THE GENERAL BOARD

United States Forces, European Theater

TANK GUNNERY

MISSION: Prepare Report and Recommendations on Tank Gunnery Technique and Other Factors Influencing Accuracy and Effectiveness of Fire from Tank Weapons.

The General Board was established by General Orders Number 125, Headquarters, European Theater of Operations, U. S. Army, dated 17 June 1945, as amended by General Orders Number 182, dated 7 August 1945, and General Orders Number 312, dated 20 November 1945, Headquarters, United States Forces, European Theater, to prepare a factual analysis of the strategy, tactics, and administration employed by the United States forces in the European Theater.

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TANK GUNNERY

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TANK GUNNERY

INTRODUCTION

1. Purpose. This study presents the conclusions and recommendations of The General Board, United States Forces, European Theater on the following factors influencing the accuracy and effectiveness of fire from tank weapons:

a. Changes in tank gunnery technique and training methods as laid down in current War Department publications.

b. Training requirement essential to attainment of uniformly high standards of tank gunnery.

c. Weapons, ammunition, and fire control equipment necessary to provide maximum accuracy and effectiveness of fire from tank weapons.

2. Scope.

a. In addition to the above factors, the study will include those general military characteristics of tanks which effect the efficiency of the crew in serving the tank weapons.

b. The subject matter is presented in two parts: training and technique, Part I, and equipment, Part II. Conclusions and recommendations are set forth after the discussion of each subject, and are also summarized Part III.

3. Source Material. This study is based on analysis of the following source material:

a. Interviews with 344 enlisted men and 98 officers, of which 75 percent were company grade. Combat experience of personnel interviewed ranged from two days to 30 months. They represented 12 of the 15 armored divisions and 10 of the 40 separate tank battalions which fought in the European Theater. Seven of the officers and twelve of the enlisted men fought with the 1 Armored Division in the Mediterranean Theater.

b. Interviews with three German panzer lieutenants.

c. Documents listed in bibliographies at the end of each chapter.

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TANK GUNNERY

PART ONE

TECHNIQUE AND TRAINING

CHAPTER 1

TANK GUNNERY TECHNIQUE

SECTION 1

GENERAL

4. War Department Publications.- The current War Department publication on tank gunnery technique is FM 17-12, Tank Gunnery, 10 July 1944.

5. Scope of Discussion.- The discussion herein is limited to those phases of tank gunnery technique which are considered to warrant comment or change. Omission of a particular phase indicates that, in the opinion of the General Board, United States Forces, European Theater, present technique should not be changed.

6. Basis of Recommended Changes.- Changes are recommended where battle experience dictates the need. The fact that a particular technique was not used is not considered sufficient to warrant its abandonment or revision. This applies particularly to certain refinements in technique set forth in FM 17-12, Tank Gunnery, 10 July 1944. The manual was not distributed to units in the European Theater before December 1944 and was not received by some units until October 1945.[1]

SECTION 2

DIRECT LAYING

7. Coordination and Control of Fire by the Platoon Leader.-

a. Current tank gunnery doctrine stresses control and coordination of the fire of a tank platoon by the platoon leader to the extent that:

(1) "He should personally supervise the firing of the whole platoon."[2]

(2) "He indicates when each section or tank is to open or cease fire."[3]

b. Interviews revealed that the extent to which platoon leaders coordinated and controlled the fire of their platoons varied greatly between units. The governing factors were: terrain, the tactical situation, and the attitude of the platoon leader towards control and coordination. Personnel who concurred in the need for close supervision of the firing considered it unwise to establish the above as a general policy. The reasons were:

(1) Often the platoon leader could not see all of his sector or all of his tanks at the same time. In these cases, he could not exercise close control.

(2) Unexpected dangerous targets were often encountered. Individual tanks must engage these targets immediately, to prevent their own destruction.

(3) A large volume of fire from individual tanks acting upon their own initiative often resulted in demoralizing the enemy.

c. The concept that platoon leaders must closely control the fire of their platoons was based partially on the necessity for conserving the limited supply of ammunition carried in a tank. However, personnel interviewed stated:

(1) Tank crews learn from experience to conserve ammunition.

(2) Ammunition expenditure can be equalized by rotating the lead tank.

d. The General Board, United States Forces, European Theater is of the opinion that coordination, control, and supervision of fire by commanders is axiomatic. However, experience in the European Theater has shown that the control must not be extended to the point of destroying the initiative of the individual tank commander.

e. It is recommended that appropriate War Department publications be revised accordingly.

8. Attack of Targets with Vertical Profile.-

a. Tank targets are of two general types: those with little or no vertical profile, such as antitank or machine guns; and, those having considerable vertical profile, such as tanks.[4] As regards the latter, FM 17-12, Tank Gunnery, states:

> "... the trajectory necessary to obtain a hit is one, which if the projectile were to continue through the target, would strike the ground beyond the target...If the round passes the target, and is not a hit, the path of the tracer furnishes more accurate information than does the point of strike. When the round passes over the target, the height of the tracer above the center of the target may be measured and the correct range change applied to obtain a hit."[5]

b. However the manual does not provide a method by which the correct range change can be determined. Experience in the European Theater indicated need for such a method.

(1) Interviewees emphasized the necessity for getting a hit before the enemy did, particularly when firing at tanks.

(2) Adjustment of tracer height can result in obtaining hits in fewer rounds than by following bracketing principles, when firing at vertical targets.

c. Accurate measurement of the height of tracer above the target is possible only with flat trajectory weapons. Since the trend is toward higher velocity armor piercing ammunition, this technique will have greater value in the future.

d. It is recommended that appropriate agencies of the War Department develop a simple method of fire adjustment for high velocity ammunition by which the height of tracer above a vertical target can be converted into the proper range change.

91 Initial Fire Orders.

a. An example of an initial fire order as set forth in FM 17-12, Tank Gunnery follows:

(1) Alert the gunner----------GUNNER

(2) Target description----------TANK

(3) Type of ammunition to fire---------SHOT

(4) Direction to traverse turret-------TRAVERSE RIGHT

(5) Stopping traverse----------STEADY-----ON

(6) Range----------ONE THOUSAND

(7) Command to open fire----------FIRE[6]

b. Most of the personnel interviewed maintained that the prescribed initial fire orders were not used. The reasons given were:

(1) Formal fire orders were not necessary for battle.

(2) The prescribed commands were too long.

(3) Crews developed their own systems which they considered quicker.

(4) Most of the information in the commands was unnecessary, particularly in the case of experienced crews.

c. On further questioning, all interviewees invariably admitted that the elements of the prescribed fire order were essential except:

(1) Opinion was divided on the necessity of alerting the gunner.

(2) A substantial number maintained that designation of the ammunition was necessary with an experienced loader only when the tank commander desired to change from the type normally employed against the target under attack. It was agreed that designation was necessary if the loader was inexperienced.

d. Nothing indicated that the systems developed by tank crews were definite or crystalized. It is believed that these systems consisted of commands such as: "Get that tank over by the barn on the side of the hill."

e. The few people who used the prescribed fire orders considered them both essential and highly satisfactory for combat.

f. It is concluded that experience in the European Theater has not shown the advisability of either revising or eliminating the initial fire orders prescribed in FM 17-12, Tank Gunnery, 10 July 1944.

g. It is recommended that there be no change in the initial fire orders as set forth in FM 17-12, Tank Gunnery, 10 July 1944.

10. Concentrating the Fire of the Platoon.-

a. FM 17-12, Tank Gunnery, prescribes a method by which the platoon leader concentrates the fire of his platoon by direct laying. It is commonly referred to as "WATCH MY BURST". It consists of the platoon leader adjusting on the target, thereby identifying the target and determining the range for his platoon. When the range has been determined, he announces it to the other tanks and they open fire. (See Appendix 1 for detailed procedure.)

b. Interviewees reported extensive employment of the "WATCH MY BURST" principle. Detailed procedure varied between units, being governed largely by their previous training. In some cases, the other tanks opened fire as soon as they identified the target and did not wait for the platoon leader to determine and announce the range. It was reported that the target usually was identified after the platoon leader had fired one or two rounds. Development of a satisfactory range finder for all tanks should eliminate the present desirability of the platoon leader determining the range before the remainder of the platoon opens fire.

c. The interviews revealed a general lack of familiarity with the procedure set forth in FM 17-12, Tank Gunnery, 10 July 1944. This can be partially explained by the relatively late date of incorporation of the current procedure in War Department publications (see Appendix 2). It is believed that this lack of familiarity can also be attributed to inadequate training.

d. Officers who stated they were familiar with the prescribed procedure felt it required too much radio transmission. They suggested simplification. More specific recommendations could not be obtained.

e. The German tank officers interviewed indicated that they did not favor the "WATCH MY BURST" method. They preferred to have one tank fire while the remainder of the platoon maneuvered.

f. The General Board, United States Forces, European Theater is of the opinion that, although the criticism of the present "WATCH MY BURST" method was due largely to lack of familiarity with prescribed procedure, combat experience has demonstrated the desirability of developing a procedure requiring a minimum of radio transmission.

g. It is recommended that appropriate agencies of the War Department investigate simplification of the "WATCH MY BURST" procedure as set forth in FM 17-12, Tank Gunnery, 10 July 1944.

11. Night Firing.-

a. Personnel interviewed reported that they had been called upon to fire at night. The method used, as well as those employed by the Germans, are discussed briefly in Appendix 3.

b. No instance was reported of the employment of the "aiming stake" and "intersection" methods of determing data set forth in FM 17-12, Tank Gunnery, 10 July 1944. The aiming stake method provides a means of accurately assigning specific targets to individual tanks and of accurately laying tanks for initial deflection. The intersection method provides an accurate means of determining range by mathematical computations. (See Appendix 4 for detailed description of these methods).

c. The failure to use the aiming stake and intersection methods can be attributed to:

(1) Lack of training, which was due to the lack of emphasis placed on night firing training in the Zone of the Interior.

(2) The fact that the intersection method was not incorporated in a War Department publication until January 1944, and the aiming stake method not until July 1944.[7]

d. Officers who had been instructed in the intersection method felt it was too involved and cumbersome, particularly when determining the range during darkness. They believed it would be difficult to train crews to overcome the tendency to return enemy fire before they had computed the firing data.

e. Officers interviewed emphasized that night firing would have been used more often had a simple method of delivering accurate fire been available.

f. The General Board, United States Forces, European Theater concludes that:

(1) Experience in the European Theater has demonstrated the need for a simple, quick method of delivering accurate fire at night.

(2) Although the aiming stake and intersection methods were not employed in the European Theater, they have possible utilization for planned night firing on pre-selected targets. In the absence of a means of illuminating the target, they are the only accurate methods available for present fire control equipment.

g. It is recommended that:

(1) Appropriate agencies of the War Department develop the equipment, ammunition, and technique required to provide tanks with a simple, quick, and accurate method of night firing.

(2) The aiming stake and intersection methods be retained in FM 17-12, Tank Gunnery, 10 July 1944 as expedients pending availability of more suitable methods.

SECTION 3

EMPLOYMENT OF TANKS AS ARTILLERY

12. Responsibility for Survey and Fire Direction.-

a. War Department Training Circular Number 125, 13 November 1943, which assigned tanks the secondary mission of reinforcing artillery stated that: "The reinforcing tank unit will execute position area survey." and "will be prepared to establish a fire direction center for computing data."[8]

b. Prior to invasion of the continent, First United States Army Group recognized that training in their primary mission had left tank battalions little opportunity for adequate artillery training. On 31 May 1944, a letter was sent to First and Third United States Armies stating that tanks would be employed as artillery:

"only under the supervision and control of the reinforced artillery. This supervision and control will include the establishment of place marks for each tank platoon, and the computation of all firing data, until such time as the artillery commander is satisfied that the tank unit is capable of operating its own fire direction center." (See Appendix 5.)

c. Interviews revealed that tanks were not employed extensively as reinforcing artillery.[9] Survey and fire direction were normally handled by the reinforced artillery. This was reported as satisfactory. Deviation was in the case of fire direction rather than survey. In some cases reinforcing tanks sent computors to the reinforced artillery's fire direction center. When tank units ran their own fire direction center, it was usually under the supervision of an officer from the reinforced artillery.

d. All tank personnel interviewed, from Combat Commanders to enlisted men, felt that tanks should not be responsible for survey or fire direction. The Division Artillery commanders of the 1, 3, 4, and 14 Armored Divisions agreed. The 5 Armored Division Artillery Commander felt they should be qualified in fire direction and survey. The 3 Infantry Division Artillery Commander considered it was not essential.

e. Tank battalions that were qualified in survey and fire direction when initially committed to action later found themselves severly handicapped by casualties since replacements had not received artillery training. Considering the large turnover of personnel in tank battalions, great weight must be given to this point.[10] Replacements received in the European Theater were not qualified in primary tank gunnery.[11] To train replacements qualified both in survey and fire direction and in tank gunnery would, by necessity, unduly lengthen the training period.

f. Experience in the European Theater indicates that the requirement that tanks perform their own survey and fire direction operations is unsound.

g. The General Board, United States Forces, European Theater recommends that appropriate War Department publications be revised to relieve tanks from the responsibility for survey and fire direction when employed as reinforcing artillery. Tank units must retain graphical firing tables and allied equipment for computation of individual firing data for their basic weapon.

SECTION 4

CARE AND MAINTENANCE OF WEAPONS AND FIRE CONTROL EQUIPMENT

13. Cleaning Cannon.-

a. War Department publications prescribe the following method of cleaning cannon tubes:

> "Swab the bore immediately after firing, while the tube is still hot, and daily thereafter on the following three days, with a solution of one-half pound of soda ash to each gallon of warm water. Rinse thoroughly with clean water and dry thoroughly before oiling."[12]

b. Approved alternatives in order of efficiency are: first a solution of one pound of soap (castile preferred) in four gallons of water; second, "cleaning, brushing, and wiping with lots of hot water"; and third, rifle bore cleaner.[13]

c. Personnel interviewed stated that guns usually were cleaned with gasoline and/or oil. When available, rifle bore cleaner was used. The necessity of heating water, and the time required for cleaning, made the other prescribed methods impractical. The tactical situation seldom, if ever, permitted cleaning a gun while it was still hot. Even with use of rifle bore cleaner, the time required prevented proper cleaning in forward areas.

d. The General Board, United States Forces, European Theater concludes that experience in the European Theater has shown:

(1) That the prescribed hot water methods of cleaning cannon are not practical for combat use.

(2) That there is need for a cleaning method developed primarily for combat utility.

e. It is recommended that appropriate agencies of the War Department develop a method for cleaning cannon tubes under combat conditions. The desired method should not require preparation of a solution by the tank crew and should be capable of cleaning a cold bore in ten minutes.

14. Adjustment of Machine Guns.

a. Appendix 6 contains notes on the Armored School methods of adjusting machine guns. These notes, with adverse comments by Headquarters European Theater of Operations, were forwarded to the War Department by the European Theater of Operations in February 1945 with the suggestion that they be considered in revising current publications.

b. The small number of interviewees who were familiar with these methods considered them superior to those prescribed by the War Department.

c. Experience in the European Theater indicates that the Armored School methods may be superior to prescribed methods.

d. It is recommended that appropriate agencies of the War Department determine whether prescribed methods of adjusting caliber .30 M1919A4 machine guns should be replaced by the Armored School method described in Appendix 6.

15. Condensation of Moisture on Exterior Sight Lenses.

a. War Department publications provide that moisture condensation on exterior lenses may be removed by taking the instrument to a warm place.[14] In battle, it is not feasible to remove the sights and periscopes from their mounts to do this.

b. Sights tend to fog badly on cold mornings, and also, when the tank is "buttoned up".[15] Interviewees reported gas mask anti-dim, applied to exterior lenses, was somewhat effective in preventing fogging. The general opinion was not as enthusiastic as that of a platoon leader from the 21 Tank Battalion who stated: "Anti-dim clears vision completely" and "lasts between six and eight hours".[16]

c. Experience in the European Theater indicates:

(1) The method of removing moisture condensation from exterior lenses, as prescribed in War Department publications, is not practical under combat conditions.

(2) There is need for a method of preventing moisture condensation on exterior lenses. Gas mask anti-dim is a good expedient.

d. It is recommended that appropriate agencies of the War Department develop:

(1) A method of removing moisture condensation from exterior lenses of tank sights which does not require removing sights from their mounts.

(2) A fully effective method of preventing moisture condensation on exterior lenses of sights. Pending such development, the use of gas mask anti-dim should be incorporated in appropriate publications as an expedient method.

16. Cleaning Exterior Lenses of Sights.

a. War Department publications prescribe the following methods of cleaning exterior lenses of sights:

> "Wipe optical parts with lens-tissue intended specifically for cleaning optical glass (use of cleaning cloths in the field is not permitted). For dust removal, go over the glass lightly with a clean camel's hair brush..... To remove grease or oil from optical surfaces, apply lens-cleaning liquid soap and gently wipe dry with clean lens paper. If the liquid soap is not available, breath heavily on the glass and wipe with clean lens paper.[17]

b. Some publications provide that "soft, dry, clean cloth" and alcohol may be used as a substitute for lens tissue and liquid lens cleansing soap.[18]

c. Interviewees universally stated they were never issued camel's hair brushes, lens-tissues, liquid lens cleansing soap, or alcohol. Even if issued, such items would soon be lost, due to lack of a proper stowage kit. Clean cloth was seldom available. Anything handy, such as a wool cap or the cuff of a combat jacket, was employed. Consequently, lenses were damaged.

d. Check of the allowances shown in Army Service Forces Catalog Ord S.N.L. K-1 reveals that except for Paper, Lens Tissue, none of the items referred to above are authorized for issue to combat units for the performance of first and second echelon maintenance.

e. The General Board United States Forces, European Theater concludes that:

(1) Lack of proper cleansing material caused damage to tank sights and periscopes.

(2) Supply of sight cleansing material as small independent items is unsatisfactory.

f. It is recommended that appropriate War Department agencies establish an adequate allowance of optical cleansing materials for use in tanks, and that such materials be issued as a kit to be included in the official stowage. The kit should include a box to be mounted in the turret convenient to the gunner.

Bibliography

Chapter 1

1. Information obtained from Publications Branch, Adjutant General's Section, Headquarters Theater Service Forces, and from personnel interviewed.

2. FM 17-12, Tank Gunnery, 10 July 1944, par 4, page 2.

3. Ibid, par 64b, page 72.

4. Ibid, par 66, page 74.

5. Ibid, par 68, page 77.

6. Ibid, par 71, page 78.

7. The "intersection" method was first published in War Department Training Circular No 2, 7 Jan 44, while the "aiming stake" method was first published in FM 17-12, Tank Gunnery, 10 July 1944.

8. WDTC 125 was rescinded by WDTC 10, 1 March 1945 because of incorporation of contents in FM 17-12, Tank Gunnery.

9. For example, 5 Armored Division Artillery Commander stated he employed tanks as artillery only twice. 3 Armored Division Artillery Commander stated he had never used tanks as artillery. 84 Infantry Division Commander stated his attached tanks were so used twice. 70 and 78 Infantry Division Artillery report so that tanks had not been used as artillery.

10. Commanding Officer 747 Tank Battalion stated that, in 11 months of combat, he had had over 100% turn-over in medium tank crew members.

11. Letter Hqs ETOUSA; subject: "Training of Armored Reinforcements"; file, AG 353 OpAFVW; dated 3 December 1944.

12. TM 9-735, Heavy Tank, T26E3, 15 January 1945, par 46d (8); TM 9-313, 75mm Gun M6 and Combination mount M64, 11 September 1944, par 28a.

13. TM 9-313, 75mm Gun, M6 and Combination mount M64, 11 September 1944, par 31c (3).

14. FM 17-12, Tank Gunnery, 10 July 1944, par 44b (1); TM 9-313, 75mm Gun M6 and Combination mount M64, 11 September 1944, par 69a (4).

15. Statement of Commanding Officer, 48 Tank Battalion, 14 Armored Division in AGF Observer Report No 693, 3 March 1945.

16. 12th Army Group Armored Report No 7, 27 March 1945, par 3b.

17. TM 9-313, 75mm Gun, M6 and Combination Mount M64, 11 September 1944, par 69a (2) & (3).

18. FM 17-12, Tank Gunnery, 10 July 1944, par 44d (1) & (2).

CHAPTER 2

TANK GUNNERY TRAINING

SECTION 1

TRAINING METHODS

17. Scope. The interviews indicated the necessity of certain refinements in application of training methods, as well as increased emphasis on certain phases of gunnery. The following discussion is limited to these modifications.

18. Adjustment of the Power Traverse.

a. Many interviewees reported that the power traverse developed drift. Few, if any, had received the necessary training to enable them to make the mechanical adjustment for eliminating drift.

b. It was pointed out that the speed and flexibility of the power traverse gave American tanks the one advantage they had over the German PANTHER and TIGER in a fire fight.

c. It is recommended that appropriate War Department publications be revised to require greater emphasis on the above adjustment, and that it be included in gunners' proficiency tests.

19. Crew Drill.

a. Junior officers and enlisted men stated that formal crew drill had little, if any, practical application in battle. However, they agreed that gun drill and simulated firing, which required them to perform their duties as crew members, was essential.

b. German tank officers stated that their crews were required to perform their duties in preparing for action, etc., in total darkness before qualifying for combat.

c. Crew drill is the only systematic method of so familiarizing crew members with their duties that they will function automatically in battle. The disciplinary value of executing these duties by formal command is obvious. However, over-emphasis of the disciplinary phase results in loss of interest and lack of realism.

d. The General Board, United States Forces, European Theater concludes that the ultimate objective of crew drill is combat efficiency and that this objective must be emphasized in training.

e. It is recommended that appropriate War Department publications be revised to contain the necessary directives.

20. Capabilities of American and Enemy Tank Weapons.

a. Officers and men stressed the lack of accurate information, during training, regarding the capabilities of our own and enemy weapons. Failure to disseminate complete and accurate information on the comparative capabilities of American and enemy weapons and tanks resulted in reduction in combat efficiency.

b. Experience in the European Theater indicates that:

(1) Tank crews must be provided with accurate information on the armor piercing capabilities of American

and enemy weapons, in an easily understandable, practical form. The data in FM 17-12, Tank Gunnery, 10 July 1944, (page 62-63) and FM 17-30, Tank Platoon, 17 June 1945 (page 212-226) is unsatisfactory.

(2) Training in the armor piercing capabilities of American and enemy weapons was inadequate.

d. It is recommended that:

(1) The War Department take the necessary action to provide tank crews with accurate information on the ranges at which American guns can penetrate enemy armored vehicles as well as the ranges at which enemy guns can penetrate American armor. This information should be in the form of cards capable of being carried in the shirt pocket or pasted in the turret, and of large silhouette charts for concurrent training in recognition of enemy vehicles.

(2) Appropriate War Department publications be revised to require greater emphasis on armor penetration capabilities of American and enemy weapons, and that this subject be included in gunners' proficiency tests.

21. Recognition of Enemy Tanks.

a. Junior officers and enlisted men felt that recognition training would have been improved by the use of full scale mock-ups of captured tanks. The small photographs and silhouettes used were not considered adequate.

b. A number of men had found recognition by sound to be valuable. However, it was not an infallible method.

c. It is recommended that:

(1) Appropriate agencies of the War Department provide more realistic training aids, such as models, full-scale mock-ups, and captured tanks.

(2) Appropriate War Department publications be revised to require greater emphasis on recognition training.

(3) Appropriate War Department agencies investigate the possibilities of recognition of enemy tanks by sound.

22. Fire Orders. The discussion on fire orders in paragraph 9, above, indicates the need for indoctrinating tank crews in the necessity for standard fire orders.

23. Sub-Caliber Firing.

a. Most interviewees considered the standard 1000 inch moving target course too unrealistic to be of value. (See FM 17-12, Tank Gunnery, page 158). Better basic moving target training was provided by the moving target tank. (See FM 17-12, Tank Gunnery, page 159).

b. A simple exercise to develop dexterity in manipulation is essential. The manipulation course described in FM 17-12, Tank Gunnery, page 156, meets this requirement. The standard 1000 inch moving target course is unnecessarily complicated for this purpose.

c. It is recommended that appropriate War Department publications be revised to eliminate the standard 1000 inch moving target course as qualification requirement for tank machine guns.

24. Service Ammunition Firing: Qualification in Gunnery.

a. Enlisted men stated that, in the light of their combat experience, they would not consider themselves qualified for battle until they had fired at least 100 rounds of service ammunition and preferably 150 rounds.

b. It is recommended that appropriate War Department publications be revised to provide that gunners' qualification require successful completion of a firing course involving supervised instructional firing of at least 100 rounds of service ammunition, including a suitable qualification test.

25. Service Ammunition Firing: Combat Firing.

a. All personnel interviewed stated that the most important phase of all training was realistic combat firing. Combat experience showed them that quick accurate shooting is required to kill the enemy before he kills you, and that such shooting is achieved only by more shooting in training.

b. It is recommended that the War Department require increased emphasis on combat firing for crew, section, and platoon training. Every effort must be made to create the maximum realism.

26. Service Ammunition Firing: Targets.

a. Interviewees pointed out the unrealistic training resulting from firing armor piercing ammunition at cloth tank silhouettes. Absence of the flash of a projectile striking armor made sensing of hits difficult.

b. Steel plate or obsolete tanks were suggested as proper targets.

c. The General Board, United States Forces, European Theater concludes that need exists for suitable targets for armor piercing ammunition.

d. It is recommended that appropriate War Department agencies provide target which when hit will produce the characteristic flash of an armor piercing projectile striking armor. Obsolete tanks are suggested.

27. Service Ammunition Firing: Ranges.

a. Officers familiar with the moving target ranges at Castlemartin, England, and Bad Lippspringe, Germany, considered them greatly superior to any in the United States in realism and training value.[19] Moving target ranges in the United States were described as unrealistic.

b. Experience in the European Theater indicates that there is need for improvement in moving target ranges in the Zone of the Interior.

c. It is recommended that appropriate War Department agencies provide more realistic moving target ranges. Desirable features of British and German ranges should be incorporated.

