Center for Night Vision and Electro-Optics

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MUZZLE FLASH EVALUATION OF THE XM197 20MM CANNON FOR THE USAF CREDIBLE CHASE PROGRAM –1971 TEST DATA–

W. P. Markey, W. B. Morrow,
E. J. Efkeman, and C. H. Mikeman

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A firing test of the XM197 Weapon System was carried out at Eglin Air Force Base, Florida on 11 - 16 October 1971 where muzzle flash signatures were obtained and statistically analyzed; several PVS-4 and TVS-5 night sights and image intensifier assemblies were also evaluated. A Laboratory simulation was developed by the Night Vision Laboratory's Advanced Development Technical Area to evaluate individual image intensifier assemblies in order to forecast the most probable field performance of the PVS-4 and TVS-5 systems.

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PREFACE

Purpose: The purpose of this effort was to determine the functional compatibility of the US Army-developed 25mm second generation image intensifier tube assembly and its associated AN/PVS-4 and AN/TVS-5 Small Starlight Scope and Crew Served Weapon Sights with the XM197 20mm Weapon System proposed for use in the US Air Force Credible Chase Program.

Background: On 28 September 1971, Advanced Development Technical Area (ADTA) was informed that the US Air Force wished to test the AN/PVS-4 and AN/TVS-5 Small Starlight Scope/Crew Served Weapon Sight (SSS/CSWS) for use as a night gun sight on the XM197 20mm cannon which was being considered for the Credible Chase Program. A meeting was held between Night Vision Laboratory and LTC Walter Lane and members of his staff on 6 October 1971 at Eglin Air Force Base in order to define the elements and requirements of a test plan for the SSS/CSWS. As a result of this meeting, Systems Development Technical Area (SDTA) agreed to supply the SSS/CSWS with photographic personnel, equipment, and technical skill in setting up and testing the night sight-weapon system. ADTA was committed to measurement of the muzzle flash profile of this system. The field testing was performed during 11-16 October 1971.

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SECTION I. REQUIREMENTS

The basic requirements for night vision devices with a high degree of weapons compatibility have been addressed by the Night Vision Laboratory during the second generation development program. The tube-power supply package developed under this program has an automatic brightness control (ABC) circuit which limits the output brightness by varying the gain of the tube when under high light level conditions. The muzzle flash of a weapon appears to the ABC circuit as a high light level and the tube gain level is reduced. At the end of the flash the tube is then required to return to its previous gain level. The delivery of accurately aimed fire requires that the tube response be sufficiently fast in order to sense impact of the round on the target. When using automatic weapons, it is highly desirable to maintain some level of imagery during the time when the weapon is being fired and to have a very fast recovery after the last round in a burst has been fired. A series of muzzle flash measurements for the .50 caliber machine gun,[1] the 106mm recoilless rifle, and the 20mm M139 cannon[2,3] were made by Night Vision Laboratory in order to define the conditions to which the tube package must respond. The results of the field measurements on the .50 caliber profile have been used in the design of a muzzle flash simulator which is used to determine the suitability of individual image intensifier assemblies for use in various night sights and to forecast the most probable field performance of the night sight itself. The flash simulator has been an invaluable tool in the study of tube response to single shot and multiple shot conditions at varying ambient light levels and with various types of weapons flash.

During the period 12-15 October 1971, preparation and tests of the SSS/CSWS were performed at Eglin Air Force Base. Complete flash measurements as outlined in the test plan were not completed due to unforeseen problems and delays. However, sufficient data was taken which allows some judgment to be made concerning the severity of the flash profile.

SECTION II. SYSTEM DESCRIPTION

XM197 ARMAMENT SYSTEM

The XM197 Armament System evaluated in this test is similar to the M61 Vulcan 20mm rapid fire cannon. The XM197 consists of three rotating barrels instead of six and has a rate of fire of approximately 400 rounds per minute (rdpm) slow rate, and 700 rdpm fast rate. For the test reported here, the gun was pedestal mounted just behind the pilot's seat in the Fairchild-Hiller Peacemaker Aircraft (Figures 1 and 2). This mounting arrangement and the location of the Night Sight/Flash Detector are shown in Figures 3 and 4. The M61 and XM197 20mm guns are automatic aircraft cannons for use against aircraft and ground or seaborne targets. These guns are electrically or hydraulically powered, belt fed or linkless fed, and electrically fired. A round of ammunition is fired through one barrel at a time, as the barrels and rotor assembly rotate once around the rotor housing.

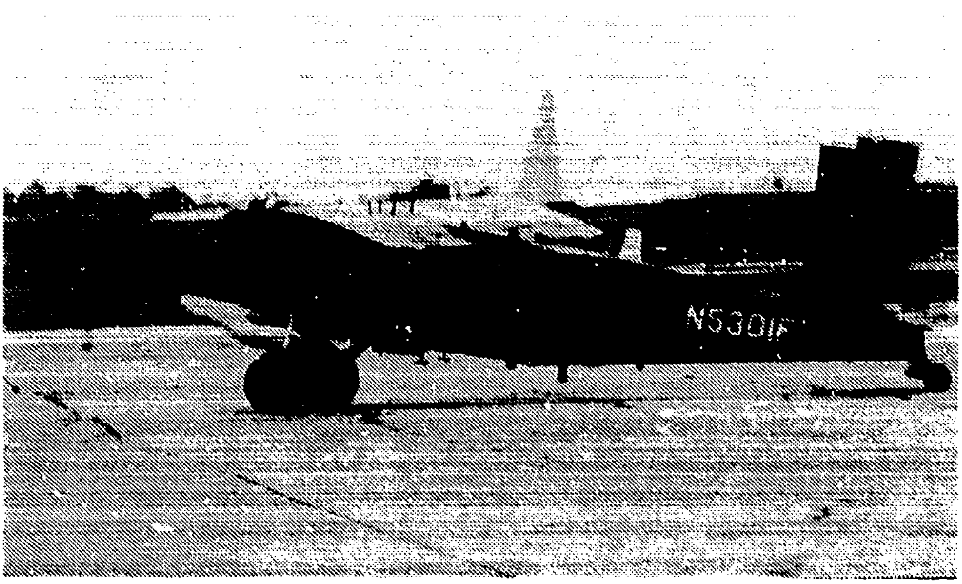


Figure 1. Peacemaker Aircraft

Figure 2. Peacemaker Aircraft on Firing Platform

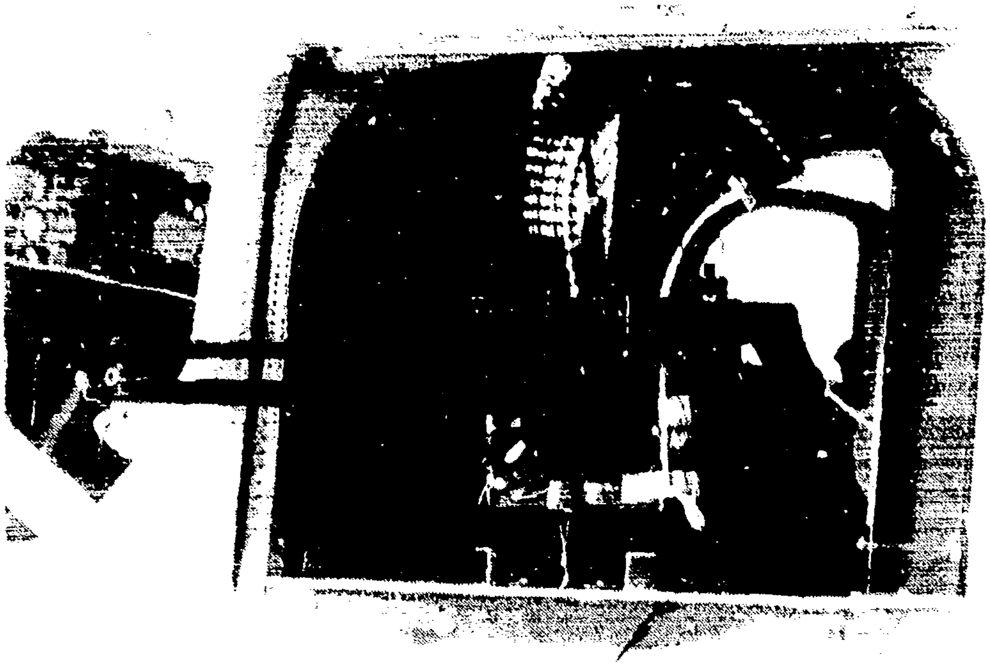


Figure 3. XM197 and Aircraft Mount

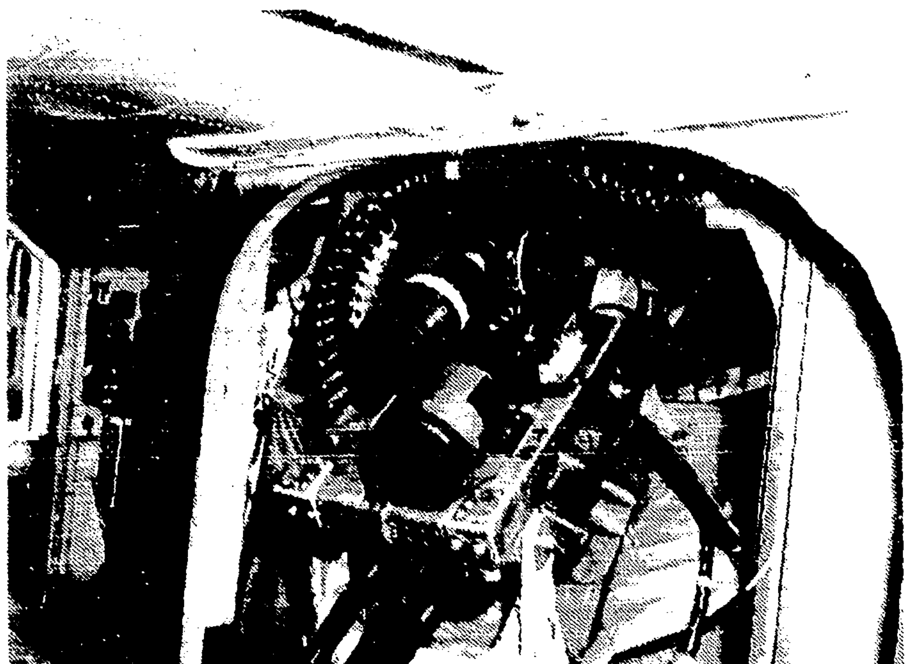


Figure 4. Flash Detector Mounting Configuration

AMMUNITION FOR THE 20MM GUN XM197

Cartridges used in the XM197 are electrically primed and are identical to the cartridges used in the M61 and the M39 series guns. Cartridges are normally loaded in ammunition belts of the disintegrating type made up from M14 series or M17 series cartridge links. Propellant charges are either single (IMR) or double base (nitrocellulose or nitrocellulose-nitroglycerine).

In general, when it is necessary to simulate combat ammunition flash profiles in the laboratory, combat ammunition is required to establish the criteria for the simulation. In some specific cases, ammunition designated as training ammunition may be suitable for this purpose; in most cases it is not. This is particularly true of tracer ammunition. Ammunition for the XM197 is classified as:

- M53 Armor-Piercing-Incendiary (API)
- M55A2 Ball or Target Practice (TP)
- M220 Target Practice Tracer (TP-T)
- M56A3 High Explosive-Incendiary (HEI)
- XM242 High Explosive Incendiary Tracer (HEI-T)
- Dummy
- High Pressure Test (HPT).

Of these, API, HEI, and HEI-T are generally considered combat ammunition, while TP and TP-T are set aside for target practice and training. Due to shortages in supply of 20mm ammunition, TP and TP-T were made available for this test along with a small amount of HEI. Specific lots of ammunition provided for this test were:

M55A2 TP *1305-180-9268* *Lot KOL 10-31* *6-71*	According to personnel of the Army Ammo Plant, Joliet, Illinois, this lot was manufactured in 1971 at Olin Matheson's Kingston Plant.
M55A2, M220 TP, TP-T linked 1/7 *(1 Tracer/7 Ball)* *1305-926-4057-A654* *Lot LCL-1-007* *1-69*	This ammunition was originally linked 1/4 and probably relinked at Eglin Air Force Base to 1/7. This lot was manufactured in 1969 at the Lake City Arsenal. The M220 TP-T component lots were handmade, and may tend to be erratic in peformance.
M56A3, HEI *1305-965-0560-A919* *Lot LCL-30-431* *3-70*	This ammunition was manufactured at the Lake City Arsenal in 1970.

