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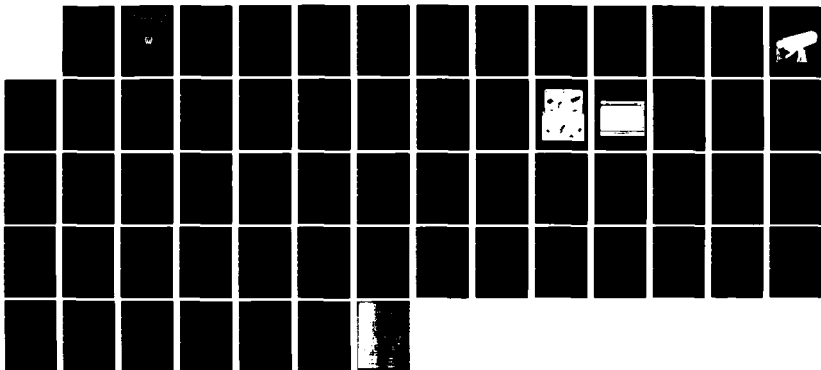
BATTLEFIELD IDENTIFICATION FRIEND-OR-FOE (BIFF) -
THERMAL SIGHT TRAINER(U) ARMY PROJECT MANAGER FOR
TRAINING DEVICES ORLANDO FL A MARSHALL ET AL. MAR 83
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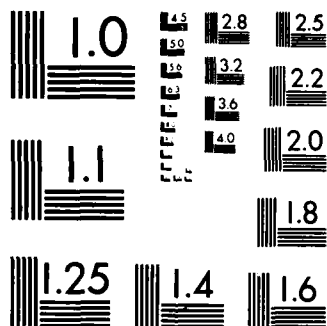
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BATTLEFIELD IDENTIFICATION FRIEND - OR - FOE (BIFF) - THERMAL SIGHT TRAINER

**BY Albert Marshall
Gary Bond
Bon Shaw**



PREPARED FOR

**U.S. ARMY PROJECT MANAGER FOR TRAINING DEVICES
NAVAL TRAINING EQUIPMENT CENTER (NTEC)
ORLANDO, FLORIDA 32813**

BY

**ADVANCED SIMULATION CONCEPTS LABORATORY
SIMULATION TECHNOLOGY BRANCH**

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)		
Few Army units have access to the ranges and opposing force vehicles required for "real-world" training in thermal-image friend-foe discrimination and specific-vehicle identification. Even given facilities, such training is time-and-resource-expensive. This report describes a low-cost interactive trainer concept developed to provide classroom or day-room training under simulated operational conditions.		

This effort employs a commercial-type riflescope with coaxially-mounted collimated light source as a substitute for the operational thermal sight. Through this "sight" the student views a highly-detailed replaceable scale model of the selected vehicle; each model is painted (with retroflective paint) in pattern replicating the real-world thermal signature under specified conditions. The model is mounted on a turntable, permitting presentation of either static or moving views from/to any quarter. Models could be prepared so as to replicate signature characteristics under any given operational and environmental conditions.

The system includes a micro-processor which controls the light source and tracks student responses and response times.



1. NAME	
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6. AND/OR	
7. OTHER	

A

SUMMARY

The Battlefield Identification Friend-or-Foe (BIFF) thermal sight trainer is a device that allows realistic, low-cost training in infrared (IR) target recognition.

Recently, the TOW, DRAGON, and M-1 Tank were equipped with heat-sensitive "IR thermal" night sights. Thermal sights allow the gunner to engage targets through darkness, smoke, dust, and fog that occur on a battlefield. However, thermal images appear different from visual images and require a trained operator. This report describes an experimental trainer developed for BIFF/thermal sight training.

This training device consists of the following components:

- (1) Simulated thermal sight,
- (2) Instructor's console,
- (3) Target board.

The targets are miniature, 1/285 scaled, micro-armor models. When an instructor places a model on the terrain board, he indicates to the system via a switch on his console whether the target is "Enemy" or "Friendly." At the time the instructor is ready to start, he pushes a "START" button which sounds a "Sonalert" buzzer. The buzzer indicates to the student that he can begin when ready. Each student has a simulated thermal sight. The sight has three buttons -- READY, FRIENDLY, and ENEMY. When the student hears the buzzer and is ready to search for a target, he pushes his "READY" button. After he finds the target, he must rapidly identify the target as either "FRIENDLY" or "ENEMY." He does this by pushing the appropriate button on his simulated thermal sight. If he is correct, a computer voice synthesis unit announces his reaction time in seconds. If the student makes an error, the voice synthesis unit announces, "Error." LCD displays on the instructor's console show the student's score as well as average reaction time.

The system design uses an electro-optic approach to simulate thermal targets. The sight is a rifle scope equipped with a thermal sight rubber eyepiece. In very close proximity to the sight is an illumination source consisting of a lens, red filter, and incandescent light bulb. The area illuminated is equivalent to the rifle scope field of view. The miniature targets are painted with retroreflective paint in the normal "Hot" areas, i.e., wheels and engine compartment. Unless the observer's eye is in close proximity to the illuminating source, he does not see the target. However, if he looks through the sight telescope, he sees the magnified target. Since the target is painted to correspond to a real thermal signature, he sees the simulated signature through the sight. Experienced thermal gunners have assessed the image a satisfactory replication of operational sight imagery.

Advantages of the system are:

- (1) Targets move,
- (2) Thermal signatures can be changed,
- (3) Interactive,
- (4) Brightness/contrast control,
- (5) Low cost,
- (6) Competitive training atmosphere,
- (7) Reliable,
- (8) No special instructor training,
- (9) Portable.

The PM TRADE Project Manager is Donald Peckham. The authors wish to thank Mr. Peckham for his assistance on the program.

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SECTION I

SYSTEM DESCRIPTION

The Battlefield Identification Friend-or-Foe (BIFF) thermal sight trainer uses an electro-optical approach to simulate thermal imagery. Night sights detect thermal-induced emission or electromagnetic energy in the far IR region. These signals are converted into a visible light image on a LED display screen for real-time viewing by the gunner. The thermal detector in the night sight is capable of resolving small temperature differences.

Thermal target images appear drastically different from visible light presentations. Therefore, the operators require special training in thermal imagery interpretation. The trainee must be capable of identifying both enemy and friendly targets. Since the IR battlefield may contain targets, false targets, and clutter noise, the trainee must be capable of sorting targets rapidly since false target effects can be a principal cause of poor operator performance. False targets might consist of a large rock heated by the sun or a cooking fire.

The approach proposed for a classroom trainer involves the use of miniature models on a small terrain board with easily interchangeable and movable models. Retroreflective paint will be used on target areas that are at a higher temperature, i.e., the engine compartment and road wheels of a tank. False targets, such as hot rocks or fires, will also be easily simulated. Varying the amount of paint on the model can simulate atmospheric effects. The trainee views the target through a low-cost variable magnification rifle scope. The trainee gets the same feel as looking through the real thermal sight scope when searching for a target.

Attached to the sighting scope is a small collimated source of red light. The retroreflective paint on the hot areas of the targets reflects the red light directly back toward the light source in a very narrow cone. Unless an observer has his eye immediately next to the light source, he does not see the retroreflected red light. However, if he places his eye within approximately six inches of the light source, he can see a strong reflection from any surface painted with the retroreflective paint. When the trainee looks through the rifle scope, he sees a magnified image of the retroreflected red light. Magnification values are selected to yield views duplicating those of the AN/TAS-4A and AN/TAS-5 sights at selected ranges. Red was selected to correspond to the LED display screen in the AN/TAS-4A and -5 thermal sights (green can easily be substituted to simulate other sights). Varying amounts of paint or types of retroreflective paint will change the brightness (i.e., target temperature) viewed by the trainee.

To increase the training effectiveness, the system is interactive with immediate voice feedback to the trainee.

Some of the advantages of the system are:

Targets Move - Targets are placed on a rotating disc which continuously varies the aspect of the observed target to the trainee.

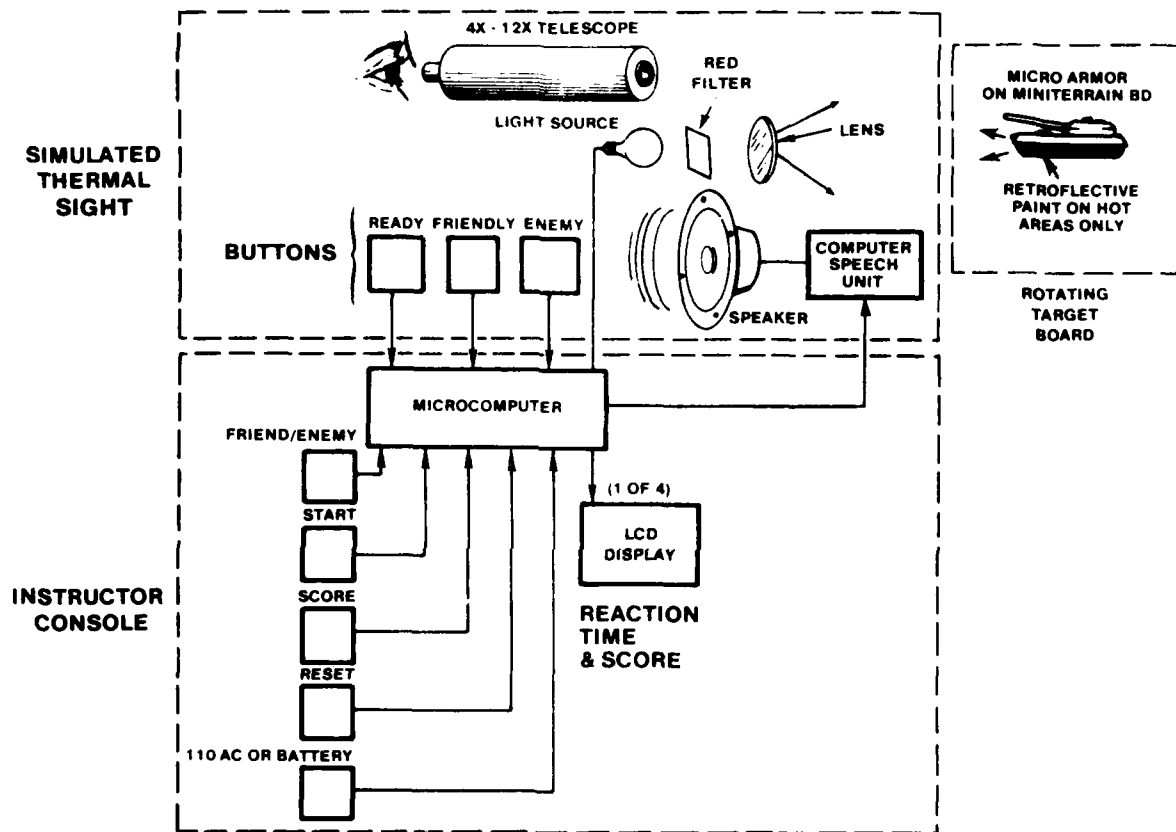


Figure I-1. System Block Diagram

Signatures Can Be Changed - Targets can be painted with a variety of signatures. Signatures can be designed to replicate any definable combination of operational and environmental conditions.

Interactive - Computer synthesized voice gives immediate feedback to trainee on correctness of identification of target as "Friend" or "ENEMY." Reaction time in seconds is separately announced to each trainee.

Brightness/Contrast of Display Can be Varied - The brightness/contrast of the display can be easily varied.

Low Cost - Minimum number of low-cost components.

Reliable - Reliable off-the-shelf microcomputer components.

No Special Operator Training - Operator training can be conducted in less than 0.5 hours.

Portable - High portability.

Figure I-1 shows a system block diagram. The laboratory system has four trainee positions; production unit capacity would be limited only by user defined group size and by capacity of the selected microprocessor.

The main components are:

Simulated thermal sight (1 of 4),

Instructor's console,

Mini-terrain board.

The main system components are discussed in Section II.

Reliable - Reliable off-the-shelf microcomputer components.

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Simulated thermal sight (1 of 4),

Instructor's console,

Mini-terrain board.

The main system components are discussed in Section II.

SECTION II

SYSTEM DESIGN

A. SIMULATED THERMAL SIGHT

The simulated thermal sight laboratory model is shown in Figure II-1 and a block diagram of the simulated thermal sight is shown in Figure II-2. The sight consists principally of a telescopic rifle sight and a target illuminator. The telescope has continuously variable magnification from 4X to 12X and is equipped with an AN/TAS-4 thermal sight eyepiece to heighten the simulation realism.

The illumination source for the retroreflective targets is an incandescent lamp. Light from the lamp is collimated by a simple single biconvex lens. The light is focused to a spot size corresponding roughly to the field-of-view of the sighting telescope. Because both the AN/TAS-4A and AN/TAS-5 thermal sight displays are red (LED), the light source is filtered to correspond to the color of the display. Display brightness is controlled by a potentiometer on the sight.

The simulated sight contains the following buttons and indicators:

READY - The student begins an exercise by pushing this button at any time after the audio signal from the Instructor's console. When the "READY" button is pushed, it:

- (1) Starts the reaction time clock and
- (2) turns on the illuminator so the trainee can see the targets. (When the lamp is off, the target cannot be observed by the trainee.)

FRIEND - When the trainee observes the target, he can select either "FRIEND" or "ENEMY." If the trainee believes the target to be friendly, he/she pushes the "FRIEND" button. This stops the reaction time clock. The synthesized voice announces the reaction time if the selection is correct.

ENEMY - If the student believes the target to be "ENEMY" he/she pushes this button; it, too stops the reaction clock.

Red LED - If the wrong selection is made by the trainee, a red LED is turned on. The LED is located on the sight.

Green LED - If the correct selection is made, the green LED is turned on.

The sight unit contains its own computer voice synthesis module. The speaker for this unit is located in close proximity to the trainee's ear, and the sound level is adjustable.

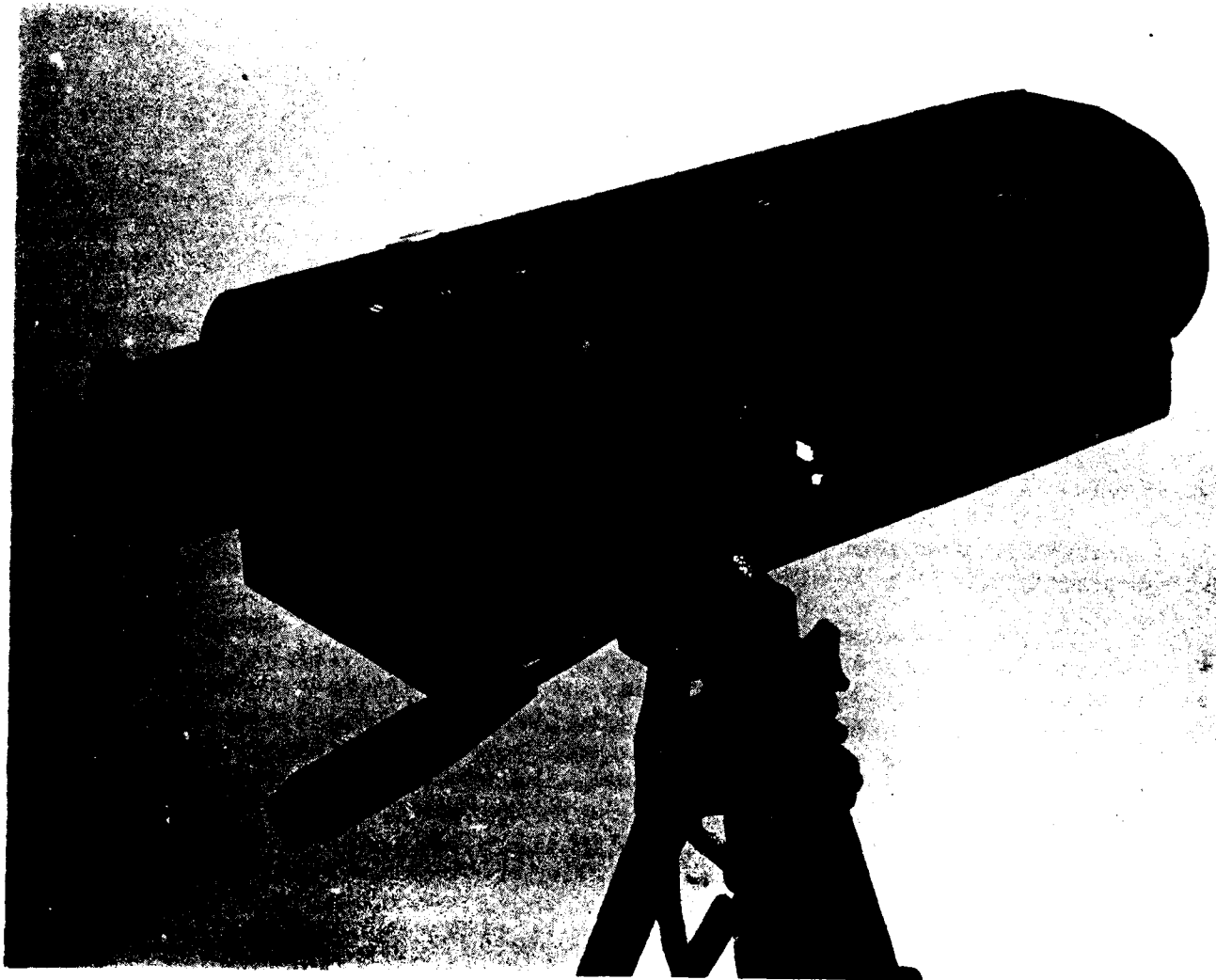


Figure II-1. Thermal Sight

An oscillator causes the target-illuminative incandescent lamp to blink, thus simulating the scanner in the operational thermal sight.

