SELF-STEERING UNDER SAIL

Autopilots and Wind-steering Systems

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Content

Foreword

For some strange reason, most cruising sailors profoundly dislike steering by hand. The prospect of spending hour after hour at the helm used to deter most people from long-distance cruising. This is undoubtly the main reason why, until relatively recently, the number of sailing boats venturing far afield was very small indeed. However, all that changed with the advent of automatic pilots specifically built for yachts plus the development of efficient wind operated self-steering devices. Suddenly, the chore of hand-steering was a thing of the past and long ocean passages could be a pleasure – even on yachts with the smallest of crews. Having made one circumnavigation of over 70,000 miles with an Aries and another of some 40,000 miles with a Hydrovane, I could not be accused of exaggeration if I state unreservedly that one of the most important pieces of equipment on any cruising yacht is a wind-operated self-steering gear.

Unfortunately, and surprisingly, this view is not shared by many cruising sailors. This is primarily because as most of us have grown up with technology around us, we tend to take the push-button mentality with us to sea. Steering a given course is easy to achieve by setting a compass course and pushing a button on the autopilot, and, nowadays, this is what most sailors prefer to do. It is usually on the first morning with flat batteries that the love-affair with their favourite toy comes to an abrupt end. Having been forced to listen to countless heart-rending stories on this very theme at the end of the ARC or similar trans-ocean rally, I managed to persuade Peter Förthmann to come to Las Palmas before the start of the ARC to talk to our participants about the pros and cons of self-steering. His talks and workshops became an instant success, not only because he knows this subject better than anyone else in the world, bus also because he always speaks generically about both wind-operated self-steering gears and electronic autopilots. He never tried to sell his own products and, in this way, enjoyed the interest and confidence of his audience.

I am therefore pleased, not only that he took my advice to write this long-overdue book, but also that he managed to do it so fairly and objectively by giving all his competitors an equal opportunity to make their products known. All existing systems are described in the following pages, allowing the reader to make up his own mind. Many sailors agree that Peter's Windpilot is currently the best gear available. Being both the inventor and manufacturer of this ingenious device, Peter has indeed shown that his name should stand alongside those of his great precursors: Blondie Hasler, Marcel Gianoli, Nick Franklin. This book confirms Peter Förthmann's standing as the world authority on wind-operated self-steering gears.

Jimmy Cornell

Preface

Whoever would have thought that the world could change so much in a single generation?

Yachts which were so recently state of the art are suddenly dated, their technology surpassed. The range of instrumentation and equipment available to the sailor has expanded beyond all belief; on-board GPS, EPIRB, INMARSAT, chart plotter, radar, and Internet access are now all but taken for granted. The market for nautical books has also been very fertile. Every topic has been explored, every hitherto mysterious subject laid bare. Hard to believe, then, that the scheme of this book has been neglected for a hole generation!

A book on self-steering systems has long been overdue. That, at least, was the feeling of Jimmy Cornell, whose encouragement finally convinced me to take up my pen. It was a decision not lightly taken, for there can hardly be a more sensitive topic for a manufacturer of windvane steering systems. But, equally, there can hardly be a better one, since few topics in sailing are as logical and intuitive. All self-steering systems rely on the same physical principles; here there is no wizardry and no impenetrable mire of theory.

This book, I hope, will cut through the tangle of conflicting opinions and contradictory hearsay surrounding the subject of self-steering. If it saves you the disappointment of a self-steering failure and the exhaustion of hours at the helm in cold, dark and stormy seas, it will have achieved its aim. If it exposes gaps in your understanding, or flaws in your own self-steering solution, take heart; it is far better to see your mistakes now, safe in harbour, than half way across the ocean. Once at sea you must live with the hand you have dealt yourself; cold comfort as with heavy arms and tired eyes you turn the wheel once more and stare of into the distance wishing that you did not still have such a long , long way to go ...

I would like to give particular thanks to the following people: Jimmy Cornell, whose words ‚you sit down and start writing’ I can still hear today! Jörg Peter Kusserow, my friend and business partner without whose illustrations this book would be a great deal poorer. Chris Sandison, who found a way to translate my language in yours. Janet Murphy of Adlard Coles Nautical, who kept on smiling as the mountain of paper continued to rise.

