A CONTINUOUS MODE DATA ACQUISITION TECHNIQUE FOR PROTON RECOIL PROPORTIONAL COUNTER NEUTRON SPECTROMETERS

by

E. F. Bennett

MASTER

FUSION POWER PROGRAM

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9700 South Cass Avenue
Argonne, Illinois 60439

Operated by
The University of Chicago
for the U.S. Department of Energy
under Contract W-31-109-Eng-38

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ARGONNE NATIONAL LABORATORY
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Work supported by

Office of Fusion Energy
U.S. Department of Energy
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ABSTRACT

The existing proton recoil proportional counter measurement technique used at FNS for joint FNS-ANL fusion blanket neutron spectroscopy requires that numerous piece-wise (but overlapping) measurements be carried out at a sequence of fixed counter voltages. The composite results of all of these independent measurements are required to construct a single neutron spectrum. This approach has been found to be both inefficient and subject to systematic errors. An alternative approach, in which data is acquired continuously using a slow time modulation of the high voltage bias supply, is here described. The electronics requirements are consistent with the basic detector/amplifier systems now operable at FNS. Some additional hardware including a programmable high voltage bias supply and a random amplitude test pulse generator are necessary. A description of the electronics and data acquisition hardware for these measurements will be provided at a later date. In this report we emphasize the numerical procedures involved to acquire and reduce data, and provide an illustrative example using one of the hardest neutron spectra readily available for this work at ANL (the JANUS facility).

1. INTRODUCTION

Proportional counters may be used for measurements of ionization down to, and including, single electrons. This, together with use of hydrogen-containing gas as part of the filling, has resulted in extensive use of proportional counters as neutron spectrometers and dosimeters. Electron multiplication at the fine-wire anode of a proportional counter varies approximately exponentially with applied voltage. It would seem, therefore, that it should be sufficient to increase the voltage on the counter until those events of least initial ionization develop a pulse height well in excess of preamplifier noise. All events of interest could then be analyzed with a pulse height analyser of adequate channel capacity. Considerations of preamplifier noise together with non-linearity (through space charge saturation) of the electron avalanche mechanism in the counter contrive to make this simple mode of operation impractical for those applications requiring a very large range of energy of events. For example, in order to amplify the ionization equivalent to that created in stopping a 1 keV proton in the counting gas to a level well in excess of noise, a gas multiplication of about 1000 is required. Events at the high-ionization limit would be subject to the same gas multiplication, and the very large accumulation of charge in the resulting anode avalanche would become space charge limited; the relationship between pulse height, as measured, and ionization, as produced initially in the gas, would cease to be linear. The space charge saturation problem can perhaps be appreciated in another context. Consider the use of a parallel plate device for ionization detection. Electron-ion pairs are separated and collected over an area determined by the range of the initiating event together with whatever diffusion broadening occurs during transit of the free-electron cloud to the positive electrode. The proportional counter, by contrast, will focus the initial electron cloud inward along radially symmetric electric field lines to the anode, which is typically only about $1/1000$ of the cathode diameter. Due to this inherent focusing effect, the spatial density of charge at the counter anode is higher by perhaps 1000 relative to the spatial density of charge collected by a parallel plate detector. At these charge density levels, space charge saturation effects occur for the proportional counter which would be non-existent in parallel plate geometry.

As a practical matter, therefore, it is desirable to minimize the total charge collection for the proportional counter in order to retain linearity between pulse height and initial ionization. Broad range energy coverage, under these restrictions, is then achieved by changes in voltage such that limits are placed upon the total charge collection (initial charge times multiplication) for events of interest. Data acquisition may proceed over a finite number of discrete voltage steps where the gain of the pulse amplifier is fixed at a conservatively high value to avoid non-linearity (but to still retain sufficiently low noise levels). This procedure leads to a piece-wise determination of the spectrum; the full result is a montage of individual results covering only a limited range of the spectrum at each voltage setting. Each piece of the spectrum must be normalized for source fluence, live time, etc. The amount of redundant data is large, there are normalization uncertainties, and a substantial amount of manipulation is required to produce a single composite final result.

In order to circumvent the above-mentioned difficulties for proportional counter data acquisition, we have tested a different approach in which data acquisition is accomplished by an arbitrary (but periodic) time modulation of the high voltage bias. For each event the value of the counter voltage is read together with the amplitude of the pulse produced. The voltage value, together with a calibration table which permits the gas multiplication to be derived for any voltage, allows the absolute energy of any event to be derived on an event-by-event basis. Since the voltage is read in as data, together with values for the pulse amplitude, any modulation of the voltage is acceptable as long as the range of the modulation is sufficiently great to include all of the energy region of interest. Restrictions may be placed upon any analyzed event to assure that the total ionization collected is within limits imposed by space charge and amplifier noise.

Having removed the restriction that pieces of the spectrum are each to be accumulated at fixed voltages, we can make use of any periodic voltage modulation profile (i.e. linear ramp, sine wave etc.). A single measurement need not be terminated until a suitable accumulation of data over the entire energy region of interest has been made, irregardless of the modulation. The modulation period will ordinarily be chosen to be rather long, of the order of several minutes or so. This implies that measurements are feasible only when

substantial source instabilities over intervals of this magnitude do not occur. The modulation technique does retain an inherent inefficiency mechanism since events are selected subject to restrictions on total ionization collected. This is an unavoidable penalty where space-charge saturation of the multiplication process is of concern. The counter will record a substantially higher total detection rate than the rate at which events of acceptable magnitude are processed. On the other hand, continuous-mode operation is relatively more efficient than fixed-voltage operation since considerable overlap of data is required for fixed-voltage operation and there is a substantial time penalty associated with repeated termination and re-start of acquisition as required for the fixed-voltage mode.

The entire data acquisition system including amplifiers, analog-digital converters, test pulser and programmable high voltage supply has been fabricated from IC components in a light-weight, low-volume package with interface to a PC. The electronics will be described elsewhere. Operation of the system is equivalent to that exhibited by the more conventional spectrometers; the detector is placed in the radiation field, acquisition is enabled for a time sufficient to gain acceptable counting statistics, and the full range of data is available at the termination of the run.

In the following, details of the operation of the acquisition system, together with codes and examples of the application of the procedures for neutron spectroscopy will be described. Hardware for implimenting the acquisition technique will be reported at a later date.

The procedures described here involve the use of a number of relatively short routines run sequentially; those routines which perform data acquisition also include an appropriate machine language counterpart. It is probably desirable not to combine these code sections together at this time even though this would substantially reduce the total code length. As outlined here, each section performs, for the most part, some operation that can be described more-or-less independently of other operations. Extensive built-in options for editing data are included in the codes. These options could largely be eliminated in a compact procedure containing only the essentials.

The basic acquisition procedure described here is, in any event, now obsolete. 32 bit processors operating at 16 MHz and higher are now widely available at low cost. Use of this newer PC equipment is highly advantageous

for this work. Larger arrays, with an attendant increase in resolution and a simplification of the acquisition code, will become possible using the newer hardware.

II. DATA ACQUISITION IN A CONTINUOUS MODE

A block diagram depicting the basic data acquisition system is depicted in Fig. 1. The arrangement shown is for positive high voltage applied to the counter anode with a high voltage blocking capacitor between anode and preamplifier. Negative high voltage applied directly to the cathode is superior since the blocking capacitor can be dispensed with. In most applications for small sized counters where space is limited the positively biased anode is more convenient since independent electrical insulation of the cathode is not required.

The preamplifier is the conventional "charge sensitive" type. Test pulses are fed directly to the input FET gate through a small-value capacitance (1pF).

High voltage is generated using a DC/DC converter with programmable input. A high voltage divider resistance is attached to the high voltage output of the converter. The divider output is proportional to high voltage but does not exceed a value of about 10 volts maximum.

Pulses from the preamplifier drive a pair of analog amplifiers in parallel. The "y" amplifier is an integrating amplifier with good low frequency response. Irregardless of the time profile of the counter induction response to an ionizing event, the y amplifier will deliver a peak pulse amplitude proportional to the value of total ionization. By contrast, the "x" amplifier has limited low frequency response and therefore tends to "differentiate" the induction profile. The differentiated pulse contains information useful for the identification of the origin of the pulse; pulses of the same energy (y pulse height) can originate from different underlying ionization phenomena (see Ref. 1 for example).

All three analog amplitudes (y, x and v) are presented to a multiplexer, digitized to 4096 channels maximum, and read into data registers of the PC. An event analysis is initiated only if the peak value of the y pulse falls within the acceptance range of a pair of level discriminators. Within the

FIG.1 BLOCK DIAGRAM OF THE DATA ACQUISITION SYSTEM.

acquisition program, the ratio of the x amplifier pulse to the y amplifier pulse is formed, and this ratio (scaled to 32 channels maximum) is stored in memory together with the appropriate energy of the event. Event energy is determined from the y amplifier pulse together with the value of gas multiplication at the voltage for the event. The gas multiplication is taken from a calibration table in which multiplication is expressed as a function of voltage. The stored result then consists of a two-dimensional array; one dimension of which is energy (actually, log of energy) and the other is the corresponding x/y value. Test pulses are fed to the preamplifier and are processed in exactly the same manner as ionization data. The rise time of the test pulser is adjusted, however, to exceed that of any pulse arising from an ionizing event. Test pulses are, in consequence, recognized as that region of the x/y spectrum of greatest amplitude.

Fig. 2 contains an example of an x/y spectrum at a single energy value for a hydrogen filled proportional counter exposed to a mixed neutron and gamma radiation field. Three distinct regions of the spectrum are apparent. The region at the highest channel number is from test pulses and is easily distinguished from events of lower x/y amplitude. The lowest (and least well defined) region is an electron loss distribution from gamma interactions in the counter walls. The central spectrum is from proton recoil events. Although the shape of the gamma and neutron spectra changes with changing energy, the test pulse line has fixed width and location. Following termination of a measurement, events in each category are integrated for each energy to provide independent spectra for test pulses, for proton recoils, and for gammas.

The test pulser provides a fixed rate of random amplitude pulses input to the preamplifier; these test pulses are processed in the same manner as are pulses whose origin is from ionizing events. It is the use of the test pulse distribution that allows the appropriate normalization to be made to the proton recoil distribution irregardless of the way in which counter voltage is varied during the course of the measurement.

Data acquisition and analysis are done using several codes which will be considered in detail together with data from a neutron spectrum measurement at the JANUS facility (see Ref. 2). The first code, designated PRINIT (Appendix I), is intended to provide results useful in setting up the system. The

FIG. 2 32 CHANNEL X/Y SPECTRA IN A MIXED GAMMA/NEUTRON FIELD
WITH RANDOM TEST PULSES INCLUDED.

machine subroutine PRMINP called by PRINIT contains the instructions for input of the actual data used. The code RAMPDA (Appendix II) is the data acquisition procedure; the actual acquisition is done within the machine callable routine RAMPIN. An option exists within RAMPDA in which only the test pulse spectrum is acquired in the absence of applied counter voltage. This option needs be run only once for a given system setup configuration. The test pulse calibration result is applied to the final analysis of all runs using identical parameter sets, which includes the type of voltage modulation and the voltage extremes. The code RMPRDN (Appendix III) contains all of the procedures necessary to provide the individual spectra for test pulses and for proton recoils and gammas from the raw data as determined from RAMPDA. In addition to the raw data generated by RAMPDA, a background gamma spectrum is also required for the analysis of raw data. It will seldom be convenient to provide a background gamma spectrum of precisely the same nature as that which exists during data acquisition in a mixed neutron/gamma field of interest. We have found that an adequate approximation to the gamma field existing during measurements can be obtained by use of pure sources alone (Co-60, Cs-137) placed in proximity to the counter. Results using the pure sources are adequate to allow data reduction to be carried out with little sensitivity to the true spectrum of the gamma source for most practical situations.

