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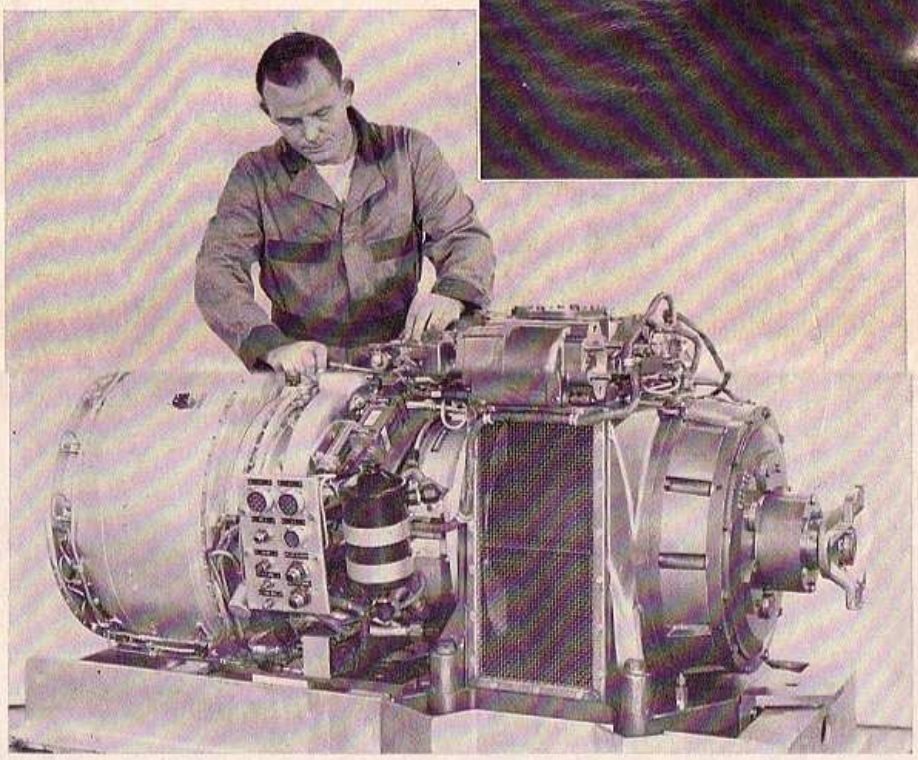
A HIGH-speed gas turbine powered amphibious cargo carrying vehicle with a planing hull, has been developed by Ingersoll Kalamazoo division of Borg-Warner Corp.

Designated the LVW (for landing vehicle, wheeled), it is a large boat with retractable rubber-tired wheels, weighing 14 tons plus 10,000 lbs. of cargo. It is capable of traveling 35 miles an hour when waterborne, and then can lower its wheels and travel at equal speeds on land. Prime power for this vehicle is provided by the 1500 hp model TF-2036 gas turbine engine produced by the Lycoming Division of Avco Corp.

Conceived and developed by the I-K engineering staff, the LVW represents "the first successful gas turbine powered amphibious wheeled vehicle capable of such high water speeds," according to Robert Schutz, president of Ingersoll Kalamazoo. "The power and range of modern weapons have increased so that ships no longer can unload in congested areas close to shore," the division president said. "Instead they will need to anchor 25 to 50 miles offshore, and cargo will be transferred from ship to shore by carriers which have high speed and maneuverability, and also provide for reasonable inland dispersal of men and material. The LVW, which was developed for the U.S. Marine Corps under a contract with the Navy Bureau of Ships, may fulfill this need by planing from ship to shore or between ships, with waterborne ranges of more than 180 miles." The project is part of a Marine Corps development program to determine which of several types of such high speed amphibious support vehicles will best suit its requirements. The LVW is designed as a water vehicle with land operation characteristics. Due to the highly-loaded hull conditions an entirely new hull form was required, and was developed by Ingersoll engineers after much experimentation and refinement of many hull models. Complete towed and self-propelled model tests of the final form were conducted by the National Physical Laboratories at Teddington, England, under direction of the division's engineering staff.

