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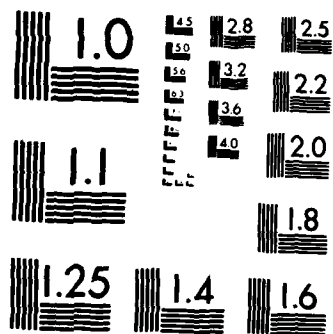
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APPLICATION TO A STUDY OF AN
ALUMINUM-IRON-CERIUM ALLOY

THESIS

Joseph F. Harmon Jr.
Second Lieutenant, USAF
AFIT/GNE/PH/84M-6

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THESIS

Presented to the Faculty of the School of Engineering of
the Air Force Institute of Technology Air University In
Partial Fulfillment of the Requirements for the Degree of
Master of Science

by

Joseph F. Harmon Jr., B.S.
Second Lieutenant, USAF

Graduate Nuclear Engineering

March 1984

Preface

This thesis is the product of my efforts to interface a new Mossbauer spectrometer to a PDP 11/03 microcomputer, which has the capabilities of analyzing Mossbauer data, and also to determine microstructure changes of an Al-Fe-Ce alloy due to various processing stages. This thesis will describe both the hardware and software changes made to assemble the new system, the system's limitations, and a complete operating procedure. For the alloy studied, a literature review and spectra for each processing stage is included.

I would like to thank Don Elworth of the Physics Department for his technical assistance throughout the project, and Doug Barker of the Air Force Materials Laboratory for supplying the alloy samples. I especially want to thank my advisor, Dr. George John, for his continuous support and guidance during this project.

Finally, I want to thank my wife, Rosie, for her constant support and understanding.

Joseph F. Harmon Jr.

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Table of Contents

	Page
Preface	ii
List of Figures	v
List of Tables	vi
Abstract	vii
I. Introduction	1
Background	1
Problem	2
Scope	3
Review of the Literature	3
II. Theory	8
Mossbauer Effect	8
Absorber Parameters	9
III. Equipment and Procedures	14
Original Mossbauer System	14
New Mossbauer System	14
Computer System	16
MOSFUN Program	17
New Spectrometer Installation	18
MOSFUN Changes	18
Mossbauer Master Changes	20
Hardware Changes	25
Absorber Parameters	30

Experimental Geometry	32
IV. Results and Discussion	34
System Capabilities	34
Alloy Results	35
Powder	39
Cold Compacted	40
Hot Vacuum Degassed	41
V. Conclusions and Recommendations	45
Bibliography	47
Appendix A: Assembly and Operating Instructions	48
Appendix B: MS-900 - PDP 11/03 Interfacing	55
Appendix C: Program Listings	57
Mossbauer Master	58
Subroutine DATI	60
Subroutine DKIVE	65
Vita	69

List of Figures

<u>Figure</u>	<u>Page</u>
1. Spectra of FeAl ₆	6
2. NFE Calibration Results From MS-900	21
3. Old Data Format	22
4. New Data Format	23
5. Super Serial Card Settings	24
6. Transmit/Recieve Data Connection	27
7. Powder Sample Preparation	39
8. Experimental Geometry	31
9. Peaks 3 and 4 of the NFE calibration run from the original Mossbauer spectrometer	38
10. Powdered Alloy Results	49
11. Cold Compacted Results	40
12,13. Cold Compacted/Hot Vacuum Degassed Results .	41,42
14. New Spectrometer Set-Up	51

List of Tables

<u>Table</u>	<u>Page</u>
1. $1/2u_{r0}^d$ as a function of $u_r/(2u_a)$	12
2. DB-25 Pin Connections for the Connector Cable	26
3. Results for all Alloy Samples and Calibration Tests .	36

Abstract

In this study, a computer based Mossbauer spectrometer was built using a new MS-900 spectrometer, an APPLE 2+ computer system, and a PDP 11/03 computer system. The APPLE was used as the link between the spectrometer and the PDP, which is used to analyze the Mossbauer spectra. In addition to minor hardware connections, software changes were made to the analysis program so that it could accept the data format produced by the new spectrometer. Due to equipment failure, only preliminary tests were made of the new system, however the tests were positive. Originally, an Al-Fe-Ce alloy was chosen to be studied by the new system. Instead, the alloy, chosen because of its excellent high temperature properties, was studied by the original Mossbauer spectrometer system. The goal was to follow and identify changes in the microstructure of the alloy due to different processing stages. Although changes in the spectra were identified with processing stages, it is still unclear as to what compounds are related to the observed spectra.

MOSSBAUER SPECTROMETRY: TESTING OF A NEW COMPUTER BASED SYSTEM AND ITS APPLICATION TO A STUDY OF AN ALUMINUM-IRON-CERIUM ALLOY

I. Introduction

Mossbauer spectrometry is becoming an increasingly important tool for the field of physical metallurgy. The goal of this study consisted of assembling and testing a computer based mossbauer spectrometer and its application to examining an alloy consisting of 88% Al, 8% Fe, and 4% Ce by weight. This alloy was chosen to be studied by the Air Force Materials Laboratory because of its attractive elevated temperature and creep resistance properties.

Background

In previous years, students have studied mossbauer spectrometry and its application to materials technology. These studies included: 1) the monitoring of chemical changes which occur during the manufacture of rare earth-cobalt magnets, 2) the determination of chemical changes in the bonding surface between a coating and its substate, and 3) the physical characteristics of amorphous metallic materials. The equipment used for these studies, including the software for data analysis, involved tedious manual transfer of data to a computer. In 1981 Pate successfully completed the programing for a DEC LSI-11/03 computer which permits rapid analysis of mossbauer spectra without the need for a central processor at

The Air Force Institute of Technology. With this completed, it was desired to replace the aging and bulky spectrometer with a new one which could be interfaced with the DEC, resulting in rapid easy collection and analysis of data.

The alloy to be studied and used as a test for the newly built system was chosen by the Materials Laboratory at Wright Patterson Air Force Base. This organization has been involved in the study of powder metallurgy aluminum base alloys in order to improve elevated temperature strength and creep resistance properties. Initially, a total of 21 binary and ternary alloys fabricated from atomized powders, hot pressed to full density, were chosen to evaluate the effect of alloy composition and fabrication parameters on mechanical properties up to 405 - 650 F. From this study, the Al-Fe-Ce alloy was most promising and demonstrated that powder metallurgy was feasible for producing a new generation of elevated temperature aluminum alloys. However, it is still unclear as to the exact mechanism surrounding Ce. Also, it is realized that the type of processing will definitely influence the final product. Thus it is desirable to better understand the microstructure and how the microstructure is affected by changes in the processing parameters.

Problem

The problem investigated in this study was twofold. First, an interface between the new spectrometer and the DEC was to be accomplished. Second, the new system was to be used for

studying the aluminum-iron-cerium alloy. In particular, the alloy was to be analyzed at each stage of processing to follow and identify changes in the microstructure. The processing stages include: 1) gas atomization, 2) cold isostatic pressing, 3) hot vacuum degassing, and 4) hot isostatic pressing followed by hot vacuum degassing.

Scope

The interfacing achieved in this study was only a temporary solution. Instead of a direct link between the new spectrometer and the DEC, an APPLE 2 Plus computer was used to link the two devices. Appendix B contains a brief discussion of how a direct interface could be accomplished. Also, due to equipment failure, the alloy tests had to be accomplished on the original equipment. However, it was possible to test the new equipment using a known source. In addition to these limitations, the testing of all samples was taken at room temperature and all samples were fabricated based on theoretical calculations to optimize the spectra obtained. A literature search was done and included sources at the Air Force Institute of Technology, School of Engineering, an Air Force Wright Aeronautical Laboratories technical report and a search by the Mossbauer Effect Data Center in North Carolina on binary and ternary alloys containing Al, Fe, and Ce.

Review of the Literature

The literature review contains information found

pertaining to the Al-Fe-Ce alloy and the possible intermetallic compounds formed. Most of this information comes from the Air Force Materials Laboratory Technical Report. In order to better understand their results, it is necessary to explain how the test alloy was fabricated. First, the alloying elements Ce and Fe were added to 99.5% pure superheated aluminum and the alloy was then gas atomized in a low-oxygen flue gas to generate a fine, irregular powder (1:3). The low-oxygen flue gas was necessary to prevent violent oxidation (1:3). Following atomization, the powder was screened through a 325 mesh sieve and cold compacted at 414 MPa (60 Ksi) to form compacts with a density of about 80% of theoretical (1:4,47). Next, the compacts were heated to temperature in argon, transferred in air to a die and hot pressed to 100% density at 600 F or 700 F (1:48). Finally, the fully dense hot compacted billets were machined into forging preforms and hot forged at 600 F or 700 F.

The study by the Air Force Materials Laboratory indicated that this and the other alloys considered were likely to produce unknown metastable compounds due to the rapid solidification resulting from atomization. In order to try and identify the metastable intermetallic phases in the alloy, X-ray and thermal analysis, as well as optical metallography and scanning transmission electron microscopy (STEM), were used to study both the atomized powders and the forgings. Guinier-deWolf X-ray analysis revealed small amounts of FeAl_6 and an unidentified phase. The same structure was seen in both the powder and the forging samples (1:55). Thermal analysis,

differential scanning calorimetry (DSC), also showed a lack of structural differences between the forgings upset at 600 F and 700 F and the atomized powders. Optical metallography revealed a very fine and uniform microstructure (1:11). Within a single particle, areas of fine, dense precipitates were interspersed with areas that appeared almost featureless at magnifications up to 1000X (1:103). It is believed that the featureless areas impart high strength while the precipitated areas contribute to increased ductility (1:164). In further efforts to identify the precipitated intermetallic phases present, a foil of the alloy was examined by STEM. The results indicated that some areas contain no Fe or Ce in the matrix while the intermetallics contained 90.5 at.% Al, 7.4 at.% Fe and 2.0 at.% Ce (1:103). These results however do not correspond to either of the ternary phases Al_8CeFe_4 and $\text{Al}_{10}\text{Fe}_2\text{Ce}$ stated to be possible formations in Al-Fe-Ce alloys (1:55).

When searching for information on ternary phases containing Al, Fe and Ce, only one other study was found. The study by Felner and Nowik shows Mossbauer spectra of an Fe57 probe replacing the Cu ion in the compound CeCu_4Al_8 (2:1040). Their spectra, taken at temperatures from -452.29 F to room temperature, show a single quadrupole doublet with an isomer shift of +0.23 mm/s relative to Fe metal.

Finally, the most likely binary compounds formed, from the ratio of elements present, include Fe Al, Fe Al₃, Fe Al₆, Fe₄Al₁₃ (3:299), and Fe₂Ce (4). Of these compounds, only information on Fe Al₆, Fe₄Al₁₃, and Fe₂Ce was found. The spectra

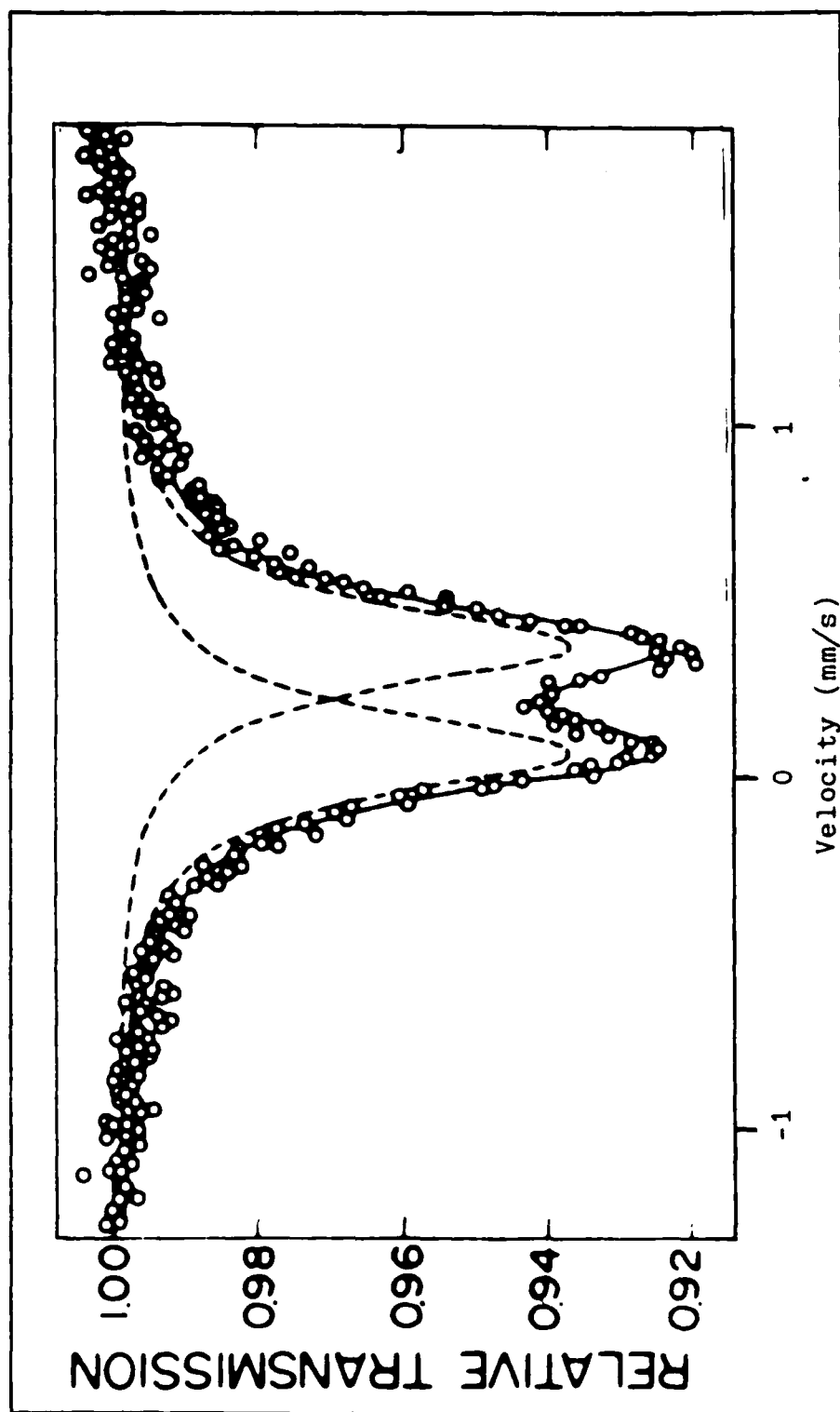


Figure 1. Spectra of FeAl₆ with respect to NFe.

of Fe Al_6 (Figure 1) is that of a quadrupole doublet with an isomer shift of $+0.25 \text{ mm/s}$ with respect to natural iron (3:301). The $\text{Fe}_4\text{Al}_{13}$ spectra is the result of five different quadrupole doublets representing five different iron sites (5:1521). This spectra appears as a closely spaced triplet centered at 0.2 mm/s relative to natural iron foil (5:1522). The Ce Fe_2 spectra is a symmetric six line pattern and the curie temperature for this compound is reported to be -32.8°F (4:762).