RMPSNS (Appendix VI) is the last of the procedures and converts measured spectra as produced from RMPRDN to neutron spectra. RMPSNS contains a substantial amount of internal edit of sequential steps and these will be followed in detail using actual data to illustrate the procedure.

Before entering a detailed discussion of each of the acquisition and reduction procedures, the calibration for the detector will be described. The proportional counter is not an absolute energy detector and a full calibration curve is required from which the energy at any value of pulse height can be inferred if the corresponding detector bias voltage is known.

Implimentation of the ramp acquisition procedure has only been carried out using a PC-XT (16 bit, 4.77 MHz). Pulse processing times for this system are long and significant dead time losses can occur for acquisition rates of only a few thousand counts per second or so. The use of only 16 bits for machine register operations limits array size as well as the accuracy of data. Software formatting for double precision operations would entail

substantial, and unacceptable, increases in event processing times. These restrictions are eliminated using the newer 32 bit processors having clock frequencies of 16 MHz or more. The numerical procedures as outlined here are specific for the old machines however, and would require re-programming to operate on the newer PC's.

III. CALIBRATION

There is no universal prescription for predicting the counter gas multiplication value A for all voltages within the range of interest for proportional counters. Gas multiplication depends upon gas species and pressure as well as upon voltage and the dimensions of the anode and cathode. Multiplication is also subject to space-charge saturation, which is sensitive to the spatial extension of the initiating event. When calibration measurements are carried out using ionizing events of substantial track length, space-charge saturation is minimized. Even if the absolute gas multiplication were derivable from gas and counter parameters, the complexities of the basic counter induction effect and of the filter characteristics of the analog amplifiers together with uncertainty in W , the energy loss per ion pair for the gas, and uncertainties in the absolute value of the preamplifier feedback capacitor would require at least one calibration against a known source of ionization. The quantity here referred to as " A " is not, therefore, to be taken as the true absolute electron multiplication, but rather as a quantity proportional to multiplication but with substantial uncertainty in the factor of proportionality. From the calibration of relative A vs. voltage and an absolute value for the energy scale at some particular voltages the energy corresponding to any value of y amplifier pulse height may be derived. The gain of the analog pulse amplifiers does not vary during data acquisition; only the counter bias voltage is modulated to allow the measurement to include the full range of energies of interest.

Although calibration data for proportional counters will be sensitive to detector details, it has been universally observed that the log of A is a smoothly varying function of voltage; and not greatly different from linear with voltage for most applications. A low order polynomial fit of $\log(A)$ vs. voltage will always provide an excellent fit over the range of voltages of practical interest. For calibration at the higher energies, we have made use

of mono-ionizing events from the exoergic reaction $\text{He-3}(n,p)t$ (764.5 keV) induced by thermal neutrons on counters containing a low partial pressure of He-3 in the filling gas. Only a very small partial pressure of He-3 is required due to the large thermal neutron cross section of He-3. Only those counters showing good resolution (as indicated by a narrow line width for the He-3 related pulse height spectrum) are acceptable for use as neutron spectrometers. An absolute calibration at a much lower energy can be obtained by observing the neutron spectrum produced by a counter surrounded by iron and exposed to fast neutrons. The scattering resonance in iron at 28 keV is very prominent in an iron environment and serves to provide a suitable absolute reference. In order to provide low energy calibration data of a relative nature, we have used the observed counter response to gamma sources (Co-60 for example) as a function of voltage. The mean ionization produced is low and this allows data to be derived over the lower energy region from about 1 keV to about 50 keV for hydrogen-filled counters at typical values for gas pressure. Although the pulse amplitude spectrum in response to gammas is broad, it is not difficult to establish some index of the distribution such as peak channel value.

Measurement results contained in this report were taken with a pair of counters; the first counter contained essentially hydrogen and will be referred to as the "hydrogen" counter while the second counter contained a 50/50 mixture of hydrogen and krypton (for improved stopping power) and is referred to as the "hydrogen/krypton" counter. Total pressure for the hydrogen counter was about 6 atmospheres, and pressure for the hydrogen/krypton counter was about 9 atmospheres. The anode wire had a diameter of 1 mil and the cathode diameter was 3/4 inch. Fig. 3 contains a joint calibration for the hydrogen counter using the $\text{He-3}(n,p)t$ reaction for the higher energies (lower values of A) together with a Co-60 gamma source for the lower energies (higher values for A). The low energy data is made absolute by normalizing measured neutron spectra to the 28 keV iron resonance. In the determination of the relative A vs. voltage for either high or low energy data, changes in amplifier gain are made commensurate with changes in voltage (multiplication) in order to maintain the pulse amplitude spectrum within range of the data acquisition electronics.

FIG. 3

LOG(A) VS VOLTAGE CALIBRATION CURVE FOR THE HYDROGEN
COUNTER TOGETHER WITH RESULTS OF A FOUR COEFFICIENT
LEAST SQUARES POLYNOMIAL FIT.

The peak channel value for the $\text{He-3}(n,p)t$ reaction cannot be relied upon at arbitrarily high voltage due to space-charge saturation distortion. Neither is it possible to extend the information from gamma data to arbitrarily low voltages since this data will ultimately be limited by amplifier noise. By observing the shape of the $\text{He-3}(n,p)t$ line as voltage increases, a point will be reached at an A of about 50 where observable distortion of the line shape will occur. Any additional calibration data above this value of A will be suspect. Since the extent of initial ionization for calibration data using a gamma source is low, this data can be extended to correspondingly higher values of A without distortion. As a consequence of these restrictions on acceptable values of A during calibration, there will be an intermediate region of the calibration curve (for the hydrogen counter) where no calibration data exists. Since $\log(A)$ is a smoothly varying function of voltage, however, this region will be adequately represented using a low order polynomial fit which includes measured results at both extremes. In Fig. 3 a four coefficient least squares polynomial fit of $\log(A)$ vs. V is shown together with measured datum points covering the extremes of low and high A values. A calibration done in this manner is highly accurate at the absolute reference points but is less reliable elsewhere. Additional calibration data taken using accelerator neutrons and also additional scattering resonance structure (other than Fe) induced in neutron spectra (author's unpublished notes) indicates that the overall calibration accuracy is not biased by more than about 5% for any value of A using results of a low order polynomial fitting scheme applied to experimentally derived values for relative A.

It is usually necessary to measure neutron spectra with a pair of counters; hydrogen for the lower energies and another counter with higher stopping power for the higher energies. For the higher stopping power counter it suffices only to use the $\text{He-3}(n,p)t$ reaction line, which is located conveniently near mid-range of the measurement region of interest from about 100 keV to about 2 MeV, for calibration. For either counter type, the product of the energy of the event corresponding to full scale pulse amplitude of the y (energy) amplifier and the gas multiplication is held to values less than about 10 MeV. It is this restriction which minimizes the extent to which space-charge saturation effects distort data.

The calibration procedure described here and based upon only two absolute energy points is entirely arbitrary. Access to an accelerator, and observation of n-p scattering spectra for different energies is desirable although this procedure is difficult to apply below about 50 keV. Numerous neutron scattering resonances in light elements may be found in the energy region above 1 keV. These can be used for additional calibration results through observation of the neutron spectrum produced when the counter is surrounded by the scattering material and subjected to fast neutron irradiation. Calibration results will improve in accuracy in proportion to the availability of additional data from use of a greater number of absolute energy points.

IV. PRINIT

The initialization utility PRINIT is listed in Appendix I together with its machine I/O routine PRMINP. The Fortran Main Program PRINIT calls the machine subroutine PRMINP according to options selected from an initial menu. Consider PRMINP first. This procedure contains the callable subroutines A1PX, A1PY, DSHV, A21P, and SETUP. All input operations from the ADC are through a standard 8255-A interface (Ref. 3). The full data word is held jointly in ports labelled "A" and "B". The "C" port is a handshaking port, and is used to indicate that a data event has been processed and is ready to read in, and also to generate reset logic for the ADC.

SETUP is only called once to program the interface and to locate the origin of data arrays in the Fortran Main Program.

A1PX and A1PY are used for single channel pulse height analysis modes for either the x or y amplifier alone. It is useful to operate in this mode for calibration or for linearizing the ADC etc.

DSHV is a routine only used for reading the high voltage level. Values for voltage are read in 256 times consecutively and the mean value and deviation about the mean are listed. This routine is useful in linearizing the ADC for voltage data and in checking ADC performance.

A21P is a special two parameter analysis mode which allows an x/y pulse amplitude distribution to be recorded for any range of the corresponding y amplifier pulses. It is useful to operate in this mode for checking system

linearity and performance and for observing the response of the system to the random amplitude test pulser. Termination of any of the acquisition options leaves the data from that procedure in the array M1P, and this array may then be displayed on the PC monitor or results may be selectively printed. The plotting routines make use of the GRAFMATICS (Ref. 4) software package; a version compatible with both the Fortran used and the monitor type is required. Data produced in the routine may be saved on disc. An option exists to read data to allow stored results to be returned for additional plotting or listing if desired.

V. RAMPDA

The procedure RAMDA (Appendix II), using the machine routine RAMPIN.ASM, is the data acquisition program for neutron spectroscopy using the voltage modulation technique described here. After receiving the calibration data and the acceptable voltage range, minimum and maximum voltage values are determined. In the proportional mode, counter gas multiplication must exceed 5 or so to prevent contamination of data by non-multiplying regions of the detector such as the field-definition tubes at each axial extremity. The upper limit of 10000 or so corresponds to events of too low an energy to be of use.

The machine program RAMPIN contains only the three subroutines SETUP, ANA and TPLSR. Again, as was the case for PRINIT, SETUP is only used to initialize the 8255 I/O port and to locate the origin of data arrays in the Fortran Main Program. ANA is the subroutine in which the basic data acquisition is done while TPLSR is a test pulser calibration mode used only in the absence of data pulses.

Counter calibration data is required initially. From the calibration procedure an expansion of $\log(A)$ vs. voltage (Fig. 3) exists and this information (C0,C1,C2,C3) is read in. Also required is the voltage range for the modulation, VBOT to VTOP, together with the corresponding ADC equivalent (modulo 4096) for each limit NBOT, NTOP.

Three tables denoted by IGAIN(3000), LOGTB(4096) and INLGTB(3548) are then filled out prior to commencing event acquisition. The table IGAIN consists of values of $\log$ of the inverse multiplication as derived from calibration data. These $\log(1/A)$ values are related to the maximum gain value

GMAX determined from the maximum allowable voltage value VTOP. The table is only filled out for the range VTOP to VBOT; events outside this range are screened out in the machine acquisition procedure. Within the voltage acceptance window VBOT to VTOP, the voltage associated with any event can be quickly derived in a single addressing operation using the IGAIn table, which is only generated once prior to commencing data acquisition. It would be possible to generate these $\log(1/A)$ values for each event from the calibration polynomial expansion data directly but this would require use of math routines and would lead to very slow acquisition and large system dead time, especially for the 4.77 MHz PC on which all of this work is based.

In addition to the IGAIn table (to determine the $\log(1/A)$ for the event from the decoded voltage) the table LOGTB(I) is generated which allows a scaled and normalized value for the log of the x or y amplifier pulse height to be determined by a single addressing operation. Also, a table INLGTB(I) is generated which is the inverse of the log table and allows an argument to be derived from the value of the log, again using a single addressing operation. Use of tables for derivation of values for log and anti-log is fast but accuracy is limited if the processor is only 16 bits.

