB) of the ship's stern (11) and tightened there from inside the hull by the nut (NT)

so that the substitution of compacts starts by removing the said nut (NT), by fixing the tunnel (TN) to the coned bearing (CNB) and, upon disconnecting the shaft line, by fitting the cover (CTN) to the tunnel whereby a closed tunnel room is formed to be flooded during the substitution

while, after the substitution, the said room is

drained, the cover (CTN) removed and the nut (NT) tightened so that the cone (CN) of the new compact seats tightly in the bearing (CNB) whereupon the shafts (23, 23i) are connected by the coupling (292F)

with the fore end of the shaft (23i) and its bearing (B23i) of both the old and new compacts being protected by the nylon or similar bag (NB) fixed to the front side of the cone (CN) during the substitution.

16. Ship rudder propeller installation together with specific joints and propeller shaft carriers after claim 15, characterized by

the possibility to substitute the compact carried by the strut bearing (244) while the ship is afloat

owing to the stationary tube (24E) connecting the strut bearing (244) and the stern tube (24) and containing the inner tube (24I) with the bearings (BR1, BR2, BR3, BR4) of the driving shaft (23A)

as well as to the inner tube (24I) being connected by thread screws (TS1, TS2) with the forward extension (55EX) of the cone-shaped connecting element (55E) in the strut bearing (244) and the forward end of the stationary tube (24E)

so that, to dismount the compact, the inner tube (24I) is turned and shifted forward whereby that tube (24I) and driving shaft (23A) get disconnected from the said forward extension (55EX) and spline (SPL) of the compact shaft (23i) whereupon the old compact is taken out

while, after inserting the new compact into its cone-shaped bearing (CNB), the inner tube (24I) is turned in the opposite direction and shifted aftward so that the tube (24I) and driving shaft (23A) get connected with the said forward extension (55EX) and spline (SPL) of the driving shaft (23i) of the new compact, respectively.

17. Ship rudder propeller installation with specific joints and propeller-shaft carriers after claims 1 through 7 and with the so-called "capsular variant" of the joint, characterized by

the stationary housing part (551) of the joint (5) made as a short vertical tube or similar element closed from above and below and provided with the aft window (5510), which part is either shrunk by its bush (55B) on the stern tube (24) or is by means of its substitute, that is the cone-shaped connecting element (55E) fixed to the stern (11) or strut bearing (244),

while the turning housing part (552) supporting the propeller (26) and being generally of the same form but somewhat larger, embraces the stationary part (551) completely except that it is provided with the forward window (552W) whereby it rides over the bush (55B) or its substitute,

the forward window (552W) being sealed by the stationary arced plate (6F) fixed to the bush

(55B) or its substitute, which plate is located in the guides (56F) fixed to the turning part (552), the said guides and turning part (552) being also provided with the window seals (S1, S2, S3) circumventing the window (552W)

while the stationary window (5510) is also provided with the seal (S4) circumventing it,

the chambers between the said seals being filled with oils from overhead tanks.

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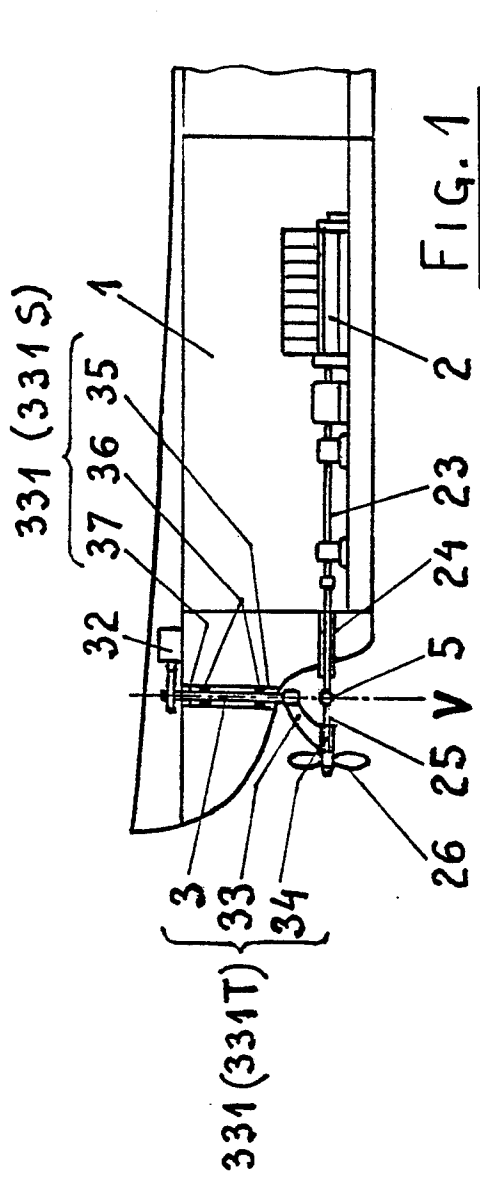


FIG. 1

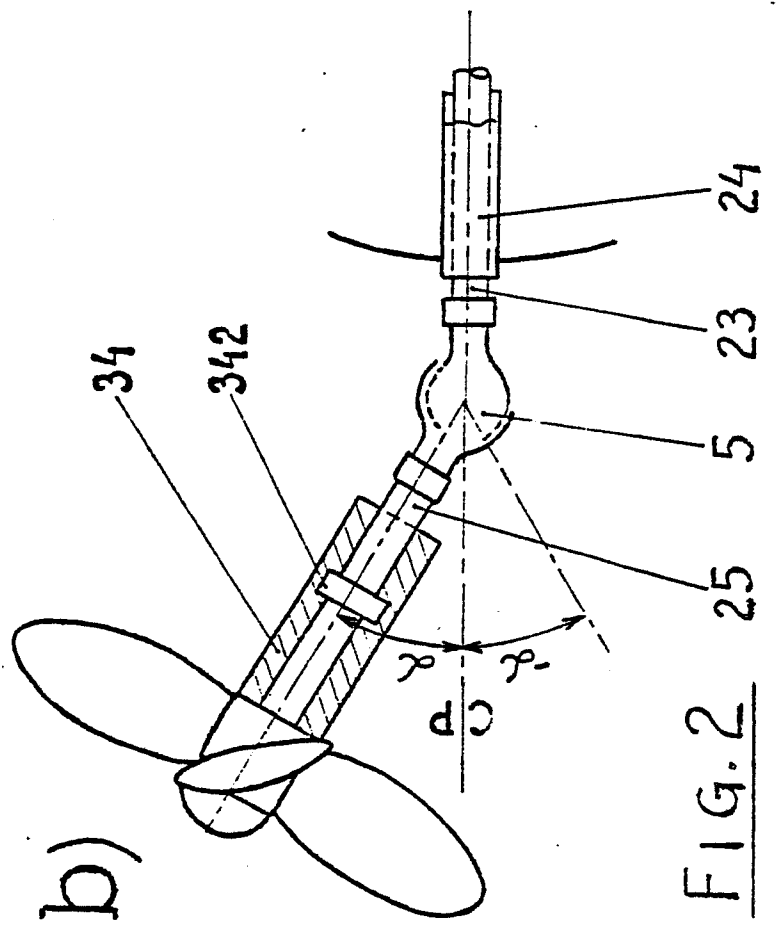
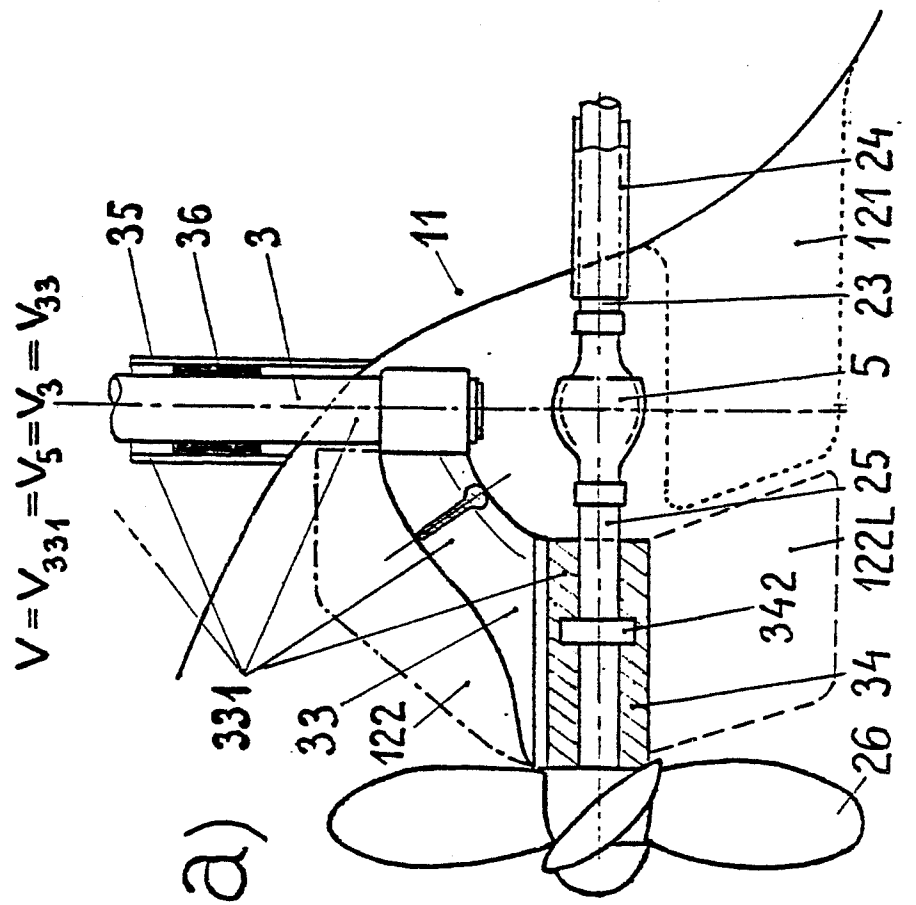


FIG. 2



a)

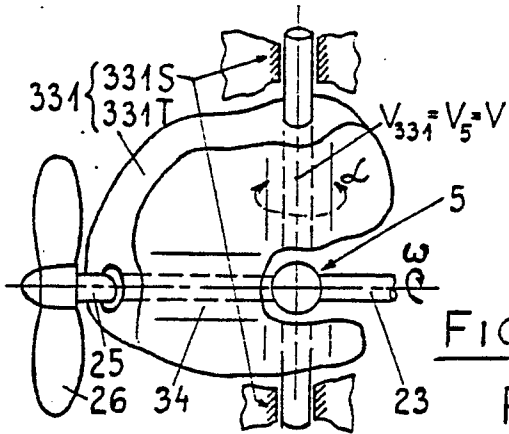


FIG. 3

FIG. 4

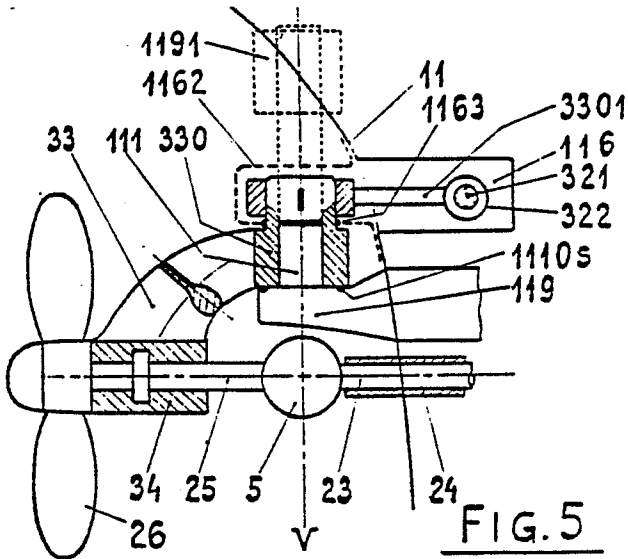
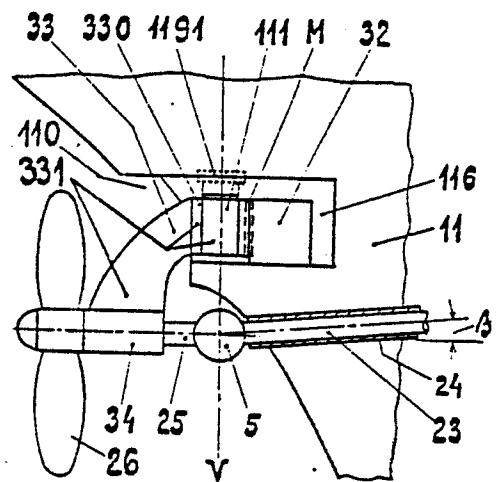


