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WEAPON TRAINING INSTRUMENTATION

FINAL REPORT

Contract No: N61339-92-C-0038

CDRL A001

PREPARED FOR:

Naval Training Systems Center

Orlando, FL 32826

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Prepared by:

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Schwartz Electro-Optics Inc.

3404 N. Orange Blossom Trail

Orlando, Fl. 32804

July 31, 1992

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SCHWARTZ ELECTRO-OPTICS, INC. SECTION 2 / RIGHT SIDE
3404 North Orange Blossom Trail PART 1 / LEFT SIDE
Orlando, Florida 32804

Bujari
NEG. NAME FILED BY.
Fax No. (407) 297-1794

Telephone No.
(407) 298-1802

July 31, 1992

Naval Training Systems Center
ATTN: AMCPM-TND-EI
12350 Research Parkway
Orlando, Florida 32826-3275

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Sincerely,

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Zelma Slusser
Zelma Slusser
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1.0 INTRODUCTION

1.1 Objective

The objective of this Small Business Innovative Research (SBIR) Phase I program is to define a non-intrusive instrumentation capability that will record the soldier/crew interactions and performance for post exercise analysis and critique. The soldier/crew instrumentation system will record sight picture, weapon spatial orientation at time of fire, and the physical interactions between the soldier/crew and weapon. The system must be small and lightweight so as not to interfere with the soldier/crew performance and will be suitable for both live fire and force on force training. The system will not interfere with installed MILES equipment.

1.2 Background

Experience has proved that the most effective individual and crew served weapon training has been accomplished when an experienced instructor is available to observe and critique each soldier on a real time basis. Unfortunately, the availability of qualified instructors is not adequate for the Army training task. SEO addressed the next best approach; recording the training events for post exercise evaluation and critique.

1.3 Approach

We investigated several phases of soldier/crew weapon training to evaluate the capabilities and limitations of the proposed instrumentation as applied to each phase of training. Our original proposal emphasized a crew weapon, such as, TOW. Our testing efforts were focused on the M-16 (AR-15) rifle because:

- a. The rifle is readily available.
- b. Live fire testing of the rifle is much more practical than that of a TOW.
- c. Since instrumentation of the rifle presents more difficult size and weight constraints than the heavy weapons a more universal system would be addressed.

1.4 Training Benefits

Training benefits from the instrumentation systems are listed below:

- a. Basic sight picture improvement and visibility to instructor.
- b. Aim point, trigger squeeze, and breathing analysis capability.
- c. Aim point correction or resolution with respect to projectile trajectory.
- d. Decrease in time required for battlesight zero and improvement of critical aim point.
- e. Decrease in time required for range qualification or proficiency sustainment firing.
- f. Decrease in number of instructors required.
- g. Decrease in upkeep of ranges.
- h. Decrease in learning of bad aiming practices.

1.5 Technical Objectives

The technical objectives of this Phase 1 SBIR program were as follows:

- a. Synthesize a system design meeting the objectives of the instrumentation system.
- b. Design, assemble/fabricate a functional instrumentation system using functionally equivalent commercial components such as, audio recorder, video camera, video recorder, computer, monitor, etc.
- c. Demonstrate functional performance of the system using a surrogate weapon.
- d. Develop a non-intrusive design for implementation during Phase II of the program.

1.6 Technical Obstacles

We have identified several technical obstacles that we must investigate to verify the validity of our approach as listed below:

- a. Demonstrate methodology of data recording and confirmation.
- b. Video camera reliability.
- c. Capability of hit pattern recording.
- d. Real time viewing of the video, video recording only, or simultaneous viewing and recording.
- e. Ultimate system size, weight, and cost.

2.0 SYSTEM DESCRIPTION

The Weapon Training Instrumentation (WTI) device (see Figure 1) is composed of a weapon mounted data collection device and a data processing station. The system block diagram for the WTI device is shown in Figure 2. The WTI device will be able to record the interactions of soldier/crew for both small arms and larger weapons and provide fast, effective and comprehensive monitoring of actions by the user or the instructor. To prove the concept that this type of video training can be applicable for both small arms and larger weapons, we chose the M-16 (AR-15) rifle as our test platform to collect data. (We might note that we selected the AR-15 rifle for the test because the AR-15 rifle was readily available, had the most user interest, has the fewest number of comparable training devices on the market and the logistics of live fire testing with the AR-15 could be done locally.)

2.1 Weapon Mounted Data Collection Device.

The weapon mounted data collection device includes a miniature CCD video camera, audio recorder, clinometer or other method for acquiring weapon position data, and weapon mounting fixture. The miniature CCD video camera will be boresighted to the weapon to record the operator's visual target acquisition as described in section 4.1.7. The audio recorder stores audio interactions between the instructor and soldier/crew and actual weapon firing times. Clinometer will be used to determine the weapon's spatial orientation during prefire operation and projectile fly-out time for some weapon types while small arm position information would be recorded as part of the actual video record. Figure 3 shows the weapon mounted data collection device implemented on the M-16 (AR-15) rifle. The video, audio, and weapon position data is collected when the soldier/crew are in position to fire. On weapons such as the DRAGON, TOW, etc. this data will be collected during the entire flight time of the projectile. The said data will be sent by wire or radio to the data processing station in real time or recorded only for post exercise analysis.

2.2 Data Processing Station

The data processing station would include VCR, AT computer, Bravado board, video scanner, TV monitor with speakers, and audio receiver. The data processing station system block diagram is shown in Figure 2. The video and audio information received from the weapon mounted data collection device will be sent to the Bravado board inside the AT computer. Inside the computer, the computer generated reticle are combined with the video image of the target. And for heavy weapons, the clinometer data is read serially by the computer and the clinometer data would also be combined. This combined data is then sent to the video scanner to be outputted to a display in two formats. The audio

information is passed through the video scanner and to the VCR. Output one (VGA graphics) format of the video scanner can be displayed on a Hi-Resolution VGA monitor. And Output two (NTSC) format of the video scanner will be sent to the VCR to record the combined video and the audio interactions. The video and audio output signals from the VCR is sent to the TV monitor, where the final image is displayed and the audio information can be heard.

3.0 TESTS and RESULTS

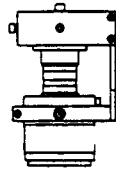
3.1 Raw Video Test

Problems in the past with mounting a video camera on a weapon have been the size of the camera, blooming of images, and slow image recovery. Recent technology advances have reduced the size and cost of video cameras. Cameras are built with high speed electronics to reduce blooming and have faster image recovery. Some concerns of mounting a miniature CCD video camera to a weapon was durability of the camera to handle the shock from firing live rounds.

Our setup for the raw video test of the video camera, VCR and monitor is shown in Figure 4. We mounted the video camera on the barrel of a M-16 (AR-15) rifle. The video image from the CCD video camera is sent to the VCR to be record and the video output of the VCR is displayed on the monitor. The monitor displayed the test in real time while the video data was being record for post exercise analysis.

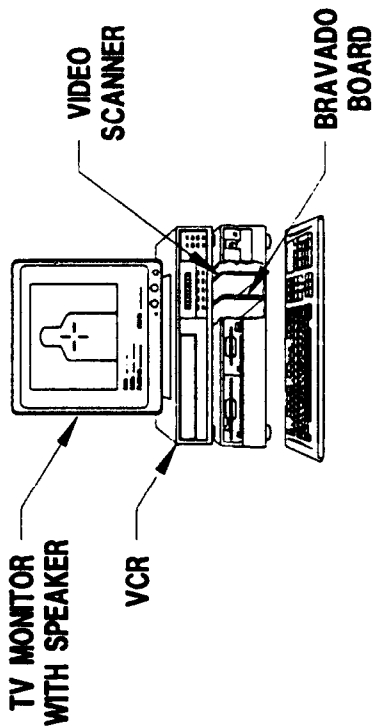
The objectives of the raw video test were 1) determine if the video camera would survive the shock from firing live rounds, 2) determine how fast the video camera recovered from the flash and the extent of the image blooming, and 3) determine what information could be collected from the video camera.

The results from our initial video test were very positive. The miniature CCD video camera mounted on the barrel survived the shock from firing 35 live rounds through the rifle. The video image did bloom from the flash of the live round, however during frame by frame play back, the video camera recovered in about three frames. Review of the initial video data was encouraging however it was impossible to determine the exact aim point, trigger squeeze and breathing pattern. Mounting the video camera on the barrel of the rifle added additional weight to the weapon that made it difficult to maintain a shooting position for any length of time.