And a final thanks to you the reader, if you find this book leaves you wiser as to how to make your sailing easier – without staying ashore.

Peter Christian Förthmann

Introduction

Throughout human history people have been taking to the water in sailing boats, be it for trade, exploration or war. Not until the twentieth century, though, did the idea first surface that a sailing boat might be able to steer itself. In the heyday of the tall ships, and even well into the modern era steering meant hands on the wheel. Crew were plentiful and cheap, and all the work on deck, in the rigging or with the anchor was performed manually. Where brute force was insufficient there were blocks and tackle, cargo runners and, for the anchor, the mechanical advantage of long bars and a capstan. Some of the last generation of tall ships, engaged in their losing battle with the expanding steamship fleet, did carry small steam-powered engines to assist the crew, but steering nevertheless remained a strictly manual task. There were three steering watches and the work was hard - even lashing the helm with a warp helped considerably. The great square-riggers plied the oceans without the help of electric motors or hydraulic systems.

In the early part of the twentieth century, recreational sailing was the preserve of the elite. Yachting was a sport for wealthy owners with large crews, and nobody would have dreamt of allowing the 'prime' position on board, the helm, to be automated.

It was only after the triumph of steam and the ensuing rapid increase in international trade and travel that the human helmsperson gradually became unnecessary; the first autopilot was invented in 1950.

Powerful electrohydraulic autopilots were soon part of the standard equipment on every new ship, and although the wheel was retained, it now came to be positioned to the side of the increasingly important automatic controls. Commercial ships and fishing boats quickly adapted electric or hydraulic systems to just about every task above and below deck - from loading gear, anchor capstans and cargo hatch controls to winches for net recovery and making fast. Before long ships had become complex systems of electric generators and consumers, and as long as the main engine was running there was power in abundance.

Today, the world's commercial and fishing fleets are steered exclusively by autopilots - a fact that should give every blue water sailor pause for thought. Even the most alert watchperson on the bridge of a container ship at 22 knots is powerless to prevent it from ploughing ahead a little longer before gently turning to one side. A freighter on the horizon comes up quickly, particularly since the height of eye on a sailing yacht is virtually zero. Collisions between sailing boats and container ships, as immortalised in the cartoons of Mike Peyton, prey on the mind of every sailor. Horror stories appear time and again in the yachting magazines, and in almost all of them the sailing boat ends up with the fish. Sometimes the sailors are rescued and the story has a happy ending. The tale of one solo sailor whose yacht inadvertently turned the tables on the merchant fleet by steering a fish cutter while he was sleeping caught the attention of the daily press all around the world. As sensational as it is unique, this incident involved the courts as well.

It is tempting on these ground to condemn single-handed sailing as highly dangerous – after all, this skipper has to sleep sooner or later. All too easily overlooked, however, is the fact that commercial vessels the world over are regularly entrusted to a lone pair of eyes on long night watches ... And if they should fall shut, the end result is same: A ghost ship and great danger for any unfortunate seafarer who strays into the wrong place at the wrong time.

The human helm's time at sea is just about up; not only tireless and more reliable, but often more competent as well, the iron helm is making the hand on the tiller all but superfluous. Even through the narrowest straits of the coast of Sweden, Stena Line's large ferries navigate every rock and shoal at full speed with only an autopilot and the Decca pulses of their purpose-designed software at the helm. All that remains for the sailor is a supervisory role – a role which, of course, you can only carry out as long as your eyes stay open!

Steering the Russian square-rigger *Sedov*

• 1 •
The history of self-steering

Shorthanded long-distance sailing started with just a few hardy pioneers - Joshua Slocum was one of the very first with his legendary *Spray*. It is said he could keep the boat on a fairly steady course using an ingenious sheeting arrangement or simply by lashing fast the wheel. This manner of self-steering willingly sacrificed a certain amount of sail power to free up a portion of the sail area just for steering trim. Of course, *Spray* had a natural tendency to sail straight, as her keel was almost as long as her waterline.

