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(54) IMPROVEMENTS IN OR RELATING TO WIND POWERED SELF-STEERING DEVICES FOR SAILBOATS

(71) We, HYDROVANE YACHT EQUIPMENT LIMITED, of Marlborough House, 1A Cranmer Street, Nottingham, England, a British Company, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to wind powered self-steering devices for sailboats.

As is well known to both commercial and sports sailors, it is frequently desirable that a sailboat have capacity to steer itself, thereby relieving the helmsman for other duties or rest. Such occasions might arise during lengthly ocean passages when sailing with a shorthanded crew, or, particularly, when sailing single handed. In all such circumstances, it is essential that the self-steering device have complete control of the helm to prevent undesired motion of the sailboat or deviations from a preset course.

Numerous efforts have been made to develop self-steering systems for sailboats, for the general purpose described as well as for other purpose. One category of such mechanisms, for example, has the purpose of maintaining a boat on a given course with a fixed compass heading. As mechanisms in this category generally require auxiliary power responsive to control by some compass device, they are of no interest to the present invention which is specifically directed to a wind powered device designed to hold the boat on a selected heading or course relative to the apparent wind direction.

In the particular category of self-steering mechanisms for sport sailboats, some fairly effective and reliable systems have been developed in the past decade for achieving self-steering relative to the apparent wind direction. Such systems generally employ a wind vane to measure the apparent wind direction, and use the wind pressure on the wind vane, when the sailboat wanders off course, to drive a steering device that will steer the boat back to the desired course. In such systems, the steering device can be a sailboat's tiller, an auxiliary rudder or trim tab, a servo blade for amplifying power, or like means, depending upon the particular system used. Self-steering mechanisms of this general type, wherein wind vanes are employed to sense apparent wind direction, are disclosed in Gianoli U.S. patent numbers 3,180,298 and 3,319,594, Ross-Clunis U.S. patent number 3,678,878, Smith U.S. patent number 3,942,461 and Saye U.S. patent number 3,765,361.

Although effective to a degree, known self-steering mechanisms of the type described have not proved to be entirely satisfactory in use.

Wind vane units which pivot about an axis in response to changes in the direction of apparent wind wherein such axis is tiltable in a vertical plane with respect to the sailboat have been employed for purposes of varying the sensitivity of the wind vane. Assuming a wind vane is normally in a vertical position and pivots about a horizontal axis, it is known to decrease the effective leverage and power of the wind vane by tilting its axis out of a horizontal disposition so as for example to better operate in various types of wind and sea conditions. However, in order to convert angular vane deflections into linear movements for actuating an auxiliary rudder means, it has been necessary to employ rather cumbersome mechanical linkage when it is desired to utilize a vane having a tiltable axis.

In addition, it has been known to utilize a transmission intermediately disposed between a wind vane having a non-tiltable axis and an auxiliary rudder so as to vary the ratio therebetween, as described and claimed in applicant's British patent 1,326,020. It has not been considered in the prior art to incorporate the advantages of a wind vane having a tiltable axis into a self-steering device having the advantages of a variable transmission means wherein the transmission means ratio could be adjusted independently of the wind vane axis tilt.

The present invention consists in a wind powered self-steering device for a sailboat having a keel, a main steering rudder and an auxiliary steering rudder, the device comprising a support base for attachment to said sail-boat, a wind vane unit mounted for pivotal movements about a vertical axis with respect to said support base, said wind vane unit comprising a wind vane mounting means disposed for pivotal movement about a horizontal pivot axis carried by said support base, a wind vane lever means including a wind vane lever pivot axis carried by said wind vane mounting means, a wind vane affixed to said wind vane lever means, means to pivot said wind vane mounting means and correspondingly said wind vane lever pivot axis about said horizontal pivot axis with respect to said support base so as to selectively adjust the angular tilt between said wind vane lever pivot axis and said support base, an output shaft operably connected to said wind vane lever means, said wind vane lever means being operable at different angles of tilt of said wind vane lever pivot axis with respect to said support base to translate pivotal movements of said wind vane lever means about said wind vane lever pivot axis to linear movements of said output shaft, the ratio of said linear movements of said output shaft to said pivotal movements of said wind vane lever means varying in correspondence to the degree of tilt of said wind vane lever pivot axis with respect to said support base, and transmission means for operably connecting said output shaft and said auxiliary rudder for transmitting the movements of said output shaft into pivotal steering movements of said auxiliary rudder, whereby, in use said wind vane and wind vane lever means can be set at a desired steering angle or course and at a desired tilt angle with respect to said support base for keel, wind and sea conditions, and thereafter operates to positively translate all wind forces produced by said sailboat being off course into corrective movements of said auxiliary rudder to return said sailboat to course wherein said transmission means includes settable means for adjusting the ratio of movements between said output shaft and said pivotal movement of said auxiliary rudder, and said settable means are operative independently of said wind vane unit.

