A HIGHLY PORTABLE DATA ACQUISITION SYSTEM FOR TOTAL MAGNETICS F-ETC(U)

STEIGER

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**Title:** A HIGHLY PORTABLE DATA ACQUISITION SYSTEM FOR TOTAL MAGNETICS FIELD MEASUREMENTS.

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**Keywords:** Intelligent terminals, Magnetics data acquisition, Real-Time processing, Portable data acquisition system, Microcomputer.

**Abstract:** At the Naval Research Laboratory, highly portable intelligent terminals are being utilized aboard oceanographic platforms for the acquisition and storage of total magnetic field measurements. Described in the paper is the design and implementation of the data acquisition system which includes a detailed description of the hardware and software utilized.
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A HIGHLY PORTABLE DATA ACQUISITION SYSTEM FOR TOTAL MAGNETICS FIELD MEASUREMENTS

I. INTRODUCTION

The Acoustic Media Characterization Branch of the Acoustics Division of NRL has since 1971 conducted magnetic field studies for the Navy in many areas of the world. Much of this work has been accomplished using aircraft to conduct the magnetic studies. The resultant data has been compiled into magnetic anomaly charts of the oceans of the world. The information is utilized by DOD for interpretation of the tectonic history of the area. These interpretations utilize state of the art theories of sea floor spreading and plate tectonics.

Many of these magnetic studies are performed on aircraft and ships of opportunity or "piggybacking" other experiments. During some of these data gathering experiments it is inappropriate or impractical to place a mini-computer system aboard the aircraft due to size, weight or the resources required to install, maintain and operate a computer system.

NRL has developed a highly portable, compact, lightweight and easy to operate data acquisition system for acquiring magnetics field data and navigational position information. The portable magnetics data acquisition system has been used successfully yielding results comparable to the mini-computer system.

II. PORTABLE DATA ACQUISITION SYSTEM

The portable data acquisition system is based around a Hewlett-Packard HP264X intelligent terminal. Figure 1 is a photograph of the terminal. The feature of the terminal that makes it intelligent is the programmable microprocessor internal to the terminal. Also, all of the necessary components of a computer such as internal storage, external storage and interface capability to peripherals provide the capability of making the terminal a data acquisition system.

The HP264X was selected as the data acquisition system because it had all of the salient features required such as, programmable processor, internal memory, external cassette storage, parallel and serial interfacing capability, portability and software development tools. In addition, several of these units are available at NRL and being used as computer terminals. In fact, the HP264X can be considered a well packag-

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ed, self-contained microcomputer.

A functional diagram of the portable terminal magnetics field data acquisition system is shown in Figure 2. The system consists of a Geometrics Model G801/803A magnetometer, a CHRONO-LOG Series 70000 Time Code Generator and a NRL designed Litton Interface that obtains aircraft position information from the aircraft Litton Model 72 Inertial Navigator. The components of the system are described below.

1. Terminal Electronic Circuit Boards

An interior view of the terminal is shown in Figure 3. There are fifteen circuit boards that can be inserted directly into the terminal. Ten of these boards are required for control of the terminal, with the microprocessor residing on one of these boards. To use the HP264X as a data acquisition device two high density HP13297A-003 32K Byte RAM (Random Access Memory) Boards are required. The strapping configuration of these boards are given in Table 1. This memory is used for display, programs, temporary data storage and assembling and debugging programs. The HP264X in this configuration leaves five empty slots for interfacing to external sensors.

2. I/O Terminal Interfaces

The HP13255 Terminal Duplex Register Board described in Reference 1 was selected for interfacing with the magnetometer, digital clock and Litton Inertial Navigator Interface. All of these devices provide Binary Coded Decimal (BCD) outputs at TTL logic levels. The Duplex Register Board contains 8 data receiving lines and 8 status lines. It was recognized that the 8 status lines could be used for data input as well as the 8 data lines resulting in 16 data lines for input. The polarity of the status lines on the interface is reversed from the data lines except for bits zero and one. By using the status lines the input capacity was increased from five 8 bit words to five 16 bit words, thereby doubling the data acquisition capacity of the terminal. Also, by using the status lines the 16 bit four character BCD output of the magnetometer and Litton Navigator Interface was fully compatible. The problem of polarity was handled with software by masking the two status bits of opposite polarity complementing the remainder and adding the two bits to the remainder to reform the byte.

3. External Storage

The HP264X Terminal has two cassette drive units mounted below the display. Each cassette is capable of storing 110K Bytes of information. The information stored on these cassettes are source, object, assembler and debugger programs and the data acquired from the magnetics
data acquisition system. The cassettes can be operated using functional keys from the keyboard or under program control. Both ASCII and binary tapes can be read and written by the terminal.

4. Litton Interface

The interface between the Litton Inertial Navigator and the data acquisition system was specially designed and built at NRL. The Litton Navigator sequentially outputs inertial navigation information on a continuous basis. The function of the interface is to service a request for data from the data acquisition system. Upon request from the controller the interface obtains and stores latitude, longitude and heading information. After acquiring this information the interface interrupts the terminal data acquisition system. Upon receiving the interrupt the terminal goes through a "handshake" sequence with the interface three times to acquire the latitude, longitude and heading which is sequentially multiplexed to the output lines of the interface.

