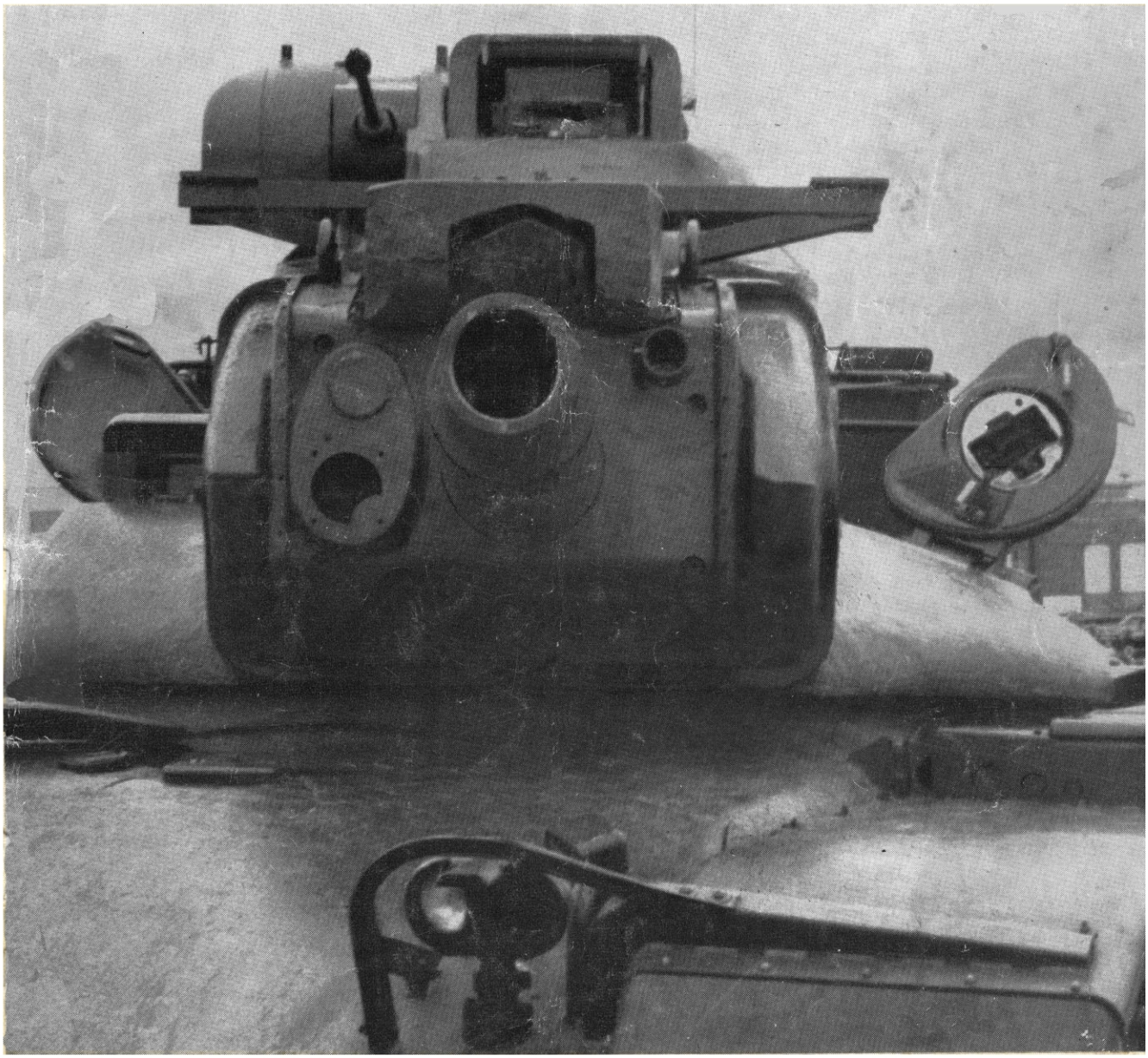
PROFILE

AFV WEAPONS

24

The M48-M60 Series of Main Battle Tanks

By Robert J. Icks, *Colonel USAR Retired*



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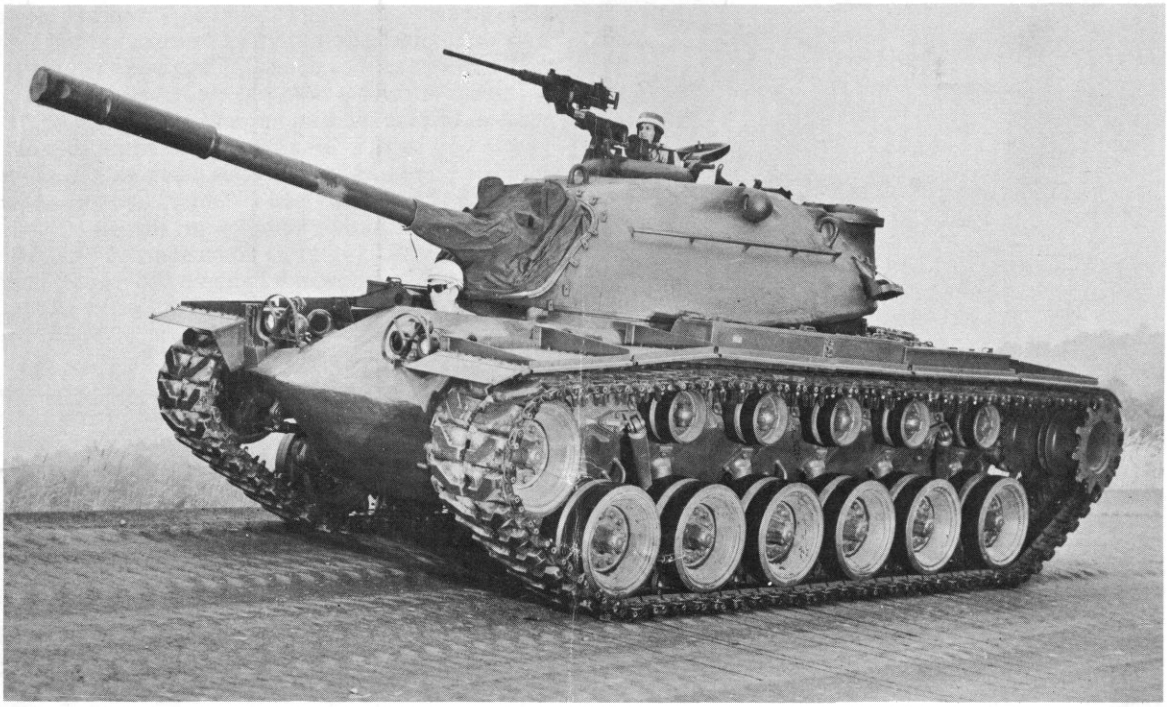


T 48 Prototype with original cupola and A/A machine-gun and with original 90-mm. gun, showing details of suspension.
Photo:—Courtesy Chrysler Corporation

The M48-M60 Series of Main Battle Tanks

by Robert J. Icks, Colonel A.U.S.–Retired

IN BATTLE

THE M48 originally was intended for use by United States forces in the Korean War had that war continued for longer than it did. However, the M48 did not become available until the war was over. M48 tanks, nevertheless, have since seen combat in traditional tank rôles in the hands of soldiers of other lands which received them from the United States by purchase or under military assistance programs. Among these were the Pakistanis, who used them in the short war against India in 1965.

After an advance into Pakistan north of Ferozepore on September 6 of that year, the Indians were driven back by Pakistani pressure. The Indians retreated to their starting point at Khem Karan but set a trap. In the area of Assal Uttar there was a river on the Indian left flank and a canal on their right. The Indians cut the canal in order to flood its immediate vicinity which made possible the channeling of the Pakistani advance. The story, somewhat extravagantly told by D. R. Mankekar in *Twenty Two Fateful Days* (Manaktaton, Bombay, 1966) continues:

"On September 8 morning, the enemy came with two squadrons of Chaffes (*sic*) and one of Pattons on a rekke-in-force (15 tanks) when he hit against our infantry positions on the main road. The rekke-in-force went back after a clash.

"That night the enemy returned with a whole combat group (one Patton regiment and two squadrons of Chaffes). It was a critical night, as he had brought armour in force and the defenders could not use tanks . . . With their infra-red eyes, the Pattons could see, but not our Shermans, which were 'blind' at night. But the Indian artillery stepped into the breach and did a grand job.

"On September 9, an Indian armoured brigade was rushed to the scene and straightaway . . . disposed . . . The entire battle plan formed into a horseshoe, into which the enemy was to be enticed.

"That day the Pakistanis launched yet another—the third—attack on our infantry position, which too was flung back. On September 10, the enemy came up in full force, with his infantry rolling up immediately behind a phalanx of armour.

"The main battle was joined at 08.30. Having failed to pierce our infantry position, the enemy armour tried a flanking movement, a sort of right hook, with a view to getting behind the infantry position. There, lying in wait, further behind, almost concealed in tall standing sugar cane crop, was a squadron of Centurions. The moment the line of Pattons turned and exposed their broadside, the Centurions opened up and threw the enemy into confusion. Here it was that we captured 15 Pak tanks intact, with their engines running and crews jumping out to surrender.

The production T48 with gun secured in the travel lock and turret to the rear, showing blackout lights and telephone box.
Photo—U.S. Ordnance Corps

"The enemy made a second, this time a wider flanking movement to get at our gun positions which had played havoc with them, and then ran into the jaws of another line of our Centurions . . . Having to fight in sugar cane and maize fields and peer through a 9 ft. high, thick, ripening standing crop, the Patton's visibility was reduced to a thousand yards, which is a Centurion's range, and thus it lost its extra advantages. Then again, quite a few of the heavy Pattons got bogged down into the submerged soft soil following the letting out of the water from the Rohi (canal) by our forces.

"This epic battle . . . comprised a series of six engagements, with which the Pakistanis were seeking a breakthrough. On the last day was fought the clincher and the fiercest of the series, when Pakistan's 4th Cavalry (50 tanks) was trapped and completely annihilated and the rest of the armoured division badly mauled.

"In the entire series, the Pakistanis lost 97 tanks counted as destroyed, disabled and captured . . ."

Contrast this poor showing by the Pakistani M48 tanks with the brilliant demonstration by Israeli armoured troops in the Six Day War in 1967. At the western end of the Gaza Strip in early June was a formidable Egyptian position. The Egyptian 7th Division had its three brigades in line parallel to the main highway south of Rahfa straight west to El Arish. Two additional battalions were east of Rahfa. A full brigade of artillery was located behind the infantry. West of there was the Jerardi hedgehog within which there were 30 bunkered Shermans, a full division plus two brigades and a hundred Stalin 3

Top view of the T48 with all hatches open and driver's periscopes lowered.
Photo—U.S. Ordnance Corps

(JS3) tanks in line behind the infantry trenches. There were deep minefields in front of the trenches and anti-tank batteries in pits extended along the entire front.

