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TECHNICAL STUDY AND PROPOSED DEVELOPMENT PROGRAM FOR

A NEW TANK MAIN ARMAMENT SYSTEM (U)

MARCH 1959

71 p.

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NEW TANK MAIN ARMAMENT SYSTEM (U)

ABSTRACT

Ballistic Research Laboratory Technical Note 1183 dated April 1958 proposed a tank armament concept utilizing a gun characterized by its large caliber combined with short travel and moderate pressure to provide a lightweight component for launching a spin stabilized dual-purpose shell having a spin compensated liner for a shaped charge. In the technical material contained herein, the BRL study has been expanded by a committee of representatives from BRL, OTAC, Picatinny and Watervliet Arsenals to establish the practicability of development of the basic approach, to provide for more detailed analysis of the components of the system, to determine compatibility of the system with direct fire, wingless guided missiles for ultimate use as the primary round, and to include the application of the system to improved vehicle designs representing complete weapons systems.

Section 1

INTRODUCTION

1.1 Background and History

During the past several years the general trend in tank design has been towards smaller and lighter weight armored vehicles. This has necessitated a search for lighter and more compact armament systems capable of defeating all enemy armor at battle ranges up to 2000 yds. To be more specific, the armament desired should possess an improved hit probability over that of current systems, have a terminal effectiveness capable of destroying the heaviest armor that an enemy could conceivably operate in the field and yet be small enough to permit its installation in a highly mobile tank sufficiently armored to survive most of the hazards of the future battlefield. Such an armament system would be applicable to the "Main Battle Tank" as reported by the Fourth Tripartite Conference on Armor.

In April 1958, BRL Technical Note 1183 proposed "A Concept Armament for the Main Battle Tank", having characteristics closely approaching those outlined above. The Office of the Chief of Ordnance requested that a study be conducted to determine the practicability of development of the BRL armament proposal (see Appendix III). A committee was formed composed of representatives from BRL, OTAC, Picatinny and Watervliet Arsenals to conduct the study. Essentially the committee endeavored to bring forth the most effective weapons system reflecting the above desired characteristics and which would also have excellent growth potential for adaptation to missiles when the state of the art in that field reaches a stage of maturity whereby the benefits of economy and effectiveness of projectiles at moderate range can be united with the merits of the missile at greater ranges. Consideration of the human engineering aspects of the system was maintained to a high degree throughout the study since it is believed by the study participants that maximum efficiency in any armament system can only be attained by reaching a proper balance of capabilities between man and machine.

The approach taken by the committee that resulted in the establishment of the concept presented in this report first considered in detail the two basic elements of a tank main armament system -- ammunition and gun, in that order. Once the desired terminal effectiveness was established and exterior and interior ballistics determined, they were then subjected to combined study with optimum gun parameters to produce the most effective over-all system. The gun, or launcher, having thus been defined, was next analyzed to ascertain its suitability for missile application. The fourth step in the study sequence consisted of combining the armament package with the vehicle concepts to attain a proper balance of the complete weapons system, and all phases of the study were then refined to insure compatibility of all elements.

This study presents, in the order indicated above, the results of the study applied to each element of the system, the complete concept, and the conclusions and recommendations of the committee.

1.2 Objective and Scope of Study

The objectives for this study were laid down in a memorandum from the Chief, Research & Development to Chief of Ordnance, file OO/8S-6402, CRD/D-6402, Comment No. 2, Subject: "Future Tank Production", dated 24 July 1958, and paragraph 5A of that memorandum is quoted in its entirety:

"Initiate a technical study to determine the practicability of development and the design parameters of a tank main armament system characterized by moderate to low pressure, lightweight, short tube, small chamber volume and capable of launching a spin-stabilized chemical energy HEAT shell having a spin-compensated liner for the shaped charge. The caliber of this armament system should be of sufficient size to penetrate the armor of all existing and future USSR heavy tanks, to defeat all compound, special or spaced armor arrangements, were the Soviets to use this technique to degrade the performance of our conventional HEAT ammunition, and to provide adequate residual damage after penetration to insure destruction. Subsequent to the completion of the above mentioned study, consideration should be given to the use of this armament system as a launcher for the delivery of direct fire, wingless, guided missiles, as a gun to deliver HEAT ammunition at minimum ranges where the missile may not be as efficient or where the destruction of the target does not warrant the delivery of the more expensive missile, and to deliver HE ammunition against soft targets at all ranges. This technical study and assessment will be conducted under DA Project 5W01-04-076, "Tank Cannon Development"."

Section 2

—— AMMUNITION ——

2.1 Objective

In order to fulfill the scope of requirements to be met by the gun-ammunition system under consideration, the following were first set forth as the objectives toward which ammunition design would be pointed.

a. Design of a spin-stabilized chemical energy HEAT shell having a spin-compensated liner for the shaped charge, the caliber of which should be of sufficient size to penetrate the armor of all existing and future USSR heavy tanks, and to defeat all compound, special or spaced armor arrangements.

b. Design of HE ammunition to be effective against soft targets at all ranges.

c. While striving toward optimization of the above designs, due consideration would be given to provide for compatibility with guided missiles currently under study.

2.2 Originating Characteristics (Ref. BRL Technical Note 1183)

(1) In the past, a HEAT shell was considered as a secondary round in a high velocity kinetic energy system. To integrate a HEAT projectile with an AP projectile, it was necessary to resort to fin stabilization of the former. This produced a round that was less than completely satisfactory due to dispersion and drag characteristics. In the study presented by BRL, defeat of armor is based entirely on chemical energy, therefore an exact spin rate for stability could be provided, and drag and dispersion reduced to a minimum. In addition, elimination of the long boom and fins results in a round configuration far more adaptable to tank weapon systems.

(2) To achieve the requirements previously specified, the following characteristics were established:

Caliber	140mm
Muzzle Velocity	2400 fps
Chamber Pressure	30000 psi (cu)
Chamber Volume	300 cu. ins.
Projectile Travel	120 ins.
Projectile Weight	35 lbs.
Twist of Rifling	50 cal./rev.
Complete Round Weight	50-55 lbs.
Ballistic Coefficient - C_1	1.7

2.3 Preliminary Design Approach

(1) In view of the current Ordnance development program on 6 inch missiles for armor, the committee decided that an increase in bore size from 140 to 152 mm (6.000 ins) would maximize the likelihood of consolidation of these systems and provide a major step toward satisfying the requirement that the weapon be a dual purpose closed breech launcher, capable of launching wingless guided missiles and conventional type projectiles.

(2) Another fundamental premise that contributed to establishing the 152mm caliber was the desirability for good anti-personnel potential in the primary HEAT shell. It was the opinion of the committee that since the weapon system under consideration must have HE capability, it would be very desirable to combine anti-tank and anti-personnel features into a single dual-purpose round, thus allowing the tanker to maintain a balanced ammunition complement at all times.

(3) Since a higher spin rate is required for good anti-personnel lethality, an increase in caliber was deemed necessary to offset the resultant degradation of the shaped charge. The twist of rifling required for this design was calculated to be one turn in 40 calibers rather than the one in 50 as for the 140mm concept. Assuming the same penetration curve for spin-compensated liners as that presented in Technical Note 1183, the depth of penetration was estimated to be approximately 50% of static as compared to 65% for the 140mm projectile.

(4) In order to compensate for this difference, it was proposed to use an Octol explosive filler in lieu of the usual Composition B. Test results on depth of penetration with these fillers indicate them to be approximately equal. However, utilizing a low impedance liner with an Octol filler should result in improved performance. In any case, Octol will produce a larger cavity diameter and increased lethality.

2.4 Terminal Effectiveness

(1) Basic Targets

Fig. 1, page 17 depicts the proposed 152mm dual purpose HE-HEAT round with combustible cartridge case. Fig. 2, page 18 illustrates the type of fluted liner to be used for spin compensation.

Scaling studies of homologous geometrically scaled fluted liners indicate that, to maintain a desired compensation efficiency, the relation wd equal to a constant must be satisfied, where

w = spin rate of liner, rps
d = liner diameter, (mm)

At a given muzzle velocity, the spin required to stabilize a given shell design is determined by the relationship

$$WD = \frac{V}{N} = \text{constant}$$

V = velocity of projectile
N = calibers of travel per revolution
W = spin rate of projectile
D = projectile caliber

It is desired to match the state of the art of the spin compensated fluted liner designs and the requirements for exterior ballistic stability and accuracy. The symbols d and D are related as follows: D = kd, where k is the ratio of caliber to cone diameter.

Typical penetration capabilities of fluted liners that have been used in past experiments are shown in Fig. 3, page 19 These experimental test results represent firing data obtained from fluted liners in the 57mm, 75mm and 105mm designs. The data are plotted as P/d versus wd, where

P = penetration into mild steel target at the optimum compensation frequency
d = liner diameter at base
w = spin rate of liner or projectile

Figure 3 also gives the penetration obtainable with current fluted liner designs for given values of cone diameter at its optimum spin rate. The spin rate for projectiles are selected on the basis of exterior ballistic requirements.

The estimates of penetration performance against basic targets for the 140mm, and three designs of a 152mm shell, are presented in Table I, assuming the uce of flute designs similar to those already tested.

TABLE I

Estimates of Penetration Performance for the 140mm design and the 152mm designs using Fluted Shaped Charge Liners (Reference Figure 3)

	A	B	C	D	E
Type	140/112/105*	152/142/120	152/132/120	152/122/97	152/132/104
Caliber Projectile, MM	140	152	152	152	152
Spin Rate for Stabilization, rps	105	120	120	97	104
Liner Diameter, mm	112	142	132	122	132
ωd (rps x mm)	11,760	17,040	15,840	11,834	13,728
P/d - Cone Diameters	4.1	2.5	2.85	4.1	3.49
P - penetration mild steel mm	459	355	375	500	461
inches	18.1	14.0	14.8	19.7	18.1
P - penetration armor mm	390	302	320	425	392
inches	15.4	11.9	12.6	16.7	15.4

$(P_{armor} = 0.85\ P_{mild\ steel})$

*designation, projectile diameter, mm/liner diameter, mm/spin rate, rps

The penetrations in Table I are for a two cone diameter standoff. The reason for a decrease in penetration performance for Rounds B and C is that both the liner diameter and the spin rate have been increased simultaneously. Consequently, on the basis represented by the plot (Fig. 3), the degree of compensation would be considerably less for the larger caliber round.

(2) Compound Targets

It is not now possible to guarantee on the basis of experimental data that the tripartite triple targets can be consistently defeated at the prescribed angle of 65°. The demonstrated capabilities indicate that this target could now be defeated at all angles less than 40° obliquity. It is believed that this current deficiency should not be viewed as overly serious for the following reasons:

(a) Any improvement in liner designs made during the development time period will automatically increase the maximum angle at which the long standoff target can be defeated.

(b) The percentage of hits on an armor arrangement in the 40-60° obliquity zone is very limited.

(c) The large quantity of high explosive contained in the shell will have a serious disruptive effect on any skirting plates placed on the outside of the suspension.

(d) A hit in the area of the suspension system will undoubtedly immobilize the vehicle even though the tank hull side is not completely perforated.

The degradation of penetration at long standoff will be more serious for a partially compensated liner than for an unrotated smooth liner or a perfectly compensated liner. Actually there are many shape charge projectile design approaches which can be taken to defeat spaced armor targets, such as:

(a) Lower the muzzle velocity and utilize a current design procedure for the partially compensated liner.

(b) Scale up original 140mm warhead design as shown by Table I, Round D.

(c) Refine liner design through an expedited test program.

With a slight design improvement the 140mm caliber round could be made to satisfy all requirements, and with a somewhat greater advancement the 152mm will do likewise. It is anticipated as a result of BRL's current research program that the necessary advancements required for either case will have been achieved within the very near future. The principles involved have already been demonstrated and designs are being contemplated.

(3) <u>Soft Targets</u>

The anti-personnel lethality of this shell is expected to be superior to any tank HE shell in existence. The high charge to mass ratio (about .6) will produce high fragment velocities, and it is proposed to consider the use of pearlitic malleable iron for the fragmenting portion of the shell in order to obtain a large number of small size fragments. Lethality estimates for the 152mm shell prepared by BRL are as follows:

3.6 times better than the 90mm M71 HE
2.7 " " " " " T91 HE
3.6 " " " " 105mm T131 HEAT

2.5 Fuzing

(1) A new fuze will be required for the 152mm dual-purpose shell. The major characteristics of this fuze will be as follows:

a. It should have the usual safety features.

b. It must be base detonating for proper HEAT functioning.

c. It must have a superquick option for HEAT functioning and certain HE applications.

d. It must have a delay option of about .05 seconds that can be initiated by graze impact for ricochet functioning against personnel.

e. It is desirable that the fuze be graze sensitive when set for superquick functioning in order to aid in sensing misses.

(2) There are several design approaches available for this fuze. One approach would be that used for the T338 Fuze developed for the 90mm, T340 Shell. This approach would utilize the T65 Electric Delay Detonator, a superquick electric detonator, and a "Lucky" located with the main fuze which in this case would be in the base. The "Lucky" is charged by setback or spin and serves as the power source for functioning the appropriate detonator. For superquick functioning as a HEAT shell, a switch located in the nose would be closed on impact to put the charged "Lucky" across the superquick detonator. In addition, an inertia activated switch would be provided which would be sensitive to graze impact. A selector switch for this purpose could also be located in the nose of the shell for convenient access. Both detonators could then be initiated by either the nose or the inertia switch. The selector switch would be used to choose the appropriate functioning mode. Another alternative approach would be to replace the nose switch by a "Lucky" and to use an inertia activated firing pin to set off a primer which would charge a second "Lucky" for firing the appropriate detonator upon graze impact.

2.6 Combustible Cartridge Case

(1) As depicted in Fig. 1, page 17, the 152mm dual purpose round utilizes a fully combustible cartridge case, which as the terminology implies, is completely consumed on firing. The combustible cartridge case was selected over metallic cases since the state of development of the former is nearly complete, its practicability has been adequately demonstrated, and the elimination of expended cases within tank turrets is considered to be highly desirable. The case can be assembled directly to the projectile base to provide a fixed round of ammunition. It will have a high degree of mechanical strength, good moisture resistant properties, and will be serviceable over a temperature range equal to that required of conventionally cased propellants. Close control over ballistics can be maintained through pre-selection of the size of propellant grains for a specified ballistic application.

(2) Current development on the combustible cartridge case includes a detailed investigation of methods for controlling ballistics and a continuation of tests on stability, surveillance, rough handling and general environmental aspects.

2.7 Ignition System

(1) There are three types of ignition systems currently under study for use with the combustible cartridge cases, anyone of which can be readily incorporated into the system. They are:

a. Electric contact - which consists of a small cylinder of combustible material with a vacuum-deposited aluminum bridge on the inside face and a metal foil ring and dot on the other face to complete the circuit. The primary explosive is spotted on the aluminum bridge. This system has been tested with satisfactory results, and further work is planned to finalize the design.

b. Electric induction - works by transformer action. There is a primary coil in the breech of the weapon, and a small aluminum coil potted in the base of the combustible cartridge case. The impulse so generated is fed by the secondary coil into an initiator similar to that described in a. above. The feasibility of this type of initiator has been demonstrated in model firings. Work remaining involves refinement of coil dimensions and method of assembly, determination of hazards and reliability, performance of environmental tests and rough handling tests.

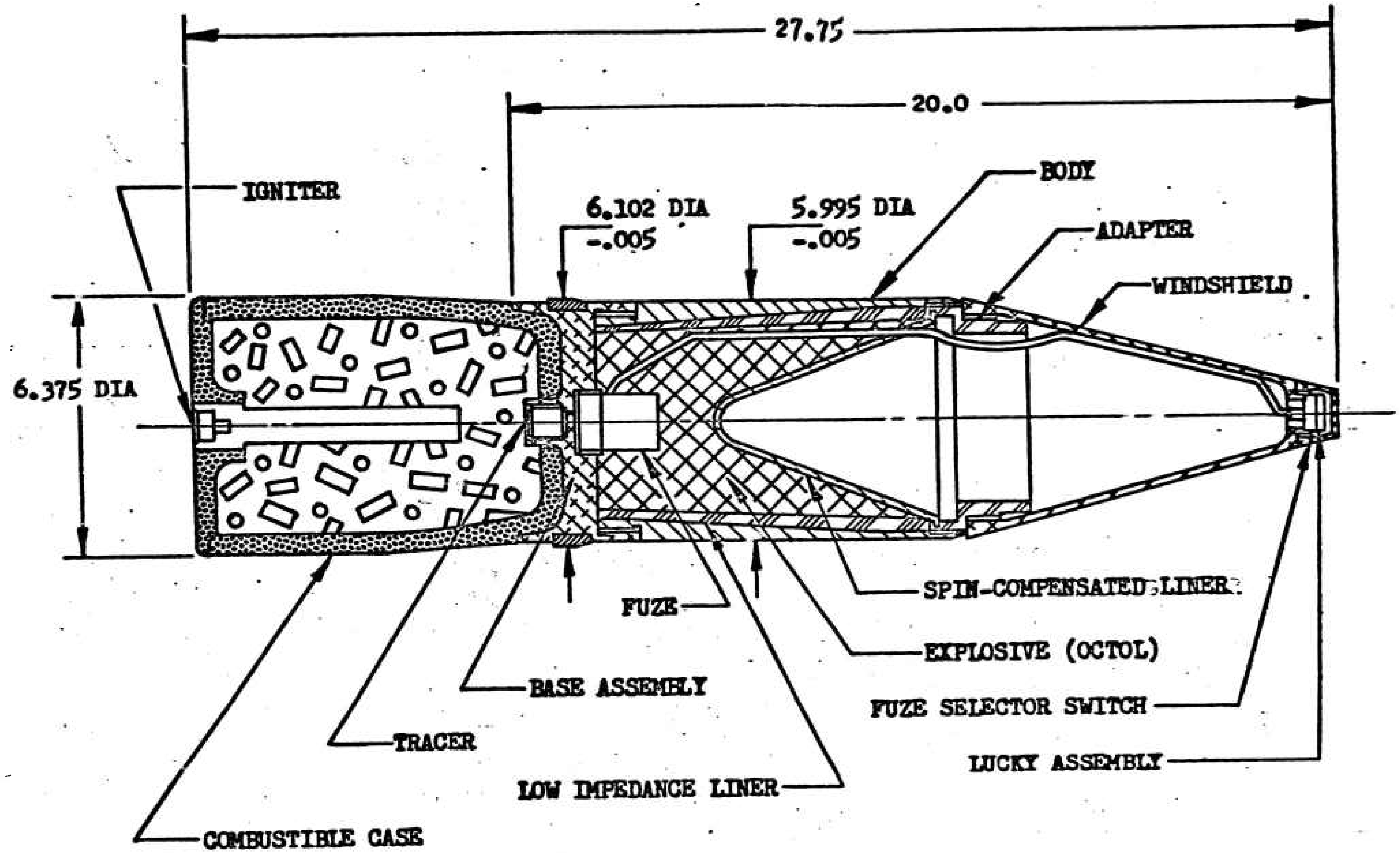
c. Mechanical - consists of a small cup of combustible material ignited by percussion. Design work on this item has been completed and safety, reliability, environmental and rough handling tests are still to be performed.