FIG. 5

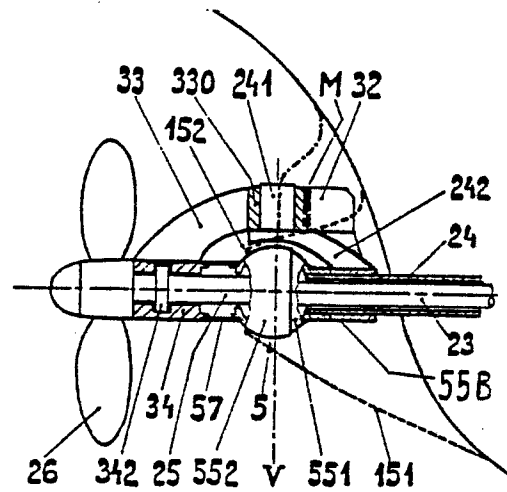


FIG. 6

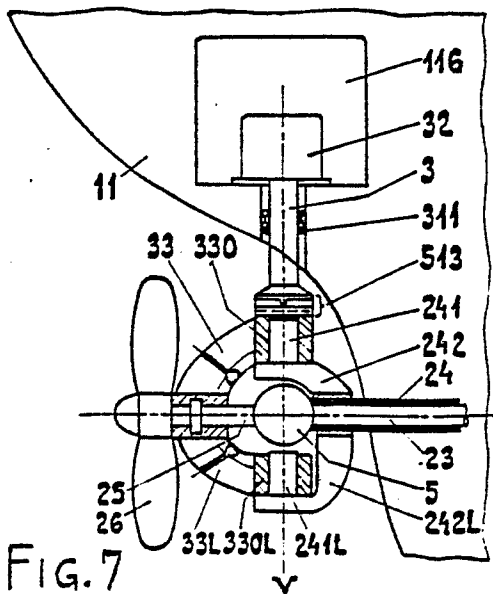


FIG. 7

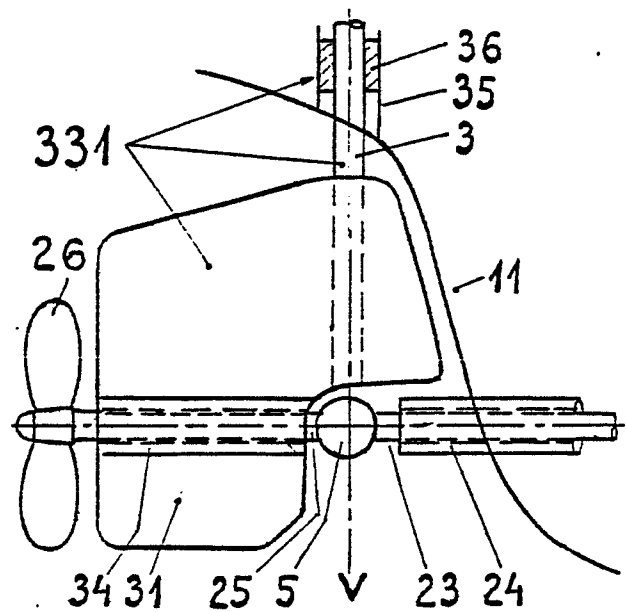


FIG. 8

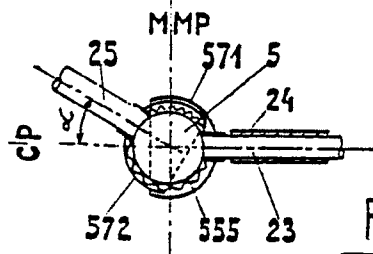


FIG. 9

2nd var.

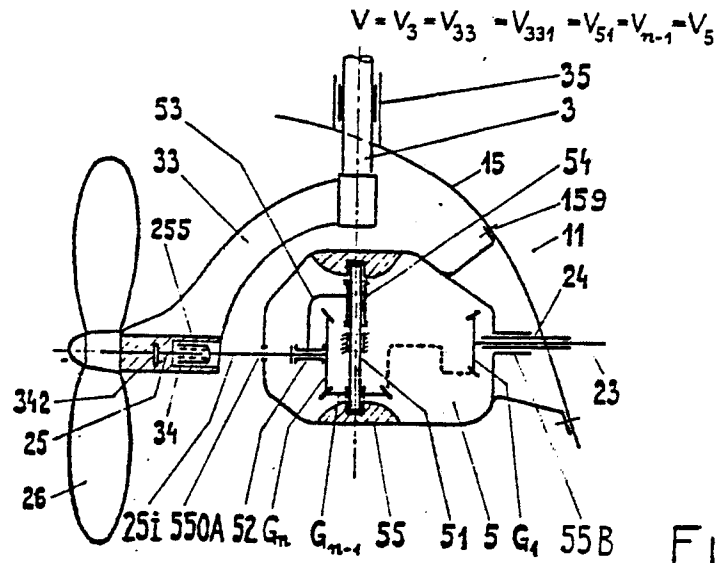


FIG. 10

3rd var.

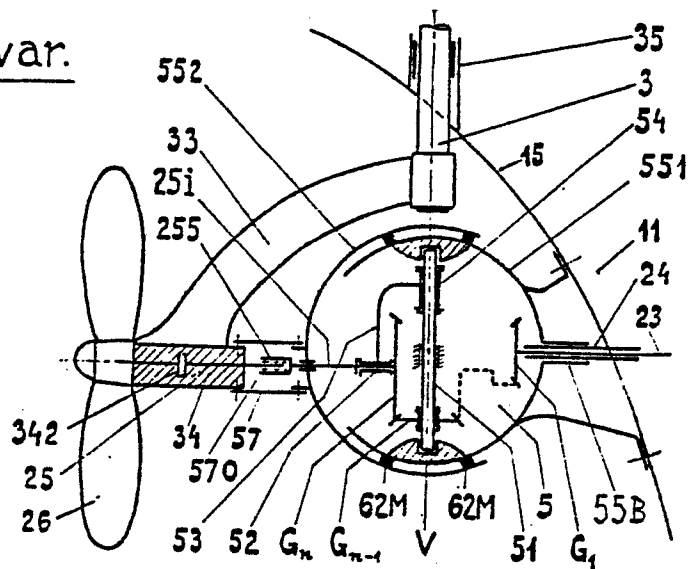


FIG. 11

4th var.

