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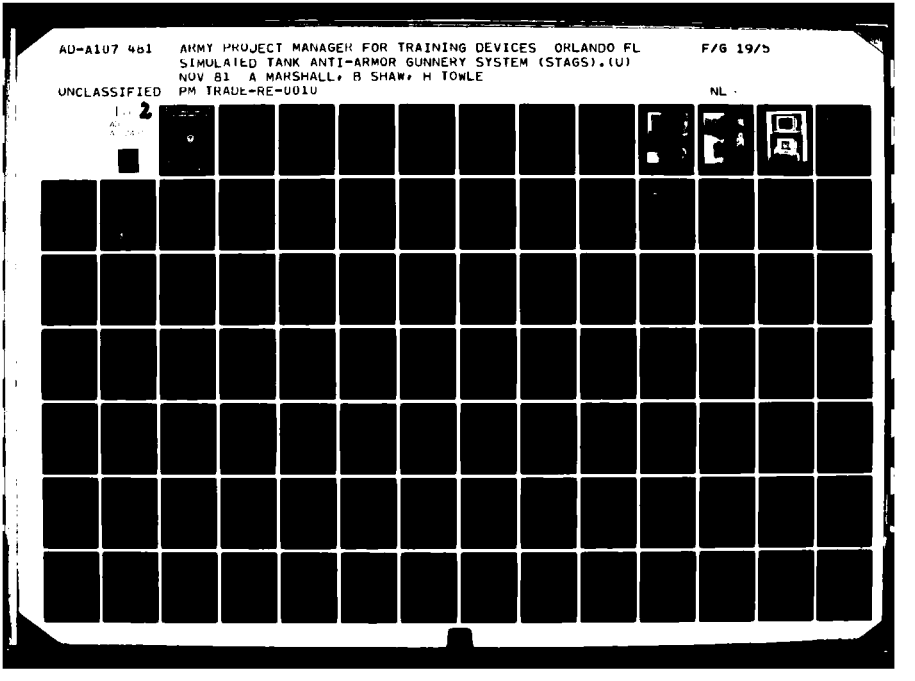

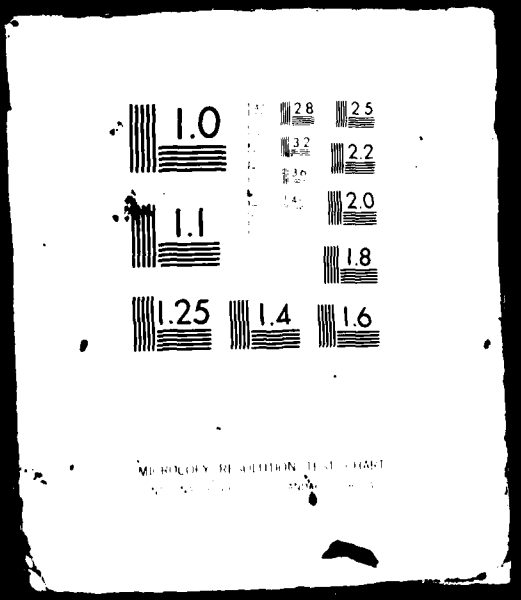

SIMULATED TANK ANTI-ARMOR GUNNERY SYSTEM (STAGS-D)

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report describes a missile flight simulator research model developed to train DRAGON gunners. It is also being adapted to a variety of similar anti-armor weapons. The system employs a terrain board with enemy armored vehicles moving in a variety of attack scenarios. When the gunner fires the missile, hears computer generated rocket sounds and experiences the weight loss, recoil and smoke of the missile launch. When the smoke clears, he views the missile in the sight as well as the target. The gunner's aiming error is measured

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20. using a micro-processor-controlled diode matrix array. The matrix detector senses an IR emitting diode which is located on the miniature target. The flight equations of motion for the missile are solved by a 16 bit microprocessor every 0.02 seconds in each axis using gunner aiming error, target position, gravity, drag and side thruster accelerations as inputs. A second coordinated 16 bit processor controls a display that plots both vertical and horizontal aiming error for analysis of the gunner's performance by an instructor. Experienced DRAGON gunners have tested the system and attested to the realism and training potential.

SUMMARY

The Simulated Tank and Anti-Armor Gunnery Systems (STAGS) is an electro-optic based, multiprocessor controlled, training device that enables training of DRAGON gunners at a reasonable cost. In a short period of time a gunner can be subjected to a variety of target scenarios and his performance can be analyzed in real-time by an instructor. When the trainee fires the training device he hears the initial explosion of the rocket motor. He experiences a weight loss due to the simulated rocket exiting the tube as well as a recoil force. Momentarily his view in the sight is obscured by simulated smoke. The trainee must overcome such launch transients and smoothly track the target and ignore the simulated missile which he can see in his sight. Thruster rocket firing sounds are included as well as the final hit or ground impact explosions. A visual indication of missile impact is also inserted into the gunners sight.

During missile flight the instructor can monitor two displays. These displays show:

(1) The gunner's sight picture, the DRAGON missile's location, and

(2) a plot of gunner aiming error versus time and the gunner error tracking limit envelopes. Thruster firings are annotated on the display.

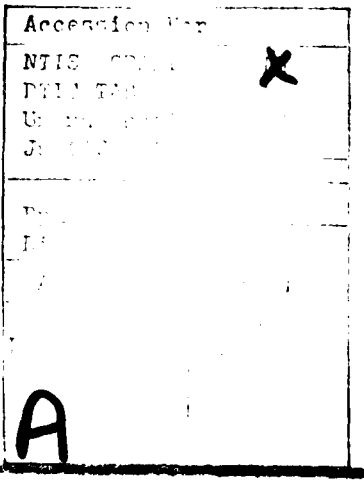
This system uses a 16 bit microprocessor to solve the flight equations every 0.02 seconds in each axis using the gunner's aiming error, target position, gravity, drag and thruster rocket acceleration as inputs. The solution also incorporates the dynamic performance of the tracker.

A prototype model was constructed by the Advanced Simulations Concepts Laboratory, Naval Training Equipment Center, Orlando, Florida for the U.S. Army Project Manager for Training Devices (PM TRADE) and the U.S. Marine Corps.

This model has been successfully evaluated by experienced DRAGON gunner teams from both the U.S. Army and U.S. Marine Corps.

Demonstrations and evaluations are planned during FY 82 using this device. Expansion of the device to include TOW is also planned.

The PM TRADE Project Manager is A. Boudreaux. The authors wish to thank him for the helpful assistance he gave during this program.



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SECTION I

INTRODUCTION

Training in the firing of modern anti-armor weapons is expensive. Each live round costs thousands of dollars.

This report describes a system that uses advanced electro-optics and microprocessor technology to enable training of DRAGON gunners at a reasonable cost.

The DRAGON is a command-to-line-of-sight guided missile system. Fired from a recoilless launcher, the missile is tracked optically and guided automatically to the target by electrical impulses transmitted via a wire link. Firing the DRAGON missile is accomplished by depressing the safety and squeezing the trigger. No other action is required of the gunner except to keep the sight cross hairs on the target. However, to score a hit the trainee must overcome many perturbations that can spoil his track.

When the trainee fires the training device he hears the initial explosion of the rocket motor. He experiences a simulated weight loss due to the rocket exiting the tube as well as a recoil force. Momentarily he is blinded in the sight by simulated smoke. The trainee must overcome such launch transients. He must smoothly track the target and ignore the simulated missile which he can see in his sight. Thruster rocket firing sounds are included as well as the final hit or ground impact explosions. A visual indication of hit is also inserted into the gunner's sight.

During missile flight the instructor can monitor two displays. These displays show:

(1) The gunner's sight picture and the DRAGON's location.

(2) Plots of gunner aiming error in azimuth and elevation versus time and the gunner error tracking limit envelopes. Thruster firings are annotated on the display and the number of thruster firings, actual versus ideal are recorded.

(3) The instructor can recall four additional plots after the mission is over: gunner aiming error and missile location in azimuth versus time; gunner aiming error and missile location in elevation versus time.

This system uses a 16 bit microprocessor to solve the flight equations every 0.02 seconds in each axis using the gunner's aiming error, target position, gravity, drag and thruster rocket acceleration as inputs. The solution also incorporates the dynamic performance of the DRAGON tracker.

Key features of the system are summarized below.

- Target hit or miss determined by solving DRAGON flight equations in real time
- Smoke obscuration

- Recoil
- Weight Loss
- Missile superimposed on gunner's view of scenario
- Sounds - thruster firing, launch, hit and miss explosions, gyro wind-up
- Gunner aiming errors versus time displayed in real time
- Missile position versus time which can be recalled along with gunner aiming errors in azimuth and elevation for analysis
- Expensive tank target and special range is not required for training
- Number of thruster rocket firing's ideal versus actual displayed
- Portable
- Record and play back capability
- Can operate with and without an instructor
- Can be used to simulate night firings with a thermal sight
- Gunner's pull down force on DRAGON launcher, and eye piece pressure is indicated
- Variety of target speeds and motions simulated
- Trainer flies like real missile because of computation of flight parameters

Photographs of the system are shown in Figure I-1 through I-4 and illustrate the student station, instructors console, and the terrain board.

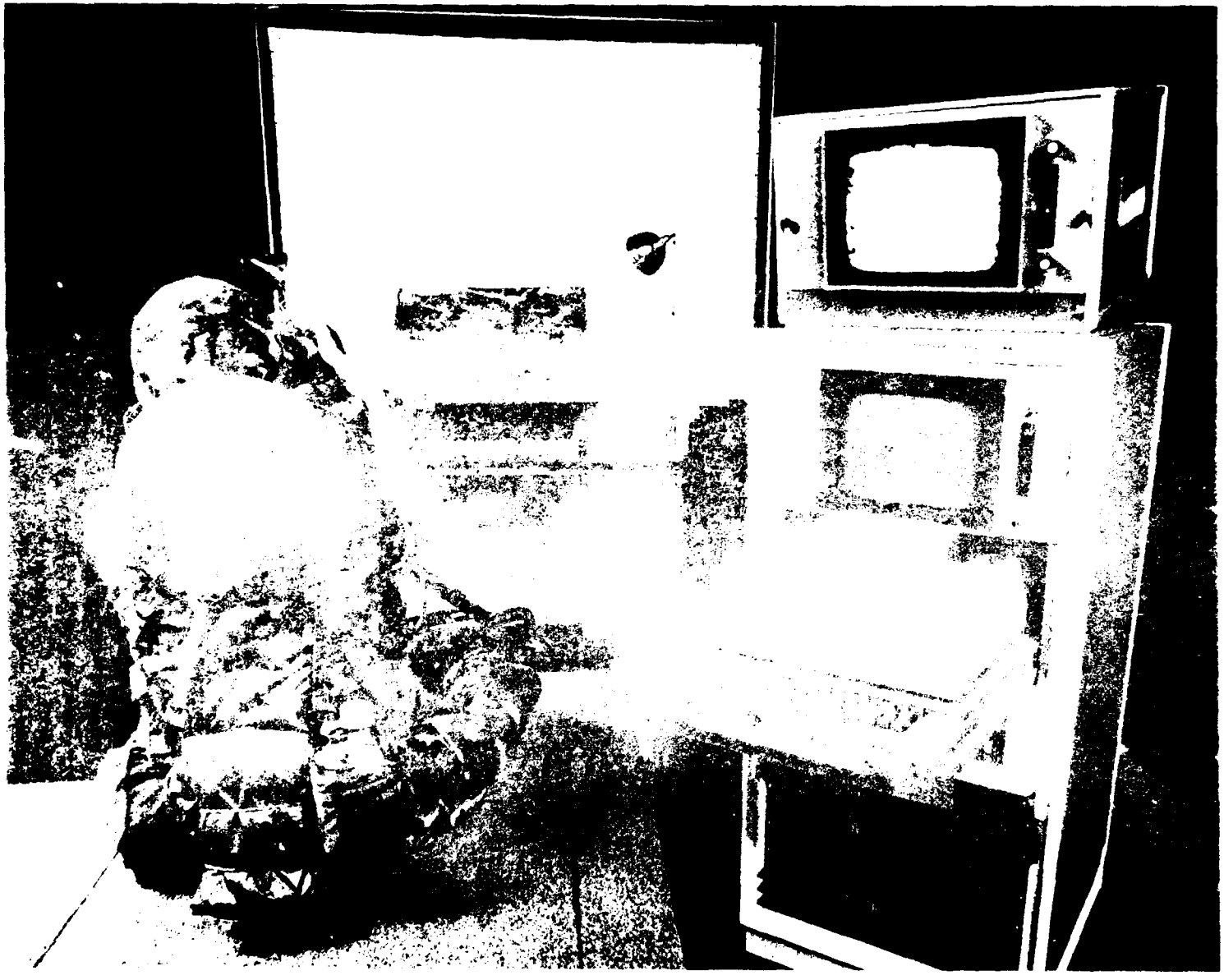

FIGURE I-1 DRAGON SYSTEM

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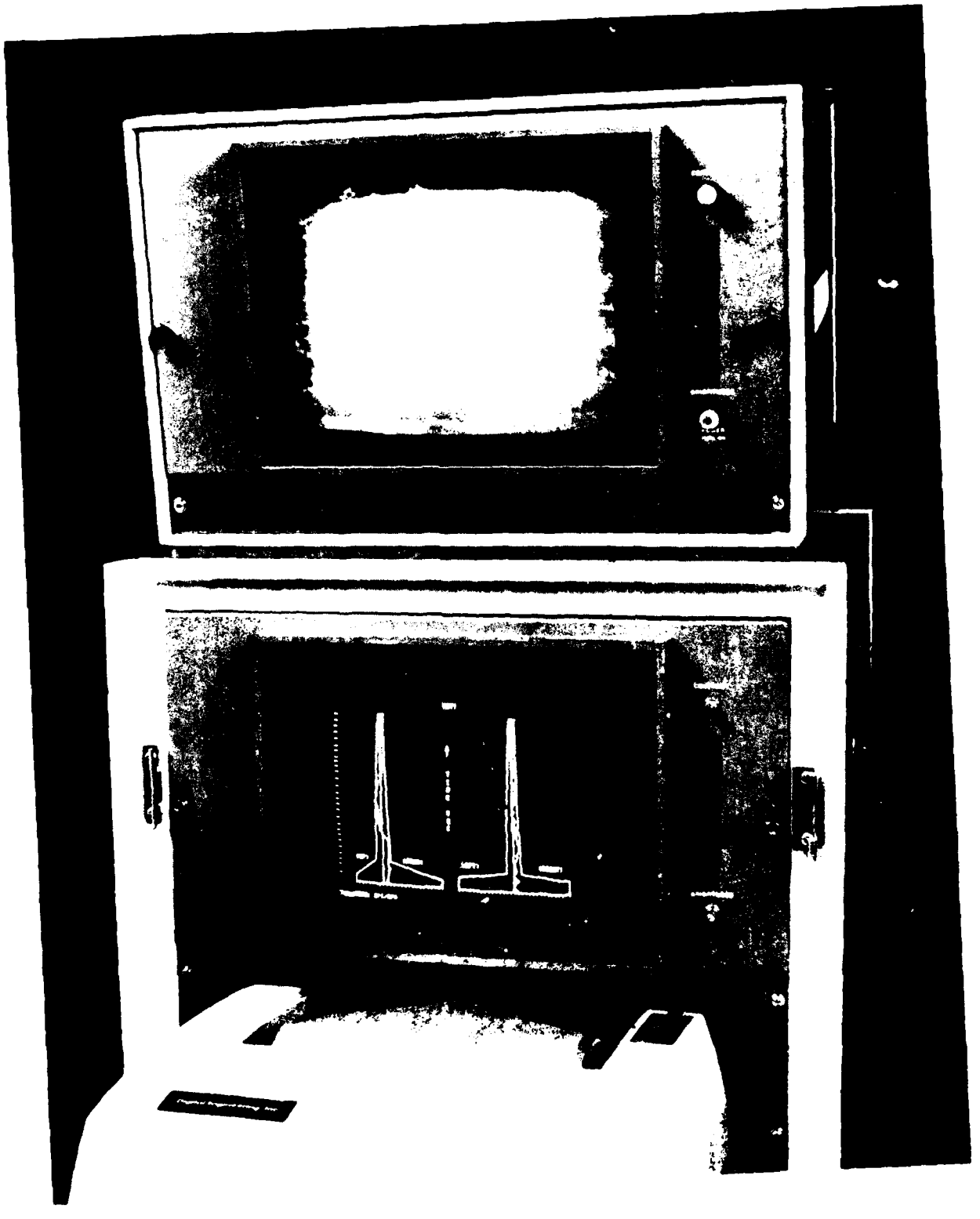


FIGURE I-1 INSTRUMENT CONSOLE

SECTION II

SYSTEM DESCRIPTION

The system block diagram is shown in Figure II-1.

Targets in this system are 1/120 minature models. Model targets were chosen because they have better resolution than either computer generated imagery or a movie display. DRAGON utilizes a 6X sighting scope. In other weapons even higher power sighting scopes are utilized, thus demanding a high resolution visual scenario.

Models are moved on a terrain board using a stepper motor under the control of a single chip microprocessor. The engagement scenario is stored in the Personnel Interface Processor (PIP) and is selected on the instructor's console by an input terminal. The stored scenario program contains the tank target's velocities, directions and range. Scenario data are provided to the DRAGON Flight Simulator Processor (DFS). At the center of mass of the scaled target is an Infrared Emitting Diode (IRED). Located in the DRAGON launch tube is a photo diode array camera to sense the IRED. The IRED is invisible to the human eye. This 100 x 100 matrix camera is boresighted to the gunner's sight telescope and used to determine the gunner's aiming error (GAE) which is input to the DRAGON Flight Simulator processor. This processor solves the DRAGON flight equations and provides DRAGON status to the Personnel Interface Processor (PIP). The PIP controls the graphics units which inserts the missile, smoke, explosion, etc., into the gunner's sight. This processor also controls the Gunner Aiming Error (GAE) display on the Instructor's Console. This display plots GAE versus time, in real time. The DRAGON Flight Simulator Processor produces launch and target explosions, thruster rocket firings and gyro noises. The thruster rocket firings are delayed to allow for the speed of sound versus the visual phenomena of the rocket firing which is optically inserted in the DRAGON gunner's sight. Rocket thruster noises are attenuated as a function of distance.

A closed circuit TV (CCTV) is located on the DRAGON tube and boresighted to the gunner's 6X sight. The Gunner's Sight Picture Display is located on the instructor's console. The DRAGON rocket as seen by the trainee is also mixed into the gunner's sight picture visual display.

An indicator on the instructor's console indicates the ammount of pulldown pressure on the launcher tube. Automatic computer controlled boresight is also incorporated.

Data print-outs for both a hit and miss training session are shown in Figures II-2 and II-3. Note that the rocket thruster firings are annotated on the left hand margin with dashes indicating the firing of a thruster rocket pair. Time between thruster firings are a function of the rate of change of gunner aiming error.

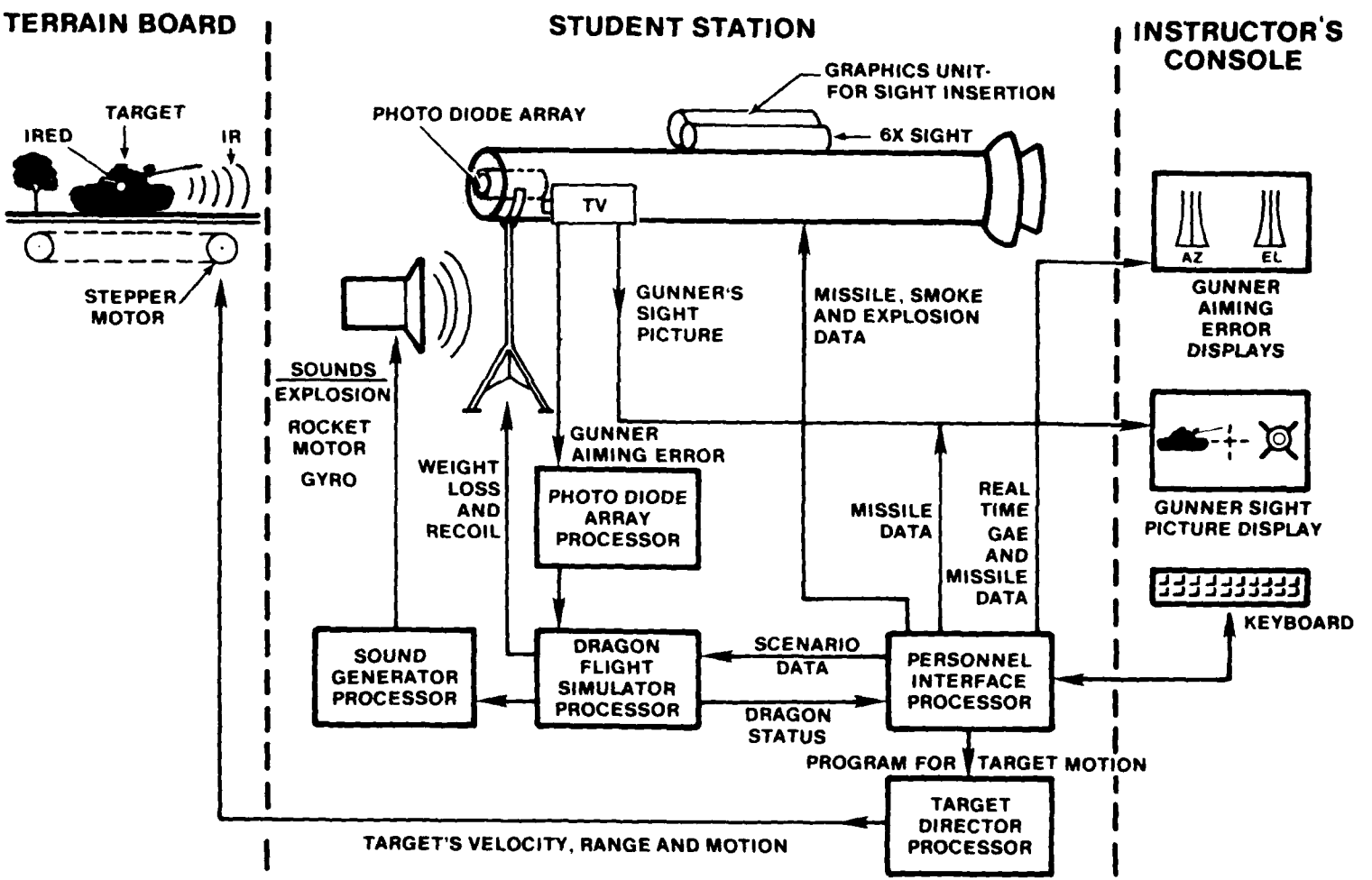


FIGURE II-1 SYSTEM BLOCK DIAGRAM

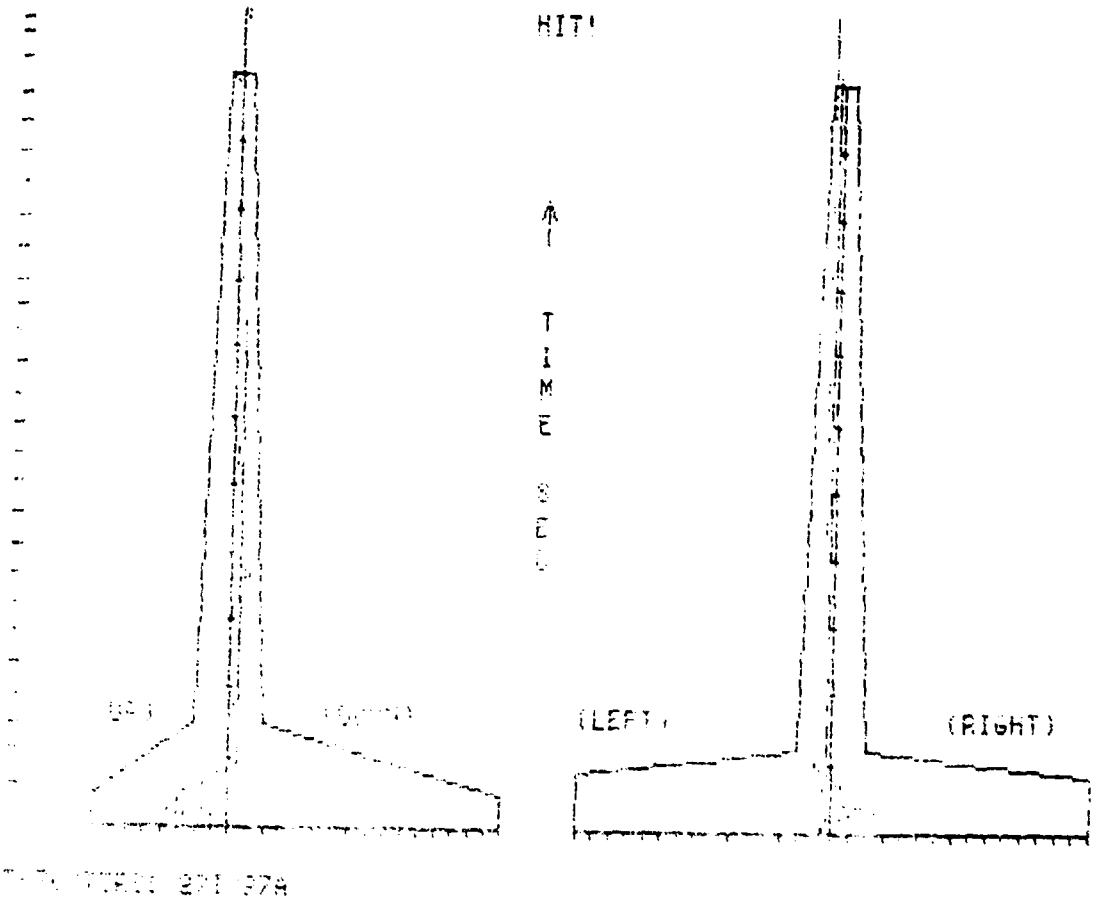


FIGURE II-2 (1 of 3) GAE vs Time
(Vertical & Horizontal Planes)
- HIT

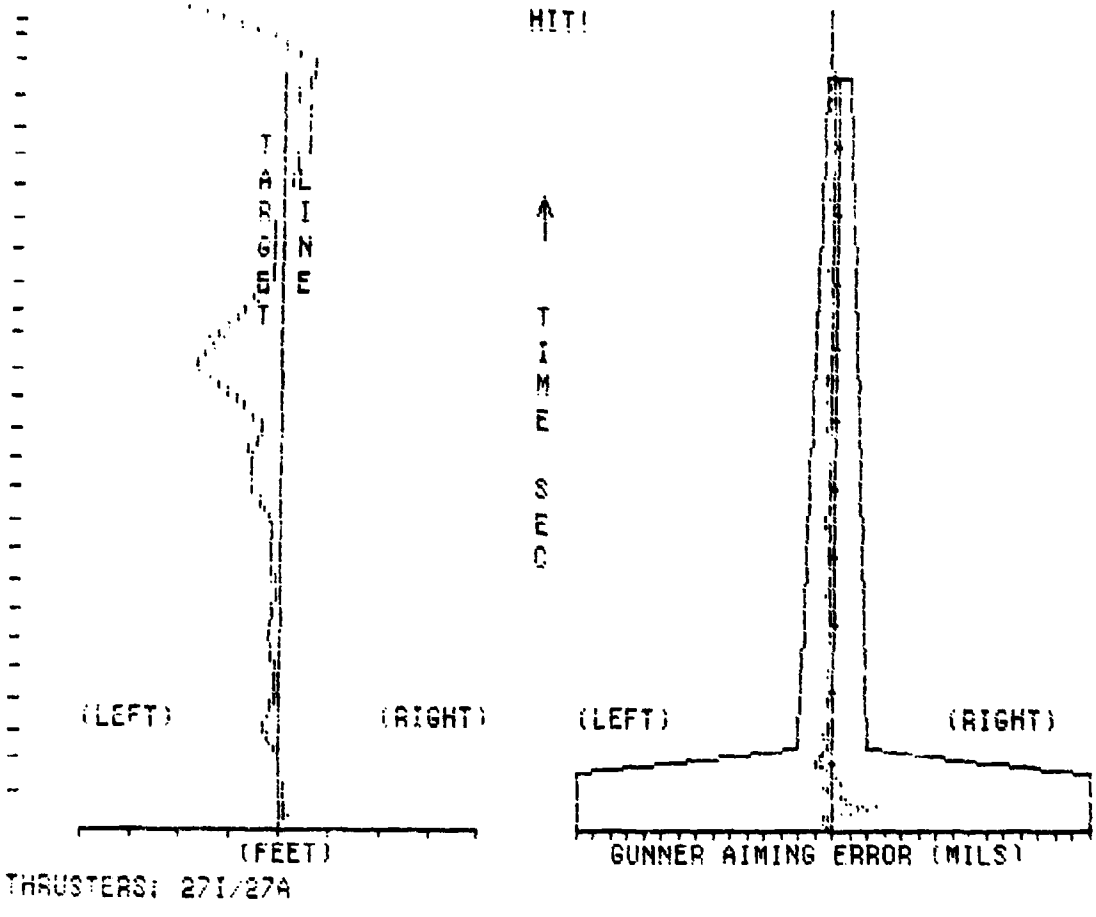


FIGURE II-2 (2 of 3) Missile Location vs Time (Horizontal Plane) - HIT

GAE vs Time (Horizontal Plane)

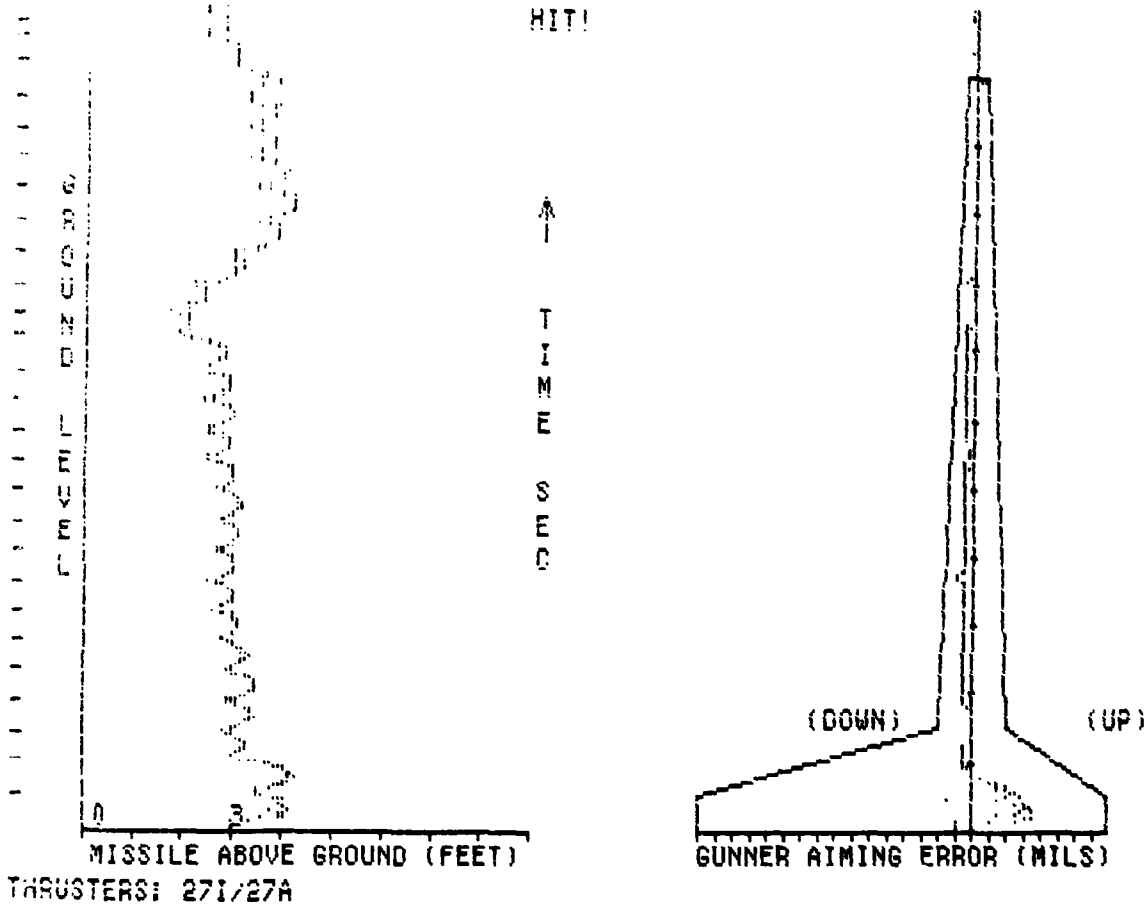


FIGURE II-2 (3 of 3) Missile Location vs Time (Vertical Plane) -HIT GAE vs Time (Vertical Plane)

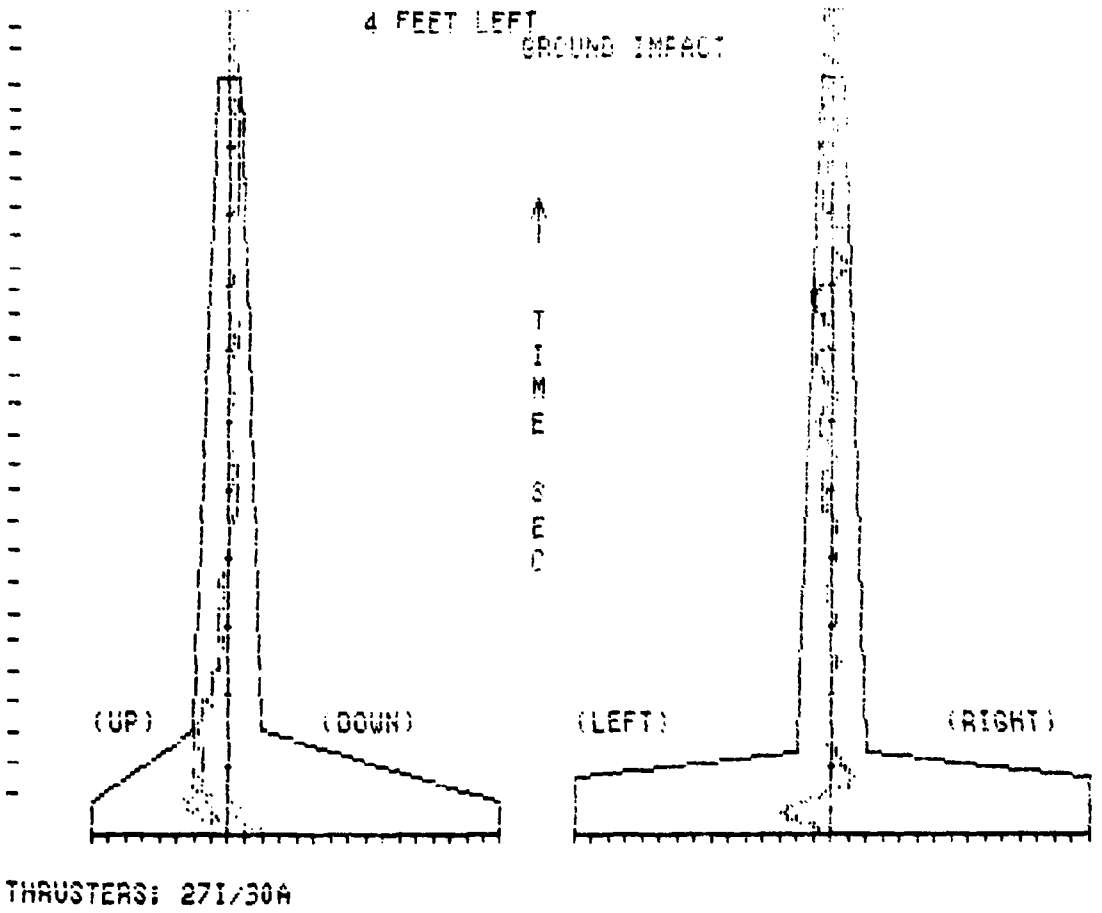


FIGURE II-3 (1 of 3) GAE vs Time
(Vertical & Horizontal Planes)
-MISS

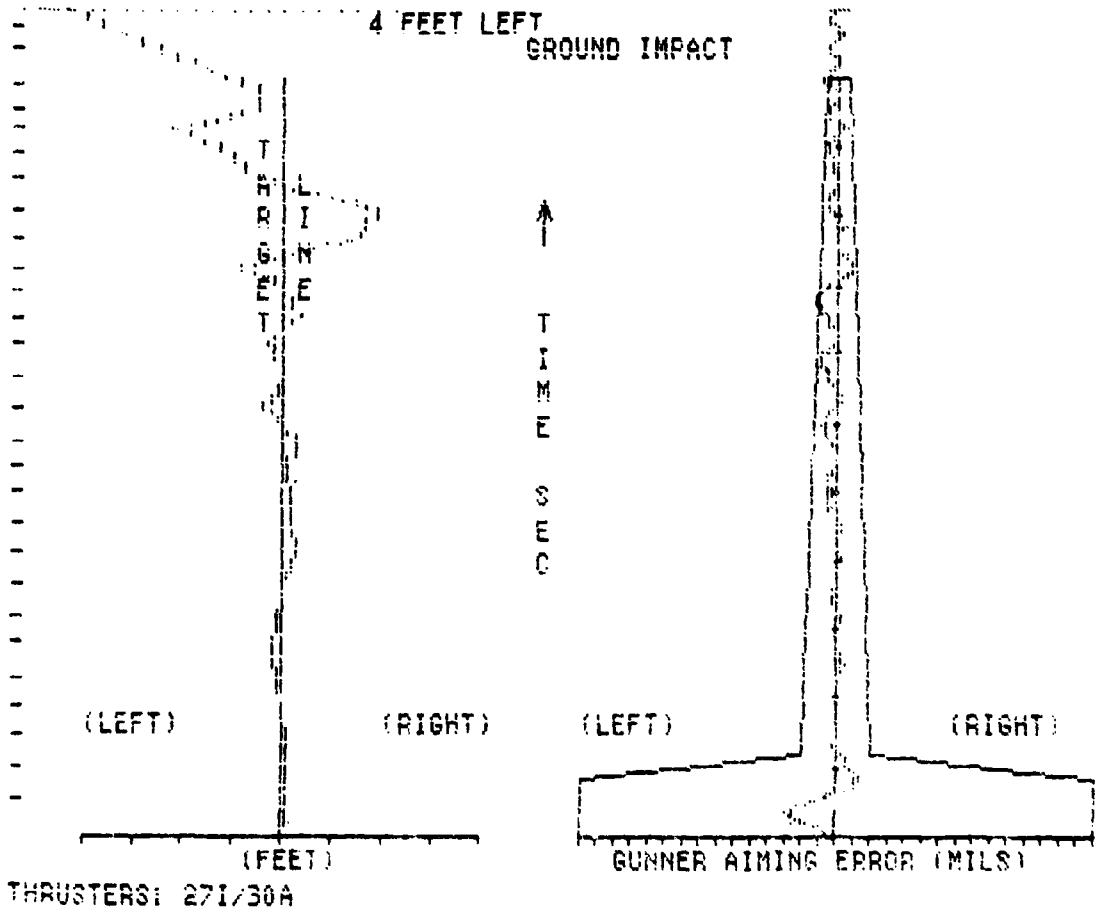


FIGURE II-3 (2 of 3) Missile Location vs Time (Horizontal Plane) GAE vs Time (Horizontal Plane)

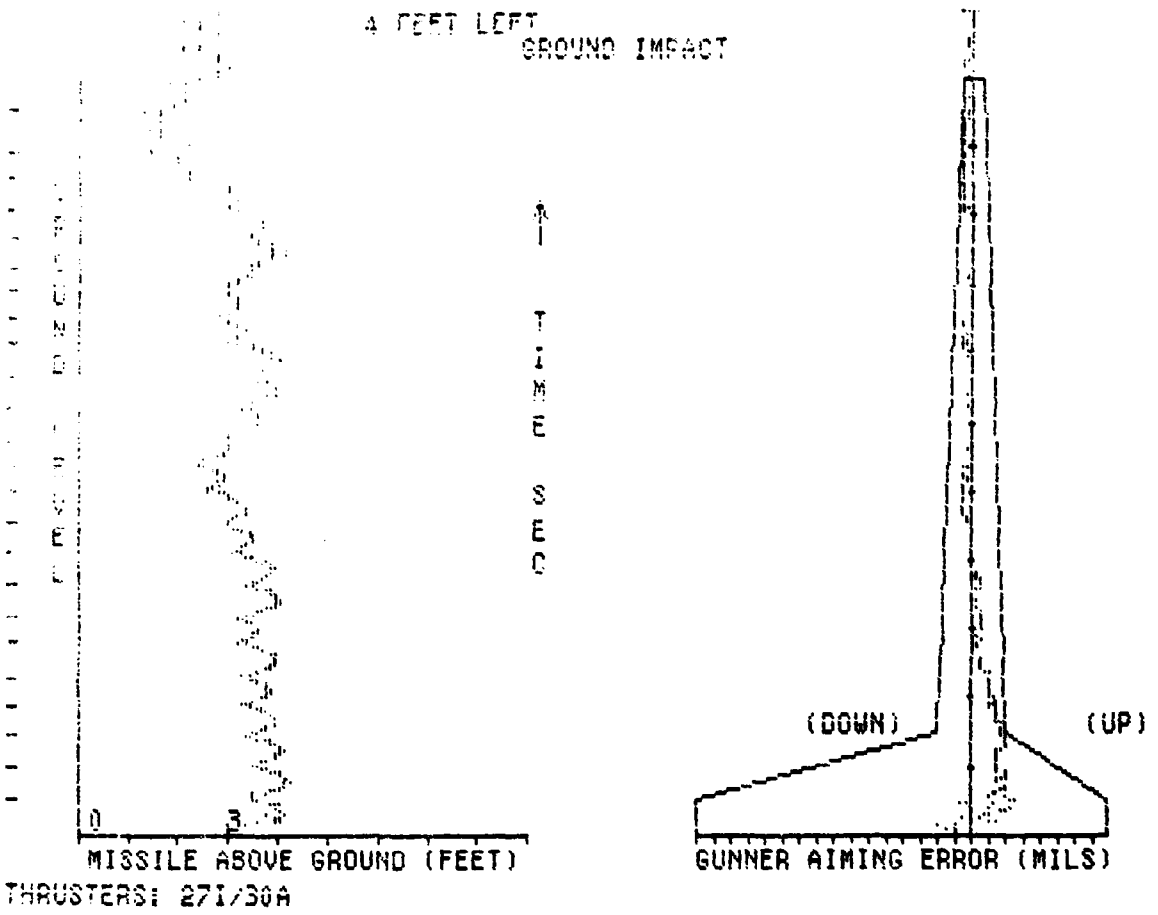


FIGURE II-3 (3 of 3) Missile Location vs Time (Vertical Plane) - MISS GAE vs Time (Vertical Plane)

SECTION III

SYSTEM DESIGN

A. Electro-Optics Subsystem

In order to solve the DRAGON flight equations several input parameters are required. These parameters are:

(a) trigger pull

(b) target position and range

(c) gunner aiming error

The STAGS measures the gunner aiming error with respect to a selected aim point on the miniature tank target, using the electro-optics subsystem.

Gunner aiming errors are determined by sensing the IRED on the target using a 100 x 100 matrix solid-state camera. The IRED is invisible to the human eye.

Solid-state imaging cameras are functionally similar to videcon type TV cameras, but with the added advantages of greater geometric accuracy, extended spectral range, higher sensitivity and scan rates, digital output, small size, low voltage and power requirements and the ruggedness and reliability of solid-state design.

The sensor is a solid-state photodiode array matrix having 10,000 pixels (100 x 100). The choice of lens determines the field viewed by the matrix camera. Using a 125 mm focal length lens and a target model distance of 22 feet, we have a field of view (FOV), of 1.05 feet or 48 milliradians. This FOV will accommodate the maximum excursions allowed for DRAGON, i.e., 32 mr horizontal and 22 mr vertical.

For a 1.05 ft FOV one pixel represents 0.126 inches on the terrain board.

Since the array is square the lengths in the X and Y axes are identical. The magnification, M, of the camera is the ratio of the FOV to the length of the array:

$$M = \frac{FOV}{Array\ Length}$$

where the array length is = 0.24 in. (0.60 cm total width/height) in both X and Y.

$$M = \frac{1.05 \times 12}{0.24} = 52.5$$

The static resolution is the array element spacing imaged into the object plane.

Resolution = Magnification x element spacing

Resolution = 52.5 x .0024 in. = 0.126 inches

This is equivalent to $\pm$ 7.5 in. resolution on a real world tank at the scaled range of 2,640 feet.

If a longer focal length lens is used the FOV is decreased and the resolution is improved.

Accuracy also depends on: image sharpness, contrast, vibration or movement of the object, light level and threshold setting of the camera.

The camera used is blemish free.

An IRED is located on the scaled model target and the center of the IRED's energy is calculated to determine hit location.

Because the IRED produces uniform illumination, the threshold setting on the camera can be adjusted to a fixed level, thus eliminating background interference.

The data from the photodiode array is electronically scanned to produce a sampled-and-held video output signal. The amplitude of each pixel is proportional to the incident light intensity integrated over the interval of one frame period. The camera essentially detects light to dark transitions of the digital area. The scene present on the camera is a light circle on a dark background. Transition data from the camera, stored as a digital line-by-line picture of the array, is handled by an interface unit. The DRAGON Flight Simulator Processor determines the GAE, from the transition data.

The electro-optic subsystem consists of the following equipments. (See Figure III-1)

Reticon MC 520 Camera

Reticon RS 520 Controller

Reticon RSB-6020 Interface Board

Nikon Zoom Lens (set at 125mm)

The RSB-6020 directly couples Reticon imaging cameras to Intel SBC/Multibus systems.

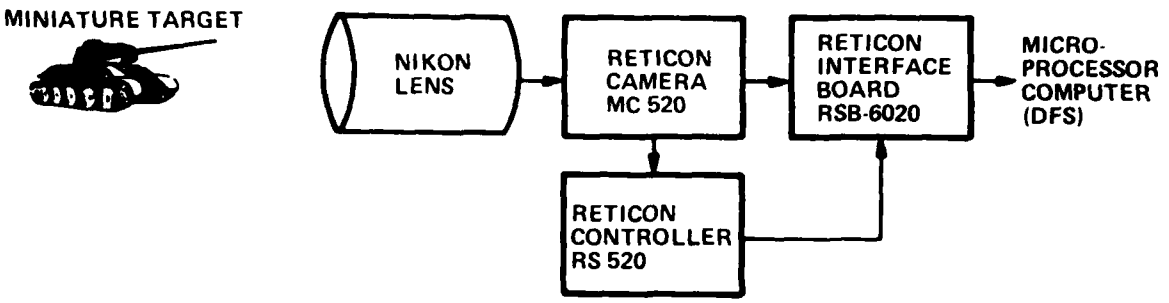


FIGURE III-1 ELECTRO-OPTIC SUBSYSTEM BLOCK DIAGRAM

B. Multiprocessor Subsystem

The multiprocessor subsystem includes six units with five being housed in the system chassis. The principal function of each of the separate units is:

(a) Personnel Interface Processing (PIP)

(b) DRAGON Flight Simulation (DFS)

(c) Sound Generation (SG)

(d) Target Control (TC)

(e) TV Display (TVD)

(f) Photodiode Array Processing (PAP)

System I/O is processed by the PIP, which is covered in the Computer Graphics and Video Subsystem Section.

Target control is detailed in the section Miniature Target Board.

The present section provides a description of the DRAGON Flight Simulator and the Photodiode Array Processor.

1. DRAGON Flight Simulator

The McDonnell Douglas Astronautics Company, Titusville Division, under Contract N61339-80-M-3518 provided a set of simplified equations and a computer program that approximate the DRAGON missile flight as directed by the gunner. (See Appendix A)

Six-degree-of-freedom equations are required to express the complete missile dynamics. Solutions of such equations were examined and simplied as much as possible by McDonnell while still maintaining a statistically accurate representation of weapon performance. Some of the simplifying assumptions were:

(1) Missile dynamics should be represented by a point mass solution,

(2) Small angle approximations to be used,

(3) The effect of tracker sampling on missile trajectory while in the linear field of view may be neglected.

The six-degree-of-freedom equations thus modified were exercised and compared to results obtained from the complete equations of motion. Modification to the thrust level and guidance parameters were made to tailor the trajectory to the more exact results. Sufficient comparative analysis was conducted to assure that the simplified equations gave acceptable results over a range of crossing and stationary target conditions and with a variety of gunner aiming errors.

Figure III-2 is the DRAGON simulation block diagram. The variables correspond with those of Figure III-3 which defines the important horizontal angles. These, and a similar set of vertical angles, were used in the McDonnel "BASIC" program which iterates the differential equations of motion using a "Delta Time" of 20 milliseconds. Thus a 10 second missile flight requires the generation of 500 solutions of the equations of motion.

The BASIC program was rewritten for an Intel Microprocessor Development (MDS) System (see Appendix A). The resulting program, while able to reproduce the McDonnell results, required several minutes to complete the 500 solutions for a simulated 10 second missile flight. It was, therefore, unsuitable for real time training.

An investigation of other floating-point-math techniques usable with Intel SBC-86/12, 8086, computers showed that real-time solutions of the missile flight could not be accomplished without using an 8087 coprocessor. The unavailability of the 8087 at that time made it ncessary to abandon the convenience of FP-math and recast the equations using integer arithmetic. This required close attention to the choice of suitable units for the variables because of the limited range of integer numbers: (-32,767, +32,767). Down-range distances, for example, are expressed in 2-inch units; 1000 meters (39,370 inches) being considered to be 19,685 "Down-range" units. Cross-range units are 0.05 inches for distances and 0.1 milliradians for angles. Unit selection for all variables is a compromise between the conflicting requirements of the desire to display variables over a wide range and the need to reduce quantization distortion while not exceeding the allowable integer range. Many comparisons between the integer and BASIC

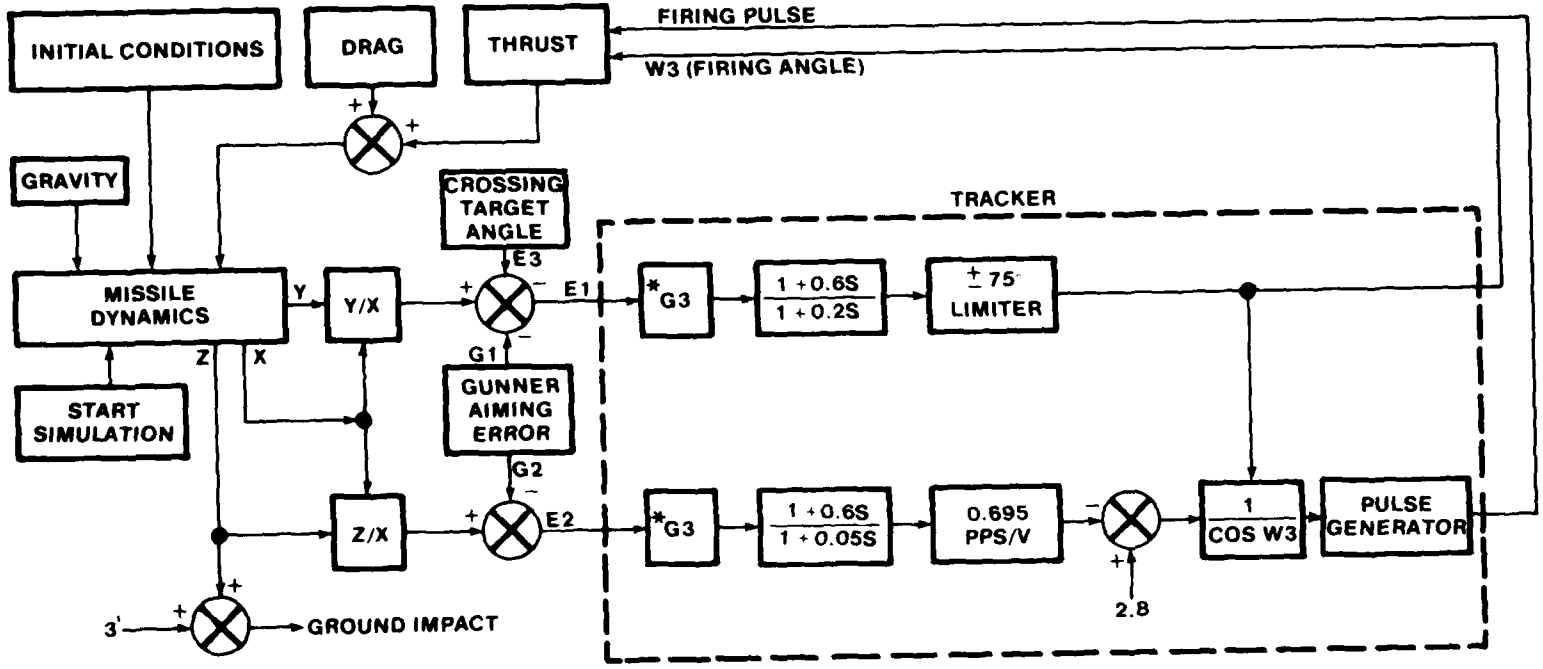


FIGURE III-2 SIMULATION BLOCK DIAGRAM

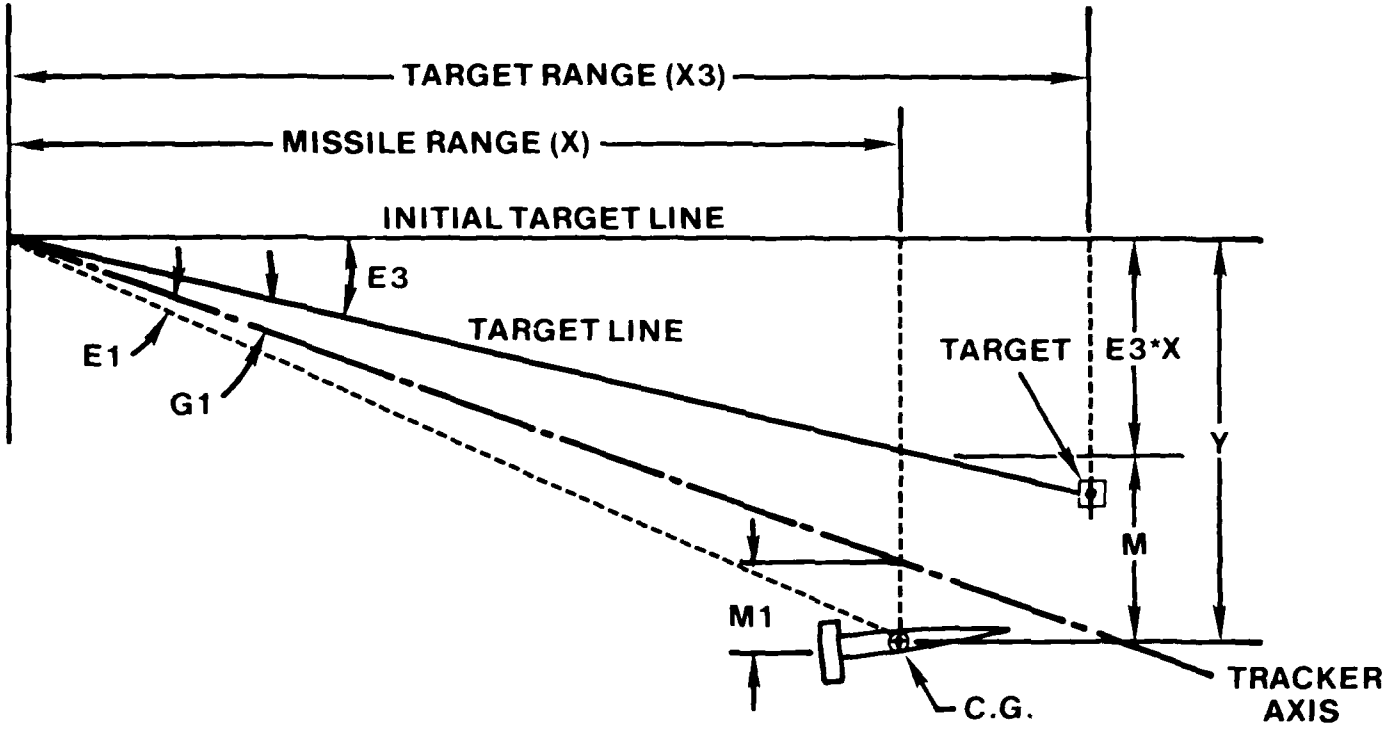


FIGURE III-3 HORIZONTAL PLANE GEOMETRY

program results have verified that good approximations to the DRAGON Flight characteristics are provided using integer arithmetic. Comments by experienced DRAGON gunners also support the validity of the approximations.