(2) A complete ignition system for a fully combustible case requires, in addition to an initiator that will be consumed, a combustible primer assembly. Such a primer has been developed. It consists of a thin-walled tube of extruded propellant loaded with fine granulation igniter powder and a length of a type of commercial explosive cord having a low explosive content. Environmental tests are required to finalize the design.

2.8 152mm Ammunition Characteristics

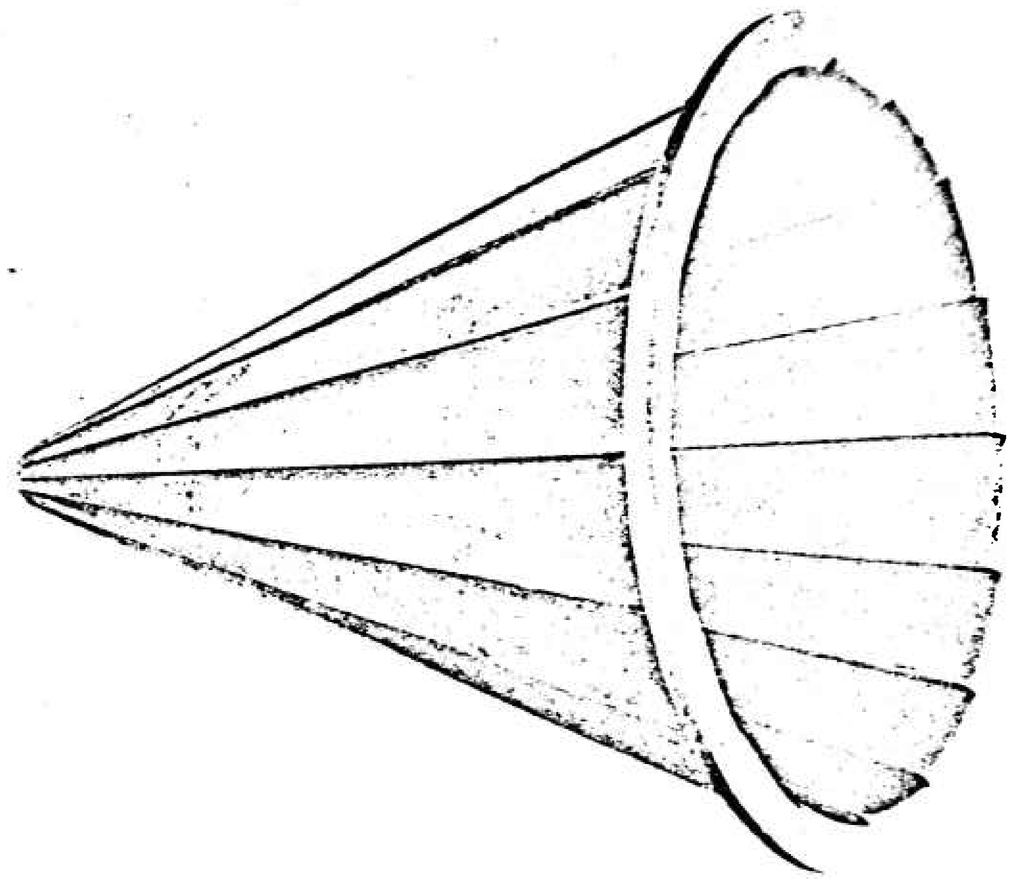
After due consideration of a vast number of parameters affecting ammunition design, the following characteristics are proposed for the 152mm dual purpose HE-HEAT projectile with combustible cartridge case.

a. Bore Size 152mm (6.000")
b. Max Rated Pressure - 32,000 psi
c. Muzzle Velocity - 2260 fps
d. Chamber Volume - 285 cu. ins.
e. Length of projectile travel - 96 in.
f. Twist of Rifling - 1 turn in 43.6 calibers
g. Complete Fixed Round Weight - 47.5 lbs.
h. Complete Fixed Round Length - 27.75 ins.
i. Max. Dia. of Round - 6.375 ins.
j. Projectile Weight - 40 lbs.
k. Projectile Length - 20 ins.
l. Explosive Capacity and Type - 8 lbs. - Octol
m. Weight of Fragmenting Metal - 15.4 lbs.
n. Type and Weight of Propelling Charge - M15 - 7.5 lbs.
o. Axial Moment of Inertia of Projectile - 227 $lb\text{-}in^2$
p. Transverse Moment of Inertia of Projectile - 719.4 $lb\text{-}in^2$
q. Center of Gravity Distance from Base - 1.155 calibers
r. Center of Pressure Distance from Base - 1.958 calibers
s. Normal Force Co-efficient - 1.13
t. Overturning Moment Co-efficient - .906
u. Ballistic Co-efficient (C_1) - 1.7



A PROPOSED DUAL-PURPOSE HE-HEAT ROUND
WITH
COMBUSTIBLE CASED PROPELLANT

FIG.1



SPIN COMPENSATED LINER

FIG. 2

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PENETRATION CAPABILITIES OF SPIN COMPENSATED FLUTED LINERS

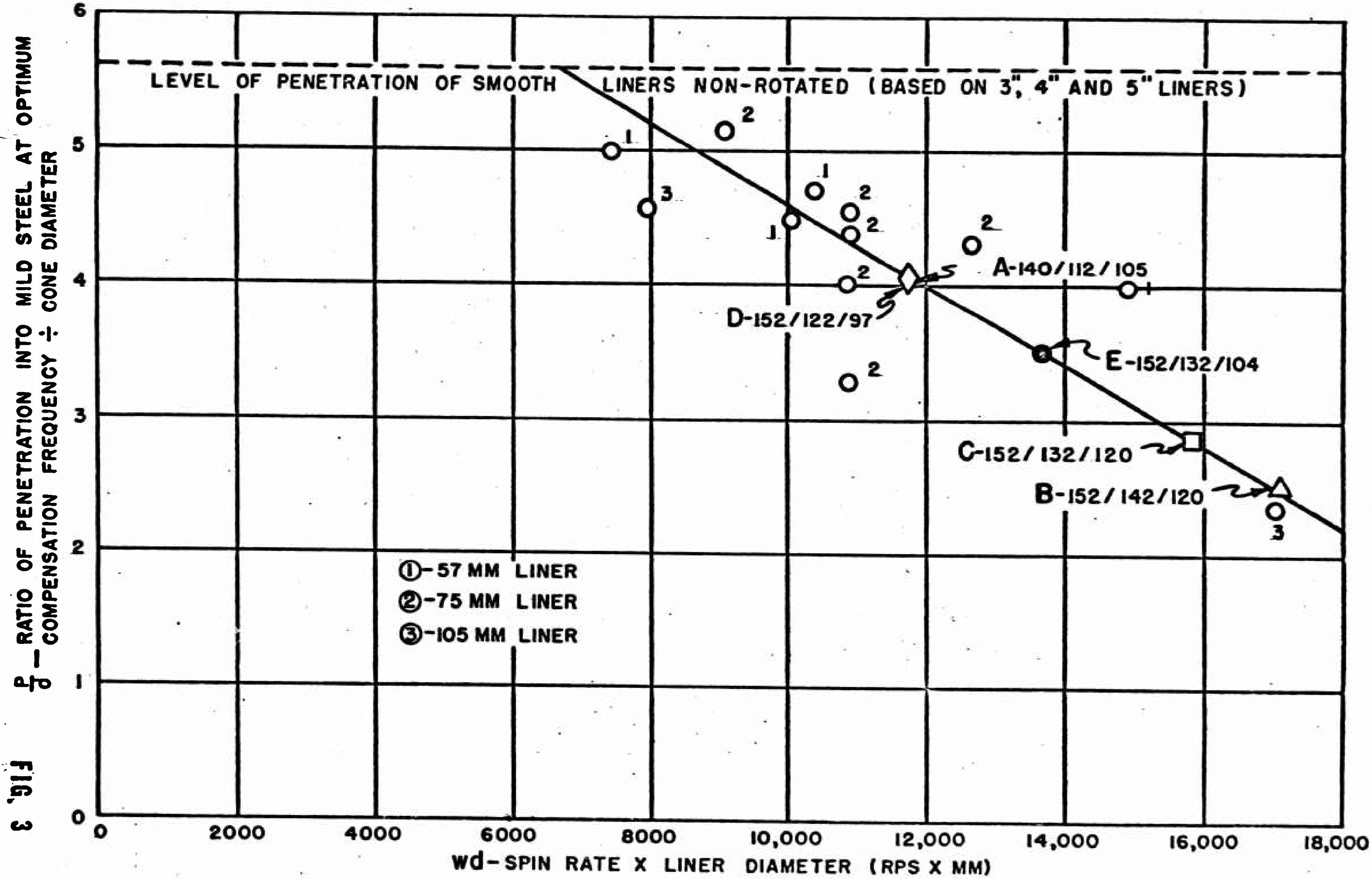

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FIG. 3

Section 3

—— GUN ——

3.1 Objective

The objectives for future gun design were clearly outlined in the report of the Ad Hoc Group on Armament for Future Tanks or Similar Combat Vehicles, dated 20 January 1958. This report states that "The ideal combat-vehicle weapon would be one which would meet all of the antitank and soft-target military requirements and yet be of a sufficiently low weight and small size and have a sufficiently low recoil force to allow its use in future combat-vehicle types. If the launching and/or guidance device for the projectile weighed well under 1,000 pounds, had low recoil forces, and used the ammunition having the general exterior physical characteristics of the present 90-to 120-mm rounds, the other vehicle-design characteristics would be substantially independent of the main weapon. Armor, combat range, munition storage, and vehicle agility and transportability could then be determined for each category of combat vehicle, depending on its planned tactical employment."

3.2 Gun Design Background

(1) There is no question but that the use of chemical energy to defeat armor will provide, in all instances, the smallest cannon and the one most adaptable for vehicle installation, particularly when the emphasis is upon smaller vehicles. The original 140mm Armament System proposal which places sole reliance on chemical energy for the defeat of armor was first presented at the Ordnance Tank-Automotive Command, Question Mark V Conference in March 1958. Based on BRL's proposal and system evaluation, the following gun characteristics were established at that time:

Caliber	140mm
Muzzle Velocity	2400 fps
Chamber Pressure	30000 psi (cu)
Chamber Volume	300 cu. ins.
Projectile Weight	35 lbs.
Projectile Travel	120 ins.
Complete Round Weight	50-55 lbs.
Gun Length	135 ins.
Gun Center of Gravity	51 ins.
Gun Weight	700 lbs.

(2) To further qualify the change in caliber from 140 to 152mm as discussed in Section 2, para. 2.3, the following excerpt from the previously mentioned Ad Hoc report is quoted:

"Since a small wingless missile must be launched at a relatively high supersonic initial velocity, it appears feasible and practical to match both a guided and unguided projectile ballistically to be launched from a single light-weight launching tube and mechanism inside the tank. Such a weapon would approach the ideal weapon characteristics for a primary combat vehicle because it would possess:

a. The highest attainable accuracy at the greatest range usable in normal vehicle combat, possibly as high as an 80% kill probability.

b. The advantages of a gun at short ranges."

3.3 Preliminary Design Approach

(1) In order to produce a compact, lightweight gun, concepts utilizing the most recent achievements in gun construction such as an improved coldwork process which permits the use of high physical materials, the employment of buttress threads, and new mechanism arrangements were investigated. Breech design was channeled through four approaches with consideration given to (a) Separable Chamber, (b) Screw Block, (c) Conventional Drop Block and (d) Six Chamber Revolver. (See concept comparison Fig. 4, page 24).

(2) The Separable Chamber Breech - This design takes full advantage of gains to be realized from the use of a fully combustible cartridge case. It is especially suited to this type of propellant since closure and sealing is accomplished in a longitudinal forward motion of the breech as opposed to the swinging motion of a screw block artillery piece. Other gains achieved with this system are:

a. Weight reduction (resulting from the fact that all major components are hollow cylinders which can be readily heat treated to high physical strength).

b. Reduction of over-all system length (since the shell and chamber are super-imposed over the same projected area during the loading cycle, the over-all length of the gun with the cartridge in loading position is minimized).

c. Improved service space (access to the origin of rifling shortens the ammunition loading stroke).

d. Adaptability to launch missiles (the sealing arrangement devised for the combustible cartridge case also applies to sealing of gases generated by burning of propellant in the missile motor). Missile "shot start" can be sufficiently up-bore where the gun chamber will absorb a considerable gas volume and thereby minimize undesirable back pressure.

(3) Screw Block Gun - This approach essentially uses the conventional artillery type breech mechanism. However, the conventional De Bange type obturator has been replaced by a metallic ring seal. Advantages realized with this system are similar but to a lesser degree than those secured from the Separable Chamber Gun.

(4) Conventional Drop Block Gun - Perpetuating the conventional brass cartridge case, this gun was introduced for comparative purposes to clearly depict the gains made by the other approaches in breech design. It should be noted that the complement of brass cased ammunition with the heavier gun will add significant weight to the over-all system. Although the reliability of this type breech has been conclusively verified, the penalties paid in loading and service space and the large area swept by the wider breech definitely shows the need for development of the more compact mechanism.

(5) Six Chamber Revolver Gun - This concept was introduced to explore the potential of a high rate of fire system. In order to keep the size of the cylinder mechanism to an absolute minimum, new low pressure interior ballistics were generated which resulted in a considerable increase in shot travel to secure the desired muzzle velocity of 2400 fps. Because of its size the revolver is not as versatile as the Separable Chamber Gun. However, it could prove to be an excellent special purpose gun should the need arise.

(6) Tube Construction: All of the aforementioned concepts employ coldworked tubes of 160,000 psi min. yield strength steel, to produce small tube diameters at the breech end. To afford a measure of protection against fragmentation and small arms fire, it was decided that a minimum tube wall of 1/2" would be necessary over the exposed area of the barrel. This thickness also gives the barrel rigidity and insures adequate heat dissipation while employing high rates of fire.

3.4 Design Selection

Selection of a gun design was based upon gun weight, size and geometry, functional and service space requirements, adaptability to vehicle installation, and human engineering factors. In each category the committee found the separable chamber proposal to be the most advanced and the most versatile type of design. This concept is forward looking in that it provides an ideal accommodation for the combustible case, readily incorporates a new method of ignition and has inherent potential as a missile launcher.

3.5 General Characteristics and Operation

(1) Fig. 5, page 25, illustrates in greater detail the proposed 152mm Gun concept selected by the committee. Characteristics of this gun are as follows:

Caliber	152mm (6.000")
Muzzle Velocity	2260 fps
Chamber Pressure	30000 psi (cu)
Chamber Volume	285 cu. ins.
Projectile Weight	40 lbs.
Projectile Travel	96 ins.
Complete Round Weight	47.5 lbs.
Gun Length	107.18 ins.
Gun C. of G.	31.8 ins.
Gun Weight	867 lbs.

(2) As noted above, the short projectile travel and subsequent short over-all gun length yields a rigid, compact system where variables such as muzzle whip, tube droop and solar heating effects can now be considered insignificant factors relative to gun accuracy. The combination of characteristics, moderate pressure, velocity, and projectile weight should also enhance accuracy since tube life is predicted to be well over 1000 rounds.

(3) As depicted in Fig. 5, the breech opening cycle consists of releasing the rear portion of the chamber from the barrel by a 30° rotation of a cylindrical coupling. The chamber is then retracted to clear the coupling and revolved downward through an arc of 64° to provide clearance for loading. The fixed dual-purpose round or missile is then loaded with a conventional forward motion either manually or with an automatic loading device. Breech closure is essentially the reverse sequence of the opening cycle. Actuating power for opening and closing will be provided by an independent hydro-mechanical unit which can be charged on counter-recoil or manually. The stored energy will then provide for semi-automatic breech operation through a simple mechanical linkage.