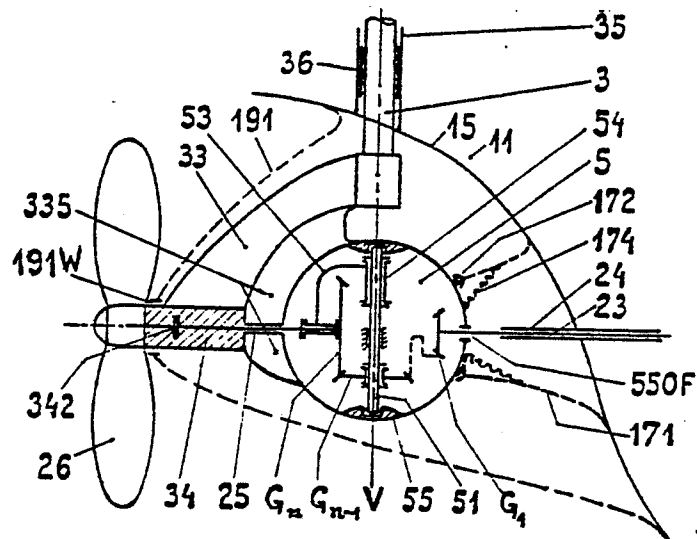


FIG. 12

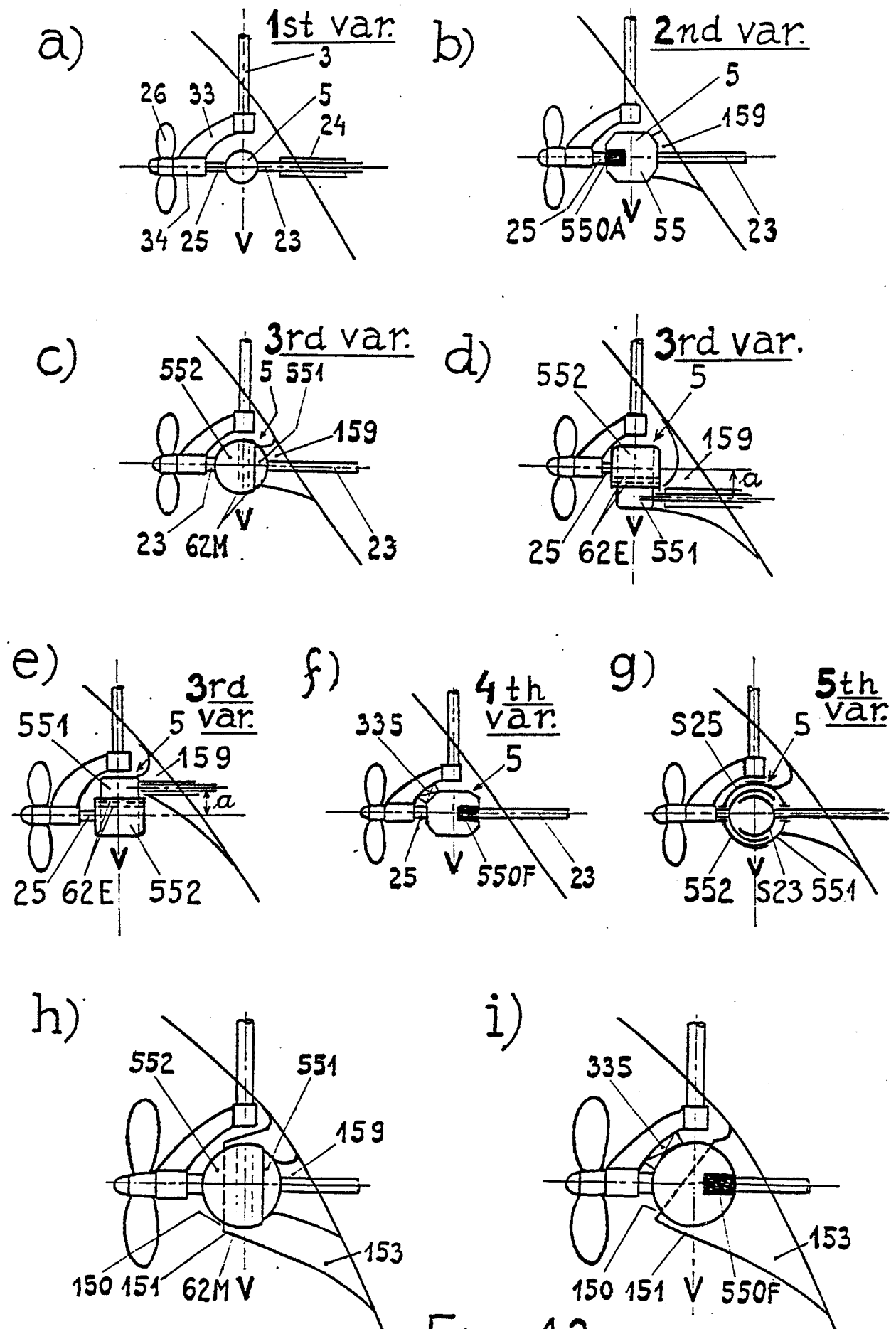


FIG. 13

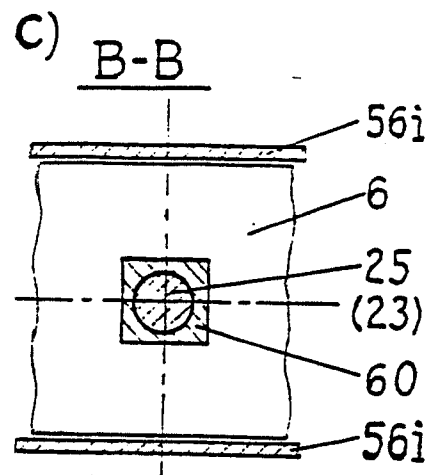
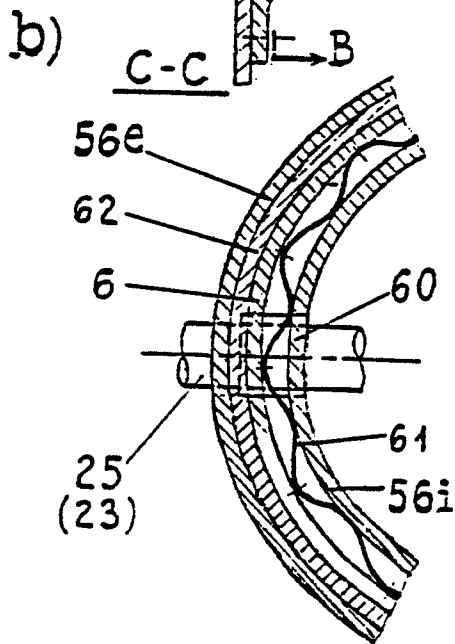
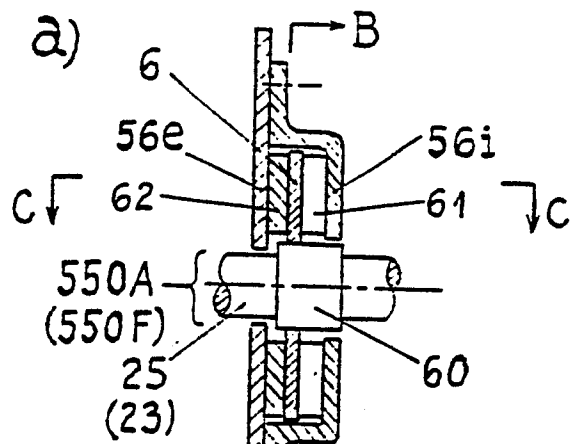


FIG. 14

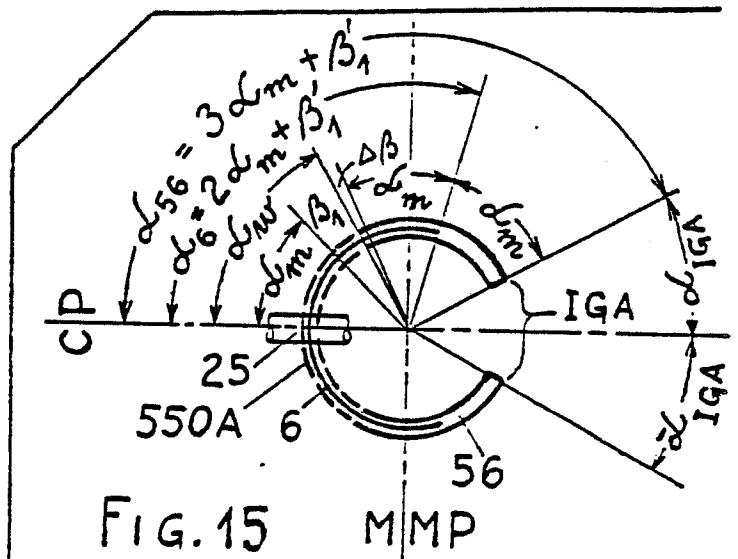


FIG. 15

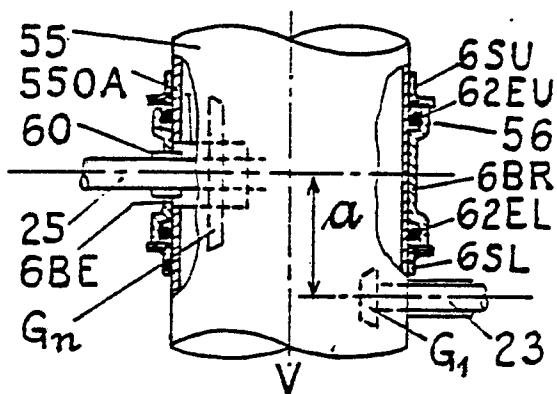


FIG. 16

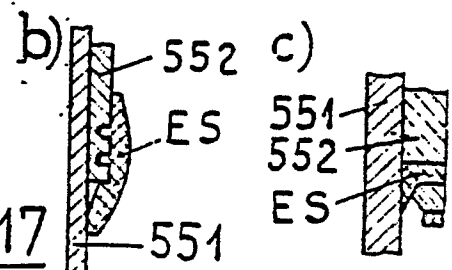
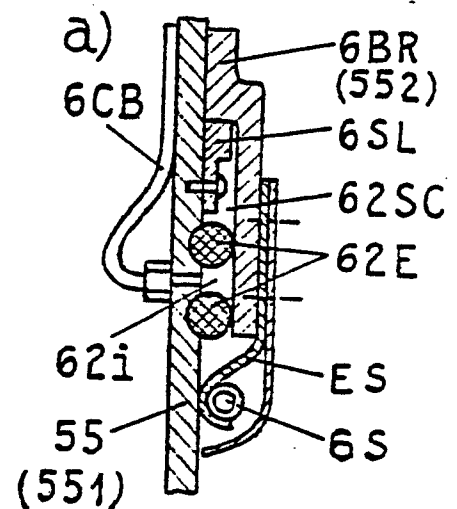


FIG. 17

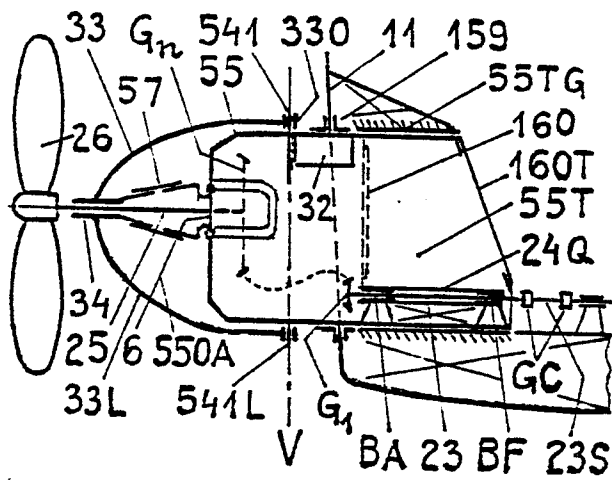
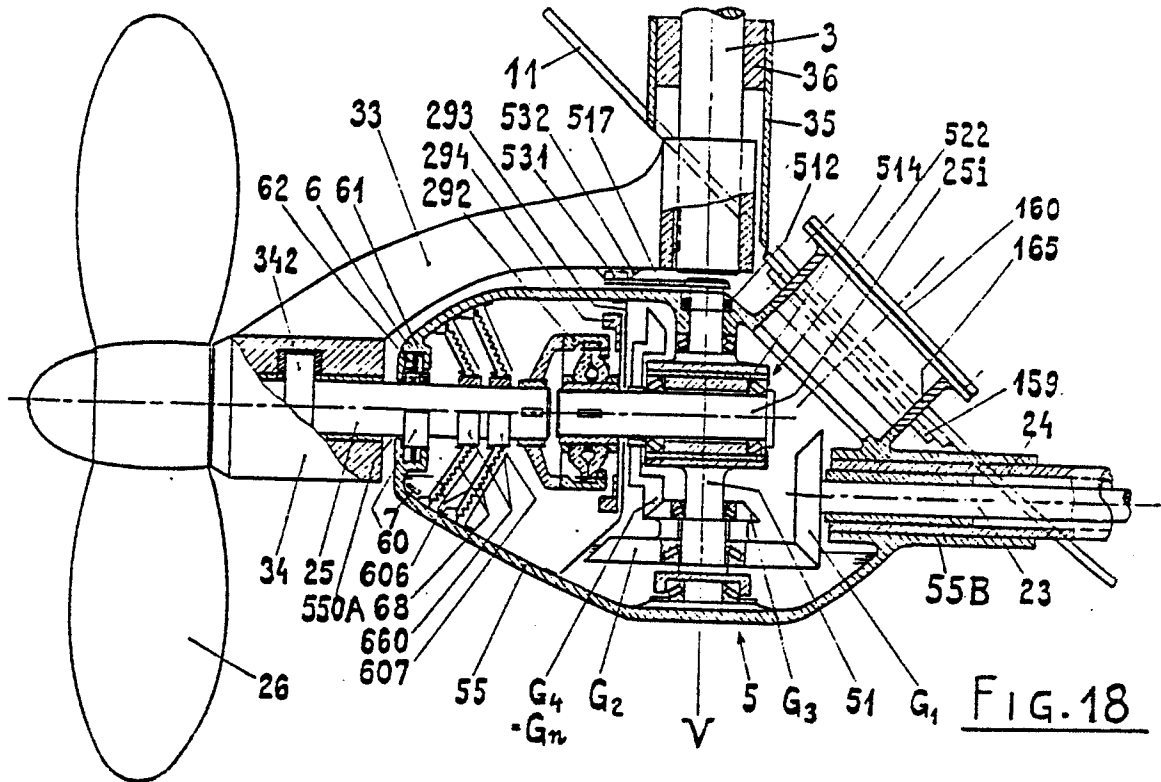


FIG. 19

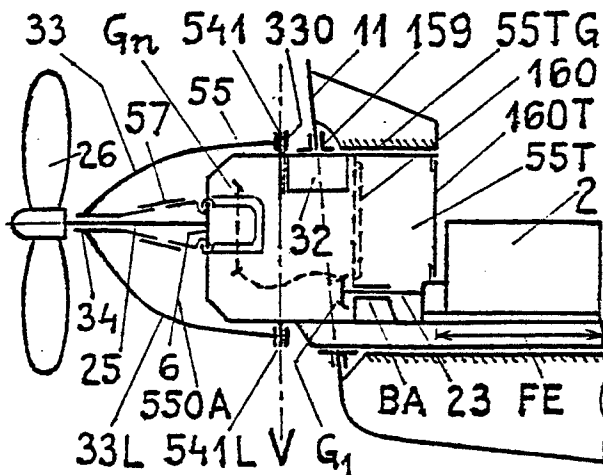


FIG. 20

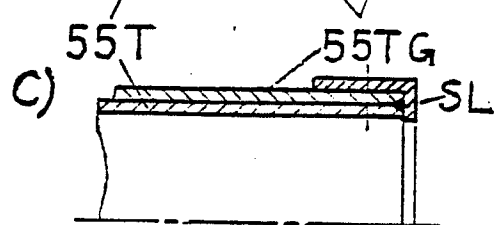
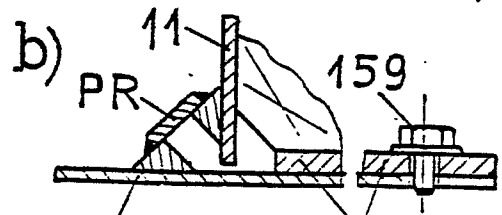
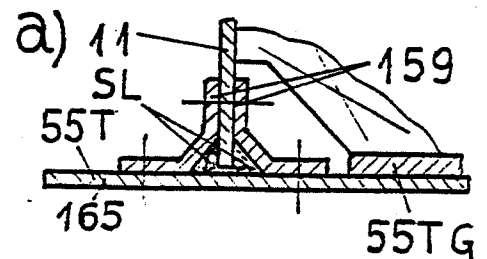