The DRAGON Flight Simulation Program includes five modules:

(1) Main-DRAGON-Module: A "Driver" module which calls other modules.

(2) DRAGON-Utility: Includes a number of start-up and other general procedures.

(3) DRAGON Flight Module: Includes the integer math missile dynamics, provides missile location information to the PIP, stores location data for possible reprise, and does the initialization of flight variables.

(4) DRAGON IR: Analyses the IR-spot data array provided by the following module.

(5) DRAGON XF: Transfers line-by-line data provided by the photo-detector line array processor into a complete picture array.

The first three modules are written in PLM 86; an Intel high level programming language. The last two are in 8086 assembly language. Total program code require slightly over 4K of ROM memory. Variable memory requires about 1K of RAM. The above programs are in Appendix B.

As noted previously, the program is located on an Intel SBC 86/12 board. This board, along with four others are housed in an Intel SBC 86/12 system chassis which provides eight card slots, power supply and ventilation. Cards within the chassis can communicate via the multibus motherboard. An SBC 86/12 provides dual-port RAM which can be accessed by both the on-and-off board processors. Missile position data resulting from the solution of the missile equations of motion are transferred to the PIP via the multibus for further processing and output. Data status bits are also read and written across the multibus as required.

Target motion is provided by the TC unit as described in the section on Miniature Modelboard. It is programmed via a stepper motor controller into which the desired target maneuver is input from a suitable menu located in program memory of the PIP. Target information needed by the DFS is transferred from the TC via the multibus.

The DFS also provides control signals to the sound generator for side-thruster pops, launch and impact explosions. It also provides signals for weight loss in response to trigger pull.

2. Photodiode Array Processor

Line scan data from the 100 x 100 photodiode array are initially stored in a set of ping-pong memories on a Reticon RSB 6020 board housed within the system chassis and attached to the multibus. Data are alternately read into ping or pong memory under control of a clock located within the Reticon RS 520. Data within the memory units give the location of light level transitions and indicates light-dark or dark-light transitions. The stored data also indicates when the last scan line is read.

After initialization, a last-line flag is output across the multibus to the DFS which causes the DRAGON XF program to begin the transfer of data from each line of the next 100 x 100 photodiode array frame to the SBC 86/12. The data read-out is then halted by the next occurrence of the last-line flag. The next 100 x 100 frame data are ignored during the analysis of the transferred frame data. New frame data analysis results are provided every other frame.

The frame rate of the Reticon camera is 100 frames per second so new IR-spot position data are provided 50 times a second or with a 20 millisecond period. Occurrence of the last-line flag acts as the master system clock with all data processing starting with its assertion.

Figure III-4 illustrates the various devices controlled by the multi-processor subsystem.

An automatic zeroing method has been incorporated to ease day to day bore-sighting of the gunner sight to the miniature targets. Zeroing is accomplished by supporting the DRAGON launcher on its resting stand and aiming the scope crosshairs at the desired aim point (Recoil and weight loss off). A Control B (CTRL B) is input from the console and the DRAGON trigger is squeezed. The computer will "read" the first frame of data from the Reticon 100 x 100 matrix camera and use this aim point for its reference boresight.

Subsequent firing will use the new boresight until the zeroing procedure is repeated or the computer is turned off.

C. Computer Graphics and Video Systems

The DRAGON computer graphic visual presentation is prepared by the Personnel Interface Processor. In addition to this processor a computer graphics board, a phase-locked-loop sync board, and an EIA composite sync generator are used. Figure III-5 shows the complete graphics and the video subsystem.

Computer generated graphics provide two major functions:

(1) Real-time video graphics are generated for the gunner sight. These graphics include a simulated missile which include thruster firings, smoke obscuration during initial launch and a final explosion.

(2) Real-time graphics are generated for the instructor which indicate both vertical and horizontal gunner aiming errors. Also, for follow up analysis, graphics may be presented for gunner aiming error versus time and missile position versus time.

Gunner's sight real-time computer graphics are generated on a Matrox 256 x 256 x 4 graphics board. Sixteen levels of gray scale provide for a full range of visual intensity which allows for smoke generation which varies from fully transparent to completely opaque in sixteen levels. The Matrox RGB-256 is a graphics imaging system in which a complete gray scale capability has been integrated onto a single printed circuit board. The card includes built-in NTSC (American) and PAL (European) gray scale encoder which can provide up to 16 shades of gray. The encoders permit the RGB-256 to directly drive standard

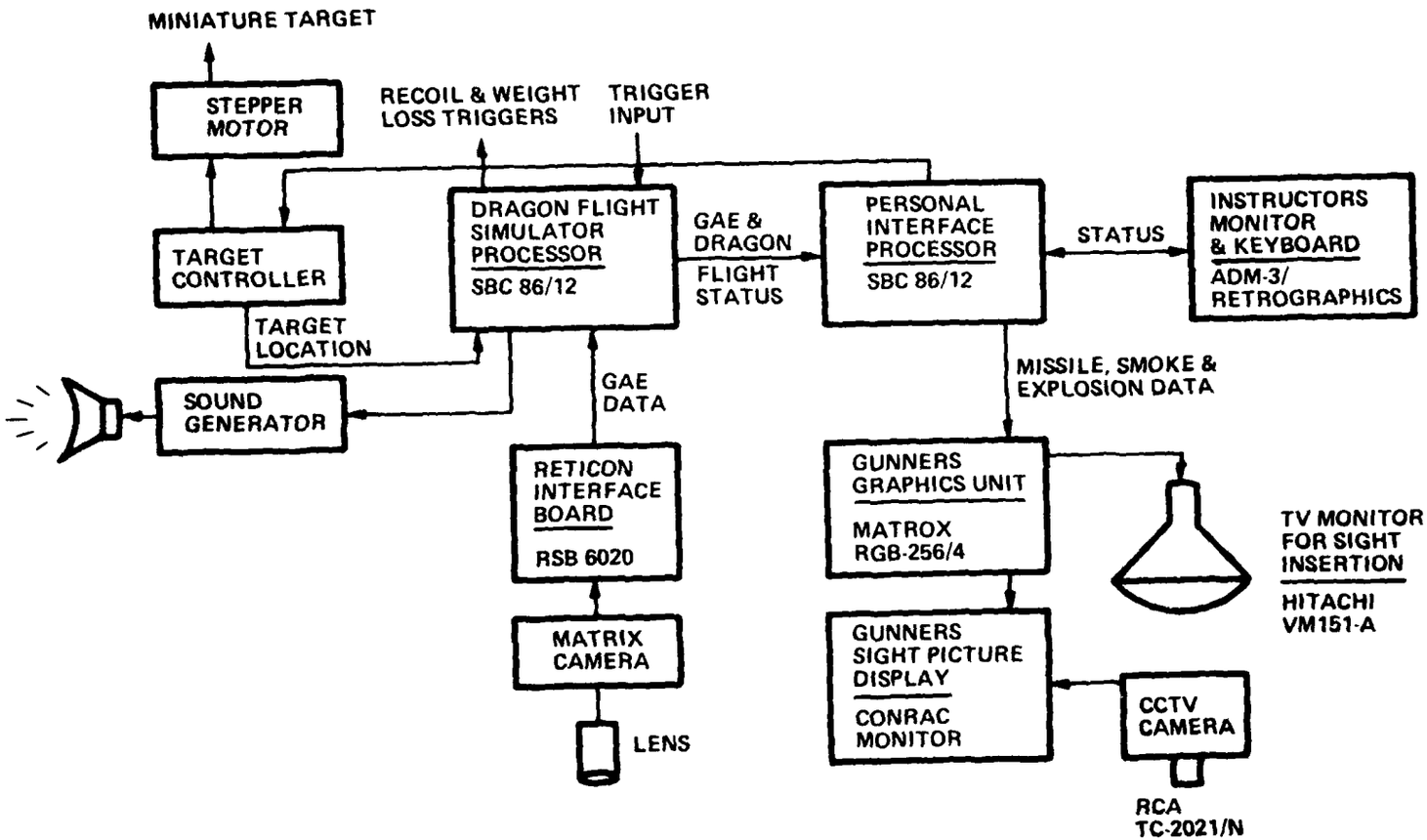


FIGURE III-4 MULTIPROCESSOR SUBSYSTEM

low cost black and white TV monitors on a single 75 ohm cable. It features the industry standard Intel Multibus which makes it directly plug compatible with all Intel single board computers.

Real-time video graphics are generated by the Personnel Interface Processor (PIP). The PIP receives gunner aiming error information from the DRAGON Flight Simulator (DFS) as well as missile angle from the line of sight of the gunner to the missile position (angle El from Figure III-3). The gunner aiming error is used to position the final explosion (hit or miss) in the DRAGON sight. The angle El is used to position the missile in the DRAGON sight.

Gunner Graphics:

DRAGON sight graphic missile simulation is accomplished by first deriving the missile position from the Angle El. Second, the size of the missile is determined by the elapsed time since the missile launch. Third, the brilliance of the missile is determined by the elapsed time since launch and if a thruster is being fired.

The size of the missile shrinks from 10 pixels down to 1 pixel from launch to maximum range. The brilliance decays from a level of ten (with fifteen being most brilliant) to a level of zero at minimum range.

An octagon was selected as the simulated missile shape as this can be quickly calculated for real-time graphics. This shape appears mostly as a circular area to the DRAGON gunner.

Smoke is simulated in the DRAGON sight by modulating the background level, i.e., overall gray scale setting of the entire graphic video insertion in the gunner sight. It is possible to tell the RGB-256 graphics board to "erase" to any given gray scale level between zero and fifteen, with zero being black (transparent) in the gunner sight and fifteen being white (opaque). The levels of background are modulated with time to effect a smoke simulation. A typical smoke simulation might consist of starting from level zero rising to level fifteen, dropping to level eight, back up to fifteen, down to four, up to eight and down to zero during a period of one to two seconds.

The final explosion of the missile and/or tank is simulated at the end of the DRAGON flight and inserted, via the RGB-256 graphics board, into the gunner sight. The explosion is a series of geometric star shapes indicating either a hit or miss. The PIP uses the missile-to-aim-point information to position the explosion wherever the missile was as it impacted the target or ground. A ground explosion is similar to a target explosion; however, it differs by only exploding in an upward sense. Thus the DRAGON gunner has visual feedback through his sight indicating hit and miss. The computer generated graphics are passed directly to the gunner's sight through a Hitachi VM151A, one and a quarter inch, closed circuit television (CCTV) monitor. The optical arrangement is shown in Figure III-6. The television screen appears at infinity along with the viewed scene through the 6x scope. The CCTV is mounted inside the DRAGON IR tracker housing and electronics for the CCTV are located where the IR tracker electronics are normally located at the bottom of the tracking head.

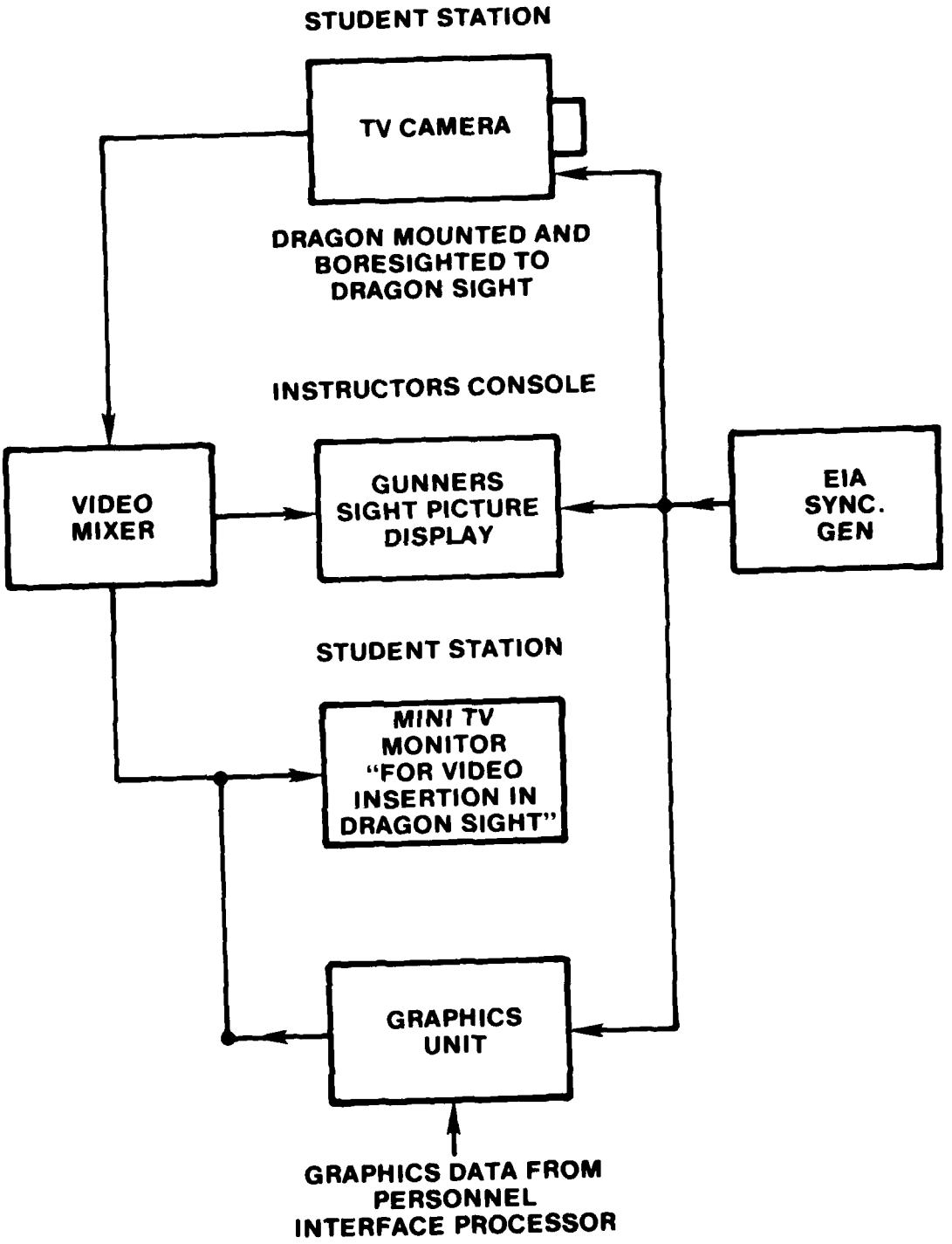


FIGURE III-5 COMPUTER GRAPHICS AND VIDEO SUBSYSTEM

Instructor Console Graphics

The instructor console graphics subsystem is composed of two units, a television representation of the gunner's sight picture and a graphical plot of gunner aiming error versus time and/or gunner aiming error versus missile position.

The television representation of the gunner's sight is accomplished by mixing the gunner's sight TV camera, which is boresighted to the 6x gunner sight, with the video graphics presented to the gunner's sight. The composite picture presents to the instructor an image of the gunner's sight which includes the target, rocket, smoke, crosshairs and final explosion.

The instructor's television representation of the DRAGON gunner's sight picture and computer graphic missile, smoke, crosshairs and explosion simulation is combined from three sources.

The model board target and terrain is looked at by a closed circuit television (CCTV) camera which is mounted outboard on the DRAGON launcher tube. This camera is zeroed to the gunners 6x scope and has the same field of view as the scope. The camera used is an RCA TC-2021/N with a NUVICON camera tube and a 135mm f3.5 still camera lens. This camera was chosen for its small size and low weight.

Secondly, a video mixer combines the CCTV image with the Matrox RGB-256 computer graphics. The combination of CCTV video and computer graphics is then a representative visual image of the gunner sight picture except for the crosshairs.

Crosshairs are added, to complete the instructor sight picture display, by passing the video presentation through an electronic crosshair generator. The crosshairs are adjustable in position and width.

The graphical plot of the gunner aiming error (GAE) versus time for both horizontal and vertical error are presented in real-time during the missile flight. The graphs indicate the actual gunner aiming error during the flight as well as the limits for a 95% probability of hit performance. The guidance rocket thruster firings are shown when they are fired as well as a final actual count of the thrusters fired versus the ideal number of thrusters that would have been fired for a given target distance with perfect aim. At the end of a flight, displayed results show the miss distance, in feet, where the missile passed the target. If the missile struck the ground before passing the target, a message is displayed stating "ground impact" as well as the remaining distance to the target when grounded. If a hit is scored a hit message is displayed to mark the event.

After a missile flight a reprise of the flight may be called. A horizontal reprise replays the horizontal GAE and the horizontal missile position versus time. Likewise the vertical reprise replays the vertical GAE and the vertical missile position versus time. The reprises indicate all the hit/miss summaries of the first real-time plot.

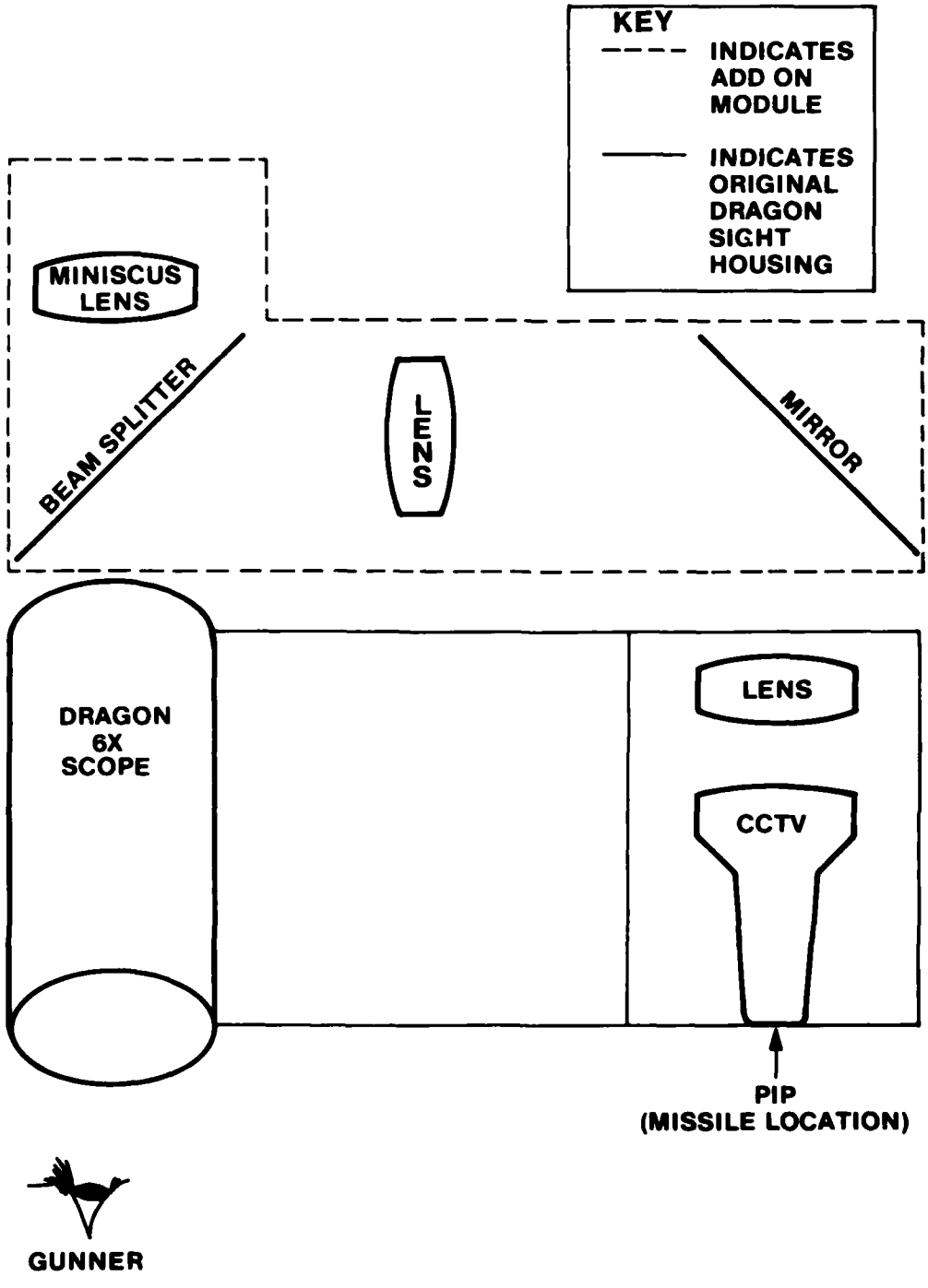


FIGURE III-6 DRAGON GUNNER'S SIGHT SYSTEM

Any of the computer graphic plots may be made into a hard-copy printout. The hard-copy may include the gunner's name or other pertinent data as desired by the instructor.

The instructor's diagnostic graphs, keyboard controls and hard copy printouts are controlled by the PIP through an ADM-3 dumb terminal and Digital Engineering Retrographics RG-512 graphic board and Digital Engineering GP-100 hard copy printer.

The operation of the Retro-Graphics equipped ADM-3A can be best understood by considering the RG-512 card as the terminal controller and the ADM-3A as a "peripheral" device. The RG-512 is situated in series between the ADM-3A and the serial input to the terminal. This means that all incoming ASCII will be received by the RG-512 and processed. Input to the terminal will only reach the ADM-3A circuitry if it is transmitted there through the RG-512.

The RG-512 can perform several functions on the incoming data. The function performed depends on the actual ASCII code received and the RG-512 operating mode. Data may be retransmitted to the ADM-3A as mentioned above if the data were alphanumeric text. This is the usual function performed by the RG-512 when in the ADM-3A Alpha Mode. Certain control codes, called mode transition codes, can set the RG-512 to one of the two graphics modes, the Vector Mode or the Point Mode. An additional alphanumerics mode, the 4010 Alpha Mode, is included and can also be entered by sending the terminal the appropriate mode transition code.

After entering one of the graphics modes, subsequent input it interpreted as x-y coordinate data and is used in the generation of a point or vector display. The RG-512 does not retransmit an ASCII code to the ADM-3A if it is being used as an x-y coordinate.

The RG-512 employes the "bit map" method of storing graphic images. This means the information is stored in a digital memory as a rectangular array of bits. Each bit in this memory is mapped onto the CRT screen and can cause a bright point to be displayed. The RG-512 displays graphs and pictures by writing the proper bits into the graphics memory. This architecture has several advantages over the traditional storage tube approach which has dominated lower cost graphics terminal designs. Since the CRT is not relied upon for storage of the image, less expensive CRTs employing more conventional long life, brighter phosphors can be used. Another important by-product is the ability to selectively erase portions of the screen. This is desirable if the application requires the use of dynamic displays employing motion or rotation to convey information.

All circuitry for the RG-512 is packaged on a single 12" x 12.31" printed circuit card. This circuitry consists of four functional elements: Z-80A microprocessor and control, 128,000 bit graphics RAM, raster synchronization and CRT refresh, and power supply.

The Z-80A microprocessor and control section performs command decoding and is responsible for the writing of information into the graphics RAM. The Z-80A automatically generates vectors from transmitted endpoints and also performs scaling and character generating functions.

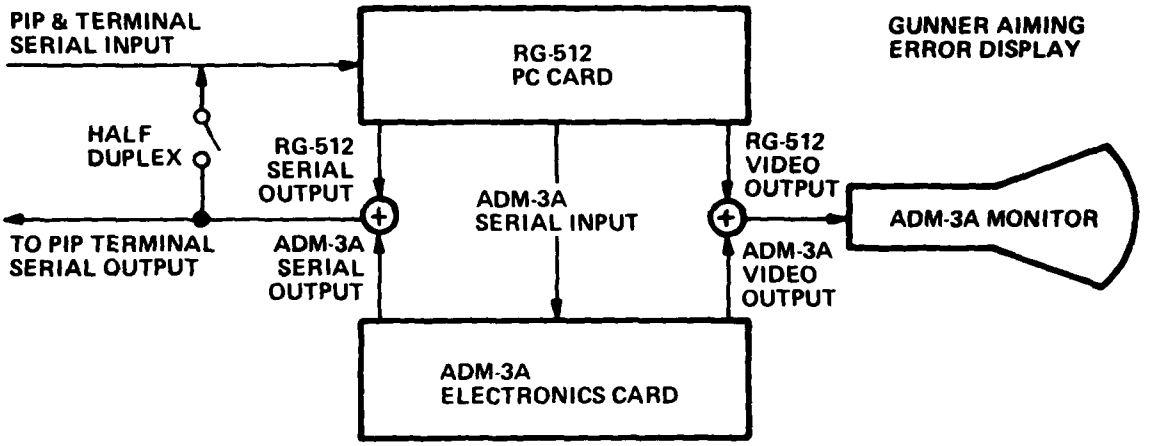


FIGURE III-7 RG-512 FUNCTIONAL BLOCK DIAGRAM

The GP-100 Graphics-Printer is designed to interface with the Retro-Graphics upgraded Lear Siegler ADM-3A (or 3A+) computer terminal.

As an optional feature to Retro-Graphics, Graphx-Printer reproduces the terminal's displayed graphics (or alphanumerics) on hardcopy. The electrosensitive device is ideal in those computer graphics applications where clear, economical printing is needed.

The GP-100's printing system is electrosensitive. This advanced technology allows the GP-100 to quietly print the displayed graphics within 16 seconds and alphanumerics at 170 lines per minute.

With the electrosensitive printing system all graphics and alphanumerics are drawn by a durable printhead that produces dark, clear images with no distortion. In other words, the high resolution graphics screen image is reproduced, dot-for-dot, on hardcopy.

Additionally, paper is the printer's only consumable. Typically an 8 1/2" x 11" hardcopy costs less than 3¢. Also, the paper can be photocopied, and it will not fade or yellow with time.

The electrosensitive paper is made from a base of black coated ordinary bond paper deposited with a thin aluminum layer; this gives the unprinted paper a metallic appearance. During printing, an electric current flows through styli that touch the aluminum. This action vaporizes the aluminum at the point of contact and exposes the contrasting black under-layer to form the graphics or character image.

The print head consists of 12 styli mounted one above the other as a unit. This head is attached to a carriage which moves the styli from left to right and maintains them in contact with the paper. The styli are pulsed electrically while crossing the paper so that the required characters or graphics are printed. During printing, each stylus burns a single dot in response to a current pulse. At the end of the line, the carriage moves the head away from the paper and returns to the left hand margin without touching the paper.

D. Computer Generated Sound System

Simulation of sounds produced during an actual DRAGON missile firing is accomplished by interfacing an Intel 8748 microcomputer to a General Instruments AY-3-8910 Programmable Sound Generator (PSG). Data necessary for the PSG to reproduce sounds is acquired from the permanent memory of the microcomputer. During missile flight time the DFS processor simply selects the sound to be made and communicates its choice to the microcomputer. This approach allows the processor to handle sound-making decisions with minimum time take from its primary functions.

The choice of sounds available to the DFS processor are:

(1) Gyro wind-up

(2) Missile launch explosions

(3) Rocket thruster motor firing

(4) Target missed explosions

(5) Target hit explosions

The General Instruments Programmable Sound Generator (PSG) is a 40 pin, 8 bit device with microprocessor compatibility. The device features three independent analog channels each with access to its own tone generator. A 16 control register array communicates to the microcomputer through an eight bit bi-directional port. Four lines are alloted for bus control logic (read and write). Each tone generator looks to two registers within the array for a 12 bit tone period. A range of frequencies covering the full eight octaves of the equal tempered chromatic scale is available.

Pseudo-random noise may be mixed to any or all channels from a noise generator with basic frequencies of 4 KHz to 125 KHz. Two modes of output control are available for each channel. The fixed level amplitude mode selects an amplitude specified in the array by the microcomputer. For use in this system the variable amplitude mode is selected, forcing an envelope generator to control the shape

and cycle of all outputs. Controlling the envelope generator is a 16 bit tone period within the array allowing for frequency ranges of 12 Hz to 7812.5 Hz and a five bit shape/cycle control register. Three D/A converters supply 0 to 1 volt signals to the output channels.

To accurately represent the flight of a DRAGON missile as it moves down-range two sound phenomena must be simulated:

(1) Time delay due to the differences in the speeds of light and sound and,

(2) The Logarithmic decay in the amplitude of sound with distance.

Software developed for the microcomputer closely approximates these conditions within a 1000 meter range.

As shown in Figure III-8, the outputs of the PSGs are input to circuits whose function is to control the amplitude of the sound. These circuits consist of operational amplifiers with closed loop gains under direct control of the micro-computer. An Intel 8243 I/O port expander is used to select feedback networks of the operational amplifiers. Harris analog switches HI518 and HI304 under the direction of the 8243 provide a variable feedback network for the rocket thruster sounds. The hit and miss explosions pass through a separate operational amplifier circuit utilizing the same HI518 for gain control. To further massage the rocket thruster sounds a Pioneer Reverberation Amplifier is inserted between the output of the operational amplifier and a Bozak Pre-amp and Mixer. Rocket thruster sounds, hit and miss explosions, and the launch explosion all pass through the mixer and a Bozak Amplifier. The launch explosion is generated from a Frazier 8-ohm speaker located at the trainees station. Rocket thruster firings are heard from a speaker near the modelboard as well as hit/miss explosions. The gyro wind-up noise emanates from a speaker located within the DRAGON tube.

The DRAGON Flight Simulator processor initiates a timer within the micro-computer upon request of a launch explosion. Thereafter, each request for a sound by the processor causes the microcomputer to inspect the timer. Assuming the missile travels at an average speed of 280 feet per second the microcomputer is able to approximate the distance covered and determine the appropriate sound amplitude. The microcomputer selects one of thirteen levels of amplitude, for rocket thruster sounds, decreasing logarithmically from a gain of 10 to 1 over a time span of 11 seconds corresponding to a distance of 1000 meters. When the missile hits its target a series of three rapid explosions are generated, each explosion louder than the previous. For a missed target two explosions occur. Distance in terms of three ranges is the criteria used to determine the amplitudes of these explosions. These ranges are: low range (less than 333 meters), mid range (334 to 630 meters), and a high range (greater than 630 meters). The gyro wind-up noise and the launch explosion have fixed amplitudes.

Time delay associated with distance covered by the missile is accomplished upon inspection of the timer for each requested sound after launch. Before signals are passed to the PSG to create a sound, software completes a sequence of three delays. The first delay represents the real-time between requests from the processor. This timeout occurs only when two or more requests are made before

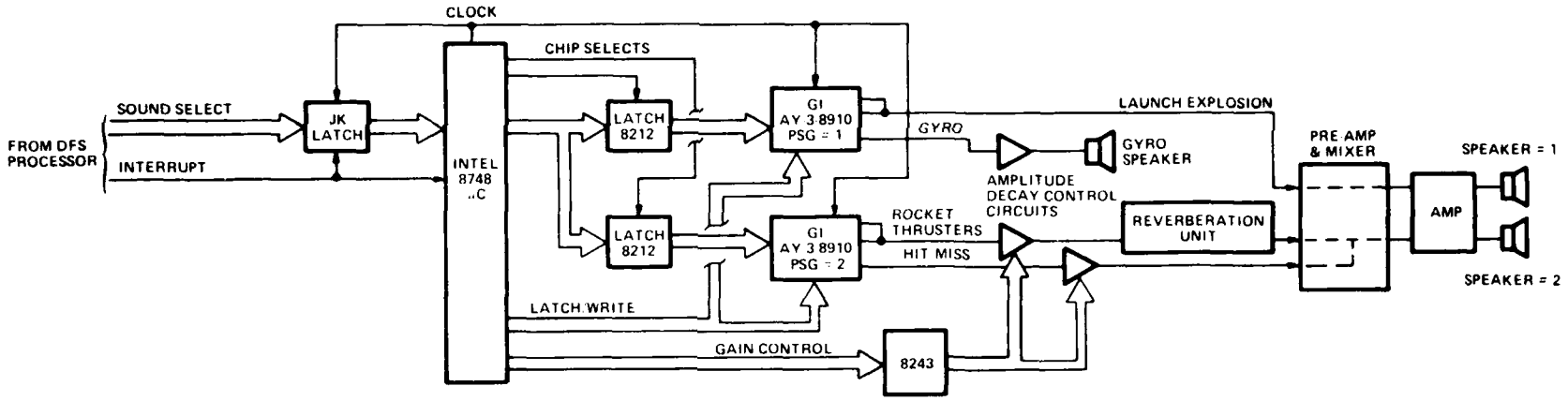
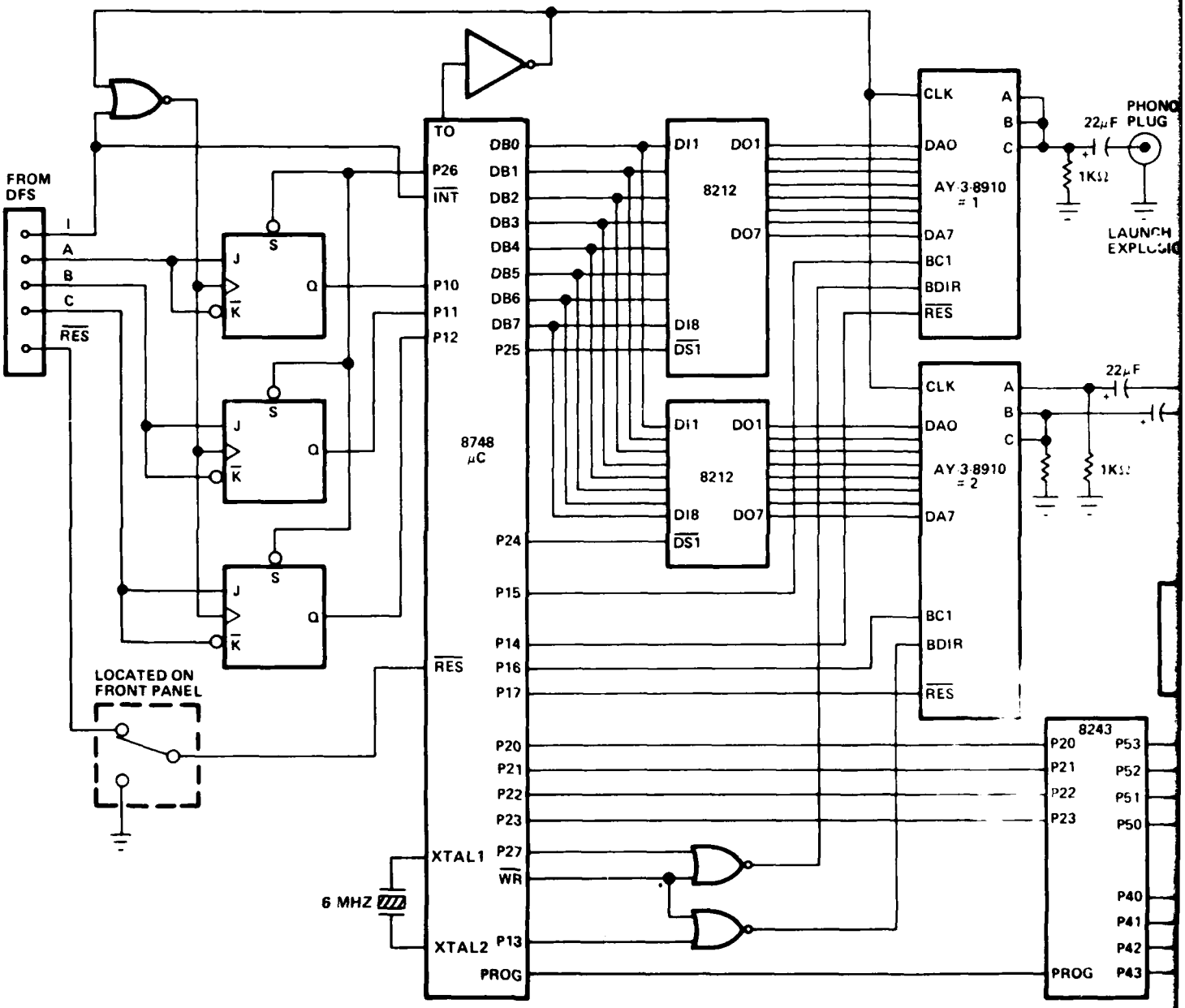


FIGURE III-8 SOUND SYSTEM FUNCTIONAL BLOCK DIAGRAM


FROM DFS
I
A
B
C
RES
J
K
S
Q
LOCATED ON FRONT PANEL
TO
P26
INT
P10
P11
P12
P25
P24
P15
P14
P16
P17
RES
P20
P21
P22
P23
P27
WR
P13
PROG
XTAL1
XTAL2
6 MHZ
DB0
DB1
DB2
DB3
DB4
DB5
DB6
DB7
8748 μC
DI1
DO1
8212
DO7
DI8
DS1
CLK
DAO
AY-3-8910 = 1
DA7
BC1
BDIR
RES
A
B
C
22μF
1KΩ
PHONO PLUG
LAUNCH EXPLOSIO
AY-3-8910 = 2
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P42
P43
PROG

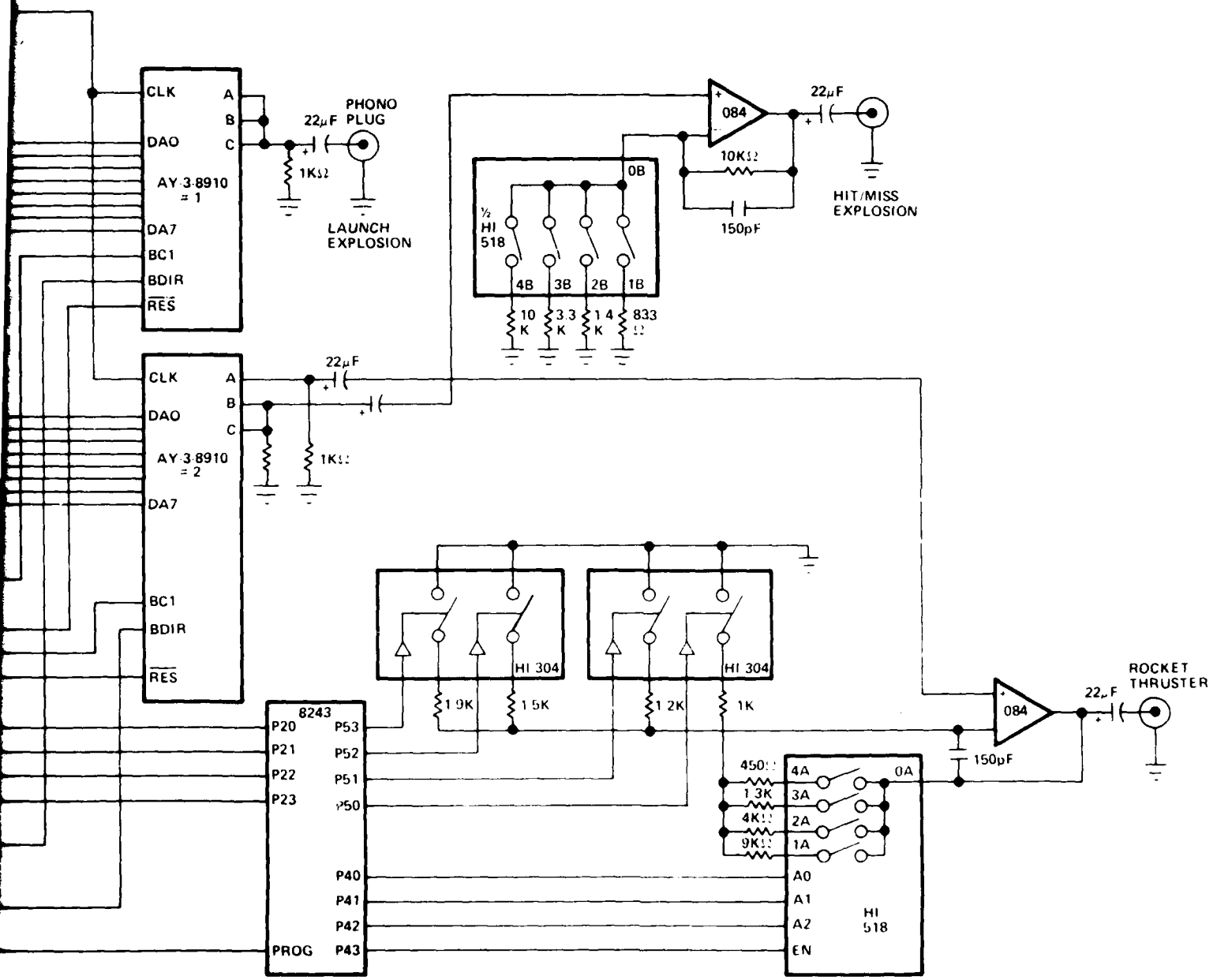


FIGURE III-9 SOUND SYSTEM SCHEMATIC

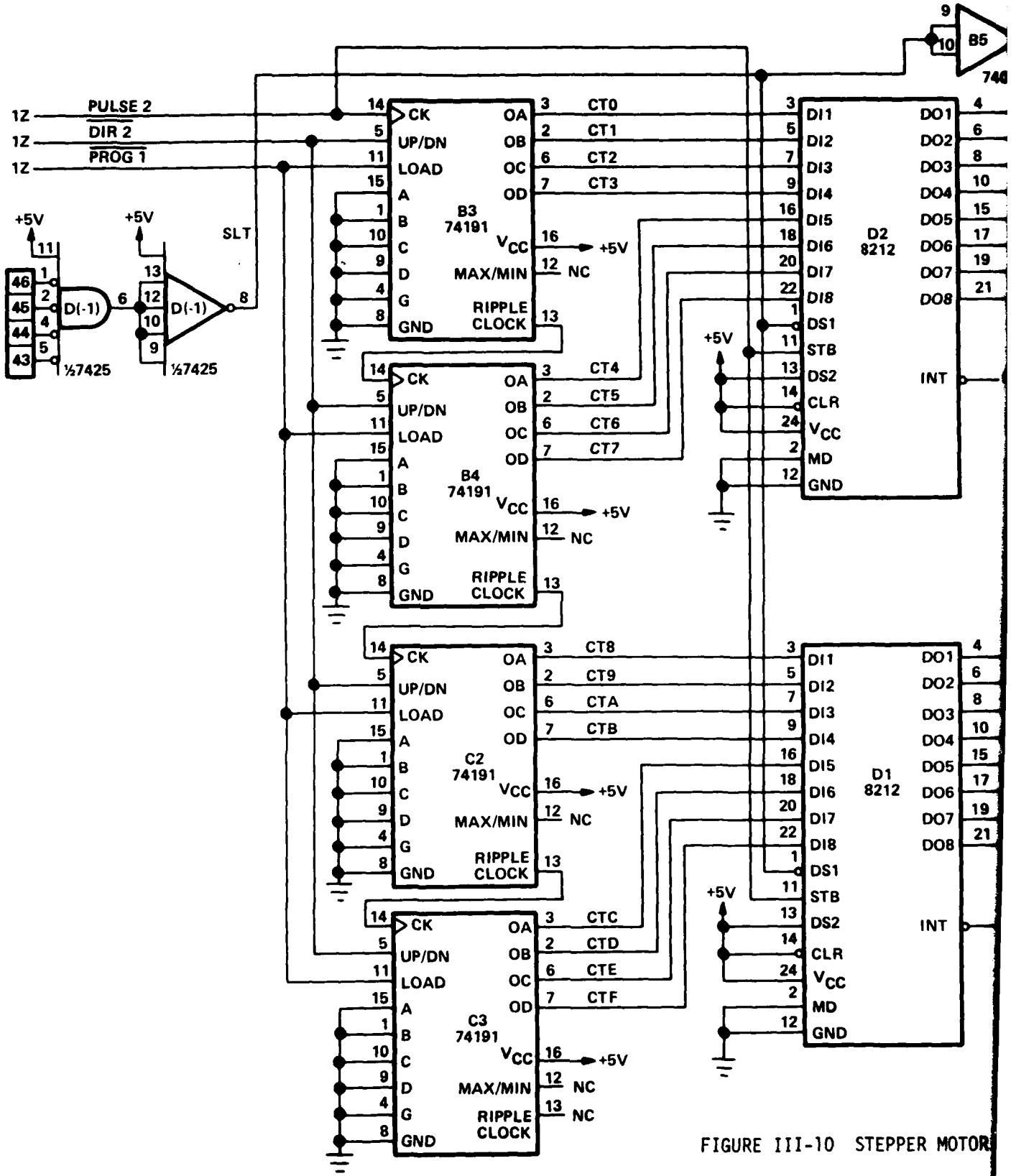


FIGURE III-10 STEPPER MOTOR

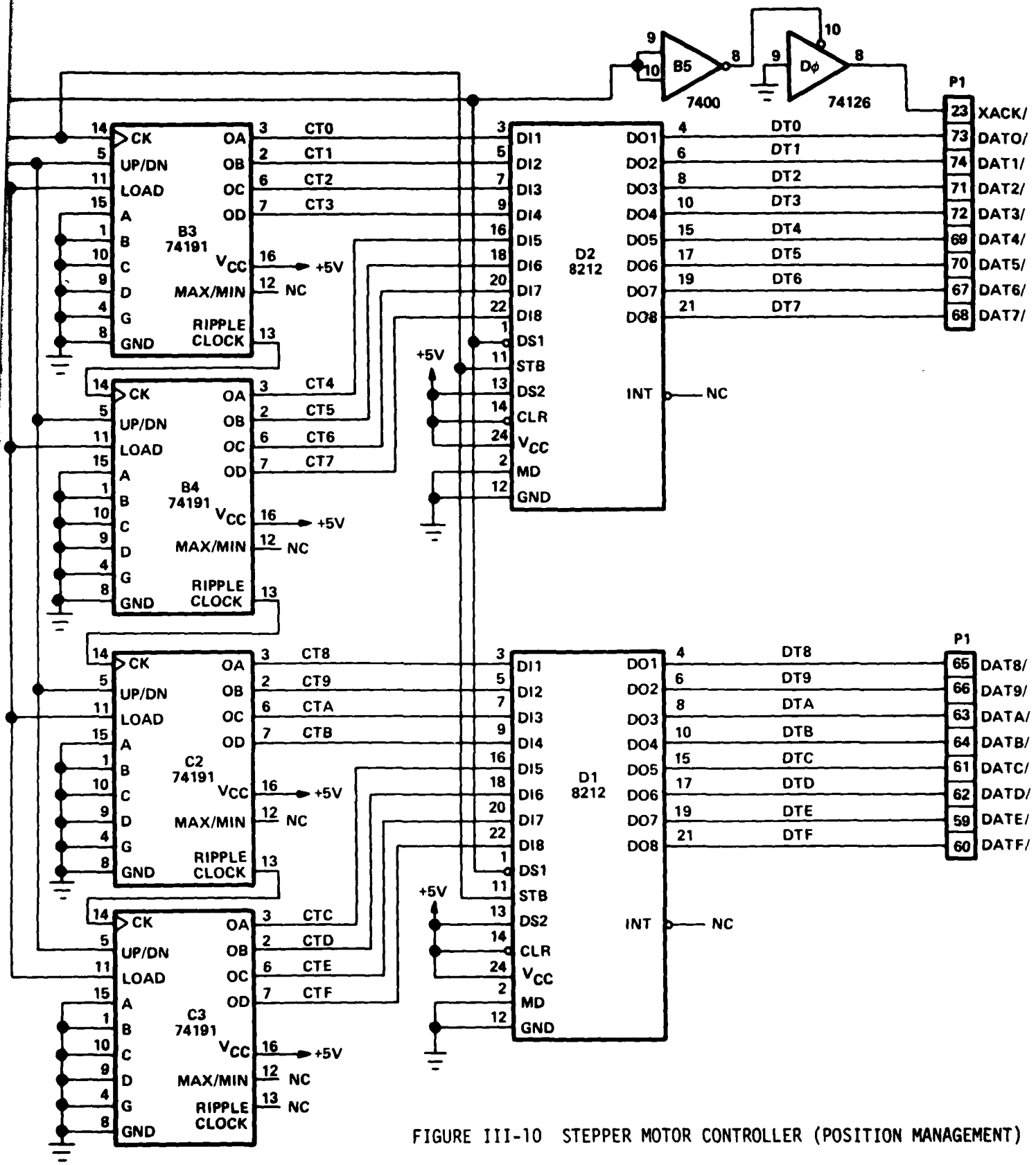


FIGURE III-10 STEPPER MOTOR CONTROLLER (POSITION MANAGEMENT)

the first request is serviced by passing signals to the PSG. The real-time between any two requests represents distance traveled by the missile and is decoded into the second time delay as determined by the time required for sound waves to travel this distance. These incremental time delays are accumulated in the microcomputers data memory. The third time delay before a sound is made is the cumulative total of all the second time delays that have already been decoded. The complete algorithm produces a series of logarithmically decaying, time delayed, sound waves that approximate the actual conditions within a 1000 meter range.

E. Miniature Target Board

Because most anti-armor devices use high power telescopes to view the targets, a 1/120 scaled miniature model was chosen. The target model has an IRED located at the center of the target mass. The model is moved using a stepper motor. The stepper motor controller is a stand-alone intelligent controller that is independent of the host computer, the Personnel Interface Processor, except for loading the scenario. The stepper motor controller uses a high level language for control of the stepper motor direction, position, speed and acceleration. The tank is moved over a 40 inch track. It takes 5,240 half steps to run this track. Using this system the tanks location is known to 0.0076 inches on the model board. Scaled to the real world one half step moves the tank 0.9 inches.

The controller utilized is a Cybernetic Micro Systems, CY 512. The CY 512 controller is a standard five volt, 40 pin LSI device configured to control a 4-phase stepper motor. The CY 512 interfaces to the microcomputer using parallel TTL input. It also has a software controllable pin which is used to initiate movement of the tanks turret.