II. Theory

Mossbauer Effect

The theory of the Mossbauer Effect has been well developed and thus will not be covered here in detail. For a detailed discussion the reader is referred to reference 6. Instead, a general description of the Mossbauer Effect will be given through the following example. Consider a nucleus of an atom bound in some type of lattice such as is the case of a metal. The nucleus may interact with its environment in three ways. First, the nuclear charge may interact electrostatically with the electrons present at the nucleus. A change in the electron density at the nucleus, from perhaps a change in the lattice structure, results in a shift of the nuclear energy levels. Second, the nuclear quadrupole moment of a nucleus can interact with an electric field gradient which is usually a result of the charge distribution of the ions in the lattice. An interaction of this type will cause splitting of the nuclear energy levels. For the case of an iron nucleus, the splitting will result in two nuclear energy levels. Finally, the magnetic dipole moment of a nucleus can interact with a magnetic field produced externally or due to ions in the lattice. This interaction also causes splitting of nuclear energy levels and for the case of an iron nucleus, six energy levels are produced.

In 1957, Rudolph Mossbauer noticed that by moving a radioactive source, the energy of a photon emitted by the nucleus was changed by a small amount. Mossbauer spectrometry takes advantage of this fact by using photons of a spectrum of

energies, produced by accelerating a radioactive source, to probe the nuclear energy levels of a nucleus in its lattice. If the emitted photon, from a source, has the correct energy needed to excite the nucleus in a lattice, or absorber, then the photon may be absorbed and re-emitted isotropically resulting in a resonant effect. This effect will take place if the source and absorber both contain the same atom. Commonly, the source contains iron in an excited state and the absorber contains iron in the ground state. If the absorber is placed between the velocity modulated source and a detector, a spectrum containing dips, or lines, will be seen where each dip is a result of the resonant absorption. Each dip is related to a particular source velocity, and thus a particular photon energy, which is characteristic of the absorbing nuclei. From studying these spectra, a great deal can be learned about the environment of the iron nucleus. In this study, the alloy being tested contains an iron nucleus which will be used as a probe to uncover information about the alloy's lattice structure.

Absorber Parameters

A Mossbauer spectrum can be optimized by choosing the proper absorber thickness. A method by Shimony (7) enables one to find the best absorber thickness for maximizing the relative intensity of the absorption lines. This method is based on maximizing a single line, but can be extended to cases where there are several lines of equal intensity (7:350).

If an absorber is made very thick, there will be a

large number of active nuclei in the path of an incident photon, resulting in a strong resonant effect. However, if the absorber is too thick, the non-resonant radiation emerging from the absorber will be very weak. Because of this, the resonance lines will appear very slowly due to statistics involved and the background noise will tend to mask it out (7:348). If the absorber is too thin, the emerging non-resonant beam will be increased but the resonance effect will be reduced because of fewer active nuclei present in the path of the incident photon. The method to be described below enables one to calculate an intermediate thickness which will result in maximum absorption peaks.

Initially, one assumes that the shape of the resonant line(s) is Lorentzian, which is true unless perturbed by the system (8:3,5). If this is the case, then the magnitude of the Lorentzian peaks, according to Shimony, can be expressed as (7:349):

$$q(d) = N_0 f_s (1 - \exp(-1/2 u_r d)) J_0(1/2 i u_r d) \exp(-u_a d) \quad (1)$$

where,

d = actual absorber thickness

N_0 = number of photons striking the absorber

f_s = recoil free fraction of the source

u_r = coefficient of resonant absorption

u_a = coefficient of non-resonant absorption

J_0 = zero-order Bessel function

If equation (1) is examined closely, it is noticed that for $d = 0$ and as $d \rightarrow \infty$, $q(d)$ vanishes. By setting the derivative of $q(d)$ with respect to d equal to zero and using the identity

$$(dJ_0(x))/dx = -J_1(x) \quad (2)$$

the following relation is found:

$$\frac{u_r}{2u_a} = \frac{(\exp(1/2u_r d_0) - J_0(1/2iu_r d_0))}{(J_0(1/2iu_r d_0) + J_1(1/2iu_r d_0))} \quad (3)$$

which yields Table 1 (7:349). If one can find the value of the dimensionless quantity $u_r/2u_a$, one can use table 1 to find the value of $1/2u_r d_0$ and thus d_0 .

The value of u_r can be found through the relation

$$u_r = f_a n s_0 / M \quad (4)$$

where

f_a = recoilless fraction of the absorber

n = number density of active nuclei in absorber

M = number of equal intensity peaks

s_0 = maximum average cross section for resonant absorption per active nucleus

Table 1.
 $1/2 u_r d_0$ as a Function of $u_r/(2u_a)$

$1/2 u_r d_0$	$u_r/(2u_a)$	$1/2 u_r d_0$	$u_r/(2u_a)$	$1/2 u_r d_0$	$u_r/(2u_a)$
0.0	0.0000	2.2	8.946	5.8	53.83
0.1	0.1078	2.3	9.760	6.0	57.03
0.2	0.2324	2.4	10.620	6.2	60.33
0.3	0.3758	2.5	11.50	6.4	63.67
0.4	0.5397	2.6	12.42	6.6	67.02
0.5	0.7264	2.7	13.36	6.8	70.42
0.6	0.9379	2.8	14.36	7.0	73.94
0.7	1.176	2.9	15.36	7.2	77.47
0.8	1.445	3.0	16.40	7.4	81.05
0.9	1.741	3.2	18.55	7.6	84.73
1.0	2.072	3.4	20.79	7.8	88.46
1.1	2.433	3.6	23.13	8.0	92.18
1.2	2.837	3.8	25.55	8.2	95.87
1.3	3.276	4.0	28.06	8.4	100.1
1.4	3.749	4.2	30.78	8.6	103.8
1.5	4.261	4.4	33.39	8.8	107.9
1.6	4.839	4.6	36.05	9.0	113.3
1.7	5.404	4.8	38.87	9.2	115.9
1.8	6.039	5.0	41.71	9.4	120.6
1.9	6.703	5.2	44.65	9.6	124.6
2.0	7.416	5.4	47.62	9.8	123.7
2.1	8.160	5.6	50.72	10.0	132.5

For the alloy being studied, no data was available on the recoil free fraction. However, a value of 0.5 was assumed which is typical of many absorbers. For an iron atom, the value of S_0 is given as $2.38E-18 \text{ cm}^2/\text{Fe atom}$ (9). The value for n was calculated to be $1.88E+19 \text{ atoms/g}$ and from initial spectra, two peaks appeared with nearly equal intensities, thus a value of 2 will be given to M . These constants lead to a value of $11.208 \text{ cm}^2/\text{g}$ for u_r .

The value for u_a in cm^2/g was found by assuming the relation

$$u_{a_t} = \sum_i w_i u_{a_i} \quad (5)$$

holds true (10:69). The values of each u_a lead to a final value of $17.3 \text{ cm}^2/\text{g}$ for the alloy. By using the values of u_r and u_a and table 1, a value of 0.047 g/cm^2 was calculated for the optimum absorber thickness. As will be shown later, this value differs from the experimentally found optimal value by approximately 50%. However, this method was useful for finding an initial value which was able to be refined experimentally.

III. Equipment and Procedures

In this section, the Mossbauer spectrometry equipment and procedures for data acquisition will be discussed. The equipment for the original system will simply be listed while the equipment and installation procedure will be included for the new system. Also discussed will be the method of absorber preparation, the experimental method for finding the optimum absorber thickness, and the experimental geometry.

Original Mossbauer System

The major components of the original Mossbauer spectrometer include a velocity transducer (motor), a motor control unit (MCU) to drive the motor at a constant acceleration, a linear amplifier/single channel analyzer, a Krypton-filled proportional counter with a preamplifier, and a high voltage supply for the detector. All of the above equipment, with exception for the detector, was manufactured by Ranger Electronics. Other equipment included a RIDL 400 multichannel analyzer (MCA) operated in a time-sequential scaling mode and driven by a RIDL time base oscillator.

New Mossbauer System

The new Mossbauer spectrometer system consists of a single unit (MS-900) which contains the Mossbauer control unit, the linear amplifier/single channel analyzer, a time base oscillator and a 1024 multichannel analyzer. This unit, built by Ranger Scientific, Incorporated, was designed to be operated

with the assistance of an APPLE 2+ or 2e computer. Other equipment used in conjunction with this unit included a velocity transducer (VT-900) also built by Ranger Scientific, Incorporated, a detector/preamplifier, and a high voltage supply. In order to transfer and display data, an APPLE 2+ computer was connected to the MS-900 via an MS-900-100 interface card inserted in the computer.

For both the new and original system, the operation is basically the same. The source is connected to the shaft of the velocity transducer, which is accelerated by the control unit. This unit is driven by the channel address ramp from the multichannel analyzer, which is driven by the time base oscillator. The pulses produced by the detector are sent through the preamplifier, linear amplifier and single channel analyzer respectively. The single channel analyzer windows are set such that only pulses resulting from the 14.4 kiloelectron volt (keV) photons are passed through the remaining circuitry. As each channel in the MCA is opened for a time specified by the time base oscillator, pulses from the SCA enter this channel and thus a spectrum of counts versus channel number is produced. Each channel is related to a particular velocity of the source and thus the spectrum is also that of counts versus velocity. How the velocity scale is assigned to the spectrum during data analysis will be discussed later. The velocity scale on this spectrum depends on whether the motor is driven in the triangular mode or flyback mode. In either case, the maximum velocity (VMAX) of the source is set and the source is moved at

a constant linear acceleration between +VMAX and -VMAX. For the flyback mode, the source velocity is varied from -VMAX to +VMAX and generates a single spectrum. For the triangular mode, the source velocity is varied from +VMAX to -VMAX and back to +VMAX. In this case, two identical spectra are seen. One spectrum is generated when accelerating from +VMAX to -VMAX and a mirror image spectra is generated when accelerating from -VMAX to +VMAX. Due to limitations in the data analysis program, to be discussed later, only the flyback mode was used in this study.

Computer System

The computer system used for data analysis with both the new and original Mossbauer spectrometers consists of a PDP 11/03 microcomputer with 64 kilobytes of memory, an RX-02 dual 8-inch floppy disk drive, and a VT-100 terminal, all manufactured by Digital Equipment Corporation. Additionally, an MX-80 F/T dot matrix printer by Epson is serially connected to provide a printout of results.

The PDP 11/03 is a 16 bit word computer consisting of an LSI 11/02 microprocessor with a KEV-11 floating point chip, a BDV-11 bootstrap and diagnostic board, a DLV-11 4 port serial interface board, and a DRV-11 parallel interface board (8:9). All programming is in FORTRAN IV version 2.5 and all FORTRAN software was provided by Digital Equipment Corporation (8:9).

The computer system used for interfacing the MS-900 unit with the PDP 11/03 consists of an APPLE 2+ with 48 kilobytes of memory, an APPLE monitor III, 5 1/4-inch floppy

disk drive, and an APPLE Super Serial Card. Also, a joystick and a Syllentype thermal printer was used for manipulating data and printing results respectively. The software for data manipulation was a Mossbauer Master program supplied by Ranger Scientific, Incorporated for an APPLE 2+ or 2e computer. This software enables one to do several things with the data obtained. The options include acquiring data, storing data on a disk, retrieving data from a disk, printing the data on a printer, and displaying the spectrum. Changes made to this software, as part of the new Mossbauer spectrometer installation, are included in later sections.

MOSFUN Program

Whether one is using the new or original spectrometer system, the data must somehow be analyzed. The computer program used for spectrum analysis in this study is MOSFUN, originally written by E.W. Muller and modified by B.E. Pate in 1981 as a thesis project. Pate modified the console version of MOSFUN, designed to run on mainframe computers using terminals, to a size and format which could fit into the PDP 11/03. By extensive use of subroutines, an overlaying technique was able to be used to fit the program into the smaller memory of the PDP 11/03. The final version allows up to 32 fit parameters, 24 lines, and 1024 data points (8:15). The parameters used by MOSFUN to fit a spectrum include intensity, position, half-width and possibly form. These parameters are used in one of four possible models provided by MOSFUN. Two models use Lorentzian lineshapes, one

using line intensity and one using line area. The other two models use Voigt lineshapes and again, one uses line intensity and one uses line area. Only when using the Voigt theory is the fourth parameter, form, used. This parameter determines whether the lineshape is more Gaussian or Lorentzian.

There are two iterative methods, Newton and Gradient, provided for correcting the initially calculated theoretical spectrum in MOSFUN. Both are equally accurate. However, Newton's method is much faster if it does not diverge. For this study, the Lorentzian - intensity and Voigt-intensity theories were used with the gradient method. Details of the parameters used and theory applied to each spectra are discussed in chapter 4 (results/discussion). For a detailed description of the modified MOSFUN program, the reader is referred to reference 8.

New Spectrometer Installation

In order to assemble a new system so that data could be sent directly to the PDP 11/03 for analysis from the new spectrometer, software and hardware changes had to be made. The software changes included modifications made to both MOSFUN and the Mossbauer Master program.

MOSFUN Changes . Basically, the changes made to MOSFUN include altering the DATI and DRIVE subroutines to allow a 1024 data point spectrum with no velocity data included, instead of a 400 point spectrum with velocity data every 10 channels. Additionally, the read statements for the time base data also had to be changed. Originally, the first 14 channels contained

time base data and the remaining 386 channels contained Mossbauer data, with velocity data every ten channels, starting with channel 19. The new spectrometer does not contain a moire system and thus the spectrum contains no velocity data. The first two channels contain time base data while the remaining channels contain Mossbauer data. The first step taken was to allow subroutine DATI to accept the new spectrum format by reading in the first two data points as time base data, instead of the first 14. These points were then set equal to zero as originally done for the first 14 points. Next, a GOTO statement was added to bypass the velocity extraction portion of DATI. Normally, velocity points are stored in an array called VCON(I) and a linear least squares fit is done on the velocity data. Since the new system does not produce velocity data, the velocity values in mm/s and peak positions of a known spectrum were entered. The velocity values and channel positions for each peak of a natural iron spectrum were inserted into subroutine DATI. The velocity values, taken from reference 9, are those with respect to sodium nitroprusside. Thus, all spectra will be analyzed with respect to sodium nitroprusside. As before, a linear least squares fit will be done on the VCON(I) array and the channel numbers for each velocity point are set equal to zero. Finally, no changes had to be made to allow a 1024 point spectra instead of a 400 point one, because MOSFUN was originally equipped to handle this option.

The changes made to subroutine DRIVE include altering arrays X(I) and XY(I). Array X(I) contains the channel number

corresponding to each velocity point and was originally assigned a value in subroutine DRIVE since velocity points were evenly spaced throughout the data. The array values are now assigned by entering them into subroutine DKIVE (see appendix A for procedure), where each channel number corresponds to a peak from the natural iron calibration run. Array XY(I) is an array containing values of VCON(I) which have been converted to mm/s. This conversion has been omitted since VCON(I) is entered as mm/s in subroutine DATI. The velocity values for each peak are from published calibration data and thus do not need to be changed. However, the channel locations for each peak, which must be entered into subroutines DRIVE and DATI, must be updated periodically to insure an accurately calibrated system. The present values are a result of a 25 micron thick natural iron absorber run at room temperature for 4.25 hours (figure 2).