152MM GUN CONCEPTS

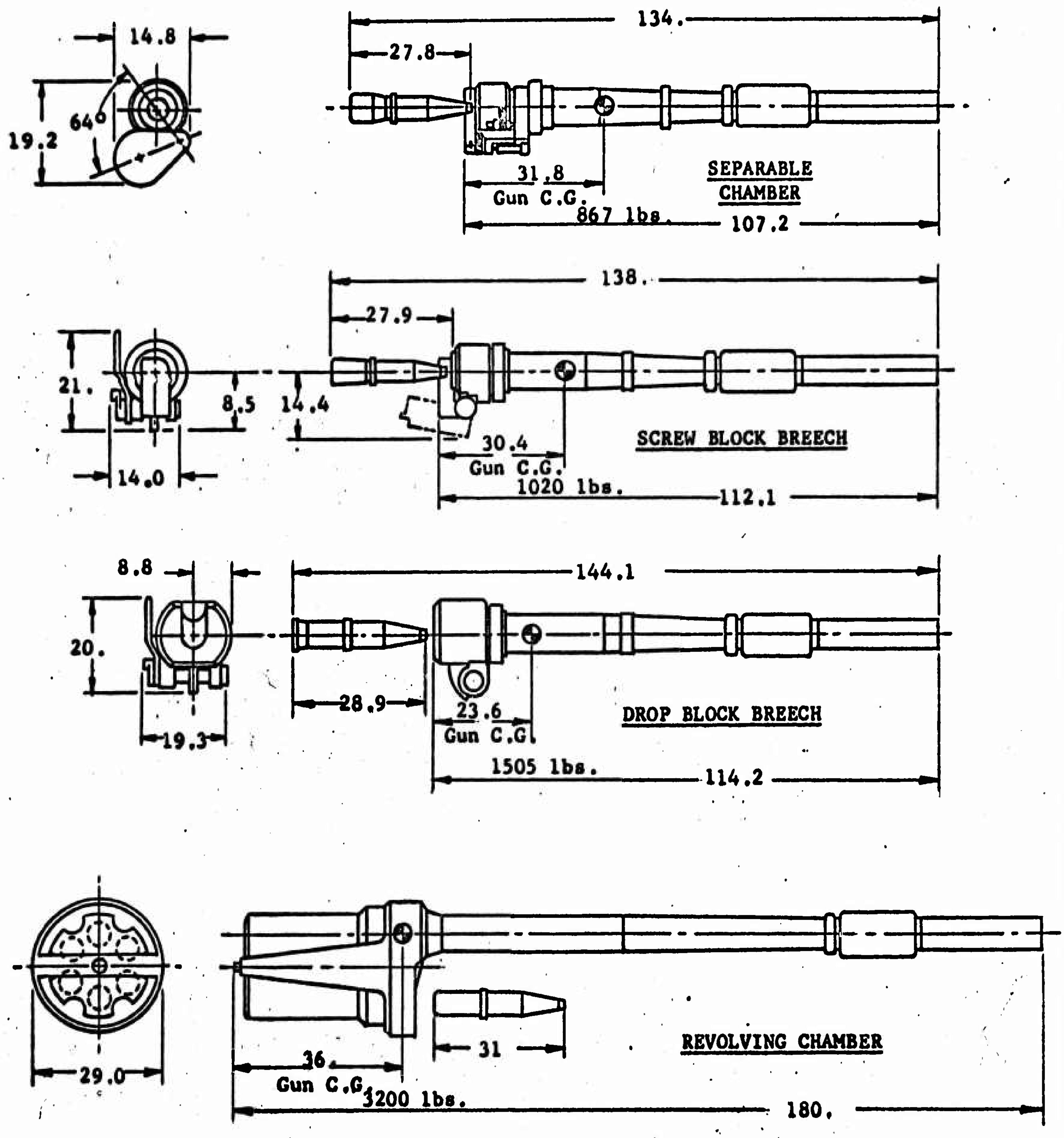

FIG. 4

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THE PROPOSED 152 MM GUN FOR A NEW TANK MAIN ARMAMENT SYSTEM

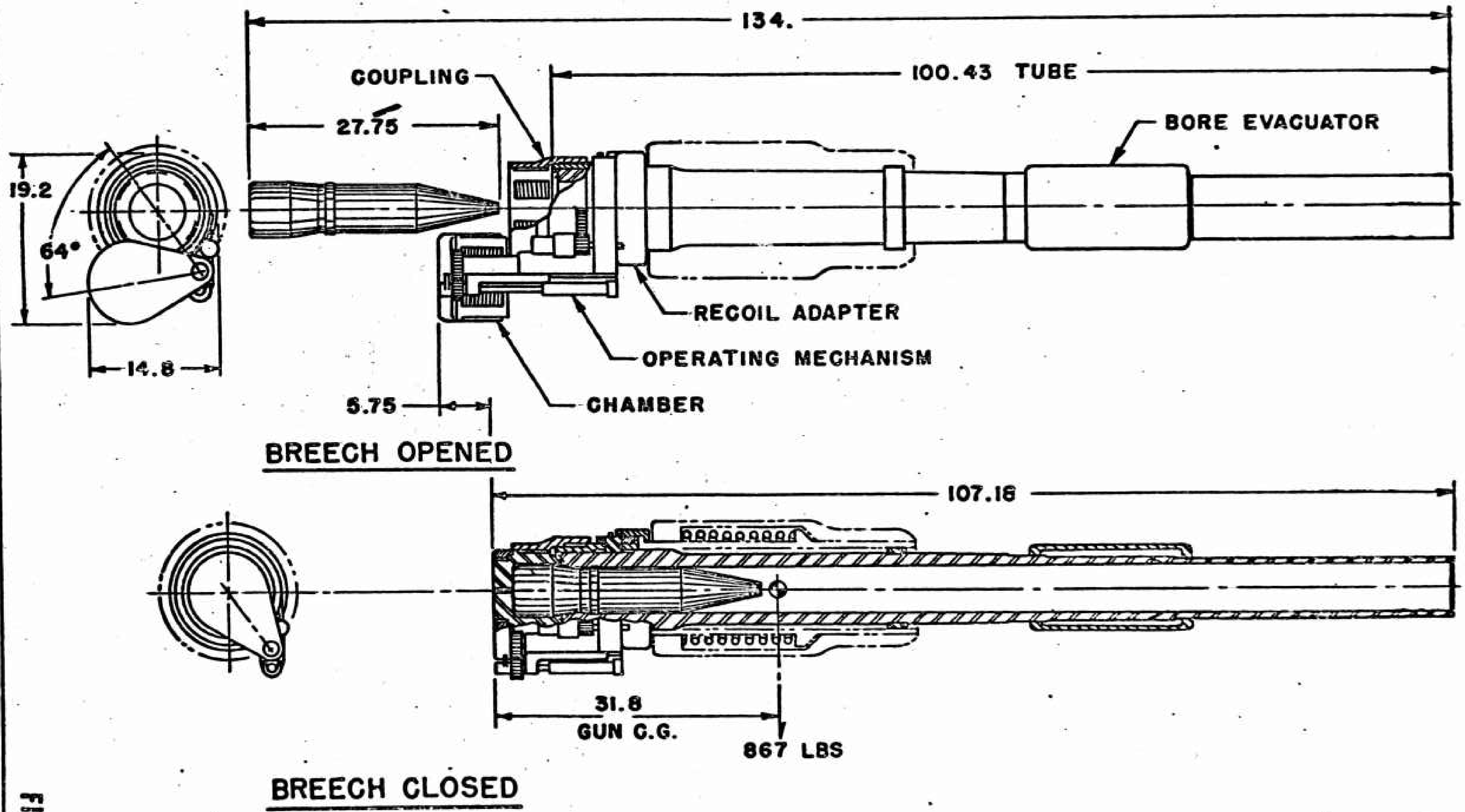

FIG. 5

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Section 4

—— POTENTIAL MISSILE CAPABILITIES OF SYSTEM ——

4.1 Background

(1) Early in 1958, contracts were awarded by Redstone Arsenal for the purpose of conducting feasibility studies on direct fire, wingless guided missiles under the project entitled "Combat Vehicle Weapons System (Pentomic)" (U). Activities to date on the CVWS program have consisted of concept and feasibility studies only, and, as of the date of preparation of this report, work has been narrowed down to two possible development contractors, Sperry Gyroscope Company of Great Neck, New York and Aeronutronic Systems, Inc., Glendale, California. It is the understanding of the committee that, early in 1959, a selection of one of the two above mentioned organizations will be made.

(2) Since the development of small, wingless guided missiles for tanks had not progressed beyond the feasibility study stage, it was realized that the relationship between the New Tank Main Armament System and the guided missile could only be discussed or studied in generalized terms. Nevertheless, the proposed 152mm armament system was presented to, and discussed with, both contractors in order to ascertain practicability of application of their missiles to this system.

4.2 Missile Features

(1) Based on the latest data available to the committee (Sperry report dated October 1958 and Aeronutronic's report dated 17 January 1959), the parameters for an appropriate missile launching device have not been firmly fixed by either contractor. However, both reports indicate that the desired launcher would be either the proposed 152mm Gun or a slightly modified version.

(2) The following are missile system characteristics proposed by each of the contractors, as pertinent to launcher design:

TABLE II

	Aeronutronic System	Sperry Gyroscope
Bore Diameter	6"	6"
Missile Length	39"	38.1"
Missile Weight (approx)	42.5 lbs.	32 lbs.
Mode of Stabilization	Fin	Spin
Motor Pressure	1000 psi	1000 psi (est)
Length of Travel	5'	8'-10'
Boost "G" Loading	25 optimum	30 sustained, 100 peak
Muzzle Velocity - approx	130 fps	100 fps

4.3 Compatibility of 152mm Gun and Missiles

(1) The ultimate goal of utilizing a guided missile as the primary armor defeating round of the 152mm Armament System was considered by the committee at all times during the study. The bore size, 152mm, was selected in accordance with that established by the missile systems' contractors for their proposed missiles. The tube length of the 152mm Gun was established nearly identical to that proposed by the contractors.

(2) Both contractors have stated that their proposed missiles can be fired from closed breech type weapons.

(3) Based upon the characteristics of the proposed missiles, the 152mm Gun appears to meet the requirements of the launcher desired in that the breech design can be easily modified, if necessary, to provide a means for (a) reducing pressure build-up on the missile motor and (b) assist in dissipation of heat over critical missile base components.

(4) Currently under study at Frankford Arsenal is a post launch correction type of missile (Polcat). Committee investigation into the use of this type of missile was not studied in detail, since it was apparent that such a missile could be readily adapted to the proposed Armament System.

4.4 Critical Design Areas

(1) Since both missile and launcher activities are still in the study phases, it is to be expected that a positive solution to all problem areas cannot be completely resolved without a more detailed study, and the possible manufacture of experimental hardware items.

(2) The Aeronutronic missile proposal is based upon fin stabilization and, as such, the missile cannot tolerate any rotation within the bore of the launcher. This will necessitate, perhaps, provision of guiding grooves parallel to the longitudinal axis of the gun. Such grooves will intersect the slow twist rifling provided for stabilization of the HE-HEAT conventional projectile. It is expected that a certain amount of experimentation with both rifling contours and projectile rotating bands will be necessary before a completely satisfactory arrangement can be attained. It is entirely possible that indexing of the conventional round may be required.

(3) The Sperry proposal indicates that, while basically the venting required will be accomplished around the sub-calibered body of the missile, there is a possibility that additional venting will be needed. This can only be verified by subsequent hardware manufacture and test. The employment in the gun of an alternate chamber of greater capacity or one embodying a variable chamber arrangement to counteract the venting requirement is feasible.

(4) Both contractors indicate that there may be a requirement to extend the firing contact of the gun forward from the rear face of the chamber in order to take full advantage of the chamber volume as noted above. If this is necessary, it will require modification to the configuration and assembly of the proposed dual-purpose HE-HEAT round.

4.5 Summary

In view of the foregoing, it is evident at the present time that experimental work will be required of the missile development agencies before the parameters of the required launcher can be definitely fixed, and the full extent of modification to the 152mm Gun (as offered in this report) be determined. However, the committee has taken the position that the proposed 152mm Armament System can be satisfactorily fitted to the guided missile, and as such, serve as an efficient launcher for both the missile and the dual-purpose shell.

Section 5

ARMAMENT SYSTEM ASSESSMENT

5.1 Introduction

In evaluating the proposed armament in order to ascertain practicability of development, it was necessary to assume that characteristics of the system be considered as established. Some changes are to be expected following program authorization in subsequent phases of design, manufacture, test and production engineering. In the final analysis, however, the hardware furnished the troops is not expected to differ greatly from the final approach depicted in this report. (See Fig. 6, page 32)

5.2 Evaluation of Primary Features

The following is a list of strong points which will be perpetuated through final hardware with a good possibility that many of them will be improved through refinement during development:

(1) The caliber of the system (152mm) and the HEAT type warhead selected will provide penetration adequate to breech the basic armor of existing or foreseeable future Soviet tanks and give a reasonable measure of insurance against the effects of special armor in the event the Soviets take such action in order to degrade the performance of HEAT ammunition.

(2) The size of the projectile will provide adequate damage after penetration.

(3) The spin stabilized projectile should permit achievement of low round to round dispersion.

(4) With the small propellant charge and low gun pressure, the attendant obscuration caused by muzzle flash, smoke and dust kick-up will be appreciably reduced from that of existing tank guns and should permit sensing of all projectile impact points. This should result in a vastly improved hit probability.

(5) Because of this ability to sense, delivery accuracy is not critically dependent upon provision of a sophisticated fire control.

(6) The proposed dual-purpose HE-HEAT round is considered most desirable in that it provides a tanker with a continuously balanced complement of ammunition. The logistic attributes of this aspect are self-evident.

(7) The warhead type selected permits redesign of the penetrator to include additional improvements which may result from future penetration development projects without requiring major redesign of the system.

(8) The weight of the complete one-piece combustible cased round will be consistent with the general requirement that the round be conveniently man-handled within the tank. In addition, the hazards of spent brass would be eliminated and ejection problems will be non-existent.

(9) Overall round length and diameter would be less than those usually associated with ammunition of comparable terminal performance.

(10) The system permits attainment of a high firepower to gun weight ratio by virtue of low pressures and a short gun tube.

(11) Gun tube accuracy life will be far in excess of current high velocity kinetic energy systems since such factors as the combination of high pressure, temperature and velocity have been significantly reduced. Therefore, gun erosion is minimized and a tube life of well over 1,000 rounds is predicted.

(12) Tank gun errors resulting from tube droop, bend and whip will be decreased.

(13) The low level intensity of muzzle blast should not have any appreciable adverse effect on exposed crew members or accompanying troops.

(14) Gun weight and inclosed length will be substantially less than those usually associated with the primary weapon mounted on light, medium or heavy gun tanks.

(15) The caliber and general configuration of the system is adequate to permit use of the gun as a launcher for guided missiles to enhance delivery accuracy at long ranges.

(16) The system will be simple, economical, easily produced, reliable and will provide a means of obtaining a safe transition during the period when primary reliance is being shifted from conventional types of ammunition to guided missiles.

With respect to the adverse characteristics of the system, three facts are evident. First and foremost, although hit probability is improved over that of existing systems, the chance of a first round hit remains at the same level as that of current weapons pending the development of the guided missile. Secondly, the system offered is predicated on chemical energy ammunition and has insufficient kinetic energy capability to permit effective utilization of both projectiles. Finally, the relatively low muzzle velocity will make it difficult to hit moving targets at the longer ranges if a simple fire control system is utilized.

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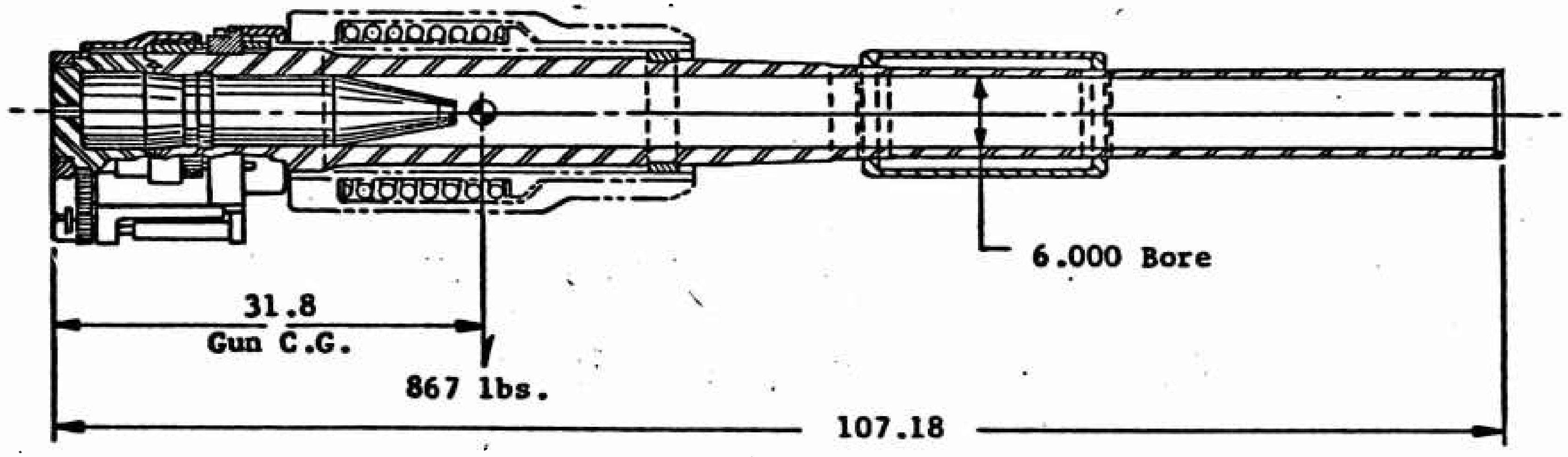
THE PROPOSED NEW TANK MAIN ARMAMENT SYSTEM



Ballistic Characteristics

Bore Diameter	152mm
Bore Length (including Chamber)	17.53 cal.
Muzzle Velocity	2260 ft/sec.
Wt. of Projectile	40 lbs.
Projectile Travel	96 ins.
Wt. of Propellant (M15)	7.5 lbs.
Vol. for Propellant	285 cu. ins.
Loading Density	.70 gm/cc
Max. Rated Pressure	32,000 psi (Cu)
Muzzle Energy	3,172,422 ft.-lbs.

Ammunition Characteristics

Fixed combustible cartridge case ammunition having dual purpose HE-HEAT projectile with Octol explosive filler, spin compensated liner and Lucky fuze. Armor penetration 7.7 inches at 60° at all ranges. Complete round weight is 47.5 lbs., over-all length is 27.75 in.

Physical Characteristics of Gun

Breech Mechanism--Semi-Automatic, Separable Chamber, Hydro-Mechanical Counter-Recoil Operation, Electric Firing

Tube ------------Monobloc Cylinder of 160,000 psi Min. Y.S. Steel, Coldworked.

Twist of Rifling--1:40 - Uniform Right Hand

Weights:

Complete Gun	867 lbs.
Tube	535 lbs.
Chamber	84 lbs.
Operating Mechanism	198 lbs.
Recoil Adapter	20 lbs.
Bore Evacuator	30 lbs.

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FIG. 6

Section 6

— VEHICLE APPLICATIONS —

6.1 Purpose

To complete the cycle of the design and evaluation study on an armament system, it is mandatory that thought be given to its final installation in the combat vehicle. Retrofit to existing vehicles, although possible, was not considered since the full benefit to be derived from the armament system could never be realized. Therefore, the current development T95 Series Tank was chosen as the first and most economical vehicle application of the 152mm Gun. Looking at future vehicle types, the 152mm package appears favorable in a main battle tank and an armored reconnaissance/airborne assault vehicle, amphibious which have been designed specifically for the proposed armament systems. Because of the small size and light weight of the 152mm Gun, many other possibilities for vehicle installation are evident and the applications depicted herein show only part of the versatility which can be achieved.

6.2 T95E Tank, (152mm Gun Turret) Fig. 7, page 40

(1) This study is comprised of an optimum turret for the 152mm Gun mounted on a standard T95 chassis. The turret will afford protection at 1500 yds. within a 60° frontal arc against the Russian 100mm round (3400 feet per second) for a combat turret assembly weight of approximately 28,000 lbs.

(2) The gun will be installed in a mount which provides seven inches of recoil. The turret and fire controls will utilize existing components or those under development. This turret will be capable of accepting either the Cadillac Gauge control or the present electric-hydraulic stabilization system.

(3) The small gun with its short C.G. permits gun mounting well forward of the turret center line. The commander is located directly behind the gun in the center of the turret and can rotate with the cupola through 360° while standing or sitting. Repositioning of the cupola to the center of the turret provides ample loading space and permits the gunner to be moved rearward in order that balanced armor protection might be applied to both sides of the turret.

(4) This turret can accept a two-meter base range finder in the commander's position. As an alternative, a one-meter base range finder can be installed in either the gunner's position or in the commander's cupola.