Instead of driving head on, the Israelis planned to send a brigade of armour and two battalions of paratroops serving as armoured infantry to probe through the dunes for an open flank to the south. The armoured brigade had a Patton battalion on the right and a Centurion battalion on the left. Colonel Uri Baron was the brigade commander and he took personal command of the Pattons. What took place then is described in *Swift Sword* by Brigadier General S. L. A. Marshall (American Heritage Publishing Company, New York, 1967):

"While Baron and his tanks looked on, waves of Israeli-built Fougas, flying very low, came on for a thirty-minute strike with rockets against the artillery bases . . . The Egyptians put up a storm of flak, but it was a perfect strafe, and not one Fouga got hit. The air force, destroying two-thirds of the fieldpieces based near Rahfa, made two hundred sorties on June 5 . . .

"Baron's Pattons then ran forward, seeking the soft spot south of the mined front. The Fougas roared back to pound the guns again as the tanks came even with the defended line, so that there would be no interval between the shock dealt to the artillery and the attempt to breach the infantry position. The company commander stood up in the turret of the leading Patton. The tank hit a mine and exploded into flames, killing both captain and crew. Their deaths saved the others. The tanks that followed saw at once that the captain had made too short a turn. Guiding on the pyre, they swung farther south through the dunes before veering west, then north, on a hook around the entrenchments.

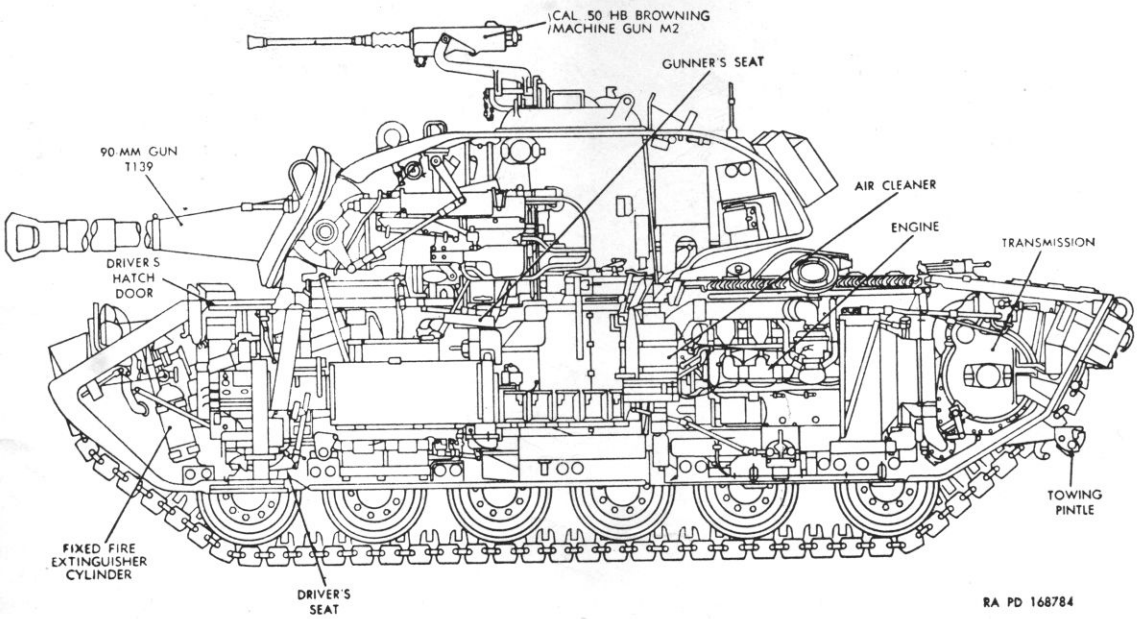
"Trailing after the tanks, using the same lanes, came the armoured infantry in half-tracks. Already the movement started to fall apart. The armour was charging on to strike deep and finish off the artillery position. The infantry was to double back and assault the main trench line from the rear. Traversing the loose dunes, however, the half-tracks simply could not keep the pace. Engineers had the mission of clearing a lane through the minefields.

"Completing the destruction of the artillery, the armour engaged a battalion of Stalins, destroyed most of them with gunfire at short range. A bit giddy with their success, both battalions ran on to attack infantry and machine-gun emplacements farther west. That was a mistake and not according to their instructions; one battalion was supposed to turn and help the armoured infantry in its mop-up of the entrenched line . . .

"After neutralizing some of the positions in the Egyptian brigade farthest south, the paratroops of one battalion had moved on north to attack the central perimeter. At that point their luck ran out. They became isolated and immobilized by fire on the ground where the two brigades joined.

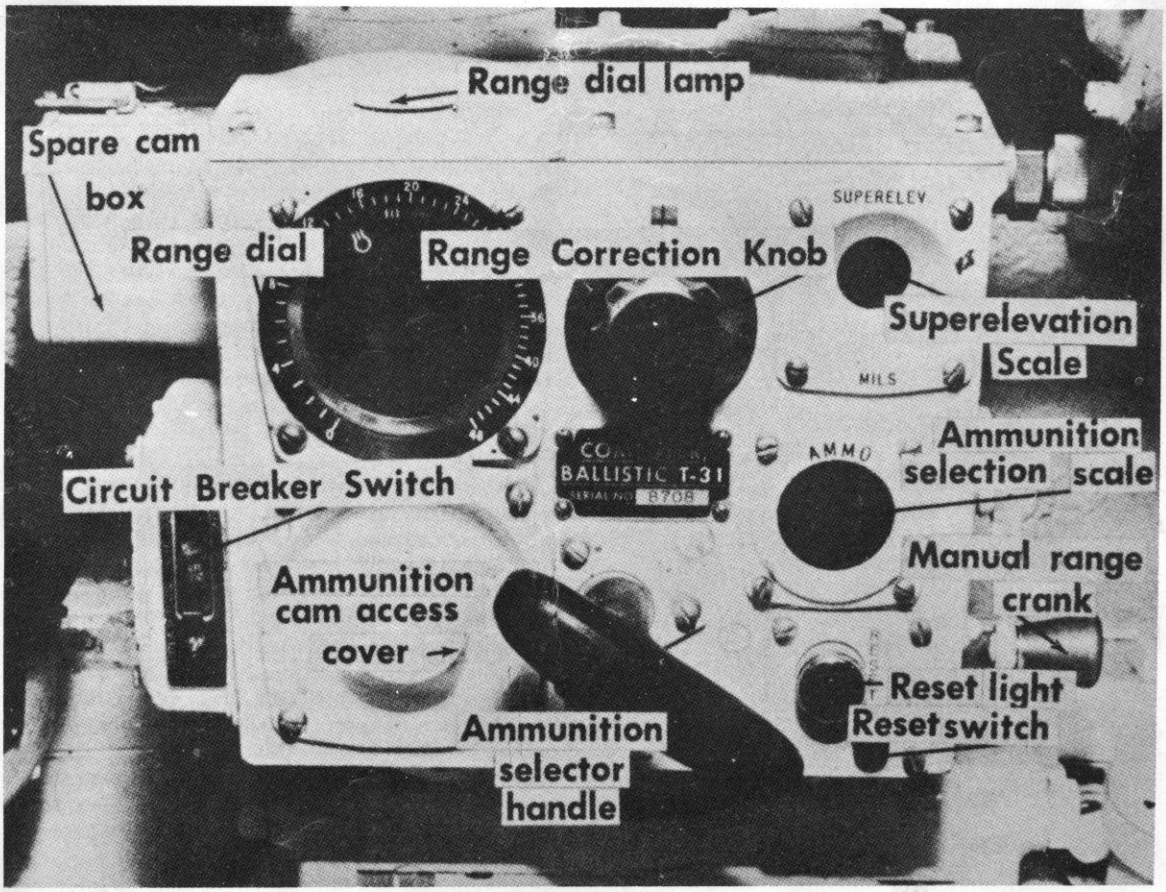
". . . The battalion of armour that had careened on was directed to reverse and carry out the mission as planned.

"Colonel Baron's tanks had already blasted the six battalions of 122-mm. and 100-mm. artillery pieces, as well as the 85-mm. and 57-mm. anti-tank batteries, to complete the destruction the Fougas has begun. Baron



Cross section of the M48 with original cupola and A/A gun. Drawing—U.S. Ordnance Corps

The T31 computer used in the M48 tank makes the corrections required for various types of ammunition. Photo—U.S. Army

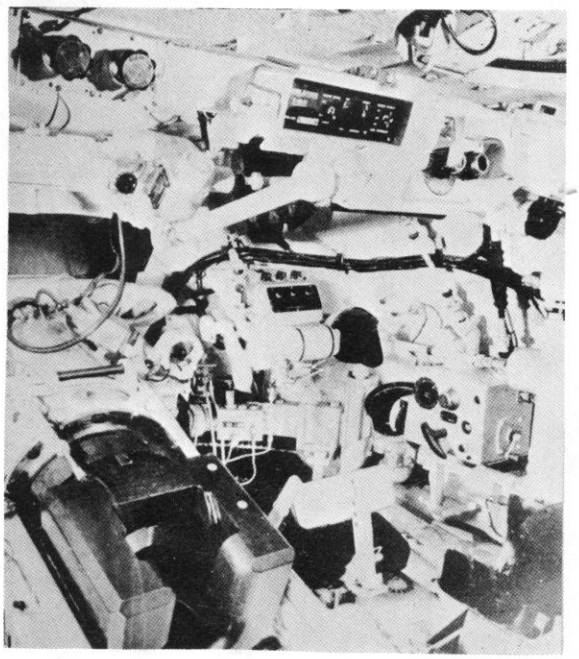


Rear view of the T48 with turret transversed to the right. In this view the engine compartment louvers and exhausts are clearly visible.
Photo—U.S. Ordnance Corps

now heard the distress calls and the new order on his command radio. His Pattons were close to the scene. . . . With his battalion well collected and in the right place, Baron decided he must move to the rescue, though uninvited. From the rear his tanks destroyed the greater part of a brigade of eighteen hundred men. The fight to save the isolated battalion lasted ninety minutes, ending around 17·00 . . ."

In Viet Nam, the use by U.S. forces of M48 and M60 tanks has been limited to less traditional tank rôles, partly because of terrain, partly because of the guerrilla character of the war and partly because of bridge limitations. In that country, the Delta region is flat but cut up by rivers and a dense network of canals. North of Saigon, the ground gradually rises within 50 miles toward the highlands and there are extensive forests and rubber plantations. The southern portion of the central plateau in the highland area near the

Gunner's position in M48 medium tank on lower right the ammunition selector lever is apparent on the T31 Computer. Photo:—U.S. Army



Laotian and Cambodian borders is good tank country but the coastal plain is cut at intervals by mountain ridges. It and the northern two-thirds of the country which comprises jungle-covered mountains are poor tank country.

Lack of manoeuvre space thus limited the use of medium or main battle tanks. The M113 Armoured Personnel Carriers because of their amphibian character were used as light tanks while the medium tanks acted as a base of fire for them. Later, when tree-levelling devices such as Rome Plows were introduced, a few tactical changes took place. The Rome Plow originally was a standard commercial tractor modified at a plant in Rome, Georgia, to enable it to cut down the jungle growth that covers so much of Viet Nam. This reduced the number of possible enemy hiding places and also provided cleared areas on the sides of roads. The plows also were used by engineer troops to lead the way into the jungle, crushing bunkers and tunnels. They were followed by infantry in armoured personnel carriers and by armoured engineer vehicles or medium tanks. Because of the short life of the Rome Plow under such conditions of use, a simpler method was devised. A 225-ft long three-ton Navy anchor chain was hooked to the rear ends of two M48A3 tanks and stretched tight just off the ground to level foliage and brush. When so used, the M113 Armoured Personnel Carriers provided flank and rear security while a third M48A3 acted as point.