The basic acquisition approach, using these tables is as follows:

From the observed ADC conversion for the x and y pulses, log values for $\log(x)$ and $\log(y)$ are looked up in the LOGTB table. The difference $\log(x) - \log(y) = \log(x/y)$ is formed and this result is converted to a normalized (32 channel) value for x/y using the inverse log table INLGTB. Biasing and scaling is required for all values to retain accuracy using only 16 bit operations. The log of the inverse multiplication $\log(1/A)$ (including biasing and scaling) is derived by lookup in the IGAIn table. This is added to $\log(y)$ forming $\log(y) + \log(1/A) = \log(y/A)$ for the event. $\log(y/A)$, apart from an additive constant, is just the log of the energy of the event, and it is this quantity that is used in establishing the two-parameter data array for the event spectrum. The true modulation range is set by an external analog programming adjustment and may be somewhat different from the input range VBOT to VTOP. This will not matter however; data that lie outside of the VBOT to VTOP interval will be discarded and the efficiency of the system reduced correspondingly.

Only 16 bit single precision arithmetic is available using the PC-XT system. Double precision is available by programming but this would result in a drastic slowing of the data acquisition process and is not an acceptable option. It is with some difficulty that the acquisition procedure can be carried out within the 16 bit limit; a considerable amount of scaling and manipulation of table limits is required. ADC conversion of all data is modulo 4096.

The acceptance range of the y amplifier is set not only by the voltage when the event occurred but by the requirement that any event analyzed be within the range 896 to 4096. 4096 is the maximum conversion count of the ADC; any event exceeding this value will be rejected. Channel 896 is a rather arbitrary low channel limit below which an event is rejected. Amplifier noise begins to significantly effect resolution if the low channel limit is set at a value below 896. In consequence of the finite range of y pulse amplitudes accepted, all spectra will exhibit a decreasing amplitude at both low and high energies irregardless of the voltage modulation profile. This does not matter however; the calibration procedure will correct for this since the random amplitude test pulses are subject to the same acceptance constraints as is the data. At some values of high and low energy extremes, statistics will become unacceptably poor and it is this consideration which will define the range of useable data from the measurements.

The Fortran program RAMPDA menu allows entry to either the subroutine ANA or TPLSR. Within ANA, data acquisition using the machine program RAMPIN.ASM is carried out, and the two-parameter data array IDAT(32,512) is generated until adequate statistics have been accumulated. For each of the $\log(y/A)$ channels (1 to 512) an associated x/y spectrum (1 to 32 channels) of the kind shown in Fig. 2 is stored. After termination of the acquisition process, an option exists to display the 32 channel x/y spectrum for any $\log(y/A)$ value. All of the relevant data for the run are then stored on disc.

The utility routine TPLSR, which may be opted for from RAMPDA, is only run with the high voltage removed from the detector (but using the same voltage modulation parameters as is done in the acquisition mode). There are no ionizing events recorded in this test pulse calibration mode since there is no detector voltage. Results are required using this calibration mode for data analysis but only one calibration result suffices for all runs done using

the same set of parameters.

Use of the TPLSR calibration mode requires some clarification. We require an acquisition program that provides the true spectrum of the unknown source, with live time normalization, independent of the time variation of the proportional counter high voltage bias supply. Consider an idealized situation in which a source of ionization of random amplitude (white) exists in the detector and can be counted, without dead-time loss, together with the unknown ionization distribution to be measured. Also assume that the two types of ionizing events are distinguishable. For any voltage modulation, the white ionization spectrum serves directly as a normalization spectrum for the unknown; the ratio of the two results at each energy becomes the absolute data spectrum.

There is no straightforward method for introducing a white ionization spectrum into the detector for calibration purposes however. It is relatively easy, on the other hand, to introduce a white test pulser amplitude spectrum in a pseudo-random fashion at least. This can be implemented using a linear function generator with a high repetition rate to provide the test pulser reference voltage. Periodic test pulse generation may be used rather than pulses which occur randomly in time; the sources of ionizing events in the data spectrum are assumed to occur at random however.

The machine routine TPLSR returns a pair of numbers for each test pulse analyzed. The first of these is essentially the log of energy (apart from shifting and scaling required to accomodate 16 bit arithmetic and the 4096 channel ADC). The second number is the log of the relative gas multiplication and is immediately converted to the gas multiplication A. Two arrays are formed using these data. The first (denoted by WHAMP in the code in Appendix II) becomes the test pulse spectrum for a white amplitude test pulse distribution while the second array (denoted by WHION) is derived from WHAMP through use of the appropriate gas multiplication value and corresponds to the test pulse spectrum for an equivalent white distribution of ionization. By running the calibration procedure in the absence of counter voltage, and with all other parameters identical, we provide a calibration which includes the effects of all parameter settings such as the acceptance limits on the y amplifier pulse height. The ratio of these two spectra are needed to provide the normalization required to convert measured spectra to absolute values (the

measured spectra will always contain the random test pulse spectrum together with the spectrum of the unknown source).

Neutron spectrum measurements were made with the system using linear (ramp) modulation, sine wave modulation, and for fixed voltage values covering only a piece of the energy range. All of these methods, after appropriate test pulser normalization, provided results in agreement with each other. The ramp (linear) modulation is perhaps preferable to the sine wave in regards overall variation in statistical precision. Sine modulation tends to emphasize data at the extremes of energy at the expense of mid-range results. It is probably better to use the linear modulation which emphasizes mid-range at the expense of limiting values.

VI. RMPRDN

The RMPRDN procedure (Appendix III) is used to reduce the raw data as generated by RAMPDA. Raw data exists as a two dimensional array consisting of a 32 channel x/y spectrum for each value of energy (Fig. 2). It is the purpose of RMPRDN to resolve this two dimensional array into distinct one dimensional spectra for proton recoils, for test pulses, and for background. The one dimensional arrays are saved for conversion to absolute proton recoil spectra and subsequently to neutron spectra; these operations are handled within the procedure RMPSNS, which is the last of the numerical procedures treated here.

In addition to the two-dimensional data array we require, as additional input, the constants GMAX and FSEX A derived during calibration. GMAX is the greatest value of gas multiplication allowed in the measurement and is derived within the data acquisition procedure RAMPDA from input values for the range of voltage modulation together with the calibration result relating multiplication to voltage. FSEX A, which is also derived from calibration data, is the product of multiplication and energy corresponding to the y pulse height that induces full scale ADC conversion. Pulse amplitude analysis for the y (energy) amplifier is restricted to events in excess of an arbitrary value denoted by LVL after ADC conversion. y amplifier events below LVL are considered to be too close to noise levels to be retained. From GMAX and FSEX A, the absolute $\log(\text{energy})$ value can be derived for any channel in excess of a value NYMIN set during table construction at the commencement of the data

acquisition procedure in RAMPDA.

To illustrate the RMPRDN procedure, consider Figs. 4-8 which show the 32 channel x/y pulse height distributions for a selection of energies ranging from below 1 KeV to a maximum of about 100 KeV for the hydrogen counter. Figs. 9-10 are x/y spectra of a pure Co-60 gamma source for a range of identical values of energy. Notice that the right-most distribution, from test pulses only, is always well resolved and has a narrow, and unchanging, line width. It requires only a very simple algorithm to recognize this region of the x/y spectrum and to integrate this data region on an energy by energy basis.

The central peak, from proton recoils, is not as simple to resolve uniquely since the shape changes continuously with energy. At the lowest energy (Fig. 4) considerable overlap between the gamma component and the neutron component can be seen, while at the higher energies (Fig. 8) where gamma events are absent, considerable broadening of the proton recoil component occurs due to an increase in range of the recoil proton to values in excess of a few millimeters. At the higher energies the proton component has broadened to include all of the region of x/y below the test pulser. The numerical procedures used to set the various integration limits for each energy value are somewhat arbitrary. Use of gamma background subtraction is required, and this leads to an improved result for proton integration especially for the lower energy values where gamma and proton x/y spectra tend to show increased overlap. The line width of the proton region of the x/y spectrum provides a means of estimating the energy limits above which there is an insignificant gamma background contribution. As energy increases, a point is reached beyond which the spatial extent of tracks increases rather rapidly. This may be observed from the effect upon the width of the proton data line. For additional increases in energy, the proton recoils include all of the region of the x/y spectrum below the test pulse data peak, which is essentially unchanging in shape or location as energy changes.

Initially, after a determination is made of acceptable energy channel limits for the data, the proton peak width is derived as a function of increasing channel number. A channel, denoted by N15, is found where the proton peak has broadened by a factor of 1.5 from its average at lower channels. Above N15 there is relatively little gamma background in the

FIG. 4 32 CHANNEL X/Y SPECTRUM IN A MIXED RADIATION FIELD FOR THE HYDROGEN COUNTER.

FIG.5 32 CHANNEL X/Y SPECTRUM IN A MIXED RADIATION FIELD
FOR THE HYDROGEN COUNTER.

FIG. 6 32 CHANNEL X/Y SPECTRUM IN A MIXED RADIATION FIELD FOR THE HYDROGEN COUNTER.

FIG. 7 32 CHANNEL X/Y SPECTRUM IN A MIXED RADIATION FIELD FOR THE HYDROGEN COUNTER.

FIG. 8 32 CHANNEL X/Y SPECTRUM IN A MIXED RADIATION FIELD
FOR THE HYDROGEN COUNTER.

FIG. 9 32 CHANNEL X/Y SPECTRUM IN PURE CO-60 GAMMA FIELD FOR THE HYDROGEN COUNTER.

FIG. 10 32 CHANNEL X/Y SPECTRUM IN PURE CO-60 GAMMA FIELD FOR THE HYDROGEN COUNTER.

data. The ratio of gamma events in a pure-gamma background spectrum to that in the mixed gamma/neutron field is derived over the lower energy region where this ratio is not very energy dependent. At higher energies, the increasing proton recoil track length will cause degradation of the events of recoil origin into lower x/y channels where they will be included with the region containing gamma counts. This will distort the ratio of gammas in the mixed field data to gammas in the pure gamma field and indicates a limit to the use of this ratio in a gamma subtraction procedure. Having arrived at an energy channel dependent ratio of background gammas to data gammas, this ratio is then used for all energies to correct data for background. The initial data reduction consists of the subtraction of gamma background using measured gamma background data.

An option in the data reduction procedure may be utilized which allows a correction to be made for events which distort the spectrum through wall-and-end effects. Consider Figs. 6-7, which contain plots of x/y spectra for the hydrogen counter at energies in the vicinity of 100 keV. Gamma events are absent from the x/y plots at these energies, but a rather distinctive residual profile remains. A region of the spectrum below about channel 10 can be recognized which is a consequence of wall-and-end distortion arising from scattering by the most energetic region of the neutron spectrum. This wall-and-end distorted data can be expected to exhibit a shape distribution (in x/y space) not greatly different from the distribution exhibited by gammas since both kinds of events involve quite long ionizing track lengths. The scattered proton recoil has entered either walls or ends of the counter; the energy loss of the recoil prior to leaving the effective counting region is comparable to recoils of a much lower energy. Using an averaged x/y distribution for pure gammas, a subtraction of the region at low x/y values for the mixed field data can be carried out. After this is done, some typical residuals are shown in Fig. 11. Compare x/y spectra for comparable energies shown in Fig. 11 to data at the same energies in Figs. 6-7 before the correction is made. Removal of the wall-and-end component amounts to perhaps a 10% correction in the region from 100 keV to 200 keV; below 100 KeV the correction rapidly becomes insignificant since the rate of normal recoils far exceeds rates for truncated events even in the rather hard JANUS spectrum used here for illustration. Above about 200 keV, the correction is meaningless since all proton recoils have assumed a significant track extension. It is not intended to use data

FIG. 11
32 CHANNEL X/Y SPECTRUM IN MIXED FIELDS AFTER
TRACK TRUNCATION CORRECTION.

from the hydrogen counter for energies higher than about 200 keV. The counter with increased stopping power is used to extend the data to higher energies and to provide a region of overlap with results using the low density hydrogen counter.

Having corrected the raw data for gamma background, and for wall-and-end truncation effects near 100 keV, it remains to integrate each x/y spectrum over appropriate channel limits that correspond to proton recoils, test pulser, and residual gamma background. This is done using least squares fitting to provide smoothing of channel limits which define the various data regions. Normalization of the proton count at each energy to the test pulser count at the same energy accomplishes the live time correction since test pulse and data events are acquired in an identical manner by the pulse analysis electronics.