FIG. 21

FIG. 22

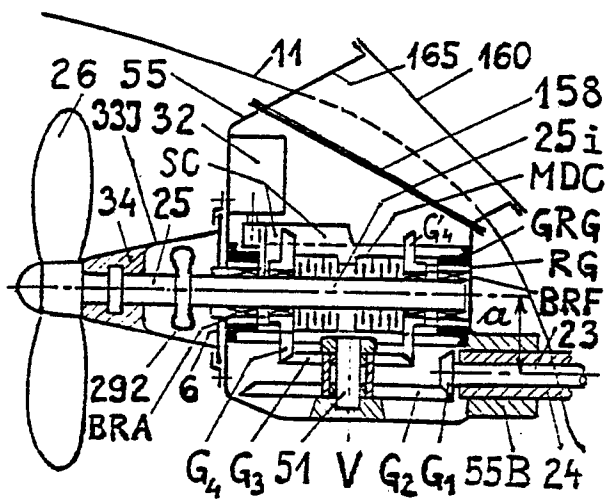
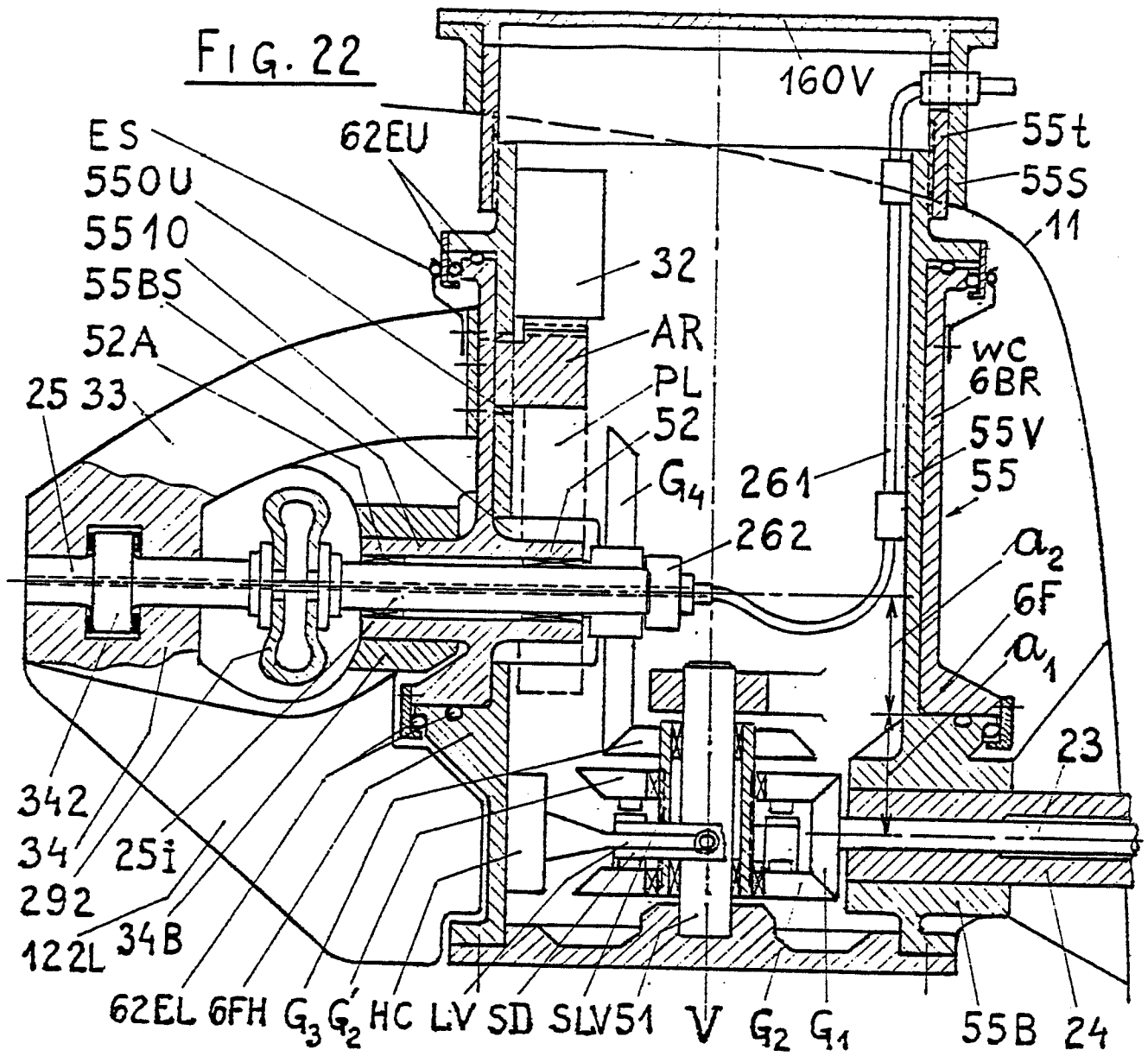


