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# Commando, Twister and High Mobility Vehicles

by Christopher F. Foss



# AFV/Weapons Profiles

Edited by **DUNCAN CROW**

This Profile by Christopher Foss on the Commando, the Twister, and American High Mobility vehicles like the Gama Goat, Terra Star, and GOER series, is a direct sequel to No. 40 *U.S. Armored Cars* by Colonel Robert J. Icks. The last page of that Profile briefly mentioned American armoured car development since the end of World War II. The whole of the present Profile is devoted to the vehicles mentioned there, as well as some others. Together, these two Profiles, Nos. 40 and 62, give a comprehensive account of U.S. armoured cars since 1898.

Other Profiles on armoured cars are Nos. 9, 21, 27, 30, 33, 39, 44, 54 (in part), and 60. Of particular interest in connection with the Twister, the Gama Goat, and the GOER series are the paragraphs in No. 30 dealing with Nicholas Straussler's articulated chassis armoured car and the Italian Pavesi vehicles.

This is Christopher Foss's third Profile. The others are Nos. 51 and 53.

The complete list of AFV/Weapons Profiles already published is:

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*Commando in Vietnam. Note the man to the right of the driver with the M79 grenade launcher, and the additional machine-gun on the rear of the vehicle. (Cadillac Gage).*

# Commando, Twister and High Mobility Vehicles

by Christopher F. Foss

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## THE COMMANDO MULTI-MISSION VEHICLE

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IN THE early 1960s the Cadillac Gage Company of Detroit, Michigan, built the W 300 vehicle. This was essentially an armoured body fitted to a Dodge truck chassis. Armament consisted of a 20mm cannon. This was followed by the first prototype of the Commando which was built in March, 1963. After trials in various parts of the world, production commenced in January, 1964.

The Commando vehicle was designed to function in a variety of roles including troop transport, convoy escort and as a reconnaissance vehicle.

The Commando V-100 has a welded hull of homogeneous ballistic plate that provides protection from small arms fire (including cal .30 ball), shell fragments, grenades and anti-personnel mines. The drive train is completely enclosed in the armoured hull. The vehicle has three doors. One is at the rear of the vehicle, to the

right of the engine; this is in two halves, the bottom half folding downwards and the top half upwards. There is also a door on each side of the vehicle; each of these doors is also in two halves, the bottom half folds downwards and the top half swings sideways.

In the top section of each of the three doors is a firing port, with a protective cover, and a direct vision block. Early vehicles had periscopes and not vision blocks. There are an additional eight firing ports and nine observation blocks around the hull of the vehicle; these observation blocks are easily replaceable. Over the driver's compartment is a large hatch that opens either side, this allows the driver to drive "head out" when not in danger. On early models he was provided with a single vision block but on more recent vehicles an additional block has been added to give him a better means of observation. There is also a single hatch in the roof to the right of the engine.

The Commando is powered by a Chrysler 361 petrol engine similar to that fitted to the M113 APC. The engine



One of the early Commando vehicles (Car Armored Light 4x4 "Commando"). Note the different vision devices.

(U.S. Army, TACOM)

is at the left hand rear of the vehicle. Two large overhead and one side hatch allow access to the engine. The cooling system is capable of 115° ambient temperature operation. The gearbox is manual and has five speeds, synchronized. Transmission is 7.24:1 low ratio. Transfer box is 1.32:1 ratio single speed and has in-out clutch for front axle drive. The 24-volt electrical system is waterproof and has radio suppression. The axles are modified M34 truck axles, 6.722:1 ratio equipped with a locking differential.

The wheels have special "run-flat" combat tyres developed by Cadillac Gage in conjunction with the Mansfield Tyre and Rubber Company. These are of 12-ply and steel-reinforced. The vehicle can cover up to 50 miles after a puncture by gunfire. The size is 14.00 x 20 and they are also self-cleaning. The brakes have a metallic lining and are size 15" diameter and 3" wide front and rear with a vacuum brake booster. The suspension consists of leaf springs with full shock absorbers at each wheel station. The vehicle is also fitted with variable power steering.

At the front of the vehicle is a hydraulic winch with a capacity of 10,000 lbs.

Another feature of the Commando is that it is fully amphibious with preparation, being propelled in the water by its wheels at a maximum speed of 3.5 mph. This enables the vehicle to cross lakes and slow flowing rivers, with care.

The vehicle is fitted with both interior and exterior lights and can be fitted with a variety of radio equipment including the following:- AN/PRC-8, 9 or 10A, AN/PRC-25, AN/VRC-8, 9 or 10, AN/GRC-8 or 9, AN/VRC-15, AN/VRC-34, AN/GRC-5 and the British C-12.

## COMMANDO V-100 VARIANTS

### Experimental Models

**90mm Gun**—this had a turret-mounted 90mm Mear gun with a maximum range of some 3000 m. Nine ready

rounds were carried in the turret. A co-axial machine-gun could also be mounted to the left of the gun.

**20mm Gun**—fitted with a 20mm Hispano-Suiza HS-820 gun and 183 rounds of ready use ammunition. Could also be fitted with the Oerlikon 204-GK or Cadillac Gage HVW-65 20mm weapons. There was also a project to fit a multiple rocket launcher (twin) on the roof.

### Twin cal .30 Machine-Guns

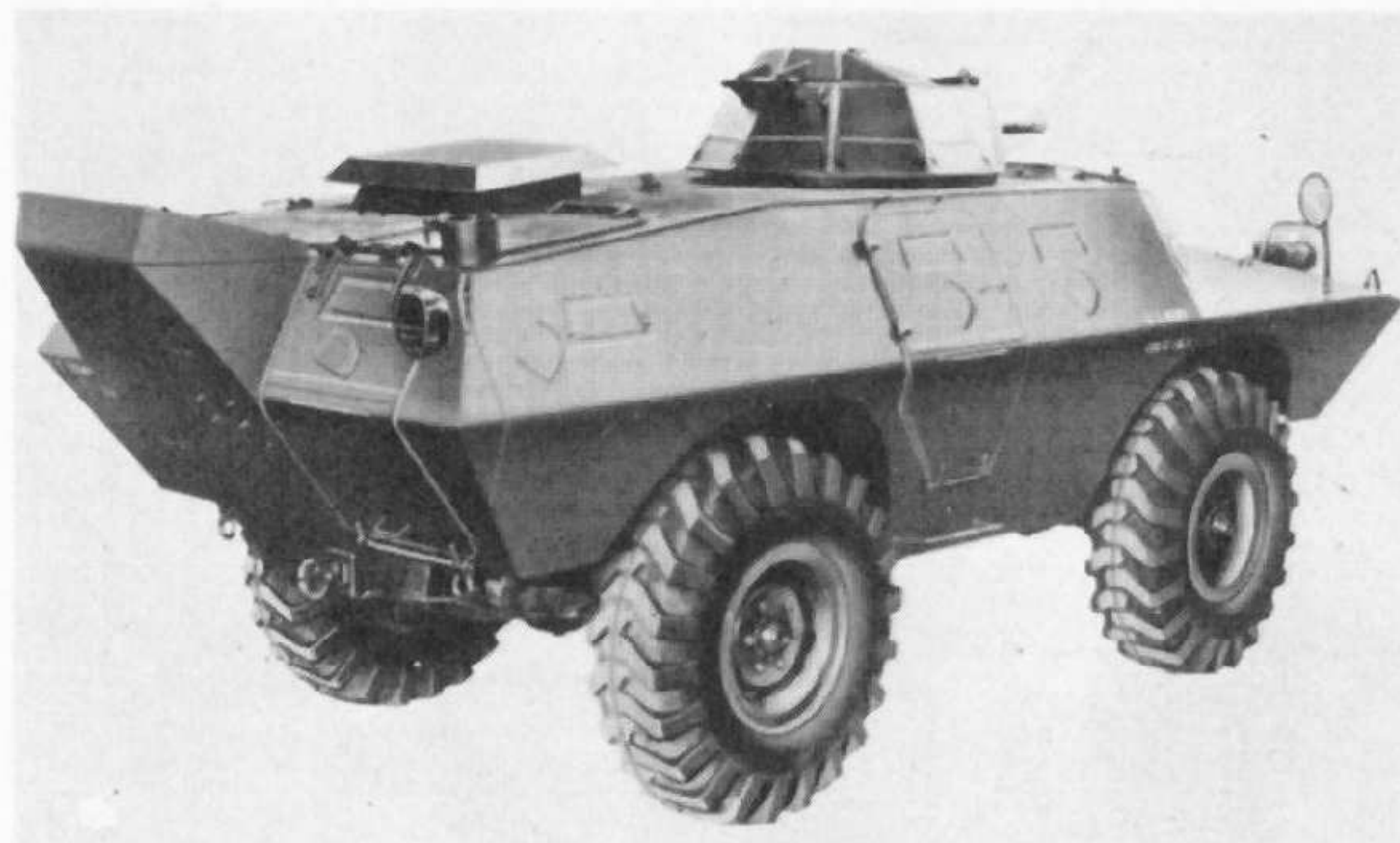
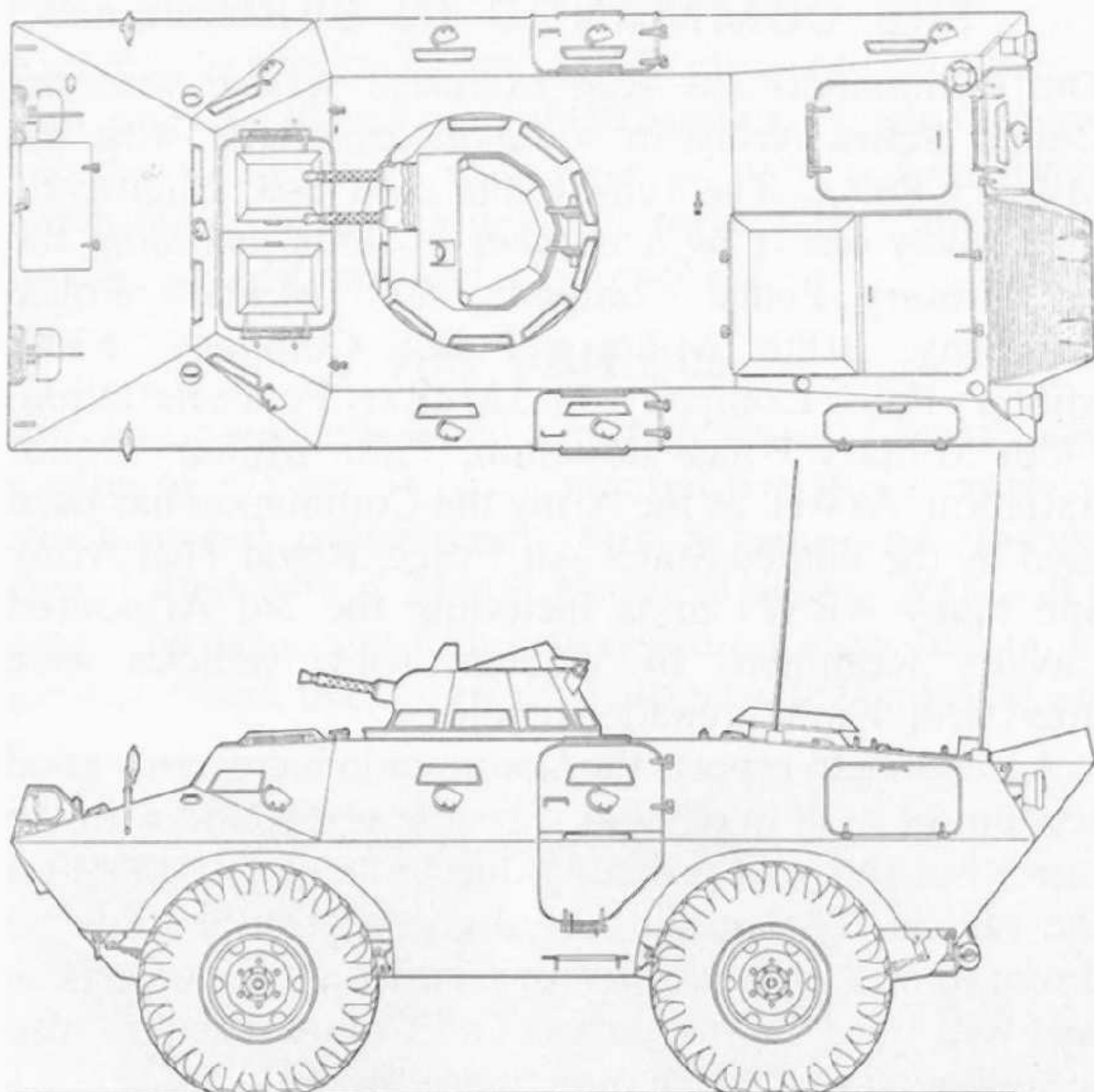
Armed with twin cal .30 Browning M37 machine-guns with an electrically operated fire control system which incorporates independent gun selection. Turret has a traverse of 360° (10 $\frac{3}{4}$ ° of turret rotation for one revolution of the hand wheel, maximum 50° a second) and an elevation of +59° (manual) and a depression of -14°. A total of eight vision blocks is provided in the turret which also has a hatch cover that opens to the rear. A total of 1000 rounds of ready ammunition is carried with a further 9000 in reserve in the hull. In addition this variant, as do most other variants of the Commando, carries a M79 grenade launcher for added protection. The crew can also fire their weapons through the firing ports provided. The turret can also be fitted with four tear gas/grenade launchers.

### Twin 7.62mm Machine-Guns

Same basic turret as the above but armed with twin German Rheinmetall MG-42 7.62mm machine-guns. Fitted with a mechanical firing system, either gun may be selected to fire. 1000 rounds of ready use ammunition are carried with additional ammunition in the turret.