Appendix IV contains a full output edit of data from the analysis of a single measurement of the JANUS neutron spectrum using the hydrogen counter. The various quantities listed are:

1) Total Points and Start Point

These are defined by the requirement that data not be retained too close to the extremes of energy where statistics are poor.

2) Initial Average Proton Line Width

Over the lower energies, the width of the proton recoil line in the 32 channel x/y spectrum is nearly fixed. As energy increases, line width broadens. At the point where the proton line width has increased by 50%, gamma background can be assumed to be absent.

3) N15 Channel

Energy channel where proton line width has increased by 50%.

4) NBRK Channel

Energy channel above which the proton region has deteriorated to the point that it occupies the entire low-x/y region of the spectrum.

5) .9WMAX Channel

Channel at which ratio of gamma component in background to gamma component in data becomes less than .9 of the maximum value the ratio assumes.

- 6) Column J varies from 1 to the total number of energy points.
- 7) DVAL are the channel boundaries that separate gammas from protons.
- 8) EDVAL are the smoothed values for DVAL.
- 9) TVAL are the channel values which separate proton recoil region from test pulse region.
- 10) ETVAL are smoothed values for TVAL.
- 11) LINE is the proton recoil line width.
- 12) RATIO is the ratio of gamma background counts in pure background to counts in mixed field data.
- 13) GAMMAS are the residual of integrated counts corresponding to the gamma region in the background-subtracted data.
- 14) PRTS are the integrated proton recoil spectra.
- 15) TIME are the integrated test pulse spectra.

Figs. 12 and 13 contain 32 channel spectra for a few specific energy values for the hydrogen/krypton counter in the JANUS mixed radiation field, and Fig. 14 contains some pure gamma background data. The higher stopping power of this gas mixture compared with hydrogen alone allows data to be acquired at correspondingly higher values of energy. There is very little gamma background above about 400 keV. The listing of analysis output for this counter data in the JANUS neutron spectrum is provided in Appendix V. Note that the GAMMAS column contains a scattering of positive and negative numbers. The quantity listed is a residual, after gamma background subtraction has been made, of counts over the x/y spectrum assigned to events of gamma origin. The presence of values of either sign is, consequently, not prohibited. Perfect subtraction would imply a null value for this quantity for all channels. It should be noted that proton peak integration extends only over a region of the x/y spectrum containing predominantly proton recoil data with relatively little contribution from gammas. The GAMMAS column in Appendices IV and V is not, therefore, any indication of the remaining contamination by gammas of the proton count; this residual will be very much less than any of the numbers listed in the GAMMAS column.

FIG.12 32 CHANNEL X/Y SPECTRUM IN MIXED RADIATION FIELD FOR THE HYDROGEN/KRYPTON COUNTER.

FIG. 13 32 CHANNEL X/Y SPECTRUM IN MIXED RADIATION FIELD FOR THE HYDROGEN/KRYPTON COUNTER.

FIG. 14 32 CHANNEL X/Y SPECTRUM IN PURE CO-60 GAMMA FIELD FOR THE HYDROGEN/KRYPTON COUNTER.

VII. RMPSNS

The final numerical procedure required, RMPSNS as listed in Appendix VI, is needed to convert the measured distribution of proton recoil events, RAPS, to an absolutely normalized proton recoil spectrum. Use is made of the test pulser spectrum (denoted by TIME) recorded simultaneously with proton recoil data and the test pulse calibration spectra (WHION and WHAMP) recorded in the TPLSR procedure within RAMPDA in the absence of ionizing events. Normalization of the proton count by the test pulse count at each energy accomplishes live time correction. Normalization by the ratio of WHION to WHAMP accomplishes conversion to a white ionization reference spectrum.

In addition to data passed through from the RAMPDA procedure, we require a value for the absolute test pulser rate CPS, and for HATM, the number of hydrogen atoms in the effective counter volume. CPS is the absolute rate at which test pulses are recorded, not the rate of test pulse generation. The difference is in consequence of the fact that no pulses are recorded if test pulse amplitude is not within the y amplifier acceptance window between LVL and 4096. This rate is best determined by a separate run using the TPLSR mode of RAMPDA (Appendix II) at any fixed voltage within table limits; the number for CPS provided in the TPLSR mode at full modulation may be incorrect (on the low side) if a swing in voltage is permitted with extremities that lie outside of the range of the tables constructed at the beginning of RAMPDA.

After all required data are input, the RMPSNS procedure determines absolute values for energy at each point (ENERGY(I)). The ionization created per unit proton energy loss becomes complicated at energies below 1 keV; use of a quantity WCTOFF set at 0.3 keV (Ref. 5) is an approximate correction for this effect which will have little impact upon energy scale except at the lowest energies.

RMPSNS contains an option to edit data at each step. Figs. 15 and 16 contain plots of the proton recoil spectrum (RAPS) and of the corresponding test pulse spectrum (TIME) respectively for a measurement using the hydrogen counter in the JANUS facility. A characteristic feature of all of these spectra will be the readily observed break points at high and low energy that signal the energy values where amplifier channel limits are encountered. Events become less frequent above and below these limits since there are increasingly fewer combinations of amplifier pulse height channel and gas

FIG.15 PROTON RECOIL SPECTRUM BEFORE NORMALIZATION FOR THE
HYDROGEN COUNTER.

FIG. 16 RANDOM TEST PULSE SPECTRUM FOR THE HYDROGEN COUNTER.

multiplication that can lead to events of these limiting magnitudes.

Figs. 17 and 18 are plots of the calibration spectra WHION and WHAMP that represent the response of the system to event spectra that are uniform in ionization and in test pulse amplitude respectively. The WHION result is weighted by an arbitrary channel-dependent scaling factor to maintain an amplitude range appropriate for plotting. WHION, as input, increases in amplitude over several decades as energy decreases.

Fig. 19 is a plot of TIME after a smoothing has been done. There is no detail in the test pulse spectrum (the high and low break points are an artifact of the discrete limits upon the acceptance range of y amplifier pulses). Since this spectrum is featureless and slowly varying, a smoothing operation can be applied to reduce the statistical uncertainty in the distribution as measured.

Fig. 20 is a plot of the proton recoil distribution normalized to the smoothed test pulse distribution. This normalization accomplishes the live time correction. Statistics in the plotted distribution are entirely in consequence of counting statistics in the RAPS spectrum.

Fig. 20 is the proton spectrum per unit test pulse amplitude spectrum. We desire the proton spectrum per unit "white" test pulse spectrum, which will simulate a normalization to a "white" ionization spectrum response. The conversion is through the ratio of white ionization to white amplitude shown in Fig. 21. This ratio involves only test pulse calibration data and is, therefore, featureless. Smoothing may, consequently, be carried out to reduce the statistical error in the ionization-to-amplitude calibration ratio.

Normalizing the spectrum of Fig. 20 to that of Fig. 21 provides the final result, which is plotted in Fig. 22 as the calibration normalized proton recoil spectrum. All normalization procedures (apart from the hydrogen atom content of the detector) have been applied and Fig. 22 is the measured result to be processed further into a neutron spectrum if desired. An arbitrary energy-dependent scaling factor has been retained to provide a range of the spectrum amplitude consistent with a linear ordinate scale for plotting purposes only. The true proton recoil spectrum increases monotonically with decreasing energy. Note that all of the high-low break channel effects are now absent; the normalization procedures using the random test pulse data has

FIG.17 WHITE IONIZATION CALIBRATION SPECTRUM.

EQUIVALENT WHITE AMPLITUDE SPECTRUM
FROM TEST CALIBRATION MODE

RELATIVE SPECTRUM

FIG.18 WHITE AMPLITUDE CALIBRATION SPECTRUM.

FIG.19 SMOOTHED TEST PULSER SPECTRUM

FIG.20 TEST-PULSER-NORMALIZED PROTON RECOIL SPECTRUM.

FIG.21 SMOOTHED RATIO OF WHITE IONIZATION TO WHITE
AMPLITUDE CALIBRATION SPECTRUM.

FIG.22 CALIBRATION-NORMALIZED PROTON RECOIL SPECTRUM.

removed these features and the final result only reflects statistics together with the true variation of proton recoil spectrum with energy.

Following completion of the normalization operations, the proton recoil spectrum is converted to a neutron spectrum using the same procedure found in Ref. 1 for example. The density of points in the neutron spectrum is reduced to be consistent with a lethargy spacing of about .05, which is sufficient for plotting, and both the proton recoil spectrum and the neutron spectrum are saved for plotting using the GRAPHER (Ref. 6) plotting routines.

Figs. 23 and 24 contain plots of the JANUS proton recoil spectrum utilizing results from both the hydrogen counter and the hydrogen/krypton counter. Detailed plots of the intermediate analysis for the hydrogen/krypton data are not included since they are very similar in appearance to those shown in Figs. 15-22 for the hydrogen data.

The hydrogen counter data in Fig. 23 does not contain the correction for the wall-and-end truncation component discussed in Section VI which has a significant impact only above about 100 keV. The proton recoil spectrum is 10% or so above that for the higher stopping hydrogen/krypton counter in this energy region if the wall-and-end truncation component is retained for the hydrogen counter data. Fig. 24 contains the proton spectrum for both counters after the track truncation correction has been made. A significant improvement in agreement in the overlap region from 100 keV to 200 keV is seen if this correction is applied. Above about 200 keV, data for the hydrogen counter becomes increasingly subject to error as recoil tracks lengthen and the analysis procedures used in the RMPRDN code of Section VI break down entirely. The data analysis routines used here are unreliable for the hydrogen counter above about 200 keV; only counters with substantially improved stopping power can be used in this energy regime. One can, however, find a region of overlap at around 100 to 200 keV where proton spectra for both counters are in substantial agreement.

An additional measurement in the JANUS facility was carried out using a counter filled with a 50/50 mixture of hydrogen and argon. Proton-recoil spectra using each of the counters (hydrogen, hydrogen/argon, hydrogen/krypton) are shown in Fig. 25 (no correction to the hydrogen counter data for wall-and-end effects were made). Results show that the proton recoil spectrum is not too greatly altered between the argon and krypton results for energies

FIG. 23 PROTON RECOIL SPECTRA FOR BOTH COUNTERS; NO CORRECTION FOR TRACK TRUNCATION TO HYDROGEN COUNTER DATA.

FIG. 24

PROTON RECOIL SPECTRA FOR BOTH COUNTERS; A
 CORRECTION MADE FOR TRACK TRUNCATION TO HYDROGEN
 COUNTER DATA.

FIG.25

PROTON SPECTRA FROM COUNTERS HAVING DIFFERENT STOPPING POWERS.

below about 1 MeV. The indication is that further increases in stopping power beyond hydrogen/krypton are only likely to result in substantial improvements in the spectrum at energies above about 1 MeV.

Fig. 26 contains the neutron spectrum using the joint hydrogen and hydrogen/krypton data taken in the irradiation room of the JANUS facility. The hydrogen counter data (Fig. 24) is used below 200 keV, the hydrogen/krypton counter data is used above about 100 keV. Statistical (rms) error bars are also shown. The spectrum is very hard; this was a primary design objective for the facility. Additional information relating to the neutron spectrum at JANUS can be found in Ref. 2.

VIII. CONCLUSIONS

The continuous acquisition mode neutron spectroscopy technique for proton recoil proportional counters offers several advantages by contrast with the conventional approach utilizing discrete voltage steps. Operation of the acquisition system is 'conventional'; the system is turned on and runs unattended for a time required to obtain adequate counting statistics. At the termination of the run all data over the full energy range is available for analysis. There are no restrictions on the voltage modulation profile. Use of a random amplitude test pulser is essential and test pulses are acquired together with data. A separate run with the test pulser in the absence of data serves to calibrate the pulse processing system completely and to provide a normalization for dead time losses. Pulse pileup and overload distortion are readily observable in their effects upon test pulse line widths for any energy.