(5) The complete description of the fire control and ammunition stowage and handling are covered in detail under 6.5 and 6.6

6.3 <u>Main Battle Tank</u> (Fig. 7, page 41)

The future main battle tank is a proposed new concept that will (a) be based on proven automotive components, (b) be of conventional configuration, (c) incorporate increased radiological protection, and (d) mount as the main armament the 152mm Gun. It is estimated that this vehicle will weigh approximately 25-35 tons. The design goal is 25 tons combat loaded. This vehicle will be capable of reduction to the Berne International Tunnel Agreement specifications and to dimensions prescribed by SR 705-30-10 for Phase III airborne operations.

The tank design approach to be taken will be toward eliminating known disadvantages of current medium tanks. In order to achieve weight reduction, the crew, including driver, is placed in the turret fighting compartment. The departure of the vehicle design from the conventional approach lies essentially in dividing the hull and turret into three separate components; these are - the turret fighting compartment, the engine compartment, and the hull support structure compartment. The turret fighting compartment is completely enclosed, heavily armored, and contains components which demand the greatest protection. The hull consists of three elements; an armored engine compartment, the heavily armored pod of the turret basket fighting compartment, and a lightly armored structure which supports the suspension.

Vehicle mobility will be enhanced in many respects. The most favorable power plant for this time frame is a diesel engine, probably an off-shoot of the current diesel developments, AVDS-1100 and the LVDS-1100 engines. The engine installation will be either in line or transversely mounted and coupled to an XTG-410 type transmission.

The suspension will be similar to that of the T95 Tank. However, the track design principles may change appreciably. This vehicle will feature a track which will have marked improvements over existing types. A shoe-type, semi-open, highly aggressive track, with removable rubber pads, is proposed. The track, without pad, will be open and self-cleaning in order to assure high traction in mud. For over-snow and domestic highway operation, it will utilize pads to assure low ground pressure. To further improve vehicle mobility, the hull underbelly will be smooth and free from projections in order to minimize resistance from soft mud and snow. The high weight density of this vehicle prohibits sufficient displacement of water to permit floating; however, studies indicate that a permanently installed, collapsible flotation kit could make this vehicle inherently capable of repeatedly negotiating inland waterways.

It is envisioned that the fire control in this tank will provide the dual capability of firing both conventional and unconventional ammunition.

6.4 Armored Reconnaissance/Airborne Assault Vehicle, Amphibious

The Armored Reconnaissance/Airborne Assault Vehicle, Amphibious is an all-aluminum vehicle weighing 25,000 lbs. with an overall reducible height of 92", width of 102", and an overall length of 256-3/4". This weight and size permits air-drop in a phase I airborne operation and makes it capable of negotiating inland waterways. The hull and turret are constructed of rolled aluminum plates of 1-1/4" thickness above the sponson and 3/4" below. The overall frontal ballistic protection is equivalent to 1" of conventional armor.

This vehicle is amphibious without added kits or flotation devices, with the water line approximately 5-1/2" below the top of the hull. The vehicle is dependent on the tracks for water propulsion with a water speed of approximately 4 MPH.

The 152mm Gun will be installed in a mount which allows 18" of recoil. A total of 45 rounds of ammunition are stowed in the manner discussed in Section 6.6 Ammunition Stowage and Handling.

The turret control for this vehicle is the standard Cadillac Gauge system. A detailed description of fire control is contained in Section 6.7.

The vehicle carries a crew of four, i.e., a commander, driver, gunner and loader. The power package is the GMT-305 multifuel turbine engine coupled to an XTG-90 transmission. It will have the capability of performing a 24 hour battlefield day.

6.5 Comparison of Vehicle Characteristics

	T95E 152mm Gun Turret	Main Battle Tank	Armored R/AAV,A
Crew	4	3	4
Weight	80,000	60,000	25,000
Hull Length	283-3/4"	227-1/2"	253"
Length w/Gun Forward	283-3/4"	249"	256-3/4"
Overall Height to Top of Turret	88-1/2"	80-3/4"	92"
Width	130"	130"	102"
Ground Clearance	17"	17"	15"
Armor:			
Hull Front	4.4 at 60° equal	4.4 at 60° equal	Alum 1½ at 35°
Hull Side	4"-2" at 0°	2" at 0°	Alum 1½ at 0-20°
Hull Side(Engine C'ptment)	1.25 at 0°	1" at 0°	Alum 1½ at 0-20°
Hull Rear	1"	1" at 10°	Alum 1½ at 30°
Hull Floor	1"-3/4"-1/2"	1" - 1/2"	Alum 1/2"
Turret Front	7" at 60°	7" at 60°	Alum 1½ at 50°
Turret Side	3" at 45°	3" at 45°	Alum 1½ at 25°
Turret Roof	1-1/2"	1-1/2"	Alum 1½"
Armament:			
Primary	152mm Gun	152mm Gun	152mm Gun
No. Rounds	50	36	45
Elevation	20°	20°	20°
Depression	10°	10°	10°
Traverse Left & Right	360°	360°	360°
Power Package:			
Engine	LVD-1100 or AVD-1100	Liq-cooled Diesel	GMT-305 Multifuel Turbine
Transmission	XTG-410	XTG-410	(XTG-90-Mod)
Performance:			
Horsepower/ton Net-Spr	9.4	12.	13.75
24 Hour Battlefield Day	Yes	Yes	Yes
Unit Ground Pressure	10.1	11.0 psi	6.4 psi

6.6 Ammunition Stowage and Handling

(1) Stowage and handling of the main armament ammunition in combat vehicles presents a major problem in tank design. The rounds must be stowed in a location that is well protected and easily accessible to the loader as well as members of the crew.

(2) The holocaust caused by ammunition fires due to a penetration justifies a much greater effort in devising systems which will assure complete immunity from this hazard. It is reasonable to assume that by eliminating the ammunition fire hazard, the tank fighting compartment could sustain a much greater number of armor penetrations before the tank is rendered inoperable.

(3) The concept studies of the various vehicles, as shown in Figures 7, 8 and 9, indicate the best place to stow a one-piece solid propellant round to be in the turret bustle. This location has several advantages:

a. The ammunition always has the same space and distance relationship to the weapon regardless of the azimuth direction of the turret with respect to the hull. This is particularly advantageous for automatic loading systems. It is a definite advantage for manual loading since the loader is always approximately between the weapon and the ammunition, and the distance the loader must move to obtain the round and transport the round to the breech is minimized.

b. The ammunition volume can be made into a separate compartment and isolated from the crew location by simply placing an armored bulkhead at the forward part of the bustle just slightly rearward of the traverse ring. The ammunition can be stowed horizontally and oriented for ease of loading. The rounds can be selected and moved to an opening in the bulkhead large enough to permit extraction of the round. Since the selected round is always delivered to the same location, both manual loading and automatic loading are simplified.

c. All the ammunition is located in one easily accessible space instead of throughout the entire fighting compartment. This tends to minimize the projected area of the ammunition, and will, therefore, minimize the probability of a hit on the ammunition. Placing all the ammunition in one location minimizes the armor required to protect it.

d. Added protection is afforded the ammunition by the turret. If we assume that in most cases the weapon will be pointing approximately in the direction of the line of fire, then we have the front armor and obliquity of the turret between the oncoming projectile and the ammunition.

(4) In the event of an ammunition fire in the bustle, a high pressure relief door is designed to blow open. This will minimize the effect of the increased pressure caused by the burning propellant on the inner bulkhead between the crew and bustle.

(5) The ammunition stowed in the hull in the conventional vehicles can also be compartmentized and the same principle applied in sealing off the ammunition in the driver's compartment to minimize the hazards of ammunition fires.

6.7 Fire Control Systems for Concept Tanks

(1) T95E 152mm Gun Turret

This concept has the capability of easily accepting any and all types of fire control either developed or presently under development. A long base coincidence type range finder has been placed cross-turret in the conventional manner for use by the commander. In the normal system the output of the range finder would be fed to an electrical computer of the XM16 type which would combine this data with other input variables, such as cant, angle of sight, cross wind and lead, to compute a final azimuth and elevation setting for the gunner's sight. The output of the computer would then be fed to the articulated telescope which in this case would be the primary sight. Boresight loss errors would be minimized, there would be no errors due to change of parallax with elevation of the gun, and the errors normally associated with periscope linkage systems such as backlash and temperature variability would be deleted.

In addition the concept shows a 50 caliber coaxial ranging machine gun, which may be used in lieu of the cross-turret range finder. With the ranging machine gun installed, a reticle projector may be used with a tilting mirror periscope of the T50 type in order to introduce the required correction for crosswind and cant. Some simplification of the present type reticle projectors may be achieved depending upon the degree of compatability of the spotting round with the main armor defeating round.

A third primary system may utilize the short base coincidence range finder T57 mounted in the cupola. This system would incorporate the computing and sighting components as outlined for the long base range finder system.

(2) Main Battle Tank

The main battle tank concept can employ the short base range finder with the full solution computer system or the ranging machine gun system. It is not feasible in this concept to utilize a long base cross-turret range finder.

(3) Armored Reconnaissance/Airborne Assault Vehicle, Amphibious

The armored reconnaissance/airborne assault vehicle, amphibious may utilize a ranging machine gun system with the required associated equipment. The practicability of using a cupola mounted range finder in this weight category is marginal but not entirely beyond feasibility.

(4) SUMMARY

a. The ranging machine gun (.50 cal) system can be utilized in all of the concept vehicles.

b. In only the T95E__ 152mm Gun Turret concept can the long base cross-turret range finder be successfully employed.

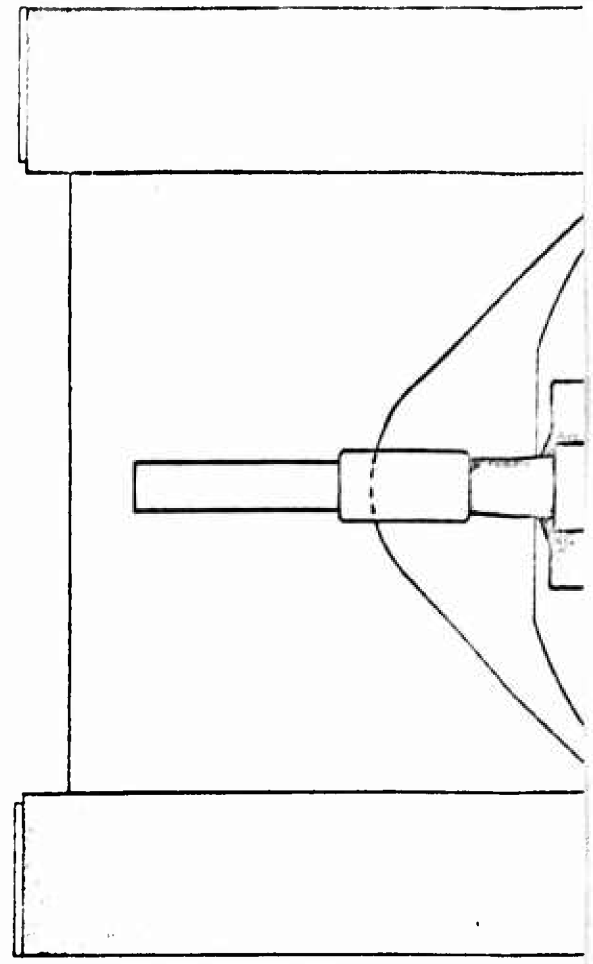
c. The short base range finder can be incorporated in all concepts; its use, however, in the armored reconnaissance/airborne assault vehicle, amphibious presents design difficulties.

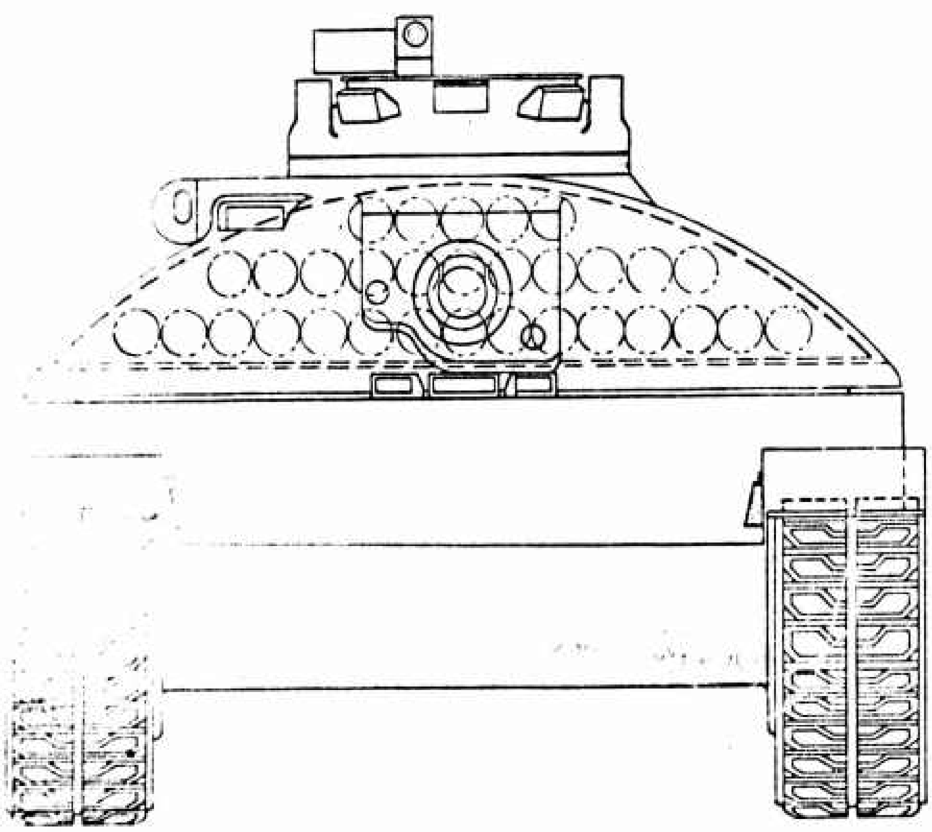
d. The conventional primary sighting system, i.e., periscope, is utilized in all concepts, an unconventional system, i.e., direct fire telescope as the primary sight, can be easily incorporated.

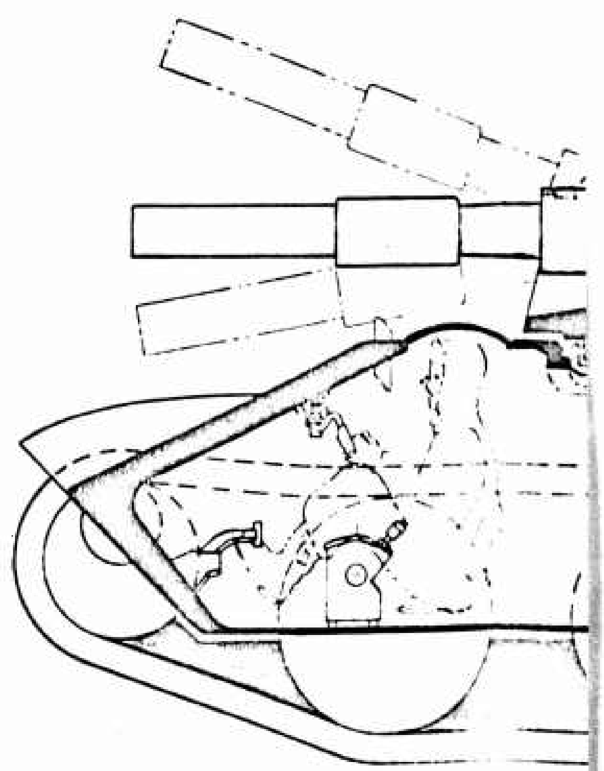
e. Systems utilizing the gunner's periscope as the primary sight incorporate the direct fire articulated telescope as the secondary sight.

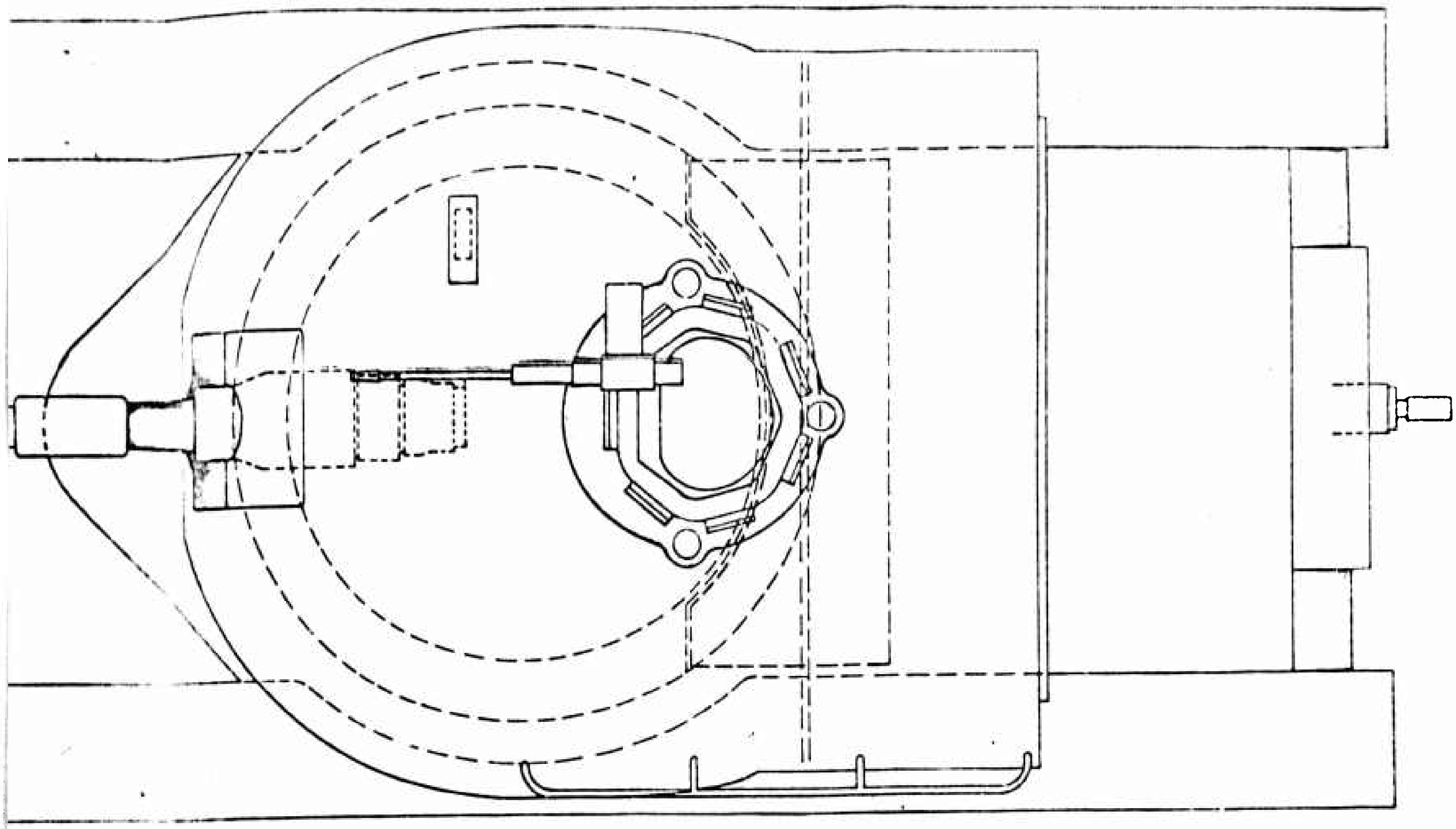
f. The muzzle boresight device will be used with all fire control systems unless future tests show the total muzzle movement of the 152mm Gun to be insignificant compared with present day tank guns.