One embodiment of the present invention is a wind powered self-steering device for sailboats wherein use is made of a wind vane which is selectively tiltable for varying conditions of sea, wind, point of sailing, and boat keel used, and which is structured to minimize the complexity of mechanical linkages related thereto. The device has both a tiltably adjustable wind vane axis and a variable ratio transmission means for transmitting wind vane deflections to an auxiliary steering apparatus, such ratios being selected independently of the tilt selected for the wind vane axis. The wind vane can be initially employed in a trailing operation to establish a desired steering or course position and thereafter operated for steering corrections. The wind vane is used to positively translate substantially all of the wind forces produced by the sailboat being off course into corrective movements of an auxiliary rudder to return the sailboat to course. In regard to the wind vane unit, the device employs a support base attached to the sailboat, wherein the vane unit is mounted for pivotal movements about a vertical axis as respects the support base. More specifically, the vane unit includes mounting means disposed for pivotal movements about a horizontal axis on the support base and a wind vane lever means pivotally mounted on the mounting means on an axis which is coplanar with and perpendicular to the horizontal pivot axis of the wind vane mounting means. Means are provided to pivot the wind vane mounting means to selectively obtain varying angles of tilt of the pivot axis of the wind vane lever as may be needed for desired sensitivity with respect to differing weather conditions and type of keel used with the sailboat. The steering mechanism further includes a pivoted connection between the vane lever means and output shaft member for converting the vane deflections into linear movements, the axis of such connection being coplanar with the axis about which the vane mounting means pivots and the axis about which the vane lever means pivots when the vane is in a vertical disposition. The pivotal movements of the vane are translated into linear movements of the output shaft at a ratio of linear response of the output shaft to the pivotal vane motion which varies in proportion to the degree of tilt of vane axis.

The present embodiment includes a transmission of variable ratio for transmitting linear movements of the aforesaid output shaft to an auxiliary rudder, the latter providing course adjustments to the sailboat. The ratio of the transmission can be set independently of the tilt provided to the vane axis whereby performance of the entire device of the present invention can be more precisely and easily determined.

The invention will now be described, by way of example, with reference to the accompanying drawings, in which:—

Figure 1 is a side elevation of a self-steering device in accordance with the invention;

Figure 2 is an end elevation of the device shown in Figure 1;

Figure 3 is an isolated view with portions broken away of a wind vane unit included in the self-steering device of Figures 1 and 2;

Figure 4 is a side elevation of the vane unit shown in Figure 3; and

Figure 5 is a transverse section taken on the line 5—5 of Figure 3.

Figures 1 to 5 of the drawings show a wind powered, self-steering device for sailboats of the type employing a main steering rudder and auxiliary steering rudder. A wind vane pivots about an axis that is tiltably adjustable with respect to the horizontal so as to adjust the sensitivity thereof in accordance with the type of keel associated with the boat, its point of sailing, and prevailing wind and sea conditions. The wind vane axis is also rotatably adjustable with respect to the centre line of the sailboat to provide course adjustment. When engaged for operation, the wind vane senses the relative ship-wind direction and, when a boat is off course, translates the wind forces on the wind vane into corrective movements of the auxiliary rudder to return the sailboat to course. The self-steering device is characterised by the coplanar nature of the axis about which the vane pivots, about which the axis of the vane is pivoted and about which pivoted motion of the vane is transmitted to the auxiliary rudder. The device is further characterized by the fact that a transmission is provided to transmit the pivotal movements of the wind vane to the auxiliary rudder in a range of settable gear ratios which can be determined independently of and in addition to the angle of tilt selected for the wind vane and the sensitivity corresponding thereto.

The self-steering devices as illustrated in the drawings is intended to be attached to the stern of a sailing boat such as is indicated at 10 in Fig. 1.