FIG. 23

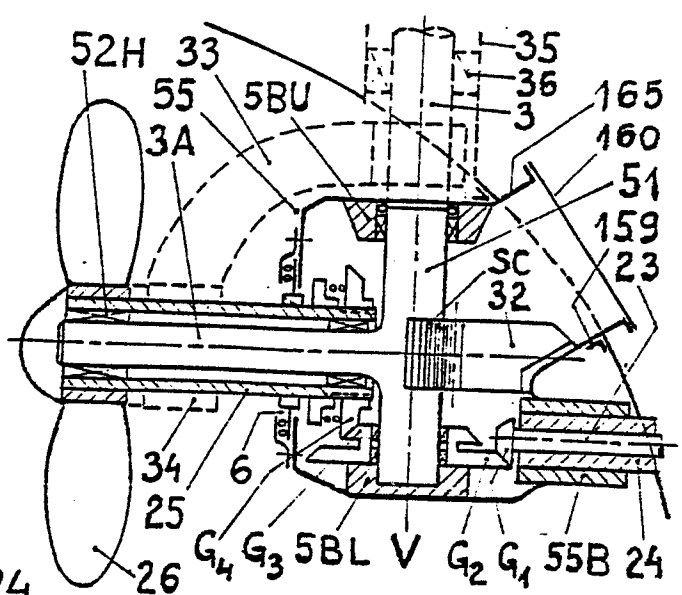


FIG. 24

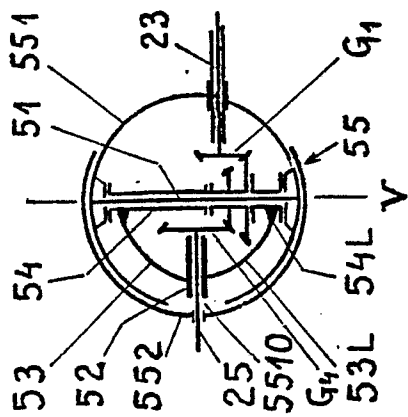


FIG. 25

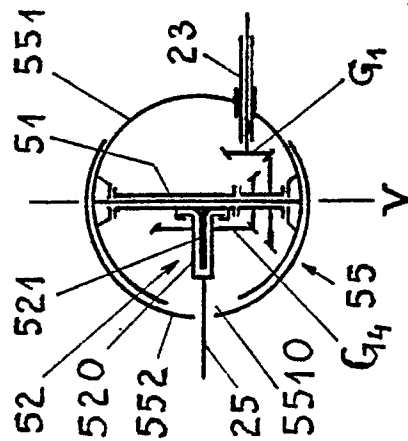


FIG. 26

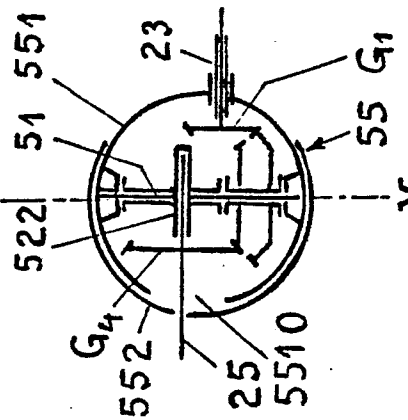


FIG. 27

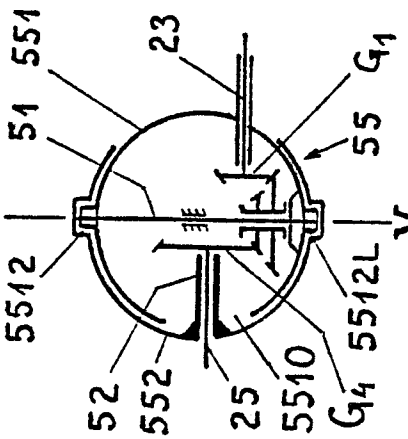


FIG. 28

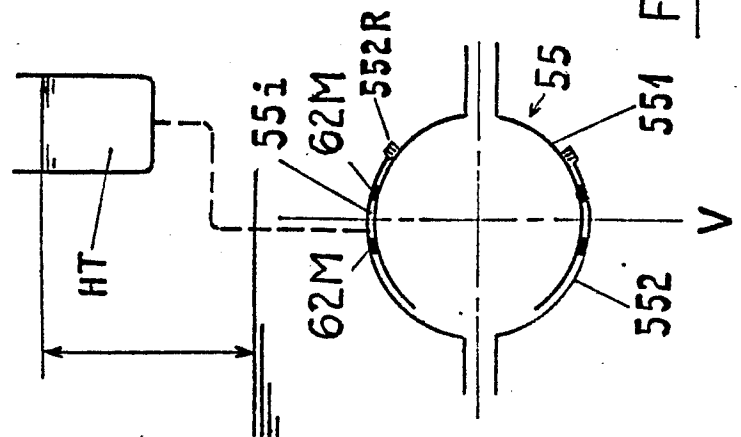


FIG. 29

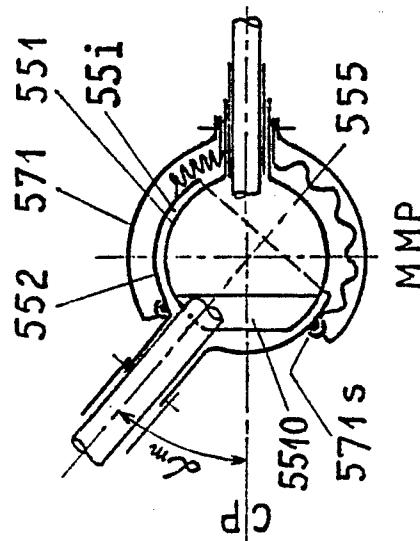


FIG. 30

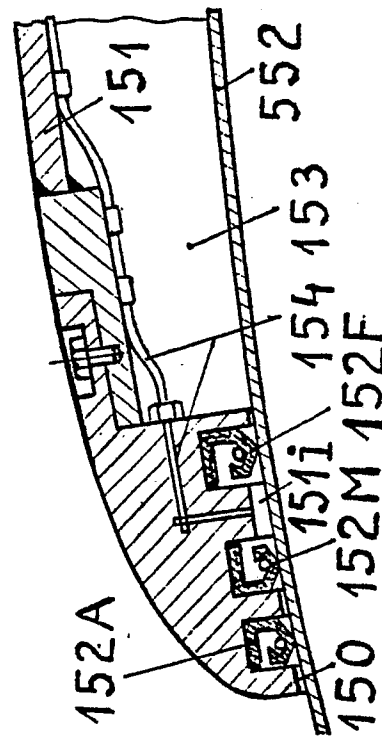
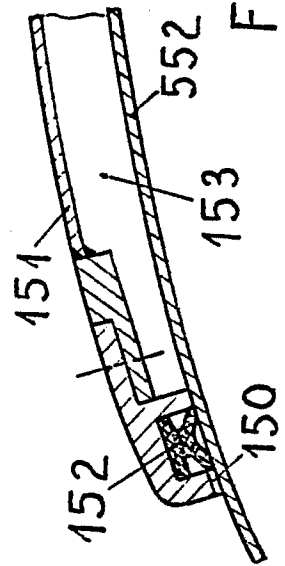
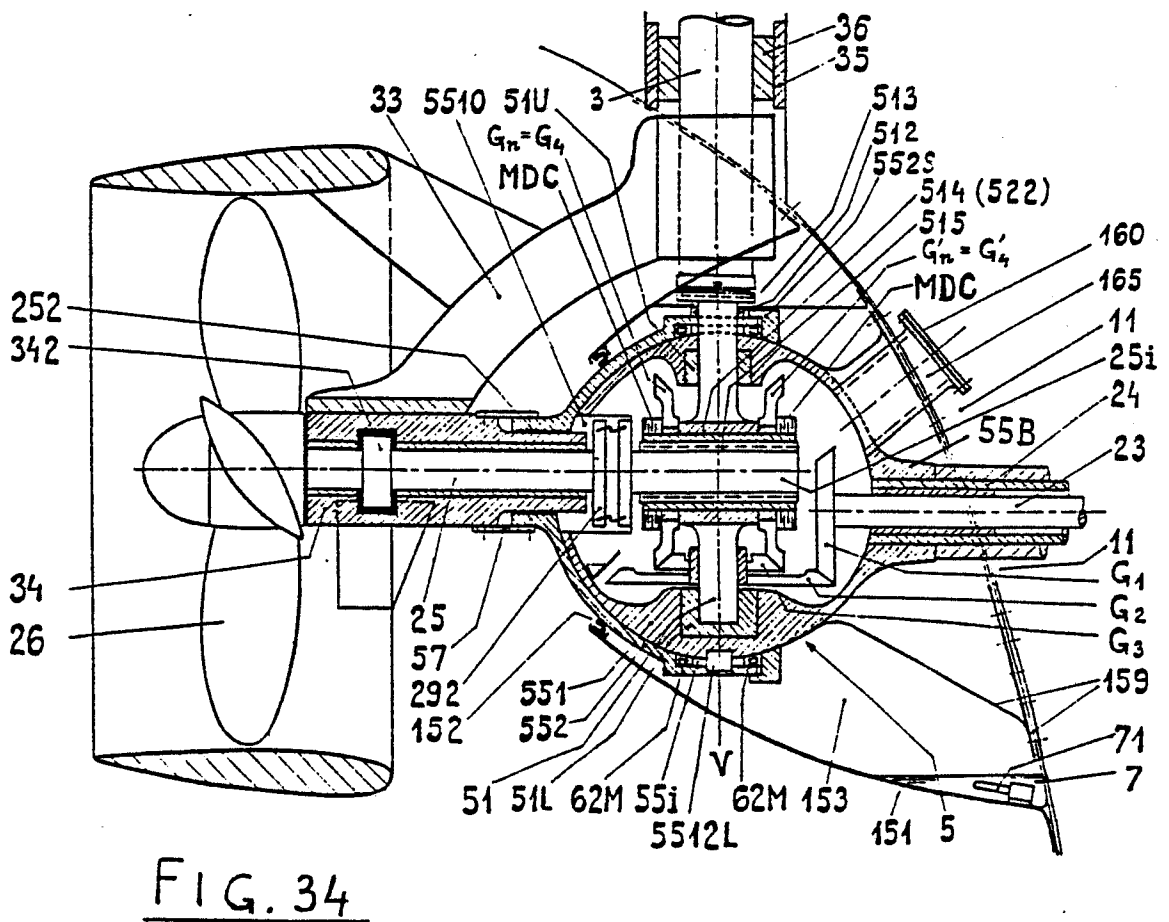
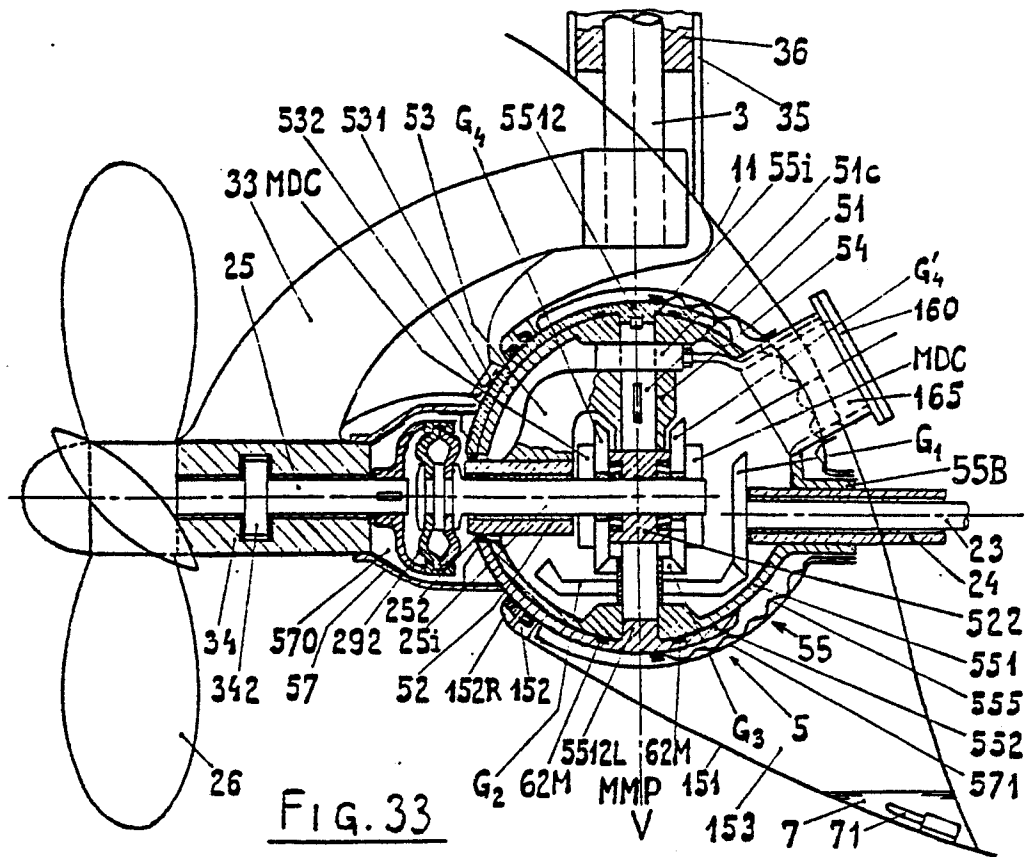
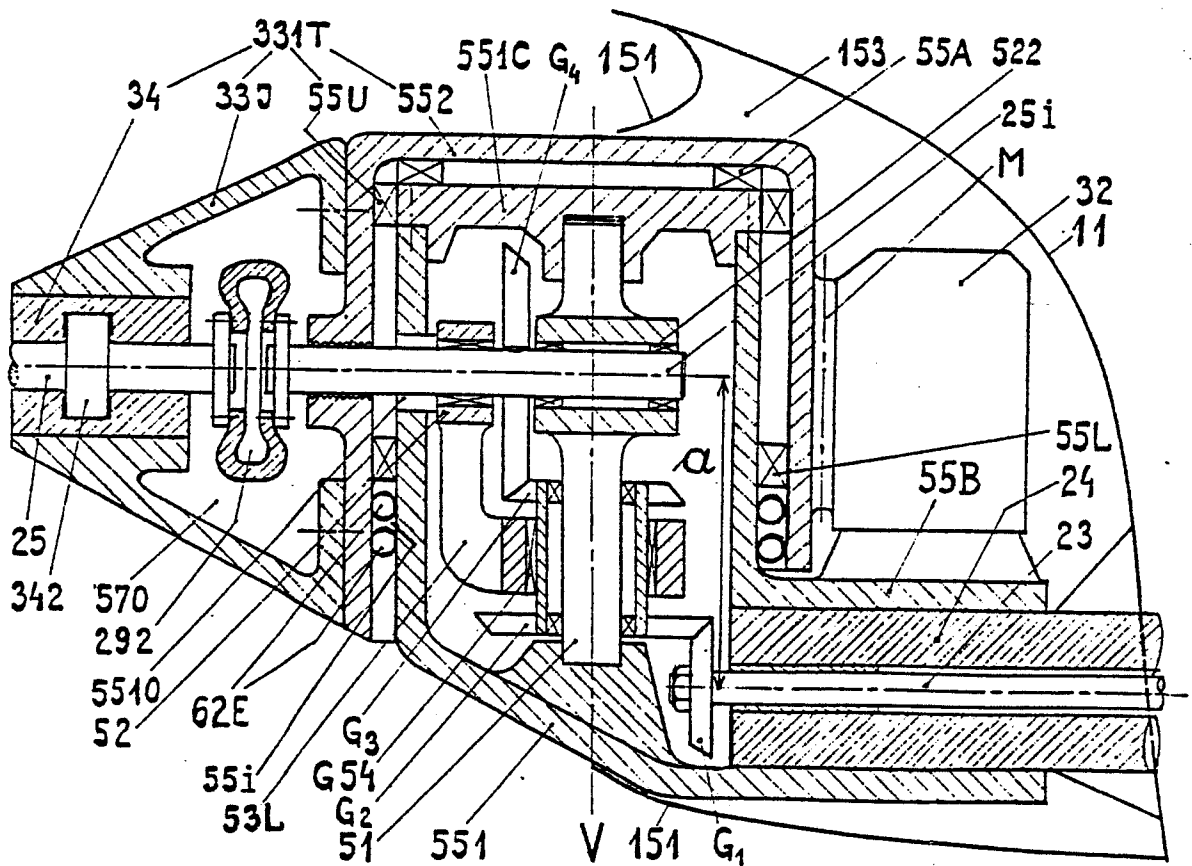
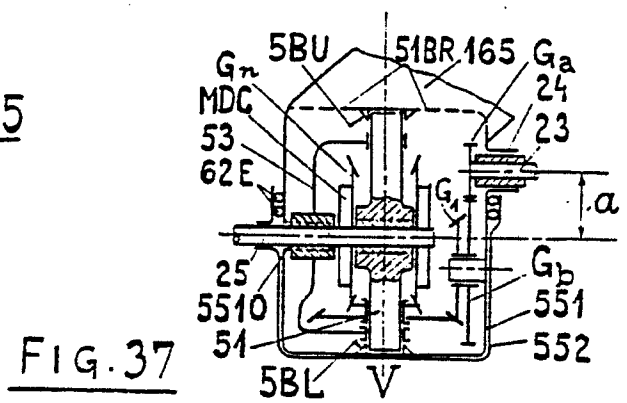
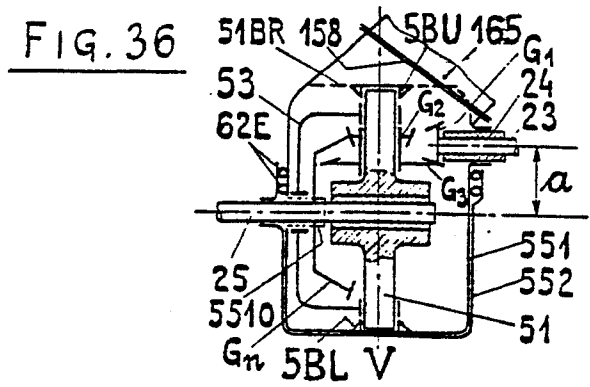
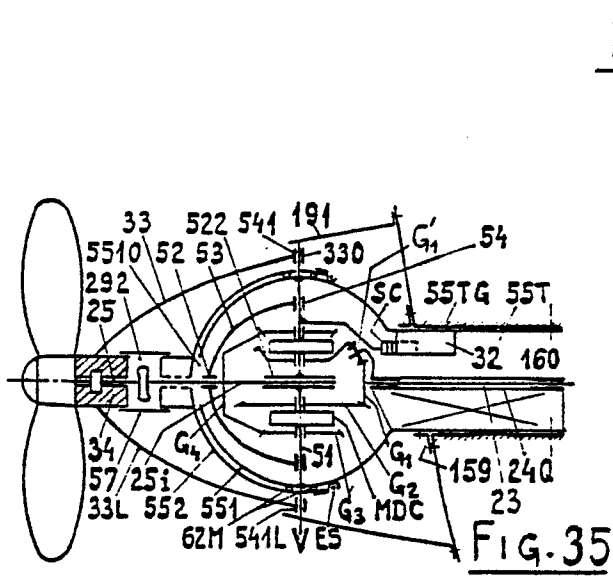