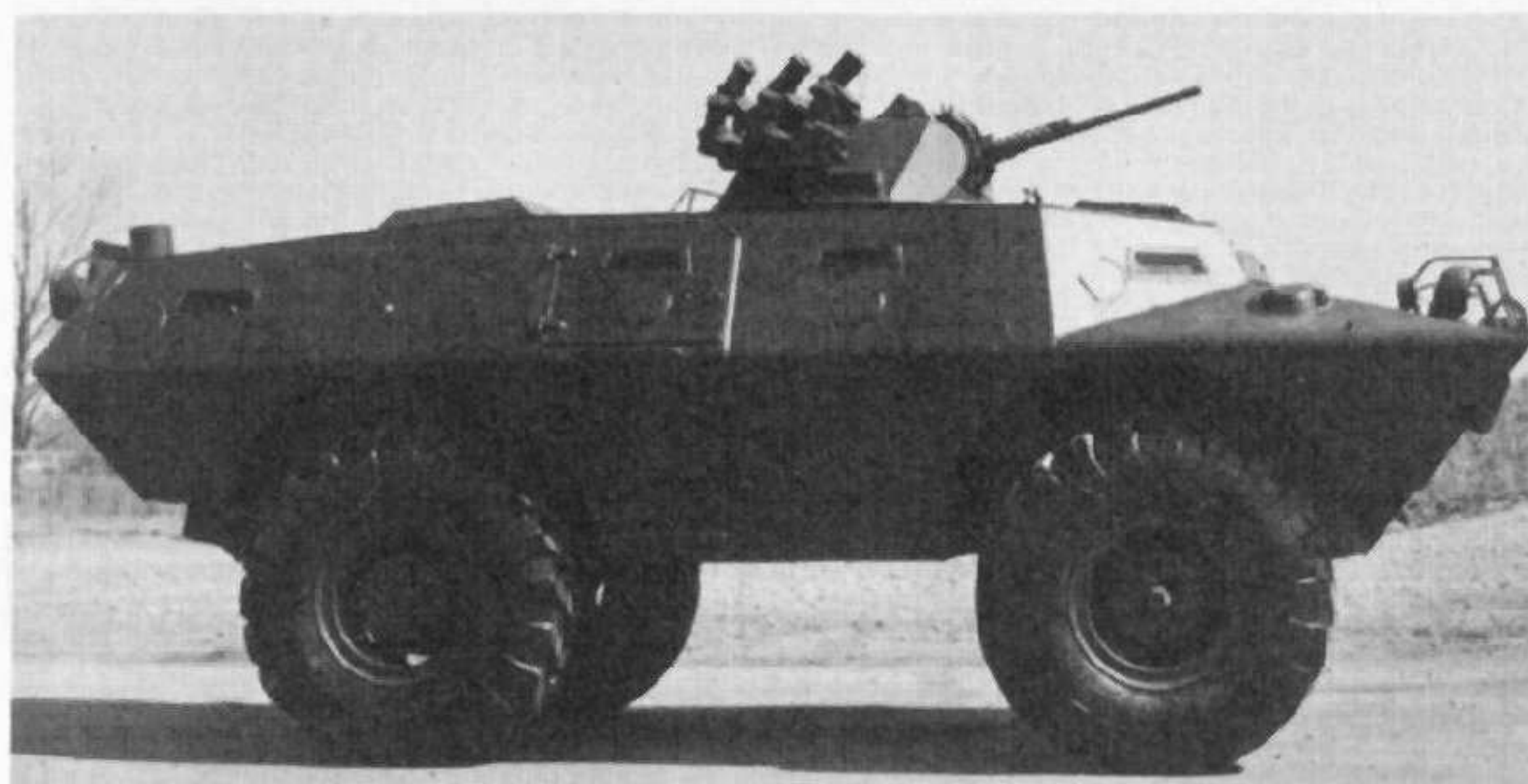
### Cal .30 and .50 Turret

Same turret as the above but mounting one Browning M37 cal .30 and one Browning M2 cal .50 machine-gun. Fire control system is electrically operated and either gun may be selected. Turret carries 500 ready rounds of



Three-quarter left rear view of the V-100 Commando. (Cadillac Gage)

Commando V-100 armoured car, top and left side views. (Cadillac Gage)



This photograph of the Commando armoured car clearly shows the firing ports and the vision blocks. (Cadillac Gage)



Commando armoured car demonstrating its amphibious capabilities. (Cadillac Gage)

cal .30 ammunition and 200 ready rounds of cal .50. Additional ammunition is carried in the vehicle.

#### **Turret Mounted 7.62mm General Electric Minigun**

Same turret as the above but fitted with the 7.62mm rapid fire minigun.

#### **TOW Missile Carrier**

This project has the command type hull with the raised roof, the roof being provided with hatch covers that open either side. Inside is a TOW missile launcher. A 7.62mm machine-gun is mounted on the hatch to the right of the driver. A recoilless rifle could be mounted in place of the TOW launcher.

#### **Dragon Missile Carrier**

This project uses the standard Commando hull with a small turret. On each side of the turret is a Dragon anti-tank missile launcher and a cal .30 machine-gun.

#### **81mm Mortar Carrier**

The mortar has a traverse of 360° and special fold down doors protect the crew when the mortar is not being fired.

#### **Twin M73 7.62mm Machine-Guns**

Two M73 7.62mm machine-guns in a similar turret to the twin cal .30 turret; these weapons have a rate of fire of 450/500 rpm. Used by the United States Army Military Police in Vietnam. Designated XM-706E1.

#### **Modular Options**

In this the Commando hull top is constructed so that any number of modules can be used for specific tactical missions. For example—mortar mount, cupola mount, command type pod or overhead hatch on which a number of 7.62mm machine-guns (each with a shield) can be mounted. The Commando in the command role can also be used in the APC role and carry 12 men.

#### **Bi-Fold Door**

This has been used by the USAF in Vietnam, designated XM-706E2. It has a bi-fold door in the roof and has five different positions for M60 machine-guns. Some were fitted in Vietnam with "A" frames for lifting obstacles.

#### **Riot/Police Vehicle**

This model has a fixed turret and additional modifications including a remote controlled fire extinguisher and a engine shield on the top of the hull over the engine to give protection against fire-bombs. This latter modification has also been incorporated in standard production Commando vehicles. The fixed turret is provided with a total of eight vertical gun ports as well as vision blocks. Additional lights are also fitted.

Optional equipment that could be fitted includes tear gas grenade launchers, water cannon and run flat tyres. Other duties for the vehicle could include flood relief or crash rescue, the latter having additional fire fighting equipment.



*Commando with the 90mm turret and gun.*



*Commando with 20mm and 7.62mm guns.*

*Impression of Commando with Oerlikon rocket launchers.  
(Cadillac Gage)*



## THE COMMANDO IN SERVICE

The Commando has seen extensive service with the United States Army in Vietnam, especially with the Military Police. The vehicle has been used extensively for convoy escort by a number of units including the 1st Military Police Company, 66th Military Police Company, 218th Military Police Company, 630th Military Police Company, 93rd Military Police Battalion, 540th Military Police Battalion, 720th Military Police Battalion. As well as the Army the Commando has been used by the United States Air Force, Royal Thai Army and many ARVN units including the 3rd Armoured Cavalry Regiment. In Vietnam some vehicles were fitted with 40mm grenade launchers.

According to reports the Commando has given a good account of itself in combat. Trouble was found with the turret but this was probably due to lack of training on the vehicle. The suspension also gave trouble, due no doubt to lack of time given to maintenance. The vehicle was well liked by the crews. The Commando has also seen combat in the Lebanon and in Brazil.

Other countries that use the Commando include Somalia, Sudan, Singapore, Muscat and Oman, and it has also been evaluated by the Canadian Armed Forces.

## COMMANDO V-150

This has been developed from the V-100 and is based on the hull of the V-100 but carries a more powerful armament. The vehicle can be powered by the same engine as the V-100 (the Chrysler 361, V-8 petrol engine), or it can be fitted with the 155 hp, V-6 Cummins diesel. Transmission can be either a manual five-speed synchronized or a three-speed automatic. Electrical system, winch, brakes, steering and suspension are the same as for the basic V-100. Heavier axles are fitted and these are double reduction equipped with silent locking differentials. Full data is given in the Commando table below.

The V-150 is fully amphibious and can, according to the manufacturers, enter the water at 40 mph. The ignition and engine are waterproofed and the front axle pressurised. It also has two high capacity bilge pumps.

It is fitted with the late type vision system for the driver. The driver's hatch opens to the left and the RHS hatch to the right.

Versions of the V-150 are as follows:

### 20mm Turret

Fitted with a powered turret armed with a 20mm gun and a co-axial 7.62mm machine-gun. A 7.62mm machine-gun is mounted on the turret roof. In addition, smoke dischargers are fitted.

### 81mm Mortar

Fitted with a 81mm mortar. There are also pintle mounts for additional weapons around the roof of the vehicle.

### Command Vehicle

This is the basic hull with the pod fitted. A 7.62mm machine-gun is fitted with a shield on the top.

### 90mm Turret

Fitted with a power operated turret with a 90mm gun and a 7.62mm co-axial machine-gun. An additional 7.62mm machine-gun is mounted on the roof. In addition six smoke dischargers are mounted on each side of the turret rear.

### Other turrets

Can also be fitted with twin cal .30 mgs, twin cal 7.62mm mgs, one cal .30 and one cal .50 mgs, or a single General Electric minigun. In each case six smoke dischargers are mounted on each side of the turret rear. Can also be used as an APC without a turret fitted.

### V-200 VEHICLE

This has a bigger hull and a more powerful Chrysler 440 engine of 275 hp. It has a manual five-speed gearbox, synchronized transmission with a two-speed transfer case. Fitted with a 24-volt electrical system with a 100 amp alternator and radio suppression. Larger fuel tanks are also fitted. Brakes are dual air-actuated and tyres are

16.00x20. Suspension is similar to the V-150, power steering is fitted. At the front of the vehicle is a 15,000 lb hydraulic winch. The vehicle is fully amphibious. Full data is given in the table. Variants are:

### Personnel Carrier

Carries 12 fully equipped troops. Curb weight excluding ammunition is 20,500 lbs. A 7.62mm machine-gun is fitted and 5000 rounds of ammunition are carried.

### 90mm Version

Armed with a 90mm gun and a 7.62mm co-axial machine-gun; a 7.62mm mg is also mounted on the roof of the vehicle. 40 rounds of 90mm and 5000 rounds of 7.62mm ammunition are carried. Six electrically fired smoke



*Commando with pod.*

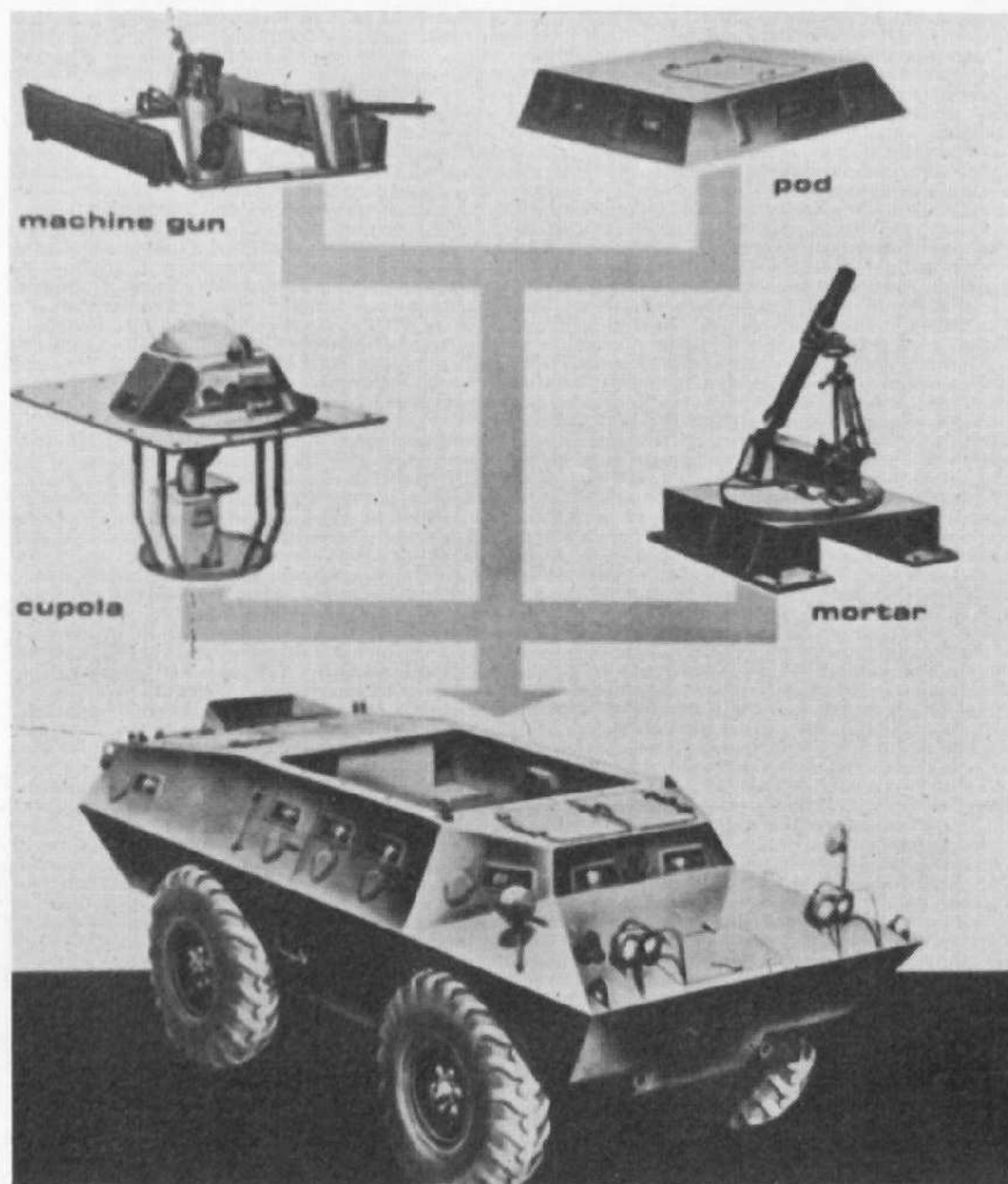
(Cadillac Gage)