In this self-steering device there is a support which is similar to that illustrated in applicant's British patent 1,326,020, published August 8, 1973, and comprises vertically spaced horizontal frame members 11 to which a vertically extending tubular mast 12 is secured. A support base upper portion 13, shown schematically in Fig. 1, is supported at the upper end of the mast 12 at a position well above the deck of the boat and the members 11. The support base is freely rotatable on the mast about the longitudinal axis 14 thereof and carries an upper lever subassembly generally indicated at 15 which is pivotally mounted on the support base portion 13, as to be described in more complete detail hereinbelow. As shown in Figs. 1 and 2, subassembly 15 is disposed for pivotal movement about a horizontal axis 16 which is laterally offset from the longitudinal axis 14 of the mast. However, as hereinafter described, the axis 16 and necessarily subassembly 15 can be tilted with respect to the horizontal.

In regard further to the general structural arrangement of the wind powered self-steering device considered herein, a wind vane 17 is rigidly mounted on the wind vane lever 15 at a position directly above the pivotal axis 16 by means of pins 18 on the wind vane lever which enter appropriate sockets in the wind vane. Although not shown, the upper extremity of the wind vane could further include a wind direction indicator which would be free to rotate relative to the wind vane for purposes of determining the direction of apparent wind.

The vane lever 15 forms a part of a transmission means for transmitting pivotal movement of the wind vane 17 to an auxiliary rudder 21 of the boat as further shown in Figs. 1 and 2. The rudder 21 is rigidly secured to the lower end of a rudder shaft 22 which extends upwardly from the rudder through a lower one of the frame members 11 to a position just above such lower frame member. The rudder shaft is mounted in a rudder tube 23 for rotation relative thereto about a vertical rudder axis 24, and the rudder tube is rigidly secured to the lower of the frame members 11.

The transmission means also includes a motion transfer member in the form of a lever 25 which is disposed between the frame members 11 and is mounted by means of pivots 26 on the side plates 27 which extend between the frame members 11, and of which one is omitted from Fig. 1 for clarity. The pivotal axis of the lever 25 is parallel to the illustrated axis 16 of the vane lever 15, and is also laterally offset from the longitudinal axis 14 of the mast.

The vane lever 15 and lever 25 are interconnected by a connecting rod 29 which extends generally along the longitudinal axis 14 of the mast so that pivotal movement of the vane lever 15 causes a corresponding pivotal movement of the lever 25.

The upper support base portion 13 and a lower support base portion 56 are mounted on the mast 12 for rotation relative thereto to permit setting of the wind vane structure as determined by the course which it is required to sail. Accordingly, at least one, and preferably as shown both, of the upper and lower ends of the connecting rod 29 is connected with its respective lever by a joint, such as a ball joint.

An adjustable operative connection between the lever 25 and the rudder shaft 22 is provided by an adjustable member 30 in cooperation with a rudder arm 31. The adjustable member 30 is mounted on the lever 25 for angular adjustment relative thereto about pivot points 32 which lie on an axis which is perpendicular to and which is intersected by the axis about which lever 25 is mounted. The rudder axis 24 passes through this intersection point. The rudder arm 31 is rigidly secured to the rudder shaft 22 at the upper end thereof and extends radially upwardly from the shaft.

The adjustable member 30 includes a first arm 33 which carries a handle 34 by means of which the adjustable member can be pivoted about pines 32, and a pin 35 which projects from the arm 33 in a direction parallel to the axial orientation of pins 32 and at a position laterally offset therefrom. The pin 35 extends through a curved slot provided in a vertical plate 36 which is attached to the lever 25. A flanged sleeve 37 surrounds the pin 35 and extends through the curved slot, the flange engaging portions of the plate 36 adjacent to the curved slot. The sleeve 37 is prevented from rotating on pin 35 in any convenient manner and a portion of the sleeve on the side of the plate 36 remote from the flange is threadedly engaged with a hand wheel 38. The plate 36 can be clamped between the flange of the sleeve 37 and the hand wheel by rotation of the latter to secure the adjustable member 30 releasably in a selected position of angular adjustment relative to the lever 25. The adjustable member 30 further includes an arm portion 30*a* which extends at right angles to the axial orientation of pins 32, conveniently in a direction opposite that of arm 33. Arm portion 30*a* is engaged in a slot 40 formed in the rudder arm 31.