28. Tank Crew Gunnery Tests.

a. All personnel who had taken the Army Ground Force Tank Crew Gunnery tests considered them of great value, when conducted properly. In the light of battle experience enlisted men expressed a sincere desire to learn the exact state of their proficiency before going overseas.

b. The General Board, United States Forces, European Theater concludes that the value of the tank crew gunnery tests may be compromised if they are not conducted by disinterested personnel.

c. It is recommended that appropriate War Department agencies provide disinterested umpires to conduct the Army Ground Force Tank Crew Gunnery Tests.

29. Firing in Towns.

a. Junior officers and enlisted men stated that their training had not included employment of tanks in towns. However, they found such employment to be common. They pointed out that town fighting requires faster shooting and closer coordination than fighting in open terrain. The lack of training in town fighting was considered a handicap.

b. Experience in the European Theater indicates that town fighting with tanks requires specialized training.

c. It is recommended that appropriate War Department publications be revised to include gunnery and tactics training in employment of tanks in towns.

30. Indoor Gunnery Trainer. Antiaircraft units found the "Dome Trainer" to have great value. It is recommended that a similar trainer be developed for tank gunnery, and be made available for year-around use to enable tank gunners to retain their proficiency. This trainer is desired in addition to the present turret trainer.

SECTION 2

TRAINING REQUIREMENTS ESSENTIAL TO HIGH STANDARDS OF TANK GUNNERY

31. Scope.

a. This section covers the requirements necessary to attain uniformly high standards of tank gunnery in training and to maintain these standards in battle.

b. The initial requirements are sound gunnery technique and training methods. These were discussed in the preceding sections. The following discussion indicates the action required to obtain maximum value from gunnery technique and training methods.

32. Uniform Training.

a. In general, personnel from units where gunnery training was emphasized by senior commanders and was conducted in close accordance with prescribed methods, discussed gunnery more intelligently and were more cognizant of the need for standard, precise technique than personnel from other organizations.

b. The lack of uniformity in training, indicated above, can be

attributed partially to the long delay between issuance of M3 and M4 series medium tanks to troops, and development of gunnery technique, publication of training literature and inauguration of courses in gunnery technique at the Armored School (See Appendix 7). Because of this delay, individual units improvised methods. Many units left the Zone of the Interior without receiving the training prescribed in current publications.

c. In the opinion of the General Board, United States Forces, European Theater, the following requirements must be met to insure uniform training:

(1) Training literature, to include technique of employment, must be available automatically at the same time any new equipment is issued to units, both in the Zone of the Interior and in overseas theaters. New equipment reached troops in the European Theater before training literature.

(2) Establishment of firing centers, similar to the Tank Destroyer Center and the Desert Training Center. All officers interviewed favored a firing center as providing ideal training.

d. It is recommended that the War Department.

(1) Take the necessary action to insure that training literature, including technique of employment, is available automatically at the same time new equipment is issued to units. Full investigation of distribution of literature is indicated.

(2) Give serious consideration to establishment of unit firing centers.

33. Officers' Schools.

a. The lack of uniformity discussed in the preceding paragraph can also be attributed to absence of a univeral appreciation by officers of the requirements of accurate firing. This is shown by the fact that;

(1) The interviews revealed a difference in the evaluation of gunnery between officers who had taken the gunnery course at the Armored School and those who had not.

(2) Junior officers and enlisted men felt that many battalion commanders had insufficient knowledge of gunnery to fully appreciate their problems.

b. The lack of universal appreciation of the requirements of gunnery was the natural result of the rapid expansion of the Armored Force with officers who lacked previous experience with 75mm cannon. This was emphasized by a combat commander the the 5 Armored Division who stated; "I was embarrassed by my lack of knowledge."

c. The necessity for full understanding of the requirements of gunnery training is illustrated by the following statement of a battalion commander in the 5th Armored Division:

"You can not have too much gunnery, It is the most important phase and the least likely to improve on the

battlefield. . . . Gunnery must be automatic. . . . The battlefield is a poor place to learn shooting."

d. Both junior and senior officers who had taken a gunnery course at the Armored School after March 1943 considered it of great value, both to themselves and their organizations. A battalion commander in the 5 Armored Division attributed the greater losses of C Company to the fact that its gunnery training had been below the level of the other companies'. He believed this resulted from the other company commanders having taken the gunnery course while the C Company commander had not.

e. The great majority of senior officers felt that officers of their rank should take a course in gunnery. This opinion was shared by junior officers and enlisted men.

f. It is considered that the necessary appreciation by all officers of the requirements for high standards of gunnery can best be obtained by requiring all officers to take a gunnery course.

g. It is recommended that all armored officers be required to take a gunnery course.

34. Replacement Training in the Zone of the Interior.

a. Enlisted men trained at the Armored Replacement Training Center considered their gunnery training inadequate for combat. The principal deficiency was insufficient firing. Certain subjects were criticized as not being pertinent to their battle needs. Examples cited were lengthy compass-course problems and frequent dismounted road marches.

b. On 3 December 1944, Headquarters European Theater of Operations informed the War Department that the average tank crew man replacement was "below the standard of proficiency required for combat, particularly in gunnery and tank driving." It was recommended that the training period be extended from seventeen to at least nineteen, and preferably twenty weeks, and "that during this additional time, attention be focused on tank driving and tank gunnery." The War Department replied that, while the regular training period could not be extended, Army Ground Forces had been authorized "to hold in a pool for not more than four weeks, all armored replacements who had completed the 17 week course at Fort Knox and were not required for immediate shipment overseas." During this period trainees were to be given further instruction in driving and gunnery. (See Appendix 8). No evidence is available to indicate the extent to which this expedient remedied the deficiencies.

c. Unit commanders, as well as enlisted men, stated that men had been assigned classification numbers for which they were not qualified, by replacement organizations both in the Zone of the Interior and the European Theater. In practice unit commanders requisitioned only "gunners" and "drivers", since men with these classifications were found to be better qualified for their positions than personnel classified as "tank crewman". In general, it was felt that replacements so classified were not qualified to assume the duties of either gunner or driver. Two alternate remedies are suggested:

(1) Limit tank crew replacements to one category, namely, "tank crewman". To qualify as a tank crewman, the replacement must be fully qualified both as a gunner and as a driver.

(2) If the available training time does not permit the complete training of tank crewmen, limit the classification to "drivers" and "gunners". In addition to being fully qualified in tank driving, drivers must also be qualified in weapons mounted in the driving compartment. Classification as gunner must include qualification in the standard gunner's qualification course as prescribed by the War Department (See recommendation in par 24, above). The degree of qualification and score should be entered on the AGO Form 20. No replacement who has not qualified as either gunner or driver should receive a classification number for any position within a tank.

d. It is recommended that the War Department adopt either of the above solutions in order to provide qualified tank crew replacements.

35. Replacement Training in Overseas Theater.

a. Replacement officers and men stated they were out of practice when they finally reached a combat unit because of the lack of training while in the replacement "pipeline". This was also the view of many organizations and senior officers.[20]

b. The War Department did not provide the European Theater with personnel or equipment for conducting refresher training.[21] Consequently, it was necessary to improvise. Equipment could be obtained only by depriving combat troops, which were seldom at full strength after "D" day. Release of equipment for refresher training was opposed by the field forces. For the most part, the Replacement System had to utilize, as instructors, personnel awaiting assignment. However, in December 1944, a small permanent training cadre was formed.

c. Initially, refresher training in the central depot was accomplished by use of a tank battalion. Operational requirements necessitated removal of the battalion for combat in August 1944. After a lapse of three to four months, during which there was no training, training was again initiated by use of makeshift equipment and personnel assigned to the depot. The effectiveness of all of the training was minimized by the shortage of tanks. These measures did not provide for refresher training in the depots supporting each army. Consequently, units were forced to conduct their own refresher training.

d. Experience in the European Theater indicates that:

(1) Refresher training in tank gunnery is essential in overseas replacement depots.

(2) Improvisation deprives combat troops of needed materiel, places an unreasonable burden on tactical units, and is unsatisfactory.

e. It is recommended that the War Department provide overseas replacement depots with the personnel and materiel necessary to provide refresher training for tank crew replacement.

Bibliography

Chapter 2

19. For location of BAD LIPPSPRINGE see GSGS 4416, sheet P3, 1/1000000.

20. AGF Observers Report N 408, 29 November 1944; AGF Observers Report No 488, 1 January 1945; IRS from CG, GFRS to G-1, Com Zone; subject "Training of Tank Crews", dated 22 October 1944; Ltr from Brig Gen J. A. Holly, AFV & W Section, Hqs ETOUSA to CG Armored Center, Fort Knox, dated 11 October 1944.

21. Material for this and following paragraphs obtained from following documents.

a. Memorandum, Hqs 9th Replacement Depot, to AFV & W Section, Com Zone, dated 5 January 1945.

b. AGF Observers Report No 488, dated 1 January 1945.

c. Memorandum, AFV & W Section, Hqs ETOUSA, subject; "Replacements", dated 24 December 1944.

d. IRS, from CG, GFRS to G-1, Com Zone, ETOUSA, subject; "Tank Crewman", dated 22 December 1944.

e. Ltr, Hqs 9th Replacement Depot, subject; "Training Armored Force Replacements", to CG, GFRS, dated 17 October 1944.

f. Memorandum, AFV & W Section, Hqs ETOUSA, subject; "Armored Replacements", dated 25 September 1944.

g. IRS from CG, GFRS to G-1, ETOUSA, subject; "Retraining of Armored Force Personnel", dated 19 October 1944.

h. IRS From AFV & W Section, Hqs ETOUSA to AG, subject; "Training of Armored Replacements", dated 12 November 1944.

i. Final Historical Report, AFV & W Section, Hqs ETOUSA.

THE GENERAL BOARD
UNITED STATES FORCES, EUROPEAN THEATER
APO 408

TANK GUNNERY

PART TWO

EQUIPMENT

CHAPTER 3

GENERAL

SECTION 1

SCOPE

36. Equipment Required for Maximum Accuracy and Effectiveness of Fire. The weapons, ammunition, and fire control equipment required for maximum accuracy and effectiveness of fire are discussed in this portion of the study. Because they effect the efficiency of the crew in serving the tank weapons, certain other military characteristics of tanks are also included.

37. Army Ground Force Equipment Review Board.

a. The Army Ground Force Equipment Review Board's recommendations and conclusions, and comments of the European Theater of Operations and Twelfth United States Army Group with respect thereto, are quoted in the appendices indicated at the beginning of each section.

b. The European Theater of Operations and Twelfth United States Army Group reviewed only the Army Ground Force Board's preliminary study which did not contain many of the complete recommendations quoted in the appendices. Therefore, omission of a reference to the comments of the European Theater of Operations and Twelfth United States Army Group in any discussion of the Army Ground Force Board's recommendations indicates that the particular recommendation was not contained in the preliminary study.

38. Limits of the Discussion. In general, the discussion in the body of this study is limited to those points not covered, or insufficiently emphasized, by the Army Ground Force Equipment Review Board, and to explanation of the non-concurrences of the General Board, United States Forces, European Theater with certain recommendations of the Army Ground Force Equipment Review Board.

SECTION 2

CHARACTERISTICS OF FUTURE DEVELOPMENT

39. Improvement in Existing Type Equipment.

a. In effect, the recommendations of the Army Ground Force Equipment Review Board provide for technological improvements in existing type tanks and cannon. The General Board, United States Forces, European Theater believes that the European campaign demonstrated the need for the recommended improvements.

b. Therefore, it is urged that appropriate agencies of the War Department execute the recommendations of the Army Ground Force Equipment Review Board quoted in the appendices mentioned in the follow-

ing chapters of this study, as qualified by the comments of the European Theater of Operations and by the recommendations in the following discussion.

40. Necessity for New Methods of Destroying Tanks.

a. Tank development has been characterized by the race between armor protection and armor penetration. The result has been steady increases in tanks' size and weight. Large tanks are undesirable. This is particularly pertinent in view of the United States' tremendous supply distances in the two world wars.

b. The most recent American and German development in tanks, as well as those recommended by the Army Ground Force Equipment Review Board, indicates that the race between gun and armor still continues.

c. Development of lighter versions of standard tanks with light metals replacing steel, and of improved armor of less weight, as recommended by the Army Ground Force Equipment Review Board and European Theater of Operations, may arrest the trend toward heavier and larger tanks. However, the General Board, United States Forces, European Theater believes that the race between gun and armor can be ended successfully only by development of entirely new methods of destroying tanks. Such methods will undoubtedly involve radical departure from firing an armor piercing projectile from a cannon.

d. It is recommended that the War Department institute exhaustive research into entirely new methods of destroying tanks.

41. Simplicity of Operation.

a. The army of the next war, like the armies of World Wars I and II, may be expected to be largely civilian with limited training.

b. Experience in the European Theater showed a large turnover of tank crew members, with the necessity of battlefield assimilation of inadequately trained replacements. There is no reason to believe that the casualty rate will decrease in the future.

c. The conclusion to be drawn from the above is that equipment must be designed with a view toward simplicity of operation for the crew members.

d. It is recommended that maximum simplicity of operation for the crew member be adopted as a fundamental principle of future development.

CHAPTER 4

TANKS AND TANK CANNON

SECTION 1

CHARACTERISTICS COMMON TO ALL TANKS

42. Army Ground Force Equipment Review Board. Appendix 9 contains the Army Ground Force Equipment Review Board's recommendations on pertinent military characteristics which are not included in the following chapters.

43. Liquid Protected Ammunition Stowage.

a. Approximately 75% of the interviewees believed that liquid protected stowage was an asset, either actual or psychological. The majority of those who had the opposite opinion took the cynical view that "the tank would burn anyway". The commanding officer of the 191 Tank Battalion, which fought in both the European and Mediterranean Theaters, stated his battalion had kept records which proved that liquid protected stowage had permitted crews to escape unburned.

b. It is recommended that the War Department seriously consider incorporation of liquid, or similarly, protected ammunition stowage in all future tanks.

44. Ammunition Stowage Racks.

a. All personnel interviewed considered a "ready rack" essential.[22] Capacity desired was at least ten, and preferably fifteen, rounds. From this standpoint, stowage in early models of the M4 series medium tanks, which included a large ready rack under the gun and a row of projectiles around the perimeter of the basket, was considered ideal.

b. Stowage of the bulk of the ammunition under the floor was preferred to stowage in the sponsons. Hinged covers for ammunition bins located under the turret floor were reported to be unsatisfactory, and they usually were removed. Interviewees suggested sliding covers.

c. In the M26 heavy tank, the necessity of traversing the turret to remove floor and side wall rounds was disliked.[23]

d. It is recommended that the following characteristics be incorporated in future tanks:

(1) A ready rack capable of holding at least 10 rounds.

(2) Bulk of the ammunition stowed under the floor, unless equal protection from fire can be obtained in the sponsons.

(3) Sliding covers, or other substitute for hinged covers on ammunition bins.

(4) Ammunition removal from stowage racks be not dependent on traversing the turret.

45. Construction of the Fighting Compartment.

a. Few interviewees favored a "half floor" in the turret such as in medium tank M4A3 (76mm gun). When traversing the turret, empty cartridge cases, ammunition bin covers, and miscellaneous equipment which often falls to floor, easily becomes jammed between the half floor and the top of the ammunition compartment. Also, the loader

must guard against his feet becoming entangled with the half floor when quick deflection changes are made.

b. Approximately 30% of the interviewees desired a moving full floor. Those opposed to the full floor felt it complicated ammunition stowage under the floor and made it more difficult for personnel in the driving compartment to escape through the fighting compartment.

c. Approximately 60% preferred no floor, such as in light tank M24. However, it was felt that tanks so designed should include:

(1) A foot rest for the gunner.[24]

(2) Folding platform for the tank commander. It should revolve with the turret and be adjustable in height.[25]

(3) A seat for the loader which would revolve with the turret.

d. It is recommended that:

(1) The half floor be considered unsatisfactory.

(2) Tests be conducted to determine whether a full moving floor or no floor should be incorporated in future tanks.

(3) All tanks equipped with a no floor fighting compartment be provided with the devices listed in paragraph c. above.

SECTION 2

CHARACTERISTICS COMMON TO ALL TANK CANNON

46. Army Ground Force Equipment Review Board. Appendix 10 contains the Army Ground Force Equipment Review Board's recommendations on military characteristics common to all cannon.

47. Accuracy and Effectiveness.

a. All personnel interviewed emphasized that the outstanding deficiency in tank armament was the lack of a cannon capable of penetrating heavy German frontal armor, at normal tank fighting ranges, i.e. up to 1500 yards.[26] 105mm howitzer HEAT (high explosive - anti-tank) could penetrate the glacis plate of the PANTHER tank. However, its accuracy limited useful employment to ranges of 500 yards and under.[27]

b. Interviewees pointed out that undesirable characteristics, such as long, heavy ammunition, were acceptable, if unavoidable in obtaining a gun of the required performance and accuracy.

c. Therefore, it is recommended that accuracy and effectiveness be considered the most important characteristics in cannon design. These characteristics must be obtained with all the types of ammunition required.

48. Tube Life.

a. The accuracy life of our gun tubes exceeds that of high velocity German cannon.[28] Due to the short battle life of tanks, the present accuracy life of gun tubes greatly exceeds that of the tanks in which they are mounted.

b. The Army Ground Force Equipment Review Board concluded

that a tube life of not less than 1000 rounds is the satisfactory minimum.[29] Both European Theater of Operations and Twelfth United States Army Group stated that "long tube life should be reduced in favor of higher velocities", but did not give a specific figure.[30] In view of the urgency of increased penetration, it is considered that a tube life of only 200-300 rounds of armor piercing ammunition is acceptable.[30a]

c. It is recommended that:

(1) The War Department consider a tube life of 200-300 rounds of armor piercing ammunition acceptable for tank guns, if necessary in obtaining required penetration.

(2) Gun mounts be so designed as to permit easy and quick replacement of tubes, because of the short acceptable accuracy life.

49. Fixed Ammunition.

a. The Army Ground Force Equipment Review Board recommended that all tank ammunition be fixed.[31] Twelfth United States Army Group concurred.[32] The European Theater of Operations modified the recommendation to be applicable to present tank gun calibers only.[33] The latter headquarters felt that ammunition stowage and loading can be developed for a larger tank cannon which will permit the maintenance of present rates of fire plus higher standards of combat efficiency.

b. The General Board, United States Forces, European Theater considers semi-fixed ammunition extremely undesirable for tank guns.[33a] (The present semi-fixed ammunition is satisfactory for the 105mm howitzer). However, it is recommended that semi-fixed ammunition be accepted, as a last resort, if the required performance cannot otherwise be obtained.

50. Overall Size and Weight of Ammunition.

a. Interviewees considered 90mm ammunition "too large" for easy handling in a turret.[34] 76mm was satisfactory. They believed that the ammunition for the 75mm gun in the PANTHER tank would be easy to load.

b. The Army Ground Force Equipment Review Board recognized the desirability of holding down the overall length and weight of ammunition.[35] Twelfth United States Army Group emphasized that ammunition should be "short", to facilitate loading.[36] The European Theater of Operations recommended that consideration also be given to the diameter of the base of the shell case on the basis that this dimension is as important as the length of the round in determining stowage capacity.[37]

c. Interviewees emphasized the urgency of being able to fire the first accurate round. Ease in loading is governed more by overall length than by weight or diameter of the round. The General Board, United States Forces, European Theater is of the opinion that the required rate of fire is of greater importance than ammunition stowage capacity.

d. It is recommended that:

(1) Reduction in overall length of ammunition be given priority over reduction in diameter of the base of the shell case, even at the expense of larger gun breeches and cradles.

(2) Ammunition stowage capacity be sacrificed, if necessary, to provide ammunition which can be loaded with sufficient ease to obtain the required rate of fire.

51. Automatic Loading.

a. The Army Ground Force Equipment Review Board recommended that all tank guns be equipped for automatic loading.[38]

b. It is considered that automatic loading is of minor importance for ammunition comparable in size and weight to the present 76mm rounds. For ammunition similar to, or larger than, present 90mm rounds, automatic loading would be desirable. However, procurement of a gun of the required performance should not be delayed pending development of automatic loading.

52. Semi-Automatic Breech. The Army Ground Force Equipment Review Board recommended that tank guns be equipped with a semi-automatic breech.[39] It is extremely desirable that the characteristics of the recoil mechanism and breech be such that automatic opening is obtained regardless of differences in muzzle velocity between the various types of ammunition employed. However, a semi-automatic breech should not be provided at the expense of accuracy and effectiveness.

53. Allowable Rate of Fire.

a. Tank guns should be designed primarily for their direct laying capabilities. The rate of fire of present tank guns is satisfactory for this mission. The relatively limited use of tanks for artillery type firing in the European Theater indicates that the ability to execute this role should receive only minor consideration in gun design. However, the extensive employment of indirect laying by 105mm howitzer medium tanks and 75mm Howitzer Motor Carriages, M8, indicates that the basic weapon of the "assault gun" platoon must be able to fire prolonged artillery missions.[39a]

b. It is recommended that: the ability of tank guns to fire prolonged artillery type missions be given minor consideration in future gun design. However, the tank mounted howitzer of the "assault gun" platoons in armored divisions, tank battalions, and cavalry units must be capable of such missions.

54. Gun Travel Locks.

a. The Army Ground Force Equipment Review Board stated:

> "A positive and rugged gun travel lock shall be provided that can readily be applied from the gunner's position. In addition to the interior travel lock an exterior travel lock shall be provided in the normal carrying position of the principal weapon."[40]

b. The normal traveling position of the 90mm gun in the heavy tank M26 necessitates traveling with gun pointing to the rear. For purely administrative marches, this is satisfactory. However, provision must be made for extensive travel with the gun forward. An exterior travel lock located on the front slope plate and capable of being operated from within the tank is recommended.

SECTION 3

SPECIFIC TANK CANNON REQUIRED

55. Army Ground Force Equipment Review Board.

a. The characteristics of the tank guns recommended by the Army Ground Force Equipment Review Board are shown in Appendix 11. The comments of the European Theater of Operations and Twelfth United States Army Group are also indicated.

b. Analysis of the penetration performance and overall ammunition size and weight, indicates that the guns recommended by the Army Ground Force Equipment Review Board are a substantial improvement over present armament. Therefore, it is considered that they will satisfy initial requirements. Their procurement should be expedited.

56. Specific Calibers. The recommendations of the Army Ground Force Equipment Review Board include specification of the caliber of the guns required. The caliber of a tank gun is immaterial as long as the gun has the required performance and rate of fire. Consequently, it is recommended that development agencies not be restricted to the development of tank guns of the specific calibers recommended by the Army Ground Force Equipment Review Board.

57. Statement of Armor Penetration Requirements.

a. The specific penetration recommended by the Army Ground Force Equipment Review Board was stated in terms of 30° attack. In view of the greater angle of armor on modern tanks, performance should be based on 45° attack.

b. Although desirable, it is obviously impractical to mount a cannon capable of destroying any enemy combat vehicle in tanks of every weight class. Therefore, the following requirements, as stated by the Army Ground Force Equipment Review Board, should be adopted as the minimum standard for future development with the additions indicated:

(1) For reconnaissance (light) tanks, a gun "capable of penetrating the sides and rear of any enemy armored vehicle", at normal tank fighting ranges.

(2) For exploitation tanks of an armored division, a gun "capable of penetrating the sides and rear of any enemy armored vehicle and the front of any but the heaviest assault tank", at normal tank fighting ranges.

c. Experience in the European Theater has shown that an infantry support tank has little opportunity for maneuver. Therefore, the guns for this tank must be capable of penetrating the sides, rear, and front of any enemy armored vehicle, at normal tank fighting ranges.

d. The European campaign demonstrated that tanks fight tanks. Therefore, there must be available a vehicle mounting a cannon capable of destroying any enemy tank and having sufficient mobility to permit it to operate with exploitation tanks. It is recognized that this may have to be a special purpose weapon, with limited traverse, small ammunition stowage capacity, and suitable only for armor piercing ammunition.

58. "Assault Gun" (Tanks Mounting a Howitzer).

a. Except for the lack of power traverse, personnel interviewed expressed satisfaction with 105mm howitzer M4 in the medium tank M4 series as the weapon for the "assault gun" platoon.[41] Due primarily to the absence of the power traverse, these weapons were not employed as regular fighting tanks.[42] They were employed more as close support artillery than as direct laying "assault guns".[43] However, interviewees indicated that, with the incorporation of a power traverse, direct laying would have been more common. For this reason, the universal opinion was that 360° traverse was essential, and also that the weapon should be mounted in a standard tank.[44]

b. The interviews revealed nothing to indicate that the 105mm ammunition stowage capacity of the M4 series medium tanks was unsatisfactory. It is not known whether the stowage would have been sufficient in the event of more extensive direct laying.

c. The General Board, United States Forces, European Theater has recommended that "assault gun" platoons in armored divisions and tank battalions in infantry divisions be equipped with 105mm howitzer tanks.45

d. The recommendations of the Army Ground Force Equipment Review Board do not include a weapon similar to medium tank M4 series with 105mm howitzer. The only self-propelled 105mm howitzer recommended has 45° traverse and is not mounted in a tank. This weapon would not be satisfactory for the "assault gun" platoons.

e. It is recommended that "assault gun" platoons in armored divisions and tank battalions in infantry divisions be equipped with 105mm howitzer, M4, mounted in a standard tank with 360° power traverse, having 105mm ammunition stowage capacity not less than that of medium tank M4 series (with 105mm howitzer).

Bibliography

Chapter 4

22. See also memorandum Hqs 3d Cav Ron Sqn to Chief, Armored Section, First US Army, dated 6 April 1945, and comments of 6 Cav Ron Sqn in AGF Observer Report No. 759, dated 25 March 1945.