This system is intended to be used in a semi-darkened room. This serves to heighten the effects of the retroreflective approach. Also, trainees can only view targets through an active simulated sight thus providing a measure of control to the instructor.

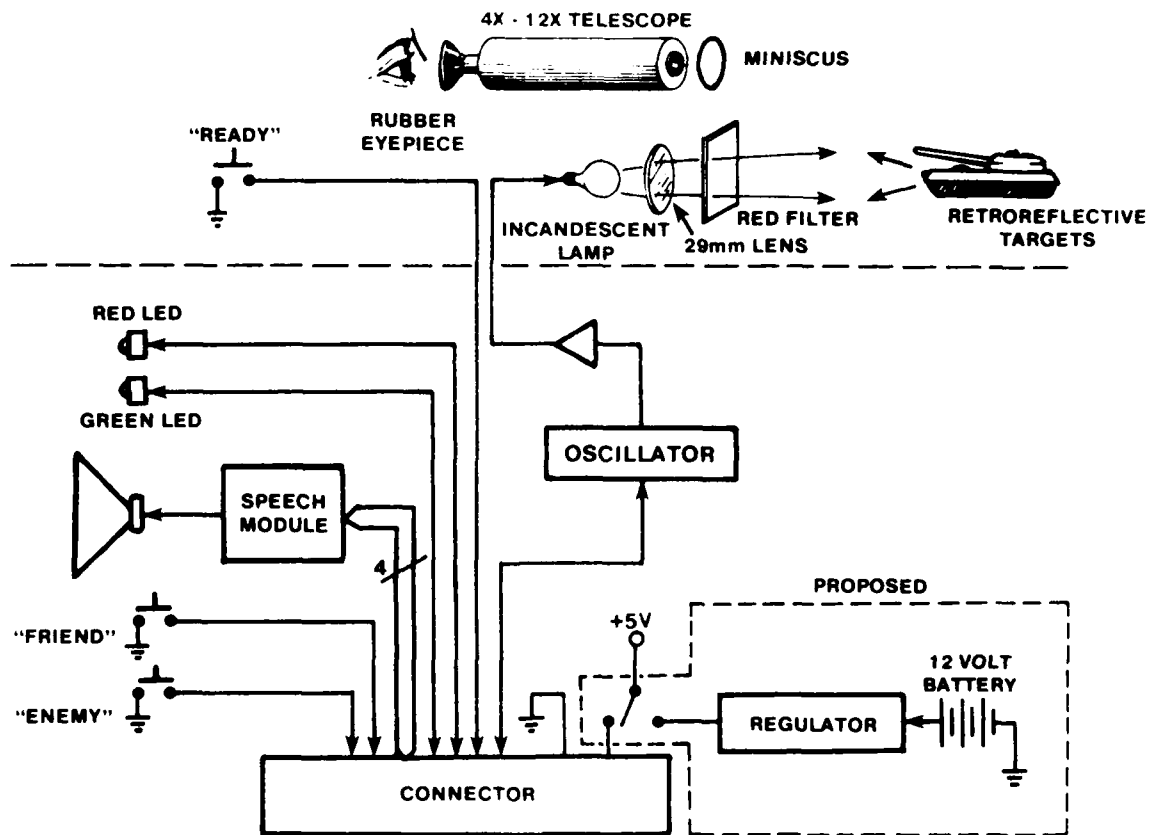


Figure II-2. Thermal Sight Block Diagram

B. MICROCOMPUTER CONTROLLER

All functions of this system are under the control of two single chip microcomputers. The master controller (MC) is an Intel 8748 microcomputer. Its function is to monitor the trainee sights, process information to be displayed on the instructor's console, and route data to its slave speech processor. A complete schematic of the instructor's console is detailed in Figure II-8.

The instructor communicates to the MC via four switches on his console (Figure II-3). The "RESET" switch clears the memory of the MC and initializes the training session. The instructor tells the MC what type target he has selected through the "FRIEND/ENEMY" switch. He then activates the trainee sights with the "START" switch. When he depresses "START," an audio buzzer will sound, notifying the trainees they may begin. Each trainee has three switches on his sight (Figure II-2) -- "READY" turns on the red target illuminator lamp and starts a clock to record his reaction time; "FRIEND" and "ENEMY" tell the MC he has decided what type target and stops his reaction time clock.

The MC utilizes an algorithm which forces a predetermined sequence of events. After reset, MC waits for the "START" signal. When this is received, the type target selected on the instructor's console is stored as 1 for friend and 0 for enemy. A master clock is started, and a buzzer is sounded for one second. At this point, the MC enters a polling algorithm, which monitors the switches on each trainee sight. The timers increment once each 100 milliseconds up to 25.5 seconds.

Two Intel 8243 I/O expanders are used to communicate to the sight switches. Each sight is assigned an 8-bit timer which is cleared and started when the MC detects the "READY" switch depressed. The MC then provides a signal, through the Friendly/Enemy (F/E) 8243, which triggers a 555 Timer. This 555 Timer, located on the sight control board in each sight (Figure II-4), provides a TTL square wave pulse adjustable around 30 Hz to a Darlington driver which activates the target illuminator lamp.

After a trainee has pressed "READY," the MC, through its polling algorithm, waits for the "FRIEND" or "ENEMY" decision. When this choice is made, the MC stores the reaction time present in the timer. Reaction time for each sight is stored in two ways. One 8-bit location in memory is dedicated to each sight and contains the most recent reaction time. Two more 8-bit locations form a 16-bit counter which accumulates reaction time up to a limit of 1.8 hours. The target decision made by the trainee, (friend (1) or enemy (0)), is compared to the instructor's choice. One 8-bit counter for each sight will increment once each time that the trainee's decision is the same as the instructor's. A second 8-bit counter increments each time the trainee makes either decision. These two counters keep track of the trainee's

decision-making progress. The maximum number of decisions (models) which can be made is ninety-nine. Thus, an error is assigned by incrementing only the second counter. If the trainee allows his/her reaction time to reach 25.5 seconds, he/she is automatically assigned an error.

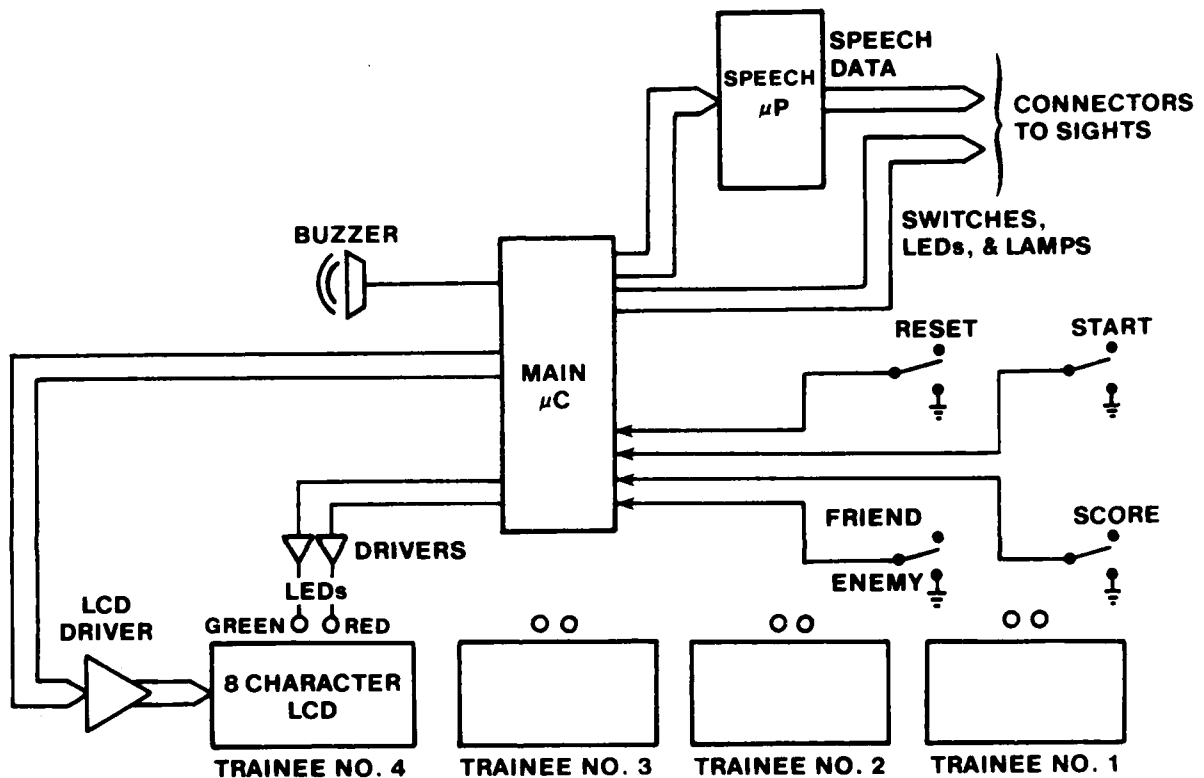


Figure II-3. Instructor's Console Block Diagram

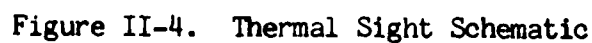
The instructor's console displays the results of each exercise and each trainee's progress through the training session. Four 8-character LCD's are located on the instructor's console, i.e., one per sight. The four left-most characters on each LCD display the trainee's decision-making progress. They represent the number of correct decisions versus the number of decisions, (e.g., 4:9, 18:27, 63:99). The four right-most characters display the most recent reaction time. The MC can calculate an average reaction time using the 16-bit reaction time counters and the counter for the number of decisions made. This average is displayed on the four right-most characters when the "SCORE" button on the instructor's console is pressed.

Two LED's are located just above each LCD, one green and one red; these LEDs work in parallel with those on their respective sights. The MC controls the LED's via the Green/Red (G/R) 8243. When a trainee has made a decision, the MC lights the green LED's if the decision is correct. Likewise, the red LED's go on for an error.

The second microcomputer in the system is the speech processor (SP). It is an Intel 8741 Universal Peripheral Interface. The function of the SP is to control the speechmaking process and operates on an interrupt basis with the MC. Immediately following the display of reaction time, the MC interrupts the SP and passes the reaction time over the data bus. The data passes from the MC to the SP in the form of three encoded 8-bit words. Bits 7 and 6 form the trainee number (0 thru 3) for four trainees. Bits 5 and 4 indicate the digit being passed; 11 for the most significant digit; 10 for the second most significant digit; and 01 for the least significant digit. The four least significant bits contain the Base 10 value of the digit. For example, a reaction time of 13.6 seconds for trainee number 2 is sent in this sequence:

First word	10	11	0001
Second word	10	10	0011
Third word	10	01	0110

The SP transmits data to the voice synthesis modules serially with four lines (see Figure II-4). The speech module requires a 7-bit address and a strobe in order to "Speak." Address bits appear on the "DATA" line and are clocked into the 74164 shift register by pulsing "RESET & CLOCK." This line also resets the speech module. If the SP detects on the "BUSY/READY" line that the speech module is ready, then "STROBE" is pulsed and the address of the word to be spoken is latched into the speech module. For those trainees who make a correct decision, the reaction time is assembled into a stack of addresses within the SP and transmitted to the proper sight. No reaction times are sent for incorrect decisions; instead, the address for "ERROR" is transmitted. The SP operates on a first-in/first-out basis; reaction time and error messages are passed to the proper sight in the order received from the MC.



C. COMPUTER SYNTHESIZED VOICE

A computer synthesized voice is used to give the trainee immediate feedback on both his correctness in identification and reaction time.

If the trainee makes an error, the synthesizer says almost immediately, "Error." If the trainee is correct, the synthesizer announces the time in seconds that the trainee took to recognize the target as "Friend" or "Enemy."

The voice synthesis unit used is a General Instrument VSM 2032 Voice Synthesis Module. This unit is a complete speech system for under \$50.00. It stores thirty seconds of speech and can announce any number from one to one less than a billion.

The synthesis module interfaces with a shift register which provides parallel addresses to the PIC1650A on-board microcomputer. The phrase to be spoken is selected with a 7-bit address. This data is strobed into the module using a STROBE line. Once selected, the VSM 2032 Voice Synthesis Module requires no support from the user's circuit. It enunciates the phrase and signals the voice microprocessor when complete.

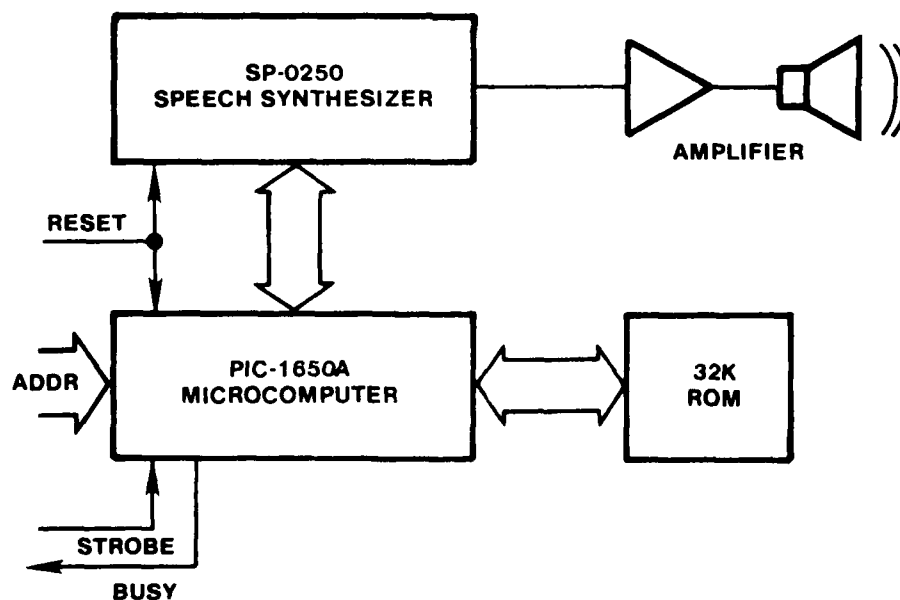


Figure II-5. Voice Synthesis Unit

The standard VSM 2032 used in this system can announce these thirty-two words and syllables:

ZERO	TWEN
ONE	THIR
TWO	FIF
THREE	TY
FOUR	TEEN
FIVE	PLUS
SIX	MINUS
SEVEN	TIMES
EIGHT	OVER
NINE	EQUALS
TEN	POINT
ELEVEN	ERROR
TWELVE	IT IS
HUNDRED	AM
THOUSAND	PM
MILLION	OH

Numbers less than one billion can be enunciated using the above phrase set. For example, 11.4 would be generated by

/eleven/ /point/ /four/

The synthesized voice is human-sounding and very understandable.

The VSM 2032 Voice Synthesis Module contains an operational amplifier which drives a small speaker on the back of each sight, in close proximity to the trainee's ear.

D. ROTATING TARGET BOARD

In order to provide a capability for viewing all aspects of a thermal target, a rotating target board was constructed (Figure II-6). The basic components of the board are:

- (1) 7RPM, 12 VOLT DC motor.
- (2) Aluminum platter.
- (3) Metal suitcase.
- (4) 12 Volt Gel-Type battery.
- (5) Gel-Type battery charger.
- (6) Speed control potentiometer.
- (7) Power switch.

The instructor may rotate the target by simply depressing the power switch. The connection made supplies power to the motor from the Gel-type battery. In series with the battery is a 100 ohm speed control potentiometer which allows the instructor to vary the platter rotational speed. If the battery charger is plugged into 120 VAC, the battery is recharged automatically when the power switch is off.

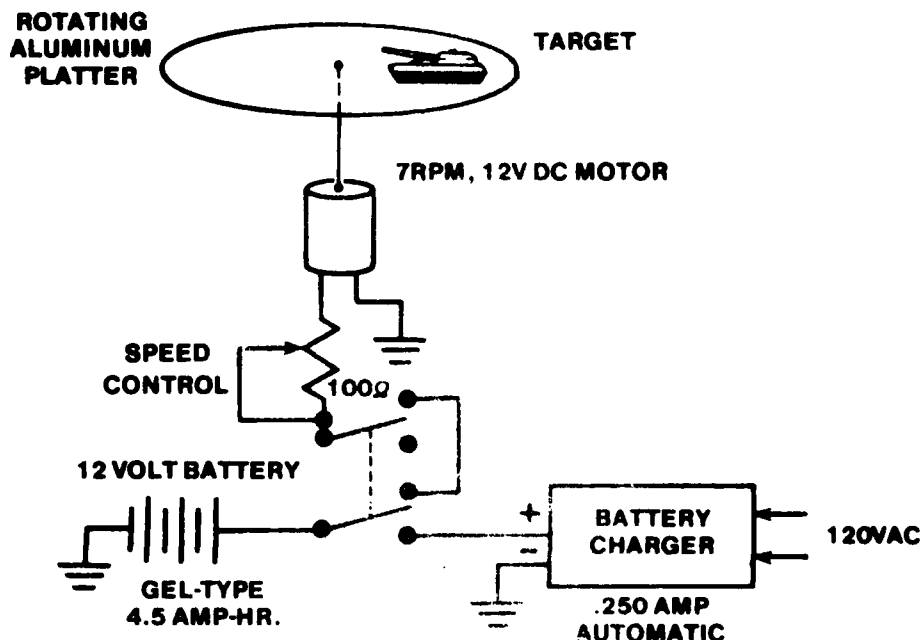


Figure II-6. Rotating Target Board.