Mossbauer Master Changes . The changes made to the Mossbauer Master program permit data to be sent to the PDP 11/03, in addition to a printer or a disk. Also, once the hardware connections were made between the APPLE and the PDP, to be discussed later, the format in which the program transmitted or printed data had to be changed. Appendix C contains a listing of the Mossbauer Master program with the changes added. The format changes include using one line for the spectrum name, a second line for specifying the format in which MOSFUN reads the data, and a third line for listing the number of time base overflows, data overflows, number of data points total, number of data points in a full period, and the drive mode.

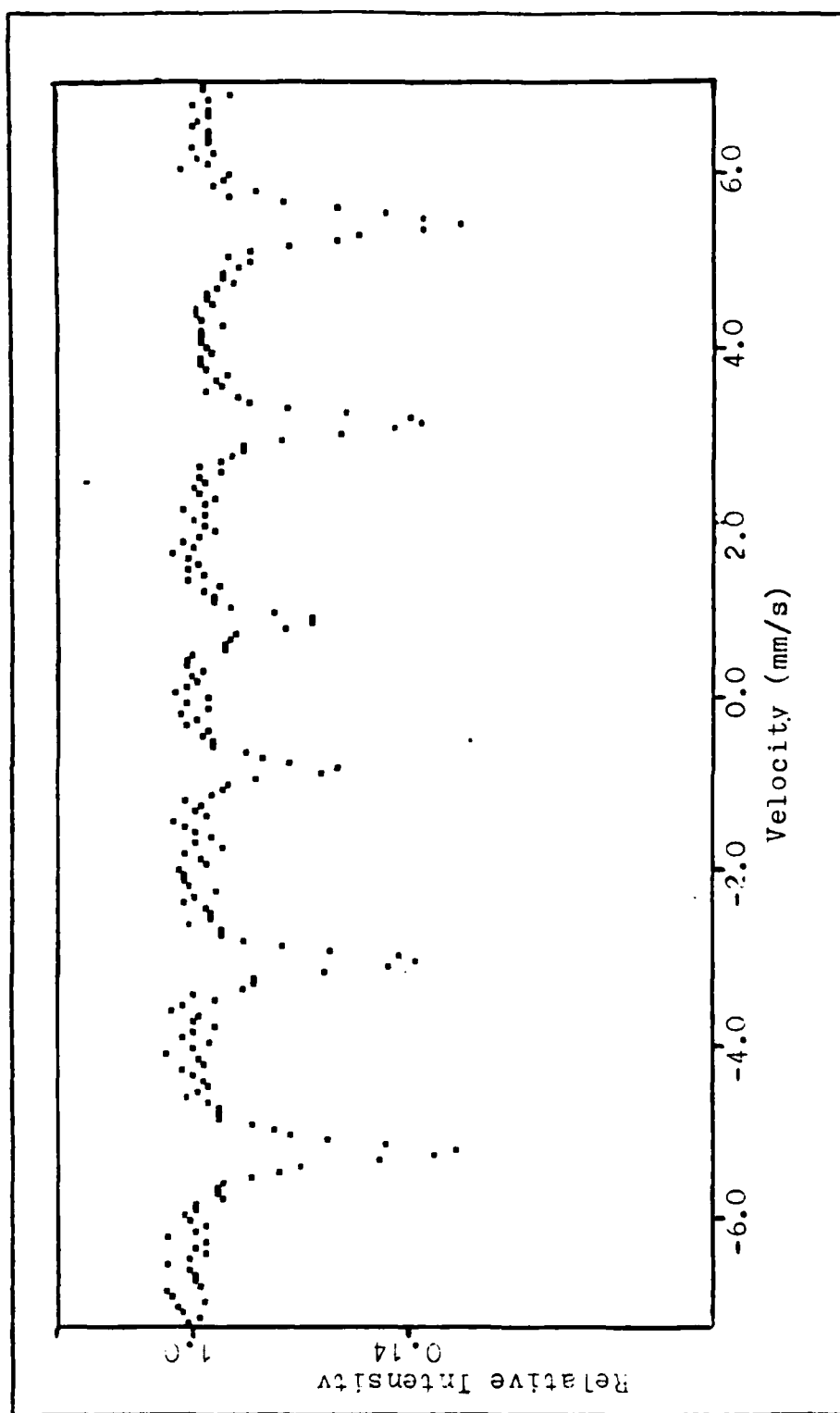


Fig 2. Natural Iron Calibration Results From MS-900
(With respect to Sodium Nitroprusside)

FE57TEST

0	14261	14261	3340	3434	3335	3382	2933	2407
8	3154	2957	2623	3231	2852	3148	2875	3036
16	3266	2593	2673	3199	3097	2151	3066	3336
24	3495	3393	3375	3315	3469	3545	3434	3391
32	3538	3400	3453	3444	3430	3469	3501	3465
40	3448	3479	3421	3457	3430	3424	3463	3462
48	3477	3472	3401	3474	3489	3484	3394	3540
56	3496	3593	3471	3455	3560	3437	3517	3429
64	3442	3488	3381	3589	3528	3415	3417	3491
72	3356	3433	3323	3465	3474	3428	3350	3578
80	3404	3428	3342	3473	3492	3428	3462	3433
88	3458	3479	3471	3428	3499	3448	3314	3474
96	3428	3454	3483	3422	3334	3438	3389	3411
104	3504	3385	3322	3483	3428	3343	3350	3404
112	3421	3356	3348	3389	3396	3339	3418	3373
120	3288	3305	3379	3336	3374	3340	3266	3287
128	3377	3253	3323	3223	3304	3314	3372	3342
136	3419	3249	3347	3223	3226	3457	3268	3232
144	3346	3168	3180	3250	3162	3138	3228	3178
152	3256	3243	3209	3128	3159	3107	3082	3061
160	3186	2983	3021	2955	2983	2899	2970	2953
168	2852	2835	2689	2845	2661	2588	2615	2510
176	2470	2460	2358	2363	2186	2182	2103	2100
184	2108	1988	1926	2011	1881	1925	1908	1893
192	2030	1985	1975	2024	2033	2199	2136	2207
200	2439	2360	2360	2392	2448	2539	2563	2686
208	2816	2707	2843	2794	2850	2904	2944	2940
216	3069	3035	3063	3216	3171	3160	3204	3037
224	3178	3173	3082	3299	3134	3231	3242	3205
232	3214	3351	3290	3323	3198	3179	3332	3358
240	3303	3192	3302	3280	3227	3261	3286	3309
248	3314	3248	3248	3341	3319	3194	3305	3314
256	3345	3272	3357	3328	3229	3263	3242	3384
264	3347	3337	3316	3320	3200	3287	3310	3259
272	3368	3229	3199	3195	3166	3193	3319	3283
280	3306	3254	3193	3190	3216	3248	3296	3113
288	3109	3096	3048	3202	3076	3014	3117	3141
296	3071	3056	3011	2959	3084	2962	2987	2882
304	2947	2875	2760	2740	2731	2633	2582	2579
312	2563	2573	2426	2530	2381	2387	2238	2196
320	2108	2102	2034	2005	2038	1916	1876	1958

Figure 3. Old Data Format

```

NFECAL.EX1
( BF9.0)
0,0,1024,2048,5
99207 99207 14447 14200 14128 14457 14255 13091
14337 14412 13433 14315 14301 13872 14443 13843
14220 14578 13507 13989 14232 14095 13076 14087
14521 14302 14656 14412 14348 14175 14344 14342
14485 14357 14446 14509 14304 14374 14488 14313
14524 14476 14269 14369 14409 14484 14407 14462
14509 14670 14573 14608 14255 14479 14499 14659
14441 14530 14372 14351 14401 14107 14310 14428
14314 14328 14414 14627 14473 14472 14612 14585
14506 14332 14487 14537 14270 14531 14363 14356
14563 14421 14271 14434 14595 14438 14409 14584
14334 14384 14569 14317 14376 14555 14084 14503
14392 14293 14367 14299 14412 14396 14329 14386
14610 14420 14400 14451 14441 14447 14487 14240
14290 14516 14282 14449 14358 14471 14396 14396
14300 14187 14457 14474 14555 14474 14399 14133
14357 14273 14598 14344 14299 14260 14650 14362
14412 14405 14369 14428 14486 14385 14420 14476
14394 14465 14375 14309 14370 14533 14402 14309
14080 14236 14172 14143 14193 13973 14242 14262
14198 14115 14081 14201 14141 14162 13972 13853
13835 13849 13698 13622 13570 13516 13494 13314
13427 13135 13044 12732 12609 12607 12306 12054
12145 11995 12047 12239 11928 12205 12320 12441
12565 12600 12985 13036 13147 13488 13386 13627
13482 13604 13800 13688 13640 13864 13917 14024
13848 13921 14019 14031 14197 14156 14176 13849
14184 14171 14193 14130 14168 14186 14192 14240
14284 14420 14246 14389 14476 14341 14493 14285

```

Figure 4. New Data Format

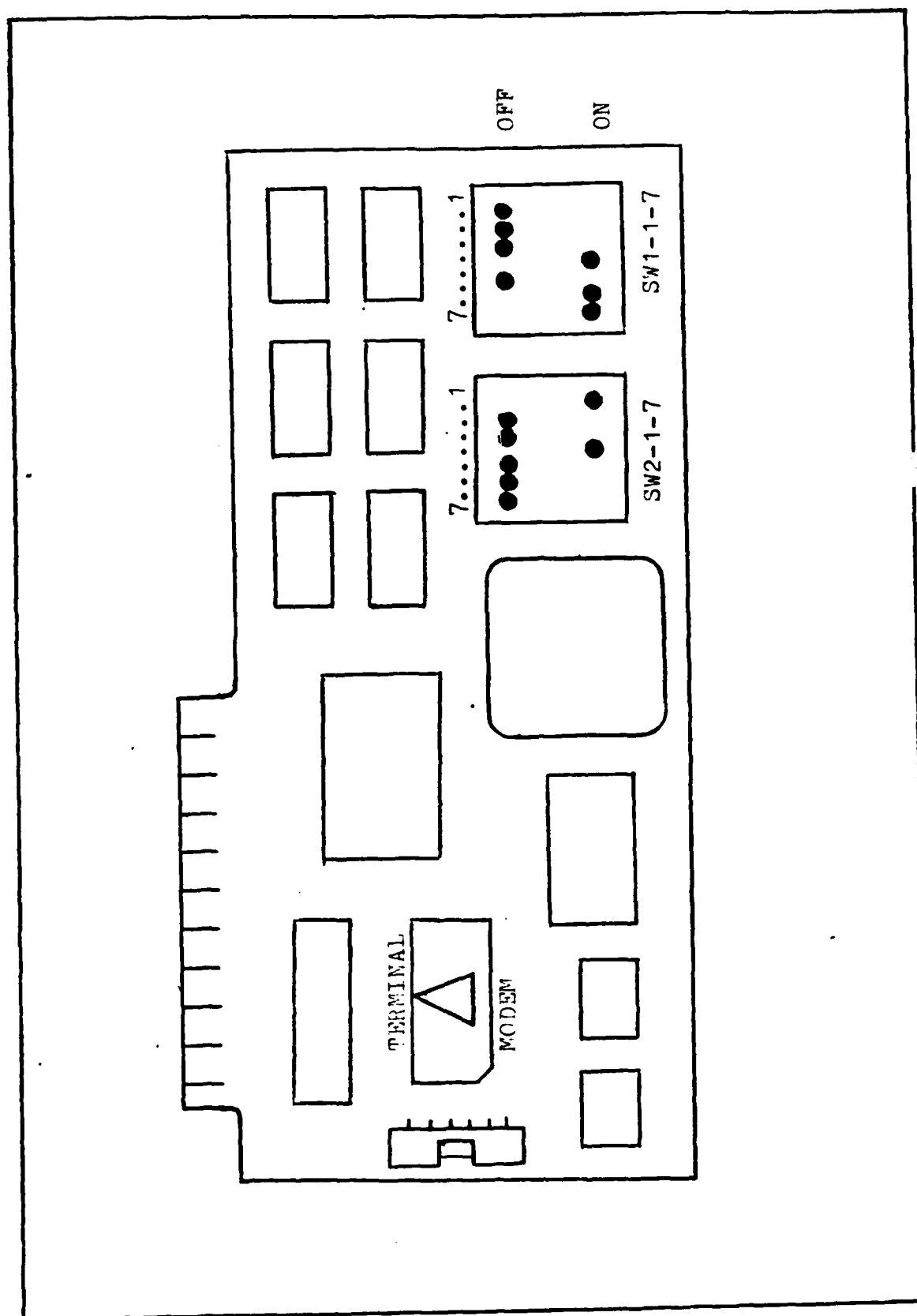


FIGURE 5. Super Serial Card Settings

Additionally, the data was made to be listed in an 8F9.0 format. In other words, there are 8 values per row with each value containing up to 9 characters. All of the changes mentioned above were made to conform to the format MOSFUN expects. Examples of the original and new formats are shown in figures 3 and 4.