Unlike Cal .50 ammunition which varies in age from 1 to 25 years, 20mm ammunition is a critical supply item. It is manufactured in limited quantities and is generally only 1 to 3 years old. Tracer ammunition used in M50 series 20mm cartridges are designed for use in non-computing (rigid sight) fire control systems in fighter or fighter-bomber aircraft. The tracer consists of two igniters and a tracer element. When the cartridge is fired, the burning propellant gases burn through an aluminum seal as the projectile travels through the barrel of the gun. As the projectile exits from the muzzle of the gun, the first igniter charge ignites and burns for approximately 15 yards. The second igniter charge ignites from the first igniter charge and burns until the projectile has traveled an additional 75 yards from the muzzle. As the second igniter burns out, the tracer element ignites and burns for a minimum of 1,500 yards. In practice, this sequence varies substantially in time with some tracers firing very close to the muzzle and others firing not at all. This variation leads to a large spread in muzzle flash intensity amplitudes.

In order to properly evaluate weapon muzzle flash, it is necessary to observe in detail the flash produced by individual rounds of all the types of ammunition in use, as well as ordered and numbered sequences of rounds in sufficient numbers so as to provide a statistically sound data base. Accordingly, the following test profile (Table 1) was proposed by Night Vision Laboratory personnel as being sufficient to provide statistically sound data. The actual test plan carried out is reviewed in Section IV of this report.

Table 1. Proposed Firing Sequence

OPTICS	NUMBER OF ROUNDS (rd)	TYPE	LINKED	FIRING MODE
CSWS	25	Ball (TP) M55A2	Individual	Single shot
CSWS	25	Tracer (TP-T) M220	Individual	Single shot
CSWS	10	HEI M56A3	Individual	Single shot
CSWS	30	Ball (TP)	6 rd group	Slow rate
CSWS	30	Ball (TP)	6 rd group	Fast rate
CSWS	30	Ball (TP) + Tracer (TP-T)	6 rd group T, 4B, T	Slow rate
CSWS	30	Ball (TP) + Tracer (TP-T)	6 rd group T, 4B, T	Fast rate
CSWS	55	Ball (TP) + Tracer (TP-T)	11 rd group T, 4B, T, 4B, T	Slow rate
CSWS	55	Ball (TP) + Tracer (TP-T)	11 rd group T, 4B, T, 4B, T	Fast rate
SSS	10	Ball (TP)	Individual	Single shot
SSS	10	Tracer (TP-T)	Individual	Single shot
SSS	10	HEI	Individual	Single shot
SSS	20	Ball (TP)	10 rd group 10 rd group	Slow rate Fast rate
CSWS with Canvas Wing Cover	5 5 20	Ball (TP) Tracer (TP-T) Ball (TP)	Individual Individual 10 rd group 10 rd group	Single shot Single shot Slow rate Fast rate

SECTION III. TEST INSTRUMENTATION

The objective of the test was to determine the amount of light as a function of time reaching the cathode of the image tube in the Crew Served Weapon Sight when mounted in its normal firing position. This was done by measuring the total current through the cathode during the weapon firing, and scaling that with the cathode sensitivity as measured in the laboratory.

The brightness of the muzzle flash reaching the tube is a function of many parameters including system objective lens "t" number, field of view, and system placement and orientation with respect to the weapon. The most obvious way to reproduce these parameters for the detector was to use the same objective lens and system mounting configuration as the CSWS. To ensure that the detector size and spectral sensitivity corresponded to the 25mm second generation CSWS image tube, one stage of a 25mm first generation image intensifier tube having a cathode typical of the spectral response of the CSWS tube was selected as a detector and potted in a CSWS package.

All of the grids and the screen of the PIP tube were shorted together to form a collecting anode for the space current coming from the cathode. The voltage across a signal preconditioner resistor element carrying this current was monitored on two storage oscilloscopes as shown in Figure 5.

The entire circuit was shielded and its frequency response measured. This must exceed the expected muzzle flash frequency components by at least two orders of magnitude. The first oscilloscope was used to record the total flash profile, and the second was used to study a particular aspect such as rise time or to back up the first oscilloscope. The second oscilloscope was synchronized via a trigger pulse from the first oscilloscope. Both oscilloscopes were mounted in metal foil lined boxes for secondary EM shielding.

The 600-volt accelerating potential for the PIP tube was provided by a regulated power supply. The complete setup was checked and calibrated together in the laboratory before taking it to the test site, and again upon return, to ensure that there was no change of characteristics of the detector or measuring instruments during the test or in transport. The detector spectral response, white light cathode sensitivity, and voltage to cathode current calibration curve of the setup are displayed in Figure 6. (**Note:** The cathode characteristics measured before and after the test differed less than 1%.)

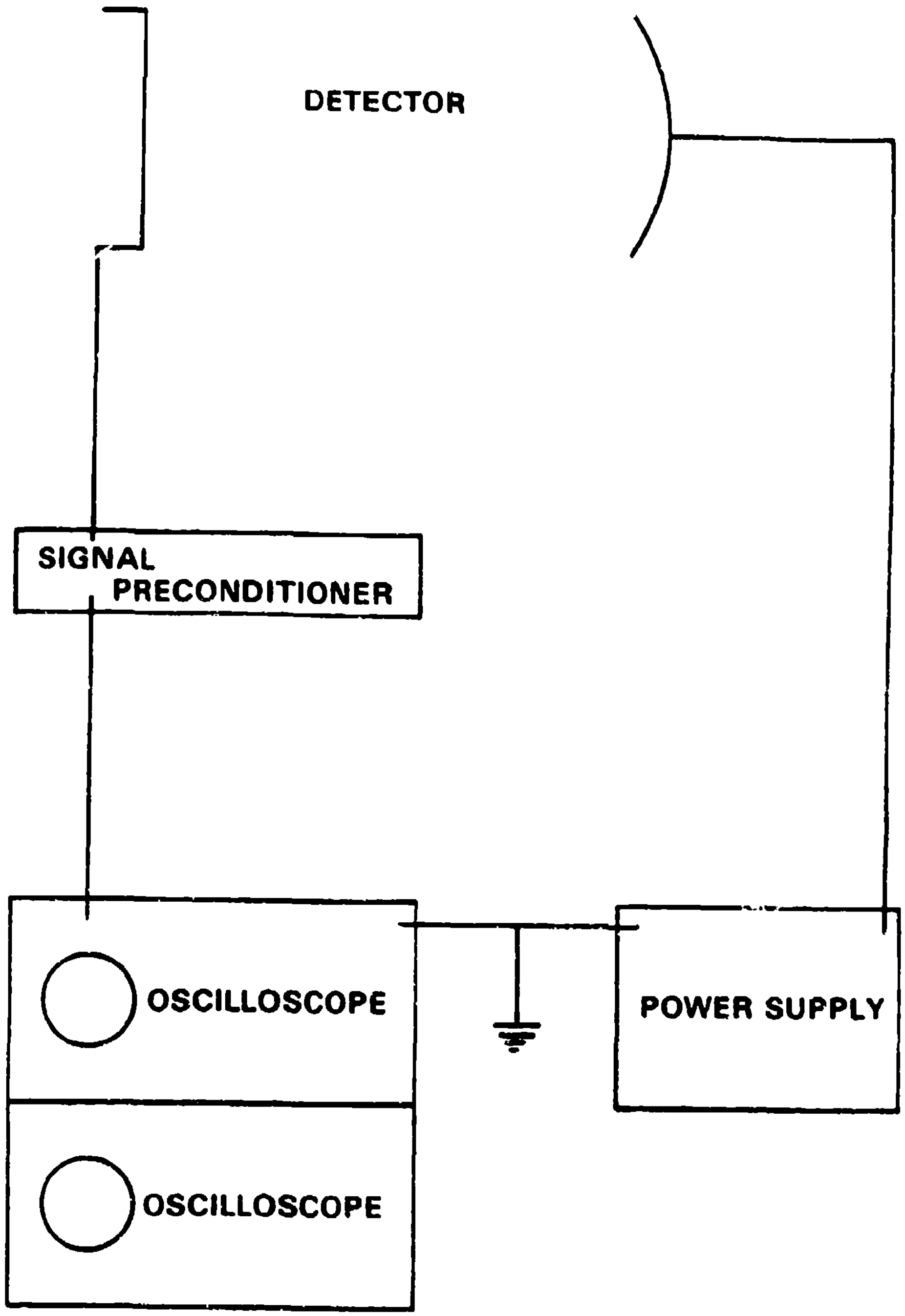


Figure 5. Block Diagram of Test Instrumentation

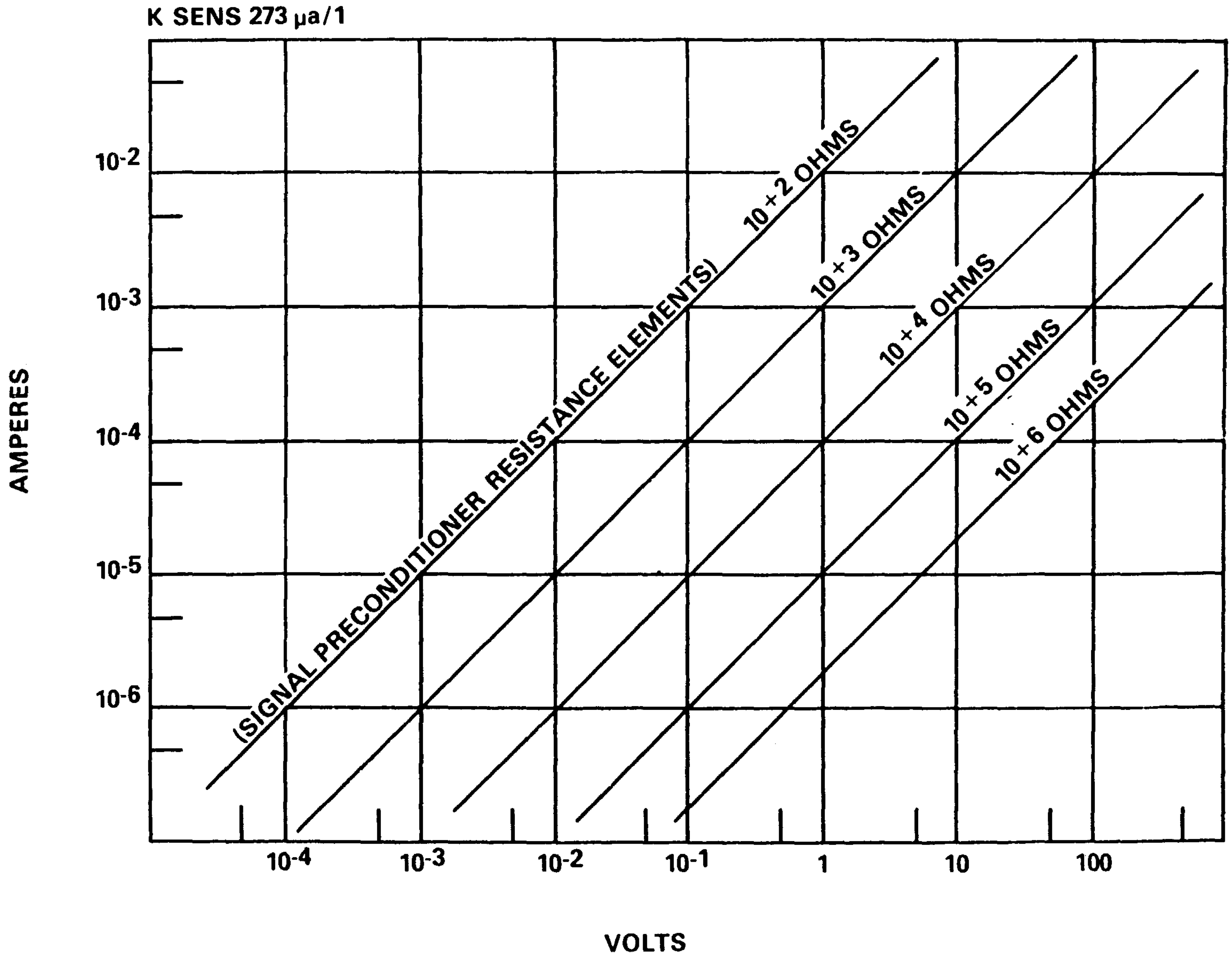


Figure 6. Detector Calibration Curve

SECTION IV. MUZZLE FLASH MEASUREMENTS

The instrumentation (described in Section III) necessary to carry the actual flash measurements was located under the test aircraft on the ground and slightly to the rear of the gunner's compartment. The placement allowed the gunner sufficient access to the weapon and yet allowed minimal lengths of cable from detector to the oscilloscopes. Power supplies and oscilloscopes were kept in shock proof and dust inhibitive boxes in order to minimize problems from these areas (Figure 7). The flash detector and optics were mounted on the weapon in place of and in the same position as the night sight, while the signal and power cables were led out the back door of the gunner's compartment to the equipment on the ground. Main power for the equipment was provided by a diesel generator. Some problems were experienced here due to transients but the appropriate adjustments of the primary oscilloscope filtered it out.