23. Report of 3 Armored Division in War Department Observer Board Report on M26 Heavy Tank, dated 20 July 1945.

24. See also documents referred to in Note 22.

25. See also documents referred to in Note 23.

26. See also following documents:

    a. Final Historical Report, AFV & W Section, Hqs ETOUSA.
    b. Ltr Major G neral I.D. White, CG 2 Armored Division to SCAEF, dated 20 March 1945, inclosing digest of opinions of officers and enlisted men.
    c. Memorandum, Hqs 33 Armored Regiment to CG 3 Armored Division, dated 20 March 1945.
    d. Ltr Major General E.H. Brooks, CG 2 Armored Division to Brig. General J.A. Holly, Chief AFV & W Section, Hqs ETOUSA, 23 June 1944.
    e. Ltr Hqs AGF, subject: "Technical Observers Report, European Theater of Operations, 9 February to 23 March 1945, dated 12 April 1945.
    f. Record of trans-Atlantic telephone conversation between Brig. General J.A. Holly, Chief AFV & W Section, ETOUSA and Major General A.W. Waldron, Hqs AGF, on 2 January 1945 at 1523 hours.
    g. AGF Observer Report No. 767, dated 28 March 1945.
    h. Ltr Hqs First US Army, subject: "Request for Gun, 90mm T15 (3200 f/s)", dated 9 February 1945.
    i. Ltr Hqs ETOUSA, subject: "Observers Report, Colonel George M. Dean", dated 12 February 1945.

27. See also report of Board of Officers appointed by SO 196 Hqs First US Army, 19 July 1944, dated 30 July 1944; Ltr Col. Claude Black, Armored Officer, Ninth US Army to Brig General J.A. Holly, Chief AFV & W Section, ETOUSA, dated 30 December 1944; AGF Observer Report No. 406, dated 29 November 1944; AGF Observers Report by Col. George M. Dean.

28. Ltr Hqs AGF, subject: "Tank and Tank Destroyer Cannon", dated 30 January 1945.

29. Army Ground Force Equipment Review Board Report (referred to hereafter as AGFERBR), Part II.

30. Ltr Hqs ETOUSA, subject: "Army Ground Force Equipment Review Board, Preliminary Study", dated 27 June 1945, and Staff Study used in preparation of above letter. (Both documents referred to hereafter as ETOUSA study).

30a. Armored Officer, First US Army also recommended this figure. See letters, Colonel P.C. Hains, Armored Officer, First US Army to Brig General J.A. Holly, Chief, AFV & W Section, ETOUSA, dated 28 July 1944 and 3 December 1944. Document referred to in Note 26a stated that units specified accuracy like need not be over "250 to 400 rounds".

31. AGFERBR, Part I, Annex N. par 11d (1).

32. ETOUSA Study referred to in Note 30.

33. Ibid

33a. This was also the opinion of all personnel interviewed in the preparation of this report as well as the documents referred to in Note 26e.

34. See also document referred to in Note 26e.

35. AGFERBR, Part I, Annex N. par 11d (3).

36. ETOUSA Study referred to in Note 30.

37. Ibid

38. AGFERBR, Part I, Annex C. par 8b.

39. AGFERBR, Part II, Inclosure A-C, par 6.

39a. AGF Observer Reports No. 406, dated 23 November 1944, and No. 685 dated 27 February 1945, and No. 1072 dated 30 June 1945, and No.396 dated 28 November 1944.

40. Ibid, par 10c.

41. See also the following documents: Memorandum AFV & W Section, Hqs ETOUSA, subject: "Report of Trip to Armies", dated 4 Dec 1944, recording comments of Major General R.G. Grow, CG 6 Armored Division; ACF Observer Reports No. 390 dated 26 November 1944 and No. 408 dated 29 November 1944.

42. See also Final Historical Report, AFV & W Section, ETOUSA; "Notes on Use of 105mm Howitzer M4 Mounted in M4 Tank" by Lt George Deiser, Assault Gun Officer 743 Tank Battalion.

43. See documents referred to in Note 41.

44. See also AGF Observer Reports No. 685, dated 27 February 1945, and No. 775, dated 29 March 1945; AGF Combat Observers Report by Colonel George H. Dean.

45. Report on "Organization, Equipment and Tactical Employment of the Armored Division" Study No. 46; and report on "Organization, Equipment and Tactical Employment of Separate Tank Battalions", Study No. 50.

CHAPTER 5

TANK MACHINE GUNS

SECTION 1

GENERAL

59. Importance of Machine Guns.

a. The emphasis during the European campaign on the need for a cannon capable of penetrating heavy German frontal armor may cause the importance of machine guns to be overlooked in future development. This must not occur.

b. The importance of the role of tank machine guns in the European Theater is shown by the following facts:

(1) All personnel interviewed desired that the bow machine gun be made more effective by addition of a sight and by increasing its traverse and depression.

(2) Most units carried approximately 50 per cent more caliber .30 ammunition than that provided in the organized stowage.[46]

(3) Some units mounted caliber .30 machine guns on the turret for use by the tank commander against ground targets. These guns either replaced or augmented the caliber .50 antiaircraft guns.[47]

(4) Many tanks carried spare machine guns because there was no opportunity to repair defective guns in battle.

c. The extensive use of tank machine guns and the expedients adopted to increase their effectiveness indicate need for increased fire power. The Army Ground Force Equipment Review Board recognized this need and recommended multiple coaxial guns as well as possible dual bow guns. (See Appendix 12). The General Board, United States Forces, European Theater is not certain that these recommendations are the optimum means of increasing fire power. Therefore, it is recommended that the War Department investigate all possible means of increasing machine gun fire power. Ammunition stowage per gun must be at least equal to that provided in present tanks.

60. Characteristics of Machine Guns.

a. Present tank machine guns are standard ground guns. Interviewees stated that, with these guns, barrel changing, loading, and reduction of stoppages is time-consuming. In addition, the weight and size of the caliber .50 gun was considered excessive. Development of improved ground guns should eliminate these deficiencies, and also effect desirable reductions in size and wight.

b. Almost all personnel interviewed considered the present cyclic rates satisfactory. They felt that greater effectiveness was obtained from sustained firing rather than from high rates of fire. All interviewees stated there was need for a gun capable of firing longer bursts, than present guns, without overheating. Overheating caused most stoppages.

c. Automatic headspace adjustment was unanimously requested.

Ruptured cartridge cases were second to heating in causing stoppages. Evidence indicates that most of these stoppages were due to improper headspace rather than to defective ammunition.

d. It is recommended that improved machine guns be provided for tanks. The caliber .50 gun must be smaller and lighter than the present M2 gun; similar reduction in the caliber .30 gun is desirable. All guns must have the following characteristics:

(1) Automatic headspace adjustment.

(2) Quick method of changing barrels.

(3) Ease in loading and reducing stoppages in fighting compartments.

(4) Ability to fire bursts of 20-30 round for maximum period without overheating.

(5) Cyclic rate of caliber .30 M1919A4 gun. (550 rounds per minute).

61. Spare Parts.

a. Each tank is authorized numerous machine gun parts. (See Appendix 13). Interviewees reported that these parts were never used; in battle there was no opportunity to repair guns. Instead, many units carried one or two extra machine guns, in each tank. The company armorer carried all the spare parts. Guns needing repair were turned in to him by the tank crews. Broken parts were reported to have caused the least number of stoppages.

b. Everyone interviewed was in favor of carrying spare machine guns rather than spare parts. Therefore, it is recommended that, stowage space permitting, spare machine guns, rather than spare parts, be authorized each tank on the basis of at least one spare gun for every three guns, or fraction thereof. Spare parts to be authorized on the company level.

SECTION 2

SPECIFIC MACHINE GUNS REQUIRED

62. Bow Machine Guns.

a. Army Ground Force Equipment Review Board's recommended armament for reconnaissance tanks includes a caliber .30 bow machine gun.[48] For larger tanks, it was recommended that consideration be given to mounting the bow gun "or guns in remote controlled ballistic blisters."[49]

b. All interviewees desired a caliber .30 bow gun. Wider traverse, increased depression, and incorporation of a sight were universally requested. On 26 September 1944, Twelfth United States Army Group requested development of a sight with at least two power magnification.[50] The European Theater of Operations concurred.[51] The Army Ground Force Equipment Review Board recommended that "an infinity sight and linkage" be provided.[52]

c. The bow machine gun mount weakens the front plate. Consequently the Germans often aimed at the bow gun.[53] Mounting the gun in a blister on the side of the tank will overcome this problem.

However, the interviews revealed that the bow gun(s) must be able to cover the ground immediately in front of the tank and between the tracks, irrespective of the field of fire of the coaxial guns.

d. The General Board, United States Forces, European Theater recommends that:

(1) All tanks be equipped with a caliber .30 bow machine gun, equipped with sight, and having greater depression and traverse than at present.

(2) Relocation of the bow gun in all tanks be investigated. Bow gun(s) must be able to cover the ground immediately in front of the tank and between the tracks.

(3) Consideration be given to providing magnification in sights for bow machine guns.

63. Coaxial Machine Guns.

a. The Army Ground Force Equipment Review Board recommended that reconnaissance tanks be equipped with three coaxial machine guns; one caliber .50 gun in the turret and two caliber .30 guns in blisters on the turret.[54] An additional caliber .30 gun inside the turret was recommended for larger tanks.[55]

b. The great majority of interviewees stated that a single coaxial gun was sufficient. These answers were based on the opinion that:

(1) Loaders could not keep another gun functioning and loaded.

(2) In view of the limited space now available for servicing coaxial machine guns, it is not practical to mount another machine gun.

(3) There would be insufficient space for the ammunition for additional guns.

c. Most junior officers and enlisted men showed little imagination and were not sufficiently experienced to discuss major advances. The General Board, United States Forces, European Theater feels that, if the above objections are overcome, tank crews would favor additional coaxial guns.[56]

d. Fifty percent of the interviewees stated the caliber .30 gun was satisfactory, whereas the balance desired a caliber .50 coaxial gun.[57] The former group based their answers primarily on the question of ammunition stowage capacity. The caliber .30 gun is more efficient than the caliber .50 against personnel. In other respects, the caliber .50 offers definite advantages. (See Appendix 14). All interviewees emphasized the increased shock action of the caliber .50 gun on the German soldier.

e. Approximately 40 percent of the interviewees stated they attempted to boresight the coaxial machine gun with the cannon. This group reported that the mounts failed to hold the guns in adjustment. This deficiency increases the time required to obtain effective fire, and prohibits ranging-in.

f. The General Board, United States Forces, European Theater recommends that:

(1) Wherever feasible, all tanks be equipped with one caliber .50 coaxial machine gun in addition to at least one coaxial caliber .30 gun.

(2) In the development of multiple coaxial machine guns, close attention be paid to ease of loading and servicing.

(3) Coaxial machine gun mounts be developed which will hold the machine gun parallel to the tank cannon.

64. Guns Mounted on Top of the Turret.

a. The Army Ground Force Equipment Review Board recommended that all tanks be equipped with a caliber .50 antiaircraft machine gun, controlled by the tank commander, and mounted for employment against ground as well as air targets.[58]

b. Approximately 85 percent of the personnel interviewed recommended retention of a caliber .50 antiaircraft gun. All wanted the gun so mounted that it could be employed easily in the anti-aircraft role.

c. The present antiaircraft gun mounts were considered difficult to use. Many suggested that a ring mount would be an improvement. The chief demand was for a mount which would permit firing the gun without exposing one's body to the extent now required.

d. Many units mounted caliber .30 guns on top of the turret for use by the tank commander against surprise, close-in ground targets.[59] The caliber .30 gun was preferred to the caliber .50 because it could be swung around easily and quickly. The great majority of interviewees were in favor of a caliber .30 gun for the tank commander.[60] They also recommended that the loader fire the anti-aircraft gun.

e. Speed and armor protection of aircraft undoubtedly will increase, nevertheless it is the opinion of the General Board, United States Forces, European Theater that the value of a caliber .50 antiaircraft gun is sufficient to warrant its retention.

f. It is recommended that all tanks be equipped with:

(1) A caliber .50 antiaircraft gun so mounted that it can be fired, without exposure of the gunner's body, by either the loader or the tank commander.

(2) A caliber .30 machine gun mounted for use by the tank commander against close-in ground targets.

Bibliography

Chapter 5

46. AGF Combat Observers Report by Colonel George M. Dean. Organized stowage in M4 series medium tanks provides 6250 rounds. It has been reported that the 15 Tank Battalion carried 10,000 rounds (AGF Observers Report No 346, dated 5 November 1944), and the 2 Armored Division 13,000 (Ltr, Col C. A. Black, Armored Officer, Ninth US Army to Brig General J. A. Holly, AFV & W Section, ETOUSA, dated 31 March 1945).

47. See also AGF Observers Reports No 693, dated 3 March 1945, and No 767, dated 28 March 1945.

48. AGFERBR, Part II, Inclosure 3-C, par 6b.

49. Ibid, Inclosure 4-C, par 6b.

50. Ltr, Hqs 12th US Army Group, subject: "Sight for Tank Bow Machine Gun", dated 26 September 1944.

51. Indorsement to above letter by Hqs ETOUSA, dated 8 October 1944.

52. AGFERBR, Part II, Inclosure 4-C, par 7b(7).

53. See document referred to in note 26e.

54. AGFERBR, Part II, Inclosure 3-C, par 6b.

55. Ibid, Inclosure 4-C, par 6b.

56. See comment of General G. S. Patton, Jr, CG Third US Army, 23 November 1944, in report of trip to armies by Brig Gen J. A. Holly, AFV & W Section, ETOUSA, dated 7 December 1944. Also comments of Col C. B. Ewing, Armored Officer, Seventh US Army, and Col L. T. Heath, Armored Officer, 6th US Army Group in letter from AFV & W Section, ETOUSA to President, Armored Board, dated 18 April 1945.

57. Officers from the 4 Armored Division stated they had mounted cal. .50 aircraft guns in medium tanks and considered them superior to the cal. .30 for the coaxial gun.

58. AGFERBR, Part II, Inclosure 3-C and 4-C, both par 6b.

59. See documents referred to in note 47.

60. See also: Ltr, Hqs 6 Armored Division, subject: "Operational Information desired on M4 Series Medium Tanks", dated 14 December 1944; AGF Observers Report No 408, dated 29 November 1944; and documents referred to in note 47.

CHAPTER 6

AMMUNITION

SECTION 1

CHARACTERISTICS COMMON TO ALL TYPES

65. Army Ground Force Equipment Review Board. Appendix 15 contains the pertinent recommendations of the Army Ground Force Equipment Review Board on ammunition.

66. Type, Length, and Weight of Tank Ammunition.

a. The undesirability of other than fixed ammunition, and the need for holding down the overall length and weight of tank ammunition were indicated in the discussion of the characteristics of tank cannon (See paragraphs 49 and 50, above.)

b. The General Board, United States Forces, European Theater urges that the War Department assign a high priority to the development of fixed ammunition having the required performance and overall length and weight necessary for ease of loading.

67. Smokeless and Flashless Propellants.

a. The Army Ground Force Equipment Review Board stated that a "uniform" demand exists for smokeless and flashless propellants.[61] The European Theater of Operations and Twelfth United States Army Group described the demand as "urgent and uniform".[62] The Army Ground Force Board also recommended that obscuration of vision by muzzle blast be reduced to an "absolute minimum by any means."[63]

b. The urgency of smokeless and flashless propellants and of unobscured vision cannot be over-emphasized.[64]

(1) Interviewees universally lamented the ease with which the Germans located American tanks by the gun flash and smoke, and the contrasting difficulty of locating enemy tanks.

(2) The urgency of being able to fire the first accurate round was pointed out in paragraph 50 c, above. Fast, accurate firing requires that the tank commander's and gunner's observation be unobscured by muzzle blast. Observation of every round is necessary to make proper range and deflection changes for the succeeding round. Even with 75mm guns and 105mm howitzers, at shorter ranges, the round often strikes before the blast has cleared sufficiently to permit observation. Obscuration of vision by muzzle blast makes 76mm and 90mm guns "one shot" weapons.

c. The muzzle brake and forward venting primer reduced obscuration of vision. However, the muzzle brake increases the weight of the gun and necessitates adding undesirable counter-weights to breech. A number of tank commanders reported that, with the muzzle brake, the blast seemed to concentrate in their vicinity, knocking off their helmets and making it difficult for infantry to stay on the rear deck of the tank. It was agreed, though, that the muzzle brake greatly improved the gunner's observation.[65]

d. It is recommended that the War Department assign a high priority to development of smokeless and flashless propellants and to perfection of other means of eliminating obscuration of vision.

68. Dim Igniter Tracer.

a. The Army Ground Force Equipment Review Board recommended that tracers "be provided with a dim igniter in order not to blind gunners or disclose gun positions during night firing."[66] European Theater of Operations and Twelfth United States Army Group recommended that illumination commence at 300 yards.[67]

b. The necessity for improving night firing capabilities was indicated in paragraph 11, above.

c. Interviewees reported that ranging in with the coaxial machine gun in daylight often revealed the location of the tank and drew fire before the target could be destroyed with the cannon. They also stated that German tanks had been located in the same manner.

d. Ranging-in will have increased application with caliber .50 coaxial machine guns.[68] Also, a caliber .50 gun can be employed against targets which formerly would require the tank cannon.[69] Dim igniter tracer will permit maximum exploitation of these advantages.

e. It is recommended that development of dim igniter tracer, with illumination commencing at 300 yards, for both cannon and machine gun ammunition be a priority project.

69. Tracer for HEAT, HE and WP Projectiles.

a. Interviewees reported difficulty in sensing HEAT rounds because of failure to detonate on impact with the ground. Incorporation of a tracer element will greatly facilitate sensing.

b. Incorporation of tracer in HE (high explosive) and WP (white phosphorous) rounds will increase facility of adjusting fire:

(1) Interviewees reported difficulty in identifying rounds, particularly HE, when several guns were firing in the same area.

(2) Lost rounds often occur in wooded areas and in terrain interspersed with gulleys and ravines.

(3) Both HE and WP were employed against targets with vertical profile. Utilizing the height of tracer above the target as a means of adjusting fire, when firing at vertical targets, was discussed in paragraph 8, above.

c. No information was obtained from interviewees regarding tracer for HE and WP rounds. The only disadvantage would seem to be possible disclosure of the tank's position, even with dim igniter tracer.

d. It is recommended that appropriate agencies of the War Department:

(1) Provide a tracer element in HEAT ammunition.

(2) Give serious consideration to incorporation of a tracer element in HE and WP ammunition for tank guns.

70. Crimping of Fixed Ammunition.

a. The Army Ground Force Equipment Review Board recommended improving crimping.[70]

b. Interviewees universally reported separation of 75mm projectiles from their cartridge cases. Separation of 76mm projectiles seemed less extensive. Adoption of the German method of crimping around the entire circumference of the cartridge case was suggested.

c. There were no reports of separation of 90mm projectiles. This may have been due to the limited employment of M26 tanks in the European Theater.

d. It is recommended that appropriate agencies of the War Department give immediate attention to development of improved crimping for fixed ammunition.

71. Crimping Tool for 105mm Howitzer Ammunition.

a. The 105mm howitzers mounted in tanks constitute too small a percentage of the total number of 105mm howitzers to warrant production of fixed ammunition for the tank howitzers.

b. The semi-fixed ammunition can cause some reduction in the rate of fire because of projectiles becoming wedged out of line in the shell cases. Many interviewees reported that they had been issued a crimping tool, which apparently had been procured in the European Theater. Since Charge VII is normally fired, this tool received extensive employment.

c. It is recommended that appropriate agencies of the War Department provide a standard crimping tool for 105mm howitzer ammunition on the basis of one per 105mm howitzer tank.

72. Ammunition Lots.

a. The Army Ground Force Equipment Review Board, The European Theater of Operations, and Twelfth United States Army Group recommended action be taken to reduce the difficulties caused by variations in muzzle velocity and performance between different lots of the same type of ammunition.[71]

b. Experience has shown that the range dispersion between different ammunition lots, even at direct laying ranges, is sufficient to cause misses. Under combat conditions, it is not feasible to so distribute resupply loads that each tank has only ammunition of the same lot. When stowing a tank, it may be possible to segregate the rounds by lot in the stowage racks. However, the construction of stowage bins, the position of the loader with respect to them, the size of the lot identification markings, and the necessity of high rates of fire make it impossible for the loader to select rounds by lot number.

c. It is recommended that appropriate agencies of the War Department assign a high priority to reduction in variations between powder lots and to increasing the quantity of ammunition in any one lot.

73. Ammunition for Training.

a. Personnel interviewed stressed the confusion caused by firing, in training, ammunition having a different trajectory from that of ammunition used in battle.

b. It is recommended that the War Department take the necessary action to eliminate the source of this confusion.

SECTION 2

PROJECTILES

74. Armor Piercing.

a. The Army Ground Force Equipment Review Board recommended development of hyper velocity armor piercing (HVAP) projectiles, as well as continued development of regular armor piercing ammunition (AP and APC), and of hollow-shaped charge for artillery projectiles.[72] The European Theater of Operations and Twelfth United States Army Group recommended development of hollow charge for "all calibers from 75mm up".[73]

b. The desired armor piercing projectile must have a proper balance between armor penetration and accuracy. Interviews revealed that effectiveness after penetration is secondary. The following evaluation of currently standard weapons indicate the accuracy required:

(1) The accuracy of 76mm HVAP is excellent.[74]

(2) The accuracy of 105mm howitzer HEAT is unsatisfactory.[75]

(3) While 76mm M62 was preferred because of its flatter trajectory, personnel interviewed considered the accuracy of 75mm APC. M61 satisfactory.

(4) Interviewees reported that most tank fighting took place at ranges under 1500 yards. At ranges up to approximately 1300 yards, the theoretical probability of hitting a tank, when the range is determined correctly, is the same for both 75mm APC. M61 and 76mm APC. M62.[76]

c. It is highly desirable that only one type of armor piercing ammunition be included in the basic load. Because of its greater effectiveness after penetration, an APC (armor piercing cap) type projectile is considered the ideal. If an APC type projectile capable of the necessary armor penetration cannot be produced, either HEAT or HVAP projectiles should be provided. Inclusion of HVAP or HEAT in the basic load should be in accordance with the following principles. (It has been assumed that both HVAP and HEAT, having the necessary penetration, can be developed.):

(1) In order to have only one type of armor piercing ammunition in a tank, HEAT or HVAP should completely replace APC. The latter is not required for anti-concrete missions since HE with a concrete piercing fuze is satisfactory.[77]

(2) If HVAP can be produced in sufficient quantity to meet total armor piercing requirements, it should be selected over HEAT because of higher possible muzzle velocity.

(3) If HVAP cannot be produced in sufficient quantity, the necessity for holding ammunition types to a minimum dictates selection of HEAT. However, the accuracy of HEAT must be at least equivalent to that of 75mm APC. M61. If this requirement cannot be met HVAP should be selected.

(4) If an HEAT round of satisfactory accuracy and greater effectiveness than HVAP at large angles of attack can be developed, it should be selected.

75. High Explosive.

a. The Army Ground Force Equipment Review Board recommended development of a high explosive round having:

> "sufficient velocity to insure pin-point accuracy in direct fire. Initial velocity should be the highest possible consistent with good fragmentation, control of ricochet, and minimum gun tube erosion."[78]

b. A large majority of personnel interviewed considered 75mm HE, M48, supercharge, the ideal high explosive round for tank guns.[79] Explosive content, control of ricochet, and ease of adjustment were considered more important than high velocity. Few interviewees preferred the high velocity 76mm HE, M42A1.

c. The necessity for maximum burst and fragmentation effect is obvious. Two other vital requirements are not as clear:

(1) The terminal velocity must be such that the gunner can make range changes "equal to the depth of the burst on the ground."[80] A gunner can do this with 75mm HE, M48, supercharge. It is not possible with 76mm HE, M42A1, the terminal velocity is too high.[81]

(2) In general, more effective fire is obtained with a DELAY fuze than with a SUPERQUICK setting.[81a] The muzzle velocity and delay element in the fuze must be such that the resulting richochet is easy to adjust. Ricochets with 75mm HE, M48, supercharge with .05 second delay fuze are satisfactory. Those with 76mm HE, M42A1 and .05 second delay fuze travel too far before bursting.

d. The characteristics recommended by the Army Ground Force Review Board may result in projectiles of too high a muzzle velocity. Therefore, it is recommended that high explosive projectiles developed for tank guns have the following characteristics:

(1) Muzzle velocity, explosive content, fragmentation, and control of ricochet similar to 75mm HE, M48, supercharge, rather than to 76mm HE, M42A1.

(2) Muzzle velocity such that the gunner can make range changes equal to the depth of the burst on the ground, at all ranges.

(3) Muzzle velocity and DELAY fuze such that ricochets do not have a greater length of travel and height of burst than those of 75mm HE, M48, supercharge, with .05 second delay fuze.

(4) Maximum explosive content and fragmentation consistent with muzzle velocity and accuracy not less than that of 75mm HE, M48, supercharge.

76. Reduced Charge High Explosive.

a. Army Ground Force Equipment Review Board recommended a reduced charge HE round "for use by tank destroyers in indirect fire."[82]

b. Personnel interviewed unanimously stated that a reduced charge HE round was unnecessary for use by tanks. Introduction of a reduced charge round for the 76mm gun in the European Theater caused confusion among tank crews.[83] It is recommended that reduced charge HE not be provided for tanks, even if they replace tank destroyers as the major anti-tank weapon.

77. Smoke and Incendiary Shells.

a. All personnel interviewed stated that a purely screening smoke, such as HC base ejection or emission, was not needed for tank cannon. On 3 October 1944, the European Theater of Operations informed the War Department that this type of ammunition was not needed for tank guns.[84] This position was reiterated in March 1945.[85]

b. White phosphorous was well liked by all personnel because of its combined casualty, incendiary, and smoke effect.[86] Instances were reported in which it had caused enemy crews to abandon their tanks. A few interviewees had actually seen white phosphorous set a tank on fire. Its employment against tanks resulted from the lack of armor piercing rounds capable of penetrating heavy German frontal armor.

c. In conjunction with its other characteristics, all personnel considered the incendiary properties of white phosphorous satisfactory for normal use, i.e. employment against personnel, buildings, etc. They did not want it replaced by a purely incendiary projectile. A small majority desired it augmented by a flame producing round. The reason for this demand is the desire for a reliable means of setting tanks on fire in the absence of an armor piercing round, having the required performance.[87]

d. The European Theater of Operations and Twelfth United States Army Group recommended improved incendiary fillers for "all types of artillery shells."[88]

e. The General Board, United States Forces, European Theater recommends that:

(1) Purely screening smoke, such as 75mm HC base emission, M89 or 105mm HC base ejection M84 not be provided for tank cannon.