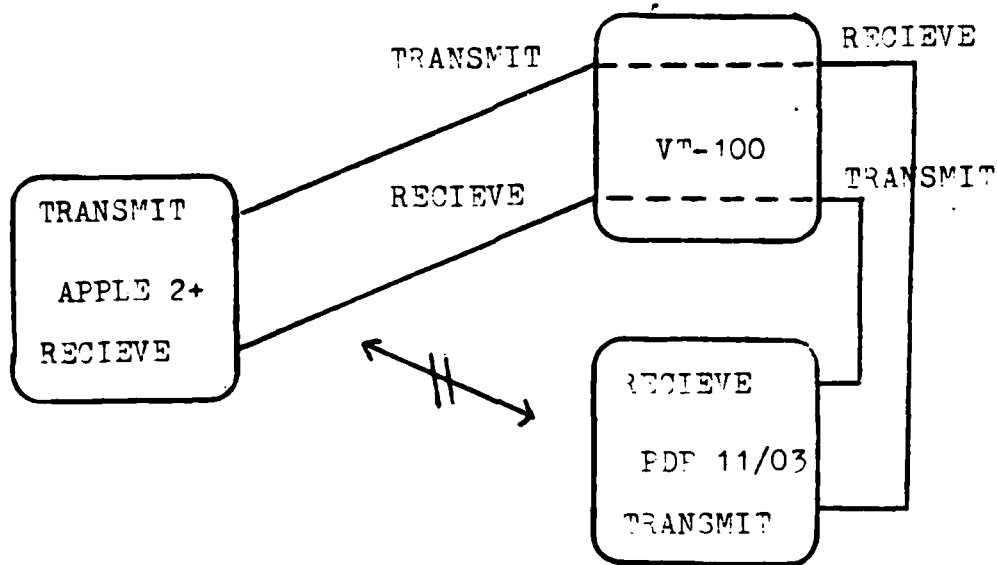
Hardware Changes . The connection between the APPLE 2+ and the PDP 11/03 was made with an APPLE Super Serial card and a modified 10 wire connector cable. The card was inserted into slot number two of the APPLE and a series of switches on the card were set to match the connecting device which, in this case, was the PDP. The switch settings, shown in figure 5, control the baud rate, number of stop bits, carriage return delay, line width, and linefeed. Switches SW1-1 through SW1-4 control the baud rate and were set for a value of 9600 to match the PDP. Switches SW1-5 and SW1-6 control the operating mode of which the printer mode was used. This mode is used when sending data to a printer, a terminal, or in this case, another computer without the use of a modem. The number of stop bits sent to signal the end of a character is controlled by SW2-1 and was set for one stop bit. The carriage return delay, controlled by SW2-2, was set equal to zero since the PDP can accept data much quicker than a printer, which normally needs a small delay. Switches SW2-3 and SW2-4 control the linewidth and were set to produce 80 characters per line. Switch SW2-5 controls linefeed generation and was set to not produce a linefeed since the PDP does this automatically. Switches SW2-6, SW2-7, and SW1-7 were

TABLE 2.
DB-25 Pin Connections For Connector Cable Exiting APPLE 2+

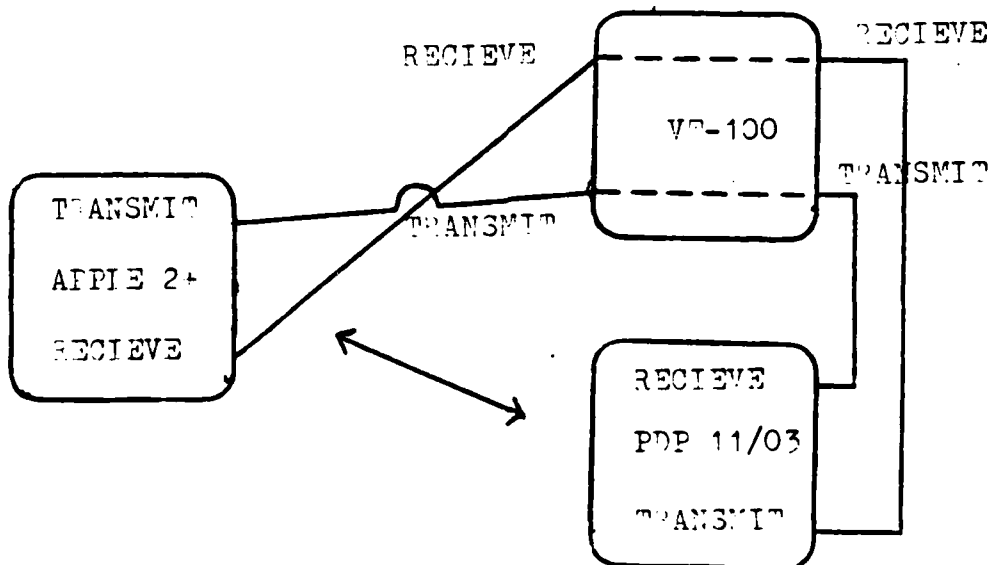
10-pin header	DB-25 connector	Signal Name
1	1	Frame Ground
2	2	Transmit Data
3	3	Recieve Data
4	4	Reouest To Send
5	5	Clear To Send
6	6	Data Set Ready
7	19	Secondary Clear To Send
8	7	Signal Ground
9	20	Data Terminal Ready
10	8	Data Carrier Detect

DB-25

The diagram shows a trapezoidal DB-25 connector with two rows of pins. The top row contains 14 pins, and the bottom row contains 11 pins. The pins are numbered 1 through 25. Pin 1 is at the bottom-left corner, pin 14 is at the top-left corner, pin 15 is at the bottom-right corner, and pin 25 is at the top-right corner.



Data Transferred to VT-100 Only



Data Transferred From APPLE 2+ To PDP 11/03 (bypass VT-100)

FIGURE 6. Transmit/recvie Data Connection

set at the default settings specified by the card manual. These switches are used for special cases and do not apply in this situation. The only other adjustment made was to put the card into printer, or terminal mode. This was accomplished by extracting and reinserting the jumper block on the card such that the triangle pointed towards terminal. This is also illustrated in figure 5.

The connecting cable between the PDP and the Super Serial card was the final step in the installation of the system. A ten strand flat cable and two male DB-25 connectors were used to make the connecting cable. The connector pin assignments for the ten pin header on the card and the corresponding pins on the DB-25 connector are shown in table 2. The opposite end of the cable, which connects to the PDP, has the same pin assignments except for the switching of pins two and three. These connections are those for transmitting and receiving data respectively. This switch is illustrated in figure 6. In the printer or terminal mode, the transmit pin of the Super Serial card is connected to the receive pin of the terminal and visa versa. This same relationship exists between the PDP and the VT-100 terminal. Thus, in order for the APPLE to communicate directly with the PDP, the transmit and receive cables were switched on one end of the connecting cable. The connection to the PDP was made by disconnecting the female end cable at the VT-100 terminal and reconnecting this end to the male end of the modified connector cable mentioned above. Now, data from the APPLE can be sent directly to the PDP to be put on

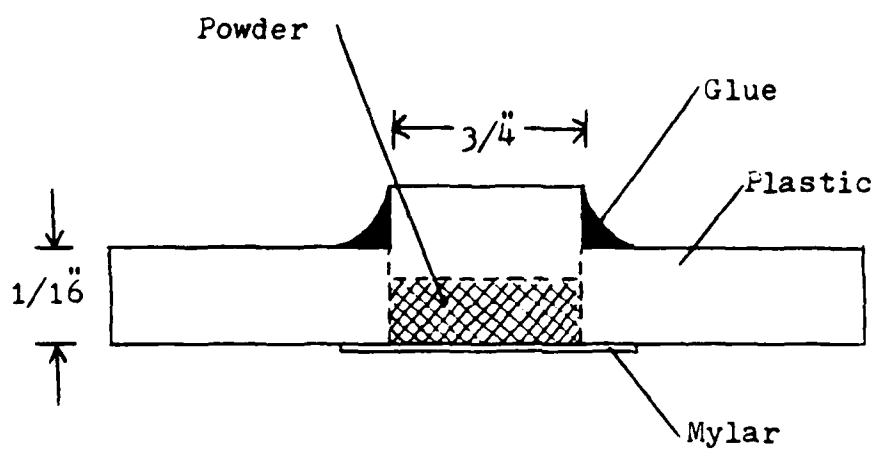


Figure 7. Powder Sample Preparation

a disk. The procedure for setting up and operating this system is included in appendix A.

Absorber Parameters

The form of the alloy samples tested in this study include: 1) atomized powder, 2) cold compacted wafers, and 3) cold compacted-hot vacuum degassed wafers. All of the above absorber forms were fabricated to have the optimum grams per square centimeter as determined experimentally. By starting near the theoretically calculated optimum value, an improved value was found through successive trial runs with powder absorbers of different g/cm^2 . Each trial run was compared with the others by the relative intensity of the lines present. The range of values tested were between 0.05 g/cm^2 and 0.15 g/cm^2 . From these tests, a value of 0.1 g/cm^2 was chosen and applied to all other forms of the alloy samples.

The fabrication method of the powder test samples was chosen to provide a uniform density of powder across the area of the absorber. Of all the methods tried, only one was successful. This method consisted of putting a specific amount of powder into a $3/4$ inch diameter hole which is in the center of a $1/16$ inch thick, 2 inch square piece of plastic. One side of the hole was sealed with a piece of mylar bonded to the plastic with rubber cement. The other side was sealed with a $3/4$ inch diameter $1/16$ inch thick plastic disk resulting from the hole in the plastic sheet. This plug was lightly pressed into place with uniform pressure and the small space around the plug was then

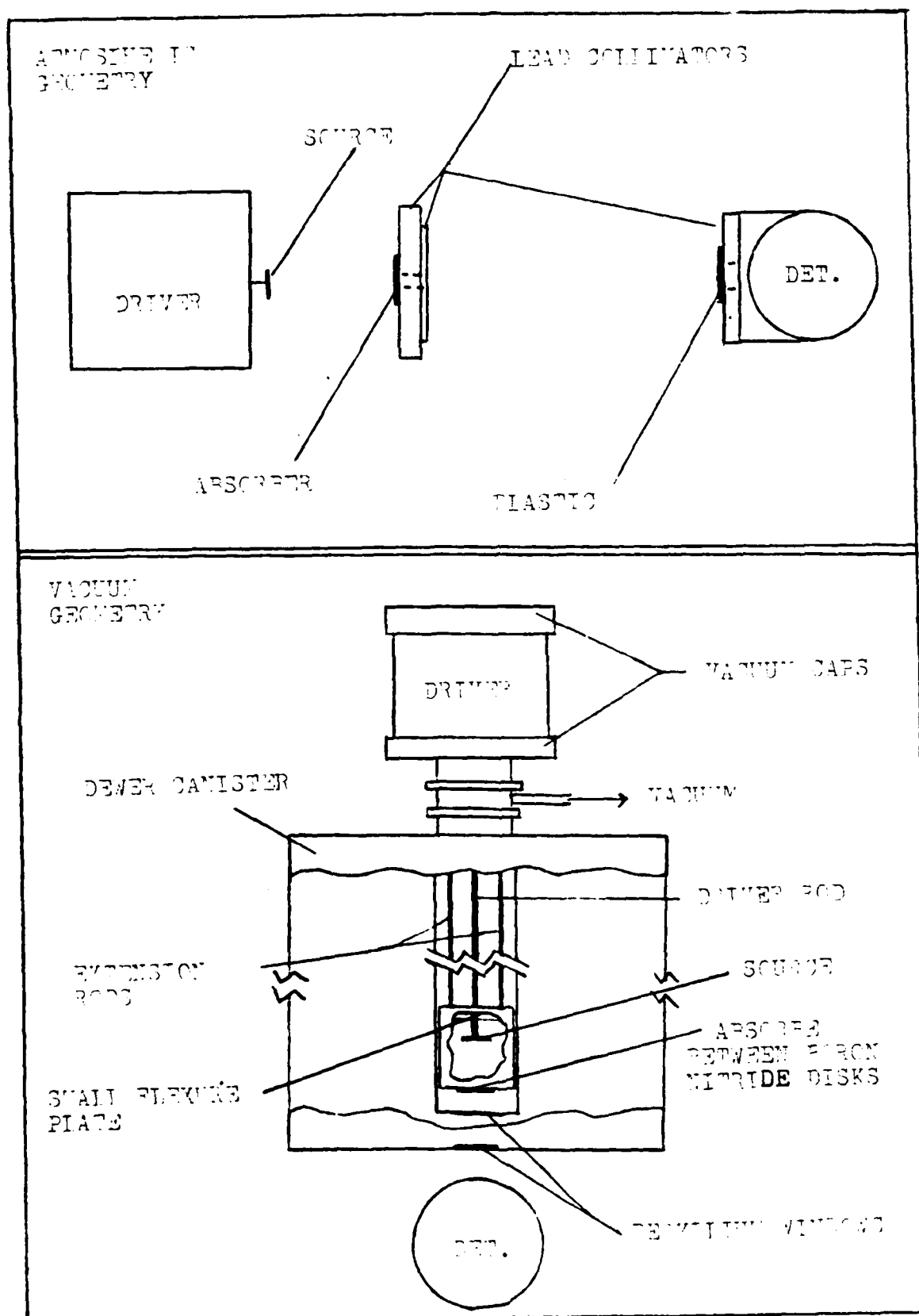


FIGURE 8. Experimental Geometry

sealed with DUCO cement. with this method, the thickness in g/cm^2 was determined by dividing the weight of the powder inserted into the hole by the area of the hole.

The fabrication of the other samples was accomplished by the High Temperature Materials Branch at the Air Force Materials Laboratory. The cold compacted absorber was made by first putting a known amount of powder into a 1/16 inch thick cardboard die with a 1/2 inch diameter hole. The die and powder were then subjected to 24,000 pounds per square inch for approximately 15 seconds with a hydraulic hand press. The thickness in g/cm^2 was then determined by dividing the weight of the wafer by its area. By trial and error, a value of 0.102 g/cm^2 was obtained. The cold compacted-hot vacuum degassed samples were made by first repeating the above procedure to obtain a pressed wafer. These wafers were then placed in a vacuum chamber for two hours where a vacuum of $3\text{E-}05$ Torr was reached. Next, still under vacuum, the samples were heated for 30 minutes at approximately 860 F. The samples were then cooled to 212 F in a period of about 1.5 hours with a final vacuum of $1.5\text{E-}05$ Torr being reached. The samples were then removed from vacuum and were exposed to atmospheric conditions for 15 minutes before being placed in a vacuum dessicator at room temperature.

Experimental Geometry

Due to component failure in the MS-900, all data for the alloy samples was obtained using the original Mossbauer system. The source used was 50 mCi cobalt-57 (date:5 June 1981)

diffused into a six micron thick rhodium matrix (8:8). The source was prepared by Amersham-Searle and produces, among other radiations, the 14.4 keV gamma ray of interest for this study. For the powder and cold compacted absorbers, the source-to-detector distance was 11.5 inches. A lead collimator with a 3/8 inch opening was placed 4 inches in front of the source, centered between the source and detector. The absorber was then placed on the front face of the collimator, centered over the hole. An additional lead collimator with a 7/8 inch opening was placed directly in front of the detector window and a plastic plate was placed over this hole to reduce the detection of 6.4keV X-rays emitted from the source.

For the cold compacted-hot vacuum degassed absorber, a vacuum system was used while acquiring data to insure that no properties of the hot vacuum degassing stage were changed by exposure to atmospheric conditions. The vacuum system was achieved by using a cylindrical dewar with a forepump and produced a vacuum of $2.79\text{E-}03$ Torr. As can be seen in figure 8, the source to detector distance was reduced (to 6 inches) as well as the source to absorber distance (to 0.69 inches). Additionally, the plastic plate in front of the detector was removed because the new set-up has two beryllium windows between the absorber and detector which is sufficient to absorb the 6.4 keV X-rays. For all three types of absorbers, the flyback mode was used and a run time of 48 hours was chosen to minimize statistical fluctuations in the spectra.

IV. Results and Discussion

In this section, the capabilities of the new computer based Mossbauer Spectrometer, as well as the results of all spectrum analysis will be presented. The spectra presented include calibration runs for both the new and original systems in addition to the spectra for each stage of alloy processing.

System Capabilities

The capabilities of the new computer based Mossbauer spectrometer include simplified operation, a larger memory for data storage, and quicker data analysis. Unlike the original system, there is not an extensive network of cables connecting many separate system components, thus resulting in a simplified assembly. Also, in addition to a simplified assembly, the number of operating controls are reduced, so setting the system for operation is much easier and faster. Once the system is operating, the data can be manipulated with a joystick and by commands entered on the keyboard. Then, at any time during data acquisition, the APPLE 2+ can be used for normal functions totally independent of the MS-900. This is possible since the MS-900 has its own random access memory (RAM) of 1024 channels with 24 bits (16 million counts) each (11). Once all data needed is obtained, it can be stored on a 5 1/4 inch floppy disk, printed out, and/or sent to the PDP to be stored on an 8 inch floppy disk and analyzed. The time it takes to send the 1024 data points to the PDP is only 1 1/2 minutes whereas it took over an hour to manually type in the 400 point spectrum of the

original system. Once the data is available to the MOSFUN program on the PDP, the same commands are used for analysis. However, with 1024 data points instead of 400, all operations take longer.