M48 or Patton series tanks are to be found in the armies of Greece, Israel, Italy, Jordan, Norway, Pakistan and Spain. The Israelis have upgunned their M48A2s with the British 105-mm. guns with which the Super Shermans are armed and have substituted diesel engines.

M48 DEVELOPMENT

The T48, as it was known originally, was initiated in December 1950 by letter contract awarded to the Chrysler Corporation. In March 1951, the Fisher Body Division of General Motors Corporation and the Ford Motor Company were awarded letter contracts for supplemental production and in October1954 Chrysler received another contract for additional vehicles. Deliveries began in April 1952 and were completed in May 1956. These were the M48C (training type), M48 and M48A1. Standardization as the M48 had taken place in May 1953 despite the fact that tests had disclosed many defects.

The Controller General of the United States and his General Accounting Office are the watchdogs for Congress over governmental expenditures. In a report to Congress in 1960 the Controller General pointed out that there were serious defects impairing the operation and maintenance of the M48 and M48A1 Full Tracked Medium Gun Combat Tanks, to use their full name. These defects were found in initial models and throughout production and continued to exist in spite of numerous and costly modifications over the period 1951-58. In fact, it was held that "Initial production vehicles were defective to such an extent that they were not acceptable even for training purposes." The Controller General also reported that the situation was due to the practice of "contracting for volume production prior to adequate assurances

that identified defects could be corrected during production or by subsequent modifications."

Tracks were thrown, the rangefinders could not be used by everyone even with normal vision and originally the tanks could be shifted into reverse while the vehicle was in motion. This last was a cause for much mechanical breakdown and later production was modified to prevent it. Despite limited usage the tanks frequently were out of commission due to breakdowns in engines, transmission, tracks and suspension, with an average of 2·7 failures for every 100 miles of operation. The Army insisted that the problems were due mainly to improper maintenance, failure to follow instruction manuals and poor driving habits, all of which probably were true.

The Army accepted responsibility based on the premise that the Korean War had justified crash procurement although most of the vehicles were delivered after hostilities in Korea had ceased in mid-1953.

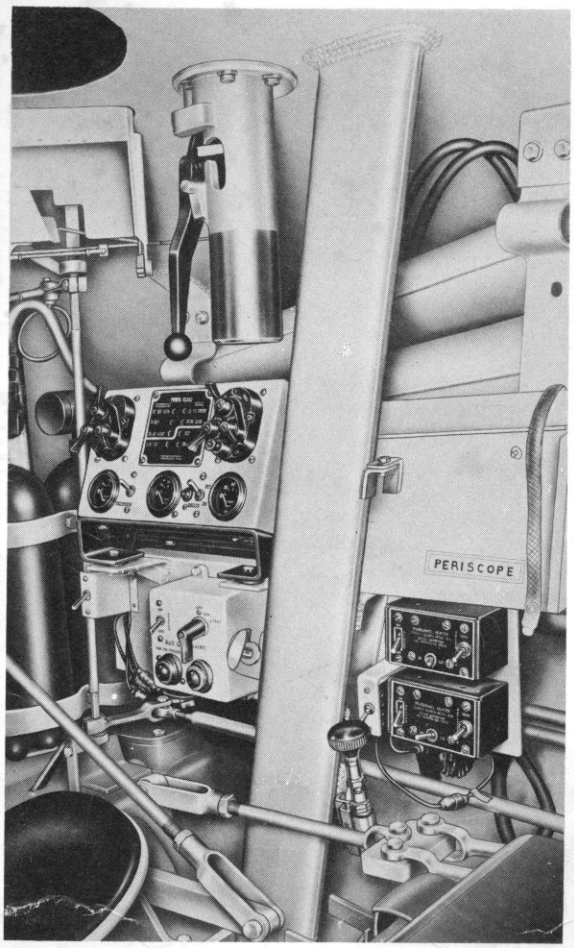
This report by the Controller General, although critical, must be viewed in the proper perspective. It is perhaps the first specific analysis of defects in a given series of tanks to be made public anywhere in the world, although the report on *Wartime Tank Production* presented to Parliament in England in July 1946 had been even more critical but on a broader base. Most tracklaying vehicles must be properly cared for and maintained or they will exhibit similar defects, a well-established fact not yet learned by commanders who lack tank experience or who are unable to enforce discipline.

The principal problem of a design nature which was encountered was in the track compensating idler spindle. Changes in this and in the engine and transmission were made with the resulting vehicle produced as the M48A2. Alco Products Inc. received a contract for these in November 1955 and additional contracts were awarded Chrysler beginning in May 1957. A new problem arose in the M48A2 in the engine fan rotor which had a tendency to disintegrate, but this too finally was corrected.

The M48 had a low operating radius. Jettison fuel tanks were added but only to 1800 vehicles. These were among those furnished to Jordan. Reports from the Six Day War indicated that these supplementary fuel tanks presented a tremendous fire hazard in combat to vehicles so equipped. Fuel capacity was increased in the M48A2. Failures in the tank commander's override control also were corrected in the M48A2.

The tank commander's machine-gun was intended for use against both ground and aerial targets. This had been one of the significant reasons given for the development of the M48 over the M47. The original cupolas designed for the M48 would not fit and changes had to be made in the turret casting. Thus the early vehicles did not have the commander's cupola which has become standard on all U.S. vehicles. This commander's cupola ·50 calibre machine-gun was to have had an elevation range of —11° to +60°, but as produced the upper limit was only 50° and therefore the gun could not be used for anti-aircraft fire. In addition the cupola had dead spots in rotation.

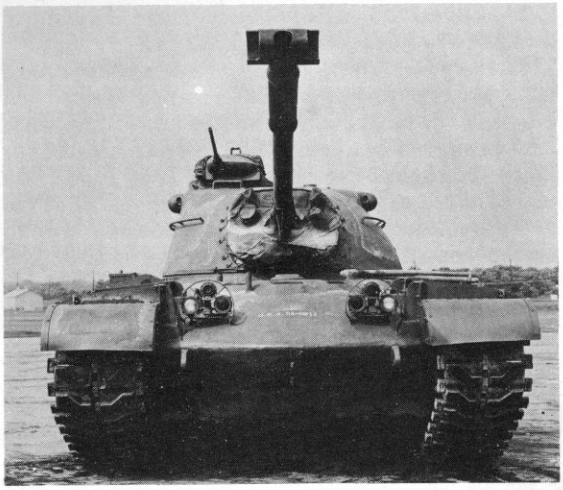
Modifications to correct all shortcomings were made by Chrysler, U.S. Industries, Inc. and Lima



The M48 driver's instruments and hatch cover lever were located on his right. This view also shows the right periscope holder.
Photo—Courtesy Chrysler Corporation

Expendable roller mine clearing device developed for use with standard M48 tanks. Photo—U.S. Corps of Engineers

One of the Pakastani M48 tanks out of action at Assal Uttar in 1965. Photo—Courtesy Tyler Segar.



In spite of the increase in height the new commander's cupola on the M48A1 was a distinct improvement. Photo—U.S. Ordnance Corps

Tank Depot, the two latter again doing work which already supposedly had been done.

The final cost per vehicle is very difficult to determine. The initial cost is estimated at $210,000 but to this must be added the cost of some $13,000 per vehicle up to 1956, and from total subsequent contract costs it is estimated that the total additional cost would be about $20,000, making the final cost per vehicle close to a quarter of a million dollars. To this must be added the cost of spare parts made obsolete by the production of an entirely new part to make a given correction.

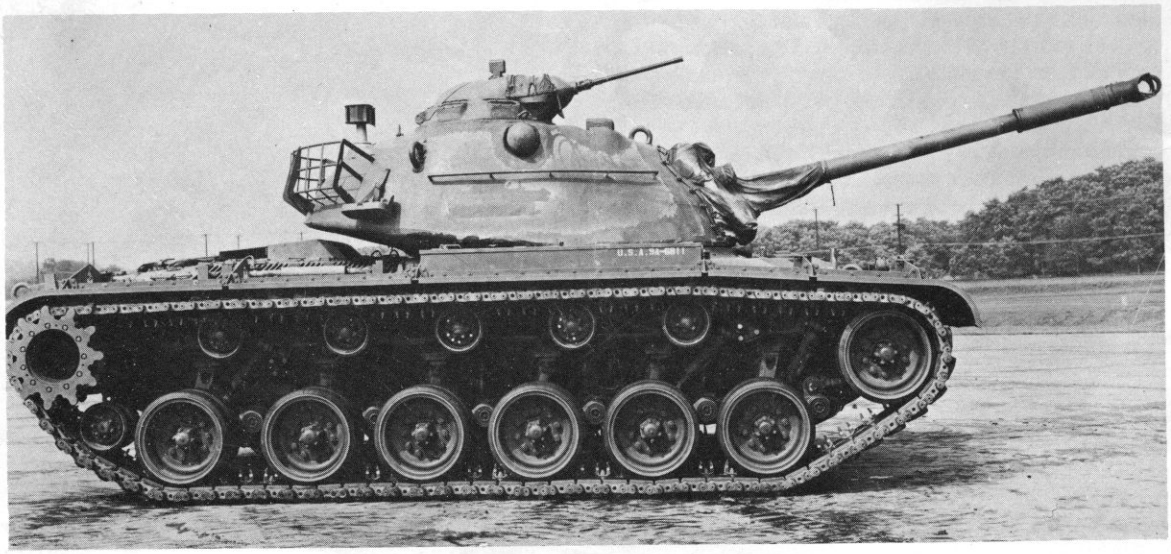
M48 DESCRIPTION

The M48 has an ellipsoid cast hull with a plate bottom and an ellipsoid cast turret. It is supported on a torsion bar suspension with six forged aluminium bogie wheels and five support rollers per side. The hull is divided into three compartments, the driving compartment in front for the driver, the engine compartment in the rear and the fighting compartment in the turret in the centre for the commander, gunner and loader. A rotatable commander's cupola with machine-gun is mounted on the right side of the turret roof in the early production vehicles and a large commander's cupola is provided in the later models. The driver controls the vehicle with a rectangular steering-wheel which resembles the pilot's control on a jet airliner. There is no bow machine-gun.

The commander stands on the tank commander's platform or is seated. The gunner's seat is to the right of the 90-mm. gun in front of the tank commander, while the loader is seated on the left of the gun or stands.

The 90-mm. M41 gun comprises the tube, bore evacuator, blast deflector and breech mechanism in Combination Mount M87 in the M48, M48A1 and

Side view of the M48A1 with the small tension adjusting idler clearly visible near the drive sprocket. Photo—U.S. Ordnance Corps



M48C. In later models, the mount has variations of several types. All consist of a gun shield and cradle with a coaxial ·30 calibre machine-gun on the left side of the 90-mm. gun. The gun mount supports the gun in trunnion bearings and provides attachments for the breech operating and firing mechanisms for both guns and the recoil guards. The bore evacuator is a thin walled cylinder fitted around the forward end of the gun tube. Eight holes are drilled in the bore and slanted at an angle of 30° toward the muzzle. After firing, the resultant vacuum draws the air out of the tube so that the fumes, which are toxic, do not escape into the turret when the breech opens automatically to eject the case after firing. This breech block is a vertical sliding wedge type. The gun tube is quickly replaceable.