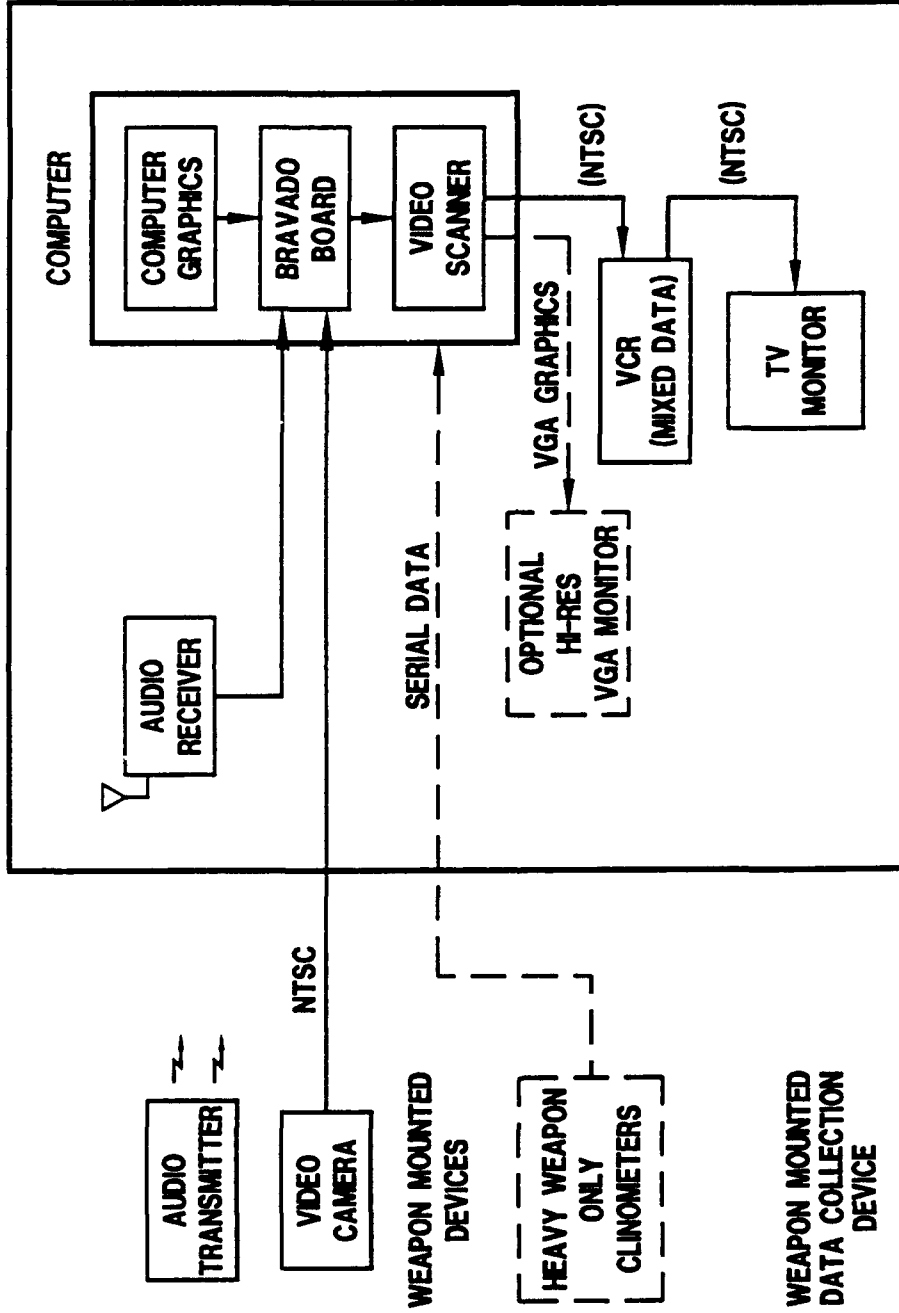
DATA COLLECTION

DATA PROCESSING STATION



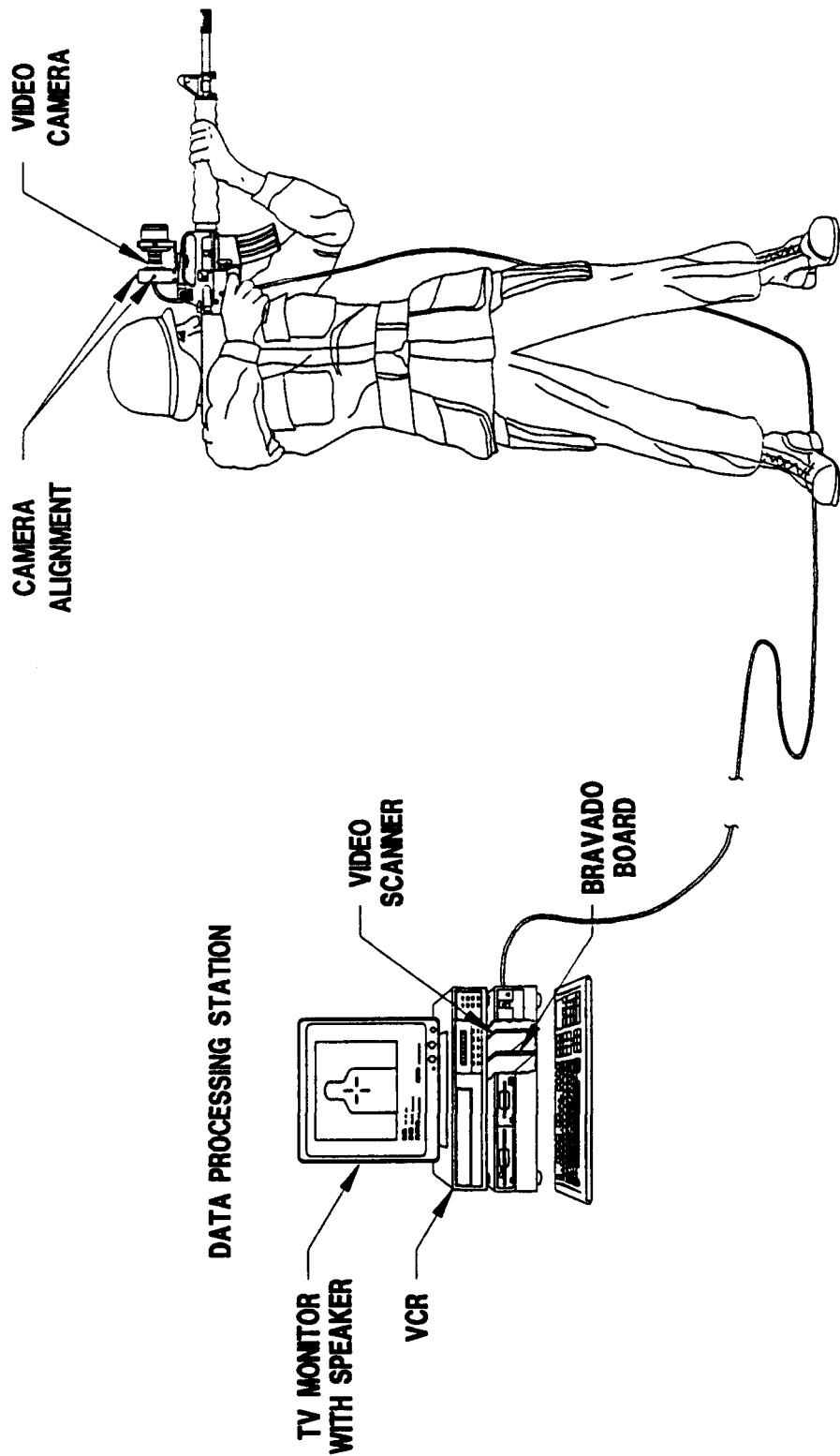
WEAPON TRAINING INSTRUMENTATION

FIGURE 1



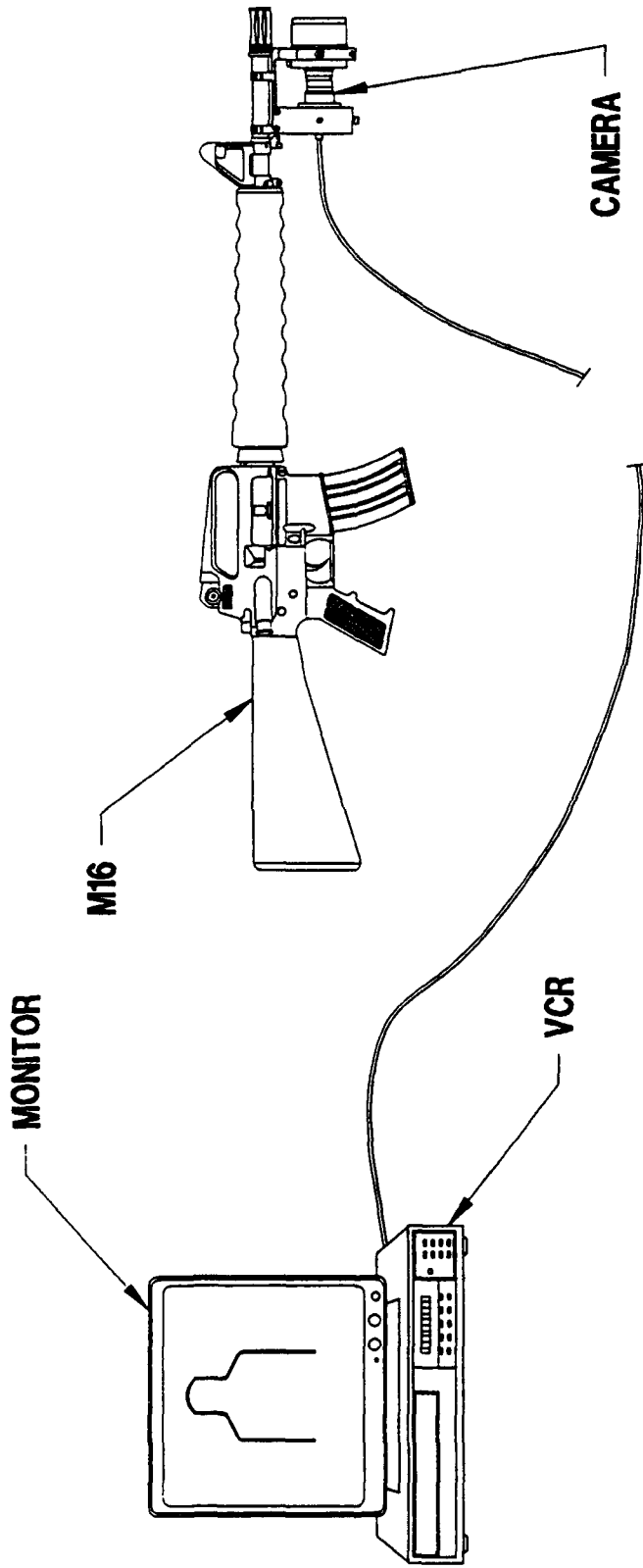
WEAPON TRAINING INSTRUMENTATION SYSTEM BLOCK DIAGRAM

FIGURE 2



THE INSTRUMENTED AR-15

FIGURE 3



RAW VIDEO CAMERA TEST SETUP

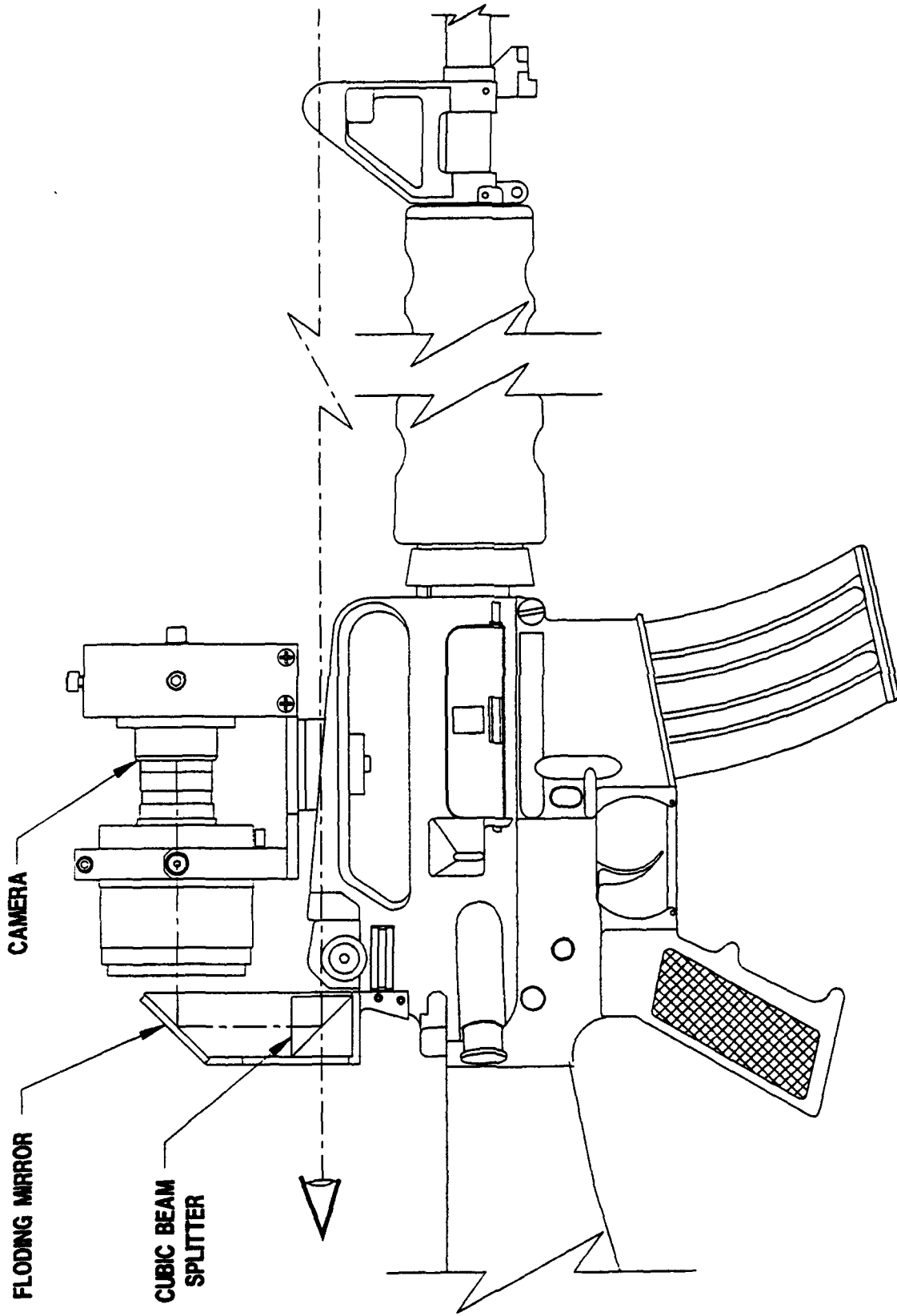
FIGURE 4

We concluded it is imperative to be able to see the sight picture for proper analysis of the exact aim point, orientation of the weapon, trigger squeeze, and breathing. Mounting the video camera at the center of mass of the rifle (above the carrying handle) would be easier for the soldier to maintain the rifle in shooting position. With the video camera mounted back away from the flash suppressor, the video image would be less effected by the flash of the live round and reduce the image blooming.

3.2 Sight Picture Experiment

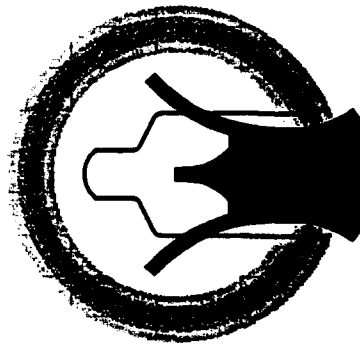
We experimented with the video camera and various optics to attempt viewing both the target and the rifle sights simultaneously. Our setup of the video camera, folding mirror, and cubic beam splitter is shown in Figure 5A. We used a cubic beam splitter to send the target image to the shooter and the folding mirror simultaneously. The folding mirror would then bounce the target image to the video camera mount above the carrying handle of the M-16 (AR-15) rifle.

We first mounted the 75mm lens on the video camera and tried to obtain a sight picture similar to Figure 5B. With the 75mm lens focused on the target at 25m, the front rifle sight was very blurred and it was difficult to determine the aim point. We then mounted 25mm lens on the video camera and focused at a 25m target at 25m, the front rifle sight was some what distinguishable but it still presented an unacceptable image. The 25mm lens also gave us a wide field of view and the target image utilized a small portion of the display. Our results showed that it is very difficult to focus on both the target and the front rifle sight with standard optics. We concluded that it may be possible to obtain the actual sight picture by using special bifocal optics that would replace the video camera lens however we decided to take the original video target image and combine it with a computer generated reticle as our rifle sight as shown in Figure 5C.

