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MILITARY MONOGRAPH

TITLE: Report of Test and Study of Military Characteristics for Gun, Machine, Combat Vehicle, Caliber .30.

SCOPE: The purpose of this monograph is to evolve the Military Characteristics for Gun, Machine, Combat Vehicle, Caliber .30.

41-142

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FOREWORD

This monograph is classified as CONFIDENTIAL and must be treated accordingly.

The contents represent pertinent extracts from a formal report of project prepared by the undersigned for Army Ground Forces Board No. 2, Fort Knox, Kentucky. Inasmuch as these extracts were taken from a draft copy of the aforementioned report, they represent the personal views of the undersigned and do not in any way represent the official views or opinions of AGF Board No. 2. On the other hand, it is an understatement to say that the patient guidance and constructive criticism of experienced members of Board No. 2 was invaluable in the preparation of this project.

As stated above, this monograph presents selections from a formal report --- a report which was concerned not only with the development of the Military Characteristics for a vehicular machine gun, but also with the selection of an interim caliber .30 weapon for use on combat vehicles. Included are the main body of the report and three of the ten appendices.

The main body depicts the purpose, background, general conclusions, and recommendations. It is presented in its entirety (with references to the interim weapon) in order to further the continuity of the monograph. Appendix B,

Bibliography, is included to establish the validity of the study and to recognize indebtedness to other researchers. Appendix F, Details and Results of Study, and Appendix H, Military Characteristics, are, of course, the subject of this paper. Omitted appendices, listed at the conclusion of the main body, cover the more technical aspects of the report, dealing with materiel, tests, and test analysis and application. References to these appendices have been included throughout the monograph --- again to further continuity and to establish, in addition, certain conclusions. Specific footnotes, however, referring to the omitted appendices have been omitted.

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REPORT OF TEST AND STUDY
OF
MILITARY CHARACTERISTICS
FOR
GUN, MACHINE, COMBAT VEHICLE, CALIBER .30

1. PURPOSE.--The purpose of this test and study is:

a. To compare current available machine guns and modifications with the intent of selecting an interim weapon for combat vehicles by testing and research.

b. To evolve military characteristics for Gun, Machine, Combat Vehicle, Caliber .30, through research, conferences, and evaluation of above test results.

2. REFERENCES.--

a. Ltr Hq, AGF, 23 August 1946, subject: "Gun, Machine, Combat Vehicle, Caliber .30" to President, AGF Board No. 2, through President, AGF Board No. 3, with two (2) indorsements, file 472.5 (23 August 1946) GNDEV-11.

b. Report of War Department Equipment Board.

c. Report of Army Ground Forces Equipment Review Board.

d. Report of Armored Equipment Board.

e. Report of Board of Officers Convened to Review AGF Equipment Review Board Report, July 1945, Fort Knox, Ky.

f. London Military Attache Report No. R4039-46, subject: "Sear Modification of the Caliber .30 Machine Gun, M1919A4" (MIS 314093), 8 October 1946.

3. DESCRIPTION OF MATERIEL.--

a. The proposed interim Gun, Machine, Combat Vehicle, Caliber .30, was selected from the following standard and modified machine guns: (For detailed description, see Appendix B, Detailed Description of Materiel Tested.)

(1) Browning Machine Gun, Caliber .30, M1919A4 --- present standard light machine gun for combat vehicles.

(2) Browning Machine Gun, Caliber .30, M1919A4 --- modified by the addition of a rear sear which will hold the bolt open between bursts.

(3) Browning Machine Gun, Caliber .30, M2, Aircraft --- standard.

(4) Browning Machine Gun, Caliber .50, M2, HB --- ground standard.

b. The proposed Gun, Machine, Combat Vehicle, Caliber .30, is to be designed for the new, shortened caliber .30 cartridge, T-65. (For detailed description, see Appendix H, Military Characteristics.)

4. BACKGROUND.--

a. The formulation of the military characteristics for the Gun, Machine, Combat Vehicle, Caliber .30, is a

portion of a general plan contemplating the improvement of combat vehicle armament. Previous reliance upon a general purpose light machine gun suitable for use by all arms, particularly infantry, has stunted the development of an efficient and practical machine gun for vehicular use. More recently, the increasing trend toward lightweight ground weapons with high cyclic rates of fire and a consequent decrease in accuracy and endurance has resulted in an even greater divergence from combat vehicle necessities. This trend makes it imperative that a machine gun suitable for combat vehicle fire missions, as well as for combat vehicle stowage and operating requirements, be developed. This need was recognized by the War Department Equipment Board, the Army Ground Forces Equipment Review Board, and the Armored Equipment Board.

b. At the same time, recognizing that the above development was a long-range project, it is necessary that a suitable interim caliber .30 weapon or weapons be selected in order to fulfill as many of the desired characteristics for a combat vehicle machine gun as possible. Dissatisfaction with the present standard machine gun, the Browning Machine Gun, Caliber .30, M1919A4, stems from deficiencies noted in combat and from the continued emphasis upon combat vehicles featuring remotely mounted and/or fired weapons. From time

to time various machine guns have been considered for installation in combat vehicles. The Browning Machine Gun, Caliber .30, M2, Aircraft, for instance, was tested by the Infantry Board in conjunction with the M2 Light Tanks, was found satisfactory for tank use, and was recommended for standardization. However, priority at that time was being given to the Air Corps for the M2, Aircraft and, as a result, the M1919A4 was accepted as standard in its place. Subsequently, the M2, Aircraft, Machine Gun was modified by the addition of a heavy cylindrical barrel designed to decrease the cyclic rate of fire and to increase accuracy and barrel life. The British, too, anticipated overheating and excessive wear of the standard M1919A4 when mounted in restricted space allowed in new tanks with remote control machine guns. In an effort to provide greater cooling, thus reducing barrel wear, and to eliminate cook-offs, the British have proposed a modification which will hold the bolt open between bursts. The modification is simple, cheap to manufacture, and easy to install in existing guns. This gun has operated satisfactorily from the added rear sear and the special components show no evidence of wear during the limited firing conducted by the British.

c. In order to determine the desirability of modifying combat vehicle machine guns, three M1919A4 Machine

Guns, modified as proposed by the British, and three M2, Aircraft, Machine Guns, modified by the addition of a heavy barrel were requested for testing and for comparison with the standard M1919A4 and M2, Aircraft, guns. To date, the modified M2, Aircraft, Machine Guns have not been received and, as a result, are not included in tests conducted in conjunction with this project.

5. SUMMARIES.--

a. Tests.--

(1) A series of machine gun firing tests were conducted in order to insure complete and factual knowledge of vehicular machine guns. (See Appendix D, Details of Tests.) Two weapons of each type were used in these tests and new barrels were employed when and where necessary.

(a) Barrel endurance was compared by firing all weapons at 140 and 100 rounds per minute through successive periods of 100 per cent keyholing (permitting return to ambient temperatures between periods) and by then comparing the length of periods, number of periods, bore gage readings, and by examination of the barrels.

(b) Accuracy was compared by firing and measuring 1000-inch shot groups prior to each endurance period, by measuring shot groups fired during the periods, and by firing and measuring shot groups fired at ranges between 300 and 900 yards with ball ammunition, tracer, ball and tracer loaded 4 to 1.

(c) Barrel heating and cooling rates were compared by taking recordings during the endurance tests and by readings taken during separate tests fired under identical conditions for each gun.

(d) Ability to withstand shock and unfavorable operating conditions and, as well, the ease of handling and operation were compared by observing all tests and by questioning personnel participating in the tests.

(e) Malfunctions, stoppages, cook-offs, excessive wear, headspace and timing adjustments were recorded and compared.

(f) Ability to engage typical combat targets was compared by using a series of gunners on each test weapon firing at known ranges --- percentage of hits, number of bursts, and elapsed time were recorded and compared, and personnel participating were questioned.

(2) A comprehensive compilation of data was possible during the course of these tests. Reports outlined in the individual tests were carefully analyzed and enumerated and with the accumulated data it was possible to compare the machine guns tested and to arrive at definite conclusions concerning the modification of machine guns and the selection of an interim combat vehicle machine gun. (See Appendix E, Selection of the Interim Machine Gun.) Moreover, with this

information as a basis, it was possible to correlate the characteristics of the proposed machine gun with reality. (See Appendix G, Analysis of Test Results.)

b. Studies.--

(1) Studies were conducted of the tactical and the mounting factors affecting the employment of combat vehicle machine guns, of the deficiencies in present machine guns as revealed by combat experience and by firing tests, of the various developments in machine guns, and of the characteristics as proposed by the different Boards and other interested agencies and personnel. (For additional details, see Appendix F, Details and Results of Studies.)

(2) Upon completion of the study, copies of the proposed Military Characteristics for the Gun, Machine, Combat Vehicle, Caliber .30, (a machine gun capable of installation and operation in any probable mount and featuring increased mechanical reliability and accuracy --- see Appendix H, Military Characteristics) ---- were submitted to interested agencies for comment. Comments were evaluated and where applicable or determined to be desirable were incorporated in the final characteristics. (See Appendix J, Comments of Interested Agencies.)

6. CONCLUSIONS.--

a. Concerning the selection of an interim combat vehicle machine gun, it was concluded that:

(1) The standard Caliber .30, M2, Aircraft, Machine Gun is not suitable for combat vehicle use because:

(a) Dispersion is approximately twice the order of that of the present standard machine gun.

(b) Barrel life is approximately one-half that of the present standard weapon.

(c) The high cyclic rate of fire results in an unwarranted and undesired expenditure of ammunition.

(2) The standard Caliber .30, M2, Aircraft, Machine Gun has certain characteristics which are desirable in combat vehicle machine guns and which are not present in the M1919A4 now standardized. These desirable features are:

(a) Right or left-hand feeding (by re-positioning components) which permits right or left-hand mounting.

(b) A receiver cover and cover latch which facilitates loading and unloading and which is less susceptible to malfunctioning than that on the M1919A4.

(c) A back plate arrangement and a back plate latch which permits the removal of that group in fewer and more simple steps than required with the M1919A4.

(d) Location of the trigger in a more protected position than on the M1919A4.