Hambley Tregoning described in a letter to *Yachting Monthly* in 1919 how the tiller of a boat could be connected to a windvane. Upon publication of his letter, owners of model boats rushed out to fit their craft with wind-guided steering. They found they could achieve admirable results with even the most simple mechanical connection between the tiller and a windvane. This type of system did not transfer very successfully, though, since the forces generated by a windvane are too small to move the tiller of a full-size vessel directly.

The first windvane steering system

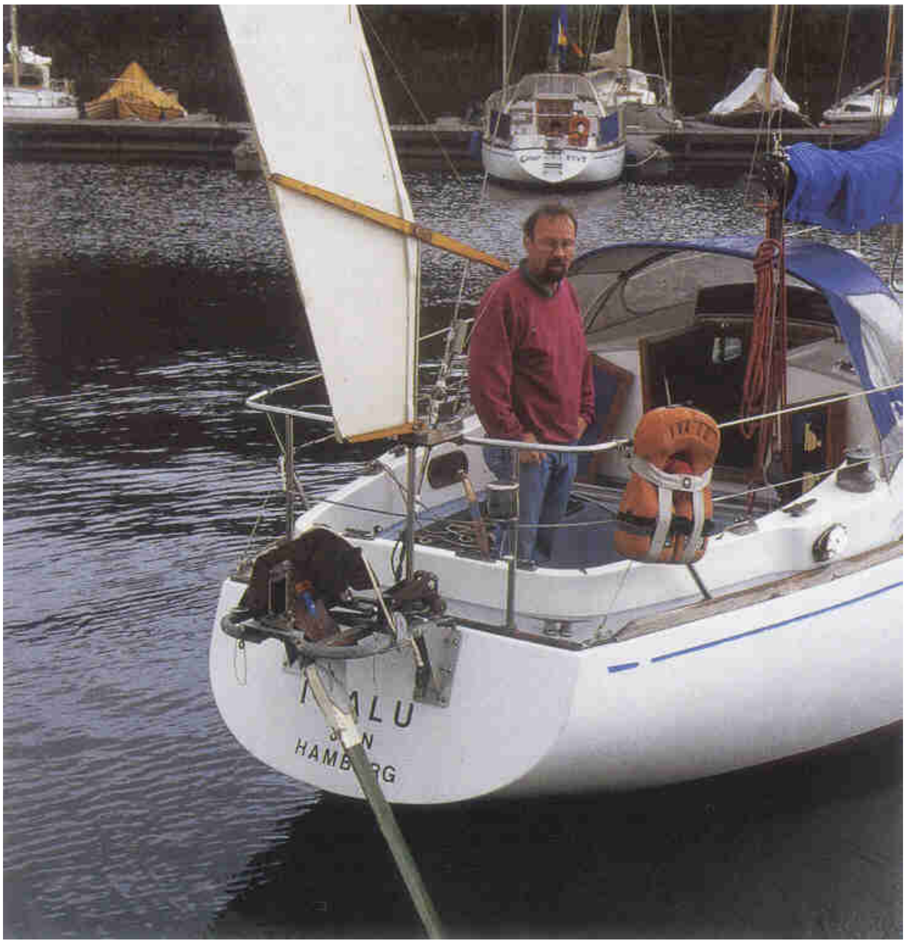
The first windvane steering system, rather ironically, was installed on a motorboat. Frenchman Marin Marie used an oversized windvane connected to the rudder by lines to steer the 14 m / 46 ft motor yacht *Arielle* during his spectacular 18-day single-handed crossing from New York to Le Havre in 1936. His windvane steering system is now on display at the Musée de la Marine in Port Louis.

British sailor Ian Major took *Buttercup* single-handed from Europe to the Antilles in 1955 using a small windvane to control a trim tab mounted on the main rudder. This was the most common system in the early days of windvane steering. It was also in 1955 when Englishman Michael Henderson fitted a personal creation, nick-named “Harriet, the third hand”, to his famous 17-footer *Mick the Miller*. His approach was to centre the main rudder and use the windvane to move a small, additional rudder blade. The system was a complete success and was able to handle more than half the steering duties. Bernard Moitessier also chose a trim tab for *Marie Thérèse II* in 1957, and used a simplified version of the same system on *Joshua* from 1965 onwards. In this second version, the windvane was fastened directly to the shaft of the trim tab.