Hi-level commands to control the device are stored externally in the PIP processor.

Under instructor control a scenario can be selected. The commands are then transferred and stored internally in a program buffer in the CY 512. The CY 512 outputs sequence the stepper drive circuits that consist of standard Darlington drivers. When absolute position commands are executed, the CY 512 automatically determines whether it is necessary to move CW or CCW to reach the specified target position.

Tank position is measured by a 16-bit counter consisting of four 74191 TTL chips. (See Figure III-10) The counter is reset whenever a new scenario is loaded into the CY 512. The counter then records half-steps of the stepper motor.

The CY 512 interface is shown in Figure III-11.

The Darlington drivers are shown in Figure III-12.

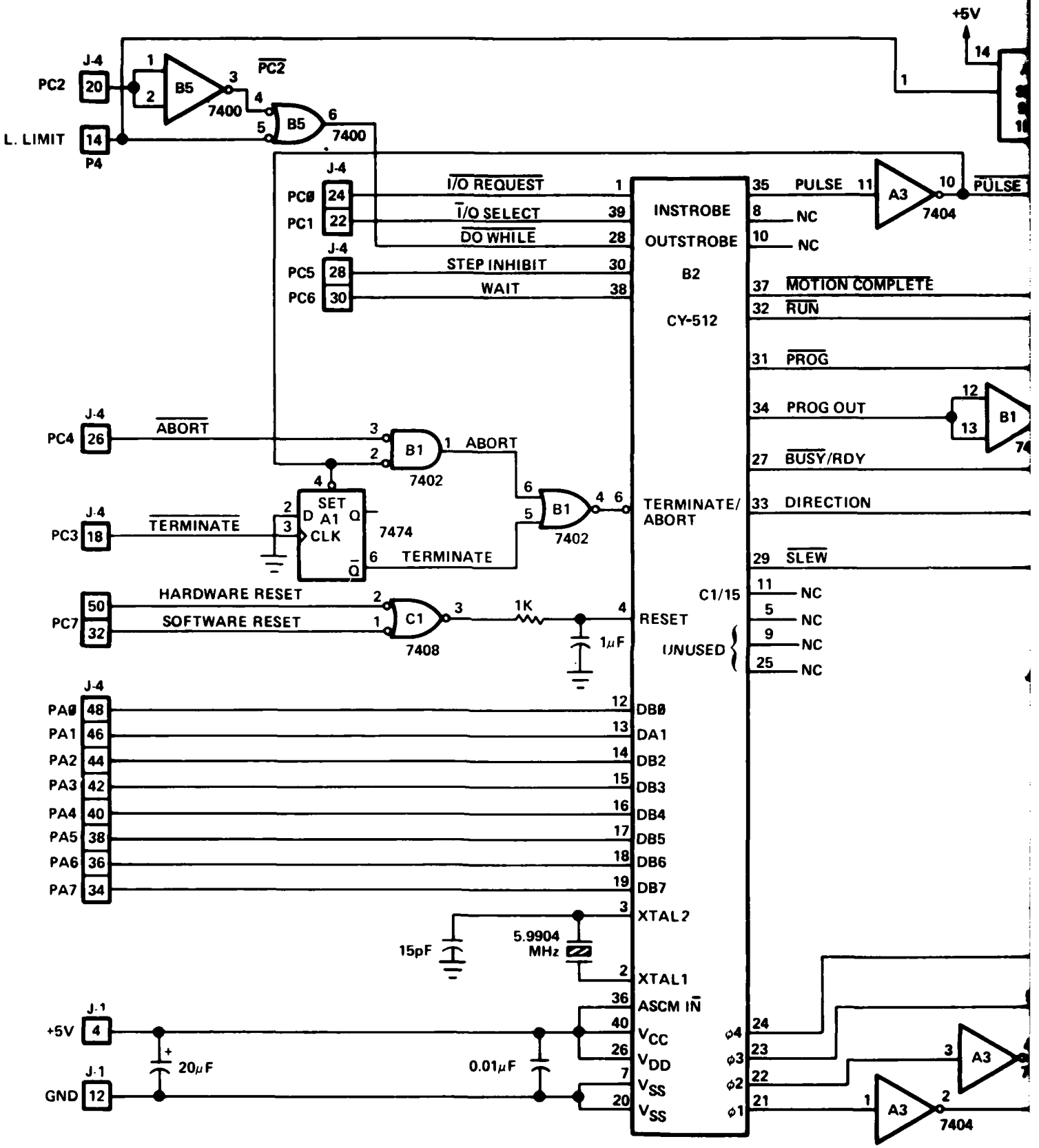


FIGURE III-11

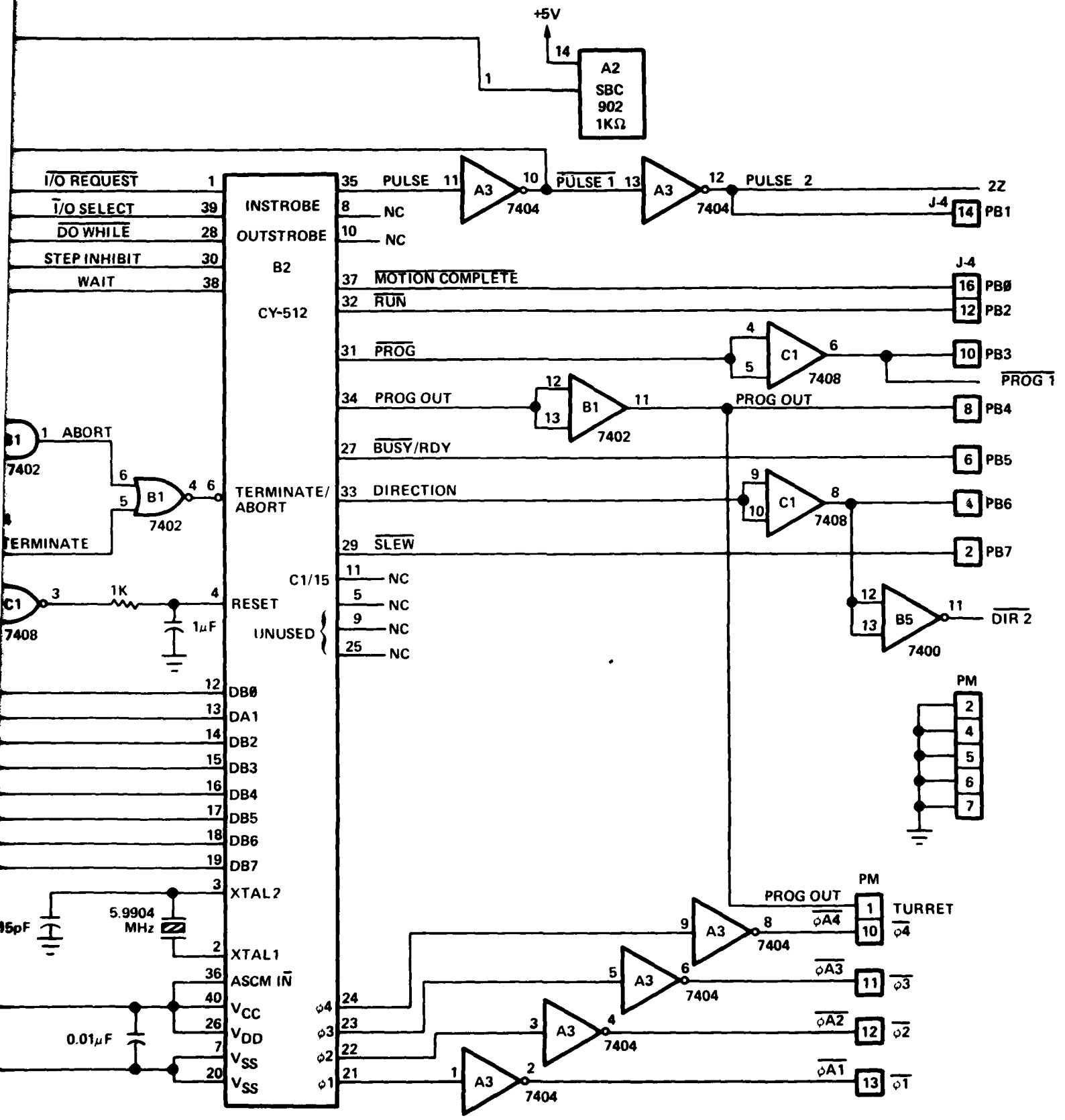


FIGURE III-11 STEPPER MOTOR CONTROLLER (CY-512 INTERFACE)

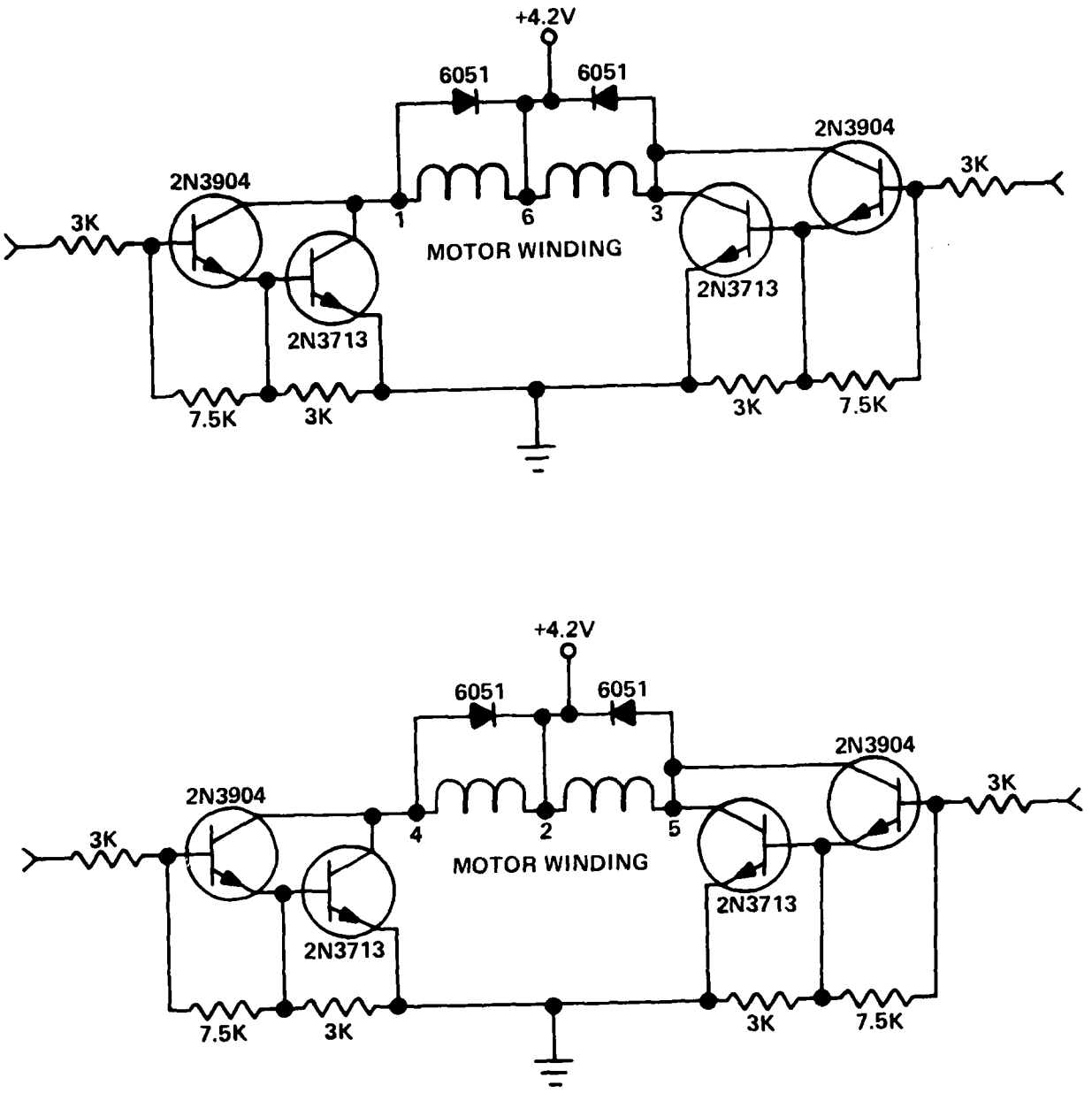


FIGURE III-12 STEPPER MOTOR DRIVERS

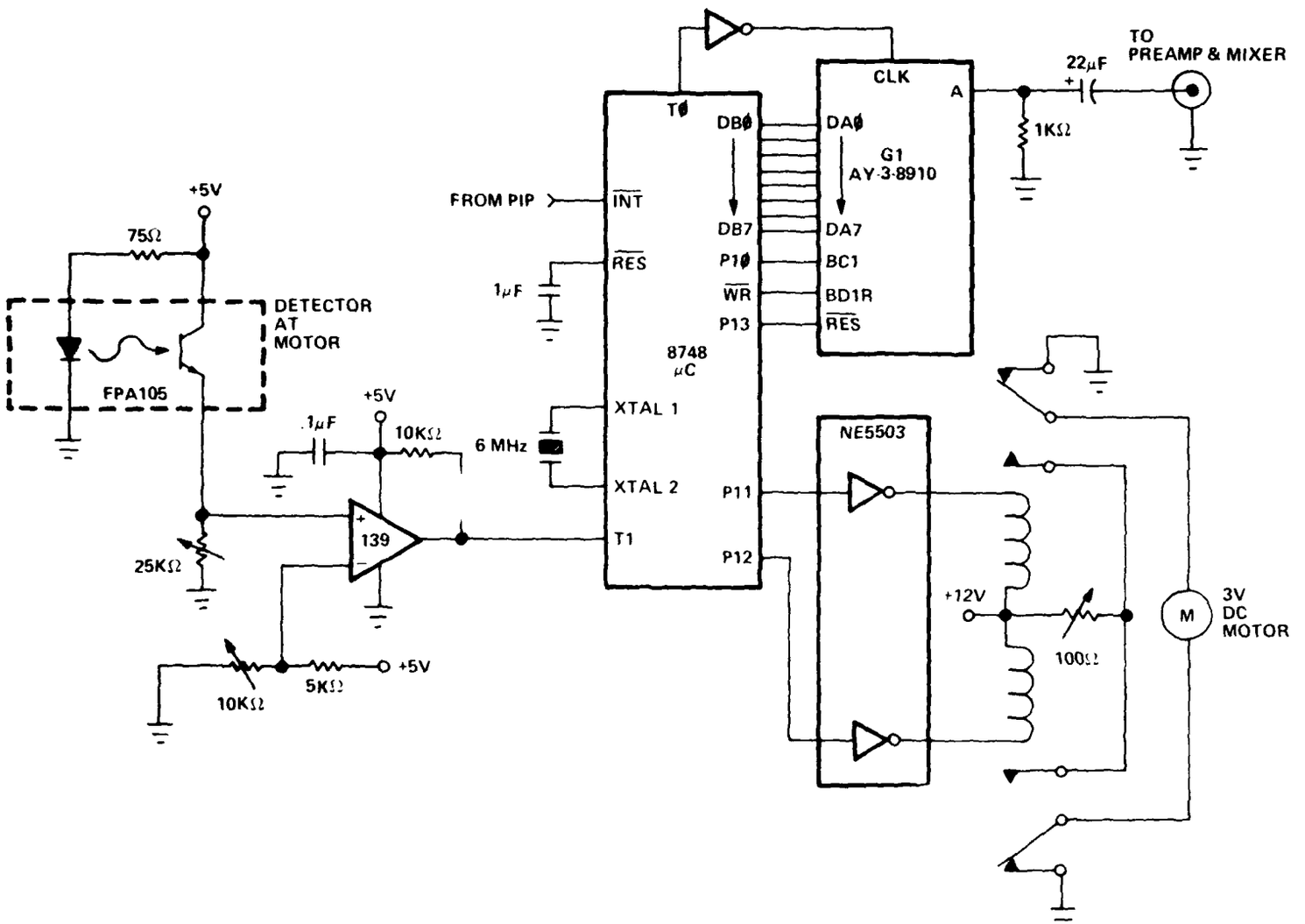


FIGURE III-13 TURRET CONTROLLER

A Superior Electric, Slo-Syn, Synchronous Stepping Motor with 200 steps per revolution was utilized.

The tank turret can be moved by using a software controlled pin on the CY-512. The CY-512 is fed into the circuit shown in Figure III-13. On software command the turret moves 90° toward the trainee and the tank gun fires. It then moves back to dead ahead after a short 2 or 3 second time delay.

F. Weight Loss and Recoil Mechanism

Launch effects of the DRAGON simulator are a very important facet of the training mission. Two of the launch transients which must be overcome by the DRAGON gunner are the weight loss due to the missile leaving the launch tube and the recoil of the launcher due to slight uncompensated differences in the pressures at launch. Weapon launch effects of weight loss and recoil are simulated via mechanical attachments to the DRAGON bipod.

The recoil mechanism is a sliding platten upon which the DRAGON bipod and gunner's feet are supported. The platten is covered with a rubber and steel hybrid material that allows the gunner to firmly plant the bipod legs in position and stabilize the launcher using his boots to press agains the bipod supports. At launch the platten is given an impulse from a pneumatic solenoid thus imparting a sensation of recoil to the launcher.

The weight loss simulation is accomplished by a weight mass that is attached to the bipod via a pivot and pneumatic cylinder. When the DRAGON simulator is armed for launch, the pneumatic cylinder is energized which in turn raises the weight and places an additional equivalent weight of the DRAGON missile on the shoulder of the DRAGON gunner through mechanical leverage. When the simulated missile is launched, the pneumatic cylinder is relaxed, thus releasing the weight and effectively removing the equivalent ROCKET weight from the gunner's shoulder. The recoil and weight loss circuit for driving the pneumatics is shown in Figure III-14.

G. Pull Down Measurement and Reticle Insertion for Gunner Sight Picture Display

Three LED indicator lights are present on the instructor's console to provide the instructor a quantitative indication of how much force a trainee places on the DRAGON tube and his shoulder. When the trainee produces a force on his shoulder equivalent to or greater than a predetermined threshold, the yellow LED comes on. If pull down force is increased beyond a second, higher threshold, a green LED comes on. If neither threshold is reached, a red LED is on. The threshold for the yellow and green LEDs are variable in a range of approximately 50 to 250 pounds force.

A circuit utilizing a strain gauge bridge was developed to generate a signal which is strictly the result of a force at the trainee's shoulder. The strain gauges used are manufactured by Wm. T. Bean, Inc. They are general purpose foil gauges constructed of Constantan with a polymide backing. Two of the strain gauges are strategically located on the DRAGON tube so as to unbalance the bridge only if the trainee has his shoulder properly positioned and is applying a downward force on the sight. The bridge, when unbalanced, supplies a DC level to a two stage DC amplifier. The amplified DC level is the input to two comparators. One comparator activates the yellow light when its threshold is breached while the other controls the green light. The circuit is shown in Figure III-15.

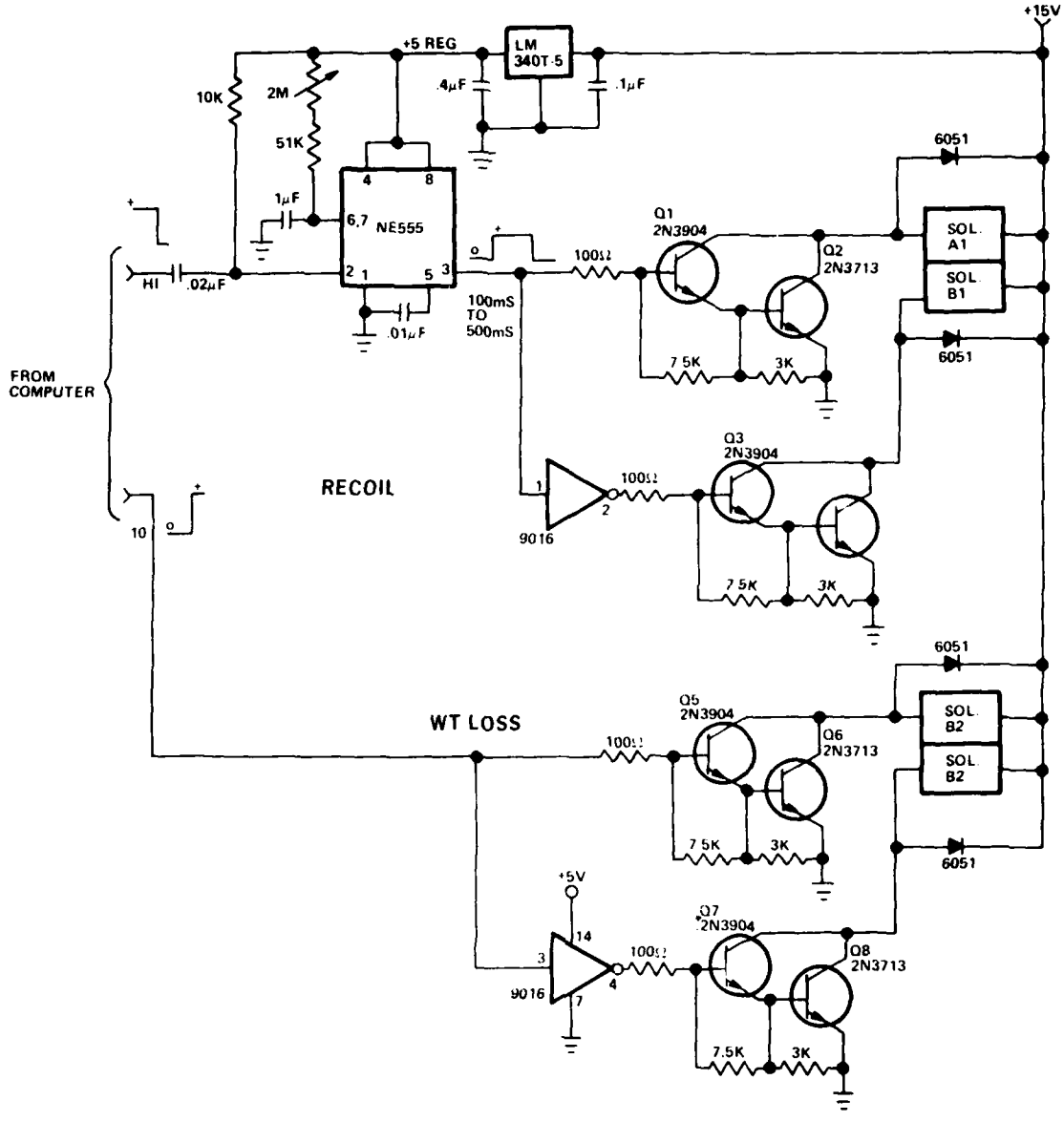


FIGURE III-14 RECOIL AND WEIGHT LOSS CIRCUIT

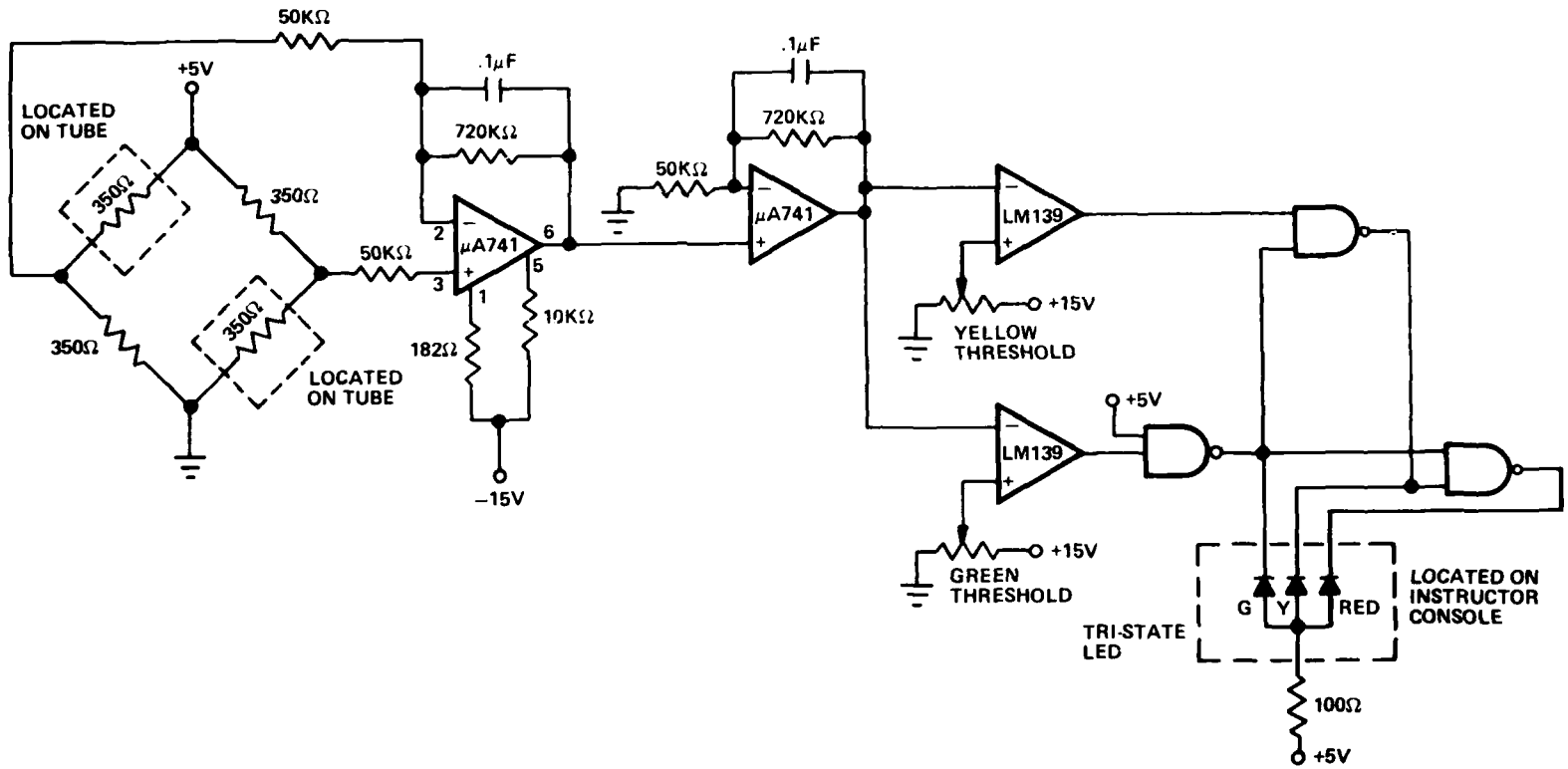


FIGURE III-15 PULL DOWN MEASUREMENT CIRCUIT

In order to provide more realism to the instructor's view of the gunner's sight picture, an electronic reticle was inserted into the instructor's TV monitor. A Cohu sync generator located inside the instructor's console provides drive signals to synchronize all the video signals throughout the system. The vertical and horizontal drive signals provide inputs to the reticle circuit. These signals each pass through a low pass active filter with a cut-off frequency centered at the repetition rate of the drive signal. In this way the square wave drive signals are filtered to provide sine wave outputs of frequency identical to the repetition rate of the inputs. The outputs of the filters input to voltage comparators which generate TTL square waves with falling edges adjustable about the midway times between two drive pulses. These falling edges trigger one shots which generates pulses whose duration determines the width of the retical lines. A horizontal reticle is produced by blanking out one or more lines of video. To insure that an entire line is blanked out and not a portion of it, a flip-flop further conditions the output of the horizontal line one shot. The clock for this flip-flop is provided by the vertical drive pulse which occurs for each line of video. An AND gate combines the output of the flip- flop (horizontal line) and the output of the vertical line one shot. This in turn controls an analog switch. The switch allows video to pass through to the TV, or when activated by the AND gate, sends a negative (black) signal to the TV. The position of the horizontal line is adjusted at the voltage comparator. The level of comparison, as it moves in relation to the sine wave input, controls the position of the falling edge at the output. The position of the vertical line is controlled by a phase shifter at the input of the voltage comparator. The reticle insertion circuit is shown in Figure III-16.

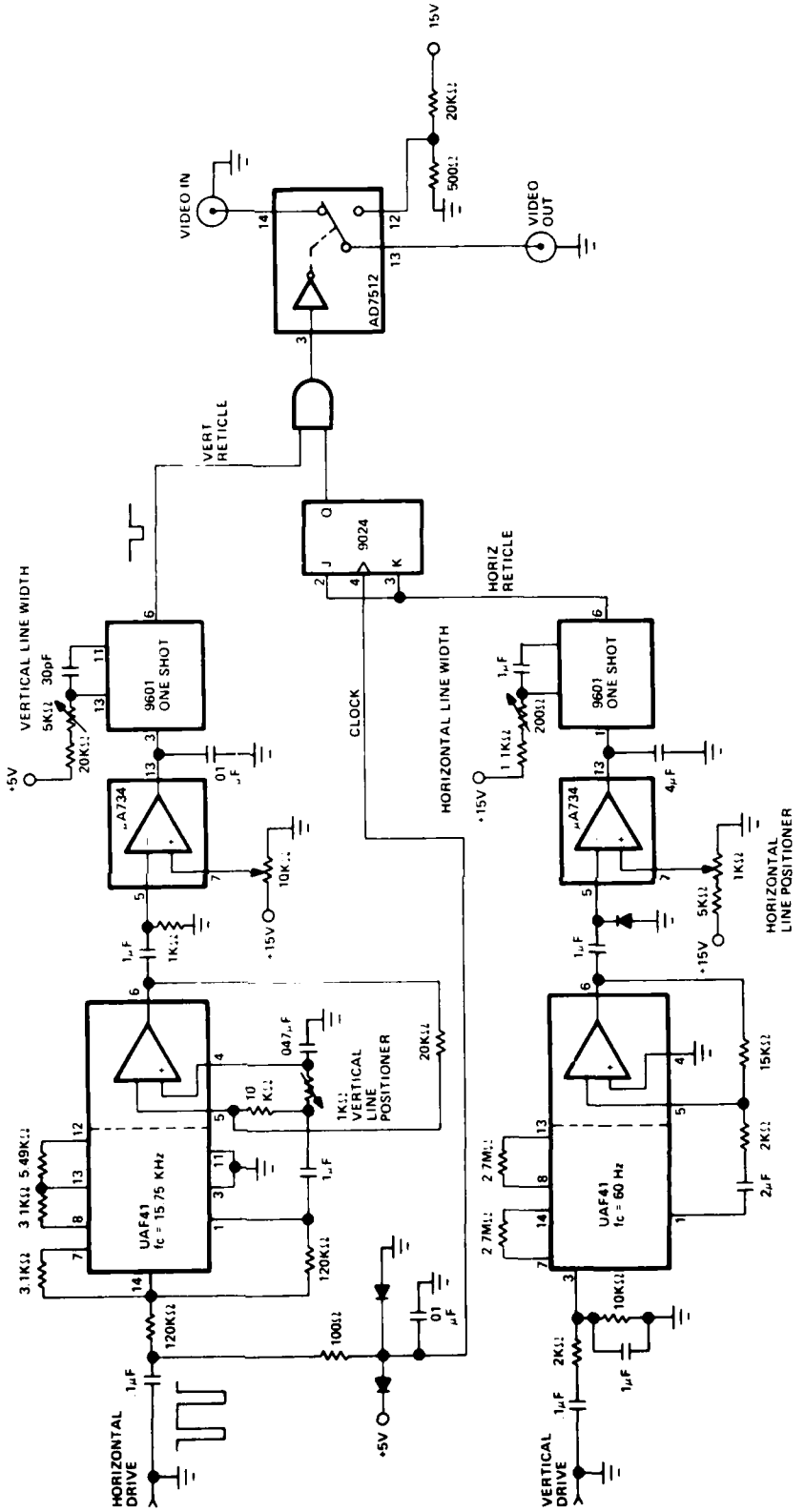


FIGURE III-16 RETICLE INSERTION CIRCUITRY

SECTION IV

CONCLUSIONS

This system has undergone preliminary evaluation by both Army and US Marine Corps experienced DRAGON gunners. All gunners were favorably impressed with its realism and teaching attributes.

The results of testing this device will be included in the final report.

Work is currently under way to include a TOW training capability as part of the STAGS system.

Development has also begun to add a speech synthesizer chip. This chip has a 274 word vocabulary and will be used to coach the student using verbal output.

Work has also started to simulate a thermal sight capability. This work will be covered in the final report.

APPENDIX A

DRAGON FLIGHT SIMULATOR EQUATIONS

The following data was provided by McDonnel Douglas Corporation under Contract N61339-80-M-3518 for use in simulating the DRAGON.

OBJECTIVE

Develop a set of simplified equations that will approximate the Dragon missile in flight when acted upon by the guidance commands as influenced by the gunner's aiming errors.

STUDY APPROACH

The equations currently programmed in the Dragon six degree of freedom simulator were examined and simplified as much as possible while still maintaining a statistically accurate representation of weapon performance. Some of the simplifying assumptions are:

(1) Missile dynamics based on a point mass solution

(2) Small angle approximation are used in the calculation of missile dynamics

(3) Effect of tracker sampling on missile trajectory while in the tracker linear field of view is negligible and is not simulated.

The six degree of freedom equations thus modified were exercised and compared to results from the six degree of freedom simulator. Modification to the thrust level and guidance parameters were made to tailor the trajectory to the more exact six degree of freedom results. Sufficient comparative analysis was conducted to assure that the simplified equations gave acceptable results over a range of crossing and stationary target conditions and with a variety of gunner aiming errors.

PROGRAM DESCRIPTION

At the beginning of each simulated flight, initial missile velocity and position is established in each of 3 orthogonal axes. The reference axes are established by the initial launch line. The target is placed on the launch line with a constant crossing velocity and time is set to zero.

Equations of motion are then solved every 0.02 seconds in each axis using gravity, drag and side thruster accelerations as inputs (see Figure A-1). At the end of each time increment, the new missile position (X, Y, Z) along with gunner aiming error (G1 and G2) and target position (E3) are seen as an angular input (E1, E2) into the tracker (See Figure A-2). The tracker calculates a side thruster firing

angle based on the azimuth error (E1) and a firing frequency based on the elevation error (E2) and the commanded firing angle (W1).

When the tracker commands a firing, the resulting velocity change is resolved into each axis. This in turn changes missile position in a direction to reduce the sensed angular displacements between tracker and missile, thereby closing the guidance loop.

The program listing in BASIC language along with a symbol reference list and symbol descriptions are included.

DISCUSSION AND CONCLUSIONS

The equations presented herein will provide a good approximation of the flight characteristics of Dragon when subjected to the gunner aiming errors used in this analysis.

To interface this Dragon flight model with STAGS, several input parameters from the STAGS are necessary. The input parameters are trigger pull; target speed, direction and range; and gunner aiming error. Trigger pull will be initiated by the gunner using the Dragon training mockup, electrically sensed and transmitted to the Dragon flight simulator. This signal will be used to begin the simulated missile launch and subsequent flight. The target speed, direction, and range information are predetermined values for a given scenario. Target information is used in the Dragon flight simulator to generate system lag characteristics, i.e., the average distance at which the missile flies behind the target center. The STAGS will measure gunner aiming error with respect to a selected aim point on the tank target. This aiming error data is needed in the Dragon simulator to generate guidance error commands.

The sequence of events in a simulated flight begins with actuation of the tracker trigger. Figure A-3 is a time line or sequence of events for the launch phase based on nominal conditions at 70°F. This is an abbreviated time line which includes only those events which are relevant to the weapons trainer. Between trigger pull and gas generator ignition batteries are building up voltage and safe and arm functions are taking place; however, gas generator ignition at 515 milliseconds after trigger pull is important as an indicator of when to apply the simulation of sound pressure level. First motion of the missile in the launch tube begins at 533 milliseconds and could be used to initiate a simulation of weight shift ending at a tube exit time 20 milliseconds later. At tube exit, launch gas (fire and smoke) visible to the gunner is released. From this point the missile is flying ballistically and the missile flare is building up to its operating level. This flare is operating at 735 milliseconds allowing the tracker to recognize missile position relative to its line of sight and guidance corrections are generated in the tracker. At 1003 millisecond the warhead is armed providing an indication of what type of simulation of ground impact should be considered. Prior to this time a ground impact appears as a dud but beyond this time ground impact would cause the warhead to detonate and simulating this situation would be

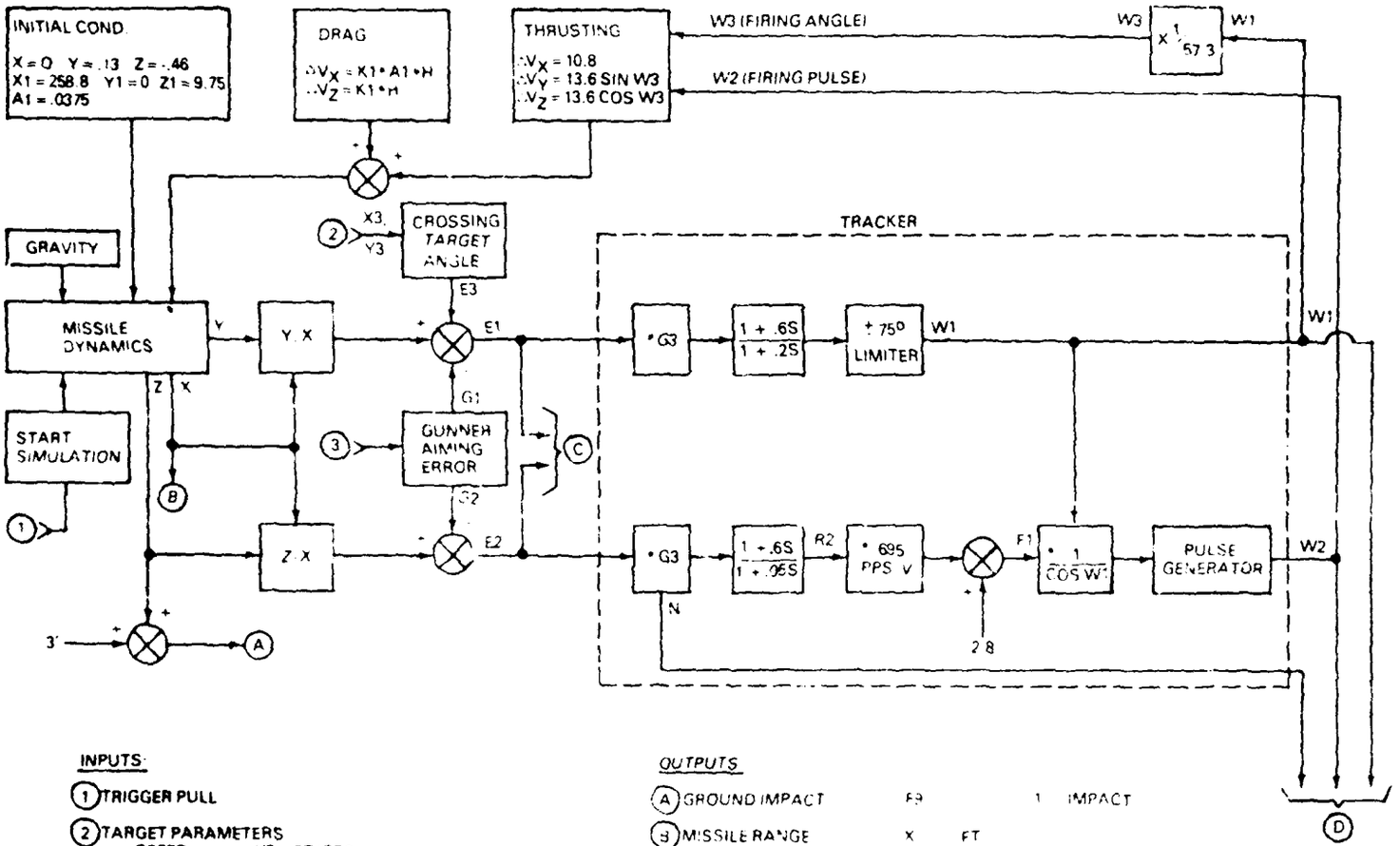


FIGURE A-1 SIMULATION BLOCK DIAGRAM

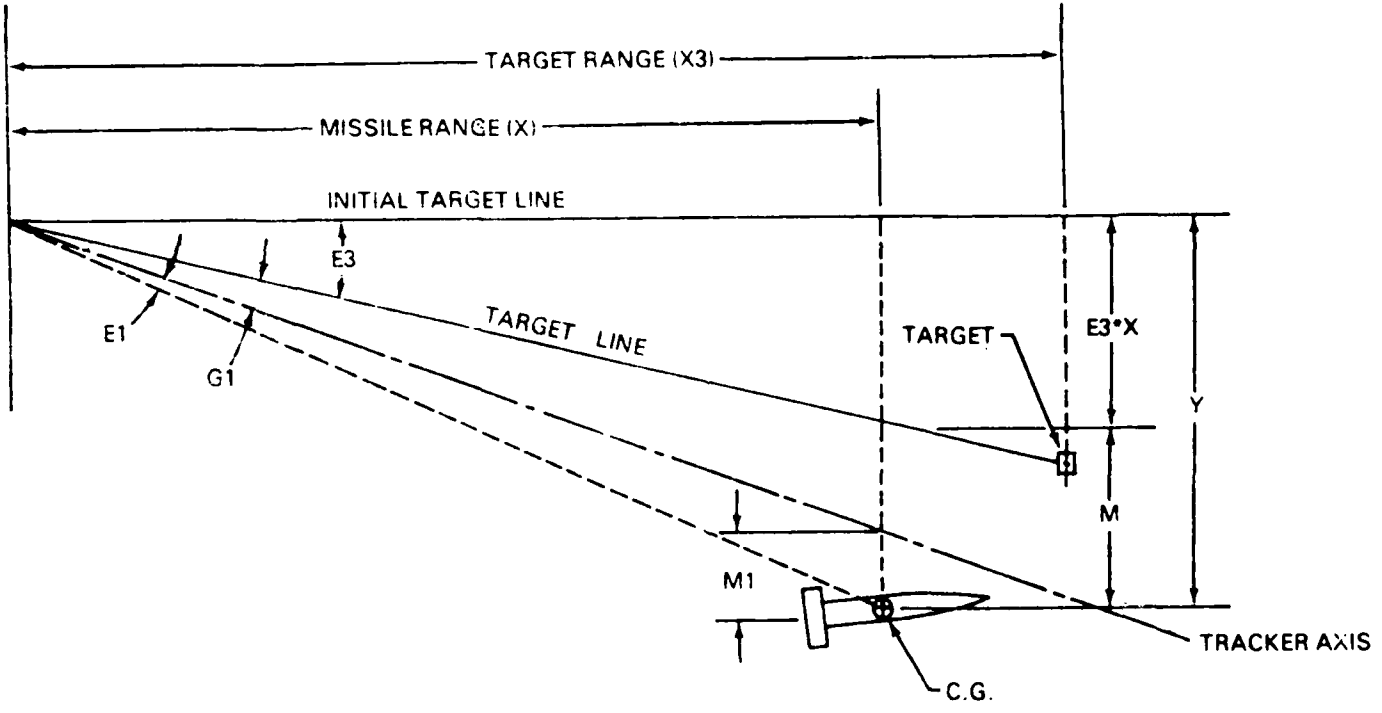


FIGURE A-2 HORIZONTAL PLANE GEOMETRY

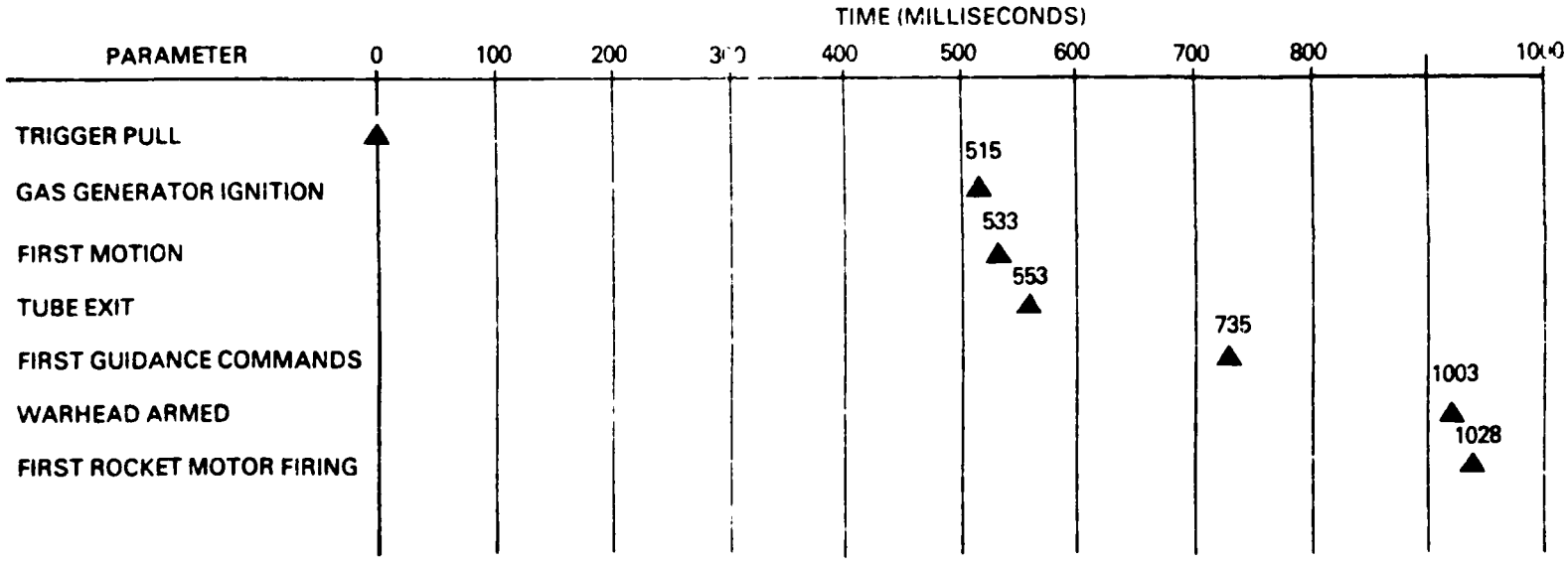


FIGURE A-3 DRAGON LAUNCH SEQUENCE TIME LINE

quite different. The ballistic phase ends with the first rocket motor firing which is commanded automatically at a fixed time of 475 milliseconds from missile first motion. Subsequent to this first firing, the normal closed loop guidance is active in both the horizontal and vertical channels. The Dragon system was designed with a set of limits established for the aiming errors and the trainer may want to incorporate these limits in its scheme of scoring the gunners performance. Figure A-4 is a plot of these limits in both channels for stationary and crossing targets. Another factor that may be considered in modeling the Dragon flight is the influence of the trackers field of view; i.e., missiles' flare image relative to the center of the trackers' IR detector (coincident with gunners line of sight). As this flare image approaches the field of view boundaries guidance performance is degraded and when these boundaries are exceeded guidance is lost and the system goes into a squelch mode. In this mode of operation the tracker commands a constant firing angle and firing rate based on the last guidance information. A more accurate model of tracker performance which includes the field of view effect may be added at a later time but does require significantly more computing than this initial model.

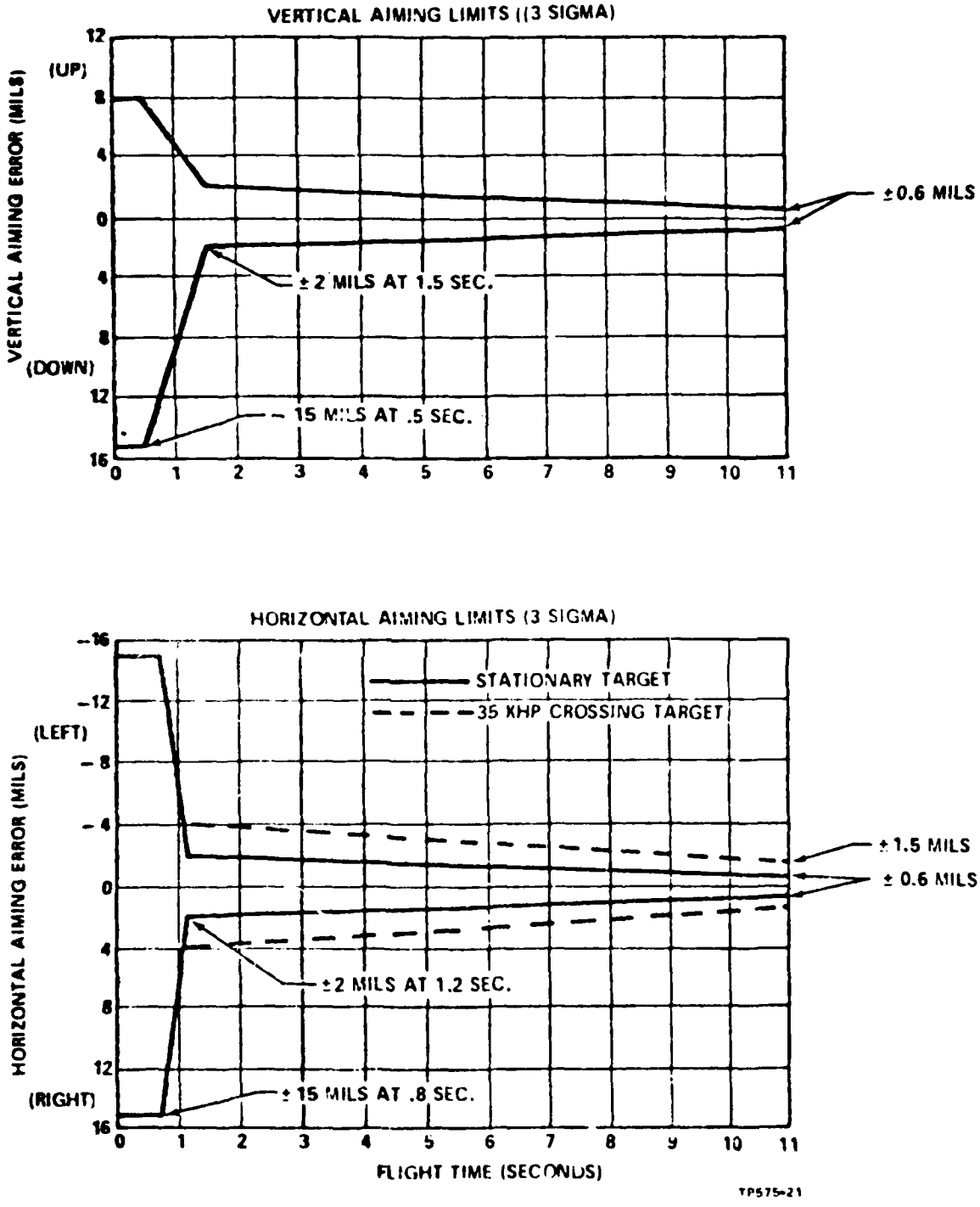


FIGURE A-4 GUNNER ERROR LIMITS

APPENDIX B

MULTI-PROCESSOR MAIN PROGRAMS

```
ISIS-II PL/M-86 V2.1 COMPILATION OF MODULE DRAGONFLIGHTMODULE
OBJECT MODULE PLACED IN  F1 DRAGFL OBJ
COMPILER INVOKED BY:  PLM86  F1 DRAGFL #11 DEBUG ROM IXREF DATE (08/16/10)


  1          DRAGON$FLIGHT$MODULE  DO;

             /*****************************************************************
                                  OFF-BOARD ABSOLUTE ADDRESSES
             *****************************************************************/

  2   1      DECLARE  (RNG_BIRD, ZANG_BIRD) INTEGER AT (0A010H), (BIRD_DT_RDY,
                 FIRE_BIRD, BIRD_HITS, BIRD_MISSES, H_REP_R0, H_REP_G0, V_REP_R0,
                 V_REP_G0, GRND_BIRD, END_REPRISE) BYTE AT (0A014H);

             /********************** END OFF-BOARD ADDRESSES **************************/

      1      DECLARE VELOCITY LITERALLY '34';   /* TARGET VELOCITY
                       IN UNITS OF 0.1 MILLI-RADIANS PER SEC */

  4   1      DECLARE (GOING, ACTION) BYTE, PORT_B LITERALLY '0CAH',
                 DEL_BIG_H INTEGER, BIG_H INTEGER;

  5   1      DECLARE (TCOUNT0, HTARG1, DEL_HTARG, DEL_HMISS, DEL_Y) INTEGER, TCNT WORD AT (0F000H);

  6   1      TARGET_Y: PROCEDURE INTEGER;
  7   2        DECLARE (TCOUNT, TTCOUNT, HTCOUNT, TENS_COUNT) INTEGER;
  8   2        TCOUNT = INT(.NOT.TCNT) - TCOUNT0;
  9   2        TENS_COUNT = TCOUNT MOD 10;
 10   2        HTCOUNT = TCOUNT/100;
 11   2        TTCOUNT = TCOUNT/1000;
 12   2        RETURN (TTCOUNT*267 + (HTCOUNT - TTCOUNT*10)*27 +
                     (TENS_COUNT - HTCOUNT*10)*3);
             /* MODEL MOVES 36 7/8" IN 5240 COUNTS   IT IS 22 FEET FROM TRAINEE
                IT THEREFORE MOVES (36.875/22*12)*10000/5240 = 0.267 (0.1 MRAD/COUNT) */
 13   2        END TARGET_Y;

 14   1      TIME_DELAY: PROCEDURE (HOW_LONG) EXTERNAL;
 15   2        DECLARE HOW_LONG WORD;
 16   2        END TIME_DELAY;

 17   1      DECLARE RESULTS(800) STRUCTURE(S_COUNT INTEGER, S_X INTEGER,
                 S_Y INTEGER, S_Z INTEGER, S_GAEV_I INTEGER, S_GAEZ_I INTEGER,
                 S_S$TCNT INTEGER, S_VMISS INTEGER, S_VOUT INTEGER) AT (2000H),
                 I INTEGER;

 18   1      DECLARE (B_Y, B_Z, DATA_RDY1) BYTE EXTERNAL;
 19   1      DECLARE SAVE_TCNT INTEGER;

 20   1      H_REPRISE: PROCEDURE PUBLIC;
 21   2        SAVE_TCNT = 0;
 22   2        H_REP_R0 = 1;
 23   2        DO WHILE NOT H_REP_G0;
 24   3          END;
 25   2        H_REP_G0 = 0;
 26   2        DO I = 0 TO COUNT - 1;
```

```
                IF RESULTS(I).S_S$TCNT > SAVE_TCNT THEN
                 THRUSTER  DO;
                  FIRE_BIRD = 1;
                  SAVE_TCNT = RESULTS(I).S_S$TCNT;
                 END THRUSTER;
                CALL TIME_DELAY(19);
                B_Y = LOW(.UNSIGN(100 - RESULTS(I).S_GREY_I));
                B_Z = LOW(.UNSIGN(RESULTS(I).S_Y + 100));
                DATA_RDY1 = 1;
                BIRD_DT_RDY = 1;
                 END;
                 END_REPRISE = 1;
                 END M_REPRISE;

V_REPRISE:  PROCEDURE PUBLIC;
 SAVE_TCNT = 0;
 V_REP_RN = 1;
 DO WHILE NOT V_REP_GO;
 END;
V_REP_GO = 0;
 DO I = M TO COUNT - 1;
  IF RESULTS(I).S_S$TCNT > SAVE_TCNT THEN
   THRUSTER  DO;
    FIRE_BIRD = 1;
    SAVE_TCNT = RESULTS(I).S_S$TCNT;
   END THRUSTER;
  CALL TIME_DELAY(3);
  B_Y = LOW(.UNSIGN(100 - RESULTS(I).S_GREZ_I));
  B_Z = LOW(.UNSIGN(RESULTS(I).S_Z + 100));
  DATA_RDY1 = 1;
  BIRD_DT_RDY = 1;
   END;
   END_REPRISE = 1;
 END V_REPRISE;

DECLARE GROUND_DUD  LITERALLY '6',
        GROUND_EXP  LITERALLY '5',
        HIT_TARGET  LITERALLY '3',
        ROCKET_POP  LITERALLY '2';

SOUND:  PROCEDURE(WHAT_KIND) EXTERNAL;
 DECLARE WHAT_KIND BYTE;
 END SOUND;
```

/* THIS VERSION OF "DRAGON" HAS BEEN TESTED AGAINST AN NTEC BASIC-80 PROGRAM. THE BASIC-80 PROGRAM, IN TURN, WAS CHECKED WITH THE MCDONNELL DOUGLAS VERSION OF TYPICAL DRAGON MISSILE FLIGHTS, WITH AND WITHOUT GUNNER ERRORS. NO SIGNIFICANT DIFFERENCES BETWEEN THE VARIOUS PROGRAMS HAVE BEEN FOUND. */

/* THE PROGRAM USES INTEGER MATH EXCLUSIVELY AND REQUIRES 2.12 MILLI-SEC TO EXECUTE EACH PASS THROUGH THE "FLIGHT" LOOP AS DETERMINED USING ICE86. A SOFT-WARE, FLOATING-POINT-MATH VERSION WAS TRIED BUT REQUIRED ABOUT 2 SECONDS PER PASS. THE PROGRAM MUST OPERATE IN REAL TIME TO SIMULATE THE MISSLE PERFORMANCE. TO DO THIS EACH PASS MUST REQUIRE NO MORE THAN 20 M-SECONDS. THEREFORE, THE FLOATING-POINT VERSION WAS ABANDONED.