The interface is connected to the terminal using two duplex boards. Two boards are required since eight BCD characters form a position word. The terminal I/O board addresses of the four most significant characters and the four least significant characters are given in Table 2. The addresses are accomplished by configuring jumpers at appropriate locations on the duplex board.

5. Magnetometer

The magnetometer measures the magnetic field intensity at either preset or continuous intervals. Five BCD TTL compatible digital characters are output through a connector on the back of the unit to the terminal and also output to the display of the magnetometer. Since each terminal interface is capable of accepting four BCD characters two interfaces are required. The most significant character from the magnetometer is interfaced to one eight bit duplex board while the four remaining characters are interfaced to a second duplex board in the terminal. The I/O strapping configurations are given in Table 2. The strapping consists of assigning the board an address that can be read by the program. The addresses of each respective board is given in Table 2.

6. Digital Clock

The function of the clock is to provide digital time in order to be able to correlate and interpolate data when future processing is performed. The clock provides in BCD format at TTL signal levels day of year, hours, minutes and seconds. In order to conserve input capacity, minutes and seconds consisting of four BCD characters were interfaced to the terminal using one duplex board. Day and hour are hand recorded on the cassette cartridge and time information is reconstructed when
further processing is performed. The address of the terminal interface board is given in Table 2. Also, it should be noted that there are several manufacturers of digital clocks which can be used and have been used since they function similarly to the CHRONO-LOG.

III. SOFTWARE DESCRIPTION

Programs for the intelligent terminal can be developed by preparing the source program and using the assembler available on the terminal or by using an HP1000 mini-computer system to prepare the program and provide a cross assembly for loading into the terminal. Since the debugging of the program can only be performed on the terminal the program for the terminal magnetics system was developed on the terminal.

The terminal uses an Intel 8080 compatible microprocessor. The microprocessor differences are in the way I/O is managed. Therefore, the program with the exception of I/O is Intel 8080 compatible. The terminal has many software subroutines stored in Read Only Memory (ROM) that can be used by the program by addressing the starting location of the subroutines. These subroutines, since they are stored in ROMs cannot be altered. The routine PUTIO for performing I/O to the terminal display and cartridge tape units was used. This routine will write ASCII records to the display and either tape drive depending upon the device specified. The terminal magnetics program has been programmed to use only the right tape drive to store data.

The terminal has a 10 millisecond internal clock. The clock is used to schedule the magnetics program by storing the number of 10 millisecond intervals required in a location called TIMER which the terminal executive system decrements. Upon decrementing the location to zero the executive system software transfers control to a predetermined location. The starting address of the user program is stored at this location which in turn permits the scheduling of subroutines. The magnetics data acquisition program was scheduled to execute every three seconds. This required the storing of 100 in the location TIMER which equates to one second and executing the timer program three times. This was required since the microprocessor is organized around an 8 bit word which has 127 as its largest positive number.

The terminal data acquisition program is entered by transferring control from the terminal executive program to the program CHTIMO. The function of CHTIMO is to schedule the data acquisition program to run at three second intervals. This is accomplished by checking for the TIMER location to go to zero and the number of repetitive seconds to go negative. When the repetitive seconds have expired software control transfers to the main program CONTRL, otherwise a return to the terminal executive program is executed.
The program CONTRL is used to call four major subroutines, namely, INIT2, INPUT, PROCES and OUTPUT. These four programs are discussed below.

1. Subroutine INIT2

The program INIT2 stores 100 in the location TIMER which allows the terminal executive system to decrement the location TIMER 100 times, which takes one second before going to zero. Also, the program sets the repeat factor of this program at two in order to obtain three second intervals between the magnetics program execution. The program INIT2 is called every time the program CNTIMO calls the program CONTRL.

2. Subroutine INPUT

The function of subroutine INPUT is to obtain the data from the external sensors and devices. It accomplishes this task by requesting data from the devices using a memory mapped I/O scheme. All of the five interface boards in the terminal have a unique address determined by the strapping configuration on the board which are given in Table 2. Under program control a request is made of the sensor, or sensor interface to send data. The data is buffered into the terminal interface I/O board. By addressing the terminal interface board with its unique address the data can be handled by the microprocessor under program control.

In the case of the Litton navigation information the process is repeated three times since the data is multiplexed out using the same two interface boards in order to obtain latitude, longitude and heading of the aircraft.

3. Subroutine PROCES

The program PROCES is used to manipulate the data into a format suitable for display and storage on cassette tapes. The first step in the process of preparing the data for output is to convert the BCD characters to an ASCII format. The status byte consisting of bits zero and one being of opposite polarity to the remaining word must be complemented and the word reformed. Following all the status words and data words being in the same BCD format, the data is manipulated by an algorithm that replaces the BCD character with its equivalent ASCII character.

In the case of latitude and longitude the first bit of the status byte is masked and tested for 0 or 1, which determines North or South for latitude and East and West for longitude.

4. Subroutine OUTPUT

In order to output the data to the display for monitoring and
the cartridge tape for storage a terminal executive system routine called PUTIO is utilized. The program moves the data in ASCII format to a terminal system output buffer and PUTIO is called. PUTIO places the data on the display and the right cartridge tape.