TANK, 152 MM GUN, T95E_









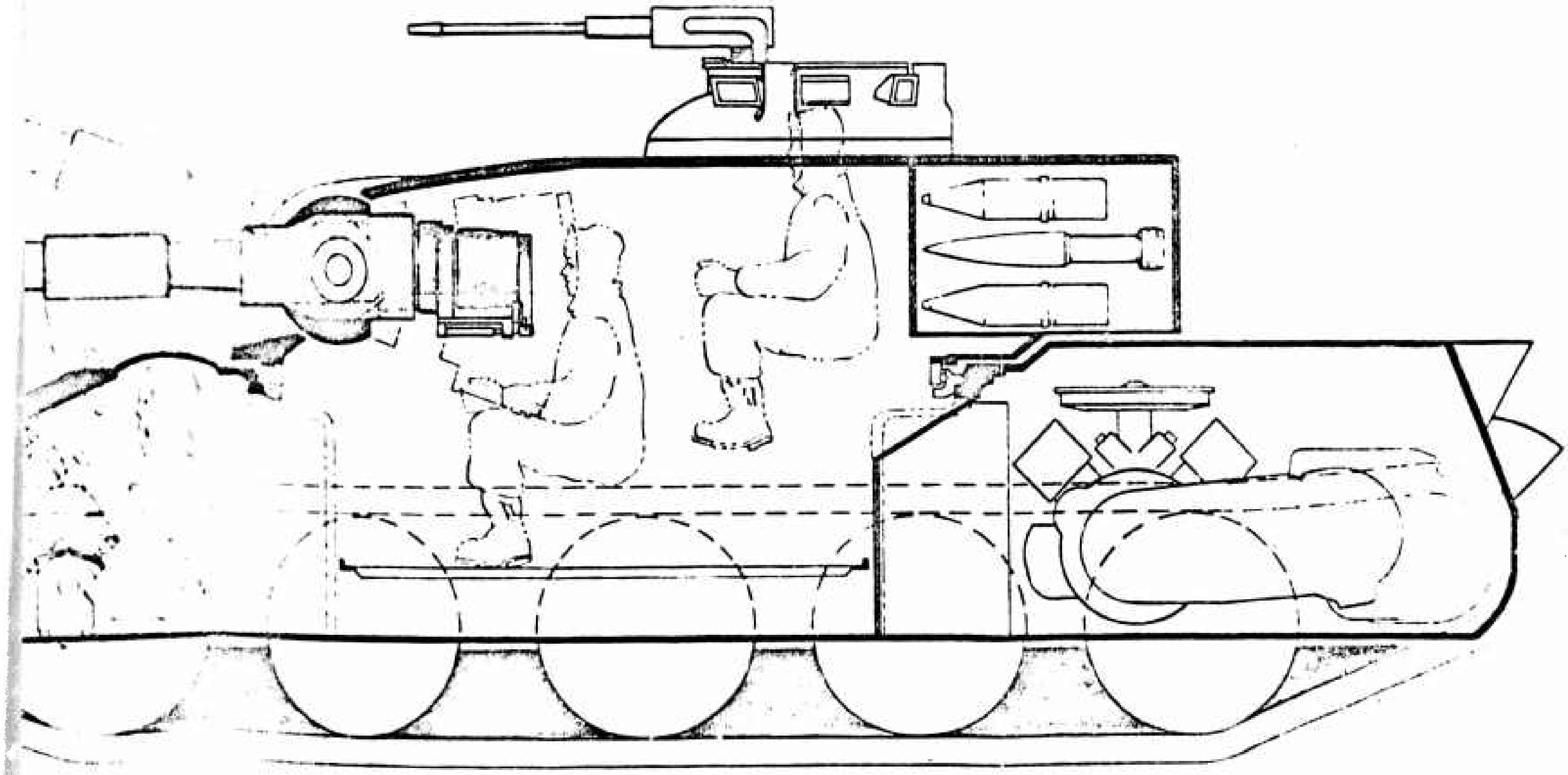


FIG 7

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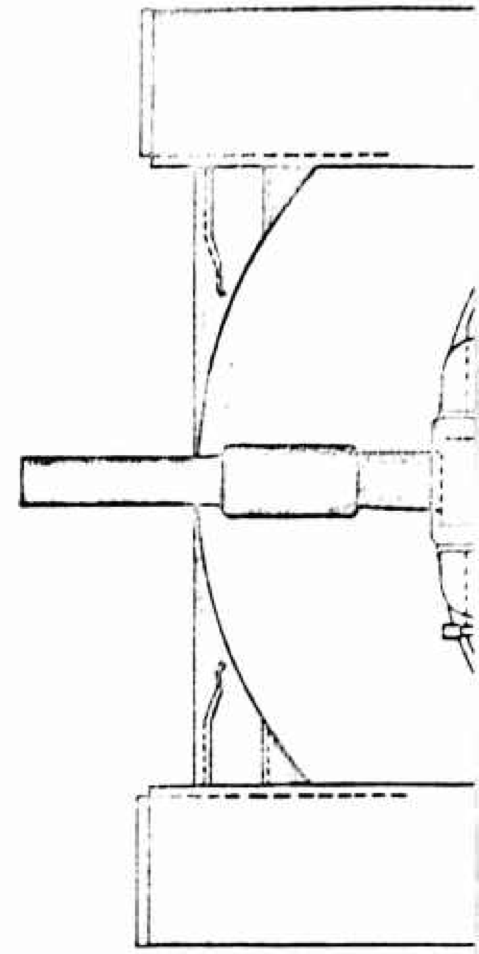
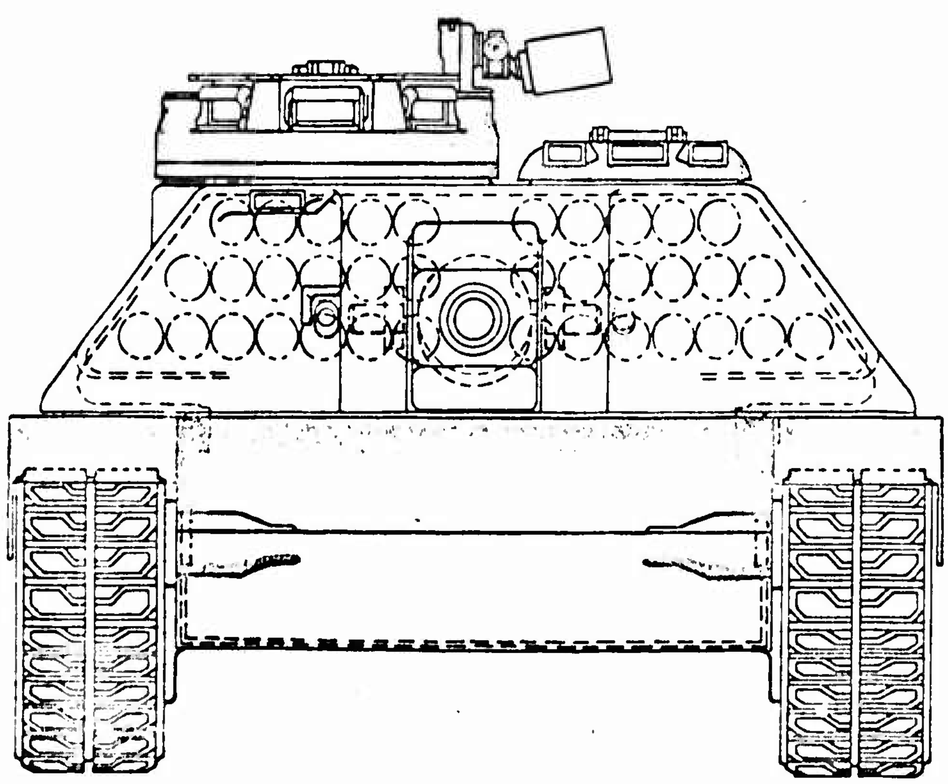
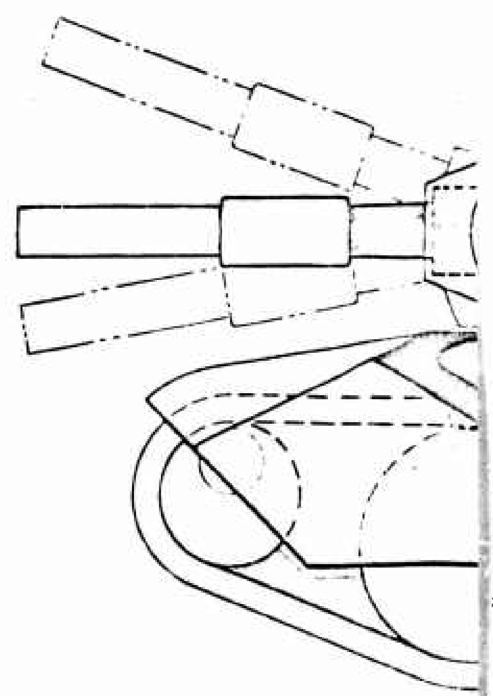


152 MM GUN, MAIN BATTLE TANK





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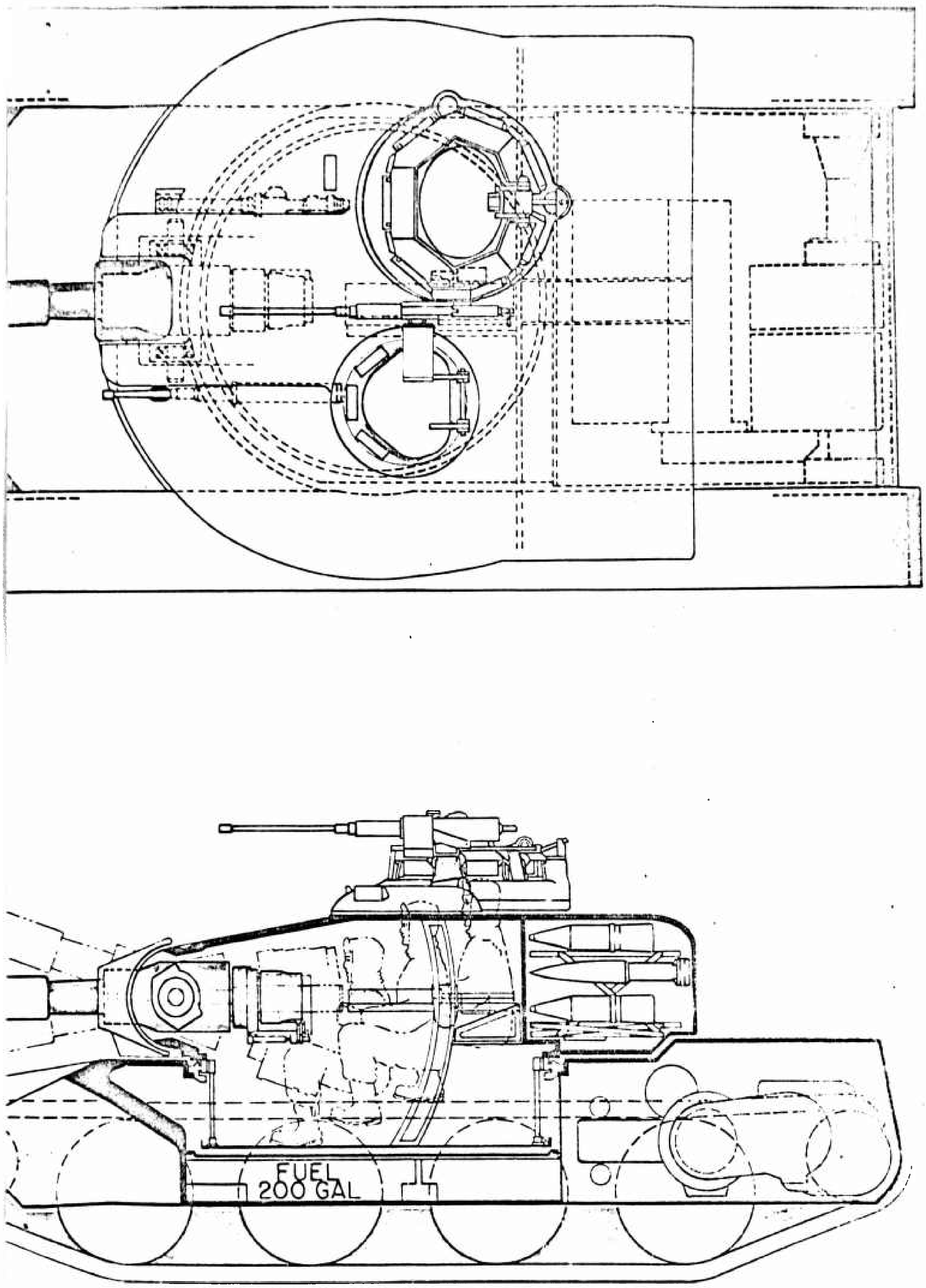

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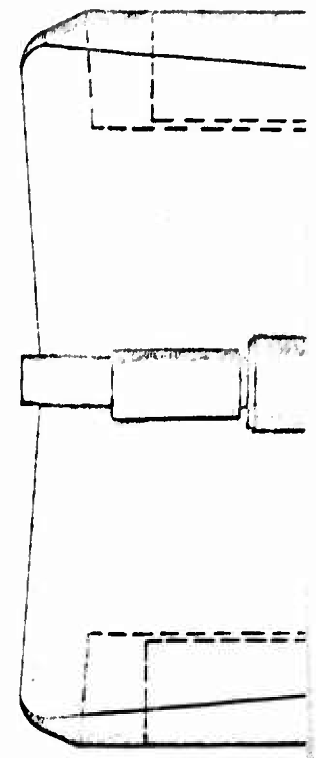
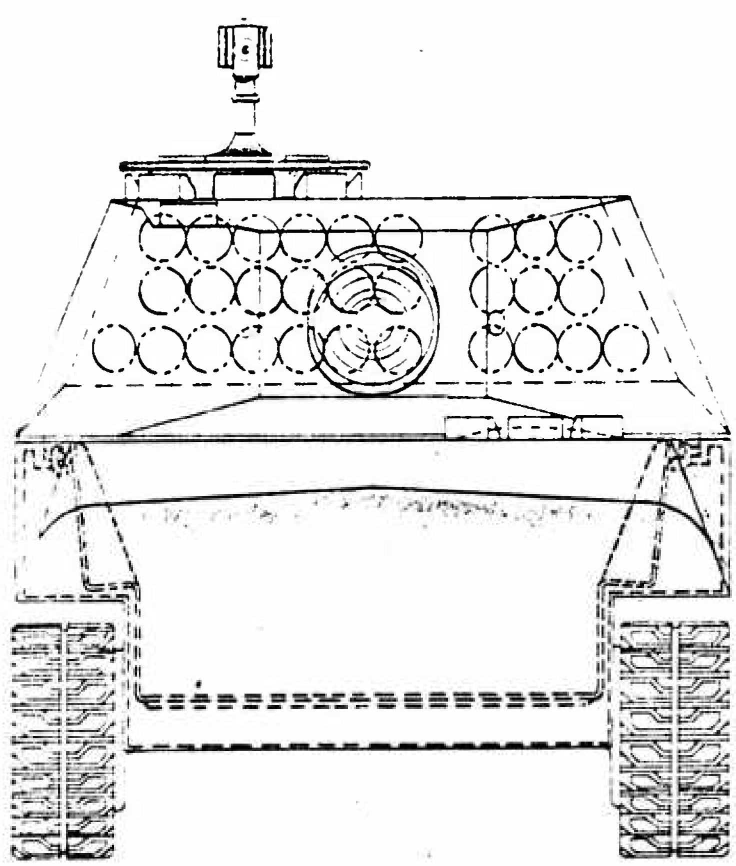
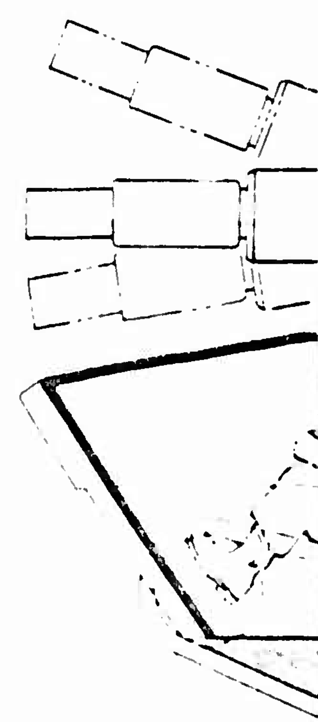


152 MM GUN, ARMORED RECONNAISSANCE AIRBORNE ASSAULT VEHICLE, AMPHIBIOUS





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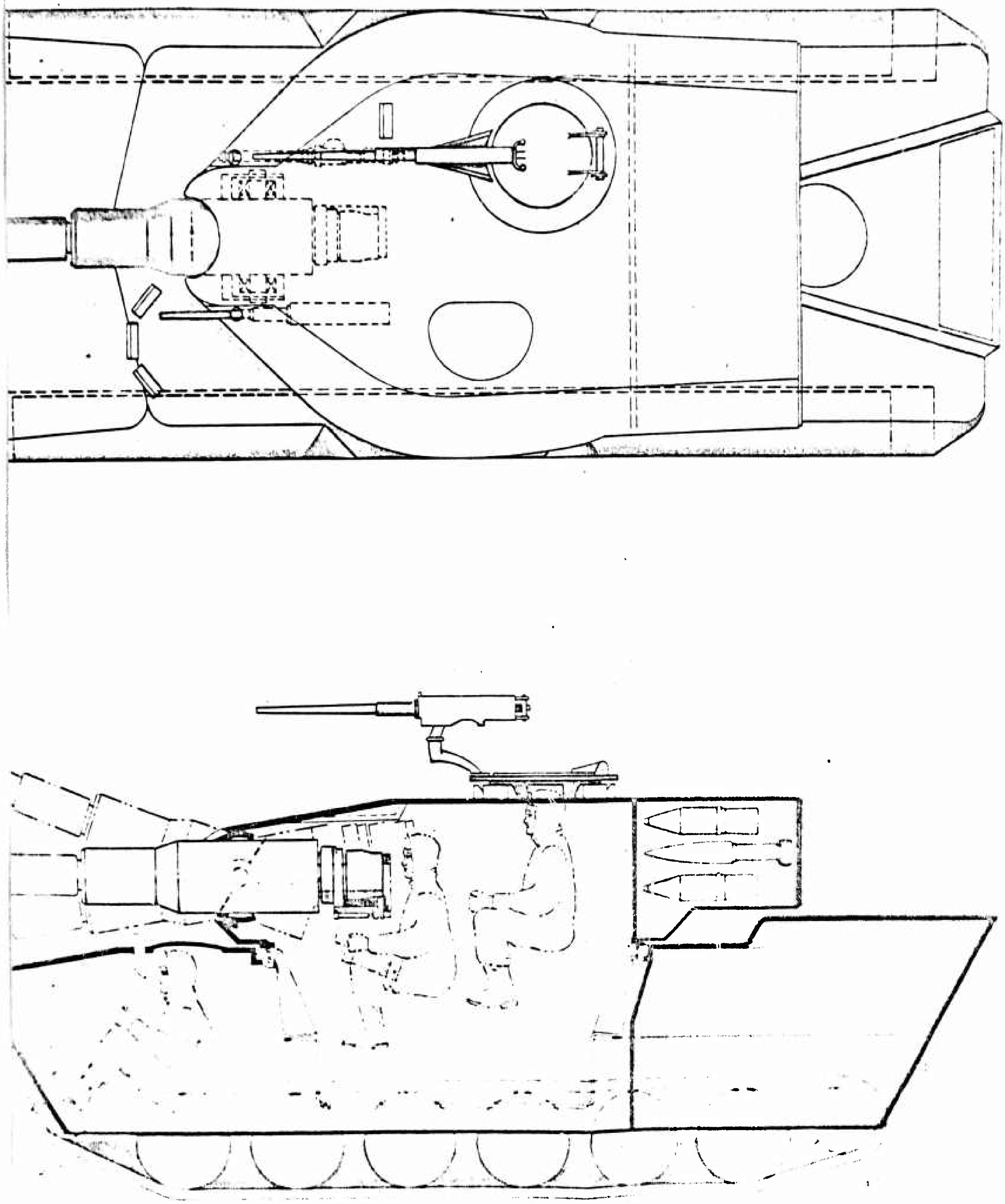

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FIG 9.