The slot 40 is straight when viewed along the axis of rudder shaft 22 and extends therethrough. Thus, in one extreme position of adjustment of the adjustable member 30, the arm 30*a* extends vertically downwards in a coaxial manner with respect to the axis of rudder shaft 22. When the adjustable member is in this extreme position, the rudder 21 is free to rotate independently of the wind vane 17, that is without transmitting any movement thereto, and the self-steering gear is not effective to steer the boat. Also, with the adjustable member 30*a* in this extreme position, the wind vane is locked in a vertical datum position by engagement of the arm with the inner end of slot 40.

When the adjustable member 30 and arm 30*a* are in any position of adjustment other than the extreme position referred to hereinabove, pivotal movement of the vane 17 about the axis 16 is transmitted by means of the vane lever 15, the connecting rod 29, the lever 25, the arm 30*a* and the rudder arm 31 to the rudder shaft 22. The velocity ratio or gear ratio of this transmission means can be varied steplessly by suitable adjustment of the member 30 about pins 32. Thus, the gear ratio may be varied to suit particular conditions of use of the self-steering device.

The adjustment means described is effective to change the value of both the effective length of the arm portion 30*a* and the effective length of the rudder arm 31. In other words the radial distances of the point of contact between these two arms from the axis extending between pins 26 on the one hand and from the rudder axis 24 on the other hand are both changed by angular adjustment of the member 30. However, the geometry of the adjustment means may be such as to vary only one of these distances. For example, the rudder arm may extend at right angles to the rudder axis 24. In this case angular adjustment of the member 30 would vary the effective length of the rudder arm, but would not vary the offective length of arm portion 30*a*. Although one exemplary construction of the aforesaid transmission means has been described, it would be obvious to one skilled in the art that various modifications to this structure could be made while still performing the same function.

Figs. 3 to 5 show in detail the structure employed whereby the axis 16 of Figs. 1 and 2, about which the wind vane 17 and associated vane lever subassembly 15 pivot, may be inclined or tilted in a selected manner with respect to the horizontal. The desirability of this feature (adjustment of the wind vane sensitivity) will be described in detail hereinbelow in connection with the operation of applicant's structure. As shown in Figs. 3 and 5, the vane 17 is rigidly affixed to the vane lever means 15 with the latter being pivoted for rotation about a wind vane mounting means 50 or more specifically a mounting means for and comprising part of the lever means 15. The mounting means 50 in turn is mounted for rotation about the pin assembly 54 with respect to the lower support base portion 56.

The pin assembly 54 therefore provides a horizontal pivot axis about which the mounting means 50 may pivot. It is accordingly to be understood with respect to Figs. 1 and 2, that the vane lever and its associated pivot axis may pivot with respect to the horizontal about the upper end of connecting rod 29, although the detail structure such as mounting means 50 and the pin assembly 54 are not shown in Figs. 1 and 2 for purposes of clarity in those views. Returning to Figs. 3 to 5, it is to be understood that the wind vane lever pivot axis 16 is coplanar with and perpendicular to the horizontal pivot axis associated with the pin assembly 54. In addition, a locking hand wheel or knob 58 is provided adjacent to the lower support base portion 56 to releasably adjust or determine the degree of tilt imparted to the mounting means 50 and correspondingly the associated wind vane pivot axis 16 with respect to the support base.

As shown further in detail in Fig. 5, the left hand side of the vane lever 15 includes a bushing type means 60 which is pivotally mounted in the gap between portions 15*a* of the vane lever by means of opposing, partially threaded pins 62. The axis associated with pins 62 is parallel to the axis associated with pins 52. The bushing 60 is pivotally connected to connecting arm 64, the latter providing an operable connection between lever 15 and the output shaft or connecting rod 29. The connection between bushing 60 and arm 64 is provided by pin 66, perpendicular to pins 62, which passes transversely through bushing 60 whereby the latter may pivot freely about the longitudinal axis of pin 66 with lever 15, the lever axis 16, and mounting means 50 pivcted as an integral unit also about the pin assembly 54 with respect to the lower base portion 56 and upper support base portion.