IV. PROGRAM DEVELOPMENT

The source program is written in a compatible INTEL 8080 language with the only exception being the I/O operations. These I/O operations are accomplished using programs stored in a terminal ROM.

1. Preparing the Program

For assembling and loading, the source and binary programs must reside on cartridge tape. The source program can be placed on the tape by entering the source code into the terminal display memory through the terminal keyboard. Once in the display memory the source code is transferred to tape using the terminal function keys which provide the capability to transfer data between the terminal and other devices. An alternate method of obtaining the source code on tape is by keying the program into a file using the HP1000 mini-computer system. The file can then be edited and "dumped" to cartridge tape in ASCII format.

2. Assembling the Program

The HP13290B Debugger/Assembler is a commercially available product from Hewlett-Packard, and it resides on cartridge tape. By placing the tape in the left drive of the terminal it is loaded using the function keys on the terminal. Once having loaded the assembler the source program which resides on tape is placed on the left drive and a blank tape to receive the assembled code in the right drive. After having successfully completed the assembly the right tape with the assembled code is then placed in the left tape drive and under keyboard command is loaded into the terminal. At this point the program is ready for execution. Operating instructions for the magnetics data acquisition system are given in Appendix II. An alternate manner of assembling the program is to use the cross-compiler available on the HP1000 mini-computer system. The assembled program is stored on tape in the same format as the assembly on the terminal. Refer to Reference 2 for specific instruction on using the HP13290B Debugger/Assembler.

V. RESULTS

The major benefits of the Magnetic Field Terminal Data Acquisition System is its compactness (all data acquisition components are integrated into the terminal), weight of 45 pounds and reliability. This can be compared with the mini-computer system which resides in a 56 inch equip-
ment rack which weighs approximately 600 pounds.

Experiments collecting magnetic field data have shown the accuracy of the terminal data acquisition system is identical to the accuracy of the mini-computer system. However, when the mini-computer system is utilized, the magnetics data can be processed to completion, whereas, the data stored by the terminal data acquisition system must be further processed by the mini-computer at some future time. Additionally, the storage capacity of the mini-computer system is far greater than the terminal resulting in the mini-computer being operated for much longer periods of time before the data must be stored in another manner such as nine track 800bpi magnetic tape.

The terminal Magnetics Field Data Acquisition System has been proven to be a viable alternative to the mini-computer when the mini-computer system is inappropriate. The terminal systems have been utilized to acquire and process data for Airborne Expendable Bathythermograph (AXBT) experiments and recording the environment during acoustic studies as well as magnetic field experiments.
Fig. 1 – Photograph of HP264X Intelligent Terminal
Fig. 2 - Functional Block Diagram of Terminal Magnetics Data Acquisition System
Fig. 3 — Interior View of HP264X Intelligent Terminal
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TABLE 2