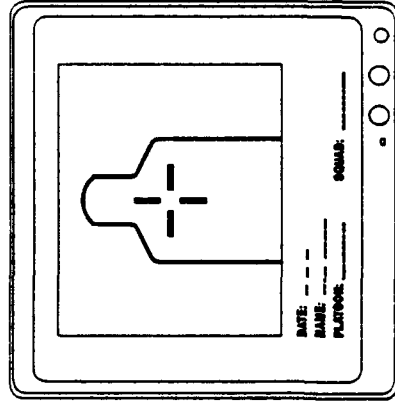


SIGHT PICTURE EXPERIMENT SETUP

FIGURE 5a



B CORRECT SIGHT PICTURE



C COMPUTER COMPOSITE DISPLAY

SIGHT PICTURE EXPERIMENT

FIGURE 5

3.3 Computer Generated Reticule

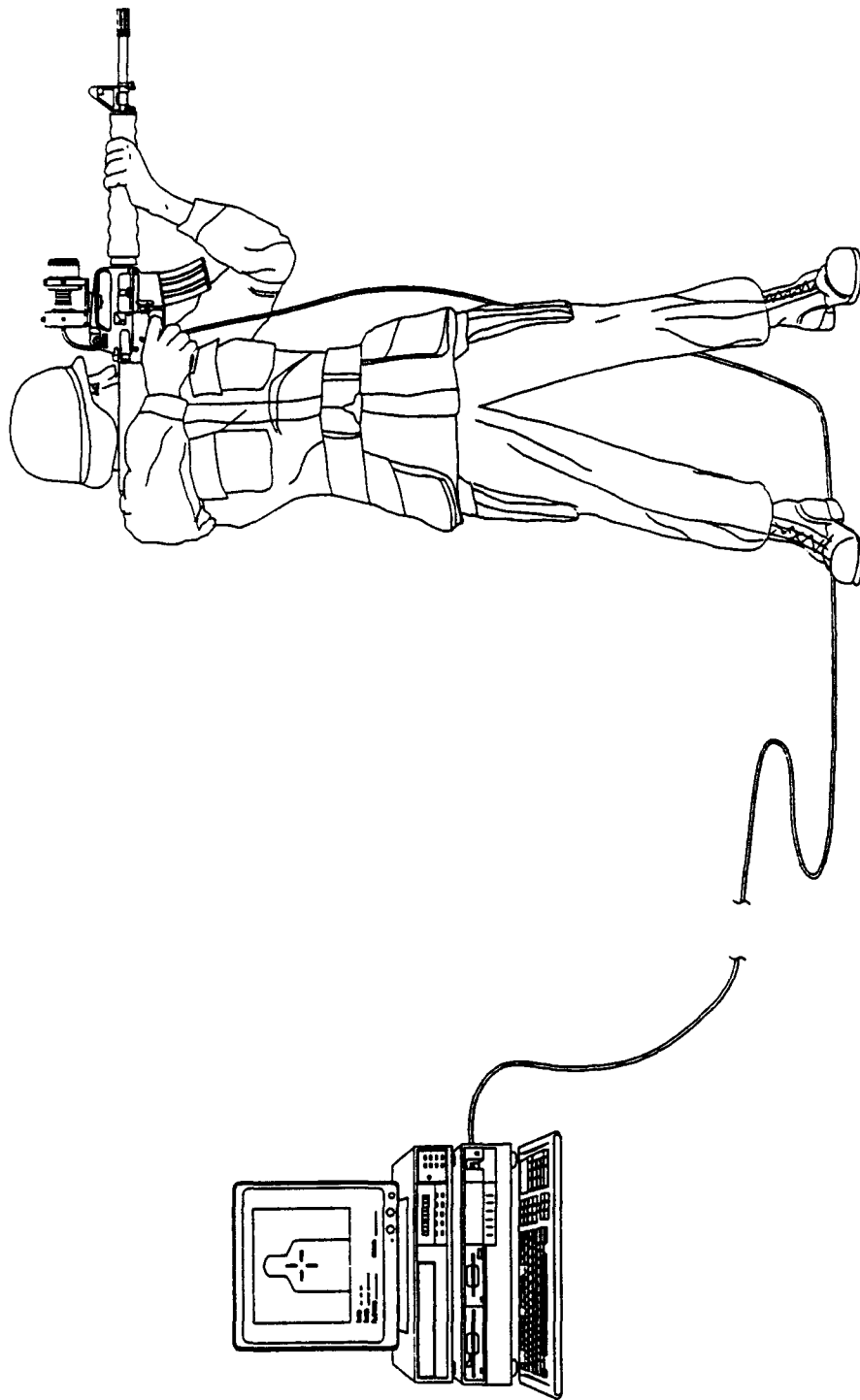
We created a computer program that displays a computer generated reticle superimposed on to the target image, the date of test, the name of soldier, the name of platoon, and the name of squad. This information would help in record keeping and monitor progress.

When viewing the combined reticle and target video, we were able to see the shooter's aim point at time of fire. We also could observe the rifle position or cant. During slow motion and frame by frame play back, we were able to determine the exact aim point, breathing pattern, and trigger pull at the time of fire.

From this analysis, we have determined that for the composite video to record accurate information about the shooters ability, it is imperative for the video camera to be boresight to the weapon and the computer reticle at battlesight zero. Using the computer generated reticle, we were able to mount a larger lens on the video camera to zoom in on our target to analyze target acquisition.

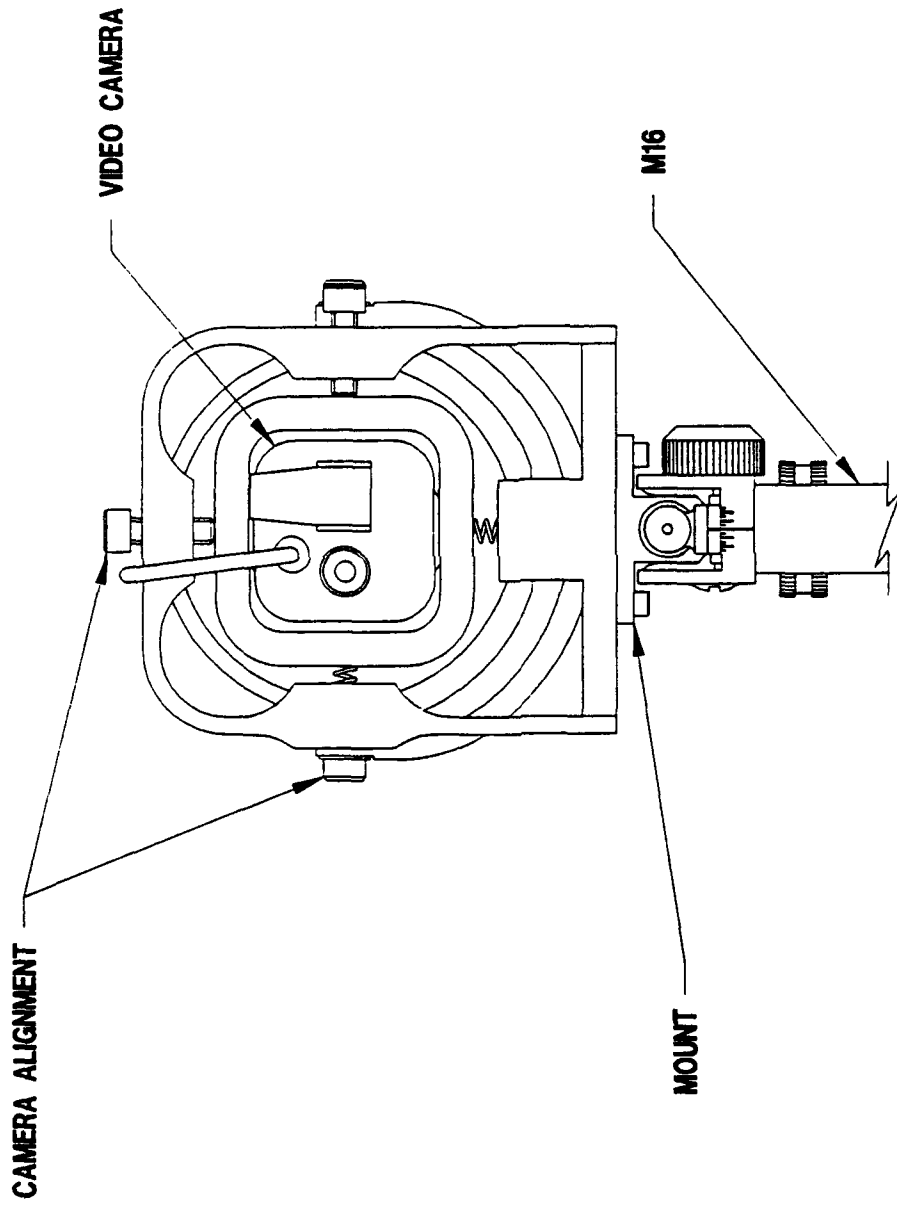
3.4 Weapon Instrumentation Training System Test

Weapon Training Instrumentation (WTI) system test was setup as in Figure 6. We made several changes since the initial raw video test. We mounted the video camera above the carrying handle toward the center of mass such that it is non-intrusive to the shooter. Figure 7 shows the video camera mount on the M-16 rifle. With this specially designed video camera mount, the shooter was able to see through the mount and use the rifle sights in a normal manner. For the WTI system test, we fired blanks to simulate live fire testing. The video from the test (target image combined with the computer generated reticle) gave us the following information: 1) exact aim point, 2) position of the weapon, 3) trigger squeeze, and 4) breathing. With the video camera mounted away from the flash suppressor, the image blooming was reduced.