Accordingly, as shown in Figs. 3 to 5 it should be apparent that when the vane is in a vertical datum position, all of the axes associated with pins 52, 54, 62 and 66 are coplanar at all angles of tilt of the vane axis and that as further shown in Fig. 5 when the vane 17 is in a vertical datum position, the axis of pin 66 is coaxial with that of pin 54 and both of these axes in turn being perpendicular to the axis associated with pins 52. It should be further appreciated, that the ratio of linear movements in a vertical direction of the output shaft or connecting rod 29 to the angular pivotal movements of the wind vane 17 and associated lever 15 will vary in correspondence to the degree of tilt of the wind vane lever pivot axis with respect to the support base. In other words, the lever 15 will transmit the relatively greatest amount of vertical movement to rod 29 when the pivot axis for lever 15 is horizontal. However, as the pivot axis for lever 15 is tilted with respect to the horizontal, with the bushing 60 pivoting about pin 66, a certain degree of the pivotal movement of lever 15 will be converted to transverse movements of connecting rod 29 with a decreasing portion of the movement of lever 15 being converted into vertical movement of the rod 29 as the axis of lever 15 is tilted farther away from the horizontal.

The operation of the self-steering device of Figs. 1 to 5 will now be described. The support base portions 56 and 13 form part of a course setting mechanism which may be provided with a peripheral groove such as 41 shown in Figs. 1 and 2 to accept a line by means of which the rotational position of the suport base can be controlled from a remote position. Necessarily, alternative means could be provided for this function.

When the boat is on the required course the support base is so rotated so that the wind vane lever axis 16 about which the vane 17 pivots is parallel to the direction of the apparent wind. The wind vane then remains in a vertical datum position until there is a change in direction of the apparent wind, such as would be caused by a deviation of the boat from the required course. This causes the wind vane to move from its datum position by pivoting about the axis 16. Such pivotal movement is transmitted to the auxiliary rudder 21 which is caused to pivot in a direction such as to counteract the deviation and steer the sailboat onto or more nearly onto its original course relative to the wind. When the wind vane returns to its datum position the auxiliary rudder 21 will return to a central position parallel to the fore and aft center line of the hull. In addition, the tilt angle of the wind vane at any point in time may be adjusted by means of knob 58. As the vane axis is tilted farther and farther away from the horizontal, the effective moment arm of the vane with respect to imparting vertical movements to connecting rod 29 decreases. To those skilled in the art, this characteristic of the wind vane is known as its sensitivity. Accordingly, when the self-steering device is utilized in heavy seas or strong wind, the vane axis may be tilted to decrease its sensitivity to accomodate such condition. In addition, it is known to employ relatively short keels on high performance sailboats with a view towards reducing sailboat drag. With such a sailboat, it is a distinct possibility that a user of the instant device would want to decrease the sensitivity of the vane so that the auxiliary rudder does not tend to overcorrect, in view of a relatively short keel, which could result in undesirable yawing of the boat. Furthermore, it is considered a distinct advantage of the present device that a variable ratio transmission, as described in Figs. 7 and 8, be provided so that the ratio of auxiliary rudder movement to vane movement can be independently selected in addition to independent selection of the vane sensitivity. It is believed that by such an arrangement, a user of the instant device may most precisely adapt the self-steering device to weather and boat conditions. Furthermore, it is believed that the arrangement of mechanical linkage as described with respect to Fig. 6 effectively provides the capabilities described hereinabove while avoiding the necessity of unduly complex mechanical structure as exists in prior art structures.

The self-steering device described above has a wind vane sensitivity which is adjustable independently from a variable ratio transmission which operably connects the wind vane to an auxiliary steering rudder. Furthermore, the mechanical linkage employed to provide a tiltable vane axis is efficient in operation and relatively compact in form.

The wind vane unit shown in Figs. 3 to 5 and described above is also disclosed in our copending application No. 11460/80, (Serial No. 1,593,504) which is divided on the present application.

WHAT WE CLAIM IS:—

1. A wind powered self-steering device for a sailboat having a keel, a main steering rudder and an auxiliary steering rudder, the device comprising a support base for attach-