JUMPER CONNECTIONS FOR HP13255
TERMINAL DUPLEX BOARDS

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APPENDIX I

SOURCE LISTING TERMINAL MAGNETICS PROGRAM
.PROGRAM TO ACQUIRE MAGNETICS DATA, PREPARED FOR ASCENSION 12/04/79

ALTIO  EQU  208  ; DEFINES PROGRAM AS ALTERNATE I/O DRIVER
TIMER  EQU  176147Q ; TIME OUT COUNTER
PUTIO  EQU  4199H  ; SUBROUTINE TO OUTPUT DATA IN ASCII FMT
OUTDEV EQU  OFF40H  ; SPECIFIES OUTPUT DEVICE
GTOB0  EQU  3D18H  ; SYSTEM SUBROUTINE TO GET AN I/O BUFFER
GETPTR EQU  3D46H  ; SYSTEM BUFFER ADDRESS
XFR1M  EQU  OFF47H  ; SPECIFIES THE NUMBER OF CHAR FOR OUTPUT
INDVM  EQU  106001Q ; ADDRESS TO INPUT DATA OF MSCHARS MAGGIE
INSTAD EQU  106000Q ; ADDRESS TO INPUT STATUS OF MSCHARS MAGGIE
INITD  EQU  106007Q ; SETS IN FF ON MSCHARS MAGGIE I/O BOARD
RSTDVM EQU  106005Q ; RESETS IN FF ON MSCHARS MAGGIE I/O BOARD
STOUTD EQU  106006Q ; SETS OUT FF ON MSCHARS MAGGIE I/O BOARD
INCLK  EQU  103001Q ; ADDRESS TO INPUT DATA (SECONDS) OF CLOCK
INSTAC EQU  103000Q ; ADDRESS TO INPUT STATUS (MIN) OF CLOCK
INICT  EQU  103007Q ; SETS IN FF ON CLOCK I/O BOARD
RSTCLK EQU  103005Q ; RESETS IN FF ON CLOCK I/O BOARD
STOUTC EQU  103006Q ; SETS OUT FF ON CLOCK I/O BOARD
INMAG  EQU  104001Q ; ADDRESS TO INPUT DATA OF LSCHARS MAGGIE
INSTM  EQU  104000Q ; ADDRESS TO INPUT STATUS OF LSCHARS MAGGIE
INITM  EQU  104007Q ; SETS IN FF ON LSCHARS MAGGIE I/O BOARD
RSTMAG EQU  104005Q ; RESETS IN FF ON LSCHARS MAGGIE I/O BOARD
STOUTM EQU  104006Q ; SETS OUT FF ON LSCHARS MAGGIE I/O BOARD
INLIT  EQU  105001Q ; ADDRESS TO INPUT DATA LSCHARS LITTON I/O BD
INSTL  EQU  105000Q ; ADDRESS TO INPUT STATUS LSCHARS LITTON I/O BD
INITL  EQU  105007Q ; SETS IN FF ON LSCHARS LITTON I/O BOARD
RSTLIT EQU  105005Q ; RESETS IN FF ON LSCHARS LITTON I/O BOARD
STOUTL EQU  105006Q ; SETS OUT FF ON LSCHARS LITTON I/O BOARD
RSOUTL EQU  105004Q ; RESETS OUT FF ON LSCHARS LITTON I/O BOARD
CHKFF EQU  105063Q ; ADDRESS TO READ FLAG ON LSCHARS LITTON I/O BD
INLIT1 EQU  102001Q ; ADDRESS TO INPUT DATA ON MSCHARS LITTON I/O BD
INSTL1 EQU  102000Q ; ADDRESS TO INPUT STATUS ON MSCHARS LITTON I/O BD
INITL1 EQU  102007Q ; SETS IN FF ON MSCHARS LITTON I/O BOARD
RSTLIT1 EQU  102005Q ; RESETS IN FF ON MSCHARS LITTON I/O BOARD
STOUTL1 EQU  102006Q ; SETS OUT FF ON MSCHARS LITTON I/O BOARD
RSOUTL1 EQU  102004Q ; RESETS OUT FF ON MSCHARS LITTON I/O BD
INFF  EQU  80H  ; MASK TO CHECK RESET STATUS ON LSCHARS LITTON BD
MASK1 EQU  17Q  ; MASKS FOUR LSBITS, USED IN BCD TO ASCII ROUTINE
MASK4 EQU  3FH  ; MASKS MSBITS OF DATA WORD, USED IN TIME ROUTINE
ZERO3 EQU  374Q  ; MASKS 6 MSBITS OF STATUS WORD, USED IN REVSTA
THREE EQU  3Q  ; MASKS 2 LSBITS OF STATUS WORD, USED IN REVSTA
MASKC EQU  60Q  ; MASKS HOUR BIT IN TIME ROUTINE
ENTRY VECTORS

ORG 6000H
DB 50H
DB 70H
JMP INIT2
JMP INIT2
JMP RETURN
JMP MONIT
JMP INPUT
JMP OUTPUT
JMP CONTRL
JMP RETURN
JMP CHTIMO

RETURN EQU $     ;RETURN ADDRESS OF PROGRAM, CHECK FOR TIMEOUT

READ THE DATA

INPUT EQU $     ;RETURN TO TERMINAL EXEC WAIT LOOP

LDA INITD     ;SET IN FF ON MS MAGGIE BYTE I/O BD
LDA RSTDVM     ;RESET IN FF ON MS BYTE MAGGIE I/O BD, CAPTURE DATA
LDA INSTAD     ;INPUT STATUS BYTE ON MS MAGGIE BYTE I/O BD
STA STAT02     ;STORE STATUS BYTE
LDA INVM      ;INPUT DATA BYTE ON MSCHAR MAGGIE I/O BD
STA DATA02     ;STORE DATA BYTE
LDA INITC     ;SET IN FF ON CLOCK I/O BD
LDA RSTCLK     ;RESET IN FF ON CLOCK I/O BD, CAPTURE TIME(MIN,SEC)
LDA INCLK     ;INPUT STATUS BYTE ON CLOCK I/O BD
STA STAT01     ;STORE STATUS BYTE
LDA INLIT     ;INPUT DATA BYTE ON CLOCK I/O BD
STA DATA01     ;STORE DATA BYTE
CALL TMBIT     ;CALL PROGRAM TO REARRANGE TIME BITS
LDA INITM     ;SET IN FF ON MS MAGGIE BYTE I/O BD
LDA RSTMAG     ;RESET IN FF ON MS MAGGIE BYTE I/O BD, CAPTURE DATA
LDA INSTAM     ;INPUT STATUS BYTE ON MS MAGGIE BYTE I/O BD
STA STAT03     ;STORE STATUS BYTE
LDA INMAG     ;INPUT DATA BYTE ON LS MAGGIE BYTE I/O BD
STA DATA03     ;STORE DATA BYTE

GETLIT EQU $     ;SAVE REGISTER INFO IN STACK
PUSH B     ;SAVE REGISTER INFO IN STACK
PUSH D     ;SAVE REGISTER INFO IN STACK
LXI B,STAT04     ;LOAD REG B WITH ADDRESS OF NEXT STATUS BYTE
LXI D,DATA04     ;LOAD REG D WITH ADDRESS OF NEXT DATA BYTE
CALL AGNLIT     ;GET LATITUDE INFO
CALL AGNLIT     ;GET LONGITUDE INFO
CALL AGNLIT     ;GET HEADING INFO
CALL AGNLIT     ;GET SELECTED INFO
POP D     ;RESTORE REGISTER D
POP B     ;RESTORE REGISTER B
CALL NSEW     ;DETERMINE NORTH, SOUTH, AND EAST, WEST
RET     ;RETURN TO CONTROLLER