An example of a spectrum obtained by the new system and analyzed by MOSFUN is shown in figure 2. This figure is that of natural iron foil with respect to sodium nitroprusside. The spectrum is shifted 0.243 ± 0.006 mm/s with respect to sodium nitroprusside instead of the standard value of 0.26 ± 0.002 mm/s (9). The calibration of this spectrum could be corrected by acquiring data for natural iron foil for a longer period of time than done previously and inserting the more accurate peak channel locations into the DATI and DRIVE subroutines discussed earlier. The current natural iron foil spectrum was obtained in only 4.25 hours and thus the peak locations were subject to statistical fluctuations. For a step by step guide for setting up and operating the new system, see appendix A.

Alloy Results

The results for the natural iron calibration run and those for each stage of alloy processing are shown in table 3. All isomer shifts in this table were adjusted to be relative to natural iron. The spectra of the calibration run and those of the alloy samples were obtained on the original Mossbauer spectrometer as mentioned earlier, and are shown in figures 9-13. Thus, the velocity scale on all of these figures is relative to cobalt 57 in a rhodium matrix.

Table 3.
MOGFUN Results for Calibration and Alloy Samples With Respect to NFE

Sample	Run Time (hrs)	Isomer Shift (mm/s)	Relative Peak Intensity (%)	Half Width (mm/s)	Peak Location (mm/s)
NFE Calibration (Original System)	21.9	0.000			
Peak # 1			26.2±4.7	0.144±0.011	-5.280±0.037
2			21.9±5.2	0.140±0.012	-3.056±0.027
3			13.2±10.6	0.132±0.020	-0.832±0.025
4			13.2±10.6	0.132±0.020	00.832±0.023
5			21.9±5.2	0.140±0.012	3.056±0.018
6			26.2±4.7	0.144±0.011	5.280±0.024
NFE Calibration (M3-900 System)	4.25	0.000			
Peak # 1			15.99±3.3	0.180±0.009	-5.316±0.026
2			14.68±4.0	0.149±0.009	-3.077±0.018
3			8.32±7.5	0.144±0.016	-0.344±0.013
4			8.32±7.5	0.144±0.016	0.344±0.017
5			14.68±4.0	0.149±0.009	3.077±0.013
6			15.99±3.3	0.180±0.009	5.316±0.013

Table 3. (Continued)

Sample	Run Time (hrs)	Isomer Shift (mm/s)	Relative Peak Intensity (%)	Half Width (mm/s)	Peak Location (mm/s)
Alloy Samples:					
Powdered Peak # 1	48	0.181±0.025	19.78±3.2	0.193±0.047	-0.032±0.039
2			20.90±3.3	0.189±0.037	0.395±0.069
Cold Compacted Peak # 1	48	0.181±0.031	19.46±3.5	0.193±0.064	-0.029±0.044
2			21.10±3.7	0.181±0.048	0.390±0.041
Cold Compacted/ Hot Vacuum Degassed (Gaussian) Peak # 1	48	0.204±0.029	17.88±2.5	0.271±0.057	-0.007±0.03
2			20.36±3.9	0.183±0.031	0.416±0.067
Cold Compacted/ Hot Vacuum Degassed (Lorentzian) Peak # 1	48	0.206±0.078	13.12±6.4	0.173±0.029	-0.109±0.050
2			12.05±6.4	0.173±0.029	0.115±0.019
3			19.91±2.4	0.173±0.029	0.411±0.058

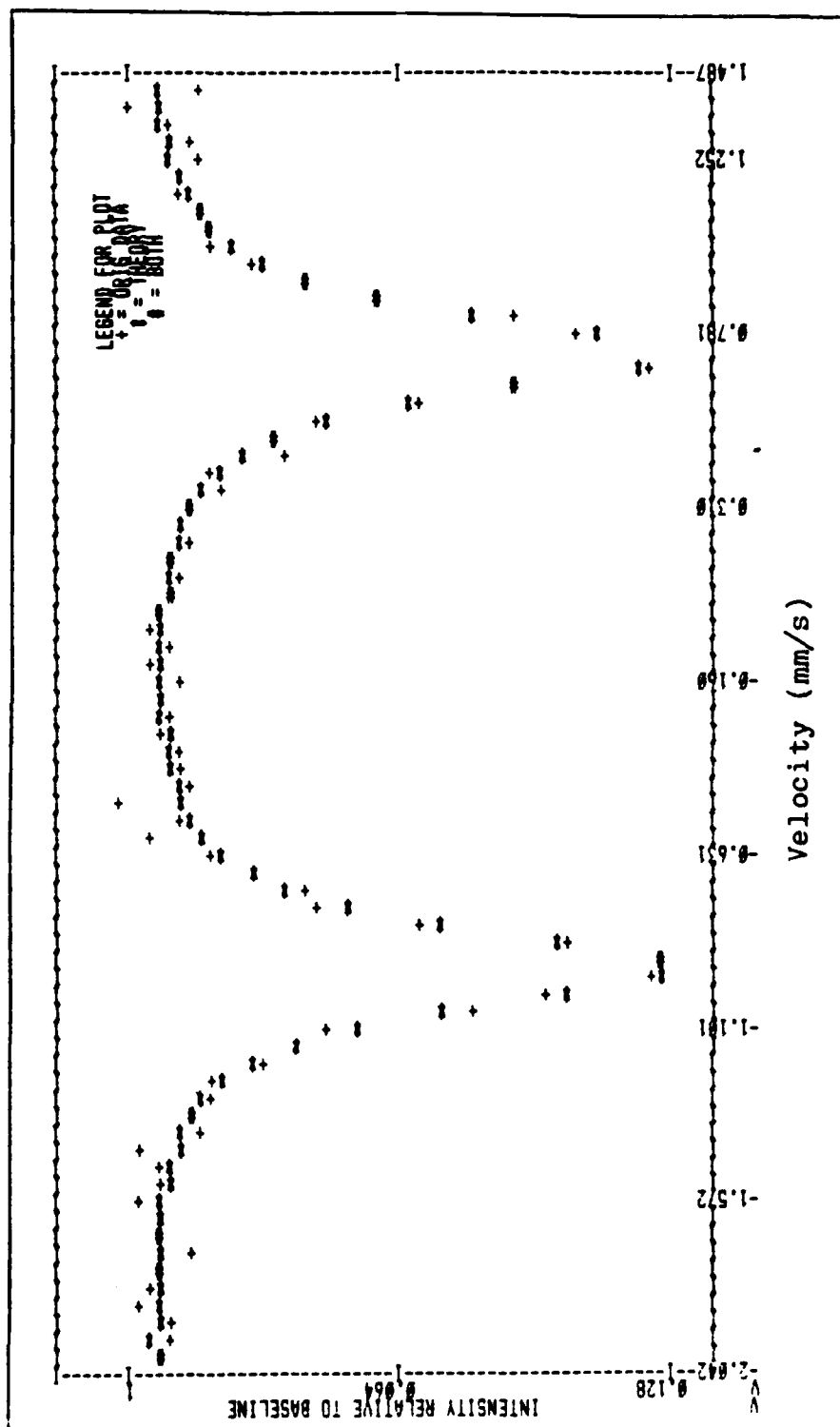


Figure 9. Natural Iron Results for Peaks 3 and 4 from Original Mossbauer Spectrometer (with respect to Co57 Source)

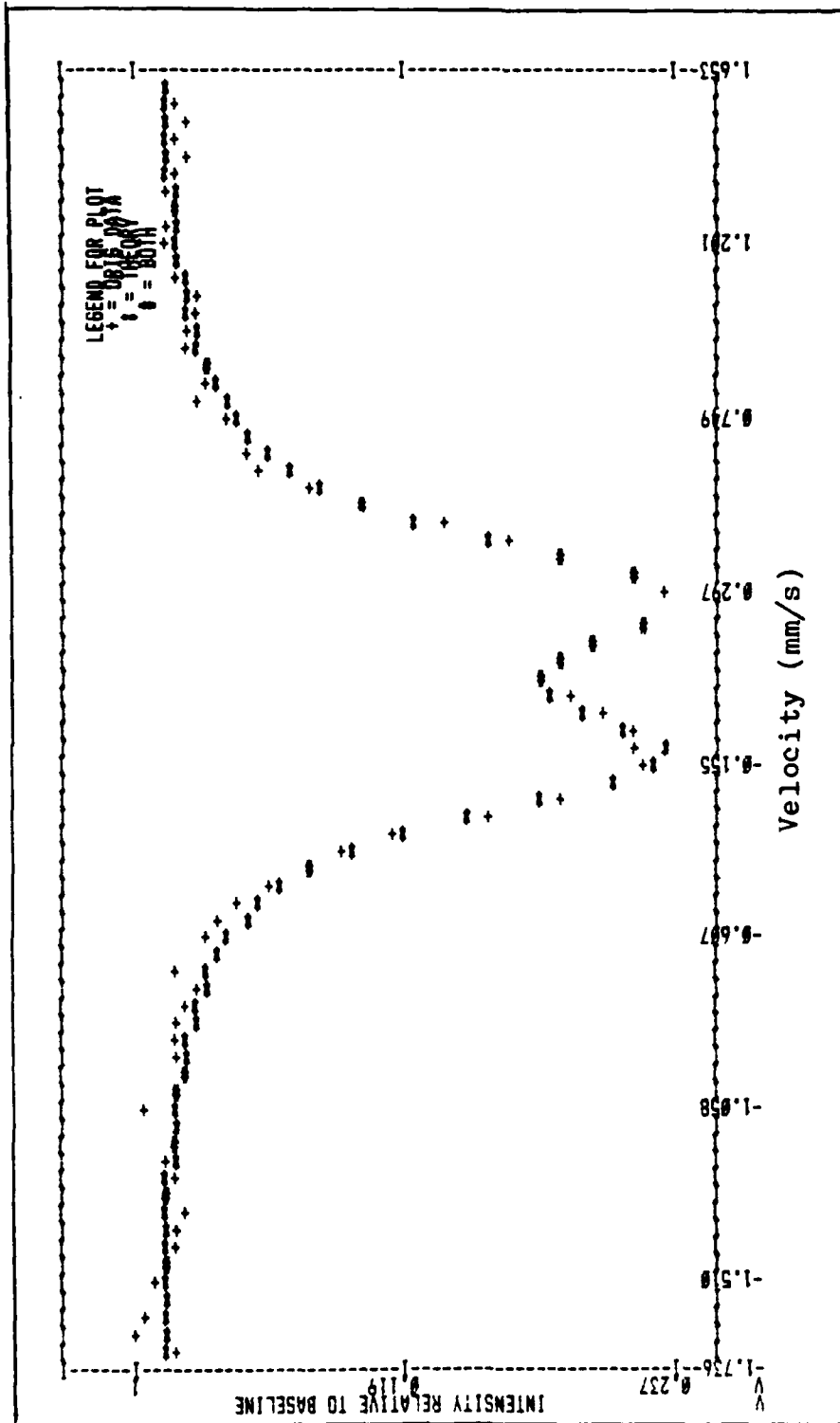


Figure 10. Results for Alloy Powder
(With respect to Co57 Source)

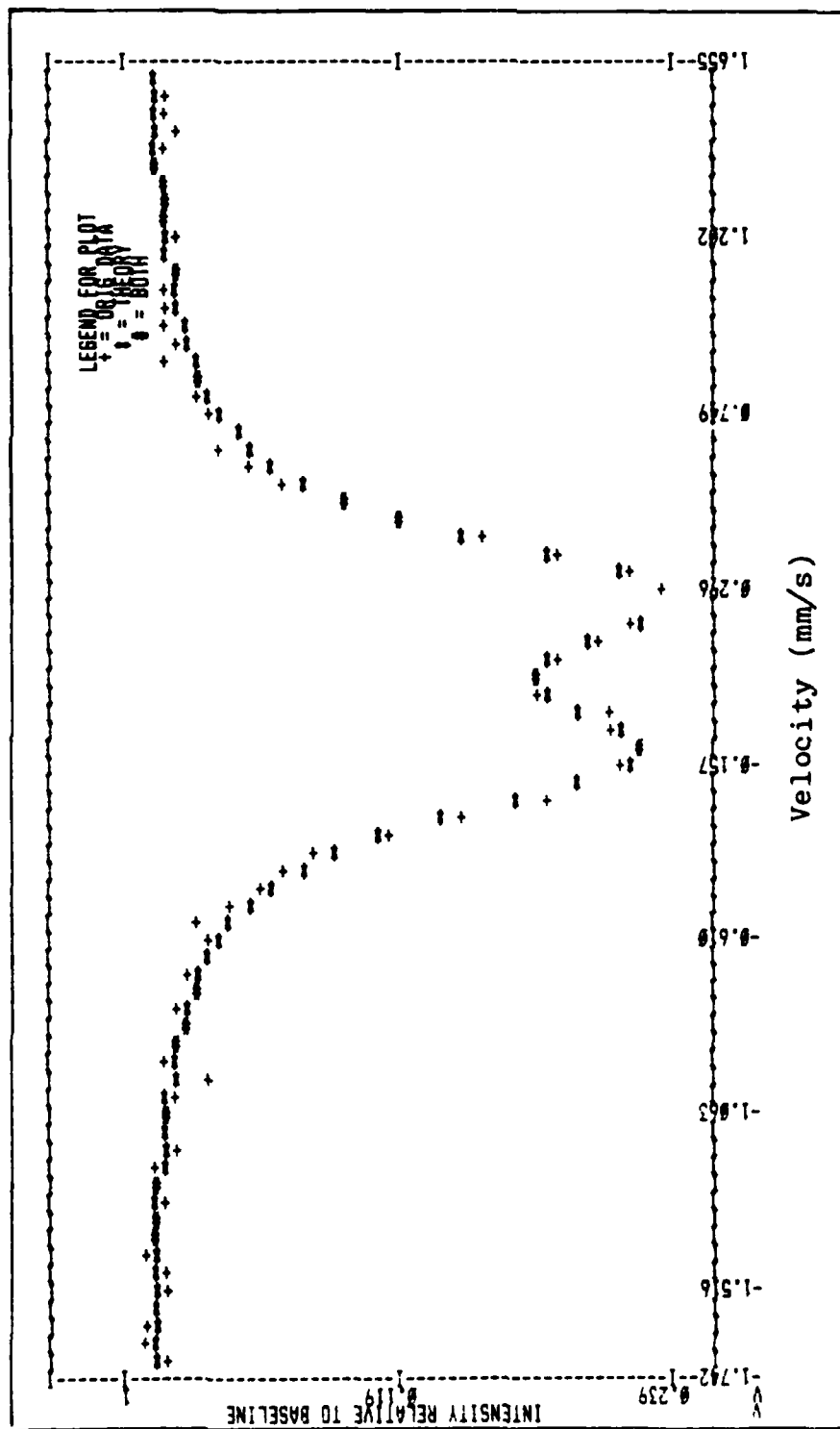


Figure 11. Results for Cold Compacted Alloy
 (With respect to Co57 source)

