Making Tanks Safe: Armored Force Medical Research Laboratory

by Dr. Sanders Marble

In July 1940 the Army established the Armored Force at Fort Knox, KY. It was responsible for establishing armored formations, doctrine and training in the use of armored vehicles. Its first surgeon was COL Albert Kenner (appointed in October 1941), who was well known to armor pioneer COL George Patton, probably a factor in Kenner's selection. Kenner had to devise medical support for armored units from scratch and select their medical equipment, but also determine the medical risks of the new environment. Right away he knew he needed a research program to make tanks safe for their crews and to maximize the battlefield performance of the man-machine combination.

One of Kenner's first steps was to request money to, as he described it, "study the human equation in … armor and vehicles used by armored forces. … I thought that a tank might be likened to occupational hazard and studied it from that standpoint. The tanks originally had been built without reference to the crews."[1] He laid out a long list of research topics: removal of the injured, ventilation, carbon-monoxide exposure, visual disturbances, flash burns, fatigue, postural hazards and injuries, head injuries, whiplash, tinnitus, rations, excessive temperature, dust, belt supports for back and trunk, sudden decompression, even blast effects from landmines. Kenner's commander, MG Jacob Devers, concurred in December 1941; Secretary of War Henry Stimson approved in February 1942; the National Research Council granted $300,000; ground was broken in March 1942; and the building (still being completed) was occupied in September 1942.

Figure 1. Albert Kenner as a major general. He is wearing the European Theater of Operations-Advanced Section shoulder-sleeve insignia. ***(Photo courtesy U.S. Army Military History Institute)***

The Armored Force Medical Research Laboratory (AFMRL) was formally established in October 1942. (Field work had already begun, with some staff spending Summer 1942 at the Camp Young, CA, Desert Training Center studying the effects of dry heat on tank crew.) Headed by a physician, AFMRL had medicine, physiology, chemistry, ventilation, physics and engineering sections.

AFMRL had a threefold mission:[2]

- Identify the sources and evaluate the magnitude of the stresses imposed upon the tank crew and other weapon operators.

- Determine the anatomical, biomechanical, physiological and psychological limits of the (assumed healthy) men selected as soldiers – what would make them unfit to fight.
- Find the balance between operating demands and human capabilities to avoid soldier breakdown and/or weapon failure.

The lab had plenty of work to do for the tankers. What protective clothing did they need? How safe were the overalls? (An early model had buttons that absorbed heat and blistered the crews.) What could the Army do to slow down their fatigue, including better seat design? Where should vehicle escape hatches be? How could tankers safely see out during the day and at night? Should tankers routinely wear earplugs to dampen noise? What about temporary deafness after repeated gunfire? How could the Army deal with claustrophobia?

The initial seven research areas were:[3]

- Cold-weather operations.
- Operations at high temperatures (particularly in tanks).
- Toxic gases in armored vehicles.
- Dust exposure in armored vehicles.
- Crew-fatigue research.
- Vision in tanks.
- Night vision from tanks.

Much research went into the tank as a working environment – what is now understood as ergonomics – and safety. One of the scientists recalled a very practical issue: "The M-4 tank of 1942 had no ventilation provided to specifically meet the needs of the crew. Engine-cooling air was drawn into the turret and through a heat-exchanger to the engine compartment. But in a stationary tank with the engine not operating, the men received no exchange air. Since the 75mm gun released considerable carbon monoxide and ammonia as the gun breech opened after firing, there was a clear toxic-gas hazard that needed to be corrected. This had not been done, I think, because it was usual to practice gunfire with the turret hatch open. Our systematic measurements of carbon monoxide and ammonia concentrations under various conditions of firing gave convincing proof of the hazard. This led to development of a compact fan to provide the necessary exhaust ventilation. The report recommending installation of such fans was not approved on the grounds that the tank already had too many gadgets! We succeeded, however, in getting two members of the headquarters general staff to take part in another test-firing of 10 rounds of 75mm shells with the tank buttoned up. One general was to be the gunner, and the other would load. I was the commander of the crew. When the ammonia reached about 400 ppm after firing four rounds, the generals were weeping copiously and ready to quit, but they were game to complete the test. Subsequently, the decision respecting our recommendation was reversed."[4]

Similarly, early tanks had forward air intakes. That was fine as long as there was no long line of vehicles on the road in front of you, in which case each vehicle down the column got more and more carbon monoxide. Simply repositioning the exhaust vents helped that problem.