E. POWER DISTRIBUTION

When the power selection switch is on "Line", the instructor's console and all the simulated sights are powered from a single, internal 5 volt power supply (see Figure II-7). In this mode or, when the switch is on "OFF" and the console is plugged into 120 VAC, the internal battery is automatically being recharged. If the power selection switch is on "Battery" the instructor's console receives power from the battery but the sights do not. Because of the high current requirements of the incandescent lamps in each sight it is proposed here that a production unit supply battery power to the sights independent of the instructor's console (see Figure II-2).

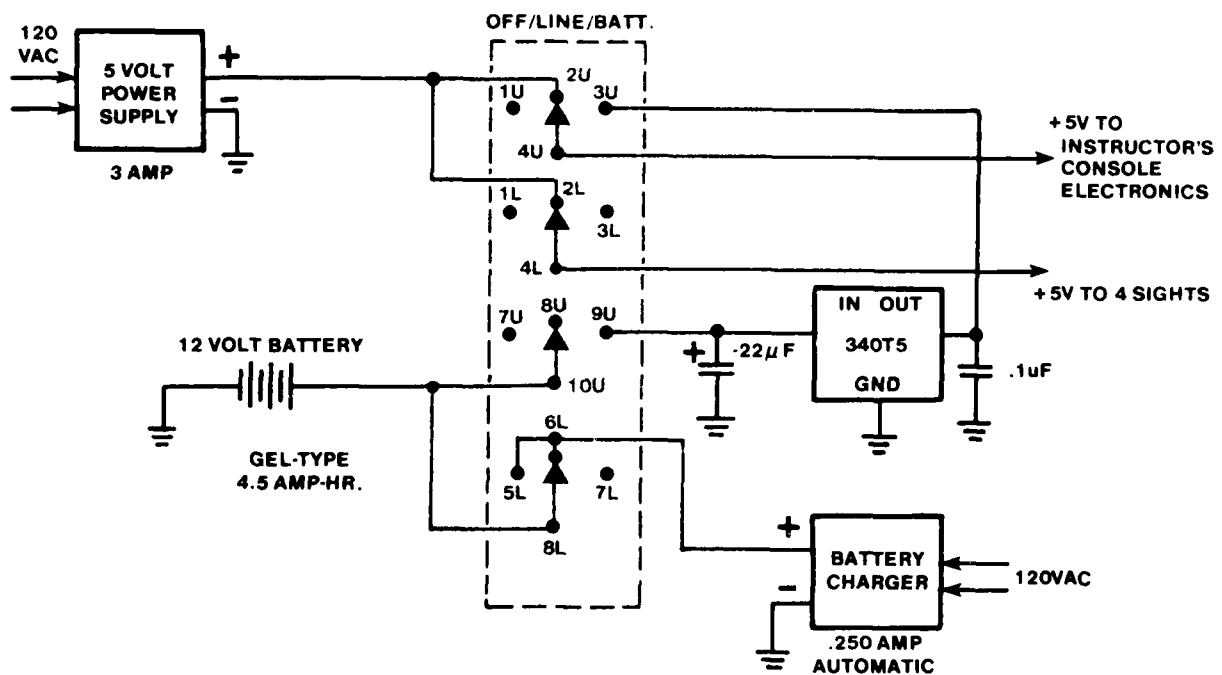


Figure II-7. Power Selection Switching



Figure II-9. Photograph of Target Board

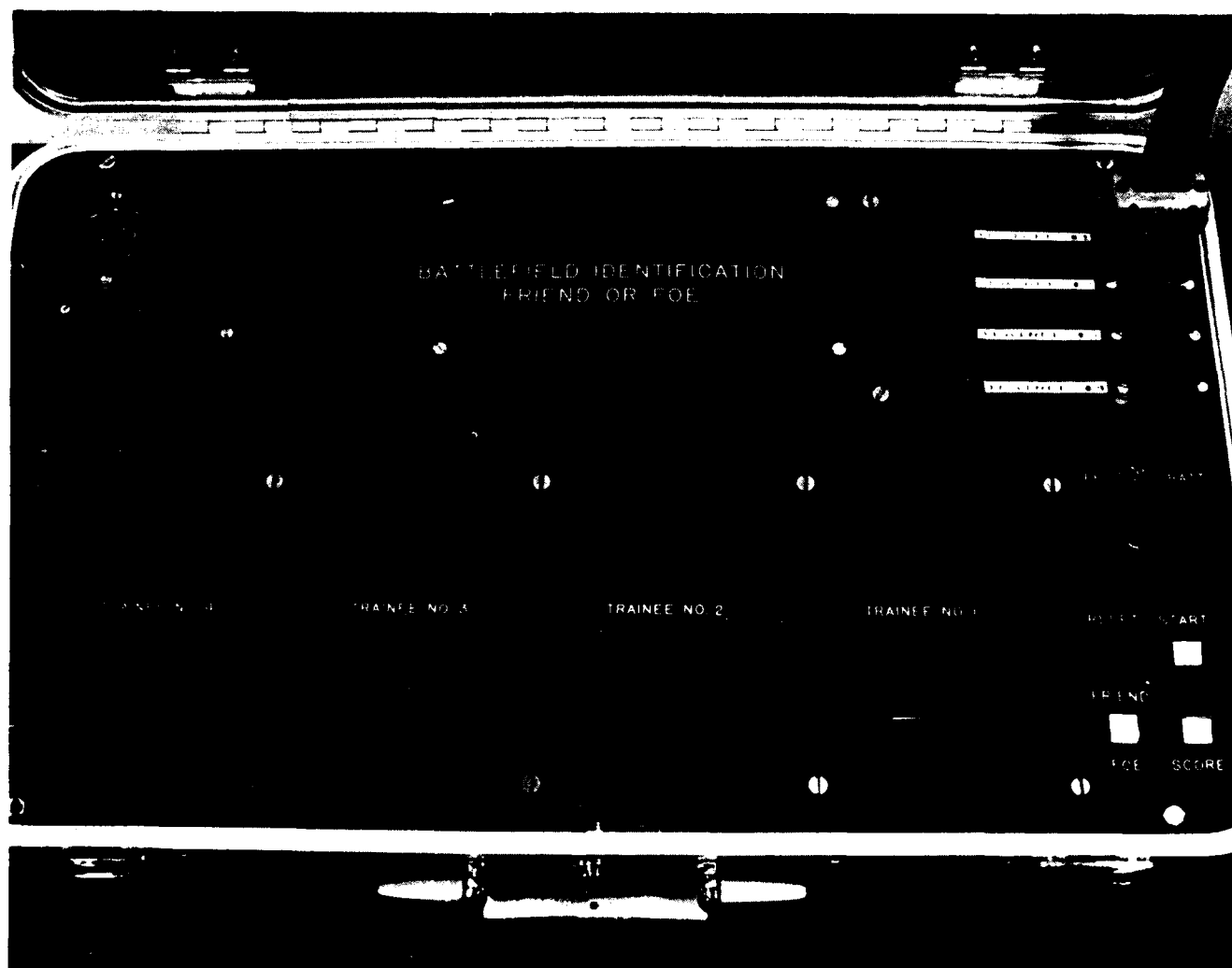


Figure II-10. Photograph of Instructor's Console

SECTION III

CONCLUSIONS

The BIFF system has undergone preliminary evaluation by U.S. Army experienced thermal sight gunners. All gunners were favorably impressed with its realism and interactive teaching attributes.

The method of simulating the thermal sight is the lowest cost method known. The same method is currently used in the STAGS anti-armor gunnery trainer.

Further evaluation will be held in late FY-83.

APPENDIX A
MICROCOMPUTER CONTROLLER PROGRAM

LDC OBJ SEQ SOURCE STATEMENT

```

1 ; 19 MARCH 1983
2
3
4 ; BATTLEFIELD IDENTIFICATION FRIEND OR FOE (BIFF)
5
6
7 ;*****
8
9
10
11 ORG 0
12 CLR A
13 MOV R0,#020H
14 MOV R1,#020H
15 JMP RAAS
16
17 ORG 7
18 JTF TIMER1
19 TIMER1: JMP TIMER
20
21 RAAS: MOV @R0,A
22 INC R0
23 DJNZ R1,RAAS
24
25 ; LOCATION 30H = CURRENT REACTION TIME FOR TRAINEE #1
26 ; 31H = ' ' ' ' ' #2
27 ; ' 32H = ' ' ' ' ' #3
28 ; ' 33H = ' ' ' ' ' #4
29 ;
30 ; LOCATION 20H & 21H = ACCUMULATED REACTION TIME FOR TRAINEE #1
31 ; ' 22H & 23H = ' ' ' ' ' #2
32 ; ' 24H & 25H = ' ' ' ' ' #3
33 ; ' 26H & 27H = ' ' ' ' ' #4
34 ;
35 ; LOCATION 34H = MODEL COUNT FOR TRAINEE #1
36 ; ' 35H = ' ' ' ' ' #2
37 ; ' 36H = ' ' ' ' ' #3
38 ; ' 37H = ' ' ' ' ' #4
39 ;
40 ; LOCATION 38H = ACCUMULATED CORRECT ANSWERS FOR TRAINEE #1
41 ; ' 39H = ' ' ' ' ' #2
42 ; ' 3AH = ' ' ' ' ' #3
43 ; ' 3BH = ' ' ' ' ' #4
44
45 CRT1 EQU 030H
46 CRT2 EQU 031H
47 CRT3 EQU 032H
48 CRT4 EQU 033H
49
50 ART1 EQU 020H
51 ART2 EQU 022H
52 ART3 EQU 024H

```

LOC	SEQ	SOURCE STATEMENT	
0026	52	RTA	026H
	53		
0027	55	BEGIN: STOP	TONT
0028	56		TONTI
0029	57	MOV	A,#0
0030	58	MOV	A,A
	59		
0031	60	MOV	A,#0FFH
0032	61	OUTL	P1,A
0033	62	OUTL	BUS,A
0034	63	OUTL	P2,A
	64		
	65		
	66		
	67		
0035	68	ANL	P2,#07FH
0036	69	CLR	A
0037	70	MOVD	P4,A
0038	71	MOVD	P5,A
0039	72	MOVD	A,A
0040	73	ORL	P1,#080H
	74		
0041	75	ANL	P2,#0EFH
0042	76	MOVD	A,P4
	77		
0043	78	MOVD	A,P7
	79		
0044	80	MOVD	A,#0FFH
0045	81	MOVD	P5,A
0046	82	MOVD	P6,A
0047	83	ORL	P2,#010H
	84		
0048	85	CALL	ERASE
	86		
0049	87	CLR	A
0050	88	SEL	R60
0051	89	MOV	R0,A
0052	90	MOV	R1,A
0053	91	MOV	R2,#5
0054	92	MOV	R3,A
0055	93	MOV	P4,A
0056	94	MOV	P5,A
0057	95	MOV	R6,A
0058	96	MOV	P7,A
0059	97	SEL	R61
0060	98	MOV	R0,A
0061	99	MOV	R1,A
0062	100	MOV	R2,A
0063	101	MOV	R3,A
0064	102	MOV	R4,A
0065	103	MOV	R5,A
0066	104	MOV	R6,A
0067	105	MOV	R7,A
0068	106	SEL	R62
	107		

; START TIMER AT 030 USED TO INSURE
 ; OVERFLOW AFTER 20 MSIC.
 ; PORT 1 -- LCD DRIVER CHIP SELECTS
 ; P17 --AH1 ... P10 --110
 ; BUS PORT: D60 THRU D65 = LCD DRIVER BUS.
 ; PORT 2: P20 THRU P23 = 8243 BUS,
 ; P24 -- P25 8243 CHIP SELECT, P27--G/P 8243
 ; P25 --SDALERT 0 = ON.
 ; P26--FRIEND(1)/ENEMY(0) FOR INSTRUCTOR
 ; P27 -- 0 = CHOOSE G/R
 ;
 ; GREEN LED'S. 0 = OFF
 ; RED LED'S. 0 = OFF
 ; HIGH IMPEDANCE STATE, PORT 6 --- TRAINEE
 ; START LINES, P60--#1 ... P63--#4
 ; P24 -- 0 = DADDS R/E
 ; PORT 4 -- TRAINEE TARGET SELECT.
 ; P1-FRIEND, 0=ENEMY, P40--#1 ... P43--#4
 ; PORT 7 -- TRAINEE DECISION COMPLETE,
 ; P70--#1, P71--#2, P72--#3, P73--#4.
 ; PORT 5 -- INCANDESCENTS FOR SIGHTS,
 ; 1 = OFF, P50--#1 ... P53--#4
 ; P60 IS THE CHIP SELECT FOR THE 8741A

LOC	OBJ	SEQ	SOURCE STATEMENT
0042	4642	108	START: JNT1 START ; LOOK FOR START SELECTION
0044	BD1E	109	MOV R5,#300 ; DELAY 300 msec TO LOOK FOR SCORE BUTTON
0046	74C1	110	CALL DELAY
0048	5654	111	JNI WHOODIN ; 'START' + 'SCORE' TURN ON ALL INCANDESCENT
		112	
004A	2310	113	MOV A,#010H
004C	74A4	114	CALL INCAN
004E	8DFF	115	MOV R5,#0FFH
0050	7421	116	CALL DELAY ; 0.5 SEC TO REMOVE FINGERS FROM BUTTONS
0052	0442	117	JMP START
		118	
0054	0A	119	WHOODIN: IN A,P2
0055	0259	120	JB6 FRIEND
0057	045B	121	ENEMY: JMP CONSTA ; ENEMY TARGET CHOSEN R7 REMAINS 0
0058	8F0F	122	FRIEND: MOV R7,#0FH ; FRIENDLY TARGET CHOSEN
		123	
005B	9ADF	124	CONSTA: ANL P2,#0DFH ; 1101/1111 SONALERT ON FOR 1 SEC
005D	BD64	125	MOV R5,#1000
005F	7421	126	CALL DELAY
0061	8A20	127	ORL P2,#020H
0063	25	128	EN TCNTI
0064	55	129	STRT T
		130	
		131	
		132	***** SCAN ROUTINE *****
		133	
		134	
		135	START FLAGS: INDICATES TRAINEE IS READY FOR TARGET
		136	RB1 R4 B0 <-- TRAINEE #1, START=1
		137	RB1 R4 B1 <-- ' #2
		138	RB1 R4 B2 <-- ' #3
		139	RB1 R4 B3 <-- ' #4
		140	
		141	FINISHED FLAGS: INDICATES TRAINEE IS DONE WITH THE SCENARIO
		142	RB1 R4 B4 <-- TRAINEE #1, FINISHED=1
		143	RB1 R4 B5 <-- ' #2
		144	RB1 R4 B6 <-- ' #3
		145	RB1 R4 B7 <-- ' #4
		146	
		147	DECISION FLAGS: A '1' INDICATES TRAINEE HAS MADE A DECISION
		148	RB1 R5 B0 <-- TRAINEE #1
		149	RB1 R5 B1 <-- ' #2
		150	RB1 R5 B2 <-- ' #3
		151	RB1 R5 B3 <-- ' #4
		152	
		153	FIRST TIME HERE FLAGS: INDICATES WHEN TO RESET LOCATIONS 30H - 33H
		154	RB1 R5 B4 <-- TRAINEE #1, FIRST TIME HERE = 0
		155	RB1 R5 B5 <-- ' #2
		156	RB1 R5 B6 <-- ' #3
		157	RB1 R5 B7 <-- ' #4
		158	
		159	TARGET ID FLAGS: INDICATES TRAINEE CHOICE OF TARGET IDENTIFICATION
		160	RB1 R6 B0 <-- TRAINEE #1, FRIENDLY=1/ENEMY=0
		161	RB1 R6 B1 <-- ' #2
		162	RB1 R6 B2 <-- ' #3

PC	DIS	SEQ	SOURCE STATEMENT	PC	DIS	SEQ	SOURCE STATEMENT
163	:			163	:		
164	:			164	:		
165	:			165	:		
166	:			166	:		
0065 140F	167	ROUTE:	ANL R2,#07FH ; CHOOSE G/R				
0066 15	168		SEL RB1				
0068 1E	169		MOVD A,R4				
0069 4C	170		ORL A,R4				
006A 4C	171		MOV R4,A				
006B 8400	172		ORL R2,#020H				
006D 9AEF	173		ANL R2,#0EFH ; CHOOSE F/R				
006F 0F	174		MOVD A,R7				
0070 4C	175		ORL A,R5				
0071 AF	176		MOV R5,A				
0073 05	177		SEL RB0				
0073 B007	178		MOV R5,#2				
0075 7431	179		CALL DELAY				
0077 05	180		SEL RB1				
0078 0C	181		MOVD A,R4				
0079 4E	182		ORL A,R4				
007A AE	183		MOV R6,A				
007B 8A10	184		ORL R2,#010H				
	185						
007D FC	186	CHEP:	MOV A,R4				
007E 92D9	187		JB4 SONNY ; JUMP ON TRAINEE #1 FINISHED				
0080 1284	188		JB0 START1 ; JUMP IF TRAINEE #1 HAS STARTED				
0082 04D9	189		JMP SONNY				
	190						
0084 FD	191	START1:	MOV A,R5				
0085 919C	192		JB4 NFTH1 ; FIRST TIME HERE FLAG				
0087 B034	193		MOV R0,#034H				
0088 1C	194		INC R0 ; INCREMENT MODEL COUNTER FOR #1				
008A D31E	195		MOV A,#01EH				
008B 14A4	196		CALL INCAN ; INCANDESCENTS FOR TRAINEE #1 ON				
008E B800	197		MOV R0,#030H				
0091 17	198		CLR A				
0091 4C	199		MOV R6,A ; RESET REACTION TIME FOR TRAINEE #1				
0092 FF	200		MOV A,R7				
0093 106E	201		ANL A,#0EH ; RESET TIME LIMIT FLAG FOR #1				
0095 AF	202		MOI R7,A				
0096 1C	203		MOV A,R5				
0097 0AE	204		ANL A,#0EH ; RESET DECISION FLAG IF NECESSARY				
0098 1510	205		ORL A,#010H				
009B AC	206		MOV R5,A ; SET FIRST TIME HERE FLAG FOR #1				
	207						
009D 1C	208	NFTH1:	MOV A,R5				
009E 11A4	209		JB0 DECIS1 ; DECISION MADE CHECK				
00A0 FF	210		MOV A,R7 ; TIME LIMIT CHECK				
00A0 13A8	211		JB0 LIMIT1				
00A2 04D9	212		JMP SONNY ; NO DECISION				
	213						
00A4 1C	214	DECIS1:	CLR R0				
00A5 1C	215		MOV A,R6				
00A6 1C	216		SEL R6				
00A7 1C	217		ORL A,R7 ; PRINT CORRECT ANSWER				