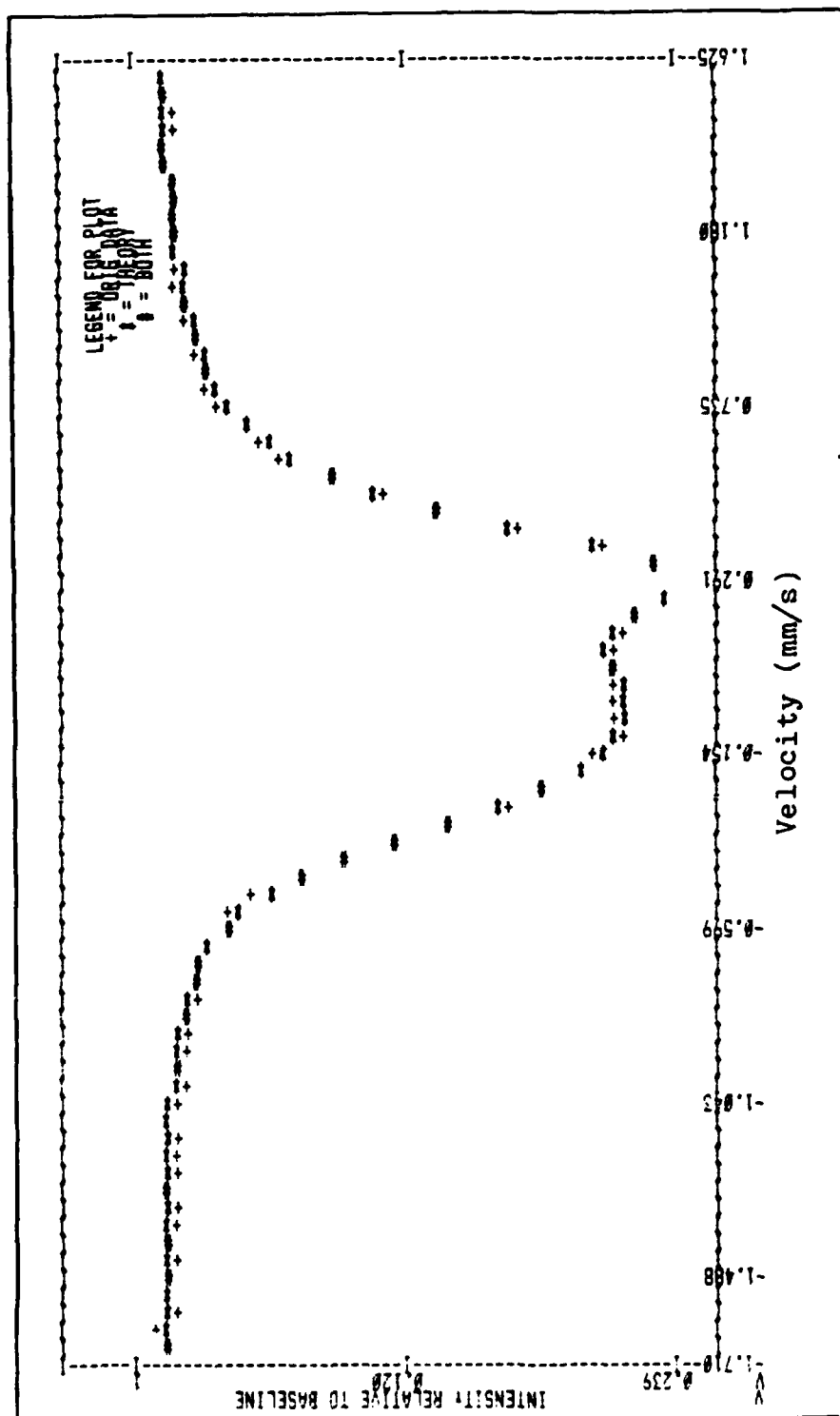


Figure 12. Results for Cold Compacted/Hot Vacuum Degassed Alloy (with respect to Co57 source)(2 line Gaussian fit)

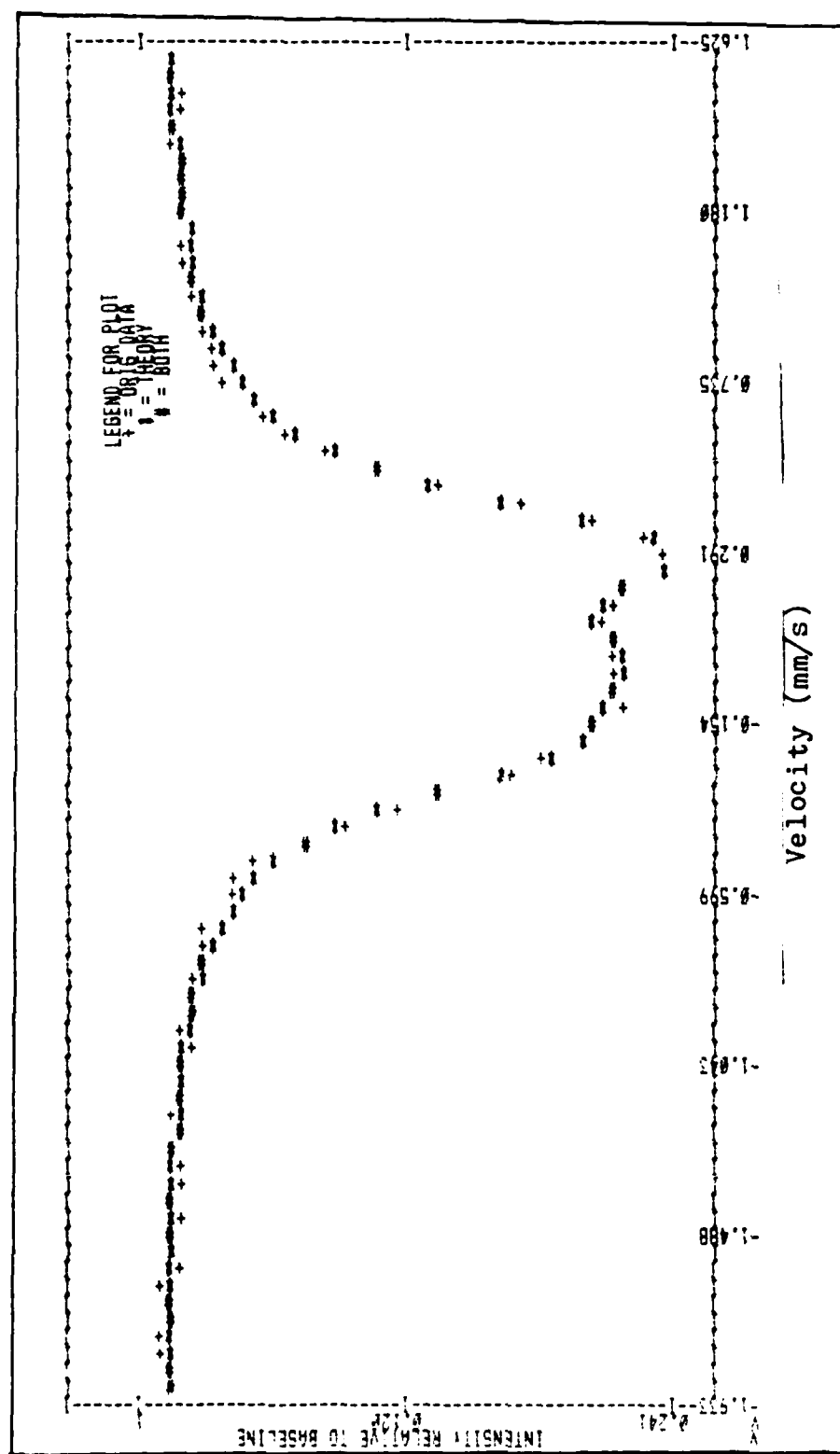


Figure 13. Results for Cold Compacted/Hot Vacuum Degassed Alloy (with respect to Co57 source) (3 line Lorentzian fit)

All of the spectra shown here were fitted by MOSFUD using the Lorentzian-intensity theory with a gradient iteration refinement. The only exception was that of figure 12. This spectrum was fitted using the Voigt-Intensity theory for better results. The parameters varied to fit the spectra included: 1) baseline, 2) geometry factor (a measure of the amount of baseline curvature), 3) line intensity (each line independent of the other), 4) isomer shift, 5) quadrupole splitting (separation of doublet lines), and 6) half width at half maximum. In addition to these, an additional parameter, form, was assigned to each line of the Voigt fitted spectrum.

Figure 10 shows the spectrum of the atomized powder form of the alloy. As can be seen, the spectrum is that of a nearly symmetric doublet. From this spectrum, it is not clear as to whether the doublet is a result of quadrupole splitting or two different compounds formed in the lattice. However, it is obvious that there is no hyperfine splitting present which indicates that agglomeration of iron atoms is unlikely. The cold compacted alloy results are shown in figure 11. Basically, the spectrum is identical to the powder alloy spectrum except for a slight decrease in the left peak intensity. However, due to the statistical errors of the parameter values, the peak intensities overlap and thus nothing conclusive can yet be stated as to whether quadrupole splitting is the mechanism present or whether a decrease in one of the two compounds occurred. The results for the cold compacted-hot vacuum degassed samples are shown in figures 12 and 13. Due to the broadening of the left line, a new

theory was needed to obtain a good fit. From figure 12 and table 3, it can be seen that the left peak has reduced in intensity and become more Gaussian shaped as opposed to Lorentzian. Even with statistical errors involved, the peak intensities are significantly different. In order to determine the cause of the left peak broadening and decrease in intensity, a new theory was considered. A spectra fit was attempted using three lines, letting each line's intensity and position vary independently. The results, shown in figure 13 and Table 3, indicate that the spectra is that of a quadrupole doublet (left two peaks) and a single line (right peak). Thus the left peak broadening is most probably due to quadrupole splitting. These results indicate that the two compound theory is the mechanism present. If this is the case, then only the third processing stage, which involved hot vacuum degassing, significantly changed the lattice structure. Although it is believed that two different compounds are present in the alloy, it is still not known what they are. The Fe Al_6 compound, which was expected to be seen, was not. Unfortunately, all efforts to match the peaks of this spectra to previous work on Al-Fe-Ce compounds has been unsuccessful.

V. Conclusions and Recommendations

Conclusions

With the new system completed, Mossbauer spectra can easily be obtained, displayed, and analyzed. In addition, the system eliminates time normally wasted transferring data manually. The only problems observed, other than the system breaking down, were minor. These include poorly made front panel switches and rear panel sockets, slow response from joystick commands, and an incomplete instruction manual.

The spectra of the alloy samples show that two compounds are formed in the gas atomization stage and remain unchanged until the hot vacuum degassing stage. No spectra were obtained for further processing stages due to a lack of prepared samples. However, it is clear that Mossbauer spectrometry is useful for following changes in the lattice structure due to mechanical processing.

Recommendations

There are several changes or additions possible which would make the new system more valuable of a tool. First of all, the MS-900 and VT-900 (motor) should be equipped with a Moire interferometer to produce velocity data as the old system does. If this is done, Pate's modified version of MOSFUN could be used with minor changes. Secondly, the problems mentioned above concerning faulty switches and sockets should be resolved by replacing them. Thirdly, since the Physics Department of the Air Force Institute of Technology has limited access to an APPLE 2+

or 2e computer, it is recommended that the MS-900 be directly interfaced with the PDP 11/03. A brief discussion of the problems for this interfacing is included in appendix B. Fourth, it is recommended that the MOSFUN program be modified to accept triangular mode spectra.

As for the alloy studied, it is recommended that hot compacted-hot vacuum degassed and extruded samples be studied to follow the changes in the spectra due to these processing stages. Lastly, it is recommended that all samples be run at liquid nitrogen temperatures. This may result in new lines being revealed or sharpening of the present lines.

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APPENDIX A

Assembly and Operating Instructions

Assembly

1. It is assumed that an APPLE 2+ Or 2e computer with a monitor is set up with a disk drive in slot #6, a printer (optional) in slot #1, and a joystick connected according to its specific instructions. Slots #2 and #4 should be vacant.
2. Remove the top of the computer and place the Mossbauer interface card, MS-900-100, into slot #4 and bring the ribbon cable through the rear panel of the computer.
3. Place the Super Serial Card, with the switch settings set as discussed earlier, into slot #2 of the computer and mount the female DB-25 connector into the rear panel of the computer.
4. Place the cover back on the computer and connect the computer's power cord into the upper 115 VAC OUT power outlet on the rear panel of the MS-900. Plug the monitor's power cord into the lower 115 VAC OUT outlet.
5. Making sure that the power on the MS-900 is OFF, connect the ribbon cable from computer slot #4 to the rear panel connector of the MS-900 labeled COMPUTER.
6. Connect a mini-coax cable from the rear panel of the MS-900, marked 24V, to the connector marked POWER on the preamplifier.
7. Connect a second mini-coax cable from the rear panel of the

MS-900, marked ANALOG IN, to the connector marked OUTPUT on the preamplifier.

8. Connect a high voltage supply (not from MS-900) to the preamplifier/detector assembly.
9. Make sure that the three toggle switches marked EXT/INT are in the DOWN internal position and then connect the Mossbauer drive cable with the BLUE hexagonal connectors to the rear panel mating connector of the MS-900, labeled VT-900, and to the VT-900.
10. Connect the power cord to the female receptacle marked 115 VAC and plug the other end into the wall (power source).
11. Finally, connect one end of the 10 wire flat ribbon to the DB-25 connector of the Super Serial Card.
12. Refer to figure 14 for a block diagram of the system set-up.

Operation

1. With the power switch for the APPLE and monitor in the ON position, turn on the power switch on the front panel of the MS-900. The MS-900 controls the power system now.
2. Press the start button and the YELLOW light should come on.
3. Load the Mossbauer Master program into the disk drive and boot the program by typing PR#6 on the keyboard. The program menu should appear on the monitor.
4. Set the sampling time (time that a channel is open to receive data) to the desired value. The first two digits give the sampling time in microseconds, and the third digit is the multiplier in exponents of 10. A value of 200

microseconds is currently used.