AGNLIT EQU $     ;RETURN TO CONTROLLER
LDA INITL1     ;SET IN FF ON MS LITTON BYTE I/O BD
LDA INITL1     ;SET IN FF ON LS LITTON BYTE I/O BD
LDA RSTL1     ;RESET IN FF ON MS LITTON BOARD, CAPTURE DATA
LDA INSTL1     ;INPUT STATUS BYTE FROM MS LITTON I/O BD
STA B     ;STORE STATUS BYTE
INX B     ;INCREMENT STATUS ADDRESS
LDA INSTAL     ;INPUT STATUS BYTE FROM LS LITTON I/O BD
STA B     ;STORE STATUS BYTE
INX B     ;INCREMENT STATUS ADDRESS
LDA INLIT1     ;INPUT DATA BYTE FROM MS LITTON I/O BD
STA B     ;STORE DATA BYTE
INX B     ;INCREMENT DATA ADDRESS
LDA INLIT1     ;INPUT DATA BYTE FROM LS LITTON I/O BD
STA D     ;SAVE DATA BYTE FROM LS LITTON I/O BD
INX D  ;INCREMENT DATA ADDRESS
WAITLT EQU $
   LDA CHKFF ;LOAD REG A WITH FLAG FROM LS LITTON I/O BD
   ANI INFF ;CHECK FOR RESET OF FLAG (IN FF)
   SUI INFF ;CHECK FOR RESET OF FLAG (IN FF)
   JP WAITLT ;WAIT FOR RESET OF FLAG
   RET  ;RETURN TO PROGRAM CONTROL

COUNT3 DB 0H ;TEMPORARY STORAGE
DATA01 DB 0H ;DATA BYTE: SEC OF TIME FROM CLOCK
DATA02 DB 0H ;MAGGIE MS I/O ??XX
DATA03 DB 0H ;MAGGIE LS I/O ??XX
DATA04 DB 0H ;LATITUDE S?XDEG X?.?MIN(S?X X?.?)
DATA05 DB 0H ;LATITUDE SIGN NORTH/SOUTH
DATA06 DB 0H ;LONGITUDE S?XDEG X?.?MIN(S?X X?.?)
DATA07 DB 0H ;LONGITUDE SIGN
DATA08 DB 0H ;HEADING UNITS AND TENTHS DEG ??X.X
DATA09 DB 0H ;HEADING NOT USED
DATA10 DB 0H ;SELECTED FROM LITTON INTERFACE
DATA11 DB 0H ;SELECTED FROM LITTON INTERFACE
STAT01 DB 0H ;MINUTES FROM CLOCK
STAT02 DB 0H ;MAGGIE-NOT USED
STAT03 DB 0H ;MAGGIE-LS I/O XX??
STAT04 DB 0H ;LATITUDE UNITS AND TENTHS MIN(X.X)
STAT05 DB 0H ;LATITUDE-USED TO SAVE SIGN
STAT06 DB 0H ;LONGITUDE UNITS AND TENTHS MIN(X.X)
STAT07 DB 0H ;LONGITUDE HUNDREDS AND SAVE SIGN
STAT08 DB 0H ;HEADING-HUNDREDS AND TENS XX??.?
STAT09 DB 0H ;HEADING-NOT USED
STAT10 DB 0H ;SELECTED FROM LITTON INTERFACE
STAT11 DB 0H ;SELECTED FROM LITTON INTERFACE
INIT2 EQU $
MVI A,100 MOVE IMMEDIATE 100 TO A
STA TIMER STORE 100 TEN MILLISEC IN TIMER(1 SEC)
MVI A,2 MOVE IMMEDIATE 2 TO REG A
STA COUNT4 STORE 2 IN COUNT FOR REPEAT TIME
RET RETURN TO CALLING PROGRAM

COUNT4 DB 0H NUMBER OF REPEAT SECONDS

ROUTINE TO OUTPUT DATA TO DISPLAY AND CU

OUTPUT EQU $
MVI A,6 MOVE IMMEDIATE 6 TO A REG
STA OUTDEV SET UP TO OUTPUT TO DISPLAY AND RT TAPE(110)
CALL GTIOBO GET A SYSTEM BUFFER
MVI M,2000 CLAIM BUFFER WITH BIT
PUSH H SAVE STATUS POINTER
DCX H DECREMENT
MVI M,377Q SET UP RECORD TRANSFER(-1)
DCX H DECREMENT
MVI M,36 SET LENGTH OF RECORD TO 36
XCHG SWAP H\&L
CALL GETPTR GET BUFFER ADDRESS
CALL MOVDAT MOVE DATA INTO BUFFER OBTAINED BY GTIOBO
POP D RESTORE STATUS POINTER
LXI H,XFRLIM TRANSFER ONE RECORD
MVI M,-1
CALL PUTIO OUTPUT THE RECORD
XCHG SWAP H\&L AND D\&E REGISTERS
MVI M,0 RELEASE BUFFER
RET RETURN TO CALLING PROGRAM CONTROL

