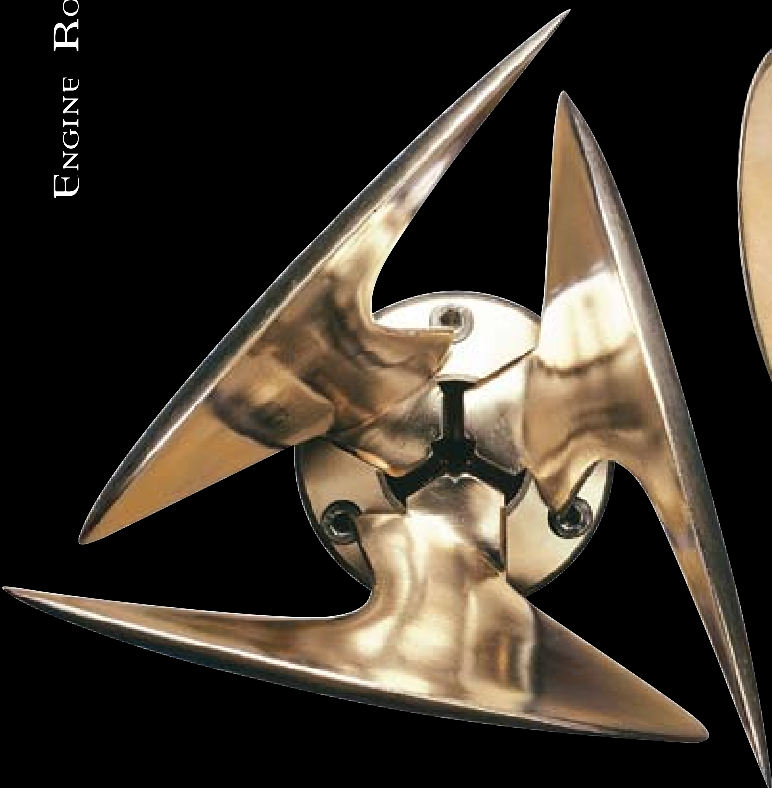
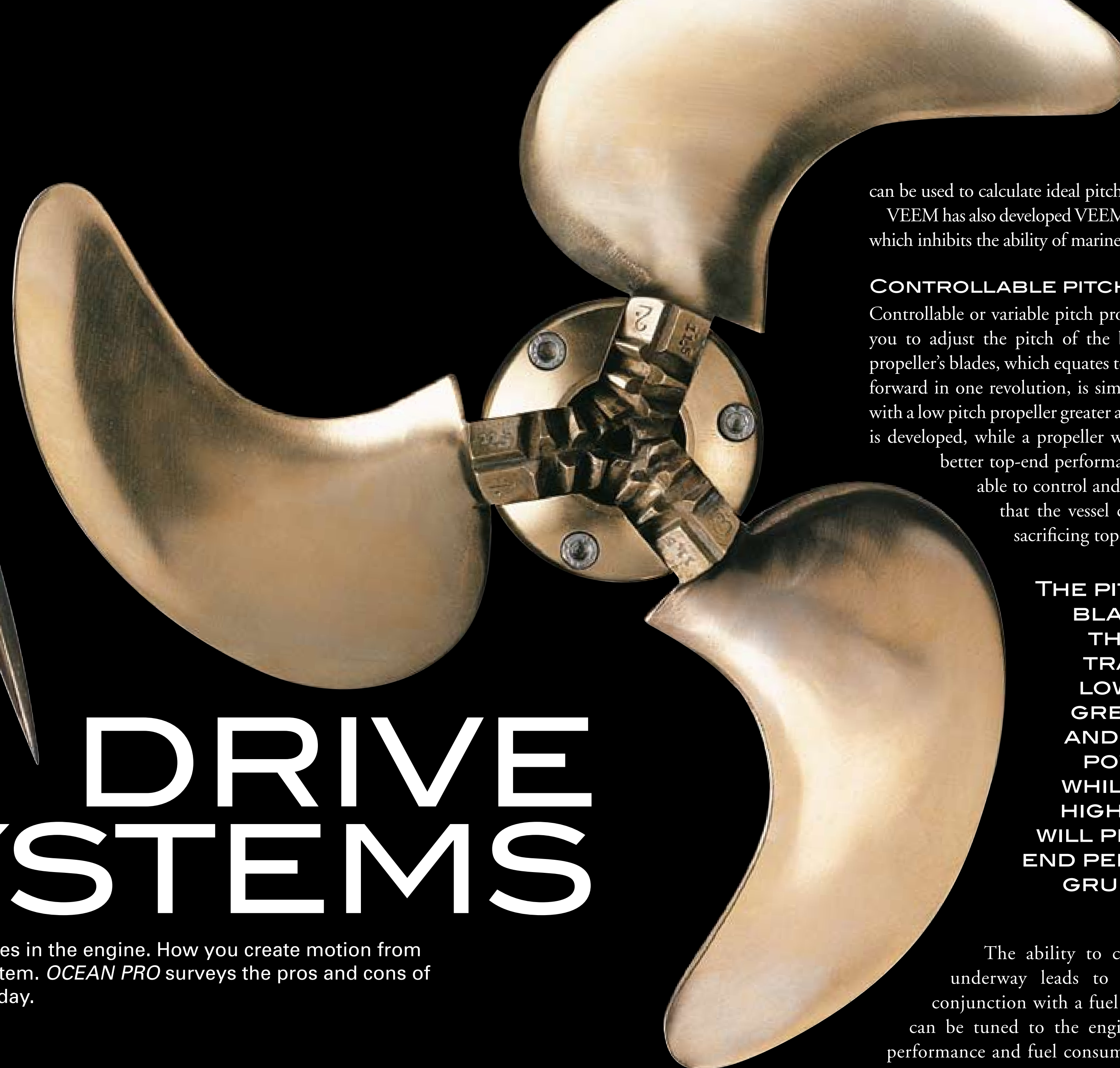