(2) Improved incendiary fillers for artillery shells not replace white phosphorous for tank cannon unless such filler has the casualty and smoke properties of white phosphorous.

(3) Improved incendiary fillers for artillery shells be utilized for an incendiary round for tank cannon, to augment white phosphorous, only if armor piercing rounds having the required performance cannot be developed and if such incendiary filler is a more reliable means of setting tanks on fire than white phosphorous.

78. Illuminating Shell. Development of illuminating shell was recommended in paragraph 11, above.

79. Canister.

a. The Army Ground Force Equipment Review Board recommended development of improved canister.[89] The European Theater of Operations and Twelfth United States Army Group concurred.[90]

b. Small quantities of canister for the 75mm gun were procured locally in the European Theater by combining 75mm howitzer canister with 75mm gun shell cases. Employment was too limited to permit definite conclusions as to its effectiveness. However, the great majority of interviewees felt that canister was not required. Their opinion was based on a desire to reduce ammunition types, and the belief that the machine guns and high explosive shell would be as effective. The General Board, United States Forces, European Theater is of the opinion that the employment of canister would be limited to specialized situations, such as operations in heavily wooded areas.

c. It is recommended that:

(1) Before improved canister for tank cannon is placed in quantity production, tests be conducted to determine if the tank machine guns and high explosive shell can be employed for canister missions with equal effectiveness.

(2) Canister not be included in the basic load, but kept in depots to be drawn as the situation indicates.

80. Percentage of Each Type Required.

a. Personnel interviewed considered the following distribution satisfactory, as a general rule, for tank guns: high explosive - 70%; armor piercing - 20%; white phosphorous - 10%. In general, these figures are comparable to the expenditures of 75mm, 76mm and 90mm tank and tank destroyer ammunition in the European campaign from June 1944 through January 1945, and to the percentages recommended by the European Theater of Operations.[91]

b. Data on ammunition expended by 105mm howitzer mounted in medium tanks is not available. The percentages recommended by the European Theater of Operations apply to both artillery and tank howitzers, and include 90% high explosive, 7.5% white phosphorous, and .5% HEAT.[92] Because of the small percentage of 105mm howitzers mounted in tanks, production in accordance with these percentages should provide sufficient quantities of white phosphorous and HEAT to meet tank requirements. However, as recommended by the Armored Section, First United States Army, the basic load must include 20% HEAT and 10% white phosphorous in order to provide each tank with sufficient rounds for one or two targets.[93]

c. It is recommended that ammunition for tank guns and howitzers be produced in such quantity that basic loads can include 70% high explosive, 20% armor piercing, and 10% white phosphorous.

SECTION 3

FUZES

81. Time Fuzes.

a. The Army Ground Force Equipment Review Board recommended that: "all types of improved fuzes developed for artillery cannon should be provided in tank...ammunition."[94]

b. Normal time fire has always been considered outside the scope of tank gunnery.[95] The interviews revealed no reason for changing this policy.[96] The use of present proximity (VT) fuzes is limited to artillery type firing. The extent of this firing by tank guns is too limited to warrant introduction of fuzes unsuited to direct laying.

c. The fuze required for illuminating shell is one designed to overcome the handicap of one man setting fuzes in the poor light of a turret. A proximity (VT) type fuze would be ideal. A normal time fuze with a minimum number of settings, easily identified in darkness, would be an improvement over existing fuzes.

d. It is recommended that:

(1) Time fuzes not be provided for high explosive ammunition for tank guns.

(2) Illuminating shell for tank cannon be equipped with a fuze designed specifically for ease of setting in a turret.

82. APC Projectiles Containing Explosive Filler. Tests in the European Theater showed that 75mm APC. M61 with P.D.F. M66A1 will detonate after penetrating 20mm spaced armor.[97] As a result of this test, all 75mm APC ammunition not containing the base fuze and explosive filler was frozen prior to the invasion of the continent in anticipation of the Germans introducing spaced armor capable of defeating the base fuzed projectiles.[98] Future incorporation of a base fuze and explosive filler in APC type projectiles should be contingent upon determination of possible defeat of such projectiles by spaced armor. It is recommended that the War Department institute extensive tests in this field.

83. Fuze for White Phosphorous Projectiles. White phosphorous ammunition available for 75mm guns and 105mm howitzers in the European campaign was fuzed with a super-quick fuze. This ammunition was used extensively against houses and similar structures. A delay fuze would permit the round to penetrate doors, windows, and light walls before detonating, thereby having greater effectiveness. It is believed ricochet bursts would prove highly effective against dug-in personnel. It is recommended that tests be conducted to determine the desirability of fuzing white phosphorous ammunition with the combination super-quick and delay fuze, used with HE shells.

84. Fuze for 105mm Howitzer HE. M1.

a. The .15 second delay fuze with which 105mm howitzer HE.M1 is fuzed was designed for field artillery use. It causes ricochets to travel from 50 to 115 yards before bursting.[99] This makes it impossible to adjust ricochet fire on small point targets.[100] Consequently this fuze was not liked.[101]

b. Ammunition supply would be unduly complicated by having a small percentage of 105mm howitzer ammunition fuzed with a .05 second delay fuze for tanks and the remainder with a .15 second delay fuze for the artillery. A combination superquick and delay fuze with two delay settings would meet both requirements. Therefore, it is recommended that a combination superquick and delay fuze for 105mm howitzer HE. M1 be developed, having two delay settings, one a .05 second setting and the other as desired by the artillery.

85. Concrete Piercing Fuze.

a. A number of interviewees reported very successful employment of 75mm HE. M48 supercharge, with concrete piercing fuze T.105, against stone buildings and light armor.

b. A concrete piercing fuze, producing satisfactory ricochets on impact with the ground and including a superquick setting for firing in soft terrain and wooded areas, would be the ideal fuze for tank guns.

HE and WP rounds would be better suited for employment against light armor and buildings. In addition, it would be unnecessary to fuze rounds especially for anti-concrete missions.

c. It is recommended that the War Department investigate the feasibility of producing such a fuze.

Bibliography

Chapter 6

61. AGFERBR, Part I, Annex N, par. 5

62. ETOUSA Study, See note 30.

63. AGFERBR, Part II, Inclosure 4-C, par. 6a.

64. See also documents referred to in notes 23 and 26e, above.

65. See also AGF Observer Report No. 693, dated 3 March 1945.

66. AGFERBR, Part I, Annex N, par. 10c.

67. ETOUSA Study, See note 30.

68. See Appendix 14.

69. Ibid.

70. AGFERBR, Part I, Annex N, par 14d (1).

71. Ibid, par 8, and ETOUSA Study referred to in note 30.

72. Ibid, par 14a, 16a.

73. ETOUSA Study, see note 30.

74. Armored Operational Instructions No. 1, Hqs. 12 US Army Group, 2 December 1944.

75. See documents referred to in note 27.

76. Chart D288B, Ballistic Section, Office of the Chief of Ordnance, Washington, D.C., 10 February 1943.

77. TM 9-1907, Ballistic Data, 23 September 1944, Section VII.

78. AGFERBR, Part I, Annex N. par 14b.

79. See also: Comment of Major General Oliver, CG, 5 Armored Division, recorded in Memorandum AFV&W Section, ETOUSA, subject: "Report of Trip to Armies", 3 December 1944; comment of Major General R. G. Grow, CG, 6 Armored Division, in memorandum AFV&W Section, ETOUSA, subject: "Report of Trip to Armies", 4 December 1944; AGF Observer Report No. 396, dated 28 November 1944.

80. FM 17-12, Tank Gunnery, 10 July 1944, par 67.

81. Ibid.

81a. Ibid, par 60b and fig. 30.

82. AGFERBR, Part I, Annex N. par 14b.

83. Information memo No. 6 AFV&W Section, ETOUSA, 11 December 1944. Statement of Corporal Willis, 761 Tank Battalion, recorded in memorandum AFV&W Section, ETOUSA, subject: "Report of Trip to Armies", 7 December 1944.

84. ETOUSA Cable EX-51978.

85. Ltr SHAEF, subject: "Elimination of Non-Essential Equipment", 25 March 1945.

86. See also AGF Combat Observers Report by Col. George M. Dean.

87. See also report of Board of Officers appointed by SO 196 Hqs First US Army, 19 July 1944, dated 30 July 1944.

88. ETOUSA Study, see note 30.

89. AGFERBR, Part I, Annex N, par 14c.

90. ETOUSA Study, see note 30.

91. Ltr Hqs ETOUSA, subject: "Ammunition Day of Supply", dated 3 March 1945.

92. Ibid.

93. Ltr. Colonel P.C. Hains, Armored Officer, First US Army to Lt. Col. W. Neil, Armored Officer, Fifteenth US Army, 7 February 1945.

94. AGFERBR, Part I, Annex N. par 14d (2).

95. FM 17-12, Tank Gunnery, 10 July 1944, par 60b (2).

96. See also document referred to in note 93.

97. IRS, Hqs ETOUSA, from G-3 to Ordnance, subject: "75mm Ammunition Qualities", 9 June 1944.

98. IRS, Hqs ETOUSA, from AFV&W Section to G-3, subject: "Freezing of 75mm APC, M61, Inert Loaded, dated 25 May 1945.

99. FM 17-12, Tank Gunnery, 10 July 1944, par 60b.

100. Ibid.

101. See also AGF Combat Observers Report by Col. George M. Dean.

CHAPTER 7

FIRE CONTROL AND OBSERVATION EQUIPMENT

SECTION 1

GENERAL

86. Relation to Tank Design.

a. The ability of a tank to accomplish its mission is governed primarily by its ability to destroy targets by gun fire. The accuracy, and hence effectiveness, of its fire depends largely upon the quality of its fire control equipment.

b. The majority of American tanks were woefully deficient in the quality of sighting equipment. Periscopic sights were inferior optically and would not remain in adjustment. These deficiencies necessitated development of the graduated elevating handwheel by the using troops. The M50 series telescopes were of poor quality. The M70 and M71 series telescopes were good sights, but required the gunner to assume an awkward position. Initial mounts for coaxial telescopes failed to hold sights in adjustment. A limited number of periscopic sights M10 (T6), installed in the spring of 1945 were extremely well received. They were considered by many to be the finest tank gun sight found on the battlefield.

c. In January 1944, a War Department mission was sent to the European Theater to coordinate modification of several thousand tanks that had been pre-shipped to England for units still in the United States.[102] Because of their relatively early date of manufacture, these tanks failed to incorporate many subsequent improvements. The highest priority in this modification program was given to fire control equipment.[103]

d. Therefore, the General Board, United States Forces, European Theater concurs most emphatically in the recommendation of the Army Ground Force Equipment Review Board that:

> "The proper placement and function of fire control shall be a primary consideration in the layout and detailed design of the vehicle."[104]

e. It is urged that the above recommendation be adopted by the War Department as a fundamental principle in future tank design.

87. Army Ground Force Equipment Review Board. Appendix 16 contains the recommendations of the Army Ground Force Equipment Review Board pertaining to fire control and observation equipment.

SECTION 2

VISION DEVICES

88. Tank Commander's Vision Cupola.

a. All personnel interviewed desired that the tank commander's vision cupola be retained. However, they recommended increased downward vision to permit the tank commander to see closer to the tank.

b. Several officers felt that the vision cupola did not afford sufficient vision. They suggested a small plastic dome which would permit the tank commander to obtain all around observation and afford protection from small arms fire.[105] One battalion commander recommended a plexiglass dome to keep out rain and snow, which caused the turret floor to become slippery. This made it difficult for the tank commander to retain his balance when the tank was moving.

c. The periscopic binoculars discussed in paragraph 90, below, may provide satisfactory all-around observation. However, a transparent, bullet-proof dome might be superior.

d. It is recommended that the range of downward vision be increased in the tank commander's vision cupola, and that development of a bullet-proof transparent dome be investigated.

89. Indirect Vision Device for Loaders.

a. Personnel interviewed reported that, when not otherwise engaged, all crew members observed fire and looked for targets. For this reason, they considered a loader's periscope essential.

b. It is recommended that vision devices be provided for all crew members in future tanks and that the War Department take immediate action to provide a loader's periscope in light tanks, M24.

SECTION 3

OBSERVING INSTRUMENTS

90. Tank Commander's Periscopic Binoculars.

a. The Army Ground Force Equipment Review Board recommended that tank commanders be provided with:

(1) Seven power periscopic binoculars, to be mounted "under armor", with 360° traverse.[106]

(2) Fifteen power periscopic binoculars, similarly mounted, but to be issued only "when the employment of the gun commonly exceeds 3000 yards."[107]

b. It is common knowledge that the necessity for the tank commander to expose his head above the vision cupola to use binoculars caused casualties. Many of these casualties would have been avoided had periscopic binoculars been available.

c. The field of view of 15 power periscopic binoculars would, of necessity, be so narrow that an instrument of lower power would also be required. In addition, it is believed that 15 power would be too great for constant use. Carrying two instruments is undesirable: first, interviewees stressed the necessity for reducing the number of stowage items; second, in battle, there would not be time to change binoculars. Therefore, development of dual power periscopic binoculars is indicated.

d. The Army Ground Force Equipment Review Board recommended "basic research to determine the optimum power for the average individual who uses observing instruments."[108]

e. It is recommended that tanks be equipped with dual power periscopic binoculars instead of two instruments. The selective magnification to be 7 and 15, or such other powers as research determines to be optimum.

91. Binoculars.

a. Interviewees desired that tank commanders be provided with ordinary binoculars.

b. In June 1944 tank commanders were authorized 6 x 30 binoculars, M13. First United States Army Group and the European Theater of Operations attempted to procure 7 x 50 binoculars, M17, because of their increased magnification and light transmission.[109] The availability of the 7 x 50 binoculars for tank commanders was limited through-

out the European campaign. However, personnel who had used them agreed that, while the optical qualities of 7 x 50 binoculars, M17, were superior, their weight and bulk were excessive. Magnification of 6 x 30 binoculars, M13, was reported as inadequate.

c. The Army Ground Force Equipment Review Board urged "continued investigation to reduce size and weight and improve optical materials" of binoculars, but stated that "present binoculars are satisfactory for the field artillery".110

d. Interviewees who had used German binoculars considered them superior to American models because of their lighter weight and smaller overall size. (See Appendix 17). The additional magnification of German ten power binoculars was considered a great advantage. In addition, German military binoculars have a set screw for locking the focus after it has been adjusted by the individual user. American practice is to use friction tape.

e. Tank commanders habitually adjust the length of the carrying strap so their binoculars will hang at chest height. The length of the strap, as issued, is such that the binoculars normally hang at stomach height. Adjustment is possible only by expedient methods, such as knotting the strap.

f. The General Board, United States Forces, European Theater recommends that:

(1) Tank commanders be issued ordinary binoculars, irrespective of development of tank-mounted periscopic binoculars.

(2) Lighter and smaller binoculars for tank commanders be developed immediately, having optimum magnification.

(3) Consideration be given to adoption of German Zeiss or Leitz type 7 x 50 or 10 x 50 binoculars.

(4) Binoculars be equipped with a set screw for locking the focus adjustment.

(5) Binocular carrying straps be adjustable to permit carrying at chest height.

SECTION 4

FIRE CONTROL EQUIPMENT FOR THE TANK COMMANDER

92. Range finders.

a. The greatest inaccuracy in tank gunnery is in determination of the initial range. Ranging-in with the coaxial machine gun is limited by the tracer burn-out range. Utilization of the deflection graduations in the sight reticle as a measuring stick is subject to inherent inaccuracies. Mathematical computation of the range by the intersection method is possible only in special situations. Estimation by eye is the most common method. The maximum proficiency of an individual in range estimation is not equal to that required for optimum accuracy of fire. During a war, proficiency will not be attained because of limitations in training time, turn-over of personnel, and constantly changing terrain in battle. Therefore, there is need for a suitable range finder.

b. Since late 1943, medium tank company headquarters, medium tank platoons and assault gun platoons have been authorized one range finder M7 or M9A1. These are fourteen power, one meter base, coincidence type. They can be mounted in the tank commander's periscope

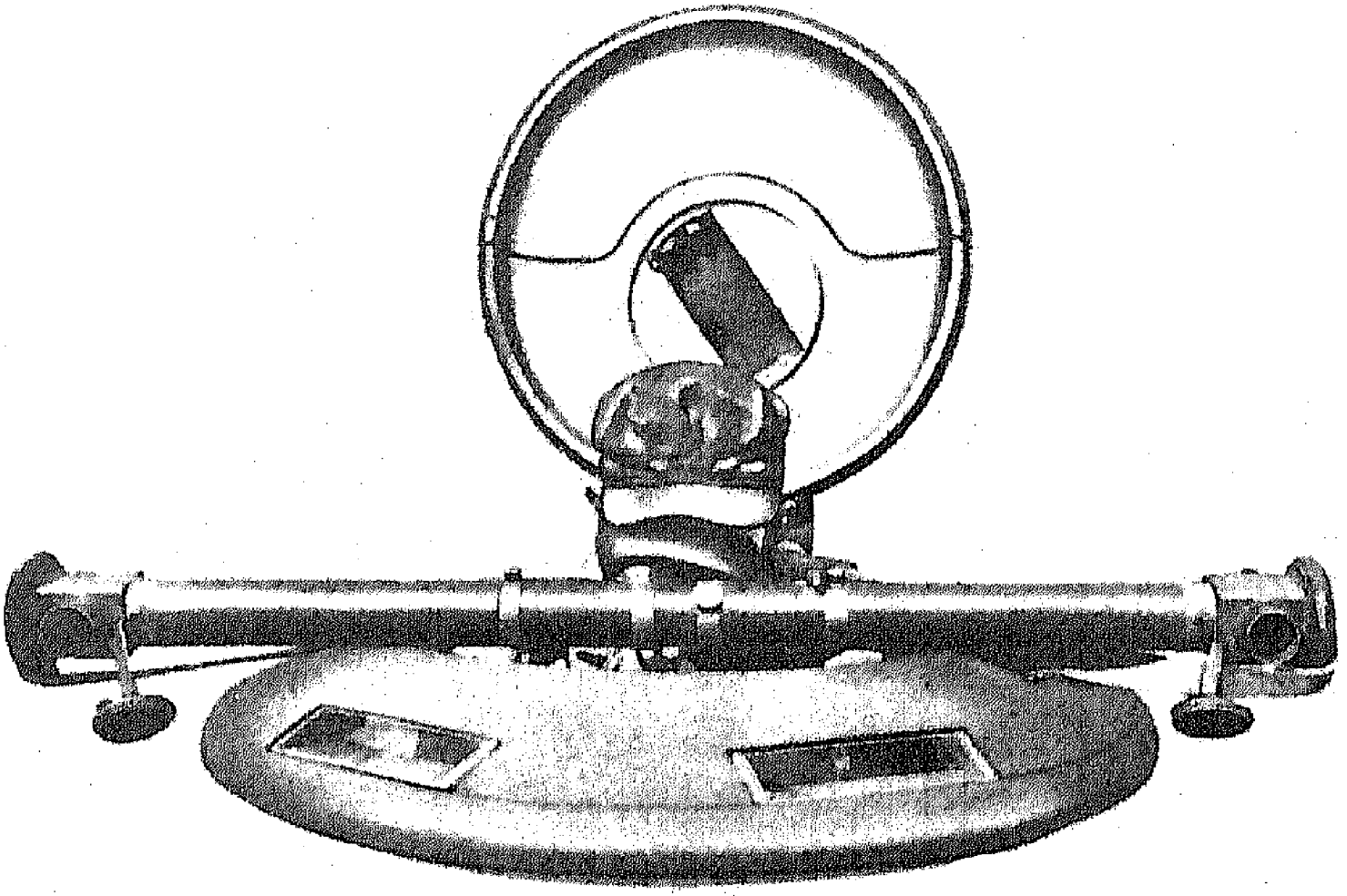


FIGURE 1 FINDER M7-M9A1

holder in the turret hatch, or laid on top of the vision cupola (See Fig.1). 111

c. On 4 January 1945, pursuant to a query from the War Department, the European Theater of Operations asked Sixth and Twelfth United States Army Groups for recommendations as to deletion of range finders M7 and M9A1 from Tables of Equipment.[112] Sixth United States Army Group recommended their deletion from all tank and assault gun units.[112a] However, Twelfth United States Army Group stated they were "not being used extensively by armored vehicle troops mainly due to lack of availability....and a corresponding lack of training in their use", and recommended retention in Tables of Equipment pending further experience by using troops.[113] The European Theater of Operations concurred in the latter recommendation.[114]

d. None of the personnel interviewed had ever used a range finder in battle. However, those who had been issued range finders, or had seen them, felt that the M7 - M9A1 models were impractical for tanks. To prevent it from being damaged by branches, etc., the tank commander would have to mount and dismount it whenever he used it. There is not time for this in battle.

e. German tank officers reported that German Mark V and Mark VI tanks were equipped with a one meter base range finder suspended from the top of the turret. German "ultra-violet" and radar range finders are referred to in Appendix 3.

f. Army Ground Force Equipment Review Board recommended development of optical and radar range finders to be built into the tank and operated by the tank commander.[115]

g. The General Board, United States Forces, European Theater recommends that:

(1) Range finders M7 - M9A1 be deleted from Tables of Equipment for medium tank company headquarters, medium tank platoons, and assault gun platoons.

(2) The War Department assign a high priority to development of built-in range finders as recommended by the Army Ground Force Equipment Review Board.

(3) The War Department fully investigate German tank range finders, including radar and "ultra-violet" devices, to determine the desirability of adopting them for American tanks.

93. Means of Laying the Gun.

a. If the tank commander had an easy quick means of laying the gunner on the target for the initial round:

(1) The accuracy of the first round would be increased in most cases.

(2) The time from the tank commander's decision to fire on a target and the firing of the first round would be reduced to a minimum.

b. The tank commander can tell when the gunner is on the target for deflection by means of the vane sight. The tank commander's overriding power traverse control is not fine enough for laying the gun. Therefore, at least the final traversing must be done by the gunner. Close teamwork is necessary to keep the gunner from stopping short of or traversing beyond the target.

c. The tank commander has no simple means of laying the gunner on the target for initial range. Consequently if the gunner

does not identify the target when given the command to stop traversing, he usually lays on a point on the ground which he estimates to be at the proper range.

d. The "Donkey Sight", developed by 1 Armored Division, is a mechanical sight by which the tank commander can tell when the gunner is on the target. (See Appendix 18). Personnel from this Division stated this device was extremely satisfactory. However, even with the "Donkey Sight", the tank commander must still tell the gunner when to stop elevating and traversing.

e. The Army Ground Force Equipment Review Board recommended that provision be made for the tank commander to lay the gunner on the target by means of an optical range finder linked to the gun, or by a radar-director set.116

f. The above recommendations provide the optimum solution. However, because of the possibility of the enemy jamming the radar, infra-red should be investigated as a substitute. In addition, the tank commander should be provided with the "Donkey Sight", or similar mechanical device, and elevating and traversing controls for emergency use in case of malfunctioning of the optical or radar range finder.

g. The General Board, United States Forces, European Theater urges that the War Department assign a high priority to development of equipment to permit the tank commander to lay the gun for the initial round without the necessity of commands to the gunner. The required equipment includes:

(1) An optical range finder linked to the gun or a radar-director set capable of automatic laying, as recommended by the Army Ground Force Equipment Review Board.

(2) Infra-red devices as a possible substitute for radar.

(3) The "Donkey Sight", or similar mechanical device, and elevating and traversing controls for emergency use.

94. Interphone.

a. Interviewees stated that confusion resulted from crew members mistaking commands from other tanks for those of their own tank commander. This was caused by the other tank commanders keeping their control switch on RADIO when giving commands to their crews. It was suggested that the interphone be so designed that the tank commander could exclude from the other crew members all transmissions except his own. However, other crew members must be able to talk to the tank commander since they frequently spot targets or rounds which he does not observe.

b. It is recommended that the interphone system be so designed that the tank commander can exclude, from the other crew members, all transmissions except his own. A spring loaded break-in device should be provided for use by other crew members in emergencies.