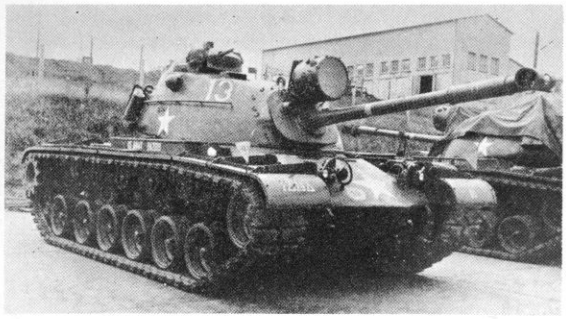
Percussion firing by electric solenoid is used. Three inches from the end of counter recoil after 12 inches of recoil the return is buffered so that the gun goes back into battery without shock. There is a replenisher assembly which takes care of the expansion of the concentric hydrospring recoil cylinder oil through heating from firing.

The bore is 14ft 9 ins long (or 48 calibres). Elevation —9° to +20°. The various forms of ammunition and their muzzle velocities are:

HE and WP	2400 f/s (high explosive and white phosphorus smoke)
AP	3050 f/s (armour piercing)
HVAP	4050 f/s (high velocity armour piercing)
HVAP-PS	4100 f/s (high velocity armour piercing super shot)
HEAT	2800 f/s (high explosive antitank)

Practice and blank rounds also are available. A canister round was developed for use in Viet Nam in 1968 and in 1969 a fixed round (flamethrower) made a flamethrower out of every tank gun. Instead of the customary "rod" of flamethrower fuel, the new round bursts into flame on arriving at target.

There are storage spaces for 19 rounds on the left of the driver and 11 rounds on the right with six rounds in the turret floor beneath the gun. There is space for 16 rounds vertically along the turret ring and there is an eight round ready rack in the turret. The 90-mm. round is long, and handling it in the turret of a moving tank is an operation requiring care, tending to slow the rate of fire.



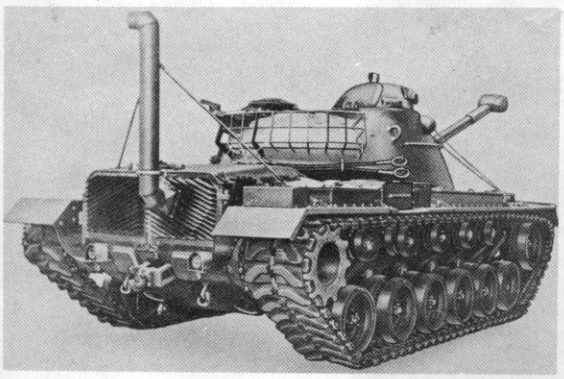
M48A1 medium tank fitted with a commercial 2000 watt searchlight. Photo—Armor Magazine

A stereo rangefinder graduated from 500 to 4,800 yards is operated by the tank commander. It transmits range data mechanically to a ballistic computer. This range datum is modified by ammunition and ballistic corrections which are manually applied by the gunner to the computer at his right. This results in what is called the super-elevation angle (the angle between the line of bore and the line of sight—in other words, the amount of parallax). This angle is transmitted electrically (or mechanically) through the ballistic drive (a mechanical linkage) to the periscope sight and the rangefinder. The computer has an ammunition selector handle providing for six changes of ammunition by means of different shaped cams. Range corrections can be made for air density, temperatures (ambient, powder and tube), tube wear, variations in lots of ammunitions, etc.

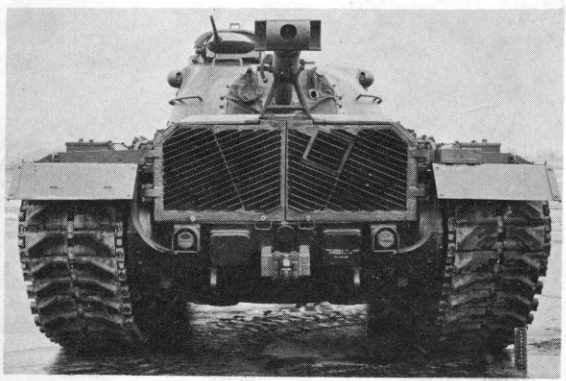
The gunner has one control handle in front of him; a grip with a trigger also traverses the turret and elevates and depresses the gun. The turret rotates at 4 rpm. The gunner is also provided with manual controls. An override control similar to the gunner's control but with electrical firing trigger only enables the commander to take over from the gunner if he so desires or if it becomes necessary to do so. There also is an interlock which enables the tank commander to control the 90-mm. gun by aligning it with the cupola machine-gun. And, as in all U.S. tanks, equipment is provided for conducting indirect fire.

It has already been mentioned that the early production vehicles could not be fitted with the cupola in-

The M48A1 tank equipped with the standard fording kit which permitted wading up to a depth of 96 inches. Photo—U.S. Ordnance Corps



The rear view of the M48A2 shows the major redesign of the engine compartment, new louvers, travel lock, pintle and inside telephone box of changed design. Photo—U.S. Ordnance Corps.



tended. These vehicles had a revolving hatch of the early Sherman type with a hinged cover and a ·50 calibre machine-gun on a cradle. In 1953 an attempt was made to eliminate the coaxial machine-gun, substituting a ·30 calibre machine-gun on a short pedestal mount welded to the turret top to the left of the loader's hatch. However there was interference from the hatch cover preventing all-round fire. A cupola mount with sloping rear and hatch cover hinged at the base was substituted. The ·50 calibre gun mounted in the cupola could be armed, charged and fired from within the turret or fired manually from within the cupola. It had a 200 round ammunition box. A refinement of this cupola was the similar M1 used on the M48A1, A2, A2C and the M67A1. It had five periscopes and a periscopic gun sight and a protruding gun mantlet, but the hatch cover was round and was pivoted on the right instead of being hinged. It used a 100 round ammunition box.

The M1 cupola had 360° traverse. The machine-gun had a range of elevation and depression of +60° and —10°. The gun is mounted with the left side down and is fired electrically. The sight for it is arranged with two settings, one for 500-800 yards and one for 800-1,000 yards. Beyond that range, fire is conducted by means of tracer ammunition. Concentric rings are provided, each of the rings representing a 100 mile per hour lead for anti-aircraft fire although the effectiveness of such fire from any tank is questionable.

The original 10X stereo rangefinder later was replaced by a coincidence type. So many men found themselves unable to use the device and disconnected it that the change was mandatory.

The need for adequate light for night firing resulted in mounting on the gun an 18in. commercial searchlight of 2,000 watts. This light was fitted with electrical shutters which prevented pre- and after-glow. Such lights finally were replaced with Xenon lights which provided infra-red as well as white light. Lights of this kind now are standard on the tanks of practically all nations.

The M48 tanks were able to ford a stream up to a depth of 48 inches. After numerous experiments to simplify the wading equipment which had been developed during World War II, a standard fording kit was developed and issued, permitting fording to a depth of 96 inches. The kit sealed the hull from the entrance of water by means of covers, ducts, hoses, tape and similar means. It also provided a means of escape for engine exhaust gases through the right rear grille door and up and out an exhaust stack. This stack could be jettisoned from within the vehicle by means of release cords. A bilge pump also formed part of the kit. Maximum speed while fording was 4 m.p.h.

HYBRIDS

There are so many variations of the M48 that the best way to keep them straight in one's mind is to list them:

T48, the original T42 chassis with a new turret and hull, 6 bogie wheels and 5 support rollers.

T48E1, numerous modifications.

T48E2, prototype of M48.

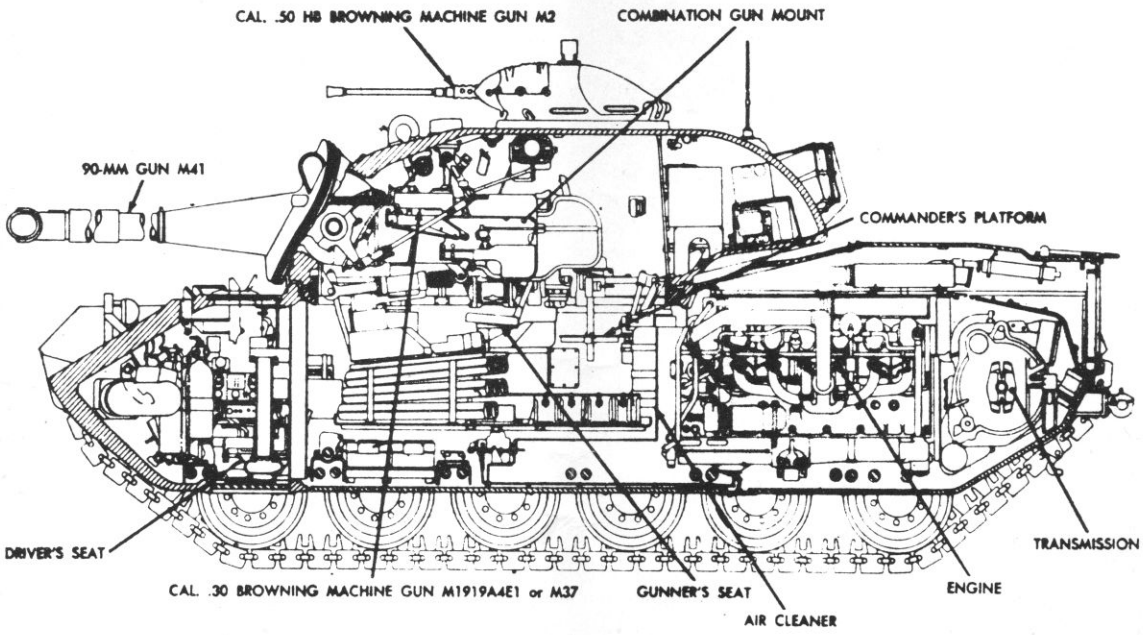
T48 with Launcher Kit, six fanned-out smoke launcher kits on each of four turret sides.

M48, original production with early Sherman type cupola and exposed remote control machine-gun and small driver's hatch.

M48 Phase III, M48 with M47 fire control equipment.

M48C, mild steel training tank.

