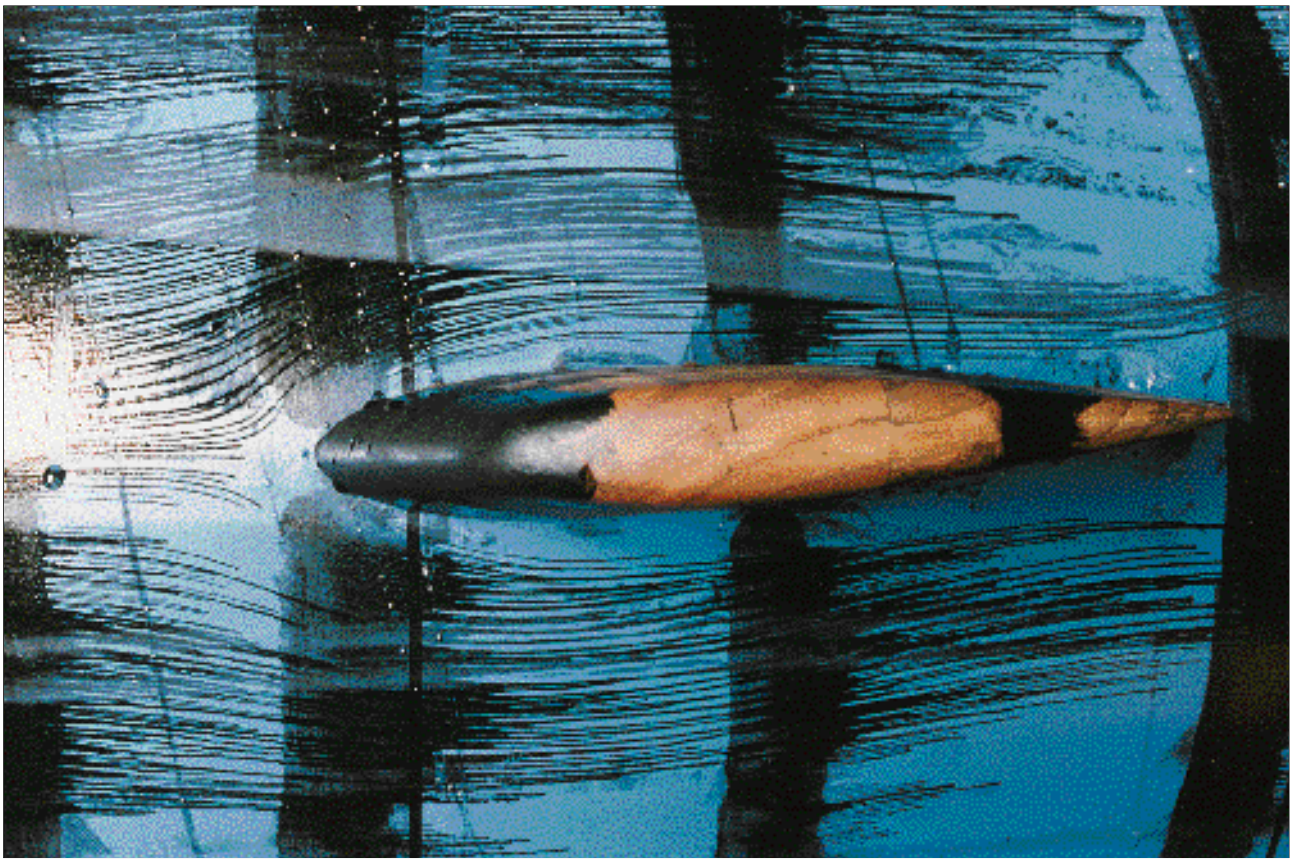
ROLLING AND STABILIZERS

While cruising in high seas and strong winds, who has not wished to stop or reduce the erratic motions of a yacht? They can definitely spoil a trip by slowing the progress of the vessel and making the guests and crew suffer from seasickness. Moreover, these violent motions can generate structural damage that can sometimes become a safety hazard. Any pleasure or commercial vessel moving through a seaway is affected by parasitic motions that are essentially caused by waves and wind.