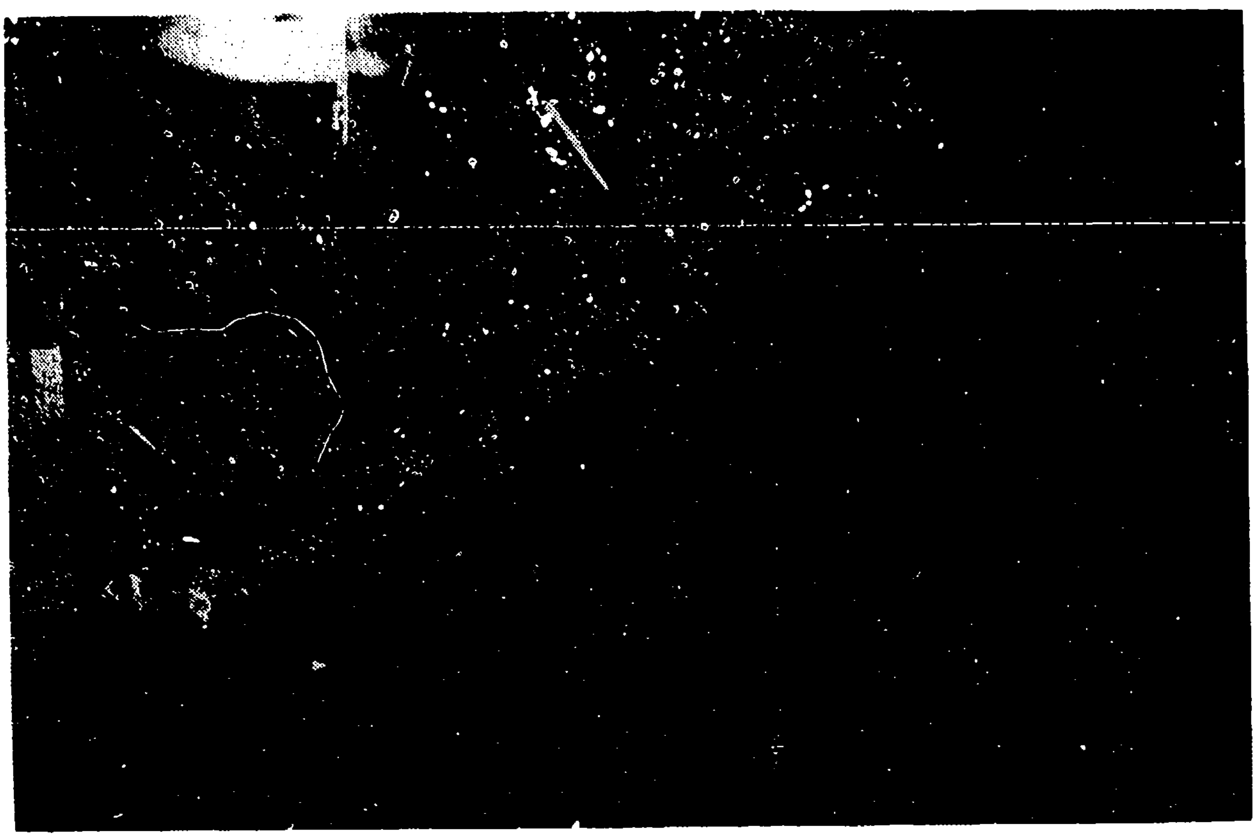


Figure 7. Test Instrumentation Field Configuration

Table 2 illustrates the number and type of rounds actually fired during the test for which data was obtained. A number of additional unlisted rounds were fired which produced no data due to problems with high frequency transients from the 110 VAC generator. Figures 8 through 13 illustrate the oscilloscope traces for pulse heights and widths for representatives of each round or burst fired. For reporting purposes, this data was normalized to a 250 μa/1 S-25 photocathode.

Table 2. Actual Firing Sequence

OPTICS	NUMBER OF ROUNDS (rd)	TYPE	LINKED	FIRING MODE
CSWS	9	(TP)	Individual	Single shot
CSWS	10	(TP-T)	Individual	Single shot
CSWS	5	(HEI)	Individual	Single shot
CSWS	24	(TP) + (TP-T)	6 rd group T, 4B, T	Slow rate
CSWS	12	(TP) + (TP-T)	6 rd group T, 4B, T	Fast rate

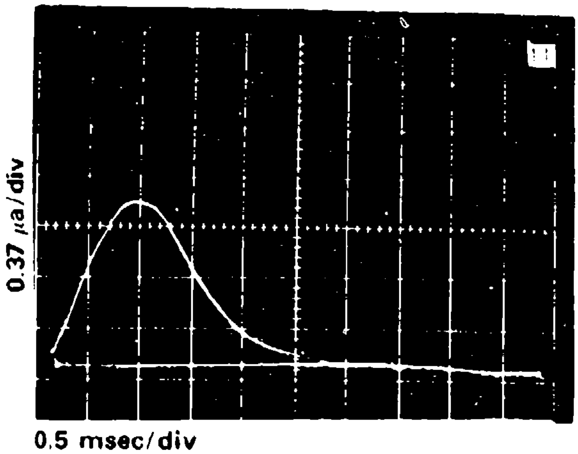


Figure 8. Typical Ball Flash Profile XM197

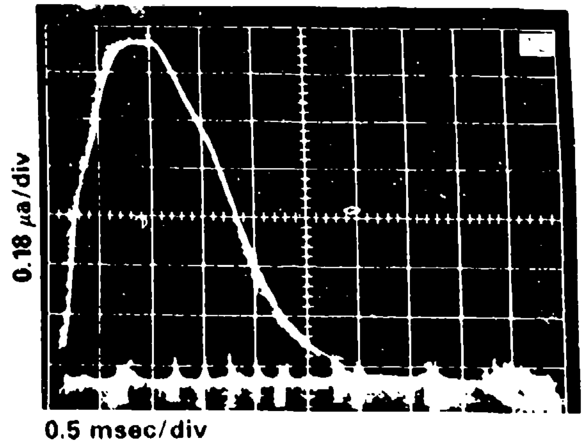


Figure 9. Typical HEI Flash Profile XM197

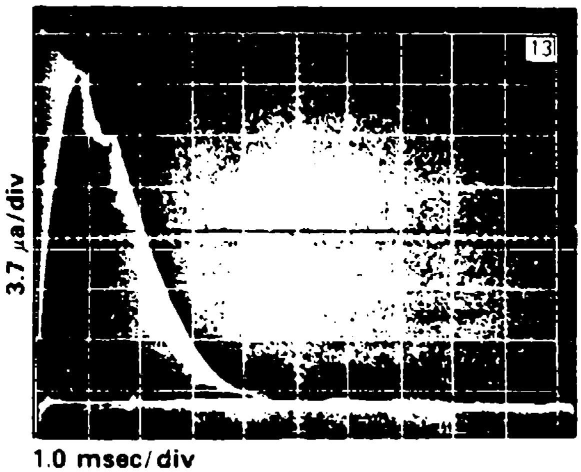


Figure 10. Sample Tracer Flash Profile (High peak) XM197

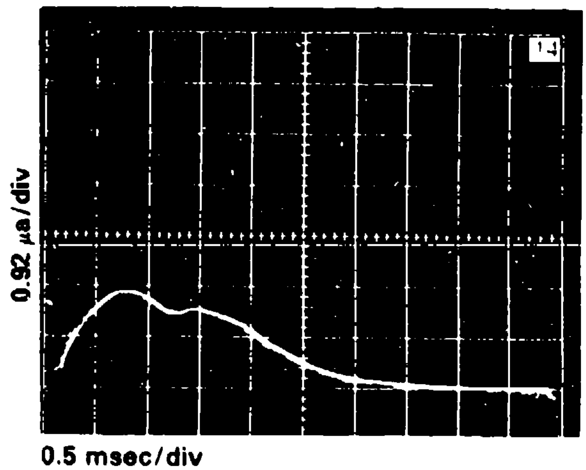


Figure 11. Sample Tracer Flash Profile (Low peak) XM197

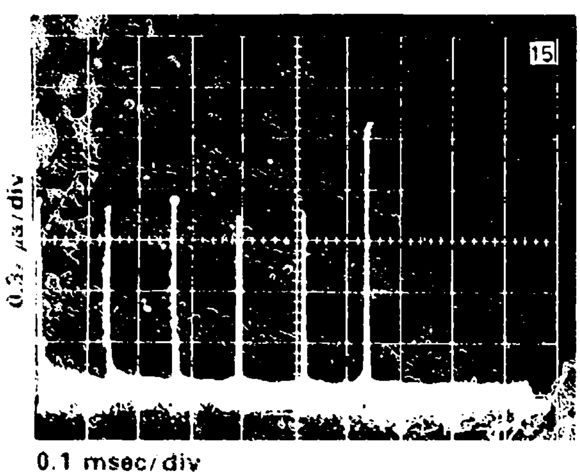


Figure 12. Sample Slow Rate Fire Ball and Tracer XM197

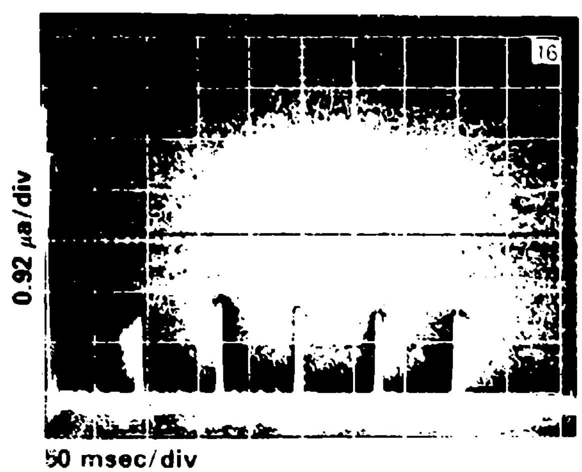


Figure 13. Sample Fast Rate Fire Ball and Tracer XM197

SECTION V. DATA ANALYSIS

Table 3 presents a limited statistical analysis of the data obtained during the test sequence cited in the previous section. Ball ammunition (TP) should show only small variations of limited significance where the night vision sight is concerned. It is reasonable and sufficient to suggest that 1.47 μa is a good approximation to the mean pulse height and is representative of the TP lot tested. It is also reasonble to expect small variations with respect to age in a given lot; however, the greatest uncertainty lies in the lot to lot variation. We are unable to suggest how great this might be. Accordingly, it is recommended that an amplitude of 1.47 $\pm$ .23 μa (Relative to a 250 μa/l photocathode) and a mean pulse width of 2.9 $\pm$ .17 milliseconds be utilized for test purposes.

The HEI sample lot tested was too small (n = 5) to treat statistically. However, the magnitudes shown in the data suggest that any differences between HEI and TP are positive; i.e., HEI is at least no more severe than TP and hence should pose few if any problems where the nigh sight is concerned. No test profile was considered necessary for HEI.