THE PURPOSE OF THE PROGRAM IS TO PROVIDE DRAGON CROSS-TRACK POSITION DATA

```
                TO THE SMALL "TV" VIEWER IN THE TRAINEE'S SIGHTING DEVICE  THE TV DRIVER
                WILL BE AN A SEPARATE PC BOARD PLUGGED INTO THE MULTIBUS  THIS WILL REQUIRE
                MULTI PROCESSOR OPERATION AND ALL M P  PROTOCAL INCLUDING "MUTUAL EXCLUSION"
                MUST BE OBSERVED  THE REQUIREMENTS THEREFORE, REMAINS TO ESTABLISH A BLOCK
                OF MEMORY THAT CAN BE ACCESSED BY MULTIPLE MASTERS ACROSS THE MULTIBUS AND
                A  SEMAPHORE FLAG MUST BE PROVIDED FOR DATA PROTECTION  */

64   1          DECLARE (GAEV, GAEZ) WORD EXTERNAL, (GAEV_I,GAEZ_I) INTEGER;

65   1          DECLARE (X,Y,Z,VX,VY,VZ,GAMMA,PHI,DEL$VX,DEL$VY,DEL$VZ) INTEGER;

66   1          DECLARE (H$FOV,V$FOV,FIRE) BYTE,
                        (GAIN$FAC,NUTAT,GAIN,REF$VOLT,COUNT) INTEGER;

67   1          DECLARE (HOUT,INT$H,ERR$H,IN$HCOMP) INTEGER;

68   1          DECLARE (VOUT,INT$V,ERR$V,IN$VCOMP) INTEGER;

69   1          DECLARE (HANG,VANG,HMISS,VMISS) INTEGER;

70   1          DECLARE (HTARG,VTARG,XTARG) INTEGER;

71   1          DECLARE FINISHED BYTE PUBLIC, FIRST$FIRE BYTE,
                        (S$TCNT,INT$FF,COS$PHI,F$FREQ) INTEGER;

72   1          DECLARE (H_MISS_HEX,V_MISS_HEX,X_MISS_HEX) INTEGER PUBLIC,
                        (IDEAL_S$TCNT,TARGET_S$TCNT) INTEGER PUBLIC;

73   1          DECLARE (DEL_OFF_H,OFF_H) INTEGER;

74   1          DECLARE SMOOTH(4) INTEGER, II BYTE;

                        /* S$TCNT IS THE NUMBER OF SIDE THRUSTER FIRINGS
                           COS$PHI: UNIT = 0.001
                           F$FREQ : UNIT = 0.001 FIRE/SEC
                           INT$FF : UNIT = 0.001 FIRINGS
                           FINISHED IS THE FLAG FOR A HIT GROUND
                           COUNT : UNIT = 0.02 SECOND
                           GAIN$FAC : UNIT = 0.01 X MCDONNELL BASIC PROGRAM "G" UNIT
                           NUTATE : UNIT = 10^-4 RADIAN
                           GAIN : UNIT = 0.1 VOLT / RADIAN
                           REF$VOLT : UNIT = 0.01 VOLT  */

                        /* H$OUT : UNIT = 0.002 VOLT -- BASIC PROGRAM R1 VALUE
                           INT$H : UNIT = 0.002 VOLT -- BASIC PROGRAM Q1 VALUE
                           GAEV_I : UNIT = 1/2 PIXEL (IS  25 MRAD) -- BASIC PROG  G1/RAD )
                                 LENS FOCAL LENGTH = 125 MM --- SEE DRAGON VAR
                           ERR$H : UNIT = 0.002 VOLT -- BASIC PROGRAM I1 VALUE
                           IN$HCOMP : UNIT = 0.002 VOLT BASIC PROGRAM P1 VALUE
                           V$OUT : UNIT = 0.002 VOLT -- BASIC PROGRAM R2 VALUE
                           INT$V : UNIT = 0.002 VOLT -- BASIC PROGRAM Q2 VALUE
                           GAEZ_I : UNIT = 1/2 PIXEL (IS  25 MRAD) -- BASIC PROG  G2/RAD)
                           ERR$V : UNIT = 0.002 VOLT -- BASIC PROGRAM I2 VALUE
                           IN$VCOMP : UNIT = 0.002 VOLT -- BASIC PROGRAM P2 VALUE
                           HMISS & VMISS = 0.1 MRAD -- G1 + E1 & G2 + E2 ANGLE FROM
                                           MISSILE TO TARGET LINE
                           XTARG  UNIT = 2 INCHES -- NOT IN BASIC
```

```
                HTARG & VTARG, UNIT = 0.1 MRAD  -- BASIC E1 & E2

              * HANG , UNIT 0.1 MILLIRADIAN --- BASIC "E1"
                VANG , UNIT 0.1 MILLIRADIAN --- BASIC "E2"
                   BIG_H ; UNIT 0.1 MIL-PAD/50
                VANG_BIRD, UNIT 0.1 MILLIRADIAN = HANG
                HANG_BIRD, UNIT 0.1 MILLIRADIAN = VANG */

            /* X IN 2 INCHES, VX IN 2 INCHES PER SECOND, Y & Z IN UNITS OF 0.05 INCHES,
              VY & VZ IN UNITS OF 0.20 INCHES PER 10 SECONDS. GAMMA & PHI ARE IN DEGREES */

            /* OFF_H IS THE HORIZONTAL DISTANCE OFF TARGET LINE  UNITS OF 0.05 INCHES */

            /* THIS PROGRAM ASSUMES THAT EVERY CYCLE REQUIRES 0.02 SECONDS.  IT MUST
            BE CORRECTED WHEN WE DETERMINE HOW LONG THE THING TAKES */

            /* ************************************************************
                        PROGRAM VARIABLE INITIALIZATION
               ************************************************************ */
 75   1     INITIATE$VAR:  PROCEDURE PUBLIC;

 76   2         TCOUNT0 = INT(NOT TCNT);     /* TCNT COMES INVERTED FROM CY512 BRD */
 77   2         HTARG1 = 0.      /* HTARG FROM PREVIOUS PASS */
 78   2         X = 0;
 79   2         OFF_H, HMISS = 0;
 80   2         SMOOTH(0), SMOOTH(1), SMOOTH(2), SMOOTH(3) = 0;
 81   2         Y = -110;
 82   2         VX = 1559;
 83   2         VY = 0;
 84   2         VZ = 5850;
 85   2         GAMMA = 2;
 86   2         PHI, HOUT, INT$H, GREY_I, VOUT, INT$V, GREZ_I, HANG, VANG, S$TCNT, INT$FF = 0;
 87   2         HTARG = TARGET_Y;
 88   2         VTARG = 0;
 89   2         XTARG = 19655.       /* THIS WILL CHANGE WITH FILM DATA NOW = 1000 M */

 90   2         IDEAL$TCNT = XTARG/720.   /***** ASSUMES FIXED XTARG **********/

 91   2         FIRE, FINISHED, FIRST$FIRE, BIRD_HITS, BIRD_MISSES, GRND_BIRD = 0;   /* NOTE- TYPE IS ALL BYTE HERE */
 92   2         H_REP_PD, H_REF_GO, V_REP_PD, V_REP_GO, END_REPPISE = 0;
 93   2         DEL_HMISS = 0;
 94   2         I = 0;
 95   2         COUNT = 0;
 96   2       END INITIATE$VAR;

            /************************* PROGRAM STARTS ******************************/

 97   1     FLIGHT:  PROCEDURE PUBLIC;

             ************************************************************************
                                MISSLE PATH SAMPLE
            ************************************************************************ */

 98   1     H_MISS_HEX = (SMOOTH(0)+SMOOTH(1)+SMOOTH(2)+SMOOTH(3))/4;

 99   2     RESULTS(I) = S_COUNT=COUNT;
```

```
100   1     RESULTS(I).S_X=X;
101   1     RESULTS(I).S_Y = H_MISS_HEX;
102   1     IF RESULTS(I).S_Y < -95 THEN RESULTS(I).S_Y = -95;
104   2     IF RESULTS(I).S_Y > 150 THEN RESULTS(I).S_Y = 150;
106   2     RESULTS(I).S_Z = ((X/100)*VMISS)/50;        /* DITTO */
107   2     IF RESULTS(I).S_Z < -95 THEN RESULTS(I).S_Z = -95;
108   2     IF RESULTS(I).S_Z > 150 THEN RESULTS(I).S_Z = 150;
111   2     RESULTS(I).S_GAEY_I=GAEY_I;
112   2     RESULTS(I).S_GAEZ_I=GAEZ_I;
113   2     RESULTS(I).S_S$TCNT=S$TCNT;

114   2     DO II = 0 TO 2;
115   3       SMOOTH(3 - II) = SMOOTH(2 - II);
116   3       END;
117   2     I=I+1

      /*************************************************************************
                                TINY TANK POSITION
      *************************************************************************/


118   2     HTARG = TARGET_Y;
119   2     DEL_HTARG = HTARG - HTARG1;
120   2     HTARG1 = HTARG;          /* SAVE TARGET POSITION TILL NEXT PASS */

121   2     COUNT = COUNT + 1;

      /* *************************************************************************
                                MISSILE  DYNAMICS
      *************************************************************************/

122   2     ZANG_BIRD = VANG;        /* TRANSFER BIRD POSITIONS TO "B_BOARD " */
123   2     VANG_BIRD = HANG;
124   2     BIRD_DT_RDY = 1;

125   2     DEL$VZ = -3*GAMMA - 386;

126   2     IF FIRE = 1 THEN DO
128   3       DEL$VZ = DEL$VZ + 7715 - PHI*PHI;
129   3       CALL SOUND(ROCKET_POP);
130   3       FIRE_BIRD = 1;
131   3       END;

132   2     GAEY_I = SIGNED(GAEY);
133   2     GAEZ_I = SIGNED(GAEZ);

134   2     TARGET_S$TCNT = S$TCNT;
135   2     X_MISS_HEX = X-XTARG;
136   2     IF IABS(X_MISS_HEX) < 25 THEN   /* 20 ==> 3 & 1/3 FT FROM RANGE OF TARGET */
137   2      AT_TARGET   DO;
138   3       IF IDEAL_S$TCNT > TARGET_S$TCNT THEN IDEAL_S$TCNT = TARGET_S$TCNT;
140   3       IF X < 2000H THEN
141   3            V_MISS_HEX = ((X/100)*VMISS)/600;  /* VERT MISS DISTANCE, FT  */
142   3          ELSE V_MISS_HEX = ((X/1000)*VMISS)/60;
143   3       IF  IABS(H_MISS_HEX) < 48 AND IABS(V_MISS_HEX) < 3 THEN  /* IN 8X6 FT RECTANGLE */
144   3          GOOD_SHOT  DO;
145   4            CALL SOUND(HIT_TARGET);
```

```
146   4            BIRD_HITS = 1;
147   4            BIRD_MISSES = 0;
148   4            FINISHED = 1
149   4            END GOOD_SHOT;
150   3          ELSE BAD_SHOT  BIRD_MISSES = 1;
151   2        END AT_TARGET;

152   2      VZ = VZ + DEL$VZ / 2;
153   2      Z = Z + VZ / 125;
154   2      VZ = VZ + DEL$VZ / 2;

155   2      DEL$VX = -Z;
156   2      IF FIRE = 1 THEN DEL$VX = DEL$VX + 62;
158   2      VX = VX + DEL$VX / 2;
159   2      DEL_X = VX/50;
160   2      X = X + DEL_X;
161   2      VX = VX + DEL$VX / 2;

163   2      GAMMA = VZ / (1 + VX*2 );

165   2      IF FIRE = 1 THEN DEL$VY = -((21598-PHI*PHI)/160)*PHI;
165   2         ELSE DEL$VY = 0;
166   2      VY = VY + DEL$VY / 2;
167   2      DEL OFF_H = VY/125 - ((DEL_X/10)*(HMISS/25) - (X/250)*DEL_HTARG;
168   2      OFF_H = OFF_H + DEL_OFF_H;
169   2      SMOOTH(0) = OFF_H/20;
170   2      VY = VY + DEL$VY / 2;
171   2      FIRE = 0;

        /*****************************************************************************
                                    DEFINING ANGLES
        *****************************************************************************/

        /* WE INTRODUCE THE TARGET DATA FOR TARGET MOVEMENT FROM I C  */

173   2      IF COUNT > 5 THEN  /* TO AVOID A "DIVIDE BY ZERO" WHEN CALCULATING "HMISS " */
173   2      ANGLES: DO;
174   3        HMISS = (2*OFF_H)/(X/120);
175   3        VMISS = ((2*Z) /(X/128) - VTARG;
176   3        HANG = HMISS - 5*GAEY_I/2;
177   3        VANG = VMISS - 5*GAEZ_I/2;
178   3         END ANGLES;


        /*****************************************************************************
                            THIS IS THE TRACKER GAIN SECTION
        *****************************************************************************/

179   2      GAIN$FAC = (144 - 2 * COUNT)/10 ;
180   2      IF GAIN$FAC > 140 THEN GAIN$FAC = 140;
181   2      IF GAIN$FAC < 100 THEN GAIN$FAC = 100;
184   2      IF COUNT < 94 THEN NUTAT = 240;     /* WITH 125MM LENS, FOV IS 24 MRAD */
184   2          ELSE NUTAT = ((28595/GAIN$FAC)*100)/COUNT;
187   2      IF COUNT > 47 THEN REF$VOLT = 875;
189   2          ELSE REF$VOLT = 18 * COUNT;
190   2      IF REF$VOLT > 875 THEN REF$VOLT = 875;
192   2      IF COUNT < 46 THEN GAIN = 43 * COUNT;
```

```
194   1          ELSE GAIN = 110 * ( 8750 / NUTAT ).

                 ********************************************************************************
                                    CHECK FOR NUTATION RADIUS EXCEEDED
                 ********************************************************************************/
195   1          H$FOV.V$FOV = 0.
196   2          IF COUNT > 20 THEN
197   2          CHECK$FOV:  DO.
198   3               IF IABS(HANG) > NUTAT THEN H$FOV = 1.
200   3               IF IABS(VANG) > NUTAT THEN V$FOV = 1.
202   3          END CHECK$FOV

                 /********************************************************************************
                              THIS IS THE HORIZONTAL RATE POSITION PORTION
                 ********************************************************************************/

203   2          IF NOT H$FOV THEN
204   2          CALC$H:  DO.
205   3               IF COUNT = 22 THEN IN$HCOMP = ((GAIN/10)*HANG)/20.  /* COUNT=22 <==> TIME= 44 S
                                                                    & FIRST FIRE OCCURS @  474 S */
207   3                    ELSE IN$HCOMP = (GAIN/200)*HANG.
208   3               END CALC$H
209   2            ELSE IN$HCOMP = (REF$VOLT/5)*HANG/IABS(HANG).

210   2          ERR$H = IN$HCOMP - HOUT.
211   2          HOUT = INT$H/10 + 3*IN$HCOMP.
212   2          INT$H = INT$H + ERR$H.

                 /********************************************************************************
                                          HORIZONTAL WIRE
                 ********************************************************************************/

213   2          PHI = HOUT/50.
214   2          IF PHI < -75 THEN PHI = -75.
215   2          IF PHI > 75 THEN PHI = 75.

                 /********************************************************************************
                              THIS IS THE VERTICAL RATE POSITION PORTION
                 ********************************************************************************/

216   2          IF NOT V$FOV THEN
217   2          CALC$V:  DO.
220   3               IF COUNT < 22 THEN IN$VCOMP = ((GAIN/10)*VANG)/20.
222   4                    ELSE IN$VCOMP = (GAIN/200)*VANG.
227   3               END CALC$V.
224   2            ELSE IN$VCOMP = (REF$VOLT/5)*VANG/IABS(VANG).

225   2          ERR$V = IN$VCOMP - VOUT.
226   2          VOUT = INT$V/5 + 9*IN$VCOMP.
227   2          INT$V = INT$V + ERR$V.

228   2          ERR$V = IN$VCOMP - VOUT.  /* HERE WE TAKE INTEGRATION @ 1/2 OF "COUNT" TWICE */
229   2          VOUT = INT$V/5 + 9*IN$VCOMP.
230   2          INT$V = INT$V + ERR$V.

                 /********************************************************************************
                                          FIRE PULSE GENERATION
```

```
                ************************************************************************/

 231    .       F$FREQ = (140H0 - 7*VOUT) / 5.
 232    1       COS$PHI = 945 - (PHI*PHI) / 7.

 233    2       IF COUNT = 24 THEN
 234    2       FIRST$SHOT  DO.
 235    3         FIRE = 1
 236    3         S$TCNT = 1.
 237    3         INT$FF = 0.
 238    3         FIRST$FIRE = 1.
 239    3         END FIRST$SHOT.

 240    2       IF FIRST$FIRE THEN
 241    2       CANFIRE  DO.
 242    3          IF S$TCNT < 30 THEN
 243    3       SOME$LEFT  DO.
 244    4             IF INT$FF > COS$PHI THEN
 245    4       FIRE$ONE  DO.
 246    5                INT$FF = 0
 247    5                FIRE = 1.
 248    5             S$TCNT = S$TCNT + 1.
 249    5             END FIRE$ONE.
 250    4              INT$FF = INT$FF + F$FREQ / 50.
 251    4              END SOME$LEFT
 252    3           END CANFIRE.

 253    2       IF Z < -720 THEN
 254    2       GROUNDED  DO.
 255    3         FINISHED, GRND_BIP = 1.
 256    3         IF COUNT > 25 THEN CALL SOUND (GROUND_EXP),
 257                ELSE CALL SOUND (GROUND_DUD),
 258    3           END GROUNDED.

 259    1       END FLIGHT.

 260    1       END DRAGON$FLIGHT$MODULE.



MODULE INFORMATION

     CODE AREA SIZE     = 0AD3H   2771D
     CONSTANT AREA SIZE = 0000H      0D
     VARIABLE AREA SIZE = 0082H    130D
     MAXIMUM STACK SIZE = 0008H      8D
     430 LINES READ
     0 PROGRAM ERROR(S)

END OF PL/M-86 COMPILATION
```

```
ISIS-II MCS-86 MACRO ASSEMBLER V2.1 ASSEMBLY OF MODULE IR_CENTER
OBJECT MODULE PLACED IN :F1:DRAGIR.OBJ
ASSEMBLER INVOKED BY:  ASM86 :F1:DRAGIR.001 DEBUG DATE(02/24/09)


LOC  OBJ                  LINE     SOURCE

                             1     NAME    IR_CENTER
                             2
                             3     ;THIS IS A DRIVER PROGRAM FOR THE PETICON 6020 USING THE 86/12 BOARD
                             4     ;IT IS BEING UPDATED 9/23/81
                             5
                             6     DGROUP  GROUP   DATA, STACK, SBC_DEGS, XFER_SEG
                             7     CGROUP  GROUP   CODE
                             8
                             9     ASSUME  SS:DGROUP, CS:CGROUP, DS:DGROUP, ES:DGROUP
                            10
----                        11     STACK   SEGMENT STACK  'STACK'
0000 (64                    12             DW      64 DUP(?)
     ????
     )

0080                        13     TOP_STK LABEL   WORD
----                        14     STACK   ENDS
                            15
                            16     ;THIS PROGRAM WILL RESIDE ON THE SBC "DFS"  IT WILL WRITE Y, Z(CENTER)
                            17     ;DATA TO THE SBC "PIP" VIA THE MULTIBUS  THE "PIP" HAS BEEN "JUMPERED"
                            18     ;SO AS TO ALLOW THE MULTIBUS TO ACCESS 8K OF ITS RAM STARTING AT LOCATION
                            19     ;A000H. THE "DFS" JUMPERS ALLOW MULTIBUS ACCESS TO 8K OF RAM STARTING
                            20     ;AT 8000H. THE ON-BOARD LOCATION OF THESE AVAILABLE 8K-S START AT 6000H
                            21     ;ON BOTH BOARDS. THE BOARDS (REF FIG 2-1 86/12) ARE JUMPERED AS FOLLOWS:
                            22     ;
                            23     ;  SBC DFS JUMPERS MULTIBUS ACCESS    SBC PIP JUMPERS MULTIBUS ACCESS
                            24     ;    ------------------------          ------------------------
                            25     ;       127-128 ==> X = 0                  127-128 ==> X = 0
                            26     ;    S1 6-11 CLOSED                     S1 6-11 CLOSED
                            27     ;    S1 5-12   "    ==> 8K              S1 5-12   "    ==> 8K
                            28     ;    S1 1-16   "                        S1 1-16   "
                            29     ;    S1 2-15 OPEN                       S1 2-15 OPEN
                            30     ;    S1 3-14 CLOSED                     S1 3-14 CLOSED
                            31     ;    S1 4-13   "    ==> 8000H           S1 4-13 OPEN  ==> A000H
                            32     ;
                            33     ;
----                        34     XFER_SEG        SEGMENT AT 0A00H        ;ON SBC "PIP" AS NOTED ABOVE
                            35                                             ;WILL PASS DATA FOR YCNTR,ZCNTR
                            36     ;IF THE "DFS" IS THE DATA "SUPPLIER" AND THE "PIP" IS THE "USER "
                            37
0000 (1                     38     START_BIT       DB      1 DUP(?)
     )

                            39             PUBLIC  B_Y,B_Z,DATA_RDY1
0001 (1                     40     B_Y             DB      1 DUP(?)
     )

0002 (1                     41     B_Z             DB      1 DUP(?)
     )

0003 (1                     42     DATA_RDY1       DB      1 DUP(?)
```

```
LOC  OBJ                  LINE    SOURCE

                          42
0031 ??                   43      BAD_MISS        DB      1 DUP(?)

0032 ??                   44      OFFSET_Y        DB      1 DUP(?)

0033 ??                   45      OFFSET_Z        DB      1 DUP(?)

                          46      XFER_SEG        ENDS
                          47
                          48      SBC_REGS        SEGMENT COMMON
0000 [                    49      SBCREG  DB      800 DUP(?)
     ??
     ]

0320 ??                   50      MISS    DB      1 DUP(?)                THE FOLLOWING 6 BYTES ARE NAMED "PARTLY_OFF"
                                    IN RT86XF

                          51
0321 ??                   52      RIGHT   DB      1 DUP(?)

0322 ??                   53      LEFT    DB      1 DUP(?)

0323 ??                   54      UP      DB      1 DUP(?)

0324 ??                   55      DOWN    DB      1 DUP(?)

0325 ??                   56              DB      1 DUP(?)        ;DUMMY BYTE TO MAKE 3 WORDS OF "PARTLY_OFF" IN RT86XF

0326 ??                   57      YCNTR   DB      1 DUP(?)        ;THE FOLLOWING 6 BYTES ARE IN "LOCATIONS" IN RT86XF

0327 ??                   58      ZCNTR   DB      1 DUP(?)

0328 ??                   59      YMAX    DB      1 DUP(?)

0329 ??                   60      YMIN    DB      1 DUP(?)

032A ??                   61      ZMAX    DB      1 DUP(?)

032B ??                   62      ZMIN    DB      1 DUP(?)
```

```
                        LINE    SOURCE

                          53
                          54            PUBLIC  GREY,GREZ
                          55    GREY    DW      1 DUP(?)

                          56    GREZ    DW      1 DUP(?)

                          57
                          58    PUBLIC  GREY,GREZ
                          59
----                      60    SRC_REGS        ENDS
                          61
                          62
                          63    EXTRN   PD_RAST  NEAR
  0064                    64    SIZ     EQU     64H
----                      65    CODE    SEGMENT PUBLIC  'CODE'
                          66
                          67            PUBLIC  SETRET
0000                      68    SETRET  PROC    NEAR
                          69            EXTRN   INIT1   NEAR
0000 55                   70            PUSH    BP
0001 1E                   71            PUSH    DS
0002 B8----         R     72            MOV     AX,DGROUP
0005 8ED8                 73            MOV     DS,AX
0007 8EC0                 74            MOV     ES,AX
0009 E80000         E     75            CALL    INIT1
000C A00000         R     76    WAIT0:  MOV     AL,START_BIT  ;THIS WAIT LOOP HOLDS UP RETICON DATA UNTIL
                          77                                  ; THE RETRO GRAPHICS BOARD IS SET UP AND THE
                          78                                  ; MATROX BOARD IS READY AND WAITING
000F  3C01                79            CMP     AL,1
0011 75F9                 80            JNE     WAIT0
0013 1F                   81            POP     DS
0014 5D                   82            POP     BP
0015 C3                   83            RET
                          84    SETRET  ENDP
                          85
                          86            PUBLIC  VZCNTR
0016                      87    VZCNTR  PROC    NEAR
0016 55                   88            PUSH    BP
0017 1E                   89            PUSH    DS
0018 B8----         R     90            MOV     AX,DGROUP
001B 8ED8                 91            MOV     DS,AX
001D 8EC0                 92            MOV     ES,AX
001F E80000         E     93            CALL    PD_RAST
                          94
                          95    ;WE NOW LOOK FOR THOSE TRANSITIONS WHICH CAN BE ASSOCIATED WITH A SINGLE
                          96    ;BRIGHT SPOT ON THE RETICON CAMERA 100X100 FIELD OF VIEW  THE SPOT WILL BE
                          97    ;LOCATED AT THE CENTER OF THE TARGET  THE RETICON CAMERA WILL BE MOUNTED ON
                          98    ;THE CENTER LINE OF THE SIMULATED WEAPON SO THAT THE OFFSET OF THE SPOT FROM
                          99    ;THE CENTER OF THE 100X100 FIELD OF VIEW WILL MEASURE THE LEAD AND ELEVATION
                         100    ;OF THE WEAPON AT TRIGGER TIME  A SAMPLE RETICON DATA LINE CONTAINING A
                         101    ;SINGLE BRIGHT SPOT IS
                         102    ;
                         103    ;       DT 0,0,1C,6H,1E,E0,64,50
```

```
[illegible] OPJ                 ;INF    SOURCE

                                114
                                115     ;THIS INDICATES THREE TRANSITIONS IN THE LINE BUT ONLY THE FIRST TWO ARE
                                116     ;SIGNIFICANT.  AT 1CH THERE IS A DARK-TO-LIGHT TRANSITION, AS INDICATED BY THE
                                117     ;HIGHEST ORDER BIT (HOB) = 0 IN DATA BYTE #3 (60).  THE FOLLOWING TRANSITION
                                118     ;IS AT 1EH AND IS A LIGHT-TO-DARK, AS INDICATED BY HOB=1 IN THE FOLLOWING
                                119     ;BYTE #5 (E0).  EVERY LINE HAS A FORCED TRANSITION AT THE END-OF-LINE.
                                120     ;LOCATION 64H=100D.  THE PROGRAM STARTS FROM LINE #0 LOOKING FOR 03 AS THE
                                121     ;INITIAL DATA BYTE.  IF 03 IS NOT FOUND, THE NEXT LINE IS EXAMINED.  THIS IS
                                122     ;CONTINUED UNTIL 100 LINES HAVE BEEN EXAMINED FOR THE PROPER NUMBER OF
                                123     ;TRANSITIONS
                                124
                                125     ;RESISTER USAGE IN "CENTER"
                                126     ;       (AL) = NUMBER OF TRANSITIONS IN DATA LINE
                                127     ;       (AH) = BYTES TO ADD TO DATA LINE POINTER
                                128     ;       (BX) = DATA LINE POINTER.  POINTS TO START OF DATA LINE IN "SBCREG"
                                129     ;       (CL) = LINE NUMBER
                                130     ;       (CH) = 64H = 100 ==> THE LAST DATA LINE
                                131
[illegible] B901[illegible]     132     CENTER  MOV     CX,6501H        ;(CH)=65H-1 + LAST LINE  (CL)=1 --> FIRST LINE
[illegible] BBFEFF              133             MOV     BX,-2           ;INITIAL VALUE OF DATA LINE POINTER
[illegible] B402                134             MOV     AH,2            ;INITIAL DATA LINE POINTER INCREMENT
[illegible] C606[illegible]364  R   135             MOV     YMIN,SIZ        ;SET INITIAL VALUE AT 64H
[illegible] C606[illegible]364  R   136             MOV     ZMIN,SIZ        ;DITTO FOR ZMIN
[illegible] C606[illegible]01   R   137             MOV     YMAX,1
[illegible] C606[illegible]01   R   138             MOV     ZMAX,1
                                139
003E 3AE9                       140     DUMP    CMP     CH,CL           ;HAVE WE FINISHED WITH LAST LINE?
0040 7503                       141             JNE     OVER            ;NEED "OVER" BECAUSE CONDITIONAL JUMPS MUST BE
                                142                                     ;LESS THAN +127 BYTES AWAY
0042 E8E90                      143             JMP     DONE
0045 02C4                       144     OVER    ADD     BL,AH           ;UPDATE DATA LINE POINTER.  NOW BECAUSE WE CANNOT
0047 80D700                     145             ADC     BH,0            ;ADD A SINGLE BYTE TO BX, WE DO IT IN TWO STEPS
                                146                                     ;USING THE CARRY FLAG, "CY".  N.B.  (BX)=0 ON
                                147                                     ;THE FIRST PASS THROUGH "DUMP."
                                148
004A 8A870000           R       149             MOV     AL,SBCREG[BX]   ;FIRST DATA BYTE ==> TRANSITIONS IN DATA LINE
                                150
004E 8AE0                       151             MOV     AH,AL           ;WILL FORM DATA LINE POINTER INCREMENT IN AH
0050 FEC4                       152             INC     AH
0052 D0E4                       153             SHL     AH,1            ;(AH)=2(AL+1), THE DATA LINE POINTER INCREMENT
                                154
0054 8A870200           R       155             MOV     AL,SBCREG[BX+2]
0058 3C04                       156             CMP     AL,SIZ
005A 7405                       157             JE      SKIP            ;IF NO SPOT, THEN GO TO NEXT DATA LINE
005C E80A00                     158             CALL    GOODLN          ;WILL UPDATE SPOT INFORMATION
005F EBDC                       159             JMP     DUMP            ;GO TO NEXT DATA LINE
                                160
0061 3ACD                       161     SKIP    CMP     CL,CH           ;THE LAST LINE?
0063 7440                       162             JZ      DONE            ;YES! SO WE JUMP TO THE FINAL CLEAN-UP
0065 FEC1                       163             INC     CL              ;NO! SO WE RETURN TO "DUMP" AND
0067 EBD5                       164             JMP     DUMP            ;EXAMINE THE NEXT LINE
                                165
0069 80BF00[illegible]02        R   166     GOODLN  CMP     SBCREG[BX],2    ;ONLY TWO TRANSITIONS?
006E 7419                       167             JE      TWOX            ;IF SO, SPOT IS ON RIGHT EDGE
0070 3A06290[illegible]         R   168             CMP     AL,YMIN         ;IF NOT, GET NORMAL CENTER.  RECALL THAT
```

```
LOC  OBJ                  LINE     SOURCE

                          169                                  ;AL CONTAINS SBCREG[BX+2]
0074  77                 170              JA      N1           ;JUMP IF (AL) IS ABOVE YMIN, IE. CY FLAG = 0
                          171
                          172    ;RECALL THAT A CMP OPERATION SUBTRACTS THE SOURCE OR 2ND OPERAND FROM THE
                          173    ;DESTINATION OR 1ST OPERAND  IT DOES THIS BY ADDING THE TWOS COMPLEMENT OF THE
                          174    ;SOURCE OPERAND TO THE DESTINATION OPERAND AND A CARRY-OUT FROM THE HIGH ORDER
                          175    ;BIT CAUSES THE CY FLAG TO SET TO 0. BECAUSE OF THE SUBTRACTION OPERATION
                          176    ;AT LEAST THIS IS WHAT THE 8080 DOES. AND THIS FLAG IS THE SAME. IN THE 8086
                          177    ;THEY SAY THAT AFTER A SUBTRACT OPERATION "CY" IS SET UPON A CARRY INTO(?)
                          178    ;THE HOB OF THE RESULT!
                          179
0076 A2?903          R    180              MOV     YMIN,AL      ;IF NO JUMP THEN UPDATE VALUE OF YMIN
0079 8A870400        R    181    N1        MOV     AL,SBCREG[BX+4] ;RIGHT EDGE OF SPOT
007D 3A062803        R    182              CMP     AL,YMAX
0081 7218                 183              JB      N4           ;JUMP IF (AL) IS BELOW YMAX, OR CY = 1
0083 A22803          R    184              MOV     YMAX,AL      ;IF NO JUMP THEN UPDATE YMAX
0086 EB1190               185              JMP     N4           ;JUMP AROUND "TWOX"
0089 C6062803?4      R    186    TWOX      MOV     YMAX,64H     ;WILL BE ON RIGHT EDGE
008E 8A870200        R    187              MOV     AL,SBCREG[BX+2]
0092 3A062903        R    188              CMP     AL,YMIN
0096 7701                 189              JA      N4
0098 A22901               190              MOV     YMIN,AL
009B 3A0E2A03        R    191    N4        CMP     CL,ZMAX      ;AT THIS POINT Z IS MEASURED DOWNWARD
009F 7204                 192              JB      N3           ;AND WE MUST COMPLEMENT Z AT END
00A1 880E2A03        R    193              MOV     ZMAX,CL      ;UPDATE ZMAX
00A5 3A0E2B03        R    194    N3        CMP     CL,ZMIN
00A9 7704                 195              JA      N9
00AB 880E2B03        R    196              MOV     ZMIN,CL      ;UPDATE ZMIN
00AF FEC1                 197    N9        INC     CL
00B1 C3                   198              RET
                          199
00B2 C606200000      R    200    DONE      MOV     MISS,0
00B7 803E2B0364      R    201              CMP     ZMIN,64H
00BC 7504                 202              JNE     N5
00BE C6062A0301      R    203              MOV     MISS,1       ;ZMIN = 64H ==> NO SPOT. SO SHOT WAS A MISS!
00C3 C606040001      R    204              MOV     BAD_MISS,1   ;WE ARE "REALLY FINISHED"
00C8 EB7E90               205              JMP     READ
00CB 803E2B0301      R    206    N5        CMP     ZMIN,1
00D0 7505                 207              JNE     N6
00D2 C606230301      R    208              MOV     UP,1         ;SPOT INCLUDED FIRST LINE ==> SHOT WAS HIGH!
00D7 803E2A0364      R    209    N6        CMP     ZMAX,64H
00DC 7505                 210              JNE     N7
00DE C606240301      R    211              MOV     DOWN,1       ;SPOT INCLUDED LAST LINE ==> SHOT WAS LOW
00E3 803E290301      R    212    N7        CMP     YMIN,1
00E8 7505                 213              JNE     N8
00EA C606220101      R    214              MOV     LEFT,1
00EF 803E280364      R    215    N8        CMP     YMAX,64H
00F4 7505                 216              JNE     FINI
00F6 C606210101      R    217              MOV     RIGHT,1
                          218
00FB B065                 219    FINI      MOV     AL,65H
00FD 2A062A00        R    220              SUB     AL,ZMAX
0101 B465                 221              MOV     AH,65H
0103 2A262B03        R    222              SUB     AH,ZMIN
0107 A22B03          R    223              MOV     ZMIN,AL
```

```
LOC  OBJ                  LINE     SOURCE

010A 88262A03       R      224              MOV     ZMAX,AH
010E A02803         R      225              MOV     AL,YMAX
0111 02062903       R      226              ADD     AL,YMIN
0115 8A1E0500       R      227              MOV     BL,OFFSET_Y     ;HORIZONTAL BORESIGHT OFFSET
0119 02C3                  228              ADD     AL,BL
011B A22603         R      229              MOV     YCNTR,AL        ;YCNTR IN HALF-PIXELS FROM LEFT SIDE OF SCREEN
011E A20100         R      230              MOV     B_Y,AL
0121 B464                  231              MOV     AH,100
0123 2AE0                  232              SUB     AH,AL
0125 8AC4                  233              MOV     AL,AH
0127 98                    234              CBW
0128 A32C03         R      235              MOV     GAEY,AX         ;GAEY +IVE TO THE RIGHT  CAMERA INVERTS
012B A02A03         R      236              MOV     AL,ZMAX
012E 02062B03       R      237              ADD     AL,ZMIN
0132 8A1E0600       R      238              MOV     BL,OFFSET_Z
0136 02C3                  239              ADD     AL,BL
0138 A22703         R      240              MOV     ZCNTR,AL        ;ZCNTR IN HALF-PIXELS FROM BOTTOM OF SCREEN
013B A20200         R      241              MOV     B_Z,AL
013E B464                  242              MOV     AH,100
0140 2AE0                  243              SUB     AH,AL
0142 8AC4                  244              MOV     AL,AH
0144 98                    245              CBW
0145 A32E03         R      246              MOV     GAEZ,AX         ;GAEZ +IVE IF HIGH  REF. MCDONNEL-DOUGLAS
0148 B001                  247     READ     MOV     AL,1
014A A20300         R      248              MOV     DATA_RDY1,AL    ;THIS TELLS THE SLAVE PROCESSOR THAT NEW
                           249                                      ;DATA ARE READY.
014D 1F                    250              POP     DS
014E 5D                    251              POP     BP
014F C3                    252              RET
                           253
                           254     YZCNTR   ENDP
                           255
----                       256     CODE     ENDS
                           257
                           258              END

ASSEMBLY COMPLETE, NO ERRORS FOUND
```