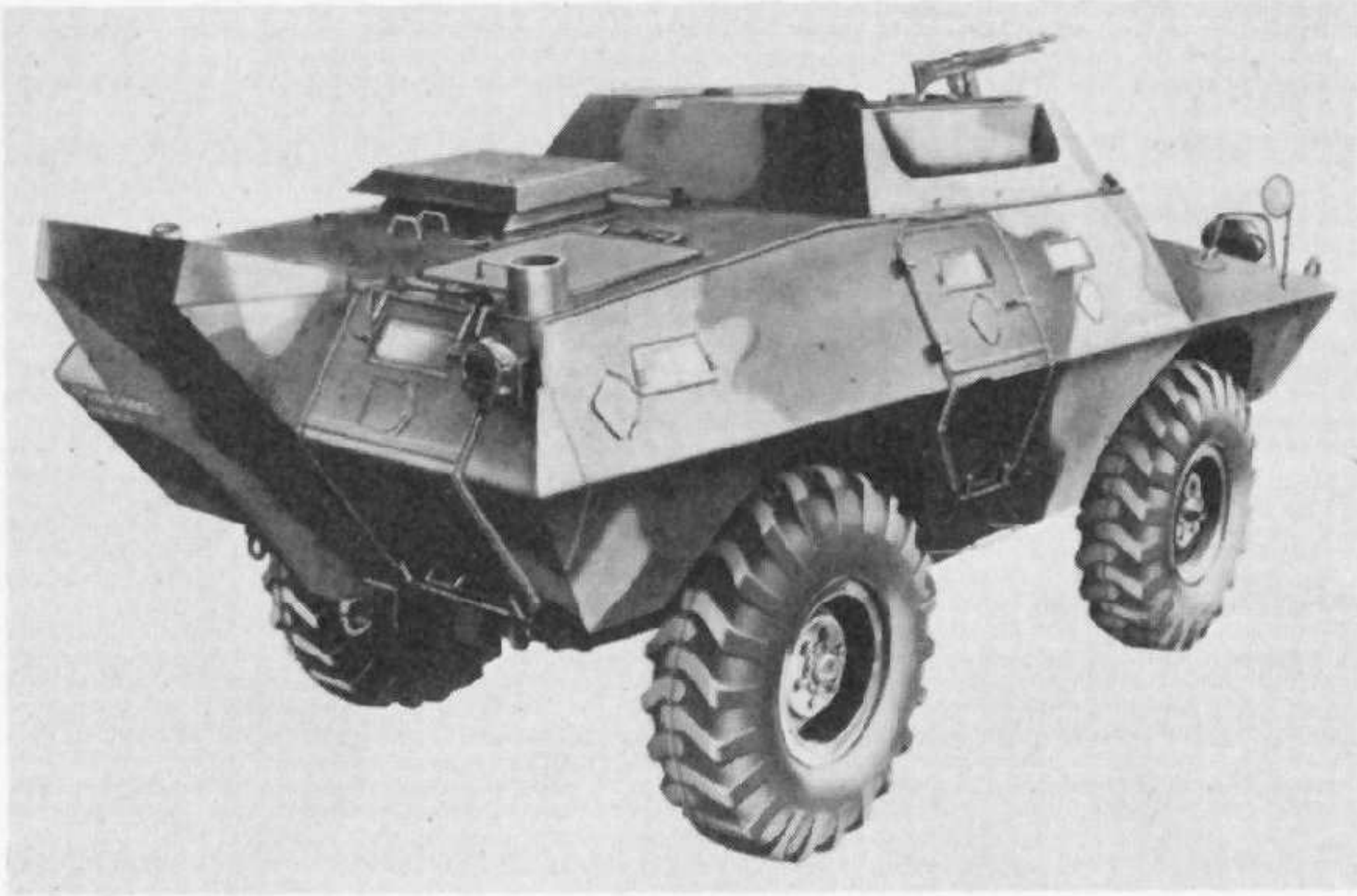
*Modular options of the Commando.*

(Cadillac Gage)

*Commando with twin .30 machine-guns.*

(Cadillac Gage)





Commando open topped version with a single M60 machine-gun in service with the U.S. Air Force. (Cadillac Gage)

Commando under test by the Canadian Armed Forces. They did not adopt the vehicle. (Canadian Armed Forces)



dischargers are fitted on each side of the turret rear. Crew consists of six men. Curb weight is 24,800 lbs, excluding ammunition.

#### 20mm Version

Armed with a 20mm gun and a 7.62mm co-axial machine-gun; another 7.62mm mg is mounted on the turret roof. 525 rounds of 20mm and 5000 rounds of 7.62mm ammunition are carried. Smoke dischargers are fitted on each side of the turret rear. Crew is 11 men, and curb weight is 24,500 lbs without ammunition.

#### 81mm Mortar

Armed with a 81mm mortar and 96 rounds of ammunition. Also fitted is a 7.62mm machine-gun with 2500 rounds of ammunition. Crew is five and curb weight is 23,000 lbs without ammunition.

#### 120mm Mortar

Armed with a 120mm mortar and one or two 7.62mm machine-guns. 75 rounds of mortar and 2500 rounds of 7.62mm ammunition are carried. Crew is seven, and curb weight is 24,200 lbs without ammunition.

#### Command Vehicle

This has a higher roof with additional firing ports and observation blocks. Crew is seven, and loaded weight is 22,600 lbs. Also fitted with a 7.62mm machine-gun and carries 5000 rounds of ammunition.

#### Engineer/Recovery Vehicle

This is fitted with an "A" frame at the front of the vehicle and a hydraulic winch with a capacity of 25,000 lbs. Crew is eight and additional lighting equipment is fitted. Armed with a 7.62mm mg with 500 rounds of ammunition. Curb weight is 24,000 lbs without ammunition.

### CHARACTERISTIC DATA—COMMANDO V-100, V-150 AND V-200

	V-100	V-150	V-200
Length overall	224"	224"	241"
Width	89"	89"	96"
Height (top of turret)	96"	100"	—
Height (Hull top)	76"	76"	78"
Wheelbase	105"	105"	128½"
Track—Front	73½"	76½"	80½"
Rear	73½"	76½"	81½"
Ground clearance (minimum)	16"	15"	17"
(maximum)	27"	25½"	21"
Ground pressure—psi	21*	—	18*
Maximum road speed—mph	62	55	60
Gradient	60%	60%	60%
Side slope	30%	30%	30%
Turning radius	28'	—	32'
Vertical obstacle	24***	24"	24"
Speed in water—mph	3.5	3.00	3.3
Freeboard in water	18"	18"	12"
Empty weight—lbs	13,500 (APC)	15,000***	—****
Payload—lbs	2,750 (APC)	5,000	—
Maximum combat weight	16,250 (APC)	20,000	—
Angle of approach	55°	55°	50°
Angle of departure	53°	53°	50°
Fuel tanks (two of) US gallons each	40	50	50
Range road—miles	425/600	425/600	300
Range—cross country—miles	250/425	250/425	—
Tyres	14:00 x 20	14:00 x 20	16:00 x 20

#### Notes

\* This depends on the variant and the soil.

\*\* During trials at the Armour Proving Ground, Aberdeen, Md., the V-100 Commando did in fact climb a 36" vertical obstacle.

\*\*\* This depends on the variant.

\*\*\*\* This depends on the variant, data is given in the text on the individual weights of the V-200 series.



## THE LOCKHEED TWISTER

In the early 1960s the Lockheed Missile and Space Company conducted a series of computer wargames covering all types of warfare in various parts of the world, including, Europe, The Middle East and Korea. These showed that new vehicles should have greater speed and agility. In December 1964, the management at Lockheed gave approval for the development of a high-performance, off-road, military vehicle. This programme was called the Advanced Vehicle Programme. Nine months were allowed to construct the vehicle and another three months for testing.

The first Twister (Lockheed Testbed) was completed on schedule in October 1965. Three months of testing both at Lockheed's Sunnyvale test course and in the Santa Cruz mountains proved that the Twister would meet expectations. The first phase of the tests was completed in December 1965. Phase Two commenced in 1966, and many tests were run under varying conditions of snow, sand, mud and rice paddies. More extended trials were then undertaken in Alaska and Nevada.

### DESCRIPTION OF THE TWISTER TESTBED

The Twister consists of two bodies which are joined by a pivotal yoke. This allows the vehicle three degrees of freedom in pitch, roll and yaw axes. In each body is a Corvair engine which drives all four wheels of that body but the vehicle can still operate with either engine shut off. The front body wheels are individually suspended, the rear wheels being mounted in pairs on walking beams. All eight wheels are always in contact with the ground. The steering system is a combination of powered yaw between the bodies, plus conventional Ackerman steering of the two front wheels. The Twister concept gives a high power loading, good control for the driver at all times, high tractive force on the ground and a good ride for the crew.

*The original Lockheed Twister demonstrating its cross-country capabilities.*



(Lockheed Missiles & Space Company)



*Commando V-150 under test.*

(Cadillac Gage)

*The V-200 Commando with a turret-mounted 20mm gun and six smoke dischargers each side of the turret rear.*

(Cadillac Gage)



Outline data of the Testbed is given in the table, other data is:

<i>Drive Train</i>	
Gross torque	160 ft. lb at 3200 rpm
Gross hp	140 at 5200 rpm
Compression ratio	9:25:1
Transmission	Allison TX-200-2B automatic transmission with manual override. Six speeds forward plus reverse
Transfer gearcase	1:1 ratio gearbox between transmission and differential
Differentials	7:11:1 ratio limited slip differential. A propeller shaft conveys power to an identical differential for the axle pair in each body
Axles	Each wheel powered by a separate variable length half shaft driven from the differential



The original Lockheed Twister under test in the rugged Santa Cruz mountains early in 1967.

(Lockheed Missile & Space Co.)

#### *Suspension*

Front body—-independent unequal length wishbones with coil springs. Double acting telescoping shock absorbers. Total vertical wheel travel of 12". Front body acts as a walking beam. Rear body—wheels mounted in tandem on a separate solid centre-pivoted walking beam on each side of the vehicle. Walking beam pitch results in 12" of vertical wheel travel. Each walking beam is mounted on a coil spring with 6" vertical travel. Double acting telescoping shock absorbers damp walking beam pitch as well as bounce.

#### *Brakes*

Dual servo, vacuum boosted, hydraulic actuated, two shoe, 12" by 2" drum type.

#### *Steering*

Hydraulically powered wheel steer and yaw steer with mechanical-hydraulic co-ordination. Hydrostatic steering with 3¼ turns lock to lock. Yaw motion of front body may be powered, trailed or locked out.

The original Twister showing its ability to move through mud.

(Lockheed Missile & Space Co.)



#### *Electrical*

Independent 12-volt systems in each body. 55 amp alternator and 90 amp-hour battery in rear body. 55 amp alternator and 35 amp-hour battery in front body. Circuit breaker on all circuits.

#### *Body Structure*

High strength 5083-H113 and 6061-T6 aluminium alloy. Unitized construction with skin ¼" thick with longitudinal and cross channel ribs. 4130 steel used for suspension, yoke and other highly stressed components.

#### *Controls*

Throttle—push-pull cables control both engines from one pedal. Transmissions—separate hydraulically actuated range selectors for each transmission. Service brakes—all eight wheel brakes controlled by one pedal. Separate master cylinders for each body. Parking brake—hand lever actuated drum brake on rear body transfer case. Steering—hydraulic. Steer mode selection—electro-hydraulic.

#### *Cooling*

Standard Corvair fan on engines. Forced air over external heat exchangers cool engine oil and transmission oil in each body.

#### *Fuel system*

Separate 17½ (US) gallon tanks for each engine interconnected. Electric booster pump for front body.

#### *Tyres*

16-20, 4 ply rating, rayon, belted radial ply configuration. Modified non-directional cross country tread. Tests showed that Twister can operate at 30 mph for 60 miles with one tyre flat.

#### *Wheels*

Steel, split rim, 16" diameter, 12" width.



*The first U.S. Army Twister.*

(Lockheed Missile & Space Co.)

## SECOND GENERATION TWISTERS

In January 1968 Lockheed signed an Army contract for three Twister vehicles consisting of one 06 testbed, one amphibious testbed and the XM-808. The programme was now named Ground Vehicle Systems and connected with the U.S. Army Tank-Automotive Command at Warren, Michigan. Total contract was worth over 3 million dollars.

These second generation Twisters were longer, slightly wider, higher and more powerful. Full data of these is given in the table.

The 06 Testbed and the XM-808 were handed over in January 1970. The 06 Testbed has an open type cab similar to the original Twister. The XM-808 has a fully enclosed cab and is armoured and it is also armed with a 20mm Hispano-Suiza cannon.

The amphibious vehicle was completed in mid-1970 and tested by Lockheed until December 1970. It is

propelled in the water by a water jet producing some 2600 lbs of thrust. This water jet is powered by the engine in the rear body, two thrusters being located on each side of the rear body. The driver controls the water jets by deflection, and can quickly alter the thrust from full ahead to full astern. Speed in water is 6 mph and the vehicle has a turning circle of only 20'.

When climbing out of the water, the rear body is pushed shoreward by the water jet, while the front body pitches up so that the four front wheels can grab the bank for traction. During tests the Twister was able to leave the water via banks of 40% (mud) and 60% (firm).