DRIVE SYSTEMS

There's more to power than the number of horses in the engine. How you create motion from power depends on your vessel's propulsion system. *OCEAN PRO* surveys the pros and cons of the different kinds of drive systems available today.

By Guy Waddilove

When choosing the type of drive unit to install on your yacht, you should ask yourself two questions: first, what do you expect it to do? Second, will it suit the hull and engines of the boat? Different configurations of drive systems suit different applications. Fitting the wrong configuration would be like fitting Formula One racing car wheels onto a tractor.

With the exception of jet drive systems, marine propulsion systems involve some form of propeller to transmit the power from the engine into motion through the water. Propellers have been around since Austrian engineer Josef Ressel invented them in 1827. They work on a screw principle with blades converting rotational motion into forward thrust.

Propellers are designed with any number of blades set up in a multitude of configurations depending on what they are to be used for. The variables that can be specified include the number of blades; the diameter of the blades; the area and shape of the blade; the pitch; the blade thickness and the material of the propeller. Entire books have been written about propeller selection but the basic requirement is that the specification of the propeller is matched to the vessel's hull shape and engine power to give desired performance.

The basic and most common set up for a drive system uses a propeller connected to a shaft which is mounted to a gear box on the vessel's engine. The shaft is generally supported along its length by bearings housed within a stern tube or hull mounted bracket. This sort of drive set up can be used with fixed propellers, controllable pitch propellers, folding propellers or self-feathering propellers.

Fixed propellers

Fixed propellers are the most commonly used component in the range of propulsion systems. A fixed propeller has no internal moving parts so maintenance is restricted to keeping it clean and ensuring that it is suitably protected from cathodic corrosion.

Western Australia-based company VEEM is one of the country's leading propeller manufacturers, manufacturing a range of propellers for various drive systems. VEEM has recently developed the innovative Interceptor Propeller™ which uses strips of a specialised polymer towards the trailing edge of the blades to produce a surface discontinuity. The strips fit into a recess in the blade. By using different width strips, which range in size from zero to four millimetres, different degrees of effective pitch can be achieved. The advantage of this system is that when the pitch of the propeller needs to be changed, for example to compensate for engine wear or for operating in different conditions, it is not necessary to change or mechanically alter the propeller; you just need to change to a new set of polymer strips, which can be done with the vessel in the water. VEEM has an interactive website that

LEFT: Folding propeller

RIGHT: A controllable pitch propeller like this one gives accurate power control for close quarters manoeuvring

can be used to calculate ideal pitch.

VEEM has also developed VEEMCoat™, a patented nickel/Teflon coating which inhibits the ability of marine growth to adhere to the propeller.