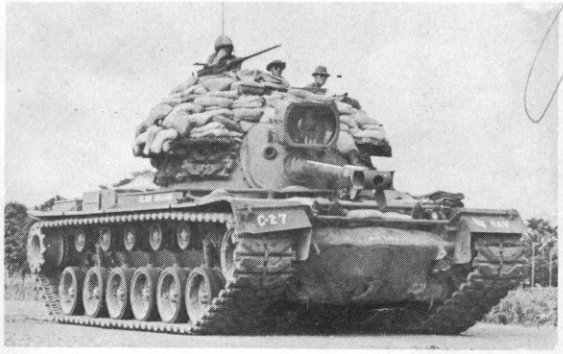
Israeli M48A2 tank during the six day war in 1967. Photo—Courtesy Tyler Segar



The differences from the M48 are apparent in this cross-section of the M48A2. Photo—U.S. Ordnance Corps

M48C with Fender Kits or remote controlled ·30 calibre machine-guns over the tracks.
M48A1, with M1 cupola and large driver's hatch.
M48E1, M48 with British 105-mm. gun, also called M60 Interim Tank.
M48A1E1, M48A1 with British 105-mm. gun.
M48A1E2, diesel engine, No. 2 and No. 4 support rollers removed and M48E2 type compensating idler installed.
M48E2, Prototype of M48A2.
M48A2, diesel engine, later M19 cupola, infra-red equipment, lowered rear doors and rear deck raised 8 inches for better cooling, No. 2 and No. 4 roller removed (except by U.S. Marine Corps), small idler wheel between sprocket and rear bogie removed.
M48A2C, mild steel, prototype M60 type turret.
M48A2E1, M48A2 with multi-fuel engine.
M48A2/SS10, two SS10 missiles right of 90-mm gun, two left, one above.
M48A3, production model of M48A1E2, larger fuel tank, No. 2 and No. 4 support roller reinstated when used in Viet Nam; late production vehicles added a vision block riser between cupola and turret. In Viet Nam, a ·50 calibre MG sometimes was mounted above the cupola and sometimes a 7·62-mm MG with shield was mounted in front of loader's hatch and another MG was substituted in mantlet for the telescopic sight.
M48A4, M48A3 with M60 turret, 105-mm gun and M19 cupola.
M48 with Shillelegh, redesigned turret for 152-mm gun.
M48 with Expendable Roller Mine Clearing Device.
M48 with AGT 1500 Gas Turbine, test rig only.
M48 with Heavy Mine Clearing Roller (High Herman), 25 plain and serrated discs.

An M48A3 in South Vietnam with sandbags on the turret forming a bunker of sorts. Photo—Courtesy J. W. Loop

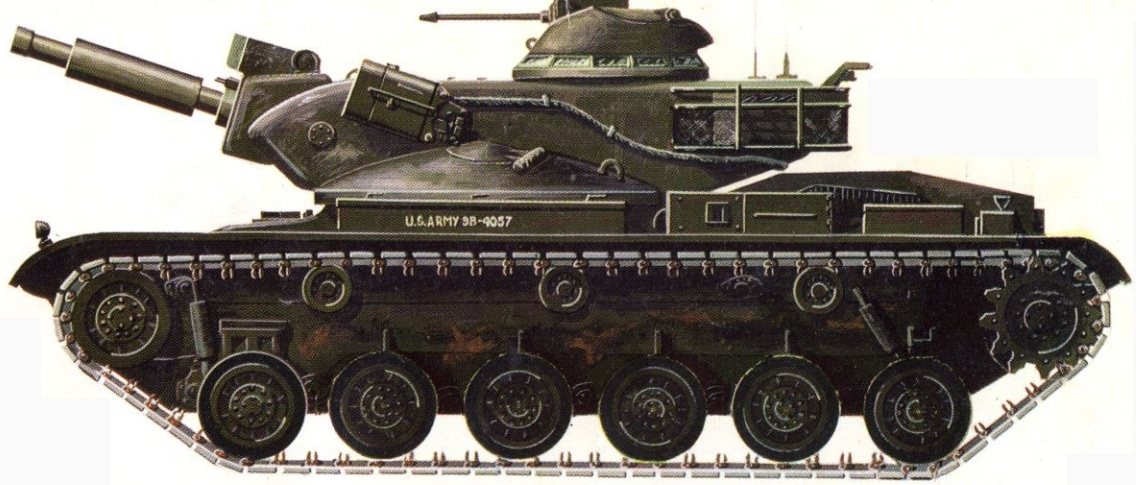


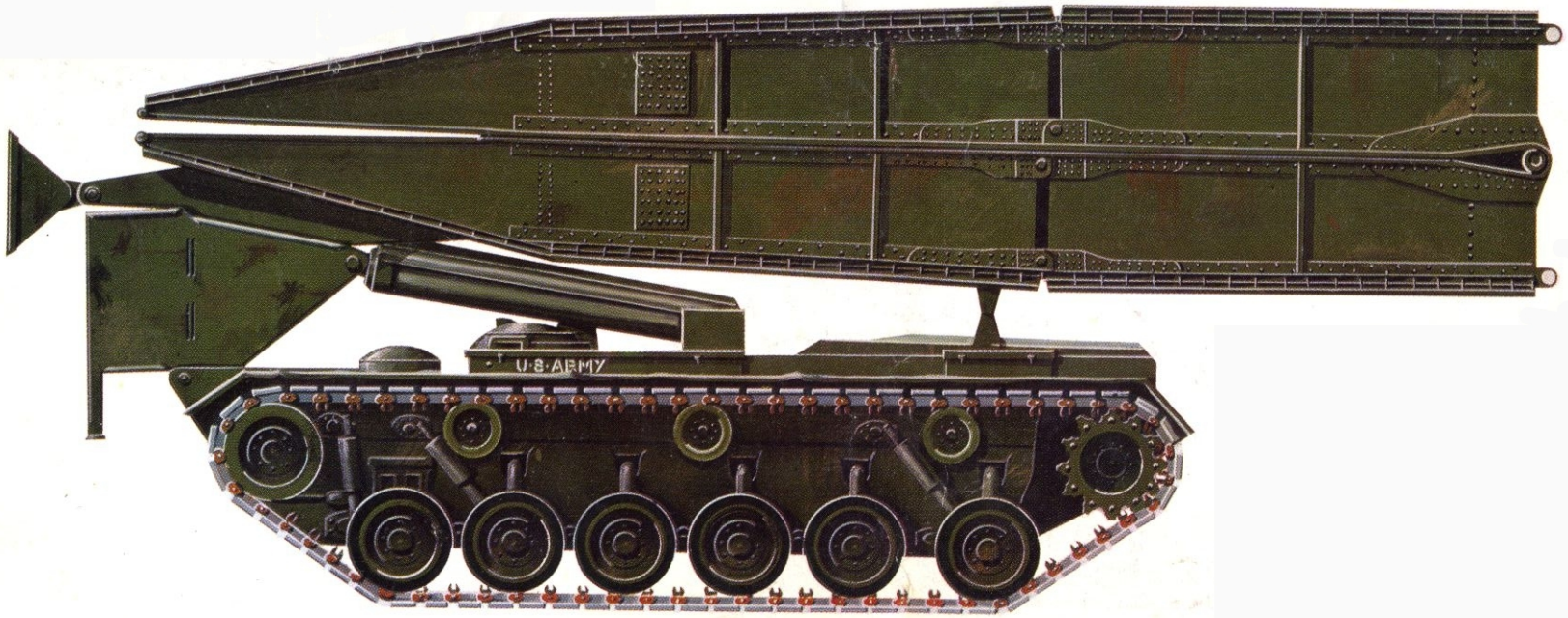
M48A3 tanks in South Vietnam as fitted with a vision block ring or vision riser between the commander's cupola and the turret. Photo—Courtesy J. W. Loop

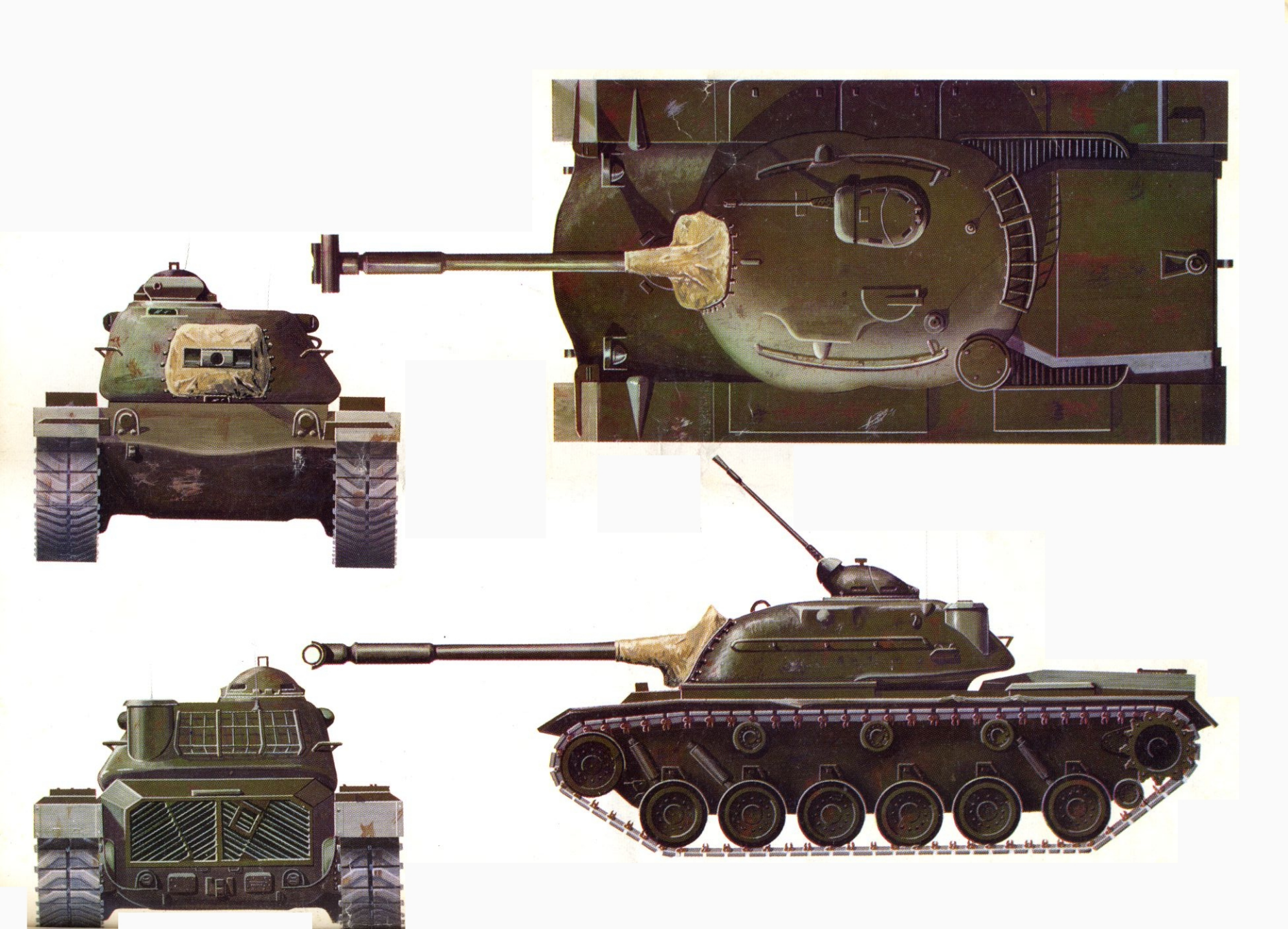
Top four views show M48 A2.

Middle: M60 A1E1 a feature of which is the interesting turret shape.

Bottom: AVLB scissors type bridging vehicle.