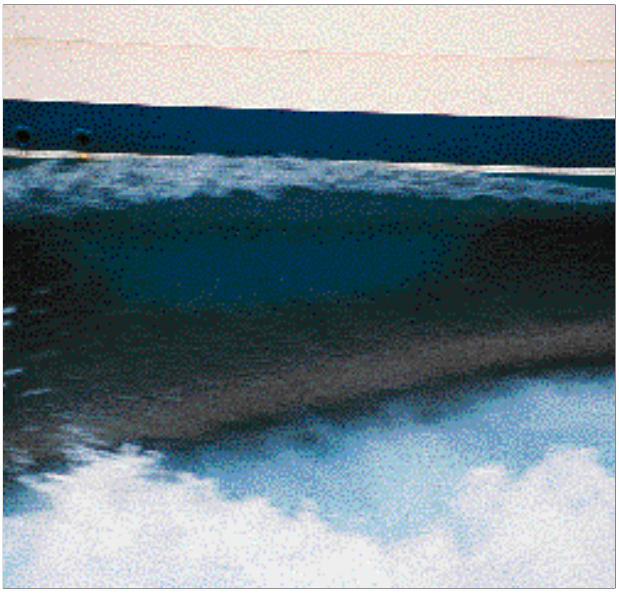


The main motions of a yacht can be classified into two main categories. The first are those which create a displacement of the center of gravity i.e. heaving, surging and sway and the elementary motions which are movements of rotation: rolling, pitching and yaw. For any ship, the roll is the most well known parasitic motion and also the most uncomfortable. While sailing, rolling is the motion induced by beam or quartering seas. A theoretical roll can be induced artificially in calm water. It is a direct function of the initial stability, hence of the metacentric radius (GM) of a boat.

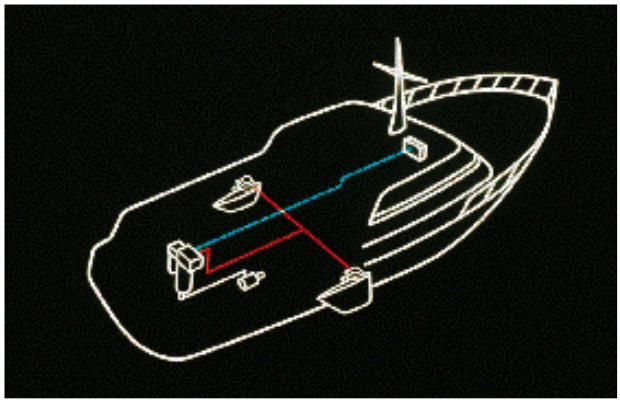
More simply, the roll varies according to the beam and the vertical position of the center of gravity. The roll is characterized by its period and its amplitude or angle. The period, i.e. the time (expressed in seconds), needed to achieve a complete oscillation from one side to the other, can be estimated by the formula, T = B / GM ^ 0.5, where B is the maximum waterline beam. In a seaway, the vessel has a different roll period influenced by the spectrum of the waves encountered. However, the resulting roll is conditioned by the theoretical or natural period. A ship with a higher initial stability has a smaller period of roll hence a harder rolling. The angle of roll is measured in degrees and indicates the inclination about the vertical axis.
When the natural period of roll of the yacht and the frequency of the waves are close, the vessel will go into a state of resonance called rhythmic rolling with a very high amplitude of the forced oscillation. For most yachts, the period of roll generally varies between 3 and 7 seconds for an angle which normally remains between 5 and 20 degrees. The period of roll can be used to evaluate or estimate the initial stability of a yacht.