WEAPON TRAINING INSTRUMENTATION SYSTEM TEST

FIGURE 6



MOUNT FOR VIDEO CAMERA

FIGURE 7

4.0 SYSTEM EVALUATION

The Weapon Training Instrumentation (WTI) device as required in a fully functional device would be expanded from the component parts as tested during this SBIR contract. The component parts would provide the same functional characteristics, but adaptation to the host weapons, actual incorporation of circuitry required for basic functions, and configurations would be modified to fit specific needs.

4.1 Weapon Training Instrumentation Device

We looked at two different general configurations of WTI devices. The larger weapons version for TOW, DRAGON, and other similar weapons would have all of the component parts of the WTI attached to the host weapon. The small arms version would have the camera, lens, and alignment components attached to the host weapon, while the remaining components would be housed in a pouch carried by the firer or at an external location so that the actual weight and balance of the weapon is not affected.

4.1.1 Larger Weapon Version

When the weapon operator comes in close contact with the weapon sight, the video and audio recording is initiated along with an artificial aimpoint, time and weapon angle information. The aimpoint, time and angle information is edited into the video and audio during the recording sequence using an internal contractor designed editor. This recorded image with superimposed data can be viewed in real time by instructor and/or played back to the firer as part of a post exercise review.

4.1.2 Small Arms Version

The small arms version is identical in concept to that described above except that the weapon position information will be obtained from direct video orientation. The video record initiation will be obtained from a different proximity device, and the device will be split into two components so that a smaller amount of weight is on the weapon.

4.1.3 Miniature CCD Video Camera

After investigating various camera types for size, construction, ruggedness, and capability, the commercially available video camera that we have chosen for this application is a WAT-902. The WAT-902 is a miniature black and white 1/2" CCD camera with auto iris control. The WAT-902 outputs video in NTSC format that is very standard in the industry. The WAT-902 is self contained and operates on 12VDC. The WAT-902 can accept any standard "C" mount lens. We determined that a 75mm auto iris lens with a 2X expander would have a footprint of 0.81m vertical and 1.1 m

horizontal at the 25m range. This lens arrangement would allow the target to fill most of the monitor screen in our test bed and therefore be better for post exercise evaluation analysis in a final product.

4.1.4 Audio Transmitter

During the initial testing we used a small audio transmitter to transfer audio information from the firer to the recording medium. We chose the commercially available Realistic audio transmitter. In the production component the audio information will be directly recorded using a modified VCR.

4.1.5 Weapon Position Indicators

The commercially available clinometer that we examined for weapon attitude during the SBIR contract was the AccuStar electronic clinometer. The AccuStar electronic clinometer is extremely accurate with range of ± 60 degrees and resolution of 0.001 degrees and provides two planar measurements with only one component. The AccuStar electronic clinometer outputs data either as an analog DC voltage or PWM output corresponding to direction and magnitude of angular displacement. This product can easily be used as the angle measuring component for the larger weapon version of the (WTI) and we would strongly consider this produce in the final system.

The small arms WTI will provide the angle information from direct video interpretation. Small arms device acceptability relies heavily on the possibility of making the component parts required on the host weapon as light and compact as possible and additional information from clinometer would be redundant. The increased size and weight required for the additional input make this approach impractical for the final product.

4.1.6 Data Editing and Processing Section

The data processing components used during our contract included 2 VCRs, AT computer, Bravado video editing board, video scanner, TV monitor, and an audio receiver. The video and audio information received from the weapon mounted data collection components was sent to the Bravado board inside the AT computer where the editing and combination of the aimpoint was done in a secondary step.

This function will be integrated into the WTI with an on board processing and editing microcontroller. During the time that video is recorded, the aimpoint and other pertinent data desired on the screen will be added such that a composite screen image can be seen through an attached monitor as the weapon is fired. The information will be recorded in the composite form for after action review.

This component part of the WTI will be designed in a pouch for the small arms version with everything except the instructor's monitor in the pouch and a single cable to the weapon will provide interface of signals and battery power to components boresighted to the weapon.

4.1.7 Video Camera Boresight

During the initial contract the video camera was boresighted to the M-16 (AR-15) rifle without the aid of special devices. This process was tedious and time consuming. The final device will be factory boresighted to the frame for larger weapon systems, but boresighting for small arms must be done in the field and in as short a time as possible. A boresighting device will be provided for small arms WTI camera component alignment to the host weapon.

The boresight kit will consist of an IR bore, focusing mirror, screen, and weapon mounting fixture. The set up of the boresight kit is shown in Figure 8.

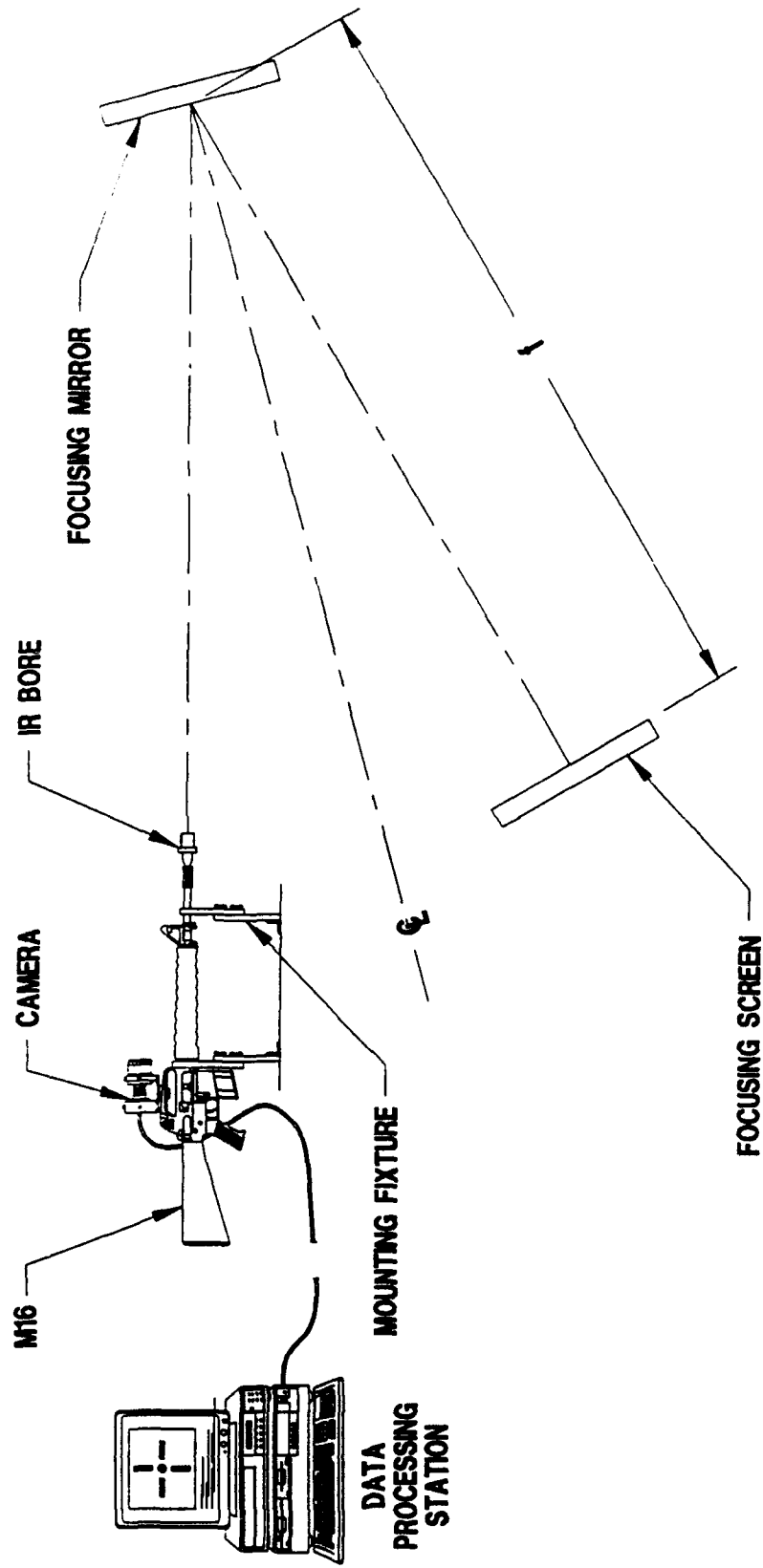
4.1.7.1 Boresight Procedure

The boresight kit provides a quick alignment of the video camera to the barrel of the M-16 (AR-15) rifle. This is accomplished with an IR bore (an IR source aligned to the barrel insertion rod) inserted down the barrel of the M-16 (AR-15) rifle as shown in Figure 9. After clamping the camera component of the WTI to the rifle, the IR source is turned on. This source is collimated and will reflect off the focusing mirror and focus down on to the screen. Viewing the video display and adjusting the video camera alignment adjustments so that the cross hairs of the display is centered on the spot produced by the IR source makes this critical and necessary alignment procedure easy and accurate. Figure 10 show this process.