(e) A trigger safety device which permits positive locking of that unit.

(f) Utilization of link belts which more nearly insures proper and continued positioning of cartridges.

(3) The open-bolt type of operation is a desirable but not an essential characteristic of combat vehicle machine guns, despite the fact that it does not retard heating or improve cooling, because this type of operation:

(a) Prevents cook-offs.

(b) Facilitates firing single shots and short, fixed bursts.

(c) Does not appear to reduce barrel life, impair functional reliability, or to decrease accuracy.

(4) The sear modification proposed by the British and tested in conjunction with this project is not suitable for combat vehicle machine guns because the added rear sear, if partially depressed without releasing the breechblock, does not return to full engagement, remaining in a "hair trigger" position. (See Test No. 8, Appendix D, Details of Tests.)

b. Concerning the proposed caliber .30, combat vehicle machine gun, it was concluded that:

(1) The Military Characteristics for the Gun, Machine, Combat Vehicle, Caliber .30, outlined in Appendix H,

incorporates the most desirable feasible requirements for this weapon as determined by past combat experience, present development trends, and projected ground warfare doctrine.

(2) The general Military Characteristics outlined in Appendix H are in agreement with the requirements for a machine gun for armored use established by the War Department Equipment Board (Section VIII of report referenced in paragraph 2b, above) except for the high cyclic rate prescribed in that report.

7. RECOMMENDATIONS.--

a. Relative to the selection of an interim combat vehicle machine gun, it is recommended that:

(1) The standard M2, Aircraft, Machine Gun be eliminated from further consideration.

(2) The modified M1919A4 with the sear modification be eliminated from further consideration.

(3) Consideration be given to the suitability as an interim weapon of the M2, Aircraft, Machine Gun modified by the addition of a heavy cylindrical barrel designed to increase barrel life and accuracy and to decrease the cyclic rate. (See paragraph 4, above.)

(4) Consideration be given to the suitability as an interim weapon of the M1919A4 Machine Gun modified to include alternate feeding, utilization of link belts, and such other features, enumerated in paragraph 6a(2), above, as are feasible.

(5) The present standard machine gun, M1919A4, be retained as a combat vehicle machine gun pending testing of the recommended modified weapons described in paragraphs 7a(3) and (4), above.

(6) No machine gun with a lesser degree of functional reliability, accuracy, and barrel life than that of the standard M1919A4 be accepted.

b. Relative to the proposed combat vehicle machine gun, it is recommended that:

(1) The Military Characteristics outlined in Appendix H and the Details and Results of Study set forth in Appendix F be used as a basis for preliminary engineering studies.

(2) The Military Characteristics and Details and Results of Study not be construed so as to limit or restrict development agencies in any way, but be considered as a statement of needs inherent in combat vehicle machine guns.

(3) The Military Characteristics be considered as an enumeration of end results desired.

(4) The Details and Results of Study be considered as a guide in arriving at compromises and in selecting means to the desired ends.

APPENDICES:--

A.--Authority (Omitted)

B.--Bibliography

C.--Detailed Description of Materiel Tested (Omitted)

D.--Details of Tests (Omitted)

E.--Selection of Interim Combat Vehicle Machine Gun (Omitted)

F.--Details and Results of Study

G.--Analysis of Test Results and Application to Military Characteristics (Omitted)

H.--Military Characteristics

I.--Graphs and Diagram (Omitted)

J.--Comments of Interested Agencies (Omitted)

APPENDIX B - BIBLIOGRAPHY

1. Ordnance Committee Meeting Item No. 26232, subject: "Light Machine Gun, Caliber .30, Status of Development," 6 January 1945.

2. Ltr British Army Staff, AFV Branch, 22 June 1944, subject: "Tentative Specifications for New Tank Machine Gun," file 472.5 (22 June 1944).

3. Report of Army Ground Forces Board No. 3, Project No. 1952, "Stellite-lined Barrels for Gun, Machine, Caliber .30, M1919A6," 28 March 1946.

4. Report of Armored Board, Project 202, "Military Characteristics of Light Machine Gun," 18 December 1941.

5. "Rifles and Machine Guns," Melvin M. Johnson, published by William Morrow and Company, New York, N.Y., 1944.

6. "Automatic Weapons of the World," Melvin M. Johnson, Jr., and Charles T. Haven, published by William Morrow and Company, New York, N.Y., 1945.

7. War Department Technical Manual 9-1205, "Browning Machine Gun, Caliber .30, All Types and Ground Mounts," 7 August 1944.

8. War Department Technical Manual 9-1225, "Browning Machine Gun, Caliber .50, M2, All Types and Ground Mounts," 23 October 1944.

9. War Department Technical Manual 9-205, "Browning Machine Gun, Caliber .30, M2, Aircraft - Fixed and Flexible," 15 October 1942, and Change 1 thereto, 31 March 1944.

10. War Department Technical Manual 9-225, "Browning Machine Gun, Caliber .50, M2, Aircraft, Basic," 15 December 1943, and Change 1 thereto, 24 May 1945.

APPENDIX - F - DETAILS AND RESULTS OF STUDY

DETAILS AND RESULTS OF STUDY
FOR
PROPOSED GUN, MACHINE, COMBAT VEHICLE, CALIBER .30

1. PURPOSE.--To obtain through research, discussion, and analysis sufficient data for the formulation of the Military Characteristics for Gun, Machine, Combat Vehicle, Caliber .30.

2. METHOD.--A thorough digest of available publications and documents, in the main, brought out the desirable qualities for a combat vehicle machine gun. (See paragraph 2, main body of the report, and Appendix B, Bibliography, for sources consulted.) Conferences and discussions with various combat-experienced personnel were held to insure that the experiences of the recent war, as well as the current trends in combat vehicle development and employment, were considered. In addition, results of past and current firing tests were evaluated and analyzed in order to correlate the proposed characteristics with reality. (See Appendix D, Details of Tests and Appendix G, Analysis of Test Results.)

3. RESULTS.--

a. Determination of Factors:--

(1) As an initial step in this study, it was determined that:

(a) Missions peculiar to combat vehicle machine guns are:

1. Primary: Attack enemy personnel.
2. Secondary:
   a. Reconnaissance by fire.
   b. Attack enemy transport.
   c. Attack unarmored installations.
   d. Emergency anti-aircraft use.

(b) Combat vehicle machine guns have certain inherent advantages:

1. A rigid mount.
2. Excellent sighting equipment.
3. Relative security in the form of armor protection for the gunner, thereby permitting him to take advantage of the foregoing in laying and adjusting.
4. Weight of the gun not a hindrance to mobility.
5. Ability to maneuver without complete elimination of the ability to fire.
6. Ammunition supply not dependent upon manpower.

(c) Combat vehicle machine guns have certain inherent disadvantages:

1. Restricted access to weapon for replenishing ammunition, clearance of stoppages, dis-assembly and assembly.
2. Confinement of vehicular mounting, hindering installation and removal of the gun.
3. Inability of the gunner to be present to service the weapon due to prevalence of remotely mounted and/or fired guns.
4. Divided control of coaxial weapon between gunner and loader.
5. Inclosure with resultant high temperatures and limited cooling.
6. Relatively restricted ammunition supply because of the limited stowage space.
7. Relatively fleeting nature of target due to limited fields of vision and movement of the vehicle.

(2) Further, it was determined that the present standard machine gun, caliber .30, M1919A4, has certain major deficiencies as follows:

(a) Inaccuracy --- figures obtained from the Ordnance Proof Manual indicate that the extreme group dispersion to be expected from machine guns, caliber .30, firing from vehicular mounts is:

	Mils Dispersion	
	Vertical	Horizontal
Coaxial Cal. .30	3.0	3.0

(b) Short barrel life.

(c) Lack of a quick barrel change feature.

(d) Difficulty in obtaining and retaining proper headspace adjustment.

(e) Stoppages resulting from:

1. Failures to feed.
2. Bent trigger bar.

(f) Difficulty in clearing stoppages.

(g) Inability to reposition the feed to operate as either a right or left-hand feed.

Firing tests conducted in conjunction with this study substantiated these charges and disclosed that all current standard and modified machine guns, caliber .30, have, to a greater or lesser degree, the same deficiencies. (See Appendix D, Details of Tests, and Appendix G, Analysis of Test Results.)

(3) As a result of the above determinations, it was decided that a machine gun characterized by great mechanical reliability, long life, and an ability to deliver accurate sustained fire at reasonable rates for extended periods of time was required for combat vehicle use. Primary use will probably be as a remotely mounted or controlled weapon effective against personnel at ranges less than 1000 yards.

Further evaluation of all pertinent data revealed that the general attributes desired, in order of priority, are:

(a) Dependability:

1. Minimum malfunctions and breakage because of lightweight construction or complex design.
2. Minimum stoppages because of failure to feed.

(b) Capable of obtaining hits on personnel at 500 yards and upon small transport and installations at 1000 yards.

(c) Ease of loading, operating and servicing.

(d) A cyclic rate, in so long as it does not fall below or above reasonable limits, conducive to the realization of the first three qualities.

In addition, it is essential that the combat vehicle machine gun use the same type of ammunition as is issued the Infantry, and it is a desirable, but not a limiting, factor to have interchangeability of parts with the new, general purpose machine gun.

Any contemplated machine gun designed to fulfill the above general qualities necessarily has to be a compromise --- it is readily apparent that one gun could not completely satisfy all requirements. Consequently, in the following discussion, which bears directly upon the selection of the specific military characteristics for the gun, machine, combat vehicle, it is necessary that the foregoing results of study be kept in mind; that the priority of general qualities outlined in paragraph c, above, be utilized as a yardstick in adjudging the military characteristics which follow.

b. Determination of Requirements:--

(1) General.

(a) Construction: It is firmly believed that maximum dependability must govern construction in order to insure mechanical reliability, proper functioning, and to facilitate rapid component replacement without complicated adjustments. Hence, simplicity, ruggedness, and the incorporation of a minimum number of parts without increasing complexity must keynote both design and manufacture. Too, both

the designer and the manufacturer must adhere to closer tolerances, must utilize new alloys of lighter weight only when equal or greater strength is also present, and must avoid methods that invite subsequent breakage and maladjustment. A combat vehicle machine gun, particularly when the prevalence of remotely mounted and/or fired guns is considered, is obliged to be dependable above all other considerations.