The tracer TP-T lot tested was plagued with the greatest uncertainties. Historically, tracers of all types are erratic in performance. They vary from tracers which do not ignite at all and are, therefore, indistinguishable from ball ammo to tracers which seem to literally explode at the muzzle, often inflicting a severe condition of flash blindness on the gunner. The TP-T lot observed in this test showed these same tendencies to a certain extent. The maximum current produced by a tracer was 33.0 μa, but other flashes were cut off due to scale settings on the oscilloscopes; hence, it was not possible to determine the worst case for the tracers of this TP-T lot, much less ascertain a general value for all tracers. A second problem existed in the data which is the apparent difference in amplitudes observed in those tracers fired singly as opposed to those fired in multiple round bursts. (See Table 3). In the latter case, the maximum amplitude was only 4.58 μa. The mean pulse height (7.13 μa) of all tracers observed was greater than the maximum of the multiples. This anomaly is not presently understood and to do so would require additional test firings of several hundred tracers, as well as a closer study of the weapon's firing mechanics and interior ballistics. The value 33.0 μa was used here as a first approximation to a working tradeoff between the true mean and a true worst case condition. Lacking further data, this is the value to use for test purposes. (Note: Only the pulse amplitude is not well established; the flash geometry is well established and consistent for many weapons and ammunition types.)

Table 3. Data Summary XM197

PULSE HEIGHT

GROUP	AMMO TYPE	MEAN PULSE HEIGHT (μa)	FOOT-CANDLE EQUIVALENT*	MAXIMUM PULSE HEIGHT (μa)	MINIMUM PULSE HEIGHT (μa)	STANDARD DEVIATION (μa)	COEFFICIENT** OF VARIATION (%)	SAMPLE SIZE
1	TP	1.47	1.1	1.83	0.92	0.23	15.6	31
2	HEI	1.22	0.9	1.28	1.01	0.12	9.8	5
3	TP-T (Single)	*11.98*	*9.1*	*33.0*	*4.0*	*9.85*	*82.3*	9
4	TP-T (Multiple)	2.56	1.9	4.58	1.37	1.22	47.7	9
5	TP-T (Total)	7.13	5.4	33.0	1.37	8.44	118.3	18

PULSE WIDTH

GROUP	AMMO TYPE	MEAN PULSE WIDTH (Msec)	MAXIMUM PULSE WIDTH (Msec)	MINIMUM PULSE WIDTH (Msec)	STANDARD DEVIATION (Msec)	COEFFICIENT** OF VARIATION (%)	SAMPLE SIZE
1	TP	2.9	3.0	2.6	0.17	5.72	5
2	HEI	3.4	4.0	2.5	0.71	21.0	5
3	TP-T (Single)	4.4	5.0	2.0	1.04	12.0	9

RATE OF FIRE

GROUP	RATE SET	MEAN TIME PEAK TO PEAK (Msec)	MEAN RATE OF FIRE (rdpm)	MAXIMUM TIME (Msec)	MINIMUM TIME (Msec)	STANDARD DEVIATION (Msec)	COEFFICIENT OF VARIATION (%)
6	Slow	131.2	458	140	120	7.57	5.36
7	Fast	74.7	803	80	70	3.84	5.14

* Equivalent foot-candles (see Figure 14) are computed from the approximation 0.76 μa = 1 foot-candle and assumes the radiation incident upon the tube is equivalent to blackbody radiation at a color temperature of 2,870°K. Figure 15 is secondary flash and of 2,870°K blackbody radiation (See AMCP 706-255, pg 2-3[4])

** *Coefficient of Variation or relative standard deviation*

$$C = \frac{\text{standard deviation}}{\text{sample mean}}$$

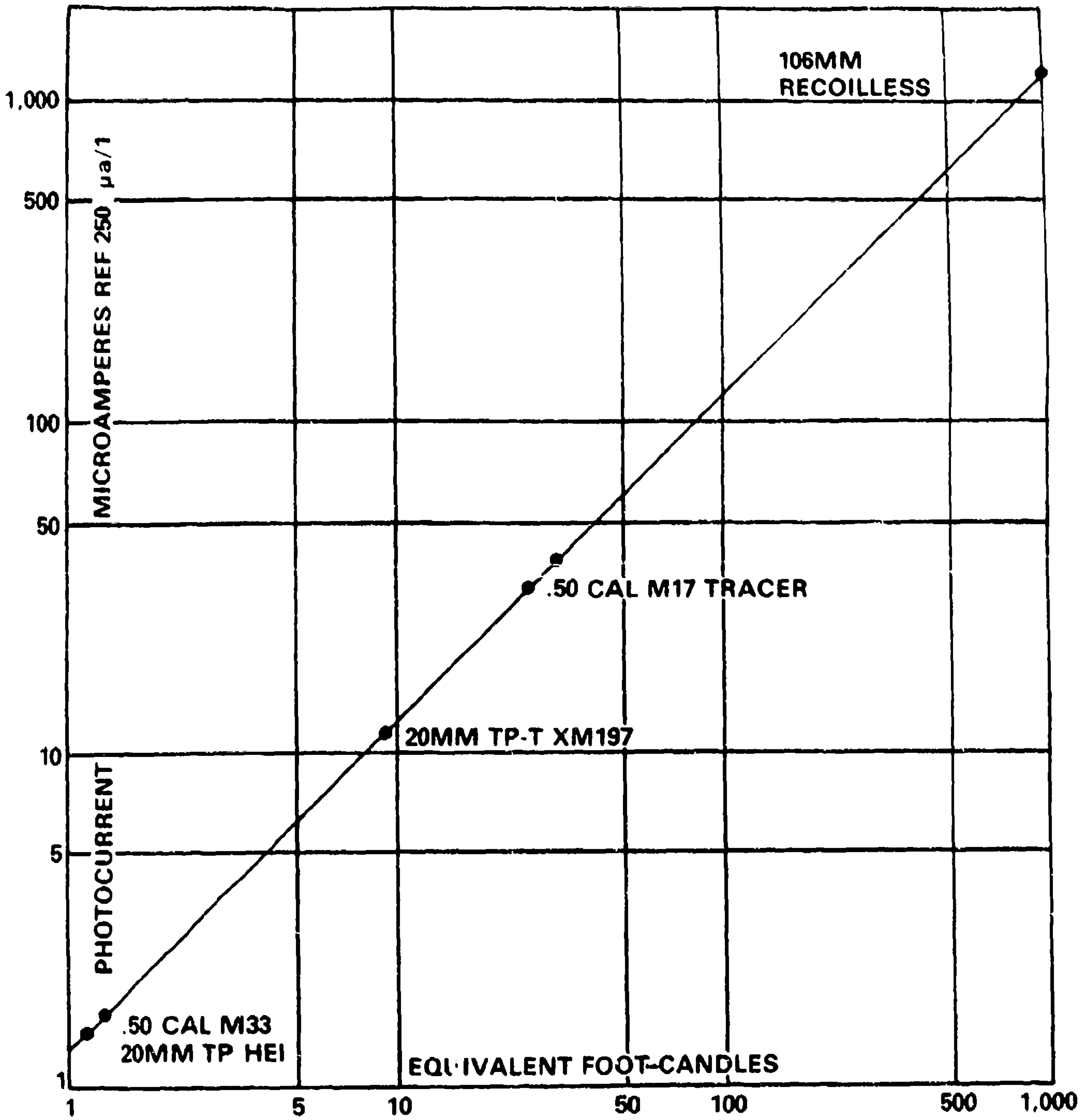


Figure 14. Equivalent Foot-Candles

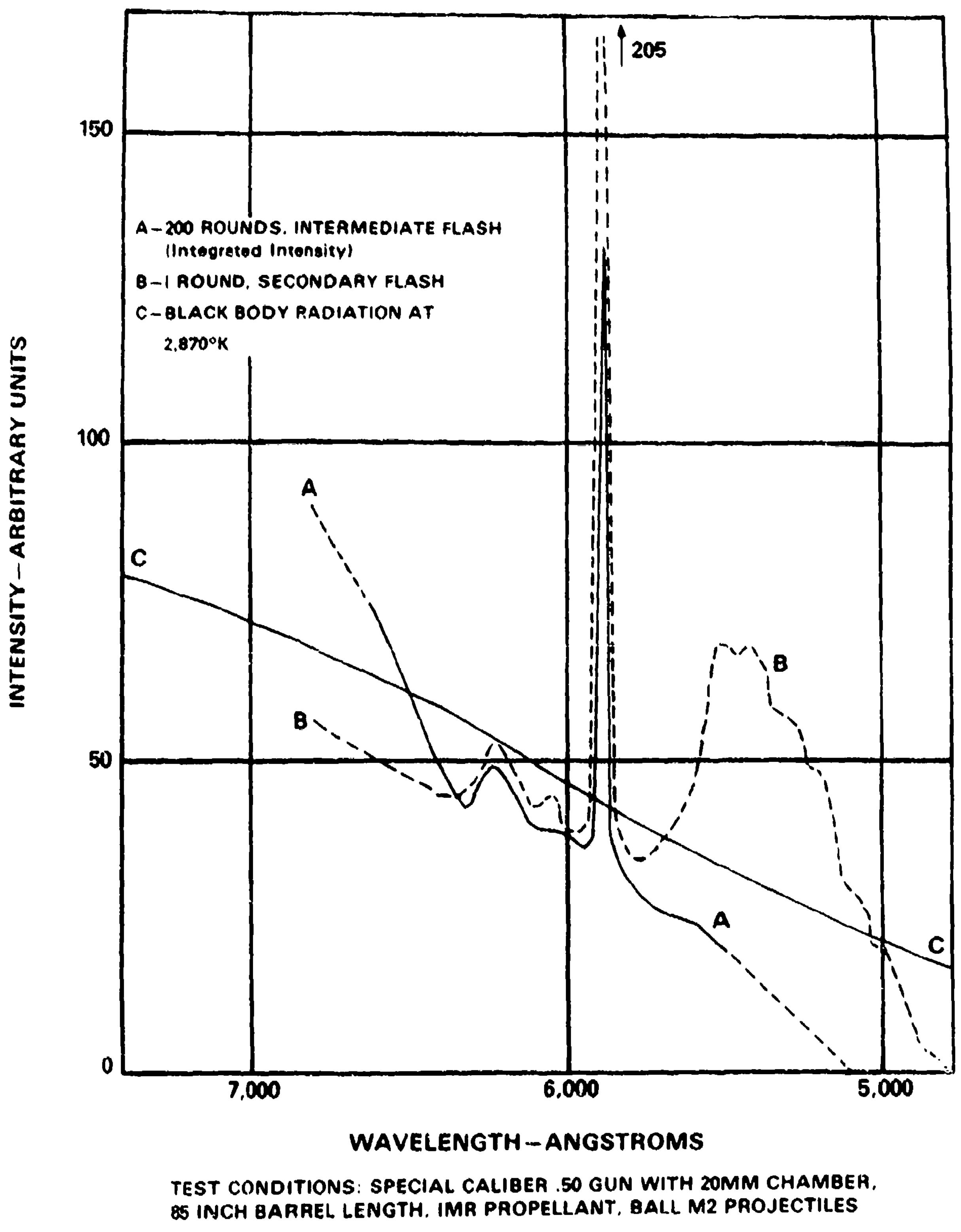


Figure 15. Comparison of 2,780 °K Blackbody Radiation and Muzzle Flash Spectrum

A graphic study of flash geometry is shown in Figures 16 through 21. These photographs integrate anywhere from 5 to 10 rounds up to bursts of 50 to 75 rounds or more. They show flash geometries both without tracers (Figures 16, 17, and 18) and with tracers (Figures 19, 20, and 21). The photographs clearly detail the primary, intermediate, and secondary phases of weapon muzzle flash. The red streaks or traces are due to a combination of the primary and secondary igniters in the TP-T rounds and possibly to a limited extent, the tracer elements themselves. (**Note:** Some traces fade before the end of the photograph frame indicating the end of at least one phase of igniter burning.)

As indicated earlier in this report, the expected firing rates for the XM197 are 400 rdpm slow rate and 700 rdpm fast rate. Flash measurements taken during this test indicate that the test firing rates were:

- Fast rate 803 ± 41 rdpm
- Slow rate 458 ± 27 rdpm

Accordingly, these frequencies are recommended by this laboratory for first approximation test profiles.