4.1.7.2 Boresight Verification

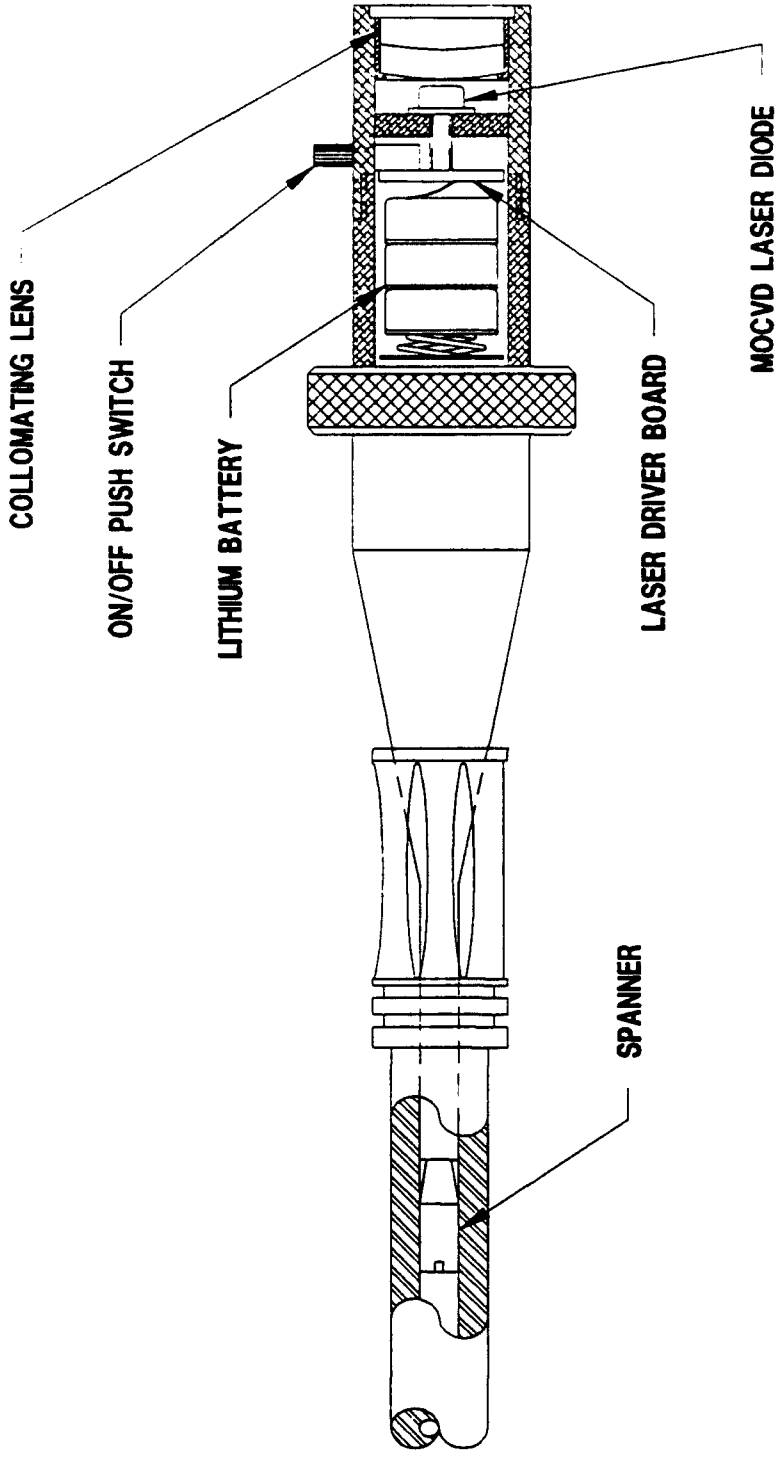
After boresighting the video camera to the weapon, the trainee or instructor will fire several live rounds to verify the boresight and adjust for windage (note: M-3 bipod may be used to help support the rifle during battlesight zero. This device is not effected by the camera components.)

For the M-16 (AR-15) rifle, battlesight zero is done at the 25 meter range as shown in Figure 11A. At 25 meters, the bullet should hit the target about 1 inch below the target line of sight. During battlesight zero, it is imperative to have a correct sight picture as shown in Figure 11B.



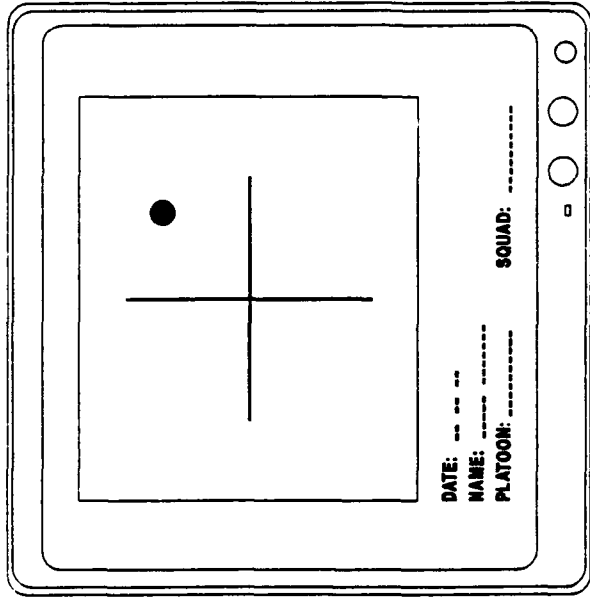
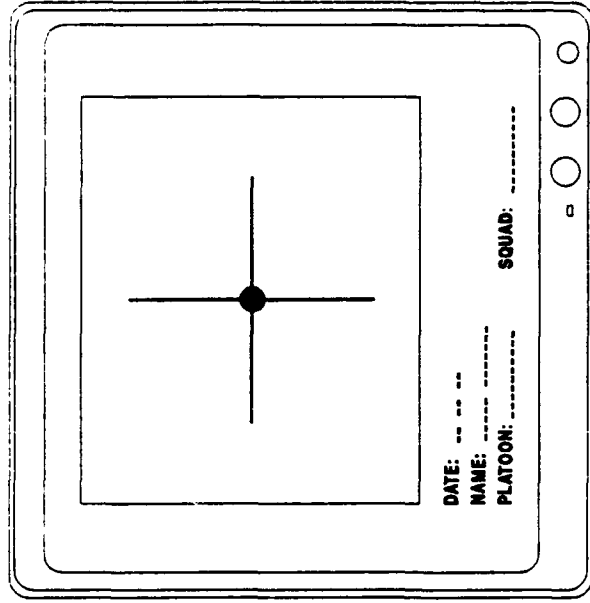
BORESIGHT KIT SETUP