The starting gun of the first OSTAR (Observer Singlehanded Transatlantic Race) in Plymouth on the 11 June 1960 signalled the real beginning of the windvane steering era. Without some form of self-steering, none of the five participants - Frances Chichester, Blondie Hasler, David Lewis, Valentine Howells and Jean Lacombe, could have reached the finish.

Frances Chichester’s first windvane gear, christened “Miranda”, consisted of an oversized windvane (almost 4 m^2 / 43 ft^2) and a 12 kg / 26,5 lb counterweight, and was connected directly to the tiller via lines and turning blocks. However, the giant windvane turned out to have anarchic tendencies, and Chichester was soon contemplating a change to the windvane/rudder proportions.

Aboard *Jester*, Blondie Hasler was using the first servo-pendulum gear with differential gearing. David Lewis and Valentine Howells both used simple trim tab systems driven directly by a windvane. Jean Lacombe used a trim tab gear, developed jointly with Marcel Gianoli, which had a variable transmission ratio.



Hasler servo-pendulum system on an S & S 30

Hasler and Gianoli, an Englishman and a Frenchman, were to play a significant role in the development of windvane steering systems. The principles they established are still used today, and we will consider both their systems later on.

The second OSTAR was held in 1964. Once again all the competitors used windvane steering systems, six of them opting for servo-pendulum gears built by HASLER, who had already undertaken a small production run. Windvane steering gears were virtually standard equipment for the 1966 and 1970 Round Britain Races as well, for electric autopilots were still banned.

The field for the 1972 OSTAR was so large that the organisers had to set an entry cap of 100 boats for the 1976 race. Electric autopilots were allowed, but could not be powered by inboard motors or generators. By now, many of the participants were using professionally built windvane steering gears. There were 12 from HASLER, 10 from ATOMS, 6 from ARIES, 4 from GUNNING, 2 from QME, 2 electric, 2 auxiliary rudder gears, 2 from QUARTERMASTER and 1 HASLER trim tab.

The rise of the great solo and short-handed blue water races, none of which would have been feasible without the windvane gear, stimulated the professional development and construction of a wide range of different systems in England, France, Italy and Germany. The early pioneers are still familiar names: HASLER, ARIES, ATOMS, GUNNING, QME and WINDPILOT.

Several factors contributed to the rapid spread of windvane steering systems, in particular the economic miracle of the post-war years, the increasing number of series-built sailing boats and the shift in boat-building away from one-at-a-time construction in wood towards mass-production with modern materials. Sailing was no longer a sport for obsessive loners or the elite, and its popularity was growing.

The first companies producing professionally designed and built windvane steering systems appeared in Britain, France and Germany in 1968, and soon after in the Netherlands.

Windvane steering systems and the year they were launched:

1962	Blondie Hasler	Hasler
1962	Marcel Gianoli	MNOP
1968	John Adam	Windpilot
1968	Pete Beard	QME
1968	Nick Franklin	Aries
1970	Henri Brun	Atoms
1970	Derek Daniels	Hydrovane
1972	Charron/Waché	Navik
1976	Boström/Knöös	Sailomat

The first cockpit autopilot

The first electric autopilots on non-commercial vessels probably appeared in the United States. The first TILLERMASTER, a miniaturised autopilot developed for small fishing boats, was produced in 1970.

British engineer Derek Fawcett, formerly employed at Lewmar, launched his AUTOHELM brand in 1974. AUTOHELM soon dominated the world market, with its small push rod models being particularly successful. The systems were manufactured in large production runs by a work force which quickly expanded to 200.

• 2 •
Windvane steering systems versus autopilots

Our aim with this book is to investigate the functioning and the pros and cons of the various systems, and to help the reader decide which is most suitable for his or her particular needs. The two main categories of self-steering system are the autopilot and the windvane steering gear. Autopilots are electro-mechanical systems that obtain their steering impulse from a compass, whereas windvane gears use wind and water power and obtain their steering impulse from the apparent wind angle. We will consider each in turn.

