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Appendixes

Appendix A

Technological Advances in the Weapons and Equipment of the Armed Forces

Little progress was made from 1794, the beginning year of this study of federal expenditures, to 1860. The Army, which had used bronze in field guns at least as far back as the Revolutionary War, adopted iron for that purpose in 1801, but discontinued iron for bronze after 1835. At the opening of 1860 all such cannon were of bronze,[1] and their bore was still smooth, as in the earlier years. Indeed, the smooth-bore field gun of 1860 had the same range, 1,670 yards,[2] as that of 1815. By 1860 the musket of the foot soldier had a percussion cap and a paper cartridge,[3] improvements over the earlier flintlock and powder horn. But the gun was muzzle-loading, as at the beginning of the period, and, consequently, recharging was slow

The important advance of the Navy was the adoption of steam motive power. The ships, however, were still made of wood.

More technological progress in the implements of warfare was made from 1860 to 1900 than in the earlier period. Field guns, which were again of iron, were rifled during the Civil War, thus

1 William E. Birkhimer, *Historical Sketch of the Organization, Matériel and Tactics of the Artillery, United States Army*, James J. Chapman, Agent, Washington, D.C., 1884, pp. 257–266.

2 This range, according to Benedict Crowell and Robert Forrest Wilson (*The Armies of Industry: I. Our Nation's Manufacture of Munitions for a World in Arms, 1917–1918*, Yale University Press, 1921, p. 188), was for 1850, but since the field guns were still smooth-bore in 1860, their range was presumably the same.

3 Compare *Report of the Colonel of Ordnance, Nov. 1, 1849*, S. Doc. 1, 31st Cong., 1st sess., p. 424, with *Report of the Chief of Ordnance, 1863*, H.R. Doc. 1, 38th Cong., 1st sess., pp. 101–103.

See also Fred Albert Shannon, *The Organization and Administration of the Union Army, 1861–1865*, A. H. Clark, 1928, Vol. 1, pp. 103–126.

greatly increasing the distance that they would throw a shell. When foreign navies began to attach iron plates to the sides of their war vessels and to use rifled cannon, long-range guns for coastal defense became necessary. So the heavy smooth-bore cannon, which were made of iron and cast hollow, were rifled. Many of them burst, with serious casualties to the crew and heavy damage to installations.[4] After nearly twenty years of experimentation, the problem was solved with the built-up steel gun, formed by shrinking several steel tubes of graded diameters successively one on another, beginning with the smallest. Disappearing carriages for large-caliber guns, and small quick-firing cannon also emerged in this period. The soldier was armed with a breech-loading single-shot or magazine rifle.

The Navy developed the full armored ship and adopted the submarine and the Whitehead, or automobile, torpedo.

The pace of technological advance was still more rapid from 1900 to 1919. But the weapons and equipment that were developed were not merely improvements of, or additions to, the existing capital items in the armory of the nation; they also involved an immense increase in the quantity, and in the amounts of ammunition and supplies needed. As the quality was improved, the stocks were enlarged. Leading developments, all of which were heavily exploited in the First World War, included the airplane, the machine gun, the motorization of the heavier pieces of artillery up to the 240-millimeter howitzer, the manufacture and use in our artillery of the French recuperator—that extraordinary mechanism for absorbing the recoil—equipment for large-scale offensive and defensive chemical warfare, the use of the motor truck for the movement of men and supplies, and a ship-building program for the transport overseas of troops and munitions. The tank, introduced to the battlefield by the British, was adopted, though it was used only in small numbers.

The latest period, from 1919 to 1952, marks an even faster rate of progress in the means for waging warfare and further great additions to the stock of weapons and equipment and to the quantity

[4] The difficulty is well described in *Report of the Joint Committee on Ordnance*, S. Rept. 266, 40th Cong., 3d sess., submitted Feb. 15, 1869.

of ammunition and supplies needed to service the military machine. The gain since the beginning of the Second World War has been particularly impressive: the large number of carriers on the water, each with its complement of planes; the trains of repair and supply vessels that permit the Navy to operate in distant portions of the globe; the massive fleets of bombers; jet propulsion of aircraft; the divisions of tanks; radar and electronic devices; the variable-time fuse and the recoilless gun; the batteries of rocket weapons; guided missiles; the atomic bomb, cannon, and submarine; and, finally, the beginning stages of the hydrogen bomb are but the more outstanding developments. Indeed, the capture for military purposes of the awful powers of atomic fission and fusion has opened incomprehensible vistas of change in the weapons and equipment of the armed forces.

We have no data for most of the century and a half on the cost of equipping a soldier, sailor, division of a given size, or other comparable military unit, and so we cannot tell how much each advance in military technology has added to that expense. But we do know that the breech-loading rifle, whether single-shot or magazine, adopted in the interval from 1860 to 1900, cost more than the muzzle-loading musket of the earlier period, the built-up steel rifled cannon more than the smooth-bore iron or bronze weapon, and the full armored warship more than the wooden vessel. Besides, the small rapid-fire cannon, submarines, and automobile torpedoes were new weapons in the arsenal of the country and so involved additional expense. Further, more ammunition and supplies had to be bought.

In the next period, 1900 to 1919, the large motorized guns cost more than the small horse-drawn field pieces of the earlier years, the French recuperator more than the previous crude recoil devices, the magazine rifle more than the former mixture of magazine and single-shot arms, and the motor truck more than the wagon and team, or shoe leather for walking. The machine gun, the airplane, the tank, and the equipment for chemical warfare were new weapons involving still more cost. And the greatly enlarged quantities of ammunition and supplies needed for military operations added to the expense.