ment to said sailboat, a wind vane unit mounted for pivotal movements about a vertical axis with respect to said support base, said wind vane unit comprising a wind vane mounting means disposed for pivotal movement about a horizontal pivot axis carried by said support base, a wind vane lever means including a wind vane lever pivot axis carried by said wind vane mounting means, a wind vane affixed to said wind vane lever means, means to pivot said wind vane mounting means and correspondingly said wind vane lever pivot axis about said horizontal pivot axis with respect to said support base so as to selectively adjust the angular tilt between said wind vane lever pivot axis and said support base, an output shaft operably connected to said wind vane lever means, said wind vane lever means being operable at different angles of tilt of said wind vane lever pivot axis with respect to said support base to translate pivotal movements of said wind vane lever means about said wind vane lever pivot axis to linear movements of said output shaft, the ratio of said linear movements of said output shaft to said pivotal movements of said wind vane lever means varying in correspondence to the degree of tilt of said wind vane lever pivot axis with respect to said support base, and transmission means for operably connecting said output shaft and said auxiliary rudder for transmitting the movements of said output shaft into pivotal steering movements of said auxiliary rudder, whereby, in use, said wind vane and wind vane lever means can be set at a desired steering angle or course and at a desired tilt angle with respect to said support base for keel, wind and sea conditions, and thereafter operate to positively translate all wind forces produced by said sailboat being off course into corrective movements of said auxiliary rudder to return said sailboat to course wherein said transmission means includes settable means for adjusting the ratio of movements between said output shaft and said pivotal movement of said auxiliary rudder, and said settable means are operative independently of said wind vane unit.

2. A wind powered self-steering device as set forth in claim 1, wherein said wind vane lever pivot axis is coplanar with and perpendicular to said horizontal pivot axis associated with said support base and said wind vane mounting means.

3. A wind powered self-steering device as set forth in claim 1 or 2, wherein said wind vane lever means is connected to said output shaft by a universal pivot connection the axes of which are coplanar with said horizontal pivot axis associated with said support base and said wind vane lever pivot axis when said wind van is in a vertical disposition.

4. A wind powered self-steering device as set forth in claim 1, 2 or 3, wherein said wind vane lever means is connected to said output shaft by a universal pivot connection having one axis which is coaxial with said horizontal pivot axis associated with said support base and a second axis which is perpendicular to said horizontal pivot axis associated with said support base when said wind vane is in a vertical disposition.

5. A wind powered self-steering device for a sailboat, the device being constructed, arranged and adapted to operate substantially as hereinbefore described with reference to, and as illustrated in, the accompanying drawings.

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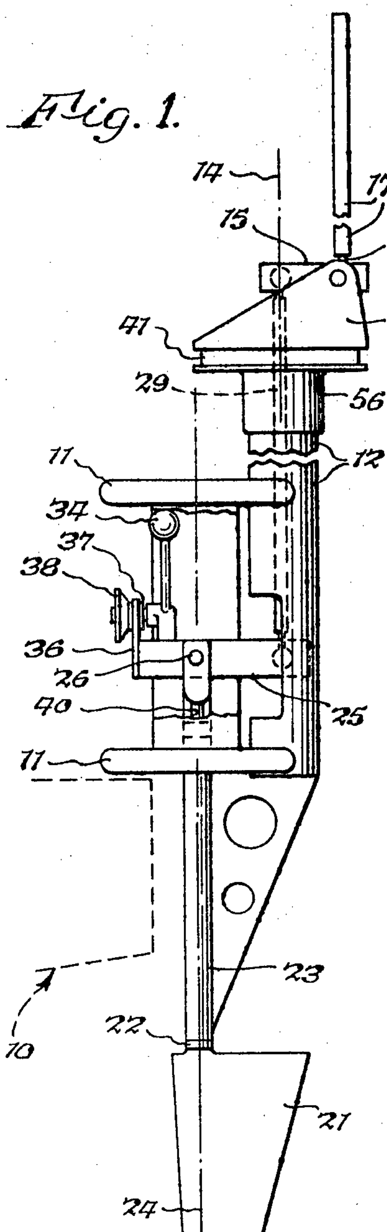
2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

Fig. 1.



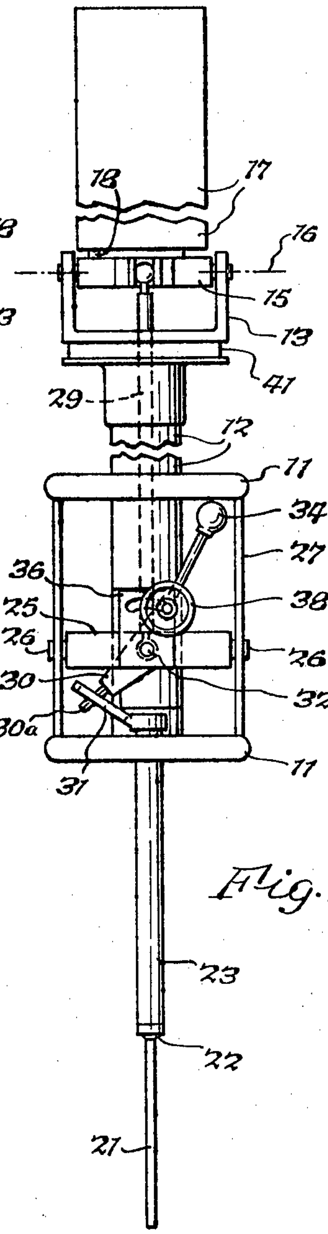


Fig. 2.