Anti-rolling devices

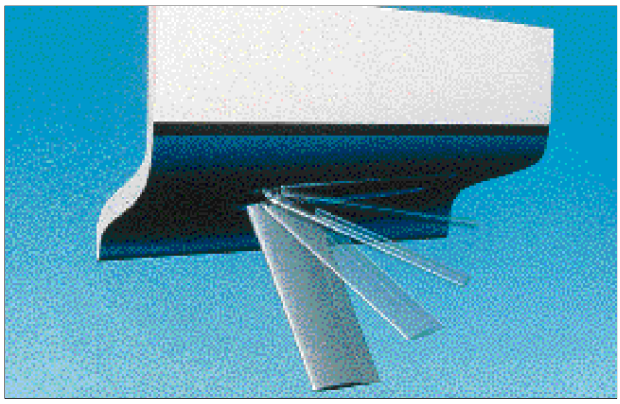
Several anti-rolling devices have been designed to reduce rolling: bilge keels, anti-rolling tanks and stabilizing fins.
The efficiency of the bilge keels has been demonstrated by the well known naval architect William



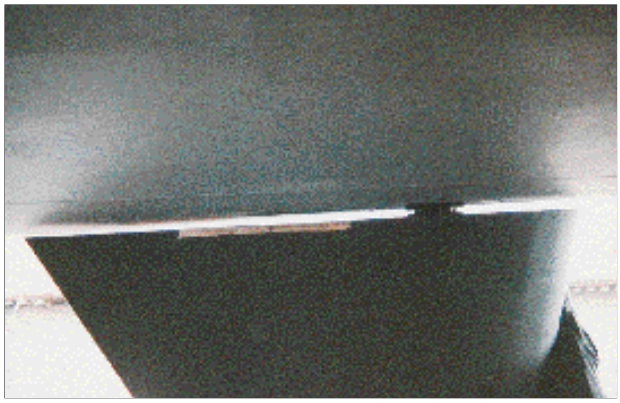
Water flow around a stabilizer fin.



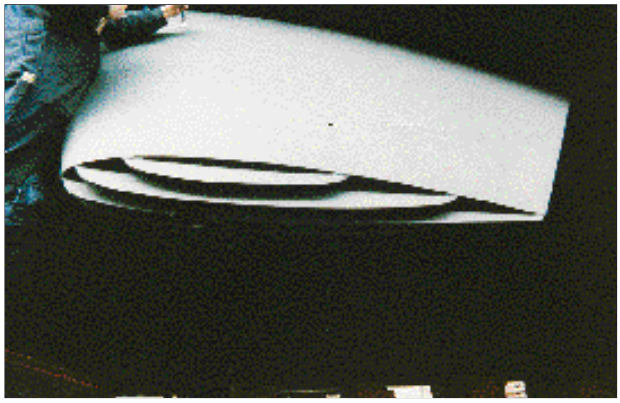
Stabilizers basic principle.



Some manufacturers are now marketing retractable stabilizers.



The stabilizer is supported by a single shaft.



Section of a high speed stabilizer fin.

...rolling and stabilizers

Froude in the last century although the efficiency has been the subject of controversy. They typically extend over the middle half to about two-thirds of the waterline length at the turn of bilge. They increase the mass of water carried along by the hull during the roll and thus create a damping effect. They are universally used on the displacement hulls where they absorb little power and are easily installed.

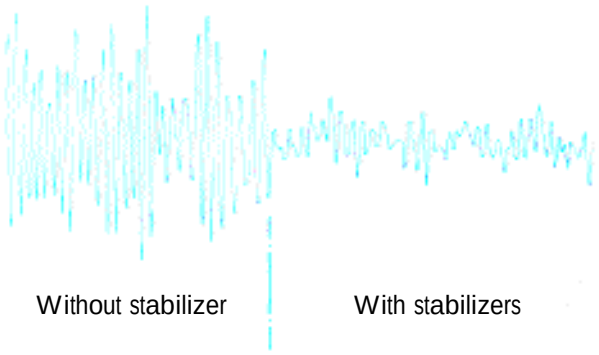
The anti-rolling tanks are essentially composed of wing tanks located symmetrically on both side. They are partially filled with water and connected by air ducts at the top and water pipes on the lower side. They can be of the active or passive type. The passive tanks allow a free circulation of water from one side to the other in a U shaped volume. Inertia and resistance slow down the water transfer from one side to the other, the mass of water then is delayed and the righting moment that is created counteracts the rolling moment.