Other problems were military but not purely armored. The scientists designed a gunsight that reduced magnification to get a broader field of view and found crews were hitting the target in one-quarter the previous time. A new artillery gunsight made use of a direct-reading scale within the field of view of the telescope itself and eliminated the major source of error. The frequency of error was reduced from 107 errors per 1,000 operations to just seven, and untrained personnel did better than those trained to operate with the old sight.[5]

Still other research was useful to the military but not purely military. The lab did some basic physiology work that needed doing: how much heat can the body shed, and through what mechanisms? How much exertion can people stand at various heat/humidity combinations? (This was when the Army decided that wet-bulb temperature was the number to monitor for heat hazards.) They learned that salt tablets were not needed, even if someone was sweating literally gallons a day, and that prompt water replenishment was important, not just total water replenishment. Many of the staff came from civilian physiological-research labs, and they were probably happy to do work related to their civilian-research interests. They investigated hot- and cold-weather clothing; cold-weather shoes and overshoes; and how to design footgear to actually handle the stress of marching rather than look smart on parade.

To do this work, the lab had remarkable facilities: “The laboratory was equipped with cold and hot rooms which approximated the conditions to which men were exposed in the field. The cold room could produce temperatures as low as [minus 63 degrees Fahrenheit], with wind velocities as high as 25 or 30 miles per hour. The hot room was capable of maintaining a temperature of 140 [degrees Fahrenheit]. This heat could be the intense dry heat of the desert or the steaming, humid heat of the jungle. A special ‘tight room’ was provided to investigate dusts and gases in relation to tank ventilation. Sufficient space was provided so that the largest vehicles used by the Armored Force could be accommodated, as well as a number of men at one time.”[6]

At the time, the Army Medical Department had no central research and development organization, and AFMRL worked under Preventive Medicine, specifically the Occupational Health and Industrial Medicine Section. Without a central control, liaison was a key, and AFMRL coordinated research projects with U.S. medical labs (civilian and military), with the Armored Force Board and with the British Armored Fighting Vehicles Physiological Laboratory. Cooperation with the Armored Force Board, also on Fort Knox, was especially close; staff were interchangeably available for advice and consultation, and the facilities of the board and laboratory were made available to each other.

By December 1943, no new designs for tanks proceeded beyond the mockup stage until they had been made the subject of study and report by the laboratory. All pilot models of new vehicles were tested by the laboratory with respect to the gun-fume hazard, contamination by carbon monoxide, placement and mounting of sights, lighting, placing of controls and seating.[7]

One thing led to another with some of the research: hot- and cold-weather physiology led to clothing research, protective clothing for cold climates and hot-weather clothing that would not itself cause overheating. By mid-war the clothing-research portfolio was assigned to AFMRL and became its largest function.[8] Its expertise in physiology also led to it being the natural place to consider what fitness was and what the ideal physical-fitness test should contain, as compared to what was being done. Since nutrition is related to physiology, a major research project began on rations. Field rations were tested both in the United States and in combat zones – groups of soldiers who had eaten only C-rations for more than 120 days had blood and urine tests to determine vitamin levels and other factors. The major finding was something fairly obvious: nutrients in food that is not eaten are worthless, so the Army needed to make sure the food is palatable and popular.

Other key research, apparently growing out of the hot/humid clothing tests for jungle warfare, was on atabrine dosing. The world’s standard anti-malaria drug was quinine, and the major supply source was the Dutch East Indies (now Indonesia), but that had recently been occupied by the Japanese. The United States had recently developed a synthetic anti-malaria drug, atabrine, and needed clinical research to test the effectiveness, dosing and dosing schedules. They learned what an effective level was, how many days it took the body to reach that level, how many days after leaving the malarial region an individual had to take the drug, and a host of other questions. Having a large pool of test subjects was important to quickly solving the questions, and Fort Knox had those (one test used 1,000 soldiers), but there was no particular reason to use AFMRL.

In February 1944, AFMRL was transferred from Armored-Force control to the Medical Department, but the director reminded his staff, “The primary function of the Medical Research Laboratory continues to deal with the problems of armored vehicles.”[9] The Armored Force Board had absorbed the ergonomics and safety concerns, and the lab was no longer needed solely for tankers. On April 1, 1947, AFMRL was redesignated the Medical Department Field Research Laboratory. The increasing focus on physiological research meant it was reasonably absorbed into the U.S. Army Research Institute of Environmental Medicine when that was established in 1961.