During the latest period the technological advances have been so tremendous as hardly to be comparable with earlier progress. The tank and the airplane have become virtually new weapons, so different are they and their equipment from earlier prototypes. The changes in these weapons, as well as the new ones that have been developed, are largely mechanical in character. And if strictly speaking they are not mechanical, their use involves mechanical devices.[5] Thus the waging of war, whether on or under the water, in the air, or on the ground, has become very largely a matter of operating machines.

Machines are expensive to buy, and, consequently, military costs mount with their adoption. This is true today and has been true throughout our history. The outfitting of an infantry division cost $19 million in the Second World War and $80 million in 1950. In the latter year 18,893 officers and men, in addition to small arms, numerous 50-caliber machine guns, bazookas, and mortars, were equipped with 120 recoilless rifles of 57 and 75 millimeters, 54 howitzers of 105 millimeters and 18 of 155 millimeters, and 9 light and 140 medium tanks. The division had 1,020 ¼-ton and 742 2½-ton trucks.[6]

The outlay for an armored division was $40 million in the Second World War and $200 million in 1950. In 1948 this unit of 15,973 men had, in addition to smaller weapons, 691 antitank rocket launchers, 3 75-millimeter rifles, 32 multiple guns with carriage and motor, 32 twin 40-millimeter guns with carriage and motor, 54 howitzers of 105, and 18 of 155, millimeters, 12 half-track carriers for 81-millimeter mortars, and 58 light and 315 medium tanks. The division also had 1,157 combat motor vehicles, of which 636 were armored, and 3,607 noncombat ones.[7]

Contrast this equipment with that during the Civil War—the muzzle-loading musket of the soldier who, except for an occasional train ride, *walked*; the horse-drawn supply wagons; the sabers, pistols, carbines, and horses of the cavalry; and the small muzzle-load-

[5] For example, atomic explosives are not machines, but their delivery, whether by airplane, guided missile, or atomic cannon, requires the use of elaborate mechanisms.
[6] *Fortune*, December 1950, p. 75.
[7] *The Army Almanac*, Armed Forces Information School, 1950, p. 277.

ing iron cannon pulled by horses. Toward the close of the war, the concentration of the Union artillery into larger commands resulted in reducing the number of field guns from three per 1,000 men to two and a half.[8] This was only fifty cannon for a unit the size of the infantry division and but forty for one the size of the armored division, the principal weapons and heavy equipment of which are given above. Further, the quantities of ammunition and of supplies required for a modern division, whether infantry or armored, are immeasurably larger than for a Civil War unit of the same number of men. Clearly, the increase in cost as a result of this factor and of the accompanying technological advances in weapons and equipment, and additions to the stock of military capital items, has been of immense magnitude.

Until the Second World War, the battleship was the major unit of the fleet. Protected by thick plates of hardened steel and armed with heavy long-range guns, this ship was the center of power around which all other ships were disposed. The increase during the past half-century in the cost of building and equipping such a vessel may be taken as a fair indication of the effect of technological developments on the cost of regular or standard naval units. The effect of this continuing factor in bringing about additional expenditures for new units and their equipment—for example, the carrier and its planes—is not shown. Three battleships of 10,288 tons were commissioned in 1895 and 1896; they mounted four 13-inch and eight 8-inch guns; and the cost of the ship and equipment ranged from $5,983,000 to $6,575,000. In 1910 two ships displacing 20,000 tons were commissioned, each armed with ten 12-inch and fourteen 5-inch guns. One cost $6,831,000 and the other $7,019,000.[9]

The two battleships of 32,300 tons completed in 1920 and 1921 mounted twelve 14-inch and sixteen 5-inch guns. The first one commissioned cost $17,975,000, and the other $19,819,000. Much

[8] Birkhimer, *op. cit.*, pp. 80, 84.

[9] Displacement and armament: *The Army Almanac*, pp. 193–196. Cost: *Navy Yearbook*, S. Doc. 247, 63d Cong., 2d sess., 1913, p. 816; letter from Department of the Navy, Bureau of Ships. The cost includes construction, machinery, ordnance, and all components necessary to place the ship in active service.

of the construction of both ships, particularly of the latter, was in a period of high prices. The latest battleships to join the fleet—the "Iowa," "New Jersey," "Missouri," and "Wisconsin," each of 45,000 tons—were completed in 1943 and 1944, and their major armament consists of nine 16-inch and twenty 5-inch guns. The "Wisconsin," built at the lowest outlay, cost $94,792,000, and the "Missouri," at the highest, $114,485,000.[10]

The costs of the Army, Navy, and Air Force in recent years are mostly for weapons, equipment, and needed supplies and maintenance, as distinguished from those for personnel. In 1952, out of total expenditures of $38.9 billion, $11.5 billion was for major procurement of aircraft, ships, and other capital items; $11.9 billion was for operation and maintenance; $1.8 billion for military public works; and $1.2 billion for research and development. The sum of these outlays, $26.3 billion, reflects directly the stage of technological development. Expenditures for military personnel, that is, for pay, subsistence, clothing, and transportation, were $11.2 billion.[11]

The total in 1953 was $43.6 billion. The sum of major procurement, operation and maintenance, military public works, and research and development was $30.8 billion. Expenditures for military personnel were $11.6 billion.

[10] See note 9.
[11] *Budget of the United States Government*, 1955, p. M 45.