ISIS-II PL/M-86 V2.1 COMPILATION OF MODULE MAIN_DRAGON_MODULE
OBJECT MODULE PLACED IN :F1:DRAGMN.OBJ
COMPILER INVOKED BY: PLM86 F1:DRAGMN.PLM DEBUG ROM IXREF DATE(10/01/10)

```
   1          MAIN_DRAGON_MODULE: DO;

              /*****************************************************************************
                                    OFF-BOARD ABSOLUTE ADDRESSES
              *****************************************************************************/

   2  1       DECLARE (H_MIS_ASCII,V_MIS_ASCII,X_MIS_ASCII) (16) BYTE AT (0A020H),
                     FEL_SHORT BYTE AT (0A01EH);

              /*********************** END OFF-BOARD ABSOLUTE ADDRESSES ******************/

   3  1       DECLARE (H_MISS_HEX,V_MISS_HEX,X_MISS_HEX) INTEGER EXTERNAL, I BYTE;

   4  1       SHOW_THRUSTERS: PROCEDURE EXTERNAL;
   5  2         END SHOW_THRUSTERS;

   6  1       MISS_COMMENT: PROCEDURE(HEX$ADR, DEC$ADR, DIRECTION) EXTERNAL;
   7  2           DECLARE (HEX$ADR, DEC$ADR) POINTER, DIRECTION BYTE;
   8  2        END MISS_COMMENT;

   9  1       DECLARE RT LITERALLY '0', LT LITERALLY '1',
                     UP LITERALLY '2', DN LITERALLY '3',
                     SH LITERALLY '4';

  10  1       DECLARE FOREVER LITERALLY 'WHILE 1', NO_TRIG_PUL LITERALLY
                   'INPUT(PORT_B) AND 1', ACTION BYTE;

  11  1       V_REPRISE: PROCEDURE EXTERNAL;
  12  2         END V_REPRISE;

  13  1       H_REPRISE: PROCEDURE EXTERNAL;
  14  2         END H_REPRISE;

  15  1       TIME_DELAY: PROCEDURE (HOW_LONG) EXTERNAL;
  16             DECLARE HOW_LONG WORD;
  17           END TIME_DELAY;

  18  1       SETRET: PROCEDURE EXTERNAL;
  19  2         END SETRET;

  20  1       SOUND: PROCEDURE(KIND) EXTERNAL;
  21  2         DECLARE KIND BYTE;
  22  2         END SOUND;

  23  1       DECLARE INITIAL_BANG LITERALLY '7', GYRO_START LITERALLY '1';

  24  1       DECLARE ARM LITERALLY '2', DISARM LITERALLY '3',
                     DROP LITERALLY '4', NO_DROP LITERALLY '5',
                     FINISHED BYTE EXTERNAL;

  25  1       DECLARE PORT_A LITERALLY '0C8H', PORT_B LITERALLY '0CAH';
```

```
                PORT_C LITERALLY '0CCH', CONTROL LITERALLY '0CEH';

 26  1      YZCNTR  PROCEDURE EXTERNAL;
 27  2       END YZCNTR;

 28  1      PPI_SET  PROCEDURE EXTERNAL;    /* SETS UP PORTS_A & _C OUTPUT, PORT_B INPUT */
 29  2       END PPI_SET;

 30  1      FLIGHT  PROCEDURE EXTERNAL;
 31  2       END FLIGHT;

 32  1      INITIATE$VAP  PROCEDURE EXTERNAL;
 33  2       END INITIATE$VAP;

              /*************************************************************
                                  PROGRAM STARTS
              *************************************************************/

 34  1      START_UP:
               CALL PPI_SET;

 35  1      OUTPUT(CONTROL) = NO_DROP   /* DRIVES PORT_C BIT-2 HIGH & J1-20 LOW */

 36  1      OUTPUT(CONTROL) = ARM;  /* DRIVES PORT_C BIT-1 LOW & "J1"-22 HIGH */
             /* PROBABLY NOT NEEDED --- PORT_C COMES UP LOW FOLLOWING PPI_SET */
 37  1      DO I = 0 TO 95;
 38  2        H_MIS_ASCII(I) = ' ';
 39  2      END;

 40  1      CALL INITIATE$VAP;      /* FOR DRAGON FLIGHT */

 41  1      DO WHILE NO_TRIG_PUL;
 42  2        END;

 43  1      CALL SOUND(GYRO_START);

 44  1      CALL TIME_DELAY (560);

 45  1      OUTPUT(CONTROL) = DROP;

 46  1      OUTPUT(CONTROL) = DISARM;

 47  1      CALL SOUND(INITIAL_BANG);

 48  1      CALL SETPET;

 49  1      DRAGON_FLYS:  DO WHILE NOT FINISHED;
 50  2        CALL YZCNTR;
 51  2        CALL FLIGHT;
 52  2      END DRAGON_FLYS;

 53  1      IF H_MISS_HEX >  2 THEN CALL MISS_COMMENT(@H_MISS_HEX,@H_MIS_ASCII,RT);
 54  1      IF H_MISS_HEX < -2 THEN CALL MISS_COMMENT(@H_MISS_HEX,@H_MIS_ASCII,LT);
 55  1      IF V_MISS_HEX >  2 THEN CALL MISS_COMMENT(@V_MISS_HEX,@V_MIS_ASCII,UP);
 56  1      IF V_MISS_HEX < -2 THEN CALL MISS_COMMENT(@V_MISS_HEX,@V_MIS_ASCII,DN);

 57  1      IF X_MISS_HEX < -24 THEN
```

```
 62  1        DROP_SHORT  DO;
 63  2         X_MISS_HEX = IABS(X_MISS_HEX)/6;
 64  2         CALL MISS_COMMENT(@X_MISS_HEX,@X_MIS_ASCII,SH);
 65  2         FELL_SHORT = 1;
 66  2        END DROP_SHORT;
 67  1      ELSE FELL_SHORT = 0

 68  1      CALL SHOW_THRUSTERS

 69  1      ACTION_WAIT             /* WAIT FOR  REPRISE */
           DO FOREVER;
 70  2        ACTION = NOT (INPUT(POPT_B));
 71  2        IF ACTION = 2 THEN CALL H_REPRISE;
 73  2        IF ACTION = 4 THEN CALL V_REPRISE;
 75  2       END ACTION_WAIT;

 76  1      END MAIN_DRAGON_MODULE;
```

```
MODULE INFORMATION

    CODE AREA SIZE     = 0181H    385D
    CONSTANT AREA SIZE = 0000H      0D
    VARIABLE AREA SIZE = 0002H      2D
    MAXIMUM STACK SIZE = 000CH     12D
    125 LINES READ
    0 PROGRAM ERROR(S)

END OF PL/M-86 COMPILATION
```

```
ISIS-II PL/M-86 V2.1 COMPILATION OF MODULE DRAGON_UTILITY
OBJECT MODULE PLACED IN  F1:DRAGUT.OBJ
COMPILER INVOKED BY:  PLM86 :F1:DRAGUT.PLM DEBUG ROM IXREF DATE (02/24/09)


   1          DRAGON_UTILITY  DO;

              /*****************************************************************************
                                    OFF-BOARD ABSOLUTE ADDRESSES
              *****************************************************************************/

   2    1     DECLARE (ACTUAL_THRUSTER_ASCII,IDEAL_THRUSTER_ASCII) (24) BYTE AT (0A050H),
                     DUMMY BYTE AT (0A020H);

              /******************** END OFF-BOARD ABSOLUTE ADDRESSES**********************/

   3    1     DECLARE  COUNTER0 LITERALLY '0D0H', COUNTER1 LITERALLY '0D2H',
                     CONTROL LITERALLY '0D6H';    /* SEE PAGE 3-3 IN 86/12 MAN */
   4    1     DECLARE CNTR0MODE LITERALLY '34H',  /* 2 BYTES, MODE 2 */
                     CNTR1MODE LITERALLY '74H';          /* 2 BYTES, MODE 2 */

              /* TO PROGRAM THE 8253 PROGRAMMABLE INTERVAL TIMER OR "PIT" NOTE THAT */
              /* THE INPUT FREQUENCY TO CLK0 IS 1.23 MHZ ==> AN 813 NANOSEC PERIOD  */

   5    1     DECLARE LOW0 LITERALLY '06';    /* COUNTER 0 PERIOD IS 5 MILLESECONDS */
                    HIGH0 LITERALLY '18H';

              /* NOW WE WILL CONNECT OUT0 TO CLK1 BY JUMPER 59-61 INSTEAD OF THE
                 DEFAULT CONNECTION, WHICH IS 59-60  */

   6    1     DECLARE LOW1 LITERALLY '5FH';          /* COUNTER 1 PERIOD IS 5 MINUTES */
                    HIGH1 LITERALLY '0EAH';     /* = 5 MIN * 60 (SEC/MIN) / 0.005 SEC -1 IN HEX */


   7    1     DECLARE TIME$LATCH LITERALLY '40H';     /* A COUNTER 1 LATCH  PAGE 3-13 OF 86/12  */
              (LS$TIME$BYTE, MS$TIME$BYTE) BYTE PUBLIC;
   8    1     DECLARE TIME ADDRESS PUBLIC;
   9    1     DECLARE LOW$TIME$BYTE BYTE AT ( TIME), HIGH$TIME$BYTE BYTE AT ( TIME + 1);

  10    1     TIMER$START:  PROCEDURE PUBLIC;
  11    2      OUTPUT(CONTROL)=CNTR0MODE;    /* SET COUNTERS 0 & 1 MODES */
  12    2      OUTPUT(CONTROL)=CNTR1MODE;
  13    2      OUTPUT(COUNTER0)=LOW0;       /* INITIALIZE COUNTERS */
  14    2      OUTPUT(COUNTER0)=HIGH0;
  15    2      OUTPUT(COUNTER1)=LOW1;
  16    2      OUTPUT(COUNTER1)=HIGH1;
  17    2      END TIMER$START;

  18    1     CLOCK$READ:  PROCEDURE ADDRESS PUBLIC;  /* GETS THE CONTENTS OF COUNTER 1 */
  19    2      OUTPUT(CONTROL)=TIME$LATCH;
  20    2      LOW$TIME$BYTE=INPUT(COUNTER1);
  21    2      HIGH$TIME$BYTE=INPUT(COUNTER1);
  22    2      RETURN TIME;
  23    2      END CLOCK$READ;

  24    1     DECLARE (IDEAL_S$TCNT,TARGET_S$TCNT) INTEGER EXTERNAL;
```

```
                /* N B  REFERENCES ARE TO ISCB 86/12 9800645A */

 25  1      DECLARE PRI_CONTROL LITERALLY '0CEH', BUS_FREE LITERALLY '0BH';

 26  1      DECLARE SENARIO BYTE AT (6000H);

 27  1      TARGET_LOC  PROCEDURE(ID) INTEGER PUBLIC;
 28  2        DECLARE ID BYTE;   /* ID IS IDENTIFICATION OF H.V. OR X TARG */
 29  2        DECLARE POSITION INTEGER;

 30  2      IF SENARIO = 'A' THEN
 31  2        SCENE_A: DO;
 32  3          IF ID = 1 THEN
 33  3          TARG_H: DO;             /* REPEAT FOR V AND X OF TARGET */
 34  4          END TARG_H;
 35  3          RETURN POSITION;
 36  3        END SCENE_A;

 37  2      IF SENARIO = 'B' THEN      /* ETC, ETC */
 38  2        SCENE_B: DO;
 39  3        END SCENE_B;

 40  2      END TARGET_LOC;

 41  1      INIT_STEPPER: PROCEDURE PUBLIC;
 42  2        IF SENARIO = 'A' THEN
 43  2        INIT_A: DO;
 44  3        END INIT_A;

 45  2        IF SENARIO = 'B' THEN    /* ETC, ETC */
 46  2        INIT_B: DO;
 47  3        END INIT_B;

 48  2      END INIT_STEPPER;

 49  1      HX2AS: PROCEDURE (HEX_ADR,ASCII_ADR) PUBLIC;
 50  2        DECLARE (HEX_ADR,ASCII_ADR) POINTER, HEX BASED HEX_ADR INTEGER,
                  ASCII BASED ASCII_ADR (5) BYTE, (N,M) BYTE, REMAINDER INTEGER;

 51  2      HEX = IABS(HEX);
 52  2      DO N=0 TO 4;
 53  3        M = 4-N;
 54  3        REMAINDER = HEX MOD 10 + 30H;
 55  3        ASCII(M) = LOW(UNSIGN(REMAINDER));
 56  3        HEX = HEX/10;
 57  3        END;
 58  2        N=0;

 59  2      DO WHILE ASCII(N) = 30H AND N<5;  /* REPLACE LEADING ZEROES WITH BLANKS */
 60  3        ASCII(N) = 20H;
 61  3        N = N+1;
 62  3        END;
 63  2      END HX2AS;

 64  1      SHOW_THRUSTERS: PROCEDURE PUBLIC;
 65  2        CALL HX2AS(@TARGET_S$TCNT,@ACTUAL_THRUSTER_ASCII);
```

```
66   1        ACTUAL_THRUSTER_ASCII(5) = 'T';
67   2        ACTUAL_THRUSTER_ASCII(6) = 'H';
68   2        ACTUAL_THRUSTER_ASCII(7) = 'R';
69   2        ACTUAL_THRUSTER_ASCII(8) = 'U';
70   2        ACTUAL_THRUSTER_ASCII(9) = 'S';
71   2        ACTUAL_THRUSTER_ASCII(10) = 'T';
72   2        ACTUAL_THRUSTER_ASCII(11) = 'E';
73   2        ACTUAL_THRUSTER_ASCII(12) = 'R';
74   2        ACTUAL_THRUSTER_ASCII(13) = 'S';
75   2        ACTUAL_THRUSTER_ASCII(14) = ' ';
76   2        ACTUAL_THRUSTER_ASCII(15) = 'O';
77   2        ACTUAL_THRUSTER_ASCII(16) = 'N';
78   2        ACTUAL_THRUSTER_ASCII(17) = 'E';
79   2        ACTUAL_THRUSTER_ASCII(18) = 0;

80   2      CALL HEX2ASC(@IDEAL_S$TCNT,@IDEAL_THRUSTER_ASCII);
81   2        IDEAL_THRUSTER_ASCII(5) = 'T';
82   2        IDEAL_THRUSTER_ASCII(6) = 'H';
83   2        IDEAL_THRUSTER_ASCII(7) = 'R';
84   2        IDEAL_THRUSTER_ASCII(8) = 'U';
85   2        IDEAL_THRUSTER_ASCII(9) = 'S';
86   2        IDEAL_THRUSTER_ASCII(10) = 'T';
87   2        IDEAL_THRUSTER_ASCII(11) = 'E';
88   2        IDEAL_THRUSTER_ASCII(12) = 'R';
89   2        IDEAL_THRUSTER_ASCII(13) = 'S';
90   2        IDEAL_THRUSTER_ASCII(14) = ' ';
91   2        IDEAL_THRUSTER_ASCII(15) = 'I';
92   2        IDEAL_THRUSTER_ASCII(16) = 'D';
93   2        IDEAL_THRUSTER_ASCII(17) = 'E';
94   2        IDEAL_THRUSTER_ASCII(18) = 'A';
95   2        IDEAL_THRUSTER_ASCII(19) = 'L';
96   2        IDEAL_THRUSTER_ASCII(20) = 'L';
97   2        IDEAL_THRUSTER_ASCII(21) = 'Y';

98   2      END SHOW_THRUSTERS;

99   1      MISS_COMMENT  PROCEDURE(HEX$ADR  DEC$ADR, DIRECTION) PUBLIC;
100  2      DECLARE(HEX$ADR  DEC$ADR) POINTER,
               PHRASE BASED DEC$ADR (16) BYTE, (N,DIRECTION) BYTE;

101  2      CALL HEX2ASC(HEX$ADR,DEC$ADR);

102  2      PHRASE(5) = ' ';
103  2      PHRASE(6) = 'F';
104  2      PHRASE(7) = 'R';
105  2      PHRASE(8) = 'E';
106  2      PHRASE(9) = 'I';
107  2      PHRASE(10) = 'G';
108  2      DO CASE DIRECTION;
109  3        ;
110  4      PHRASE(11) = 'F';
111  4      PHRASE(12) = 'I';
112  4      PHRASE(13) = 'S';
113  4      PHRASE(14) = 'H';
114  4      PHRASE(15) = 'I';
115  4        END;
116            ;
```

```
                PHRASE(11) = ' '
                PHRASE(12) = 'B'
                PHRASE(13) = 'F'
                PHRASE(14) = 'T'
                  END;
                  DO;
                PHRASE(11) = 'M'
                PHRASE(12) = 'I'
                PHRASE(13) = 'S'
                PHRASE(14) = 'S'
                  END;
                  DO;
                PHRASE(11) = 'I'
                PHRASE(12) = 'O'
                PHRASE(13) = 'W'
                  END;
                  DO;
                PHRASE(11) = 'F'
                PHRASE(12) = 'H'
                PHRASE(13) = 'O'
                PHRASE(14) = 'P'
                PHRASE(15) = 'T'
                  END;
              END;
            END MISS_COMMENT;


            SOUND: PROCEDURE (WHAT_IND) PUBLIC;
              DECLARE WHAT_IND BYTE, PORT_A LITERALLY '0C8H';
              OUTPUT (PORT_A) = WHAT_IND;      /* SOUND COMMAND OUTPUT THRU PORT_A */
              OUTPUT (PPI_CONTROL) = 1;      /* SETS PPI PORT_C BIT 0 FOR SOUND CONTROL */
              OUTPUT (PPI_CONTROL) = 1      /* EXTRA ONES FOR 6 MICRO-SEC TIMING */
              OUTPUT (PPI_CONTROL) = 1;
              OUTPUT (PPI_CONTROL) = 0; /* RESETS PPI PORT_C BIT 0 */
              END SOUND;


            ON_BRD_SET: PROCEDURE (SEMA4_PTR, BIT) PUBLIC;
              DECLARE SEMA4_PTR POINTER, BIT BYTE, BUS_LOCK LITERALLY '0AH';
                /* N.B. 8255 (-5, WHEN RESET (=0), ASSERTS THE BUS "OVERRIDE" */
                /* REFER TO PAGE 3-16,-17 FOR PPI PORT_C BIT SET/RESET */
              DECLARE TEMP BYTE, SEMA4 BASED SEMA4_PTR BYTE,
             TEMP = 1;

             IF BIT = 1 THEN SET_SEMA4

             DO WHILE TEMP = 1;
              FIRST_CHECK: DO WHILE SEMA4 = 1; /* WAIT HERE TO AVOID REPEATEDLY LOCKING/UNLOCKING BUS */
                END FIRST_CHECK;

              OUTPUT (PPI_CONTROL) = BUS_LOCK;  /* THIS REQUESTS A BUS-LOCK WHEN WE GET CONTROL */
              TEMP = DUMMY;  /* WHEN THIS EXECUTES, WE HAVE CONTROL OF A LOCKED BUS */
              TEMP = SEMA4;  /* SAVE CURRENT BIT OF THE SEMA4 */
              SEMA4 = 1;      /* SEMA4 IS NOW SET  WILL DETERMINE LATER IF WE DID IT */
              OUTPUT(PPI_CONTROL) = BUS_FREE  /* IF SEMA4 WERE OFF-BOARD, COULD REPLACE THESE */
                                    /* LAST FIVE STEPS WITH "LOCKSET(SEMA4_PTR,1)" */
```

```
                /* IF SEMA4 WAS SET ANOTHER MASTER DID IT.  SO MUST WAIT TILL USER RESETS IT  */

 163   3          END SET_SEMA4;

 164   2        IF BIT = 0 THEN CLEAR_SEMA4: DO;
 166   3          OUTPUT(PPI_CONTROL) = BUS_LOCK;
 167   3          TEMP = DUMMY;
 168   3          SEMA4 = 0;  /* ASSUMES PROGRAM NEVER CLEARS SEMA4 UNLESS SAME PROG SET IT */
 169   3          OUTPUT(PPI_CONTROL) = BUS_FREE;
 170   3          END CLEAR_SEMA4;

 171   2        RETURN;

 172   2         END ON_BRD_SET;


 173   1       PPI_SET:  PROCEDURE PUBLIC;
 174   2         DO;
 175   3          DECLARE PPI_MODE LITERALLY '82H',     /* PORTS A & C OUTPUT  B INPUT  */
                                 /* REF PAGES 2-10 & 3-15 */
 176   3          DECLARE SFLAG LITERALLY  '0',         /* RESETS PORT "C" BIT 0  */
                    /* WHICH OUTPUTS A "1" FROM 7400. SETTING THE "SOUND-FLAG" TO 8748 */

 177   3          OUTPUT(PPI_CONTROL) = PPI_MODE;   /* ALL PPI OUTPUTS GO LOW INCLUDING
                      PORT-C. BIT-5. WHICH ASSERTS THE MULTI-BUS "OVERRIDE " */
 178   3          OUTPUT(PPI_CONTROL) = BUS_FREE;   /* NEGATES THE MULTI-BUS OVERRIDE  */
 179   3          OUTPUT(PPI_CONTROL) = SFLAG;
 180   3           END;
 181   2         END PPI_SET;

 182   1       TIME_DELAY:  PROCEDURE (HOW_LONG) PUBLIC;
 183   2          DECLARE (HOW_LONG, TEST_WORD) WORD;
 184   2         LOOPA:  DO WHILE HOW_LONG <> 0;
 185   3             TEST_WORD = 39H;
 186   3             LOOPB:  DO WHILE TEST_WORD <> 0;
 187   4                TEST_WORD = TEST_WORD -1;
 188   4               END LOOPB;
 189   3            HOW_LONG = HOW_LONG - 1;
 190   3           END LOOPA;
 191   2         END TIME_DELAY;

 192   1       END DRAGON_UTILITY;



MODULE INFORMATION

     CODE AREA SIZE     = 0475H   1141D
     CONSTANT AREA SIZE = 0000H      0D
     VARIABLE AREA SIZE = 000EH     14D
     MAXIMUM STACK SIZE = 001AH     26D
     264 LINES READ
     0 PROGRAM ERROR(S)

END OF PL/M-86 COMPILATION
```

```
ISIS-II MCS-86 MACRO ASSEMBLER V2.1 ASSEMBLY OF MODULE RDRSB
OBJECT MODULE PLACED IN  F1:RDRSB.OBJ
ASSEMBLER INVOKED BY:  ASM86  F1:RDRSB.SRC DEBUG DATE(02/24/09)

LOC  OBJ                  LINE     SOURCE

                             1     THIS PROGRAM, STARTED SEPT 5, 1979, READS DATA FROM THE RETICON RSB6020
                             2      INTERFACE BOARD INTO THE 86/12 MEMORY  REFERENCES ARE:
                             3           1  RSB6020 OPERATING INSTRUCTIONS, MARCH 9, 1979, EG&G RETICON
                             4              SUNNYVALE, CALIFORNIA
                             5           2  MCS-86 ASSEMBLE LANGUAGE REFERENCE MANUAL, #9800640A,
                             6              INTEL CORP, SANTA CLARA, CALIFORNIA
                             7
                             8     IT IS BEING CLEANED UP A BIT FEB 20, 1981
                             9
                            10     EQUATES AT TOP OF PROGRAM PER P  8-1, REF 2
                            11
                            12             NAME    RDRSB
                            13     DGROUP  GROUP   DATA, STACK, SBC_REGS, RSB_REGS
                            14     CGROUP  GROUP   CODE
                            15
0001                        16     INMSK   EQU     01      ;SET UP FOR CAMERA 1 ONLY  SEE P  19, REF 1
0064                        17     LINES   EQU     100
0010                        18     ENDFP   EQU     10H     ;MASK FOR THE 2-TO-THE-4TH BIT, P  45, REF 1
                            19
                            20     ASSUME SS:DGROUP, CS:CGROUP, DS:DGROUP, ES:DGROUP
                            21
----                        22     SBC_REGS SEGMENT COMMON         ;NOTE THAT "COMMON" FILES MUST BE
                            23                                     ;COMMON IN ALL MODULES, I E  CAN'T BE
0000 (800                   24     SBCREG  DB      800 DUP (?)     ;"AT" IN ONE AND "COMMON" IN ANOTHER
     ??
     )
                            25                                     ;THEY DO NOT, HOWEVER, HAVE TO BE POINTED
                            26                                     ;TO BY THE SAME SEGMENT REGISTER IN BOTH
                            27                                     ;MODULES, NOR DO THEY HAVE TO
                            28                                     ;OF THE SAME LENGTH
0320 (6                     29     PARTLY_OFF      DB      6 DUP (?)       ; INITIALIZE = 0
     ??
     )
0326 (6                     30     LOCATIONS       DB      6 DUP (?)       ; INITIALIZE = 1
     ??
     )
----                        31     SBC_REGS ENDS
                            32
----                        33     RSB_REGS SEGMENT AT 0E000H      ;BASE ADDRESS OF RETICON BOARD IS 0E000H
0000 (512                   34     RSBDTA  DB      200H DUP (?)
     ??
     )
0200 (1                     35     STAT1   DB      1 DUP (?)       ;THIS FORM IS NECESSARY TO AVOID LOADING ERRORS
     ??
     )
0201 (11                    36     STAT2   DB      0BH DUP (?)
     ??
     )
020C (2                     37     RESET   DB      2 DUP(?)
     ??
     )
```

```
LOC  OBJ                  LINE    SOURCE

                          ,
020E (1                    38     CNFG15  DB      1 DUP (?)
     ??
     )
020F (1                    39     PROCOM  DB      1 DUP (?)
     ??
     )
----                       40     RSB_REGS ENDS
                           41
----                       42     STACK   SEGMENT STACK  'STACK'
0000 (10                   43             DW      10 DUP (?)
     ????
     )
0014                       44     STKTOP  LABEL   WORD
----                       45     STACK   ENDS
                           46
                           47
----                       48     CODE    SEGMENT PUBLIC  'CODE'
                           49
                           50             PUBLIC  INIT1
0000                       51     INIT1   PROC    NEAR            ;INITIALIZATION OF RSB 6020 INTERFACE BOARD
0000 A20C02          R     52     RTINIT  MOV     RESET,AL        ;RESET IS A "DUMMY" REGISTER, ALL IT NEEDS
0003 C6060E0201      R     53             MOV     CNFG15,INMSK    ;IS THE "MWTC/" PULSE FROM P1 #20
0008 A20F02          R     54             MOV     PROCOM,AL       ;PROCOM IS ALSO A "DUMMY" REGISTER
0008 C3                    55             RET
                           56     INIT1   ENDP
                           57
                           58             PUBLIC  RD_RAST
000C                       59     RD_RAST PROC    NEAR
000C A20F02          R     60     LAST    MOV     PROCOM,AL       ;WILL WAIT FOR LAST RASTER LINE
000F A00002          R     61     WTLP0   MOV     AL,STAT1        ;FROM HERE TO CHECK IS ST'D NUCMCV
0012 D0E0                  62             SHL     AL,1
0014 7303                  63             JNB     WTLP3
0016 A20F02          R     64     PSPR0   MOV     PROCOM,AL
0019 A00002          R     65     WTLP3   MOV     AL,STAT1
001C D0E0                  66             SHL     AL,1
001E 7206                  67             JB      CHECK
0020 D0E0                  68             SHL     AL,1
0022 72F5                  69             JB      WTLP3
0024 EBF0                  70             JMP     PSPR0
0026 A00300          R     71     CHECK   MOV     AL,RSBDTA[3]
0029 2410                  72             AND     AL,ENDFR
002B 74DF                  73             JZ      LAST
                           74
                           75     ;HAVING FOUND THE LAST LINE OF THE FRAME, WE WILL TRANSFER THE RETICON
                           76     ;DATA, LINE-BY-LINE THE THE INTEL 86/12 BOARD.  EACH LINE TRANSFERRED STARTS
                           77     ;WITH A "NEW COMMAND CYCLE" AS PER PAGE 40 OF REFERENCE 1 .
                           78
002D B164                  79             MOV     BL,LINES                ;WILL DECREMENT FROM 100 TO ZERO
002F BF0000          R     80             MOV     DI,OFFSET DGROUP:SBCREG
                           81
0032 A20F02          R     82     NUCMCV  MOV     PROCOM,AL       ;AGAIN, PROCOM IS A DUMMY
0035 A00002          R     83     WTLP1   MOV     AL,STAT1
0038 D0E0                  84             SHL     AL,1
003A 7303                  85             JNB     WTLP
```

```
LOC  OBJ                  LINE    SOURCE

003C A20F02         R       86    PSPR:   MOV     PROCOM,AL
003F A00002         R       87    WTLP:   MOV     AL,STAT1
0042 D0E0                   88            SHL     AL,1
0044 7206                   89            JB      OTLP
0046 D0E0                   90            SHL     AL,1
0048 72F5                   91            JB      WTLP
004A EBF0                   92            JMP     PSPR
                            93
                            94    ;NOW TRANSFER A SINGLE LINE OF RETICON RSB 6020 DATA TO THE INTEL 86 BOARD.
                            95
004C A00000         R       96    OTLP:   MOV     AL,RSBDTA               ;TRANSITIONS IN THE LINE
004F 32E4                   97            XOR     AH,AH
0051 40                     98            INC     AX                      ;NUMBER OF WORDS TO XFER
0052 D1E0                   99            SHL     AX,1                    ;X2 NUMBER OF BYTES TO XFER
0054 8BC8                  100            MOV     CX,AX
0056 BE0000         R      101            MOV     SI,OFFSET DGROUP:RSBDTA
0059 F3                    102    REP     MOVS    BYTE PTR SBCREG[DI], BYTE PTR RSBDTA[SI]
005A A4
005B FEC8                  103            DEC     BL
005D 7503                  104            JNZ     NUCMCY
                           105
005F C3                    106            RET
                           107
                           108    RD_RAST ENDP
                           109
- --                        110    CODE    ENDS
                           111
                           112            END

ASSEMBLY COMPLETE, NO ERRORS FOUND
```

APPENDIX C

COMPUTER GRAPHICS AND VIDEO SUBSYSTEM PROGRAMS

SERIES-III 8086/8087/8088 MACRO ASSEMBLER V1.0 ASSEMBLY OF MODULE MATROX
OBJECT MODULE PLACED IN :F2:MATROX.OBJ
INVOCATION LINE CONTROLS: DEBUG

```
LOC  OBJ                  LINE     SOURCE

                             1     NAME MATROX
                             2
                             3     CGROUP  GROUP   CODE
                             4
                             5     DATA_GROUP      GROUP   DGROUP,DATA_SEG,GAE_SEG
                             6     ASSUME  CS:CGROUP, DS:DATA_GROUP
                             7     PUBLIC  BACKGROUND, MATROX_START_UP,START_BIT,X_Y,DATA_READY,ERROR
                             8     PUBLIC  XCNT,YCNT,BAD_MISS,FIRE_BIRD,THRUSTER_FIRE
                             9     EXTRN   SMOKE_SET: NEAR,GAE_GT_FOV:NEAR,GRAPH_VREP:NEAR
                            10     EXTRN   GRAPH_GAE_POINT: NEAR,GRAPH_HREP:NEAR
                            11     EXTRN   SMOKE_CHECK: NEAR
                            12     EXTRN   GRAPH1  NEAR
                            13     EXTRN   SMOKE_START_UP:NEAR
                            14     EXTRN   GAE_START_UP:NEAR
                            15     EXTRN   COUT:NEAR
                            16     EXTRN   CIN:NEAR
                            17     EXTRN   HIT_EXPLOSION:NEAR,GROUND_EXPLOSION:NEAR
                            18     EXTRN   TANK_INIT:NEAR,TANK_KILLED:NEAR
                            19     EXTRN   USART_SET_UP_FOR_ADM:NEAR
                            20     EXTRN   DELAY_3:NEAR  ;160MS DELAY FOR CLEARING RETRO_GRAPHICS SCREEN
                            21
----                        22     DGROUP  SEGMENT PUBLIC 'DATA'
----                        23     DGROUP  ENDS
                            24
----                        25     DATA_SEG        SEGMENT PUBLIC
                            26     EXTRN   H_REP_FLAG:BYTE,V_REP_FLAG:BYTE
----                        27     DATA_SEG        ENDS
                            28
----                        29     GAE_SEG         SEGMENT  PUBLIC
                            30     EXTRN   ELAPSED_TIME:WORD
----                        31     GAE_SEG         ENDS
                            32
                            33
  0014                      34     XREG    EQU     14H
  0016                      35     YREG    EQU     16H
  0010                      36     GSCALE  EQU     10H
  0012                      37     SCROLL  EQU     12H
  0012                      38     FLAGS   EQU     12H
  0014                      39     ERASE   EQU     14H
                            40
----                        41     DATA_SEG        SEGMENT PUBLIC
                            42
0000 (1                     43     XCNT            DB      1 DUP(?)
     ??
     )
0001 (1                     44     YCNT            DB      1 DUP(?)
     ??
     )
0002 (1                     45     XCNT_OLD        DB      1 DUP(?)
     ??
```

```
LOC  OBJ                  LINE     SOURCE

                          46       YCNT_OLD        DB      1 DUP(?)
0003 (1
     ??
                          47       XCNT_SAVE       DB      1 DUP(?)
0004 (1
     ??
                          48       YCNT_SAVE       DB      1 DUP(?)
0005 (1
     ??
                          49       GSCALE_VAL      DB      1 DUP(?)
0006 (1
     ??
                          50       GSCALE_NUM      DB      1 DUP(?)
0007 (1
     ??
                          51       THRUSTER_FIRE   DB      1 DUP(?)
0008 (1
     ??
                          52       SIZ             DW      1 DUP(?)
0009 (1
     ????
                          53       XMIN            DW      1 DUP(?)
000B (1
     ????
                          54       YMIN            DW      1 DUP(?)
000D (1
     ????
                          55       XMAX            DW      1 DUP(?)
000F (1
     ????
                          56       YMAX            DW      1 DUP(?)
0011 (1
     ????
                          57       XMAX_TMP        DW      1 DUP(?)
0013 (1
     ????
                          58       XMIN_TMP        DW      1 DUP(?)
0015 (1
     ????
                          59       TMP_WRD         DW      1 DUP(?)
0017 (1
     ????
                          60       ONE_THIRD       DW      1 DUP(?)
0019 (1
     ????
                          61       TWO_THIRDS      DW      1 DUP(?)
001B (1
     ????
                          62       THREE           DB      1 DUP(?)
001D (1
     ??
                          63       COUNT_EM        DB      1 DUP(?)
001E (1
     ??
     )
```

```
LOC  OBJ                  LINE     SOURCE

 001F (1                    64     BACKGROUND       DB     1 DUP(?)
       ??
       )
 0020 (1                    65     GSCALE_SAVE      DB     1 DUP(?)
       ??
       )
 0021 (1                    66     COUNT            DB     1 DUP(?)
       ??
       )
 0022 (1                    67     BLINK_COUNT      DB     1 DUP(?)
       ??
       )
 0023 (1                    68     REPLAY           DB     1 DUP(?)
       ??
       )
 0024 (1                    69     ERROR            DB     1 DUP(?)
       ??
       )
 0025 (1                    70     ERROR_MESG_FLAG  DB     1 DUP(?)
       ??
       )
 0026 (1                    71     GRND_BIRD_FLAG   DB     1 DUP(?)
       ??
       )
 0027 (1                    72     HIT_FLAG         DB     1 DUP(?)
       ??
       )
 0028 (1                    73     DIST_FRO_TGT_FLAG DB    1 DUP(?)
       ??
       )
 0029 (1                    74     RESULTS_FLAG     DB     1 DUP(?)
       ??
       )
 002A (1                    75     THRUSTERS_FLAG   DB     1 DUP(?)
       ??
       )
 002B (1                    76     TWO              DW     1 DUP(?)
       ????
       )
 002D (1                    77     YANG_SCALED      DW     1 DUP(?)
       ????
       )
 002F (1                    78     ZANG_SCALED      DW     1 DUP(?)
       ????
       )
 0031 (1                    79     YANG2_OLD        DW     1 DUP(?)
       ????
       )
 0033 (1                    80     ZANG2_OLD        DW     1 DUP(?)
       ????
       )
 0035 (1                    81     YANG2_SAVE       DW     1 DUP(?)
       ????
       )
 0037 (1                    82     ZANG2_SAVE       DW     1 DUP(?)
```

```
LOC  OBJ                  LINE     SOURCE

     ????
     )
0039 (1                    83     YANG2          DW      1 DUP(?)
     ????
     )
003B (1                    84     ZANG2          DW      1 DUP(?)
     ????
     )
003D (1                    85     FLAG           DB      1 DUP(?)
     ??
     )
003E (1                    86     POP_LEVEL      DB      1 DUP(?)
     ??
     )
003F (1                    87     BORE_SIGHT     DB      1 DUP(?)
     ??
     )
0040 (1                    88     START_UP_BYTE  DB      1 DUP(?)
     ??
     )
                           89
----                       90     DATA_SEG       ENDS
                           91
                           92
----                       93     XFER_SEG        SEGMENT        AT 0600H
0000 (1                    94     START_BIT      DB      1 DUP(?)
     ??
     )
0001 (1                    95     X_Y            DW      1 DUP(?)
     ????
     )
0003 (1                    96     DATA_READY     DB      1 DUP(?)
     ??
     )
0004 (1                    97     BAD_MISS       DB      1 DUP(?)
     ??
     )
0005 (1                    98     OFFSET_X       DB      1 DUP(?)
     ??
     )
0006 (1                    99     OFFSET_Y       DB      1 DUP(?)
     ??
     )
0007 (9                   100     DUMMYS         DB      9 DUP(?)
     ??
     )
0010 (1                   101     YANG           DW      1 DUP(?)
     ????
     )
0012 (1                   102     ZANG           DW      1 DUP(?)
     ????
     )
0014 (1                   103     BIRD_DTA_RDY   DB      1 DUP(?)
     ??
     )
```

```
LOC  OBJ                  LINE     SOURCE

0015 (1                    104      FIRE_BIRD       DB      1 DUP(?)
     ??
     )
0016 (1                    105      BIRD_HIT        DB      1 DUP(?)
     ??
     )
0017 (1                    106      BIRD_MISSES     DB      1 DUP(?)
     ??
     )
0018 (1                    107      H_REP_REQ       DB      1 DUP(?)
     ??
     )
0019 (1                    108      H_REP_GO        DB      1 DUP(?)
     ??
     )
001A (1                    109      V_REP_REQ       DB      1 DUP(?)
     ??
     )
001B (1                    110      V_REP_GO        DB      1 DUP(?)
     ??
     )
001C (1                    111      GRND_BIRD       DB      1 DUP(?)
     ??
     )
001D (1                    112      END_OF_RPV      DB      1 DUP(?)
     ??
     )
001E (1                    113      HIT_SHORT       DB      1 DUP(?)
     ??
     )
001F (1                    114      DUMMY_ALSO      DB      1 DUP(?)
     ??
     )
0020 (16                   115      H_MIS_ASCII     DB      16 DUP(?)
     ??
     )
0030 (16                   116      V_MIS_ASCII     DB      16 DUP(?)
     ??
     )
0040 (16                   117      DIS_FRO_TGT     DB      16 DUP(?)
     ??
     )
0050 (24                   118      ACTUAL_THRUST   DB      24 DUP(?)
     ??
     )
0068 (24                   119      IDEAL_THRUST    DB      24 DUP(?)
     ??
     )
----                       120      XFER_SEG        ENDS
                           121
----                       122      STACK_SEG       SEGMENT STACK 'STACK'
0000 (64                   123                      DW      64D DUP(?)
     ????
     )
0080                       124      STKTOP  LABEL   WORD
```

```
LOC  OBJ                  LINE    SOURCE

---                        125    STACK_SEG       ENDS
                           126
----                       127    CODE    SEGMENT PUBLIC 'CODE'
                           128
0000 47524F554E4420        129    MESSAGE         DB      'GROUND IMPACT',350
     494D50414354
0000 1D
000E                       130    FIN_OF_MESSAGE  LABEL   WORD
                           131
000E 4D495353494C45        132    MESSAGE2        DB      'MISSILE POSITION EXCEEDED GRAPH BOUNDS',350
     20504F53495449
     4F4E2045584345
     454454204752
     415048204F55
     4E4453
0034 1D
0035                       133    FIN_OF_MESSAGE2 LABEL   WORD
                           134
0035 544852555354          135    MESSAGE3        DB      'THRUSTERS: '
     52533A20
0040 02                    136    END_OF_MESSAGE3 DB      WORD
                           137
0041 B80000                138    DRIVER          MOV     AX,XFER_SEG
0044 8EC0                  139                    MOV     ES,AX
0046 B8----          R     140                    MOV     AX,STACK_SEG
0049 8ED0                  141                    MOV     SS,AX
004B B88000          R     142                    MOV     AX,OFFSET STKTOP
004E 8BE0                  143                    MOV     SP,AX
0050 B8----          R     144                    MOV     AX,DATA_GROUP
0053 8ED8                  145                    MOV     DS,AX
0055 26C606000000          146                    MOV     ES:START_BIT,0
005A 803E400001      R     147                    CMP     START_UP_BYTE,1
005F 740C                  148                    JE      NOT_START_UP
0061 26C606050000          149                    MOV     ES:OFFSET_X,0
0068 26C606060000          150                    MOV     ES:OFFSET_Y,0
006E C6064000001     R     151    NOT_START_UP:   MOV     START_UP_BYTE,1
0073 C606230000      R     152                    MOV     REPLAY,0
0078 C7062B000200    R     153                    MOV     TWO,2
007E C606280000      R     154                    MOV     DIST_FRO_TGT_FLAG,0
0083 C606260000      R     155                    MOV     GRND_BIRD_FLAG,0
0088 C606270000      R     156                    MOV     HIT_FLAG,0
008D C606290000      R     157                    MOV     RESULTS_FLAG,0
0092 C6063F0000      R     158                    MOV     BORE_SIGHT,0
0097 C606240000      R     159                    MOV     ERROR,0
009C C606250000      R     160                    MOV     ERROR_MESG_FLAG,0
00A1 C606260000      R     161                    MOV     GRND_BIRD_FLAG,0
00A6 C606270000      R     162                    MOV     HIT_FLAG,0
00AB C606280000      R     163                    MOV     DIST_FRO_TGT_FLAG,0
00B0 E80000          E     164                    CALL    USART_SET_UP_FOR_ADM
00B3 E80000          E     165                    CALL    USART_SET_UP_FOR_ADM
00B6 E80000          E     166                    CALL    SMOKE_START_UP
00B9 E80000          E     167                    CALL    GAE_START_UP ;INITIALIZES THE GAE PROGRAM
00BC E8C901                168                    CALL    MATROX_START_UP  ;CLEARS MATROX SCREEN
00BF BAD600                169                    MOV     DX,0D8H
00C2 B01D                  170                    MOV     AL,350
```

```
LOC  OBJ                  LINE    SOURCE

00A4 E80000         E     171                 CALL    COUT
00A7 B013                 172                 MOV     AL,310
00C9 E80000         E     173                 CALL    COUT
00CC E80000         E     174                 CALL    DELAY_3   ;DELAY 160MS
00CF B000                 175                 MOV     AL,150
00D1 E80000         E     176                 CALL    COUT
00D4 B018                 177                 MOV     AL,0380
00D6 E80000         E     178                 CALL    COUT
00D9 B01A                 179                 MOV     AL,320  ;CLEAR ADM-3 SCREEN
00DB E80000         E     180                 CALL    COUT
00DE E80000         E     181                 CALL    TANK_INIT  ; ALLOWS INST. TO SELECT FROM MENU
00E1 B80006               182                 MOV     AX,XFER_SEG   ;THIS & THE NEXT INST. ARE A CLUGE
                          183                                       ;TO GUARD THE ES IF NECESSARY???
00E4 8EC0                 184                 MOV     ES,AX
00E6 B01A                 185                 MOV     AL,320
00E8 BA0800               186                 MOV     DX,0D8H
00EB E80000         E     187                 CALL    COUT    ;CLEAR ADM-3 SCREEN
00EE E80000         E     188                 CALL    GRAPH1 ;DRAWS AND CLEARS ENVELOPES ON ADM-3 SCREEN
00F1 26C606000001         189                 MOV     ES:START_BIT,1
00F7 E86007               190   WAY_UP_HERE:  CALL    CHECK_FOR_B    ;BORESIGHT CHECK
00FA 80FC01               191                 CMP     AH,1
00FD 7511                 192                 JNE     DO_IT_OVER
00FF 3C02                 193                 CMP     AL,0002H        ;CTRL-B ??
0101 750D                 194                 JNE     DO_IT_OVER
0103 BA0800               195                 MOV     DX,0D8H
0106 B042                 196                 MOV     AL,1020      ;OUTPUT A 'B' TO ADM-3
0108 E80000         E     197                 CALL    COUT
010B C6063F0001     R     198                 MOV     BORE_SIGHT,1
0110 26803E030001         199   DO_IT_OVER:   CMP     ES:DATA_READY,1  ;DATA_READY???
0116 7520                 200                 JNE     CHK_FOR_RPV
0118 803E3F0001     R     201                 CMP     BORE_SIGHT,1
011D 7508                 202                 JNE     BEYOND
011F E84507               203                 CALL    CALIBRATE       ;CALIBRATE FROM FIRST DATA POINTS
0122 C6063F0000     R     204                 MOV     BORE_SIGHT,0
0127 26803E040001         205   BEYOND        CMP     ES:BAD_MISS,1   ;BAD_MISS???
012D 7506                 206                 JNE     DO_IT
012F E80000         E     207                 CALL    GAE_GT_FOV
0132 E94601               208                 JMP     OVER2    ;DO NOT GET NEW DATA IF BAD_MISS
0135 E9FF00               209   DO_IT:        JMP     DO_IT_LONG
                          210
0138 26803E1A0001         211   CHK_FOR_RPV   CMP     ES:V_REP_REQ,1
013E 7423                 212                 JE      V_REP_SHORT
0140 26803E180001         213                 CMP     ES:H_REP_REQ,1
0146 741E                 214                 JE      H_REP_SHORT
0148 26803E1E0001         215                 CMP     ES:HIT_SHORT,1
014E 7436                 216                 JE      DIST_FROM_TGT
0150 26803E1D0001         217                 CMP     ES:END_OF_RPV,1
0156 744C                 218                 JE      ERROR_MSG_CHK
0158 26803E170001         219                 CMP     ES:BIRD_MISSES,1
015E 741C                 220                 JE      TEST1
0160 EB0790               221                 JMP     BACK
0163 E9AF00               222   V_REP_SHORT   JMP     V_REP
0166 E98A00               223   H_REP_SHORT   JMP     H_REP
                          224
0169 26803E160001         225   BACK:         CMP     ES BIRD_HIT,1
```

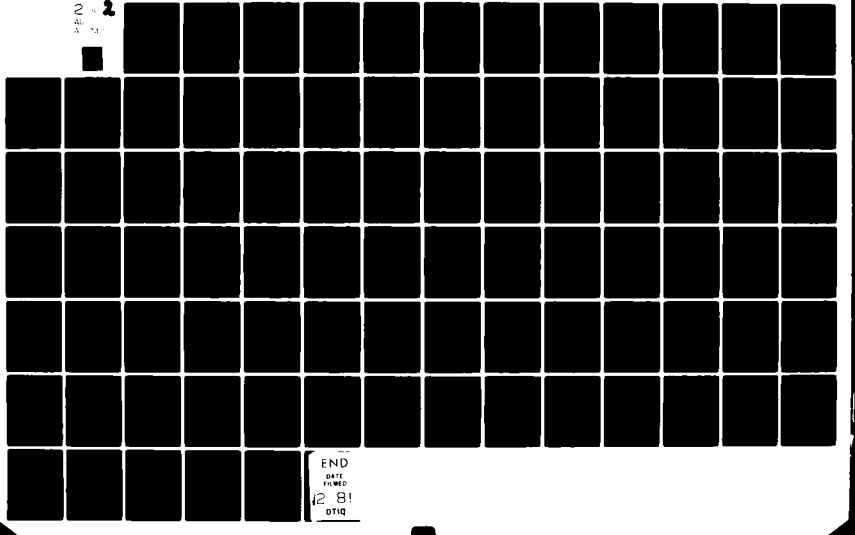
```
LOC  OBJ                  LINE    SOURCE

016F 7427                  226                JE      PRNT_HIT
0171 2680:3E1C0001         227                CMP     ES:GRND_BIRD,1
0177 747                   228                JE      PRNT_GRND_BRD
0179 E97BFF                229                JMP     WAY_UP_HERE
                           230
017C 2680:3E1C0001         231     TEST1:     CMP     ES:GRND_BIRD,1 ;WAIT FOR END OF FLIGHT BEFORE
0182 7406                  232                JE      PRINT_RESULT   ;PRINTING MESSAGES
0184 EBE3                  233                JMP     BACK
                           234
0186 E8FE00                235     DIST_FROM_TGT: CALL   MATROX_START_UP
0189 E80000        E       236                CALL    GROUND_EXPLOSION
018C E98704                237                JMP     DIST_FRO_TGT
018F E8F500                238     PRINT_RESULT: CALL    MATROX_START_UP
0192 E80000        E       239                CALL    GROUND_EXPLOSION
0195 E96804                240                JMP     PRINT_RESULTS
0198 E8EC00                241     PRNT_HIT   CALL    MATROX_START_UP
019B E80000        E       242                CALL    HIT_EXPLOSION
019E E80000        E       243                CALL    TANK_KILLED
01A1 E95405                244                JMP     PRINT_HIT
                           245
01A4 803E280001    R       246     ERROR_MSG_CHK: CMP    DIST_FRO_TGT_FLAG,1
01A9 7506                  247                JNE     SKIP
01AB 26C6061E0001          248                MOV     ES:HIT_SHORT,1
01B1 803E260001    R       249     SKIP       CMP     GRND_BIRD_FLAG,1
01B6 7506                  250                JNE     SKIP2
01B8 26C6061C0001          251                MOV     ES:GRND_BIRD,1
01BE 803E270001    R       252     SKIP2      CMP     HIT_FLAG,1
01C3 7506                  253                JNE     SKIP3
01C5 26C606160001          254                MOV     ES:BIRD_HIT,1
01CB 803E290001    R       255     SKIP3      CMP     RESULTS_FLAG,1
01D0 7506                  256                JNE     SKIP4
01D2 26C606170001          257                MOV     ES:BIRD_MISSES,1
01D8 803E240001    R       258     SKIP4      CMP     ERROR,1
01DD 740E                  259                JE      ERROR_MESG_LONG
01DF 26C6061D0000          260                MOV     ES:END_OF_RPY,0
01E5 C606000000    E       261                MOV     H_REP_FLAG,0
01EA E923FF                262                JMP     DO_IT_OVER
01ED E91A06                263     ERROR_MESG_LONG: JMP    ERROR_MESG
                           264
01F0 E9C905                265     PRNT_GRND_BRD JMP    PRINT_GRND_BIRD
                           266
01F3 C606230001    R       267     H_REP      MOV     REPLAY,1
01F8 26C606180000          268                MOV     ES:H_REP_REQ,0
01FE E80000        E       269                CALL    GRAPH_HREP
0201 E80000        E       270                CALL    GAE_START_UP
0204 E80000                271                CALL    MATROX_START_UP
0207 C606000001    E       272                MOV     H_REP_FLAG,1
020C 26C606190001          273                MOV     ES:H_REP_GO,1
0212 E9FEFE                274                JMP     DO_IT_OVER
                           275
0215 C606230001    R       276     V_REP      MOV     REPLAY,1
021A 26C6061A0000          277                MOV     ES:V_REP_REQ,0
0220 E80000        E       278                CALL    GRAPH_VREP
0223 E80000        E       279                CALL    GAE_START_UP
0226 E85E00                280                CALL    MATROX_START_UP ;THIS MIGHT BE "MATROX_CANCELL"
```

```
LOC  OBJ                  LINE     SOURCE

0229 C6060000001     E    281                 MOV     V_REP_FLAG,1
022E 26C606E1B0001        282                 MOV     ES:V_REP_GO,1
0234 E9C9FE               283                 JMP     DO_IT_OVER
                          284
0237 A00000          R    285     DO_IT_LONG  MOV     AL,XCNT
023A A20200          R    286                 MOV     XCNT_OLD,AL
023D A00100          R    287                 MOV     AL,YCNT
0240 A20300          R    288                 MOV     YCNT_OLD,AL
0243 A13400          R    289                 MOV     AX,YANG2
0246 A33100          R    290                 MOV     YANG2_OLD,AX
0249 A13E00          R    291                 MOV     AX,ZANG2
024C A33300          R    292                 MOV     ZANG2_OLD,AX
024F 268B16010D           293                 MOV     DX,ES:X_Y    ;THIS INST GETS XCNTR,YCNTR IN ONE GULP.
0254 88160000        R    294                 MOV     XCNT,DL
0258 883E0100        R    295                 MOV     YCNT,DH
025C 26A11000             296                 MOV     AX,ES:YANG
0260 A33900          R    297                 MOV     YANG2,AX
0263 26A11200             298                 MOV     AX,ES:ZANG
0267 A33B00          R    299                 MOV     ZANG2,AX
026A 26C606B70000         300                 MOV     ES:DATA_READY,0
0270 2680BE040001         301                 CMP     ES:BAD_MISS,1
0276 7403                 302                 JE      OVER2
0278 E80000          E    303                 CALL    GRAPH_GAE_POINT  ;PLOTS DOTS ON ADM-3.
027B E84D00               304     OVER2       CALL    START   ;PLOTS ROCKET AND SMOKE ON MATROX.
027E 26C606040000         305                 MOV     ES:BAD_MISS,0
0284 E989FE               306                 JMP     DO_IT_OVER
                          307
0287 C606070009      R    308     MATROX_START_UP:MOV     GSCALE_NUM,09D
028C A00700          R    309                 MOV     AL,GSCALE_NUM
028F A20600          R    310                 MOV     GSCALE_VAL,AL
0292 C70609000900    R    311                 MOV     SIZ,09D
0298 C6063E000A      R    312                 MOV     POP_LEVEL,10D
029D C6061D0003      R    313                 MOV     THREE,3D
02A2 C6063D0000      R    314                 MOV     FLAG,0
02A7 C6061F0000      R    315                 MOV     BACKGROUND,0
02AC C606210000      R    316                 MOV     COUNT,0
02B1 C6061E0000      R    317                 MOV     COUNT_EM,0
02B6 B000                 318                 MOV     AL,0
02B8 E612                 319                 OUT     SCROLL,AL
02BA A01F00          R    320                 MOV     AL,BACKGROUND
02BD E610                 321                 OUT     GSCALE,AL
02BF E414                 322                 IN      AL,ERASE
02C1 E412                 323     WAIT1       IN      AL,FLAGS
02C3 2401                 324                 AND     AL,1
02C5 74FA                 325                 JZ      WAIT1
02C7 C3                   326                 RET
                          327
02C8 E95401               328     STILL_SMOKE_SHORT:      JMP     STILL_SMOKE
02CB 803E230001      R    329     START       CMP     REPLAY,1
02D0 7408                 330                 JE      FIN_OF_MAT
02D2 813E0000F000    E    331                 CMP     ELAPSED_TIME,240D
02D8 7603                 332                 JNA     FIN_OF_MAT
02DA EB0490               333                 JMP     TO
02DD E9C601               334     FIN_OF_MAT  JMP     FIN_OF_MATPOS
02E0 A00700          R    335     TO          MOV     AL,GSCALE_NUM
```

AD-A107 461 ARMY PROJECT MANAGER FOR TRAINING DEVICES ORLANDO FL F/G 19/5
SIMULATED TANK ANTI-ARMOR GUNNERY SYSTEM (STAGS).(U)
NOV 81 A MARSHALL, B SHAW, H TOWLE
UNCLASSIFIED PM TRADE-RE-0010 NL



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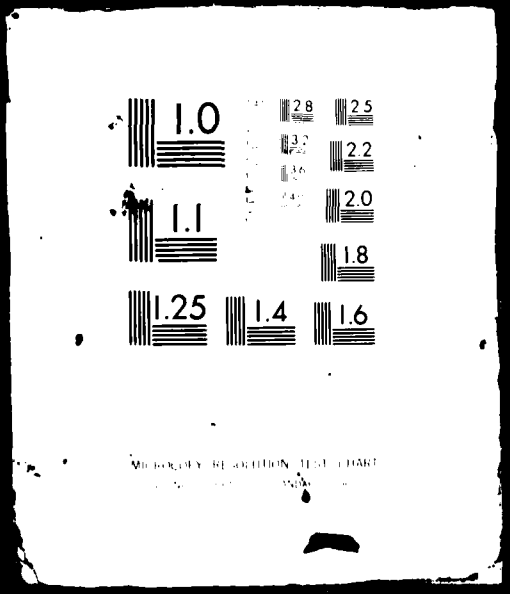

```
LOC  OBJ                  LINE    SOURCE

02E3 A20600         R     336             MOV     GSCALE_VAL,AL
02E6 E80000         E     337             CALL    SMOKE_CHECK
02E9 80FC01               338             CMP     AH,1
02EC 75DA                 339             JNE     STILL_SMOKE_SHORT
02EE A13900         R     340             MOV     AX,YANG2
02F1 A33500         R     341             MOV     YANG2_SAVE,AX
02F4 A13B00         R     342             MOV     AX,ZANG2
02F7 A33700         R     343             MOV     ZANG2_SAVE,AX
02FA A00600         R     344             MOV     AL,GSCALE_VAL
02FD A22000         R     345             MOV     GSCALE_SAVE,AL
0300 C606060000     R     346             MOV     GSCALE_VAL,0
                          347
0305 A00000         R     348             MOV     AL,XCNT
0308 A20400         R     349             MOV     XCNT_SAVE,AL
030B A00200         R     350             MOV     AL,XCNT_OLD
030E A20000         R     351             MOV     XCNT,AL
                          352
0311 A00100         R     353             MOV     AL,YCNT
0314 A20500         R     354             MOV     YCNT_SAVE,AL
0317 A00300         R     355             MOV     AL,YCNT_OLD
031A A20100         R     356             MOV     YCNT,AL
                          357
031D A13B00         R     358             MOV     AX,ZANG2
0320 A33700         R     359             MOV     ZANG2_SAVE,AX
0323 A13300         R     360             MOV     AX,ZANG2_OLD
0326 A33B00         R     361             MOV     ZANG2,AX
                          362
0329 A13900         R     363             MOV     AX,YANG2
032C A33500         R     364             MOV     YANG2_SAVE,AX
032F A13100         R     365             MOV     AX,YANG2_OLD
0332 A33900         R     366             MOV     YANG2,AX
                          367
0335 E86F01               368             CALL    OCT_DRAW
0338 A02000         R     369             MOV     AL,GSCALE_SAVE
033B A20600         R     370             MOV     GSCALE_VAL,AL
                          371
033E A00400         R     372             MOV     AL,XCNT_SAVE  ;THESE NEXT 4 INST. RESTORE XCNT,YCNT
0341 A20000         R     373             MOV     XCNT,AL       ;AFTER AN ERASE CYCLE.
0344 A00500         R     374             MOV     AL,YCNT_SAVE
0347 A20100         R     375             MOV     YCNT,AL
                          376
034A A13500         R     377             MOV     AX,YANG2_SAVE ;THESE NEXT 4 INST RESTORE YANG2,ZANG2
034D A33900         R     378             MOV     YANG2,AX      ;AFTER AN ERASE CYCLE.
0350 A13700         R     379             MOV     AX,ZANG2_SAVE
0353 A33B00         R     380             MOV     ZANG2,AX
0356 E80300               381             CALL    S_P_AND_GSCALE_SET
0359 E9BE00               382             JMP     SIZ_IS_SET2
                          383     ;*****************************************************************
035C A10000         E     384     S_P_AND_GSCALE_SET:     MOV     AX,ELAPSED_TIME
035F 3DFA01               385             CMP     ,506D  ; WAS 500
0362 7513                 386             JNE     WAIT0    ;START THE SIZ,POP,AND GSCALE SETTING ROUTINE
0364 C706090000000  R     387             MOV     SIZ,8D
036A C6060700008    R     388             MOV     GSCALE_NUM,8D
036F C6063E0008     R     389             MOV     POP_LEVEL,08D
0374 E9A200               390             JMP     SIZ_IS_SET
```

```
LOC  OBJ                  LINE    SOURCE

0377 3DF403               391     WAIT0:      CMP     ,1012D  ; WAS 1000
037A 7513                 392                 JNE     WAIT2
037C C70609000700   R     393                 MOV     SIZ,7D
0382 C606070007     R     394                 MOV     GSCALE_NUM,7D
0387 C6063E0007     R     395                 MOV     POP_LEVEL,7
038C E98A00               396                 JMP     SIZ_IS_SET
038F 3DEE05               397     WAIT2:      CMP     ,1518D  ;WAS 1500
0392 7513                 398                 JNE     WAIT3
0394 C70609000600   R     399                 MOV     SIZ,6D
039A C606070006     R     400                 MOV     GSCALE_NUM,6D
039F C6063E0006     R     401                 MOV     POP_LEVEL,6
03A4 EB7390               402                 JMP     SIZ_IS_SET
03A7 3DD207               403     WAIT3:      CMP     ,2002D  ;WAS 2000
03AA 7513                 404                 JNE     WAIT4
03AC C70609000500   R     405                 MOV     SIZ,5D
03B2 C606070005     R     406                 MOV     GSCALE_NUM,5D
03B7 C6063E0006     R     407                 MOV     POP_LEVEL,6
03BC EB5B90               408                 JMP     SIZ_IS_SET
03BF 3DC60B               409     WAIT4:      CMP     ,3014D ;WAS 3000
03C2 7513                 410                 JNE     WAIT7
03C4 C70609000400   R     411                 MOV     SIZ,4D
03CA C606070003     R     412                 MOV     GSCALE_NUM,3D
03CF C6063E0006     R     413                 MOV     POP_LEVEL,6
03D4 EB4390               414                 JMP     SIZ_IS_SET
03D7 3D9813               415     WAIT7:      CMP     ,5016D
03DA 7513                 416                 JNE     WAIT5
03DC C70609000400   R     417                 MOV     SIZ,4
03E2 C606070002     R     418                 MOV     GSCALE_NUM,2
03E7 C6063E0004     R     419                 MOV     POP_LEVEL,4
03EC EB2B90               420                 JMP     SIZ_IS_SET
03EF 3D6A1B               421     WAIT5:      CMP     ,7018D
03F2 7510                 422                 JNE     WAIT50
03F4 C70609000400   R     423                 MOV     SIZ,4D
03FA C606070001     R     424                 MOV     GSCALE_NUM,1
03FF C6063E0004     R     425                 MOV     POP_LEVEL,4
0404 3D3C23               426     WAIT50:     CMP     ,9020D
0407 7510                 427                 JNE     SIZ_IS_SET
0409 C70609000400   R     428                 MOV     SIZ,4D
040F C606070001     R     429                 MOV     GSCALE_NUM,1
0414 C6063E0002     R     430                 MOV     POP_LEVEL,2  ;THIS ENDS THE SIZ SETTING ROUTINE.
0419 C3                   431     SIZ_IS_SET: RET
                          432     ;*****************************************************************
041A C606210000     R     433     SIZ_IS_SET2:MOV     COUNT,0
                          434
041F E412                 435     STILL_SMOKE:IN      AL,FLAGS  ;CHECK TO SEE IF MATROX IS STILL BUSY
0421 3C01                 436                 CMP     AL,1      ;1=NOT BUSY, 0=BUSY
0423 740C                 437                 JE      GO_ON2    ;JMP IF MATROX IS NOT BUSY
0425 26A00300             438                 MOV     AL,ES:DATA_READY  ;MATROX IS BUSY=>CHECK FOR DATA READY
0429 3C01                 439                 CMP     AL,1
042B 75F2                 440                 JNE     STILL_SMOKE
042D C3                   441                 RET             ;IF DATA IS READY WE BAIL OUT AND RET
042E EB1B90               442     DRAW_OCT_SHORT: JMP DRAW_OCT
0431 803E210000     R     443     GO_ON2:     CMP     COUNT,0
0436 74F6                 444                 JE      DRAW_OCT_SHORT  ;DRAW NEW OCTAGON
0438 E821FF               445                 CALL    S_P_AND_GSCALE_SET ;SETS SIZ,POP DURING SMOKE GEN
```

```
LOC  OBJ                  LINE    SOURCE

043B E80000         E      446    SIZ_IS_SET3:    CALL    SMOKE_SET
043E A01F00         R      447                    MOV     AL,BACKGROUND
0441 E610                  448                    OUT     GSCALE,AL
0443 E414                  449                    IN      AL,ERASE  ;ERASE SCREEN
0445 C606210000     R      450                    MOV     COUNT,0
044A C3                    451                    RET
                           452
044B 803E210000     R      453    DRAW_OCT:       CMP     COUNT,0  ;ARE WE DRAWING OR ERASING? COUNT=0=DRAW
0450 752F                  454                    JNE     BY_PAS
0452 803E080001     R      455                    CMP     THRUSTER_FIRE,1 ;AND IS THERE A THRUSTER FIRE??
0457 7508                  456                    JNE     CHK_COUNT_EM
0459 C6061E0003     R      457                    MOV     COUNT_EM,3
045E EB0690                458                    JMP     DO_IT_HERE
0461 803E1E0000     R      459    CHK_COUNT_EM:   CMP     COUNT_EM,0
0466 7419                  460                    JE      BY_PAS
0468 C606080000     R      461    DO_IT_HERE:     MOV     THRUSTER_FIRE,0 ;ZERO THIS FLAG. AS WE HAVE SEEN IT.
046D FE0E1E00       R      462                    DEC     COUNT_EM
0471 A00600         R      463                    MOV     AL,GSCALE_VAL
0474 02063E00       R      464                    ADD     AL,POP_LEVEL ;IF THERE IS THEN INC GSCALE_VAL BY P_L
0478 3C0F                  465                    CMP     AL,15D  ;HOWEVER,GSCALE_VAL CANNOT BE GREATER THAN 15D
047A 7602                  466                    JBE     OK
047C B00F                  467                    MOV     AL,15D  ;IF GREATER THAN 15 THEN LOWER TO 15
047E A20600         R      468    OK:             MOV     GSCALE_VAL,AL
0481 A00600         R      469    BY_PAS:         MOV     AL,GSCALE_VAL
0484 38061F00       R      470                    CMP     BACKGROUND,AL
0488 7206                  471                    JB      THERE
048A C606210001     R      472                    MOV     COUNT,1
048F C3                    473                    RET             ;NO NEED TO DRAW OCTAGON IF SMOKE WILL HIDE IT
                           474
0490 26A01400              475    THERE:          MOV     AL,ES:BIRD_DTA_RDY
0494 3C01                  476                    CMP     AL,1
0496 75F8                  477                    JNE     THERE
0498 26C606140000          478                    MOV     ES:BIRD_DTA_RDY,0
049E E80600                479                    CALL    OCT_DRAW
04A1 C606210001     R      480                    MOV     COUNT,1
04A6 C3                    481    FIN_OF_MATROX:  RET
                           482
                           483
04A7 833E390000     R      484    OCT_DRAW:       CMP     YANG2,0
04AC 7509                  485                    JNE     NEXT
04AE C7062D000000   R      486                    MOV     YANG_SCALED,0
04B4 EB0C90                487                    JMP     NEXT1
04B7 A13900         R      488    NEXT:           MOV     AX,YANG2
04BA 99                    489                    CWD
04BB F73E2B00       R      490                    IDIV    TWO
04BF A32D00         R      491                    MOV     YANG_SCALED,AX
04C2 833E3B0000     R      492    NEXT1:          CMP     ZANG2,0
04C7 7509                  493                    JNE     NEXT2
04C9 C7062F000000   R      494                    MOV     ZANG_SCALED,0
04CF EB0C90                495                    JMP     NEXT3
04D2 A13B00         R      496    NEXT2:          MOV     AX,ZANG2
04D5 99                    497                    CWD
04D6 F73E2B00       R      498                    IDIV    TWO
04DA A32F00         R      499                    MOV     ZANG_SCALED,AX
04DD A10900         R      500    NEXT3:          MOV     AX,SIZ  ;THIS STARTS THE OCTAGON DRAW ROUTINE!!!
```

```
LOC  OBJ                  LINE    SOURCE

04E0 D1E8                  501             SHR     AX,1
04E2 BA7F00                502             MOV     DX,127D ;THIS WAS XCNT
04E5 03162D00        R     503             ADD     DX,YANG_SCALED
04E9 B97F00                504             MOV     CX,127D ;THIS WAS YCNT
04EC 030E2F00        R     505             ADD     CX,ZANG_SCALED
04F0 2BD0                  506             SUB     DX,AX
04F2 2BC8                  507             SUB     CX,AX
04F4 89160B00        R     508             MOV     XMIN,DX
04F8 890E0D00        R     509             MOV     YMIN,CX
04FC A10900          R     510             MOV     AX,SIZ
04FF 03C2                  511             ADD     AX,DX
0501 A30F00          R     512             MOV     XMAX,AX
0504 A10900          R     513             MOV     AX,SIZ
0507 03C1                  514             ADD     AX,CX
0509 A31100          R     515             MOV     YMAX,AX
050C A10900          R     516             MOV     AX,SIZ
050F F6361D00        R     517             DIV     THREE
0513 80FC01                518             CMP     AH,1
0516 7602                  519             JBE     GO_ON
0518 FEC0                  520             INC     AL
051A 8AD8                  521     GO_ON:  MOV     BL,AL
051C 32E4                  522             XOR     AH,AH
051E 03060D00        R     523             ADD     AX,YMIN
0522 A31900          R     524             MOV     ONE_THIRD,AX
0525 8AC3                  525             MOV     AL,BL
0527 D0E0                  526             SHL     AL,1
0529 32E4                  527             XOR     AH,AH
052B 03060D00        R     528             ADD     AX,YMIN
052F A31B00          R     529             MOV     TWO_THIRDS,AX
0532 A11900          R     530     FIRST_THIRD:    MOV     AX,ONE_THIRD
0535 2BC1                  531             SUB     AX,CX
0537 A31700          R     532             MOV     TMP_WRD,AX
053A 03060B00        R     533             ADD     AX,XMIN
053E A31500          R     534             MOV     XMIN_TMP,AX ;SETS XMIN
0541 A10F00          R     535             MOV     AX,XMAX
0544 2B061700        R     536             SUB     AX,TMP_WRD
0548 A31300          R     537             MOV     XMAX_TMP,AX  ;SETS XMAX
054B 803E3D0001      R     538             CMP     FLAG,1
0550 740D                  539             JE      OVER_THIS
0552 833E090005      R     540             CMP     SIZ,5
0557 7506                  541             JNE     OVER_THIS
0559 41                    542             INC     CX
055A C6063D0001      R     543             MOV     FLAG,1
055F E86600                544     OVER_THIS:      CALL    LINE
0562 41                    545             INC     CX
0563 3B0E1900        R     546             CMP     CX,ONE_THIRD
0567 7EC9                  547             JLE     FIRST_THIRD
0569 C6063D0000      R     548             MOV     FLAG,0
056E A10B00          R     549     SECOND_THIRD    MOV     AX,XMIN
0571 A31500          R     550             MOV     XMIN_TMP,AX
0574 A10F00          R     551             MOV     AX,XMAX
0577 A31300          R     552             MOV     XMAX_TMP,AX
057A E84B00                553     OVER1:  CALL    LINE
057D 41                    554             INC     CX
057E 3B0E1B00        R     555             CMP     CX,TWO_THIRDS
```