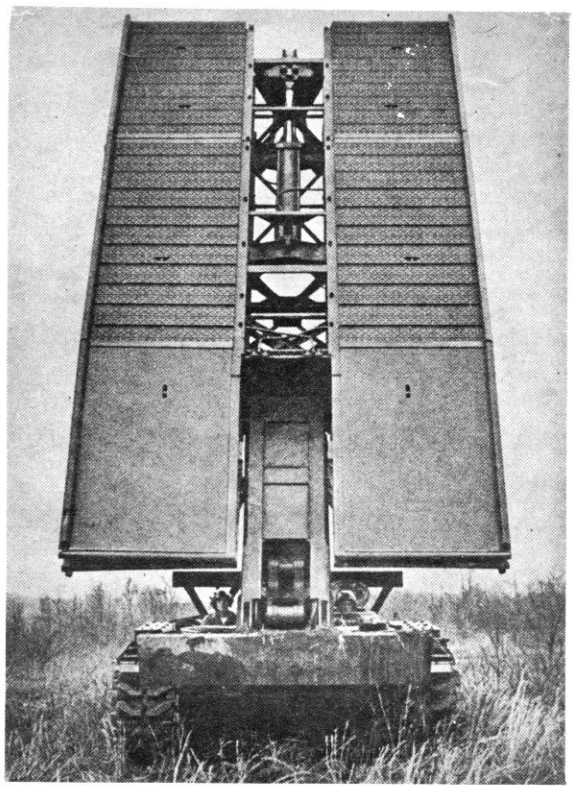






The gunner in the M48A3 has his controls compactly arranged.
Photo—U.S. Army

The M48AVLB was a conventional type of scissors bridgelayer.
Photo—Martin Iger



M48 with Light Mine Clearing Roller (Larrapin' Lou), two units of six serrated discs each.
AVLB, M48 or M48A2 scissors type bridgelayer.
M67 Flame Tank, M48A1 with flame gun replacing the 90-mm. gun.
M67A1, same with tank cupola added.
M67A2, M48A3 with flame gun, three support rollers (except in U.S. Marine Corps).
M88 Tank Recovery Vehicle, ARV with M48 components.

When it became apparent that the 100-mm. L/54 gun on the post-war Soviet tanks was a weapon superior to the 90-mm. L/48 gun of the M48, upgunning of the M48 began as can be seen from the above list. Again, developments elsewhere had forced U.S. designers to follow. During World War II it had been the Germans who continually forced the U.S. to upgun. Now it was the Russians. Since the British and Commonwealth armies as well as those of several of the NATO nations were equipped with the British Centurion tank, it was decided that the successful tests of the Centurion's 105-mm. gun in the M48E1 justified a changeover to that weapon.

THE M60

Thus the M60 armed with the British 105-mm. gun grew out of the M48. In 1960, some 180 were ordered and tested, following which 720 more were ordered. The M60A1 with its longer-nosed turret went into production in 1962. Austria, France, Iran and Italy also received the M60A1. In addition to the 200 furnished to Italy, more were produced there under license even though several European tanks at least its equal were available at the time. The Swedish STRV 103, the French AMX 30 and the German Leopard have better horse-power/weight ratios and far superior silhouettes. With the 105-mm. L/51 gun, the M48A3 is the equal of the M60A1. Unit cost is not greatly different, since the M60A1 cost is stated to be $220,000.

THE SHILLELEGH

At the same time as the British 105-mm. gun was being considered, the U.S. Army established a requirement for future armoured combat vehicles, stating that "a direct fire, armored vehicle-mounted missile . . . be available for operational use at the earliest possible date." The first result of this was the initiation of the Sheridan light reconnaissance vehicle which is not considered by the army to be a tank. It was to be armed with a weapons system known as the Shillelegh. This system was to include the use of a combustible cartridge case which the Army had been working on for a number of years and for which it believed a satisfactory solution had been reached.

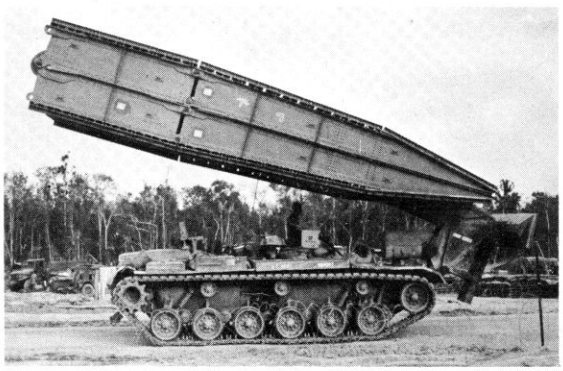
The Shillelegh was developed by the Aero-Neutronics Division of Philco-Ford. It is a 152-mm. gun/howitzer capable of firing a conventional projectile as well as a missile. The missile, when fired, is controlled by the gunner who keeps the target in sight through a collimator linked by radio micro-wave acting on the rocket motor nozzle, thus varying the movement of the missile. The gunner must have continuous observation so the gun cannot fire when on the move or at night. It also has the disadvantage which it shares with many other missile systems in that it bathes the

The AVLB scissors type bridging vehicle increased the operating range of its companion M48 and M60 main battletanks.
Photo—Ordnance Magazine

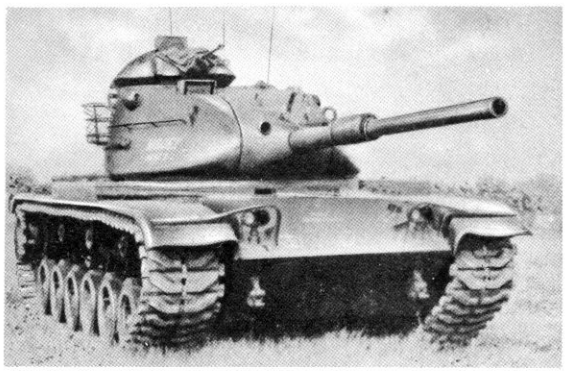
target in IR light before the missile is launched so that it provides early warning through IR energy.

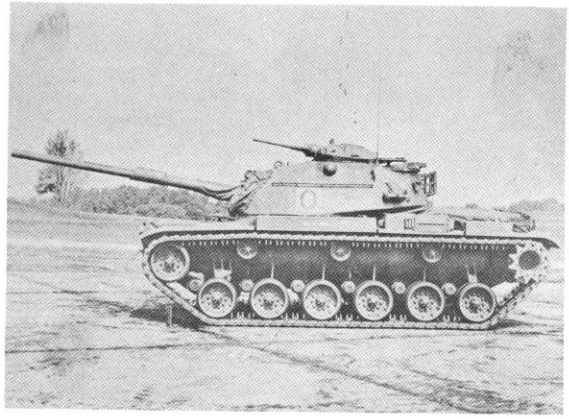
Because it is capable also of firing a conventional projectile the weapon has rather a complicated breech mechanism. The conventional rounds are caseless or rather the cases are combustible, requiring no ejection or disposition. The missile projectile is a solid fuel rocket engine about 44 inches long and weighing about 60 pounds. It has recessed fins which open on firing to stabilize flight. This weapons system adopted for the M551, or Sheridan, was to become the foundation for an improvement also in the main battle tank programme, beginning with the M60A1, converting it into the M60A1E1 and M60A1E2, and also the MBT 70. The last-named was developed jointly with the Republic of Germany (where it is called the Keiler) although the Germans have decided to substitute their own 120-mm. full automatic gun. Unit costs of the MBT 70 rose to about $700,000 and, beginning in 1970, each country decided to go its own way on this design. The U.S. model was to be simplified, eliminating the variable suspension system, the fire control system and reducing the engine power in order to cut the unit cost to $500,000. The many problems which plagued the programme were due to over-emphasis and misuse of systems analysis techniques. Civilian analyzers apparently evaluated tanks solely as anti-tank weapons which operated as stationary artillery, not taking into consideration the elements of speed, mobility and agility. The full name of this tank is Tank, Combat, Full Tracked, 152-mm. Gun/Launcher, XM 803. Eventually the name of some general will be given to it. But instead of producing the XM 803 in 1970, it was decided to produce the M60A1 with wider tracks for several more years, adding full gun stabilization and improved fire control instrumentation involving solid state electronic computer, laser rangefinder and add-on stabilization. This will make possible the replace-

The M60 AVLB like its M48 predecessor was a conventional type of of scissors bridgelayer. Photo—Courtesy J. W. Loop



The M60A1 long nose turret provided considerably more interior room than its predecessor turret. Photo—U.S. Army





The M60 interim tank was the standard M48 modified for installation of the British 105 mm gun. Photo—U.S. Ordnance Corps

ment of M48 series vehicles still in the hands of both Regular and Reserve units.

The Defense Department originally had intended to adopt the Shillelegh system on a crash basis which would upgun these vehicles until the MBT 70 became available. Modified M60A1 vehicles were to become the M60A1E1 in which an electronic computer replaced the previous mechanical computer. New vehicles produced in the same form were to be called M60A1E2. The first of the former appeared in 1965. The turrets from the modified M60A1 tanks were then to be placed on M48A3 tanks. In the new turret, the gunner and loader are located low on either side of the main armament. The commander is high and to the rear of the gun. The silhouette of the vehicle is low except for the commander's cupola which raises it considerably as is the case with all tanks of the M48-M60 series.

The M60A1E2 tank has night vision devices, a target designating system, laser rangefinder, an electronic computer with cant corrector and a target lead sensor. Both the main gun and the commander's gun are stabilized.

An M60A1 main battle tank being fitted for combat in Vietnam. Photo—U.S. Army

The House Armed Service Committee of the Congress noticed in 1967 that, in spite of funds having been appropriated each year, the Army had not deployed these new vehicles. A special investigating subcommittee was created for the purpose of determining the cause of the delay. Production of the M60A1 had been slowed down and finally stopped in 1967 in anticipation of producing the M60A1E2.

The report of the subcommittee was submitted in 1969. It was critical of the programme and its findings received considerable newspaper publicity at the time. However, the report was unfair in that it criticized the entire Shillelegh weapons system whereas the missile handling capacity of the Shillelegh operated extremely well. It was the caseless ammunition for the conventional projectile which caused the problem. It was true that the caseless conventional ammunition developed for the Shillelegh had been considered unsafe by virtue of residue and smoke as early as 1961. By 1964 the effects of humidity which caused misfires and broken rounds had become another problem, followed by another of premature detonation. In 1966, Army Research and Development approved procurement because of a fear of loss of funds in spite of a recommendation to stop procurement until the problems were solved.

Another redesign of the ammunition eliminated the premature detonation problem but the smouldering residue problem continued to be troublesome and dangerous. The weapon itself received an open breech scavenging mechanism using air jets in 1967. In the same year the M60A1E1 turrets were found to have defective hydraulic stabilizers. They could not be mounted but continued to be produced. They were placed in storage while studies continued toward developing a new stabilizer. The scavenger device also was produced before testing and when it became available was found to be dangerous, resulting in slowing the rate of fire. The report went on to describe another redesign of the breech scavenger in 1968. This time it was of the closed breech type.