Controllable pitch propellers

Controllable or variable pitch propellers (CPPs) are propellers that allow you to adjust the pitch of the blade while underway. The pitch of a propeller's blades, which equates to the linear distance a blade would move forward in one revolution, is similar to the gears in a car's transmission: with a low pitch propeller greater acceleration and low-speed pulling power is developed, while a propeller with higher pitched blades will produce better top-end performance but less grunt at low speeds. Being able to control and adjust the pitch of the propeller means that the vessel can have good low-end power without sacrificing top-end speed.

THE PITCH OF A PROPELLER'S BLADES … IS SIMILAR TO THE GEARS IN A CAR'S TRANSMISSION: WITH A LOW PITCH PROPELLER, GREATER ACCELERATION AND LOW-SPEED PULLING POWER IS DEVELOPED, WHILE A PROPELLER WITH HIGHER PITCHED BLADES WILL PRODUCE BETTER TOP-END PERFORMANCE BUT LESS GRUNT AT LOW SPEEDS

The ability to change the pitch of the blade while underway leads to fuel efficiencies as, when used in conjunction with a fuel consumption display, the blade pitch can be tuned to the engine revs to provide optimum engine performance and fuel consumption. Another feature of the CPP is that it can be used for very accurate power control in close quarters manoeuvring. By setting the engine rpms at a certain level, the pitch of the blades can be increased or decreased to provide more or less propulsion power. The pitch can also be reversed to provide astern power without the need for a reversing gearbox.

CPPs are often specified for larger sailing yachts as when under sail the blades can be feathered totally to lie parallel to the direction of water flow so there is no drag on the blades.

Hundested Propeller is one of the market leaders supplying CPPs to larger sailing yachts. The Danish company has a range of propeller sizes and a range of pitch control units with hydraulic or mechanical control. The hydraulic control units allow the pitch to be changed at full engine revs and full propeller load. They rely on a continuously running external hydraulic pump to provide pressure to either change the pitch angle of the blades or maintain the angle of the blades in the selected position. The mechanical control units, actuated by a manual hand wheel or electric motor, will only allow pitch to be adjusted at low engine revs and low propeller load.

Amartech also manufactures CPPs. Amartech's hydraulically actuated units are set up so that it is not necessary to provide continuous hydraulic pressure to the unit. Hydraulic power is only required to adjust the blade's pitch angle, and the blades then stay at this selected pitch angle without continual hydraulic input to maintain the position.

Folding propellers

Folding propellers are used mainly on small to mid-size sailing yachts. They work on a centrifugal force principle where the rotation of the shaft causes the tips of the blades to be pushed outwards, opening the propeller. Positive pressure and forward thrust is developed as the blades fully open and bite into the water. When the shaft stops rotating the blades revert to their folded position.

Gori produces a range of two, three and four-bladed folding propellers. It also produces a racing propeller that is popular because its streamlined geometry offers absolute minimum drag when under sail.