FIGURE 8



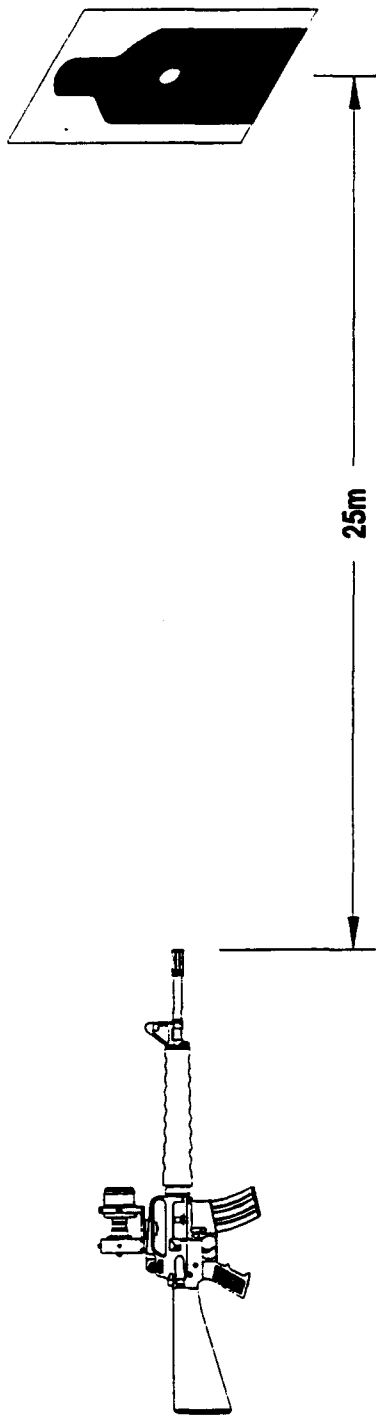
IR BORE

FIGURE 9

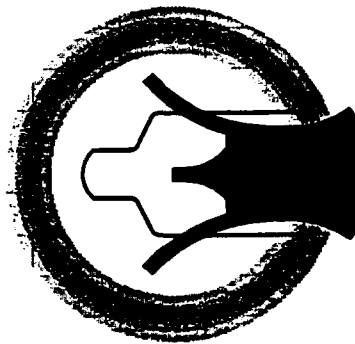


VIDEO CAMERA ALIGNMENT

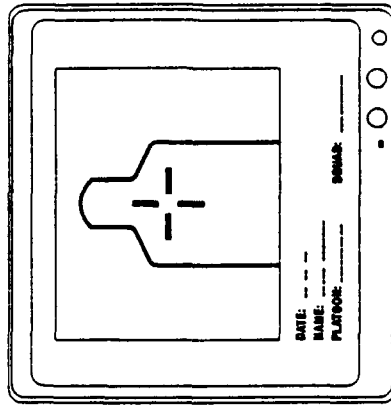
FIGURE 10



A BATTLESIGHT ZERO CONCEPT



B CORRECT SIGHT PICTURE



C COMPUTER COMPOSITE DISPLAY

BORE SIGHT VERIFICATION

FIGURE 11

Because we generate the cross hair in our video to a predetermined point with respect to the bore of the weapon, direct comparison of where the sights should have been located and where the firer aims his weapon can be determined.

4.1.8 Correction for Range

An advantage in making a computer generated aimpoint is that not only that a battlesight zero sight picture can be represented, but also a sight picture that would show the bullet impact point for any range based on the trajectory of the bullet fired from the host weapon type. The computer generated reticle could be moved up or down from the battlesight zero point to correspond to the actual target range. By external command from switch setting or computer interface, the range-to-target information could be input to the reticle positioning circuitry. From this range information, a look-up table will provide the variation from battlesight zero necessary to show the bullet impact point on the target. The reticle aimpoint will be moved to that point and the recorded image will show where the firer should have aimed.

4.1.9 Secondary Video

During our testing a second recording camera focussed on the target and was used to provide a time tagged comparison of the firing event that the shooter actually saw and a close-up picture of the target showing the bullet penetration points. This secondary recorded image would be offered as an additional tool for firer training and evaluation.

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

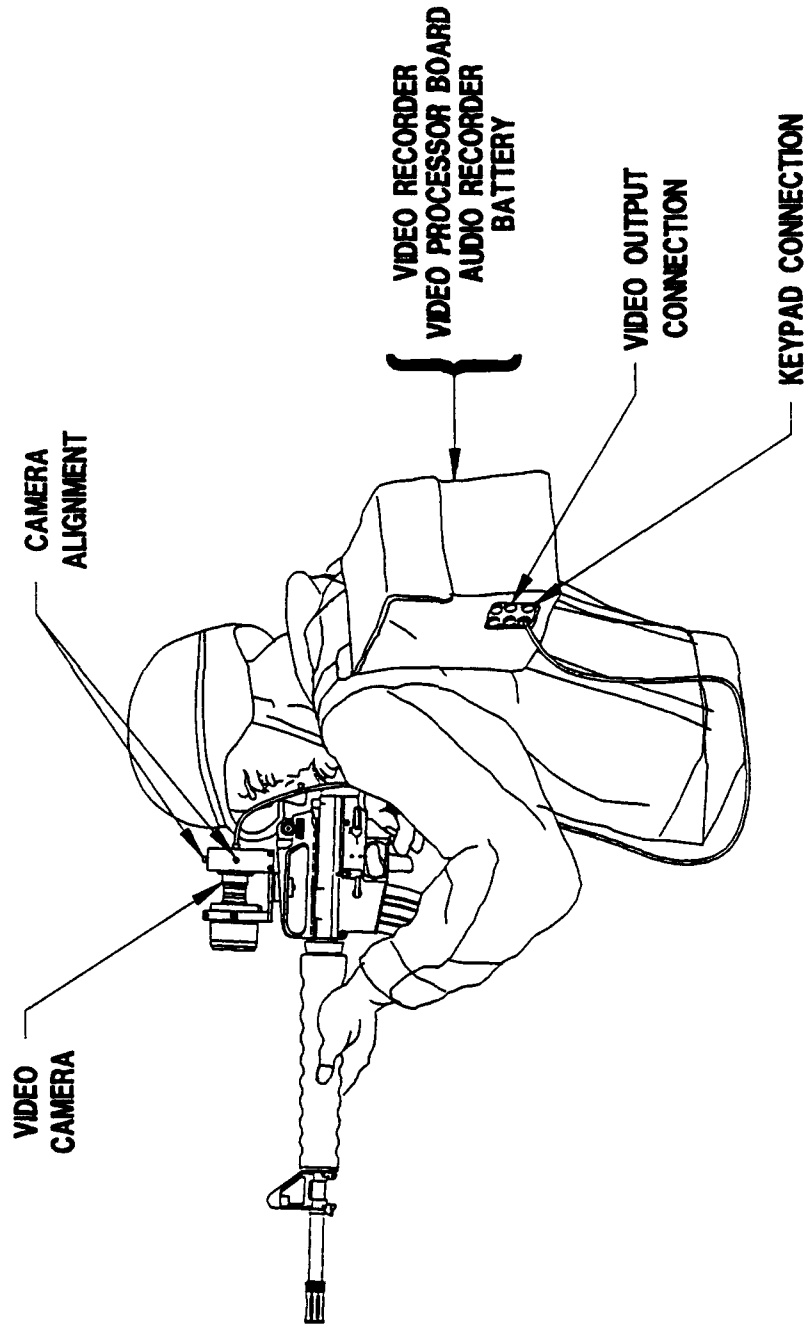
Based on the analysis, fabrication and tests, we conclude the following:

1. The WTI is not cost effective to record the actual sight picture on the M-16 rifle because of the complexity of the optical system required. (Three lenses would be required to focus on each of the component parts of the sight picture including the actual target and the front and rear sights)
2. The WTI would be cost effective for crew served weapon sight picture acquisition and target tracking because system alignment would be done at the factory.
3. The WTI is very effective for recording small arms aiming, trigger squeeze sequence and breathing analysis. The WTI clearly records the reticle in relation to the target during the entire sequence of target acquisition. Aiming, breathing, and trigger squeeze movements up to the actual firing of the round were recognized in the recorded video.

4. The WTI can be very effective in obtaining a better battle sight zero boresight. This is especially true whenever the range to target information can be placed into the system for trajectory correction.
5. The WTI would be very effective in target acquisition and tracking training for crew served weapon such as the TOW.
6. The WTI is very effective for non-intrusive recording of live firing on the range for qualification or proficiency maintenance training. The recording could be evaluated and critiqued by an experienced instructor and provide feedback to the trainee during playback. The performance could be compared with previous data for evaluation of positive progress or elimination of bad habits.
7. The WTI is especially beneficial in non-intrusive recording of rapid fire exercises. At the time of live fire, the camera recovers within a few frames (much quicker than successive rounds can be squeezed off).
8. Non-intrusive recording can be played back in real time or not recorded at all - direct display from the camera to the instructor's monitor.
9. The technology could be extended to a real time trainee eyepiece display providing a new sighting/aiming capability to the soldier to fire around corners or overhead without exposing the soldier to enemy fire. This could be an extremely valuable capability for the remote operation of a crew served weapon, such as, TOW. (user safety)