A sailing yacht generates all its drive from the position of the boat and the orientation of the sails with respect to the wind; trim the sails poorly and there will be no drive. This simple relationship explains why a windvane gear is so ideal for steering a sailing yacht. The wind angle it uses is exactly that which gives the boat drive; set this angle once, and drive is assured. The benefits of steering to the apparent wind angle are particularly pronounced when sailing to weather. Even the slightest shift in the wind is immediately translated into a course change and optimum drive is ensured - a degree of sensitivity beyond even the best human helm.

This 65 foot Koopmans is steered by both autopilot and windvane gear.

Why autopilots?

Put simply, autopilots are compact and discreet. When it comes to buying a self-steering system, probably the largest single factor counting against windvane gears is their incongruous appearance. They are generally large and bulky - hardly the ideal transom ornament. Not only that, but some are also rather unwieldy and heavy and tend to get in the way when manoeuvring in harbour under engine.

Autopilots, by contrast, are virtually invisible in the cockpit and may even be completely concealed below deck. Once installed they are simple to operate, only requiring mastery of a few buttons. Cockpit autopilots are light and generally inexpensive and they steer a compass course. For some sailors this argument is compelling; autopilots were programmed to succeed.

Over many years the sailing world polarised into two camps. In the 1970s windvane steering systems became a common sight on blue water yachts, where they were indispensable. Only in exceptional cases were they to be seen on holiday and weekend boats (and some of these can almost certainly be put down to wishful thinking!).

There has been heated debate over the last 25 years between advocates of the two different systems. One particular bone of contention was the repeated insistence by some that vessels of several tonnes or more are ‘easily’ steered with just fractions of an ampere. Views today are more realistic. There is no getting around the laws of physics: every desired ‘output’ (steering force) requires a certain ‘input’ (current/energy). Who could forget the ‘Conservation of Energy’ law so familiar from school physics lessons?

• 3 •
Autopilots

How they work

Autopilots depend on a compass. A steering impulse produced by the compass actuates an electric or hydraulic motor which extends or retracts a rod or hydraulic cylinder, moving the rudder so as to bring the boat back on course. The compass carries out a desired/actual value comparison and continues the steering operation until the vessel is back on the desired course. There is a direct relationship between

- the steering force;
- the speed with which the steering force is exerted; and
- the current consumption.

The physical constants between these factors are fixed, so the only relationship that matters on a sailing yacht - steering performance (output) / current consumption (input) - is always a compromise. It is never possible to obtain maximum steering performance using minimum power.

This gives rise to a dilemma, since an electric motor can be geared to produce either a lot of power slowly or a little power quickly (this relates to a car managing a steep gradient slowly in first gear, but not at all in top gear).

Autopilots are distinguished by motor capacity. This automatically fixes the relationship between the force applied by the push rod and its speed of operation. Virtually all autopilot manufacturers rely on this proven arrangement, and systems with variable speed motor drives are very seldom seen. Such pronounced gearing-down of the force from the electric motor (to produce more force at the push rod) is not practical anyway, since the corrective movement of the rudder would then be effected too slowly to bring the vessel efficiently back to the desired course.

To identify the appropriate autopilot it is necessary first determine the maximum rudder torque for the boat in question; the critical factors here are rudder size (length and width), counterbalance (distance from the centre of the rudder post to the leading edge of the rudder) and speed potential of the boat. The rudder torque can either be calculated or worked out empirically, that is by actually measuring the force on the tiller or wheel. If the maximum load on the rudder exceeds the maximum torque of the drive unit, failure is inevitable. Choose a low power consumption model for a relatively heavy boat, and the steering performance will be less than wonderful. Choose a system which will be constantly at its limits and it will need replacing long before an overdimensioned one. Choose a powerful autopilot, and no battery in the world will be able to meet the power demand without regular recharging. Every compromise has its price!

Cockpit autopilots for tiller steering

Push rod systems, in which an electric motor is connected via a transmission directly to a push rod, are the most straightforward form of autopilot. The push rod is extended or retracted to move the tiller.

Simple cockpit autopilots consist of a single module which includes the compass, the motor and the push rod. In larger cockpit models, the control unit and compass are separate modules which may be linked to other external transducers via a data bus. Autohelm indicates its network-compatible instruments with the ‘ST’ (SeaTalk) prefix and Navico uses the ‘Corus’ badge.