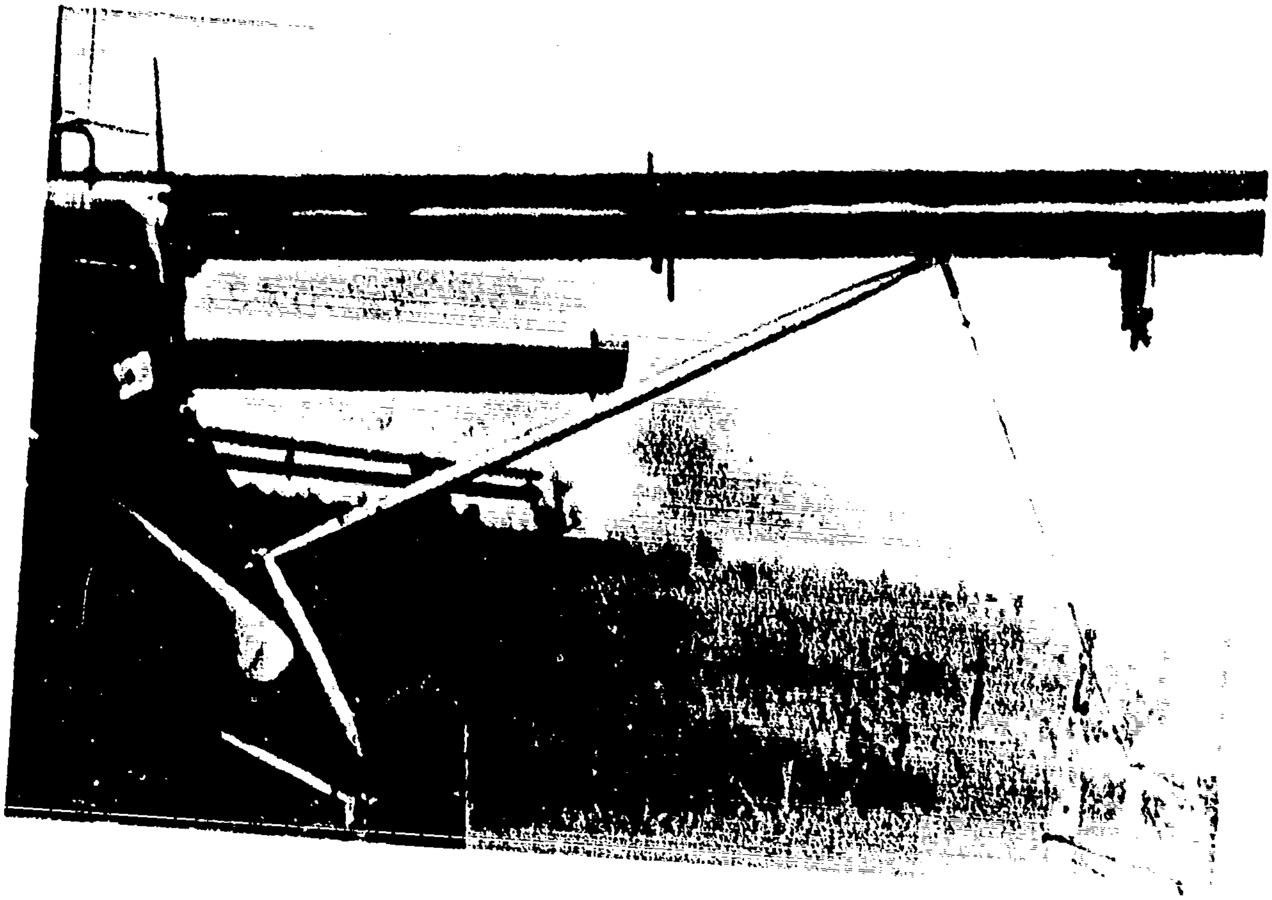


Figure 16. XM197 Daylight Firing

Figure 17. Ball, HEI Flash Geometry, Short Burst

Figure 18. Ball, HEI Flash Geometry, Long Burst

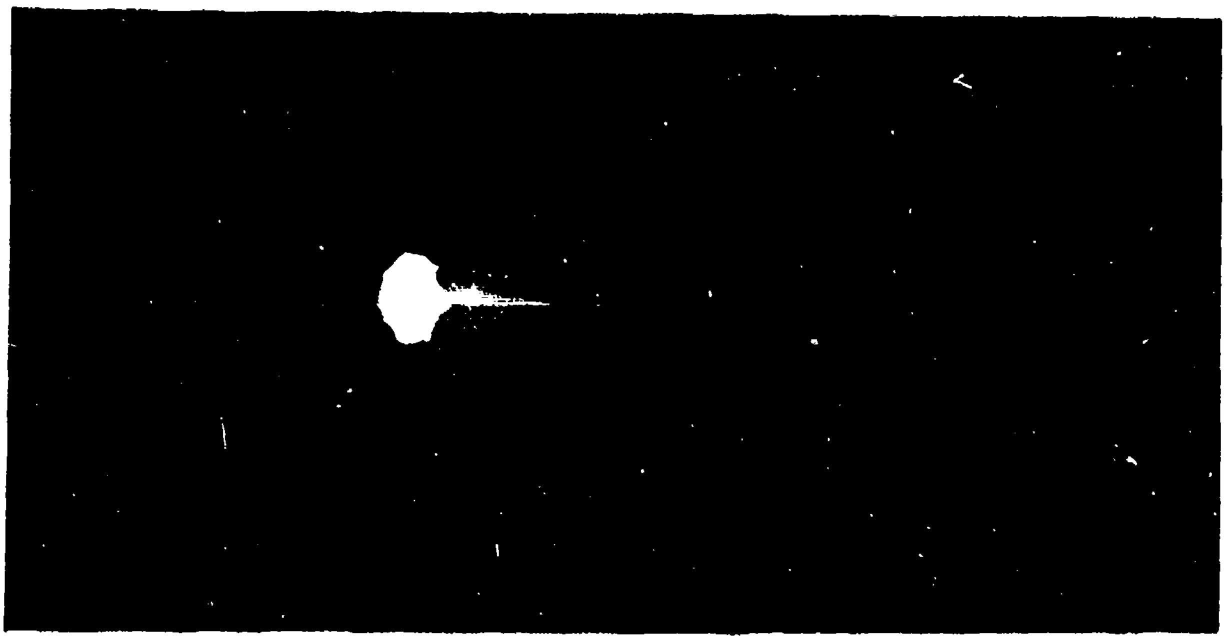


Figure 19. Ball, Tracer Flash Geometry, Short Burst

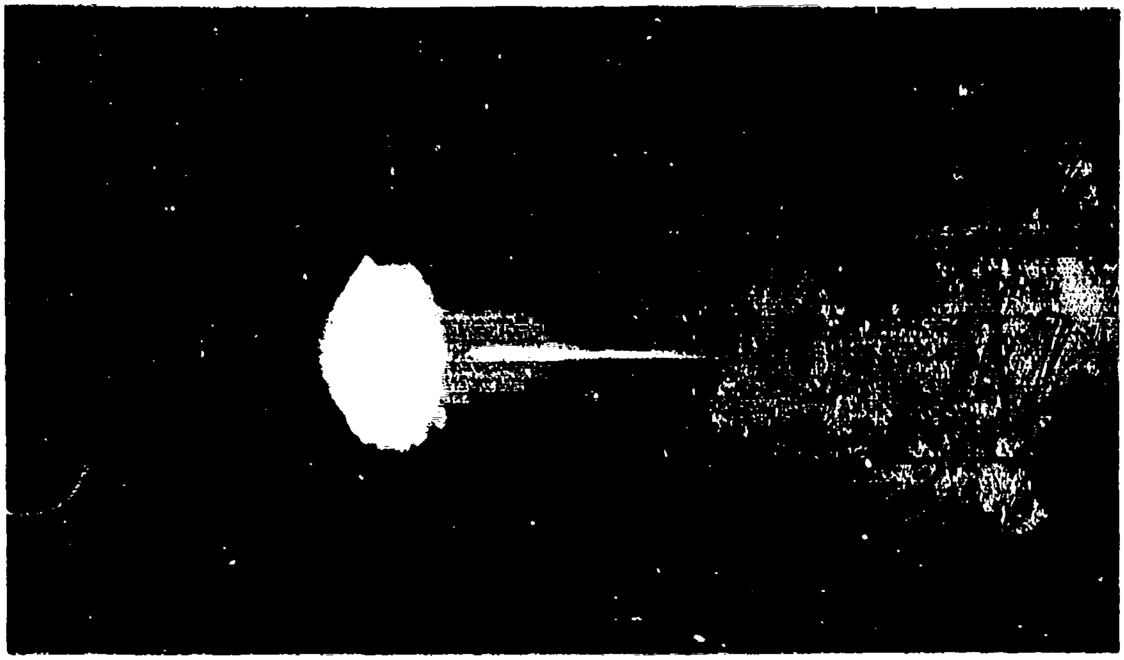


Figure 20. Ball, Tracer Flash Geometry, Medium Burst

Figure 21. Ball, Tracer Flash Geometry, Long Burst

SECTION VI. COMPARISON OF XM197 TO OTHER WEAPON SYSTEMS

In the past, Night Vision Laboratory personnel have carried out several investigations of weapon muzzle flash in order to properly design the active components of several night vision systems currently under development. Certain areas of information generated in these tests should be of interest to Air Force personnel and are presented here for informational purposes.

Table 4 shows the values of pulse amplitudes obtained for Cal .50 ammunition including M33 Ball, M2 Armor Piercing, M17 Tracer, and M10 Tracer. Various ages of ammunition are represented also. These test were carried out at Camp A. P. Hill, Virginia, between October 1970 and April 1971.[1,2] Additional tests on Cal .50 ammunition were carried out at the USMC Base at Quantico, Virginia.[2] Figures 22 and 23 illustrate Cal .50 M33 ball ammo with and without flash suppression. Figures 24 and 25 illustrate Cal .50 M17 tracer/M33 ball with and without flash suppression. Figures 26 and 27 illustrate Cal .50 tracer (delayed ignition)/M2 Armor Piercing with and without flash suppression.

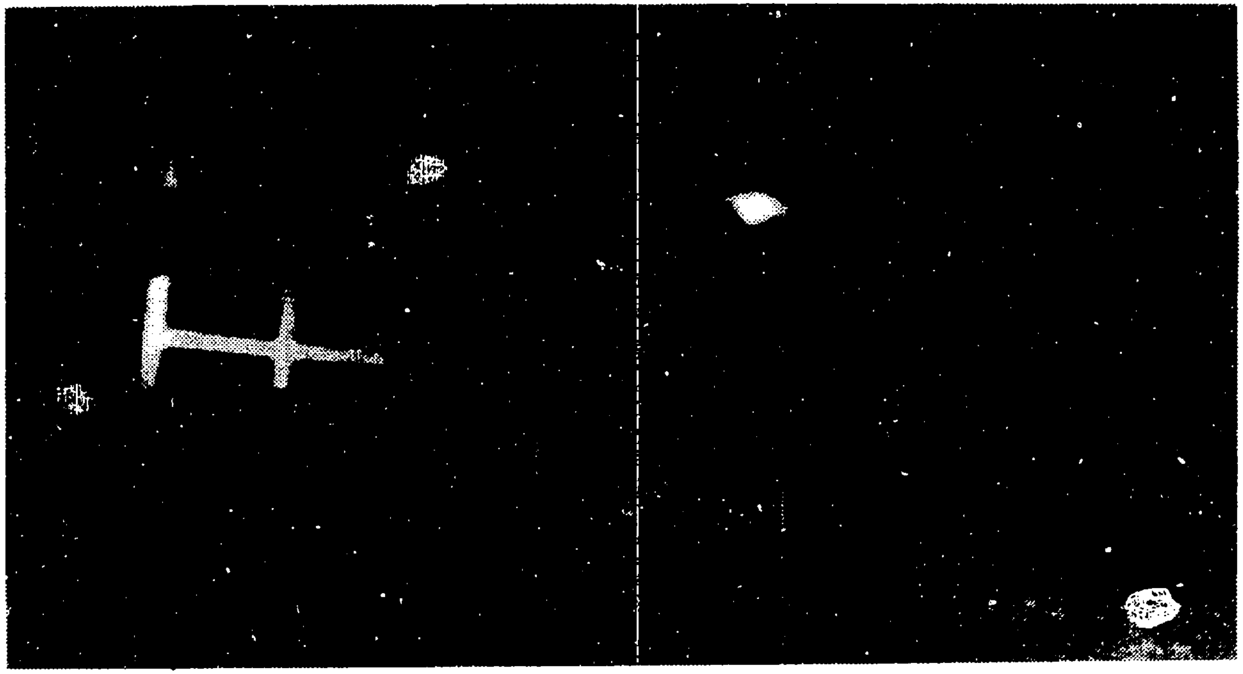
In January 1971, personnel of this laboratory carried out an evaluation of the M139 Hispano Suisa 20mm Cannon at Aberdeen Proving Grounds, Maryland.[5] This weapon has a muzzle velocity of 1,050 meters/second and a rate of fire of 200, 800-1,050 rdpm. It is normally mounted on the M114A1 Armored Command and Reconnaissance Vehicle. This weapon is also routinely equipped with a standard flared flash suppressor. This flash suppression reduced observed flash pulses from armor piercing incendiary tracers (API-T) to values ranging from 0.05 to 0.24 μa or from 1 to 2 orders of magnitude less than nonflash suppressed Cal .50 and 20mm tracers. This weapon produces the least severe flash environment of any major weapon tested thus far.