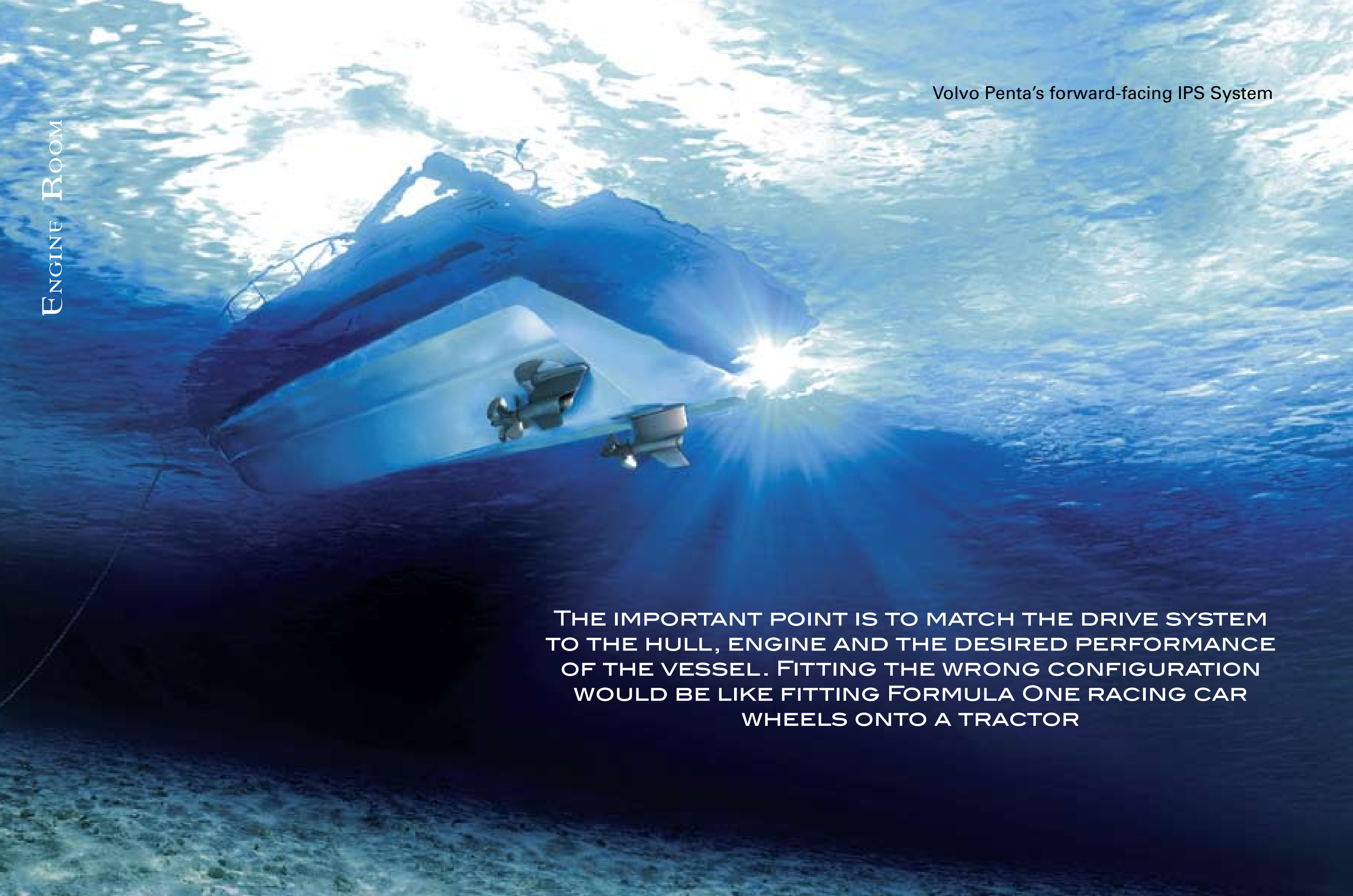
Self-feathering propellers

Self feathering propellers offer adjustable pitch without the use of external controls. Max-Prop produces a prop that, when sailing, self feathers to a low drag shape with forward momentum through the water because the symmetrical profile of the blades ensures that the blades align with the flow of water passing over them when sailing. When the engine is started and the prop shaft rotates, the torque of the shaft turning pushes the blades into their driving position. When astern is selected on the gearbox, the blades are turned, again by the shaft's torque, in the opposite direction on the hub so that the Max-Prop presents the same leading edge and the same pitch when going astern. This makes the Max-Prop more efficient than a fixed blade propeller when backing down and provides better directional control as prop walk is minimised. The Max-Prop is popular amongst racers as it has a more favourable 'PF' (Propeller Factor) than a folding prop under the IOR rule.

Surface-piercing propellers

Surface-piercing propellers, because of their distinct characteristics, are used for a limited range of specialist applications. Surface-piercing props are designed so that when the vessel is underway, the hub of the propeller is on the waterline. The propellers are normally extended out beyond the hull of the vessel to work in the flat water of the wake, and for this reason a larger diameter, more efficient propeller can often be specified because no allowance needs to made for propeller tip clearance on the hull. The physics of the hydrodynamic advantages offered by the prop are way beyond the scope of this article, but basically by introducing bubbles of air from the out-of-water blades to the low pressure cavity behind the blades in the water, cavitation, which is an energy-sapping undesirable feature of fully submerged propeller blades, is avoided. Surface piercing props are also efficient as underwater drag is reduced because there is no drag-inducing shaft, hub, or support bracket underwater as with submerged propeller drive systems.

