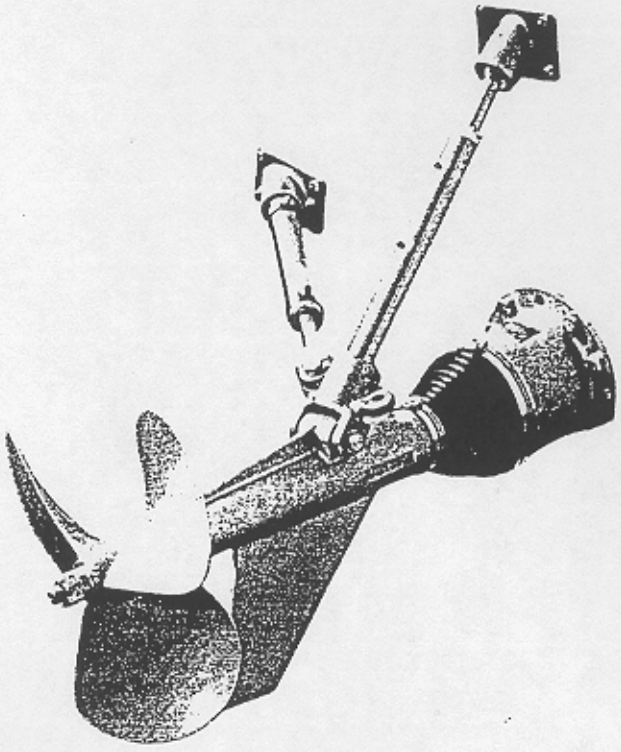

ASD MECHANICAL DESIGN

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ASD DEVELOPMENT HISTORY

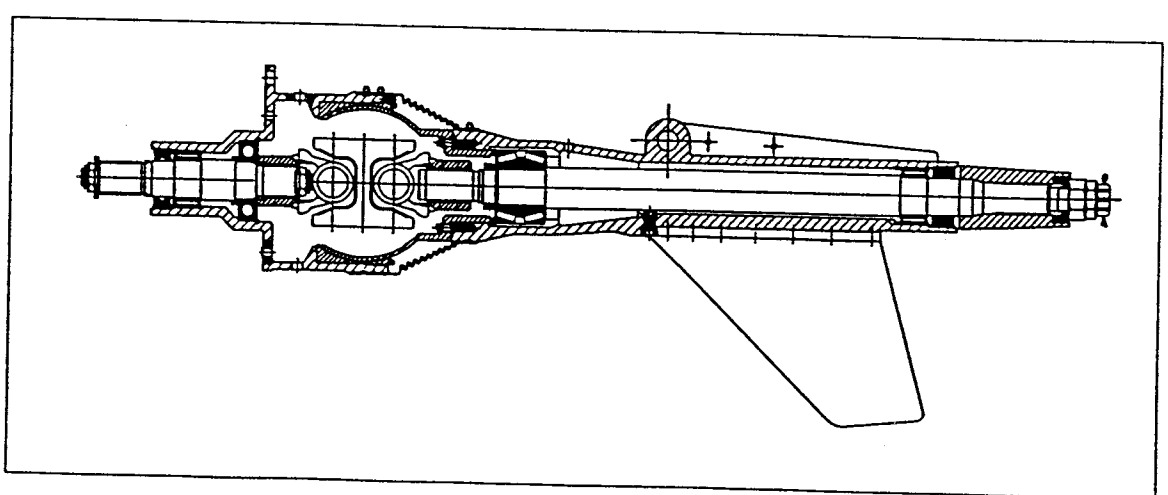
The Arneson Surface Drive (ASD) was developed as a result of tests conducted on fixed surface drives during the 1970's. After working with a number of fixed surface drive configurations for four years, the current configuration for the Arneson Surface Drive was conceived in 1979 and the first models were constructed and tested in early 1980. Shortly after that, production began on the smallest model which we now call the ASD 6.

The development of different ASD sizes has continued since that time to meet a wide range of applications in the boating industry, and today, Twin Disc offers seven different model sizes for gas, diesel and turbine engines up to 10,000 HP. All ASD models are produced in the in-line configuration, and models ASD 6 through ASD 10 are offered in both the in-line and drop-center configurations. The drop-center units are offered with a variety of reduction and overdrive ratios. They provide a vertical offset between the input and output shafts which allows flexibility in installation of drive and engine.

In addition to the basic drive, various accessory items including trim and steering indicators, electrolysis kits, drive line components and mechanical and hydraulic tie bars have been designed.

DESIGN DETAILS

As shown in the illustration below, the Arneson Surface Drive consists of a propeller shaft connected to an input shaft via a universal joint that allows articulation for both steering and trim. The input shaft of the ASD unit passes through the transom and is connected to the driveline from the vessel's gearset. In-line ASD units have no reduction gearing and may be used with either clockwise or counterclockwise rotation.



Arneson Surface Drive In-line unit

The propeller shaft is enclosed in a thrust tube which contains high precision roller thrust bearings that transmit thrust to the transom of the vessel through the socket or drop-center housing. The thrust tube also has an integral or detachable steering fin. The thrust tube is attached to a precision-machined ball that surrounds the universal joint. The patented ball-and-socket assembly is fitted with a series of O-ring and packing materials so that water is excluded from the interior of the unit. The Arneson ball-and-socket sealing arrangement has proven to be highly reliable for preventing water intrusion into the drive. However, if for any reason these seals malfunction, water cannot get inside the boat because of the two shaft seals located in the thrust socket forward snout section.

Some early ASD models used constant-velocity (CV) universal joints as the coupler between the input and propeller shafts. These proved to be unreliable for certain operating conditions, and a major redesign was undertaken to replace all CV joints with double-cardan universal joints. This has been completed and now all ASD models are equipped with the U-joints. The double-cardan U-joints have a much greater life expectancy than than the CV joints for the ASD applications.