Some of the new tanks were completed as M60A1 and some were tested with other types of armament. A metal cartridge case was proposed in the same year but it was not adopted because it still was felt that a solution was "just around the corner." The constant optimism and fear of losing funds may have caused a compromise with the original goals but the report was unfair in stating that the result was a weapon lacking any real improvement over existing weapons. The missile firing capability of the Shillelegh is satisfactory and it is to be expected that a solution will be found for the problems of the conventional ammunition even if a return has to be made to cased ammunition.

Some of the Sheridans were sent to Viet Nam. There some problems were found in the considerable shock of firing a heavy weapon in this lighter vehicle, with fouling, with the gun not always returning to battery and with the ammunition which sometimes proved fragile. In general, however, the vehicle and weapon were considered satisfactory by the using service and to have definite potential. The problem of

humidity was solved by encasing the rounds in thin plastic in the ammunition racks.

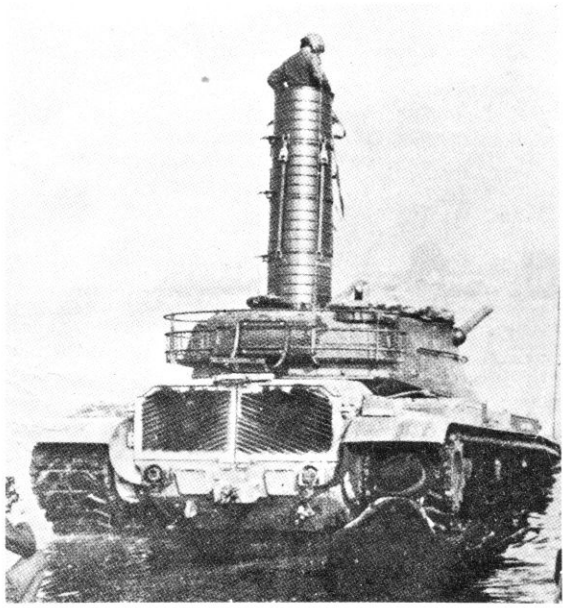
The subcommittee held that the Soviet armour threat was not growing fast enough to justify the actions which had permitted production before development was complete, but General Westmoreland, the Army Chief of Staff, reminded the Armed Services Committee in later testimony that the threat was considered real at the time the decision was made and that it continued to exist. He admitted that the integration of gun, turret and stabilization in the M60A1E2 "proved more difficult" than anticipated.

The result of the hearings was that service testing of the Shillelegh in Viet Nam and at proving grounds undoubtedly will lead to the answers but in the meantime only M60A1 tanks are to be produced. The turrets for the later models will be stored until a final solution is reached.

It would appear that the problems which developed in this and other programs were due to the subdivision of responsibility initiated by the former Secretary of Defense, Robert McNamara, when he caused a complete reorganization of the Defense Department. Prior to that time, the Ordnance Corps developed and the using arm tested and either accepted or rejected the offering. Inter-service rivalry made the system work. The organization later adopted eliminated the Ordnance Corps as a design agency and set up a system which was based on computer-determined "cost-effectiveness" and not only created many more agencies but the agencies apparently were under less control. This was hinted at in another report, this one by the Office of the Controller General.

Weapons developments under the later organization were managed by Project Managers who reported to Army Materiel Command who in turn advised the Assistant Chief of Staff for Force Development who authorized production rather than the Chief of Staff doing so. An over-optimistic Project Manager, or one with the human desire to "look good" so that the Secretary of Defense and the Bureau of the Budget would not be critical from a financial standpoint, could ignore user test reports and submit optimistic reports to higher-ups. Often the reports at higher headquarters were not examined critically and continued to be initialled without question and passed

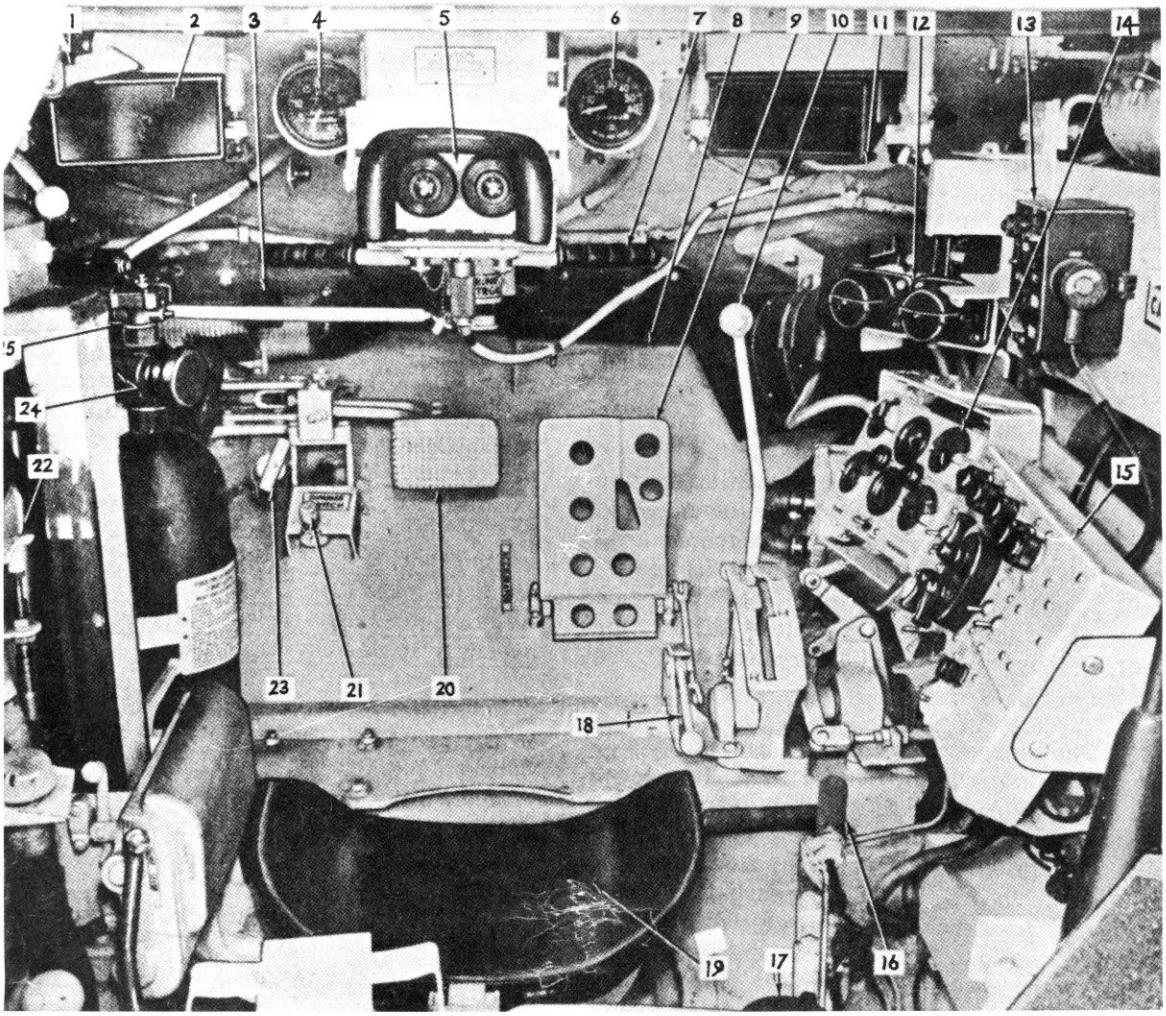
Project K, the redesigned M60A1 with longer Shillelegh mounted in a new armor plate turret of improved ballistic design.
Photo—Courtesy Defense Operations Division Chrysler Corporation.



M60A1 medium tank with deep water fording kit and commander's tower.
Photo—U.S. Army

An M60A1 tank equipped with dozer blade and snorkel indicating a maximum depth of 17 feet which could be forded.
Photo—U.S. Army

The M60A1 as used in Austria shows the change made in the glacis and the simplified supports for the fenders.
Photo—Courtesy Heeres-Film und Lichtbild Stelle



Driver's seat and controls in the M60A1 main battle tank. Photo—U.S. Army

1. *Driver's hatch cover control handle.*
2. *Periscope M27(3).*
3. *Brake pressure gage.*
4. *Tachometer.*
5. *Periscope, M24.*
6. *Speedometer.*
7. *Steering control.*
8. *Heat diffuser sliding door.*
9. *Accelerator pedal.*
10. *Transmission shift lever.*
11. *Dome light (behind periscope).*
12. *Auxilliary Power (slaving) receptacles.*
13. *Control box, interphone.*
14. *Gage indicator panel.*
15. *Master control panel.*
16. *Purge pump handle and heater switch.*
17. *Headlight assembly stowage bracket.*
18. *Accelerator locking lever.*
19. *Seat.*
20. *Brake pedal.*
21. *Dimmer switch.*
22. *Fuel shut-off valve handle.*
23. *Turret seal hand pump.*
24. *Turret seal pressure gage.*
25. *Fixed fire extinguishers.*

along. The review by the two agencies bears out this is what happened in the case of the Shillelegh.

As a result of these events, the Defense Department late in 1969 set up what was called PROMAP-70. This was a 300 man task force which began studying the life-cycle costs of new weapons systems in order to develop tighter controls and more realistic cost estimates. One of the first five systems to come under study was the M60A1E2 tank and the Shillelegh missile system. According to *Army* magazine in April, 1970, "the turret stabilization problems which have dogged the M60A1E2 program have now been solved, permitting modification to get those the Army already has procured into service." Only a limited number will be built because the MBT 70/XM803 is expected to be produced and issued by 1975. The others were completed as M60A1 vehicles.

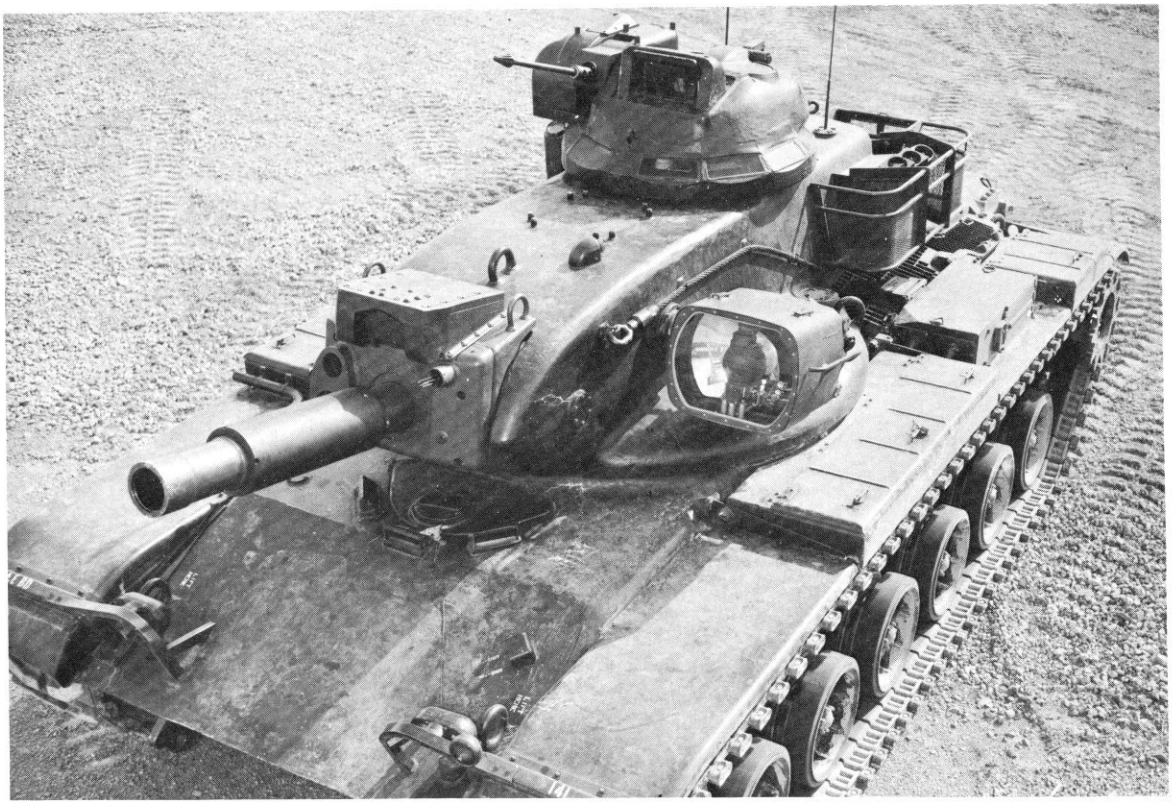
In addition, the task force stated, as one of its first recommendations, that there should be a better selection of Project Managers initially and that they should be kept on the job longer since the study had shown that 60 per cent of the Project Managers and their staffs had served in such capacities for less than two years.