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Sheet 2

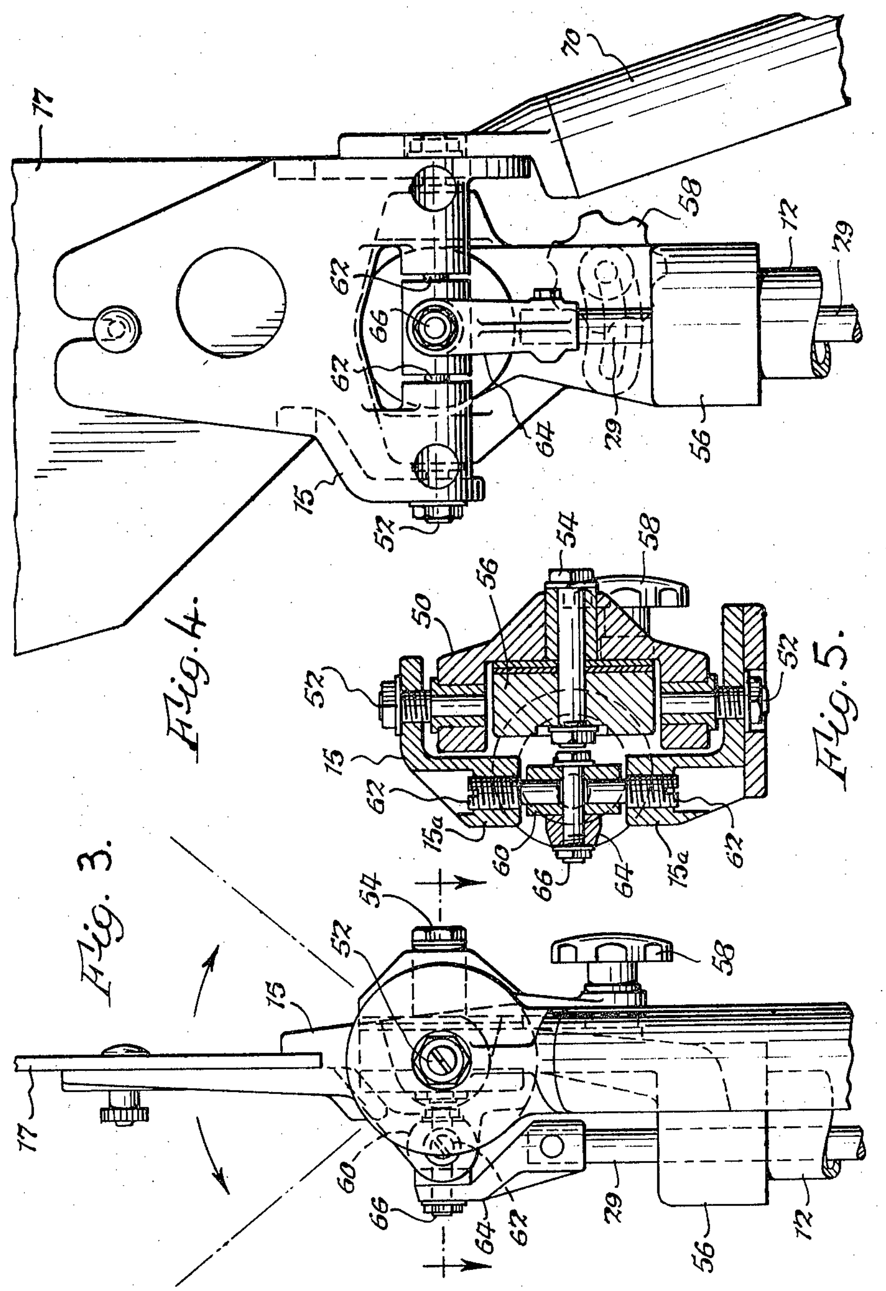

Fig. 3. Fig. 4. Fig. 5.