Table 4. Cal .50 Pulse Amplitudes

PHOTOCURRENT μa (Relative to a 250 μa/1)

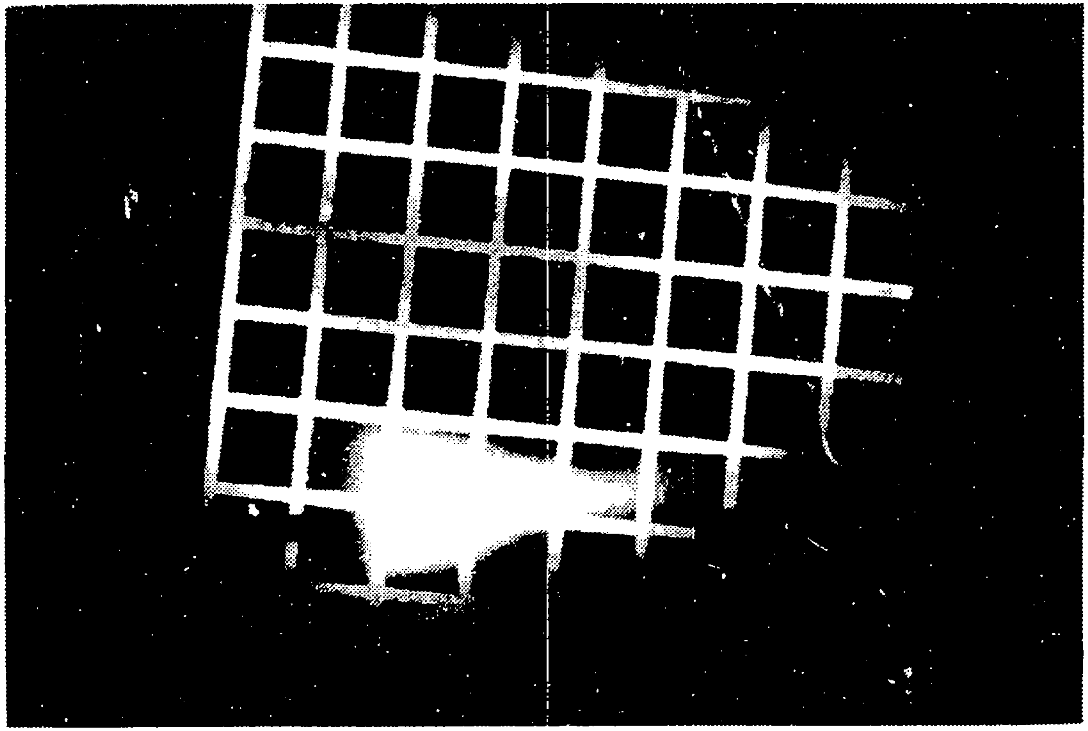
	MEAN	EQUIVALENT FOOT-CANDLE*	MAXIMUM	MINIMUM	SAMPLE SIZE
1. Ball (1971) M33 (12 April Test)	.42	0.30	.62	.17	38
2. Ball (1971) M33 w/Flash Hider (12 April Test)	.10	.08	.10	.10	about 30
3. Tracer (1971) M17 (12 April Test)	16.30	12.30	56.00	2.30	16
4. Tracer (1971) M17 w/Flash Hider (12 April Test)	21.00	15.90	60.00	1.00	18
5. Armor Piercing (1945) M2 (12 April Test)	1.32	1.00	2.50	1.00	30
6. Armor Piercing (1945) M2 w/Flash Hider (12 April Test)	.10	.08	.10	.10	about 30
7. Tracer (1945) M10 (12 April Test)	1.95	1.50	3.20	1.50	6
8. Tracer (1945) M10 w/Flash Hider (12 April Test)	.10	.08	.10	.10	about 30
9. Ball (1969) M33 (17 February Test)	(2.58)	(1.90)	(4.30)	(1.70)	(121)
10. Tracer (1969) M17 (17 February Test)	(7.12)	(5.40)	(16.00)	(2.70)	(33)
11. Ball (abt 1953) M33 (14 October Test)	.71	0.50	.91	.45	15
12. Tracer (abt 1953) M17 (12 April Test)	318	24	750	2.10	10

* 0.76 ma = Foot-Candle 2,870°K radiation.



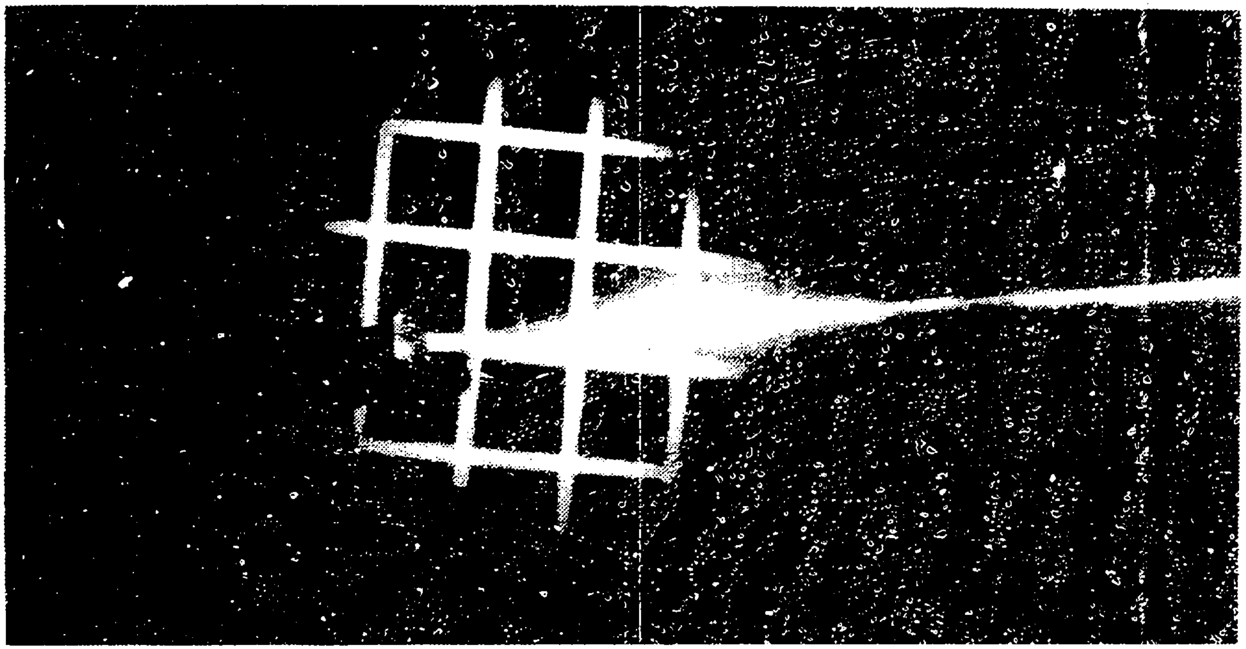
AMMUNITION LOT #88692
4 BALL ROUNDS
WITH MUZZLE FLASH SUPPRESSOR
INTENSITIES: NOT MEASURABLE

Figure 22. Cal .50 Flash Suppressed M33 Ball



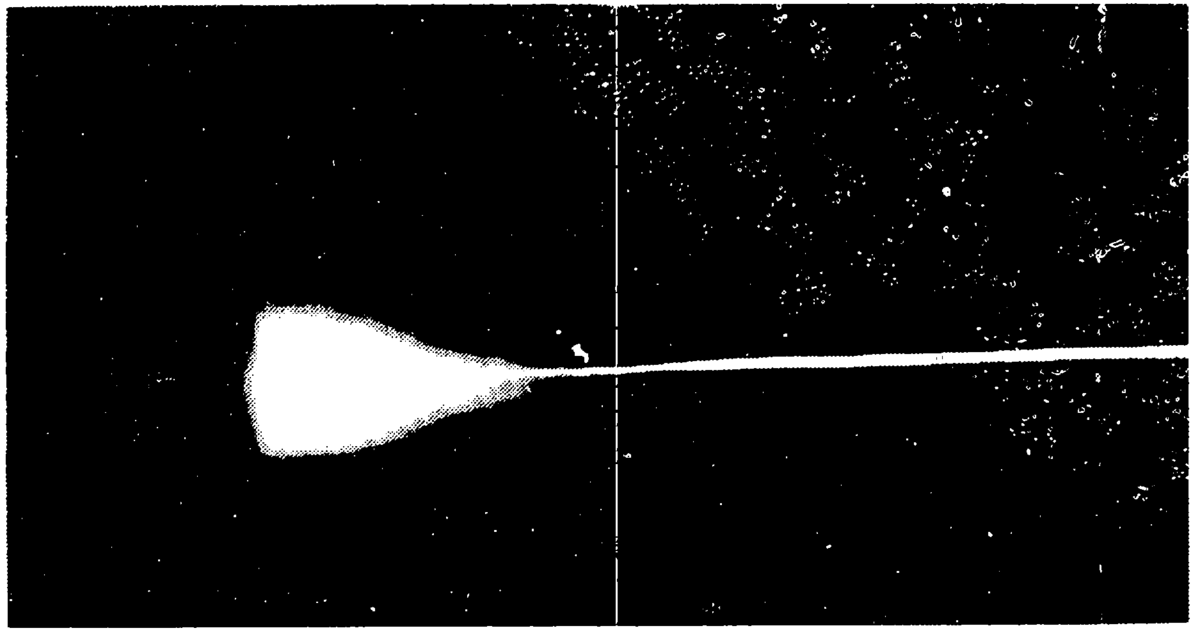
AMMUNITION LOT #88692
3 BALL ROUNDS
WITHOUT MUZZLE FLASH SUPPRESSOR
INTENSITIES: 15mv, 17mv, 19mv

Figure 23. Cal .50 Unsuppressed M33 Ball



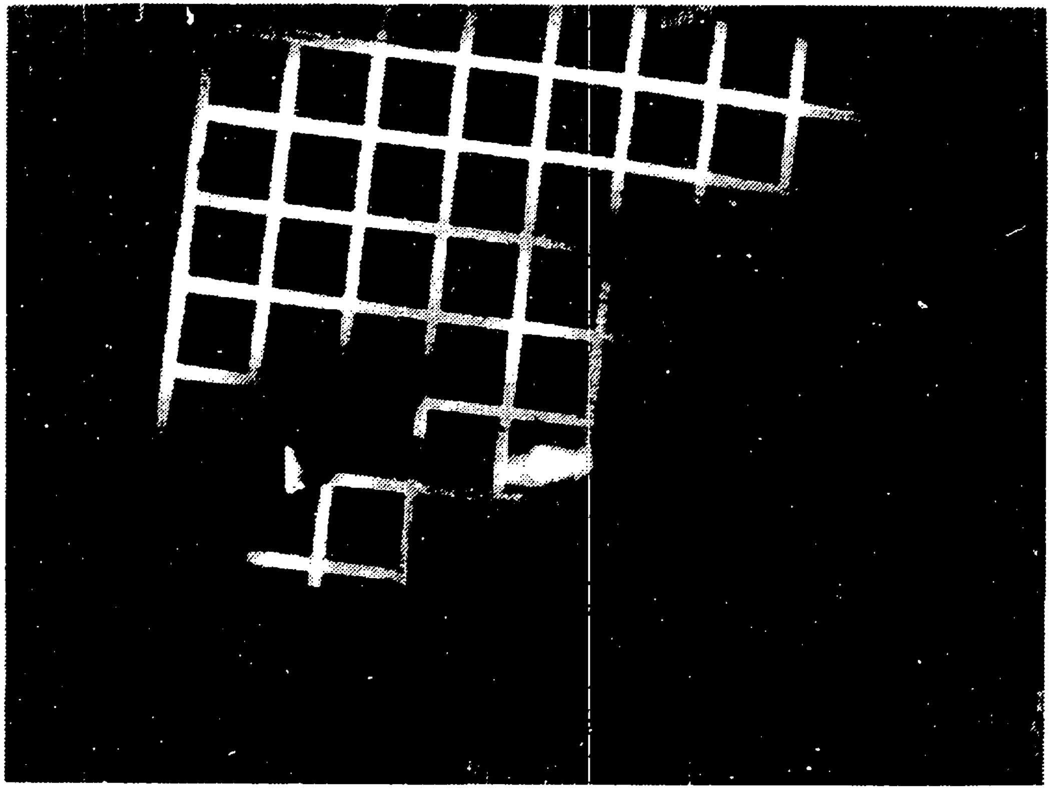
AMMUNITION LOT #104873
1 TRACER, 4 BALL ROUNDS
WITH MUZZLE FLASH SUPPRESSOR
ILLUSTRATING INCEPTION OF TRACER BURN
INTENSITIES: TRACER 19mv