The active tanks work along the same principles but the transfer of water is then generated by a pump system controlled by a roll sensor which monitors the mass and flow of the water to be transferred. The advantage ofthese devices, compared to the stabilizers is their higher efficiency at low speed or at anchor.

Only the larger yachts have the required internal volume for the installation of anti rolling tanks. The megayaght LIMITLESS is equipped with such a tank which contains 73 tons of water and reduces the amplitude of roll by half. Moreover, this yacht is also fitted with bilge keels and stabilizing fins.

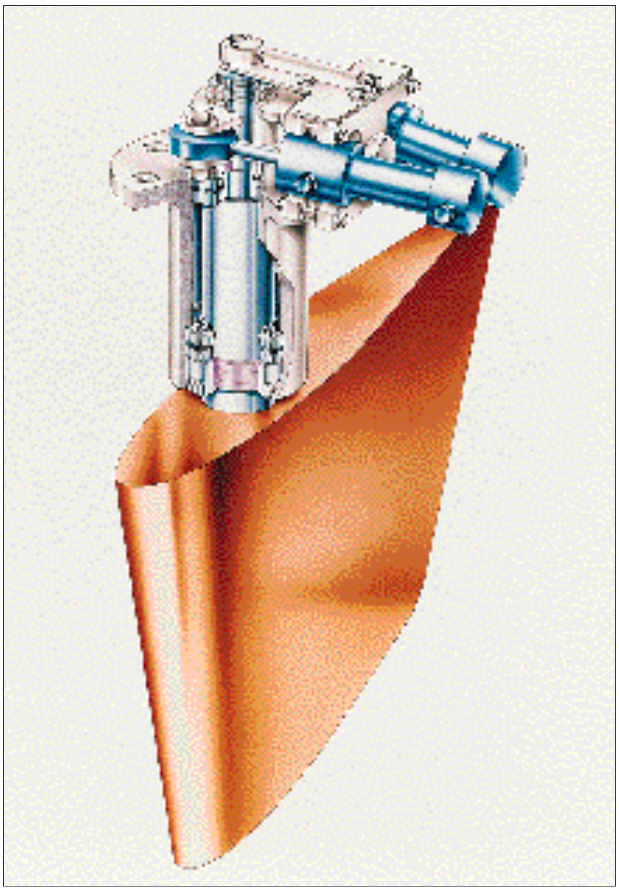
The Stabilizers

The principle is not exactly new ; it was developed and patented in England in 1889 by Sir John Thornycroft, but stabilizers have recently been fitted, for the first time, on a Japanese ferry designed by Doctor Matoro of the Mitsubushi Group. The stabilizing fins or stabilizers are active devices which constantly generate a righting action based on the roll angle. The motions of the ship are measured either by a gyroscope or by a computerized control system which senses and computes the velocity, the roll and the acceleration. These devices transmit orders to hydraulic and electronic circuits which, through a control system, adjust the fins' angle of incidence to generate the optimum righting action based on the measured roll. This action is the result of the hydrodynamic lift generated by the fins. The fins, like rudders, are movable lifting surfaces. Lift varies with the