(b) Weight: Necessarily, the first major problem to be resolved concerned the weight and dimensions of the gun. Although the need for a light, compact machine gun is recognized and respected, it was decided that a weight above that acceptable for ground use could be readily tolerated in a combat vehicle machine gun. Ground use of vehicular guns is limited and, in addition, is normally confined to relatively short carrys from the vehicle. Consequently, ease of mounting and dis-mounting alone dictated this particular characteristic insofar as the top weight limit was concerned. As a result, 40 pounds was selected as the maximum desirable weight but a greater weight is acceptable if necessary. Moreover, reliability and light weight are not easily reconciled, and it was determined that this weight figure would more nearly permit the attainment of the ultimate in reliability and, as well, an exceptionally high degree of accuracy --- the two latter attributes being first and second respectively on the aforementioned priority list of desired qualities.

(c) Dimensions: The question of over-all dimensions was not as easily or as definitely solved. Bulkiness, in contrast to weight, is a distinct handicap in a combat vehicle gun. Necessarily, the length of the weapon must be such that it can be mounted in the fighting compartment or ballistic blister and must be such that it does not overcrowd the already limited space in the compartment of the smallest combat vehicle. That much is axiomatic but still permits fairly elastic limits. Unfortunately, other factors influence the size of a machine gun --- design exactments of dependability, accuracy, cyclic rate, muzzle velocity and, as well, accessibility to the feed mechanism, cooling, and even the method of mounting. As a result, it was decided to limit the maximum cross section of the barrel jacket to two inches in order to permit minimum mounting aperture; to require the over-all length of the gun (in so long as it can be readily mounted and dismounted) to be consistent with other design requirements, primarily those affecting dependability, accuracy, and accessibility; and to fix influencing factors (where possible without sacrifice of primary objectives) in order to promote compactness and to further accessibility. For instance, the front sight should fold into a recess in the barrel jacket.

(d) Cooling: In order to allow the fullest utilization of the permissible weight and to encourage compactness, the combat vehicle machine gun must be air-cooled. Various features designed to offset or compensate for the lack of a more efficient cooling medium have been included or incorporated in other characteristics and will be discussed subsequently. Nevertheless, full regard should be given to the employment of fins or other devices which will facilitate cooling or dissipation of heat. An aluminum fin radiator attachment, for example, with a round casing protruding beyond the muzzle will enable the bullet, as it passes from the muzzle, to pull a cooling draft of air over the fins. This attachment, if feasible, should be forward of that portion of the barrel jacket which guides the recoiling barrel and should be attached permanently to the jacket proper. This action must not interfere with the gas trap located at the muzzle and housed in either a prolonged barrel jacket or in the extension formed by the radiator, if that feature is necessary to achieve proper functioning.

(e) Rate of fire: The second major problem, the question of the rate of fire, was equally vexing. Initial studies, including those embracing the reports of the various boards, revealed that fairly high rates of fire --- from 800 to 1200 rounds per minute --- were desired.

Recent discussions with combat-experienced personnel revealed that the preponderance of opinion (exclusive of that of the boards cited previously which were necessarily not consulted) was shifting to more moderate rates --- in the vicinity of 600 rounds per minute. In no case did anyone wish to sacrifice dependability and accuracy in order to obtain a high rate of fire.

As a result, fairly elastic limits are advocated and for the proposed combat vehicle machine gun a minimum rate of 450 rounds per minute and a maximum of 700 rounds per minute were set in order to achieve good distribution, observation of strike, and to conserve ammunition. The tactical and psychological advantages of a high cyclic rate are highly debatable. Certainly, combat vehicle machine guns do not require a high rate of fire in order to project a unit of projectiles upon the target. Although normal targets are relatively fleeting in nature, they do not approach the order of those engaged in the air by aircraft which themselves move at exceptional speeds. On the other hand, high cyclic rates do have a tangible effect upon the essential requirements of dependability and accuracy, decreasing same markedly.

High cyclic speeds require a light barrel which is undesirable from the standpoint of accuracy alone, and a light breechblock, both moving at high speeds

with a lessened belt-pulling capacity. If, on the other hand, barrel and breechblock weight is retained, increased recoil and counter-recoil power is needed to maintain the cyclic rate. This, although it increases belt-pulling capacity, does introduce accelerated extraction with its inherent dangers and accentuated pounding with its corollary buffering problems. Reliability again was the deciding factor. Positive feeding, minimum pounding, and even increased barrel life take precedence over the rate of fire.

In addition, cyclic rates directly and indirectly affect dispersion. When the gun is firing with a cyclic rate best suited to it, there is a smoothness of operation that gives uniform performance and compact shot groups. This does not necessarily mean that the slower the rate the tighter the group, but rather that for any one design of a machine gun there is a point of balance or sensitivity below or above which dispersion increases. As stated above, other factors of design must take precedence in order to achieve a dependable, accurate weapon. The rate of fire is secondary and should, in so long as it does not fall outside of the established limits, be a result of gun design and not a factor of that design.

It was further decided that there must be one rate of fire only, full automatic, in order not to increase the number of parts or the complexity of design.

It was felt that the best way to control or to obtain a selective rate of fire was to train the gunners properly, to regulate the rate, so to speak, by spacing and firing bursts as desired. Naturally, single shots, possible by pulling and releasing the trigger, are desirable. The open-bolt type of operation facilitates firing single shots and is acceptable for a vehicular machine gun.

(f) Dispersion: Another outstanding problem was that of accuracy. The personal factor of marksmanship does not enter into the application of full automatic fire as much as it does in other small arms. In the case of machine guns, accuracy is contingent upon gun design, upon mounting, and upon the relative adjustments of the component parts of the gun.

As a result of consulting combat-experienced personnel, the combat vehicle machine gun was visualized as a long choke shotgun: in other words, a weapon that was capable of placing a compact shot group upon a relatively small target at 500 yards and a somewhat larger group upon a larger target in the vicinity of 1000 yards. The normal rate of delivery, bursts of 10 rounds, laying between bursts, is between 100 and 150 rounds per minute and is often far less due to the somewhat fleeting nature of targets, the need for shifting and relaying, and the time required to spot

targets and to adjust sights. Only occasionally is a sudden application of intense fire from a single source necessary. Consequently, the majority of the time, a well-placed burst from an advantageous position is worth more than a volume. In addition, the process of bracketing a target is expedited by precisely delivered groups. A small cone of fire, or burst accuracy, is essential.

In order to fulfill the above general requirements and in order to take advantage of the rigid mount and excellent sights afforded, plus the armor protection which will permit full exploitation of mount and sight, a standard of $1\frac{1}{2}$ mils maximum dispersion for a 100 per cent group at 500 yards was established. This will permit the projection of one compact unit of projectiles upon normal combat vehicle machine gun targets at 500 yards with the minimum of delay resulting from erratic adjustments; will assure minimum waste of ammunition, and will minimize the danger to closely supported ground troops from excessive dispersion. It is not felt that the sheer volume possible with machine guns is even a partial substitute for accuracy. Accuracy in the fullest sense of the word not only means the number of hits, but also the number of rounds expended to obtain those hits and the rate of delivery. Efficiency of fire, perhaps, is a more apt expression for accuracy and the combat vehicle machine gun should

certainly be as efficient as a semi-automatic rifle, 10-round magazine, which in the hands of a trained rifleman can deliver 16 shots in 1 minute, all grouped within a 25-inch circle, centered on the aiming point, at 500 yards.

(g) Safety: As in any automatic weapon, there must be positive and adequate safety arrangements. Consideration should be given to a trigger safety device which can be used, as desired, to hold the trigger in the "no fire" position. In addition, the gun must not be able to fire if the bolt is not fully locked, if the receiver is not correctly locked to the barrel jacket, if the various covers are not closed, and, last but certainly not least, if the quick release barrel is not properly positioned. No recoiling parts should be located outside of the gun casing in order to avoid interference with functioning in the cramped confines of the turret or blister. Similarly, fumes must not be able to pass from the muzzle or any port in the barrel into the fighting compartment and thus lower the efficiency of the crew.

(h) Protection: Working parts, particularly recoiling parts, must be enclosed against weather and unfavorable operating conditions in order to insure continuous functioning. Furthermore, protruding components such as the trigger must be protected so as to eliminate the possibility of bending if jarred during mounting, dismounting, or operation.

(i) Interchangeability: Interchangeability of parts with the new lightweight, all-purpose machine gun, caliber .30, is, of course, a desirable, but not a limiting, factor. This would simplify manufacture as well as supply but must not be sought at the expense of more essential characteristics.

(2) Functioning:

(a) General: The combat vehicle machine gun must function reliably whether upright or on either side and at angles of elevation between -45 and + 90 degrees to permit installation in special mounts and use as an emergency anti-aircraft weapon. In addition, it must function reliably within the extremes of ambient temperature prescribed by the War Department.

(b) Adjustments: The matter of adjustments is part and parcel with dependability and ease of operation and, because of its singular importance, is worthy of separate discussion. Control of the combat vehicle machine gun is either divided or decidedly limited. Unlike the ground machine gunner, the vehicle crewman is distracted by a multitude of servicing and maintenance problems --- radios, sights, the primary piece, gun stabilizers, turret traversing mechanisms, several secondary weapons, and the vehicle itself.

Under these conditions it is readily apparent that dependability is an essential quality, and, although less apparent, it is no less important that adjustments, particularly during operation, be reduced to a minimum.

Headspace, timing, and adjustment of the barrel muzzle gland have always been sources of trouble in the Browning --- not only affecting mechanical functioning but also dispersion. Proper adjustment is difficult to obtain and is subject to loss during operation, particularly the uniformity of packing in the muzzle gland. The proposed vehicular machine gun should eliminate these adjustments insofar as possible. Increased permissible weight, higher standards of manufacture, and improved alloys will mitigate this problem considerably. However, adjustments that cannot be eliminated must be simple, positive, and once procured should be capable of retention.