DATAWD DB 0H TEMPORARY STORAGE
STATUS DB 0H TEMPORARY STORAGE

ROUTINE TO MOVE DATA TO BUFFER

MOVDAT EQU $
MVI A,43 MOVE IMMEDIATE 43 TO REGISTER A
STA COUNT1 STORE IT
LXI B,ASBCD1 LOAD IMMEDIATE ADDRESS OF FIRST ASCII CHAR

SAVMOR EQU $
LDAX B LOAD ASCII CHARACTER INTO REGISTER A
MOV M,A MOVE CHARACTER TO BUFFER FOR OUTPUT
INX H INCREMENT BUFFER ADDRESS
INX H INCREMENT ASCII DATA ADDRESS
LDA COUNT1 LOAD COUNT VALUE IN REG A
DCR A DECREMENT THE COUNT
STA COUNT1 STORE THE COUNT
JP SAVMOR JUMP ON POSITIVE TO MOVE MORE ASCII CHAR
STC FINISHED SET CONTROL
RET RETURN TO CALLING PROGRAM OUTPUT

COUNT1 DB 0H CHARACTER COUNT
MONITOR ROUTINE FOR TIMING DATA INPUT

MONIT EQU $  
LXI H,TIMER   ;LOAD IMMEDIATE ADDRESS OF TIMER  
DCR M   ;DECREMENT TIMER  
RET   ;RETURN TO TERMINAL EXEC  

ROUTINE TO CHECK FOR TIMEOUT

CHTIMO EQU $  
LDA TIMER   ;LOAD REG A WITH VALUE STORED AT LOC TIMER  
ORA A   ;IF TIMER IS POSITIVE RETURN TO TERMINAL EXEC  
LDA COUNT4   ;TIMER NEQ-LOAD REG A WITH REPEAT TIMER COUNT  
DCR A   ;DECREMENT COUNT  
STA COUNT4   ;STORE COUNT  
JM CONTRL   ;IF REPEAT IS NEG TIME TO EXECUTE MAGGIE PROGRAM  
MVI A,100   ;THREE SECONDS HAVE NOT OCCURRED RESET 1 SEC TIMER  
STA TIMER   ;SAVE 1 SEC IN TIMER  
JMP RET   ;RETURN TO TERMINAL EXEC  

CONTROL ROUTINE TO GET AND PROCESS DATA

CONTRL EQU $  
CALL INIT2   ;CALL INITIALIZATION ROUTINE(RESCHEDULES PROGRAM)  
CALL INPUT   ;GET THE DATA  
CALL PROCES   ;PROCESS THE DATA  
CALL OUTPUT   ;OUTPUT THE DATA  
RET   ;RETURN TO CHTIMO  

DATA PROCESSING ROUTINE

PROCES EQU $  
LXI B,STAT01   ;LOAD IMMEDIATE ADDRESS OF FIRST STATUS BYTE  
LXI H,DATA01   ;LOAD IMMEDIATE ADDRESS OF FIRST DATA BYTE  
LXI D,ASBCD1   ;LOAD IMMEDIATE ADDRESS OF FIRST CHAR BYTE  
MVI A,10   ;MOVE IMMEDIATE NUMBER OF WORDS TO PROCESS TO A REG  
STA COUNT2   ;STORE NUMBER OF WORDS  
CVTMOR EQU $  
LDAX B   ;LOAD A WITH STATUS BYTE  
STA STATUS   ;STORE IT TEMPORARILY  
CALL REVSTA   ;COMPLEMENT STATUS BITS 0 AND 1(XXXXXCC)  
LDA STATUS   ;LDA REG A WITH COMPLEMENTED STATUS BYTE  
STA B   ;SAVE IT IN STATUS LOCATION  
STA CXBYTE   ;SAVE STATUS BYTE IN TEMP LOCATION  
CALL BCD2AS   ;CONVERT STATUS 2 CHAR BCD BYTE TO 2 ASCII CHAR  
LDA ASMSB   ;LOAD MOST SIGNIFICANT(MS) ASCII CHAR TO REG A  
STA D   ;STORE CHAR IN ASCII BUFFER FOR OUTPUT  
INX D   ;INCREMENT ASCII STORAGE LOCATION  
LDA ASLSB   ;LOAD LEAST SIGNIFICANT(LS) ASCII CHAR IN REG A  
STA D   ;STORE CHAR IN ASCII BUFFER FOR OUTPUT  
INX D   ;INCREMENT ASCII BUFFER ADDRESS  
XCHG   ;SWAP REGISTERS H&L AND D&E  
LDAX D   ;LOAD DATA BYTE INTO REG A  
STA DATAWD   ;STORE TEMPORARILY  
CALL CMPDAT   ;COMPLEMENT THE DATA BYTE  
LDA DATAWD   ;LOAD THE DATA BYTE INTO THE A REG  
STA D   ;STORE THE DATA BYTE INTO DATA LOCATION  
XCHG   ;SWAP HAL AND D&E  
STA CNBYTE   ;STORE DATA BYTE TEMPORARILY  
CALL BCD2AS   ;CONVERT BYTE INTO TWO ASCII CHARACTERS  
LDA ASMSB   ;LOAD MS ASCII CHAR INTO REG A  
STA D   ;STORE CHAR IN ASCII OUTPUT BUFFER  
INX D   ;INCREMENT ADDRESS OF ASCII OUTPUT BUFFER  
LDA ASLSB   ;LOAD LS ASCII CHAR INTO REG A  
STA D   ;STORE CHAR IN ASCII OUTPUT BUFFER  
INX D   ;INCREMENT ADDRESS OF ASCII BYTE  
INX H   ;INCREMENT ADDRESS OF DATA BYTE  
INX B   ;INCREMENT ADDRESS OF ASCII OUTPUT BUFFER  
LDA COUNT2   ;COUNT TO REG A  
DCR A   ;DECREMENT COUNT
STA COUNT2 ;STORE COUNT
JP CVTMOR ;CONVERT MORE BYTES TO ASCII EQUIV IF POSITIVE
STC ;SET CONTROL
RET ;RETURN TO CALLING PROGRAM CONTRL
COUNT2 DB 0H ;COUNT FOR CONVERTING ALL STATUS AND DATA BYTES TO ASCII.
CNBYTE DB 0H ;TEMPORARY STORAGE
, ROUTINE TO REARRANGE STATUS WORD BITS
REVSTA EQU $
LDA STATUS, LOAD STATUS BYTE INTO REG A
CMA, COMPLEMENT THE BYTE
ANI THREE, MASK OFF BITS 0 AND 1
STA REVBIT, STORE IT
PUSH H, SAVE CURRENT ADDRESS H REG
LXI H, REVBIT, LOAD IMMEDIATE ADDRESS REVBIT
LDA STATUS, LOAD STATUS BYTE INTO REG A
ANI ZERO3, MASK OFF BITS 2 THRU 7
ORA M, COMBINE BITS 0, 1 AND 2-7
STA STATUS, STORE NEW STATUS BYTE
POP H, RESTORE H REGISTER
RET, RETURN TO CALLING PROGRAM