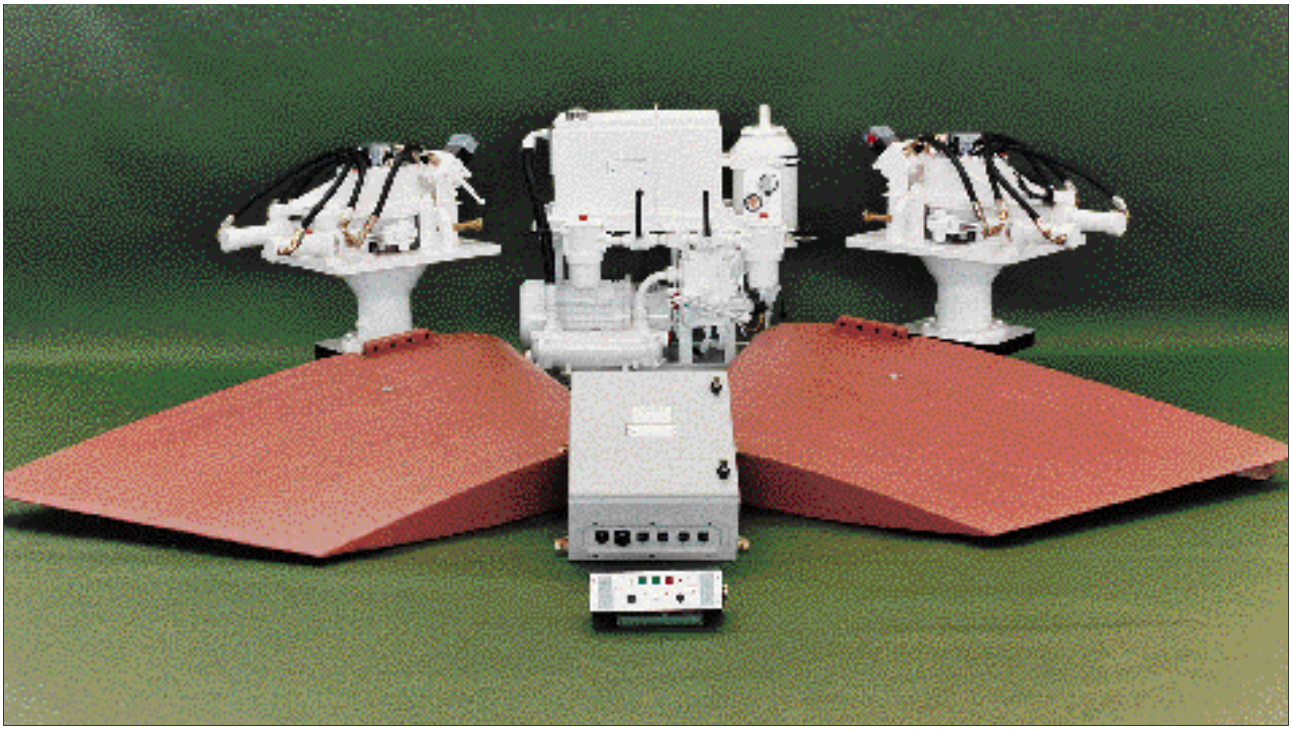
Actual chart of recorded roll motion.

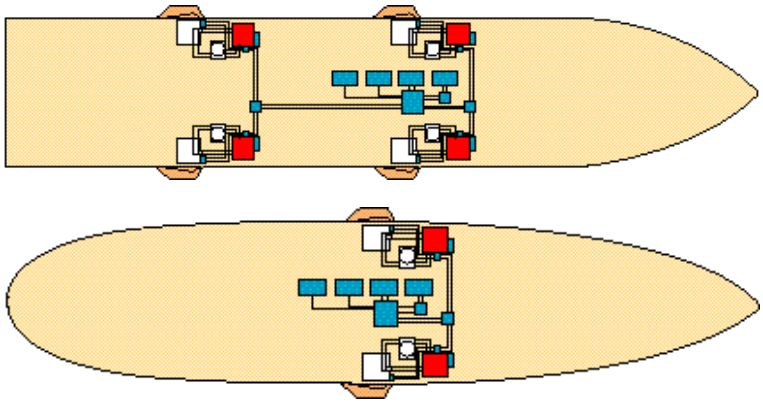
surface, the angle of incidence and water speed squared. Therefore, speed is an important factor and is why the stabilizers are considered less efficient for vessels operating under 20 knots. The maximum angle of incidence is normally around 20 degrees. The first generation of fins were simple steel plates welded on a shaft or stock. The modern stabilizing fins have, as well as the rudders, benefited from the developments of the aerospace industry applicable to naval architecture. The sections currently used for the design and manufacturing of fins are basic modern wing sections developed in the 1940's by the predecessor to NASA NACA (National Advisory Committee for Aeronautics). These airfoil data and characteristics



can be found in a well known reference book, "Theory of Wing Sections", which should be part of every yacht designer's library. The most currently used section for stabilizers and rudders is known as NACA 0015. It has a maximum thickness equal to 15% of the

Components of a complete system, in the middle, the hydraulic system, the gyroscope and the control panel.