Tiller push rod systems are not particularly powerful, and are therefore only suitable for smaller boats. They use relatively small (power-saving) electric motors whose force has to be multiplied by major gearing down before it is applied to the push rod. This makes them noisy and the sound of a cockpit autopilot in operation is quite intrusive. Cockpit autopilots are relatively frugal in normal operation but, under high loads, consumption can approach 3 amps. They tend to be rather ponderous in their movements.

The AUTOHELM ST 800 Tiller autopilot

The following systems are available:

- AUTOHELM 800
- AUTOHELM ST 1000
- AUTOHELM ST 2000
- AUTOHELM ST 4000 Tiller
- NAVICO TP 100
- NAVICO TP 300

Cockpit autopilots for wheel steering

Wheel steering autopilot systems are similar to those described above, except that the course corrections are effected by a driving belt, toothed belt or toothed wheel acting on a pulley attached to the vessel’s wheel. Cockpit autopilots for wheel steering may be linked to a data network.


Navico WP 300 CX Wheel autopilot

The following systems are available:

Autohelm ST 3000
Autohelm ST 4000 Wheel
Navico WP 100
Navico WP 300 CX

Inboard autopilots

Inboard autopilots use push rod or hydraulic systems with powerful motors which are connected to the rudder post or quadrant and turn the main rudder directly. It is also possible to replace the mechanical linkage and shaft with a hydraulic system in which a hydraulic pump provides oil pressure to drive a hydraulic cylinder which in turn moves the main rudder. This type of system is suitable for larger boats. Vessels over 21m / 60ft in length with sizeable hydraulic rudder arrangements use constantly running pumps controlled by solenoid valves for the autopilot.

The three modules of an inboard autopilot

Control unit

The control unit is used to call up all the functions of the autopilot and any other modules linked via the data bus. It is usually operated via push buttons (Autohelm) or turning knobs (Robertson). Display sizes vary and, not surprisingly, larger displays are generally easier to read. Modern high-contrast LCD displays will fade if exposed to excessive direct sunlight, so they should ideally be mounted vertically and never flat on the deck. It is usually possible to fit additional control units wherever they are needed, so the operator is not restricted to the main cockpit. A hand-held remote control unit provides even more freedom to move about the deck. Joysticks offering direct control of the autopilot drive unit are also available.

Central processing unit

The central processing unit consists of: course computer, compass, rudder position indicator, windvane transducer, and peripherals.

Course computer

The course computer, installed below deck, is responsible for processing all commands and signals, for calculating the rudder movements necessary for course correction and for actuating the drive unit. In short, it links software and hardware and converts signals into actions. There are two kinds of course computers:

- The manual version which is adjusted and set up by the user and/ or installer;
- The auto-adaptive version which learns from recent operations and from recorded data.

Both have their advantages, but sailors may well prefer the ease of the auto-adaptive black box. Aside from seeing to a few basic decisions (mode of gain, auto tack, compass or windvane), the user has only to sit back and watch that the software carries on doing its job. The overriding aim is to combine high performance with reduced power consumption and neither option is perfect: factory programmed units are never properly set up for real conditions, and manually-adjusted units are also unlikely to deliver their full potential unless the user is a professional.

Compass

Compasses work best on land. Once afloat, the trouble starts: pitching, rolling, heeling, acceleration and deceleration all make things difficult for a compass. The course computer needs a clear, readable signal from the compass to control the drive properly – an autopilot course can only be as good as the steering impulse from the compass.

The position of the compass is very important. Consider the following points prior to installation:

- The further the compass is from the boat’s centre, the greater the number of movements which will have to be filtered out.
- Any variations in local magnetic fields will prevent an accurate signal. The compass should be kept well away from electric motors, pumps, generators, radios, TVs, navigation instruments, power cabels and metal objects.
- Compasses prefer constant temperatures; avoid sites exposed to sunlight or heat from the engine, cooker or heater.