FIG. 31

FIG. 32







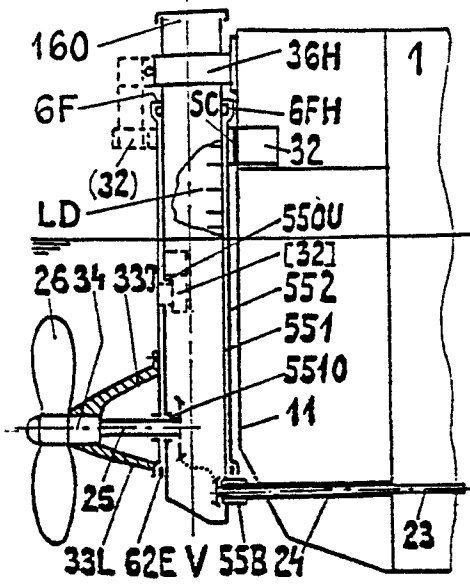


FIG. 42

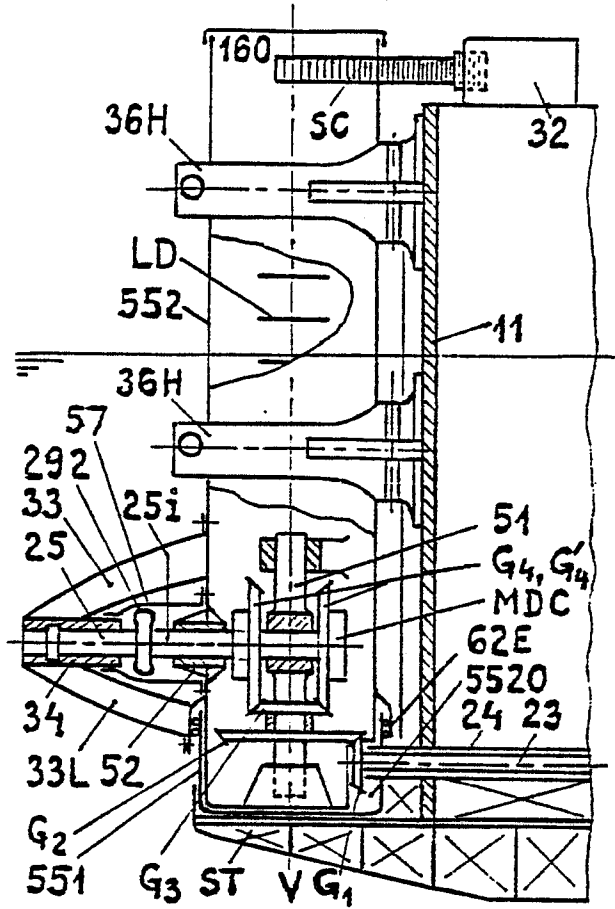


FIG. 43

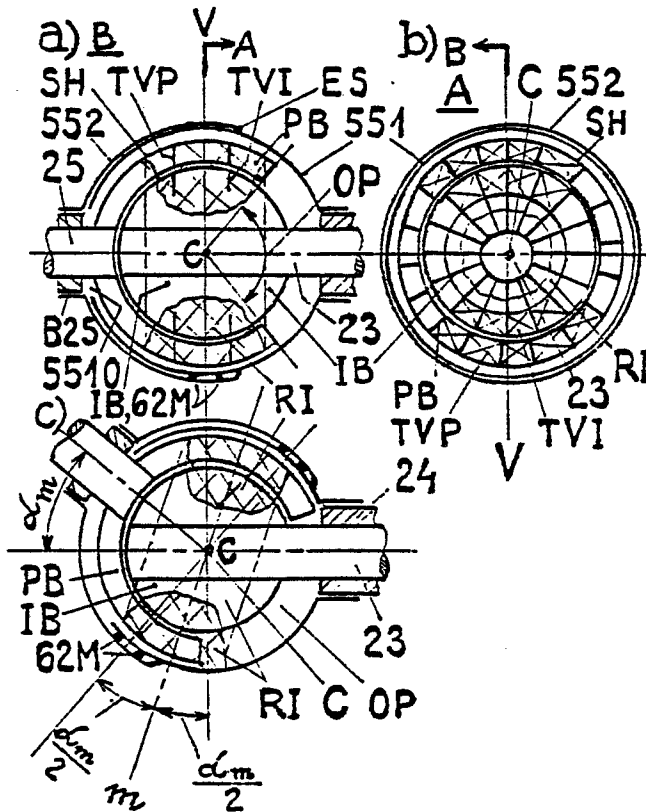


FIG. 44

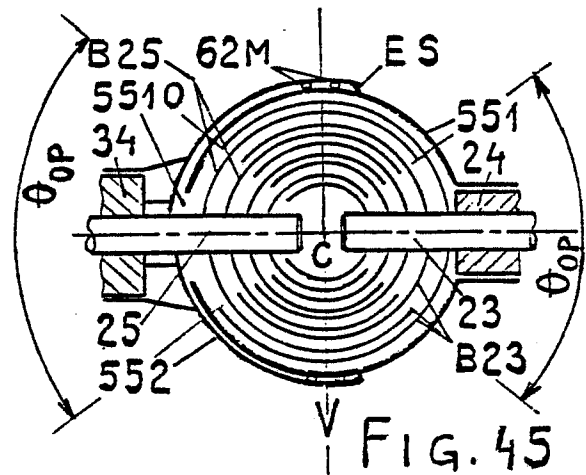


FIG. 45

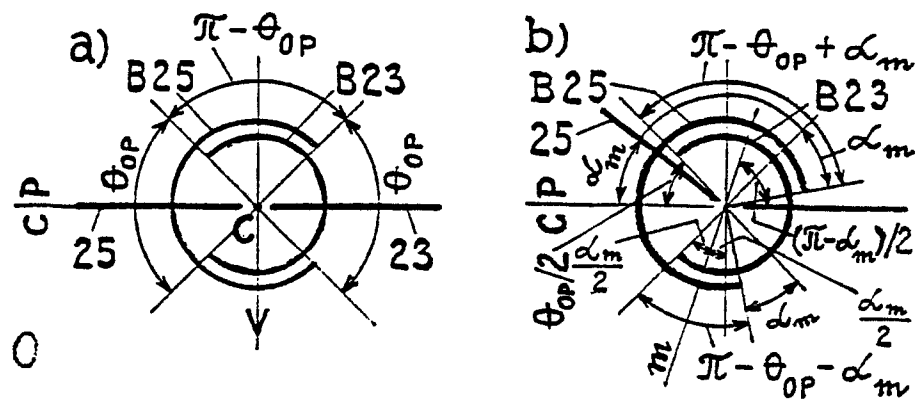


FIG. 46

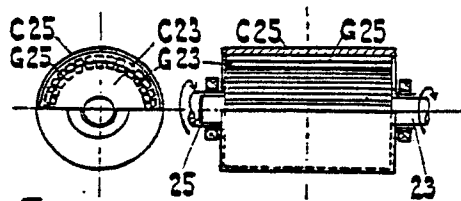


FIG. 47

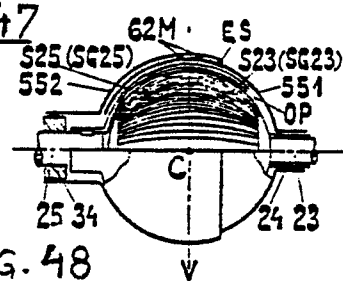


FIG. 48

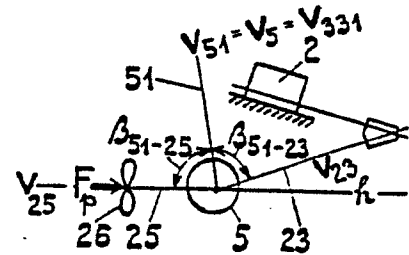


FIG. 49

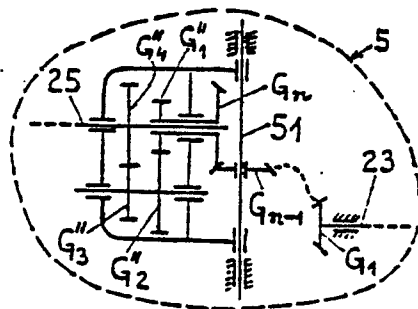


FIG. 50

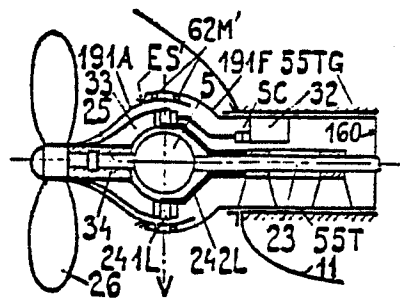


FIG. 51

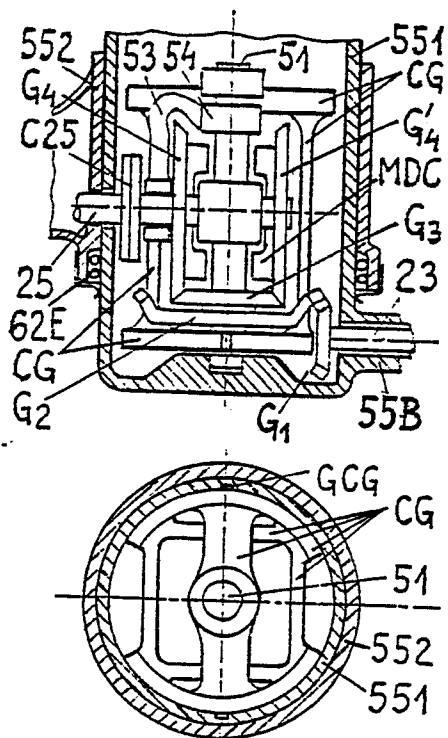
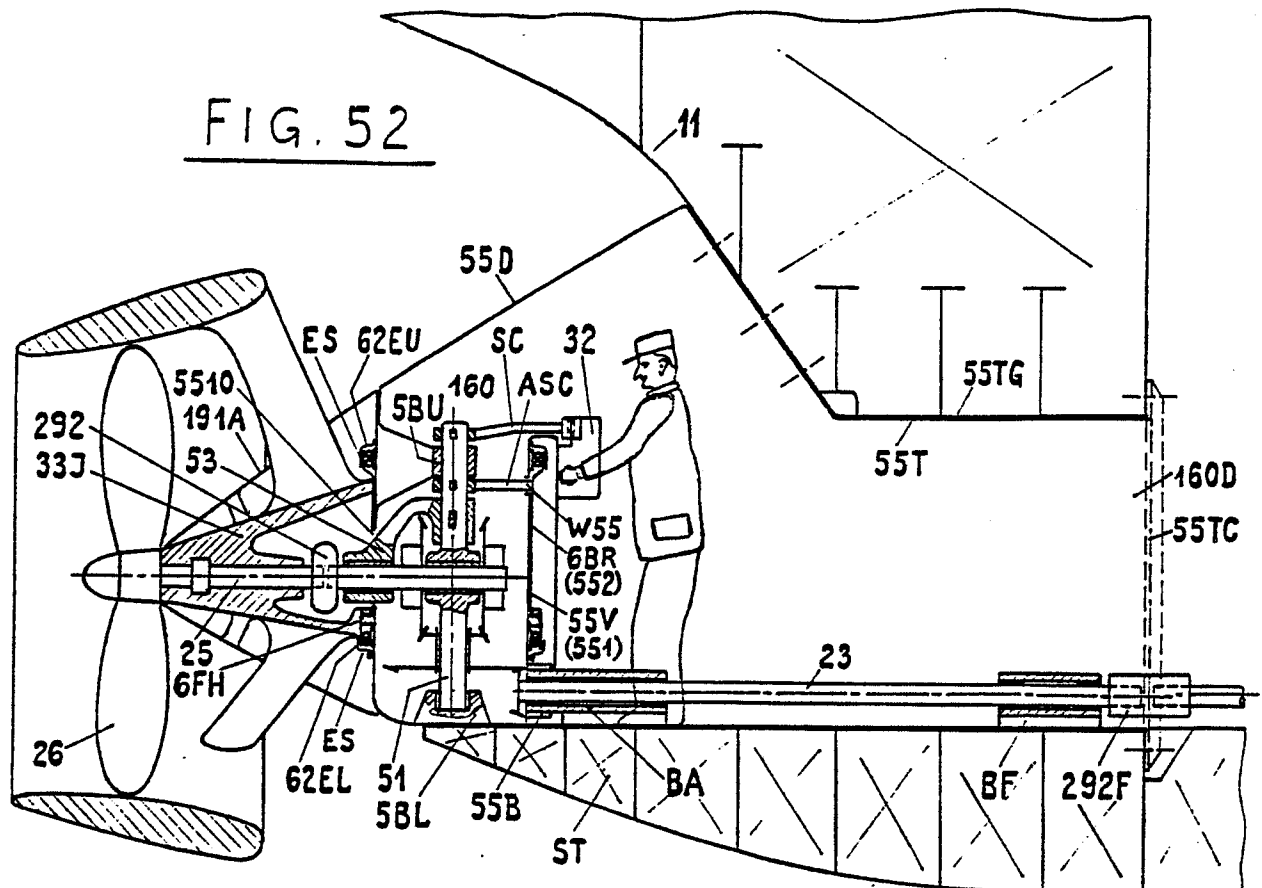