On some vessels, the system requires two pairs of fins.

cord length (width of the fin). The maximum thickness is located at 30% of the cord aft of the leading edge which allows the use of a shaft or stock with a large enough diameter to withstand the twisting and bending moments generated by the forces applied on the fin in rough seas. Some movable fins can be fitted with a trailing edge flap to increase their efficiency. The fins can be built of stainless steel, aluminum alloy or even composite materials. The stabilizers, as all appendages of a motor yacht, have an important influence on the total resistance, mainly at high speeds. Therefore retractable fins have been designed to be fitted on some high speed craft.

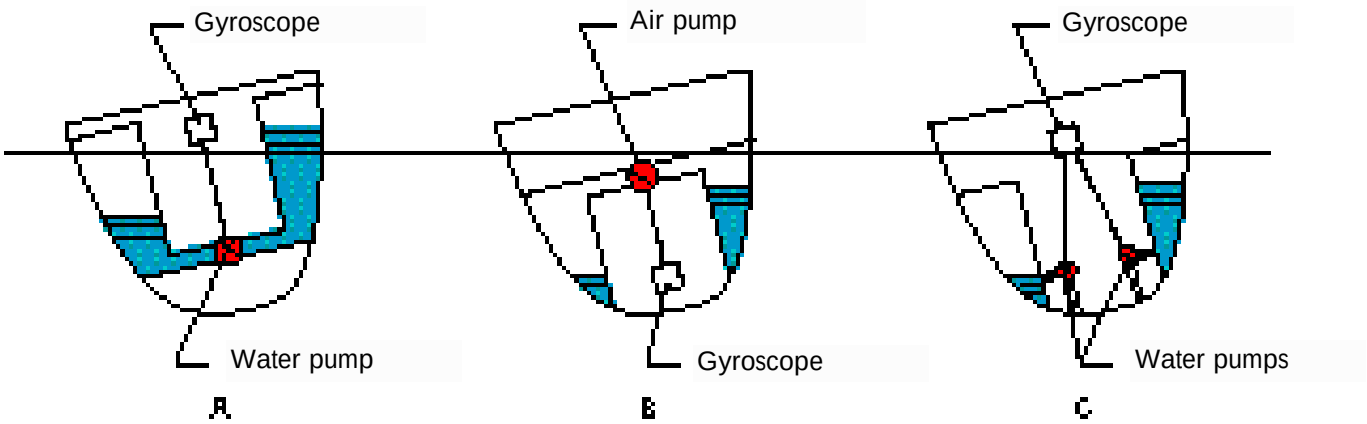
They are particularly useful in the pre-planning stage where roll damping is low even on hard bilge hulls. Retractable stabilizers can have a much higher aspect ratio (length to width ratio), of about 2 : 1 compared to 0.7 : 1 for fixed fins. It is well known that increasing the aspect ratio of a lifting surface (aircraft wing, rudder or sailboat fin keel) greatly improves its efficiency.

The aerospace industry has been continuously developing new sensors and electronic control systems similar to those used on the last generation of airliners. These new technologies, already used by some manufacturers of stabilizers, should enable them to design and build increasingly efficient stabilizing systems. These improvements will allow new devices to anticipate, counteract the motions of the vessel and reduce the time of response which today is about two seconds. However, even the most sophisticated stabilizers will no doubt never cure seasickness in a fully efficient manner.

By Eric A. Ogden

Photos : Courtesy of manufacturers, R.J.

Vosper control box.



Three types of anti-roll tanks of the active type, with a roll sensor, water and air pumps.