LOC	DEC	SEG	SOURCE STATEMENT
0040 05	218	LIMIT1:	SEL R0: IF TRAINEE INCORRECT. ADD---
0044 0338	219		MOV R0:#038H
0048 0471	220		ANL R2:#07FH
004C 12B6	221	JBO	NCORR1 : JUMP ON INCORRECT
00AF 05	222		CPL F0
00B0 10	223		INC R0
00B1 2301	224		MOV A:#1
00B3 8C	225	ORLD	P4:A : TURN ON GREEN LED #1
00B4 04B9	226		JMP DISP1
00B6 2301	227	NCORR1:	MOV A:#1
00B8 8C	228	ORLD	P5:A : TURN ON RED LED #1
00B9 8A80	229	DISP1:	ORL R2:#080H
	230		
00B8 54D7	231		CALL REACT1 : DISPLAY REACTION TIME FOR TRAINEE #1
00BD 86C1	232		JFO OVER1
00BF 880F	233		MOV R0:#0FH
00C1 74AF	234	OVER1:	CALL VOICE1
	235		
00C1 99FD	236		ANL P1:#0FDH
00C5 8834	237		MOV R0:#034H : DISPLAY # CORRECT VS. MODEL COUNT
00C7 4E	238		CLR F1
00C8 7494	239		CALL SENDUP
00CA 883E	240		MOV R0:#038H
00CD 85	241		CPL F1
00CD 7494	242		CALL SENDUP
00CF 5902	243		ORL P1:#2
	244		
00C1 2301	245		MOV A:#01H
00D3 74A4	246		CALL INCAN : TURN OFF INCANDESCENTS TO #1
	247		
00D8 7C	248		MOV A:R4 : GET FINISHED FLAG FOR TRAINEE #1
00DA 831C	249		ORL A:#010H
00DA 41	250		MOV R4:A
	251		
	252		
	253		
00E1 7C	254	BONNY:	MOV A:R4
00DA 82DE	255		JBS BOND1 : JUMP ON TRAINEE #2 FINISHED
00DC 32F4	256		JBI START2 : JUMP IF TRAINEE #2 HAS STARTED
00DE 2439	257	BOND1:	JMP BOND
	258		
00EA 2404	259	DEIII2:	JMP DECIS2
00E7 00	260		NOP
00E7 00	261		NOP
	262		
00E4 7C	263	START2:	MOV A:R5
00E5 82FC	264		JBS R5THC : TEST FOR FIRST TIME HERE FLAG
00E7 8835	265		MOV R0:#035H
00E9 10	266		INC R0 : INCREMENT MODEL COUNTER FOR #2
00EA 161C	267		MOV A:#010H
00EE 74A4	268		CALL INCAN : INCANDESCENTS FOR #2 GO ON
00EE 8831	269		MOV R0:#031H
00F0 07	270		CLR A
00F1 7C	271		MOV R0:A
00F1 7C	272		MOV A:R7

OBJ	SEQ	MACRO STATEMENT	
0001 0000	073	ANL A,*00H	
0005 48	074	MOV R1,	: SET TIME LIMIT FLAG
0009 01	075	RL A,R1	
0013 00 0	076	MOV A,*0F0H	: RESET EMISSION FLAG IF NECESSARY
0017 41 0	077	ORL A,*000H	: SET FIRST TIME HERE FLAG
0021 10	078	MOV R5,A	
	079		
0025 00	080 NEXT42:	MOV A,R5	
0029 00 0	081	DETH	: DECISION MADE CHECK
0033 00	082	RL A,R1	
0037 00 0	083	RL A,R1	: TIME LIMIT CHECK
0041 00 0	084	MOV R5,A	: NO DECISION YET
	085		
0045 48	086 DECIS2:	CLR R0	
0049 00	087	MOV A,R1	
0053 00	088	SEL R0	
0057 00	089	RL A,R1	: IF TRAINEE #1 CORRECT: ACC B1 ---0
0061 00	090 LIMIT2:	SEL R0	: IF TRAINEE #2 INCORRECT: ACC B1 ---1
0065 00 0	091	MOV R0,*00H	
0069 00 0	092	ANL R0,*00H	
0073 00 0	093	JB1 NDCORR	: JUMP ON INCORRECT
0077 00	094	ORL R0,	: SET R0 IF CORRECT
0081 10	095	INC R0	
0085 00 0	096	MOV A,*0	
0089 00	097	ORLD R4,A	: TURN ON GREEN LED #2
0093 00 0	098	JMP DISP2	
0097 00 0	099 NDCORR:	MOV A,*0	
0101 00	100	ORLD R5,A	: TURN ON RED LED #2
0105 00 0	101 DISP2:	ORL R0,*00H	
	102		
0109 40 0	103	CALL R0,R1	: DISPLAY REACTION TIME FOR TRAINEE #2
0113 00 0	104	MOV R0,	
0117 00 0	105	MOV R0,R1	
0121 00 0	106 OVER2:	CALL R0,R1	
	107		
0125 40 0	108	ANL R1,*0F7H	: CHOOSE LCD CHI
0129 00 0	109	MOV R0,*005H	: DISPLAY # CORRECT VS. MODEL COUNT
0133 00	110	CLR R1	
0137 00 0	111	CALL SENDUP	
0141 00 0	112	MOV R0,*009H	
0145 00	113	CLR R1	
0149 00 0	114	CALL SENDUP	
0153 00 0	115	ORL R1,*0	
	116		
0157 00 0	117	MOV R0,*00H	
0161 00 0	118	CALL INCRN	: INCR INCREMENT
	119		
0165 00	120	MOV A,*0	
0169 00 0	121	ORL A,*00H	: LED FINISHED FLAG
0173 00	122	MOV R0,A	
	123		
0177 00	124 BOND:	MOV A,*0	
0181 00 0	125	JB1 JFAME	: IF TRAINEE #3 FINISHED
0185 00 0	126	JB1 JFAME	: IF TRAINEE #3 HAS STARTED
0189 00 0	127	JMP JFAME	

LOC	OBJ	SEQ	SOURCE STATEMENT
		328	
0140 FD		329	START3: MOV A,R5
0141 0256		330	JB6 NFTH3 ; TEST FOR FIRST TIME HERE FLAG
0143 8836		331	MOV R0,#36H
0145 10		332	INC @R0 ; INCREMENT MODEL COUNTER FOR #3
0146 231B		333	MOV A,#01BH
0148 74A4		334	CALL INCAN ; INCANDESCENTS FOR #3 GO ON
014A 8632		335	MOV R0,#032H
014C 27		336	CLR A
014D A0		337	MOV @R0,A ; RESET REACTION TIME FOR TRAINEE #3
014E FF		338	MOV A,R7
014F 530E		339	ANL A,#0BH ; RESET TIME LIMIT FLAG
0151 AF		340	MOV R7,A
0153 FC		341	MOV A,R5
0155 03FB		342	ANL A,#0FEH ; RESET DECISION FLAG
0156 4340		343	ORL A,#040H ; SET FIRST TIME HERE FLAG
0157 AD		344	MOV R5,A
		345	
0158 FD		346	NFTH3: MOV A,R5
0159 5260		347	JB2 DECIS3 ; DECISION MADE CHECK
015B FF		348	MOV A,R7 ; TIME LIMIT CHECK
015C 5264		349	JB2 LIMIT3
015E 2495		350	JMP JEANNE
		351	
0160 35		352	DECIS3: CLR F0
0161 FE		353	MOV A,R6
0162 05		354	SEL RB0
0163 DF		355	XRL A,R7 ; IF TRAINEE CORRECT: ACC B2<--0
0164 05		356	LIMIT3: SEL RB1 ; IF TRAINEE INCORRECT: ACC B2<--1
0165 883A		357	MOV R0,#03AH
0167 3A7F		358	ANL P2,#07FH
0169 5271		359	JB2 NDCORF3 ; JUMP ON INCORRECT
016B 35		360	CPL F0 ; SET F0 IF CORRECT
016C 10		361	INC BR0
016D 2304		362	MOV A,#4
016F 7C		363	ORLD P4,A ; TURN ON GREEN LED #3
0170 2475		364	MP DISP3
0172 2304		365	NDCORF3: MOV A,#4
0174 30		366	ORLD P5,A ; TURN ON RED LED #3
0176 5A80		367	DISP3: ORL P2,#080H
		368	
0177 54E3		369	CALL REACT3 ; DISPLAY REACTION TIME FOR TRAINEE #3
0179 647D		370	JFO OVER3
017B 880F		371	MOV R0,#0FH
017D 74E7		372	OVER3: CALL VOICE3
		373	
017F 290F		374	ANL P1,#0DFH ; CHOOSE LCD 361
0181 883A		375	MOV R0,#036H ; DISPLAY # CORRECT VS. MODEL COUNT
0183 AF		376	CLR F1
0184 7494		377	CALL SENDUP
0186 883A		378	MOV R0,#03AH
0188 35		379	CPL F1
0189 7494		380	CALL SENDUP
018B 2916		381	ORL P1,#020H
		382	

LOC	DEL	SEG	SOURCE STATEMENT	
0180	1304	383	MOV A:04H	
0181	7444	384	CALL INCAH	INCAH INCREMENTS TO #3
		385		
0181	FD	386	MOV A:8H	
0182	4140	387	ORL A:040H	LEFT FINISHED FLAG
0184	AD	388	MOV R4:A	
		389		
0185	FD	390	JEANNE: MOV A:8H	
0186	FDH	391	JBT SCAR	IF JBT ON TRAINEE #4 FINISHED
0186	7290	392	JB3 START4	IF JBT ON TRAINEE HAS STARTED
0184	74F1	393	JMP SCAR	
		394		
0185	FD	395	START4: MOV A:8H	
0186	F2B4	396	JBT NETH4	IF JBT TIME HERE FLAG CHECK
018F	5837	397	MOV R0:03H	
01A1	10	398	INC R0	INCREMENT MODEL COUNTER FOR #4
01A2	2317	399	MOV A:017H	
01A4	7444	400	CALL INCAH	INCAH INCREMENTS
01A6	B833	401	MOV R0:10H	
01A8	27	402	CLR A	
01A9	A0	403	MOV R0:4H	IF REACT REACTION TIME
01A4	FF	404	MOV A:8H	
01A8	5307	405	ANL A:07	
01AD	AF	406	MOV R7:4	IF REACT TIME LIMIT FLAG FOR #4
01AE	FD	407	MOV A:8H	
01AT	53F7	408	ANL A:047H	IF REACT DECISION FLAG
01B1	4380	409	ORL A:080H	IF REACT FIRST TIME HERE FLAG
01B3	AD	410	MOV R5:A	
		411		
01B4	FD	412	NETH4: MOV A:8H	
01B5	71BD	413	JBT DECIS4	IF DECIS4 ON MADE CHECK
01B7	FF	414	MOV A:8H	
01B8	7000	415	JBT LIST4	IF LIST4 ON CHECK
01BA	74F1	416	JMP SCAR	IF DECISION
		417		
01B8	FD	418	DECIS4: CLF FC	
01B1	76	419	MOV A:8H	
01BF	FD	420	SEL R0	
01C0	FD	421	XRL A:8H	IF CORRECT: ADD B3C--0
01C1	FD	422	INIT4: SEL R0	IF INCORRECT: ADD B3C--1
01C2	FD	423	MOV R0:03EH	
01C3	FD	424	ANL R2:047H	
01C4	FD	425	JBT R0:047H	IF CORRECT INCURRED
01C5	FD	426	ORL R0:047H	IF CORRECT
01C6	FD	427	ORL R0:047H	
01C7	FD	428	MOV A:8H	
01C8	FD	429	ORL R0:047H	
01C9	FD	430	JBT R0:047H	
01CA	FD	431	ORL R0:047H	
01CB	FD	432	ORL R0:047H	
01CC	FD	433	ORL R0:047H	
01CD	FD	434	ORL R0:047H	
01CE	FD	435	ORL R0:047H	
01CF	FD	436	ORL R0:047H	
01D0	FD	437	ORL R0:047H	
01D1	FD	438	ORL R0:047H	
01D2	FD	439	ORL R0:047H	
01D3	FD	440	ORL R0:047H	
01D4	FD	441	ORL R0:047H	
01D5	FD	442	ORL R0:047H	
01D6	FD	443	ORL R0:047H	
01D7	FD	444	ORL R0:047H	
01D8	FD	445	ORL R0:047H	
01D9	FD	446	ORL R0:047H	
01DA	FD	447	ORL R0:047H	
01DB	FD	448	ORL R0:047H	
01DC	FD	449	ORL R0:047H	
01DD	FD	450	ORL R0:047H	
01DE	FD	451	ORL R0:047H	
01DF	FD	452	ORL R0:047H	
01E0	FD	453	ORL R0:047H	
01E1	FD	454	ORL R0:047H	
01E2	FD	455	ORL R0:047H	
01E3	FD	456	ORL R0:047H	
01E4	FD	457	ORL R0:047H	
01E5	FD	458	ORL R0:047H	
01E6	FD	459	ORL R0:047H	
01E7	FD	460	ORL R0:047H	
01E8	FD	461	ORL R0:047H	
01E9	FD	462	ORL R0:047H	
01EA	FD	463	ORL R0:047H	
01EB	FD	464	ORL R0:047H	
01EC	FD	465	ORL R0:047H	
01ED	FD	466	ORL R0:047H	
01EE	FD	467	ORL R0:047H	
01EF	FD	468	ORL R0:047H	
01F0	FD	469	ORL R0:047H	
01F1	FD	470	ORL R0:047H	
01F2	FD	471	ORL R0:047H	
01F3	FD	472	ORL R0:047H	
01F4	FD	473	ORL R0:047H	
01F5	FD	474	ORL R0:047H	
01F6	FD	475	ORL R0:047H	
01F7	FD	476	ORL R0:047H	
01F8	FD	477	ORL R0:047H	
01F9	FD	478	ORL R0:047H	
01FA	FD	479	ORL R0:047H	
01FB	FD	480	ORL R0:047H	
01FC	FD	481	ORL R0:047H	
01FD	FD	482	ORL R0:047H	
01FE	FD	483	ORL R0:047H	
01FF	FD	484	ORL R0:047H	

LOC	OBJ	SEQ	SOURCE STATEMENT
01D9	748F	438	OVER4: CALL VOICE4
		439	
01DB	497F	440	AML P1:#07FH ; CHOOSE LCD 4HI
01DD	8837	441	MOV R0:#037H ; DISPLAY # CORRECT VS. MODEL COUNT
01DF	A5	442	CLF F1
01E0	7494	443	CALL SENDUP
01E2	883B	444	MOV R0:#03BH
01E4	BE	445	CPL F1
01E5	7494	446	CALL SENDUP
01E7	898C	447	ORL P1:#080H
		448	
01E9	2306	449	MOV A:#8
01EB	74A4	450	CALL INCAN ; TURN OFF INCANDESCENTS
		451	
01ED	FC	452	MOV A:R4
01EE	4380	453	ORL A:#080H ; SET FINISHED FLAG
01F0	AC	454	MOV R4:A
		455	
		456	
		457	
		458	*****
		459	
		460	
		461	; SCAN FOR FRIEND, ENEMY, OR SCORE BUTTONS
		462	
01F1	26F5	463	SCAN: JMI REAGAN
01F3	4444	464	JMP SCORE
01F5	58F9	465	REAGAN: JTI BEGIN1
01F7	0465	466	JMP ROUTE
		467	
01F9	040F	468	BEGIN1: JMP BEGIN
		469	
		470	
		471	
		472	
		473	*****
		474	
		475	; SUBROUTINES
		476	
		477	*****
		478	
		479	
		480	
		481	
		482	*****
		483	
		484	THIS ROUTINE ERASES ANSWER BY WRITING
		485	AN 'F' TO ALL DIGITS OF THE DRIVER.
		486	
01FE	74	487	NOF
		488	
01FC	494B	489	ERASE: MOV R3:#8
01FE	747F	490	MOV R2:#07FH
0200	EA	491	MOV A:R2
0201	7F	492	OUTL P1:A