Below deck near the base of the mast is a good spot for most cruising designes, provided they do not have a steel hull. The most stable point on more extreme modern yachts is further aft, normally about one third of the way from the stern to the bow. On steel boats there are different ways to get proper steering signals. An arrangement in which a magnetic compass with course dectector is fitted under the compass bowl detects changes in magnetic fields and has been use most successfully by Robertson on commercial fishing vessels. Other manufacturers position their fluxgate compasses above deck or even in the mast, not always the ideal location because of its accentuated motion. Careful installation and thorough calibration of the compass are particularly important on steel boats (a fluxgate compass cannot be used below deck on a steel boat).

The distance from the compass to the course computer should be kept as short as possible to minimise the problem of voltage drops. The longer this distance, the thicker the cables that will be needed. One final point to bear in mind regarding installation: the compass should ideally be easily accessible in its final position.

There are three types of compass to choose from, the magnetic compass, the fluxgate compass and the gyrocompass. Fluxgate sensors which supply the course computer with electronic course data are standard with nearly all manufacturers. Steering performance in testing conditions can be optimised by installing a special fluxgate system. Autohelm uses a ‘GyroPlus’ transducer while Robertson has a novel type of compass in which fluxgate signals are translated into frequency signals whose variations can more easily be monitored. Further optimisation measures include fluid damping and electronic averaging. The quality of the final signal for actual steering actions is directly related to the price and quality of the sensor unit. You really do get what you pay for, and unfortunately the price range, which starts around £200 for an ordinarily fluxgate compass and £240 for a magnetic compass and course detector, extends the way up to £9000 for a high-tech gyrocompass unit.

Rudder position indicator

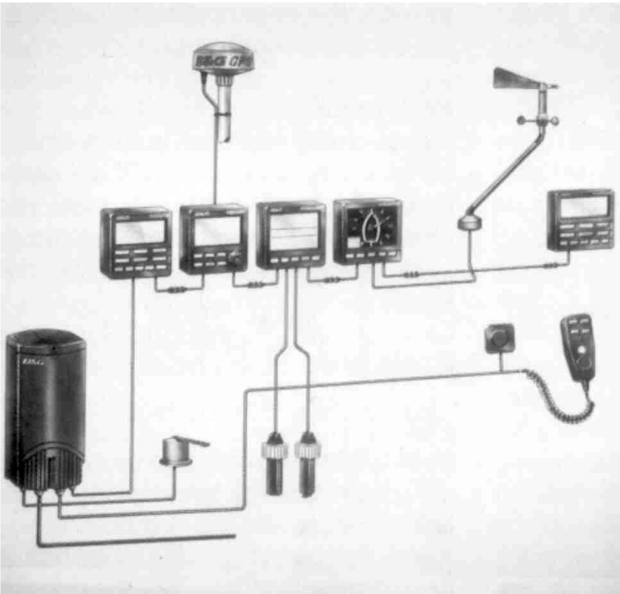
The rudder position transducer is arranged on the rudder and informs the course computer of the position of the rudder. It can be fitted inside the drive unit (protected from errant footsteps) or externally at the rudder post (more vulnerable).

Windvane transducer

A transducer attached to a windvane or to the masthead passes information of the apparent wind angle to the course computer.

Peripherals

Signals from other navigation equipment such as Decca, GPS, Loran, radar, log and depth sounder can also be fed to the course computer to give additional data to aid precise steering.



The modules of an inboard pilot; a Brookes & Gatehous example

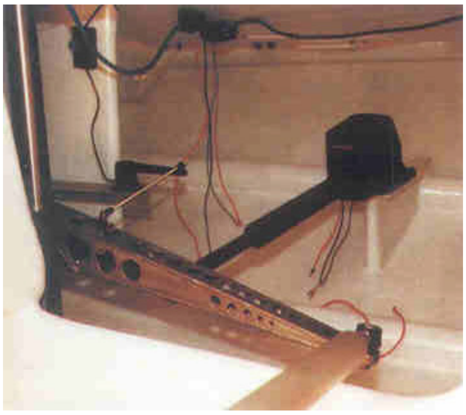
Drive unit

There are four alternatives.