Section 7

— PROPOSED DEVELOPMENT PROGRAM —

7.1 Armament System Schedule

(1) To fully establish the practicability of development of the proposed Armament System, thorough consideration must be given to the period of time required before such a system can materialize and be integrated with the using forces. Since missile development is being conducted under a separate program, the armament development schedule presented herein deals exclusively with the gun and conventional dual-purpose round.

(2) Figure 10, page 46 reflects the development time frame and funding requirements for the New Tank Main Armament System. Based on a presumed availability of funds and an OTCM project approval by 1 April 1959, the following significant dates can be established:

a. Complete system firing demonstration by October 1960.

b. Completion of final engineering tests of the dual-purpose round by October 1962.

c. Submission of the production engineered system for User test in July 1963.

d. First production systems available to troops in December 1963.

7.2 Vehicle Development Schedule

(1) Figure 11, page 47 shows program time and funding requirements for three types of futuristic combat vehicles which fully utilize the merits of the proposed armament system. For economic reasons the T95 type tank has been included since a major portion of development on this vehicle has already been completed. The Main Battle Tank and the Armored Reconnaissance/Airborne Assault Vehicle, Amphibious are proposed since they represent the most advanced type of combat vehicles which can be developed within the specified time frame.

(2) Using the same project approval and funding date as for the Armament System, programming for vehicle development can be highlighted as follows:

a. Review of vehicle mock-ups by August 1959.

b. T95 Tank engineering decision by June 1960.

c. Complete systems firing demonstration by October 1960.

d. Main Battle Tank and Armored Reconnaissance/Airborne Assault Vehicle, Amphibious engineering decision by November 1961.

e. Submission of the production engineered systems for User test in July 1963.

f. First production systems available to troops in December 1963.

7.3 Comparison of Development Phases between New Tank Main Armament System (NTMAS) and the Combat Vehicle Weapons System (Pentomic) (CVWS)

(1) In view of the desirability for both systems to employ a common launcher, the following similarity and differences in development schedules are to be noted:

a. Ordnance Firing Demonstration dates:

October 1960 (NTMAS)
August 1961 (CVWS)

b. Availability for User test:

January 1962 (CVWS)
July 1963 (NTMAS)

c. An operational availability date of December 1963 is scheduled for both systems.

(2) The later date listed for the missile system "Ordnance Firing Demonstration" primarily results from the difference in development procedure between "in-house" work on conventional type ammunition and missile development work on contract.

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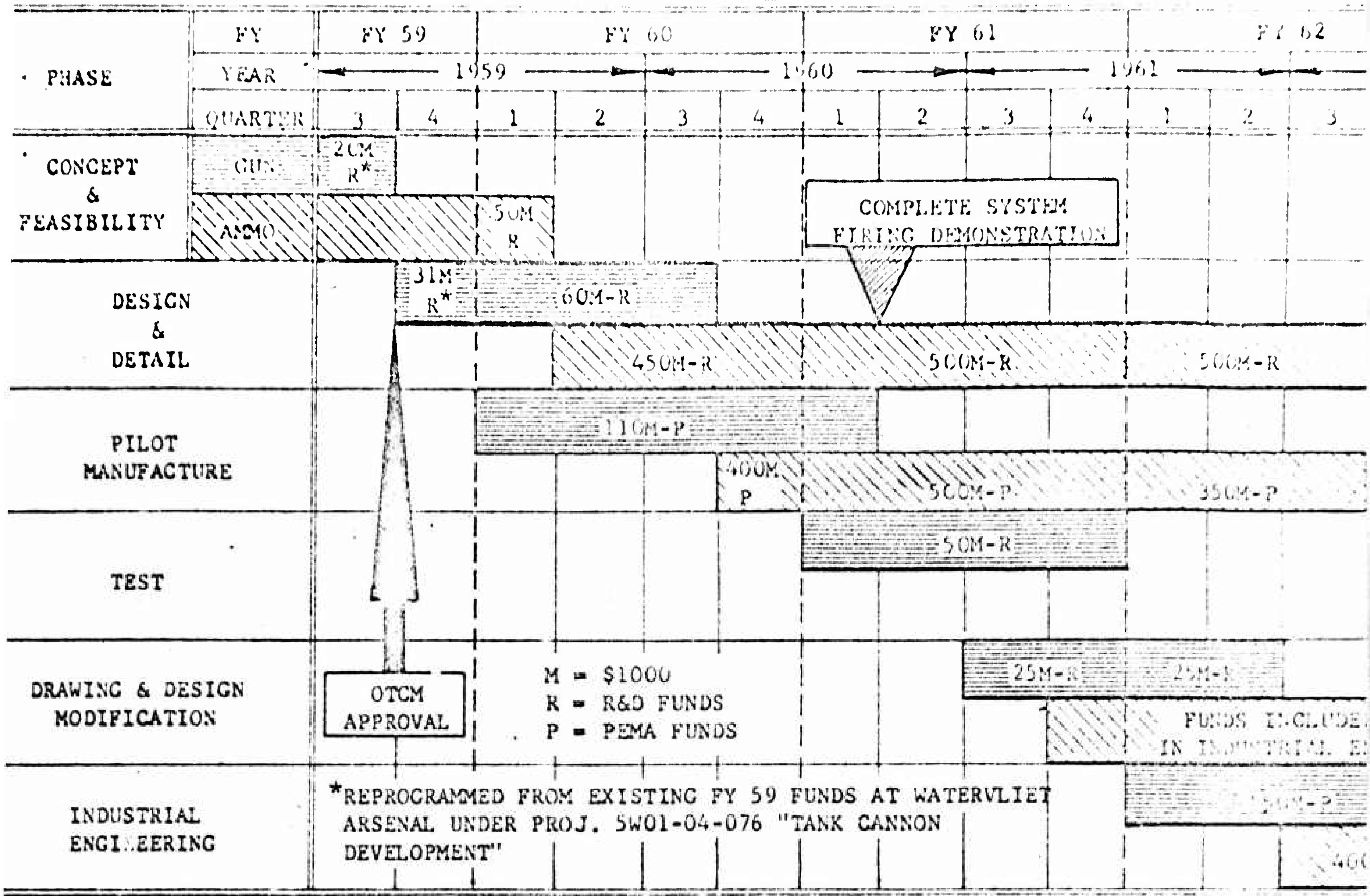
Procedure calls for missile demonstration by the missile contractor prior to the termed "Ordnance Firing Demonstration" and time is allowed to permit the contractor to refine designs before the actual Ordnance demonstration. Differences in User test availability dates result from the fact that pre-production missiles will be furnished to the User while the dual-purpose rounds will be furnished from an R & D production engineered lot of ammunition. Since selection of the missile contractor has not been made at the time of preparation of this report, the schedules listed for missile development are perhaps more tentative than those laid down for the conventional ammunition. Following contractor selection, coordination will be exercised to provide greater compatibility between development dates.

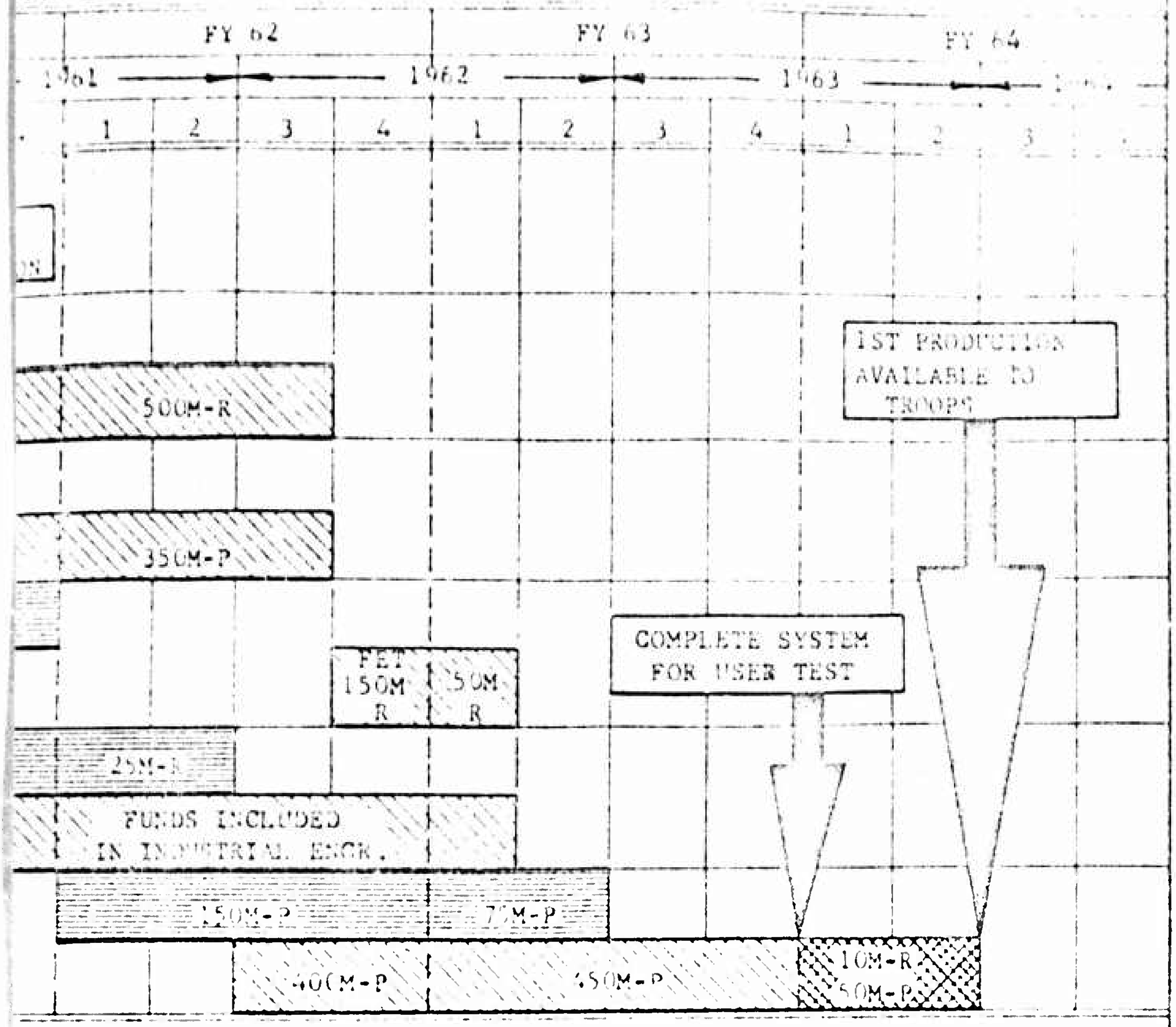
NEW TANK MAIN ARMAMENT SYSTEM



COMBINED FUNDING TOTALS BY FISCAL YE

	FY 59	FY 60	FY 61	FY 62
CONCEPT	$20,000 R&D	$50,000 - R&D	—	—
DESIGN	$31,000 R&D	$510,000 - R&D	$500,000 - R&D	$500,000 - R&
MANUFACTURE	—	$510,000 - PEMA	$500,000 - PEMA	$350,000 - PEM
TEST	—	—	$50,000 - R&D	$150,000 - R&
DESIGN MODIFICATION & INDUSTRIAL ENGRG	—	—	$25,000 - R&D	$25,000 - R& $5[illegible]0,000 - PEM
FY TOTALS	$51,000 R&D	$560,000 - R&D $510,000 - PEMA	$575,000 - R&D $500,000 - PEMA	$6[illegible],000 - R& $[illegible]00,000 - PEM

...IAMENT SYSTEM



...LS BY FISCAL YEAR

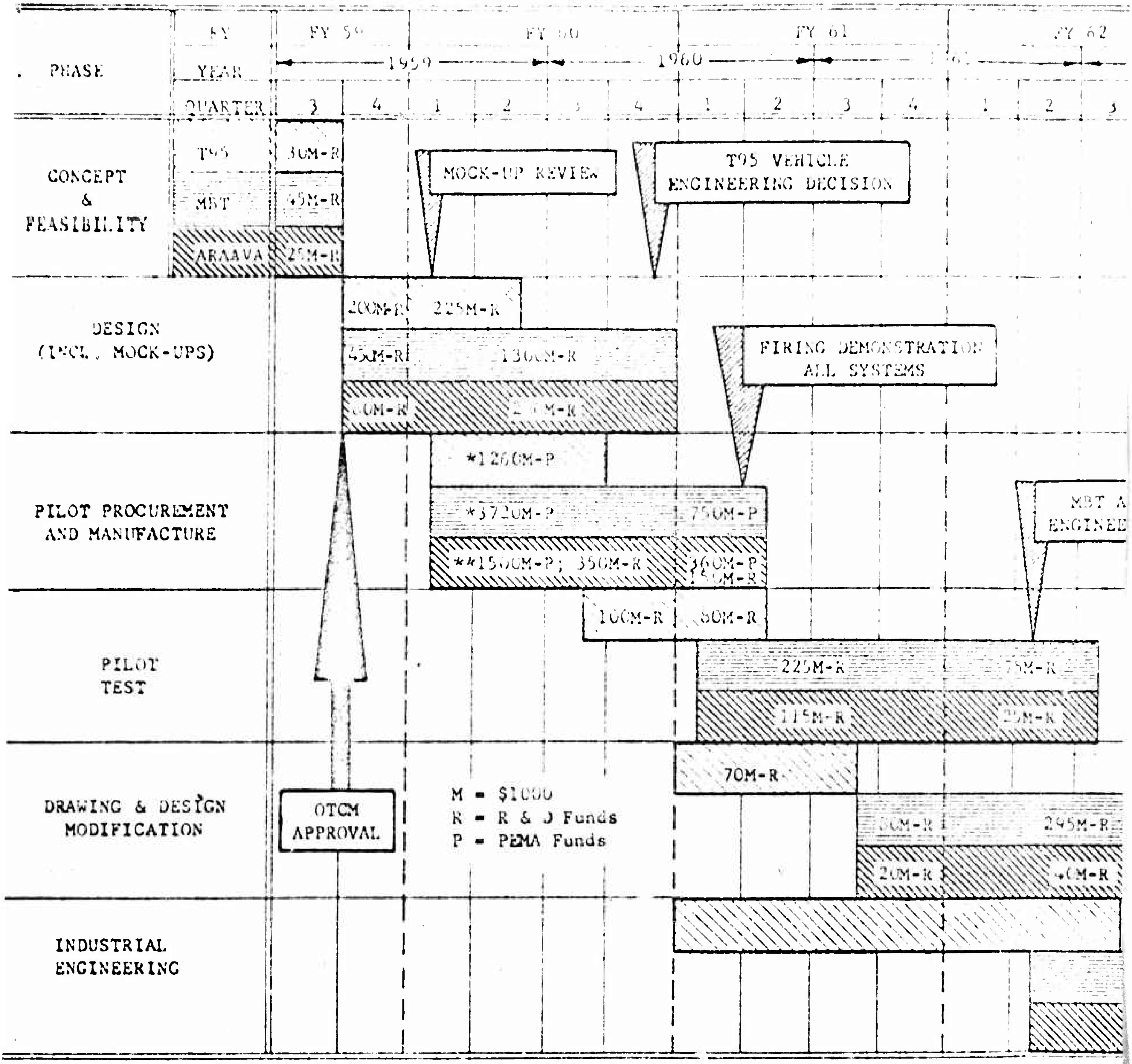
—	—	—
$500,000 - R&D	—	—
$350,000 - PEMA	—	—
$150,000 - R&D	$50,000 - R&D	—
$25,000 - R&D $550,000 - PEMA	$525,000 - PEMA	$10,000 - R&D $50,000 - PEMA
$675,000 - R&D $900,000 - PEMA	$50,000 - R&D $525,000 - PEMA	$10,000 - R&D $50,000 - PEMA