8086/8087/8088 MACRO ASSEMBLER MATROX

```
LOC  OBJ                  LINE    SOURCE

                           556                    JLE     OVER1
0582 7EF6                  557    LAST_THIRD:     MOV     AX,TWO_THIRDS
0584 A11B00          R     558                    MOV     BX,CX
0587 8BD9                  559                    SUB     BX,AX
0589 2BD8                  560                    MOV     AX,BX
058B 8BC3                  561                    MOV     TMP_WRD,AX
058D A31700          R     562                    ADD     AX,XMIN
0590 03060800        R     563                    MOV     XMIN_TMP,AX
0594 A31500          R     564                    MOV     AX,XMAX
0597 A10F00          R     565                    SUB     AX,TMP_WRD
059A 2B061700        R     566                    MOV     XMAX_TMP,AX
059E A31300          R     567                    CMP     FLAG,1
05A1 803E3D0001      R     568                    JE      OVER_THIS_2
05A6 7410                  569                    CMP     SIZ,4
05A8 833E090004      R     570                    JNE     OVER_THIS_2
05AD 7509                  571                    DEC     YMAX
05AF FF0E1100        R     572                    MOV     FLAG,1
05B3 C6063D0001      R     573    OVER_THIS_2:    CALL    LINE
05B8 E80C00                574                    INC     CX
05BB 41                    575                    CMP     CX,YMAX
05BC 3B0E1100        R     576                    JLE     LAST_THIRD
05C0 7EC2                  577                    MOV     FLAG,0
05C2 C6063D0000      R     578                    RET
05C7 C3                    579
                           580
                           581    ;THE ROUTINE DOT WILL NOT BE USED FOR A WHILE
                           582    ;               MOV     AL,SIZ
                           583    ;               CMP     AL,3
                           584    ;               JE      DOT
                           585    ;               SUB     SIZ,3D
                           586    ;               JMP     START
                           587    ;DOT:           MOV     DL,ES:X
                           588    ;               MOV     CL,ES:Y
                           589    ;               MOV     XMAX_TMP,DL
                           590    ;               CALL    OVER
                           591    ;               MOV     AL,BACKGROUND
                           592    ;               OUT     GSCALE,AL
                           593    ;               IN      AL,ERASE
                           594    ;               HLT
                           595
                           596
05C8 8B161500        R     597    LINE:           MOV     DX,XMIN_TMP
05CC 83F900                598                    CMP     CX,0D
05CF 7E20                  599                    JLE     DUN
05D1 81F9FF00              600                    CMP     CX,255D
05D5 7D1A                  601                    JGE     DUN
05D7 BBFF00                602                    MOV     BX,255D
05DA 2BD9                  603                    SUB     BX,CX
05DC 81FAFF00              604    OVER:           CMP     DX,255D
05E0 7D08                  605                    JGE     NO_WAY
05E2 83FA00                606                    CMP     DX,0D
05E5 7E03                  607                    JLE     NO_WAY
05E7 E80000                608                    CALL    OUTPUT
05EA 42                    609    NO_WAY:         INC     DX
05EB 3B161300        R     610                    CMP     DX,XMAX_TMP
```

```
LOC  OBJ                  LINE    SOURCE

05EF 7EEB                  611                JLE     OVER
05F1 C3                    612     DUN:       RET
                           613
05F2 8AC2                  614     OUTPUT:    MOV     AL,DL
05F4 E614                  615                OUT     XREG,AL
05F6 8AC3                  616                MOV     AL,BL
05F8 E616                  617                OUT     YREG,AL
05FA A00600          R     618                MOV     AL,GSCALE_VAL
05FD E610                  619                OUT     GSCALE,AL
05FF C3                    620                RET
                           621
0600 26C606170000          622     PRINT_RESULTS: MOV ES:BIRD_MISSES,0
0606 C606290001      R     623                MOV     RESULTS_FLAG,1
060B BAD800                624                MOV     DX,0D8H
060E B01D                  625                MOV     AL,0350 ;VECTOR MODE
0610 E80000          E     626                CALL    COUT
0613 B037                  627                MOV     AL,0670
0615 E80000          E     628                CALL    COUT
0618 B078                  629                MOV     AL,1700
061A E80000          E     630                CALL    COUT
061D B028                  631                MOV     AL,0500
061F E80000          E     632                CALL    COUT
0622 B040                  633                MOV     AL,1000
0624 E80000          E     634                CALL    COUT
0627 B01F                  635                MOV     AL,0370 ;ALPHA MODE
0629 E80000          E     636                CALL    COUT
062C B92000                637                MOV     CX,32D
062F BE2000                638                MOV     SI,OFFSET H_MIS_ASCII
0632 268A04                639     AGAIN:     MOV     AL,ES:[SI]
0635 E80000          E     640                CALL    COUT
0638 E81502                641                CALL    SHORT_DELAY
063B 46                    642                INC     SI
063C E2F4                  643                LOOP    AGAIN
063E B01D                  644                MOV     AL,0350
0640 E80000          E     645                CALL    COUT
0643 E9CAFA                646                JMP     DO_IT_OVER
                           647
0646 26C6061E0000          648     DIST_FRO_TGT: MOV  ES:HIT_SHORT,0
064C C606280001      R     649                MOV     DIST_FRO_TGT_FLAG,1
0651 BAD000                650                MOV     DX,0D0H
0654 B01D                  651                MOV     AL,0350 ;VECTOR MODE
0656 E80000          E     652                CALL    COUT
0659 B037                  653                MOV     AL,0670
065B E80000          E     654                CALL    COUT
065E B078                  655                MOV     AL,1700
0660 E80000          E     656                CALL    COUT
0663 B028                  657                MOV     AL,0500
0665 E80000          E     658                CALL    COUT
0668 B040                  659                MOV     AL,1000
066A E80000          E     660                CALL    COUT
066D B01F                  661                MOV     AL,0370 ;ALPHA MODE
066F E80000          E     662                CALL    COUT
0672 B91000                663                MOV     CX,16D
0675 BE4000                664                MOV     SI,OFFSET DIS_FRO_TGT
0678 268A04                665     AGN:       MOV     AL,ES:[SI]
```

```
LOC  OBJ                LINE    SOURCE

067B E80000         E    666                CALL    COUT
067E E8CF01              667                CALL    SHORT_DELAY
0681 46                  668                INC     SI
0682 E2F4                669                LOOP    AGN
0684 B01D                670                MOV     AL,350
0686 E80000         E    671                CALL    COUT
0689 E964FA              672                JMP     DO_IT_OVER
                         673
068C BAD800              674    THRUSTERS_MSG:  MOV     DX,0D8H
068F B01D                675                MOV     AL,0350
0691 E80000         E    676                CALL    COUT
0694 B020                677                MOV     AL,400
0696 E80000         E    678                CALL    COUT
0699 B060                679                MOV     AL,1400
069B E80000         E    680                CALL    COUT
069E B020                681                MOV     AL,400
06A0 E80000         E    682                CALL    COUT
06A3 B040                683                MOV     AL,1000
06A5 E80000         E    684                CALL    COUT
06A8 B01F                685                MOV     AL,370
06AA E80000         E    686                CALL    COUT
06AD B90B00              687                MOV     CX,(OFFSET END_OF_MESSAGE3 - OFFSET MESSAGE3)
06B0 BE3500         R    688                MOV     SI,OFFSET MESSAGE3
06B3 2E8A04              689    AGN7:       MOV     AL,CS:[SI]
06B6 E80000         E    690                CALL    COUT
06B9 E89401              691                CALL    SHORT_DELAY
06BC 46                  692                INC     SI
06BD E2F4                693                LOOP    AGN7
06BF B90200              694                MOV     CX,2
06C2 BE6B00              695                MOV     SI,OFFSET (IDEAL_THRUST +3)
06C5 268A04              696    IT_AGAIN:   MOV     AL,ES:[SI]
06C8 E80000         E    697                CALL    COUT
06CB E86201              698                CALL    SHORT_DELAY
06CE 46                  699                INC     SI
06CF E2F4                700                LOOP    IT_AGAIN
06D1 B049                701                MOV     AL,1110
06D3 E80000         E    702                CALL    COUT
06D6 B02F                703                MOV     AL,570
06D8 E80000         E    704                CALL    COUT
06DB B90200              705                MOV     CX,2
06DE BE5300              706                MOV     SI,OFFSET (ACTUAL_THRUST+3)
06E1 268A04              707    IT_AGAIN2:  MOV     AL,ES:[SI]
06E4 E80000         E    708                CALL    COUT
06E7 E86601              709                CALL    SHORT_DELAY
06EA 46                  710                INC     SI
06EB E2F4                711                LOOP    IT_AGAIN2
06ED B041                712                MOV     AL,1010
06EF E80000         E    713                CALL    COUT
06F2 B01D                714                MOV     AL,350
06F4 E80000         E    715                CALL    COUT
06F7 C3                  716                RET
                         717
                         718
06F8 E891FF              719    PRINT_HIT:  CALL    THRUSTERS_MSG
06FB C606220003     R    720                MOV     BLINK_COUNT,030
```

```
LOC  OBJ                  LINE    SOURCE

3700 C606270001     R      721                MOV    HIT_FLAG,1
0705 26C606160000          722                MOV    ES:BIRD_HIT,0
070B BAD800                723    PRINT_HIT_AGN: MOV DX,0D8H
070E B01D                  724                MOV    AL,0350 ;VECTOR MODE
0710 E80000         E      725                CALL   COUT
0713 B037                  726                MOV    AL,0670
0715 E80000         E      727                CALL   COUT
0718 B078                  728                MOV    AL,1700
071A E80000         E      729                CALL   COUT
071D B02E                  730                MOV    AL,0560
071F E80000         E      731                CALL   COUT
0722 B042                  732                MOV    AL,1020
0724 E80000         E      733                CALL   COUT
0727 B01F                  734                MOV    AL,0370 ;ALPHA MODE
0729 E80000         E      735                CALL   COUT
072C B048                  736                MOV    AL,1100 ;H
072E E80000         E      737                CALL   COUT
0731 B049                  738                MOV    AL,1110 ;I
0733 E80000         E      739                CALL   COUT
0736 B054                  740                MOV    AL,1240 ;T
0738 E80000         E      741                CALL   COUT
073B B021                  742                MOV    AL,0410 ;!
073D E80000         E      743                CALL   COUT
0740 B01D                  744                MOV    AL,0350
0742 E80000         E      745                CALL   COUT
0745 E8FE00                746                CALL   DELAY
0748 B01D                  747                MOV    AL,0350
074A E80000         E      748                CALL   COUT
074D 26803E1A0001          749                CMP    ES:V_REP_REQ,1 ;ARE "WE"NEEDED ANYWHERE??
0753 7464                  750                JE     DOWN
0755 26803E180001          751                CMP    ES:H_REP_REQ,1 ;ARE "WE" NEEDED ANYWHERE??
075E 745C                  752                JE     DOWN
0750 FE0E2200       R      753                DEC    BLINK_COUNT
0761 803E220000     R      754                CMP    BLINK_COUNT,0
0766 7451                  755                JE     DOWN
0768 B018                  756                MOV    AL,0330 ;
076A E80000         E      757                CALL   COUT    ;
076D B07F                  758                MOV    AL,1770 ;THESE FOUR INSTRUCTIONS CHANGE THE
076F E80000         E      759                CALL   COUT    ;DATA LEVEL TO BLACK!
0772 B037                  760                MOV    AL,670
0774 E80000         E      761                CALL   COUT
0777 B078                  762                MOV    AL,1700
0779 E80000         E      763                CALL   COUT
077C B02E                  764                MOV    AL,560
077E E80000         E      765                CALL   COUT
0781 B042                  766                MOV    AL,1020
0783 E80000         E      767                CALL   COUT
0786 B01F                  768                MOV    AL,370
0788 E80000         E      769                CALL   COUT ;ALPHA MODE
078B B048                  770                MOV    AL,1100 ;"BLACK 'H'"
078D E80000         E      771                CALL   COUT
0790 B049                  772                MOV    AL,1110 ;"BLACK 'I'"
0792 E80000         E      773                CALL   COUT
0795 B054                  774                MOV    AL,1240 ;"BLACK 'T'"
0797 E80000         E      775                CALL   COUT
```

```
LOC  OBJ                  LINE    SOURCE

079A B021                  776                 MOV     AL,410 ;"BLACK '1'"
079C E80000          E     777                 CALL    COUT
079F B021                  778                 MOV     AL,410
07A1 E80000          E     779                 CALL    COUT
07A4 B01E                  780                 MOV     AL,330 ;THESE NEXT FOUR INSTRUCTIONS SET
07A6 E80000          E     781                 CALL    COUT
07A9 B061                  782                 MOV     AL,1410 ;THE DATA LEVEL BACK TO WHITE
07AB E80000          E     783                 CALL    COUT
07AE B01D                  784                 MOV     AL,350 ;RETURN TO VECTOR MODE
07B0 E80000          E     785                 CALL    COUT
07B3 E89A00                786                 CALL    SHORT_DELAY
07B6 E952FF                787                 JMP     PRINT_HIT_AGN
07B9 E954F9                788     DOWN:       JMP     DO_IT_OVER
                           789
07BC E8C1FE                790     PRINT_GRND_BIRD:    CALL    THRUSTERS_MSG
07BF 26C6061C0000          791                 MOV     ES:GRND_BIRD,0
07C5 C6062600001     R     792                 MOV     GRND_BIRD_FLAG,1
07CA BAD800                793                 MOV     DX,0D8H
07CD B01D                  794                 MOV     AL,0350
07CF E80000          E     795                 CALL    COUT
07D2 B037                  796                 MOV     AL,0670
07D4 E80000          E     797                 CALL    COUT
07D7 B061                  798                 MOV     AL,1410
07D9 E80000          E     799                 CALL    COUT
07DC B02E                  800                 MOV     AL,0560
07DE E80000          E     801                 CALL    COUT
07E1 B042                  802                 MOV     AL,1020
07E3 E80000          E     803                 CALL    COUT
07E6 B01F                  804                 MOV     AL,0370 ;ALPHA MODE
07E8 E80000          E     805                 CALL    COUT
07EB B90E00                806                 MOV     CX,(OFFSET FIN_OF_MESSAGE - OFFSET MESSAGE)
07EE BE0000          R     807                 MOV     SI,OFFSET MESSAGE
07F1 2E8A04                808     REPEAT:     MOV     AL,CS:[SI]
07F4 E80000          E     809                 CALL    COUT
07F7 E85600                810                 CALL    SHORT_DELAY
07FA 46                    811                 INC     SI
07FB E2F4                  812                 LOOP    REPEAT
07FD E910F9                813                 JMP     DO_IT_OVER
                           814
0800 C606240000      R     815     ERROR_MESG:     MOV     ERROR,0
0805 C606250001      R     816                 MOV     ERROR_MESG_FLAG,1
080A 26C6061D0000          817                 MOV     ES:END_OF_RPV,0
0810 BAD800                818                 MOV     DX,0D8H
0813 B01D                  819                 MOV     AL,350
0815 E80000          E     820                 CALL    COUT
0818 B020                  821                 MOV     AL,400
081A E80000          E     822                 CALL    COUT
081D B060                  823                 MOV     AL,1400
081F E80000          E     824                 CALL    COUT
0822 B02E                  825                 MOV     AL,560
0824 E80000          E     826                 CALL    COUT
0827 B041                  827                 MOV     AL,1010
0829 E80000          E     828                 CALL    COUT
082C B01F                  829                 MOV     AL,370 ;ALPHA MODE
082E E80000          E     830                 CALL    COUT
```

```
LOC  OBJ                  LINE    SOURCE

0831 B92700               831                     MOV     CX,(OFFSET FIN_OF_MESSAGE2 - OFFSET MESSAGE2)
0834 BE0E00         R     832                     MOV     SI,OFFSET MESSAGE2
0837 2E8A04               833     REPT2:          MOV     AL,CS:[SI]
083A E80000         E     834                     CALL    COUT
083D E81000               835                     CALL    SHORT_DELAY
0840 46                   836                     INC     SI
0841 E2F4                 837                     LOOP    REPT2
0843 E9CAFB               838                     JMP     DO_IT_OVER
                          839
0846 B850C3               840     DELAY:          MOV     AX,50000D
0849 48                   841     AGAIN_N_AGAIN:  DEC     AX
084A 3D0000               842                     CMP     AX,0
084D 75FA                 843                     JNE     AGAIN_N_AGAIN
084F C3                   844                     RET
0850 B81027               845     SHORT_DELAY:    MOV     AX,10000D
0853 48                   846     AGN_N_AGN:      DEC     AX
0854 3D0000               847                     CMP     AX,0
0857 75FA                 848                     JNE     AGN_N_AGN
0859 C3                   849                     RET
                          850
085A B400                 851     CHECK_FOR_B:    MOV     AH,0
085C E40E                 852                     IN      AL,0DEH   ;USART_STATUS
085E 2402                 853                     AND     AL,2
0860 7404                 854                     JZ      GO_BACK
0862 E40C                 855                     IN      AL,0DCH
0864 B401                 856                     MOV     AH,1
0866 C3                   857     GO_BACK:        RET
                          858
0867 2688160100           859     CALIBRATE:      MOV     DX,ES:X_Y
086C B064                 860                     MOV     AL,64H
086E 2AC2                 861                     SUB     AL,DL
0870 2600060500           862                     ADD     ES:OFFSET_X,AL
0875 B064                 863                     MOV     AL,64H
0877 2AC6                 864                     SUB     AL,DH
0879 2600060600           865                     ADD     ES:OFFSET_Y,AL
087E C3                   866                     RET
                          867
                          868     CODE            ENDS
                          869
                          870                     END     CS:DRIVER,DS:DATA_GROUP,SS:STACK_SEG
```

ASSEMBLY COMPLETE, NO ERRORS FOUND

```
SERIES-III 8086/8087/8088 MACRO ASSEMBLER V1.0 ASSEMBLY OF MODULE SMOKEY_THE_BARE
OBJECT MODULE PLACED IN :F2:SMOKE.OBJ
INVOCATION LINE CONTROLS:  DEBUG


LOC  OBJ                  LINE     SOURCE

                            1      NAME    SMOKEY_THE_BARE
                            2
                            3      DATA_GROUP      GROUP   DAT_SEG,DATA_SEG
                            4      CGROUP          GROUP   CODE
                            5
                            6      ASSUME CS:CGROUP,DS:DATA_GROUP
                            7
                            8      PUBLIC  SMOKE_CHECK,SMOKE_SET,SMOKE_START_UP
                            9
----                        10      DATA_SEG        SEGMENT PUBLIC
                            11      EXTRN   BACKGROUND: BYTE
----                        12      DATA_SEG        ENDS
                            13
----                        14      DAT_SEG SEGMENT PUBLIC
0000 (1                     15      DONE            DB      1 DUP(?)
     ??
     )
0001 (1                     16      SERIES_NO       DB      1 DUP(?)
     ??
     )
----                        17      DAT_SEG ENDS
                            18
----                        19      CODE            SEGMENT PUBLIC  'CODE'
0000 C606000000     R       20      SMOKE_START_UP: MOV     DONE,0
0005 C606010001     R       21                      MOV     SERIES_NO,1
000A C3                     22                      RET
                            23
000B 803E000000     R       24      SMOKE_CHECK:    CMP     DONE,0
0010 7405                   25                      JE      GO_BACK
0012 B401                   26                      MOV     AH,1
0014 EB0390                 27                      JMP     GO_BACK2
0017 B400                   28      GO_BACK:        MOV     AH,0
0019 C3                     29      GO_BACK2:       RET
                            30
001A 803E000000     R       31      SMOKE_SET:      CMP     DONE,0
001F 7403                   32                      JE      START
0021 B401                   33                      MOV     AH,1
0023 C3                     34                      RET
                            35
                            36
0024 803E010001     R       37      START:          CMP     SERIES_NO,1
0029 741F                   38                      JE      SERIES_1
0026 803E010002     R       39                      CMP     SERIES_NO,2
0030 742A                   40                      JE      SERIES_2
0032 803E010003     R       41                      CMP     SERIES_NO,3
0037 7435                   42                      JE      SERIES_3
0039 803E010004     R       43                      CMP     SERIES_NO,4
003E 7440                   44                      JE      SERIES_4
0040 803E010005     R       45                      CMP     SERIES_NO,5
0045 7446                   46                      JE      SERIES_5
```

```
LOC  OBJ                  LINE    SOURCE

0047 E85B90                47                      JMP     SERIES_6
                           48
004A FE060000         E    49      SERIES_1:       INC     BACKGROUND
004E 803E00000F       E    50                      CMP     BACKGROUND,15D
0053 7401                  51                      JE      DONE1
0055 C3                    52                      RET
0056 C606010002       R    53      DONE1:          MOV     SERIES_NO,2
005B C3                    54                      RET
                           55
005C FE0E0000         E    56      SERIES_2:       DEC     BACKGROUND
0060 803E000008       E    57                      CMP     BACKGROUND,8D
0065 7401                  58                      JE      DONE2
0067 C3                    59                      RET
0068 C606010003       R    60      DONE2:          MOV     SERIES_NO,3
006D C3                    61                      RET
                           62
006E FE060000         E    63      SERIES_3:       INC     BACKGROUND
0072 803E00000F       E    64                      CMP     BACKGROUND,15D
0077 7401                  65                      JE      DONE3
0079 C3                    66                      RET
007A C606010004       R    67      DONE3:          MOV     SERIES_NO,4
007F C3                    68                      RET
                           69
0080 FE0E0000         E    70      SERIES_4:       DEC     BACKGROUND
0084 803E000004       E    71                      CMP     BACKGROUND,4
0089 7401                  72                      JE      DONE4
008B C3                    73                      RET
008C C606010005       R    74      DONE4:          MOV     SERIES_NO,5
0091 C3                    75                      RET
                           76
0092 FE060000         E    77      SERIES_5        INC     BACKGROUND
0096 803E000008       E    78                      CMP     BACKGROUND,8D
009B 7401                  79                      JE      DONE5
009D C3                    80                      RET
009E C606010006       R    81      DONE5:          MOV     SERIES_NO,6
00A3 C3                    82                      RET
                           83
00A4 FE0E0000         E    84      SERIES_6:       DEC     BACKGROUND
00A8 803E000000       E    85                      CMP     BACKGROUND,0
00AD 7401                  86                      JE      FINISHED
00AF C3                    87                      RET
00B0 C606000001       R    88      FINISHED:       MOV     DONE,1
00B5 C2                    89                      RET
                           90
----                       91      CODE            ENDS
                           92                      END

ASSEMBLY COMPLETE, NO ERRORS FOUND
```

```
RIES-III 8086/8087/8088 MACRO ASSEMBLER V1 0 ASSEMBLY OF MODULE PETER_RABBIT
BJECT MODULE PLACED IN  F2 GAE OBJ
INVOCATION LINE CONTROLS  DEBUG


LOC  OBJ                  LINE     SOURCE

                             1     NAME    PETER_RABBIT
                             2
                             3     DATA_GROUP      GROUP   GAE_SEG,DATA_SEG,XFER_SEG
                             4     CGROUP          GROUP   CODE
                             5
                             6     EXTRN GRAPH1 NEAR,FIRE_BIRD BYTE
                             7     PUBLIC GRAPH_GAE_POINT,GAE_START_UP,GAE_GT_FOV,H_REP_FLAG,V_REP_FLAG
                             8     PUBLIC ELAPSED_TIME
                             9     EXTRN COUT NEAR
                            10
                            11     ASSUME CS CGROUP,DS DATA_GROUP
                            12
----                        13     XFER_SEG        SEGMENT AT 0600H
                            14     EXTRN BAD_MISS BYTE,START_BIT BYTE,DATA_READY BYTE
----                        15     XFER_SEG ENDS
                            16
  --                        17     DATA_SEG        SEGMENT PUBLIC
                            18     EXTRN YCNT BYTE,XCNT BYTE,THRUSTER_FIRE BYTE,ERROR BYTE
--                          19     DATA_SEG ENDS
                            20
----                        21     GAE_SEG SEGMENT PUBLIC
                            22
0000 (1                     23     BIT_BUCKET              DB      1 DUP(?)
      ??
      )
0001 (1                     24     ELAPSED_TIME            DW      1 DUP(?)
      ????
      )
0003 (1                     25     FIFTEEN                 DW      1 DUP(?)
      ????
      )
0005 (1                     26     FOUR                    DW      1 DUP(?)
      ????
      )
                            27     V_SCALE_FACTOR          EQU     03D
0007 (1                     28     H_X_GRAPHIC_POINT       DW      1 DUP(?)
      ????
      )
0009 (1                     29     H_Y_GRAPHIC_POINT       DW      1 DUP(?)
      ????
      )
000B (1                     30     HGAE_OFFSET             DW      1 DUP(?)
      ????
      )
000D (1                     31     FIFTY                   DW      1 DUP(?)
      ????
      )
000F (1                     32     H_REP_FLAG              DB      1 DUP(?)
      ??
      )
```

```
LOC  OBJ                  LINE    SOURCE

 010 (1                     33    V_REP_FLAG          DB      1 DUP(?)
     ??
     )
 011 (1                     34    BIG_MISS            DB      1 DUP(?)
     ??
     )
0012 (1                     35    THRUSTER_FIRED      DB      1 DUP(?)
     ??
     )
                            36
----                        37    GAE_SEG             ENDS
                            38
----                        39    CODE    SEGMENT PUBLIC 'CODE'
                            40
0000 C606000000     R       41    GAE_START_UP:       MOV     BIT_BUCKET,0
0005 C606110000     R       42                        MOV     BIG_MISS,0
000A C70601000000   R       43                        MOV     ELAPSED_TIME,0
0010 C70603000F00   R       44                        MOV     FIFTEEN,15D
0016 C70605000400   R       45                        MOV     FOUR,4D
001C C7060D003200   R       46                        MOV     FIFTY,50D
0022 C7060E00D502   R       47                        MOV     HGAE_OFFSET,725D
0028 C606120000     R       48                        MOV     THRUSTER_FIRED,0
002D C6060F0000     R       49                        MOV     H_REP_FLAG,0
0032 C606100000     R       50                        MOV     V_REP_FLAG,0
0037 C3                     51                        RET
                            52
0038 BAD800                 53    GAE_GT_FOV:         MOV     DX,0D8H
003B 26C606000000   E       54                        MOV     ES:DATA_READY,0
0041 B01D                   55                        MOV     AL,035D ;VECTOR MODE
0043 E80000         E       56                        CALL    COUT
0046 E80900                 57                        CALL    CONTINUE
0049 C3                     58                        RET
                            59
004A BAC800                 60    GRAPH_GAE_POINT:          MOV     DX,0C8H
004D B01C                   61                        MOV     AL,034D
004F E80000         E       62                        CALL    COUT
0052 33C0                   63    CONTINUE:           XOR     AX,AX
0054 803E000001     R       64                        CMP     BIT_BUCKET,1 ;IF SET THEN WE'RE ON PASS TWO
0059 740D                   65                        JE      NORMAL      ;I.E.,LEFT SIDE OF SCREEN
005B 803E100001     R       66                        CMP     V_REP_FLAG,1
0060 7506                   67                        JNE     NORMAL
0062 C7060E004D03   R       68                        MOV     HGAE_OFFSET,845D
0068 8B1E0E00       R       69    NORMAL:             MOV     BX,HGAE_OFFSET
006C 81FBD502               70                        CMP     BX,725D
0070 7412                   71                        JZ      X1
0072 81FB4D03               72                        CMP     BX,845D
0076 740C                   73                        JZ      X1
0078 A00000         E       74                        MOV     AL,YCNT
007B B3C8                   75                        MOV     BL,200D
007D 2AD8                   76                        SUB     BL,AL
007F 8AC3                   77                        MOV     AL,BL
0081 EB0490                 78                        JMP     ONWARD
0084 A00000         E       79    X1:                 MOV     AL,XCNT
0087 B400                   80    ONWARD:             MOV     AH,0
0089 F7260300       R       81                        MUL     FIFTEEN
```

```
LOC  OBJ                  LINE    SOURCE

008D F7?e0500       R      82                    DIV     FOUR
0091 83FA02                83                    CMP     DX,02D
0094 7C01                  84                    JL      GO_ON
0096 40                    85                    INC     AX
0097 8B1E0000       R      86    GO_ON:          MOV     BX,HGRE_OFFSET
009B B97701                87                    MOV     CX,3750
009E 81FB0502              88                    CMP     BX,7250
00A2 7413                  89                    JZ      X2
00A4 81FB4D03              90                    CMP     BX,845D
00A8 7400                  91                    JZ      X2
00AA 8A1E0000       E      92                    MOV     BL,YCNT
00AE B2C8                  93                    MOV     DL,200D
00B0 2AD3                  94                    SUB     DL,BL
00B2 8ADA                  95                    MOV     BL,DL
00B4 EB0590                96                    JMP     ONWARD1
00B7 8A1E0000       E      97    X2:             MOV     BL,XCNT
00BB 80FB64                98    ONWARD1:        CMP     BL,100D
00BE 7314                  99                    JNB     SUBT
00C0 2BC8                 100    AD:             SUB     CX,AX
00C2 8BC1                 101                    MOV     AX,CX
00C4 8B1E0000       R     102                    MOV     BX,HGRE_OFFSET
00C8 03060000       R     103                    ADD     AX,HGRE_OFFSET
00CC 3DF203               104                    CMP     AX,1010D
00CF 7F15                 105                    JG      ONWARD3
00D1 EB0D90               106                    JMP     GO_ON5
00D4 2BC1                 107    SUBT:           SUB     AX,CX
00D6 8B1E0B00       R     108                    MOV     BX,HGRE_OFFSET
00DA 2BD8                 109                    SUB     BX,AX
00DC 7E11                 110                    JLE     ONWARD2
00DE 8BC3                 111                    MOV     AX,BX
00E0 A30700         R     112    GO_ON5:         MOV     H_X_GRAPHIC_POINT,AX
00E3 EB1090               113                    JMP     OVER_THERE
00E6 C7060700F203   R     114    ONWARD3:        MOV     H_X_GRAPHIC_POINT,1010D
00EC EB0790               115                    JMP     OVER_THERE
00EF C706070000000  R     116    ONWARD2:        MOV     H_X_GRAPHIC_POINT,0
00F5 E82B01               117    OVER_THERE:     CALL    TIME
00F8 8B0300               118                    MOV     BX,Y_SCALE_FACTOR
00FB F7E3                 119                    MUL     BX
00FD 05B80B               120                    ADD     AX,3000D
0100 F7360D00       R     121                    DIV     FIFTY
0104 83FA19               122                    CMP     DX,25D
0107 7C01                 123                    JL      GO_ON4
0109 40                   124                    INC     AX
                          125
010A 3D0B03               126    GO_ON4:         CMP     AX,779D  ;IS TIME GOING TO EXCEED THE TOP OF
010D 7E03                 127                    JNG     GO_ON6   ;THE ADM-3 SCREEN?? IF YES THEN REDUCE
010F B80B03               128                    MOV     AX,779D  ;THE MAGNITUDE TO 779D.
                          129
0112 A30900         R     130    GO_ON6:         MOV     H_Y_GRAPHIC_POINT,AX
0115 BAD800               131                    MOV     DX,0D8H
                          132    ;THIS ROUTINE OUTPUTS HIGH Y, LOW Y, HIIGH X AND LOW X FOR HORIZONTAL
                          133    ;AIM ERROR TO ADM3.
0118 26803E000001   E     134                    CMP     ES:BAD_MISS,1  ;BAD_MISS???
011E 7505                 135                    JNE     BY_PASS  ;IF YES THEN
0120 B01D                 136                    MOV     AL,035D  ;GO TO VECTOR MODE
```

```
LOC  OBJ                  LINE    SOURCE

0122 E80000         E     137                       CALL    COUT    ;ELSE,STAY IN POINT MODE
                          138
0125 A10900         R     139     BY_PASS:          MOV     AX,H_Y_GRAPHIC_POINT
0128 B105                 140                       MOV     CL,5
012A D3E8                 141                       SHR     AX,CL
012C 241F                 142                       AND     AL,00011111B
012E 0C20                 143                       OR      AL,00100000B
0130 E80000         E     144                       CALL    COUT
0133 A10900         R     145                       MOV     AX,H_Y_GRAPHIC_POINT
0136 241F                 146                       AND     AL,00011111B
0138 0C60                 147                       OR      AL,01100000B
013A E80000         E     148                       CALL    COUT
013D A10700         R     149                       MOV     AX,H_X_GRAPHIC_POINT
0140 B105                 150                       MOV     CL,5
0142 D3E8                 151                       SHR     AX,CL
0144 241F                 152                       AND     AL,00011111B
0146 0C20                 153                       OR      AL,00100000B
0148 E80000         E     154                       CALL    COUT
014B A10700         R     155                       MOV     AX,H_X_GRAPHIC_POINT
014E 241F                 156                       AND     AL,00011111B
0150 0C40                 157                       OR      AL,01000000B
0152 E80000         E     158                       CALL    COUT
0155 26803E000001   E     159                       CMP     ES:BAD_MISS,1
015B 751E                 160                       JNE     BY_PASS2
015D B01F                 161                       MOV     AL,0370 ;ALPHA MODE
015F E80000         E     162                       CALL    COUT
0162 803E120001     R     163                       CMP     THRUSTER_FIRED,1
0167 7508                 164                       JNE     AST
0169 B05F                 165                       MOV     AL,1370 ;OUTPUT A '_' WHEN A THRUSTER FIRES.
016B E80000         E     166                       CALL    COUT
016E EB0B90               167                       JMP     BY_PASS2
0171 B02A                 168     AST:              MOV     AL,0520 ;OUTPUT ASTERISK
0173 E80000         E     169                       CALL    COUT
0176 B01D                 170                       MOV     AL,0350
0178 E80000         E     171                       CALL    COUT
017B 803E000001     R     172     BY_PASS2:         CMP     BIT_BUCKET,1
0180 743A                 173                       JE      AGAIN2
0182 832E010016     R     174                       SUB     ELAPSED_TIME,220  ;USED TO BE 20
0187 C6060000001    R     175                       MOV     BIT_BUCKET,1
018C 803E0F0001     R     176                       CMP     H_REP_FLAG,1  ;IF REP THEN A DIFFERENT OFFSET
0191 7409                 177                       JE      ABNORMAL      ,FROM REGULAR IS USED
0193 C7060B00C300   R     178                       MOV     HGRE_OFFSET,1950  ;CHANGE THE OFFSETS TO GET
0199 EB0790               179                       JMP     ACROSS            ;READY TO DO THE VERTICALGRE
019C C7060B00EF00   R     180     ABNORMAL:         MOV     HGRE_OFFSET,2390
01A2 803E0000C8     E     181     ACROSS:           CMP     YCNT,2000
01A7 7210                 182                       JB      AROUND
01A9 26C606000001   E     183                       MOV     ES:BAD_MISS,1
01AF C606000001     E     184                       MOV     ERROR,1
01B4 C606000C8      E     185                       MOV     YCNT,2000
01B9 E996FE               186     AROUND:           JMP     CONTINUE
01BC C606000000     R     187     AGAIN2:           MOV     BIT_BUCKET,0
01C1 803E120001     R     188                       CMP     THRUSTER_FIRED,1
01C6 7464                 189                       JE      HERE
01C8 26803E000001   E     190                       CMP     ES:FIRE_BIRD,1
01CE 755C                 191                       JNE     HERE
```

```
LOC  OBJ                  LINE    SOURCE

01D0 C606120001     R      192                     MOV     THRUSTER_FIRED,1
01D5 C606000001     E      193                     MOV     THRUSTER_FIRE,1
01DA C606110001     R      194                     MOV     BIG_MISS,1
01DF 26C606000001   E      195                     MOV     ES:BAD_MISS,1
01E5 C606000001     R      196                     MOV     BIT_BUCKET,1
01EA E83600                197                     CALL    TIME
01ED 832E010016     R      198                     SUB     ELAPSED_TIME,22D
01F2 2D1600                199                     SUB     AX,22D
01F5 BB0300                200                     MOV     BX,Y_SCALE_FACTOR
01F8 F7E3                  201                     MUL     BX
01FA 05B80B                202                     ADD     AX,30000
01FD F7360D00       R      203                     DIV     FIFTY
0201 83FA19                204                     CMP     DX,25D
0204 7C01                  205                     JL      GO_ON_ARND
0206 40                    206                     INC     AX
0207 3D0B03                207     GO_ON_ARND:     CMP     AX,7790
020A 7603                  208                     JNA     GO_ON_ARND2
020C B80B03                209                     MOV     AX,7790
020F A30900         R      210     GO_ON_ARND2:    MOV     H_Y_GRAPHIC_POINT,AX
0212 C706070000000  R      211                     MOV     H_X_GRAPHIC_POINT,0
0218 BAD800                212                     MOV     DX,0D8H
021B B01D                  213                     MOV     AL,35D
021D E80000         E      214                     CALL    COUT
0220 E90CFF                215                     JMP     BY_PASS
                           216
                           217
0223 8306010016     R      218     TIME:           ADD     ELAPSED_TIME,22D
0228 A10100         R      219                     MOV     AX,ELAPSED_TIME
022B C3                    220                     RET
                           221
022C BAD800                222     HERE:           MOV     DX,0D8H
022F B01C                  223                     MOV     AL,0340  ;CHANGE RGB TO POINT MODE
0231 E80000         E      224                     CALL    COUT
0234 C7060B000502   R      225                     MOV     HGRE_OFFSET,725D
                           226
023A 803E110001     R      227                     CMP     BIG_MISS,1
023F 7516                  228                     JNE     LEAVE
0241 26C606000000   E      229                     MOV     ES:BAD_MISS,0
0247 C606000000     R      230                     MOV     BIT_BUCKET,0
024C 26C606000000   E      231                     MOV     ES:FIRE_BIRD,0
0252 C606110000     R      232                     MOV     BIG_MISS,0
0257 C606120000     R      233     LEAVE:          MOV     THRUSTER_FIRED,0
025C C3                    234                     RET
                           235
                           236
----                       237     CODE            ENDS
                           238
                           239                     END

ASSEMBLY COMPLETE, NO ERRORS FOUND
```

```
SERIES-III 8086/8087/8088 MACRO ASSEMBLER V1.0 ASSEMBLY OF MODULE MARLYN_MONROE
OBJECT MODULE PLACED IN :F2:RETRO.OBJ
INVOCATION LINE CONTROLS:  DEBUG


LOC  OBJ                  LINE     SOURCE

                             1     NAME    MARLYN_MONROE
                             2     PUBLIC          GRAPH1,COUT,CIN,GRAPH_VREP,GRAPH_HREP,USART_SET_UP_FOR_ADM
                             3     PUBLIC          DELAY_3
                             4
                             5     CGROUP  GROUP   CODE
                             6
                             7     ASSUME  CS:CGROUP
                             8
----                         9     CODE    SEGMENT PUBLIC  'CODE'
                            10
  00D6                      11     TIMER_CNTRL     EQU     0D6H
  00D4                      12     TIMER_CNTRL2    EQU     0D4H
  00B6                      13     CNTR2_MODE      EQU     0B6H
  0004                      14     LOW_ADM         EQU     04H
  0000                      15     HIGH_ADM        EQU     00H
  00DA                      16     USART_CNTRL     EQU     0DAH
  0040                      17     USART_RESET     EQU     40H
  004E                      18     USART_MODE      EQU     4EH
  0037                      19     USART_CMMND     EQU     37H
  00DE                      20     USART_STATUS    EQU     0DEH
                            21
  0075                      22     DELAY_VAL       EQU     75H
                            23
                            24
0000 1D                     25     PICPOINTS       DB      1DH,21H,7CH,2FH,54H,23H,6CH,2FH,54H,440,1440,0650,1270
0001 21
0002 7C
0003 2F
0004 54
0005 23
0006 6C
0007 2F
0008 54
0009 24
000A 64
000B 35
000C 57
000D 36                     26     PICPOINTS1      DB      0660,1570,0660,1120,0660,1570,0660,1360,440,1440,0670,1230,43
                                   0,1540,0750,1260,410
000E 6F
000F 36
0010 4A
0011 36
0012 6F
0013 36
0014 5E
0015 24
0016 64
0017 37
0018 53
```

```
LOC  OBJ                  LINE    SOURCE

0019 23
001A 6C
001B 3D
001C 56
001D 21
001E 7C                    27     PICPOINTS2      DB      1740,0750,1260,410,1740,570,1240,0350,410,1740,0660,1250,0660
                                  ,1570,0660
001F 3D
0020 56
0021 21
0022 7C
0023 2F
0024 54
0025 1D
0026 21
0027 7C
0028 36
0029 55
002A 36
002B 6F
002C 36
002D 55                    28     PICPOINTS3      DB      1250,340,640,1640,660,1230,620,1700,660,1230,680,1740,660,123
                                  0,570,1480,660,1230,550,1440,660,1230,530
002E 1C
002F 34
0030 74
0031 36
0032 53
0033 32
0034 78
0035 36
0036 53
0037 30
0038 7C
0039 36
003A 53
003B 2F
003C 60
003D 36
003E 53
003F 2D
0040 64
0041 36
0042 53
0043 28
0044 68                    29     PICPOINTS4      DB      1500,660,1230,510,1540,660,1230,470,1600,660,1230,450,1640,66
                                  0,1230,430,1700,660,1230,640,1640,660
0045 36
0046 53
0047 29
0048 6C
0049 36
004A 53
004B 27
004C 70
```

```
LOC  OBJ                  LINE     SOURCE

004D 36
004E 53
004F 25
0050 74
0051 36
0052 53
0053 23
0054 78
0055 36
0056 53
0057 34
0058 74
0059 36
005A 57                     30     PICPOINTS5      DB      1270,620,1700,660
005B 32
005C 78
005D 36
005E 57                     31     PICPOINTS6      DB      1270,680,1740,660,1270,570,1400,660,1270,550,1440,660,1270,53
                                   0,1580,660,1270,510
005F 30
0060 7C
0061 36
0062 57
0063 2F
0064 60
0065 36
0066 57
0067 2D
0068 64
0069 36
006A 57
006B 2B
006C 68
006D 36
006E 57
006F 29
0070 6C                     32     PICPOINTS7      DB      1540,660,1270,470,1680,660,1270
0071 36
0072 57
0073 27
0074 70
0075 36
0076 57
0077 25                     33     PICPOINTS8      DB      450,1640,660,1270,430,1700,660,1270,350,570,1640,560,1140,370
                                   ,1240
0078 74
0079 36
007A 57
007B 23
007C 78
007D 36
007E 57
007F 1D
0080 2F
0081 74
```

```
LOC  OBJ                  LINE     SOURCE

0082 2E
0083 4C
0084 1F
0085 54
0086 1D                    34     PICPOINTS9      DB      350,560,1660,560,1140,370,1110,350,550,1700,560,1140,370,1150
0087 2E
0088 76
0089 2E
008A 4C
008B 1F
008C 49
008D 1D
008E 2D
008F 78
0090 2E
0091 4C
0092 1F
0093 4D
0094 1D                    35     PICPOINTS10     DB      350,540,1720,560,1140,370,1050,350,520,1760,560,1140,370,1230
                                  ,530,520,1400,560,1140
0095 2C
0096 7A
0097 2E
0098 4C
0099 1F
009A 45
009B 1D
009C 2A
009D 7E
009E 2E
009F 4C
00A0 1F
00A1 53
00A2 1D
00A3 2A
00A4 60
00A5 2E
00A6 4C
00A7 1F                    36     PICPOINTS11     DB      370,1050,350,510,1420,560,1140,370,1030,350,610,1770,560,1220
                                  ,630,1440,560,1220
00A8 45
00A9 1D
00AA 29
00AB 62
00AC 2E
00AD 4C
00AE 1F
00AF 43
00B0 1D
00B1 31
00B2 7F
00B3 2E
00B4 52
00B5 33
00B6 64
```

```
LOC  OBJ                  LINE     SOURCE

00B7 2E
00B8 52
00B9 32                    37     PICPOINTS12     DB      620,1660,560,1380,350,620,1660,560,1140,630,1440,560,1220
00BA 76
00BB 2E
00BC 58
00BD 1D
00BE 32
00BF 76
00C0 2E
00C1 4C
00C2 33
00C3 64
00C4 2E
00C5 52
00C6 1D                    38     PICPOINTS13     DB      350,440,1660,570,1240,370,500,1140,1050,1060,1240,510,350,440
                                  ,1660,710,1310
00C7 24
00C8 76
00C9 2F
00CA 54
00CB 1F
00CC 28
00CD 4C
00CE 45
00CF 46
00D0 54
00D1 29
00D2 1D
00D3 24
00D4 76
00D5 39
00D6 59
00D7 1F                    39     PICPOINTS14     DB      370,500,1220,1110,1070,1100,1240,510
00D8 28
00D9 52
00DA 49
00DB 47
00DC 48
00DD 54
00DE 29
00DF 1C                    40     PICPOINTS15     DB      340,410,1710,570,1240,410,1660,570,1240,410,1710,580,1030,410
                                  ,1660,680,1030
00E0 21
00E1 79
00E2 2F
00E3 54
00E4 21
00E5 76
00E6 2F
00E7 54
00E8 21
00E9 79
00EA 30
00EB 43
```

```
LOC  OBJ                  LINE    SOURCE

00EC 21
00ED 76
00EE 30
00EF 43
00F0 21                     41    PICPOINTS16     DB      410,1710,680,1220,410,1660,680,1220,410,1710,610,1010,410,166
                                  0,610,1010
00F1 79
00F2 30
00F3 52
00F4 21
00F5 76
00F6 30
00F7 52
00F8 21
00F9 79
00FA 31
00FB 41
00FC 21
00FD 76
00FE 31
00FF 41
0100 21                     42    PICPOINTS17     DB      410,1710,610,1200,410,1660,610,1200,410,1710,610,1370,410,166
                                  0,610,1370
0101 79
0102 31
0103 50
0104 21
0105 76
0106 31
0107 50
0108 21
0109 79
010A 31
010B 5F
010C 21
010D 76
010E 31
010F 5F
0110 21                     43    PICPOINTS18     DB      410,1710,620,1160,410,1660,620,1160,410,1710,620,1350,410,166
                                  0,620,1350
0111 79
0112 32
0113 4E
0114 21
0115 76
0116 32
0117 4E
0118 21
0119 79
011A 32
011B 50
011C 21
011D 76
011E 32
011F 50
```