The continuous mode data acquisition is also more efficient than are procedures using discrete voltages since considerable overlap of data from adjacent voltage settings is required if voltages are discrete. Also, efficiency is improved by avoiding the interruption of acquisition to check, store, and re-initialize acquisition as is required when using discrete voltages.

The basic period for the modulation will ordinarily be chosen rather long; several minutes or so. If the source intensity varies significantly over time intervals of several minutes, the continuous modulation procedure would become unsatisfactory and should not be considered.

FIG.26 NEUTRON SPECTRUM AT THE JANUS FACILITY SHOWING
STATISTICAL ERRORS.

It appears, rather unfortunately, that a pair of counters that provide overlapping data will be required to obtain good-quality measurements over the full energy region from about 1 keV to about 2 MeV. Hydrogen gas is certainly preferable for use at energies below about 200 keV. Admixing hydrogen with heavy noble gases will extend the upper energy response well beyond that attainable with hydrogen alone. These noble gas counters will acquire sensitivity to soft photons however, and measurements at the lower energies will become difficult to perform since discrimination against this type of background may be poor. If one can tolerate a somewhat more limited result, a 50/50 mixture of hydrogen and argon may be acceptable and single counter data from about 10 keV to about 1 MeV can be obtained if a careful calibration for the counter is carried out over this energy region. For many practical applications, including fast-neutron dosimetry in degraded fission spectra, it may suffice to only obtain recoil proton data in this more restricted energy region.

ACKNOWLEDGMENTS

We wish to acknowledge the participation of T. J. Yule in carrying out the development program outlined here.

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APPENDIX I

LISTING OF THE CODES PRINIT.FOR AND PRMINP.ASM USED FOR SETUP AND TESTING

LISTING OF THE CODES PRINIT.FOR AND PRMINP.ASM USED FOR
SETUP AND TESTING.

```

$NODEBUG
$NOFLOATCALLS
$STORAGE:2
C  PRINIT.FOR
C  SETUP ROUTINES FOR USE IN INITIALIZING RAMP CODES.
C  DATA ACCUMULATION DONE IN SUBROUTINE PRMINP.ASM ENTERED
C  BY KEYBOARD SELECTION OF MODE AND TERMINATED BY SWITCH ON ADC.
C  M1P IS A 256 CHANNEL ARRAY FOR ALL SINGLE PARAMETER ANALYSIS.
C  IPLT IS ONLY USED TO HOLD NORMALIZED VALUES FOR PLOTTING.
C
      DIMENSION M1P(256),IPLT(256)
      CHARACTER FNAME*16,IDENT*80,CHAR
C
1  FORMAT(/31H          -ENTRY TO MAIN MENU- ///
X34H TYPE(I2) FOR ALL OPTIONS IN MENU. //
X45H TYPE 00 FOR 256 CHANNEL 1-PARAMETER PLOTTING. /
X42H TYPE 01 TO ANALYSE IN THE 1-P MODE FOR Y. /
X38H TYPE 02 TO ANALYSE IN 1-P MODE FOR X. /
X36H TYPE 03 TO ANALYSE IN THE X/Y MODE. /
X35H TYPE 04 TO GET HIGH VOLTAGE VALUE. /
X22H TYPE 05 TO PRINT 1-P. /
X21H TYPE 06 TO SAVE 1-P. /
X32H TYPE 07 TO READ IN A 1-P ARRAY. /
X36H TYPE 77 TO ERASE DATA BUFFER ARRAY. / )
2  FORMAT(I2)
3  FORMAT(10I7)
4  FORMAT(33H HIGH VOLTAGE AND DISPERSION = 2E12.5/)
5  FORMAT(54H INPUT(I3/I3) LOWER AND UPPER Y LIMITS(1-256) FOR X/Y.)
6  FORMAT( ' INPUT THE LOW CHANNEL CUTOFF (1-256). ' )
8  FORMAT(I3)
9  FORMAT( ' INPUT AN 80 CHAR. RUN DESCRIPTION. ' )
10 FORMAT(A)
11 FORMAT( ' INPUT FILE NAME. ' )
C
C  USE THE SETUP CALL TO FIND THE LOCATION OF DATA IN MAIN.
C  ALSO, WITHIN SETUP, PROGRAM THE 8255A-5 ADC INTERFACE .
C
      CALL SETUP(M1P)
C
C  MAIN MENU LISTED HERE; ALL ACQUISITION RETURNS TO THIS POINT.
19 WRITE(*,1)
      READ(*,2) IGO
C
C
      IF(IGO)19,35,37
37 IF(IGO-77)36,29,36
36 IF(IGO-7)20,20,19
20 GO TO(21,22,23,24,25,26,27),IGO
C
C  PLOT ONE PARAMETER SPECTRA.
C  FIRST, SCALE THE ARRAY TO 199 FULL SCALE.
C
35 WRITE(*,6)
      READ(*,3) IBC
      IF(IBC) 35,35,68

```

```

63 IF (IBC, 256) 67, 67, 35
67 MAX1P=1
   DO46 I=IBC, 256
   IF (M1P(I) - MAX1P) 46, 46, 47
47 MAX1P=M1P(I)
16 CONTINUE
   DO48 I=1, 256
48 IPLT(I)=IFIX(199.*(FLOAT(M1P(I)))/FLOAT(MAX1P))
C
C DRAW AXES, PLOT DATA TOGETHER WITH A VERTICAL LOCATOR AT
C ANY VALUE OF ABSCISSA. TICS APPEAR EVERY 25 CHANNELS.
C A NULL OR NEGATIVE ABSCISSA TERMINATES PLOT.
C
   CALL QCOLOR(0,1)
45 CALL QSMODE(6)
   WRITE(*,3) MAX1P
   READ(*,8) IX
   IF (IX) 59, 59, 42
42 IF (IX-256) 43, 43, 45
43 IX=(5*IX)/2 - 1
   CALL QLINE(0,0,0,199,1)
   CALL QLINE(0,0,639,0,1)
   KYD=5
   DO41 I=1, 10
   KX=(125*I)/2 - 1
41 CALL QLINE(KX,0,KX,KYD,1)
   CALL QLINE(IX,0,IX,199,1)
   DO40 I=IBC, 256
   IX=(I*5)/2 - 1
   IY=IPLT(I)
   IYP=IY+1
   IYM=IY-1
40 CALL QLINE(IX,IYM,IX,IYP,1)
   READ(*,10) CHAR
   GO TO 45
C EXIT FROM PLOT ROUTINE AND RETURN TO MAIN MENU.
59 READ(*,10) CHAR
   CALL QSMODE(2)
   GO TO 19
C
C SAVE ONE PARAMETER ARRAY ON DISC.
C
26 WRITE(*,11)
   READ(*,10) FNAME
   WRITE(*,9)
   READ(*,10) IDENT
   OPEN(10, FILE=FNAME, STATUS='NEW')
   WRITE(10,10) FNAME
   WRITE(10,10) IDENT
   WRITE(10,3) (M1P(I), I=1, 256)
   CLOSE(10)
   GO TO 19
C
C FRASE ALL DATA STORAGE AREAS.
C

```

```

      29 DO31 I=1,256
      31 M1P(I)=0
      GO TO 19
C
C ANALYSE Y IN ONE PARAMETER.
      21 CALL A1PY
      GO TO 19
C
C ANALYZE FOR X IN ONE PARAMETER ONLY.
      22 CALL A1PX
      GO TO 19
C
C ANALYZE IN THE X OVER Y RATIO MODE.
C REQUIRES LOWER(NLO) AND UPPER(NHI) Y CHANNEL(1-256) LIMITS.
      23 WRITE(*,5)
C NLO AND NHI INPUT MODULUS 256, BUT USED MODULUS 4096 IN
C MACHINE ROUTINE. CHECK THAT NLO AND NHI ARE WITHIN RANGE
C AND THEN SCALE TO 4096.
      READ(*,8) NLO
      READ(*,9) NHI
      IF(NHI-NLO)19,52,52
      52 IF(NHI-256)53,53,19
      53 IF(NLO)19,19,54
      54 NLO=NLO*16
      NHI=NHI*16
      CALL A21P(NLO,NHI)
      GO TO 19
C
C PRINT THE SINGLE CHANNEL DISTRIBUTION.
      25 WRITE(*,3) (M1P(I),I=1,256)
      GO TO 19
C
C GET HIGH VOLTAGE AND VARIATION OF HV ABOUT MEAN.
      24 CALL DSHV
      AVG=0.0
      DO50 I=1,256
      50 AVG=AVG+FLOAT(M1P(I))
      AVG=AVG/256.
      DISP=0.0
      DO51 I=1,256
      51 DISP=DISP+(FLOAT(M1P(I))-AVG)**2
      DISP=SQRT(DISP/256.)
      WRITE(*,4) AVG,DISP
      GO TO 19
C READ A 256 CHANNEL 1 P SPECTRUM FROM DISC STORAGE.
      27 WRITE(*,11)
      READ(*,10) FNAME
      OPEN(10,FILE=FNAME,STATUS='OLD')
      READ(10,10) FNAME
      READ(10,10) IIDENT
      WRITE(*,10) IIDENT
      READ(10,3) (M1P(I),I=1,256)
      CLOSE(10)
      GO TO 19
END

```

```

PAGE      ,132
TITLE     PRMINP.ASM      ;SETUP ROUTINE FOR RAMP PROCEDURE.

```

```

; .....
; PRMINP IS A UTILITY PROGRAM FOR PULSE AMPLITUDE ANALYSIS
; USING HIGH VOLTAGE BIAS MODULATION.
; INPUT IS FROM A 4096 ADC THROUGH AN 8255A-5 INTERFACE IN COMPAQ.
; PRMINP ANALYSES SEQUENTIALLY ALL THREE INPUT VARIABLES.
; PRMINP CONTAINS THE FOLLOWING PUBLIC ROUTINES:
; 1) A1PX....ANALYSE THE X ADC IN 1 PARAMETER
; 2) A1PY....ANALYSE THE Y ADC IN 1 PARAMETER.
; 3) DSHV....DETERMINE HIGH VOLTAGE VALUE.
; 4) A21P....ANALYSE IN THE IP MODE OF 2P.
; 5) SETUP....LOCATE THE ARRAYS IN MAIN, PROGRAM INTERFACE.
; .....

```

```

; DATA NEEDED FOR QUAD TECHMAR 8255 INTERFACE.
; BASE ADDRESS AND RELATIVE LOCATION OF PORTS.
; ALSO LOCATION OF THE EXIT BIT INDICATING RUN TERMINATION.
;

```

```

BASE      EQU      240      ;8255A-5 BASE ADDRESS FOR UNIT #0.
PP        EQU      0        ;CONTROL PORT ADDRESS.
PA        EQU      3        ;A PORT ADDRESS.
PB        EQU      2        ;B PORT ADDRESS.
PC        EQU      1        ;C PORT ADDRESS.
EXB       EQU      10000000B ;TOP BIT OF B BYTE FOR EXIT.
; .....

```

```

; DATA SEGMENT 'DATA'
M1P       DW(0)      ;THE ONE PARAMETER SPECTRA (X, Y, X/Y) RESIDE HERE.
NLO       DW(0)      ;LOWER Y CHANNEL(1-4096) BOUND FOR X/Y.
NH1       DW(0)      ;UPPER Y CHANNEL(1-4096) BOUND FOR X/Y.
DATA      ENDS
;

```

```

; DGROUP GROUP DATA
CODE      SEGMENT 'CODE'
ASSUME CS:CODE,DS:DGROUP,SS:DGROUP
; .....