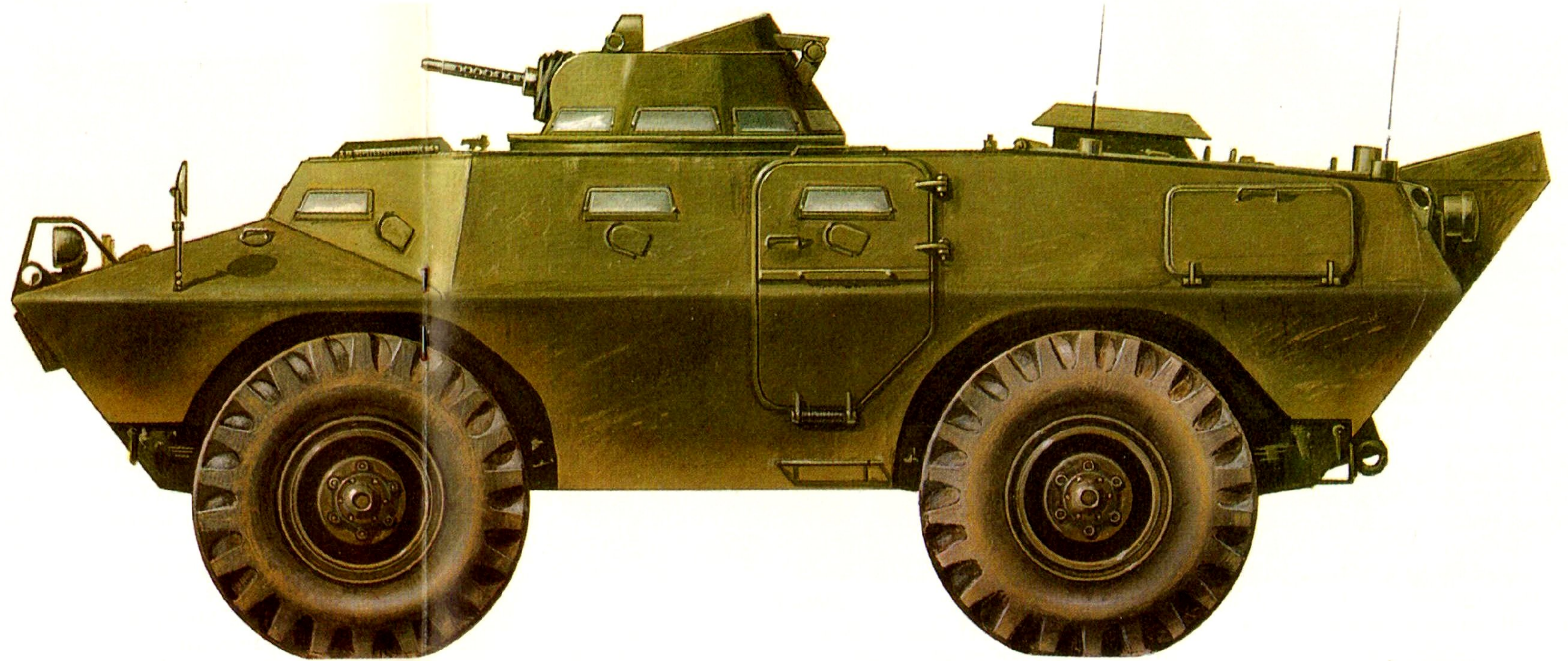
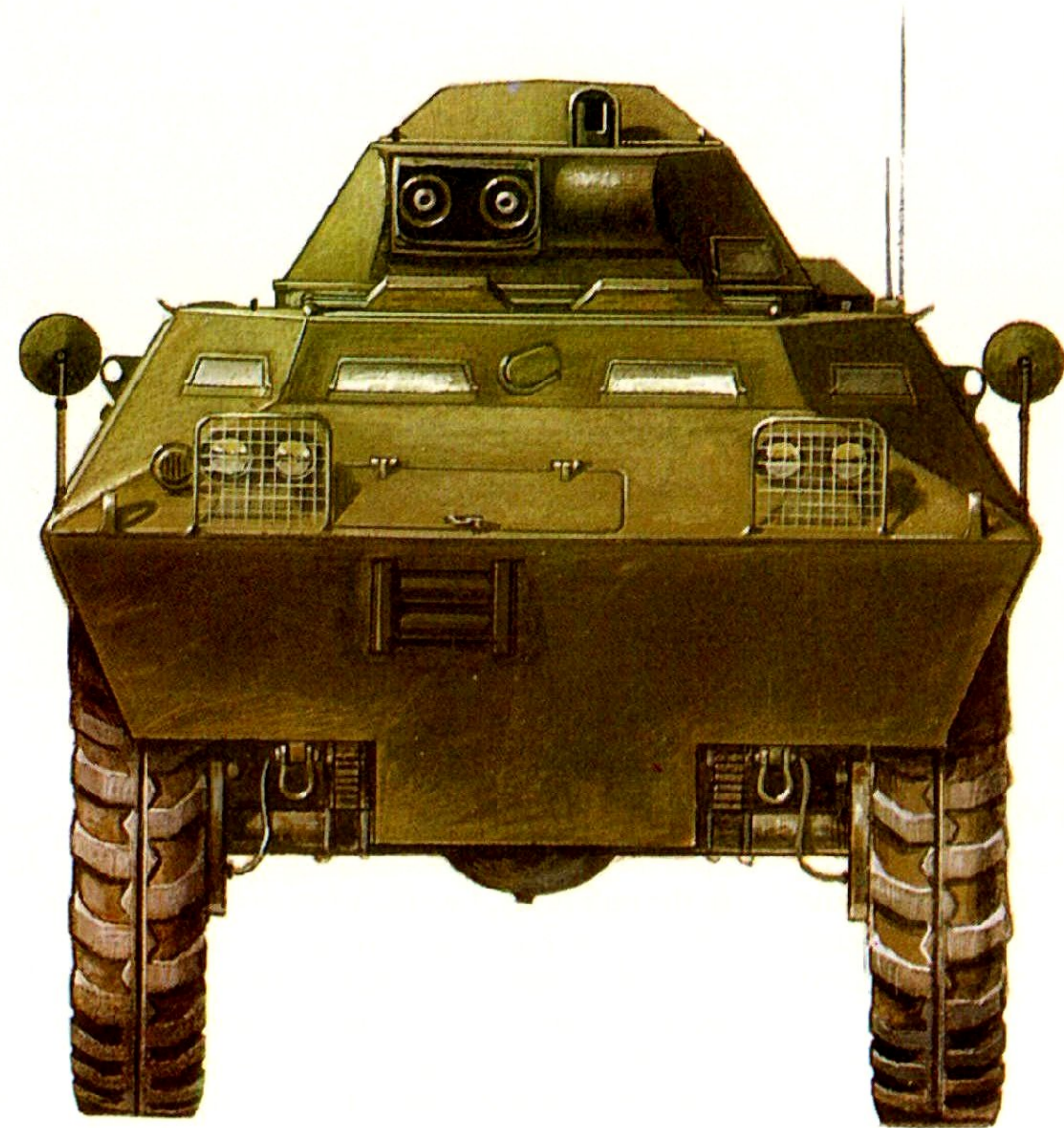
Lockheed have retained their original prototype and have built a version called the Dragon Wagon for heavy duty civilian and military applications. This has only one engine of 225 hp in the front body, loaded weight being some 30,000 lbs.

Lockheed have proposed two series of the Twister—

*The U.S. Army's first Twister climbing a 3-foot vertical wall—October 1969.*

(Lockheed Missile & Space Co.)

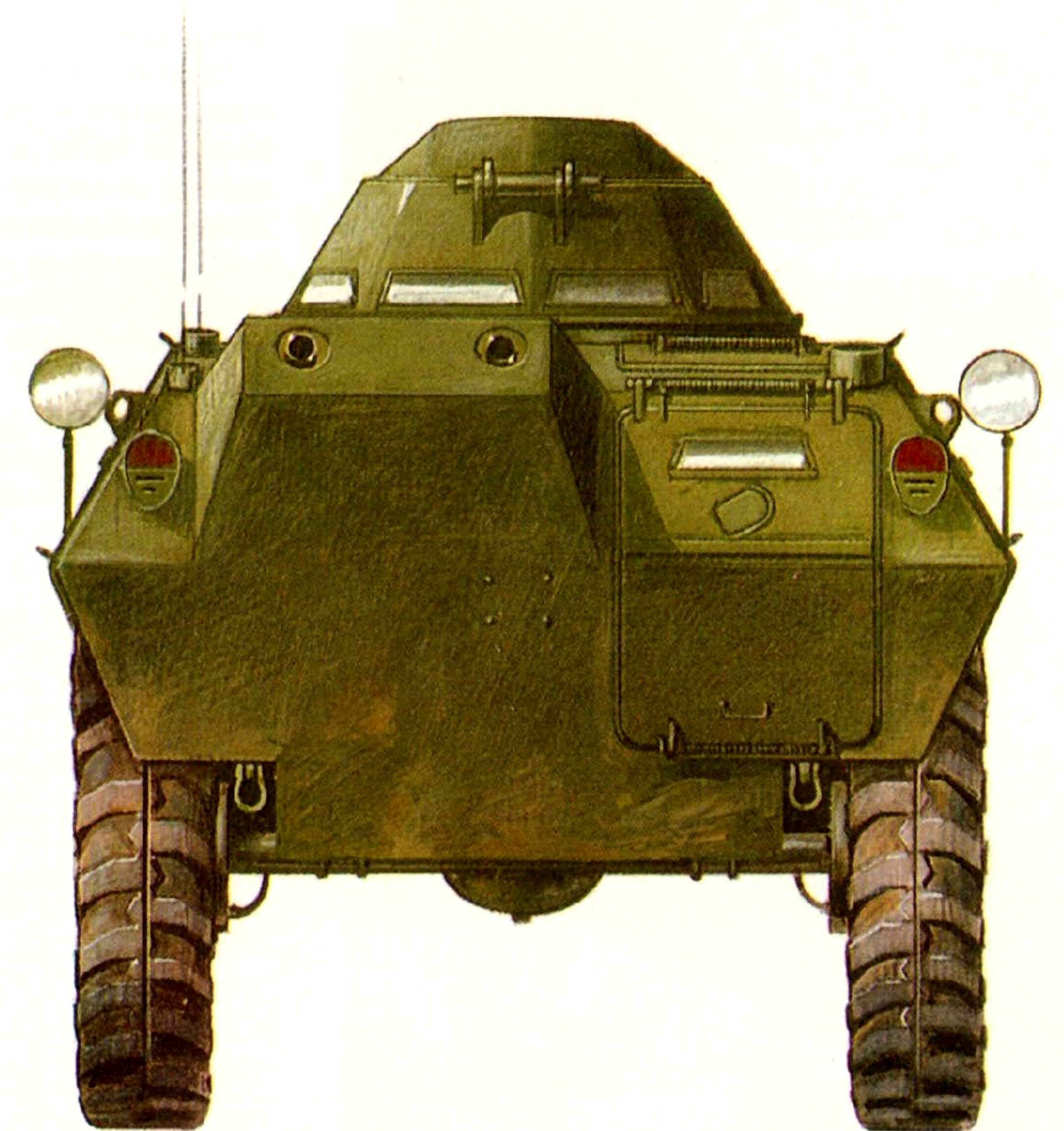
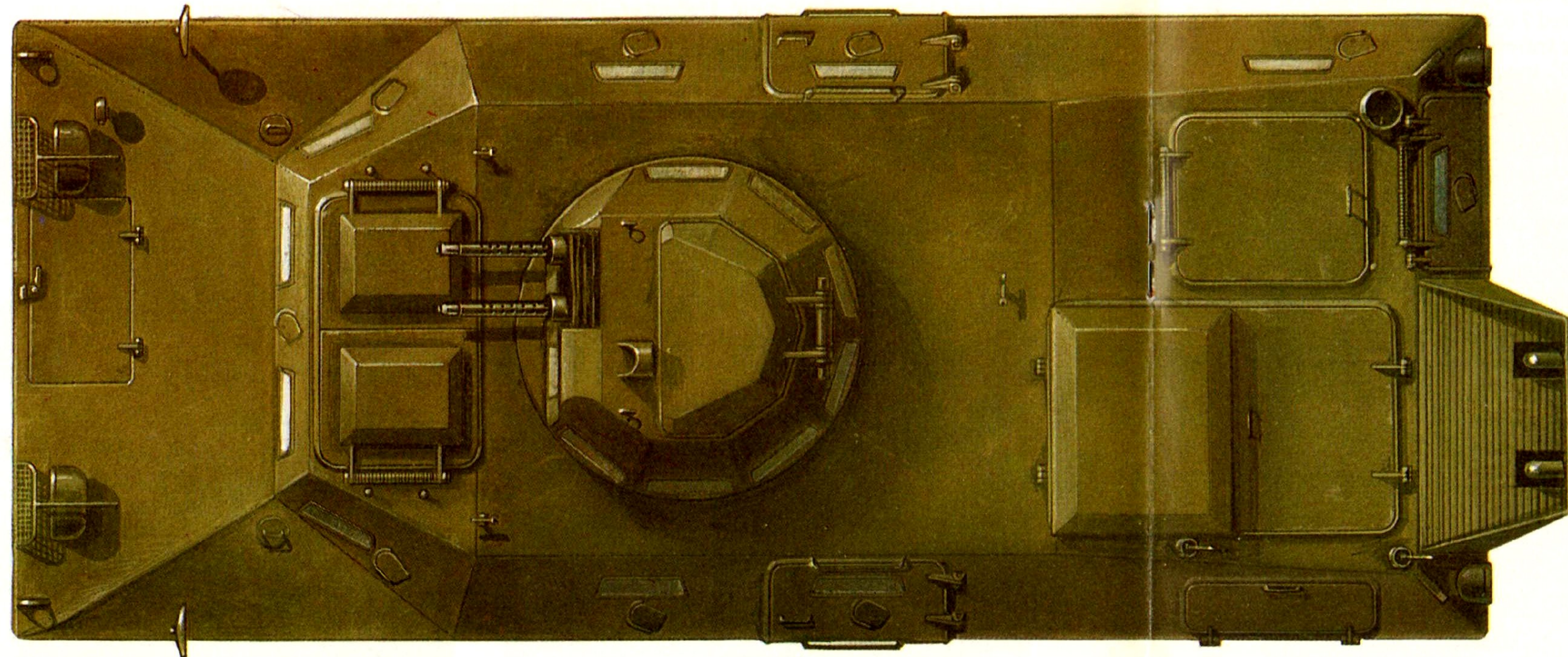




0 5ft

Four views of the Commando – a vehicle designed to function in a variety of roles.

*Terry Hadler © Profile Publications Ltd.*





The first amphibious Twister shows its paces as it leaves a river—December 1970. (Lockheed Missile & Space Co.)

one light series weighing some 17,000–18,000 lbs for reconnaissance, escort duties etc, and a medium range in the 23,000–25,000 lbs class for use as an infantry fighting vehicle, anti-tank assault vehicle and forward area air defence vehicle.

In 1972 Lockheed was one of the two companies (the other being FMC) selected to build prototypes of the XM-800 ARSV (Armoured Reconnaissance Scout Vehicle). This vehicle will have six wheels. Four prototypes are being built by Lockheed under a 12 million dollar contract, the first three to be built by the end of 1973. The FMC vehicle is tracked.

**TWISTER COMPARISON TABLE**

	Testbed	06 Testbed	XM-808
Gross vehicle weight	12,070 lbs	16,570 lbs	20,450 lbs
Overall length	200"	220"	220"
Width	103"	105"	105"
Height	77"	82"	97"
Ground clearance	16"	18"	18"
Power Loading	38 hp/ton	69 hp/ton	56 hp/ton
Turn radius	19.5'	19'	19'
Max. Rim Pull	15,469 lbs	36,595 lbs	36,595 lbs
Acceleration 0–30 mph	10 sec	5.4 sec	6.5 sec
Cruise speed	50 mph	65 mph	65 mph
Top speed	55 mph	65 mph	65 mph
Speed on 60% grade	4 mph	12 mph	11.5 mph
Ground pressure	4.5 psi	5 psi	6 psi
Maximum side slope	60%	55%	50%
Articulation freedom:—			
pitch	+35° –27°	+35° –27°	+35° –27°
roll	±30°	±30°	±30°
yaw	±23°	±31.5°	±31.5°

The armoured Twister, XM808, climbing a steep slope. Note the 20mm cannon. (Lockheed Missile & Space Co.)



## SWAT AND OTHER ARMOURED CARS

The Defense Operations Division of the Chrysler Corporation has designed three types of armoured car, light, medium and the SWAT.

### LIGHT ARMOURED CAR

This was a project only and was to have been armed with a .30 turret-mounted machine-gun, or a water cannon. It was similar to the British Shorland Armoured Patrol Car in appearance, and was designed for a similar purpose. Basic data was:

Length overall	16' 8"	Width	6' 8"
Height	6' 11"	Wheelbase	10' 6"
Ground clearance	12½"		

### MEDIUM ARMOURED CAR

Also called the MAC-1 and Mk.IV Armoured Car. Fifteen of these were built for Mexico and delivered in 1960/1961. The vehicle was not amphibious and was powered by a Chrysler 361 engine developing 190 bhp, giving a road speed of 65 mph and a range of some 300 miles. Crew was four. Armed with a turret-mounted 20mm cannon. Other data was:

Length	17' 3"	Width	8'
Height	6' 11"	Wheelbase	9' 4"
Weight	6.7 tons		

### SWAT

The SWAT (Special Warfare Armoured Transporter) did not progress further than the mockup stage and, according to the manufacturers, was designed to perform a variety of missions including convoy escort, armoured assault and infantry carrier. The flat underbody would have provided mine blast protection for the crew, and the axle centre sections and propeller shafts would have been completely enclosed.