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LOC  OBJ                  LINE    SOURCE

0120 21                    44     PICPOINTS19     DB      410,1710,630,1140,410,1660,630,1140,410,1710,630,1330,410,166
                                  0,630,1330
0121 79
0122 33
0123 4C
0124 21
0125 76
0126 33
0127 4C
0128 21
0129 79
012A 33
012B 5B
012C 21
012D 76
012E 33
012F 5B
0130 21                    45     PICPOINTS20     DB      410,1710,640,1120,410,1660,640,1120,410,1710,640,1310,410,166
                                  0,640,1310
0131 79
0132 34
0133 4A
0134 21
0135 76
0136 34
0137 4A
0138 21
0139 79
013A 34
013B 59
013C 21
013D 76
013E 34
013F 59
0140 21                    46     PICPOINTS21     DB      410,1710,650,1100,410,1660,650,1100,410,1710,650,1270,410,166
                                  0,650,1270
0141 79
0142 35
0143 48
0144 21
0145 76
0146 35
0147 48
0148 21
0149 79
014A 35
014B 57
014C 21
014D 76
014E 35
014F 57
0150 21                    47     PICPOINTS22     DB      410,1710,660,1060,410,1660,660,1060,410,1710,660,1250,410,166
                                  0,660,1250
0151 79
0152 36
```

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LOC  OBJ                  LINE     SOURCE

0152 46
0154 21
0155 76
0156 36
0157 46
0158 21
0159 79
015A 36
015B 55
015C 21
015D 76
015E 36
015F 55
0160 21                   48       PICPOINTS23     DB      410,1710,670,1040,410,1660,670,1040,410,1710,670,1230,410,166
                                   0,670,1230

0161 79
0162 37
0163 44
0164 21
0165 76
0166 37
0167 44
0168 21
0169 79
016A 37
016B 53
016C 21
016D 76
016E 37
016F 53
0170 21                   49       PICPOINTS24     DB      410,1710,700,1020,410,1660,700,1020,410,1710,700,1210,410,166
                                   0,700,1210

0171 79
0172 38
0173 42
0174 21
0175 76
0176 38
0177 42
0178 21
0179 79
017A 38
017B 51
017C 21
017D 76
017E 38
017F 51
0180 21                   50       PICPOINTS25     DB      410,1710,710,1000,410,1660,710,1000,410,1710,710,1170,410,166
                                   0,710,1170

0181 79
0182 39
0183 40
0184 21
0185 76
0186 39
```

```
LOC  OBJ                  LINE     SOURCE

0187 40
0188 21
0189 79
018A 39
018B 4F
018C 21
018D 76
018E 39
018F 4F
0190 21                     51     PICPOINTS26     DB      410,1710,710,1360,410,1660,710,1360,410,1710,720,1150,410,166
                                   0,720,1150
0191 79
0192 39
0193 5E
0194 21
0195 76
0196 39
0197 5E
0198 21
0199 79
019A 3A
019B 4D
019C 21
019D 76
019E 3A
019F 4D
01A0 21                     52     PICPOINTS27     DB      410,1710,720,1340,410,1660,720,1340,410,1710,730,1130,410,166
                                   0,730,1130
01A1 79
01A2 3A
01A3 5C
01A4 21
01A5 76
01A6 3A
01A7 5C
01A8 21
01A9 79
01AA 3B
01AB 4B
01AC 21
01AD 76
01AE 3B
01AF 4B
01B0 21                     53     PICPOINTS28     DB      410,1710,730,1320,410,1660,730,1320,410,1710,740,1110,410,166
                                   0,740,1110
01B1 79
01B2 3B
01B3 5A
01B4 21
01B5 76
01B6 3B
01B7 5A
01B8 21
01B9 79
01BA 3C
```

```
LOC  OBJ                  LINE    SOURCE

01BB 49
01BC 21
01BD 76
01BE 3C
01BF 49
01C0 21                     54    PICPOINTS29     DB      410,1710,740,1380,410,1660,740,1300,410,1710,750,1070,410,166
                                  0,750,1070
01C1 79
01C2 3C
01C3 58
01C4 21
01C5 76
01C6 3C
01C7 58
01C8 21
01C9 79
01CA 3D
01CB 47
01CC 21
01CD 76
01CE 3D
01CF 47
01D0 21                     55    PICPOINTS30     DB      410,1710,750,1260,410,1660,750,1260
01D1 79
01D2 3D
01D3 56
01D4 21
01D5 76
01D6 3D
01D7 56
                            56
01D8 10                     57    PICPOINTS31     DB      350,410,1740,420,1140,420,1710,420,1140,440,1650,450,1850,660
                                  ,1570,450,1310
01D9 21
01DA 7C
01DB 22
01DC 4C
01DD 22
01DE 79
01DF 22
01E0 4C
01E1 24
01E2 75
01E3 25
01E4 45
01E5 36
01E6 6F
01E7 25
01E8 59
01E9 36                     58    PICPOINTS32     DB      660,1570,460,1140,440,1650,470,1010,420,1710,550,1230,410,174
                                  0,550,1230
01EA 6F
01EB 26
01EC 4C
01ED 24
```

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LOC  OBJ                  LINE     SOURCE

01EE 75
01EF 27
01F0 41
01F1 22
01F2 79
01F3 20
01F4 53
01F5 21
01F6 70
01F7 20
01F8 53
01F9 21                    59     PICPOINTS33     DB      410,1740,420,1140,350,410,1740,460,1030,660,1570,460,1030
01FA 70
01FB 22
01FC 4C
01FD 10
01FE 21
01FF 70
0200 26
0201 43
0202 36
0203 6F
0204 26
0205 43
0206 10                    60     PICPOINTS34     DB      340,640,1640,460,1010,620,1780,460,1010,680,1740,460,1010,570
                                  ,1400,460,1010
0207 34
0208 74
0209 26
020A 41
020B 32
020C 78
020D 26
020E 41
020F 70
0210 70
0211 26
0212 41
0213 3F
0214 60
0215 26
0216 41
0217 20                    61     PICPOINTS35     DB      550,1440,460,1010,530,1580,460,1010,510,1540,460,1010,470,160
                                  0,460,1010
0218 64
0219 26
021A 41
021B 2B
021C 6C
021D 26
021E 41
021F 29
0220 6C
0221 26
0222 41
```

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LOC  OBJ                  LINE    SOURCE

0223 27
0224 70
0225 26
0226 41
0227 25                     62    PICPOINTS36     DB      450,1640,460,1010,430,1700,460,1010,640,1640,460,1050,620,170
                                  0,460,1050
0228 74
0229 26
022A 41
022B 23
022C 78
022D 26
022E 41
022F 34
0230 74
0231 26
0232 45
0233 32
0234 78
0235 26
0236 45
0237 30                     63    PICPOINTS37     DB      680,1740,460,1050,570,1400,460,1050,550,1440,460,1050,530,150
                                  0,460,1050
0238 7C
0239 26
023A 45
023B 2F
023C 60
023D 26
023E 45
023F 20
0240 64
0241 26
0242 45
0243 2B
0244 68
0245 26
0246 45
0247 29                     64    PICPOINTS38     DB      510,1540,460,1050,470,1600,460,1050,450,1640,460,1050,430,170
                                  0,460,1050
0248 6C
0249 26
024A 45
024B 27
024C 70
024D 26
024E 45
024F 25
0250 74
0251 26
0252 45
0253 23
0254 78
0255 26
0256 45
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LOC	OBJ	LINE	SOURCE		
0257	21	65	PICPOINTS39	DB	410,1710,420,1140,410,1660,420,1140,410,1710,420,1330,410,166
			0,420,1330		
0258	79				
0259	22				
025A	4C				
025B	21				
025C	76				
025D	22				
025E	4C				
025F	21				
0260	79				
0261	22				
0262	5B				
0263	21				
0264	7A				
0265	22				
0266	5B				
0267	21	66	PICPOINTS40	DB	410,1710,430,1120,410,1660,430,1120,410,1710,430,1310,410,166
			0,430,1310		
0268	79				
0269	23				
026A	4A				
026B	21				
026C	76				
026D	23				
026E	4A				
026F	21				
0270	79				
0271	23				
0272	59				
0273	21				
0274	76				
0275	23				
0276	59				
0277	21	67	PICPOINTS41	DB	410,1710,440,1100,410,1660,440,1100,410,1710,440,1270,410,166
			0,440,1270		
0278	79				
0279	24				
027A	48				
027B	21				
027C	76				
027D	24				
027E	48				
027F	21				
0280	79				
0281	24				
0282	57				
0283	21				
0284	76				
0285	24				
0286	57				
0287	21	68	PICPOINTS42	DB	410,1710,450,1060,410,1660,450,1060,410,1710,450,1250,410,166
			0,450,1250		
0288	79				
0289	25				

```
LOC  OBJ                  LINE     SOURCE

0284 46
0285 21
0286 76
0287 25
0288 46
0289 21
028A 79
028B 25
028C 55
028D 21
028E 76
028F 25
0290 55
0291 21                     69     PICPOINTS43     DB      410,1710,460,1020,410,1660,460,1020,410,1710,460,1230,410,166
                                   0,460,1230
0292 79
0293 26
0294 42
0295 21
0296 76
0297 26
0298 42
0299 21
029A 79
029B 26
029C 53
029D 21
029E 76
029F 26
02A0 53
02A1 21                     70     PICPOINTS44     DB      410,1710,470,1020,410,1660,470,1020,410,1710,470,1210,410,166
                                   0,470,1210
02A2 79
02A3 27
02A4 42
02A5 21
02A6 76
02A7 27
02A8 42
02A9 21
02AA 79
02AB 27
02AC 51
02AD 21
02AE 76
02AF 27
02B0 51
02B1 21                     71     PICPOINTS45     DB      410,1710,500,1000,410,1660,500,1000,410,1710,500,1170,410,166
                                   0,500,1170
02B2 79
02B3 28
02B4 40
02B5 21
02B6 76
02B7 28
```

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LOC  OBJ                  LINE    SOURCE

026E 40
026F 21
0270 79
0271 28
0272 4F
0273 21
0274 76
0275 28
0276 4F
0277 21                    72     PICPOINTS46     DB      410,1710,500,1360,410,1660,500,1360,410,1710,510,1150,410,166
                                  0,510,1150
0278 79
0279 28
027A 5E
027B 21
027C 76
027D 28
027E 5E
027F 21
0280 79
0281 29
0282 4D
0283 21
0284 76
0285 29
0286 4D
0287 21                    73     PICPOINTS47     DB      410,1710,510,1340,410,1660,510,1340,410,1710,520,1130,410,166
                                  0,520,1130
0288 79
0289 29
028A 5C
028B 21
028C 76
028D 29
028E 5C
028F 21
0290 79
0291 2A
0292 4B
0293 21
0294 76
0295 2A
0296 4B
0297 21                    74     PICPOINTS48     DB      410,1710,520,1320,410,1660,520,1320,410,1710,530,1110,410,166
                                  0,530,1110
0298 79
0299 2A
029A 5A
029B 21
029C 76
029D 2A
029E 5A
029F 21
02A0 79
02A1 2B
```

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LOC  OBJ                  LINE    SOURCE

02F2 49
02F3 21
02F4 76
02F5 28
02F6 49
02F7 21                    75     PICPOINTS49     DB      410,1710,530,1300,410,1660,530,1300,410,1710,540,1070,410,166
                                  0,540,1070
02F8 79
02F9 28
02FA 58
02FB 21
02FC 76
02FD 28
02FE 58
02FF 21
0300 79
0301 20
0302 47
0303 21
0304 76
0305 20
0306 47
0307 21                    76     PICPOINTS50     DB      410,1710,540,1260,410,1660,540,1260,410,1710,550,1050,410,166
                                  0,550,1050
0308 79
0309 20
030A 56
030B 21
030C 76
030D 20
030E 56
030F 21
0310 79
0311 20
0312 45
0313 21
0314 76
0315 20
0316 45
0317 21                    77     PICPOINTS51     DB      410,1710,550,1230,410,1660,550,1230
0318 79
0319 20
031A 52
031B 21
031C 76
031D 20
031E 55
031F 10                    78     PICPOINTS52     DB      350,440,1660,420,1140,370,500,1250,1200,510,350,440,1660,500,
                                  1240
0320 24
0321 76
0322 22
0323 40
0324 1F
0325 28
```

```
LOC  OBJ                  LINE     SOURCE

0326 55
0327 50
0328 29
0329 1D
032A 24
032B 76
032C 28
032D 54
032E 1F                    79     PICPOINTS53     DB      370,500,1040,1170,1270,1160,510,150,300
032F 28
0330 44
0331 4F
0332 57
0333 4E
0334 29
0335 00
0336 18
                           80
                           81
                           82
0337                       83     LAST    LABEL   WORD
                           84
                           85     ;*****************************************************************************
                           86     ;                           START VERTICAL REP  DATA
                           87     ;*****************************************************************************
                           88
                           89     ;START VERTICAL ENVELOPE
0337 1D                    90     VREP1           DB      350,410,1740,620,1350,420,1720,620,1350,440,1660,710,
                                                     1170
0338 41
0339 70
033A 72
033B 50
033C 22
033D 7A
033E 72
033F 50
0340 24
0341 76
0342 39
0343 4F
0344 76                    91     VREP2           DB      660,1570,720,1040,660,1570,720,1260,440,1660,730,
                                                     1130,420,1720,760,1030
0345 6F
0346 7A
0348 44
0348 26
0349 6F
034A 3A
034B 56
034C 24
034D 76
034E 3B
034F 4B
0350 62
```

```
LOC  OBJ                  LINE    SOURCE

0351 7A
0352 3E
0353 4C
0354 21                    92     VREP3       DB      410,1740,760,1030,410,1740,620,1350,350,410,1740,720,
                                                   1150,660,1570,720,1150
0355 70
0356 3E
0357 4C
0358 21
0359 70
035A 32
035B 50
035C 1D
035D 21
035E 70
035F 3A
0360 4D
0361 36
0362 6F
0363 3A
0364 4D
                           93     ;END VERT ENVELOPE
                           94     ;START WORDS "UP,DOWN" ON RIGHT SIDE OF SCREEN
0365 15                    95     VREP4       DB      350,440,1660,750,1210,370,580,1250,1200,510,350,440,
                                                   1660,650,1340,370,580,1040,1170,1270,1160,510
0366 24
0367 76
0368 30
0369 51
036A 1F
036B 28
036C 55
036D 50
036E 29
036F 1D
0370 24
0371 76
0372 35
0373 5C
0374 1F
0375 28
0376 44
0377 4F
0378 57
0379 4E
037A 29
                           96     ;END
                           97     ;START VERTICAL REP MIL TICS
037B 10                    98     VREP5       DB      340,410,1710,620,1350,410,1660,620,1350,410,1710,630,
                                                   1140,410,1660
037C 21
037D 79
037E 32
037F 50
0380 21
```

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LOC  OBJ                  LINE     SOURCE

0381 76
0382 32
0383 5D
0384 21
0385 79
0386 33
0387 4C
0388 21
0389 76
038A 33                    99     VREP55          DB      630,1140,410,1710,630,1330,410,1660,630,1330
038B 4C
038C 21
038D 79
038E 33
038F 5B
0390 21
0391 76
0392 33
0393 5B
0394 21                   100     VREP6           DB      410,1710,640,1120,410,1660,640,1120,410,1710,640,1310,
                                                          410,1660,640,1310
0395 79
0396 34
0397 4A
0398 21
0399 76
039A 34
039B 4A
039C 21
039D 79
039E 34
039F 59
03A0 21
03A1 76
03A2 34
03A3 59
03A4 21                   101     VREP7           DB      410,1710,650,1160,410,1660,650,1160,410,1710,650,1270,
                                                          410,1660,650,1270
03A5 79
03A6 35
03A7 48
03A8 21
03A9 76
03AA 35
03AB 48
03AC 21
03AD 79
03AE 35
03AF 57
03B0 21
03B1 76
03B2 35
03B3 57
03B4 21                   102     VREP8           DB      410,1710,660,1060,410,1660,660,1060,410,1710,660,1250,
                                                          410,1660,660,1250
```

```
LOC  OBJ                  LINE     SOURCE

03B5 79
03B6 36
03B7 46
03B8 21
03B9 76
03BA 36
03BB 46
03BC 21
03BD 79
03BE 36
03BF 55
03C0 21
03C1 76
03C2 36
03C3 55
03C4 21                   103      VREP9           DB      410,1710,670,1040,410,1660,670,1040,410,1710,670,1230,
                                                           410,1660,670,1230
03C5 79
03C6 37
03C7 44
03C8 21
03C9 76
03CA 37
03CB 44
03CC 21
03CD 79
03CE 37
03CF 53
03D0 21
03D1 76
03D2 37
03D3 53
03D4 21                   104      VREP10          DB      410,1710,700,1020,410,1660,700,1020,410,1710,700,1210,
                                                           410,1660,700,1210
03D5 79
03D6 38
03D7 42
03D8 21
03D9 76
03DA 38
03DB 42
03DC 21
03DD 79
03DE 38
03DF 51
03E0 21
03E1 76
03E2 38
03E3 51
03E4 21                   105      VREP11          DB      410,1710,710,1000,410,1660,710,1000,410,1710,710,1170,
                                                           410,1660,710,1170
03E5 79
03E6 39
03E7 40
03E8 21
```

```
LOC  OBJ                  LINE     SOURCE

03E9 76
03EA 39
03EB 40
03EC 21
03ED 79
03EE 39
03EF 4F
03F0 21
03F1 76
03F2 39
03F3 4F
03F4 21                   106      VREP12          DB      410, 1710, 710, 1360, 410, 1660, 710, 1360, 410, 1710, 720, 1150,
                                                           410, 1660, 720, 1150
03F5 79
03F6 39
03F7 5E
03F8 21
03F9 76
03FA 39
03FB 5E
03FC 21
03FD 79
03FE 3A
03FF 4D
0400 21
0401 76
0402 3A
0403 4D
0404 21                   107      VREP13          DB      410, 1710, 720, 1340, 410, 1660, 720, 1340, 410, 1710, 730, 1130,
                                                           410, 1660, 730, 1130
0405 79
0406 3A
0407 5C
0408 21
0409 76
040A 3A
040B 5C
040C 21
040D 79
040E 3B
040F 4B
0410 21
0411 76
0412 3B
0413 4B
0414 21                   108      VREP14          DB      410, 1710, 730, 1320, 410, 1660, 730, 1320, 410, 1710, 740, 1110,
                                                           410, 1660, 740, 1110
0415 79
0416 3B
0417 5A
0418 21
0419 76
041A 3B
041B 5A
041C 21
```

```
LOC  OBJ                LINE    SOURCE

041D 79
041E 7C
041F 49
0420 21
0421 76
0422 3C
0423 49
0424 21                 109     VREP15          DB      410,1710,740,1300,410,1660,740,1300,410,1710,750,1070
0425 79
0426 7C
0427 5[illegible]
0428 21
0429 76
042A 3C
042B 58
042C 21
042D 79
042E 3D
042F 47
0430 21                 110     VREP05          DB      410,1660,750,1070,410,1710,750,1260,410,1660,750,1260
0431 76
0432 3D
0433 47
0434 21
0435 79
0436 3D
0437 56
0438 21
0439 76
043A 3D
043B 56
                        111     ;END
                        112     ;START TIME TICS
043C 1C                 113     VREP16          DB      340,640,1640,720,1130,620,1700,720,1130,600,1740,720,
                                                1130,570,1400,720,1130
043D 34
043E 74
043F 3A
0440 4B
0441 1C
0442 78
0443 3A
0444 4B
0445 30
0446 7C
0447 3A
0448 4B
0449 2F
044A 6[illegible]
044B 3A
044C 4B
044D 2D                 114     VREP17          DB      550,1440,720,1130,530,1500,720,1130,510,1540,720,1130,
                                                470,1600,720,1130
044E 64
044F 3A
```

LOC	OBJ	LINE	SOURCE		
0450	4F				
0451	2B				
0452	68				
0453	7A				
0454	4B				
0455	29				
0456	67				
0457	7A				
0458	4B				
0459	27				
045A	79				
045B	3A				
045C	4B				
045D	25	115	VREP18	DB	450,1640,720,1130,430,1700,720,1130,640,1640,720,1170, 620,1700,720,1170
045E	74				
045F	3A				
0460	4B				
0461	2C				
0462	78				
0463	3A				
0464	4B				
0465	24				
0466	74				
0467	7A				
0468	4F				
0469	32				
046A	79				
046B	7A				
046C	4F				
046D	30	116	VREP19	DB	680,1740,720,1170,570,1480,720,1170,550,1440,720,1170, 530,1500,720,1170
046E	7C				
046F	3A				
0470	4F				
0471	2F				
0472	69				
0473	7A				
0474	4F				
0475	2D				
0476	64				
0477	39				
0478	4F				
0479	2B				
047A	66				
047B	3A				
047C	4F				
047D	29	117	VREP20	DB	510,1540,720,1170,470,1600,720,1170,450,1640,720,1170, 430,1700,720,1170
047E	6F				
047F	3A				
0480	4F				
0481	27				
0482	70				
0483	3A				

```
                        LINE    SOURCE

0484 4F
0485 2E
0486 74
0487 3A
0488 4F
0489 2E
048A 72
048B 3A
048C 4F

                        118     .END
                        119     ;START "TIME-SEC ARROW"
048D 1D                 120     VREP21          DB      350,570,1640,560,1140,370,1240,350,560,1660,560,1140,
                                                        370,1110,350,550,1700,560,1140,370,1150
048E 2F
048F 74
0490 2E
0491 4F
0492 1F
0493 54
0494 1D
0495 2E
0496 76
0497 2E
0498 4C
0499 1F
049A 49
049B 1D
049C 2D
049D 78
049E 2E
049F 4C
04A0 1F
04A1 4D
04A2 1D                 121     VREP22          DB      350,540,1720,560,1140,370,1050,350,520,1760,560,1140
04A7 2C
04A4 7A
04A5 2E
04A6 4C
04A7 1F
04A8 45
04A9 1D
04AA 2A
04AB 7A
04AC 2E
04AD 4C
04AE 1F                 122     VREP02          DB      370,1230,350,520,1400,560,1140,370,1050,350,510,1420
04AF 53
04B0 1D
04B1 2A
04B2 6A
04B3 2E
04B4 4C
04B5 1F
04B6 47
04B7 1D
```

```
LOC  OBJ                 LINE     SOURCE

04B8 29
04B9 62
04BA 2E                   123     VREP23          DB      560,1140,370,1030
04BB 40
04BC 1F
04BD 41
04BE 1D                   124     VREP24          DB      350,610,1770,560,1220,630,1440,560,1220,620,1660,560
04BF 71
04C0 7F
04C1 2E
04C2 52
04C3 33
04C4 64
04C5 2E
04C6 52
04C7 32
04C8 76
04C9 2E
04CA 58                   125     VREP04          DB      1300,350,620,1660,560,1140,630,1440,560,1220
04CB 1D
04CC 32
04CD 76
04CE 2E
04CF 40
04D0 33
04D1 64
04D2 2E
04D3 52
                          126     ;END
                          127     ;START LEFT ENVELOPE
04D4 1D                   128     VREP25          DB      350,410,1740,560,1110,410,1740,420,1000,660,1570,420,
                                                          1000
04D5 21
04D6 7C
04D7 2E
04D8 43
04D9 21
04DA 7C
04DB 22
04DC 40
04DD 36
04DE 6F
04DF 22
04E0 40
                          129     ;END
                          130     ;START "MISSILE ABOVE GROUND (FEET)"
04E1 1D                   131     VREP26          DB      350,400,1760,420,1100,370,1150,1110,1230,1230
                                                          1110,1140,1050,400,1010,1020,1170,1260,1050
04E2 20
04E3 7E
04E4 22
04E5 48
04E6 1F
04E7 40
04E8 49
```

```
LOC  OBJ                  LINE     SOURCE

04E9 52
04EA 52
04EB 49
04EC 4C
04ED 45
04EE 20
04EF 41
04F0 42
04F1 4F
04F2 56
04F3 45
04F4 20                   132      VREP86          DB      480,1070,1220,1170,1250,1160,1040,480,580,1060,1050,
                                                            1050,1240,510,350
04F5 47
04F6 52
04F7 4F
04F8 55
04F9 4E
04FA 44
04FB 20
04FC 28
04FD 46
04FE 45
04FF 45
0500 54
0501 2D
0502 1D
                          133      .END
                          134      .START "GROUND LEVEL"
0503 1D                   135      VREP86          DB      350,630,1440,410,1100,370,1070,350,620,1460,410,1100,
                                                            370,1220,350,610,1500,410,1100,370,1170
0504 33
0505 64
0506 21
0507 48
0508 1F
0509 47
050A 1D
050B 32
050C 66
050D 21
050E 48
050F 1F
0510 52
0511 1D
0512 31
0513 68
0514 21
0515 48
0516 1F
0517 4F
0518 1D                   136      VREP27          DB      350,600,1520,410,1100,370,1250,350,570,1540,410,1100,
                                                            370,1160,350,560,1560,410,1100,370,1040
0519 38
051A 64
```

```
LOC  OBJ                  LINE     SOURCE

051B 21
051C 48
051D 1F
051E 55
051F 1D
0520 2F
0521 6C
0522 21
0523 48
0524 1F
0525 4E
0526 1D
0527 2E
0528 6E
0529 21
052A 48
052B 1F
052C 44
052D 1D                   137      VREP28          DB      350,540,1620,410,1100,370,1140,350,530,1640,410,1100,
                                                            370,1050,350,520,1660,410,1100,370,1260
052E 2C
052F 72
0530 21
0531 48
0532 1F
0533 4C
0534 1D
0535 2B
0536 74
0537 21
0538 48
0539 1F
053A 45
053B 1D
053C 2A
053D 76
053E 21
053F 48
0540 1F
0541 56
0542 1D                   138      VREP29          DB      350,510,1700,410,1100,370,1050,350,500,1720,410,1100,
                                                            370,1140
0543 2A
0544 7
0545 21
0546 48
0547 1F
0548 45
0549 1D
054A 28
054B 7A
054C 21
054D 48
054E 1F
054F 4C
```

```
LOC  OBJ                LINE    SOURCE

                        139     ;END
                        140     ;START "FEET TICS"
0550 10                 141     VREP30          DB      340,410,1710,420,1000,410,1660,420,1000,410,1710,430,
                                                        1140,410,1660,430,1140
0551 21
0552 79
0553 22
0554 40
0555 21
0556 76
0557 22
0558 40
0559 21
055A 79
055B 23
055C 40
055D 21
055E 76
055F 23
0560 40
0561 21                 142     VREP31          DB      410,1710,440,1270,410,1660,440,1270,410,1710,460,1030,
                                                        410,1660,460,1030
0562 79
0563 24
0564 57
0565 21
0566 76
0567 24
0568 57
0569 21
056A 79
056B 26
056C 43
056D 21
056E 76
056F 26
0570 43
0571 21                 143     VREP32          DB      410,1710,470,1170,410,1660,470,1170,410,1710,500,1320,
                                                        410,1660,500,1320
0572 79
0573 27
0574 4F
0575 21
0576 76
0577 27
0578 4F
0579 21
057A 79
057B 28
057C 5A
057D 21
057E 76
057F 28
0580 5A
0581 21                 144     VREP33          DB      410,1710,520,1060,410,1660,520,1060,410,1710,530,1220,
```

```
LOC  OBJ                  LINE     SOURCE

                                                410,1660,520,1220
0582 79
0583 2A
0584 46
0585 21
0586 76
0587 2A
0588 46
0589 21
058A 79
058B 2B
058C 52
058D 21
058E 76
058F 2B
0590 52
0591 21                   145      VREP34          DB      410,1710,540,1350,410,1660,540,1350,410,1710,560,1110,
                                                          410,1660,560,1110
0592 79
0593 2C
0594 50
0595 21
0596 76
0597 2C
0598 50
0599 21
059A 79
059B 2E
059C 49
059D 21
059E 76
059F 2E
05A0 49
                          146
                          147      ;*****************************************************************************
                          148      ;                  THESE NEXT DATA ARE FOR HORIZONTAL REPRIESE
                          149      ;*****************************************************************************
                          150
                          151      ;END
                          152      ;START "0 AND 3"
05A1 1D                   153      VREP35          DB      350,420,1410,420,1120,370,680,350,420,1410,460,1030,
                                                          370,630
05A2 22
05A3 61
05A4 22
05A5 4A
05A6 1F
05A7 30
05A8 1D
05A9 22
05AA 61
05AB 26
05AC 43
05AD 1F
05AE 33
```

```
LOC  OBJ                LINE    SOURCE

                        154     ;END
                        155     ;START "GUNNER AIMING ERROR (MILS)"
0580 10                 156     VREP36          DB      350,400,1760,620,1350,370,1070,1250,1160,1160,1050,1220
                                                        400,1010,1110,1150,1110,1160,1070,400,1050
0581 20
0582 7F
0583 32
0584 5D
0585 1F
0586 47
0587 5F
0588 4E
0589 4E
058A 45
058B 52
058C 20
058D 41
058E 4D
058F 49
0590 4E
0591 47
0592 20
0593 45
0594 52                 157     VREP37          DB      1220,1220,1170,1220,400,500,1150,1110,1140,1230,510,350
0595 52
0596 4F
0597 52
0598 20
0599 28
059A 4D
059B 49
059C 4C
059D 53
059E 2D
059F 10

                        158     ;END
                        159
05A0                    160     LAST_OF_VREP    LABEL   WORD
                        161
                        162     ;START HORIZONTAL GAE ENVELOPE
                        163
05A0 10                 164     HREP    DB      350,410,1740,570,1240,430,1540,570,1240,440,1440,0650,1270
05A1 21
05A2 7D
05A3 2F
05A4 54
05A5 23
05A6 6C
05A7 2F
05A8 54
05A9 24
05AA 64
05AB 35
05AC 57
```

```
LOC  OBJ                  LINE     SOURCE

05DD 36                    165     HREP1   DB      0660,1570,0660,1120,0660,1570,0660,1360,440,1440,0670,1230,430,1540,0
                                   750,1260,410
05DE 6F
05DF 36
05E0 4A
05E1 36
05E2 6F
05E3 36
05E4 5E
05E5 24
05E6 64
05E7 37
05E8 53
05E9 23
05EA 6C
05EB 3D
05EC 56
05ED 21
05EE 7C                    166     HREP2   DB      1740,0750,1260,410,1740,570,1240,0350,410,1740,0660,1250,0660,1570,06
                                   60
05EF 3D
05F0 56
05F1 21
05F2 7C
05F3 2F
05F4 54
05F5 1D
05F6 21
05F7 7C
05F8 36
05F9 55
05FA 36
05FB 6F
05FC 36
                           167     ;END
                           168     ;START TIME TICS
05FD 55                    169     HREP3   DB      1250,340,640,1640,660,1230,620,1700,660,1230,600,1740,660,1230,570,14
                                   00,660,1230,550,1440,660,1230,530
05FE 1C
05FF 34
0600 74
0601 36
0602 53
0603 32
0604 78
0605 36
0606 53
0607 30
0608 7C
0609 36
060A 53
060B 2F
060C 60
060D 36
060E 5
```

```
LOC  OBJ                  LINE     SOURCE

060F 20
0610 64
0611 36
0612 53
0613 2B
0614 68                    170     HREP4   DB      1500,660,1230,510,1540,660,1230,470,1600,660,1230,450,1640,660,1230,4
                                   30,1700,660,1230,640,1640,660
0615 36
0616 53
0617 29
0618 6C
0619 36
061A 53
061B 27
061C 70
061D 36
061E 53
061F 25
0620 74
0621 36
0622 53
0623 23
0624 78
0625 36
0626 53
0627 34
0628 74
0629 36
062A 57                    171     HREP5   DB      1270,620,1700,660
062B 32
062C 78
062D 36
062E 57                    172     HREP6   DB      1270,600,1740,660,1270,570,1400,660,1270,550,1440,660,1270,530,1500,6
                                   60,1270,510
062F 30
0630 7C
0631 36
0632 57
0633 2F
0634 60
0635 36
0636 57
0637 2D
0638 64
0639 36
063A 57
063B 2B
063C 68
063D 36
063E 57
063F 29
0640 6C                    173     HREP7   DB      1540,660,1270,470,1600,660,1270
0641 36
0642 57
0643 27
```

```
LOC  OBJ                  LINE     SOURCE

0644 7A
0645 16
0646 57

                          174      ;END SOMEWHERE NEAR HERE
                          175      ;START ARROW
0647 25                   176      HREP8   DB      450,1640,660,1270,430,1700,660,1270,350,570,1640,560,1140,370,1240
0648 74
0649 16
064A 57
064B 33
064C 76
064D 36
064E 57
064F 1D
0650 2F
0651 74
0652 3E
0653 4C
0654 1F
0655 54
0656 1D                   177      HREP9   DB      350,560,1660,560,1140,370,1110,350,550,1700,560,1140,370,1150
0657 2E
0658 76
0659 2E
065A 4C
065B 1F
065C 49
065D 1D
065E 2C
065F 78
0660 2E
0661 4C
0662 1F
0663 4D
0664 1D                   178      HREP10  DB      350,540,1720,560,1140,370,1050,350,520,1760,560,1140,370,1230,350,520
                                   ,1400,560,1140
0665 2C
0666 7A
0667 2E
0668 4C
0669 1F
066A 45
066B 1D
066C 2A
066D 7E
066E 2E
066F 4C
0670 1F
0671 53
0672 1D
0673 2A
0674 60
0675 2E
0676 4C
0677 1F                   179      HREP11  DB      370,1050,350,510,1420,560,1140,370,1030,350,610,1770,560,1220,630,144
```

```
LOC  OBJ                  LINE    SOURCE

                                  0,560,1220
0678 45
0679 1D
067A 29
067B 62
067C 2E
067D 4C
067E 1F
067F 43
0680 1D
0681 31
0682 7F
0683 2E
0684 52
0685 33
0686 64
0687 2E
0688 52
0689 32                   180     HREP12  DB      620,1660,560,1300,350,620,1660,560,1140,630,1440,560,1220
068A 76
068B 2E
068C 58
068D 1D
068E 32
068F 76
0690 2E
0691 4C
0692 33
0693 64
0694 2E
0695 52
0696 1D                   181     HREP13  DB      350,440,1660,570,1240,370,500,1140,1050,1060,1240,510,350,440,1660,71
                                  0,1310
0697 24
0698 76
0699 2F
069A 54
069B 1F
069C 28
069D 4C
069E 45
069F 46
06A0 54
06A1 29
06A2 1D
06A3 24
06A4 76
06A5 39
06A6 59
06A7 1F                   182     HREP14  DB      370,500,1220,1110,1070,1100,1240,510
06A8 28
06A9 52
06AA 49
06AB 47
06AC 48
```

```
LOC  OBJ                  LINE     SOURCE

06AD 54
06AE 29
                          183      ;END
                          184      ;START MIL TICS
06AF 1C                   185      HREP15  DB      340,410,1710,570,1240,410,1660,570,1240,410,1710,600,1030,410,1660,60
                                   0,1030
06B0 21
06B1 79
06B2 2F
06B3 54
06B4 21
06B5 76
06B6 2F
06B7 54
06B8 21
06B9 79
06BA 30
06BB 43
06BC 21
06BD 76
06BE 30
06BF 43
06C0 21                   186      HREP16  DB      410,1710,600,1220,410,1660,600,1220,410,1710,610,1010,410,1660,610,10
                                   10
06C1 79
06C2 30
06C3 52
06C4 21
06C5 76
06C6 30
06C7 52
06C8 21
06C9 79
06CA 31
06CB 41
06CC 21
06CD 76
06CE 31
06CF 41
06D0 21                   187      HREP17  DB      410,1710,610,1200,410,1660,610,1200,410,1710,610,1370,410,1660,610,13
                                   70
06D1 79
06D2 31
06D3 50
06D4 21
06D5 76
06D6 31
06D7 50
06D8 21
06D9 79
06DA 31
06DB 5F
06DC 21
06DD 76
06DE 31
```

```
LOC  OBJ                  LINE     SOURCE

06DF 5F
06E0 21                    188     HREP18  DB      410,1710,620,1160,410,1660,620,1160,410,1710,620,1350,410,1660,620,13
                                   50
06E1 79
06E2 32
06E3 4E
06E4 21
06E5 76
06E6 32
06E7 4E
06E8 21
06E9 79
06EA 32
06EB 5D
06EC 21
06ED 76
06EE 32
06EF 5D
06F0 21                    189     HREP19  DB      410,1710,630,1140,410,1660,630,1140,410,1710,630,1330,410,1660,630,13
                                   30
06F1 79
06F2 33
06F3 4C
06F4 21
06F5 76
06F6 33
06F7 4C
06F8 21
06F9 79
06FA 33
06FB 5B
06FC 21
06FD 76
06FE 33
06FF 5B
0700 21                    190     HREP20  DB      410,1710,640,1120,410,1660,640,1120,410,1710,640,1310,410,1660,640,13
                                   10
0701 79
0702 34
0703 4A
0704 21
0705 76
0706 34
0707 4A
0708 21
0709 79
070A 34
070B 59
070C 21
070D 76
070E 34
070F 59
0710 21                    191     HREP21  DB      410,1710,650,1100,410,1660,650,1100,410,1710,650,1270,410,1660,650,12
                                   70
0711 79
```

```
LOC  OBJ                  LINE    SOURCE

0712 35
0713 48
0714 21
0715 76
0716 35
0717 48
0718 21
0719 79
071A 35
071B 57
071C 21
071D 76
071E 35
071F 57
0720 21                   192     HREP22  DB      410,1710,660,1060,410,1660,660,1060,410,1710,660,1250,410,1660,660,12
                                  50
0721 79
0722 36
0723 46
0724 21
0725 76
0726 36
0727 46
0728 21
0729 79
072A 36
072B 55
072C 21
072D 76
072E 36
072F 55
0730 21                   193     HREP23  DB      410,1710,670,1040,410,1660,670,1040,410,1710,670,1230,410,1660,670,12
                                  30
0731 79
0732 37
0733 44
0734 21
0735 76
0736 37
0737 44
0738 21
0739 79
073A 37
073B 53
073C 21
073D 76
073E 37
073F 53
0740 21                   194     HREP24  DB      410,1710,700,1020,410,1660,700,1020,410,1710,700,1210,410,1660,700,12
                                  10
0741 79
0742 38
0743 42
0744 21
0745 76
```

```
LOC  OBJ                  LINE    SOURCE

0746 36
0747 42
0748 21
0749 79
074A 38
074B 51
074C 21
074D 76
074E 38
074F 51
0750 21                   195     HREP25  DB      410,1710,710,1000,410,1660,710,1000,410,1710,710,1170,410,1660,710,11
                                  70
0751 79
0752 39
0753 40
0754 21
0755 76
0756 39
0757 40
0758 21
0759 79
075A 39
075B 4F
075C 21
075D 76
075E 39
075F 4F
0760 21                   196     HREP26  DB      410,1710,710,1360,410,1660,710,1360,410,1710,720,1150,410,1660,720,11
                                  50
0761 79
0762 39
0763 5E
0764 21
0765 76
0766 39
0767 5E
0768 21
0769 79
076A 3A
076B 4D
076C 21
076D 76
076E 3A
076F 4D
0770 21                   197     HREP27  DB      410,1710,720,1340,410,1660,720,1340,410,1710,730,1130,410,1660,730,11
                                  30
0771 79
0772 3A
0773 5C
0774 21
0775 76
0776 3A
0777 5C
0778 21
0779 79
```

```
LOC  OBJ                  LINE     SOURCE

077A 3B
077B 4B
077C 21
077D 76
077E 3B
077F 4B
0780 21                    198     HREP28  DB      410,1710,730,1320,410,1660,730,1320,410,1710,740,1110,410,1660,740,11
                                   10
0781 79
0782 3B
0783 5A
0784 21
0785 76
0786 3B
0787 5A
0788 21
0789 79
078A 3C
078B 49
078C 21
078D 76
078E 3C
078F 49
0790 21                    199     HREP29  DB      410,1710,740,1300,410,1660,740,1300,410,1710,750,1070,410,1660,750,10
                                   70
0791 79
0792 3C
0793 58
0794 21
0795 76
0796 3C
0797 58
0798 21
0799 79
079A 3D
079B 47
079C 21
079D 76
079E 3D
079F 47
07A0 21                    200     HREP30  DB      410,1710,750,1260,410,1660,750,1260
07A1 79
07A2 3D
07A3 56
07A4 21
07A5 76
07A6 3D
07A7 56
                           201     ;END MIL TICS
                           202
                           203     ;START "GUNNER AIMING ERROR (MILS)"
07A8 10                    204     HREP31          DB      350,400,1760,600,1220,370,1070,1250,1160,1160,1050,1220,
                                                           400,1010,1110,1150,1110,1160,1070,400,1050
07A9 20
07AA 7E
```

```
LOC  OBJ                LINE     SOURCE

07AB 30
07AC 52
07AD 1F
07AE 47
07AF 55
07B0 4E
07B1 4E
07B2 45
07B3 52
07B4 20
07B5 41
07B6 49
07B7 4D
07B8 49
07B9 4E
07BA 47
07BB 20
07BC 45
07BD 52                 205      HREP32          DB      1220,1220,1170,1220,480,580,1150,1110,1140,1230,510,350
07BE 52
07BF 4F
07C0 52
07C1 20
07C2 28
07C3 4D
07C4 49
07C5 4C
07C6 53
07C7 29
07C8 1D
                        206      ;END
                        207
                        208      ;START "FEET TICS"
07C9 1C                 209      HREP33          DB      340,410,1710,420,1080,410,1660,420,1080,410,1710,430,
                                                        1140,410,1660,430,1140
07CA 21
07CB 79
07CC 22
07CD 40
07CE 21
07CF 76
07D0 22
07D1 40
07D2 21
07D3 79
07D4 23
07D5 4C
07D6 21
07D7 76
07D8 23
07D9 4C
07DA 21                 210      HREP34          DB      410,1710,440,1270,410,1660,440,1270,410,1710,460,1030,
                                                        410,1660,460,1030
07DB 79
07DC 24
```

```
LOC  OBJ                  LINE     SOURCE

07DD 57
07DE 21
07DF 76
07E0 24
07E1 57
07E2 21
07E3 79
07E4 26
07E5 43
07E6 21
07E7 76
07E8 26
07E9 43
07EA 21                   211      HREP35          DB      410,1710,470,1170,410,1660,470,1170,410,1710,500,1320,
                                                           410,1660,500,1320
07EB 79
07EC 27
07ED 4F
07EE 21
07EF 76
07F0 27
07F1 4F
07F2 21
07F3 79
07F4 28
07F5 5A
07F6 21
07F7 76
07F8 28
07F9 5A
07FA 21                   212      HREP36          DB      410,1710,520,1060,410,1660,520,1060,410,1710,530,1220,
                                                           410,1660,530,1220
07FB 79
07FC 2A
07FD 46
07FE 21
07FF 76
0800 2A
0801 46
0802 21
0803 79
0804 2B
0805 52
0806 21
0807 76
0808 2B
0809 52
080A 21                   213      HREP37          DB      410,1710,540,1350,410,1660,540,1350
080B 79
080C 2C
080D 50
080E 21
080F 76
0810 2C
0811 50
```

```
LOC  OBJ                  LINE     SOURCE

                          214      ;END
                          215
                          216      ;START LEFT ENVELOPE
                          217
0812 1D                   218      HRE38          DB      350,410,1740,540,1350,410,1740,420,1000,350,410,1740,
                                                          470,1170,660,1570,470,1170
0813 21
0814 7C
0815 2C
0816 5D
0817 21
0818 7D
0819 22
081A 40
081B 1D
081C 21
081D 7C
081E 27
081F 4F
0820 36
0821 6F
0822 27
0823 4F
                          219      ;END
                          220      ;START "TARGET LINE"
0824 1D                   221      HREP38         DB      350,640,1520,460,1270,370,1240,350,630,1540,460,1270,
                                                          370,1010,350,620,1680,460,1270,370,1220
0825 34
0826 6A
0827 26
0828 57
0829 1F
082A 54
082B 1C
082C 33
082D 6C
082E 26
082F 57
0830 1F
0831 41
0832 1D
0833 32
0834 70
0835 26
0836 57
0837 1F
0838 52
0839 1D                   222      HREP39         DB      350,610,1680,460,1270,370,1070,350,600,1620,460,1270,
                                                          370,1050,350,570,1640,460,1270,370,1240
083A 31
083B 70
083C 26
083D 57
083E 1F
083F 47
```

```
LOC  OBJ                  LINE     SOURCE

0840 1D
0841 30
0842 72
0843 26
0844 57
0845 1F
0846 45
0847 1D
0848 2F
0849 74
084A 26
084B 57
084C 1F
084D 54
084E 1D                   223      HREP40          DB      350,630,1540,470,1320,370,1140,350,620,1680,470,1320,370
                                                           ,1110,350,610,1600,470,1320,370,1160
084F 33
0850 6C
0851 27
0852 5A
0853 1F
0854 4C
0855 1D
0856 32
0857 70
0858 27
0859 5A
085A 1F
085B 49
085C 1D
085D 31
085E 70
085F 27
0860 5A
0861 1F
0862 4E
0863 1D                   224      HREP41          DB      350,680,1620,470,1320,370,1050
0864 30
0865 72
0866 27
0867 5A
0868 1F
0869 45
                          225      ;END
                          226      ;START "(FEET)"
                          227
086A 1D                   228      HREP42          DB      350,400,1760,460,1150,370,500,1060,1050,1050,1240,510
086B 20
086C 7E
086D 26
086E 4D
086F 1F
0870 28
0871 46
0872 45
```

```
LOC  OBJ                  LINE     SOURCE

0873 45
0874 54
0875 29
                          229      ;END
                          230      ;START "(LEFT),(RIGHT)"
0876 1D                   231      HREP43          DB      350,440,1660,420,1000,370,500,1140,1050,1060,1240,510,
                                                          350,440,1660,520,1060,370,500,1220,1110
0877 24
0878 76
0879 22
087A 40
087B 1F
087C 28
087D 4C
087E 45
087F 46
0880 54
0881 29
0882 1D
0883 24
0884 76
0885 2A
0886 46
0887 1F
0888 28
0889 52
088A 49
088B 47                   232      HREP44          DB      1070,1100,1240,510,350
088C 48
088D 54
088E 29
088F 1D
                          233
0890                      234      LAST_OF_HREP    LABEL   WORD
                          235
                          236
0890 E88600               237      GRAPH1:                 CALL CLEAR_SCREEN
                          238
0893 BE0000         R     239      GRAPH:                  MOV     SI,OFFSET PICPOINTS
0896 B93703               240                              MOV     CX,(OFFSET LAST-OFFSET PICPOINTS)
0899 BAD800               241                              MOV     DX,0D8H
089C 2E8A04               242      AGAIN:                  MOV     AL,CS:[SI]
089F E86400               243                              CALL    COUT
08A2 46                   244                              INC     SI
08A3 E88A00               245                              CALL    DELAY_2
08A6 E2F4                 246                              LOOP    AGAIN
08A8 C3                   247                              RET
                          248
08A9 E86D00               249      GRAPH_VREP:             CALL    CLEAR_SCREEN
08AC BE3703         R     250                              MOV     SI,OFFSET VREP1
08AF B99902               251                              MOV     CX,(OFFSET LAST_OF_VREP-OFFSET VREP1)
08B2 BAD800               252                              MOV     DX,0D8H
08B5 2E8A04               253      AGN_N_AGN               MOV     AL,CS:[SI]
08B8 E84800               254                              CALL    COUT
08BB 46                   255                              INC     SI
```

08E.8086/8088 MACRO ASSEMBLER MARLYN_MONROE

LOC	OBJ		LINE	SOURCE		
08BC	E87100		256		CALL	DELAY_2
08BF	E2F4		257		LOOP	AGN_N_AGN
08C1	C3		258		RET	
			259			
08C2	E85400		260	GRAPH_HREP:	CALL	CLEAR_SCREEN
08C5	BED005	R	261		MOV	SI,OFFSET HREP
08C8	B9C002		262		MOV	CX,(OFFSET LAST_OF_HREP-OFFSET HREP)
08CB	BADA00		263		MOV	DX,0D8H
08CE	2E8A04		264	AGN2_N_AGN	MOV	AL,CS:[SI]
08D1	E83200		265		CALL	COUT
08D4	46		266		INC	SI
08D5	E85800		267		CALL	DELAY_2
08D8	E2F4		268		LOOP	AGN2_N_AGN
08DA	C3		269		RET	
			270			
			271			
			272			
08DB	BADA00		273	USART_SET_UP_FOR_ADM:	MOV	DX,TIMER_CNTRL
08DE	B0B6		274		MOV	AL,CNTR2_MODE
08E0	EE		275		OUT	DX,AL
08E1	BAD400		276		MOV	DX,TIMER_CNTRL2
08E4	B004		277		MOV	AL,LOW_ADM
08E6	E84100		278		CALL	DELAY
08E9	EE		279		OUT	DX,AL
08EA	B000		280		MOV	AL,HIGH_ADM
08EC	E83B00		281		CALL	DELAY
08EF	EE		282		OUT	DX,AL
08F0	BADA00		283		MOV	DX,USART_CNTRL
08F3	B040		284		MOV	AL,USART_RESET
08F5	E83200		285		CALL	DELAY
08F8	EE		286		OUT	DX,AL
08F9	B04E		287		MOV	AL,USART_MODE
08FB	E82C00		288		CALL	DELAY
08FE	EE		289		OUT	DX,AL
08FF	B037		290		MOV	AL,USART_CMMND
0901	E82600		291		CALL	DELAY
0904	EE		292		OUT	DX,AL
0905	C3		293		RET	
			294			
0906	50		295	COUT:	PUSH	AX
0907	E4DE		296	OVER1:	IN	AL,USART_STATUS
0909	2401		297		AND	AL,1
090B	74FA		298		JZ	OVER1
090D	58		299		POP	AX
090E	EE		300		OUT	DX,AL
090F	C3		301		RET	
			302			
0910	E4DE		303	CIN:	IN	AL,USART_STATUS
0912	2402		304		AND	AL,2
0914	74FA		305		JZ	CIN
0916	E4DC		306		IN	AL,0DCH
0918	C3		307		RET	
			308			
0919	BADA00		309	CLEAR_SCREEN:	MOV	DX,0D8H ;THIS PROCEDURE CLEARS THE
091C	B01D		310		MOV	AL,29D ;ADM-3 SCREEN

```
LOC  OBJ              LINE     SOURCE

091E E8E5FF             311              CALL    COUT
0921 B019               312              MOV     AL,310
0923 E8E0FF             313              CALL    COUT
0926 E81100             314              CALL    DELAY_3 ;THE CLEAR SCREEN MODE TAKES
                        315                      ;160MS TO COMPLETE
0929 C3                 316              RET
                        317
092A B90300             318      DELAY:  MOV     CX,3
092D E2FE               319      TAG:    LOOP    TAG
092F C3                 320              RET
                        321
0930 B87500             322      DELAY_2:MOV     AX,DELAY_VAL
0933 48                 323      AGAIN_AND_AGAIN:DEC AX
0934 3D0000             324              CMP     AX,0
0937 75FA               325              JNE     AGAIN_AND_AGAIN
0939 C3                 326              RET
                        327
093A B850C3             328      DELAY_3:MOV     AX,50000D
093D 48                 329      OVER_AND_OVER:  DEC AX
093E 3D0000             330              CMP     AX,0
0941 75FA               331              JNE     OVER_AND_OVER
0943 B850C3             332              MOV     AX,50000D
0946 48                 333      ONE_MORE_TIME:  DEC AX
0947 3D0000             334              CMP     AX,0
094A 75FA               335              JNE     ONE_MORE_TIME
094C C3                 336              RET
                        337
----                    338      CODE    ENDS
                        339
                        340              END

ASSEMBLY COMPLETE, NO ERRORS FOUND
```