Dr. Sanders Marble is the senior historian in the Office of Medical History, Office of the Chief of Staff, Medical Command. He has been a historian with the Army Medical Department since 2003. Dr. Marble studied history at the College of William and Mary and King’s College of the University of London. He has written a variety of books and articles on World War I, military technology and military medicine.

Notes

[1] Albert Kenner interview with Forrest Pogue, May 27, 1948, U.S. Army Military History Institute.
[2] Theodore F. Hatch, “Some Reminiscences: The Armored Force Medical Research Laboratory in WWII,” ***Medical Bulletin of the US Army, Europe*** 42/1 (January 1985).

[3] Historical Section, Army Ground Forces, ***Study No. 27, The Armored Force Command and Center***, Washington, DC, 1946.
[4] Hatch.
[5] Hatch.
[6] ***The Armored Force Command and Center***.
[7] ***The Armored Force Command and Center***.
[8] Ebbe Hoff and Phebe Hoff, ***Medical Department, United States Army, Preventive Medicine in World War II, Volume III, Personal Health Measures and Immunization***, Washington, DC: Government Printing Office, 1955.
[9] ***The Armored Force Command and Center***.

Other sources

Armored Medical Research Laboratory, ***Project T-14 - Discussion of Ventilation Requirements of Armored Vehicles***, Oct. 22, 1945; DTIC AD658569.

Armored Medical Research Laboratory, ***Report No.3 A Critique of Physical Fitness Tests,*** Feb. 19, 1947; DTIC AD806395.

William B. Bean, "The Ecology of the Soldier in World War II," ***Medical Bulletin of the US Army, Europe*** 42/9 (September 1985).

Ebbe Hoff and Phebe Hoff, ***Medical Department, United States Army, Preventive Medicine in World War II, Volume IX, Special Fields***, Washington, DC: GPO, 1969.

Acronym Quick-Scan

AFMRL – Armored Force Medical Research Laboratory

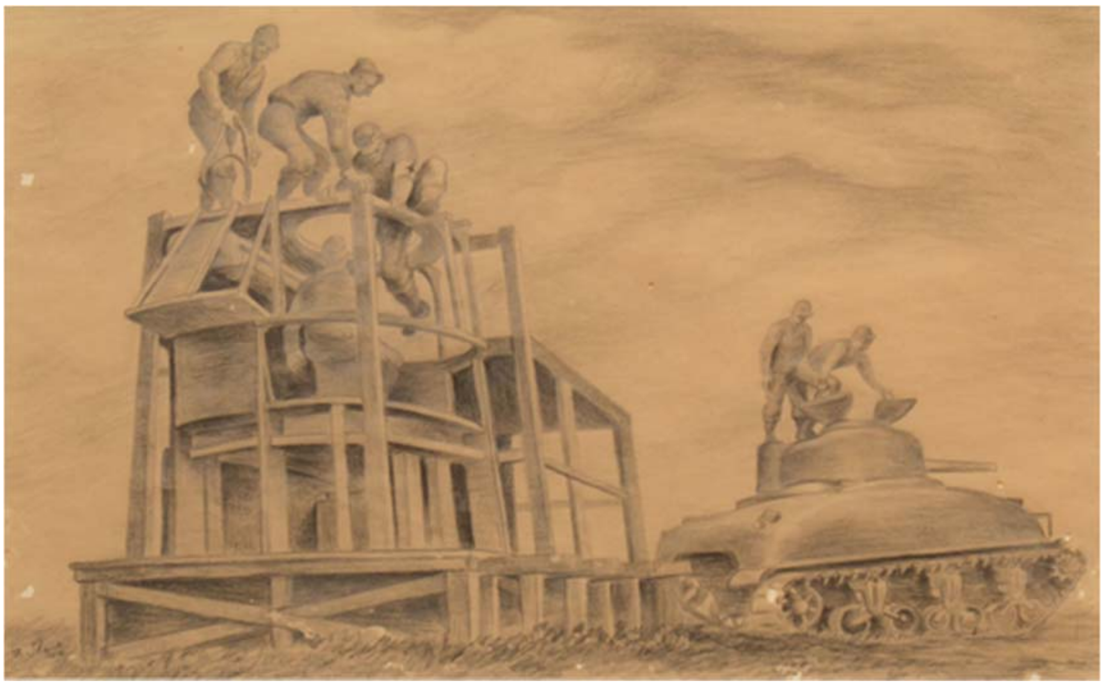

Figure 2. Medics training on evacuating wounded from a training aid of a Sherman tank turret. *(Pencil drawing by Frederick Shane, 1944. Courtesy Army Art Collection and Army Medical Department Museum)*