Loading Shillelegh projectile through loader's hatch in the M60A1E1 medium tank. Photo—U.S. Army

The opened hatches of this prototype M60A1E2 main battle tank show the ease of access which the vehicle possesses. Photo—R. J. Icks

Three-quarter front view of the M60A1E1 shows the unusual turret design, the gun depression limit bar and the crew ladder on the left glacis. Photo—U.S. Army

This three-quarter rear view of the M60A1E2 shows the vision riser below the cupola and the unusual turret bustle. Photo—U.S. Army



M60A1E2 main battle tank—vision devices are provided for all crew members.

Photo—U.S. Army

THE M60 SERIES

The succession of vehicles in the M60 series can be epitomized as follows:

M60E1, M60 Interim Tank, new long nose turret.

M60E2, driver and driver controls in the turret.

M60A1, improved model, M19 cupola, loader equipped with periscope.

M60A1E1, new turret mounting Shillelegh applied to existing M60A1 tanks.

M60A2 (M66), similar to M60A1 with further turret changes.

M60A1E2, new turret with Shillelegh applied to newly produced M60 tanks.

M60 AVLB, scissors bridgelaying tanks of two different bridge lengths.

T118E1, Armored Engineering Vehicle (Trankdozer), M60A1 chassis with 15 ton crane, A-frame and dozer.

The M88 medium recovery vehicle was based on M48 components and is capable of following main battle tanks into combat if necessary.

Photo—U.S. Ordnance Corps.

The cupola on the M60A1 is the M19, larger than the M1 used on the M48, being four inches higher and nine inches longer. The ·50 calibre machine-gun was electrically fired and charged but the cupola was manually operated. The gun had an elevation of —15° to +60°. This cupola has eight periscopes and the hatch cover was hinged to the rear.

Mention previously was made of the fording kits furnished for the M48 tanks. In the case of the M60, "shore kits" or deep water fording devices have been developed. The vehicles are sealed as before, but in addition a high cylinder is provided for the commander so that the vehicle can be completely submerged, the driver then being controlled by the commander through an interphone. This snorkel is a device similar to that in use in a number of armies today, most of them differing in detail only. With it the M60 can ford up to a depth of 15 feet.

A new device considered for adoption on the later tanks is a blade antenna for the radios. The success of this type of antenna in helicopters led to its test on tanks. Its low silhouette eliminates a hazard when the vehicle is near power lines but the principal advantage is that it provides much sharper tuning and therefore much better reception.

In addition to the normal radios that can be carried, there is available the VRC-24, a special radio with a short cylindrical antenna for using the tactical aircraft radio network.

The Chrysler Corporation in 1970 offered commercially a variation of the M60A1 which was known as Project K. This is a version which compared favourably with the M60A1E2. The armament is a stabilized

longer barrelled Shillelegh with coaxial 7·62-mm. M73 machine-gun and equipped with a three round loader's assist device in a new ballistically well-shaped low silhouette plate armour turret with new vision cupola and remote controlled 50 calibre machine-gun. Ammunition stowage was raised to 57/7600/1530 rounds. Suspension changes included doubling the number of torsion bars, substituting rotary hydraulic shock absorbers which replaced the previous friction snubbers and substituting a new aluminium body track with detachable pads. These changes permit bogie wheel movement to be increased from 12·3 in. to 17·8 in., making possible an improvement in both speed and cross-country ability. Total weight of the vehicle increased somewhat less than one short ton.

TANK NUMBERING SYSTEM

As might be expected there is a system for numbering vehicles in the U.S. Army but, even though a single system is provided for in regulations, liberties seem to be taken with it because numbers appearing on vehicles in photographs occasionally do not appear to follow the system.

Since 1954, all vehicle numbers have been centrally controlled and consist of a combination of letters and numbers, excluding the letters I, O and Q. The number for each vehicle is supposed to comprise a uniform length of six places. The first numerals designate the type. This is followed by a letter or letters singly going through the alphabet and then double letters going through the alphabet again. Finally there is a number within the particular letter group.

Tanks and armoured recovery vehicles have the prefix 09; cargo vehicles (except amphibious) are 11; self-propelled guns, armoured personnel carriers and armoured utility vehicles are 12; while armoured cars, amphibious cargo carriers, half tracks and LVTs are 13. In interpreting the regulation, however, the zero (zed) sometimes is omitted before the 9 in the case of tanks, thus adding another digit to the number following the letter or letters.

A.F.V. Series Editor: DUNCAN CROW

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The flame gun on the M67 flame tank was a close replica of the 90-mm. gun on the standard tank. Photo—Chemical Warfare Service

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The T118E1 Armoured Engineer Vehicle was a general purpose vehicle armed with a 165-mm. assault gun. Photo: Courtesy J. W. Loop

DATA COMPARISON CHART FOR THE BASIC VEHICLES IN THE M48-M60 SERIES

Item	M48, M48C	M48A1	M48A2, A2C	M48A3	M60	M60A1	M60A1E1, E2	M67 USMC	M67A1 US Army
Crew	4	4	4	4	4	4	4	3	3
Length									
Travel	292 5/16"	283 5/16"	292 3/4"	292 3/4"	320"	325"	275 1/2	274 3/8"	271 1/8"
Gun F'w'd	332 9/16"	343 23/32"	342"	342"	366 1/2"	371 1/2"	288 3/4"	324 1/4"	320 3/8"
Vehicle	264"	270 1/2"	270 3/8"	293"	273 1/2"	273 1/2"	275 1/2"	274 3/8"	270 1/2"
Width	148"	143"	143"	143"	143"	143"	143"	143"	143"
Height									
O/A	127 3/8"	123 5/16"	121 5/8"	123" (A)	126 1/2"	128 1/4"	130 3/8"	121 5/8"	121 5/8"
Vehicle	107 1/2"	123 5/16	121 5/8"	123"	126 1/2"	118"	130 3/8"	121 5/8"	121 5/8"
Armament									
Main	90mm. L/48	90mm. L/48	90mm. L/48	90mm. L/48	105mm. L/51	105mm. L/51	152mm.	M7-6 F/T	M7A1-6 F/T
Coax	·30 Cal	·30 Cal	·30 Cal	·30 Cal	7·62mm.	7·62mm.	7·62mm.	·30 Cal	·30 Cal
AA	·50 Cal	·50 Cal	·50 Cal	·50 Cal	·50 Cal	·50 Cal	12·7mm.	·50 Cal	·50 Cal
Ammo (Rds)									
90mm.	60	60	64	62	57	60*	46	380 gals	380 gals
·30 Cal	5900	5900	5950	6000	5000	5000*	5500	3500	3500
·50 Cal	180	500	1365	630	846	500*	900	660	660
Armour*									
Tracks***									
Width									
Pitch									
Shoes	79	79	79	79	81	81		79	79
Weight (Pds)									
Combat	99,000	104,000	104,000	104,000	102,000	106,000	113,500	104,790	105,790
Empty	93,125	97,000	97,000	98,000	95,300	97,000	97,000	99,975	100,975
Road Wheels	6	6	6	6	6	6	6	6	6
Support Wheels	5	5	3	3-5	3	3-5	3	5	3
Clearance	15 1/2"	15 1/2"	15 1/2"	16"	16"	18"	18"	15 1/4"	15 1/4"
Grd Pressure	11·2	11·8	11·9	11·8	11·1	11·3	12·2	11·9	12·0
Electrical	24v	24v	24v	24v	24v	24v	24v	24v	24v
Fuel (US Gals)	200	200	335	375	375	375	—	200	335
Engine	AV 1790-5B, 7, 7B, 7C	7C	7C	2A	2	2A	2A	7	8
Transmission	CD 850-4, 4A, 4B	4B	5	6	6	6A	6A	6	6
Speeds	2F2R	2F2R	2F2R	2F2R	2F2R	2F2R	2F2R	2F2R	2F2R
HP/rpm	810/2800	810/2800	810/2800	865/2800	750/2400	—	—	810/2800	—
Traverse	Man/Mech	—	Man/Hydr	—	—	—	—	Man/Mech	Man/Hydr
Vehicle Speed	26 m.p.h.	26	30	30	30	30	30	26	30
Radius (Miles)	70	70	160	288	310	310	370	160	160
Remarks	Small Driver Hatch	Large Driver Hatch	Large	Large	Large	Large	—	—	—

ALL
Grade 60 per cent.

Turn Pivot

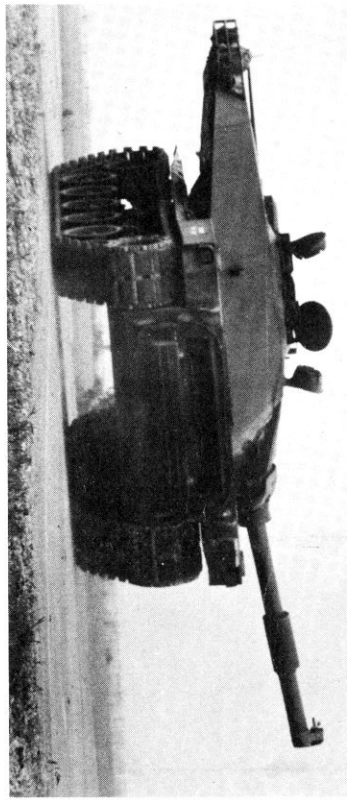
Ford 48"****

Trench 102"

Climb 36"

Radio Various

* Later 63/5500/900 Rounds
** All 25-110 mm.
*** All 28" wide, 6 5/6" pitch
**** Ford 96" with Snorkel
(A) About 130" with vision ring



The MBT 70 tank is fitted with a different version of the Shillelegh
Photo: Courtesy Allison Division
General Motor Corporation

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