FIG. 53

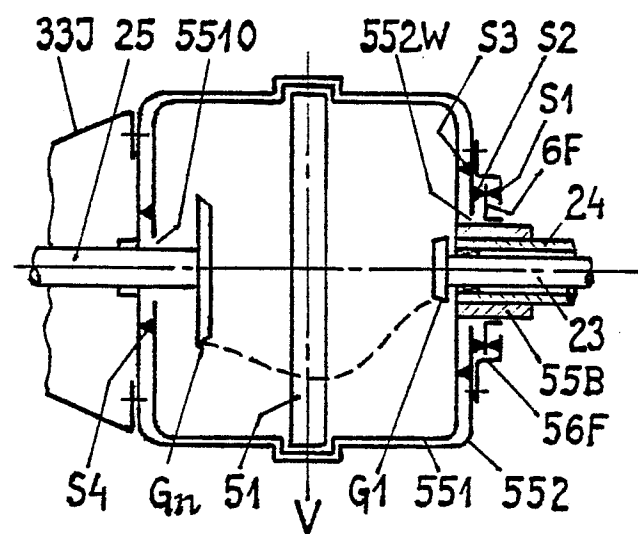


FIG. 54

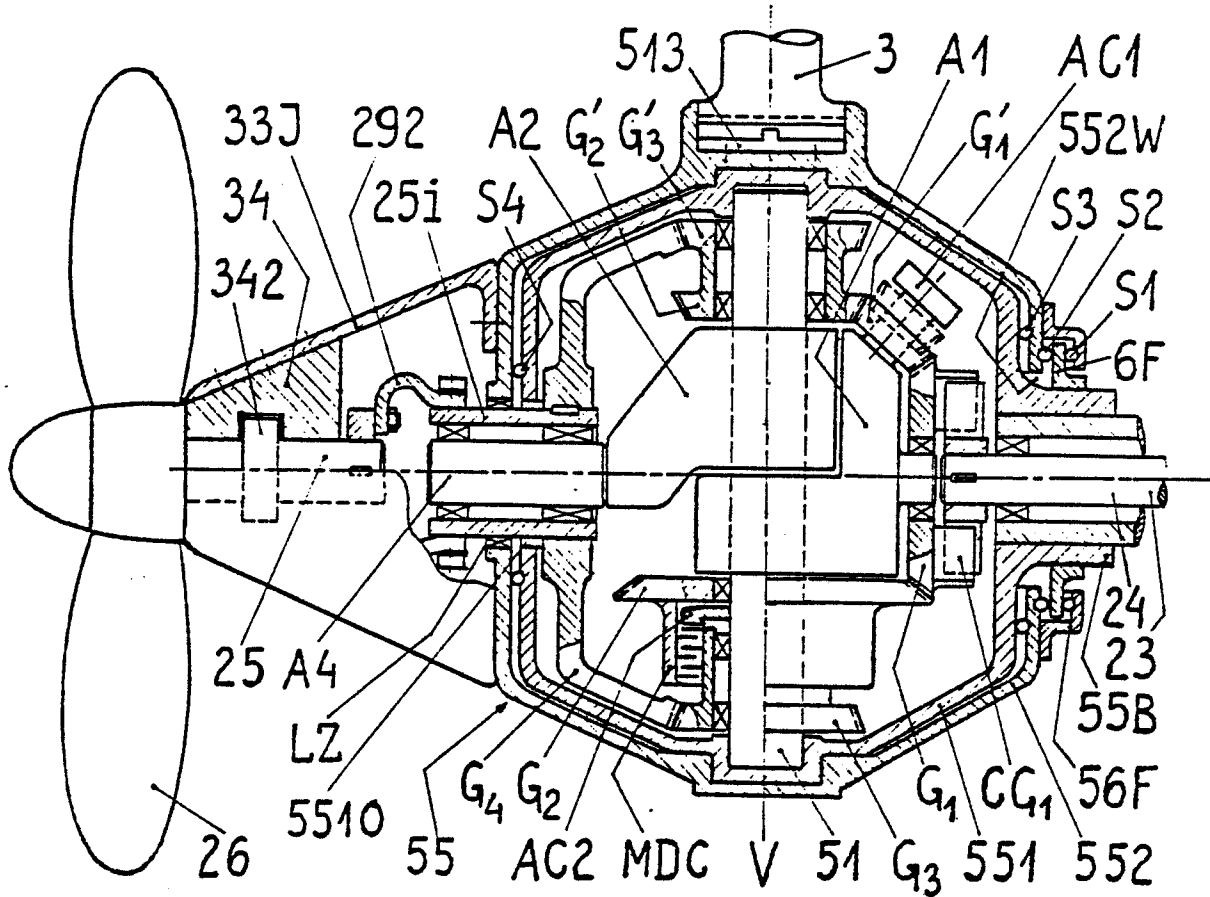
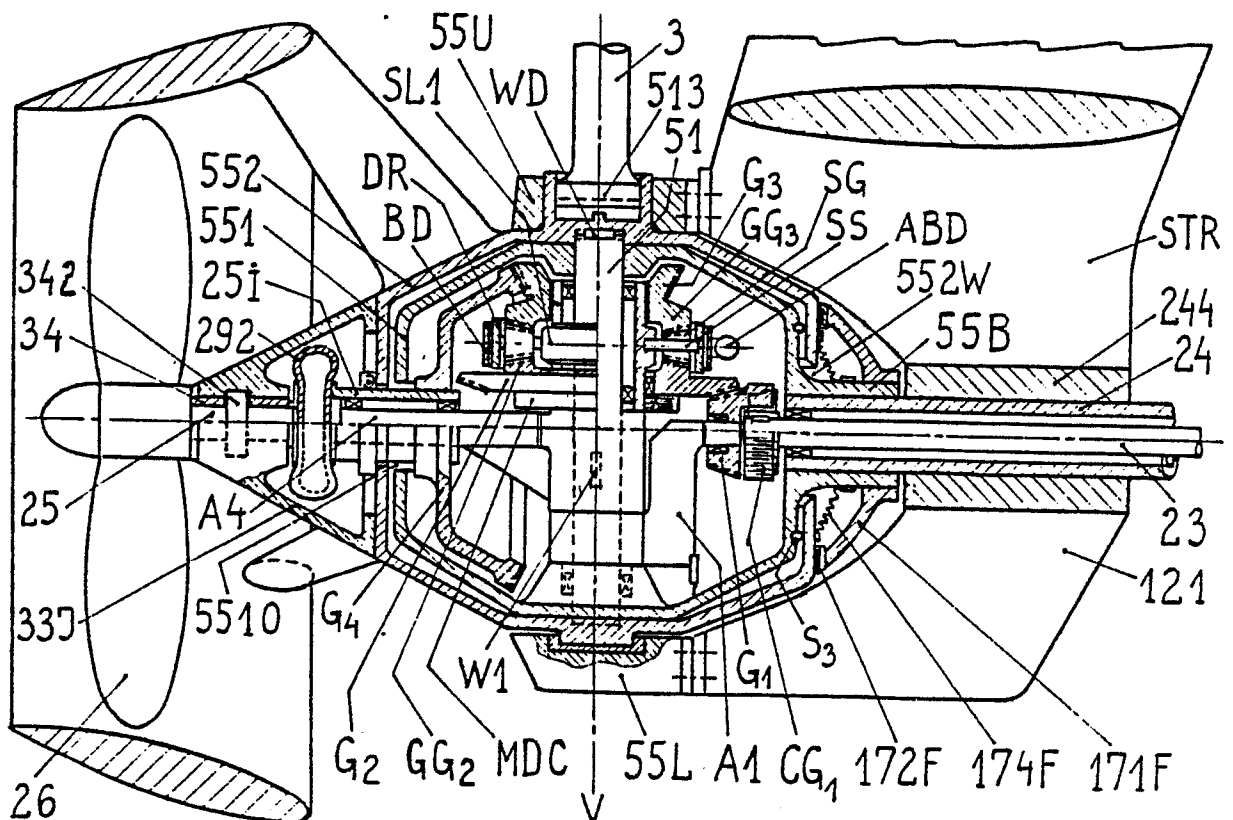


FIG. 55

FIG. 56



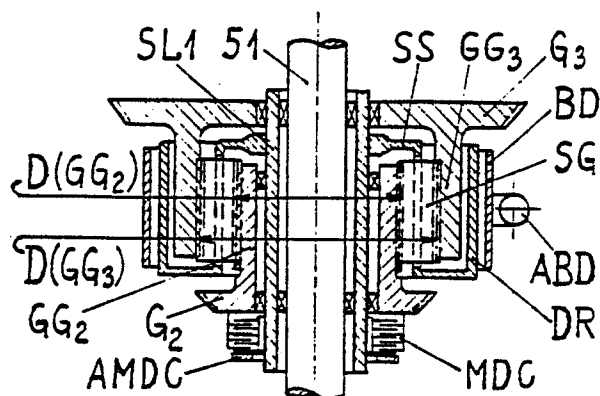


FIG. 57

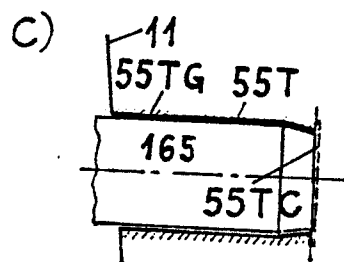
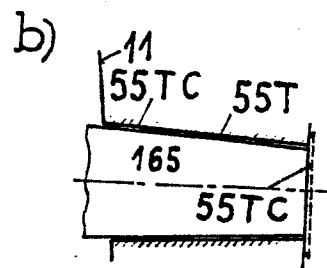
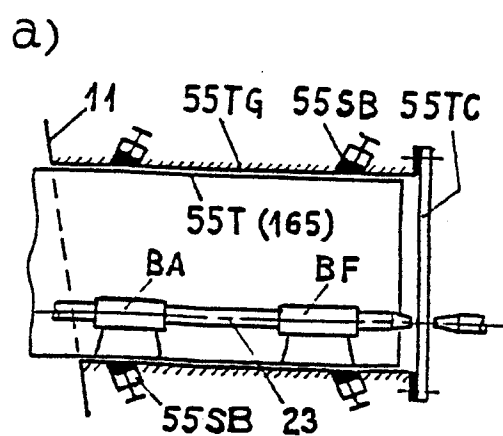