```

```

; .....
; SETUP IS USED TO LOCATE THE ADDRESSE OF DATA ARRAY FROM MAIN.
; ALSO, PROGRAMMING OF THE 8255A-5 IS CARRIED OUT IN SETUP.
; .....

```

```

SETUP     PROC      FAR
PUBLIC   SETUP
PUSH     BP
MOV      BP,SP
MOV      BX,[BP+6]    ;ADDRESS OF 1P ARRAY.
MOV      M1P,BX
; .....

```

```

; PROGRAM THE 8255 I/O PORT.
MOV      AL,0B6H      ;MODE 1, OPTION 2.
OUT      BASE+PP,AL
POP      BP           ;BACK TO MAIN.
RET      4
; .....

```



```

SETUP      ENDP
;.....
; EXIT FROM ALL ACQUISITION ROUTINES IS ACCOMPLISHED BY RAISING
; DATA BIT 16 (TOP BIT OF MOST SIGNIFICANT BYTE IN PORT B).
; THIS BIT IS ATTACHED DIRECTLY TO A SWITCH ON THE ADC.
;.....
;
;.....A1PX ANALYSE THE X ADC IN A 256 CHANNEL ARRAY.....
A1PX      PROC      FAR
          PUBLIC    A1PX
          MOV       SI,M1P                ;PUT STARTING 1P ADDRESS IN SI.
;
; RSET REQUIRED INITIALLY AND WHEN DATA IS NOT WITHIN AN
; ACCEPTABLE RANGE. RESET IS ACCOMPLISHED BY TOGGING BIT 7
; OF THE C PORT UP AND THEN DOWN.
; IN SINGLE PARAMETER MODES, CONVERSION IS 4096 FULL SCALE BUT
; ARRAY IS SAVED ONLY TO EXTENT OF 256 CHANNELS.
;
          MOV       AL,0FH                ;LOAD BIT HIGH.
          OUT       BASE+PP,AL            ;SET BIT HIGH.
          IN        AL,BASE+PA            ;INPUT A PORT AND CLEAR.
          IN        AL,BASE+PB            ;INPUT B PORT AND CLEAR.
          MOV       AL,0EH                ;LOAD BIT 7 LOW.
          OUT       BASE+PP,AL            ;SET BIT 7 LOW AND RESET.
;
; READ IN Y AS A DUMMY PROCEDURE TO INITIATE CONVERSION OF X.
STRT1X:   IN        AL,BASE+PC            ;GET C PORT DATA.
          TEST      AL,02                 ;TEST BIT 2 HIGH.
          JE        STRT1X                ;LOOP TILL DATA READY.
          IN        AL,BASE+PA            ;INPUT LOW BYTE OF DATA FROM PORT A.
          IN        AL,BASE+PB            ;INPUT HIGH BYTE FROM PORT B.
;
; REPEAT THE INPUT PROCEDURE TO ACQUIRE X.
STRT2X:   IN        AL,BASE+PC            ;GET C PORT DATA.
          TEST      AL,02                 ;TEST BIT 2 HIGH.
          JE        STRT2X                ;LOOP TILL DATA READY.
          IN        AL,BASE+PA            ;INPUT LOW BYTE OF DATA FROM PORT A.
          MOV       DL,AL                 ;AND PUT INTO DL.
          IN        AL,BASE+PB            ;INPUT HIGH BYTE FROM PORT B.
          MOV       DH,AL                 ;FULL WORD IN DX.
; ONE MORE TIME TO CLEAR HV AND RE-ENABLE.
STRT3X:   IN        AL,BASE+PC
          TEST      AL,02
          JE        STRT3X
          IN        AL,BASE+PA
          IN        AL,BASE+PB
;
          TEST      DH,EXB                ;TEST EXIT BIT.
          JNE       RET1X                 ;IF EXIT BIT SET, RETURN TO MAIN.
          INC       DX                    ;TOP VALID X = 4096.
          INC       DX
          CMP       DX,4096                ;START OVER IF PULSE IS TOO LARGE.
          JNS       STRT1X
          SAR       DX,1
          SAR       DX,1                    ;SCALE FROM 4096 TO 256 (2 BYTES).

```

```

        SAR      DX,1
        AND      DX,01FEH          ;LOWEST BIT TO 0 AND RESTRICT SPACE.
        MOV      BX,DX             ;BX REGISTER FOR ADDRESSING.
        INC      WORD PTR [SI+BX]  ;INCREMENT COUNT.
        JMP      STRT1X

RET1X:  RET
;
A1PX    ENDP
;
;.....A1PY ANALYSE THE Y ADC IN A 256 CHANNEL ARRAY.....
A1PY    PROC     FAR
PUBLIC  A1PY
        MOV      SI,M1P            ;PUT STARTING 1P ADDRESS IN SI.
;
        MOV      AL,0FH            ;LOAD BIT HIGH.
        OUT      BASE+PP,AL        ;SET BIT HIGH.
        IN       AL,BASE+PA        ;INPUT A PORT AND CLEAR.
        IN       AL,BASE+PB        ;INPUT B PORT AND CLEAR.
        MOV      AL,0EH            ;LOAD BIT 7 LOW.
        OUT      BASE+PP,AL        ;SET BIT 7 LOW AND RESET.
;
;  READ IN Y.
STRT1Y: IN       AL,BASE+PC        ;GET C PORT DATA.
        TEST     AL,02             ;TEST BIT 2 HIGH.
        JE       STRT1Y           ;LOOP TILL DATA READY.
        IN       AL,BASE+PA        ;INPUT LOW BYTE OF DATA.
        MOV      DL,AL
        IN       AL,BASE+PB        ;INPUT HIGH BYTE FROM PORT B.
        MOV      DH,AL            ;FULL DATA WORD IN DX.
        TEST     DH,EX8           ;TEST EXIT BIT.
        JNE      RET1Y            ;IF EXIT BIT SET, RETURN TO MAIN.
;
;  DUMMY INPUT PROCEDURE TO CLEAR X AND ENABLE HV CONVERSION.
STRT2Y: IN       AL,BASE+PC        ;GET C PORT DATA.
        TEST     AL,02             ;TEST BIT 2 HIGH.
        JE       STRT2Y           ;LOOP TILL DATA READY.
        IN       AL,BASE+PA        ;INPUT LOW BYTE OF DATA AND CLEAR A.
        IN       AL,BASE+PB        ;INPUT HIGH BYTE FROM PORT B.
;  ANOTHER DUMMY INPUT TO CLEAR HV AND RE-ENABLE FOR NEXT EVENT.
STRT3Y: IN       AL,BASE+PC
        TEST     AL,02
        JE       STRT3Y
        IN       AL,BASE+PA
        IN       AL,BASE+PB
;
        INC      DX                ;TOP VALID Y = 4096.
        INC      DX
        CMP      DX,4096           ;REJECT IF PULSE EXCEEDS LIMITS.
        JNS      STRT1Y
        SAR      DX,1              ;SCALE FROM 4096 TO 256 (2 BYTES).
        SAR      DX,1
        SAR      DX,1
        AND      DX,01FEH          ;LOWEST BIT TO 0 AND RESTRICT SPACE.
        MOV      BX,DX

```

```

        INC      WORD PTR [SI+BX]          ; INCREMENT COUNT AT ADDRESS.
        JMP      STRT1Y
RET1Y:  RET
;
A1PY    ENDP
;
; .....
; HIGH VOLTAGE ANALYSIS. READ IN THE HIGH VOLTAGE VALUE (MOD 4096)
; 256 TIMES AND THEN EXIT..
;
DSHV    PROC     FAR
        PUBLIC   DSHV
        MOV      SI,M1P                   ; HOLD ARRAY START IN SI REGISTER.
; PRODUCE AN INITIAL RESET.
        MOV      AL,0FH                   ; LOAD BIT HIGH.
        OUT      BASE+PP,AL               ; SET BIT HIGH.
        IN       AL,BASE+PA               ; INPUT A PORT AND CLEAR.
        IN       AL,BASE+PB               ; INPUT B PORT AND CLEAR.
        MOV      AL,0EH                   ; LOAD BIT 7 LOW.
        OUT      BASE+PP,AL               ; SET BIT 7 LOW AND RESET
;
; INPUT A HIGH VOLTAGE VALUE 256 TIMES, AND THEN EXIT.
        MOV      BX,0                     ; USE BX FOR ADDRESSING.
        MOV      CX,256                   ; SET UP CX FOR LOOP COUNT.
; DO TWO DUMMY INPUT OPERATIONS TO CLEAR Y AND X AND ALLOW HV.
STRT2P: IN       AL,BASE+PC               ; GET C PORT DATA.
        TEST     AL,010B                  ; TEST IF BIT 2 HIGH.
        JE       STRT2P                   ; LOOP TILL DATA READY.
        IN       AL,BASE+PA               ; INPUT LOW BYTE FROM A PORT.
        IN       AL,BASE+PB               ; INPUT HIGH BYTE FROM B PORT.
STRT3P: IN       AL,BASE+PC
        TEST     AL,010B
        JE       STRT3P                   ; DUMMY X READ IN.
        IN       AL,BASE+PA
        IN       AL,BASE+PB
; NOW, ADC BEGINS HIGH VOLTAGE CONVERSION.
STHV:   IN       AL,BASE+PC
        TEST     AL,010B
        JE       STHV
        IN       AL,BASE+PA
        MOV      DL,AL
        IN       AL,BASE+PB
        MOV      DH,AL                     ; DX HAS THE VOLTAGE VALUE.
        MOV      [SI+BX],DX               ; PUT VOLTAGE INTO ARRAY.
        INC      BX
        INC      BX                     ; INCREASE ADDRESS ONE WORD.
        LOOP     STRT2P
        RET                                     ; EXIT BACK TO MAIN.
;
DSHV    ENDP
;
; .....
; .....ONE PARAMETER MODE OF TWO-P.....
; BOTH ADC'S CONVERT TO 4096 FULL SCALE. ANY Y DATA BELOW CHANNEL
; 640, HOWEVER, ARE CONSIDERED TO BE TOO LOW TO BE USEFUL AND ARE

```

```

; REJECTED. THE X/Y SPECTRUM FOR ALL Y VALUES ARE PUT IN A 256 CHANNEL
; ARRAY.
;
A21P PROC FAR
PUBLIC A21P
PUSH BP
MOV BP,SP
MOV BX,[BP+10] ;VALUE OF LOW Y LIMIT FOR X/Y.
MOV AX,[BX]
MOV NLO,AX
MOV BX,[BP+6] ;VALUE OF HIGH LIMIT FOR X/Y.
MOV AX,[BX]
MOV NHI,AX
MOV SI,M1P ;BRING 1P ARRAY START INTO SI REGISTER.
; PRODUCE AN INITIAL RESET OR RESET FOLLOWING BAD DATA.
RS21P: MOV AL,0FH ;LOAD BIT HIGH.
OUT BASE+PP,AL ;SET BIT HIGH.
IN AL,BASE+PA ;INPUT A PORT AND CLEAR.
IN AL,BASE+PB ;INPUT B PORT AND CLEAR.
MOV AL,0EH ;LOAD BIT 7 LOW.
OUT BASE+PP,AL ;SET BIT 7 LOW AND RESET.
;
ST21P: IN AL,BASE+PC ;GET C PORT DATA.
TEST AL,010B ;TEST IF BIT 2 HIGH.
JE ST21P ;LOOP TILL DATA READY.
IN AL,BASE+PA ;INPUT LOW BYTE FROM A PORT.
MOV DL,AL ;SAVE IN DX REGISTER
IN AL,BASE+PB ;INPUT HIGH BYTE FROM B PORT.
; AT THIS POINT, ADC BEGINS X CONVERSION.
MOV DH,AL ;FULL WORD FOR Y IS IN DX.
TEST DH,EXB ;TEST EXIT BIT.
JNE RET21P ;IF EXIT BIT SET, RETURN TO MAIN.
INC DX ;TOP VALID Y = 4096.
INC DX
MOV BX,DX ;SAVE Y VALUE IN BX.
SUB DX,640 ;TEST LOWER LEVEL.
JL RS21P ;IF FAILS, START OVER.
CMP DX,3456 ;CHECK IF TOO LARGE.
JNS RS21P ;IF TOO LARGE, START OVER.
IN AL,BASE+PA ;INPUT LOW X BYTE FROM A PORT.
MOV DL,AL ;SAVE IN DX.
IN AL,BASE+PB ;INPUT HIGH X BYTE FROM B PORT.
; ADC IS NOW RESET AND CAN PROCESS HIGH VOLTAGE.
MOV DH,AL ;FORM WORD IN DX FOR X DATA.
; CHECK TO SEE THAT NLO<Y<NHI BEFORE PROCEEDING.
INC DX ;TOP VALID X = 4096.
INC DX
CMP BX,NLO ;TEST Y AGAINST NLO.
JS RS21P ;IF Y LESS, RE-START.
CMP BX,NHI ;TEST Y AGAINST NHI.
JNS RS21P ;IF Y GREATER, RE-START.
CMP BX,DX ;DON'T LET X EXCEED OR EQUAL Y.
JLE ST21P ;IF IT IS, START OVER ON NEW DATA.
ROL DX,1 ;MULTIPLY X BY 512.
XCHG DL,DH