The boot is used primarily for mechanical protection of the thrust ball to prevent marine growth, and, although it is water-tight, no water will penetrate into the interior of the drive or the boat even if the boot does happen to develop a leak. This is not the case for typical I/O stern drives where the boot is absolutely necessary for keeping water out of the boat interior.

The materials used in the ASD construction include bronze for all housing and fin components, 17-4 ph stainless steel for both input and propeller shafts, and 316 stainless steel for all of the fasteners and miscellaneous hardware. Although bronze is our standard housing material, several of the drive models are available in aluminum alloy (Almag 35) for aluminum boat installations at the customer's request. The trim and steering cylinder assemblies are constructed of bronze, 316 stainless steel and 17-4 ph stainless steel materials.

All ASD units are filled with oil for lubrication of bearings, and in the in-line models, there is an inboard lube oil reservoir inside the vessel to allow for monitoring and changing of the oil and to provide a positive oil pressure within the ASD unit.

DRIVE OPERATION

The engine/gearbox torque is transferred to the input shaft typically by a driveline. The torque is then carried by the input shaft through the universal joint to the propeller shaft and propeller.

Thrust is transferred from the propeller to the propeller shaft and through tapered roller thrust bearings to the thrust ball. The thrust is then transmitted from the ball to the socket and from the socket to the transom. Neither the U-joint, socket shaft, nor driveline carry any propeller thrust.

Articulation of the drive for steering and trim is accomplished by action of the patented ball-and-socket system. The Arneson patent has 49 claims of which we believe the main strength to be is the unique ball-and-socket design.

OTHER IMPORTANT FEATURES

The Arneson Surface Drive with its simplicity of design has excellent reliability. Components and materials used in the ASD construction are of the highest quality and selected because of their ruggedness and longevity in the marine environment. The in-line drive has only nine moving components including the propeller and five bearings. Our failure rate to date on universal joint-equipped drives has been extremely low.

Because of simplicity of design and the small number of parts, service and maintenance of the drive is easy. Because all ASD models are similar in design except for size, training of technicians for service and maintenance on one ASD unit applies to all ASD units. Service on a major portion of the drive can be done without removing the thrust socket from the transom. This is accomplished by removing the thrust ball retainer and "unplugging" the thrust tube/thrust ball from the socket. By doing this, all components within the thrust tube can be serviced. The socket shaft and universal joint can also be removed from the unit outside of the transom once the driveline coupler has been disconnected.

DROP-CENTER UNITS

ASD drop-center models are available with gear or chain drive arrangements allowing from six to sixteen inches of offset between the input shaft and propeller shaft, depending on the model. Chain drive units provide similar rotation of input and propeller shafts. Gear drives provide opposite rotation of propeller and input shafts.

DRIVE CONFIGURATION

As previously stated, Twin Disc manufactures a wide range of both in-line and drop-center surface drives. The Arneson Surface Drive consists of the following:

- a thrust assembly containing the propeller, propeller shaft, input shaft, universal joint coupler and associated bearings and seals
- a trim cylinder for trimming the drive and also for structural support
- a steering cylinder for turning the drive and counteracting propeller side thrust.

Both trim and steering cylinder systems are 100% hydraulic. All drives come with a conical-shaped boot to provide protection to the thrust ball from abrasion and marine growth. Mechanical tie bars are used for twin-drive installation on deep "V" vessels, and hydraulic tie bars are used for drives installed on catamarans.

DRIVE INSTALLATION

Arneson Surface Drives are transom-mounted. The drives are mounted at a height on the transom so that the water flow off the bottom of a planing vessel misses the thrust socket and boot and strikes the lower fin and lower half of the propeller. The trim and steering cylinders are mounted on the transom. They are located high enough on the drive to be out of the water stream on planing vessels. Installation of both the in-line and drop-center drives is very easy, and the work is facilitated through the use of Twin Disc supplied templates and easy-to-use gauges.

For single-drive installations, the steering cylinder is mounted so that the propeller rotates toward the steering cylinder. For twin-drive installations, two steering cylinders, one for each drive, are usually employed. These can be mounted facing either inboard or outboard when a mechanical tie bar is used. The steering cylinder is always mounted with the propeller rotating away from the cylinder when a hydraulic tie bar is used.

DRIVE SPECIFICATIONS

The Arneson Surface Drives are designed to handle a wide range of horsepower as illustrated in the Surface Drive specification sheet. The largest gasoline engine available for marine use can be accommodated. Diesels up to 5,000 HP and gas turbine engines up to 10,000 HP can be interfaced with the Arneson drive.

The horsepower and torque range shown in the specification sheet are shown only to illustrate the wide range available with the Twin Disc family of drives. In establishing the torque rating for each specific drive, we take into account several factors including the U-joint life, bearing life and shaft strength. The analysis also takes into account the horsepower, RPM, boat speed, propeller diameter and the propeller pitch-to-diameter ratio (P/D). To be in the acceptable safe range, the actual calculated torque must fall beneath the appropriate P/D curve. A single maximum torque rating cannot be used in rating a particular drive.

FUTURE DEVELOPMENT

The basic design for the entire family of Arneson Surface Drives is complete. The dual-fin drive is now available in the ASD 8 and ASD 10 and soon will be available in the ASD 12 models. Future engineering work will be concentrated on total product refinement, value engineering and improvements and additions to the ASD accessory line. Value engineering and weight reduction studies are being done on all aspects of the product to reduce manufacturing costs and maximize product efficiency.

Contact Twin Disc for more information on new product designs and developments.