LOC	OBJ	SEQ	SOURCE STATEMENT
		493	
0202	8C04	494	ECON: MOV R4,#4 ; ERASE 4 DIGITS
0204	88F0	495	MOV RO,#0F0H
0206	F8	496	EASY: MOV A,R0
0207	47	497	SWAP A
0208	90	498	MOVX @R0,A
0209	18	499	INC R0
020A	ED06	500	DJNZ R4,EASY
		501	
020C	FA	502	MOV A,R2
020E	77	503	RR A
020E	AA	504	MOV R2,A
020F	EB00	505	DJNZ R3,ERAE
0211	89FF	506	ORL P1,#0FFH
0213	FC	507	RETR
		508	
		509	*****
		510	
		511	: SCORE (AVERAGE REACTION TIME) ROUTINES
		512	
0214	8934	513	SCORE1: MOV R1,#034H ; MODEL COUNT LOCATION FOR #1
0216	8821	514	MOV RO,#021H ; GET HI BYTE OF #1
0218	99FE	515	ANL P1,#0FEH ; OUTPUT AVERAGE REACTION TIME TO #1
021A	5454	516	CALL SAAB
021C	74AF	517	CALL VOICE1
021E	4447	518	JMP SAE
		519	
0220	8935	520	SCORE2: MOV R1,#035H
0222	8823	521	MOV RO,#023H ; GET HI BYTE OF #2
0224	99FB	522	ANL P1,#0FBH ; OUTPUT AVERAGE REACTION TIME TO #2
0226	5454	523	CALL SAAB
0228	74B3	524	CALL VOICE2
022A	444A	525	JMP SBE
		526	
022C	8936	527	SCORE3: MOV R1,#036H
022E	8825	528	MOV RO,#025H ; GET HI BYTE OF #3
0230	99EF	529	ANL P1,#0EFH ; OUTPUT AVERAGE REACTION TIME TO #3
0232	5454	530	CALL SAAB
0234	74B7	531	CALL VOICE3
023A	444D	532	JMP SCE
		533	
023E	8937	534	SCORE4: MOV R1,#037H
023A	8827	535	MOV RO,#027H ; GET HI BYTE OF #4
023C	99BF	536	ANL P1,#0BFH ; OUTPUT AVERAGE REACTION TIME TO #4
023E	5454	537	CALL SAAB
0247	74B6	538	CALL VOICE4
024E	4450	539	JMP WABF
		540	
0244	FC	541	SCORE: MOV A,R4 ; SCORE ONLY THOSE TRAINEES THAT HAVE FINISHED
0245	9214	542	JB4 SCORE1
0247	FC	543	SAE: MOV A,R4
0249	8220	544	JB5 SCORE2
024A	FC	545	SBE: MOV A,R4
024B	0220	546	JB6 SCORE3
024D	FC	547	SCE: MOV A,R4

LOC	DB	SEQ	SOURCE STATEMENT
024E F238		548	JB7 SCORE*
		549	
0250 4650		550	WASP: JNT1 WASP
0252 040F		551	JMP BEGIN
		552	
0254 97		553	SAAB: CLR C
0255 35		554	CLR F0
0256 F1		555	MOV A,R1
0257 AE		556	MOV R6,A
0258 FB		557	MOV A,R0
0259 AD		558	MOV R5,A
025A 8B00		559	MOV R3,#0
025C F0		560	MOV A,R0 ; GET HI BYTE INTO ACC
025D AF		561	MOV R7,A
025E FF		562	SAAC: MOV A,R7
025F 0667		563	JZ SAAD
0261 07		564	DEC A
0262 4F		565	MOV R7,A
0263 544F		566	CALL HISC
0265 44EE		567	JMP SAAC
0267 F0		568	SAAC: MOV A,R5
0268 97		569	DEC A
0269 AC		570	MOV R0,A ; R0 GETS ADDRESS OF LO BYTE
026A 5482		571	CALL LISC
026C FE		572	MOV A,R3
026D 6400		573	JMP SEND
		574	
		575	*****
		576	
		577	; HIGH BYTE DIVIDE SUBROUTINE
		578	
026F 97		579	HISC: CLR C
0270 37		580	CLR A
0271 A8		581	HI4: MOV R0,A
0272 5E		582	ADD A,R6
0273 5470		583	JC HIB
0275 18		584	INC R3
0276 837		585	JPL HIA
0278 07		586	DEC A
0279 95		587	CPL F0
027A 4471		588	JMP HIA
027C 58		589	HIB: MOV A,R0
027E 07		590	CPL A
027F 8823		591	MOV A0,#02B
0280 AC		592	MOV R0,A ; R0H GETS REMAINDER OF HI BYTE DIVIDE
0281 93		593	RETR
		594	
		595	*****
		596	
		597	; LOW BYTE DIVIDE SUBROUTINE
		598	
0282 97		599	LISC: CLR C
0283 07		600	MOV A,R0
0284 07		601	CPL A
0285 AC		602	MOV R0,A

LOC	OBJ	SEQ	SOURCE STATEMENT
0286	6E	603	ADD A,R6
0287	F68C	604	JC LOB
0289	1B	605	INC R3
028A	4485	606	JMP LOA
028C	7B	607	LOB: MOV A,R0
028D	37	608	CPL A ; ACC GETS REMAINDER OF LO BYTE DIVIDE
028E	B82B	609	MOV R0,#028H
0290	6C	610	ADD A,R0 ; ACC GETS SUM OF TWO REMAINDERS
0291	97	611	CLR C
0292	37	612	CPL A
0293	6E	613	LOC: ADD A,R6
0294	F699	614	JC LOD
0296	1B	615	INC R3
0297	4493	616	JMP LOC
0299	73	617	LOD: RETR
		618	
		619	*****
		620	
		621	; TIMER SERVICE INTERRUPT ROUTINE
		622	
		623	; THE TIMER REGISTER (T) INCREMENTS EVERY 80 USEC AND
		624	OVERFLOWS AT 20 MSEC.
		625	
		626	; R0 R2 OVERFLOWS AT 5XT = 100 MSEC. R0 R3 COUNTS THE
		627	NUMBER OF R2 OVERFLOWS.
		628	
029A	05	629	TIMER: SEL R0
029B	4B	630	MOV R3,A
029C	2306	631	MOV A,#6
029E	62	632	MOV T,A ; RESTORE 480 USEC TO TIMER REGISTER
029F	EA01	633	DJNZ R2,TIMRET
02A1	B970	634	MOV R1,#030H
02A3	B404	635	MOV R2,#4
02A5	235F	636	TIMDOT: MOV A,#0FFH ; TEST FOR 25.5 SEC LIMIT
02A7	01	637	XRL A,R1
02A8	940B	638	JNZ TIMOUT
02AA	F	639	MOV A,R1
02AB	05	640	SEL R0
02AC	028C	641	JB1 TIME
02AE	12B6	642	JBO TIME
02B0	FF	643	MOV A,R7
02B1	4301	644	ORL A,#1
02B2	AF	645	MOV R7,A ; R1 = 30H
02B4	440B	646	JMP TIMCL
02B6	FF	647	TIMA: MOV A,R7 ; R1 = 31H
02B7	4302	648	ORL A,#2
02B9	AF	649	MOV R7,A
02BA	440B	650	JMP TIMCL
02BC	1204	651	TIMB: JS0 TIME
02BE	FF	652	MOV A,R7 ; R1 = 32H
02BF	4304	653	ORL A,#4
02C1	AF	654	MOV R7,A
02C2	440B	655	JMP TIMCL
02C4	FF	656	TIMC: MOV A,R7 ; R1 = 33H
02C5	430B	657	ORL A,#B

LOC	OBJ	SEQ	SOURCE STATEMENT
02C7	AF	658	MOV R7,A
02C8	C5	659	TIMCL: SEL R80
02C9	440C	660	JMP TIMLIM
		661	
02CB	11	662	TIMCUT: INC @R1
02CC	19	663	TIMLIM: INC R1
02CD	EAA5	664	DJNZ R2,TIMDOT
02CF	BA05	665	MOV R2,#5 ; RESTORE R2
02D1	FB	666	TIMRET: MOV A,R3
02D2	93	667	RETR
		668	
		669	*****
		670	
		671	; REACTION TIMES ARE STORED AT LOCATIONS
		672	; 30 THRU 33 AND 20 THRU 27. THESE ROUTINES OUTPUT TO THE
		673	; CHOSEN LCD THE BASE 10 TIME.
		674	
02D3	640A	675	RA4444: JMP RAA4
02D5	6402	676	RA2222: JMP RAA2
		677	
02D7	B830	678	REACT1: MOV R0,#CRT1
02D9	B920	679	MOV R1,#ART1
02DB	44ED	680	JMP RACK
02DD	B831	681	REACT2: MOV R0,#CRT2
02DF	B922	682	MOV R1,#ART2
02E1	44ED	683	JMP RACK
02E3	B832	684	REACT3: MOV R0,#CRT3
02E5	B924	685	MOV R1,#ART3
02E7	44ED	686	JMP RACK
02E9	B833	687	REACT4: MOV R0,#CRT4
02EB	B926	688	MOV R1,#ART4
		689	
02ED	97	690	RACK: CLR C
02EE	F0	691	MOV A,@R0
02EF	61	692	ADD A,@R1
02F0	A1	693	MOV @R1,A
02F1	E6F5	694	JNC RACE
02F3	19	695	INC R1
02F4	11	696	INC @R1
02F5	F8	697	RACE: MOV A,R0
02F6	32FC	698	JB1 RACA
02F8	12D5	699	JB0 RA2222
02FA	6406	700	JMP RAA1
02FC	12D3	701	RACA: JB0 RA4444
		702	
02FE	99EF	703	RAA3: ANL P1,#0EFH
0300	640C	704	JMP SAND
0302	99FB	705	RAA2: ANL P1,#0FEH
0304	640C	706	JMP SAND
0306	99FE	707	RAA1: ANL P1,#0FLH
0308	640C	708	JMP SAND
030A	99BF	709	RAA4: ANL P1,#0BFH
		710	
030C	F0	711	SAND: MOV A,@R0
030E	742C	712	SEND: CALL DECODE

LOC	OBJ	SEQ	SOURCE STATEMENT
030F	F8	712	MOV A,R0
0310	4330	714	ORL A,#030H
0312	90	715	MOVX @R0,A
0313	F9	716	MOV A,R1
0314	4320	717	ORL A,#020H
0316	90	718	MOVX @R0,A
0317	FA	719	MOV A,R2
0318	4310	720	ORL A,#010H
031A	90	721	MOVX @R0,A
031B	2505	722	MOV A,#08H
031D	90	723	MOVX @R0,A
031E	89FF	724	ORL R1,#0FFH
0320	93	725	RETR
		726	
		727	*****
		728	
		729	DELAY SUBROUTINE: 10 MSEC PER R5 BIT
		730	
0321	8908	731	DELAY: MOV R0,#8
0323	BCFF	732	LOOP1: MOV R4,#0FFH
0325	EC25	733	LOOP2: DJNZ R4,LOOP2
0327	E8C3	734	DJNZ R0,LOOP1
0329	E021	735	DJNZ R5,DELAY
032B	93	736	RETR
		737	
		738	
		739	*****
		740	
		741	THIS ROUTINE DECODES THE AMOUNT IN THE ACCUMULATOR INTO A
		742	BASE 10 NUMBER.
		743	(R6) R2 = R2 X 100
		744	(R6) R1 = R1 X 10
		745	(R6) R0 = R0 X 1
		746	R3 = GENERAL PURPOSE
0321	8A00	748	DECODE: MOV R2,#0
032E	8900	749	MOV R1,#0
0330	8800	750	MOV R0,#0
0332	F7	751	RLC A
0333	E63A	752	JNC DECA : TEST BIT 7
0335	1A	753	INC R2 : REACTION TIME AT LEAST 12.8 SEC
0336	19	754	INC R1
0337	19	755	INC R0
0338	7484	756	CALL INCR08
033A	F7	757	DECA: RLC A
033E	E641	758	JNC DECF : TEST BIT 6
033D	748D	759	CALL INCR10 : REACTION TIME AT LEAST 6.4 SEC
033F	748E	760	CALL INCR04
0341	F7	761	DECB: RLC A
0342	E648	762	JNC DECD : TEST BIT 5
0344	7490	763	CALL INCR10 : REACTION TIME AT LEAST 3.2 SEC
0346	18	764	INC R0
0347	18	765	INC R1
0348	F7	766	DECC: RLC A
0349	E64E	767	JNC DECD : TEST BIT 4

LOC	ORG	SEQ	SOURCE STATEMENT
0249	19	768	INC R1 ; REACTION TIME AT LEAST 1.6 SEC
0340	7486	769	CALL INCR06
024E	F7	770	DECD: PLC A
034F	E652	771	JNC DECE ; TEST BIT 3
0351	7484	772	CALL INCR09 ; REACTION TIME AT LEAST .8 SEC
0353	F7	773	DECD: RLC A
0354	E659	774	JNC DECF ; TEST BIT 2
0356	7488	775	CALL INCR04 ; REACTION TIME AT LEAST .4 SEC
0358	F7	776	DECF: RLC A
0359	E650	777	JNC DECI ; TEST BIT 1
035B	18	778	INC R0 ; REACTION TIME AT LEAST .2 SEC
035C	18	779	INC R0
035E	F7	780	DECD: RLC A
035E	E641	781	JNC PATTI ; TEST BIT 0
0360	18	782	INC R0 ; REACTION TIME AT LEAST .1 SEC
		783	
		784	
		785	MAX COUNT IN R0 IS 35
		786	MAX COUNT IN R1 IS 15
		787	
0361	F7	788	PATTI: CLR C
0367	18	789	MOV A,R0
0363	37	790	CPL A
0364	030A	791	ADD A,#100
0366	F679	792	JC KAREN ; R0 = 0 TO 9
0368	AB	793	MOV R3,A
0369	19	794	INC R1
036A	030A	795	ADD A,#100
036C	F676	796	JC PATTI ; R0 = 10 TO 19
036E	AB	797	MOV R3,A
036F	19	798	INC R1
0370	030A	799	ADD A,#100
0372	F676	800	JC PATTI ; R0 = 20 TO 29
0374	AB	801	MOV R3,A ; R0 = 30 TO 35
0375	19	802	INC R1
0376	FE	803	PATTI: MOV A,R3
0377	37	804	CPL A
0378	AB	805	MOV R0,A
		806	
		807	DECODE R1 TO INCREMENT R2 IF NECESSARY
		808	
0379	37	809	KAREN: CLR C
037A	FE	810	MOV A,R1
037C	37	811	CPL A
037D	030A	812	ADD A,#100
037E	F683	813	JC PA
0380	1A	814	INC R1
0381	37	815	CPL A
0382	AB	816	MOV R1,A
		817	
0383	93	818	KEN: RETR
		819	
0384	12	820	INCR05: INC R0
0385	13	821	INC R0
0386	12	822	INCR06: INC R1

LOC	OBJ	SEG	SOURCE STATEMENT
0387	18	823	INC R0
0388	18	824	INCR04: INC R0
0389	18	825	INC R0
038A	18	826	INC R0
038B	18	827	INC R0
038C	93	828	RETR
		829	
038D	19	830	INCR16: INC R1
038E	19	831	INC R1
038F	19	832	INC R1
0390	19	833	INCR13: INC R1
0391	19	834	INC R1
0392	19	835	INC R1
0393	93	836	RETR
		837	
		838	
		839	*****
		840	
		841	OUTPUT THE ACC TO THE UPPER TWO DIGITS OF
		842	THE CHOSEN LCD DRIVER.
		843	
0394	F0	844	SENDUP: MOV A,R0
0395	742C	845	CALL DECODE
0397	769B	846	JF1 SENDVR
0399	8A20	847	MOV R2,#020H
039B	F8	848	SENDVR: MOV A,R0
039C	4310	849	ORL A,#010H
039E	4A	850	ORL A,R2
039F	90	851	MOVX @R0,A
03A0	F8	852	MOV A,R1
03A1	4A	853	ORL A,R2
03A2	90	854	MOVX @R0,A
03A3	93	855	RETR
		856	
		857	*****
		858	
		859	ROUTINE TO TURN ON OR OFF THE CHOSEN INCANDESCENT
		860	BIT4 = 0 THEN 'OFF'
		861	BIT4 = 1 THEN 'ON'
		862	
03A4	94EF	863	INCAN: ANL R2,#0EFH
03A6	93AB	864	JB4 INON
03A8	8D	865	INOFF: ORL R5,A
03A9	644C	866	JMP INRET
03AB	9D	867	INON: ANL R5,A
03AC	8A10	868	INRET: ORL R2,#010H
03AF	93	869	RETR
		870	
		871	*****
		872	
		873	PASS DATA TO AN 8741 SPECIFYING THE REACTION TIME IN ORDER
		874	FOR THIS TIME TO BE BROKEN BY THE GI VOICE UNIT.
		875	
		876	IF R7,R6 THEN TRAINEE #1 DATA IS TO BE PASSED.
		877	IF R7,R6 THEN TRAINEE #2