The turret diameter was 34" which would have allowed other turrets to be fitted. Basic armament would have been one turret-mounted 40mm grenade launcher M75 and one co-axially mounted 7.62mm machine-gun M73. These would have had a traverse of 360°, elevation of +60°, depression of –10°, traverse and elevation being manual. Also fitted would be two 3-tube cluster anti-personnel grenade launchers. 3000 rounds of 7.62mm and 300 rounds of 40mm ammunition would be carried. A total of 13 gun ports were provided in the hull. Twelve fully equipped troops could be carried. The vehicle would have been fully amphibious, and the hull would provide protection against .30 ball ammunition at point blank range and against .30 armour-piercing ammunition at 50 m. Optional extras would include a 10,000 lb hydraulic winch. Data is as follows:

Length:	20'	Width:	8'
Height:	8' 3"	Ground clearance:	15"
Curb weight lbs:	15,500	Maximum speed:	65 mph
Payload:	4,000 lbs	Water speed:	3 mph
Gross weight lbs:	19,500	Gradient:	60%
Range (miles):	500 (maximum)	Vertical obstacle:	22"
Turning radius:	32'	Suspension:	independent
Engine:	Chrysler 361,215 HP at 4,000 rpm		
Transmission:	Automatic 3-speed with torque converter		
Axles:	Hypoid drive through with in-out engagement for 4 or 8 wheel drive		
Electrical:	24-volt waterproof, radio suppression		
Bilge pump:	Two pumps, electric, 50 gallons a minute		
Fire extinguisher:	Fixed 5 lb carbon dioxide in engine compartment		
Vision devices:	Hull—four periscopes and 16 ballistic vision blocks		
	Turret—one M28C modified and 11 direct vision blocks		
Tyres:	18 x 19.50 (special run-flat)		
Shock absorbers:	Hydraulic, direct, double acting (two each wheel)		
Steering:	Semi-integral hydraulic cam & lever power assisted		
Brakes:	Sealed drum and shoe. Vacuum/hydraulic		

## U.S. ARMY T115

This was conceived in 1957 at Tank Automotive Command as a four-wheel reconnaissance vehicle. A whole series of these were projected to include a weapons carrier and an ambulance. The basic vehicle was armed with a .50 machine-gun. The project progressed as far as a mock-up of the basic vehicle.

There were also other projects for wheeled APCs and armoured cars in the early 1950s.



*The XM808 under test.*

(Lockheed Missile & Space Co.)

*The Chrysler MAC-1 armoured car in Mexico. (top right)*

(J. Quijas via R. J. Icks)

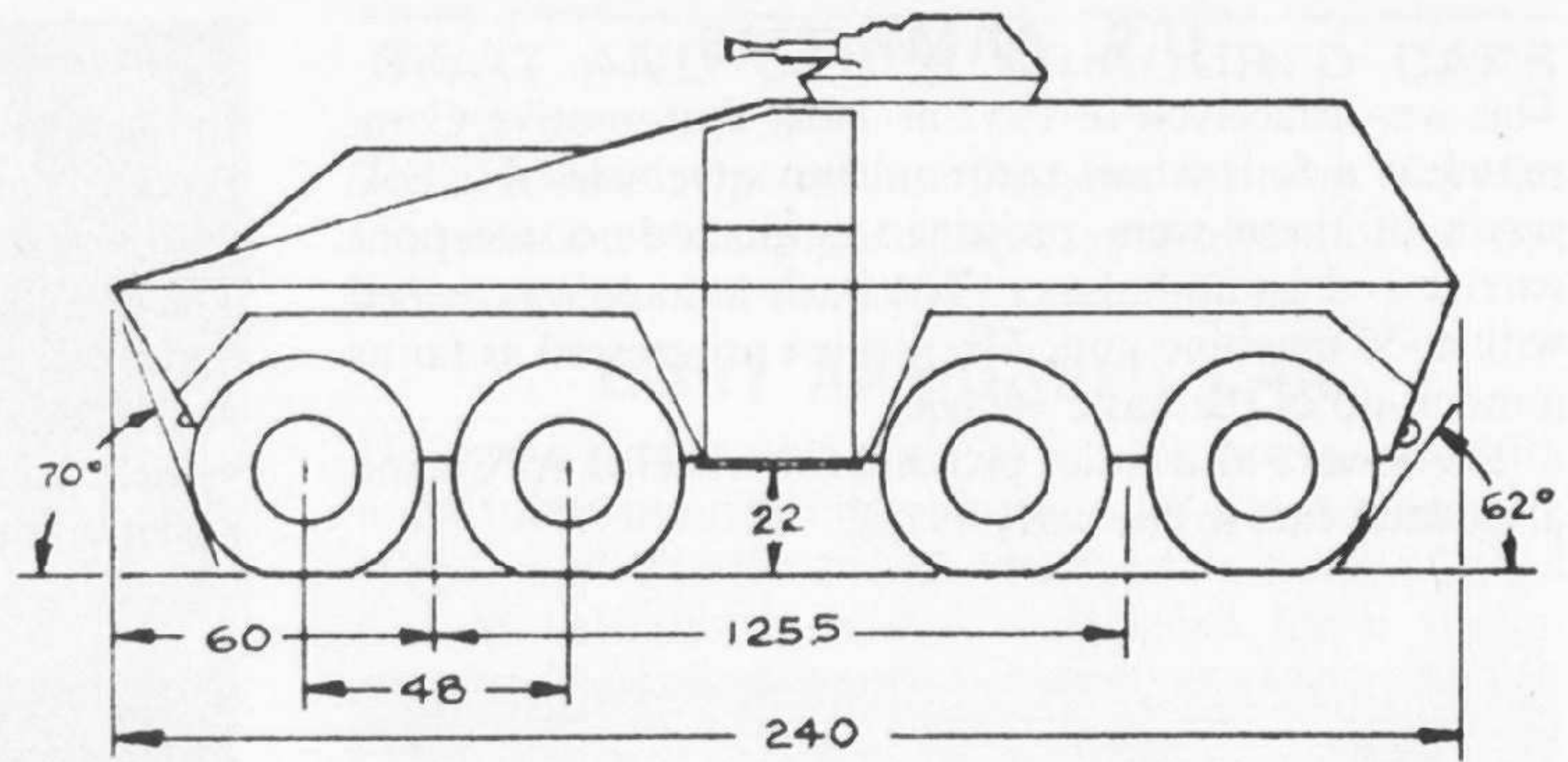
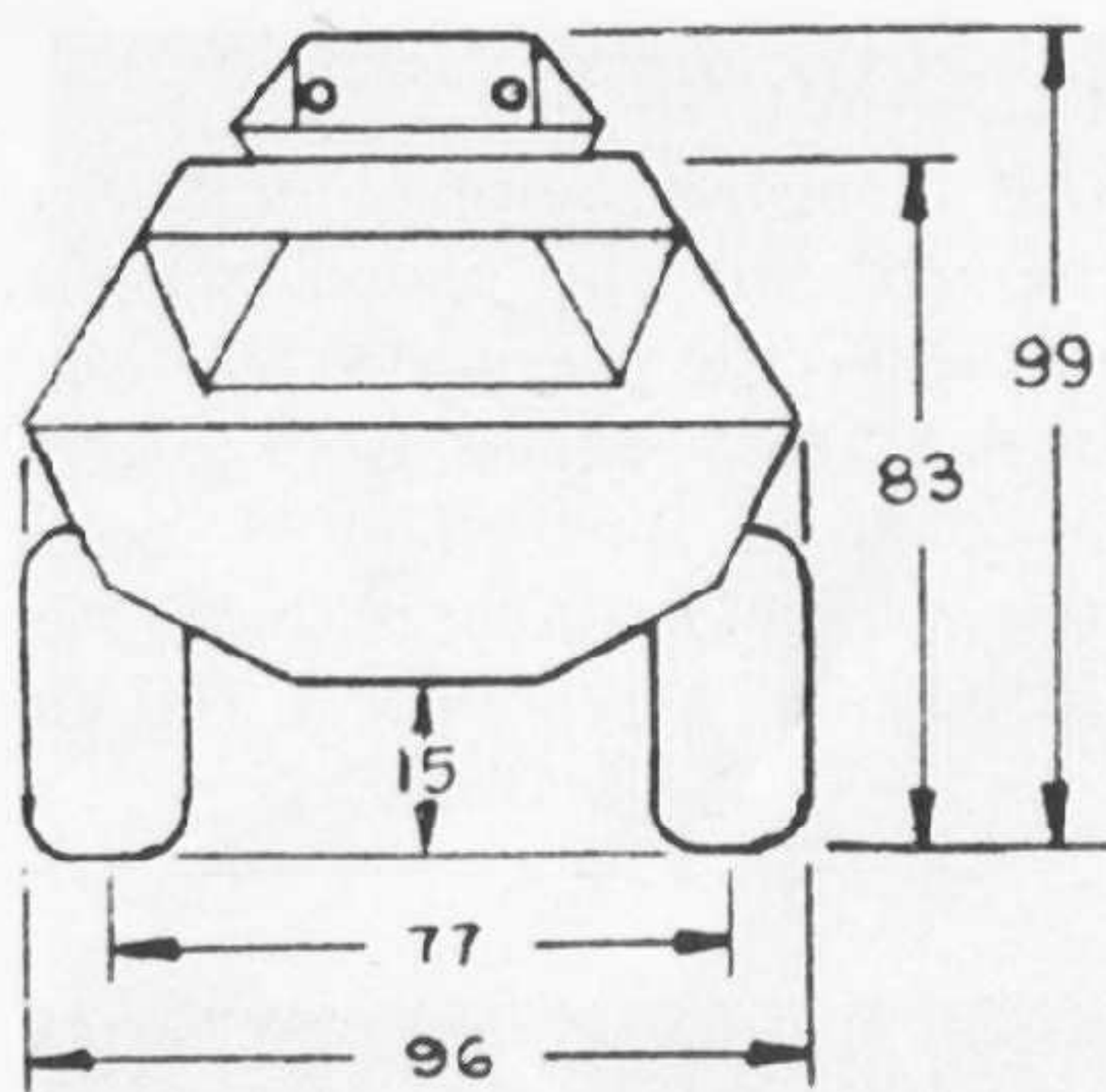


*XM808 carries out a high speed turn. (Lockheed Missile & Space Co.)*

*XM808 on trials.*

(Lockheed Missile & Space Co.)





Front and left side views of SWAT which did not progress further than the mockup stage.

(Chrysler)

## HIGH MOBILITY/OFF ROAD VEHICLES

The United States Army has over the past few years developed a large number of high mobility vehicles. Below are some of the more interesting ones.

### GAMA GOAT

The original Gama Goat was invented, designed and built by Roger L. Gamaunt in his shop at Fawnskin, California in the 1950s. The vehicle was powered by a 6-cylinder air-cooled Corvair engine.

A United States Army requirement for a vehicle of this type already existed. According to a report issued in 1971 ("Need to improve management of the Army's tactical vehicles development programme", January 27, 1971, Reference B-133256), "The essential characteristics originally expressed by the user included decreased weight, increased cargo space, improved reliability and ease in loading and unloading of personnel as compared

with the characteristics of the M37  $\frac{3}{4}$  Ton Truck which it was to replace. These characteristics were not met, however, and possibly were not realistically achievable."

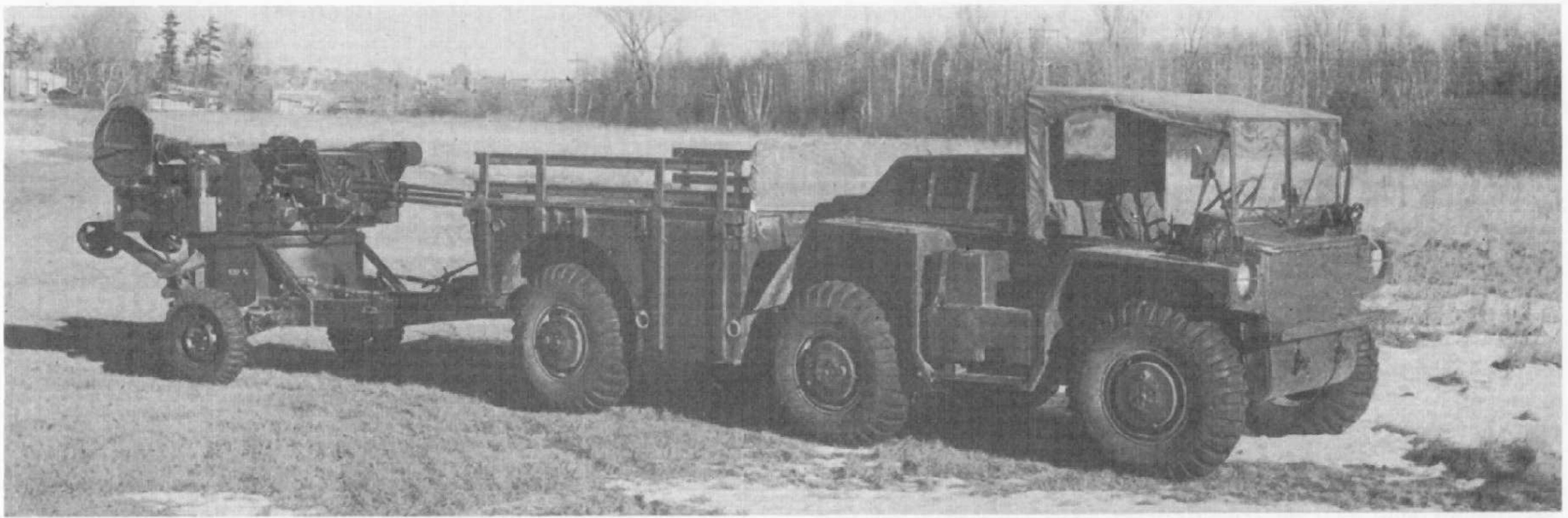
The Ling-Tempo-Vought (LTV) Corporation of Dallas from the early 1960s built 4 test rigs, 14 pilot models and 4 advance production engineering vehicles. These were tested in the United States, Panama and Thailand by the U.S. Army and U.S. Marine Corps. The vehicle was also tested in a British/U.S. exercise in Thailand called "Exercise Mudlark." Development costs amounted to some 9 million dollars. The engineering design and test phase of the programme started in March 1963 with the award of a R & D contract to LTV. Concurrently with this R & D phase an advance production engineering programme was also conducted with LTV.

The vehicle was made Standard "A" in June 1966 and cleared for production on the basis that defects shown up during tests were corrected prior to the awarding of the production contract. The production contract was

The original Gama Goat demonstrating its capabilities over rough ground and its troop carrying capacity.

(via R. W. Forsyth)





Early Gama Goat towing an M167 20mm Vulcan gun.  
(General Electric, Armament Department)



The original Gama Goat swimming. (via R. W. Forsyth)

delayed for some two years and when it was finally awarded in June, 1968, tests were still being carried out on the vehicle.

LTV and Kaiser Jeep bid for the production contract together, but the contract was given to the Consolidated Diesel Division of the CONDEC Corporation at Schenectady, N.Y. The first production vehicles were delivered in 1971 and production problems were encountered with various components and strikes. The programme was also scaled down and only active army units were to be equipped. The original order was to have been for 29,649 units.