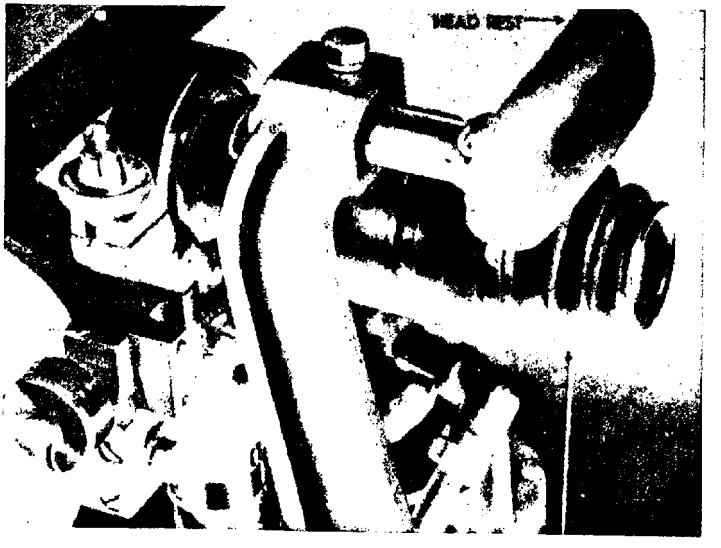
SECTION 5

FIRE CONTROL EQUIPMENT FOR THE GUNNER

95. Sights.

a. The M70 (three power) and M71 (five power) series coaxial telescopes were well liked by all personnel interviewed. The additional magnification of the five power sights was desired by 65% of the interviewees. Those who had used the six power M10 (T8) periscope considered it superior. The field of vision was considered satisfac-

OLD STYLE HEADREST



NEW STYLE HEADREST

FIGURE 2

tory in all sights. About one-fourth of the interviewees desired sights of interchangeable power; six power for normal employment and ten power for obscure targets. The present sight reticle was considered superior.

b. Adjustable focus was reported to have been a definite aid. Personnel who had used both old and new style telescope headrests preferred the old style because it gave greater support. (See Figure 2). All interviewees stated that latest type mounts for coaxial telescopes held the sights in adjustment. However, a number of men felt that they were too difficult to adjust.

c. Retention of a unit power periscope for general observation was desired by everyone. The unit power portion of the M10 (T8) periscope was considered greatly superior to the M4 type periscope.

d. The Army Ground Force Equipment Review Board stated that "power depends upon the greatest range at which the sight will be used."[117] Most targets were engaged at ranges under 1500 yards. Assuming 2000 yards to be the maximum common range, the Army Ground Force Equipment Review Board's formula would result in a maximum magnification of 5-power.[118] This is less than that of the M10 periscope. In addition, one-fourth of the interviewees stated that as much as ten power would be desirable. This magnification is not for use at extreme ranges, but to enable the gunner to identify and lay more accurately on indistinct targets at normal ranges. Therefore, a reduction in field of view at shorter ranges is acceptable in order to obtain the magnification required.

e. The Army Ground Force Equipment Review Board recommended that sights be equipped with a central aiming point (hollow cross) rather than a graduated reticle.[119] Lead and elevation would be set in the primary sight (4-6 power) automatically by a 10-power range finder linked to the gun and operated by the tank commander. For moving fire lead would be controlled by the gyro-stabilizer. The aiming point in the auxiliary sight (3-8 power) would be adjusted manually by the gunner with reference to a deflection and range scales in the sight field. These scales would be such as to accommodate the various types of ammunition employed.

f. The above fire control system is based on the assumption that the tank commander can, and will, observe every round better than the gunner. Experience has shown that this is not true.[120] Consequently, the above system does not permit maximum exploitation of the gunner's capabilities in that he has no means of measuring deflection errors, nor of determining the height of tracer above the target. Furthermore, the gunner will have to release the elevating or traversing controls to move the central aiming point in order to make range and deflection changes in the event of malfunctioning of the linked range finder or when he senses a round which the tank commander fails to sense. This is unsatisfactory. A graduated reticle does not have these deficiencies.

g. The discussion in paragraphs 74 and 75, above, indicates that the high explosive shell desired probably will have a different trajectory from armor piercing ammunition. It is as necessary that reticles be graduated for HE as for AP. The only satisfactory solution is to equip sights with two reticles which can be interchanged by pushing a button or moving a lever. The alternatives, indicated below, are unsatisfactory:

(1) Sacrificing the desired HE or AP characteristics to obtain corresponding trajectories.

(2) Omission of either the HE or AP reticle, requiring the gunner to interpolate when using the ammunition whose reticle is omitted.

h. It is recommended that:

(1) Consideration be given to development of dual power sights, having 10-power as the maximum magnification.

(2) All sights be equipped with adjustable focus.

(3) Telescopic sights be equipped with the old, rather than the new, style headrest (See Figure 2).

(4) Maximum magnification not be determined solely by the greatest range at which the sight will be employed, but that cognizance be taken of the fact that high magnification is needed for indistinct targets at normal ranges.

(5) The auxiliary sight recommended by the Army Ground Force Equipment Review Board be equipped with a fully graduated reticle instead of a central aiming point.

(6) Sights with graduated reticles be equipped with two easily interchangeable reticles, one graduated for HE and the other for armor piercing ammunition. Reticle pattern to be the same as present design.

96. Graduated Elevating Handwheel.

a. The graduated elevating handwheel was used when the gunner was unable to identify the target or when atmospheric conditions or camouflage made the target indistinct. Everyone interviewed desired that this device be retained in future tanks.

b. The Army Ground Force Equipment Review Board did not comment on the graduated handwheel. This device provides a means of accurately making range changes without the use of sights. Therefore, it is recommended that it be incorporated in all future tanks for emergency use, irrespective of improvements in sighting equipment.

97. Solenoids.

a. Interviewees reported limited malfunctioning of cannon solenoids. It is believed that the chief cause of malfunctions was shorting of the wiring. It was suggested that solenoids be assembled with screws rather than rivets to facilitate minor repairs.

b. Solenoids often failed to actuate the coaxial machine gun trigger. This was caused by the loosened solenoid suspension bracket and/or swivel.

c. Opinion was divided on the desirability of retaining a finger trigger on the power traverse spade grip. A number of experienced gunners stated that, when tracking a moving target, it was impossible to actuate the trigger and at the same time continue to turn the grip smoothly. They felt that foot firing was superior. The solenoid for the 75mm gun in light tank M24 is located on the elevating handwheel. It was pointed out that actuation of the solenoid without moving the handwheel was extremely difficult, particularly in the excitement of battle. Any movement of the elevating handwheel when firing will destroy the accuracy of the gunner's laying. Therefore, it is considered that foot electrical firing should also be provided in addition to hand firing as recommended by the Army Ground Force Equipment Review Board.[21]

d. Any arrangement of firing devices under which the gunner must release the traversing or elevating controls to fire was considered unsatisfactory by all interviewees. In the light tank M24 the coaxial

machine gun trigger is located on the power traverse grip. A mechanical firing device is not provided. Therefore, when using manual traverse, the gunner must release traversing or elevating controls in order to fire.

e. The General Board, United States Forces, European Theater recommends that:

(1) Consideration be given to assembly of solenoids by screws instead of rivets to permit minor repairs.

(2) The solenoid suspension bracket and/or swivel on coaxial machine guns be so designed that it will not loosen.

(3) Foot, as well as hand, electrical firing be provided for the turret weapons in all future tanks, and that present standard tanks be modified to incorporate this feature.

98. Power Traverse.

a. The tendency of the power traverse to develop drift was mentioned in paragraph 18, above.

b. In light tank M24, which was not equipped with an auxiliary generator, it was reported that the power traverse was a serious drain on the batteries.

c. Difficulty was experienced in the winter because of snow, etc. getting into the turret race and freezing the turret so it could not be traversed.

d. It is recommended that:

(1) Efforts be made to eliminate tendency of power traverse mechanism to develop drift.

(2) Light tanks M24 be provided with an auxiliary generator to permit maximum utilization of the power traverse.

(3) Immediate action be taken to modify present tanks to prevent snow, etc. from getting into the turret race.

99. Gyro-Stabilization.

a. Although a few units reported extensive and effective use of the gyro-stabilizer, on the whole, it received only limited employment. It is believed this was due the following factors:

(1) Lack of familiarity and confidence.

(2) Many units had received their training on the old stabilizer which was much less efficient.

b. Most interviewees stated there were occasions when they would have used a stabilizer in which they had confidence. Only a few felt that future development should be discontinued.

c. Therefore, the General Board, United States Forces, European Theater concurs in the recommendation of the Army Ground Force Equipment Review Board for development of both lateral and vertical stabilization.[122]

100. Azimuth Indicator.

a. In addition to its employment for artillery type firing, the azimuth indicator was used:

(1) When the gunner was unable to identify the target or when atmospheric conditions made the target indistinct.

(2) To measure and set off the deflection to potential target locations for firing at night.

b. Only a few interviewees reported slippage of the pointers. However, a large majority recommended changing the position of the instrument to facilitate reading the dials. Such a change has been recommended by the Army Ground Force Equipment Review Board.123

c. In addition to meeting the requirement for an instrument for artillery type firing, the azimuth indicator provides a means of accurately laying for deflection without the use of sights. Therefore, it is recommended that it be incorporated in all future tanks for emergency use, irrespective of improvements in sighting equipment.

101. Elevation Quadrant.

a. Interviewees stated that the shock of continued firing at times caused the quadrant to slip out of adjustment, and the mounting bolts to loosen.124 They also reported that the night lighting devices did not provide sufficient illumination.

b. It is recommended that:

(1) A more secure means of holding the quadrant in adjustment and of preventing the mounting screws from loosening be developed.

(2) Night lighting devices be improved to provide sufficient illumination for reading the scales and bubble.

102. Panoramic Sight.

a. The Army Ground Force Equipment Review Board recommended that tanks be equipped with a panoramic sight to be mounted on the exterior of the turret.125

b. Employment of this sight would be limited to artillery type firing. For this mission, it offers technical advantages over the azimuth indicator, particularly as regards cross-leveling to eliminate the effect of cant.

c. It is considered that the extensive employment of 105mm howitzer tanks for artillery type missions warrants their being equipped with a panoramic sight. However, this sight is not required for gun tanks in view of their limited employment of indirect laying.

d. It is recommended that panoramic sight be provided for the basic weapon of the "assault gun" platoon (105mm howitzer tanks) but not for gun tanks.

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Chapter 7

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114. Ltr Hqs ETOUSA, subject: Deletion of Range Finders from Tables of Organization and Equipment, dated 30 January 1945.

115. AGFERBR, Part I, Annex T, par 8, Part II, Inclosure 1-C(c), par 5a, and 4-C, par 7a.

116. Ibid.

117. Ibid, Inclosure 1-C, par 2a.

118. Ibid, Magnification = Range/400

119. Ibid, par 2c, Inclosure 4-C, par 7a.

120. FM 17-12 Tank Gunnery, 10 July 1944, par 73a. Interviews revealed that many tank crews who had not received training in the method prescribed in pars 73a (3) and (4) approximated it through experience. Interviewees also reported that, at times, the tactical situation prevented the tank commander from observing.

121. AGFERBR, Part II, Inclosure 4-C, par 10d.

122. Ibid, par 10c.

123. Ibid, par 7c.

124. See also information memo No. 8, AFV & W Section, ETOUSA, dated 16 March 1945.

125. AGFERBR, Part II, Inclosure 4-C, par 7d.

THE GENERAL BOARD
UNITED STATES FORCES, EUROPEAN THEATER
APO 408

TANK GUNNERY

PART THREE

SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

CHAPTER 8

TECHNIQUE AND TRAINING

SECTION 1

TECHNIQUE

103. Conclusion. Experience in the European Theater indicates need for the changes and developments in tank gunnery technique recommended in paragraph 104 below.

104. Recommendations. It is recommended that:

a. Appropriate War Department publications be revised to provide that control and supervision of fire by the platoon commander must not be extended to the point of destroying the initiative of the individual tank commander.

b. Appropriate agencies of the War Department develop a simple method of fire adjustment for high velocity ammunition, by which the height of tracer above a vertical target can be converted into the proper range change.

c. Appropriate agencies of the War Department investigate simplification of the "WATCH MY BURST" procedure as set forth in FM 17-12, Tank Gunnery, 10 July 1944.

d. Appropriate agencies of the War Department develop the equipment, ammunition, and technique required to provide tanks with a simple, quick, and accurate method of night firing.

e. The aiming stake and intersection methods of night firing be retained in FM 17-12, Tank Gunnery, 10 July 1944, as expedients pending availability of more suitable methods.

f. Appropriate War Department publications be revised to relieve tanks from the responsibility for survey and fire direction when employed as reinforcing artillery.

g. Appropriate agencies of the War Department develop a method for cleaning cannon tubes under combat conditions.

h. Appropriate agencies of the War Department determine whether prescribed methods of adjusting caliber .30 M1919A4 machine guns should be replaced by the Armored School method described in Appendix 6.

i. Appropriate War Department agencies develop:

(1) A method of removing moisture condensation from

exterior lenses of tank sights which does not require removing sights from their mounts.

(2) A fully effective method of preventing moisture condensation on exterior lenses of sights. Pending such development, the use of gas mask anti-dim should be incorporated in appropriate publications as an expedient method.

j. Appropriate War Department agencies establish an adequate allowance of optical cleansing materials for use in tanks, and that such materials be issued as a kit to be included in the official stowage. The kit should include a box to be mounted in the turret convenient to the gunner.

SECTION 2

TRAINING METHODS

105. Conclusion. Experience in the European Theater indicates that certain changes are required in the application of training methods and in the emphasis placed on various phases of tank gunnery.

106. Recommendations. It is recommended that:

a. Appropriate War Department publications be revised to provide greater emphasis on adjustment of the power traverse to eliminate drift and that this adjustment be included in gunners' proficiency tests.

b. Appropriate War Department publications be revised to recognize the fact that the ultimate objective of crew drill is combat efficiency and that this objective be emphasized in training.

c. The War Department take the necessary action to provide tank crews with accurate information on the ranges at which American guns can penetrate enemy armored vehicles as well as the ranges at which enemy guns can penetrate American armor.

d. Appropriate War Department publications be revised to require greater emphasis on armor penetration capabilities of American and enemy weapons, and that this subject be included in gunners' proficiency tests.

e. Appropriate agencies of the War Department provide more realistic aids, such as models, full-scale mock-ups, and captured tanks, for training in recognition of enemy tanks.

f. Appropriate War Department publications be revised to require greater emphasis on recognition training.

g. Appropriate War Department agencies investigate the possibilities of recognition of enemy tanks by sound.

h. Appropriate War Department publications be revised to eliminate the standard 1000 inch moving target course as a qualification requirement for tank machine gun.

i. Appropriate War Department publications be revised to provide that gunners' qualification require successful completion of

a firing course involving supervised instructional firing of at least 100 rounds of service ammunition, including a suitable qualification test.

j. The War Department require increased emphasis on combat firing for crew, section, and platoon training.

k. Appropriate War Department agencies provide targets which when hit will produce the characteristic flash of an armor piercing projectile striking armor.

l. Appropriate War Department agencies provide more realistic moving target ranges.

m. Appropriate War Department agencies provide disinterested umpires to conduct the Army Ground Force Tank Crew Gunnery Tests.

n. Appropriate War Department publications be revised to include gunnery and tactics training in employment of tanks in towns.

o. A trainer, similar to the antiaircraft "Dome Trainer", be developed for tank gunnery, and be made available for year-round use to enable tank gunners to retain their proficiency.

SECTION 3

TRAINING REQUIREMENTS ESSENTIAL TO HIGH STANDARDS OF TANK GUNNERY

107. Conclusion. Experience in the European Theater indicates that the measures recommended in paragraph 108, below, are necessary for the attainment of uniformly high standards of tank gunnery in training and for the maintenance of these standards in battle.

108. Recommendations. It is recommended that:

a. The War Department take the necessary action to insure that training literature, including technique of employment, is available automatically at the same time new equipment is issued to units.

b. The War Department give serious consideration to establishment of unit firing centers.

c. Appropriate agencies of the War Department require all armored officers to take a gunnery course.

d. The War Department adopt either of the following solutions as a means of providing qualified tank crew replacements:

(1) Limit tank crew replacements to one category, namely, "tank crewman". To qualify as a tank crewman, the replacement must be fully qualified both as a gunner and as a driver.

(2) If the available training time does not permit the complete training of tank crewmen, limit the classification to "drivers" and "gunners". In addition to being fully qualified in tank driving, drivers must also be qualified in weapons mounted in the driving compartment. Classification as gunner must include qualification in the standard gunners'

qualification course as prescribed by the War Department (See recommendation in par 24, above). The degree of qualification and score should be entered on the AGO Form No. 20. No replacement who has not qualified as either gunner or driver should receive a classification number for any position within a tank.

e. The War Department provide overseas replacement depots with the personnel and materiel necessary to provide refresher training for tank crew replacements.

CHAPTER 9

EQUIPMENT

SECTION 1

GENERAL

109. Army Ground Force Equipment Review Board.

a. The General Board, United States Forces, European Theater concludes that, in general, experience in the European Theater indicates need for the equipment recommended by the Army Ground Force Equipment Review Board, as described in Appendices 9, 10, 11, 12, 15 and 16.

b. Therefore, it is recommended that appropriate agencies of the War Department execute the recommendations of the Army Ground Force Equipment Review Board quoted in the above appendices, as qualified by the comments of the European Theater of Operations and by the recommendations in the following paragraphs.

110. Necessity for New Methods of Destroying Tanks. It is recommended that the War Department institute exhaustive research into entirely new methods of destroying tanks.

111. Simplicity of Operation. It is recommended that maximum simplicity of operation for the crew member be adopted as a fundamental principle of future development.

SECTION 2

TANKS AND TANK CANNON

112. Characteristics Common to all Tanks. It is recommended that:

a. The War Department seriously consider incorporation of liquid, or similarly protected, ammunition stowage in all future tanks.

b. Ammunition stowage having the following characteristics be incorporated in future tanks:

(1) A ready rack capable of holding at least 10 rounds.

(2) Bulk of the ammunition stowed under the floor, unless equal protection from fire can be obtained in the sponsons.

(3) Sliding covers, or other substitute for hinged covers, on ammunition bins.

(4) Ammunition removal from stowage racks not dependent on traversing the turret.

c. The half floor be considered unsatisfactory for fighting compartments.

d. Tests be conducted to determine whether a full moving floor or no floor should be incorporated in future tanks.

e. All tanks equipped with a no floor fighting compartment

be provided with a foot rest for the gunner, folding platform for the tank commander, and a seat for the loader.

113. Characteristics Common to all Tank Cannon. It is recommended that:

a. Accuracy and effectiveness be considered the most important characteristics in cannon design.

b. The War Department consider a tube life of 200-300 rounds of armor piercing ammunition acceptable for tank guns, if necessary in obtaining required penetration.

c. Gun mounts be so designed as to permit easy and quick replacement of tubes.

d. Although extremely undesirable, semi-fixed ammunition be accepted, as a last resort, if the required performance cannot otherwise be obtained.

e. Reduction in overall length of ammunition be given priority over reduction in diameter of the base of the shell case, even at the expense of larger gun breeches and cradles.

f. Ammunition stowage capacity be sacrificed, if necessary, to provide ammunition which can be loaded with sufficient ease to obtain the required rate of fire.

g. Procurement of a gun of the required performance not be delayed pending development of automatic loading or a semi-automatic breech.

h. The ability of tank guns to fire prolonged artillery type missions be given minor consideration in future gun design. However, the tank mounted howitzer must be capable of such missions.

i. Tanks be equipped with an exterior gun travel lock located on the front slope plate and capable of being operated from within the tank.

114. Specific Tank Cannon Required. It is recommended that:

a. Procurement of the tank guns recommended by the Army Ground Force Equipment Review Board be expedited.

b. Development agencies not be restricted to the development of tank guns of the specific calibers recommended by the Army Ground Force Equipment Review Board.

c. Armor penetration be based on 45°, instead of 30°, angle of attack.

d. The following requirements be adopted as the minimum standard for future development:

(1) For reconnaissance (light) tanks, a gun capable of penetrating the sides and rear of any enemy armored vehicle, at normal tank fighting ranges.

(2) For exploitation tanks (medium tanks organic in Armored Divisions) a gun capable of penetrating the sides and rear of any enemy armored vehicle and the front of any but the heaviest tank, at normal tank fighting ranges.

(3) For infantry support tanks, (tanks organic in Infantry Divisions) a gun capable of penetrating the sides, rear, and front of any enemy armored vehicle, at normal tank fighting ranges. For general characteristics of this tank see Study Number 50, Theater General Board, United States Forces, European Theater.

e. Appropriate War Department agencies develop a vehicle mounting a cannon capable of destroying any enemy tank and having sufficient mobility to permit it to operate with exploitation tanks. This may have to be a special purpose weapon, and is recommended as a development type combat vehicle for possible future use.

f. It is recommended that "assault gun" platoons in armored divisions and tank battalions in infantry divisions be equipped with 105mm howitzer, M4, mounted in a standard tank with 360° power traverse, having 105mm ammunition stowage capacity not less than that of medium tank M4 series (with 105mm howitzer).

SECTION 3

TANK MACHINE GUNS

115. General. It is recommended that:

a. The War Department investigate all possible means of increasing machine gun fire power. Ammunition stowage per gun must be at least equal to that provided in present tanks.

b. Improved machine guns be provided for tanks. The caliber .50 gun must be smaller and lighter than the present M2 gun; similar reduction in the caliber .30 gun is desirable. All guns must have the following characteristics:

(1) Automatic headspace adjustment.

(2) Quick method of changing barrels.

(3) Ease in loading and reducing stoppages in fighting compartments.

(4) Ability to fire bursts of 20-30 rounds for maximum period without overheating.

(5) Cyclic rate of caliber .30 M1919A4 gun. (550 rounds per minute).

c. Stowage space permitting, spare machine guns, rather than spare parts, be authorized each tank on the basis of at least one spare gun for every three guns, or fraction thereof.

116. Specific Machine Guns Required. It is recommended that:

a. Wherever possible, all tanks be equipped with:

(1) A caliber .30 bow machine gun, equipped with sight, and having greater depression and traverse than at present.

(2) One caliber .50 coaxial machine gun in addition to at least one coaxial caliber .30 gun.

(3) A caliber .50 antiaircraft gun so mounted that it can be fired, without exposure of the gunners' body, by either the loader or the tank commander.

(4) A caliber .30 machine gun mounted for use by the tank commander against close-in ground targets.

b. Relocation of the bow gun in all tanks be investigated.

c. Consideration be given to providing magnification in sights for bow machine guns.

d. In the development of multiple coaxial machine guns, close attention be paid to ease of loading and servicing.

e. Coaxial machine gun mounts be developed which will hold the machine gun parallel to the tank cannon.

SECTION 4

AMMUNITION

117. Characterisitcs Common to all Types. It is recommended that:

a. The War Department assign a high priority to:

(1) Development of fixed ammunition having the required performance and overall length and weight necessary for ease of loading.

(2) Development of smokeless and flashless propellants and to perfection of other means of eliminating obscuration of vision.

(3) Reduction in variations between powder lots and to increasing the quantity of ammunition in any one lot.

b. Development of dim igniter tracer, with illumination commencing at 300 yards, for both cannon and machine gun ammunition be a priority project.

c. A tracer element be provided in HEAT ammunition.

d. The War Department give serious consideration to incorporation of a tracer element in HE and WP ammunition for tank guns.

e. Appropriate agencies of the War Department give immediate attention to development of improved crimping for fixed ammunition.

f. Appropriate agencies of the War Department provide a standard crimping tool for 105mm howitzer ammunition on the basis of one per 105mm howitzer tank.

g. The War Department take the necessary action to provide that ammunition used for training has the same trajectory as that to be used in battle.

118. Projectiles. It is recommended that:

a. Only one type of armor piercing ammunition be included in the basic load. If an APC type projectile capable of the necessary armor penetration cannot be produced, either HEAT or HVAP projectiles

should be provided in accordance with the following principles (it has been assumed that both HEAT and HVAP of the required penetration can be developed):

(1) HEAT or HVAP should completely replace APC.

(2) If HVAP can be produced in sufficient quantity to meet total armor piercing requirements, it should be selected over HEAT.

(3) If HVAP cannot be produced in sufficient quantity, HEAT should be selected. The accuracy of HEAT must be at least equivalent to that of 75mm APC M61. If this requirement cannot be met, HVAP should be selected.

(4) If an HEAT round of satisfactory accuracy and greater effectiveness than HVAP at large angles of attack can be developed, it should be selected.

b. High explosive projectiles developed for tank guns have the following characteristics:

(1) Muzzle velocity, explosive content, fragmentation, and control of ricochet similar to 75mm HE, M48, supercharge, rather than to 76mm HE, M42A1.

(2) Muzzle velocity such that the gunner can make range changes equal to the depth of the burst on the ground, at all ranges.

(3) Muzzle velocity and DELAY fuze such that ricochets do not have a greater length of travel and height of burst than those of 75mm HE, M48, supercharge, with .05 second delay fuze.

(4) Maximum explosive content and fragmentation consistent with muzzle velocity and accuracy not less than that of 75mm HE, M48, supercharge.

c. Reduced charge HE not be provided for tanks.

d. Purely screening smoke, such as 75mm HC base emission, M89 or 105mm HC base ejection M84 not be provided for tank cannon.

e. Improved incendiary fillers for artillery shells not replace white phosphorous for tank cannon unless such filler has the casualty and smoke properties of white phosphorous.

f. Improved incendiary fillers for artillery shells be utilized for an incendiary round for tank cannon, to augment white phosphorous, only if armor piercing rounds having the required performance cannot be developed and if such incendiary filler is a more reliable means of setting tanks on fire than white phosphorous.

g. Before improved canister for tank cannon is placed in quantity production, tests be conducted to determine if the tank machine guns and high explosive shell can be employed for canister missions with equal effectiveness.

h. Ammunition other than HE, WP, and armor piercing not be included in the basic load, but kept in depots to be drawn as the situation indicates.

i. Ammunition for tank guns and howitzers be produced in such quantity that basic loads can include 70 percent high explosive, 20 percent armor piercing, and 10 percent white phosphorous.

119. Fuzes. It is recommended that:

a. Time fuzes not be provided for high explosive ammunition for tank guns.

b. Illuminating shell for tank cannon be equipped with a fuze designed specifically for ease of setting in a turret.

c. The War Department institute tests to determine the possibility of spaced armor defeating APC projectiles containing an explosive filler and base fuze.

d. Tests be conducted to determine the desirability of fuzing white phosphorous ammunition with the combination super-quick and delay fuze used with HE shells.

e. A combination superquick and delay fuze for 105mm howitzer HE M1 be developed, having two delay settings, one a .05 second setting and the other as desired by the artillery.

f. The War Department investigate the feasibility of producing a concrete piercing all-purpose fuze, producing satisfactory ricochets on impact with the ground and including a superquick setting.

SECTION 5

FIRE CONTROL AND OBSERVATION EQUIPMENT

120. Relation to Tank Design. It is recommended that the War Department adopt as a fundamental principle of tank design the recommendation of the Army Ground Force Equipment Review Board that fire control be a "primary consideration in the detailed design of the vehicle."

121. Vision Devices. It is recommended that:

a. The range of downward vision be increased in the tank commander's vision cupola, and that development of a bullet-proof transparent dome be investigated.

b. Vision devices be provided for all crew members in future tanks and that the War Department take immediate action to provide a loader's periscope in light tanks, M24.

122. Observing Instruments. It is recommended that:

a. Tanks be equipped with dual power periscopic binoculars instead of two instruments. The selective magnification to be 7 and 15, or such other powers as research determines to be optimum.

b. Tank commanders be issued ordinary binoculars, irrespective of development of tank-mounted periscopic binoculars.

c. Lighter and smaller binoculars for tank commanders be developed immediately, having optimum magnification.

d. Consideration be given to adoption of German Zeiss or Leitz type 7 x 50 or 10 x 50 binoculars.

e. Binoculars be equipped with a set screw for locking the focus adjustment.

f. Binocular carrying straps be adjustable to permit carrying at chest height.