LOC	HEX	SEQ	SOURCE STATEMENT
		378	IF ' = 1 ' #3
		379	IF ' = 2 ' #4
		380	
		381	IF B5:B4 = 1 THEN AC IS SPECIFIED
		382	IF ' = 2 ' R1
		383	IF ' = 3 ' R2
		384	
		385	CHIP SELECT FOR 8741A IS PIN P30 ON THE P/E 8243
		386	
03AF	BB00	387	VOICE1: MOV A, #0
03B1	64B0	388	JMP A, #0
03B3	BB40	389	VOICE2: MOV A, #1
03B5	64B0	390	JMP A, #0
03B7	BB80	391	VOICE3: MOV A, #2
03B9	64B0	392	JMP A, #0
03BB	BB00	393	VOICE4: MOV A, #3
		394	
03BD	PAEF	395	VACE: ANL A, #0EFH
03BF	230E	396	MOV A, #0EH
03C1	3E	397	MOVD A, #A ; CHIP SELECT FOR 8741A
		398	
03C2	F8	399	MOV A, #0 ; CHECK FOR ERROR SIGNAL
03C3	D30F	900	XRL A, #0FH
03C5	C6D3	901	JZ VERR
		902	
03C7	FA	903	MOV A, #0
03C8	4330	904	ORL A, #030H
03CA	4B	905	ORL A, #0
03CB	740F	906	CALL VSEND
03CD	F8	907	MOV A, #0
03CE	4320	908	ORL A, #020H
03D0	4B	909	ORL A, #0
03D1	740F	910	CALL VSEND
03D3	F8	911	VERR: MOV A, #0
03D4	4310	912	ORL A, #010H
03D6	4B	913	ORL A, #0
03D7	740F	914	CALL VSEND
03D9	230F	915	MOV A, #0FH
03DE	3E	916	MOVD A, #A
03DF	9A10	917	ORL A, #0A10H
03DE	93	918	RETR
		919	
03DF	90	920	VSEND: MOVX A, #0
03E0	05	921	SEL R0
03E1	B028	922	MOV A, #000
03E3	EDE3	923	VOSEL: DJNZ A, #000 ; 200 USCE DELAY
03E5	05	924	SEL R0
03E6	93	925	RETR
		926	
		927	
		928	
		929	END

USER SYMBOLS

ART1 0020 ART2 0021 ART3 0022 ART4 0023 ART5 0024 ART6 0025 ART7 0026 ART8 0027 ART9 0028 ART10 0029 ART11 0030 ART12 0031 ART13 0032 ART14 0033 ART15 0034 ART16 0035 ART17 0036 ART18 0037 ART19 0038 ART20 0039 ART21 0040 ART22 0041 ART23 0042 ART24 0043 ART25 0044 ART26 0045 ART27 0046 ART28 0047 ART29 0048 ART30 0049 ART31 0050 ART32 0051 ART33 0052 ART34 0053 ART35 0054 ART36 0055 ART37 0056 ART38 0057 ART39 0058 ART40 0059 ART41 0060 ART42 0061 ART43 0062 ART44 0063 ART45 0064 ART46 0065 ART47 0066 ART48 0067 ART49 0068 ART50 0069 ART51 0070 ART52 0071 ART53 0072 ART54 0073 ART55 0074 ART56 0075 ART57 0076 ART58 0077 ART59 0078 ART60 0079 ART61 0080 ART62 0081 ART63 0082 ART64 0083 ART65 0084 ART66 0085 ART67 0086 ART68 0087 ART69 0088 ART70 0089 ART71 0090 ART72 0091 ART73 0092 ART74 0093 ART75 0094 ART76 0095 ART77 0096 ART78 0097 ART79 0098 ART80 0099 ART81 0100 ART82 0101 ART83 0102 ART84 0103 ART85 0104 ART86 0105 ART87 0106 ART88 0107 ART89 0108 ART90 0109 ART91 0110 ART92 0111 ART93 0112 ART94 0113 ART95 0114 ART96 0115 ART97 0116 ART98 0117 ART99 0118 ART100 0119 ART101 0120 ART102 0121 ART103 0122 ART104 0123 ART105 0124 ART106 0125 ART107 0126 ART108 0127 ART109 0128 ART110 0129 ART111 0130 ART112 0131 ART113 0132 ART114 0133 ART115 0134 ART116 0135 ART117 0136 ART118 0137 ART119 0138 ART120 0139 ART121 0140 ART122 0141 ART123 0142 ART124 0143 ART125 0144 ART126 0145 ART127 0146 ART128 0147 ART129 0148 ART130 0149 ART131 0150 ART132 0151 ART133 0152 ART134 0153 ART135 0154 ART136 0155 ART137 0156 ART138 0157 ART139 0158 ART140 0159 ART141 0160 ART142 0161 ART143 0162 ART144 0163 ART145 0164 ART146 0165 ART147 0166 ART148 0167 ART149 0168 ART150 0169 ART151 0170 ART152 0171 ART153 0172 ART154 0173 ART155 0174 ART156 0175 ART157 0176 ART158 0177 ART159 0178 ART160 0179 ART161 0180 ART162 0181 ART163 0182 ART164 0183 ART165 0184 ART166 0185 ART167 0186 ART168 0187 ART169 0188 ART170 0189 ART171 0190 ART172 0191 ART173 0192 ART174 0193 ART175 0194 ART176 0195 ART177 0196 ART178 0197 ART179 0198 ART180 0199 ART181 0200 ART182 0201 ART183 0202 ART184 0203 ART185 0204 ART186 0205 ART187 0206 ART188 0207 ART189 0208 ART190 0209 ART191 0210 ART192 0211 ART193 0212 ART194 0213 ART195 0214 ART196 0215 ART197 0216 ART198 0217 ART199 0218 ART200 0219 ART201 0220 ART202 0221 ART203 0222 ART204 0223 ART205 0224 ART206 0225 ART207 0226 ART208 0227 ART209 0228 ART210 0229 ART211 0230 ART212 0231 ART213 0232 ART214 0233 ART215 0234 ART216 0235 ART217 0236 ART218 0237 ART219 0238 ART220 0239 ART221 0240 ART222 0241 ART223 0242 ART224 0243 ART225 0244 ART226 0245 ART227 0246 ART228 0247 ART229 0248 ART230 0249 ART231 0250 ART232 0251 ART233 0252 ART234 0253 ART235 0254 ART236 0255 ART237 0256 ART238 0257 ART239 0258 ART240 0259 ART241 0260 ART242 0261 ART243 0262 ART244 0263 ART245 0264 ART246 0265 ART247 0266 ART248 0267 ART249 0268 ART250 0269 ART251 0270 ART252 0271 ART253 0272 ART254 0273 ART255 0274 ART256 0275 ART257 0276 ART258 0277 ART259 0278 ART260 0279 ART261 0280 ART262 0281 ART263 0282 ART264 0283 ART265 0284 ART266 0285 ART267 0286 ART268 0287 ART269 0288 ART270 0289 ART271 0290 ART272 0291 ART273 0292 ART274 0293 ART275 0294 ART276 0295 ART277 0296 ART278 0297 ART279 0298 ART280 0299 ART281 0300 ART282 0301 ART283 0302 ART284 0303 ART285 0304 ART286 0305 ART287 0306 ART288 0307 ART289 0308 ART290 0309 ART291 0310 ART292 0311 ART293 0312 ART294 0313 ART295 0314 ART296 0315 ART297 0316 ART298 0317 ART299 0318 ART300 0319 ART301 0320 ART302 0321 ART303 0322 ART304 0323 ART305 0324 ART306 0325 ART307 0326 ART308 0327 ART309 0328 ART310 0329 ART311 0330 ART312 0331 ART313 0332 ART314 0333 ART315 0334 ART316 0335 ART317 0336 ART318 0337 ART319 0338 ART320 0339 ART321 0340 ART322 0341 ART323 0342 ART324 0343 ART325 0344 ART326 0345 ART327 0346 ART328 0347 ART329 0348 ART330 0349 ART331 0350 ART332 0351 ART333 0352 ART334 0353 ART335 0354 ART336 0355 ART337 0356 ART338 0357 ART339 0358 ART340 0359 ART341 0360 ART342 0361 ART343 0362 ART344 0363 ART345 0364 ART346 0365 ART347 0366 ART348 0367 ART349 0368 ART350 0369 ART351 0370 ART352 0371 ART353 0372 ART354 0373 ART355 0374 ART356 0375 ART357 0376 ART358 0377 ART359 0378 ART360 0379 ART361 0380 ART362 0381 ART363 0382 ART364 0383 ART365 0384 ART366 0385 ART367 0386 ART368 0387 ART369 0388 ART370 0389 ART371 0390 ART372 0391 ART373 0392 ART374 0393 ART375 0394 ART376 0395 ART377 0396 ART378 0397 ART379 0398 ART380 0399 ART381 0400 ART382 0401 ART383 0402 ART384 0403 ART385 0404 ART386 0405 ART387 0406 ART388 0407 ART389 0408 ART390 0409 ART391 0410 ART392 0411 ART393 0412 ART394 0413 ART395 0414 ART396 0415 ART397 0416 ART398 0417 ART399 0418 ART400 0419 ART401 0420 ART402 0421 ART403 0422 ART404 0423 ART405 0424 ART406 0425 ART407 0426 ART408 0427 ART409 0428 ART410 0429 ART411 0430 ART412 0431 ART413 0432 ART414 0433 ART415 0434 ART416 0435 ART417 0436 ART418 0437 ART419 0438 ART420 0439 ART421 0440 ART422 0441 ART423 0442 ART424 0443 ART425 0444 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ART924 0943 ART925 0944 ART926 0945 ART927 0946 ART928 0947 ART929 0948 ART930 0949 ART931 0950 ART932 0951 ART933 0952 ART934 0953 ART935 0954 ART936 0955 ART937 0956 ART938 0957 ART939 0958 ART940 0959 ART941 0960 ART942 0961 ART943 0962 ART944 0963 ART945 0964 ART946 0965 ART947 0966 ART948 0967 ART949 0968 ART950 0969 ART951 0970 ART952 0971 ART953 0972 ART954 0973 ART955 0974 ART956 0975 ART957 0976 ART958 0977 ART959 0978 ART960 0979 ART961 0980 ART962 0981 ART963 0982 ART964 0983 ART965 0984 ART966 0985 ART967 0986 ART968 0987 ART969 0988 ART970 0989 ART971 0990 ART972 0991 ART973 0992 ART974 0993 ART975 0994 ART976 0995 ART977 0996 ART978 0997 ART979 0998 ART980 0999 ART981 1000 ART982 1001 ART983 1002 ART984 1003 ART985 1004 ART986 1005 ART987 1006 ART988 1007 ART989 1008 ART990 1009 ART991 1010 ART992 1011 ART993 1012 ART994 1013 ART995 1014 ART996 1015 ART997 1016 ART998 1017 ART999 1018 ART1000 1019 ART1001 1020 ART1002 1021 ART1003 1022 ART1004 1023 ART1005 1024 ART1006 1025 ART1007 1026 ART1008 1027 ART1009 1028 ART1010 1029 ART1011 1030 ART1012 1031 ART1013 1032 ART1014 1033 ART1015 1034 ART1016 1035 ART1017 1036 ART1018 1037 ART1019 1038 ART1020 1039 ART1021 1040 ART1022 1041 ART1023 1042 ART1024 1043 ART1025 1044 ART1026 1045 ART1027 1046 ART1028 1047 ART1029 1048 ART1030 1049 ART1031 1050 ART1032 1051 ART1033 1052 ART1034 1053 ART1035 1054 ART1036 1055 ART1037 1056 ART1038 1057 ART1039 1058 ART1040 1059 ART1041 1060 ART1042 1061 ART1043 1062 ART1044 1063 ART1045 1064 ART1046 1065 ART1047 1066 ART1048 1067 ART1049 1068 ART1050 1069 ART1051 1070 ART1052 1071 ART1053 1072 ART1054 1073 ART1055 1074 ART1056 1075 ART1057 1076 ART1058 1077 ART1059 1078 ART1060 1079 ART1061 1080 ART1062 1081 ART1063 1082 ART1064 1083 ART1065 1084 ART1066 1085 ART1067 1086 ART1068 1087 ART1069 1088 ART1070 1089 ART1071 1090 ART1072 1091 ART1073 1092 ART1074 1093 ART1075 1094 ART1076 1095 ART1077 1096 ART1078 1097 ART1079 1098 ART1080 1099 ART1081 1100 ART1082 1101 ART1083 1102 ART1084 1103 ART1085 1104 ART1086 1105 ART1087 1106 ART1088 1107 ART1089 1108 ART1090 1109 ART1091 1110 ART1092 1111 ART1093 1112 ART1094 1113 ART1095 1114 ART1096 1115 ART1097 1116 ART1098 1117 ART1099 1118 ART1100 1119 ART

CHEP 0070	CONSTA 0058	CRT1 0030	CRT2 0031	CRT3 0032	CRT4 0033	DECA 003A	DEEP 0041
DECE 0048	DECD 004E	DECE 0053	DECF 0058	DECG 005D	DECIS1 00A4	DECIS2 0104	DECIS3 0106
DECT54 0181	DECODE 032C	DEIII2 00E0	DELAY 0321	DISP1 0089	DISP2 0119	DISF3 0175	DISF4 0101
EASY 0206	ECON 0202	ENEMY 0057	ERAB 0206	ERASE 01FC	FRIEND 0059	HIA 0271	HIE 0270
HISC 026F	INCAN 03A4	INCR04 0388	INCR06 0386	INCR08 0384	INCR13 0390	INCR16 0380	INOFF 03A8
INON 03AE	INRET 03AC	JEANNE 0195	KAREN 0379	KEN 0383	LIMIT1 00A8	LIMIT2 0108	LIMIT3 0164
LIMIT4 0100	LOA 0285	LOB 028C	LOC 0293	LOD 0299	LOOP1 0323	LOOP2 0325	LOSC 028C
NCORR1 00E6	NCORR2 0116	NCORR3 0172	NCORR4 01CE	NFTH1 009C	NFTH2 00FC	NFTH3 0158	NFTH4 0184
OVER1 00C1	OVER2 0121	OVER3 017D	OVER4 0109	PATTA 0376	PATTI 0361	RA2222 02D5	RA4444 02D9
RAA1 0306	RAA2 030E	RAA3 02FE	RAA4 030A	RAAS 000B	RACA 02FC	RACE 02F5	RACY 02ED
REACT1 02D7	REACT2 02D0	REACT3 02E3	REACT4 02E9	REAGAN 01F5	ROUTE 0065	SAAB 0254	SAAC 025E
SAAD 0267	SAE 0247	SAND 030C	SBE 0244	SCAN 01F1	SCE 024D	SCORE 0244	SCORE1 0214
SCORE2 0220	SCORE3 022C	SCORE4 0238	SEND 030D	SENDUP 0394	SENOVR 039B	SONNY 00D9	START 0042
START1 0084	START2 00E4	START3 0140	START4 019C	TIMA 02B6	TIMB 02BC	TIMC 02C4	TIMCL 02C8
TIMCHT 02CB	TIMOOT 02A5	TIMER 029A	TIMER1 0009	TIMLIN 02CC	TIMRET 02D1	VACE 03B0	VERR 03D3
VODEL 03E3	VOICE1 03AF	VOICE2 03B3	VOICE3 03B7	VOICE4 03BB	VOSEND 03DF	WASP 0250	WHOOH 0054

ASSEMBLY COMPLETE, NO ERRORS

APPENDIX B

SPEECH PROCESSOR PROGRAM

LOC	OBJ	SEQ	SOURCE STATEMENT
		1	
		2	
		3	19 MARCH 1983
		4	
		5	
		6	THIS PROGRAM PRODUCES THE SERIAL DATA REQUIRED TO GIVE SPEECH
		7	CAPABILITY TO THE TRAINEE SIGHTS. THE HOST 8748 INTERRUPTS THE
		8	8741 AND SUPPLY'S THE DATA IT NEEDS TO ASSEMBLE REACTION TIMES TO
		9	BE SPOKEN TO EACH OF THE SIGHTS.
		10	
		11	
		12	
0000		13	ORG 0
		14	
0010		15	AMASK1 EQU 00010000B
0020		16	AMASK2 EQU 00100000B
0040		17	AMASK3 EQU 01000000B
0080		18	AMASK4 EQU 10000000B
		19	
0000 0409		20	JMP 9
		21	
0003		22	ORG 3
0003 643E		23	JMP INTER
		24	
0009		25	ORG 9
0009 8D0A		26	RESET: MOV R5,#100
000E 742A		27	CALL DELAY ; DELAY TO INSURE 8748 HAS RESET
000D 05		28	EN I
		29	
000E 23F0		30	MOV A,#0F0H
0010 39		31	OUTL P1,A
0011 23FE		32	MOV A,#0FEH
0012 3A		33	OUTL P2,A
		34	
0014 27		35	CLR A
0015 B821		36	MOV R0,#33D ; COUNTER
0017 B91F		37	MOV R1,#01FH ; POINTER
0019 A1		38	CLEAR: MOV @R1,A ; CLEAR OUT RAM
001A 19		39	INC R1
001B E819		40	DJNZ R0,CLEAR
		41	
001D B800		42	MOV R0,#13D ; COUNTER
001F B933		43	MOV R1,#033H ; POINTER
0021 27		44	CLR A
0022 AA		45	MOV R2,A ; R2 --- DATA
0023 A1		46	INDATA: MOV @R1,A ; SET UP DATA LIST
0024 19		47	INC R1
0025 1A		48	INC R2
0026 FA		49	MOV A,R2
0027 E823		50	DJNZ R0,INDATA
0029 B933		51	MOV R1,#033H ; RESTORE POINTER
		52	