1 Mechanical linear drive unit

An electric motor operates the push rod mechanically via a transmission. These drives are similar in principle to cockpit autopilots, but are considerably more powerful. The electric motor can be constant speed (simple and cheap but power-hungry) or variable speed (more efficient). The mechanical linear drive is more energy efficient than its hydraulic linear sister but is also more susceptible to mechanical overload under extreme conditions. Wear and tear on this kind of mechanical drive also increase the operating noise of the unit under load, so it will get louder as it gets older and could eventually irritating. Depending on the particular use and the size of the system it may be advisable to use metal for the transmission components since plastic is not always able to withstand the heavy loading associated with extended operation. Autohelm offers the ‘Grand Prix’ package as an upgrade for its linear drive units; Robertson and almost all other manufacturers fit metal transmission components as standard.

A hydraulic linear driving unit needs more installation space than a simple mechanical unit to accommodate the balancing ram which protrudes from the back. Mark Parkin of Simrad UK has observed that quite a number of naval architects ‘forget about the bigger space required by hydraulic rams’ and so end up having to fit a linear drive.



Autohelm mechanical linear drive unit aboard the 18m/ 60ft ULDB Budapest

2 Hydraulic linear drive unit

The push rod is operated by a hydraulic pump. Hydraulic linear drives appear on large yachts with particularly high rudder forces. The drives may be supplied either by separately installed hydraulic pumps (Autohelm, VDO) or by pumps directly incorporated into the push rod system (Brookes and Gatehouse, Robertson). Robertson also offers ‘dual drives’, in which two linear drives double the force applied. Hydraulic drives are protected against mechanical overload by an overload valve, which opens above a certain oil pressure, and by the inherent ‘oil cushion’. A hydraulic linear drive produces far less operating noise than a mechanical linear drive and will remain smoother and quieter, and hence more pleasant to have aboard, throughout its life. Hydraulic linear drives also last much longer, an important advantage for long distance cruising, and only a replacement set of seals needs to be carried as spares. As mentioned, hydraulic linear drives have a balancing ram which protrudes from the back of the unit. They therefore need to be mounted higher up to prevent the balancing ram striking inside of the hull.

3 Hydraulic drive units

These electromechanical hydraulic pumps tap directly into the existing wheel steering hydraulic system. A constantly running pump may be used to supply the force required to steer boats of 25 tonnes or more. The constantly high pressure introduces sudden high loads into the steering system with every rudder movement, and the resulting noise has earned this type of drive the name ‘bang-bang pilot’.

Robertson hydraulic linear drive units

4 Chain drive unit

An electric motor operates the main rudder via a chain. Chain drives are preferred where space is limited or where the rod-operated or geared wheel steering on an older boat precludes the use of other drive units. Whitlock steering wheel drives offer the option of an installed mechanical motor which taps into the system's transmission below deck. Only the cpu and control module than remain to be fitted.

The drive unit has to be connected to the rudder with a comparatively short arm either via its own small tiller or at the quadrant itself. Both alternatives demand very strong mounting on the side of the hull, and structural reinforcements will often be required.

The existing wheel steering should be mechanically disconnected when the autopilot is in use to reduce inertia. This can be done using:

a) A mechanical pin clutch (Edson),
b) A mechanical pin lock (Alpha),
c) A solenoid activated mechanical clutch (Autohelm), or
d) A solenoid activated hydraulic bypass

If the manual steering arrangement is not properly disconnected, the autopilot will operate with a delay and consume more power. Equally, when the boat is being steered manually, the drive unit should be disconnected or bypassed to afford better sensitivity on the helm and to allow the full range of rudder angle, which is normally limited under autopilot. Reducing interia for manual helming also means less work for the hand on the wheel.

When mechanically disconnected, the drive unit connecting arm should be fixed in position to prevent it from bouncing around. The end stops of the drive unit must be within the maximum limits of the rudder itself to prevent the autopilot from driving the hydraulic ram into the rudder stops.

It is absolutely essential that every autopilot has an emergency stop switch within easy reach of the helm in case the system runs into difficulties or manual steering suddenly becomes necessary. This switch should never be below deck. The distance from the helm to the nav-station or circuit breaker panel is simply too great in an emergency where the delay could result in damage to the autopilot or worse. Robertson autopilots all have such a switch included in every deck display unit.

It is extremely unwise to attempt DIY installation of an inboard autopilot. The procedure is very complex and there are far too many potential errors for the inexperienced yacht owner to make. Robertson, for one, refuses outright to provide any warranty for DIY systems.