Surface-piercing props give fantastic top end performance and, as the extension legs can often be adjusted laterally as well as vertically, turning characteristics at high speed can be exceptional. However, manoeuvring at low speeds is very limited as there is very little pressure on the rudders, and the rudders themselves are normally very small in surface area. Also the practicality of having a couple of large propellers sticking out



Volvo Penta's forward-facing IPS System

The important point is to match the drive system to the hull, engine and the desired performance of the vessel. Fitting the wrong configuration would be like fitting Formula One racing car wheels onto a tractor

the back of the boat isn't to everyone's taste. Another disadvantage cited against surface-piercing props is that because of the constant loading and unloading of the blades as they pass from air to water, fatigue is a lot higher and therefore the longevity of the propeller is compromised.

Surface-piercing props are used in power boat racing and on some large planing sports boats.

Arneson is probably the best known producer of surface drives for sizes 100 hp to 10,000 hp and, as well as producing for the offshore power boat racing market, it sells its units to Sunseeker for its 95 and 108 Predators and Pershing and Magnum for their large, high-performance cruisers.

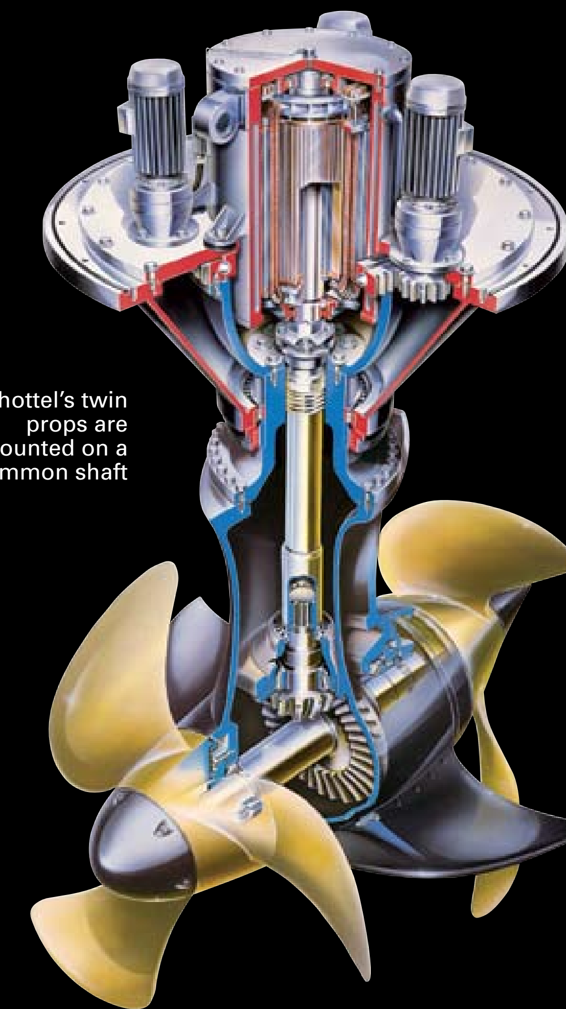
Seafury International, based in New Zealand, have 20 years of experience in the manufacture of surface drive systems. They have become specialists in high speed applications such as military, government and patrol vessels, along with high speed tourist vessels and pleasure craft. Seafury surface drives are a fixed system, with research showing there is little-to-no benefit obtainable in most applications from trimming a surface drive. This lack of hydraulics and multiple moving parts associated with a trimmable drive makes the Seafury drive system robust and reliable, with minimal maintenance requirements. Seafury even offer a five year limited warranty on them.

RT Marine produces the Top System range of adjustable trim and steering surface marine propulsion for high-performance craft up to 20 metres. Top System's drive joint is based on patented special cardanic technology that enables a large trim angle and supports torque stress which reduces the possibility of ruptures at the joint associated with high torque stress. The company's sea trials showed that Top System surface drives deliver higher performances than many of its competitors given the same engines and propellers because of lower friction inside the drives, resulting in an increased overall efficiency of the engine-shaft-prop system.

The blade of a VEEM Interceptor with a polymer strip that produces surface discontinuity

Q-SPD of Auckland uses surface-piercing technology to deliver the performance one expects from a surface-drive propeller, but with conventional propulsion usability. Q-SPD's designers wanted to develop a system that enabled the vessel to perform not just at high speed, but right through the speed range, and that would manoeuvre well through the speed range as well as when going astern. Q-SPD's drive system is suitable for most applications where normal cruising speeds are 20 knots or higher.