By the same token, the possibilities of incorrect assembly must be reduced or eliminated. Too, parts withstanding great strain or susceptible to uneven wear or bending should be materially strengthened in design and composition. This is particularly true in the case of the trigger group assembly and in the feed mechanism. Moreover, all locking devices should be positive in action, conducive to simple operation but not affected by vibration or jarring.

Every effort must be made to eliminate the human element in adjustments, the effect of friction, vibration, and strain, as well as high operating temperatures.

(c) Method of operation: The question of recoil or gas method of operation posed another paramount problem. Short recoil provides mass, positive breech unlocking power without the harshness of the gas system. Long recoil functions well with a low cyclic rate but requires a long heavy frame with resulting loss of compactness and a wasteful utilization of allowable weight. Too, in any recoil system the barrel pounds the whole gun and must not only be buffered but also returned to battery with a spring. On the other hand, the fixed barrel of the gas systems is preferable for that reason and for the resulting simplicity of mounting. Yet, this advantage is more than offset in the gas expansion type system because of the complicated mechanism needed to allow the power gas to expand in the cylinder --- the inlet must be quickly opened and closed in order to control the volume of gas entering; while the gas impinging system accentuates the aforementioned harshness of action and increases the problems of extraction.

After investigation it was decided that a short recoil, gas assisted if necessary, system was the most suitable for a combat vehicle machine gun. This system

provides positive action, permits more worthwhile utilization of permissible weight, avoids the danger of gas fouling, evades the introduction of additional gas fumes into the compartment, facilitates slow extraction, permits minimum barrel aperture in the mantlet, and, above all, offers the most suitable design for rapid barrel replacement. It was further felt that some of the disadvantages of the recoil system can be obviated by use of the new shortened cartridge and the resulting shortened breechblock stroke. Long recoil affords the next most suitable type of operation for a vehicular machine gun.

To review --- a self-operating weapon depends upon the basic forces of each cartridge discharged to supply supplementary power, which, in turn, must impart momentum to the operating parts. Momentum equals mass times initial velocity. The recoil system provides a positive means of transmitting the force of discharge, particularly since the proposed machine gun features a relatively moderate cyclic rate and, consequently, decreased velocity and increased mass. The short recoil will then enable the designer to juggle or balance the cyclic rate and the weight of the recoiling parts and to arrive at a proper proportion without introducing the complications inherent in a gas system and without sacrifice of other primary characteristics.

In order to reduce vibration and to decrease dispersion, the recoiling parts should move directly along the prolongation of the axis of the bore. For the same reason, the weight of the recoiling parts should be distributed along the same line. This will enhance the results of having a cyclic rate that is in phase with the recoiling parts so that the gun and muzzle are not out of position in respect to each shot in such a way as to create climb.

In this short recoil system, the breechblock stroke should be as short as practicable in order to conserve space and to take advantage of the new, shortened cartridge. It must, of course, be long enough to impart the desired action to the belt feed lever. In addition, consideration should be given to a means for accelerating the stroke of the breechblock and, at the same time, retarding the rearward movement of the barrel. The accelerator as it is known in the Browning machine guns provides an efficient, simple method of transmitting momentum.

Consideration should be given to the elimination of cook-offs by, if needs be, designing the weapon so that the breech remains open between bursts upon releasing the trigger. The combat vehicle machine gun, therefore, can incorporate the open-bolt type of operation, if this is the only effective means of preventing cooking-off. The resultant

dispersion of the initial shot is slight and can be disregarded. Natrually, it is also desirable that the breech remain open at the end of a belt to facilitate changing belts, if this can be accomplished without increasing the complexity of the gun unduly.

(d) Cocking and firing: To permit right or left-hand mounting, the combat vehicle machine gun must be capable of being cocked, by repositioning parts, from either side. In addition, the gun must readily lend itself to adaptation to a remote control attachment or a solenoid since manual firing of the weapon when mounted in a tank or armored car will normally be either impossible or undesirable.

(e) Method of feeding: The method of feeding must permit the greatest flexibility of mounting and employment. In this connection, consideration should be given any means or device that will provide an uninterrupted flow of a volume of cartridges to a remotely mounted and/or controlled machine gun. Such means or devices must be certain in action and must be superior to the belt method of feeding. If such means or devices are not feasible, it is considered absolutely essential that combat vehicle machine guns be capable of using the ammunition boxes or liners issued to other using arms, and, although this study includes the characteristics of a liner suitable for vehicular use, any

standard liner can be utilized in so long as it can be readily positioned. The ammunition tray subsequently described provides this versatility.

On the other hand, it is firmly believed that this method of positioning cartridge belts should be supplemented by additional means. In the case of remotely mounted or fired weapons where servicing is impossible or impracticable, a bulk container with a capacity for as many linked rounds as the size of the mounting will permit is recommended. Such containers can be loaded when the opportunity is present and will permit extensive periods of firing without the delays and possibilities of stoppages encountered in loading under fire.

These bulk containers should be capable of holding and feeding a large number of rounds in a link belt. They should be conducive to easy mounting and dismounting; should be capable of being reloaded easily and quickly with two or more normal link belts without special loading equipment. The method of coiling the belt and feeding from the container must preclude any stoppages from that source if properly maintained. Maximum protection of the ammunition from dust, moisture, and unfavorable operating conditions is essential. Full consideration should be given to any device or means that will permit the attainment of the

aforementioned qualities. Similarly, the employment of a means, such as gravity, spring, or power, to assist feeding should be considered.

At the same time, emergency feed must be possible by use of the normal ground ammunition boxes mentioned previously. Sealed, expendable liners are desired so that combat vehicle machine guns can utilize the same packaged ammunition as is used by the Infantry. The liners should be provided with an attachment to facilitate mounting; should afford a high degree of protection; and should have a hinged lid --- the open end of which has overlapping sides and which can be locked in a partially raised position to permit feeding while still furnishing protection. An offset handle which will permit carrying two or more liners in one hand and a wire loop on one end which will lessen the difficulties of removal from storage racks are desirable conveniences.

An alternate method of feeding, convertible by repositioning components, in the form of a 100-round drum should also be considered. This will permit use as an anti-aircraft weapon. Such conversion should not be considered as a field replacement and must not detract from other primary characteristics.

(f) Ejection: Normal ejection must be downward in order to permit wide variation in mounting and in

order to simplify collection of empty brass. Necessarily, the empty case must be thrown clear of the ejection opening and should be substantially out of that port before the bolt engages a live round. In other words, ejection should take place ahead of the point where the breechblock picks up a new round in order to reduce the possibilities of jams from that source. Moreover, when the gun is on its side, empty cases must have just enough energy to clear the receiver and a live round when ejected should not be able to roll back and obstruct the breech.

(g) Extraction: The extraction must be of the slow type --- the relative speed of the extractor and breechblock should be slow prior to disengagement of the lock. This will reduce the possibility of ruptured cases, which is a continual source of difficulty in automatic weapons operating at high temperatures. Barrel recoil, incidentally, is a distinct aid to slow extraction. In addition, consideration should be given to a chamber design that will facilitate extraction without interfering with the seating of the cartridge. A fluted chamber, for instance, may enable the gas to exert a compensating pressure upon the outside of the case. Fluting in the chamber of a combat vehicle machine gun will not be as susceptible to dust and dirt as in a ground weapon. Normally there should be no necessity for lubricating cartridges.

(h) Lubrication: The combat vehicle machine gun should not require special lubricants in order to simplify supply.

(3) Accessibility and Stripping: Initially, it was pointed out that ease of loading, operating, and servicing was a prime requisite --- one of the general qualities most desired. Various items furthering this quality or characteristic have already been touched upon; however, a detailed enumeration of features especially worthy of incorporation in the gun for that purpose is necessary, because the installation of a machine gun in the limited space of a combat vehicle imposes some very real limitations and requires equally real measures to counter-balance. Accessibility as it pertains to mounting will be covered later.

(a) Stripping: It should be possible to carry out complete stripping of the gun, when mounted in the vehicle, without using tools and in a minimum of time. This must include the removal of such major items as the receiver, the breechblock, and the feed mechanism. Removal of the receiver from the barrel jacket, for instance, leaving only the jacket and attachments in the mount will facilitate cleaning, repair, and replacement, and will permit sectionalizing the gun for handling. Removal of the breechblock as a unit when the gun is cocked, by opening the rear face of the receiver, will permit cleaning and replacement of the unit and

testing of sights. Furthermore, it must be possible to remove the feed mechanism as a unit or the receiver cover with feed mechanism attached as an entity in order to further ease of maintenance and field replacement, and to remove the buffer group complete from the rear face of the receiver when the latter is opened downward or removed.

(b) Incorrect assembly and adjustments: The design of the weapon must preclude incorrect adjustments as well as incorrect assembly so that replacement of parts can be made with a minimum of difficulty and practice.

(c) Field replacement: Parts requiring field replacement should be designed with a view to ease of assembly and disassembly. Ease of maintenance and unit replacement should be sought.

(d) Quick barrel change: As the principal solution to the question of adequate barrel life, a quick barrel change from the breech requirement is recommended. The average accuracy life of present .30 caliber barrels is in the vicinity of 1200 rounds (when fired at the rate of 50 rounds per minute) and while it is entirely within reason to expect a higher limit, it is seriously questioned that this limit will ever approach that desired in a combat vehicle machine gun. It is obvious that it is inefficient to secure a high degree of initial accuracy and dependability only to lose

those qualities through barrel wear occasioned by sustained firing. It is equally apparent that the limited ammunition in a combat vehicle is more profitably spent through a new barrel than through a burned out barrel; that, in addition, serious stoppage might result from continued use of an expanded barrel. As stated previously, the solution is a barrel suited to the gun design and incorporating approved advances in barrel design itself and in metallurgy; a barrel that can be replaced readily and easily from the breech so that two or more barrels can be rotated, thereby sustaining the initial high efficiency.