```

```

; DO A DUMMY READ IN TO RE-ENABLE ADC AFTER HV CONVERSION
IN      AL,BASE+PA
IN      AL,BASE+PB
;
MOV     AX,DX          ;USE AX:DX JOINTLY FOR DIVISION.
AND     AX,1111111000000000B    ;CLEAR LOW 512 FROM AX.
AND     DX,0000000111111111B    ;CLEAR HIGH BITS FROM DX.
DIV     BX              ;DIVIDE X BY Y.
AND     AX,01FEH        ;LOWEST BIT TO 0 AND RESTRICT SPACE.
MOV     BX,AX           ;BX CAN BE USED IN ADDRESSING.
INC     WORD PTR [SI+BX] ;INCREMENT COUNT AT ONE-P ADDRESS.
JMP     ST21P
RET21P: POP     BP
RET     8
;
A21P    ENDP
;
CODE    ENDS
END

```

APPENDIX II

LISTING OF THE CODES RAMPDA.FOR AND RAMPIN.ASM FOR DATA ACQUISITION

LISTING OF THE CODES RAMPDA.FOR AND RAMPIN.ASM FOR DATA ACQUISITION.

```

$NODEBUG
$NOFLOATCALLS
$STORAGE:2
C RAMPDA.FOR
C RAMP VOLTAGE MODULATION ACQUISITION FOR RECOIL PROTON COUNTERS.
C RECOIL PROTON ACQUISITION DONE IN MACHINE ROUTINE RAMPIN.ASM.
C RAMPIN HAS ANA FOR PROTON RECOIL ACQUISITION AND TPLSR FOR
C TEST PULSE CALIBRATION.
C
C DO NOT INCREASE ARRAY DIMENSIONS OR PROGRAM MAY EXCEED ONE PAGE.
  DIMENSION IGAIN(3000),LOGTB(4096),INLGTB(3548),IDAT(32,512),
  XIDUM(512),WHION(512),WHAMP(512)
C
  EQUIVALENCE (WHAMP(1),IDAT(1,1)),(WHION(1),IDAT(1,50))
C
  INTEGER*4 MAX,IDUM,NSEC
  CHARACTER FNAME*16,IDENT*72,OPTION*6,DELETE*6
C
C GGAIN IS THE LOG OF THE GAS GAIN FOR ANY VALUE OF VOLTAGE.
C GGAIN IS PROVIDED BY CALIBRATION PROCEDURES WHICH PRODUCE
C A FOUR COEFFICIENT FIT TO LOG(A) VS VOLTAGE.
  GGAIN(VOLTS)=C0+VOLTS*(C1+VOLTS*(C2+VOLTS*C3))
C
  1 FORMAT(8F8.0)
  2 FORMAT(6E12.5)
  3 FORMAT( ' INPUT(I3) NEGATIVE TO CALIBRATE, POS TO RUN. ' )
  4 FORMAT( ' FOUR COEFFICIENTS FOR THE LOGA(V) VS V FIT. ' )
  5 FORMAT(16I5)
  6 FORMAT( ' INPUT A FILE NAME FOR THE BASIC CALIBRATION DATA. ' )
  7 FORMAT( ' VOLTAGE LIMITS AND CORRESPONDING ADC COUNTS. ' )
  8 FORMAT(12I6)
  9 FORMAT(/45H TURN ON PRINTER TO SAVE GAS GAIN TABLE EDIT. )
10`FORMAT(//10X,24H EDIT OF DATA AND TABLES //
  X52H THE FOUR CONSTANTS WHICH PARAMETERIZE LOGA VS V ARE /
  X4E14.7/41H THE ALLOWED GAS GAIN RANGE (GMIN,GMAX) = 2E12.5/
  X33H THE ADC LOW BIAS CHANNEL FOR Y = I7//)
11 FORMAT(39H THE RAMP VOLTAGE UPPER LIMIT IS VTOP = F8.3 /
  X39H THE RAMP VOLTAGE LOWER LIMIT IS VBOT = F8.3 /
  X47H THE ADC NUMBER CORRESPONDING TO VTOP IS NTOP = I6 /
  X47H THE ADC NUMBER CORRESPONDING TO VBOT IS NBOT = I6 ///)
12 FORMAT(8E10.4)
13 FORMAT( ' INPUT DISC NAME FOR TEST CALIBRATION SPECTRUM ' )
14 FORMAT(4E14.7)
15 FORMAT(I3)
16 FORMAT(50H INPUT(I3) THE LOG ENERGY CHANNEL(1-512) TO PRINT. /
  X60H NULL INPUT TO SAVE, NEGATIVE INPUT TO CONTINUE ACQUISITION.//)
17 FORMAT(//40H TWO PARAMETER LOG(Y/A) VS X/Y SPECTRUM.//
  X28H THE VOLTAGE RAMP LIMITS ARE 2F8.3 /
  X39H THE CORRESPONDING ADC COUNT VALUES ARE 2I6/
  X51H THE FOUR COEFFICIENTS IN LOG(A) VS V EXPANSION ARE /4E14.7 /
  X24H THE Y PULSE ADC BIAS IS I7 /
  X30H THE GAS GAIN RANGE IS BETWEEN 2E12.5//
  X30H I/64 IS THE ABSOLUTE VALUE OF /
  X49H LOG(Y/A) FOR ANY DATA CHANNEL I FROM 1 TO 4096. //)
18 FORMAT(32H TOTAL COUNT OVER ALL CHANNELS = E12.5 / )

```

```

20 FORMAT(9H CHANNEL= I4 / 11H MAX COUNT= I6 )
21 FORMAT(/41H LIST OF ENERGY SPECTRUM SUMMED OVER X/Y. //)
22 FORMAT(10I8)
23 FORMAT(A)
24 FORMAT( ' INPUT DISK FILE NAME ' )
25 FORMAT( ' INPUT 72 CHARACTER FILE DESCRIPTOR ' )
26 FORMAT(44H INPUT "DELETE" TO AVOID SAVING FILE ON DISC )
27 FORMAT( ' INPUT(I8) RUN TIME IN SECONDS ' )
28 FORMAT(32H TEST PULSER COUNTS PER SECOND = E12.5 /
X/55H LIST THE CALIBRATION SPECTRA. WHION FIRST, THEN WHAMP. //))
C
C NABS AND NORD ARE X AND Y POINT COUNT FOR PLOTTING ROUTINES.
NABS=640
NORD=200
C
C FIRST, FILL OUT THE VARIOUS TABLES USED TO PROCESS PULSE AMPLITUDE
C AND BIAS VOLTAGE DATA. IGAIN IS A TABLE OF VALUES FOR 4096*LOG(A) VS
C VOLTAGE. VOLTAGE RANGE USED IS BETWEEN VBOT AND VTOP. LOG(A) IS
C ASSUMED TO BE FIT BY C0+C1*V+C2*V**2+C3*V**3. DIGITAL CONVERSION TO
C 4096 CHANNELS FULL SCALE. TABLE VOLTAGE RANGE IS VBOT TO VTOP. VTOP
C CORRESPONDS TO THE INTEGER NTOP AND VBOT CORRESPONDS TO THE INTEGER
C NBOT. IT IS ASSUMED THAT THE HIGH VOLTAGE VARIES LINEALY WITH
C THE ADC COUNT OVER THE RANGE NBOT TO NTOP.
C THE TABLE VOLTAGE LIMITS, AS INPUT, SHOULD BOUND THE ACTUAL
C OPERATING VOLTAGE RANGE, BUT NOT BY MORE THAN JUST SUFFICIENT OR
C CALCULATIONS MAY NOT STAY WITHIN 16 BIT LIMITATIONS ON ARITHMETIC.
C
C CALIBRATION DATA PLACED ON A SEPARATE DISC FILE.
50 WRITE(*,6)
READ(*,23) FNAME
OPEN(10,FILE=FNAME,FORM='FORMATTED',STATUS='OLD')
C READ AN IDENTIFIER FOR THE BASIC DATA.
READ(10,23) IDENT
WRITE(*,23) IDENT
C READ VOLTAGE LIMITS AND CORRESPONDING ADC COUNT VALUES.
READ(10,2) VBOT,VTOP
READ(10,5) NBOT,NTOP
WRITE(*,7)
WRITE(*,2) VBOT,VTOP
WRITE(*,5) NBOT,NTOP
C INPUT THE 4 POLYFIT COEFFICIENTS WHICH EXPRESS LOGA(A) VS. V.
READ(10,14) C0,C1,C2,C3
CLOSE(10)
WRITE(*,4)
WRITE(*,14) C0,C1,C2,C3
C
C DETERMINE THE GAS GAIN LIMITS FROM VBOT AND VTOP.
C IF MINIMUM GAS GAIN, GMIN, IS NOT AT LEAST 5 OR SO,
C NO PROPORTIONAL MODE WILL EXIST. IF MAXIMUM GAS
C GAIN, GMAX, EXCEEDS ABOUT 10000, EVENTS COUNTED WILL BE TOO LOW
C IN ENERGY TO BE OF INTEREST.
C
GMAX=EXP(GGAIN(VTOP))
GMIN=EXP(GGAIN(VBOT))
WRITE(*,2) GMIN,GMAX