123. Fire Control Equipment for the Tank Commander. It is recommended that:

a. Range finders M7 - M9A1 be deleted from Tables of Equipment for medium tank company headquarters, medium tank platoons, and assault gun platoons.

b. The War Department assign a high priority to development of built-in range finders as recommended by the Army Ground Force Equipment Review Board.

c. The War Department fully investigate German tank range finders, including radar and "ultra-violet" devices, to determine the desirability of adopting them for American tanks.

d. The War Department assign a high priority to development of equipment to permit the tank commander to lay the gun for the initial round without the necessity of commands to the gunner. The required equipment includes:

(1) An optical range finder linked to the gun or a radar-director set capable of automatic laying, as recommended by the Army Ground Force Equipment Review Board.

(2) Infra-red devices as a possible substitute for radar.

(3) The "Donkey Sight", or similar mechanical device, and elevating and traversing controls for emergency use.

e. The interphone system be so designed that the tank commander can exclude, from the other crew members, all transmissions except his own. A spring loaded break-in device should be provided for use by other crew members in emergencies.

124. Fire Control Equipment for the Gunner. It is recommended that:

a. Consideration be given to development of dual power sights, having 10-power as the maximum magnification.

b. All sights be equipped with adjustable focus.

c. Telescopic sights be equipped with the old, rather than the new, style headrest. (See figure 2).

d. Maximum magnification not be determined solely by the greatest range at which the sight will be employed, but that cognizance be taken of the fact that high magnification is needed for indistinct targets at normal ranges.

e. The auxiliary sight recommended by the Army Ground Force Equipment Review Board be equipped with a fully graduated reticle instead of a central aiming point.

f. Sights with graduated reticles be equipped with two easily inter-changeable reticles, one graduated for HE and the other for armor

piercing ammunition; reticle pattern to be the same as present design.

g. All tanks be equipped with a graduated elevating hand-wheel and azimuth indicator for emergency use, irrespective of improvements in sighting equipment.

h. Consideration be given to assembly of solenoids by screws instead of rivets to permit minor repairs.

i. The solenoid suspension bracket and/or swivel on coaxial machine guns be so designed that it will not loosen.

j. Foot, as well as hand, electrical firing be provided for the turret weapons in all future tanks, and that present standard tanks be modified to incorporate this feature.

k. Efforts be made to eliminate tendency of power traverse mechanism to develop drift.

l. Light tanks, M24, be provided with an auxiliary generator to permit maximum utilization of the power traverse.

m. Immediate action be taken to modify present tanks to prevent snow, etc, from getting into the turret race.

n. A more secure means of holding the elevation quadrant M9 in adjustment and of preventing the mounting screws from loosening be developed.

o. Night lighting devices for the elevation quadrant M9 be improved to provide sufficient illumination for reading the scales and bubbles.

p. A panoramic sight be provided for the basic weapon of the "assault gun platoon" (105mm howitzer tanks) but not for gun tanks.

APPENDIX 1

PROCEDURE FOR CONCENTRATING THE FIRE

OF A PLATOON BY DIRECT LAYING

(Extracted From FM 17-12, Tank Gunnery, 10 July 1944, par 80)

"80. DIRECT LAYING, TWO OR MORE TANKS. a. General. (1) The platoon commander concentrates the fire of all or part of his platoon; the section leader concentrates the fire of his section. The platoon or section leader adjusts the fire of his tank on the target and thus determines the data to enable the other tanks to open fire.

(2) Normally, the platoon commander concentrates the fire of his platoon on small area targets. However, he may employ this type of fire against point targets (see FM 17-30). The fire of a section is normally concentrated on point targets.

b. Initial fire order. In his initial fire order the platoon or section leader designates the target both to his gunner and the other tank commanders as follows:

(1) Over radio to tanks which are to fire--

FIRST SECTION
WATCH MY BURST
MY DIRECT FRONT
GUNNER
ANTITANK
HE
TRAVERSE RIGHT
STEADY.....ON
TWO THOUSAND

(2) To own gunner without using interphone or radio--

FIRE

(3) Over radio to tanks which are to fire--

ON THE WAY

c. Adjustment. (1) The commanders of the other tanks order their gunners to watch the burst and have them traverse as necessary to put the burst in the field of view of the gunner's telescope. To the range announced, each tank commander adds or subtracts any estimated difference in the range between his tank and the platoon or section commander's tank. For example:

GUNNER
WATCH HIS BURST
TRAVERSE RIGHT, STEADY.....ON
TWO ONE HUNDRED

(2) The gunners lay the appropriate range mark on the point of strike of shot or the base of the effect of the burst of HE or smoke.

(3) While adjusting his fire on the target, the platoon or section leader transmits ON THE WAY as each round is fired. On receiving this information, all gunners lay on the burst without further command using the initial range.

d. Fire for effect. (1) When the platoon or section commander obtains a target hit or a 100-yard bracket, he commands, GUNNER, RANGE. After relaying, his gunner notes the range mark in the reticle at which that burst or tracer appeared and announces it.

(2) The platoon or section leader then transmits his range to the other tanks and orders them to fire. The range transmitted is that of the target hit or of the center of the 100-yard bracket. When a 100-yard bracket has been obtained, he adds or subtracts 50 yards from the range reported by the gunner. His commands to the other tanks are for example:

(a) Over radio to tanks which are to fire--

FIRST SECTION
MY RANGE TWO TWO FIVE ZERO
FIRE

(b) To own gunner without using interphone or radio--

SHORT
UP ONE
FIRE

(3) The platoon or section leader now fires one round at the range of the target hit or the center of the 100-yard bracket, transmitting ON THE WAY. He continues to fire on the target, without transmitting ON THE WAY, until the mission is accomplished.

(4) On receiving the above commands, the other tank commanders order their gunners to fire. To the range announced, each tank commander adds or subtracts any difference in range between his tank and the platoon commander's tank. For example:

HE
TWO THREE FIVE ZERO
FIRE

The announcement of the ammunition is the command to load.

(5) The gunners of the remaining tanks lay the range line for the announced range on the effect of the burst fired by the adjusting tank in above, and fire. For accurate results it is necessary that the effect of the burst be clearly visible.

(6) If necessary, the remaining tanks adjust their fire on the target, or on the burst of the platoon or section leader if they are unable to identify the target. The initial range change is 100 yards.

(7) Tanks fire at will until given CEASE FIRING by the platoon or section commander.

e. When there may be difficulty in identifying bursts, the platoon or section commander may transmit a method of fire. For example: MY RANGE TWO THREE HUNDRED, PLATOON RIGHT, FIRE."

APPENDIX 2

HISTORY OF THE "WATCH MY BURST" PROCEDURE PRESCRIBED

IN FM 17-12, TANK GUNNERY, 10 JULY 1944

1. The first edition of FM 17-12, dated 22 April 1943 contained only a general statement of the "WATCH MY BURST" method of concentrating the fire of a platoon.

2. The method prescribed in the current edition of FM 17-12 was developed in the summer of 1943. This method was included in a mimeographed change to the first edition of FM 17-12, which was distributed in the Zone of the Interior only in the winter of 1943.

3. The current edition of FM 17-12 was published on 10 July 1944 and did not reach units in the European Theater before December 1944.

APPENDIX 3

METHOD OF NIGHT FIRING EMPLOYED IN THE EUROPEAN THEATER

1. American Methods.

a. Illumination of the target by illuminating shell. Employment was restricted due to limited availability of the ammunition. Illuminating shell for tank cannon was available only by local adaptation of 3" illuminating projectiles to the 76mm gun. Personnel who used illuminating shell stated it was satisfactory, and desired it available in sufficient quantity to permit adequate employment.

b. Illumination by artificial moonlight produced by anti-aircraft searchlights. Employment was limited, but the method was considered satisfactory. Comparative data on searchlights and illuminating shell was not obtainable.

c. When tanks were placed in defensive positions, potential target locations, such as road junctions, were selected. Azimuth indicator readings to these points were determined and recorded. Ranges were estimated and recorded in yards for laying with the illuminated reticle or in mils for laying with the elevation quadrant. Fire was adjusted by sensing tracer or HE bursts with respect to flashes of enemy guns. This was the most common method. Interviewees felt that their fire was of extremely dubious accuracy.

2. German Methods.

a. The German tank officers interviewed stated that their most common method of night firing was to employ two tanks as a team. One fired illuminating shell while the other engaged the target.

b. One prisoner stated that in the early stages of the advance into Russia they had mounted headlights on the tanks and in the tanks guns. The prisoner did not like this method since it made his tank too good a target.

c. Another prisoner mentioned an "ultra violet" device which was used for determining range and locating targets. It was employed both during day and night. He insisted that with this device the first round was always a hit. The prisoner insisted that the device was not infra-red. Investigation of various technical intelligence sources has revealed no further information on this device.

d. The Germans have developed infra-red sights for tank guns and infra-red searchlights for night firing.1 A radar device in self-propelled anti-tank guns for locating targets and laying the gun was reported by one prisoner.[2]

Bibliography

Appendix 3

1. Interim Report on German Infra-Red Devices Employing Image Tubes, Office of the Chief Signal Officer, ETOUSA, 1 May 1945; Status of German Military Applications of Infra-Red in 1943, Office of the Chief Signal Officer, ETOUSA, 1 June 1945; War Office Technical Intelligence Summary, Number 177, 22 May 1945 and Number 179, 13 June 1945.

2. Interrogation of Corporal Hermann Schneider by Lt Col James Hart, Armored Section, Ninth U.S. Army, 27 November 1944.

APPENDIX 4

THE "AIMING STAKE" AND "INTERSECTION" METHODS OF DETERMINING DATA FOR NIGHT FIRING

(Extract From FM 17-12, Tank Gunnery, 10 July 1944, pars 81b-d)

81b. "Computing data during daylight. The following method may be used:

(1) Select a firing position and drive a stake for the tank position.

(2) Set up an aiming circle over the tank position stake, set the azimuth scale and micrometer index at zero, and using the lower motion lay on the target.

(3) Next using the upper motion turn the aiming circle until it is sighted along a line upon which aiming stakes may be conveniently placed. This line may be to the rear or either side; rarely will it be to the front.

(4) Line in two aiming stakes on the line now indicated by the aiming circle, placing one stake 50 yards and one stake 100 yards from the gun position. Read the target-tank position stake-aiming stake angle.

(5) To assist in driving the tank into position, a white tape about 40 yards long may be stretched on the tank-target line either in front of or behind the tank position stake.

(6) Determine the range and the angle of site to the target and compute the quadrant elevation.

c. Placing tank in position. The tank is placed in position and laid on the target as follows:

(1) Run tank into position placing gun as nearly over the tank position stake as possible. The white tape will assist in this action.

(2) Lay on the near aiming stake and set the azimuth indicator at zero.

(3) Next lay on the far stake and read the angle between the far and near stakes.

(4) Continue to traverse beyond the far stake until the same angle as measured in (3) above is laid off.

(5) Now set the azimuth indicator at zero and traverse through the target-tank-aiming stake angle, previously measured in b(4) above. The tank is now laid for direction.

d. Computing data at night. Two tanks or two aiming circles may be used to locate point or small area targets at night. Procedure is as follows:

(1) Have sights, elevation quadrants, and gunner's quadrants in adjustment.

(2) Place two tanks on terrain as level as possible; cant of the tanks may not exceed 40 mils. Measure cant by placing the gunner's quadrant on the breech parallel to the trunnions.

(3) The tanks determining the range should have no obstructions, such as trees or hills, between them. The distance between tanks must be close to 20 percent of the range to the target. Place both tanks at approximately the same range from the target.

(4) Pace or tape the distance between tanks; deduct 5 percent for rolling terrain, if necessary.

(5) Lay the boresighting cross of the coaxial telescope in both tanks on the target and level the bubble of the elevation quadrant with the micrometer knob. The reading of the elevation quadrant is the angle of site to the target. If the tanks are at different elevations, determine the angle of site to the target for each tank individually.

(6) With the tanks still laid on the target set the azimuth indicators at zero. The two tanks then lay on each other, sighting on the coaxial telescope. To facilitate laying at night, shine a faint light through the coaxial telescope. (Take great care to hide from the enemy any light used in laying.)

(7) Record the readings on the azimuth indicators. Subtract the smaller of the readings from the larger. Subtract 3200 when the 6400 mil indicator is used. The remainder is the angle at the target. Using the mil relation R = W/m, divide the distance between the tanks in yards by the number of mils in this angle. The result is the range to the target in thousands of yards. In case of a point target upon which ricochet fire is to be used, such as a target with little or no overhead cover, adjust with fuze set at superquick and then subtract an appropriate amount from the range before firing with shell set at delay. For all practical purposes for ranges up to 1000 yards this can be determined by dividing the muzzle velocity in feet by four and then multiplying by the time of delay in seconds. For example, the adjusted range for shell HE set at superquick for the 75-mm tank gun, M3, has been determined as 900 yards. The muzzle velocity is 2030 feet per second and fuze delay .05 seconds. Then $\frac{2030}{4} \times .05 = 25$ yards, the amount to subtract. The range will be 900 - 25 or 875 yards.

(8) Convert the range to mils of elevation with the firing table, and correct for the angle of site. This is the elevation to be fired. Fire at this elevation and at elevations one mil above and one mil below this elevation.

(9) Cautions. (a) The base line is selected so that the angle at the target is not less than 100 mils. The base line must not be displaced from the perpendicular to the direction of fire by more than 300 mils. When using a short base table instead of the mil relation to solve the triangle, these cautions may be disregarded.

(b) This method is most successful when it is set up prior to the time the flash of the target appears. It is especially desirable for the tanks to lay on each other before laying on the flash. This insures accuracy in laying for direction. In this case, set the azimuth indicators at zero when the tanks lay on each other.

(10) The two aiming circles are used in a manner similar to the sights."

APPENDIX 5

FIRST UNITED STATES ARMY GROUP POLICY ON EMPLOYMENT OF TANKS AS ARTILLERY

FIRST US ARMY GROUP
APO 655

470.8 (Armd) 31 May 1944

SUBJECT: Use of Tanks as Reinforcing Artillery.

TO : Commanding General, First US Army, APO 230
Commanding General, Third US Army, APO 403

1. It is believed that the limitations of tanks when employed as reinforcing artillery are not fully appreciated. This may result in tanks being given artillery missions which they are incapable of accomplishing.

2. Tank units must be proficient in their primary mission before the initiation of training in the artillery mission. War Department Training Circular No. 125, 13 November 1943, with reference to the use of tanks as reinforcing artillery, states the following: "Tank units acting as field artillery will perform the role traditionally filled by reinforcing artillery, that is, fire the scheduled or pre-arranged fires asked for by the reinforced artillery." The circular further states that tank units will execute position survey from control established by the artillery and "will be prepared to establish a fire direction center for computing data." These capabilities are present in few tank units. In this connection attention is invited to Ground Force directive of 28 February 1944. (353/2233) (6 Nov 43) GNGCT, which states that the training of tank units in this mission "will be undertaken after combined or maneuver training, provided a unit is satisfactorily trained in its primary mission as determined by firing tests."

3. In view of the fact that the training of tank units in their primary mission has provided little opportunity for detailed and exact training as reinforcing artillery, such use must be made only under the supervision and control of the commander of the reinforced artillery. This supervision and control will include the establishment of place marks for each tank platoon, and the computation of all firing data, until such time as the artillery commander is satisfied that the tank unit is capable of operating its own fire direction center.

For the Commanding General:

/s/ H.B. Lewis
/t/ H.B. LEWIS
Brigadier General, USA
Adjutant General

APPENDIX 6

ADJUSTMENT OF MACHINE GUNS

Appendix 6-X 12th US Army Group basic letter and ETOUSA indorsements.

Appendix 6-A Description of proposed method.

Appendix 6-B Comparison of present and proposed methods.

APPENDIX 6-X

474 (Arty) 13 January 1945

SUBJECT: Adjustment of Machine Guns.

TO : Commanding General, European Theater of Operations, US Army, APO 887.

1. The attached papers marked Tabs A and B indicate a possibility that present teachings on the inspection and adjustment of the Browning Machine Gun Cal. .30, M1818A4, may be faulty.

2. This headquarters has neither the facilities nor the personnel either to verify or to disprove the conclusions in the attached papers.

3. Forwarded for your information and any action you deem necessary.

For the Army Group Commander:

/s/ J.H. Bloss
/t/ J.H. BLOSS
Lt Col AGD
Asst Adj Gen

2 Incls:

Incl 1 - Informal notes, "Adjustment of Browning Machine Gun, Caliber .30 HB, M1919A4. (in dup)

Incl 2 - Comparison of present and proposed methods of inspecting and adjusting Browning Machine Gun, Caliber .30, HB, M1919A4 (in dup)

R-E-S-T-R-I-C-T-E-D

(Ltr - Hq 12th Army Group subj: Adjustment of Machine Guns dtd 13 Jan 45)

AG 472.5 OpGC 1st Ind REL/OEE-OVP/emj

Hq European Theater of Operations, APO 887 - 7 February 1945
TO: Commanding General, 12th Army Group.

1. With reference to the proposed publication (Tab A), these comments are furnished:

a. Paragraph 3a. Inclosure 1. Adjustment No.1, Belt Feed Slide.

Ordnance Service does not desire to have the using arm attempt to correct feeding by straightening or bending the belt feed lever. Untrained personnel attempting to do this will invariably bend the belt feed lever too much, causing the belt feed lever to move the belt feed slide too much to the right. When this occurs, the cartridge is forced against the cartridge stop with unnecessary force, and the cartridge case is distorted or the stud of the belt feed lever breaks.

b. Paragraph 3b. Inclosure 1. Adjustment No.2, Headspace.

The proposed method of headspacing does not provide for wear of the face of the bolt, breech lock recess in the bolt or the breech lock. The additional notch of headspace mentioned in FM 23-50 is not for the purpose of providing for heat expansion but to insure that all cartridges will chamber correctly. If this is not done, cartridges of a maximum dimension will not chamber, and the gun will fail to function.

c. Paragraph 3c. Inclosure 1. Adjustment No.3, Timing.

The proposed method for timing is correct except that, as in the case of the belt feed lever mentioned above, it is not desired to have untrained personnel attempt to bend the trigger (called trigger bar in Inclosure 1). Untrained personnel will break a considerable amount of triggers in attempting to correct timing. Also, it is desired to point out that if the gun is firing too late, the barrel extension will pound against the trunnion block and eventually the barrel extension will break, usually at the recess for the barrel locking spring. In addition to the method proposed, it is suggested that a check be made to insure that the gun is firing before it reached its foremost position. The firing pin should be released when the barrel extension is .020 from the trunnion block.

d. Paragraph 3d. Inclosure 1. Adjustment No.4, Recoil Buffer.

The back plate adjusting screw must be kept screwed up tight at all times. The buffer disks have a great deal of resiliency and absorb the recoil of the bolt only when they form a solid stack in the back plate. If the back plate adjusting screw is not kept tight, the screw has a tendency to back off during firing and eventually the disks do not function as a shock absorber, the bolt being stopped by the body of the back plate, which in turn transmits the force of recoil to the back plate slots in the receiver. This causes the side plates to spread or to crystallize and break.

2. Copies of recommendations contained in inclosures as well as the remarks made above with reference to your recommendation, have been forwarded to the War Department with the suggestion that both be taken into consideration in revising FM 23-50.

By command of General EISENHOWER:

/s/ R.E. Lewis
/t/ R.E. LEWIS
Major AGD
Assistant Adjutant General

2 Incls: n/c

R-E-S-T-R-I-C-T-E-D

APPENDIX 6-A

HEADQUARTERS TWELFTH ARMY GROUP
APO 655

November 1944

ADJUSTMENT OF BROWNING MACHINE GUN, CALIBER .30 HB, M1919A4
(Mounted in Combat Vehicles)

1. INTRODUCTION.-a. The procedures herein were developed to eliminate most common stoppages, and in general supplement those in FM 23-50, Browning machine gun, caliber .30 HB, M1919A4 (mounted in combat vehicles).

b. Extensive tests with guns adjusted in accordance with current methods have shown that stoppages will run from three to twenty per 1000 rounds. When inspected and adjusted as prescribed herein, the same guns fired from 1000-1500 rounds without stoppages.

2. INSPECTION BEFORE FIRING.-a. Make the following before-firing inspection whenever possible. It can be completed in about two minutes after the procedure is mastered.

(1) Inspect muzzle plug and barrel bearing for oil and carbon deposits. The barrel must be free in bearing.

(2) Inspect barrel jacket for tightness. A loose jacket throws the barrel out of line, often causing sufficient binding to stop the gun from operating.

(3) Inspect front sight for tightness and setting. Check rear sight for operation.

(4) Inspect and adjust bolt feed slide. See adjustment No.1, below, for procedure. NOTE: This is probably the most important inspection. A high percentage of all malfunctions occur in the feed mechanism.

(5) Raise cover, and inspect cover extractor spring, feed slide, holding pawl. Examine feedway for heavy burrs caused by carelessness in adjusting headspace.

(6) Inspect extractor, its plunger, ejector, and spring.

(7) Pull bolt to rear. Release it. Hold up extractor, and while looking down the T slot, pull trigger. If firing pin striker shows through bolt face, the mechanism is operating. Repeat this test once more to prove functioning.

(8) Inspect and adjust headspace. See adjustment No.2, below, for procedure.

(9) Check and adjust timing. See adjustment No.3, below, for procedure.

(10) Inspect and adjust buffer assembly. See adjustment No.4, below, for procedure.

NOTE: Ragged operation or undue dispersion has been traced to disturbance of the gun caused by violent pounding of the bolt against the solid buffer.

b. Inspection of a machine gun does not always indicate its operating condition. Even new guns, as received, are not necessarily properly adjusted. Stoppages may not show up until the gun is fired at automatic, using relatively long bursts. If possible, always test

fire a gun after inspection and adjustment.

3. ADJUSTMENTS.-- The following four adjustments will eliminate most common stoppages.

a. Adjustment No.1. Bolt feed slide. Close the cover. Press the feed slide to the left. It should still protrude 1/32" (thickness of a US dime or the edge of a dog tag) to the right of the cover. If it does not, remove the belt feed lever from the cover and straighten (bend) slightly, using any suitable object. If new parts are available, check pivot, feed lever, slide, etc. and replace worn parts. Selective assembly alone may cure the trouble.

b. Adjustment No.2, Headspace. The following procedure supercedes that prescribed in FM 23-50, par 11:

(1) When assembling gun, screw barrel all the way into the barrel extension and replace in receiver. When gun is completely assembled, allow bolt to go forward and note if barrel locking notches show between trunnion block and barrel extension. If they do not, make no further adjustment. If they show, insert a combination tool or screw driver in a notch on left of barrel and take off one notch. Allow bolt to go forward. If barrel locking notches still show, continue to take off one notch at a time, until the bolt just goes forward. Do not make any further adjustments. Headspace is correct.

(2) The greater the heat generated during firing, the looser the headspace becomes. Therefore, if firing long bursts, check after about 1000 rounds to see if barrel can be screwed into extension one more notch.

c. Adjustment No.3. Timing. After cocking firing pin, pull bolt short distance to rear. Insert a .30 caliber timing gage or coin 1/16" thick (US nickel, Belgian franc, German 10 pfennig, or French franc, if others are not available) between trunnion block and barrel extension. Ease the bolt forward. Squeeze trigger. The firing pin should not be released. If firing pin is released, the gun is firing too soon. Substitute another trigger bar or bend the front of the trigger bar slightly by hammering until required effect is obtained, i.e. firing pin not released with gage in position, but must release with gage removed.

d. Adjustment No.4. Recoil buffer. Tighten adjusting screw as far as it will go. Part of the last thread must still show when the screw is fully home. If not add fiber discs. Then if buffer tube is disc type (has all fiber discs) back off $\frac{1}{2}$ turn; if spring type, back off $1\frac{1}{2}$ turns If in doubt, back off 1 turn.

APPENDIX 6-B

COMPARISON OF PRESENT AND PROPOSED METHODS OF INSPECTING AND ADJUSTING BROWNING MACHINE GUN, CALIBER .30 HB M1919A4 (Mounted in Combat Vehicles)

1. General.-a. Stoppages are a common occurence with this weapon. The proposed methods were developed, to eliminate stoppages, by the Armored School after close study of the Browning patents and extensive tests in conjunction with the Armored Board. These methods are currently being taught at the Armored School. Tests by the British AFV school confirmed the results obtained in the US. The material in the following paragraphs has been obtained from the report of the tests and the school's study of the Browning patents.

b. Both old and new guns were fired in the tests. Inspection and adjustment was in conformity with FM 23-50, Browning Machine Gun, Caliber .30 HB, M1919A4 (mounted in combat vehicles). It was found that most guns would fire reliably for 1000" firing, using bursts of three or single shots. However, when subjected to long bursts of automatic fire, they developed stoppages running from three to twenty per thousand runs. This was especially true when firing at a minus elevation, which is common when firing at ground targets from tanks. The same guns were then given the four adjustments set forth below and refired 1000-1500 rounds each without a stoppage.

c. The rests showed conclusively that, if guns are checked and adjusted in accordance with the proposed procedures, the majority of stoppages will be eliminated. In addition to their superiority, the proposed methods are quicker and easier to use than those prescribed in FM 23-50.

2. Inspection before Firing.-a. In general, the proposed prefiring inspection supplements par.28 a.(2) of FM 23-50 which merely states: "See that working parts of the gun are clear, oiled, and function smoothly."

b. The proposed inspection is as follows:

"1. Inspect muzzle plug and barrel bearing for oil and carbon deposits. The barrel must be free in the bearing.

2. Inspect barrel jacket for tightness. A loose jacket throws the barrel out of line, often causing sufficient binding to stop the gun from operating.

3. Inspect front sight for tightness and setting. Check rear sight for operation.

4. Inspect and adjust belt feed slides. See adjustment No.1, below, for procedure.

NOTE: This is probably the most important inspection. A high percentage of all malfunctions occur in the feed mechanism.

5. Raise cover, and inspect cover extractor spring, feed slide, holding pawl. Examine feedway for heavy burrs caused by carelessness in adjusting headspace.

6. Inspect extractor, its plunger, ejector, and spring.

7. Pull bolt to rear. Release it. Hold up extractor, and while looking down the T slot, pull trigger. If firing pin striker shows through bolt face, the mechanism is operating. Repeat this test once more to prove functioning.