Rotation of barrels will not unduly increase stowage problems since three barrels will normally be sufficient --- two for rotation purposes and the third in reserve for emergency substitution. It is also recommended that all combat vehicle machine guns be equipped with a readily detachable thermostat or other device for use on the gun in the vehicle so that a positive means is present to warn the gunner when a barrel change is mandatory. Naturally, sustained fire missions still sometimes prohibit a barrel change, but such instances will be the exception rather than the rule. Furthermore, sustained missions requiring such intense fire are normally fired on large concentrations and do not require as high a degree of efficiency as is habitually expected.

A quick barrel change feature is, naturally, somewhat less essential in remote mounts, but it is still a distinct asset for it will permit and encourage changes when the opportunity is present.

Unfortunately, a quick barrel change from the breech characteristic does introduce complications. Three main possibilities for effecting this replacement were apparent. The first, and the simplest from a construction standpoint, involves pushing the barrel forward through the muzzle. This will, of course, require clearance through the receiver; i.e., easily removable rear cover, ability to quickly withdraw the entire breechblock assembly to gain access to the rear of the barrel --- desirable features in any event. This chain replacement by shoving a new barrel in from the rear of the receiver and pushing the old barrel out through the muzzle requires considerable time, means loss of the old barrel, and necessitates sufficient space in the rear of the receiver to handle the inserted barrel.

A variation of this system involves withdrawing the barrel through the rear of the receiver. This does away with barrel loss but does not obviate the space problem which is actually only pertinent in awkward, remote mounts where quick barrel change is a convenience, not a necessity. However, the time element is again excessive.

The second possibility consists of a barrel release cover and latch in the jacket that would permit the barrel to be withdrawn through the side or, preferably, through the top of the jacket. This solution conserves space, saves the barrel for further use, and is the quickest method possible. It also provides positive access to the chamber area, an important advantage.

The third solution is somewhat more radical --- rotation of the receiver about its long axis and away from the barrel jacket, thereby exposing the rear end of the barrel. This method provides a positive means of barrel replacement, ready access to the chamber area and, if the receiver is capable of both clockwise or counter-clockwise rotation, it does away with space difficulties and should be usable in any conceivable mount. As a variation of this method, the receiver could break or turn away from the rear of the jacket, providing much the same advantage as rotation but, of course, increasing space requirements. However, any method involving receiver movement unnecessarily complicates the problem of attaching the barrel jacket to the receiver and further complicates mounting difficulties since both the receiver and jacket would require a degree of rigidity beyond that needed for a normal design gun. Movement of the receiver, too, means an extra motion in that it must first be unlocked from the mount.

A quick barrel change from the breech feature is considered to be an absolute essential. To accomplish this it is recommended that the barrel jacket include a cover and latch through which the old barrel may be withdrawn and a new barrel inserted; that in the interests of speed a device which will raise or partially eject the rear portion of the barrel, be operational from either side of the gun (by repositioning parts), be included. This method will permit a barrel change in the minimum amount of time, will provide a quick and positive means of access to the chamber area, and will not unnecessarily complicate the fastening of the jacket to the receiver. This cover and latch should be located in the top of the barrel jacket to permit access to the barrel from either side of the jacket. Incidentally, by locating both the barrel change cover and the receiver cover in the top of the jacket and receiver respectively, problems of accessibility are materially reduced. Naturally, barrel ejection must be possible with a cartridge partially protruding from the chamber.

Rotation of the receiver about its long axis and away from the end of the barrel jacket is recommended as an alternate solution. Here again barrel removal must be possible with a cartridge protruding from the chamber.

Consideration should be given to a barrel handle. Such a handle, constructed of material which is a non-conductor of heat, will materially aid in the handling of hot barrels. It should be a permanent part of the barrel. If it is possible to combine the functions of the handle with the barrel release lever, it will result in increased efficiency.

(e) Loading and unloading: In a combat vehicle machine gun the feed mechanism and feed mouth must be readily accessible. No objection can be seen to installing the feed components in a hinged cover located in the top of the receiver which, when raised, will expose the vital feed area and ways. This cover, however, must be fastened in such a way that no play or distortion of the feed mechanism is possible; and it must permit the removal of that unit or, if that is not feasible, it must be capable of ready removal itself with the feed components attached.

(f) Fastenings: All locks or fastening devices must be positive in action and must be simple to operate. This is axiomatic.

(g) Versatility: A combat vehicle machine gun must be versatile --- capable of installation in a wide variety of positions, some exceedingly awkward or cramped. Consequently, all external devices designed to further accessibility must be located on top of the weapon or at the butt

end and open downward, or must be capable, by repositioning parts, of installation on either side of the weapon. By the same token, the levers or locks operating these devices must be located in the top of the weapon or must be capable of operation, by repositioning, from either side. In other words, inasmuch as vehicular machine guns may be mounted on either side of the primary weapon or in blisters which expose one or the other of the sides, every device designed to abet accessibility must be capable of repositioning to allow right or left-hand operation or must be located on top of the gun. This, along with the right or left-hand feed and alternate cocking feature, makes interchangeability feasible and permits a wide variety of positions without major changes in design. Naturally, the mount and ammunition trays are subject to the same requirements.

(4) Components:

(a) Barrel: The length and weight of the barrel must be consistent with other design requirements in order to provide in order of priority, accuracy, functional reliability, and endurance. The standard of accuracy or efficiency required ($1\frac{1}{2}$ mils maximum dispersion up to 500 yards when rigidly mounted and fired in 20-round burst) and functional reliability must primarily dictate barrel design. Other factors rate secondary, although important, consideration.

Firing tests and studies of past tests revealed that none of the current modified or standard caliber .30 machine guns approximate this degree of accuracy. Dispersion is generally on the order of $1\frac{1}{2}$ to 2 times that required.

All other things being equal, greater accuracy can be realized with a heavy, long barrel. In addition, a heavy, long barrel resists sustained, intense heat longer, increases muzzle velocity to some extent and more nearly permits the muzzle to protrude through the mantlet without necessitating the mounting of the receiver so far forward as to materially lessen accessibility. On the other hand, a short, light barrel is capable of a faster rate of cooling, abets compactness, increases the possible cyclic rate, and decreases the impact of recoil. Consequently, any barrel design based on heating and cooling factors, compactness, and the like, will be, at best an unhealthy compromise. As stated previously, accuracy and functional requirements must be given first consideration and endurance second place.

Although endurance or barrel life has been relegated to secondary consideration in the conception of the barrel, it still rates as a problem of major proportions and cannot be neglected. It was decided to solve this problem through expedients and compromises. Studies revealed and test substantiated that normal barrel life requirements (8000 rounds firing in bursts of 50 rounds) when coupled with other features such as a cyclic rate of 800 rounds per minute, were figments of imagination. In sober fact, any air-cooled barrel is doomed to short life if fired until the temperature rises to a point

where expansion begins --- at that point the damage is done and, while subsequent cooling is an aid, it is merely a temporary respite for the accuracy life of the barrel has already been lessened immeasurably. Only a water-cooled barrel could give the desired life.

Consequently, it is recommended that, after due consideration has been given to accuracy and functioning requirements, maximum obtainable barrel life must be sought through utilization of new alloys, liners, and other design features. Minimum requirements are the retention of barrel accuracy life up to 2000 rounds when fired in approximately 20-round bursts at the rate of 60 rounds per minute in order to permit normal firing with a minimum of barrel changes, and when fired at the full cyclic rate for 20 seconds in order to permit emergency application of uninterrupted fire without barrel destruction. The comparatively low cyclic rate, the higher permissible weight, and the inclusion of cooling devices were all motivated in part by a desire to increase barrel life. In addition, the quick barrel change feature was incorporated in order to permit rotation of barrels before the above limiting points are exceeded. Too, as mentioned previously, full consideration should be given to cooling aids such as fins and/or induced drafts.

Last, but not least, the design of the chamber and the breech end of the barrel should be such as to mitigate the problem of headspace adjustment and to insure uniform seating of the cartridges. This will lesson the possibility of ruptured cases, increase accuracy, and improve functioning. It is particularly essential in view of the quick barrel change feature. It is recognized that headspace is a necessary evil but it is felt that the problem of adjustment can be eliminated or, at least, solved in a more satisfactory manner than on the Brownings. Naturally, this will require an increased mass at the breech end of the barrel and much closer tolerances.

(b) Barrel jacket: The jacket must insure maximum stability and minimum vibration for the recoiling barrel; must house a gas booster or trap, if necessary, in order to assist recoil by increased gas pressure impinging upon the end of the muzzle, and should be designed to assist cooling. If necessary, the rearward portion of the barrel jacket should be designed to facilitate quick barrel change and, as well, proper and continued positioning of the inserted barrel. The higher allowable weight was again, in part, motivated by the need for insuring this latter feature in order to attain accuracy and uniform seating of the cartridge.

Moreover, if feasible with a quick barrel change, the rear of the jacket should contain a sleeve,

rather than barrel bearings, to guide the recoiling barrel. A sleeve will provide a more uniform surface and will more readily resist wear. The forward portion of the jacket will, of course, house the aforementioned gas booster, if that feature is required, and should, if feasible with a gas assist, contain the cooling aid previously discussed or some other device that will facilitate cooling.

(c) Feed mechanism: The feed mechanism of a combat vehicle machine gun must permit the greatest possible variation of feed positions to guns in special mounts in order to meet future developments featuring remotely mounted weapons. It must permit the gun firing while lying on either of its sides with the belt entering from either the upper or lower side of the feed mouth. This will permit use of multi-gun mountings in awkward positions. In line with the established policy of providing versatility to meet all mounting requirements, right or left-hand feed must be possible by repositioning components. In addition, emergency use as an anti-aircraft weapon requires firing at 90 degrees elevation.

Naturally, the feed mechanism must be easily and quickly adaptable to a pneumatic or similar type charging device, if so mounted that that operation cannot be performed manually. In order for the gun to utilize long, linked belts, the feed must permit utilization of some type of belt pull assist, such as gravity, spring, or power.