FIG. 10

...NTIAL

FOR RELATED VEHICLE DEVELOPMENT

1. TANK, T95E_ 2. MAIN BATTLE TANK (MBT) 3. ARMORED RECON



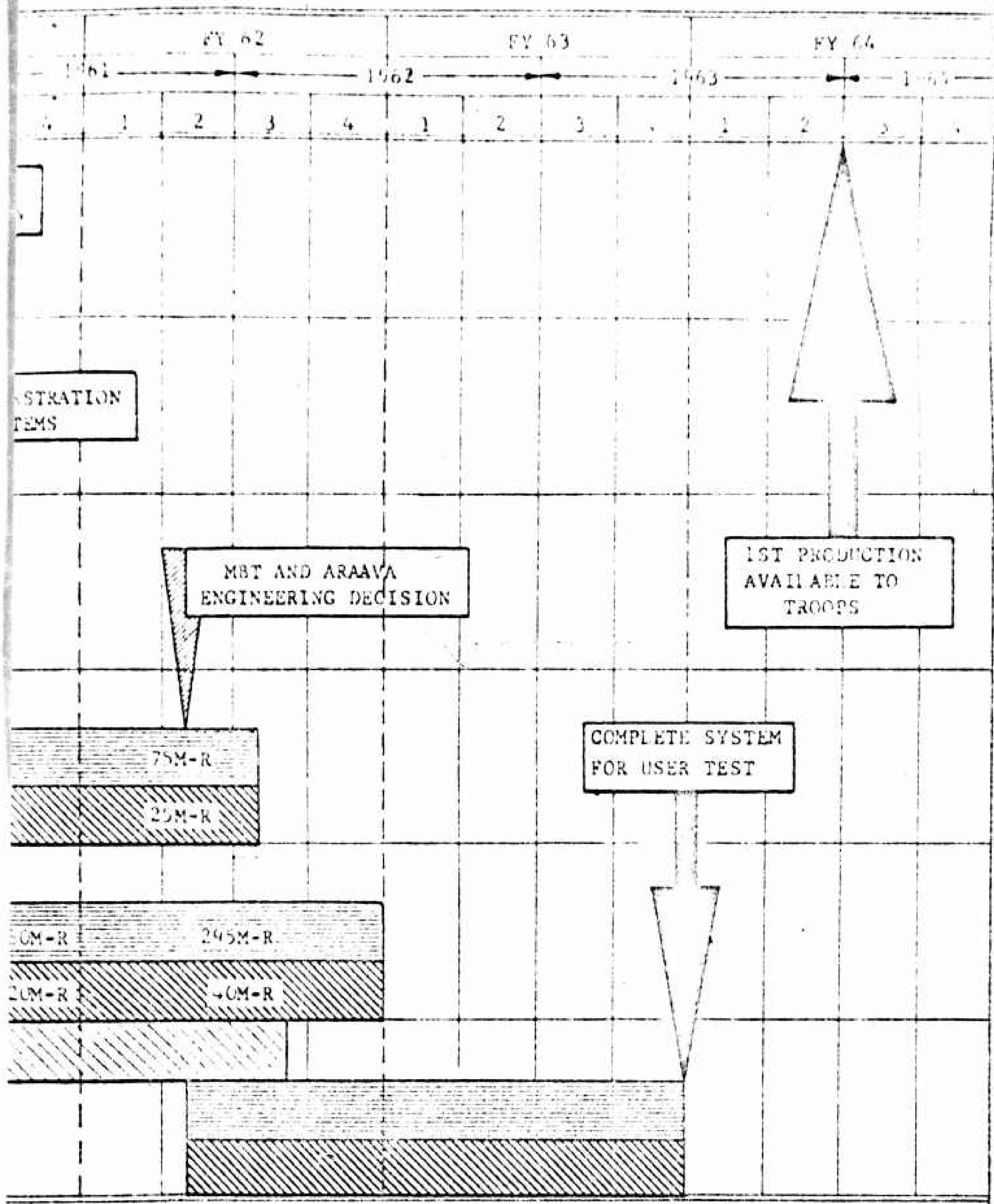
Funds listed under FY 59 are not available.

The above estimates cover four (4) pilots each of the T95 and the Main B. two (2) assault vehicle pilots. Also included with fiscal estimates are ware procurement requirement by other agencies, such as Watervliet and F

* includes $220,000 for guns and spare barrels
** includes $110,000 for guns and spare barrels

CONFIDENTIAL

ARMORED RECON./ASSAULT VEHICLE (ARAAVA)



the T95 and the Main Battle Tanks and
h fiscal estimates are vehicular hard-
ch as Watervliet and Frankford Arsenals.

FIG. 11

Section 8

—— SYSTEM EVALUATION ——

8.1 Objective

(1) The objective of the study presented in this section is to estimate the over-all capability of the 152mm concept armament system in the anti-tank role. The evaluation which was performed deals only with the offensive capability of the system against the JS 3 tank. The quantity used to indicate this capability is expected time to achieve a kill.

(2) Numerous pieces of input data were required to arrive at the expected time to kill. Throughout the study, an effort was made to utilize data which were the most representative of combat situations.

(3) For comparison purposes, identical calculations were performed for the 105mm T254E2 gun firing the kinetic energy APDS"H" type ammunition. The T254E2 gun is the proposed armament for the XM60 tank. The fire control assumed for the 152mm utilizes a spotting rifle. This type of fire control has been shown by previous studies to be the best for a gun such as the proposed 152mm armament. The fire control to be used on the XM60 tank is one similar to that currently on the M48A2 tank. It is planned also to eventually use a ranging machine gun on the XM60. Therefore, calculations were performed for the 105mm gun using these two fire controls. Some characteristics of the 152mm and 105mm armament systems are shown in Table III.

TABLE III

Comparative Characteristics of the 105mm & 152mm Armament Systems

		152mm Concept	105mm T254E2
Round weight	(lbs.)	47.5	40.5
Round length	(ins.)	27-3/4	31.8
Gun weight	(lbs.)	867	2475
Gun length	(ins.)	107.2	218.5
Breech to C. G.	(ins.)	31.8	63.7
Max. dist. from C. of G. to rear of rd. when loading	(ins.)	57.8	88.5
Muzzle velocity	(ft/sec)	2400*	4850
Penet. into RHA at 60° at 2000 yds	(ins.)	7.7	4.2

*Work in this section is based on the 2400 fps velocity and a reduction of velocity to 2260 fps and the slightly increased time of projectile flight should not seriously affect the results presented herein.

8.2 Procedure

(1) The procedure used in this study is not unusual. Initially, the over-all problem was divided into a number of sub-problems which could be studied individually. Then the results of these sub-problem studies were used as inputs to calculations intended to provide the estimate of overall capability. The sub-problem areas considered were:

a. 1st round hit probability

b. Probability of kill given a hit

c. Probability of, and errors in, sensing the location of missing rounds

d. Hitting probability of a round fired after a missing round was sensed

e. Hitting probability of a round fired after a missing round was lost

f. Hitting probability of a round fired after a hit on a previous round

g. Rate of fire

(2) Treatment of each of the above mentioned problem areas was straightforward and will not be discussed in detail here. Rather, results of the sub-problem studies will be given along with a few pertinent remarks and a reference as to where details may be found.

(3) Combination of the results of the sub-problem studies was simple in principle, but, due to the large number of factors involved, it became complex in practice. Rather than devote several pages to a series of equations to explain the way in which the end product is computed, the diagram of Fig. 12 was prepared to indicate the information flow pattern. An examination of this diagram reveals that all of the transition probabilities required for calculating the chance of kill on any given round or within any given number of rounds can be calculated by use of the input data obtained from the sub-problem studies. (See pg 55)

8.3 Input Data

(1) The inputs obtained from the sub-problem studies are given in Table IV. Details of the computation of first round hitting probability (entry 1 of Table IV) may be found in refs. 1 and 12 of Appendix I, page 61. Note that the first round hitting probabilities of the 152mm system are about the same as those for the 105mm system using the M48 tank type fire control while those of the 105mm system using the ranging machine gun (with the technique employed by the U.K.) are considerably lower. This result emphasizes the advantage of the spotting rifle with the low muzzle energy system. The spotting rifle does an excellent job of correcting for errors which increase as velocity fall-off and time of flight increase when the trajectory of the spotter is nearly a match of the major caliber trajectory. Errors of jump are not corrected by a ranging machine gun. The 152mm system offers a close match of trajectories and low jump. Hence, a relatively high hitting probability is obtained with the spotting rifle system. The 105mm ranging machine gun system, on the other hand, has a very poor match of the two trajectories and high jump is associated with the high velocity, heavy, long gun. Hence, while the machine gun decreases the ranging error and some or all of the cant and cross wind error, it does nothing to correct for other errors and, in addition, it introduces its own round to round dispersion, muzzle velocity variations, jump, etc.

(2) The probability of hit given a hit on a previous round (entry 2) involves only round to round dispersion. It was assumed that perfect sensing is had on hitting rounds. The round to round dispersion of the 152mm projectile was taken as .24ₘ std. dev. and for the 105mm projectile as .31ₘ std. dev.

(3) The probability of hitting given one lost missing round is entry 3. These probabilities are very low. It was assumed that after the first loss the subsequent round would be fired with the same lay, the primary object being to gain information by sensing. If more than one loss occurred it was assumed that a bold change in lay (equal to one target dimension) would be made after each such loss. Hitting probabilities for such circumstances are shown as entry 4 in Table IV. Details of the method of computation of the hitting probability of rounds fired after lost rounds are given in ref. 12, Appendix I.

TABLE IV

INPUT DATA

	1000 yds			200 yds		
	152*	105 (M48)	105**	152*	105 (M48)	105**
1. P_{H_1}	.87	.81	.68	.39	.38	.27
2. $P_{H/H}$	1.00	.99	.99	.85	.72	.72
3. P_{H/L_1}	.02	.02	.02	.04	.04	.04
4. P_{H/L_2}	.20	.20	.20	.15	.15	.15
5. $P_{H/S}$	.57	.40	.40	.47	.20	.20
6. P_S	.99	.19	.19	.99	.19	.19
7. $P_{K/H}$ (M or F)	.70	.71	.71	.70	.70	.70
8. $\bar{t}_1$ (sec)	23	18	23	30	18	30
9. $\bar{t}_2$ (sec)	19	18	18	19	18	18

NOTE: All hitting probabilities are against a 7.5' x 7.5' target.

* with spotting rifle
** with ranging machine gun using technique employed by the U.K.

(4) Entry 5 of Table IV gives the probability of hitting given a missed round that was sensed. These probabilities involve errors due to round to round dispersion and the errors in estimating the location of sensed rounds. The lower probabilities for the 105mm gun reflect the slightly higher round to round dispersion of this gun and the greater inaccuracy with which the location of a missing round can be estimated.

(5) Entry 6 gives the probability of sensing. This is one of the most important areas of gain for the 152mm system. The data on probability of sensing and on the accuracy of estimating the location of sensed rounds came from sensing tests conducted at APG (not yet reported on) and from ref. 12. Considerably more weight was given to the APG test data because in these tests more varied conditions of target background and firing site dustiness were utilized. Hence, the APG tests were more representative of the variety of conditions which are likely to be met in combat.

(6) Entry 7 gives the probability that a random hit on the JS 3 tank achieves either an M or F kill averaged over the expected attack angles. Note that there is little difference in these probabilities for the two projectiles. Details of the input data and computational procedures for this quantity are given in ref. 12.

(7) Entries 8 and 9 give the mean time to fire and subsequent rounds. First round firing times are measured from the time of locating a target and were obtained from Frankford Arsenal. Subsequent round firing times are based on data obtained in various tests designed to simulate combat situations which are summarized in ref. 13. The firing times used are for well trained crews. Note the larger first round firing times with the spotting rifle and ranging machine gun systems, especially at 2000 yards.

8.4 Results

(1) Using the input data of Table IV the results shown in Figs. 13 and 14 and Table V were obtained. Fig. 13 shows the expected probability of at least one lethal hit (M or F kill) on the JS 3 at 1000 yds. as a function of time for each of the three systems considered. Fig. 14 shows similar information for 2000 yds. range. (See pgs 56 and 57)

(2) Fig. 13 indicates a rather small superiority of the 152 system over the 105 with the M48 type fire control. At short times (due to higher rate of fire on First rounds) the 105-M48 fire control is somewhat better but after about 30 seconds the 152 is better. The 105 ranging machine gun system is inferior all along the line. The expected time to get a kill for each system is indicated on each curve by the short vertical line. Again there is little difference between the 152 (77 sec) and the 105-M48 fire control system (79 sec). The 105 ranging machine gun system is considerably longer (103 sec.).

(3) At 2000 yards the story is the same at short times, i.e. up to about 35 sec. After that the 152 system is considerably better than the 105-M48 fire control system and the 105 ranging machine gun system is worse than each of the other two at all times. These observations are again reflected in the mean time to get a kill, viz., 110 sec. for the 152 system; 154 sec. for the 105-M48 fire control system, and 185 sec. for the 105 ranging machine gun system.

TABLE V

RESULTS

	1000 yds			2000 yds		
	152*	105 (M48)	105**	152*	105 (M48)	105**
1. $\bar{t}_K$ (sec)	77	79	103	110	154	185
2. K/M	.78	.76	.58	.55	.39	.32
3. K/M/XM60 K/M	1.03	1.00	.76	1.41	1.00	.82
4. R/K	3.7	4.6	5.0	4.8	8.6	8.9
5. R/K/XM60 R/K	.80	1.00	1.09	.56	1.00	1.03
6. Cost	.85	1.00	1.00	.85	1.00	1.00
7. K/M/Cost	.92	.76	.58	.65	.39	.32
8. K/105 (M48) K	1.21	1.00	.76	1.67	1.00	.82

* with spotting rifle
** with ranging machine gun using technique employed by the U.K.

(4) Table V summarizes the results obtained from Figs. 13 and 14 and gives additional information. Entry 1 of Table V gives mean times to get a kill of the JS 3 tank at 1000 and 2000 yds. Entry 2 reduces entry 1 to expected kills per minute (K/M). Entry 3 given the ratio of the kill rate of each tank to that of the 105-M48 fire control system. These numbers point up the gain, system for system, of going to the 152mm system. Entry 4 gives the expected number of rounds per kill and entry 5 the ratio of the expected number of rounds per kill of each system to that of the 105-M48 fire control system. It is seen here that at 1000 yds. the 152 takes 80% of the ammo required by the 105-M48 fire control system and at 2000 yds. only 56%. Entry 6 gives a cost indication of a vehicle utilizing each armament system. In this instance cost is assumed proportional to weight. It was indicated by Detroit Arsenal that of two vehicles having identical armor protection, number of stowed rounds, BHP per ton, etc., the one designed around the 152 system would weigh about 85% of the weight of the vehicle designed around the 105 gun. If this cost factor is divided into the kill rate, one obtains the kill rate per unit of cost,

the unit of cost being the cost of the vehicle with the 105 gun. The ratio of kills per unit cost divided by the same ratio for the 105-M48 armament system gives the expected number of kills per kill by the 105-M48 system for a given cost outlay. This latter is shown at entry 8. It is seen, then, that a tank designed around the 152 would give 21% more kills at 1000 yds. and 67% more kills at 2000 yds. than a tank designed around the 105-M48 fire control system for a given cost effort and assuming the tanks are identical in all features except the armament system.

8.5 Conclusions

(1) From the foregoing it is concluded that at the present state of the art of spin compensation for HEAT projectiles, the proposed 152mm armament system:

a. Gives considerably better armor perforation and over-all performance against the JS 3 tank at lower cost than the 105mm T254E2 gun firing APDSH type ammunition. It is similarly better than any known system using a kinetic energy penetration.

b. The 152mm gun has greater insurance against target hardening than the 105mm T254E2 gun firing APDSH type ammo or any other feasible systems utilizing KE projectiles for penetration.

c. Comes closer to defeating all of the tripartite heavy tank targets than any feasible gun using a KE penetrator.

(2) In addition to the above, the 152mm system:

a. Has the potential for being the launcher for the pentomic round of tank ammunition if and when it is developed.

b. Has the potential for greatly improved performance against hard targets as the art of spin compensation improves by modifications to the warhead only.

c. With the expected improvements in the art of spin compensation it will satisfy the requirements for the heavy gun tank at a net burden less than that usually associated with medium gun tanks.

d. Has the advantage of utilizing a single type of ammunition for both the HE and anti-tank roles.