8. Inspect and adjust headspace. See adjustment No.2, below, for procedure.

9. Check and adjust timing. See adjustment No.3, below, for procedure.

10. Inspect and adjust buffer assembly. See adjustment No.4, below, for procedure.

NOTE: Ragged operation or undue dispersion has been traced to disturbance of the gun caused by violent pounding of the belt against the solid buffer."

3. Adjustment No.1. Belt Feed Slide.-a. The proposed method of adjusting the belt feed slide is as follows:

"Close the cover. Press the feed slide to the left. It should still protrude 1/32" (thickness of a US dime or edge of a dog tag) to the right of the cover. If it does not, remove the belt feed lever from the cover and straighten (bend) slightly, using any suitable object. If new parts are available, check pivot, feed lever, slide, etc. and replace worn parts. Selective assembly alone may cure the trouble."

b. This method is the same as that in FM 23-50 (see par 43d(1)) except it prescribes that the feed lever be straightened instead of replaced, if new parts are not available. However, under FM 23-50, the feed mechanism is inspected "in event of recurrent or permanent failure to feed." As indicated below, proper adjustment must be made at regular intervals to eliminate stoppages and that new guns must be adjusted before firing:

(1) A high percentage of all stoppages occur because feed is incorrect. This is particularly true in vehicles where the belt is fed at an angle or over a feedway or chute.

(2) A check of several hundred machine guns revealed that only about 5% had correct feed adjustments.

(3) Inspection also revealed that units were receiving many new guns which had feed levers improperly manufactured or feed mechanisms improperly adjusted for vehicular installation requiring long belt feed.

(4) The rate of wear of feed parts is such that they must be readjusted every 5000-10000 rounds. Wear in the feed mechanism prevents the slide from being carried all the way to the right. Unless the slide holds the belt and cartridge firmly against the cartridge stops, the following stoppage may occur:

(a) Belt becoming clogged in the feedway.

(b) Extractor hitting the head of the round, and causing a short round.

(c) Belt pocket being dragged to the rear as a round is extracted from the pocket, causing the belt outside the feedway to swing. This often allows a round to catch on the feed guide.

(d) There may be enough slack in the parts so that a heavy or long belt cannot be pulled over the holding pawl.

(5) Lack of adjustment often results in a stoppage due to the belt loop becoming wedged between the cartridge stop and the next round fed in. This stoppage is common

in tank installations, especially with belts which have been used previously.

4. Adjustment No.3. Headspace.-a. Par.11, FM 23-50 states the present method of adjusting headspace. This method is based on the assumption that expansion of the metal from heat generated during firing will cause headspace to tighten. Consequently, headspace is adjusted to allow for this expansion. The tests showed that this method results in loose headspace.

b. The proposed method is as follows:

"1. When assembling gun, screw barrel all the way into the barrel extension and replace in receiver. When gun is completely assembled, allow belt to go forward and note if barrel locking notches show between trunnion block and barrel extension. If they do not, make no further adjustment. If they show, insert a combination tool or screw driver in a notch on left of barrel and take off one notch. Allow bolt to go forward. If barrel locking notches still show, continue to take off one notch at a time, until the bolt just goes forward. Do not make any further adjustments. Headspace is correct.

2. The greater the heat generated during firing, the looser the headspace becomes. Therefore, if firing long bursts, check after about 1000 rounds to see if barrel can be screwed into extension one more notch."

c. The advantage, explanation and proof of the proposed method are given below:

(1) Over 100 machine guns were set up with headspace adjusted so that bolt and parts bound slightly. In each case, after 1000 rounds automatic fire, the barrel could be screwed into the barrel extension one more notch. Firing was then resumed with positive functioning. When the guns had cooled, it was impossible to take up the barrels one notch. Therefore there is no need to loosen the barrel to allow for expansion.

(2) Patent #1,293,021 February 1919 by John M. Browning states that the parts should be adjusted so that they are in firm contact, and that after continuous firing the adjustment should be checked to see if it is possible to screw the barrel into its extension an additional notch. Browning states definitely that no looseness should exist between the barrel and bolt, and that headspace adjustment must give firm support to the chambered cartridge.

(3) With only one notch backed off, a gun has a headspace sufficient to permit some cartridge cases to rupture.

(4) Ruptured cartridge cases often are encountered after the gun gets warm, especially when intermittent fire is used. The reason is that the gun, originally set with loose headspace (one, or more, notches backed off) gains additional headspace. A round left in the hot chamber builds up additional chamber pressure. The combination of loose chambering and excess pressure ruptures the case. During the tests, guns with headspace adjusted according to the proposed method failed to give a single ruptured case, even though rounds were filed to weaken the cases and were left in hot guns to build up chamber pressure.

(5) The tests indicated that all cases of broken parts in the barrel extension and bolt recesses were the result of firing with loose headspace (barrel unscrewed one or more notches after initial adjustment). A slight

motion of the bolt to the rear, under instantaneous high pressure, causes a hammer blow by the bolt against adjoining parts, causing crystalization.

5. Adjustment No.3. Timing.-a. The effect of improper timing is not mentioned in FM 23-50, nor is a method given for checking and adjusting timing.

b. The proposed method of adjusting timing is as follows:

"After cocking firing pin, pull bolt short distance rear, insert a .30 caliber timing gage or coin 1/16" thick (US nickel, Belgian franc, German 10 pfennig, or a French franc if others are not available) between trunnion block and barrel extension. Ease the bolt forward. Squeeze the trigger. The firing pin should not be released. If firing pin is released, the gun is firing too soon. Substitute another trigger bar or bend the front of the trigger bar slightly by hammering until required effect is obtained, i.e. firing pin not released with gage in position, but must release with gage removed."

c. The reasons for checking and adjusting timing are as follows:

(1) The timing was incorrect in most of the guns tested. It varied from correct to release of the firing pin 3/16", or more, out of battery.

(2) Timing changes through wear of the parts.

(3) The act of firing must take place while the extractor is in position to engage the extracting groove of a round in the feedway. Therefore, faulty timing can cause the following malfunctions:

(a) Firing during automatic fire may move the action to the rear before the extractor engages a new round. This results in failure to feed and load.

(b) Failure to extract. This occurs when the gun fires before the extractor can engage the round.

(c) Runaway gun resulting from a bent trigger.

(d) Weapon fires with moving parts out of battery resulting in irregular shot patterns (usually vertical dispersion). During the test, dispersion was affected both by early and late timing.

6. Adjustment No.4. Recoil Buffer.-a. The proposed method of adjusting the buffer is as follows:

"Tighten adjusting screw as far as it will go. Part of the last thread must still show when the screw is fully home. If not add fiber discs. Then, if buffer tube is disc type (has all fiber discs), back off $\frac{1}{2}$ turn; if spring type, back off $1-\frac{1}{2}$ turns. If in doubt, back off 1 turn."

b. This method is essentially the same as that prescribed in FM 23-50, par.20a(2). However, in FM 23-50, adjustment of the buffer is in the section entitled "Dissembling of Parts Dismounted Only for Repairs". As indicated below, this should be a routine check and adjustment:

(1) On the many new guns inspected during the tests, all buffers were adjusted solid, i.e. the adjusting screw fully home.

(2) Browning's patent (See J.M. Browning Patent #1,548, 708 and application #183,841) indicates that the purpose of the buffer is to absorb shock and not to act as a rebound unit. Loosening the adjusting screw accomplished this purpose.

(3) A solidly adjusted buffer causes considerable vibration of the gun which often results in ragged operation and increased dispersion. Also, the rear of bolts may break from their solid impact on a rigid buffer plate.

APPENDIX 7

DELAY IN DEVELOPMENT OF GUNNERY TECHNIQUE

1. Medium tank M3 was initially issued to troops in the summer of 1941.

2. Medium tank M4 was initially issued to troops in the summer of 1942.

3. Mimeographed copies of FM 17-12, Tank Gunnery, were distributed to units by Armored Force Headquarters in the winter of 1943-44. This was the first manual on tank gunnery technique and training methods.

4. Course in gunnery technique and firing was inaugurated at the Armored School in March 1943. Previous gunnery course consisted principally of instruction in nomenclature and functioning of material.

5. First edition of FM 17-12, Tank Gunnery, was published by the War Department on 22 April 1943.

6. Second edition of FM 17-12, Tank Gunnery, was published by the War Department on 10 July 1944.

APPENDIX 8

TRAINING OF ARMORED REPLACEMENTS

HEADQUARTERS
EUROPEAN THEATER OF OPERATIONS
UNITED STATES ARMY

RBL/ JR/mc

APO 887
3 December 1944

AG 353 OpAFVW

SUBJECT: Training of Armored Replacement.

TO : The Adjutant General, Washington, D. C.

1. The average tank crewman replacement supplied to this theater to date, while well trained considering that only seventeen (17) weeks are allowed for the purpose, is below the standard of proficiency required for combat. Principal deficiencies are in tank driving and gunnery.

2. These men have driven tanks under all the required training conditions, but have not had sufficient hours to qualify as combat drivers. The lack of confidence in their own ability which they express when questioned on the subject, has been proven well justified by their actual driving performance. Similarly, they have grasped part of what was taught them in gunnery, but are hazy on ammunition types and capabilities, uncertain in range estimation, weak on fire orders, and far too slow in laying the gun. They have received good instruction, but have not been afforded the opportunity for sufficient practice to "gell" that instruction.

3. When there were several armored divisions in the United States, it was the policy to send men for six (6) months training with an armored division upon completion of the Armored Replacement Training Center course, prior to shipment overseas. This policy is no longer in force, and the lack of additional training which it provided is very evident in current replacements.

4. It is recommended that the War Department extend the armored replacement training period from seventeen (17) weeks to nineteen (19) weeks at the minimum, and preferably to twenty (20) weeks, and that during this additional time, attention be focused on tank driving and tank gunnery.

For the Commanding General:

/s/ R. B. Lovett
/t/ R. B. LOVETT
Brigadier General, USA
Adjutant General

AG 353 (3 Dec 44) OB-S-C 1st Ind MNE/fab 2B-939 Pentagon
WD, ACO, Washington 25, D. C., 23 December 1944.

TO: Commanding General, European Theater of Operations.

1. Present urgent requirements for replacements, particularly infantry, and the limitations of manpower resources, do not permit extension of the present regular training period for armored replacements.

APPENDIX 8

However, driving deficiencies of tank crewmen replacements are being corrected by an increase in actual tank driving for each individual trainee at the Armored Replacement Training Center. Also the War Department recently authorized Army Ground Forces to hold in a pool for not more than 4 weeks, all armored replacements who had completed the 17 week course at Ft Knox and were not required for immediate shipment overseas. During this 4 week period the trainees are given advanced training which includes further instruction in driving and gunnery.

2. This additional driver training and the advanced training period should insure the desired proficiency of armored replacements. However this advanced training cannot be given to replacements if overseas requirements necessitate shipment of all trainees immediately upon completion of the 17 week course.

By order of the Secretary of War:

/s/ Lester B. Johnson,
/t/ LESTER B. JOHNSON,
Adjutant General.

APPENDIX 9

MILITARY CHARACTERISTICS COMMON TO ALL TANKS

(Extracted from Army Ground Force Equipment Review Board Report, Part II, 20 June 1945)

NOTE: These characteristics were not contained in the preliminary study reviewed by ETOUSA and 12th US Army Group. The General Board, United States Forces, European Theater concurs in the following characteristics.

1. Temperature limitations. All standard equipment shall be able to start and operate efficiently within the following extremes of conditions: from -10° F. to +120° F. with wind velocities up to 40 m.p.h. Winterizing kits shall be provided to extend the range of use to -40° F. All equipment shall be capable of withstanding temperatures of 95° F. with 95 percent relative humidity for six months without deterioration.

2. Noise. The noise level within closed combat vehicles during operation on hard surface road or elsewhere shall be the minimum practicable and in no case greater than 100 db except during firing of weapons in which case blast pressures inside shall not exceed two p.s.i.

3. Vibration. Vehicles carrying guns and sighting equipment shall be sufficiently free from vibration or the vibration damped so as not to interfere with sighting and accurate gun laying. General vibration shall be reduced to a minimum in the main power plant, gear train and suspension system and shall be isolated and damped insofar as possible from the rest of the vehicle.

4. Physical Fatigue limitations. The level of work of all men in closed combat vehicles under the most severe operating conditions must not exceed rates of 5 Cal/Kg/hour, except for periods not to exceed one hour and normally should not be more than 3 Cal/Kg/hour for prolonged operations. Equipment shall be so designed that the work required in first and second echelon maintenance will not exceed the above levels.

5. Gun fumes and carbon monoxide. The carbon monoxide concentration in the vehicle from any source under any anticipated rate of fire shall not exceed 0.05 percent.

6. Heat. Adequate heat control against sources of excessive temperatures shall be provided. In closed combat vehicles every effort shall be made to minimize the transfer of heat to the crew compartment.

7. Crew cooling. In closed combat vehicles consideration should be given in the initial design to the space requirements and necessary power for the operation of individual cooled suits or other means of crew cooling. Design should provide for either the rapid field installation of such equipment or provide the basic elements in production.

8. Crew heating. In closed combat vehicles provision should be made for crew heating either by electrical outlets with capacities of 150 watts each, located conveniently to each crew position, or by well distributed air-blast heating.

9. Seating. Seats shall provide anchorage and comfort and be

designed for natural posture. Seats shall be easily adjustable in height and forward movement to place 95 percent armored personnel occupants in a natural position for operation of controls, operation of visual instruments, etc. Padding shall be provided to protect against excessive heat or cold. Springiness shall not be such as to interfere with the use of sights.

10. Crew Safety. Safety precautions shall be incorporated in design to preclude, insofar as possible, hazards other than those imposed by battle. In general these include: equilibrated doors and hatches with strong positive locks, non-interfering handles, elimination or protection against sharp corners, adequate well placed padding, treated outside and inside surfaces to prevent slipping, removal of non-essential protrusions, supplying adequate hand hold supports, steps, etc.

11. Interior lighting. Red and white dual lighting capable of adjustment shall be provided in all combat vehicles and in such others as indicated by tactical needs. The location of fixtures and bulb requirements shall be determined for each vehicle on the basis of light requirements needed to perform the visual tasks of the occupants, including reading of maps and orders. The fixtures shall be shaded and located so as to minimize direct illumination through vision devices. Individual instrument lights shall be provided for instruments having fine graduations which are impractical to illuminate with standard fixtures. Warning and signal lights shall be bright enough to attract attention but shall not constitute a glare source. In general, all danger lights shall be red; if other colors are necessary the brightness must be controllable or be reduced so as not to interfere with dark adaptation. Power for such illumination shall be drawn from the vehicle's electrical system.

12. Inflammability. Stowage and protection of ammunition in all vehicles shall be such as to minimize the danger of a hit with the least sacrifice to its accessibility. Insofar as possible, fire proof materials shall be used throughout the vehicles. Provisions shall be made in design for adequate drainage and easy cleaning of oil, gasoline, and grease from locations where they may create a fire hazard. Simple, accessible fire extinguishing equipment shall be provided in all vehicles. Automatic fire extinguishers shall be provided in combat vehicles, if practicable.

13. Hatchways. Escape hatches shall be provided in all closed combat vehicles. All hatchways shall be sufficiently large to accomodate 95 percent armored personnel wearing winter clothing. Where escape hatches are provided the mechanism shall be dependable and require not more than 40 pound pull to open. All other hatches shall be equilibrated and require not more than 20 pound push to open and allow for selective partial and complete opening. Quick acting, easily operated, noninterfering, inside fasteners shall be provided. The number and type of hatches shall be determined on the basis of rapid evacuation of the crew from the vehicle, assuming fire.

14. Gas protection. In closed combat vehicles provision should be made in the ventilating system for the field installation of a gas cannister. The air shall be supplied to the crew compartment through this canister at a rate not less than 400 c.f.m. and if feasible 600 c.f.m. Sealage shall be such as to maintain a pressure within the crew compartment of at least one inch water guage. Intakes shall be protected against the direct entrance of liquid and so located as to drew in a minimum of dust. For open and non-combat vehicles, the most efficient light-weight individual protective means will be employed.

15. Basic dimensions. All vehicular equipment must fit the men who use it; therefore, equipment and crew must be considered as a unit. Where difficulties of design require it, equipment may be made to fit the central 90 percent in the range in sizes of men. In general, design should consider the whole range of sizes up to 95 percent. No armored unit equipment shall impose limitations size on the personnel who use it unless otherwise specified.

16. Gun controls. Placement of gunner's seat, optical instruments, gun hand control and firing buttons shall be integrated so that all gunner operations can be easily and naturally performed. Optical instruments shall be so placed in height and distance forward that they are readily accessible from a single seat position without hampering freedom and natural use of hand controls. Hand controls shall be approximately 15 inches forward from the center of the seat. Adequate clearance shall be provided around the gunner so that there will be no obstruction to free rotation of hand controls. If possible, hand traverse shall be for the right hand. Hand controls shall be on a line approximately six inches above the knee and approximately four inches laterally. Handles shall afford a positive fist grip and be sufficiently large to be operated easily with gloves. Accessory fire control equipment, azimuth indicator, gunner's quadrant, shall be readily visible to the gunner without undue contortion or change of position.

17. Auxiliary charging facilities. An auxiliary charging unit shall be provided in vehicles, which shall be capable of furnishing all electrical power requirements for the vehicle in addition to keeping the vehicular battery fully charged. This must not only meet the requirements for vehicular operation and signal communication, but also such requirements as may be interjected by the operation of auxiliary equipment.

18. Vision. Vision requirements shall be essential considerations in shaping turret and hull armor. Employment of vision units shall not require interruption of other essential crew functions. Driver vision shall be such as to permit the normal maneuvering of the vehicle without hand manipulation of vision units. Combined vision by all members of crew shall provide adequate sky and ground vision on all sides. Provision shall be made to maintain the function of vision units against rain, dust, dirt, moisture, condensation and fungus.

19. Secondary armament. Provision shall be made for adequately armored, externally mounted smoke bomb projectors to provide for simultaneous projection of not less than six smoke pots or bombs, and capable of being fired from inside the turret. The firing mechanism shall be simple, reliable and provided with suitable safety devices. The projectors should be set to project the smoke bombs 150 to 200 yards to the front of the turret at lateral intervals of 20 yards. Other means such as rockets, hand guns, etc., should be investigated to determine most efficient method.

20. Provision shall be made for an antipersonnel device having a casualty producing effect to a distance of approximately 10 yards from the tank to sides and rear of the tank.

21. General provisions for turrets:

a. 360° traverse.

b. The turret shall be fully balanced.

c. An adequate, positive, and easily operated turret lock shall be positioned convenient to the gunner.

APPENDIX 10

CHARACTERISTICS COMMON TO ALL TANK CANNON

(Extracted from Army Ground Force Equipment Review Board Final Report, Part II, inclosure 4-C)

NOTE: These characteristics were not included in the preliminary study reviewed by the European Theater of Operations and 12th US Army Group. The General Board, United States Forces, European Theater concurs in these recommendations subject to the discussion in Section 10 of this report.

1. Guns specially designed in view of space limitations in tanks.

2. As short a chamber as practicable.

3. As short a distance from trunnion to breech block as is consistent with a balanced turret.

4. Compact recoil mechanism.

5. Short recoil.

6. Breech, semi-automatic.

7. Maximum backlash in elevating and traversing mechanisms shall not exceed ½ mil.

8. Life of tube to be dependant upon performance desired. Life of not less than 1000 rounds is the satisfactory minimum.

9. The gun mount shall be of such design as to prevent bullet splash and shell fragments from entering the turret.

10. Gun mounts shall provide adequate ballistic strength, be properly balanced, free from backlash, and shall insure rapid, positive laying by the gunner. A means of readily providing breech heaviness shall be available for firing from a stationary tank. A positive and rugged gun travel lock shall be provided that can be readily applied from the gunner's position. In addition to interior travel lock, an exterior travel lock shall be provided in the normal carrying position of the principal weapon. A turret lock shall be provided for locking the turret in position when the gun is carried in the exterior travel lock.

APPENDIX 11

CANNON RECOMMENDED FOR FUTURE TANKS

(Extracted from Army Ground Force Equipment Review Board Report, Parts I & II).

NOTE: The only portion of the following data which was contained in the preliminary study reviewed by the European Theater of Operations and 12th US Army Group has been underlined. Both these headquarters concurred in the underlined data, except the latter did not concur in development of guns larger than 90mm. The General Board, United States Forces, European Theater concurs in the following characteristics subject to the discussion in Sections 10 and 11 of this report.

1. For reconnaissance (light) tanks, a gun of approximately 76mm caliber capable of penetrating 5" homogeneous armor at 30° obliquity at 1000 yards with special ammunition, or capable of "destroying personnel and of penetrating the sides and rear of any enemy armored vehicle." Overall length of a complete round not to exceed 25"; weight not to exceed 25 lbs. Minimum of 60 rds to be stowed.

2. For exploitation (medium) tanks, a gun of approximately 3-inch caliber capable of penetrating at least 3" homogeneous armor at 30° obliquity at 1000 yards with special ammunition, or capable of "destroying personnel and of penetrating the sides and rear of any enemy armored vehicle and the front of any but the heaviest assault tank." Overall length of complete round not to exceed 33"; desired length 30". Weight not to exceed 35 lbs. Not less than 85 rds to be stowed.

3. For infantry or assault (heavy) tanks, a gun of approximately 90mm caliber capable of penetrating at least 10" of homogeneous armor at 30° obliquity at 2000 yards with special ammunition, or capable of "destroying personnel and weapons impeding the advance of the ground troops". Overall length of complete round not to exceed 35"; weight not to exceed 50 lbs. Not less than 60 rds to be stowed.

4. For a super tank, to be developed for research and experimentation, a gun at least 105mm. in caliber capable of penetrating 10" of homogeneous armor at 30° obliquity at 4,000 yards.

5. With reference to the gun for the super tank, 12th US Army Group stated that the caliber of any tank gun should not exceed 90mm since described penetration can be obtained by increasing the velocity of the projectile. The European Theater of Operations concurred with the Army Ground Force Equipment Review Board. The General Board, United States Forces, European Theater also does not concur with 12th US Army Group, and adopts the reasons stated by the European Theater of Operations in its non-concurrence. They are as follows:

> "It is not considered desirable from a long range development standpoint to limit tank gun development for super tanks to guns of 90mm maximum caliber." 12th AGp's recommendation based on the premise that loading will always have to be accomplished manually and by one man is not considered sound for the following reasons:

(1) The restriction of 90mm caliber closes the door to the possible development of light weight, medium velocity, five to seven inch, hollow charge projectiles that have armor penetration capabilities upwards to 20 inches.

(2) Relatively speaking, a 90mm gun would be small principal armament for a 150-ton tank. A 90mm gun is readily installed in the well-armored, 75-ton heavy tank recommended in the Board Study. In sacrificing mobility and building a still heavier tank, the possibilities of greater gun power should be exploited along with the addition of greater armor protection.

(3) Assuming a muzzle velocity in excess of 4,000 f/s would be attainable with a 90mm projectile (approximately 23 lbs), present research indicates penetrations in excess of 10 to 12 inches are difficult to obtain, particularly against a reasonable amount of obliquity, because the mass of the section of armor plate attacked materially "overmatches" the mass of the projectile, and defeats it by breaking it up. This deficiency can be overcome by increasing the mass of the projectile by an increase in caliber to 105 or 120mm."

(Source of material in above paragraph was ETOUSA Study referred to in footnote 30, Chapter IV).

APPENDIX 12

MACHINE GUNS RECOMMENDED FOR FUTURE TANKS

(Extracted from Army Ground Force Equipment Review Board Report, Part II)

NOTE: The following recommendations were not included in the preliminary study reviewed by the European Theater of Operations and 12th US Army Group. The General Board, United States Forces, European Theater concurs in the following recommendations subject to the discussion in Chapter V of this report.

1. For reconnaissance (light) tanks:

a. One caliber .50 machine gun mounted coaxially in the turret.

b. Two caliber .30 machine guns symmetrically located on Tank turret in ballistic blisters so mounted as to fire coaxially with the main weapon.

c. One caliber .30 bow gun.

d. One caliber .50 AA gun controlled by tank commander and so mounted as to be capable of being fired at ground targets as well as air targets.

e. Stowage of caliber .30 ammunition - 1000 rounds per gun in ballistic blister; 2000 rounds per bow gun. Total: 4000 rounds.

f. Stowage of caliber .50 ammunition - 800 rounds per gun. Total: 1600 rounds.

2. For exploitation (medium) and infantry (heavy) tanks:

a. One caliber .50 machine gun and one caliber .30 gun mounted coaxially inside the turret.

b. Two caliber .30 machine guns mounted in blisters - equivalent to reconnaissance tanks.

c. One caliber .30 machine gun capable of being fired by the assistant driver. Consideration to be given to mounting bow gun or guns in remote controlled ballistic blisters.

d. One caliber .50 antiaircraft gun -equivalent to reconnaissance tank.

e. Stowage of caliber .30 ammunition - 2500 rounds per gun, (minimum). Total: 10,000 rounds.

f. Stowage of caliber .50 ammunition - 600 rounds per gun, minimum. Total: 1200 rounds.