REVBIT DB 0H, TEMPORARY STORAGE OF STATUS BYTE

, ROUTINE TO COMPLEMENT DATA WORD
CMPDAT EQU $
LDA DATAWD, LOAD A WITH DATA BYTE
CMA, COMPLEMENT DATA BYTE
STA DATAWD, STORE IT
RET, RETURN TO CALLING PROGRAM

, BCD TO ASCII CONVERSION ROUTINE
BCD2AS EQU $
LDA CNBYTE, LOAD REG A WITH DATA BYTE IN BCD FMT
RRC, ROTATE RIGHT FOUR TIMES
RRC,
RRC,
RRC,
ANI MASK1, MASK OFF BCD CHAR
ACI 30H, ADD 30 HEX TO CHAR TO CONVERT TO ASCII
STA ASMSB, STORE MOST SIGNIFICANT ASCII CHAR
LDA CNBYTE, LOAD A WITH DATA BYTE IN BCD FMT
ANI MASK1, MASK OFF BCD CHARACTER
ACI 30H, ADD 30 HEX TO CHAR TO CONVERT TO ASCII
STA ASLSB, STORE LEAST SIGNIFICANT ASCII CHAR
RET, RETURN TO CALLING PROGRAM
ASMSB DB 0, TEMP STORAGE
ASLSB DB 0, TEMP STORAGE

, ROUTINE TO SET UP BITS FOR NS AND EW
NSEW EQU $
LDA STAT04, LOAD REG A WITH LATITUDE STATUS BYTE
RRC, ROTATE RT 2 BITS
RRC, THESE ARE THE SIGN BITS
ANI MASKC, MASK OFF THESE SIGN BITS
CMA, COMPLEMENT THE SIGN BITS
STA DATA05, SAVE THE BITS IN THE LAST BYTE OF THE LAT WORD
LDA STAT04, LOAD REG A WITH LATITUDE STATUS BYTE
ANI MASK4, MASK OFF DEGREES LATITUDE WITHOUT SIGN
STA STAT04, STORE DEG LAT IN STATUS BYTE
LDA STAT06, LOAD REG A WITH LONGITUDE BYTE
RRC, ROTATE RT 2 BITS
RRC, GET SIGN BITS
ANI MASKC, MASK OFF SIGN BITS
CMA, COMPLEMENT SIGN BITS
STA DATA07, STORE SIGN BITS IN LAST 2 CHAR OF LONGITUDE WORD
LDA STAT06, LOAD REG A WITH LONG BYTE
ANI MASK4, MASK OFF DEG LONG WITHOUT SIGN
STA STAT06, STORE DEG LONG IN STATUS BYTE
LDA STAT08, LOAD REG A WITH HEADING BYTE
RRC, ROTATE RT 2 BITS
RRC, GET SIGN BITS
ANI MASKC, MASK OFF SIGN BITS
CMA, COMPLEMENT THE SIGN BITS
STA DATA09, STORE SIGN BITS IN LAST BYTE OF HEADING WORD

20
LDA STAT08 ;LOAD REG A WITH HEADING BYTE
ANI MASK4 ;MASK OFF THE BYTE WITHOUT SIGN
STA STAT08 ;SAVE HEADING IN STATUS BYTE
RET ;RETURN TO CALLING PROGRAM PROCE