APPENDIX D

COMPUTER GENERATED SOUND SYSTEMS PROGRAMS

```
LOC  OBJ        SEQ        SOURCE STATEMENT

                    1 ;                              1 SEPTEMBER 1981
                    2
                    3
                    4 ;       THIS PROGRAM WRITTEN IN INTEL 8748 ASSEMBLY LANGUAGE IS THE SOURCE
                    5 ; FOR SOUNDS PRODUCED DURING A SIMULATED DRAGON FIRING AND RESIDES IN EPROM
                    6 ; OF THE SOUND SYSTEM MICROCOMPUTER (SSM).  THESE SOUNDS ARE:
                    7
                    8 ;       1.  GYRO WIND UP
                    9 ;       2.  LAUNCH EXPLOSION
                   10 ;       3.  THRUSTER FIRINGS
                   11 ;       4.  IMPACT EXPLOSIONS
                   12 ;             A.  TARGET HIT
                   13 ;             B.  TARGET MISSED
                   14
                   15
                   16 ;       THE DFS PROCESSOR SENDS A FOUR BIT WORD WHICH IS DECODED BY THE
                   17 ; SSM INTO ONE OF THE ABOVE SOUNDS  THE SSM IN TURN PASSES DATA BYTES TO
                   18 ; A GENERAL INSTRUMENTS AY-3-8910 PROGRAMMABLE SOUND GENERATOR (PSG).  THE
                   19 ; PSG INTERPRETS 14 DATA BYTES STORED IN THE LOWER 14 LOCATIONS OF AN ON
                   20 ; CHIP 16 BYTE REGISTER ARRAY AS A SOUND, THEREBY GENERATING AN ANALOG
                   21 ; SIGNAL
                   22
                   23 ;*******************************************************************************
                   24
                   25 ;       INITIALIZATION ROUNTINE
                   26
0000               27          ORG     0
0000 0409          28          JMP     ANIT
                   29
0003               30          ORG     3
0003 0401          31          JMP     DECODE
                   32
0007               33          ORG     7
0007 1606          34          JTF     TIMER
                   35
0009               36          ORG     09H
0009 4465          37 ANIT:    JMP     CAKAP
000B 65            38 INIT:    STOP    TCNT
000C 27            39          CLR     A
000D 62            40          MOV     T,A             ;INITIALIZE TIMER AND ENABLE INTERRUPT
000E 25            41          EN      TCNTI
                   42
000F 05            43          EN      I               ;ENABLE INTERRUPT
0010 75            44          ENT0    CLK             ;ENABLE CLOCK ON T0
0011 23FF          45          MOV     A,#0FFH
0013 39            46          OUTL    P1,A            ;INITIALIZE PORTS 1 & 2
0014 3A            47          OUTL    P2,A
                   48
0015 23FB          49          MOV     A,#0FBH         ;INITIALIZE PORTS 4 & 5
0017 3C            50          MOVD    P4,A
0018 27            51          CLR     A
0019 3D            52          MOVD    P5,A
```

```
LOC  OBJ        SEQ        SOURCE STATEMENT

                  53
001A 996F         54 RESPG:  ANL     P1,#06FH        ;RESET PSG'S
001C 8990         55         ORL     P1,#090H
                  56
                  57
001E 9ABF         58 FLIP:   ANL     P2,#0BFH        ;SET FLIP/FLOPS
0020 8A40         59         ORL     P2,#040H
                  60
                  61
                  62 ;*************************************************************************
                  63
                  64 ;       LOOP ROUTINE I.E  WAIT FOR INTERRUPT
                  65
0022 85           66         CLR     F0
0023 27           67         CLR     A
0024 B93E         68         MOV     R1,#03EH
0026 B82F         69         MOV     R0,#02FH
0028 A0           70         MOV     @R0,A
0029 C8           71         DEC     R0
002A A0           72         MOV     @R0,A
002B C8           73         DEC     R0
002C A0           74         MOV     @R0,A
002D A1           75         MOV     @R1,A
002E 19           76         INC     R1
002F A1           77         MOV     @R1,A
0030 AB           78         MOV     R3,A
0031 AC           79         MOV     R4,A
0032 AD           80         MOV     R5,A
0033 D5           81         SEL     RB1
0034 A8           82         MOV     R0,A
0035 A9           83         MOV     R1,A
0036 AA           84         MOV     R2,A
0037 AB           85         MOV     R3,A
0038 AC           86         MOV     R4,A
0039 AD           87         MOV     R5,A
003A AE           88         MOV     R6,A
003B AF           89         MOV     R7,A
003C C5           90         SEL     RB0
                  91
003D B82F         92 DRANG:  MOV     R0,#02FH
003F F0           93         MOV     A,@R0
0040 C63D         94         JZ      DRANG
0042 27           95         CLR     A
0043 A0           96         MOV     @R0,A
0044 5428         97         CALL    DRAGON
                  98
0046 B82F         99 INFIN:  MOV     R0,#02FH
0048 F0          100         MOV     A,@R0
0049 C646        101         JZ      INFIN
                 102
004B 1494        103         CALL    CHECK
                 104
004D B820        105         MOV     R0,#020H
004F F0          106         MOV     A,@R0
0050 AF          107         MOV     P4,A            ;R4 GETS TIME
```

```
LOC  OBJ        SEQ        SOURCE STATEMENT

0051 5488       108        CALL    ROPOF
0053 C676       109        JZ      SINFIN
                110
0055 AF         111        MOV     R7,A          ;R7 GETS COUNT
0056 B921       112        MOV     R1,#021H
0058 F1         113        MOV     A,@R1
0059 AA         114        MOV     R2,A
005B 14B4       115        CALL    DELAY
005D AA         116        MOV     R2,A
005F 14B4       117        CALL    DELAY
0061 B820       118        MOV     R0,#020H
0063 B921       119        MOV     R1,#021H
                120
0065 F1         121 UNFIN  MOV     A,@R1
0066 20         122        XCH     A,@R0
0067 EF72       123        DJNZ    R7,ANFIN
0069 B646       124        JF0     INFIN
006B 05         125        SEL     RB1
006C 27         126        CLR     A
006D A6         127        MOV     R0,A
006E A6         128        MOV     R3,A
006F C5         129        SEL     RB0
0070 B5         130        CPL     F0
0071 B5         131        CPL     F0
0072 0446       132        JMP     INFIN
                133
0074 18         134 ANFIN  INC     R0
0075 19         135        INC     R1
0076 0465       136        JMP     UNFIN
                137
0078 B82E       138 SINFIN MOV     R0,#02EH      ;LOCATION OF RB1R3 PPEVIOUS
007A F0         139        MOV     A,@R0
007B C67E       140        JZ      SAFON
007D AA         141        MOV     P2,A
007F 14BF       142        CALL    DALAY
0081 B820       143 SAFON  MOV     R0,#020H      ;LOCATION OF RB1R0 PREVIOUS
0083 F0         144        MOV     A,@R0
0084 C687       145        JZ      SAVOB
0086 B8FF       146        MOV     R2,#0FFH
0088 14BF       147        CALL    DALAY
008A B5         148 SAVOB  SEL     RB1
008B FB         149        MOV     A,P3
008C C5         150        SEL     RB0
008D B82E       151        MOV     R0,#02EH
008F A0         152        MOV     @R0,A
0090 B5         153        SEL     RB1
0091 F8         154        MOV     A,R0
0092 C5         155        SEL     RB0
0093 C8         156        DEC     R0
0094 A0         157        MOV     @R0,A
0095 0446       158        JMP     INFIN
                159
0097 27         160 CHECK  DEC     A
0098 9E9D       161        JNZ     CHAK
009A B8FF       162        MOV     R0,#0FFH
```

```
LOC  OBJ        SEQ        SOURCE STATEMENT

0099 F0         163        MOV     A,@R0
009A 96A1       164        JNZ     DEXO
009C 18         165        INC     R0
009D F0         166        MOV     A,@R0
009E 96B6       167        JNZ     HEXO
00A0 97         168 CHAK   RETR
                169
00A1 18         170 DEXO   INC     R0
00A2 F0         171        MOV     A,@R0
00A3 96A7       172        JZ      DEXAA
00A5 4460       173        JMP     CHKAP
00A7 14AF       174 DEXAA  CALL    GETTA
00A9 4477       175        JMP     DUDEX
                176
00AB 14AF       177 HEXO   CALL    GETTA
00AD 443A       178        JMP     HITEX
                179
00AF B820       180 GETTA  MOV     R0,#020H
00B1 F0         181        MOV     A,@R0
00B2 AC         182        MOV     R4,A
00B3 93         183        RETR
                184
                185
                186 ;*****************************************************************************
                187
                188 ;              DELAY    SUBROUTINES
                189
                190
00B4 B308       191 DELAY  MOV     R1,#8          ;DELAY = R2 X  01 SEC
00B6 B8FF       192 LOOP1  MOV     R0,#0FFH
00B8 E8B8       193 LOOP2  DJNZ    R0,LOOP2
00BA E9B6       194        DJNZ    R1,LOOP1
00BC EAB4       195        DJNZ    R2,DELAY
00BE 93         196        RETR
                197
00BF B8C8       198 DALAY  MOV     R0,#0C8H       ;DALAY = R2 X .001 SEC
00C1 E8C1       199 DLY    DJNZ    R0,DLY
00C3 EABF       200        DJNZ    R2,DALAY
00C5 93         201        RETR
                202
                203
                204 ;*****************************************************************************
                205
                206 ;       TIMER INTERPUPT SERVICE ROUTINE
                207
                208 ;       THE TIMER INCREMENTS EVERY 80USEC   (T)
                209 ;       R4 INCREMENTS EVERY 20MSEC
                210 ;       R5 INCREMENTS EVERY 5.24 SEC
                211
                212
00C6 D5         213 TIMER  SEL     RB1
00C7 AD         214        MOV     R5,A
00C8 1C         215        INC     R4
                216                                          D-3
00C9 1F         217        INC     R6
```

```
                        SOURCE STATEMENT

                        MOV     A,R6
                        JNZ     DELO
                        INC     R7
                DELO    MOV     A,R5
                        SEL     MB0
                        RET
                ;
                ;***************************************************************
                ;
                ;       EXTERNAL INTERRUPT SERVICE ROUTINE  DECODE LOWER 3 BITS OF 4 BIT
                ;       WORD FROM OFS PROCESSOR  FLIP/FLOP'S  LATCH WORD ONTO PORT 1
                ;
                DECODE  SEL     MB1
                        MOV     R5,A
                        IN      A,P1
                        ANL     A,#7
                ;
                        JZ      DRAGO           ;       000     INIT BANG
                        DEC     A
                        MOV     P1,#03EH
                        JZ      DUDE            ;       001     GND DUD
                        DEC     A
                        JZ      DUDEX1          ;       010     GND EXPLO
                        DEC     A
                        JZ      DUDEX1          ;       011     MISS EXPLO
                        DEC     A
                        JZ      HITE1           ;       100     HIT EXPLO
                        DEC     A
                        JZ      POP01           ;       101     ROCK POP
                ;
                        JMP     PUPP
                ;
                DUDEX1  MOVX    A,@R0           ; STOP TIMER
                        JMP     DUDEX0
                HITE1   MOVX    A,@R0           ; STOP TIMER
                        JMP     HITE
                POP01   JMP     POP0
                ;
                DRAGO   MOV     P1,#02FH        ;       PSG#1
                        INC     @R1
                        JMP     PUPPET
                DUDE    INC     @R1
                        INC     P1
                        INC     @R1
                        MOV     P1,#02FH
                        IN      @R1
                        JMP     PUPP            ;       PSG#2
                DUDEX0  INC     @R1
                        JMP     POP0            ;       PSG#2
                HITE    INC     P1
                        IN      @R1             ;       PSG#2
                PUPP    MOV     P1,#02FH
                        IN      @R1
```

```
LOC  OBJ        SEQ        SOURCE STATEMENT

                273
0106 F1         274        MOV     A,@P1
0107 AA         275        MOV     R2,A            ;R2 GETS COUNT
0108 B920       276        MOV     R1,#020H        ;R1 GETS ADDRESS
010A FC         277        MOV     A,R4            ;ACC GETS TIME
                278
010B EA12       279 PUSS:  DJNZ    R2,POSS
010D A1         280        MOV     @R1,A
010E 2415       281        JMP     PASS
                282
0110 19         283 POSS:  INC     P1
0111 2406       284        JMP     PUSS
                285
0113 BC00       286 PASS:  MOV     R4,#0
0115 F5         287 PUPP:  MOV     A,R5
0116 C5         288        SEL     RB0
0117 93         289        RETR
                290
0118 8E1E       291 PUPPET INT     POKER
011A 2415       292        JMP     PUPP
011C 2308       293 POKER: MOV     A,#8
011E 07         294        MOV     PSW,A
011F 15         295        DIS     I
0120 BA64       296        MOV     R2,#100D
0122 14B4       297        CALL    DELAY
0124 0406       298        JMP     INIT
                299
                300
                301 ;*************************************************************************
                302
                303 ;      SUBROUTINE TO CHECK TIMER AND GIVE ASSOCIATED DELAY AND AMPLITUDE
                304 ;      DECAY
                305
0126 C5         306 TSTR45 SEL     RB0
0127 BB00       307        MOV     R3,#0
0129 BE0F       308        MOV     R6,#0FH
012B BF00       309        MOV     R7,#0
012D D5         310        SEL     RB1             ;CUMULATIVE DELAY SO FAR
012E FB         311        MOV     A,R3
012F C5         312        SEL     RB0
0130 C637       313        JZ      TARC
0132 AA         314        MOV     R2,A
0133 146F       315        CALL    DALAY
0135 D5         316 TARC:  SEL     RB1
0136 F8         317        MOV     A,R0
0137 C5         318        SEL     RB0
0138 C640       319        JZ      TESTR4
013A BAFF       320        MOV     R2,#0FFH
013C 14EF       321        CALL    DALAY
013E 2440       322        JMP     TESTR4
                323 ;                           IF R5 = 1 THEN FLIGHT TIME = 5 243SEC
                324 ;                           AT LEAST  THEN DELAY = 1 352SEC
                325
                326 ;                           IF R5 = 2 THEN FLIGHT TIME = 10 486SEC
                327                              AT LEAST. THEN DELAY = 2 704SEC
```

```
LOC  OBJ          SEQ        SOURCE STATEMENT

                   328
                   329
0149 27            330 TAR    CLR    A
014A FB            331        MOV    A,R3          ;R0R3 KEEPS INCREMENTAL DELAY
014B D5            332        SEL    RB1
014C 68            333        ADD    A,R0
014D AB            334        MOV    R3,A          ;RB1R3  HOLDS CUMULATIVE DELAY
014E E653          335        INC    TAPB
0150 18            336        INC    R0
0151 C5            337 TAPE   SEL    RB0
0152 83            338        RETR
                   339
                   340
0153 C5            341 TESTR4 SEL    RB0
0154 FC            342        MOV    A,R4
0155 1257          343        JB7    BIT7
0157 1256          344 JP6    JB6    BIT6
0159 1255          345 JP5    JB5    BIT5
015B 1254          346 JP4    JB4    BIT4
015D 1253          347 JP3    JB2    BIT3
015F 1252          348 JP2    JB2    BIT2
0161 1251          349 JP1    JB1    BIT1
0163 1250          350 JP0    JB0    BIT0
0165 0465          351        JMP    TAPAP
                   352
0167 BA67          353 BIT7   MOV    R2,#67D       ;FOR BIT 7 TRAVEL = 2.621SEC
0169 14F4          354        CALL   DELAY         ;THEREFORE DELAY =  676SEC
016B BA05          355        MOV    R2,#5
016D 14EF          356        CALL   DALAY
016F BB44          357        MOV    R3,#68D
0171 2450          358        JMP    JP6
                   359
0173 BA21          360 BIT6   MOV    R2,#33D       ;FOR BIT 6 TRAVEL = 1.311SEC
                   361 ;                            THEREFORE DELAY =  338SEC
0175 14F4          362        CALL   DELAY
0177 BA06          363        MOV    R2,#6
0179 14EF          364        CALL   DALAY
017B FB            365        MOV    A,R3
017C 0322          366        ADD    A,#340
017E AB            367        MOV    R3,A
017F FC            368        MOV    A,R4
0180 4482          369        JMP    JP5
                   370
0182 BA0A          371 BIT5   MOV    R2,#16D0      ;FOR BIT 5 TRAVEL =  655SEC
                   372 ;                            THEREFORE DELAY =  169SEC
0184 14EF          373        CALL   DALAY
0186 FB            374        MOV    A,R3
0187 0311          375        ADD    A,#170
0189 AB            376        MOV    R3,A
018A FC            377        MOV    A,R4
018B 4454          378        JMP    IP4
                   379
018D BA04          380 BIT4   MOV    R2,#84D       ;TRAVEL =  328SEC   DELAY =  084SEC
018F 14F4          381        CALL   DALAY
0191 FB            382        MOV    A,R3
```

```
LOC  OBJ        SEQ        SOURCE STATEMENT

01A6 0309       381        ADD     A,#9D
01A8 A6         384        MOV     R3,A
01AE FC         385        MOV     A,R4
01AF 2456       386        JMP     JP3
                387
01B1 BA2A       388 BIT3:  MOV     R2,#42D      ;TRAVEL = 164SEC  DELAY = 042SEC
01B3 146F       389        CALL    DALAY
01B5 F6         390        MOV     A,R2
01B6 0304       391        ADD     A,#4
01B8 AE         392        MOV     R3,A
01B9 FC         393        MOV     A,R4
01BA 245A       394        JMP     JP2
                395
01BC BA15       396 BIT2:  MOV     R2,#21D      ;TRAVEL = 082SEC  DELAY = 021SEC
01BE 146F       397        CALL    DALAY
01C0 18         398        INC     R3
01C1 18         399        INC     R3
01C2 FC         400        MOV     A,R4
01C3 245A       401        JMP     JP1
                402
01C5 BA0B       403 BIT1:  MOV     R2,#11D      ;TRAVEL = 041SEC  DELAY = 011SEC
01C7 146F       404        CALL    DALAY
01C9 19         405        INC     R3
01CA FC         406        MOV     A,R4
01CB 245C       407        JMP     JP0
                408
01CD BA05       409 BIT0:  MOV     R2,#5D       ;TRAVEL = 020SEC  DELAY = 005SEC
01CF 146F       410        CALL    DALAY
01D1 1B         411        INC     R3
                412
                413
                414 ;      AMPLITUDE DECAY IS DEPENDENT ON THE TOTAL TIME STORED
                415 ;      IN REGISTERS RB1R6 (20 MSEC PER BIT) AND RB1R7.
                416
                417
01D2 D5         418 TARAP: SEL     RB1
01D3 FF         419        MOV     A,R7
01D4 C5         420        SEL     RB0
01D5 C6C0       421        JZ      TRAP
01D7 07         422        DEC     A
01D8 C6BE       423        JZ      TRIP
01DA BE02       424        MOV     R6,#2        ;TRAVEL=10 486 SEC
01DC 2442       425        JMP     TAR
01DE BE08       426 TRIP:  MOV     R6,#8
01E0 D5         427 TRAP:  SEL     RB1
01E1 FE         428        MOV     A,R6
01E2 C5         429        SEL     RB0
01E3 F20F       430        JB7     BAT7
01E5 D2E8       431 PB6:   JB6     BAT6
01E7 B2EF       432 PB5:   JB5     BAT5
01E9 32F7       433 PB4    JB4     BAT4
01EB 72FF       434 PB3    JB3     BAT3
01ED 5205       435 PB2    JB2     BAT21
01EF 3207       436 PB1    JB1     BAT11
01F1 1209       437 PB0    JB0     BAT01
```

```
                        438          JMP     TRANF
                        439
                        440 BAT11    JMP     BAT2
                        441 BAT11    JMP     BAT1
                        442 BAT01    JMP     BAT0
                        443
                        444 PBY      SEL     RB1
                        445          MOV     A,P6
                        446          SEL     RB0
                        447          RETR
                        448
                        449 BAT7     DEC     R6
                        450          DEC     R6
                        451          DEC     R6
                        452          MOV     R7,#42D
                        453          JMP     PB6
                        454
                        455 BAT6     DEC     R6
                        456          MOV     A,#57D
                        457          ADD     A,R7
                        458          MOV     R7,A
                        459          CALL    PBY
                        460          JMP     PB5
                        461
                        462 BAT5     MOV     A,#66D
                        463          ADD     A,R7
                        464          MOV     R7,A
                        465          CALL    PBY
                        466          JMP     PB4
                        467
                        468 BAT4     MOV     A,#33D
                        469          ADD     A,R7
                        470          MOV     R7,A
                        471          CALL    PBY
                        472          JMP     PB3
                        473
                        474 BAT3     MOV     A,#16D
                        475          ADD     A,R7
                        476          MOV     R7,A
                        477          CALL    PBY
                        478          JMP     PB2
                        479
                        480 BAT2     MOV     A,#8
                        481          ADD     A,R7
                        482          MOV     R7,A
                        483          CALL    PBY
                        484          JMP     PB1
                        485
                        486 BAT1     INC     R7
                        487          INC     R7
                        488          INC     R7
                        489          INC     R7
                        490          JMP     PB0
                        491
                        492 BAT0     INC     R7
```

```
LOC  OBJ       SEQ        SOURCE STATEMENT

0[illegible] 1F          493        INC     R7
                         494
                         495
0217 FF          496 TRAMP: MOV     A,R7
                         497
                         498 ;      FOR FURTHER AMPLITUDE CONTROL R7 IS NOW TESTED
                         499
0218 F21E        500        JB7     BEA
021A 0225        501 TAP1   JB6     BEB
021C 2442        502        JMP     TAR
                         503
021E CE          504 BEA:   DEC     R6
021F 537F        505        ANL     A,#07FH        ;  - 1280MSEC
0221 0336        506        ADD     A,#54D         ;  +  540MSEC
0223 441A        507        JMP     TAP1
                         508
0225 CE          509 BEB:   DEC     R6
0226 2442        510        JMP     TAR
                         511
                         512
                         513 ;*************************************************************************
                         514
                         515 ;      ROUTINE TO INITIATE INTERNAL TIMER & GIVE
                         516 ;      INITIAL LAUNCH EXPLOSION
                         517
                         518
0228 55          519 DRAGON: STPT   T
                         520
02[illegible] A0         521        MOVX    A,@R0          ;START TIMER
                         522
022A 996F        523        ANL     P1,#06FH
022C 8890        524        ORL     P1,#090H               ;RESET PSG'S
                         525
022E 9A0F        526        ANL     P2,#0DFH               ;SELECT NO. 1
                         527
                         528 ;      LOAD  PSG #1
                         529
                         530
0230 B820        531        MOV     R0,#020H
0232 BFC0        532        MOV     R7,#03000              ;BANG ON CHANNELS A,B & C  OF PSG#1
                         533
[illegible]4 5438        534        CALL    LODRAM
                         535
0236 7400        536        CALL    LOADP1
                         537
[illegible]8 8A30        538        ORL     P2,#030H               ;TRI-STATE
                         539
023A 97          540        RETR
                         541
[illegible]B 2350        542 LODRAM: MOV    A,#1350
023D A0          543        MOV     @R0,A          ;R0
023E 18          544        INC     R0
[illegible]F [illegible]0D       545        MOV     A,#150
0241 A0          546        MOV     @R0,A          ;R1
0242 [illegible]         547        INC     R0
```

```
LOC  OBJ        SEQ        SOURCE STATEMENT

0247 2350       548        MOV     A,#1350
0249 B1         549        MOV     @R0,A           ;R2
024A 18         550        INC     R0
024B 2300       551        MOV     A,#150
024D B0         552        MOV     @R0,A           ;R3
024E 18         553        INC     R0
024F 2350       554        MOV     A,#1350
0251 B0         555        MOV     @R0,A           ;R4
0252 18         556        INC     R0
0253 2300       557        MOV     A,#150
0255 B0         558        MOV     @R0,A           ;R5
0256 18         559        INC     R0
0257 231F       560        MOV     A,#370
0259 B0         561        MOV     @R0,A           ;R6
025A 18         562        INC     R0
025B 2F         563        MOV     A,R7
025C B0         564        MOV     @R0,A           ;R7
025D 18         565        INC     R0
025E 2310       566        MOV     A,#200
0260 B1         567        MOV     @R0,A           ;R8
0261 18         568        INC     R0
0262 B0         569        MOV     @R0,A           ;R9
0263 18         570        INC     R0
0264 B1         571        MOV     @R0,A           ;R10
0265 18         572        INC     R0
0266 23FF       573        MOV     A,#0FFH
0268 B1         574        MOV     @R0,A           ;R11
0269 18         575        INC     R0
026A 233F       576        MOV     A,#0770
026C B0         577        MOV     @R0,A           ;R12
026D 18         578        INC     R0
026E 27         579        CLR     A
026F B0         580        MOV     @R0,A           ;R13
0270 47         581        PCTR
                582
                583
                584 ;*************************************************************************
                585
                586 ;       THIS ROUTINE WAITS FOR A SYSTEM RESET TO START A NEW FLIGHT.
                587
0272 2308       588 LAUNCH  MOV     A,#8
0274 62         589         MOV     PSW,A
0275 15         590         DIS     I
0276 8675       591 BRAVE   INT     COKOP
0278 4477       592         JMP     BRAVE
027A 0400       593 COKOP   JMP     INIT
                594
                595
                596 ;*************************************************************************
                597
                598         THIS ROUTINE PRODUCES A DOUBLE EXPLOSION WHEN MISSILE
                599         HAS MISSED THE TARGET
                600
027C 3AEF       601 DUMEX   ANL     P2,#0EFH        ;SELECT PSG #2
                602
```

```
LOC  OBJ        SEQ        SOURCE STATEMENT

0279 3428       603        CALL    TSTR45          ;CALL DELAY AND AMPLITUDE
                604
027B BD02       605        MOV     R5,#2           ;LOOP COUNTER FOR AMP DECAY
                606
027D B5         607        CPL     F1
                608
027E 397F       609 CAKET  ANL     P1,#07FH
0280 8980       610        ORL     P1,#080H        ;RESET PSG #2
                611
0282 B830       612        MOV     R0,#030H
0284 BF10       613        MOV     R7,#3110        ;MISS ON CHANNEL B & C ONLY (PSG#2)
                614
0286 543B       615        CALL    LODRAM
0288 7492       616        CALL    HITAMP
028A 7423       617        CALL    LOADP2
                618
028C BAFF       619        MOV     R2,#0FFH
028E 146F       620        CALL    DALAY
                621
0290 7696       622        JF1     JIERT
0292 B5         623        CPL     F1
0293 CD         624        DEC     R5
0294 447E       625        JMP     CAKET
                626
0296 8A30       627 JIERT  ORL     P2,#030H        ;TRI-STATE
                628
0298 44A0       629        JMP     CAKAP
                630
                631
                632 ;*****************************************************************
                633
                634 ;      THIS POUTINE PRODUCES A TRIPLE EXPLOSION WHEN MISSILE
                635 ;      HITS THE TARGET.
                636
029A B803       637 HITEX  MOV     R5,#3           ;LOOP COUNTER
                638
029C 3428       639        CALL    TSTR45          ;CALL DELAY AND AMPLITUDE
                640
029E 9AEF       641 KAKOT  ANL     P2,#0EFH        ;SELECT PSG #2
                642
02A0 397F       643        ANL     P1,#07FH
02A2 8980       644        ORL     P1,#080H        ;RESET PSG #2
                645
02A4 B830       646        MOV     R0,#030H
02A6 BF10       647        MOV     R7,#3110        ;HIT ON CHANNEL B & C ONLY (PSG#2)
                648
02A8 543B       649        CALL    LODRAM
02AA 7492       650        CALL    HITAMP
02AC 7423       651        CALL    LOADP2
                652
02AE 8A10       653        ORL     P2,#010H
                654
02B0 BAFF       655        MOV     R2,#0FFH
02B2 146F       656        CALL    DALAY
                657
```

```
LOC  OBJ          SEQ        SOURCE STATEMENT

02E4 F4AE          658        DJNZ    R5,KAKOT
                   659
02E6 44A0          660        JMP     CAKAP
                   661
                   662
                   663 ;*****************************************************************
                   664
                   665 ;      THIS ROUTINE PRODUCES A SOUND SIMULATING THE IGNITION OF A
                   666        SIDE ROCKET THRUSTER PAIR.
                   667
02E8 14xx          668 RUPOP  CALL    TSTP45
                   669
02EA 53xx          670        ANL     P1,#07FH
02EC 43xx          671        ORL     P1,#080H                ;RESET PSG #2
                   672
02EE 9AEF          673        ANL     P2,#0EFH                ;SELECT PSG #2
                   674
02F0 B8xx          675        MOV     R0,#030H
02F2 27C0          676        MOV     A,#1350
02F4 A0            677        MOV     @R0,A           ;R0
02F5 18            678        INC     R0
02F6 2300          679        MOV     A,#150
02F8 A0            680        MOV     @R0,A           ;R1
02F9 18            681        INC     R0
02FA 27C0          682        MOV     A,#1350
02FC A0            683        MOV     @R0,A           ;R2
02FD 18            684        INC     R0
02FE 2396          685        MOV     A,#150
0300 A0            686        MOV     @R0,A           ;R3
0301 18            687        INC     R0
0302 27C0          688        MOV     A,#1350
0304 A0            689        MOV     @R0,A           ;R4
0305 18            690        INC     R0
0306 2396          691        MOV     A,#150
0308 A0            692        MOV     @R0,A           ;R5
0309 18            693        INC     R0
030A 23FF          694        MOV     A,#370
030C A0            695        MOV     @R0,A           ;R6
030D 18            696        INC     R0
030E 27F6          697        MOV     A,#366Q
0310 A0            698        MOV     @R0,A           ;R7     CHANNEL A ONLY (PSG#2)
0311 18            699        INC     R0
0312 2710          700        MOV     A,#010H
0314 A0            701        MOV     @R0,A           ;R8
0315 18            702        INC     R0
0316 A0            703        MOV     @R0,A           ;R9
0317 18            704        INC     R0
0318 A0            705        MOV     @R0,A           ;R10
0319 18            706        INC     R0
031A 23A1          707        MOV     A,#161D
031C A0            708        MOV     @R0,A           ;R11
031D 18            709        INC     R0
031E 2306          710        MOV     A,#3D
0320 A0            711        MOV     @R0,A           ;R12
0321 18            712        INC     R0
```

```
LOC  OBJ        SEQ        SOURCE STATEMENT

02F2 27         717        CLR     A
02F3 A0         718        MOV     @R0,A          ;P13
                719
02F4 744A       720        CALL    POPAMP
02F6 7425       721        CALL    LOADP2
                722
02F8 8A30       723        ORL     P2,#030H
                724
02FA B02F       725        MOV     R0,#02FH
02FC F0         726        MOV     A,@R0
02FD 07         727        DEC     A
02FE A0         728        MOV     @R0,A
                729
02FF 93         730        RETR
                731
                732
                733 ;*****************************************************************
                734
                735 ;       SUBROUTINE TO LOAD PSG#1 FROM MEMORY LOCATIONS
                736 ;       20H TO 2DH CORRESPONDING TO REGISTERS 0 TO 13 OF PSG#1.
                737
0300 9A7F       738 LOADP1  ANL     P2,#07FH
                739
0302 C5         740        SEL     RB0
0303 B920       741        MOV     R1,#020H
0305 BA00       742        MOV     R2,#0
0307 BB0E       743        MOV     R3,#14D
                744
0309 741A       745 JACKO   CALL    LADP1
030B EB16       746        DJNZ    R3,THERE
030D 8A80       747        ORL     P2,#080H
030F B92D       748        MOV     R1,#02DH
0311 27         749        CLR     A
0312 A1         750        MOV     @R1,A
0313 19         751        INC     R1
0314 A1         752        MOV     @R1,A
                753
0315 93         754        RETR
                755
0316 19         756 THERE   INC     R1
0317 1A         757        INC     R2
0318 6409       758        JMP     JACKO
                759
031A 8920       760 LADP1   ORL     P1,#020H
031C FA         761        MOV     A,R2
031D 90         762        MOVX    @R0,A
031E 99DF       763        ANL     P1,#0DFH
0320 F1         764        MOV     A,@R1
0321 90         765        MOVX    @R0,A
0322 83         766        RETR
                767
                768 ;*****************************************************************
                769
                770 ;       SUBROUTINE TO LOAD PSG#2 FROM MEMORY LOCATIONS
```

```
LOC  OBJ        SEQ        SOURCE STATEMENT

                768 ;       30 TO 3D CORRESPONDING TO REGISTERS 0 TO 14 OF P56#2
                769
0123 99F7       770 LOADP2  ANL     P1,#0F7H
                771
0125 C5         772         SEL     RB0
0126 B830       773         MOV     R1,#030H
0128 BA00       774         MOV     R2,#0
012A B80E       775         MOV     R3,#14D
                776
012C 74 7       777 LAPOR:  CALL    LADP2
012E EB[illegible]  778         DJNZ    R3,HERE
0[illegible] 8[illegible]   779         ORL     P1,#08H
                780
0132 93         781         RETR
                782
0133 19         783 HERE    INC     R1
0134 1A         784         INC     R2
0135 642C       785         JMP     LAPOR
                786
0[illegible] 8940       787 LADP2:  ORL     P1,#040H
0139 FA         788         MOV     A,R2
013A 90         789         MOVX    @R0,A
013B 994F       790         ANL     P1,#0BFH
013D F1         791         MOV     A,@R1
013E 90         792         MOVX    @R0,A
013F 83         793         RETR
                794
                795
                796 ;*************************************************************************
                797
                798 ;       DECODE REGISTER R6 TO DETERMINE PROPER AMPLITUDE FOR A
                799 ;       THRUSTER ROCKET SOUND.  1 OF 13 POSSIBLE AMPLITUDES DECAYING
                800 ;       LOGARITHMICALLY
                801
[illegible]     [illegible] 802 POPAMP  SEL     RB0
0141 FE         803         MOV     A,R6
0142 5[illegible]F       804         ANL     A,#0FH
0144 7268       805         JB3     POPA
0146 5252       806         JB2     ROPB
0148 1[illegible]4E       807         JB0     POPC
014A 23B8       808         MOV     A,#0B8H         ; R6=2, LEVEL=1
[illegible]     [illegible] 809         JMP     CAMPO
014E [illegible]B1       810 POPC    MOV     A,#0B1H         ;   =3,     =4
[illegible]     [illegible] 811         JMP     CAMPO
                812
0152 325E       813 ROPB    JB1     POPD
0154 1[illegible]5A       814         JB0     POPE
0[illegible] 23A4       815         MOV     A,#0A4H         ; R6=4, LEVEL=5
0158 642E       816         JMP     CAMPO
015A 23A2       817 POPE    MOV     A,#0A2H         ;   =5,     =6
[illegible]     [illegible] 818         JMP     CAMPO
015E 1264       819 POPD    JB0     ROPF
0160 23A1       820         MOV     A,#0A1H         ;   =6,     =7
0162 648E       821         JMP     CAMPO
0164 239A       822 ROPF    MOV     A,#098H         ;   =7,     =8
```

```
[illegible]  [illegible]  SEQ  SOURCE STATEMENT

[illegible]  [illegible]  823          JMP     CAMP0
                          824
[illegible]  [illegible]  825 POPH     JB2     POP0
[illegible]  [illegible]  826          JB1     POPH
[illegible]  [illegible]  827          JB0     POPI
[illegible]  [illegible]  828          MOV     A,#094H         ; R6=8, LEVEL=9
[illegible]  [illegible]  829          JMP     CAMP0
[illegible]  [illegible]  830 POPI.    MOV     A,#092H         ;   =9,      =10
[illegible]  [illegible]  831          JMP     CAMP0
0376 1A7C                 832 POPH.    JB0     POPJ
0378 2391                 833          MOV     A,#091H         ;   =10,     =11
037A 648E                 834          JMP     CAMP0
037C 2388                 835 POPJ.    MOV     A,#088H         ;   =11,     =12
037E 648E                 836          JMP     CAMP0
                          837
[illegible]  [illegible]  838 POPG     JB1     POPK
0382 1288                 839          JB0     POPL
[illegible]  [illegible]  840          MOV     A,#084H         ; R6=12, LEVEL=13
[illegible]  [illegible]  841          JMP     CAMP0
0388 2282                 842 POPL.    MOV     A,#082H         ;   =13,     =14
038A 648E                 843          JMP     CAMP0
[illegible]  [illegible]  844 POPK.    MOV     A,#081H         ;   =14,15,  =15
                          845
[illegible]  [illegible]  846 CAMP0    MOVD    P5,A
[illegible]  [illegible]  847          SWAP    A
0390 3C                   848          MOVD    P4,A
0391 93                   849 CHIK     RETR
                          850
                          851
                          852 ;*****************************************************************************
                          853
                          854 ;        THIS ROUTINE DECODES REGISTER R6 TO DETERMINE IF THE MISSILE
                          855 ;        IS IN THE LOW RANGE (LESS THAN 333 METERS), MID RANGE (333 TO
                          856 ;        666 METERS), OR HIGH RANGE (GREATER THAN 666 METERS).
                          857
                          858 ;        THE AMPLITUDES OF 3 SUCCESSIVE EXPLOSIONS ARE SET FOR A TARGET
                          859 ;        HIT.  A MISSED TARGET PRODUCES ONLY THE FIRST TWO EXPLOSIONS.
                          860
0392 C5                   861 HITAMP   SEL     RB0
0393 FE                   862          MOV     A,R6
0394 72AE                 863          JB3     HADU
0396 52A1                 864          JB2     HITU
                          865
[illegible]  [illegible]  866 MARY     MOV     A,R5
[illegible]  [illegible]  867          DEC     A
[illegible]  [illegible]  868          JZ      JOHN3           ; R6=2,3,4,5   3RD EXPLO   HIGH RANGE
[illegible]  [illegible]  869          DEC     A
[illegible]  [illegible]  870          JZ      JOHN2           ;              2ND EXPLO
03AD A5C5                 871          JMP     JOHN1           ;              1ST EXPLO
                          872
[illegible]  [illegible]  873 HITU     JB1     HOAX
[illegible]  [illegible]  874          JMP     MARY
                          875
[illegible]  [illegible]  876 HOAX     MOV     A,R5
[illegible]  [illegible]  877          DEC     A
```

```
LOC  OBJ      SEQ      SOURCE STATEMENT

03A7 C6CD     878      JZ      JOHN4          ; R6=6, ,10  3RD EXPLO   MID RANGE
03A9 07       879      DEC     A
03AA C6C5     880      JZ      JOHN2          ;            2ND EXPLO
03AC 04C1     881      JMP     JOHN1                       1ST EXPLO
              882
03AE 52E8     883 HADU  JB2     HOPE
03B0 3CB4     884       JB1     HADE
03B2 64A5     885       JMP     HOAX
03B4 12B8     886 HADE  JB0     HOPE
03B6 64A5     887       JMP     HOAX
              888
03B8 FD       889 HOPE  MOV     A,R5
03B9 07       890       DEC     A
03BA C6CD     891       JZ      JOHN4          ; R6=11, ,15  3RD EXPLO   LOW RANGE
03BC 07       892       DEC     A
03BD C6C9     893       JZ      JOHN3          ;            2ND EXPLO
03BF 04C5     894       JMP     JOHN2          ;            1ST EXPLO
              895
03C1 23BF     896 JOHN1 MOV     A,#0FH         ; SOUND LEVEL 1 (LOWEST)
03C3 3C       897       MOVD    P4,A
03C4 93       898       RETR
03C5 23BE     899 JOHN2 MOV     A,#0EH         ; SOUND LEVEL 2
03C7 3C       900       MOVD    P4,A
03C8 93       901       RETR
03C9 23BD     902 JOHN3 MOV     A,#0DH         ; SOUND LEVEL 3
03CB 3C       903       MOVD    P4,A
03CC 93       904       RETR
03CD 23BC     905 JOHN4 MOV     A,#0CH         ; SOUND LEVEL 4 (LOUDEST)
03CF 3C       906       MOVD    P4,A
03D0 93       907       RETR
              908
              909
              910
              911
              912
              913
              914
              915       END
```

USER SYMBOLS

?INFIN	0072	ANIT	0009	BAT0	0215	BAT01	01D9	BAT1	020F	BAT11	01D7	BAT2	0207	BAT21	01D5
BAT3	01FF	BAT4	01F7	BAT5	01EF	BAT6	01E6	BAT7	01DF	BEA	021E	BEB	0225	BIT0	01A0
BIT1	01A5	BIT2	019C	BIT3	0191	BIT4	0186	BIT5	017B	BIT6	016C	BIT7	0160	BRAVE	0271
CAMAF	026D	CAKET	027E	CAMPO	038E	CHAK	00A0	CHECK	0094	CHIK	0391	COKOP	0275	DALAY	00BF
DECODE	00D1	DELAY	00B4	DEXAA	00A7	DEXO	00A1	DLY	00C1	DRAGO	00F3	DRAGON	0228	DRANG	0030
DUDF	00F8	DUDEX	0277	DUDEX1	00EB	DUDEXO	0100	FLIP	001E	GETTA	00AF	HADE	03B4	HADU	03AE
HAFE	0333	HEXO	00AB	HITAMP	0392	HITE	0103	HITE1	00EE	HITEX	029A	HITU	03A1	HOAX	03A5
HUFE	0368	INFIN	0046	INIT	0008	JACKO	0309	JIERT	029E	JOHN1	03C1	JOHN2	03C5	JOHN3	03C9
JOHN4	03CD	JP0	015C	JP1	015A	JP2	0158	JP3	0156	JP4	0154	JP5	0152	JP6	0150
LAHIT	029E	LADP1	031A	LADP2	0337	LAPOR	032C	LOADP1	0300	LOADP2	0323	LOORAM	023B	LOOP1	00B6
LOOP2	00E8	MARY	0398	OBLO	00CE	PASS	0115	PB0	01D1	PB1	01CF	PB2	01CD	PB3	01CB
PB4	01C9	PB5	01C7	PB6	01C5	PBY	01DB	POKER	011E	POSS	0112	PUPP	0117	PUPPET	011A
RESET	0100	RESPG	0018	ROPA	0368	ROPAMP	0340	ROPB	0352	ROPC	034E	ROPD	035E	ROPE	035A
ROPF	0364	ROPG	0380	ROPH	0376	ROPI	0372	ROPJ	037C	ROPK	0380	ROPL	0388	ROPO	0105
ROPO1	00F1	ROPOP	0208	SAFON	00AE	SAVOB	0087	SINFIN	0076	TAP1	021A	TAP	0142	TAPAP	01B2

TAPE 014A TARC 0137 TESTR4 014C THERE 0316 TIMER 00C6 TRAMP 0217 TRAP 01C0 TRIP 01BE
TR45 0128 UNFIN 0063

ASSEMBLY COMPLETE, NO ERRORS

```
LOC  OBJ        SEQ        SOURCE STATEMENT

                  1
                  2
                  3 .              16 SEPTEMBER 1981
                  4
                  5
                  6 .       THIS IS A PROGRAM TO TURN THE TURRET ON A TANK MODEL
                  7 .       90 DEGREES, HOLD IT THERE FOR 1.5 SECONDS, AND RETURN IT
                  8
                  9
                 10         INITIALIZATION
                 11
0000             12         ORG     0
0000 0409        13         JMP     INIT
0003             14         ORG     3
0003 0419        15         JMP     TURN
0009             16         ORG     9
0009 23FF        17 INIT    MOV     A,#0FFH
000B 39          18         OUTL    P1,A
000C 97F7        19         ANL     P1,#0F7H            ;RESET P5G
000E 8908        20         ORL     P1,#8
0010 75          21         ENT0    CLK
0011 05          22         EN      I
0012 09          23 TRIG    IN      A,P1
0013 9212        24         JB4     TRIG                ;TEST P14 FOR TRIGGER PULSE
0015 14EB        25         CALL    GYRO
0017 0412        26         JMP     TRIG
                 27
                 28
                 29 .       RUN TURRET FORWARD
                 30
0019 99FD        31 TURN    ANL     P1,#0FDH            ; 1111/1101 = PORT 1
001B BAC8        32         MOV     R2,#200D
001D 1414        33         CALL    DELAY
001F 561F        34 WHITE1  JT1     WHITE1
0021 8906        35         ORL     P1,#06
                 36
0023 1446        37         CALL    SOUND
                 38
0025 BAC8        39         MOV     R2,#100D
0027 1414        40         CALL    DELAY
                 41
                  4
                  4         RUN TURRET REVERSE
                  4.
                  .         ANL     P1,#0FBH            . 1111/1011 = PORT 1
                            MOV     R2,#200
                            CALL    DELAY
                            ORL     P1,#04
                            JT1     WHITE2
                            CALL    SOUND
                            MOV     R2,#100D
                            CALL    DELAY
                            JMP     TURN
```

```
LOC  OBJ        SEQ        SOURCE STATEMENT

0034 B908          57 DELAY:  MOV     R1,#8              ; DELAY = R2 X  01 SEC
0036 B8FF          58 LOOP1:  MOV     R0,#0FFH
0038 E838          59 LOOP2:  DJNZ    R0,LOOP2
003A E936          60         DJNZ    R1,LOOP1
003C EA34          61         DJNZ    R2,DELAY
003E 83            62         RET
                   63
003F B8C8          64 DALAY:  MOV     R0,#0C8H           ; DELAY = R2 X .001 SEC
0041 E841          65 DAY:    DJNZ    R0,DAY
0043 EA3F          66         DJNZ    R2,DALAY
0045 83            67         RET
                   68
                   69
                   70 ;       THIS IS THE SOUND MAKING ROUTINE
                   71
0046 99F7          72 SOUND:  ANL     P1,#0F7H           ; ALL PSG REGISTERS GET 0
0048 8908          73         ORL     P1,#8
                   74
004A BA32          75         MOV     R2,#50D
004C 1434          76         CALL    DELAY
                   77
004E B830          78         MOV     R0,#030H
0050 2300          79         MOV     A,#0
0052 A0            80         MOV     @R0,A              ; R0
0053 18            81         INC     R0
0054 2336          82         MOV     A,#036D
0056 A0            83         MOV     @R0,A              ; R7
0057 18            84         INC     R0
0058 2307          85         MOV     A,#07H
005A A0            86         MOV     @R0,A              ; R10
                   87
005B BF48          88         MOV     R7,#048H           ; LOOP COUNTER
005D B830          89         MOV     R0,#030H
                   90
005F 8901          91 WHISTL: ORL     P1,#1
0061 27            92         CLR     A
0062 90            93         MOVX    @R0,A
0063 99FE          94         ANL     P1,#0FEH
0065 F0            95         MOV     A,@R0
0066 90            96         MOVX    @R0,A              ; WRITE TO REGISTER R0
                   97
0067 8901          98         ORL     P1,#1
0069 2301          99         MOV     A,#1
006B 90           100         MOVX    @R0,A
006C 99FE         101         ANL     P1,#0FEH
006E 2301         102         MOV     A,#1
0070 90           103         MOVX    @R0,A              ;                  R1
                  104
0071 8901         105         ORL     P1,#1
0073 2306         106         MOV     A,#6
0075 90           107         MOVX    @R0,A
0076 99FF         108         ANL     P1,#0FFH
0078 230F         109         MOV     A,#17D
007A 90           110         MOVX    @R0,A              ;                  R6
                  111
```

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LOC  OBJ        SEQ        SOURCE STATEMENT

0078 8901       108        ORL     P1,#1
007A 2307       109        MOV     A,#7
007C 90         110        MOVX    @R0,A
007D 98FE       111        ANL     P1,#0FEH
007F 18         112        INC     R0
0080 F0         113        MOV     A,@R0
0081 90         114        MOVX    @R0,A                          R7
                115
0082 8901       116        ORL     P1,#1
0084 2308       117        MOV     A,#100
0086 90         118        MOVX    @R0,A
0087 98FE       119        ANL     P1,#0FEH
0089 18         120        INC     R0
008A F0         121        MOV     A,@R0
008B 90         122        MOVX    @R0,A                          R10
                123
008C BA07       124        MOV     R2,#7
008E 143F       125        CALL    DALAY                  ; 7 MSEC PER STEP
                126
0090 EF97       127        DJNZ    R7,CONT
0092 049C       128        JMP     EXPLO
0094 B830       129 CONT   MOV     R0,#030H
0096 10         130        INC     @R0
0097 A45F       131        JMP     WHISTL
                132
0099 8901       133 EXPLO  ORL     P1,#1
009B 27         134        CLR     A
009C 90         135        MOVX    @R0,A
009D 98FE       136        ANL     P1,#0FEH
009F 2350       137        MOV     A,#1350
00A1 90         138        MOVX    @R0,A                  ; WRITE TO REGISTER R0
                139
00A2 8901       140        ORL     P1,#1
00A4 2301       141        MOV     A,#1
00A6 90         142        MOVX    @R0,A
00A7 98FE       143        ANL     P1,#0FEH
00A9 2350       144        MOV     A,#150
00AB 90         145        MOVX    @R0,A                          R1
                146
00AC 8901       147        ORL     P1,#1
00AE 2306       148        MOV     A,#6
00B0 90         149        MOVX    @R0,A
00B1 98FE       150        ANL     P1,#0FEH
00B3 231F       151        MOV     A,#370
00B5 90         152        MOVX    @R0,A                          R6
                153
00B6 8901       154        ORL     P1,#1
00B8 2307       155        MOV     A,#7
00BA 90         156        MOVX    @R0,A
00BB 98FE       157        ANL     P1,#0FEH
00BD 2360       158        MOV     A,#0360
00BF 90         159        MOVX    @R0,A                          R7
                160
00C0 8901       161        ORL     P1,#1
00C2 2308       162        MOV     A,#8
```

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LOC  OBJ          SEQ          SOURCE STATEMENT

00C7 90           163          MOVX    @R0,A
00C8 99FE         164          ANL     P1,#0FEH
00CA 2310         165          MOV     A,#0200
00CC 90           166          MOVX    @R0,A                          ;                R10
                  167
00CD 8901         168          ORL     P1,#1
00CF 230B         169          MOV     A,#130
00D1 90           170          MOVX    @R0,A
00D2 99FE         171          ANL     P1,#0FEH
00D4 23FF         172          MOV     A,#0FFH
00D6 90           173          MOVX    @R0,A                          ;                R13
                  174
00D7 8901         175          ORL     P1,#1
00D9 2314         176          MOV     A,#140
00DB 90           177          MOVX    @R0,A
00DC 99FE         178          ANL     P1,#0FEH
00DE 233F         179          MOV     A,#0770
00E0 90           180          MOVX    @R0,A                          ;                R14
                  181
00E1 8901         182          ORL     P1,#1
00E3 2300         183          MOV     A,#150
00E5 90           184          MOVX    @R0,A
00E6 99FE         185          ANL     P1,#0FEH
00E8 27           186          CLR     A
00E9 90           187          MOVX    @R0,A                          ;                R15
                  188
00EA 83           189          RET
                  190
                  191
00EB BA0A         192 GYRO     MOV     R2,#10D
00ED 1434         193          CALL    DELAY
                  194
00EF 8901         195          ORL     P1,#1
00F1 2302         196          MOV     A,#2
00F3 90           197          MOVX    @R0,A
00F4 99FE         198          ANL     P1,#0FEH
00F6 23FF         199          MOV     A,#0FFH
00F8 90           200          MOVX    @R0,A                          ;                R2
                  201
00F9 8901         202          ORL     P1,#1
00FB 2303         203          MOV     A,#3
00FD 90           204          MOVX    @R0,A
00FE 99FE         205          ANL     P1,#0FEH
0100 2303         206          MOV     A,#3
0102 90           207          MOVX    @R0,A                          ; B = 4XFREQ     R3
                  208
0103 8901         209          ORL     P1,#1
0105 2304         210          MOV     A,#4
0107 90           211          MOVX    @R0,A
0108 99FE         212          ANL     P1,#0FEH
010A 23FF         213          MOV     A,#0FFH
010C 90           214          MOVX    @R0,A                          ;                R4
                  215
010D 8901         216          ORL     P1,#1
010F 2305         217          MOV     A,#5
```

```
LOC  OBJ        SEQ        SOURCE STATEMENT

0111 90          218        MOVX    @R0,A
0112 99FE        219        ANL     P1,#0FEH
0114 230F        220        MOV     A,#0FH
0116 90          221        MOVX    @R0,A              ; C = 1XFREQ      R5
                 222
0117 8901        223        ORL     P1,#1
0119 2306        224        MOV     A,#6
011B 90          225        MOVX    @R0,A
011C 99FE        226        ANL     P1,#0FEH
011E 230F        227        MOV     A,#0FH
0120 90          228        MOVX    @R0,A              ;                 R6
                 229
0121 8901        230        ORL     P1,#1
0123 2307        231        MOV     A,#7
0125 90          232        MOVX    @R0,A
0126 99FE        233        ANL     P1,#0FEH
0128 2309        234        MOV     A,#3110
012A 90          235        MOVX    @R0,A              ;                 R7
                 236
012B 8901        237        ORL     P1,#1
012D 2309        238        MOV     A,#110
012F 90          239        MOVX    @R0,A
0130 99FE        240        ANL     P1,#0FEH
0132 230F        241        MOV     A,#0FH
0134 90          242        MOVX    @R0,A              ;                 R11
                 243
0135 8901        244        ORL     P1,#1
0137 230A        245        MOV     A,#120
0139 90          246        MOVX    @R0,A
013A 99FE        247        ANL     P1,#0FEH
013C 230F        248        MOV     A,#0FH
013E 90          249        MOVX    @R0,A              ;                 R12
                 250
013F BA32        251        MOV     R2,#500
0141 1434        252        CALL    DELAY
                 253
0143 93F7        254        ANL     P1,#0F7H
0145 8908        255        ORL     P1,#8
                 256
0147 83          257        RET
                 258
                 259
                 260
                 261
                 262
                 263        END

USER SYMBOLS
CONT   0097   DALAY  003F   DAY    0041   DELAY  0034   EXPLO  009C   GYRO   00EB   INIT   0009   LOOP1  0036
LOOP2  0038   SOUND  0046   TRIG   0012   TURN   0019   WHISTL 005F   WHITE1 001F   WHITE2 002F

ASSEMBLY COMPLETE,  NO ERRORS
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