It is believed that it is impossible to devise a fool-proof feed mechanism; that any weapon requiring automatic insertion of more than four successive rounds is going to be subject to failures to feed. However, a machine gun feed mechanism must be as nearly perfect as possible. In this connection, the belt feed of the Browning Machine Gun, Caliber .50, as a result of study and testing, appears to be as satisfactory as any, although difficulty has been experienced due to improper adjustment of the belt feed lever and slide. The design, therefore, must prohibit improper adjustment of the feed mechanism as well as maladjustment resulting from sustained fire, and it must seek to reduce sensitivity in the feed mechanism to small variations in the size of the belt and in the positioning of the cartridges. In addition, this defect can be further obviated by decreasing the permissible degree of tolerance in the design and manufacture of these parts and by using alloys with a high degree of wearing strength in order to decrease wear and malformation. As stated previously, no objection can be seen to housing this mechanism in the cover as long as the cover is solidly mounted and the mechanism can be readily removed as a unit, or in so long as the cover with the feed components attached can be readily removed. A short round positioning device and a rear cartridge aligning pawl should be incorporated in the feed group. Too, like every

other feature of the gun, the feed mechanism should be designed as a unit --- devices designed to alleviate feed difficulties should be an integral part of the whole and not just an extra part added as an afterthought.

It is felt that there is no single solution to the problem of feeding. Features previously described under the heading of extraction and ejection tend to further a solution. Items subsequently described in the discussion of the extractor and ejector tend to obviate the problem still further. In addition, several other features cited previously indirectly influence feeding. The short recoil, gas assisted if needs be, incorporating a relatively heavy breechblock provides a positive source of feed power and permits slow extraction, because the heavy breechblock starts more slowly, loses momentum more slowly and is less sensitive to friction. A comparatively low cyclic rate and the open-bolt type operation (or other means designed to prevent cook-offs) both tend to discourage breeching failure due to ruptured cases.

However, the process of feeding a machine gun, to use a trite but apt phrase, is no stronger than its weakest link. Belt feed permits unlimited capacity as well as adaptability to any type installation. It also means that the already strained mechanism must pull the heavy belt. It is essential that nothing interfere with or interrupt the flow of these belted rounds from their container to

the feed opening. Hence, the mount, ammunition tray, and/or the ammunition container should all be designed to facilitate this movement and to remove as much of the burden from the feed mechanism as is possible under the circumstances. It is essential also that these rounds arrive at the feedway positioned for feeding. The metallic or plastic link belt provides the most efficient means of accomplishing this without recourse to a magazine, a clip, or a drum.

(d) Breechblock: In order to insure the required degree of dependability, the breechblock must be heavy enough to supply, in conjunction with the velocity of recoil, the operating momentum required in a positive action belt-fed weapon. If possible, the breechblock should be heavier than the barrel so that the breechblock will start to recoil slowly and provide slow extraction and its related benefits. Too, it will lose momentum more slowly and will thus insure complete action, although at the expense of increased impact and resultant necessity for a heavier receiver --- a limiting factor to this feature. Such a breechblock will, of course, be less sensitive to friction.

(e) Driving spring: The driving spring as used in the Browning machine guns is a desirable feature provided it does not hinder the removal of the rear face of the receiver. It must have sufficient power to drive the

breechblock forward, seat a live round firmly in the chamber, and lock the bolt. It should be located directly behind the breechblock in order to act directly along the axis of recoil. The open-bolt type of operation, if used, necessitates that it be capable of retaining required tension when compressed for long periods. It, in addition, aids in cushioning recoil and acts as insurance against buffer failure. A stranded wire spring is recommended.

(f) Barrel return spring: Like the driving spring, it, too, is a desirable feature. The barrel return spring relieves the strain on the former and somewhat cushions recoil. It should have sufficient power to return the barrel to the forward position without recourse to the driving spring.

(g) Extractor: In order to further the solution of the problem of feeding, the extractor should be located in the front face of the breechblock so as to engage two sides of the case rim. It must then hold the empty case until the ejector positively operates.

(h) Ejector: The ejector should be of the hinged type. Spring ejectors, if possible, should be avoided in order to escape the dangers of fouling and loss of strength due to the proximity of high temperatures.

It should, again if possible, be located so as to strike the side of the case near the rear end in order to procure adequate leverage to loosen the case from the extractor.

(i) Receiver: The receiver must be extremely rugged in order to protect and guide the recoiling parts and to withstand their impact and the affect of friction and continual camming action. Naturally, it must not be any larger or heavier than necessary to the accomplishment of its primary mission. However, its very sturdiness influences smoothness of recoil, cushioning of recoil, and insures complete and uniform locking of the bolt over long periods of use; consequently, that selfsame sturdiness is of paramount importance.

In addition, the receiver should properly position the feed mechanism and must provide ready access to that component for cleaning and replacement purposes and in order to load, unload, and clear stoppages --- of vital necessity in a belt-fed weapon. It is recommended that the feed components be housed in a hinged cover in the top of the forward part of the receiver. Such a location, if the barrel change device is located in the top of the barrel jacket, will mean that sufficient clearance must be left above the mounted weapon. This will, in turn, simplify accessibility problems. Consideration should be given to a spring plunger which will hold the cover open when raised. Removal of the receiver

from the barrel jacket should also receive consideration. Such a feature will be an aid to repair and cleaning and will, as well, facilitate handling.

(j) Rear face of the receiver: The buffer group must be housed in the rear face of the receiver. This rear face should be in the form of a hinged plate which can be opened downward or, at least, removed without undue difficulty. This will permit the withdrawal of the breechblock assembly, an important feature, and will expose the buffer group for adjustment and replacement when and if required. For convenience, the rear face or plate should be prepared for a pad or a pistol grip.

(k) Buffer group: The buffer assembly must be constructed so as to return the breechblock to the forward position after the initial round has been fired and upon completion of recoil without recourse to the driving spring. No adjustment of this unit should be necessary, but, if required, it must be simple and must be retained during sustained firing. Use of the vertical type buffer should be considered in order to conserve space. In addition, the entire unit should be readily detachable from the rear face of the receiver for purposes of replacement.

(l) Trigger group: As bending of the trigger bar is a recurrent source of trouble, the design of

the trigger group in the combat vehicle machine gun must be simple and extremely rugged. In addition, this design should prohibit improper adjustment and must permit retention of the adjustment during sustained firing. Since remote firing is an important characteristic of combat vehicle weapons, the trigger group should be readily adaptable to a solenoid. Its location should afford maximum protection from jarring and also facilitate the hinged movement of the rear face of the receiver.

(m) Bolt: The bolt should be of the rotary or horizontal type, locked symmetrically about its long axis by vertical lugs, in order to distribute the weight along the axis of recoil, to reduce the size of the receiver, and to insure positive and uniform seating of the cartridge. Such a bolt also lends itself to more effective utilization in controlling recoil and extraction. It must be an alternate feed type.

(5) Method of Mounting:

(a) Coaxial in turret: In order to take full advantage of the various features furthering accessibility, the gun must be mounted or installed so that the gunner can load, unload, clear stoppages; can readily see and reach the feed mechanism and feed mouth; and can readily operate the barrel change device. This means, in short, that the critical area in the forward portion of the receiver and the rear portion

of the barrel jacket should be accessible and should be so positioned as to provide adequate clearance and work room at that point. For this reason, it is believed that gun design is inseparable from the design of the mounting, particularly for the coaxial weapon.

The mount itself must so support the machine gun as to eliminate vibration and permit simple, quick, and accurate adjustment in elevation and deflection of the gun with the vehicular sight in order to bring the machine gun into coincidence with the main armament at ranges from 200 to 1500 yards. It must facilitate quick removal of the receiver and/or the entire gun; should eliminate as completely as possible muzzle whip --- that is, the forward support must be as close to the muzzle as practical; and it must permit the muzzle to protrude through the mantlet or, at least, into the mantlet aperture for safety and in order to reduce fumes in the compartment and to aid cooling.

In order to provide the utmost flexibility, the mount itself should be capable of installation on either the right or left-hand side of the primary weapon and it must provide for the installation of either the caliber .30 machine gun or the anti-aircraft gun with a minimum of changes and the least possible difficulty. Naturally, all locking devices and adjusting elements must be positive in

action, simple to operate, and capable of operation from either side of the weapon --- right or left-hand mounting.

These features combined with the accessibility characteristics previously discussed provide a very large order, indeed. As a result of this study, this mount was visualized in the form of a cradle, adjustable in length, with two or, possible, three points of support for the gun. The rear support, adjustable in length in order to handle any length weapon, should fasten to the underside of the receiver near the rear extremity. It must include a mechanism or means that will permit small adjustments in elevation and deflection so that the gun can be aligned with the vehicular sights. Such adjustments must be easily and quickly made, should be accurate, and should be capable of retention during sustained firing. A positive lock is essential. This rear support must insure absolute rigidity and prohibit vibration. In addition, it should be designed to facilitate the release of the receiver.

The forward portion of the cradle must firmly support the barrel jacket and prohibit vibration. Inasmuch as this point of support will normally be too far forward to be readily accessible, consideration should be given to designing a support that will enable adjustments in the receiver to be met by corresponding movements in the

barrel jacket without any necessity for unlocking that forward support. It is, of course, essential that the clamps or means of fastening the jacket to the support be positive and simple in operation.

This mount should include a detachable ammunition tray or rack so positioned as to best facilitate feeding from any position. It must be capable of attachment to either side of the mount and it must be adjustable both in size and location so as to firmly hold either a caliber .30 or an anti-aircraft machine gun ammunition box or liner, and so as to always be opposite the feed mouth.

(b) Remote control: The combat vehicle machine gun must be capable of installation and operation in ballistic blisters outside of the turret and/or in fender mounts. Such guns must be coaxial with the primary weapon and must be so mounted as to be capable of adjustment in elevation and deflection. The demand for sustained fire, it appears, is inevitable with the perfection of complete stabilization. Two or more caliber .30's in turret blisters, if they are coaxial with the primary arm, will permit low or high rates and continuous accurate fire throughout the run by using alternate guns.

(c) Anti-aircraft: The combat vehicle machine gun should be capable of installation and use as an anti-aircraft weapon with a minimum of difficulty.