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;THIS ROUTINE rearranges TIME BITS

MIN1 EQU 77Q ;MASK FOR MINUTES OF TIME
SEC1 EQU 177Q ;MASK FOR SECONDS OF TIME
SEC2 EQU 200Q ;MASK FOR MINUTES OF TIME SECOND WORD

;TIME BIT
LDA DATA01 ;LOAD A WITH SECONDS OF TIME
CMA ;COMPLEMENT DATA
STA DATA01 ;STORE IT
LDA DATA01 ,
ANI SEC1 ;MASK OFF SECONDS OF TIME
STA DATA01 ;STORE IT
LDA DATA01 ;LOAD REG A WITH SEC DATA BYTE
ORA A ;
ANI SEC2 ;MASK OFF BIT ASSOCIATED WITH MINUTES(MSBIT)
ORA A ;
RLC ;ROTRATE BIT LEFT ONCE,PUTS IT AT BIT ZERO
STA DATA02 ;STORE MINUTES BIT
LDA DATA01 ;LOAD REG A WITH SEC BYTE
CMA ;COMPLEMENT BYTE
STA DATA01 ;RETURN BYTE TO DATA WORD
LDA STAT01 ;LOAD A WITH MINUTES BYTE
STA STATUS ;STORE TEMP
CALL REVSTA ;REVERSE BITS 0 AND 1
LDA STATUS ;LOAD REG A WITH MINUTES BYTE
STA STAT01 ;STORE MINUTES IN STATUS BYTE
LDA STAT01 ,
ORA A ;
ANI MIN1 ;MASK OFF MIN FROM STATUS BYTE
ORA A ;
RLC ;ROTRATE LEFT ONCE,GET READY TO FORM NEW MIN WORD
ORA A ;
STA STAT01 ;SAVE MIN SHIFTED
LXI H,DATA02 ;LOAD IMMEDIATE ADDRESS OF MINUTES BIT
LDA STAT01 ;LOAD REGISTER A WITH MIN BYTE
ADD M ;ADD MINUTES BIT TO MIN BYTE
STA STAT01 ;STORE FULL MINUTES WORD IN STATUS BYTE
LDA STAT01 ,
STA STATUS ;STORE TEMP
CALL REVSTA ;PLACE MINUTES BYTE IN USUAL FORMAT
LDA STATUS ;LOAD MINUTES BYTE INTO REG A
STA STAT01 ;STORE MINUTES BYTE INTO STATUS BYTE IN RECONSTR FMT
RET ;RETURN TO CALLING PROGRAM INPUT

DATA01 DB 0H ;TEMPORARY LOCATION
DATA02 DB 0H ;TEMPORARY LOCATION
TEMP10 DB 0H ;TEMPORARY LOCATION-NOT USED

;SETUP OUTPUT WORDS
ASBCD1 DS 10 ;ASCII FILE SET UP FOR OUTPUT
ASBC19 DS B ,
ASBC27 DS B ,
ASBC35 DS B ,
ASBC43 DS B ,
END
APPENDIX II

OPERATING INSTRUCTIONS FOR THE TERMINAL MAGNETICS FIELD
DATA ACQUISITION SYSTEM

1. Turn on power to the terminal, Litton Interface and Clock.

2. Set the thumbwheel switch on the Litton Interface to "0".
   Explanation: By setting the select code on "0" Latitude will
   be selected and displayed on the interface. The
   terminal receives latitude information from the
   display.

3. Insert cartridge tape marked Debugger/Assembler in left tape
   drive of terminal.

4. Press the key marked READ on the terminal. Wait for completion.
   Explanation: The first record of the Debugger/Assembler tape
   will be displayed.

5. Press the key marked f2 on the terminal. Wait for completion.
   Explanation: By pressing f2 the second record on the Debugger/
   Assembler tape will be loaded into the terminal memory.
   The message "OK>" will be displayed on the terminal.

6. Remove the Debugger/Assembler tape from left drive and insert the
   tape marked Magnetics Version 13 Binary.
   Explanation: This is the binary magnetics program to be loaded
   into terminal memory.

7. Type the characters "L" and "CR" (Carriage Return). Wait for
   completion.
   Explanation: This sequence will load the binary program into
   terminal memory. The message "HP264X ASSEMBLER V2.0"
   will appear on the terminal display followed by an
   "OK>" prompt.
8. Place a blank cartridge in the right terminal drive.

Explanation: The data will be recorded on this tape cartridge. The cartridge should be unprotected by moving the protect lever to the left position. The tape cartridge should be labeled by hand. The recommended labeling is day of year and starting hour of tape.

9. Type "/9169" then "CR" on the terminal.

Explanation: An instruction in location 9169 must be modified so that control will be transferred from the terminal executive software to the magnetics program. An "87" will appear on the display.

10. Type "601A" then "CR" on the terminal.

Explanation: The starting location of the magnetics program is 601A. An "0" will appear on the display.

11. Type ":" (colon) on the terminal.

Explanation: The ":" will terminate the modification process. An "OK>" will appear on the terminal display.

12. Press the RESET button on the terminal only once.

Explanation: Pressing the RESET button once forces a transfer in the terminal executive to the magnetics program. The program will start execution.
REFERENCES