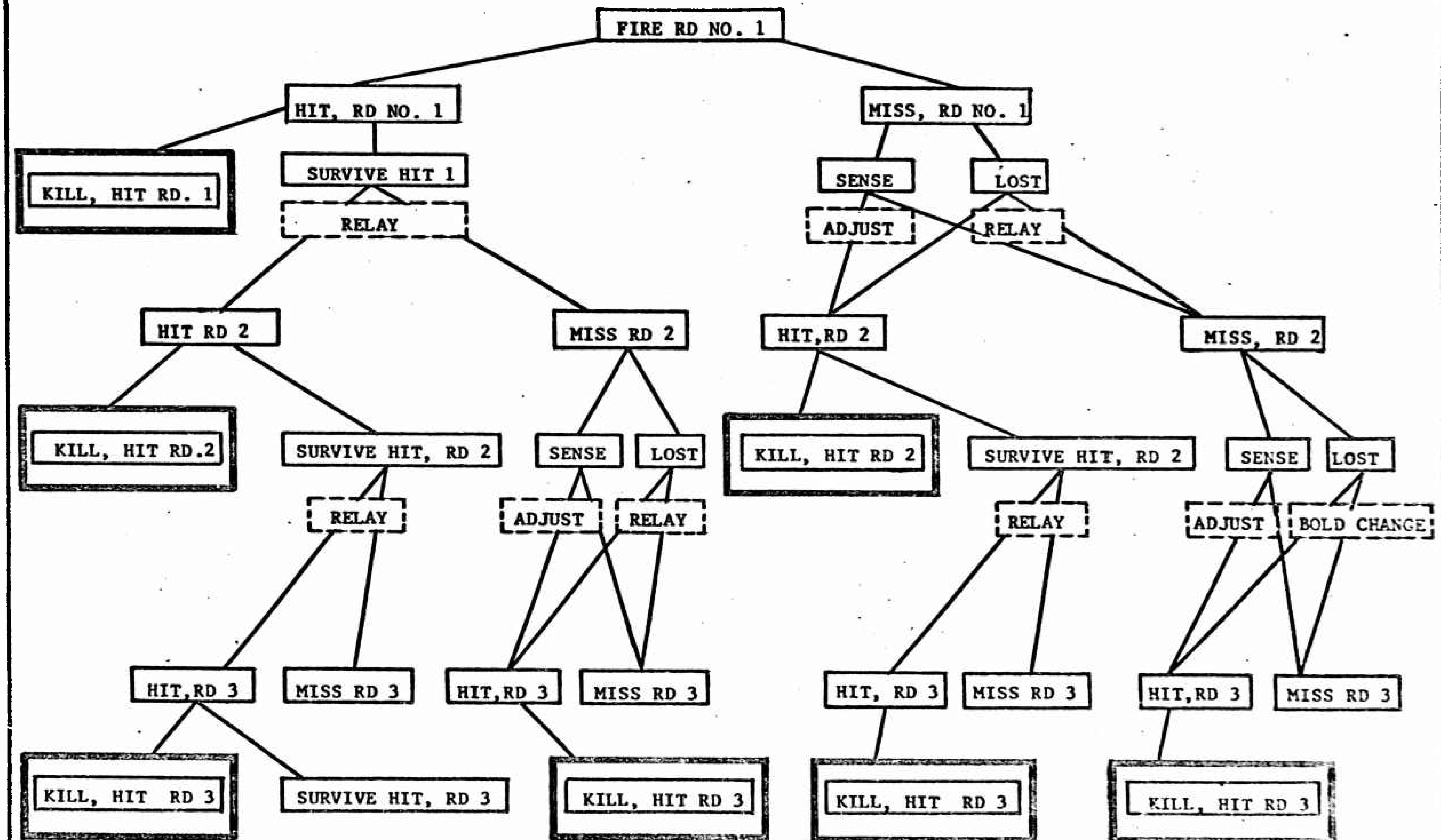


FIG.12

INFORMATION FLOW PATTERN

PROBABILITY OF AT LEAST ONE LETHAL HIT ON THE JS3 TANK vs. TIME

1000 YDS

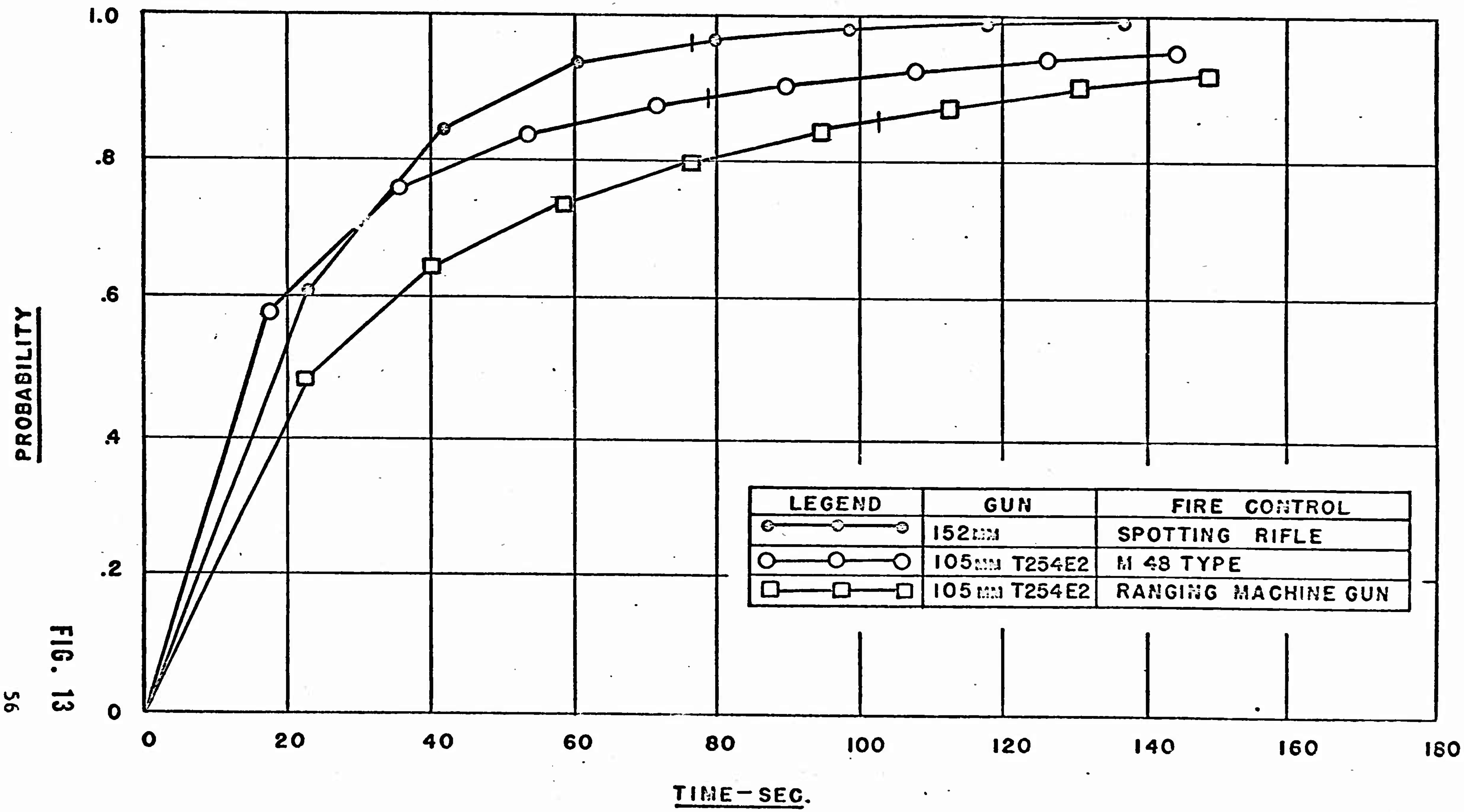


FIG. 13

PROBABILITY OF AT LEAST ONE LETHAL HIT ON THE JS3 TANK vs. TIME — 2000 YDS

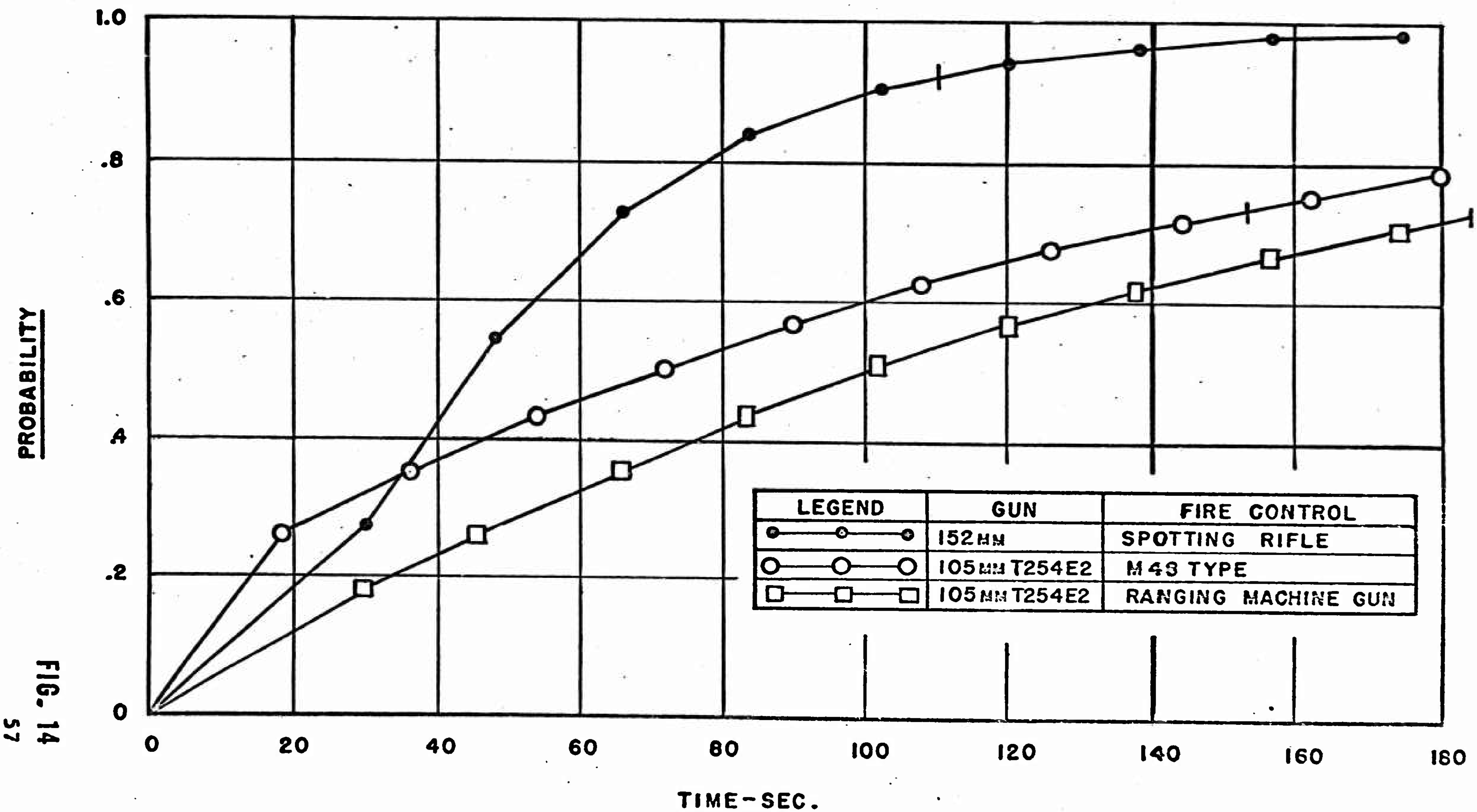


FIG. 14

Section 9

SUMMARY AND CONCLUSIONS

9.1 Summary

The caliber (152mm) of the proposed armament system was selected to meet the basic requirements specified in the Objective of this study and maximize the likelihood of missile application. The armament system is comprised of an 867 lb. gun, which features a separable chamber breech; a coldworked high physical strength tube; and fires a 47½ lb. fixed, combustible cased, dual purpose round. The projectile is spin stabilized and utilizes a spin-compensated liner for the shaped charge which provides adequate effectiveness against basic and compound armored targets. The projectile also provides adequate soft target lethality. In applying the armament system to vehicle concepts such as the T95E__, the Main Battle Tank, and the Armored Reconnaissance/Airborne Assault Vehicle, Amphibious, an efficient installation is achieved which is directly attributed to the compact size of both gun and ammunition.

The "Pentomic" contractors for the development of direct fire, wingless guided missiles advocate in their feasibility studies the use of a closed breech launcher of the 152mm type, and it is considered that compatibility between the missile and the 152mm armament system can be achieved.

9.2 Conclusions

(1) From the technical study and assessment conducted, the committee concludes that the New Tank Main Armament System will meet the characteristics specified in the Staff directive and that the system is practical for development.

(2) It further concludes that the proposed system can be adapted to launch direct fire, wingless guided missiles under consideration on the CVWS (Pentomic) project and missiles of the Polcat type.

(3) In addition to meeting basic requirements the system offers significant improvements in subsequent round hit probability, in versatility of ammunition employment through the dual purpose round and in adaptability to vehicular installation.

(4) Weapons systems incorporating the proposed armament will provide our combat forces with weapon vs weapon superiority over the enemy and will significantly aid in equalizing the numerical superiority possessed by the enemy.

APPENDICES

I List of References

II Read for Record - Initiation of Project - dated 22 August 1958

III Letter from OCO (ORDTW) 00/8S-8894 to Watervliet Arsenal, dated 12 August 1958

APPENDIX I

LIST OF REFERENCES

1. Report of the Ad Hoc Group, Armament for Future Tanks or Similar Combat Vehicles, 20 Jan 58

2. Cannon Potential 1960-1970, Mar 58, Watervliet Arsenal

3. BRL Technical Note No. 1183, A Concept Armament System for the Main Battle Tank (U), Apr 58, D. C. Hardison and B. N. Goulet

4. BRL Technical Note No. 1214, Design of a Non-Spin Shaped Charge Projectile, Sep 58, Elizabeth Dickinson

5. Proposed Concepts for Heavy Infantry Assault Weapon System (Hiawatha), 11 Apr 58 (Rev), Frankford Arsenal Pitman-Dunn Labs

6. Missile System, Armored Combat Vehicle, 19 May 58, Aeronutronic Systems, Inc.

7. Armored Combat Vehicle Weapons System, Jul 58, Sperry Gyroscope Company

8. The Application of the Combustible Cartridge Case to Advanced Weapon Systems, Jun 58, Feltman Research and Engineering Laboratories, Picatinny Arsenal

9. Armored Combat Vehicle Weapons System, Oct 58, Sperry Gyroscope Company

10. Missile System, Armored Combat Vehicle, 17 Jan 59, Aeronutronic Systems, Inc.

11. BRL Memorandum Report No. 1186, Shape Charge Performance in the New Tank Main Armament Concept (U), Feb 59, R. J. Eichelberger, J. Simon, R. DiPersio

12. Report on XM60 Weapon System Evaluation, APG/TW-419/1Oct58

13. Tank Gunnery Accuracy Evaluations, Frankford Arsenal Report R1380A, Feb 58

14. Preliminary Design of a Dual-Purpose Round for a New Main Battle Tank Armament System, Nov 58, J. Dubin, Picatinny Arsenal

APPENDIX II

ORDBF-RD 400.112/156(S) 1st Ind Mr.Roeck/hdo/4214
00/8S-8894
SUBJECT: New Tank Main Armament System (U)

Ord Corps, Watervliet Arsenal, Watervliet, N. Y., 22 August 1958

TO: Chief of Ordnance, Department of the Army, Washington 25, D.C.
ATTN: ORDTW-CVS, Mr. S. Weiss

1. The inclosed draft of a "Read for Record", covering the initiation of the subject technical assessment under DA project 5W01-04-076 (TW-411) has been prepared in compliance with paragraph 3 of the basic letter.

2. It is anticipated that a meeting of all agencies concerned will be scheduled at this arsenal on 9 September 1958 for the purpose of formulating the scope of activities to be performed under this project.

FOR THE COMMANDER:

WILLIAM R. DOCK
Assistant

1 Incl
w/d Incl 1
Added 1 Incl (in dupe)
2. "Read for Record" (S)
dated 22 Aug 58

CC: w/1 Incl:
CG, APG-BRL, Mr. D. Hardison
CG, OTAC, Attn: ORDMC-RC.2 - Mr. J. Tannenbaum
CO, Picatinny Arsenal, Attn: Messrs R.H.Wood, J.Dubin

REGRADED UNCLASSIFIED WHEN SEPARATED FROM BASIC LETTER AND INCLOSURE

DEPARTMENT OF THE ARMY
OFFICE OF THE CHIEF OF ORDNANCE

Mr.Roeck/hdo/4214
22 August 1958

READ FOR RECORD

MEMORANDUM FOR THE SECRETARY OF THE ORDNANCE TECHNICAL COMMITTEE

SUBJECT: NEW TANK MAIN ARMAMENT SYSTEM (U) - INITIATION OF PROJECT APPROVED BY OCR&D

1. REFERENCES:

a. BRL Technical Note No. 1183, April 1958, "A Concept Armament for the Main Battle Tank" (U)

b. File 00/8S-6402, CRD/D-6402, Comment No. 2, C/R&D to Chief of Ordnance, Subj: "Future Tank Production", dated 24 July 1958.

c. Letter from OCO (ORDTW) 00/8S-8894 to Watervliet Arsenal, dated 12 August 1958.

2. Reference "a" describes "A Concept Armament System for the Main Battle Tank" based upon the potentialities of a system predicated on the use of chemical energy projectiles. This system to have the ability of breaching the armor of Soviet heavy tanks, and the projectile size (140mm) would be sufficient for complete immobilization and/or destruction of the vehicle.

3. Reference "b" from the Chief of Research and Development to the Chief of Ordnance, requests the following action, and paragraph 5a of the referenced Comment No. 2 is quoted in its entirety:

> "Initiate a technical study to determine the practicability of development and the design parameters of a tank main armament system characterized by moderate to low pressure, light weight, short tube, small chamber volume and capable of launching a spin-stabilized chemical energy HEAT shell having a spin-compensated liner for the shaped charge. The caliber of this armament system should be of sufficient size to penetrate the armor of all existing and future USSR heavy tanks to defeat all compound, special or spaced armor arrangements, were the Soviets to use this technique to degrade the performance of

our conventional HEAT ammunition, and to provide adequate residual damage after penetration to insure destruction. Subsequent to the completion of the above mentioned study, consideration should be given to the use of this armament system as a launcher for the delivery of direct fire, wingless, guided missiles, as a gun to deliver HEAT ammunition at minimum ranges where the missile may not be as efficient or where the destruction of the target does not warrant the delivery of the more expensive missile, and to deliver HE ammunition against soft targets at all ranges. This technical study and assessment will be conducted under DA Project 5W01-04-076, "Tank Cannon Development"."

4. Reference "c" directs the initiation of the technical study described in paragraph 3 above.

5. The purpose of this item is to record authorization for this study and assessment under DA Project 5W01-04-076 (TW-411) "Tank Cannon Development".

6. To permit expeditious action as directed above, it is requested that a D/A priority of 1A be assigned this project.

7. This Read for Record is classified SECRET.

M. A. KINLEY
Colonel, Ord Corps
Assistant

APPENDIX III

DEPARTMENT OF THE ARMY
OFFICE OF THE CHIEF OF ORDNANCE
WASHINGTON 25, D. C.

ORDTW-CVS 00/8S-8894 Mr Weiss/chs/54137

SUBJECT: New Tank Main Armament System (U)

TO: Commanding Officer
Watervliet Arsenal
Watervliet, New York
ATTN: ORDBF-RD

12 August 1958

REFERENCES: a. File 00/8S-6402, CRD/C - 6042, Comment Nr 2, C/R&D to Chief of Ordnance, Subject: "Future Tank Production, dated 24 July 1958 (copy inclosed)

b. BRL Technical Note No. 1183, April 1958, "A Concept Armament for the Main Battle Tank" (U)

1. By reference a, above, paragraph 5a, the Chief of Research and Development requests the initiation of a technical study to determine the practicability of development and the design parameters of a new tank main armor defeating round at the shorter ranges. The caliber of this armament system, intended for the future main battle tank, should be based on a projectile that would be capable of perforating the armor of the heaviest known or projected Soviet tanks in substantially all attack conditions whether utilizing compound, special, or spaced armor arrangements. It should have the ability of defeating the Tripartite heavy tank targets and provide adequate residual damage after penetration to insure immobilization or destruction of the vehicle. In essence, the weapon should be a dual purpose launcher. It should be capable of (a) launching direct fire, wingless, guided missiles, (b) delivering HEAT ammunition at minimum ranges where the missile may not be as efficient or where the destruction of the target does not warrant the delivery of the more expensive missile and (c) delivering HE ammunition against soft targets at all ranges. Armament concepts for this type of a system are further discussed in BRL Tech. Note No. 1183, Ref. b, above.

2. The above study is to be conducted under Ord Project TW 411, "Tank Cannon Development" at your arsenal, and is to be carried out in conjunction with the BRL and Picatinny Arsenal and coordinated with OTAC. Costs and time frame of development would be included in the final report. It is further requested that this study be expedited.

ORDTW-CVS 00/8S-8894 12 August 1958
SUBJECT: New Tank Main Armament System (U)

3. A "Read for Record" covering this task under Project TW 411 for submission to the Ord. Tech. Committee should be prepared and forwarded to this office as early as practicable.

FOR THE CHIEF OF ORDNANCE:

/s/ N. Glassman
for M. A. KINLEY
Colonel, Ord Corps
Assistant

1 Incl:
1. Thermofax cy of D/F Cmt #2, dtd 24 July 58

Copy Furnished: w/1 Incl:
CG, APG, ATTN: BRL
CO, PA, ATTN: ORDBB-TE5
CG, OTAC, ATTN: ORDMC-R