The Gama Goat (M561) is a dual body configuration with 6 wheels and selected 2 or 6 wheel drive. Its two aluminium bodies are connected by an articulating assembly permitting them to arch vertically (pitch) and rotate (roll) with respect to each other, so that the two bodies always conform independently to all types of terrain. Co-ordinated 4 wheel steering of front and rear

wheels is provided. Oversized tyres, allowing a low tyre pressure, provide increased traction and drawbar pull in mud, snow or sand. The vehicle can cross inland waterways by swimming. It can also be air-dropped or carried by helicopters (ie internally and externally with a CH-47A).

#### Variants

The following kits were developed for the vehicle:

Kit, ambulance, 3 litter or 6 sitting patients, plus attendant. (Also M792, Ambulance, Frontline, 1½ ton, 6 × 6.)

Electronic Shelter, S-250.

Kit, Heater, Ambulance.

Kit, Machine Gun, 7.62mm, M60 on RHS of vehicle, 800 rounds of ammunition. Traverse was 85° right, 32° left, elevation -9° to +18°. Without the canopy the mg could be traversed through 360°.

Kit, Mortar, 81mm, M29 (Stowage) for ground firing, plus 80 rounds of ammunition.

Gama Goat on test.

(LTV)







½ ton infantry load carrier, infantry burden carrier, MICV, Forsyth MBT (1962), and the ARSV.

### PATA

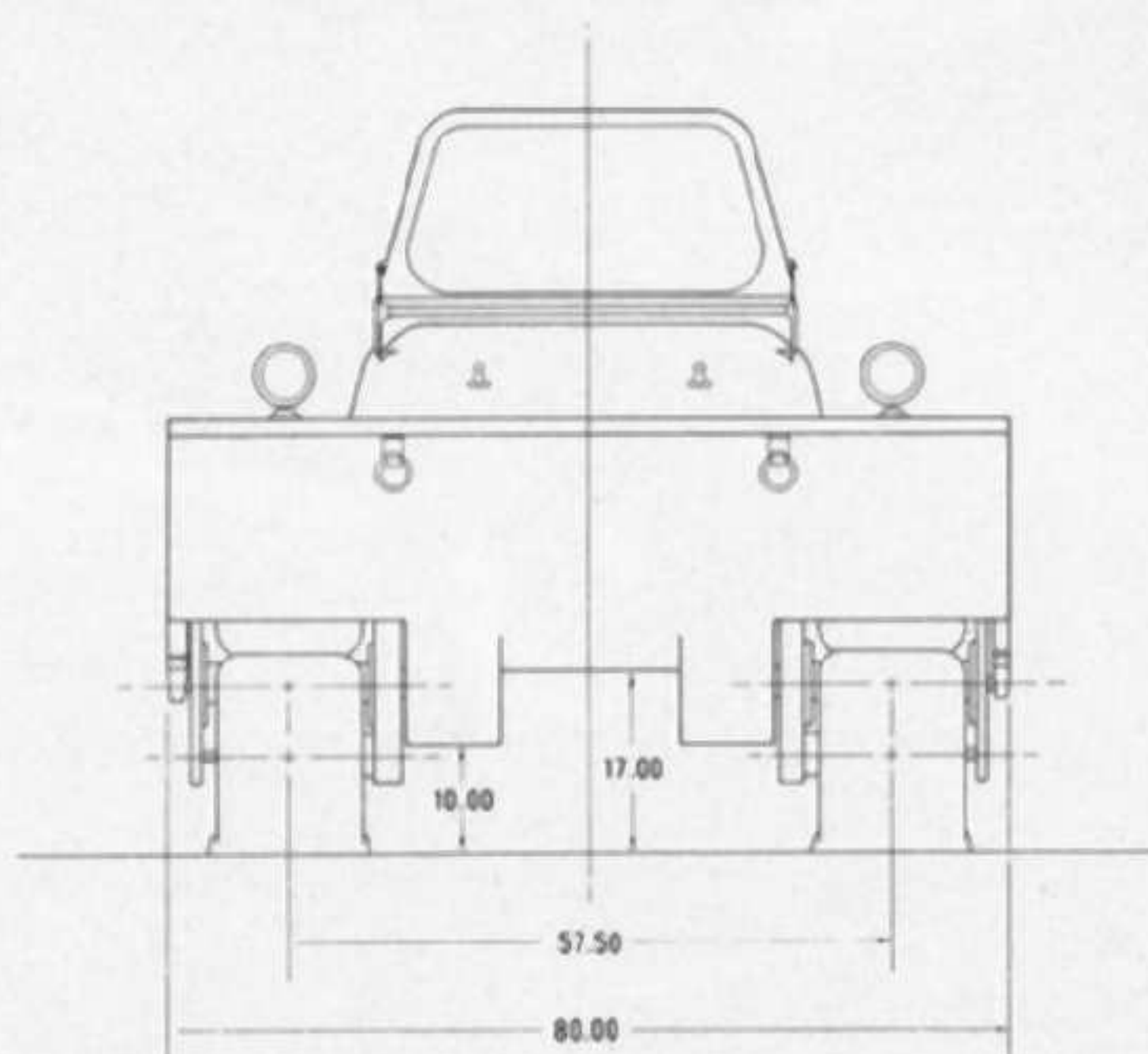
The PATA (Pneumatic All-Terrain Amphibian) was developed by Ling-Temco-Vought Incorporated of Warren, Michigan. The vehicle is basically a rubber-tracked vehicle with its cargo-carrying hold supported by rotating cushions of air. Each of the two oval treads consists of an endless belt with 34 inflated air cells attached. The air pressure in these cells is approximately 1½ psi. These air cells are made up of two parts—an outer shoe, and an inner bladder. Both are made of natural rubber. The air cells, hinged to each other, are assembled in a continuous belt to form one complete tread. Poly V belting is used in each tread for its ability to provide side load support when used in matching rollers that take the vertical load. Alternate air cells are interconnected in groups of four by manifold types of air ducts.

The vehicle is powered by a Buick V-8 of 215 cu. in. Power is via a 4 speed Corvair transmission and a regenerative control differential to drive the two rear sheaves; these, in turn, are friction-coupled to the treads. Tread matching is assured by matching Poly V belting material bonded to the sheaves over which the treads run.

When on land the vehicle is steered by the conventional steering wheel, signals being sent to the regenerative control differential which then appropriately applies steering effort to either tread. In water operation, manifold vacuum-operated brakes may be applied to slow or completely stop either tread. PATA was also known as Plenum Air Tread Amphibian.

Basic data of the research Testbed were:

Length:	216"	Maximum height:	118"
Width:	118"	Width reducible to:	99"
Cargo hold length:	119"	Curb weight:	6569 lb
Cargo hold width:	46"	Normal gross weight:	9069 lb
Cargo hold height:	47"	Overload weight:	10,069 lbs
Speed land:	35 mph	Speed water:	10 mph
Gradient:	60%	Side slope:	30%



The PATA can carry ten fully equipped troops plus a crew of two. The rear of the vehicle can be folded down to gain entry to the vehicle.

### NOTE

The Japanese developed a number of swamp crossing vehicles during the Second World War. One of these vehicles weighed 5 tons and had a length of 22' 2", width of 9' 3" and a height of 9' 3". These were very similar to the PATA type vehicles developed some 20 years later.

### XM759 MARGINAL TERRAIN VEHICLE

This vehicle was developed by the United States Army for the United States Marine Corps for use in South-East Asia. The approved development project, initiated in May 1966, provided just 17 months to the first production roll off. In April 1969 however, the USMC revised its requirements to a more normal development programme.

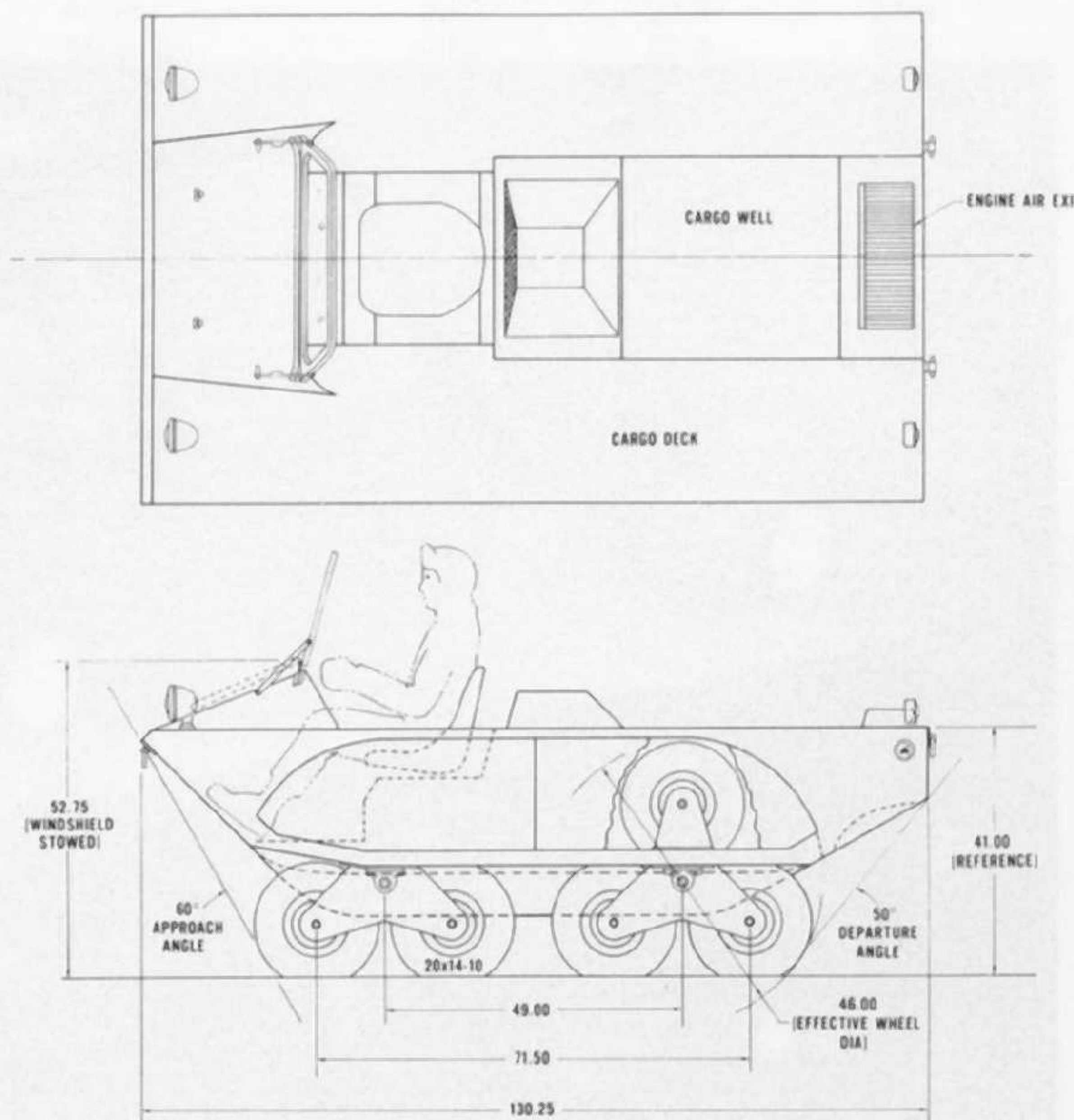
Seven pilots were built at Detroit Arsenal and according to a GAO Report (B-133256) they had numerous deficiencies including: unsafe braking system, unachievable water speeds, unreliable and vulnerable tyres, high maintenance requirements, hazardous slope operation and high curb weight. There was a total of 17 tyres on each side of the vehicle. Full designation: XM759, 1½ ton, cargo carrier (soft tyre tracked). Gross weight 11,500 lbs, carries 3000 lb of cargo or 14 fully equipped men plus a crew of 2. Speed on land 35 mph, and on water 7 mph (these speeds would appear to be rather liberal).

Side view of Terra Star showing the wheel assemblies.

(Lockheed Aircraft Service Co.)

General arrangement drawings of Terra Star top, side and front.

(Lockheed Aircraft Service Co.)





The Lockheed Terra Star at speed. (Lockheed Aircraft Service Co.)

### AIR ROLL 1

This was developed in the early 1960s and designated LVA-X1—Swamp Carrier—Amphibious, personnel, weapons,  $\frac{1}{2}$  ton, Air Roll 1. It had a total of 13 tyres either side in a similar manner to the XM759. Other data was: weight 3 tons, land speed 25 mph, water speed 6-8 mph, range on land 68 miles and on water 31 miles, engine hp 102. It was 16' long, 7' 10" wide and 7' 10" high. There was also a Borg-Warner/USN Air Roll which weighed some 19,000 lbs.

### THE GOER SERIES

In 1956 the Armour Board studied current large tyred earthmoving and construction vehicles. These studies led to the development of the GOER vehicles. In 1958 contracts were awarded to the Clark Equipment Company for a 5 ton test vehicle (XM520, 4x4) and to LeTorneau/Westinghouse for 15 ton vehicles (XM437). After trials, further vehicles were built:

*8 ton series*—by Caterpillar, first prototype completed in 1961 followed by a contract in May 1963 for a further 23 vehicles (13 cargo, 8 tankers and two wreckers). These were delivered to the U.S. Army by June 1964.

*16 ton series*—by LeTorneau/Westinghouse. XM437E1, XM438 (5000 gallon tanker).

### Description of 8-ton GOER

The GOER is an articulated vehicle that has no suspension as such; instead it relies on large diameter high flotation tyres to provide mobility. Positive articulated steering increases the mobility of this type as it allows the unit to be swung from side-to-side over soft or wet underfooting. It has a 60° right and left steer capability and air brakes are fitted. Each swing draws the trailing unit forward and is continued until the unit has passed over the soft ground. The vehicle is fully amphibious. Lateral articulation between front and rear units is 20° on each side, providing adequate oscillation for the roughest terrain. This enables the vehicle to cross gullies etc which vehicles with a solid frame would find a strain. It also permits all the four wheels to remain in contact with the ground at all times.

The vehicle is powered by a Caterpillar D333 4-cycle in line, 6-cylinder diesel engine, displacement being 638 cu. in. From the engine the power is carried through the transmission, a drop box and short propeller shaft, to the front differential and out to the planetary drives in the front wheels. Power to the rear wheels is carried from the front differential through a disconnect clutch, then through propeller shafts and universals to the rear differential. The final drives in the rear wheels are also planetary. The vehicle is fitted with a Caterpillar designed six speed, planetary-torque converter powershift transmission. All 6 forward and 1 reverse speeds are controlled by a single shifting lever at the driver's RHS. The electrical system is 24v. The front and rear units can be changed with those of other vehicles at base workshop level.