Figure 24. Cal .50 Flash Suppressed M17 Tracer/M33 Ball



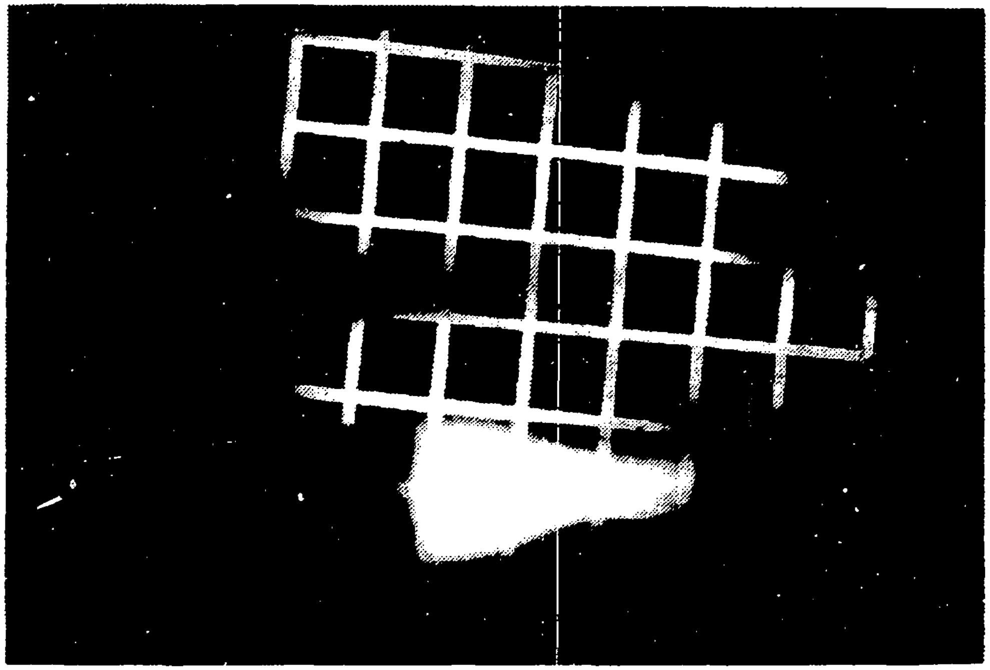
AMMUNITION LOT #104373
1 TRACER, 2 BALL ROUNDS
WITHOUT MUZZLE FLASH SUPPRESSOR
ILLUSTRATING INCEPTION OF TRACER BURN

Figure 25. Cal. 50 Flash Unsuppressed M17 Tracer/M33 Ball



AMMUNITION LOT #88692
3 TRACER, 12 BALL ROUNDS
WITH MUZZLE FLASH SUPPRESSOR
INTENSITIES: BALL NOT MEASURABLE

Figure 26. Cal .50 Flash Suppressed M10 Tracer/M2 AP



AMMUNITION LOT #88692
2 TRACER, 3 BALL ROUNDS
WITHOUT MUZZLE FLASH SUPPRESSOR
INTENSITIES: 11mv, 15mv, 14mv, 16mv

Figure 27. Cal .50 Unsuppressed M10 Tracer/M2 AP

SECTION VII. FLASH SIMULATION

Due to the high cost and complexities of repeated field firing tests of night vision devices and the lack of control inherent in these tests, Night Vision Laboratory has felt the need of undertaking simulation, of many field conditions, one important aspect of which is weapon muzzle flash simulation. By developing a flexible weapon muzzle flash simulation this laboratory has been able to effectively tackle problems of image tube and power supply design, carry out power supply breadboard studies, substantially reduce costly field tests, and accurately forecast night sight system performance as influenced by muzzle flash environments.

The Night Vision Laboratory simulator consists of a slit in a disc which is rotated past a stationary, high intensity light source which is then focused on the tube photocathode. By shaping the slit in the moving disc, the output flash profile can be adjusted to desired brightness and duration. The disc is easily removed so a variety of flashes may be simulated. The motor to drive the disc is a variable speed (0 to 120 rpm) constant torque D-C velocity servo. Electronic shutters allow the flash to be intermittently released into the test chamber for various numbers of rounds without having to shut off the motor. When the flash enters the test chamber, it passes through a beam splitter and then strikes the cathode of the tube in test and also the cathode of a 25mm image intensifier photodetector used to determine the beginning and ending time of the flash. A photomultiplier tube is positioned against the screen of the tube in test to determine the profile of the flash emitting from the tube. The signal from the 25mm photodetector and the P.M.T. are displayed on a dual-trace storage oscilloscope for comparison of response time. The beam splitter allows an image to be projected on the cathode at controlled brightness to determine if a simulated target is visible or not. Small bulbs are located in the test chamber which can be adjusted to control ambient light level. Figure 28 is a cut away view of the Night Vision Laboratory Muzzle Flash Simulator. This simulator is sufficiently versatile as to allow simulation of muzzle flashes of most of the individual and crew served weapons presently in service in the Armed Forces.

Figures 29 through 40 illustrate typical test profiles and typical response of several second generation image intensifier tube assemblies to impose flash profiles. The profiles include Cal .50 Ball and Tracer, Cal .50 Tracer only (Ball Flash Suppressed), and 20mm TP (Ball) and TP-T (Tracer), XM197 fast rate of fire. The basic image intensifiers are similar in performance but differ markedly in power supply design which predetermines the tube assemblies' response to the transients produced by muzzle flash.

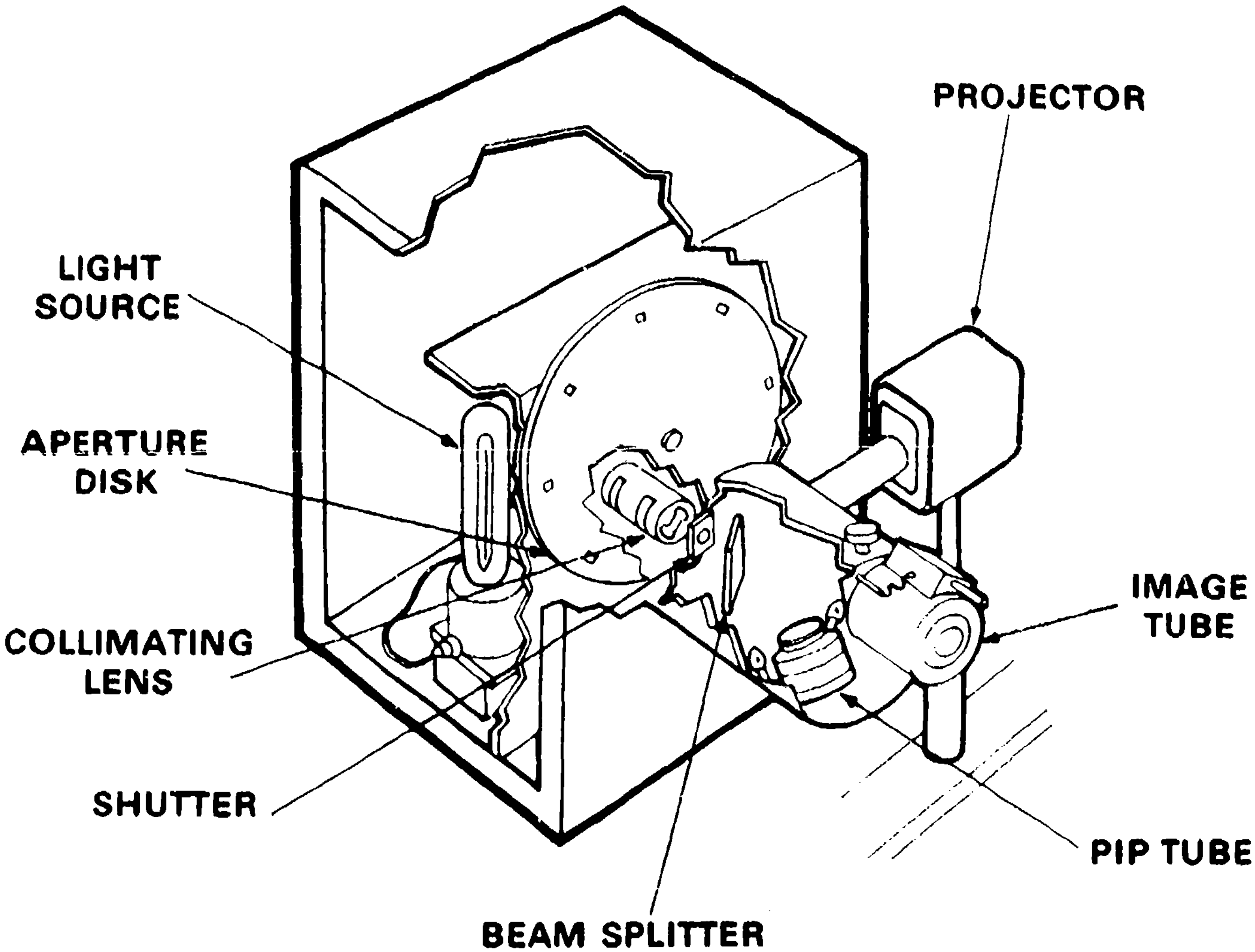


Figure 28. Cut Away of Night Vision Laboratory Flash Simulator

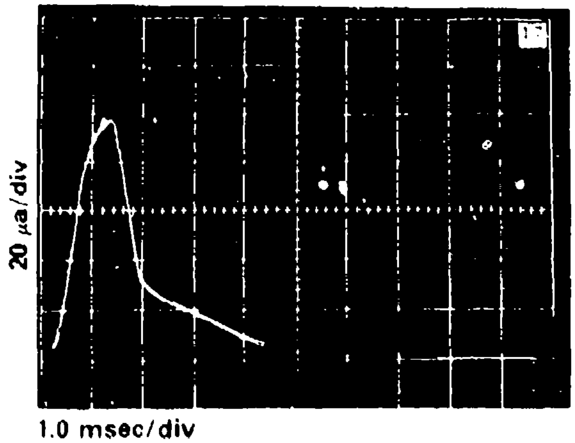


Figure 29. Cal .50 Tracer Flash Simulation

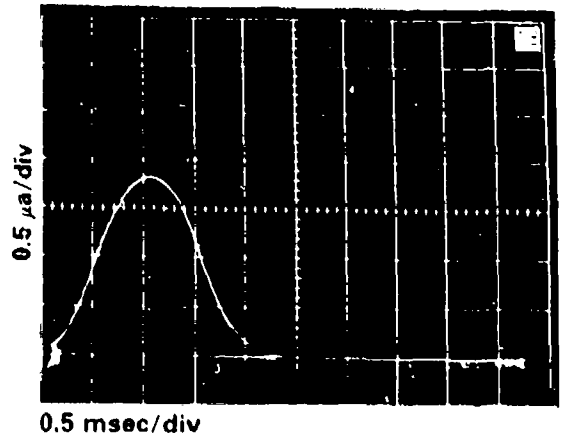


Figure 30. Cal. 50 Ball Flash Simulation

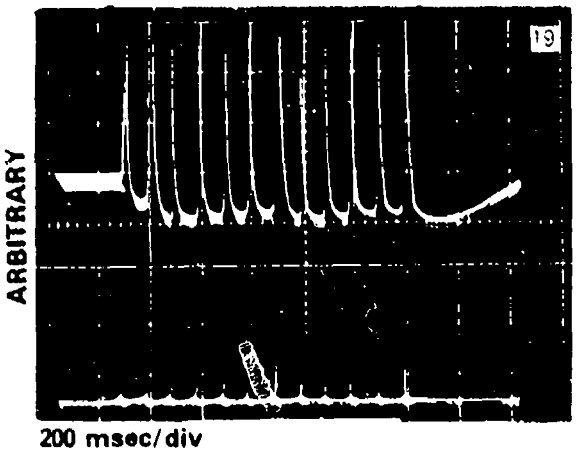


Figure 31. Second Generation Image Tube Cal .50 Ball/Tracer Response Design ABC 121