Construction of the Q-SPD systems is mostly from composite so they are lightweight and do not have the same corrosion issues as other systems. As all steering and thrust assemblies are inboard there are no sensitive parts like thrust bearings and hydraulics outboard to be attacked by the elements. Q-SPD supplies a complete drive package including



Shottel's twin props are mounted on a common shaft

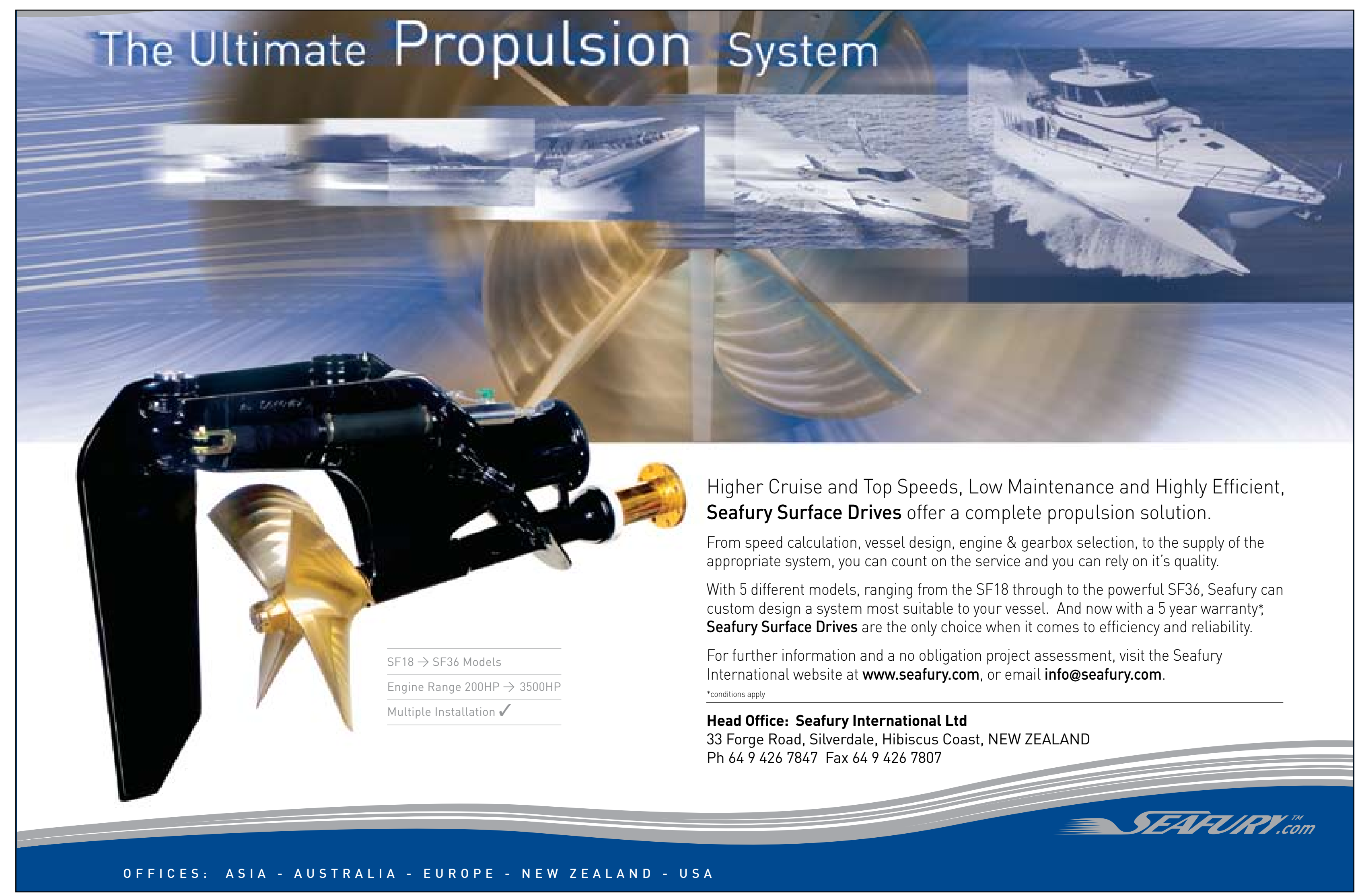
drive system, propeller and driveshaft from the drive flange to the gearbox flange. The model range covers power from 200 hp to 3000 hp and vessels from 10 metres to over 30 metres.