LOC	OBJ	SEQ	SOURCE STATEMENT
002B 1494		53	CALL RESEH
		54	
		55	MAIN LOOP ROUTINE
		56	
002D BC32		57 MAIN:	MOV R4,#032H ; RESERVED STACK POINTER
002F BE14		58	MOV R6,#200 ; RESERVED STACK COUNTER
0031 FD		59	MOV A,R4
0032 AD		60	MOV R0,A
0033 F0		61	MOV A,R0
0034 9640		62	JNZ LOP0
0036 EE3A		63 GETNXT: DGNZ	R6,GETCON ; CHECK FOR BOTTOM OF STACK
0038 0420		64	JMP MAIN
003A CC		65 GETCON: DEC	R4
003B FC		66	MOV A,R4
003C AB		67	MOV R0,A
003D F0		68	MOV A,R0
003E C636		69	JZ GETNXT
		70	
0040 F246		71 LOP0:	JBT LARA ; ACC HAS WORD TO BE SPOKEN
0042 D256		72	JBT TRAC ; TRAINEE #2
0044 044A		73	JMP TRAI ; TRAINEE #1
0046 D26A		74 LARA:	JBT TRAF ; TRAINEE #4
0048 0460		75	JMP TRAC ; TRAINEE #3
		76	
004A 3404		77 TRAI:	CALL DEC001 ; SAY WORD IMMEDIATELY
004C 23FF		78 TDA1:	MOV A,#0FFH ; LOOP UNTIL WORD IS SPOKEN
004E 1479		79	CALL WAIT1
0050 C64C		80	JZ TDA1
0052 1474		81 TRET:	CALL CLR4
0054 0436		82	JMP GETNXT ; CONTINUE DOWN THE STACK
		83	
0056 3486		84 TRA2:	CALL DEC002
0058 23FF		85 TDA2:	MOV A,#0FFH
005A 147C		86	CALL WAIT2
005C C658		87	JZ TDA2
005E 0452		88	JMP TRET
		89	
0060 5404		90 TRA3:	CALL DEC003
0062 23FF		91 TDA3:	MOV A,#0FFH
0064 147E		92	CALL WAIT3
0066 C66C		93	JZ TDA3
0068 0452		94	JMP TRET
		95	
006A 548E		96 TRA4:	CALL DEC004
006C 23FF		97 TDA4:	MOV A,#0FFH
006E 147E		98	CALL WAIT4
0070 C66C		99	JZ TDA4
0072 0452		100	JMP TRET
		101	
0074 FD		102 CLR4:	MOV A,R4
0076 AB		103	MOV R0,A
0078 F0		104	MOV A,R0
007A 9640		105	JNZ RETR
007C 0452		106	JMP RETR
		107	

[illegible]

LOC	OBJ	SEQ	SOURCE STATEMENT
		163	;..... ; FINEE #1
		164	
		165	
0047	B810	166	SPEAK1: MOV R0, #ANASK1
0049	14B5	167	JMP TALK
004B	B820	168	SPEAK2: MOV R0, #ANASK2
004D	14B5	169	JMP TALK
004F	B840	170	SPEAK3: MOV R0, #ANASK3
00B1	14B5	171	JMP TALK
00B3	B8B0	172	SPEAK4: MOV R0, #ANASK4
		172	
00B5	BAD5	174	TALK: MOV R2, #5 ; COUNTER
00B7	37	175	CPL A
00B8	AB	176	MOV R3, A ; STORAGE
00B9	53FE	177	TALA: ANL A, #0FEH ; INQUIRY RESET LINES KEPT HIGH
00BB	3A	178	OUTL P2, A
		179	
00BC	BA01	180	ORL P2, #1 ; CLOCK PULSE
00BE	9AFE	181	ANL P2, #0FEH
		182	
00C0	FB	183	MOV A, R3
00C1	E7	184	RL A
00C2	AE	185	MOV R3, A
00C3	EAE9	186	DJNZ R2, TALA
		187	
00C5	BA64	188	MOV R2, #1000
00C7	EAC7	189	DAY: DJNZ R2, DAY ; NECESSARY DELAY
		190	
		191	; IT IS ASSUMED AT THIS POINT THAT THE VSM IS READY
		192	
00C9	FB	193	STROBE: MOV A, R0
00CA	92DC	194	JB4 STROBE1
00CC	B2DB	195	JB5 STROBE2
00CE	D2D4	196	JB6 STROBE3
		197	
00D0	B90B	198	STROBE4: ORL P1, #3
00D2	04DE	199	JMP STBRET
00D4	B909	200	STROBE3: ORL P1, #4
00D6	04DE	201	JMP STBRET
00D8	04DE	202	STROBE2: ORL P1, #2
00DA	04DE	203	JMP STBRET
00DC	B901	204	STROBE1: ORL P1, #1
		205	
00DE	00	206	STBRET: NOP
00DF	00	207	NOP
00E0	00	208	NOP
00E1	99F0	209	ANL P1, #0F0H
		210	
00E3	BA10	211	MOV R2, #0F0H
00E5	EAE5	212	DEY: DJNZ R2, DEY ; HOLD TIME DELAY
		213	
00E7	99	214	RETF
		215	
		216	;XX
		217	

LOC	OBJ	SEQ	SOURCE STATEMENT
		218	
0100		219	ORG 100H
		220	
0100 641A		221	T1SER1: JMP T1SERR
0102 640A		222	T1SPT1: JMP T1SPT
		223	
		224	
		225	; DECODE THE AMOUNT IN THE ACC FOR TRAINEE #1 TO SPEAK.
		226	
0104 B22D		227	DECODE1: JB5 STEEN1
0106 7435		228	CALL CACC ; CONDITION THE ACC
0108 C600		229	JZ T1SER1 ; "ERROR"
010A 07		230	DEC A
010B C602		231	JZ T1SPT1 ; "POINT"
010D 07		232	DEC A
010E C676		233	JZ T1S20 ; "TWENTY"
		234	
0110 FA		235	MOV A,R2
0111 7229		236	JB3 DAC1
0113 521F		237	JB2 DEC1
0115 321B		238	JB1 DIC1
0117 1254		239	JB0 T1S1 ; "ONE"
0119 2455		240	JMP T1S0 ; "ZERO"
011B 1252		241	DIC1: JB0 T1S3 ; "THREE"
011D 2453		242	JMP T1S2 ; "TWO"
011F 3225		243	DEC1: JB1 DEC1
0121 1250		244	JB0 T1S5 ; "FIVE"
0123 2451		245	JMP T1S4 ; "FOUR"
0125 124E		246	DEC1: JB0 T1S7 ; "SEVEN"
0127 244F		247	JMP T1S6 ; "SIX"
0129 124C		248	DAC1: JB0 T1S9 ; "NINE"
012B 244D		249	JMP T1S8 ; "EIGHT"
		250	
012D 7245		251	STEEN1: JB3 BAA1
012F 523B		252	JB2 BAB1
0131 3237		253	JB1 BAC1
0133 124A		254	JB0 T1S11 ; "ELEVEN"
0135 244B		255	JMP T1S10 ; "TEN"
0137 126E		256	BAC1: JB0 T1S13 ; "THIRTEEN"
0139 2449		257	JMP T1S12 ; "TWELVE"
013B 3241		258	BAB1: JB1 BAD1
013D 1272		259	JB0 T1S15 ; "FIFTEEN"
013F 245F		260	JMP T1S14 ; "FOURTEEN"
0141 125C		261	BAD1: JB0 T1S17 ; "SEVENTEEN"
0143 245D		262	JMP T1S16 ; "SIXTEEN"
0145 125A		263	BAA1: JB0 T1S19 ; "NINETEEN"
0147 245E		264	JMP T1S18 ; "EIGHTEEN"
		265	
		266	; ROUTINE TO CALL UPON TRAINEE #1 TO SPEAK "ZERO" THRU "TWELVE"
		267	
0149 19		268	T1S12: INC R1
014B 19		269	T1S11: INC R1
014D 19		270	T1S10: INC R1
014F 19		271	T1S9: INC R1
0140 19		272	T1S8: INC R1

LOC	ORG	SEQ	SOURCE STATEMENT
014E 19	273	T157:	INC R1
014F 19	274	T156:	INC R1
0150 19	275	T155:	INC R1
0151 19	276	T154:	INC R1
0152 19	277	T153:	INC R1
0153 19	278	T152:	INC R1
0154 19	279	T151:	INC R1
0155 F1	280	T150:	MOV A+@R1
0156 B935	281	T15PM:	MOV R1+@B935 ; RESTORE POINTER
0158 04A7	282	JMP	SPEAK1
	283		
	284 :		SPEAK "THIRTEEN" AND "NINETEEN"
	285		
015A 19	286	T1519:	INC R1
015B 19	287	T1518:	INC R1
015C 19	288	T1517:	INC R1
015D 19	289	T1516:	INC R1
015E 19	290		INC R1
015F 19	291	T1514:	INC R1
0160 19	292		INC R1
0161 19	293		INC R1
0162 19	294		INC R1
0163 F1	295	MOV	A+@R1
0164 14A7	296	TEEN1:	CALL SPEAK1
0166 2014	297	TEN1A:	MOV A+@10100E
0168 1479	298		CALL WAIT1
016A C466	299	JZ	TEN1A
0170 2436	300	JMP	T15PM
	301		
016F 2311	302	T1512:	MOV A+@10001E
0170 2464	303	JMP	TEEN1
	304		
0172 2012	305	T1515:	MOV A+@10010B
0174 2464	306	JMP	TEEN1
	307		
	308 :		SPEAK "NINETEEN"
	309		
0176 2310	310	T1520:	MOV A+@10000B
0178 14A7	311		CALL SPEAK1
017A 2312	312	T152A:	MOV A+@10011B
017C 1479	313		CALL WAIT1
017E C474	314	JZ	T152A
0180 04A7	315	JMP	SPEAK1
	316		
	317		*****
	318		
	319 :		DECODE THE POINT IN THE ACC FOR TRAINEE #2 TO SPEAK.
	320		
0182 441E	321	TEEN2:	JMP T15PM
0184 440E	322	TEN2:	JMP T15PM
	323		
0186 B2AF	324	DECODE2:	MOV A+@B2AF
0188 7435	325	JZ	A0 ; CONDITION THE ACC
018A C681	326	JZ	255H ; "ERROR"
018C 07	327	DEC	A

LOC	OBJ	SEQ	SOURCE STATEMENT
0180	0684	328	JZ T2SPT2 : 'POINT'
018F	07	329	DEC A
0190	06F8	330	JZ T2S20 : 'TWENTY'
		331	
0192	FA	332	MOV A+R2
0193	72AB	333	JB3 DAC2
0195	52A1	334	JB2 DEC2
0197	329D	335	JB1 DIC2
0199	12D6	336	JB0 T2S1 : 'ONE'
019B	24D7	337	JMP T2S0 : 'ZERO'
019D	12D4	338 DIC2:	JB0 T2S3 : 'THREE'
019F	24D5	339	JMP T2S2 : 'TWO'
01A1	32A7	340 DEC2:	JB1 DEC2
01A3	12D2	341	JB0 T2S5 : 'FIVE'
01A5	24D3	342	JMP T2S4 : 'FOUR'
01A7	12D0	343 DEC2:	JB0 T2S7 : 'SEVEN'
01A9	24D1	344	JMP T2S6 : 'SIX'
01AB	12CE	345 DAC2:	JB0 T2S9 : 'NINE'
01AD	24CF	346	JMP T2S8 : 'EIGHT'
		347	
01AF	72D7	348 STEEN2:	JB3 BAC2
01B1	52B0	349	JB2 BAB2
01B3	32B9	350	JB1 BAC2
01B5	12CC	351	JB0 T2S11 : 'ELEVEN'
01B7	24CD	352	JMP T2S10 : 'TEN'
01B9	12F0	353 BAC2:	JB0 T2S13 : 'THIRTEEN'
01BB	24CB	354	JMP T2S12 : 'TWELVE'
01BD	32C3	355 BAB2:	JB1 BAD2
01BF	12F4	356	JB0 T2S15 : 'FIFTEEN'
01C1	24E1	357	JMP T2S14 : 'FOURTEEN'
01C3	12DE	358 BAD2:	JB0 T2S17 : 'SEVENTEEN'
01C5	24DF	359	JMP T2S16 : 'SIXTEEN'
01C7	12DC	360 BAA2:	JB0 T2S19 : 'NINETEEN'
01C9	24D0	361	JMP T2S18 : 'EIGHTEEN'
		362	
		363 :	ROUTINE TO CALL UPON TRAINEE #2 TO SPEAK 'ZERO' THRU 'TWELVE'
		364	
01CB	19	365 T2S17:	INC R1
01CC	19	366 T2S11:	INC R1
01CD	19	367 T2S10:	INC R1
01CE	19	368 T2S9:	INC R1
01CF	19	369 T2S8:	INC R1
01D0	19	370 T2S7:	INC R1
01D1	19	371 T2S6:	INC R1
01D2	19	372 T2S5:	INC R1
01D3	19	373 T2S4:	INC R1
01D4	19	374 T2S3:	INC R1
01D5	19	375 T2S2:	INC R1
01D6	19	376 T2S1:	INC R1
01D7	F1	377 T2S0:	MOV R1, R2
01D8	B932	378 T2SFK:	MOV R1, R2
01DA	04AB	379	JMP SPEAK
		380	
		381 :	SPEAK 'THIRTEEN' THRU 'NINETEEN'
		382	

LOC	OBJ	SEQ	SOURCE STATEMENT
010C	19	383	T2S19: INC R1
010D	19	384	T2S18: INC R1
010E	19	385	T2S17: INC R1
010F	19	386	T2S16: INC R1
01E0	19	387	INC R1
01E1	19	388	T2S14: INC R1
01E2	19	389	INC R1
01E3	19	390	INC R1
01E4	19	391	INC R1
01E5	F1	392	MOV A, @R1
01E6	14AB	393	TEEN2: CALL SPEAK2
01E8	2314	394	TEN2A: MOV A, #10100B
01EA	147D	395	CALL WAIT2
01EC	06EB	396	JZ TEN2A
01EE	240B	397	JMP T2SPK
		398	
01F0	2311	399	T2S13: MOV A, #10001B
01F2	24E6	400	JMP TEEN2
		401	
01F4	2312	402	T2S15: MOV A, #10010B
01F6	24E6	403	JMP TEEN2
		404	
		405	; SPEAK 'TWENTY'
		406	
01F8	2310	407	T2S20: MOV A, #10000B
01FA	14AB	408	CALL SPEAK2
01FC	2313	409	T2S2A: MOV A, #10011B
01FE	147D	410	CALL WAIT2
0200	0604	411	JZ T2S22
0202	04AB	412	JMP SPEAK2
		413	
0204	24FC	414	T2S22: JMP T2S2A
		415	
		416	;XX
		417	
		418	
0206	6422	419	T3SER3: JMP T3SERR
0208	6412	420	T3SPT3: JMP T3SPT
		421	
		422	
		423	; DECODE THE AMOUNT IN THE ACC FOR TRAINEE #3 TO SPEAK
		424	
020A	B233	425	DECODE3: JB5 STEEN3
020C	7435	426	CALL CACC ; CONDITION THE ACC
020E	0606	427	JZ T3SER3 ; 'ERROR'
0210	07	428	DEC A
0211	0608	429	JZ T3SPT3 ; 'POINT'
0213	07	430	DEC A
0214	067C	431	JZ T3SC0 ; 'TWENTY'
		432	
0216	FA	433	MOV A, R2
0217	722F	434	JB3 DAC3
0219	5215	435	JB2 DEC3
021B	3221	436	JB1 DIC3
021D	125A	437	JB0 T3S1 ; 'ONE'

LOC	ORG	SEQ	SOURCE STATEMENT
021F	4456	430	JMP T350 ; 'ZERO'
0211	1216	439	DIC3: JB0 T353 ; 'THREE'
0223	4459	440	JMP T357 ; 'TWO'
0225	322B	441	DEC3: JB1 0003
0227	1256	442	JB0 T355 ; 'FIVE'
0229	4457	443	JMP T354 ; 'FOUR'
022B	1254	444	0003: JB0 T357 ; 'SEVEN'
022D	4455	445	JMP T356 ; 'SIX'
022F	1252	446	DAC3: JB0 T359 ; 'NINE'
0231	4453	447	JMP T358 ; 'EIGHT'
		448	
0233	724B	449	STEEN3: JB3 BAA8
0235	5241	450	JB2 BAB1
0237	323D	451	JB1 BAC3
0239	1250	452	JB0 T3511 ; 'ELEVEN'
023B	4451	453	JMP T3510 ; 'TEN'
023D	1274	454	BAC3: JB0 T3513 ; 'THIRTEEN'
023F	444F	455	JMP T3512 ; 'TWELVE'
0241	3247	456	BAB3: JB1 BAC3
0243	1278	457	JB0 T3515 ; 'FIFTEEN'
0245	4465	458	JMP T3514 ; 'FOURTEEN'
0247	1262	459	BAC3: JB0 T3517 ; 'SEVENTEEN'
0249	4463	460	JMP T3516 ; 'SIXTEEN'
024B	1260	461	BAA3: JB0 T3519 ; 'NINETEEN'
024D	4461	462	JMP T3518 ; 'EIGHTEEN'
		463	
		464 ;	ROUTINE TO CALL UPON TRAINEE #3 TO SPEAK 'ZERO' THRU 'TWELVE'
		465	
024F	19	466	T3512: INC R1
0250	19	467	T3511: INC R1
0251	19	468	T3510: INC R1
0252	19	469	T359: INC R1
0253	19	470	T358: INC R1
0254	19	471	T357: INC R1
0255	19	472	T356: INC R1
0256	19	473	T355: INC R1
0257	19	474	T354: INC R1
0258	19	475	T353: INC R1
0259	19	476	T352: INC R1
025A	19	477	T351: INC R1
025B	F1	478	T350: MOV A+GR1
025C	B933	479	T35PK: MOV R1+023F
025E	34AF	480	JMP DEAN2
		481	
		482 ;	SPEAK 'THIRTEEN' THRU 'NINETEEN'
		483	
0260	19	484	T3519: INC R1
0261	19	485	T3518: INC R1
0262	19	486	T3517: INC R1
0263	19	487	T3516: INC R1
0264	19	488	INC R1
0265	19	489	T3514: INC R1
0266	19	490	INC R1
0267	19	491	INC R1
0268	19	492	INC R1