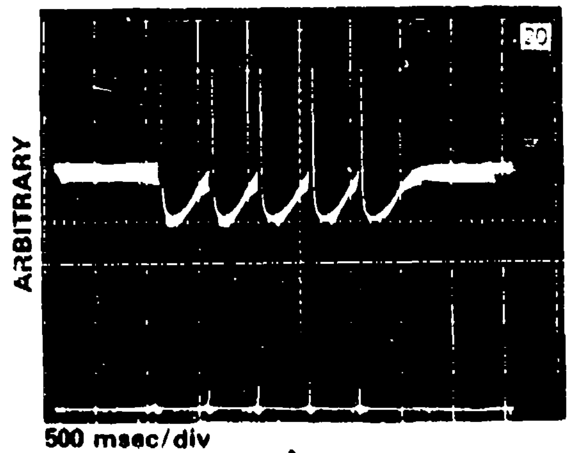


Figure 32. Tube Design ABC 121 Cal .50 Tracer Response Flash Suppressed Weapon

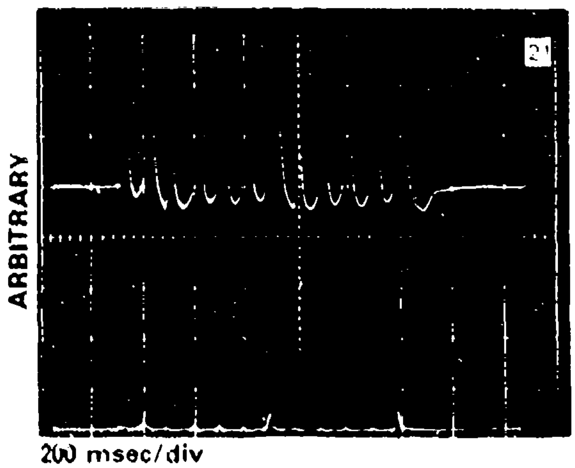


Figure 33. Second Generation Image Tube 015 (Flash Corrected Tube) Cal .50 Ball/Tracer Response

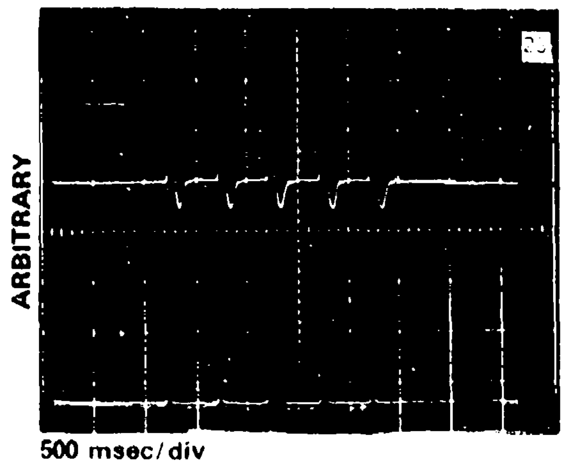


Figure 34. Tube 015 Cal .50 Tracer Response (Flash Suppressed Weapon)

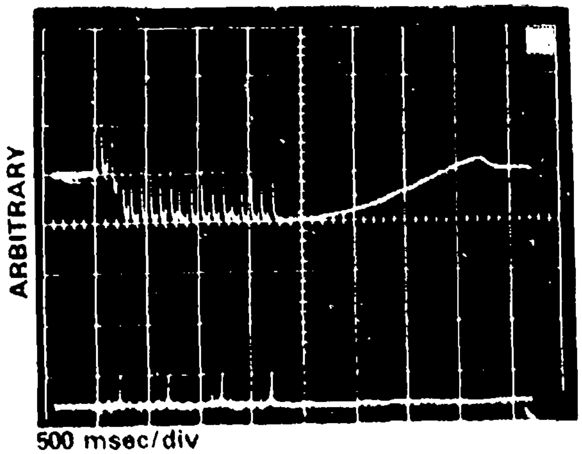


Figure 35. Tube ABC 351 Cal .50 Ball/Tracer Response

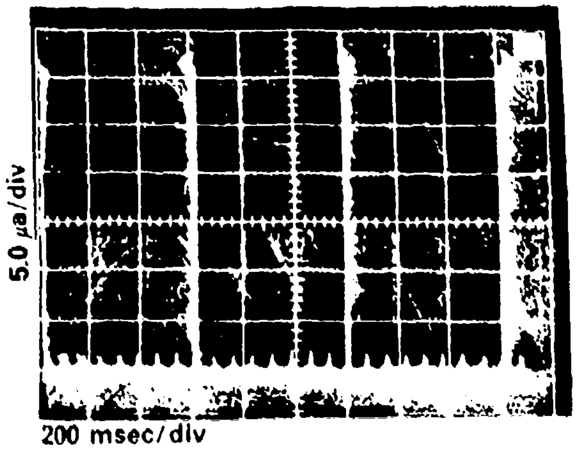


Figure 36. XM197 Ball/Tracer Simulation, Fast Rate

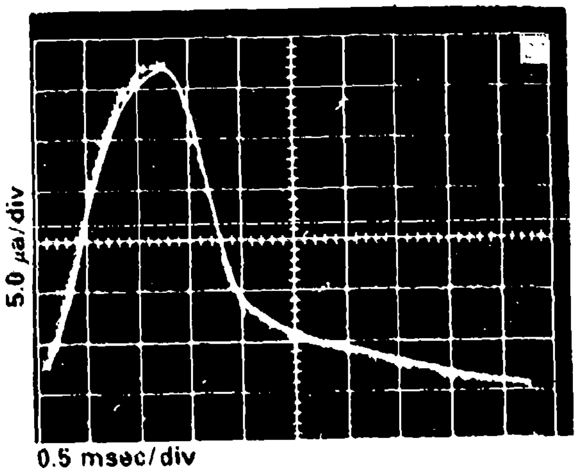


Figure 37. XM197 Tracer Flash Simulation

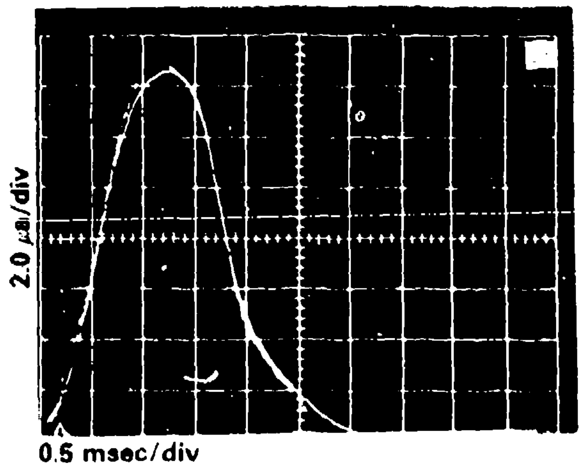


Figure 38. XM197 Ball Flash Simulation

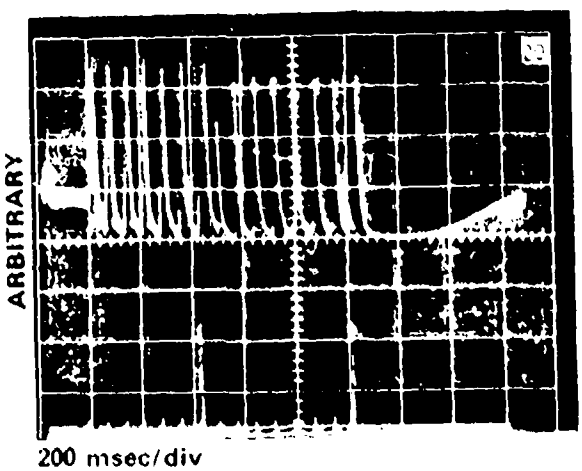


Figure 39. Tube ABC 121 XM197 Ball/Tracer Response

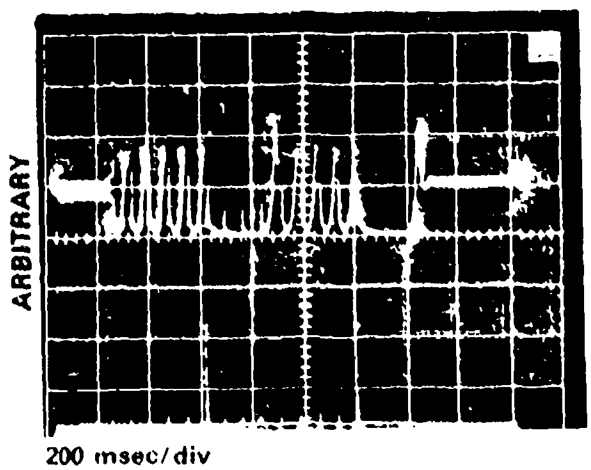


Figure 40. Tube 468 XM197 Ball/Tracer Response

SECTION VIII. DISCUSSION OF MUZZLE FLASH RESULTS

The muzzle flash characteristics of the XM197 20mm cannon do not appear to be too severe and it is expected that the SSS/CSWS will function satisfactorily as a night gun sight on this weapon. These conclusions are based upon limited muzzle flash data. Sufficient muzzle flash data is not available at this time to define a hard contractual specification for power supply recovery time under simulated firing conditions. Flash measurements were taken from the same mounting position where the camera/Night Vision System (NVS) was operated. The relative mounting position of the direct view NVS during the October Eglin tests is shown in Figure 4, page 3. The planned mounting position for future applications is similar to the direct view NVS position but shifted to the left over the center line of the gun frame. No significant difference in muzzle flash effects on the AN/TVS-5 are expected from these different positions due to the observed symmetry of the flash profile.

Subsequent simulation tests of the XM197 at the Night Vision Laboratory indicate that the image tube recovery for the slow rate of fire mode is satisfactory and should allow the gunner to deliver accurate fire on the target. The tube recovery is, however, marginal when tested under a simulated fast rate of fire with low contrast targets. Under these conditions, the image quality is reduced and the target is just barely visible. A well trained gunner or a novice with sufficient self discipline to concentrate on the target should still be able to deliver effective fire at the fast rate but a reduction in accuracy may be expected. It is therefore desirable to use image tubes with the best available response time.

SECTION IX. CONCLUSIONS AND RECOMMENDATIONS

- Muzzle flash amplitudes of the XM197 are slightly less severe than Cal .50 machine gun. Reference Figure 14 and Tables 3 and 4.
- 25mm image intensifiers as presently constituted and being purchased for the PVS-4 and TVS-5 gun sights are satisfactory for use on the XM197 when fired in the slow rate mode.
- Based on laboratory simulations derived from field test data, the recovery of the present power supply used with the image intensifier tube is marginal for use with the XM197 when fired in the fast rate mode. Some loss in imagery is expected during the fast rate of fire.
- The position of the night gunsight when used for direct observation by the gunner and the position used to obtain motion picture sequences and flash signatures were different. No significant difference in muzzle flash effects on the AN/TVS-5 are expected from this difference in position.

It is recommended that the new fast response image intensifier tube power supplies as recently developed at the Night Vision Laboratory should be field tested in the AN/TVS-5 Night Gun Sight in the event that sustained periods of fast rate of fire from the XM197 are required.

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