Pod drives

A relative newcomer to the yachting propulsion scene is the pod drive system. Pod drives have been used for decades aboard commercial ships because of their efficiency and manoeuvrability. With pod drives the drive and steering function are integrated into one unit, similar in principal to outboard motors, so the full thrust from the pod can be directed precisely in the direction that thrust is required. When multiple pods are fitted they are generally configured to be controlled independently which allows precise manoeuvring with on the spot turning and sideways, walking possibilities.

ZF, in conjunction with Cummins MerCruiser Diesel, has developed the Zeus drive system with twin counter-rotating propellers on each pod. The Zeus pod's hydrodynamic shape creates much less drag than a shaft, strut and rudder, so as well as improved manoeuvrability, fuel efficiency and performance are also superior to conventional fixed shaft and rudder arrangements. ZF is also working with Yanmar, Caterpillar and MAN to release pod drives with nominated engines. Additionally, ZF can supply drivelines, props, rudders and shafts for all types of installations.

Volvo Penta has its version of the pod drive: the Volvo Penta IPS. The main way that the IPS system differs from other pods is that the propellers face forward. According to Volvo, this produces further efficiencies as the



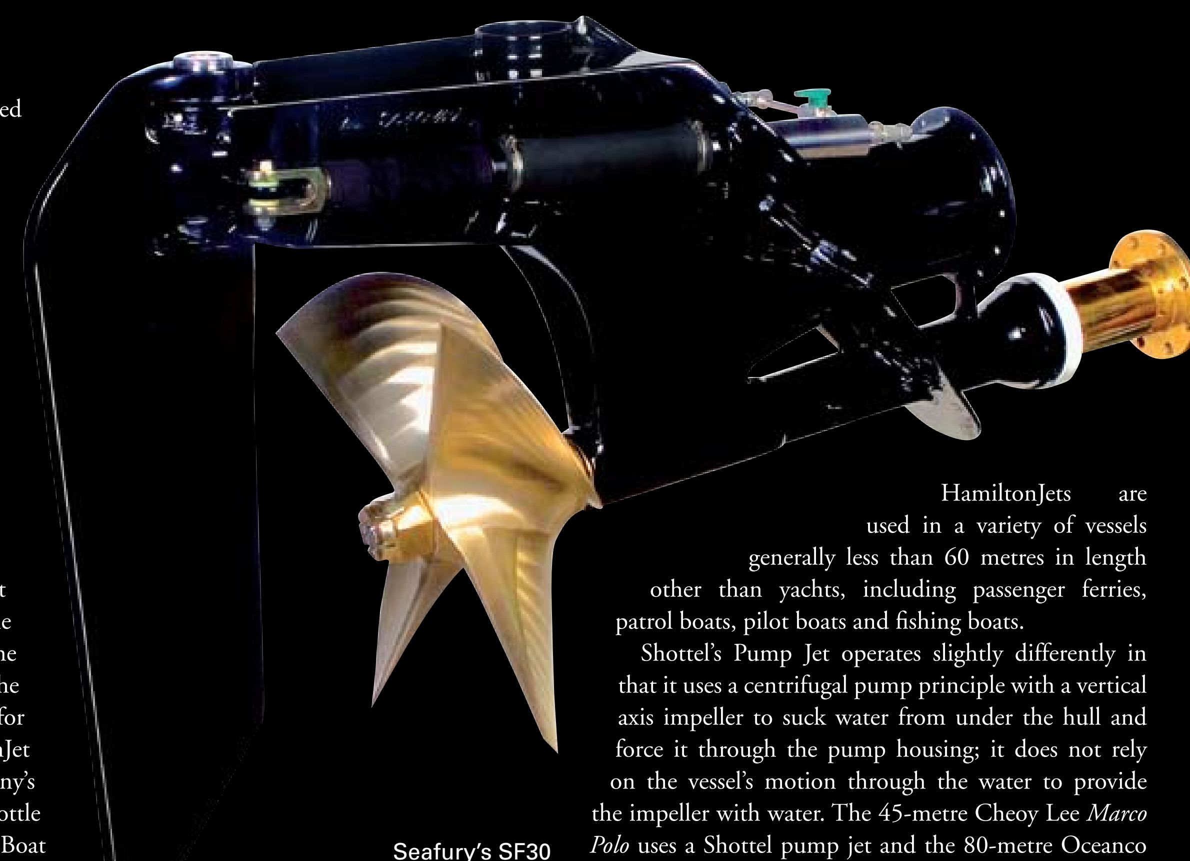
propellers are acting in 'clean' water which has not been disturbed by the housing of the pod.