### 8 ton cargo truck M520

This carries six standard military pallets, or one CONEX container and two pallets or up to 25 55-gallon drums. The two side doors and rear door are interchangeable and when these doors are closed they are watertight. Cargo unit dimensions are: length inside 196", width between wheel wells 58", width of side doors 106", width of rear doors 58", width of inside 100" and height of

When the Terra Star is swimming the major-wheel mode operates. Entering and leaving the water the minor-wheels are used.

(Lockheed Aircraft Service Co.)





XM759 Marginal Terrain Vehicle.

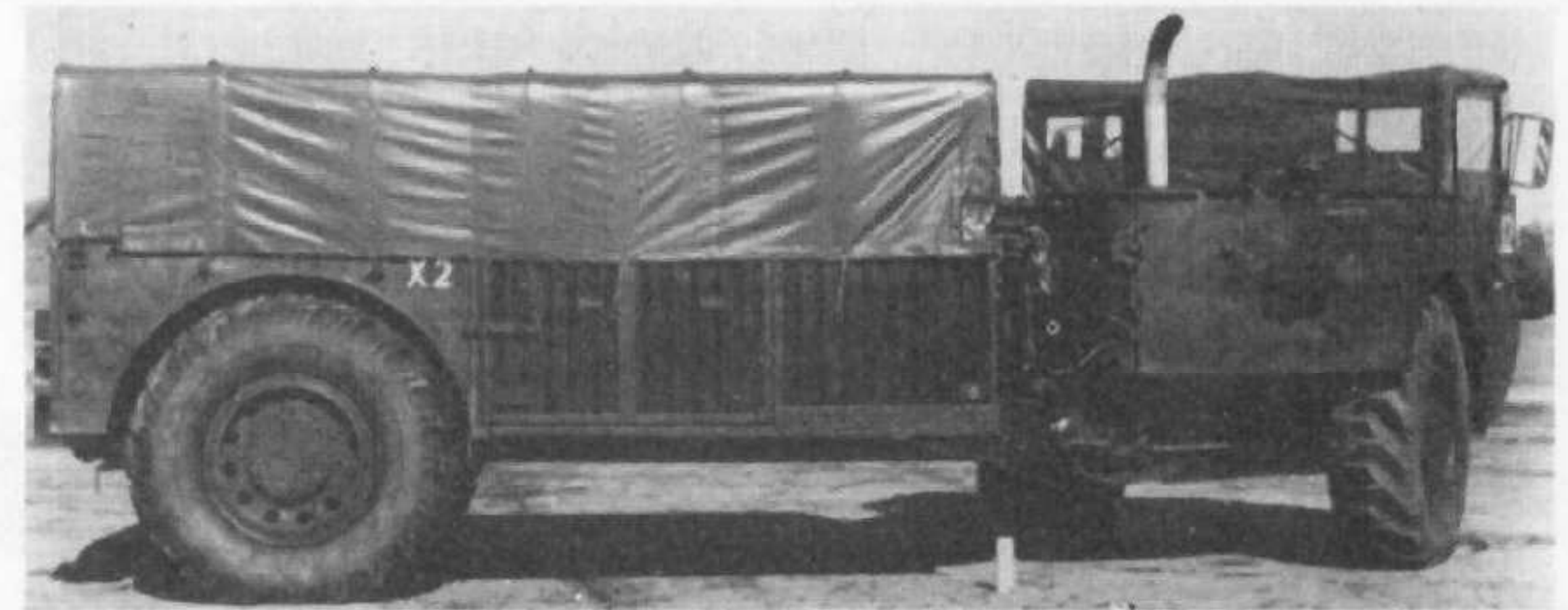
(U.S. Army, TACOM)



The U.S. Army PATA test bed. PATA=Pneumatic All-Terrain Amphibian. It is a rubber-tracked vehicle supported by rotating cushions of air.

The 8-ton GOER XM520E1 with vehicle at full 60 degrees left steer.

(U.S. Army, TACOM)



sides 48". A 10,000 lb hydraulic winch is provided at the front of the vehicle.

### 2500 gallon tanker M559

This carries 2500 gallons of fuel. Three discharge hoses are provided, centre one for 100 gpm, left and right for 50 gpm, and another outlet with a maximum discharge of 300 gpm. In addition 2 x 55 gallon drums of lubricating oil are carried.

### 10 ton wrecker XM553

This has a 17-75' boom with a 3' hydraulic extension and a traverse of 360°. At 16' it will lift 10,000 lb, at 11' 15,000 lb and at 6' 20,000 lb. Extra stability is provided by manually operated outriggers. A hydraulic pump driven from the engine crankshaft operates the hoisting mechanism. It can also carry two spare tyres. As with all the GOERs it can tow up to 20,000 lbs.

### Trials with prototype GOERs

From 1961 trials were conducted with these GOERs in the USA, Panama and Alaska. In June 1964, 23 vehicles were sent to Germany for troop testing where they proved highly successful under all conditions. These trials were completed at the end of 1964, and the vehicles stored in Germany.

In 1966 it was decided to deploy the vehicles to Vietnam. 19 were sent to Vietnam comprising 11 cargo, 7 tankers and one wrecker. Two of these came from the US and the other 17 from Germany, the first vehicles arriving in June 1966.

In their first 18 months they moved 20 million pounds of cargo and 1.7 million gallons of fuel. Availability was 87.3% which was excellent when one considers that the vehicles were prototypes and somewhat old, having already been used in Germany. By the end of June 1968 they had travelled 190,476 miles, carried 1,982,051 gallons of fuel and hauled 31,717,000 lbs of freight. Whilst in Vietnam two were lost to mines and one by fire.

In May 1971 a contract was awarded to Caterpillar for

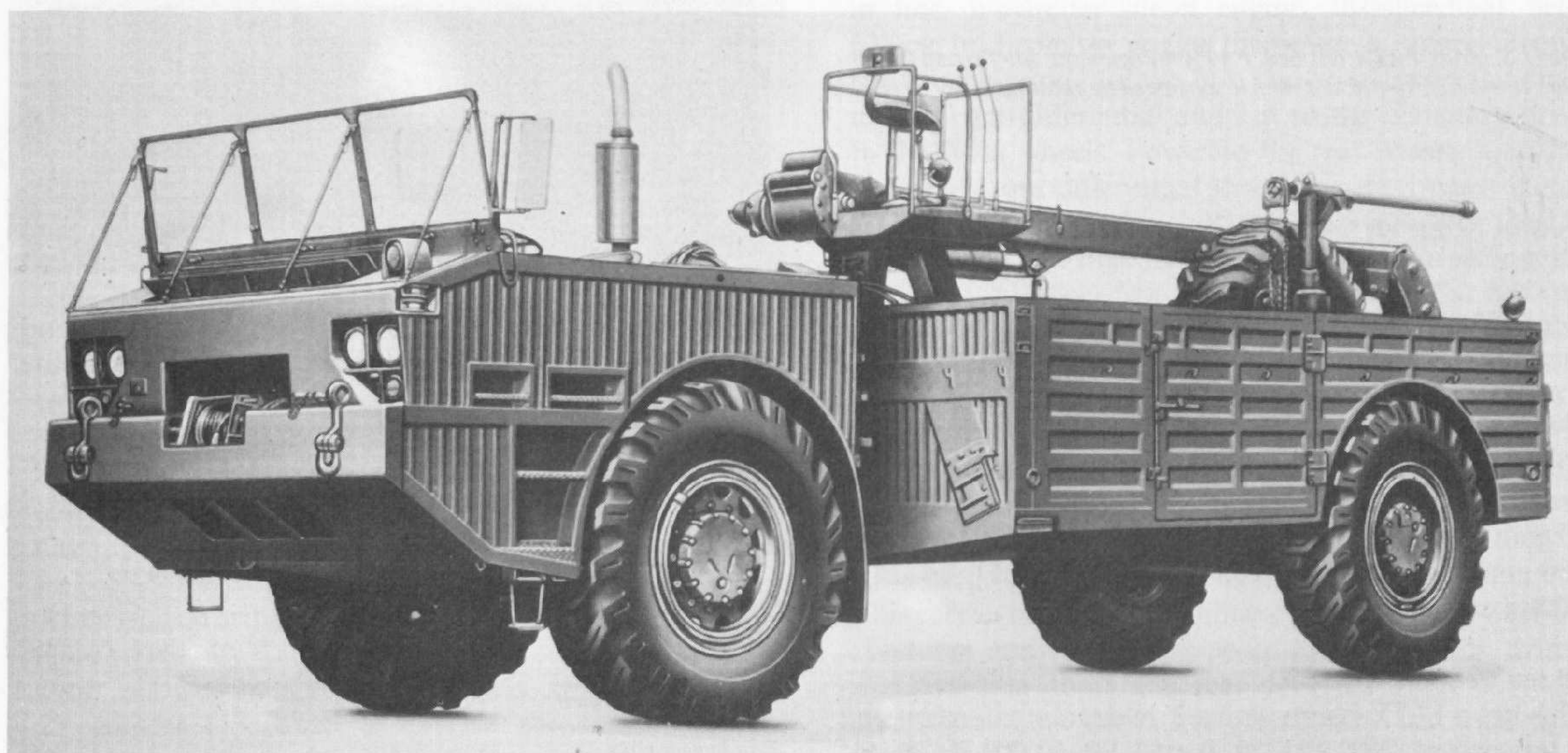
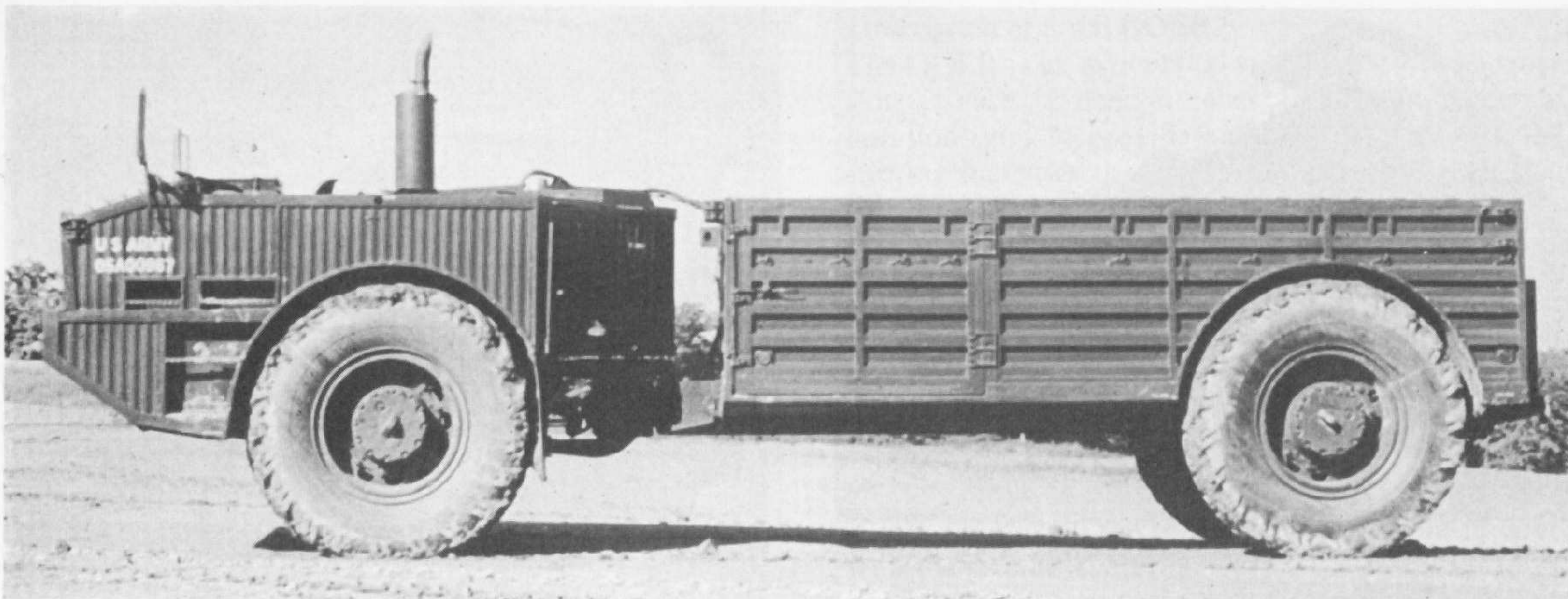
the production of 812 M520s, 117 M553 Wreckers and 371 M559 tankers, the contract being worth some \$61.5 million.

### GOER CHARACTERISTICS

	M520 Cargo	M559 Tanker	M553 Wrecker
Curb Weight lbs	24690	28350	39240
Gross Vehicle Weight lbs	41090	45850	46540
Payload lbs	16400	16000	8610
Length inches	308.8	391	401
Width inches	108	108	108
Height empty (top of exhaust stack)	133.8	133.8	133.8
Height reducible to—			
inches	96.1	101	118
Wheelbase—	235	235	235
inches			
Tread—Front—	86.8	86.8	86.8
inches			
Tread—Rear—	86.8	86.8	86.8
inches			
Ground Clearance (Min)			
Rear Axle	23.3	23.3	23.3
Front	23.3	23.3	23.3
Midship	29.3	29.3	29.3
Angle of approach	35°	35°	35°
Angle of departure	41°	35°	35°
Pintle Height empty—			
inches	33	—	—
Min. Turning diameter, Right & Left—			
ft.	54.5	54.5	54.5
Water speed mph	3.3	3.3	3.3
Engine HP Gross	213/2000 rpm	213/2000 rpm	213/2000 rpm
Fuel—US gallons	110	110	110
Tyres	18.00 x 33	18.00 x 33	18.00 x 33
Max speed mph	30.2	30.2	30.2
Maximum gradient	60%	60%	60%
Cruising ranges—miles	300/400	300/400	300/400