5. The lower level and upper level discriminators of the SCA are set in a modified pulse height analysis mode. This mode is engaged by pressing the PHA button ONCE. With the LLD set at the lowest value and the ULD set at the highest value, press the GREEN button marked STORE. Now press the A key to start data acquisition. The CLEAR button may be used to erase the spectrum at any time. The scale of the spectra can be increased or decreased by moving the joystick up or down. Once a spectrum is seen, identify the 14.4keV peak and adjust the gain until this peak is centered on the screen. At this point one should see a pulse-height spectrum with three numbers on the bottom of the screen. From left to right, these numbers are the channel number, number of counts in that channel, and the full scale number of counts displayed. To select the 14.4keV peak only, move the vertical line cursor to the left edge of the peak and increase the LLD until no more counts are seen on the left side of the cursor. The cursor is controlled by moving the joystick left or right. Now move the cursor to the right edge of the peak and decrease the ULD until no more counts are seen on the right side of the cursor. To stop acquiring data, press the STORE button again and the light should go out. Now press CLEAR to erase the memory. If the PHA button is pressed again, the light will still be on and the normal PHA mode is engaged.
6. To obtain a Mossbauer spectrum, first press the ESC button

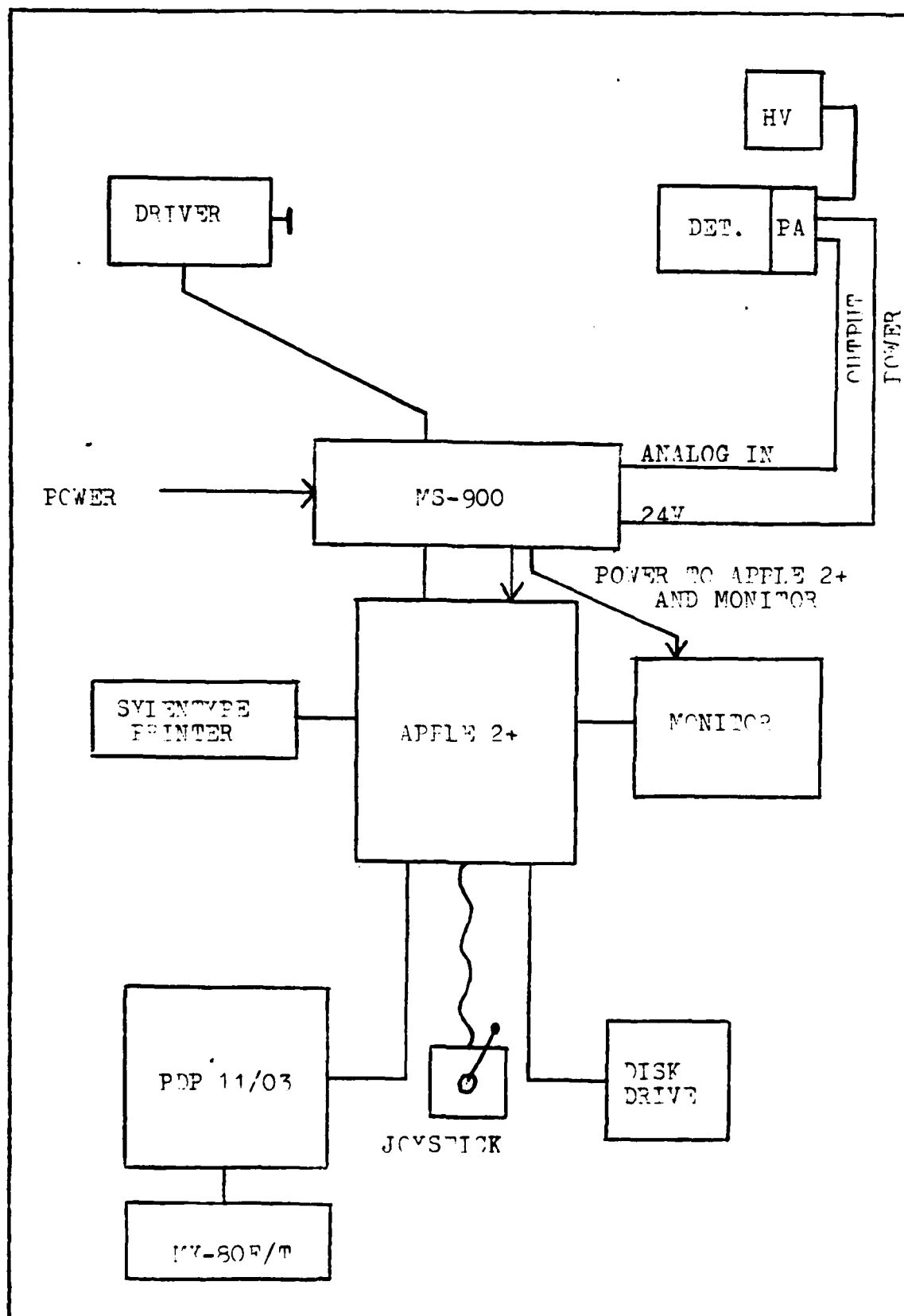


FIGURE 14. New Spectrometer Set-up

on the keyboard to return to the menu. Next, adjust the velocity values on the thumbwheel switches. For a full spectra, set the MAX VELOCITY to zero and the MIN VELOCITY to 6.0. Unlike the original spectrometer, these settings can be varied to produce a window through which only a part of the spectrum is acquired. Now press either the flyback or triangular mode button. The VT-900 driver should begin oscillating. The symmetry is now set by turning the symmetry potentiometer until the equilibrium position of the flexure plate is centered. Now, by pressing the STORE button and entering A on the keyboard, a Mossbauer spectrum should be seen.

7. Other buttons on the front panel include SUB, SINGLE, TIME, and an unmarked blue button. The SUB button is used to subtract, instead of add, counts from the spectrum. With the STORE button OFF, a single subtraction scan can be executed by activating the SINGLE button and pressing the START button. The TIME button is activated to store the number of pulses from the crystal controlled clock. When not activated, the number of sweeps are recorded. In either case, this data is stored in the first two channels. The blue button is pressed to activate the acquiring of velocity data if a Moire interferometer is installed.
8. At any time during operation, one can return to the menu by pressing the ESC key. This will not affect data acquisition at all. To use the APPLE for other purposes while data is being collected, return to the menu and type D for

displaying data. Then use CTRL-C to stop the program.

Finally, type TEXT to exit from the graphics mode.

9. Once all data needed is acquired, simply deactivate the STORE button. Next, return to the menu and follow the directions given. To send the data to the PDP, choose the "print spectral data option". Before entering all the information requested by the program, boot the PDP and type EDIT FILENAME.EXT/C on the PDP terminal. Then disconnect the DB-25 connector from the back of the VT-100 and connect it to the male DB-25 at the other end of the 10 wire ribbon coming from the Super Serial Card. Now enter all information about the spectrum as prompted by the program. One should then have to wait 90 seconds until all data is transferred. Now one should reconnect the VT-100 to the PDP and save the file by using the GOLD 7-EXIT command of the keyboard editor.
10. Before the file can be analyzed, one defect in the file must be eliminated. When the data is sent over, an extra line is placed at the beginning of the file. This line must be deleted before the file can be analyzed.
11. If the data is that of a calibration spectra, the peak channel locations (a total of 6) should be entered into the DATI and DRIVE subroutines of MOSFUN. The peak locations can be found by printing the data file and manually searching for them. Once found, follow the directions at the beginning of the MOSFUN program for editing MOSFUN subroutines. A more detailed description is provided in appendix A of Pate's

thesis.

12. Finally, to obtain a printout of the spectrum, the printer connected to the Apple should be used. The spectra printed by the MOSFUN program is very spread out since 1024 data points are plotted instead of 400. The ZOOM GRAPHICS program donated for use with an APPLE computer system is capable of printing spectra or parts of spectra in many different sizes and formats.

APPENDIX B

Interfacing the MS-900 Directly to the PDP 11/03

An interfacing of the MS-900 directly to the PDP would result in a simplified operation and eliminate the need for an APPLE computer system. Once completed, the PDP would perform all of the functions previously done by the APPLE and there would not be a need to connect/disconnect cables in order to send data to the PDP.

The work involved for this interfacing involves both hardware connections and software changes. From discussions with Captain Paul Bailar, U.S.A.F, who had previously worked on a spectrometer - computer interfacing, a basic outline of the problem was obtained (12). First, the interface card for the MS-900 should be studied to understand exactly what functions it performs. This would enable one to build a similar interface for joining the MS-900 and the PDP. Second, once a hardware connection is made, software will have to be written for the PDP so that it may understand the signals sent from the MS-900. Third, the Mossbauer Master program will have to be studied so that it may be re-written for the PDP. The current version is written in BASIC for an APPLE computer and uses machine specific commands. Thus, a simple translation to FORTRAN is not possible. Finally, in order for the spectra to be displayed on a terminal as it is currently done, graphics capability will have to be added to the VT-100 or the VT-100 can be replaced with a VT-55

terminal. In either case, the FORTRAN version of the Mossbauer Master program should permit the joystick functions to be replaced by keyboard commands.

APPENDIX C

Listings For:

Mossbauer Master program

Subroutine DATI •

Subroutine DRIVE

THE DISK ?": PRINT

```

4511 INPUT "ENTER TOUR,NOUR,N,PERI,NDRU SEPARATED BY COMAS.":TU,NO,N,PE,N
0
4512 INPUT "FORMAT? (EX. 8F9.0) ":F$
4520 INPUT "SEND DATA TO SILENTYPE OR PDP-11? (1 OR 2):":Z
4521 PR# Z
4530 PRINT : PRINT A$
4531 PRINT F$
4532 PRINT TU;" ";NO;" ";N;" ";PE;" ";NO;" ";MP;" ";NS
4540 BASE = 35072
4550 FOR T = 0 TO 3048 STEP 24
4570 FOR S = 0 TO 21 STEP 3
4580 X = PEEK (BASE + T + S) + PEEK (BASE + T + S + 1) * 256 + PEEK (BA
SE + T + S + 2) * 65536
4581 IF X < 10000000 THEN Q = 3
4582 IF X < 1000000 THEN Q = 4
4583 IF X < 100000 THEN Q = 5
4585 IF X < 10000 THEN Q = 6
4586 IF X < 1000 THEN Q = 7
4587 PRINT SPC( Q - 1)X;
4590 NEXT S
4600 PRINT
4605 IF PEEK (49152) = 155 THEN 4620
4607 Q = 0
4610 NEXT T
4620 PR# 0
4630 GOTO 20
5000 REM DISPLAY SUBROUTINE
5005 IF PEEK (2783) < > 160 THEN GOSUB 6000
5010 IF PEEK (34304) = 162 THEN 5030
5020 PRINT : PRINT D$;"BLOAD JOYSTICK"
5030 CALL 34304
5040 BASE = 35072
5042 CH = PEEK (961) + PEEK (962) * 256
5045 C3 = CH * 3
5050 COUNT = PEEK (C3 + BASE) + PEEK (C3 + BASE + 1) * 256 + PEEK (C3 +
2 + BASE) * 65536
5055 UTAB (21)
5057 PRINT " "; HTAB (27): PRINT " ";
5058 HTAB (1)
5060 PRINT CH;: HTAB (10): PRINT COUNT;: HTAB (24): PRINT 2 ^ (24 - PEEK
(975));" FS"
5070 FOR T = 0 TO 39
5080 POKE 2640 + T, PEEK (1616 + T)
5090 NEXT
5100 A = PEEK (49152)
5110 IF A < > 155 THEN RETURN
5120 GOTO 20
6000 T = 2640:U = 2768:V = 2896:W = 3024
6010 FOR S = 0 TO 39
6020 POKE (S + T),160
6030 POKE (S + U),160
6040 POKE (S + V),160
6050 POKE (S + W),160
6060 NEXT S
6070 RETURN

```

SUBROUTINE DAT1 (N1,N2,N3)

COMMON /UNIT/ NRD,NWR,NCR,LFR,LFD,NFL,NVS,MAXN,MAXM,MAXF,NV(121)
COMMON /DAT/ VMAX,PERI,Y(1024),ID(40),NDRV,N,NF,VEL(10)
COMMON /THEO/ F,P(32),DF(32),NTEO,M,MF,KTEO(20),KP(32)
COMMON /FLD/ P3,B,V,VCON(65),V1,V2,GEO,B0,C0,NFLD,MSH,MPLX,1(11)
COMMON /TRA/ IN(81),OUT(16)

DIMENSION KFRM(8),IFRM(8),INST(4)
DATA IFRM/2H(1,2H0F,2H8.,2H0),2H ,2H ,2H ,2H /
DATA INST(1)/1HL/,INST(2)/1HZ/,INST(3)/1HH/,INST(4)/1H#/
DATA NY/1HY/

N1 = INPUT UNIT
N2 = FACTOR FOR SEARCHING DROPPED CHANNELS
N3.NE.0 ERROR RETURN

N9=N2
IF (N1.EQ.0) GOTO 285
READ(N1,5200,END=202) (ID(I),I=1,40)
READ(N1,5200,END=202) (KFRM(I),I=1,8)
READ(N1,5210,END=202) (IN(I),I=1,80)
GOTO 203

EOF

202 WRITE(NWR,6205) N1

N=0

N3=1

RETURN

207 CALL TRANS(NN)

TOVR=OUT(1)

NOVF=OUT(2)

N=OUT(3)

PERI=OUT(4)

NDRV=OUT(5)

MPLX=OUT(6)

NST=OUT(7)

NST=189

205 IF (N.EQ.0) N=1024

MORE THAN MAXN POINTS

IF (N.LE.MAXN) GOTO 220

N=0

N3=1

WRITE(NWR,6200) MAXN

RETURN

220 IF (NDRV.EQ.0) NDRV=3

IF (PERI.EQ.0.) PERI=N*2.