(6) Ammunition: It is necessary that the combat vehicle machine gun be designed to use the proposed, shortened caliber .30 cartridge, T-65, for it is essential that the same ammunition as is standardized and used by other arms be employed. This will simplify production and supply. However, full consideration must be given to the effect of new ammunition upon machine guns. Cartridge design, pressure, thickness and elasticity of the case directly affect functioning and extraction, which are already acute problems. Present standards of elasticity must be retained and should, if possible, be improved upon.

The vehicle machine gun requires three types of ammunition. It must have an armor-piercing round which will be effective against unarmored vehicles up to 1000 yards range, an incendiary which will be capable of igniting fuels, rubber and duffle under favorable weather conditions up to 1000 yards, and, in addition, a dim-igniting tracer is necessary for observation of strikes from the limited vision available from a turret in unfavorable terrain and weather. This tracer should ignite at approximately 200 yards and should not burn out much before 1500 yards.

Consideration should be given to the development of one cartridge embodying all of the above features or to combinations embodying two such characteristics. It is

normally impossible to predicate loading upon tactical requirements or to change belts to meet changing situations. Hence, combinations of effect features immeasurably aid a belt-fed machine gun operator.

(7) Ammunition Belts: Ammunition belts should be of the disintegrating link type, close pitch, easily attachable. Consideration should be given to the use of either metal or plastic. The present web belts vary in uniformity, react unfavorably to dampness or excessive dryness, and do not clasp the rounds firmly enough to prevent the vibration of the vehicle from shaking them loose. Combat has definitely proved them to be unsatisfactory. Metal or plastic belts eliminate or mitigate all of these deficiencies, and, in addition, the disintegrating link feature solves the problem of disposing of empty belts. In addition, links should be near the center of gravity of the cartridge to obtain balance and so that the rounds will lie flat.

4. SUMMARY.--A serious effort has been made to merge tactical and technical considerations in evolving the proposed combat vehicle machine gun. The contemplated weapon must be mechanically reliable under all conditions, must be capable of furnishing a small cone of fire or burst accuracy, must be capable of installation, operation, and maintenance in any probable mounting or position, and must have a capacity for sustained fire.

This weapon should be a recoil-operated, belt-fed, air-cooled type, incorporating an alternate feed belt and using metal or plastic link belts from bulk containers. The gun must necessarily be designed for the new, shortened ammunition, but gun, mount, ammunition belts and, to a lesser extent, containers and other accessories must be designed as a unit in order to realize the full potentialities of, as well as to overcome the limitations of, vehicular use. Accessibility to recoiling parts and to the feed mechanism and feed ways is essential.

The gun should be designed to insure functioning with a minimum of adjustments and to insure ease of maintenance by unit replacement with minimum adjustments. The gun should not be a hybrid built to achieve irrelevant ends. Dependability, accuracy, and ease of loading, operating and servicing are the desired ends and can be obtained only through a weapon that is rugged, simple, and operating with an inherent smoothness resulting from good design and careful manufacture. These ends must also be the main factors, as a result, which influence design. Less stringent weight and size requirements must be tolerated to permit application of these as factors. Compromises will be necessary, but they must be based upon a sound consideration, in order of priority, of relevant ends and factors directly affecting such ends. Barrel life, for instance, is both a factor and a result. Its importance as a

factor was minimized by inclusion of a quick barrel change feature, thereby permitting more essential results, such as accuracy, to retain primary design consideration. The cyclic rate, on the contrary, is a result of design --- not a factor.

APPENDIX - H - MILITARY CHARACTERISTICS

MILITARY CHARACTERISTICS
FOR
COMBAT VEHICLE LIGHT MACHINE GUN, CALIBER .30

1. GENERAL.--

a. Construction:--

(1) Shall be simple and rugged in order to achieve maximum dependability.

(2) Shall incorporate a minimum number of parts without complicating the design.

(3) Shall utilize new alloys of lighter weight only when equal or greater strength is also present.

(4) Shall adhere in design and manufacture to close tolerances in order to insure dependability, proper functioning without complicated adjustments after rapid component replacement, and to facilitate servicing.

b. Weight:--

(1) Shall be consistent with other design necessities.

(2) Consideration should be given to a weight in the vicinity of 40 pounds so as to more nearly permit the realization of the ultimate in reliability without sacrificing relative ease of mounting and dismounting. However, a greater weight is acceptable if necessary.

c. Dimensions:--

(1) Over-all length shall be as short as possible consistent with accuracy and functioning requirements in order to facilitate handling and mounting in a confined space.

(2) Maximum cross section of the barrel jacket shall be consistent with other design needs but shall not exceed two inches in order to allow the barrel to be fitted into a small aperture. The front sight should fold into a recess in the barrel jacket.

(3) See paragraph 5, Method of Mounting, for further requirements.

d. Cooling:--

(1) Air-cooled.

(2) Consideration should be given to the utilization of fins, induced drafts, or other devices which will facilitate cooling or dissipation of heat.

e. Rate of fire:--

(1) Shall have one rate of fire, full automatic, in order not to increase the number of parts or the complexity of the design.

(2) Rate of fire itself shall be consistent with the design requirements of accuracy and functional reliability. It shall not fall below 450 rounds per minute nor

exceed 700 rounds per minute in order to achieve good distribution, observation of strike, and to conserve ammunition.

(3) Single shots, possible by pulling and releasing the trigger, are desirable.

f. Dispersion:--Shall not exceed 1½ mils up to and including 500 yards range when rigidly mounted and fired in 20-round bursts.

g. Safety:--

(1) There shall be positive and adequate safety arrangements to include definite locking of the trigger in the "no fire" position.

(2) The gun shall not be able to fire if the bolt is not fully locked, if the receiver is not correctly locked to the barrel jacket, if the various covers in the receiver are not closed, or if the quick release barrel is not properly positioned.

(3) It is desirable that no recoiling parts be located outside of the gun casing.

(4) Fumes shall not be able to pass from the muzzle or any port in the barrel into the fighting compartment.

h. Protection:--Working parts, particularly recoiling parts, shall be enclosed against weather and unfavorable handling and operating conditions.

i. Interchangeability:--Interchangeability of parts with the new lightweight all-purpose machine gun, caliber .30, is a desirable, but not a limiting, factor.

2. FUNCTIONING.--

a. General:--

(1) Shall function reliably whether upright or on either side and at angles of elevation between -45 and +90 degrees to permit installation in special mounts and use as an emergency anti-aircraft weapon.

(2) Shall be designed to function within the extremes of ambient temperature prescribed by the War Department.

b. Adjustments:--No adjustments affecting functioning shall be required, or, if initial adjustments are essential, such adjustments shall be simple and retained even during extended firing. This characteristic is expressly applicable to headspace and timing.

c. Method of operation:--

(1) Consideration should be given to short recoil, gas assisted if necessary, to permit minimum mounting aperture, to decrease weight, to provide positive action, and to facilitate rapid barrel change.

(2) It is desired that the recoiling parts move directly along the prolongation of the axis of the bore and the weight of these parts should be distributed along the same axis in order to reduce vibration and to decrease dispersion.

(3) It is desired that the breechblock stroke be as short as practicable to conserve space and to take advantage of the new, shortened cartridge, T-65.

(4) It is desirable that a means be incorporated for accelerating the movement of the breechblock and, at the same time, retarding the recoil of the barrel.

(5) Consideration should be given to a means for eliminating cook-offs --- open-bolt type of operation is acceptable as a method of accomplishing this.

(6) It is desired that the breech remain open at the end of a belt to facilitate changing belts, if this can be accomplished without unduly increasing the complexity of the weapon.

d. Cocking and firing:--

(1) It is desirable that the gun be capable of being cocked, by repositioning components, from either side in order to make possible right or left-hand mounting.

(2) The gun shall be capable of being fitted with a remote control attachment or a solenoid.

e. Method of feeding:--

(1) Shall permit greatest possible flexibility of mounting and employment.

(2) Normal feed should be by disintegrating link belt from bulk containers, preferably located above the

gun in order to utilize gravity feed.

(3) Emergency feed should be by disintegrating link belt, 250-round capacity, from normal ground ammunition boxes, positioned by an ammunition tray attached to the mount.

(4) Alternate feed, convertible by changing feed mechanism, in the form of 100-round drum for anti-aircraft use, should be considered.

(5) Although belt feed is cited throughout, consideration should be given to any method of feeding that will provide an uninterrupted flow of cartridges to a remotely mounted and/or fired machine gun.

f. Ejection:--

(1) It is desired that normal ejection be downward through bottom of the receiver.

(2) Shall be capable of throwing empty cases clear of ejection opening.

(3) Empty cases shall be substantially out of the ejection port before the bolt engages a live round.

(4) When gun is on its side, empty cases shall have just enough energy to clear the receiver and a live round shall not be able to roll back and obstruct breech.

g. Extraction:--

(1) There shall be slow extraction --- the relative speed of the extractor and breechblock shall be slow

prior to lock disengagement in order to avoid ruptured cases.

(2) Consideration should be given to a chamber design that will facilitate extraction without interfering with the seating of the cartridge.

(3) Normally, there shall be no necessity to lubricate cartridge cases.

h. Lubricants:--Shall not require special lubricants in order to simplify supply.

3. ACCESSIBILITY AND STRIPPING.--

a. Stripping:--Shall be possible to carry out complete stripping of the gun when mounted in the vehicle without using tools and in a minimum of time, to include removal of:

(1) The receiver from the barrel jacket.

(2) The buffer group from the rear face of the receiver when latter is opened downward or removed.

(3) The breechblock as unit when the gun is cocked (by opening the rear face of the receiver) in order to permit replacement and cleaning of the unit, and testing of sights.

(4) The feed mechanism as a unit or the cover with feed mechanism attached as an entity.

b. Incorrect Assembly and Adjustments:--Design shall preclude incorrect adjustments as well incorrect assembly.

c. Field replacement:--Parts requiring field replacement shall be designed with a view to ease of assembly and

disassembly. Ease of maintenance and unit replacement shall be sought.

d. Quick barrel change:--Barrel change from the breech shall be possible without dismounting the gun and with minimum delay so that barrel replacement, cleaning, and extraction of ruptured and/or jammed cases can be accomplished easily and without re-testing the sights. Consideration should be given to the inclusion of a non-conductive handle for the barrel.

e. Loading and unloading:--Feed mechanism and feed mouth shall be readily accessible in order to load, unload, and clear stoppages in a minimum of time and with a minimum of difficulty.

f. Fastenings:--All locking or fastening devices shall be certain in action and shall be simple to operate.

g. Versatility:--All external devices, except the rear face of the receiver shall be designed to further accessibility and all locks or levers operating those items shall be located on top of the weapon or shall be capable of installation or operation, by repositioning, on or from either side of the weapon.

h. See paragraph 5, Method of Mounting, for further discussion of accessibility.