The Lycoming TF-2036 gas turbine engine installed in the LVW is rated 1500 hp for continuous duty, and up to 1650 hp for maximum service, at minimum output shaft speed of 3600 rpm. This engine is a geared, free power turbine incorporating a seven stage axial and single stage centrifugal compressor, annular vaporizing combustor, a single stage gas producer turbine and a two stage free power axial turbine. The engine has a nominal pressure ratio of 6:1. Interstage bleed is utilized at low power. Average weight is 1300 lbs., including all accessories.



The [illegible] is powered by Lycoming rated 1500 hp for continuous service. Full turbine output is utilized for waterborne operations, two speed power transmission is engaged for land travel which requires only fraction of turbine capabilities.

LVW (landing vehicle wheeled) is new amphibian designed for U.S. Marines by Ingersoll Kalamazo Division of Borg-Warner. Planing hull and retractable wheels enable vehicle to reach 35 mph on both land and water.

Turbine exhaust pipe is most prominent feature as LVW reaches planing speed in demonstration. Large tires are rotated 180° for operation on water. Two propellers drive LVW on water.

Maximum compressor speed of the TF-2036 is 18,000 rpm. Maximum power turbine speed is approx. 13,500 rpm. The output shaft is at the air inlet side of the engine. The self-contained power package consists of two main assemblies: the power producer which includes the compressor, combustion chamber and turbine unit; and the output assembly which includes the air inlet casing, accessory gear box, reduction gear and oil sump. Power takeoff drives are normally coupled to the power turbine but are automatically crossed over to the gas producer when power turbine rpm is too low. The free power turbine drives to the output shaft through a 3.6:1 ratio gear train.

The turbine engine is equipped with a Woodward model X1883 fuel control which includes an integral fuel pump and governor control with automatic temperature compensator for engine inlet air temperature. An overspeed governor, driven by the free power turbine, limits overspeed by overriding the gas producer governor control.

The engine is installed on the starboard side of the LVW. Hull space is used as the air inlet plenum chamber. The air inlet is in the hull behind the operator's cab, thus shielding the inlet from water entry in heavy surf. The exhaust is cooled with an air eductor system and exhaust gases are carried to head height above the deck. The engine is equipped with safety devices to guard against effects of low oil pressure, turbine overtemperature and high oil temperature. Other sensors indicate chip detected, oil temperature, oil and fuel pressure, and exhaust gas temperature.

Full turbine horsepower is required for water operation at the vehicle's top planing speeds, but only a fraction of this power is required for operation on even the roughest terrain ashore. This dual power requirement led to development of a new two-speed power transmission utilizing an overdrive-type gear for low power, low speed maneuvering operations on land, with a conventional gear arrangement for high speed, high power cross-country land performance. The transmission also provides selective two or four-wheel drive, as well as marine drive to a pair of counter-rotating 24-inch propellers.

The vehicle is 36′ long, stands 10′10″ high, and is about 11′8″ wide. Its hull is weld-constructed of high tensile aluminum. Cargo is carried on the open deck, protected by side gates which can be lowered for ease in loading. Loading is further facilitated by partially retracting the wheels, reducing the overall height to the deck.

In operation, the vehicle is driven by a two-man crew, in complete control from the driver's cab in front. The LVW is steered with a conventional steering wheel, whether on land or water. On land, the operator has the option of either conventional two-wheel steering or of four-wheel oblique or "crab" steering. All wheels are steered by individual hydraulic units. The vehicle is driven with a throttle quadrant when in the water and foot accelerator pedal on land.