IF (NST.EQ.0) NST=189

P3=PERI * .5 + .5

230 IF (IFRM(1).NE.IFRM(8)) GOTO 240

DO 250 I=1,8

250 IFRM(I)=IFRM(I)

```

240 WRITE(NWR,6230) (ID(I),I=1,39)
WRITE(NWR,6240) TOVR,NOVF,N,PERI,NDRV,KFRM
DO 241 I=1,MAXN
241 Y(I)=0.
READ(N1,KFRM,END=250) (Y(I),I=1,N)
C
C CALCULATE AVERAGE TIME OSC. COUNTS
C
99 TIME=0.
DO 100 I=1,2
TIME=TIME+Y(I)+16777216.*TOVR
100 Y(I)=0.
TIME=TIME/2
C
C Fe57 peaks 1 thru 6 (mm/sec) w/respect to SNP.
VCON(2)=-5.0494
VCON(3)=-2.8167
VCON(4)=-0.5800
VCON(5)=1.1007
VCON(6)=3.3376
VCON(7)=5.5754
C
C Y(I) where I=channel numbers for above peaks. From NFECAL.EXT
C 18-NOV-83 on MS-900.
Y(189)=0.
Y(331)=0.
Y(476)=0.
Y(582)=0.
Y(733)=0.
Y(878)=0.
C
C Use GOTO statement to by-pass normal velocity extraction from
C data.
C GOTO 107
C
C EXTRACT VELOCITY DATA, ACCOUNT FOR
C OVERFLOWS AND ZERO AFTER PUTTING IN VCON.
C
IIII=0
III=0
NEND=PERI/2
DO 101 I=19,NEND,MPLEX
VJMP=Y(I+MPLEX)-Y(I)
IF(VJMP.GE.500000.) III=III+1
101 CONTINUE
J=1
DO 102 I=NST,NEND,MPLEX
J=J+1
IF(III.EQ.0) GOTO 105
VJMP=Y(I+MPLEX)-Y(I)
IF(J.GT.65) GOTO 102
VCON(J)=Y(I)+FLOAT(III)*16777216.
IF(VJMP.GE.500000.) III=III-1

```

```

      GOTO 102
105  VJMP=Y(I)-Y(I+MFLEX)
      IF(J.GT.65) GOTO 102
      VCON(J)=Y(I)+FLOAT(IIII)*16777216.
      IF(VJMP.GE.500000.) IIII=IIII+1
102  Y(I)=0.
      Y(399)=0.
      III=-1
      DO 106 I=3,J-1
      VJMP=ABS(VCON(I-1))-VCON(I)
      IF(ABS(VCON(I)-VCON(I+1)).GT.(2.*VJMP)) III=1
      VCON(I)=VCON(I)*FLOAT(III)
106  CONTINUE
      VCON(2)=-VCON(2)

107  VCON(1)=7
      NN=N1
      NK=N2
      N1=0
      N2=NST
      CALL DRIVE(N1,N2)
      N1=NN
      N2=NK
      GOTO 260

C
C      LESS THAN N DATA IN PARTITION N1
C
250  WRITE(NWR,6210) I,N
      DO 255 J=I,N
255  Y(J)=0.
      GOTO 99

C
C      ADD OVERFLOWS, ZERO CHANNELS OUT OF RANGE
C
260  IF(N1.NE.NCR) REWIND N1
      MSH=0
      G4=16777216.*FLOAT(NOVF)
      IF(NOVF.LT.0) G4=-1048576.*FLOAT(NOVF)
      IF(N9.EQ.0) GOTO 264
      DO 262 I=3,N
      IF(Y(I).NE.0.) GOTO 263
262  CONTINUE
263  G2=N9
      G3=Y(I)+G4
      G2=SQRT(G3+G4)*G2
264  DO 280 I=1,N
      IF(Y(I).EQ.0.) GOTO 280
      Y(I)=Y(I)+G4
      IF(N9.EQ.0) GOTO 280
      IF(ABS(Y(I)-G3).LE.G2) GOTO 275

```

```

WRITE(NWR,6220) I,Y(I)
IF(NVS.EQ.0) GOTO 270
265 WRITE(NWR,9000)
READ(NRD,5210,END=265)JJ
IF(JJ.NE.NY) GOTO 280
270 Y(I)=0.
GOTO 280
275 G3=Y(I)
280 CONTINUE
C
C ZERO CHANNELS, FIT INTERVALS, GENERATE HALF SPECTRA
C
285 DO 286 I=1,N
286 Y(I)=ABS(Y(I))
290 IF(NVS.EQ.0) GOTO 287
WRITE(NWR,9210)
NN=PERI
IF(N.LT.NN) GOTO 287
WRITE(NWR,9215)
287 READ(NRD,5210,END=290) NN
DO 291 K=1,4
IF(NN.EQ.INST(K)) GOTO 294
291 CONTINUE
C
C INVALID INPUT
C
IF(NVS.EQ.1) GOTO 290
292 WRITE(NWR,6275)
N3=1
RETURN
294 GOTO (295,295,300,340),K
295 IF(NVS.EQ.1) WRITE(NWR,9220)
READ(NRD,5210,END=295) (IN(J),J=1,NPL)
IF(IN(1).EQ.INST(4)) GOTO 290
CALL TRANS(NN)
IF(NN.EQ.0) GOTO 290
K1=ABS(OUT(1))
K2=ABS(OUT(2))
IF(K2-K1) 300,302,302
300 NN=K1
K1=K2
K2=NN
302 IF(K2.GT.N) GOTO 295
IF(K1.EQ.0) K1=K2
IF(K1.EQ.0) GOTO 295
KK=K-2
IF(KK.EQ.-1) WRITE(NWR,6250) K1,K2
IF(KK.EQ.0) WRITE(NWR,6260) K1,K2
DO 304 J=K1,K2
304 Y(J)=FLOAT(KK)*ABS(Y(J))
GOTO 295
320 NN=PERI
IF(N.LT.NN) GOTO 290

```

```

      IF (NVS.EQ.1) WRITE(NWR,9240)
      KP(3)=0
      READ(NRD,5210) KK
      IF(KK.EQ.INST(1)) GOTO 330
      NN=N/2
      DO 325 I=1,NN
      G1=Y(I)
      II=N-I+1
      Y(I)=Y(II)
325   Y(II)=G1
330   N=N/2
      WRITE(NWR,6270) N
      GOTO 290
340   NF=N
      DO 350 I=1,N
      IF(Y(I)) 345,345,346
345   NF=NF-1
      GOTO 350
346   B=Y(I)
350   CONTINUE
      NFLD=0
      RETURN
C      *****
5200  FORMAT(40A2)
5210  FORMAT(80A1)
C      *****
9000  FORMAT(1H0,'ZERO Y/N'/)
9200  FORMAT(1H0,F5.0,' TIME OVERFLOWS',',',',',15,' DATA OVERFLOWS'/)
9210  FORMAT(1H0,'* = END'/ ' Z = ZERO CHANNELS'/ ' L = SET FIT LIMITS'/)
9215  FORMAT(1H , 'H = GENERATE HALF PERIOD SPECTRUM'/)
9220  FORMAT(1H , 'CHANNEL 1, CHANNEL 2'/)
9240  FORMAT(1H , 'L = LEFT, R = RIGHT HALF'/)
C
6200  FORMAT(1H0,'***** ERROR ***** MORE THAN',15,' POINTS')

6205  FORMAT(1H0,'***** ERROR ***** EOF ON UNIT',13)
6210  FORMAT(1H0,'***** WARNING ***** POINTS',15,' TO',15,' ZEROED')
6220  FORMAT(1H0,'***** WARNING ***** POINT',14,' OUT OF RANGE',F10.0)
6225  FORMAT(1H0,'***** WARNING ***** VELOCITY OVERFLOW PROBLEM')
6230  FORMAT(1H0,1H ,39A2)
6240  FORMAT(1H0,4X,'TIME OVERFLOWS',F6.0,/5X,'DATA
      1 OVERFLOWS',15/5X,'CHANNELS',7X,15/5X,
      2'PERIOD',7X,F10.3/5X,'DRIVE MODE',6X,13/5X,
      3'INPUT FORMAT ',8A2)
6250  FORMAT(1H0,14,' - ',14,' NOT FITTED')
6260  FORMAT(1H ,14,' - ',14,' ZEROED')
6270  FORMAT(1H , 'HALF PERIOD SPECTRUM ',15,' CHANNELS')
6275  FORMAT(1H , '***** ERROR ***** INVALID INPUT')
      END

```

```

SUBROUTINE DRIVE (N1,N2)
COMMON /UNIT/ NRD,NWR,NCR,LPR,LFD,NPL,NVS,MAXN,MAXM,MAXF,NV(121)
COMMON /DAT/ VMAX,PERI,Y(1024),ID(40),NDRV,N,NF,VEL(10)
COMMON /THEO/ F,P(32),DF(32),NTEO,M,MF,KTEO(20),KP(32)
COMMON /FLD/ P3,B,V,VCON(65),V1,V2,GEO,B0,C0,NFLD,MSH,MPLX,TIME
COMMON /TRA/ IN(81),OUT(16)
COMMON /LIN/ BB(32),A(32,32)

C
C   DIMENSION X(65),XY(65),XDP(10),XYDP(10)
C
C   N1 = 0  CALCULATE VELOCITY COEFF.
C   N1 = 1  VELOCITY V FROM CHANNEL NUMBER XX
C   N1 = 2  V,GEO
C   N1 = 3  DERIVATIVES P(1)-P(3)
C   N1 = 4  DERIVATIVES P(1)-P(2)
C
C   N2 = 1st CHANNEL CONTAINING VELOCITY (N1=0)
C   N2 = CHANNEL NUMBER (FOR N1 = 1-4)
C   N2 = 0  ERROR RETURN
C
C   NDRV = 1  TRIANGULAR WAVE MODE
C   NDRV = 2  SINE WAVE MODE
C   NDRV = 3  FLYBACK WAVE MODE**
C
C   IF(N1.NE.0) GOTO 1000
C   NST=N2
C   NFN=VCON(1)
C   GOTO (1,2,3), NDRV
1  WRITE(NWR,6000)
   RETURN
2  WRITE(NWR,6200)
   VCON(1)=0.
   RETURN
3  WRITE(NWR,6300)

C   Channel numbers for NFECAL.EXT peaks 1 thru 6.

C   X(2)=NST
C   X(3)=331.0
C   X(4)=476.0
C   X(5)=582.0
C   X(6)=733.0
C   X(7)=878.0
C   XY(2)=VCON(2)*156.25/TIME
C   XY(2)=VCON(2)
C   DO 401 I=3,NFN
C   X(I)=X(I-1)+MPLX
C401 XY(I)=VCON(I)*156.25/TIME
401 XY(I)=VCON(I)
C   L=2
C   K=1

```

```

C
C      FIND MIN AND MAX VALUES FOR X
C
      XMIN=X(2)
      XMAX=X(2)
      DO 402 I=3,NFN
      XMIN=AMIN1(XMIN,X(I))
402   XMAX=AMAX1(XMAX,X(I))
C
C      ZERO ARRAYS FOR SUMMING
C
      MM=2*K+1
      DO 403 I=1,MM
      XDP(I)=0.
      XYDP(I)=0.
403   CONTINUE
C
C      TRANSFORM RANGE OF X TO (-1,1) AND COMPUTE SUMS OF
C      POWERS OF X AND SUMS OF XY TIMES POWERS OF X.
C
      C1=2.0/(XMAX-XMIN)
      C2=(XMAX+XMIN)/(XMAX-XMIN)
      LU=2*K+1
      LL=K+2
      DO 404 II=2,NFN
      XP=1.
      XI=C1*X(II)-C2
      DO 405 I=1,L
      XDP(I)=XDP(I)+XP
      XYDP(I)=XYDP(I)+XP*XY(II)
405   XP=XP*XI
      DO 404 I=LL,LU
      XDP(I)=XDP(I)+XP
404   XP=XP*XI
      DO 406 I=1,L
      BB(I)=XYDP(I)
      DO 406 J=1,L
      A(I,J)=XDP(I+J-1)
406   CONTINUE
C
C      CALL LINEQ AND FIT VELOCITY DATA
C
      N1=0
      N2=2
      CALL LINEQ(N1,N2)
C
C      MOVE VELOCITY CALIB. TO VEL ARRAY
C
      DO 407 I=1,L
      JK=K-1+2
407   VEL(JK)=BB(I)
C
C      ADJUST COEFF. TO ORIGINAL RANGE OF X
C

```

```

DO 408 I=1,K
DO 408 J=1,I
408 VEL(J)=VEL(J)*C1
C1=(XMAX+XMIN)/2.0
DO 409 I=1,K
MM=L-I+1
DO 409 J=2,MM
409 VEL(J)=-C1*VEL(J-1)+VEL(J)
C
C COMPUTE MAXIMUM AND ROOT MEAN SQUARE
C ERRORS AND OUTPUT ERROR ANALYSIS
C
WRITE(NWR,6400)
EMAX=0.
SUM=0.
VMAX=0.
DO 410 I=2,NFN

YC=VEL(1)
DO 411 J=1,K
411 YC=YC*X(I)+VEL(J+1)
VMAX=AMAX1(VMAX,ABS(YC))
DIFF=YC-XY(I)
IF (I-1.GT.L) GOTO 413
WRITE(NWR,6410) I,X(I),XY(I),YC,DIFF,VEL(I-1)
GOTO 412
413 WRITE(NWR,6420) I,X(I),XY(I),YC,DIFF
412 EMAX=AMAX1(EMAX,ABS(DIFF))
410 SUM=SUM+DIFF**2
ERMS=SQRT(SUM/FLOAT(NFN-1))
WRITE(NWR,6430) EMAX,ERMS
RETURN

C
1000 GOTO (10,100,200),NDRV
C
C FLYBACK MODE
C
200 IF(N1.GE.3) GOTO 250
XX=N2
PER=PERI/4.
IF(XX.LE.PERI/2.) GOTO 232
XX=XX-PERI
C1=P3-PER-XX
S=1.
GOTO 240
232 C1=P3+PER-XX
S=-1.
240 C4=S*VMAX/PER
V=VEL(1)*XX+VEL(2)
IF(N1.EQ.1) RETURN
CX=V/VMAX
C2=S*(CX*CX-1.)
C5=1.+P(2)*C2
GEO=1./C5/C5
RETURN

```

```

C
C      DERIVATIVES
C
250  MM=KP(1)
      IF (MM.GT.0) DF(1)=GEO
      MM=KP(2)
      IF (MM.GT.0) DF(MM)=-2.*GEO*B0*C2/C5
      IF (N1.EQ.4) RETURN
      MM=KP(3)
      IF (MM.GT.0) DF(MM)=GEO*((V/XX)*C0-B0*P(2)*V*4./C5/VMAX/PER)
      RETURN

C
C      TRIANGULAR MODE
C
10   WRITE(NWR,6000)
      RETURN

C
C      SINE WAVE NOT AVAILABLE
C
100  WRITE(NWR,6200)
      RETURN

C
5000 FORMAT(80A1)
6000 FORMAT(1H ,4X,'DRIVE MODE TRIANGULAR WAVE NOT AVAILABLE')

6200 FORMAT(1H ,4X,'DRIVE MODE SINE WAVE NOT AVAILABLE')
6300 FORMAT(1H ,4X,'DRIVE MODE FLYBACK WAVE')
6400 FORMAT(1H ,//,10X,36HPOLYNOMIAL LEAST SQUARE FIT
1ANALYSIS,/,4H 1,6X,7HX-GIVEN,7X,7HY-GIVEN,6X,
28HY-FITTED,8X,5HERROR,10X,6HVEL(1),/)
6410 FORMAT(1H ,I3,4X,4(1PE10.3,4X),1PE13.6)
6420 FORMAT(1H ,I3,4X,4(1PE10.3,4X))
6430 FORMAT(1H ,9X,5HEMAX=,1PE15.6,9X,5HERMS=,1PE15.6)
      END

```

VITA

Joseph Freddie Harmon Jr. was born on July 27, 1960, in Charleston, South Carolina and is the son of Joseph F. Harmon Sr. and Peggy V. Harmon. He graduated from R.B. Stall High School in Charleston, South Carolina in June, 1978. He attended The Citadel from August, 1978 until May, 1982 and was enrolled in Air Force R.O.T.C. during this period. In May of 1982 he graduated with a Bachelor of Science in Physics and recieved a commission in the United States Air Force. He and his wife Rosie have a daughter, Ashley.

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) In this study, a computer based Mossbauer spectrometer was built using a new MS-900 spectrometer, an Apple 2+ computer system, and a PDP 11/03 computer system. The APPLE was used as the link between the spectrometer and the PDP, which is used to analyze the Mossbauer spectra. In addition to minor hardware connections, software changes were made to the analysis program so that it could accept the data format		

produced by the new spectrometer. Due to equipment failure, only preliminary tests were made of the new system, however the tests were positive. Originally, an Al-Fe-Ce alloy was chosen to be studied by the new system. Instead, the alloy, chosen because of its excellent high temperature properties, was studied by the original Mossbauer spectrometer system. The goal was to follow and identify changes in the micro-structure of the alloy due to different processing stages. Although changes in the spectra were identified with processing stages, it is still unclear as to what compounds are related to the observed spectra.

END

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