Fig. 58

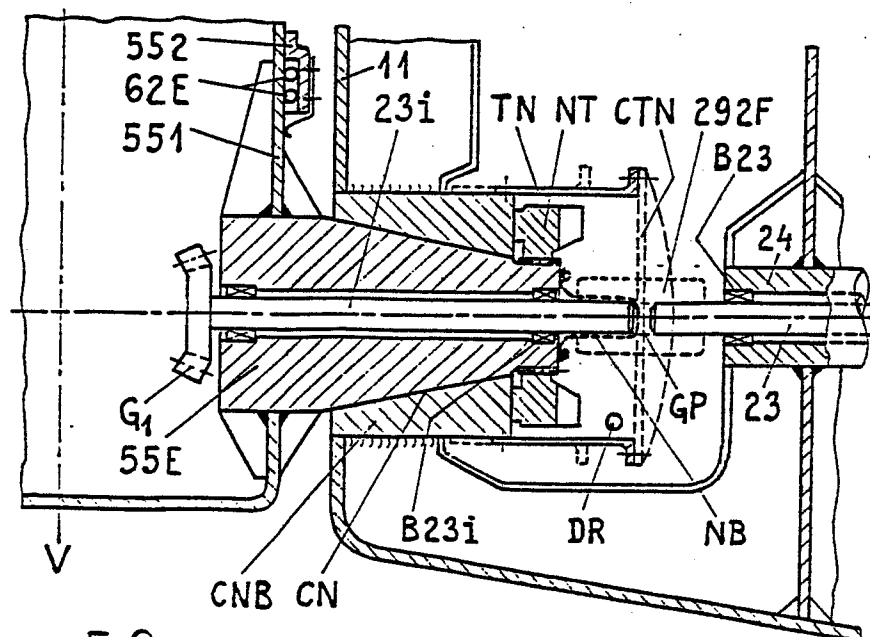


FIG. 59

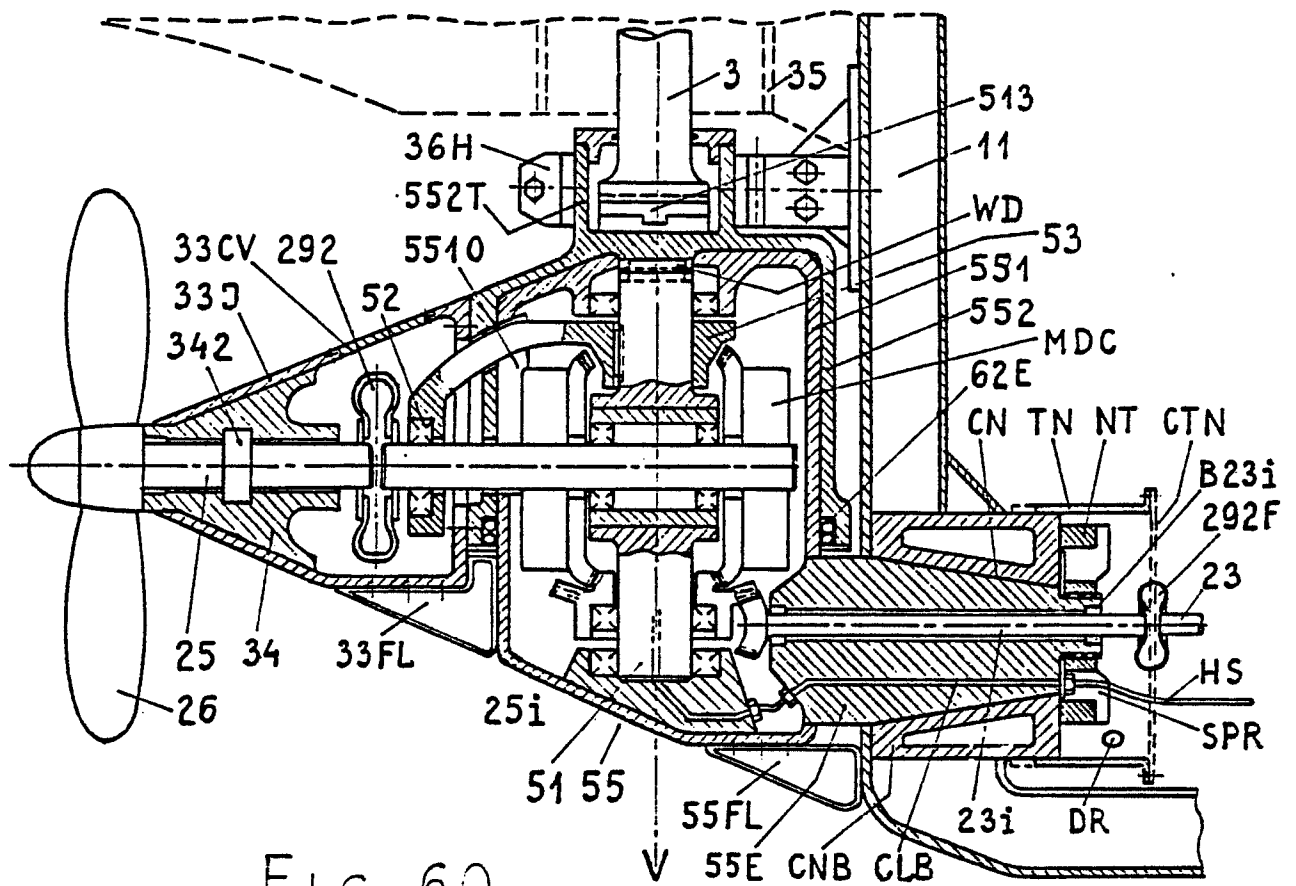


Fig. 60

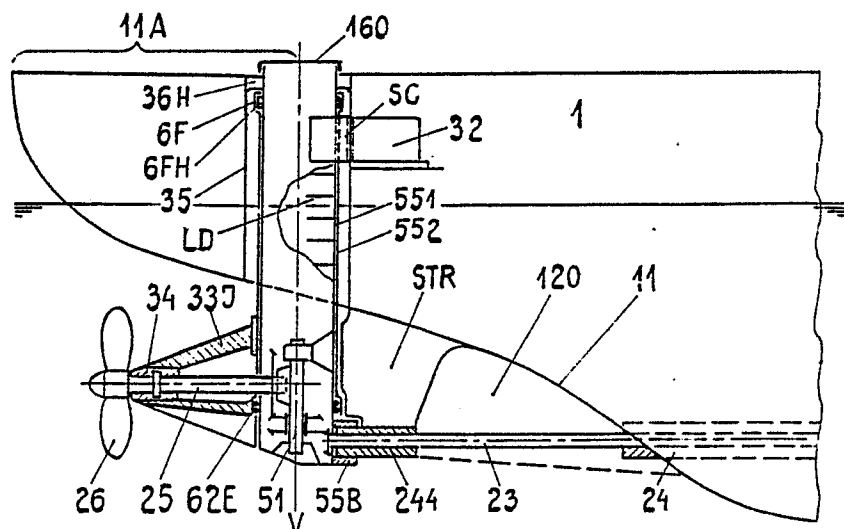


FIG. 61

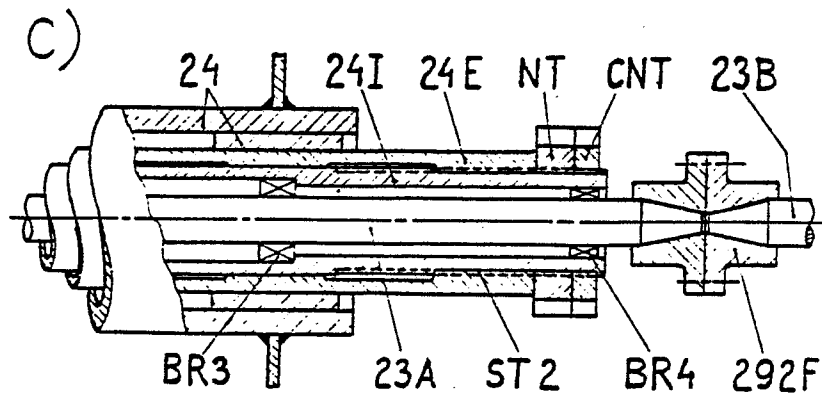
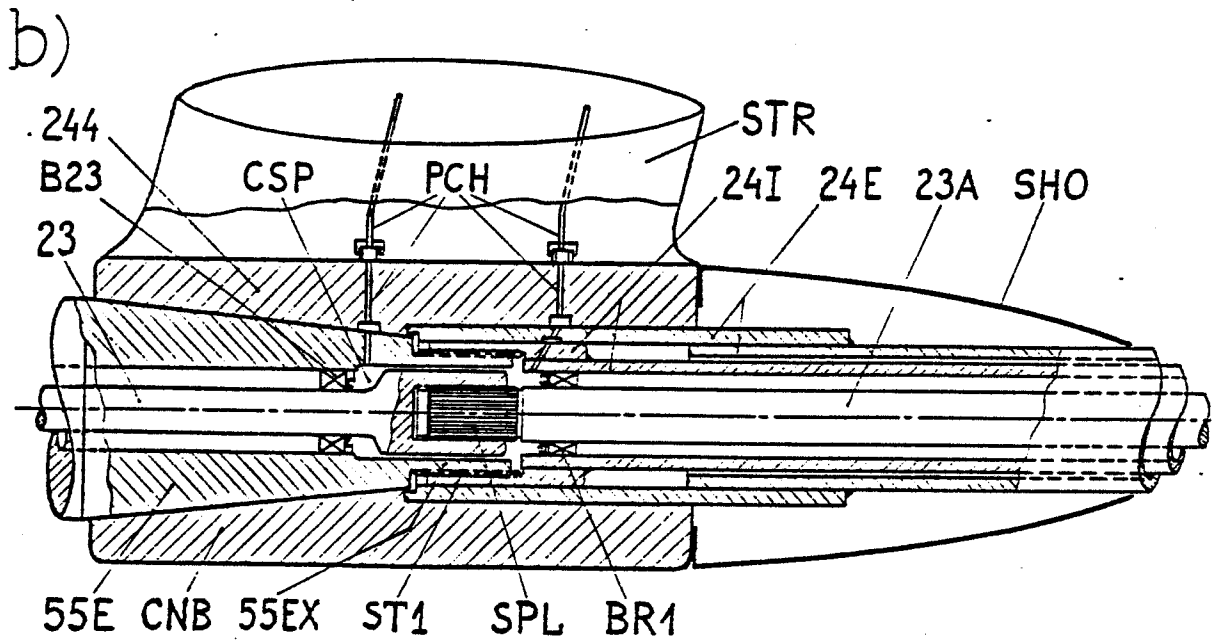
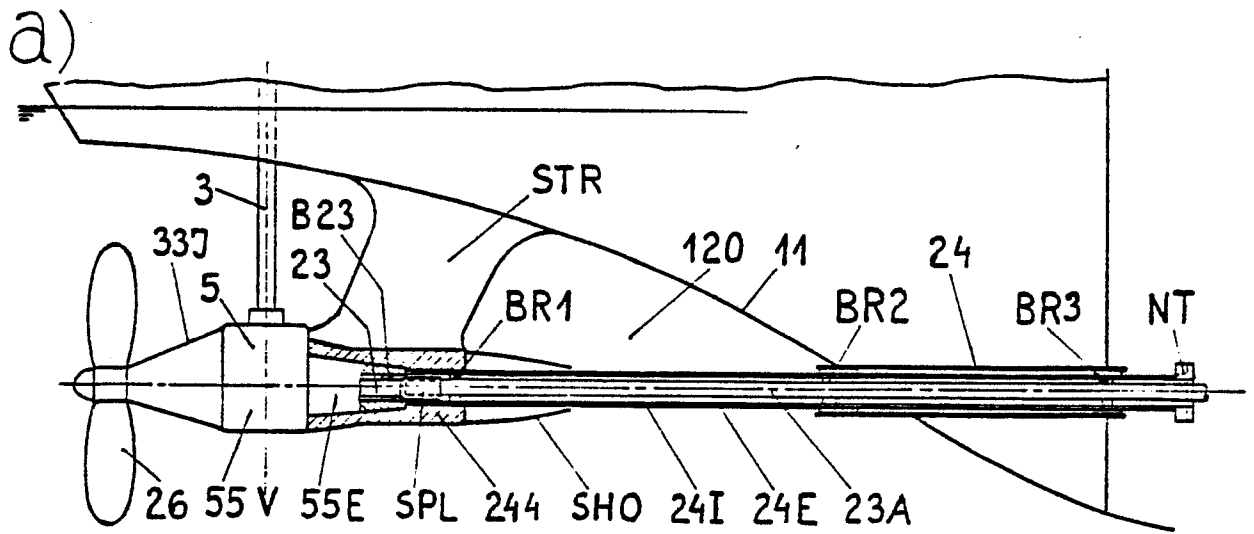


FIG. 62



DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 4)
X	US-A-2 956 536 (KILVINGTON) * Whole document * ---	1,2,5	B 63 H 5/13 B 63 H 25/42
X	FR-A-1 156 779 (QUESTIAUX) * Whole document * ---	1,3	
X	FR-A- 618 319 (BARRERE) * Whole document * ---	1,3	
X	FR-A- 645 087 (LEFEBVRE) * Whole document * ---	1,3	
X	FR-A- 637 613 (BASSET) * Whole document * ---	1,3	
X	DE-C- 5 120 (DIETRICH) * Whole document * ---	1	
A	GB-A-1 353 184 (HARRIS) ---		
A	GB-A-2 092 973 (CONNOR) ---		TECHNICAL FIELDS SEARCHED (Int. Cl. 4)
A	FR-A-1 023 513 (LE LOUER) ---		B 63 H
A	FR-A-2 003 041 (B.M.W.) ---		
A	US-A-3 919 965 (ROSS) ---		
A	US-A-3 430 603 (PARISH) -----		
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 13-07-1988	Examiner DE SCHEPPER H.P.H.
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons ----- & : member of the same patent family, corresponding document			