4. COMPONENTS.--

a. Barrel:--

(1) Length and weight shall be consistent with other design requirements so as to provide, in order of priority, the following:

(a) Accuracy prescribed: $1\frac{1}{2}$ mils maximum dispersion up to 500 yards when rigidly mounted and fired in 20-round bursts.

(b) Functional reliability in order to attain positive feeding, smoothness of operation.

(c) Endurance required:

1. Retention of accuracy life up to 2000 rounds minimum when fired in approximately 20-round bursts at the rate of 60 rounds per minute in order to permit normal firing with a minimum number of barrel changes.

2. Retention of accuracy life when fired at full cyclic rate for 20 seconds minimum in order to permit emergency application of uninterrupted fire without barrel destruction.

(2) Maximum obtainable life shall be sought through utilization of new alloys, liners, and other design features.

(3) Replacement of the barrel by one man shall be accomplished from the breech without removal of component parts and in the minimum amount of time in order to permit rotation of barrels before the above limiting points are exceeded.

(4) Consideration should be given to the design of the breech end of the barrel and the chamber so as to mitigate the problem of headspace adjustment and to insure uniform seating of the cartridge.

b. Barrel jacket:--

(1) Shall insure maximum stability and minimum vibration for the recoiling barrel in order to promote the required degree of accuracy.

(2) Shall house a gas booster or trap in order to help recoil by increased gas pressure impinging upon the muzzle end of the barrel, if such an assist is required.

(3) Shall assist cooling in order to obtain maximum barrel life.

(4) Shall, if necessary, be designed to facilitate quick barrel change and, as well, proper and continued positioning of the inserted barrel.

c. Feed mechanism:--

(1) Shall permit greatest possible variation of feed positions to guns in special mounts in order to meet future developments featuring remotely mounted weapons.

(2) Shall be changeable from left to right as desired by reversing components within the weapon in order to permit interchanging weapons within a vehicle.

(3) Shall permit gun firing while lying on either of its sides with the belt entering from either the upper or lower side of the feed mouth so as to permit use of multi-gun mountings in awkward positions.

(4) Shall permit firing at 90 degrees elevation to allow emergency use as an anti-aircraft weapon.

(5) Shall be easily and quickly adaptable to a pneumatic or similar type charging device if so mounted that that operation cannot be performed manually.

(6) Shall be capable of utilizing some type of belt pull assist, such as gravity, spring, or power.

(7) Shall have positive action with sufficient reserve power to cope with long ammunition belts or accidental obstructions.

(8) Consideration should be given to incorporation of a rear cartridge aligning pawl and a short round positioning device as integral components in order to insure continuous feeding.

(9) Shall lend itself to easy removal and replacement as a unit.

(10) Design shall prohibit improper adjustment as well as maladjustment resulting from sustained firing; must seek minimum sensitivity to small variations in the size of belts and in the positioning of cartridges.

d. Breechblock:--

(1) Shall be heavy enough to supply, in conjunction with the velocity of recoil, the operating momentum required in a positive action belt-fed machine gun.

(2) If possible, the breechblock shall be heavier than the barrel so that it will start recoil slowly (thereby providing slow extraction); so that it will lose momentum more slowly (thus insuring complete action); and so that it will be less sensitive to friction. It shall not be so heavy that the frame cannot withstand the increased impact.

e. Driving spring:--

(1) It is desired that it be located directly behind the breechblock in order to act directly along the axis of recoil.

(2) Shall have sufficient power to drive the breechblock forward, seat a live round firmly in the chamber, and lock the bolt.

(3) Shall be capable of retaining required tension when compressed for long periods during the open-bolt type operation.

(4) It is desirable that it not hinder the removal of the rear face of the receiver.

f. Barrel return spring:--Shall have sufficient power to return the barrel to the forward position without recourse to the driving spring in order to relieve the load on the latter.

g. Extractor:--It is desired that it be located in the front face of the breechblock so as to engage two sides of the case rim and so that it can hold the case until the ejector positively operates.

h. Ejector:--It is desired that it be hinged and located so as to strike the side of the case near the rear end in order to procure adequate leverage to loosen the case from the extractor.

i. Receiver:--

(1) Shall be rugged in order to protect and guide the recoiling parts, to withstand their impact and the affect of friction and camming action.

(2) Shall provide steady support for and ready access to the feed mechanism for cleaning and/or replacement and in order to load, unload, and clear stoppages.

(3) It is desired that it be capable of removal as a unit from the barrel jacket for repair and cleaning purposes.

j. Rear face of the receiver:--

(1) It is desired that it house the buffer group.

(2) Shall be capable of removal or of opening downward in order to expose the buffer group and to permit withdrawal of the breechblock.

k. Buffer group:--

(1) Shall be constructed so as to return the breechblock to the forward position after the initial round has been fired and upon completion of the rearward movement without resort to the driving spring.

(2) Shall not require adjustment, but, if such adjustment is necessary, it shall be simple and shall be retained during sustained firing.

(3) Consideration should be given to a vertical type to conserve space.

(4) Shall be readily detachable from the rear face of the receiver for purposes of replacement.

l. Trigger group:--

(1) Design shall be simple and extremely rugged in order to prohibit bending.

(2) Design shall prohibit improper adjustment and should permit retention of initial adjustment during prolonged operation.

(3) Shall be adaptable to a solenoid.

(4) It is desired that its location should facilitate the removal or opening of the rear face of the receiver and afford protection against bending.

m. Bolt:--

(1) Consideration should be given to a rotary or horizontal type, locked symmetrically about its long axis by vertical lugs, in order to distribute weight along axis of recoil, to reduce size of the receiver, and to insure uniform seating of the cartridge.

(2) Shall be an alternate feed type.

5. METHOD OF MOUNTING.--

a. Coaxial in turret:--

(1) Mount shall permit ready access to, as well as provide sufficient clearance for the operation or movement of, the:

(a) Feed mechanism (and feed mouth) in order to allow loading, unloading, clearing of stoppages, and replacement of the feed group.

(b) Barrel change device in order to facilitate replacement and to permit removal of ruptured and/or jammed cases.

(c) Rear face of the receiver in order to remove the breechblock.

(2) The mount shall so support the gun as to:

(a) Eliminate vibration.

(b) Allow simple, quick, and accurate adjustment in elevation and deflection of the gun with the vehicular sight in order to bring the machine gun into coincidence with the main armament at ranges from 200 yards to 1500 yards.

(c) Permit quick removal of the receiver and/or the entire gun.

(d) Eliminate as completely as possible muzzle whip.

(3) The mount shall permit the muzzle to protrude through the mantlet, or, at least, into the mantlet aperture.

(4) All locking devices and adjusting elements shall be positive in action and simple to operate.

(5) The mount shall provide for the installation of the caliber .30 or the anti-aircraft machine gun with a minimum of difficulty.

(6) The mount shall include a detachable ammunition tray or rack so positioned as to facilitate feeding from any position, capable of attachment to either side of the mount and adjustable so as to firmly hold either a caliber .30 or anti-aircraft machine gun ammunition box or liner.

b. Remote control:--

(1) Shall be capable of installation and use in blisters outside of the turret and/or fender mounts coaxial with primary weapon.

(2) Shall be capable of adjustment in elevation and deflection.

c. Anti-aircraft:--Shall be capable of installation and use as an anti-aircraft machine gun with minimum of difficulty.

6. AMMUNITION.--

a. Shall use proposed, shortened caliber .30 cartridge, T-65, in order to simplify supply.

b. Types:--

(1) Armor-piercing which must be effective against unarmored vehicles at 1000 yards.

(2) Tracer, dim-igniting, which ignites at approximately 200 yards and burns out at approximately 1500 yards.

(3) Incendiary, which will be capable of igniting fuels, rubber, duffle under favorable weather conditions at ranges of 1000 yards.

c. Trajectories of all types of ammunition shall coincide as nearly as possible and must intersect at 1000 yards.

d. Present standards of case elasticity shall be retained and, if possible, shall be improved upon.

e. Consideration should be given to one cartridge, AP-T-I, or combinations such as AP-I, AP-T, or T-I, which are the most feasible for belt-fed weapons due to normal inability to predicate loading upon tactical requirements or to change belts. Such a cartridge or such combinations shall not result in the sacrifice of effect requirements cited above in paragraph 6 c.

7. AMMUNITION BELTS.--

a. Shall be disintegrating link, close pitch, easily attachable.

b. Links shall lie near the center of gravity of the cartridge to obtain balance and so that rounds will lie flat.

8. ACCESSORIES.--

a. Fittings shall be provided for the rear face of the receiver to suit various types of mountings.

b. Consideration should be given to a thermostat, readily detachable, so as to furnish an adequate means of registering barrel temperature in order to warn when barrel replacement is required.

c. Covers:--

(1) Barrel jacket cover.

(2) Receiver cover.

(3) Expendable muzzle covers.

d. Spares:--

(1) Sub-assemblies only --- no loose parts.

(2) Breechblock assembled complete.

(3) Feed mechanism with feed pawls assembled complete, or receiver cover and feed group complete.

(4) Two (2) barrels with covers.

(5) Muzzle attachments.

(6) Return spring and guide.

(7) Buffer group complete.

(8) Spare parts box for items 2, 3, 5, 6, and 7.

e. Tools:--

(1) Carbon-removing tool.

(2) Combination wrench.

(3) Appropriate gages.

(4) Jammed case extractor.

(5) Barrel extracting tool to assist changing and holding hot barrels, if required.

(6) Cleaning rod, double pull through type.

f. Empty brass and link container (s).