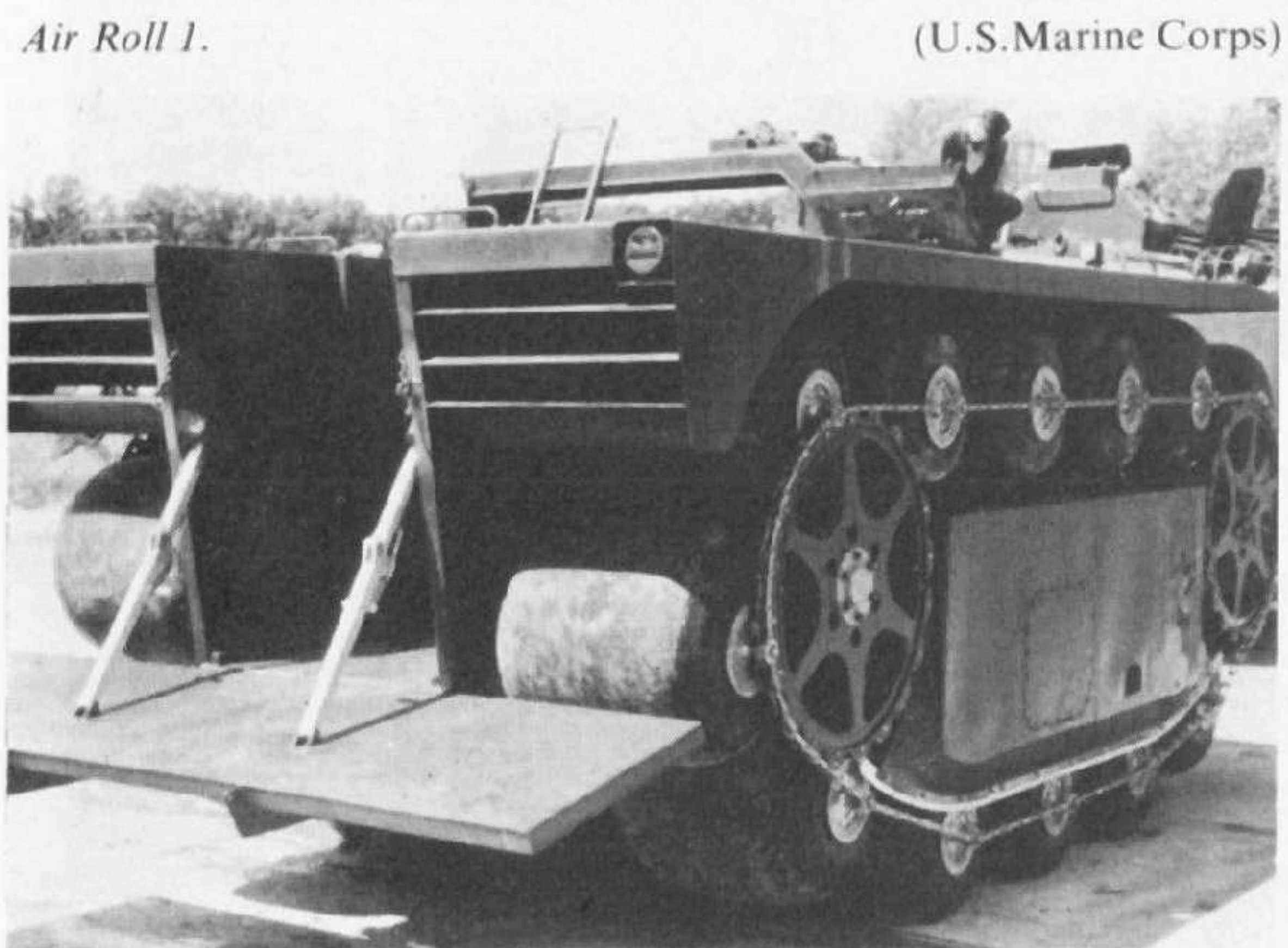
Note the above data relates to the 1965 vehicles, data in current models may vary.

	XM437E1 Cargo	XM438E2 Tanker	XM554 Wrecker
Curb weight—lbs	38670	39580	57600
Payload—lbs	32000	32000	8650
Length	40' 11"	38' 2"	41' 6"
Width	10' 3"	10' 3"	10' 3"
Height (min)	8' 11"	9' 6"	9' 11"
Ground clearance (loaded)	30.5"	30"	30"
Engine	all had GMC Diesel 336 HP at 2300 rpm		
Tyres	29.5 x 25	29.5 x 25	29.5 x 25



*Three-quarter left front view of the XM553 GOER wrecker.*  
(Caterpillar Co.)

*The MS20 GOER cargo vehicle. (top)*  
(Caterpillar Co.)



*Air Roll 1.*  
(U.S. Marine Corps)

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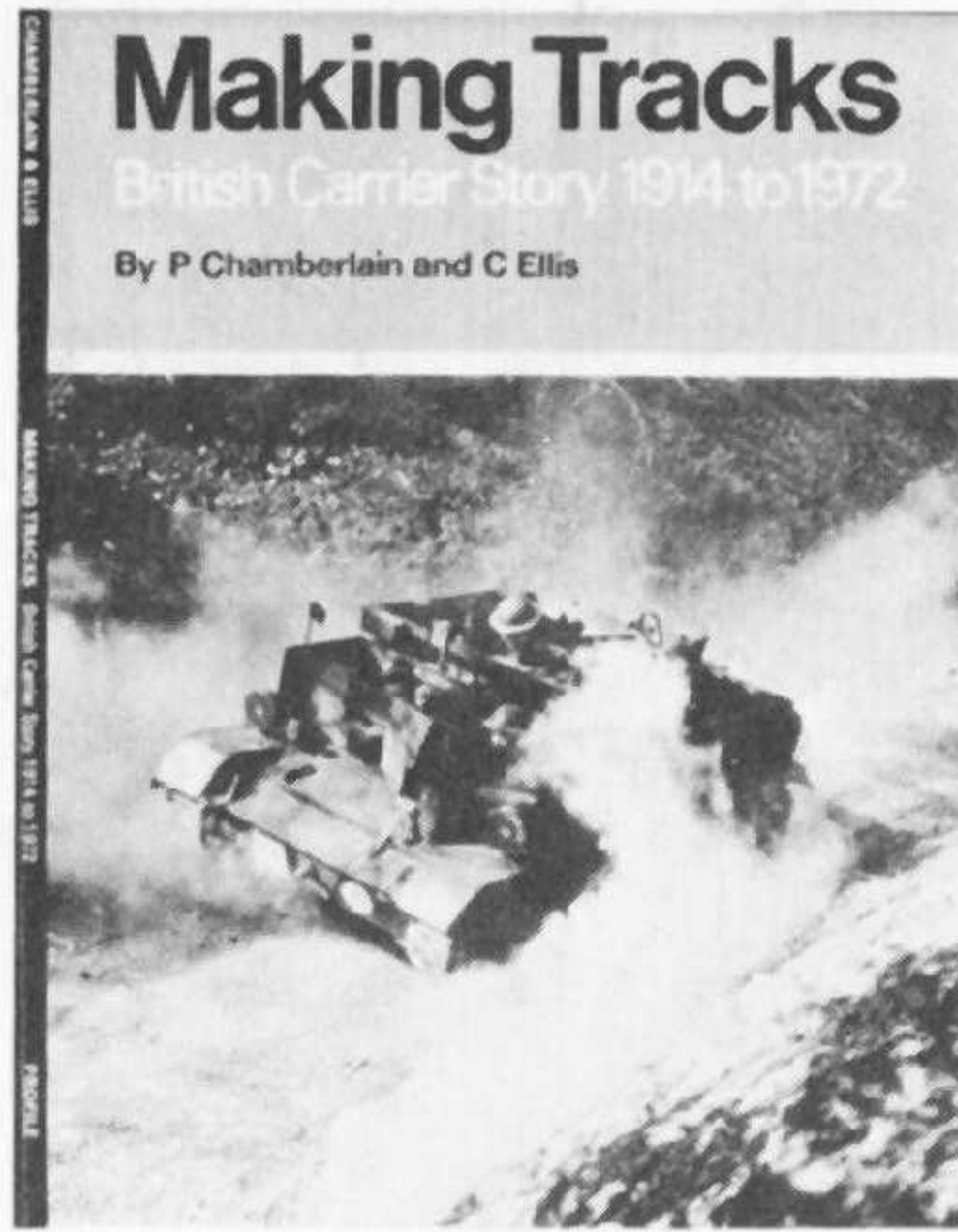
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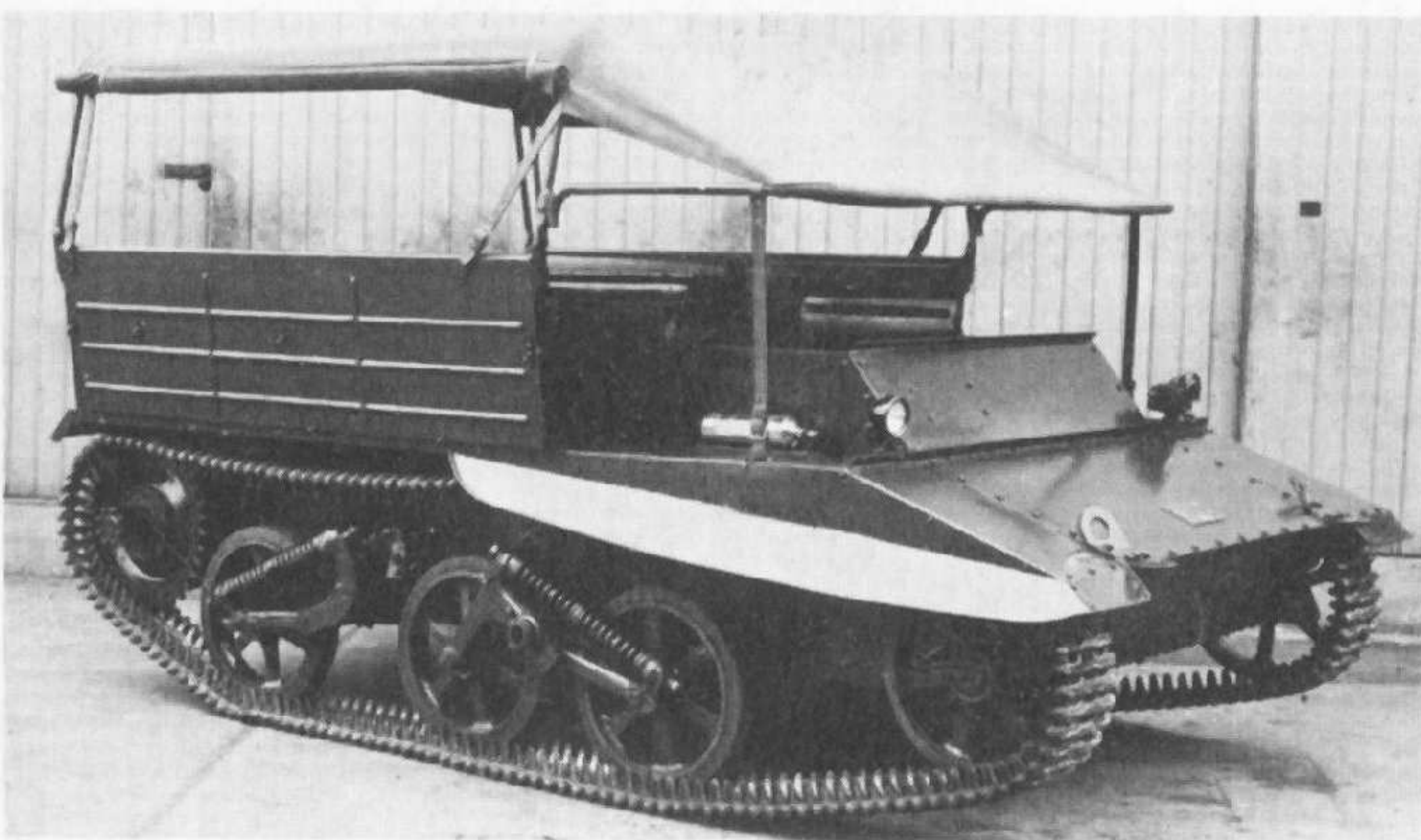
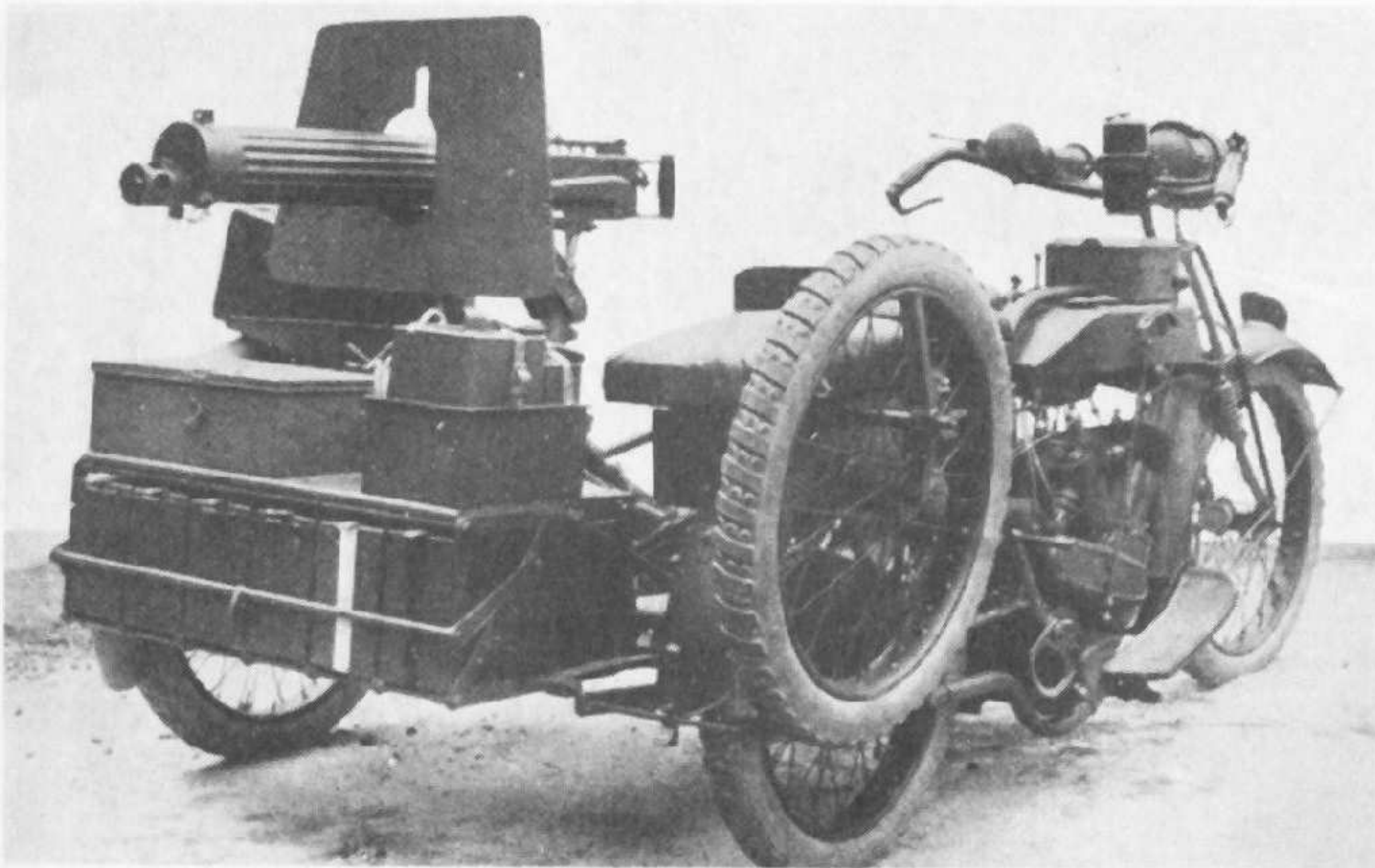
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