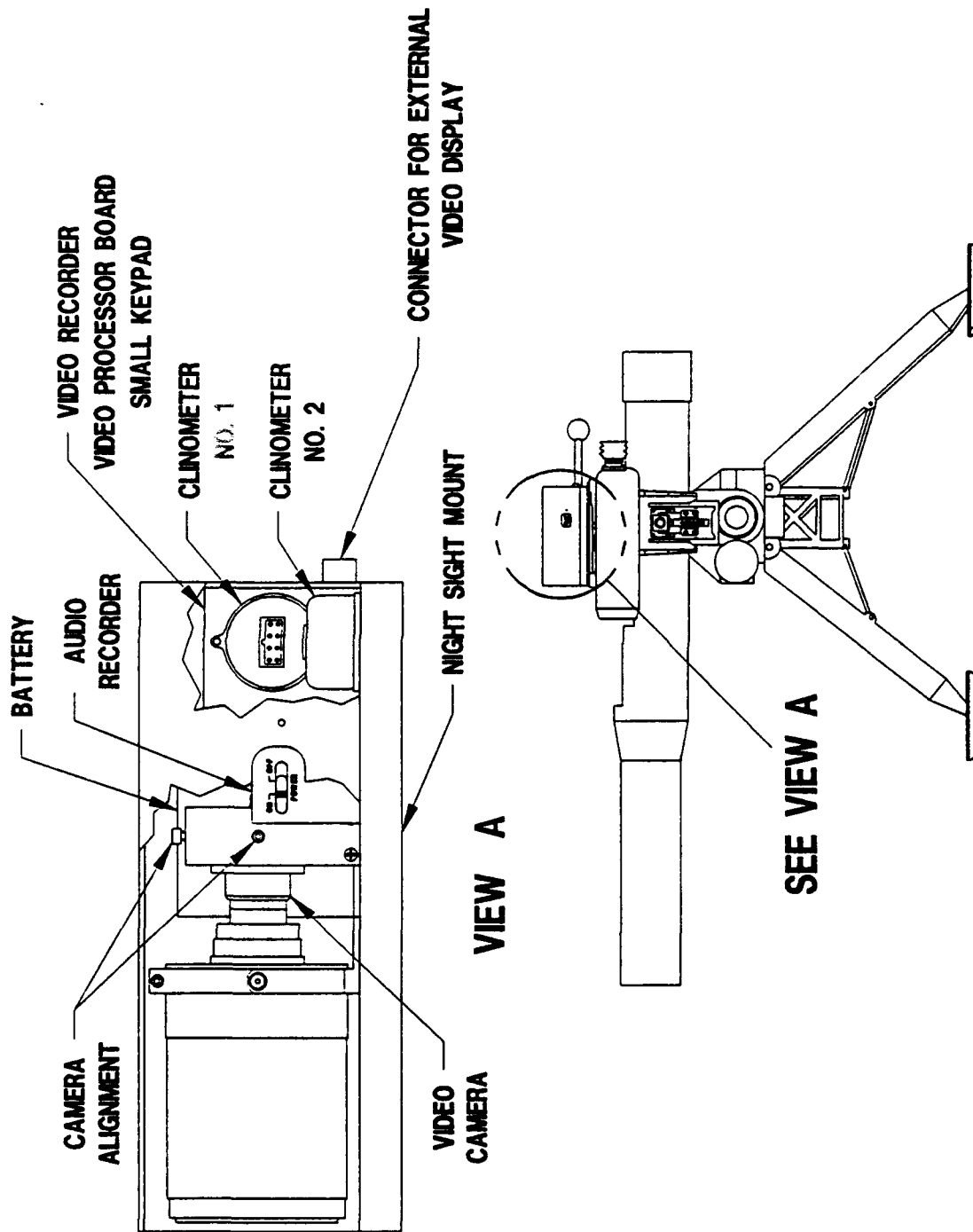
5.2 Recommendations

SEO recommends a continuation of this effort to design, fabricate and test a non-intrusive instrumentation system that could be mounted on a M-16 rifle and boresighted with the rifle (see Figure 12. In addition the effort should include design, fabrication and test of a non-intrusive instrumentation system that could be mounted on and aligned with a TOW missile (see Figure 13. A third component that needs further investigation would be to design, fabricate and test an intrusive instrumentation system that could be mounted on a M-16 rifle and boresighted with the rifle with an eye piece display to allow the soldier to accurately fire the weapon without exposing himself to enemy fire.



PHASE II - INSTRUMENTED AR-15

FIGURE 12



PHASE II . INSTRUMENTED TOW

FIGURE 13

5.3 Anticipated Phase II Results

We anticipate that additional work would expand upon the data gathered in phase one and would develop and package a full multi-purpose weapon instrumentation system with multiple weapon applications. An additional effort also would encompass the necessary applications and cost savings studies required to support the implementation of the weapon instrumentation package.

5.4 Anticipated Product Resulting from Program

A fully developed and tested instrumentation system available for both military and civilian users with a focus on small arms training that could reduce the time spent in determining "battle sight zero" and greatly reduce the training time required for effective weapon operation.

5.4 Applications

All weapon training, including small arms, would benefit from this type of instrumentation system. Specific aids include the following:

1. Reduction in time spent setting up "Battlesight Zero" and reduced time required to become an effective marksman.
2. Increase of soldier knowledge and use of range to target as part of the requirement for effecting a hit.
3. Reduction in the quantity of live rounds required to be fired during training and reduction in the number of training officers required to support weapon proficiency training.
4. Increased feedback provided to the trainee and increased student scoring capability.

These are tasks which supposedly you have, but are not yet awarded. Check for accuracy of work estimates.

OPEN_TASKS

Jay

EN NAME	TASK NO	FJM PIME CODE	FUNDS EST	PI DATE	PI ACT DATE	DB DATE	SRC1 EXP DATE	TITLE
DALY	0180	M PDA4	0.00	930823	930710	931030		E-2 TECH DATA CHANGES
DALY	0180	N PDA4	0.00	930903	930710	931030		E-2 DATA CHANGES
DALY	0180	E PDA4	178,000.00	940110	940112	940212		E-2 PRIME SPARES
DALY	2261	C PDA4	0.00	930409	930415	930415		E-2C THROTTLE QUADRANT PEDESTAL MOD
DALY	2261	D PDA4	0.00	931108	931123	931122		E-2 DEBIT CREDIT PKG REALIGN CONTRA
HAHN	2219	P02 B PDA5	0.00	931018	931021	931030		S-3 REALIGN FUNDS ON DO
HAHN	2219	P04 A PDA5	0.00	931018	931021	931030		S-3 REALIGNMENT OF FUNDS
HAHN	8506	T PDA5	0.00	931015	931025	931029		VISUAL UPGRADE NO COST MODE
HAHN	9212	AJ PDA5	0.00	930429	930429	930513		P-3 INCORP SCHEDULE CHANGE
HAHN	9212	AL PDA5	8,128.00	931020	931206	931130		P-3 PRIME SPARES
HAHN	9212	AM PDA5	870.00	931020	931112	931130		P-3 PRIME VENDOR SPARES
HAHN	9212	AN PDA5	1,900.00	931020	931112	931130		P-3 PRIME VENDOR SPARES
HAHN	9212	AO PDA5	241,766.00	931224	940104	930110		P-3 WX/DRLMS LOT V OPTION
MALDONADO	3168	A PDA5	0.00	931123	931117	931130		P-3 TRAINER RELOCATION DD254
MALDONADO	3168	B PDA5	0.00	940104	940112	940214		P-3 DEVICE DELIVERY CHANGE
MALDONADO	3168	P02 PDA5	148,765.00	940110	940112	940114		P-3 DEVICE MOVE (2F87(T))#4
MINOR	2001	D PDAT	0.00	930916	930916	931001		MOD OF N61339-93-D-0003
MINOR	4026-01	PDA7	25,000.00	931013	931028	931211		R/M MOD SOM
MINOR	4164	P10 PDAT	143,303.00	930920	930917	930909	940930	CSS FOR A-6E/EA-6B TSSA
MINOR	4164	P12 PDAT	83,268.00	930924	930928	931015	940930	CSS FOR SH-60B TSSA
MINOR	4164	P13 PDAT	78,033.00	930924	930928	931015	940930	CSS FOR SH-60F TSSA
MINOR	4164	P14 PDAT	95,463.00	930920	930917	930909	940930	CSS FOR F/A-18 TSSA
MINOR	9205	Q PDA5	357,000.00	930603	930709	931201		SPARE SUPP EQUIPMENT ACQ SUPPORT
MONTILLA	0190	V PDB2	0.00	930224	930224	930312		ENGINEERING SUPPORT SERVICES
MONTILLA	1211	G PDA5	0.00	931214	931220	931230		TSSA GASS SPT- EXTEND WORK COMPL DT
MONTILLA	1211	P07 PDA5	118,993.00	940110	940106	940218		P-3 ASQ212 DESIGN FOR 14853
MONTILLA	2152	K PDA5	0.00	930607	930607	930715		P-3 NO COST MOD ENG/TECH SPT
MONTILLA	2152	L PDA5	0.00	930604	930607	930715		P-3 NO COST MOD TO ENG/TECH SPT
MONTILLA	2152	M PDA5	25,000.00	930727	930726	930822		P-3 MOFFET FIELD LOGISTIC SPT
MONTILLA	2152	NA PDA5	0.00	931007	931004	931019		P-3 GASS NO COST DEL ORDER MOD
MONTILLA	2215	P01 PDA6	75,000.00	930716	940112	930816		INTERACTIVE MINING SYSTEM (AIMS)
SHARPE	7150	AG PDA7	-31,369.43	930729	930727	930816		TOTS INTEREST DEOBLIGATIONS
VALENTINE	1200	P04 A PDA6	19,820.00	930413	930409	930423		S-3B/ES-3A VS-41 INCREASE LINE ITEM
VALENTINE	4160	PDA5	1,800,000.00	930614	930722	940614		P-3 ENGR & TECH SUPPORT
VALENTINE	7197	AD PDA5	12,070.00	930630	930624	930730		P-3 REPAIR OF REPAIRABLES

RPT TOTALS 3,381,009.57
TOTAL RECORDS SELECTED = 35