Shottel produces various drive systems for large yachts and commercial vessels including rudder propellers and twin props. Shottel rudder propellers combine the drive and steering functions into one unit that can be turned through 360 degrees. The range of motion of the rudder props give huge benefits when manoeuvring within close quarters, and underway optimum thrust is achieved as the units are aligned with direction of travel. The range of motion of the drives also allows the units to be used as part of a dynamic positioning system, whereby the vessel is automatically kept on one spot with the drives maintaining the position against the forces of wind and current. Shottel's twin props are similar in principal to the Zeus and IPS system, and Shottel have chosen the middle ground on prop positioning with one prop facing forward and one facing aft on the drive pod. The props are mounted on a common shaft and rotate in the same direction which makes construction of the units straightforward as internal reversing gears are not required. Fewer moving parts are involved in the pod with the common shaft so maintenance is minimised. Shottel's propulsion systems can be seen aboard a range of large motor yachts including the 126-metre Lurssen *Octopus*, the 96-metre Lurssen *Limitless* and the 37-metre Heesen *Alumeria*.

Jet Drives

Jet drives, or pump jets as they are also known, use a high-pressure jet of water for propulsion. Water is drawn up from beneath the vessel, accelerated through an impeller and stator and expelled as a high-velocity jet stream behind the boat. Steering is achieved by changing the direction of the jet and astern propulsion is produced by reversing the thrust of the jet with a deflector or 'bucket' arrangement. Jets are often considered to be safer than conventional props on small craft as there are no external moving parts to damage swimmers around the boat. They can generally be run in shallower water than conventional propellers as the intakes are usually flush or nearly flush with the underside of the hull. Jets also provide efficiency as they give less drag than a prop arrangement with no protrusions on the underside of the hull. On the negative side, jets are not quite as efficient as a propeller arrangement and if they do suck up debris they are harder to clear than a fouled propeller.

HamiltonJet, having pioneered the development of the modern water jet in the 1950s, is probably the most well-known name in water-jet propulsion. The HamiltonJet is most suited to vessels operating in the 20-50 knot range, although they can also be used for certain displacement vessel applications. HamiltonJet water jets can be used in conjunction with the company's Blue Arrow control system which integrates throttle and steering controls into one control: the MouseBoat manoeuvring control which makes make handling very simple even for inexperienced boaters. The system can be used in conjunction with a single or twin water-jet installation.



Seafury's SF30 drive unit

HamiltonJets are used in a variety of vessels generally less than 60 metres in length other than yachts, including passenger ferries, patrol boats, pilot boats and fishing boats.

Shottel's Pump Jet operates slightly differently in that it uses a centrifugal pump principle with a vertical axis impeller to suck water from under the hull and force it through the pump housing; it does not rely on the vessel's motion through the water to provide the impeller with water. The 45-metre Cheoy Lee *Marco Polo* uses a Shottel pump jet and the 80-metre Oceanco *Constellation* uses two for propulsion.

Wartsila produces a water jet system similar in principle to the HamiltonJet for larger applications including

JET DRIVES CAN GENERALLY BE RUN IN SHALLOWER WATER THAN CONVENTIONAL PROPELLERS AS THE INTAKES ARE USUALLY FLUSH OR NEARLY FLUSH WITH THE UNDERSIDE OF THE HULL

the military, commercial and superyacht markets. Amongst the superyachts fitted with Wartsila jets is the 44-metre *The World Is Not Enough*, billed as the world's fastest superyacht with top speeds of up to 68 knots.

Rolls-Royce produces its Kamewa Aluminium waterjet range from 200 kW to 2500 kW. Integrated interceptors can now be packaged and installed on the waterjet unit. The interceptor trim tabs will assist with optimising running trim and reducing heeling during high-speed turns. There are currently 20 vessels under construction with Kamewa waterjets in Australia and New Zealand.

There is a considerable range of options for powering a vessel through the water, each of which has been proven to be reliable for its purpose. The important point when specifying the system is to match the drive system to the hull, engine and the desired performance of the vessel. And to further complicate matters with even more options you could always consider a hybrid system like the 86-metre Feadship *Ecstasea*, which uses a Wartsila system combining a waterjet and two controllable pitch propellers. This configuration allows the yacht to be driven in economical, cruising or max speed mode using different combinations of the props and jet. O