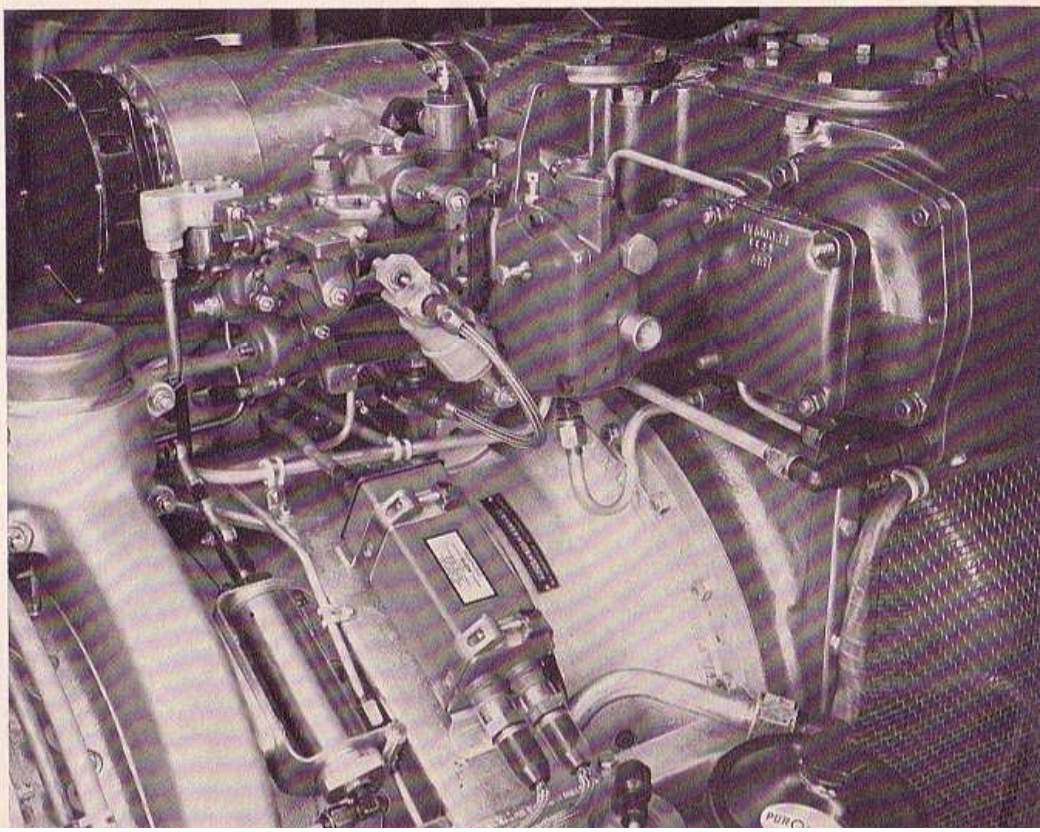
The LVW has no mechanical suspension system, all load shock being absorbed by large 18.00 x 25 tubeless tires. A centralized tire inflation system controlled by the driver from inside the cab permits varying tire pressures during operation of the vehicle to suit the terrain over which it travels.

After entering the water under its own power, the LVW is put through a series of operations to trim it for waterborne operation. When waterborne, its wheels are retracted from the down position in an 180 degree arc. Hydraulically powered rear wheel flaps are lowered to extend the hull planing surface. Next, the propellers and rudders, mounted on a hydraulic-powered retracting plate, are lowered from their protected position within the hull, and the vehicle is ready for boating operation.

The great amount of available power provides high acceleration under all operating conditions, but complete control of the LVW's direction is maintained by the twin hydraulically-actuated rudders. When returning to land, the trim operations are repeated in reverse order and the vehicle is driven onto the beach under its own power.

Summary of Specification

Model	TF-2036-B1A
Continuous power	1500
Maximum power, emergency	1650
Fuel consumption, lb./hr. (at optimum speed)	
@ Continuous	1100
@ Min. Idle	260
Nominal output shaft speed	3600
Output shaft rotation (viewed from rear)	Clockwise
Gear ratio	3.6:1
Average total weight, pounds	1250
Dimensions, inches	
height	35″
width	24″
length	60″
Pressure ratio	6:1
Axial compressor	7 Stage
Centrifugal compressor	1 Stage
Combustor	Annular Vaporizing
Gas producer turbine	1 Stage
Free power turbine	2 Stage
Oil sump capacity, gallons	8



Closeup view of top of turbine shows Bendix 400 amp starter, rear; Woodward model 1883 fuel control and topping power turbine governor, center; rear power takeoff pad, right; and acceleration air-bleed actuator, lower left. Note Purolator fuel filter.