LOC	OBJ	SEQ	SOURCE STATEMENT
0269	F1	493	MOV A:BR1
026A	14AF	494	TEEN3: CALL SPEAK3
026C	2314	495	TEN3A: MOV A:#10100B
026E	1481	496	CALL WAIT3
0270	066C	497	JZ TEN3A
0272	445C	498	JMP T3SPK
		499	
0274	2311	500	T3S12: MOV A:#10001B
0276	446A	501	JMP TEFN3
		502	
0278	2312	503	T3S15: MOV A:#10010B
027A	446A	504	JMP TEFN3
		505	
		506	; SPEAK 'TWENTY'
		507	
027C	2310	508	T3S20: MOV A:#10000B
027E	14AF	509	CALL SPEAK3
0280	2313	510	T3S2A: MOV A:#10011B
0282	1481	511	CALL WAIT3
0284	0680	512	JZ T3S2A
0286	04AF	513	JMP SPEAK3
		514	
		515	*****
		516	
		517	; DECODE THE AMOUNT IN THE ACC FOR TRAINEE #4 TO SPEAK.
		518	
0288	6426	519	T4SER4: JMP T4SER4
028A	6416	520	T4SPT4: JMP T4SPT
		521	
028C	8285	522	DECODE4: JB5 STEEN4
028E	7435	523	CALL CACC ; CONDITION THE ACC
0290	0688	524	JZ T4SER4 ; 'ERROR'
0292	07	525	DEC A
0293	068A	526	JZ T4SPT4 ; 'POINT'
0295	07	527	DEC A
0296	06FE	528	JZ T4S20 ; 'TWENTY'
		529	
0298	FA	530	MOV A:R2
0299	72E1	531	JB3 DAC4
029B	52A7	532	JB1 DEC4
029D	32A3	533	JB1 DIC4
029F	120C	534	JB0 T4S1 ; 'ONE'
02A1	440D	535	JMP T4S0 ; 'ZERO'
02A3	12DA	536	DIC4: JB0 T4S3 ; 'THREE'
02A5	44DB	537	JMP T4S2 ; 'TWO'
02A7	32AD	538	DEC4: JB1 DEC4
02A9	1208	539	JB0 T4S5 ; 'FIVE'
02AB	44D9	540	JMP T4S4 ; 'FOUR'
02AD	1206	541	DEC4: JB0 T4S7 ; 'SEVEN'
02AF	44D7	542	JMP T4S6 ; 'SIX'
02B1	1204	543	DAC4: JB0 T4S9 ; 'NINE'
02B3	44D5	544	JMP T4S8 ; 'EIGHT'
		545	
02B5	72CD	546	STEEN4: JB3 BAA4
02B7	52C3	547	JB2 SAB4

LOC	OBJ	SEO	SOURCE	STATEMENT
02B9	02BF	549	JB1	BAC4
02BB	12D2	549	JB0	T4S11
02BD	4403	550	JMP	T4S10
02BF	12F6	551	BAC4:	JB0
02C1	44D1	552	JMP	T4S13
02C3	32C9	553	BAC4:	JB1
02C5	12FA	554	JB0	T4S15
02C7	44E7	555	JMP	T4S14
02C9	12E4	556	BAC4:	JB0
02CB	44E5	55	JMP	T4S11
02CD	12E1	558	BAA4:	JB0
02CF	44E3	559	JMP	T4S11
		560		
		561 :	ROUTINE TO CALL UPON TRAINEE #4 TO SPEAK 'ZERO' THRU 'TWELVE'	
		562		
02D1	19	563	T4S12:	INC R1
02D2	19	564	T4S11:	INC R1
02D3	19	565	T4S10:	INC R1
02D4	19	566	T4S9:	INC R1
02D5	19	567	T4S8:	INC R1
02D6	19	568	T4S7:	INC R1
02D7	19	569	T4S6:	INC R1
02D8	19	570	T4S5:	INC R1
02D9	19	571	T4S4:	INC R1
02DA	19	572	T4S3:	INC R1
02DB	19	573	T4S2:	INC R1
02DC	19	574	T4S1:	INC R1
02DD	F1	575	T4S0:	MOV A+0B1
02DE	B733	576	T4SPK:	MOV R1, #033H
02E0	04B3	577	JMP	SPEAK4
		578		
		579 :	SPEAK 'THIRTEEN' THRU 'NINETEEN'	
		580		
02E2	19	581	T4S19:	INC R1
02E3	19	582	T4S18:	INC R1
02E4	19	583	T4S17:	INC R1
02E5	19	584	T4S16:	INC R1
02E6	19	585		INC R1
02E7	19	586	T4S14:	INC R1
02E8	19	587		INC R1
02E9	19	588		INC R1
02EA	19	589		INC R1
02EB	F1	590		MOV A+0B1
02EC	14B3	591	TEEN4:	CALL SPEAK4
02EE	1D14	592	TEN4A:	MOV A, #10101B
02F0	14B5	593		CALL TEN4A
02F2	06EE	594		JC TEN4A
02F4	44DE	595		HF T4S0
		596		
02F6	0211	597	T4S13:	MOV R1, #10101B
02F8	44E1	598	JMP	T4S0
		599		
02FA	0211	600	T4S15:	MOV R1, #10101B
02FB	44E1	601	JMP	T4S0
		602		

LOC	OBJ	SEQ	SOURCE STATEMENT
		603 ;	SPEAK 'TWENTY'
		604	
02FE 2310		605 T4S20:	MOV A,#10000B
0300 14B3		606	CALL SPEAK4
0302 2313		607 T4S2A:	MOV A,#10011B
0304 14B5		608	CALL WAIT4
0306 0602		609	JZ T4S2A
0308 04B3		610	JMP SPEAK4
		611	
		612 ;	*****
		613	
		614	
		615 ;	SPEAK 'POINT'
		616	
030A 231A		617 T1SPT:	MOV A,#11010B
030C 04A7		618	JMP SPEAK1
030E 231A		619 T2SPT:	MOV A,#11010B
0310 04AB		620	JMP SPEAK2
0312 231A		621 T3SPT:	MOV A,#11010B
0314 04AF		622	JMP SPEAK3
0316 231A		623 T4SPT:	MOV A,#11010B
0318 04B3		624	JMP SPEAK4
		625	
		626 ;	SPEAK 'ERROR'
		627	
031A 231B		628 T1SERR:	MOV A,#11011B
031C 04A7		629	JMP SPEAK1
031E 231B		630 T2SERR:	MOV A,#11011B
0320 04AB		631	JMP SPEAK2
0322 231B		632 T3SERR:	MOV A,#11011B
0324 04AF		633	JMP SPEAK3
0326 231B		634 T4SERR:	MOV A,#11011B
0328 04B3		635	JMP SPEAK4
		636	
		637 ;	*****
		638	
032A 8A50		639 DELAY:	MOV R2,#050H ; DELAY SUBROUTINE, 100MSEC PER R5 BIT
032C 8EFF		640 LOOP1:	MOV R3,#0FFH
032E 8E2E		641 LOOP2:	DJNZ R3,LOOP2
0330 EA2C		642	DJNZ R2,LOOP1
0332 ED1A		643	DJNZ R5,DELAY
0334 93		644	RETR
		645	
		646 ;	CONDITION THE ACCUMULATOR FOR THE DECODE ROUTINE
		647	
0335 AA		648 CACC:	MOV R2,A
0336 530F		649	ANL A,#0FH
0338 030F		650	XRL A,#0FH
033A 93		651	RETR
		652	
		653 ;	*****
		654	
		655 ;	INTERRUPT ROUTINE TO STORE A WORD IN THE STACK
		656	
033E 05		657 INTER:	SEL R81

LOC	OBJ	SEG	SOURCE STATEMENT	COMMENT	
0330	AA	658	MOV	A, #0	: STORAGE
0330	22	659	NEWLOC: IN	A, #0B	
033E	AE	660	MOV	R3, A	: STORAGE
033F	AC	661	MOV	R4, A	: STORAGE
0340	530F	662	ANL	A, #0FH	
0342	530F	663	JRL	A, #0FH	
0344	9E4C	664	JNZ	ICON	: IF ZERO THEN WORD IS 'ERROR'
0346	8800	665	MOV	R0, #1	: RAM OFFSET
034E	7495	666	CALL	SUBB	
034A	FA	667	MOV	A, R1	
034B	93	668	RETR		
		669			
034C	FE	670	ICON: MOV	A, #0	
034D	B251	671	JBS	INA	
034F	645E	672	JMP	STOR1	: REGISTER R0 FROM 8748
0351	927D	673	INA: JB4	STOR2	: REGISTER R2 FROM 8748
0353	6466	674	JMP	STOR1	: REGISTER R1 FROM 8748
		675			
0355	5300	676	STOR0: ANL	A, #000H	
0357	430E	677	JRL	A, #0EH	: CODE ACC TO XX00/1110 TO SAY 'POINT'
0359	AE	678	MOV	R3, A	
035A	B801	679	MOV	R0, #1	: RAM OFFSET FOR POINT
035C	7495	680	CALL	SUBB	
035E	FC	681	MOV	A, R3	
035F	AE	682	MOV	R3, A	
0360	B800	683	MOV	R0, #0	: RAM OFFSET FOR LS DIGIT
0362	7495	684	CALL	SUBB	: ACC GETS '(NUMBER)'
0364	FA	685	MOV	A, R2	
0365	93	686	RETR		
		687			
0366	530F	688	STOR1: ANL	A, #0FH	: CHECK FOR 8748 R2=1 OR 2
0368	966D	689	JNZ	STR1A	
034A	49	690	JRL	A, R1	: CODE ACC TO XX(R1)/XXXX
036B	927B	691	JB4	STR1B	
036D	FB	692	STR1A: MOV	A, R3	
036E	530F	693	ANL	A, #0CFH	: CODE ACC TO XX00/XXXX
0370	49	694	JRL	A, R1	: SET B5 OR NOT
0371	4010	695	JRL	A, #010H	: 50 AS TO SAY 'ZERO'
0373	AE	696	MOV	R3, A	
0374	B800	697	MOV	R0, #0	: RAM OFFSET FOR SECOND DIGIT
0376	7495	698	CALL	SUBB	
037B	D37B	699	STR1B: JIRF	STR1B	: LOOP TILL NEW VALUE GIVEN
0374	A43D	700	JMP	NEWLOC	
		701			
037C	5900	702	STOR2: MOV	A, #0	
037E	328B	703	JBI	A, #0E	: FOR 'TWENTY'
0380	1284	704	JBC	A, #0E	: SET 10 THRU 19
0382	617B	705	JF		
0384	B920	706	NOTPER: MOV	A, #100H	: R1 = 0010/0000 FOR 8748 R2=1
0386	647B	707	JF		
0388	B910	708	NOTPER: MOV	A, #100H	: R1 = 0001/0000 FOR 8748 R2=2
038A	5300	709	ANL	A, #0FH	
038C	4300	710	JRL	A, #0H	: SET ACC TO XX00/1101 TO SAY 'TWENTY'
038F	AE	711	MOV	R3, A	
039F	A604	712	MOV	R0, #0	: RAM OFFSET FOR 45 DIGITS

LOC	OBJ	SEQ	SOURCE STATEMENT
0391	7495	713	CALL SUBB
0393	6478	714	JMP STR1B
		715	
0395	FB	716	SUBB: MOV A,R3
0396	F2A5	717	JB7 WHOAA
0398	02A1	718	JB6 WHOBB
039A	232E	719	MOV A,#2EH ; TRAINEE #1 2E,2F,30,31,32
039C	68	720	SUBBRT: ADD A,R0 ; ADD IN OFFSET
039D	A8	721	MOV R0,A ; USE AS POINTER
039E	FB	722	MOV A,R3
039F	A0	723	MOV @R0,A ; STORE DATA
03A0	83	724	RET
		725	
03A1	2329	726	WHOBB: MOV A,#29H ; TRAINEE #2 29,2A,2B,2C,2D
03A3	649C	727	JMP SUBBRT
		728	
03A5	02AB	729	WHOAA: JB6 WHOCC
03A7	2324	730	MOV A,#24H ; TRAINEE #3 24,25,26,27,28
03A9	649C	731	JMP SUBBRT
		732	
03AB	231F	733	WHOCC: MOV A,#1FH ; TRAINEE #4 1F,20,21,22,23
03AD	649C	734	JMP SUBBRT
		735	
		736	
		737	
		738	END

USER SYMBOLS

AMASK1 0010	AMASK2 0020	AMASK3 0040	AMASK4 0080	BAA1 0145	BAA2 01C7	BAA3 024B	BAA4 02C0
BAB1 013B	BAB2 01BD	BAB3 0241	BAB4 02C3	BAC1 0137	BAC2 01B9	BAC3 023D	BAC4 02BF
BAD1 0141	BAD2 01C3	BAD3 0247	BAD4 02C9	BUSY 0092	CACC 0335	CLEAR 0019	CLR4 0074
DAC1 0129	DAC2 01AB	DAC3 022F	DAC4 02B1	DAY 00C7	DEC1 011F	DEC2 01A1	DEC3 0225
DEC4 02A7	DEC0D1 0104	DEC0D2 0186	DEC0D3 020A	DEC0D4 028C	DELAY 032A	DEV 00E5	DIC1 011B
DIC2 019D	DIC3 0221	DIC4 02A3	DOC1 0125	DOC2 01A7	DOC3 022B	DOC4 02AD	GETCON 003A
GETNXT 0036	ICON 034C	INA 0351	INDATA 0023	INTER 033B	LAPA 0046	LOOP1 032C	LOOP2 032E
LOPO 0040	MAIN 002D	NEWLOC 033D	R2TEEN 0384	R2TWEN 0388	RESDEL 009E	RESEE 0095	RESEQ 0094
RESET 0009	RESRER 00A5	SPEAK1 00A7	SPEAK2 00AB	SPEAK3 00AF	SPEAK4 00B3	STBRET 00DE	STEEN1 012D
STEEN2 01AF	STEEN3 0233	STEEN4 02B5	STORG 0355	STOR1 0366	STOR2 037C	STR1A 036D	STR1B 037B
STORB1 00DC	STORB2 00D8	STORB3 00D4	STORB4 00D0	STORB 00C9	SUBB 0395	SUBBRT 039C	T1S0 0155
T1S1 0154	T1S10 014B	T1S11 014A	T1S12 0149	T1S13 016E	T1S14 015F	T1S15 0172	T1S16 015D
T1S17 015C	T1S18 015B	T1S19 015A	T1S2 0153	T1S20 0176	T1S2A 017A	T1S3 0152	T1S4 0151
T1S5 0150	T1S6 014F	T1S7 014E	T1S8 014D	T1S9 014C	T1SER1 0100	T1SERR 031A	T1SPK 0156
T1SPT 030A	T1SPT1 0102	T2S0 01D7	T2S1 01D6	T2S10 01CD	T2S11 01CC	T2S12 01CB	T2S13 01F0
T2S14 01E1	T2S15 01F4	T2S16 01DF	T2S17 01DE	T2S18 01DD	T2S19 01DC	T2S2 01D5	T2S2C 01FB
T2S22 0204	T2S2A 01FC	T2S3 01D4	T2S4 01D3	T2S5 01D2	T2S6 01D1	T2S7 01D0	T2S8 01CF
T2S9 01CE	T2SER2 01B2	T2SERR 031E	T2SPK 01D8	T2SPT 030E	T2SPT2 01B4	T3S0 025B	T3S1 025A
T3S10 0251	T3S11 0250	T3S12 024F	T3S13 0274	T3S14 0265	T3S15 0278	T3S16 0263	T3S17 0262
T3S18 0261	T3S19 0260	T3S2 0259	T3S20 027C	T3S2A 0280	T3S3 0258	T3S4 0257	T3S5 0256
T3S6 0255	T3S7 0254	T3S8 0253	T3S9 0252	T3SER3 0206	T3SERR 0322	T3SPK 025C	T3SPT 0312
T3SPT3 0208	T4S0 02D0	T4S1 02DC	T4S10 02D3	T4S11 02D2	T4S12 02D1	T4S13 02F6	T4S14 02E7
T4S15 02FA	T4S16 02E5	T4S17 02E4	T4S18 02E3	T4S19 02E2	T4S2 02DB	T4S20 02FE	T4S2A 0302
T4S2 02DA	T4S4 02D9	T4S5 02D8	T4S6 02D7	T4S7 02D6	T4S8 02D5	T4S9 02D4	T4SER4 02BB
T4SERR 0326	T4SPK 02DE	T4SPT 0316	T4SPT4 02BA	TALA 00B9	TALK 00B5	TDA1 004C	TDA2 005B
TDA3 0052	TDA4 006C	TEEN1 0164	TEEN2 01E6	TEEN3 026A	TEEN4 02EC	TEN1A 0166	TEN2A 01EB
TEN3A 026C	TEN4A 02EE	TRA1 004A	TRA2 0056	TRA3 0060	TRA4 006A	TRET 0052	WADEL 00B7

WAIT1 0079 WAIT2 007D WAIT3 0081 WAIT4 0085 WATT 008B WAXX 0089 WHDAA 03A5 WHDDE 03A1
WHCCC 03AE

ASSEMBLY COMPLETE, NO ERRORS

WAIT1 0079 WAIT2 007D WAIT3 0081 WAIT4 0085 WATT 008B WAXX 0089 WHDAA 03A5 WHDBE 03A1
WHOCC 03AE

ASSEMBLY COMPLETE, NO ERRORS

END

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