APPENDIX 13

MACHINE GUN SPARE PARTS AUTHORIZED LIGHT TANKS M24

(Extracted from Stowage List for Light Tank M24 as shown in Appendix A, 12th Army Group Armored Report No 5, 30 November 1944)

CALIBER .30 MACHINE GUN

1 Accelerator
1 Band, lock, front bbl. brg.
2 Barrel
2 Bolt, assy
1 Bushing, belt feed, lever pivot
1 Cover, assy
1 Extension, barrel, assy
2 Extractor, assy
1 Frame, lock, assy
3 Lever, cocking
2 Lever, feed belt
1 Lock, breech
1 Nut, belt feed, lever pivot
2 Pawl, Feed, Belt
2 Pawl, Holding, Belt
3 Pin, accelerator, assy
1 Pin, belt feed pawl, assy
1 Pin, belt holding pawl, split
3 Pin, cocking lever
3 Pin, firing, assy
2 Pin, trigger
1 Pivot, belt feed lever
1 Plunger, barrel, assy
2 Rod, driving spring, assy
2 Screw, belt feed, lever pivot
2 Sear
1 Slide, feed belt assy
2 Spring, belt feed holding pawl
2 Spring, belt feed pawl
2 Spring, barrel plunger
2 Spring, driving
2 Spring, cover extractor
2 Spring, locking barrel
4 Spring, sear, assy
2 Spring, trigger pin
2 Trigger
2 Washer, lock, internal teeth, reg. S., No 5 (0.125)

CALIBER .50 MACHINE GUN

1 Arm, belt feed pawl
1 Barrel, assy
1 Disk, buffer
1 Extension, firing pin assy
1 Extractor, assy
1 Lever, cocking
1 Pawl, feed, belt, assy
1 Pin, belt feed pawl, assy
1 Pin, cotter, split, S., Type B, 3/32 x 3/4
1 Pin, cotter, split, S., Type B, 1/8 x 5/8
1 Pin, cotter, split, S., Type B, 1/16 x 3/4
1 Pin, firing
1 Plunger, belt feed lever
1 Rod, driving spring, w/spring, assy

1 Slide, feed, belt, assy
1 Spring, belt feed lever plunger
1 Spring, belt feed pawl
1 Spring, belt holding pawl
1 Spring, cover extractor
1 Spring, locking barrel
1 Spring, sear
1 Stud, bolt

APPENDIX 14

ADVANTAGES OF A CALIBER .50 COAXIAL MACHINE GUN

1. The trajectory of the caliber .50 gun more closely approximates that of the tank cannon at longer ranges than the caliber .30 gun. In addition, the caliber .50 has a longer tracer burning time. These factors will make ranging-in with the coaxial machine gun easier and will permit ranging-in at ranges where the tank cannon often will not obtain a hit in the first round.

2. The increased effectiveness of the caliber .50 armor piercing round will permit the coaxial machine gun to be used against targets which formerly would have required the tank cannon.

3. The caliber .50 incendiary round can start fires which formerly would have required white phosphorous.

4. These advantages will result in a saving of tank cannon ammunition.

APPENDIX 15

AMMUNITION

(Extracted from Army Ground Force Equipment Review Board Report, Part I, Annex N.)

NOTE: Subject to the discussion in Chapter VI of this report, the General Board, United States Forces, European Theater concurs in the following recommendations of the Army Ground Force Equipment Review Board as qualified by the comments of the European Theater of Operations and 12th US Army Group.

1. a. It is becoming increasingly apparent from developments in the field of electronics, jet propulsion, recoilless guns, rockets, and new methods of harnessing fuel energy that a future war may witness radical, if not revolutionary, departures from our standard weapons and ammunition. The impetus of science is so great and the power of the scientist "group", working in close cooperation, has been demonstrated to be so fruitful that we must be prepared to abandon, if necessary, certain conventional artillery and ammunition. This possibility should not be considered lightly, nor its scope underestimated.

b. Some of the tried and true designs will remain as the experience of this war and any radical change in such designs should be most carefully reviewed.

c. It is with the above in mind that the following general program is presented. The program is a live one, since it arises from both the solved and unsolved problems of today. At this time no specific limitations on any phase of ammunition development should be indicated beyond the general problems and trends listed hereafter.

2. General objectives. General objectives for post war development of ammunition, as listed in the paragraphs of this section, apply to many or all calibers.

3. Projectiles. Continuous research and development must emphasize the following for all types of projectiles:

a. Improvement in exterior ballistics to gain greater accuracy through uniformity in manufacture, smaller weight tolerances, smoother ogives, further boattailing, and improved rotating bands.

ETOUSA and 12th US Army Group recommended addition of: "A finish, to be applied like paint, should be developed that provides a completely uniform surface."

b. Increased velocity by elimination of coppering. A substitution of other metals for copper in the manufacture of rotating bands should be sought.

c. The effectiveness of all projectiles must be increased by improvement in the steels used in the manufacture of HE and armor piercing shells.

ETOUSA and 12th Army Group recommended addition of: "The minimum requirement for the steel should at least equal the core in present HVAP ammunition."

d. Further study of the design of the walls in HE shell must be made to secure more uniform fragmentation. In this connection effort

must be made to attain common or matched exterior ballistics for HE and WP or smoke shells for both direct and indirect fire weapons.

e. The number of types must be kept to a minimum. Interchangeability of common types between all using arms of the army, as well as between similar weapons of both Army and Navy, should be the objective.

4. Cartridge cases. a. Due to the possible shortage of copper, research must be conducted to develop a metal having the same or better physical characteristics than brass for use in the manufacture of cartridge cases for all types of artillery and small arms ammunition.

ETOUSA and 12th Army Group recommended the following additions:
Research should include not only metal but also "other substances, possibly plastic."
Reduction in weight is an essential consideration. Research should include the possible use of a stable, durable explosive case which will supplement the charge and be self-destroying.
A cartridge case to eliminate difficulties of extraction and stoppages with particular reference to small arms should be developed.

b. Cartridge cases must be developed from some metal or other material which resists the products of combustion to such an extent that they may be resized and reused. Cartridge cases should be non-corrosive.

c. Further attempts should be made to improve the obturation of those types which now give occasional leaks. In this connection, study should be made toward gaining obturation in calibers now using separate loading ammunition, through the use of cartridge cases in lieu of the gas check pad method of obturation.

5. Propellants. a. There is a uniform demand for propellants possessing smokeless and flashless characteristics. At the present time, most of our weapons, including small arms, do not possess either quality.

ETOUSA and 12th US Army Group recommended substitution of the following for the first sentence: "There is an urgent and uniform demand for moisture resistant propellants possessing smokeless and flashless characteristics."

b. Higher velocities and increased accuracy must be attained to satisfy the needs of tank, tank destroyer, antiaircraft, and field artillery guns.

ETOUSA and 12th US Army Group recommended addition of the following: This increased velocity should not be obtained by a decrease in the weight of the projectile."

c. Improved ignition, with the absence of toxic fumes and odors, must be sought.

d. Erosive effect on gun tubes must be reduced.

ETOUSA and 12th US Army Group recommended addition of the following: "..., but not at the cost or loss of essential velocities. Undue emphasis on reduction of erosion will result in loss of velocity, and as a result high velocity guns may be developed that will not give peak performance on the battlefield."

e. Uniform performance of propellants at both high and low temperatures must be researched.

f. Powder, in the varying charges of the same weapon, should be of uniform composition.

g. Investigation should be made of the use of high explosives, suitably incorporated, to develop new and more desirable propellant powders.

h. Several of the specifications and requirements of ideal propellants are mutually antagonistic. The solution will be a challenge to the best scientific effort of the nation. The problem should be placed before the Research Board for National Security.

ETOUSA and 12th US Army Group recommended addition of the following: "All rounds should be manufactured and issued to include propellant increments up to the maximum charge."

6. Explosives. a. New and more powerful explosives, possessing maximum oxygen balance and low sensitivity, should be developed.

b. The field of composite explosive mixtures should be investigated further to determine the advantages to be gained in power and sensitivity, in conservation of those highly brisant explosives that are more difficult to manufacture, and as a possible method of obtaining "matched explosives", that is, explosives matched to projectiles, bombs, grenades, and rockets to obtain optimum blast effect and fragmentation.

c. Explosives should have maximum stability in storage under all conditions.

d. Development should continue on the hollow-shaped charge for use in artillery projectiles.

ETOUSA and 12th US Army Group recommended that development should "all calibers from 75mm up."

7. Fuzes. a. The danger to personnel and material from premature burst must be eliminated by making all fuzes not only bore safe but safe from explosions occuring too soon after the projectile leaves the gun.

b. All point detonating fuzes should have the same shell thread size and booster in order to permit maximum interchangeability in the various calibers of shells.

c. VT fuzes must be improved and, except for antiaircraft artillery fuzes, should have a percussion element included to meet the contingency of failure of the electronic element to function.

ETOUSA recommended addition of the following: "Means should be provided for adjustment of the sensitivity of VT fuzes so that maximum effectiveness can be obtained against different types of targets."

e. Not pertinent to this study.

f. The present combination delay and super-quick fuze should have improved safety features and be made equally useful for tank, tank destroyer, and field artillery weapons.

g. The objective of development in fuzes should be a single fuze combining time, delay and super-quick elements which could be used with equal facility by all arms in all calibers.

h. Fuzes must be designed to withstand greater setback and rotational forces due to the tendency toward higher velocities and shorter time of flight, particularly in tank and anti-tank guns.

8. Ammunition lots. a. The quantity of ammunition in any particular lot should be as large as possible in order to keep to a minimum the number of separate lots.

b. Variations in muzzle velocity and performance between different lots of the same type of ammunition must be reduced to a minimum by development in manufacturing processes as well as by research in materials used.

ETOUSA and 12th US Army Group recommended addition of the following: "The possibility of determining the amount of propellant from each powder lot required to establish a standard muzzle velocity for each charge for every weapon should be investigated. Powder increments should be assembled to produce this standard velocity, thus obviating dispersion from one powder lot to another. All components of the complete round of fixed and semi-fixed ammunition must be of the same lots to insure identical powder, shell weight, and finish. Accuracy is important, but it is essential that the necessity of segregating artillery ammunition by lot number at the firing position be eliminated. HE and smoke shells should have same ballistic characteristics to allow the use of smoke shell in registration."

9. Packing boxes and containers. Development should emphasize the following:

a. Packed ammunition should be able to withstand a drop of thirty feet on concrete in any position and still retain its full ability to function.

b. It should be capable of withstanding storage for two years in the open in the tropics, and still be suitable for shipment and its contents usable.

c. Containers or boxes should have such size and volume that they will float in water when filled with ammunition.

d. The method of closure of containers or boxes should be improved with a view to quick and easy opening, together with sure water tight closure.

e. Lighter and stronger metal containers should be provided.

f. All ammunition should be so waterproofed that in the "as packed" condition it may be left under one foot of water for twenty-four hours without injury.

g. New plastic and metal waterproof bag materials for storing and shipping ammunition should be developed.

ETOUSA and 12th US Army Group recommended addition of the following: "Packages must be portable by one man (75 lbs or less). Marking for easy identification in darkness should be improved. It is further recommended that some simple type of color code be adopted so that where unskilled labor is used in handling, the different types can readily and easily be distinguishable. Model and code numbers should be reduced."

10. Tracer. a. Research should be undertaken to protect and improve the stability of tracer mixtures.

b. Improved compositions, which are not susceptible to deterioration due to humidity or to temperature cycles, should be sought. Such compositions should perform satisfactorily after storage in either tropical or arctic climates and in the temperature range of minus 40° to plus 150° F.

c. Tracers should be provided with a dim igniter in order not to blind gunners or disclose gun positions during night firing.

ETOUSA and 12th US Army Group recommended that illumination commence at 300 yards.

d. The range of burning of the tracer element of all small arms (rifle and machine gun) ammunition should be increased by at least fifty per cent.

e. Tracers for all armor piercing ammunition used in tank and anti-tank cannon should have a burning range of 4,500 yards.

11. Smoke and chemical ammunition. a. Improvement should be made in all types to get the optimum distribution of smoke and chemical in all appropriate calibers.

b. The number of types of smoke shells should be reduced to a minimum.

ETOUSA and Twelfth US Army Group recommended addition of the following:

"Research should develop an improved method of shell filling to obviate the tendency of the WP filler to settle 'off center' during storage, thus causing erratic flight."

"An improved incendiary filler for grenades, rockets, and all types of artillery shells."

"A thin case, base ejection shell for use with incendiaries, flares, and propaganda leaflets."

"Range and effectiveness of battlefield illuminants should be increased. Both parachute flares and ground burning flares should be available for projection from a variety of weapons. Ballistics of illuminant shells should be identical with those of the standard projectiles..."

12. Not pertinent to this study.

13. Not pertinent to this study.

b. Not pertinent to this study.

c. A spotting round should be developed for use in all .30 cal., .50 cal., and 20mm rifles and machine guns.

d. A high velocity armor piercing and incendiary cartridge is required for use in .30 cal. and .50 cal. machine guns.

e. Development of non-corrosive primers for use in all types of cartridges is required.

f. A complete .50 cal. round susceptible of manufacture by mass production methods which gives the shortest time of flight to 1,000 yards and which will be interchangeable between antiaircraft, infantry, and other elements of the ground forces, is desired.

g. Development should be undertaken to provide incendiary bullets of all calibers which will ignite other fuels as well as gasoline.

h. Not pertinent to this study.

14. Tank and tank destroyer ammunition. Tank and tank destroyer ammunition should be designed specifically for use in tank and tank destroyer guns. Ammunition in the following categories should be developed for all types of tanks and tank destroyers.

a. Armor Piercing. (1) HVAP - An armor piercing round should be designed having the highest muzzle velocity practicable in order to achieve the armor piercing ability required. Consideration should be given to the non-shedding sabot type ammunition.

(2) AP or APC - Due to limitations in the supply of tungsten, development should continue on AP and APC.

(3) Spotting or smoke powder should be included in the ballistic wind shield to aid in spotting strike of round.

b. High explosive - An HE round for the tank and tank destroyer cannon should be developed having sufficient velocity to insure pinpoint accuracy in direct fire. Initial velocity should be the highest possible consistent with good fragmentation, control of ricochet, and minimum gun tube erosion. The external ballistics of this projectile should be identical with those of a chemical WP projectile. A reduced charge HE round should be developed for use by tank destroyers in indirect fire.

c. Canister. (1) Canister rounds should be improved to increase the size and range of the pattern of the canister.

(2) Canister rounds should be developed which will not interfere with any muzzle brake or blast deflector on the end of the gun tube, and which will have the minimum erosive effect on gun tubes.

d. Miscellaneous. (1) All tank and tank destroyer ammunition should be of the ready fuzed, fixed type. Better crimping should be employed to prevent separation.

(2) All types of improved fuzes developed for artillery cannon should be provided in tank and tank destroyer ammunition.

(3) To insure ease of loading, weights of complete rounds should be the minimum consistent with the muzzle velocities required. Complete rounds should not exceed the following weights and lengths: Light tank 25 lbs. and 25 inches; medium tank 35 lbs, and 33 inches; heavy tank 50lbs. and 30 inches.

15. Not pertinent to this study.

16. Field Artillery ammunition. General post war development for field artillery ammunition are covered in Section I of this paper. In addition to the broad problems, two special fields of development must be emphasized, namely -

a. HEAT ammunition, which will have its greatest use in field artillery, should have increased velocity and range, increased penetration of armor, improved effect at greater angles of attack, and improved fuze action. HEAT ammunition should have the same exterior ballistics as a comparable charge of HE for the weapon in which used.

Remainder of Annex N not pertinent to this study.

APPENDIX 16

FIRE CONTROL EQUIPMENT

(Extracted from the Army Ground Force Equipment Review Board Report, Parts I and II).

NOTE: The General Board, United States Forces, European Theater concurs in the following recommendations subject to the discussion in Chapter VII of this study. The European Theater of Operations and 12th US Army Group concurred in the general recommendation that tank guns be stabilized and that a built-in rader range finder and lead computing sight be developed. The other recommendations were not included in the preliminary study reviewed by the latter organizations.

1. General.

a. Fire control equipment shall be suited to the needs of the gun and its employment. The proper placement and function of fire control shall be a primary consideration in the layout and detailed design of the vehicle.

b. The fire control systems shall be an integrated part of the turret and should include the following:

(1) A built-in range finder (approximately 10 power) linked to the gun and operated by the tank commander, which furnishes, through suitable control mechanisms, proper lead and elevation to a single aiming point in a sight field of 4-6 power. Provision shall be made to lay the gunner on the target through the agency of the range finder. In juxtaposition with this sight field there shall be a wide field of unit power. (A reflex reticle is desirable in this field).

(2) There shall be an auxiliary sight changeable from 3 to 8 power. This sight shall employ a central aiming point and shall be adjustable with respect to the gun to provide for range setting. A moveable reticle shall be provided for deflection. Deflection and range scale shall appear in the sight field and be such as to accommodate the various types of ammunition employed.

(3) An elevation quadrant mounted upon the gun mount in a position where it can be easily operated by the gunner. It must be provided with an illuminated scale and bubble, and must be easily read and accurate to 0.2 mils.

c. The following general provisions to assure accurate and satisfactory fire control are necessary:

(1) Ruggedness, simplicity, and accuracy of linkages shall be stressed in the construction and installation of sights and sight linkages. Long lever linkages shall be employed to minimize error and play introduced because of bearing tolerences.

(2) The mechanism employed to provide boresight adjustment shall be simple, accurate, rugged and capable of being positively locked in adjustment. The movement for vertical and lateral adjustment, shall, in general, be

entirely independent; each movement shall be either smooth or with detents not to exceed 1/4 mil separation.

(3) Alignment of the sights with gun shall be retained within 1/4 mil under loads of 25 pounds applied at any point. Alignment shall be retained throughout the elevation travel of the gun.

(4) Sight units must be replaceable within 1 1/2 mils. The sight unit must not suffer a loss of more than 1/4 mil when withdrawn and reinserted.

(5) The auxiliary sights must be accessible and usable without the requirement of moving gunner's seat from the position used for primary sight.

(6) Vertical eye travel shall not be more than eight inches.

(7) An infinity sight and linkage shall be provided for the bow guns.

d. An azimuth indicator shall be provided. The azimuth indicator face shall be vertically positioned at approximately gunner's eye level. The azimuth indicator shall be easily read and accurate to 1/4 mil. The dial shall be illuminated. The gunner's aid shall be provided.

e. A panoramic telescope equipped for cross-leveling shall be provided. Provision shall be made for mounting at a suitable location on the turret exterior.

2. Binoculars.

a. Present binoculars are considered satisfactory for the field artillery; however, continued investigation to reduce size and weight and improve optical qualities is urged.

b. Basic research to determine the optimum power for the average individual who uses (observing) instruments should be instituted.

3. Periscopic Binoculars.

a. The tank commander shall be provided with a binocular instrument of not less than seven power and the widest possible field of view. This instrument shall be mounted under armor with provision for scanning through 360° azimuth and covering a vertical range not less than the elevation of the gun. This mount shall be provided with an azimuth scale easily read to one mil.

b. When the employment of the gun commonly exceeds 3000 yards, a higher (15) power binocular instrument shall be provided. Its power shall be adequate for the greatest range. (A stereo range finder may satisfy this additional demand for a higher power instrument).

c. A finder field of unit power shall be provided in close juxtaposition to the seven power binocular instrument.

4. Fire Control Radar-Director. When operating as a surveillance set this equipment should be capable of detecting terrestrial and low-flying aerial targets in any desired sector or throughout the entire 360° in azimuth. When operating as a fire control set the radar should

automatically track any selected target and the out-put data from the associated director should automatically lay the accompanying armament for the conduct of effective fire at ranges of at least 10,000 yards.

5. Stabilization. Lateral and vertical stabilization of main armament and coaxial machine guns shall be provided. The following general features shall be incorporated.

a. Maximum excursion shall not exceed one mil for 90 percent of the time.

b. Over-all response time shall not exceed 1/10 of a second.

c. The tank commander shall be provided with elevation and traverse controls that will follow the same response curves and shall override the gunner's controls.

d. Maintenance and adjustment requirements shall be within the capabilities of 1st and 2nd echelons of maintenance.

6. Firing Controls. Impulse firing solenoid or equivalent for the main weapon shall be provided. Hand firing shall be provided for the main weapon which will not require the gunner to remove his hands from the controls or disturb the use of the controls. An alternative mechanical means for firing the main weapon shall be provided. Provision shall be made for electrical firing of coaxial weapons. This shall incorporate combined or separate firing for caliber .50 and caliber .30 machine guns.

7. Traversing Mechanism. Traversing mechanism shall be power-operated and shall follow the control response curve smoothly, regardless of torque, up to the limit of the apparatus. Speed must not vary with torque. Change from power-traverse control to manual-traverse control must not require shifting of gears or clutch operation. The mechanism must prevent slippage on side slopes. Adequate seals against water and dirt shall be provided for the turret race.

8. Protection and Sealing.

a. Fire control units shall be protected wherever practicable by armored flaps operated from the inside, which furnish protection from dirt, rain, and small arms projectiles. These shall be adjustable where practicable to serve as sun and sky shades.

b. Where complete outside protection is not possible, provision shall be made for clearing the surface.

c. Fire control units shall be sealed effectively against condensation fungi or other agencies which diminish their effectiveness.

APPENDIX 17

COMPARISON OF AMERICAN AND GERMAN BINOCULARS

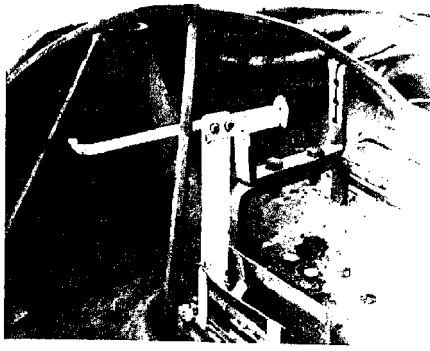
	AMERICAN	GERMAN		
	M-17, 7 x 50	Leitz-7 x 50	Zeiss-7 x 50	Zeiss-10 x 50
Length	$7^{5}/16$"	7"	$7^{1}/8$"	7"
Weight	2lbs 12ozs	1 lb 13ozs	2lbs 9ozs	2lbs 3ozs

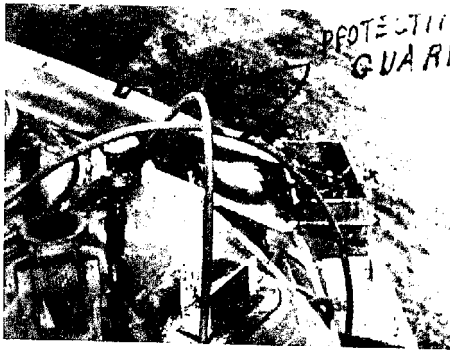
APPENDIX 18

"DONKEY SIGHT"

Appendix 18 - A - Photographs

Appendix 18 - B - Method of Employment





DONKEY SIGHT

HEADQUARTERS FIRST ARMORED DIVISION
APO 251 US Army

2 August 1945

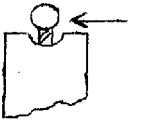
TRAINING MEMORANDUM)
:
NUMBER . . . . 39)

DONKEY SIGHT

1. On the receipt of new vehicles units will make arrangements direct with the 123d Ordnance Maintenance Battalion for the installation of the Donkey Sight on all medium tanks 76mm, medium tanks 105mm and light tanks M24.

2. Units will include in their gunnery training proper instruction in the functioning and use of the Donkey Sight. Experience has proved this Sight to be of definite value in speeding up the process of "getting off" the first round; careful instruction and a clear understanding of the sight, however, is necessary if confusion is not to result.

3. The Sight when installed is zeroed in with the zero cross hair in the gunners periscopic sight and is adjustable to permit rezeroing when it gets out of line. The Sight is built like the open sights on a rifle and the target is lined up the same.



4. a. The Donkey Sight was devised to designate an obscure target to the gunner in open country when the terrain is all alike, such as one particular bush or house among many; or in any case where it is difficult to designate the target by oral description. It is used not only to lay the gun horizontally, but to assist the gunner in laying vertically as well. When used in this fashion the sight positively indentifies the target to the gunner so that he will have an accurate initial lay.

Example: "Gunner:
"Antitank
"H.E.
"Traverse right (left) . . . . . steady . . . on
"Elevate . . . . . steady . . . on
"Bush
"Two Thousand
"Fire"

When adjusted the Donkey Sight merely designates the particular target by laying the zero cross hair of the gunner's sight on it. The gun is not laid until the gunner lays off the correct range on his sight. Thus in the above example the gunner would have to lay the 2000 yard line of his sight on the bush before firing.

5. In many cases it may be impossible for the gunner to see the target due to rain on the sight, fog, or smoke. With the Donkey Sight it is not necessary for the gunner to see the target. (Note will be taken of this during range firing by covering the gunner's sight with a piece of cloth).

APPENDIX 18 - B

The tank commander after laying the gun with the Donkey Sight then gives up so many mils according to the estimated range of the target.

a. For the 76mm tank gun a rule of thumb would be one mil for each 100 yards of range. Thus for a target at an estimated range of 2000 yards, the fire order would be:

"Gunner:
"Antitank
"H.E.
"Traverse right (left) . . . . . steady . . . on
"Elevate . . . . . steady . . . on
"Up two zero
"Fire"

b. For the 75mm tank gun a rule of thumb, which all car commanders should memorize, would be "up 10" mils for 1000 yards, and then up 10 mils for each 500 yards increase in range, thus:

"Up 10" - for 1000 yards
"Up 20" - for 1500 yards
"Up 30" - for 2000 yards
"Up 40" - for 2500 yards
"Up 50" - for 3000 yards

c. For the 105mm tank gun using charge seven the tank commander would give up so many mils for the rough mil setting for ranges as follows: up 20 for 1000 yards, and then up 15 mils for each 500 yards increase in range, thus:

"Up 20" - for 1000 yards
"Up 35" - for 1500 yards
"Up 50" - for 2000 yards
"Up 65" - for 2500 yards
"Up 80" - for 3000 yards

6. When a tank commander becomes experienced in the use of the Donkey Sight he will instinctively know when to use it in combination with target description; when to use it exclusively with the gunner not bothering with the sight; and when not to use it other than as a sighting vane. Speed in "getting off" the first round is of paramount importance in good tank gunnery. Do not use the Donkey Sight with obvious targets when it would be a waste of time. Thus where there is no possibility of the gunner mistaking the target the fire order would be:

"Gunner:
"Antitank
"H.E.
"Traverse right . . . . . steady . . . on

BY COMMAND OF MAJOR GENERAL ALLEN:

OFFICIAL: /s/ A. B. McEowen
/t/ A. B. McEOWEN
2d Lt, AGD
Asst Adj General

/s/ W. P. Johnson
/t/ W. P. JOHNSON
Colonel, G.S.C.
Chief of Staff

DIST: "A"
784 Tk Bn (8)
XXI Corps (3)
7th Army (3)

NOTE: Destroy all previous copies of TM No 39, 2 August 1945, this will substitute therefore.