```



```

      PAUSE ' ARE THE LIMITS OF GAS GAIN ACCEPTABLE? '
C
C IN ADDITION TO CHECKING THAT GAS GAINS ARE WITHIN ACCEPTABLE
C LIMITS, CHECK TO MAKE SURE GAS GAIN TABLE LENGTH DOES NOT
C EXCEED 3000. MUST KEEP WHOLE PROGRAM WITHIN ONE PAGE.
C FOR SINGLE PRECISION COMPUTATIONAL ACCURACY, DATA SCALED BY 4096.
C PULSE HEIGHTS ANALYSED 1-4096, BUT NO DATA USED BELOW 896.
C ALTHOUGH GAS GAIN MAY NEVER EXCEED LIMITS OF GMIN TO GMAX, THE
C RANGE OF LOGY/A DATA COULD STILL EXCEED 15 BITS. THIS POSSIBILITY
C IS CHECKED BEFORE PROCEEDING.
C
71 RANGE=4096.*ALOG((4096.*GMAX)/(896.*GMIN))
   IF(RANGE-32767.)72,82,82
82 PAUSE ' VOLTAGE RANGE EXCESSIVE FOR 16 BITS. '
   GO TO 50
C
C CAN NOW PROCEED TO FILL OUT ALL TABLES REQUIRED.
72 KNA=NTOP-NBOT+1
   IF(KNA-1)93,43,63
93 PAUSE ' GAS GAIN TABLE COUNT ERROR '
   GO TO 50
63 IF(KNA-3000)91,91,92
92 PAUSE ' MORE THAN 3000 IN GAIN TABLE '
   GO TO 50
91 DENOM=FLOAT(NTOP-NBOT)
   GO TO 59
43 DENOM=1.0
C
C DETERMINE LOG GAS GAIN TABLE. GAINS ARE RELATIVE TO THE MAXIMUM
C VALUE GMAX.
59 GMXLG=ALOG(GMAX)
   DO40 I=1,KNA
   U=VBOT+(VTOP-VBOT)*FLOAT(I-1)/DENOM
40 IGAIN(I)=IFIX(4096.*(GMXLG-GGAIN(U)))
C
C GENERATE A TABLE OF VALUES FOR 4096*LOG(I/LVL) WHERE I IS THE X OR Y
C CHANNEL NUMBER RANGING FROM 1 TO 4096 CHANNELS. LVL IS THE ADC
C DISCRIMINATOR LEVEL BELOW WHICH NO Y PULSE IS ACCEPTED.
54 LVL=896
   DO41 I=1,4096
41 LOGTB(I)=IFIX(4096.*ALOG(FLOAT(I)/FLOAT(LVL)))
C
C GENERATE A TABLE OF VALUES OF ADDRESSES CORRESPONDING TO X/Y VALUES
C FROM 1 TO 31 FROM GIVEN VALUES FOR 1024*LOG(32*X/Y). THE TABLE LENGTH
C IS LINTA (LINTA=3548). RESTRICTIONS UPON X AND Y WILL PREVENT ANY
C PULSE AMPLITUDE EVENT FROM FALLING OUT OF THE RANGE 1 TO 3548.
   LINTA=IFIX(1024.*ALOG(32.))
   DO42 I=1,LINTA
42 INLGTB(I)=IFIX(EXP(FLOAT(I)/1024.))
C
C EDIT THE GAS GAIN TABLE AND PARAMETERS.
   WRITE(*,9)
   PAUSE
   WRITE(*,10) C0,C1,C2,C3,GMIN,GMAX,LVL
   WRITE(*,11) VTOP,VBOT,NTOP,NBOT

```

```

C
C PASS THE LOCATION OF TABLES AND DATA TO RAMPIN.ASM.
C   CALL SETUP(IGAIN,NBOT,NTOP,LOGTB,INLGTB,IDAT,II,NVLT,KBIF)
C
C IF IGO NEGATIVE, TEST PULSE ONLY DATA TO CALIBRATE FOR WHITE
C AMPLIFIER AND IONIZATION. IF POSITIVE, DO DATA ACQUISITION.
C
C   44 WRITE(*,3)
C     READ(*,15) IGO
C     IF(IGO) 200,201,201
C 201 DO46 I=1,512
C     DO46 J=1,32
C   45 IDAT(J,I) = -32767
C
C NOW ENTER MAIN ROUTINE ANA IN RAMPIN.ASM. IN ANA, ANALYSE PULSE
C DATA UNTIL TERMINATION IS FORCED BY BIT TOGGLE ON THE ADC.
C
C 119 CALL ANA
C   PAUSE ' RUN TERMINATED '
C
C IMMEDIATELY AFTER COMPLETION OF DATA ACQUISITION,
C DISPLAY THE 32 CHANNEL X/Y SPECTRUM FOR ANY Y AND ALSO
C PRINT THE 32 CHANNEL X/Y SPECTRUM. NEGATIVE VALUE FOR IY
C TO CONTINUE CURRENT ACQUISITION. NULL VALUE FOR IY
C TO SAVE SPECTRUM ON DISC.
C
C 118 WRITE(*,16)
C   READ(*,15) IY
C   IF(IY-512)117,117,118
C 117 IF(IY)119,121,116
C 116 DO111 I=1,32
C 111 IDUM(I)=IDAT(I,IY) + 32767
C   WRITE(*,22) (IDUM(I),I=1,32)
C   MAX=1
C   DO113 I=1,32
C   IF(IDUM(I)-MAX)113,113,114
C 114 MAX=IDUM(I)
C 113 CONTINUE
C   CALL PLTINIT
C   CALL LINAX(NABS,NORD)
C   DO115 I=1,32
C   IX=IFIX((FLOAT(I))*FLOAT(NABS)/32.)-1
C   JY=IFIX(.95*FLOAT(NORD)*FLOAT(IDUM(I))/FLOAT(MAX))
C   IXX=IX-3
C   CALL SPLT(IXX,JY,-1,6)
C   LENGTH=2
C   JYY=JY-1
C   IF(JYY)112,112,115
C 112 JYY=0
C   LENGTH=1
C 115 CALL SPLT(IX,JYY,1,LENGTH)
C   WRITE(*,20) IY,MAX
C   CALL PLTOUT
C   GO TO 118
C

```

```

C  ADD UP THE X/Y FOR ALL Y AND PRINT RESULT FOLLOWING LISTING
C  OF THE RELEVANT INPUT PARAMETERS.
C  GMAX IS THE MAXIMUM GAS GAIN OF 10000 ALLOWED. LVL IS THE ADC BIAS.
C
121 PAUSE ' PRINTER ON TO SAVE OUTPUT DATA EDIT '
    WRITE(*,17) VBOT,VTOP,NBOT,NTOP,C0,C1,C2,C3,LVL,GMIN,GMAX
    WRITE(*,21)
    ALL=0.0
    DO64 I=1,512
    MAX=0
    DO62 J=1,32
62  MAX=MAX+IDAT(J,I) + 32767
    ALL=ALL+FLOAT(MAX)
64  IDUM(I)=MAX
    WRITE(*,18) ALL
    WRITE(*,22) (IDUM(I),I=1,512)
C
C  SAVE THE UNFORMATTED MAIN DATA ARRAY ON DISC.
C
    WRITE(*,26)
    READ(*,23) OPTION
    IF(OPTION.EQ.'DELETE') GO TO 44
    WRITE(*,24)
    READ(*,23) FNAME
    WRITE(*,25)
    READ(*,23) IDENT
    WRITE(*,27)
    READ(*,22) NSEC
    OPEN(10,FILE=FNAME,FORM='UNFORMATTED',STATUS='NEW')
    WRITE(10) FNAME
    WRITE(10) IDENT
    WRITE(10) NSEC
    WRITE(10) LVL
    WRITE(10) GMAX
    WRITE(10) IDAT
    CLOSE(10)
    GO TO 44
C
C  CALIBRATION MODE USING TEST PULSER ONLY. DETERMINE THE RESPONSE
C  TO AN EQUIVALENT WHITE IONIZATION SPECTRUM (WHION) AND ALSO TO
C  A WHITE AMPLIFIER SPECTRUM (WHAMP). FOR THE WHITE IONIZATION
C  SPECTRUM, MUST REDUCE THE PROBABILITY BY A TO ACCOUNT FOR THE
C  EQUIVALENT SCALE-UP OF THE PULSE AMPLITUDE BY A.
C
C  CLEAR ARRAYS AND COMMENCE, TERMINATE IF KBIT NON ZERO.
200 DO203 I=1,512
    WHAMP(I)=0.0
203 WHION(I)=0.0
C  READ SEQUENCES OF  $II=512\log(Y/A)$ ,  $NVLT=4096\log(GMAX/A)$ , KBIT.
C  THE TPLSR ROUTINE IS FOUND IN MACHINE UTILITY RAMPIN.ASM.
207 CALL TPLSR
C  NON ZERO FOR KBIT CAUSES TERMINATION.
    IF(KBIT)206,206,205
206 AMUL=GMAX*EXP(-FLOAT(NVLT)/4096.)
    II=II+1

```

```

        WHION(II)=WHION(II) + 1.0/AMUL
        WHAMP(II)=WHAMP(II) + 1.0
        GO TO 207
C
C   GET THE TOTAL COUNT IN THE WHAMP DISTRIBUTION.
C   THIS CAN BE USED FOR TEST PULSE RATE.
205 U=0.0
        DO202 I=1,512
202 U=U+WHAMP(I)
        PAUSE ' PRINTER ON TO SAVE CALIBRATION DATA '
        WRITE(*,27)
        READ(*,22) NSEC
        CPS=U/FLOAT(NSEC)
        WRITE(*,28) CPS
C LIST SPECTRA AND SAVE ON DISC IF OPTION SELECTED.
        WRITE(*,2) (WHION(I),I=1,512)
        WRITE(*,1) (WHAMP(I),I=1,512)
        WRITE(*,26)
        READ(*,23) OPTION
        IF(OPTION.EQ.'DELETE') GO TO 44
        WRITE(*,13)
        READ(*,23) FNAME
        WRITE(*,25)
        READ(*,23) IDENT
        OPEN(10,FILE=FNAME,FORM='FORMATTED',STATUS='NEW')
        WRITE(10,23) FNAME
        WRITE(10,23) IDENT
        WRITE(10,22) NSEC
        WRITE(10,2) CPS
        WRITE(10,22) LVL
        WRITE(10,2) GMAX
        WRITE(10,2) (WHION(I),I=1,512)
        WRITE(10,1) (WHAMP(I),I=1,512)
        CLOSE(10)
        GO TO 44
C
        END
C
C   SUBROUTINE SPLT(IX,IY,IHV,LANGTH) PLOTS ON THE STORAGE SCOPE A
C   VERTICAL(IHV POSITIVE) LINE OR A HORIZONTAL(IHV NEGATIVE) LINE
C   OF LENGTH LANGTH STARTING AT IX AND IY.
C
        FUNCTION SPLT(IX,IY,IHV,LANGTH)
C
        IF(IHV)1,2,2
1 NX=IX+LANGTH
        CALL QLINE(IX,IY,NX,IY,1)
        RETURN
2 NY=IY+LANGTH
        CALL QLINE(IX,IY,IX,NY,1)
        RETURN
        END
C
C   LINAX DRAWS LINEAR AXES. 32 CHANNEL TICS FOR ABSCISSA.
C

```

```

      FUNCTION LINAX(NABS,NORD)
C
      CALL SPLT(0,0,1,NORD)
      CALL SPLT(0,0,-1,NABS)
      IDEL=NABS/32
      LENGTH=NORD/40
      IX=IDEL-1
      DO1 I=1,32
      CALL SPLT(IX,0,1,LENGTH)
1 IX=IX+IDEL
      RETURN
      END
C
C FUNCTION PLTINIT INITIALIZES PLOTTING ROUTINES.
C
      FUNCTION PLTINIT
C
      CALL QCOLOR(0,1)
      CALL QSMODE(6)
      RETURN
      END
C
C FUNCTION PLTOUT RETURNS FROM PLOTTING ROUTINES.
C
      FUNCTION PLTOUT
C
      CHARACTER CHAR
1 FORMAT(A)
      READ(*,1) CHAR
      CALL QSMODE(2)
      RETURN
      END

```

PAGE,132
TITLE RAMPIN.ASM

RAMPIN IS A UTILITY FOR PULSE AMPLITUDE ACQUISITION BASED UPON
A RAMP VARIATION OF THE COUNTER BIAS VOLTAGE TIME DEPENDENCE.
COMPUTATIONS ARE ORGANIZED AROUND A 16 BIT WORD AND NO USE
IS MADE OF EXTENDED MATH FUNCTIONS.
INPUT ADC CONVERSION FOR X AND Y PULSE HEIGHT AND FOR
VOLTAGE ARE FROM 0 TO 4095 CHANNELS (12 BITS).
2 IS ADDED TO ALL CONVERSIONS TO PRODUCE 4097 CHANNELS FULL SCALE.
THIS ADDITION OF 2 IS INTENDED TO AVOID ADC MISSING BIT EFFECT.
LINEARITY, AS DETERMINED IN PRINIT, IS MAINTAINED AS 1 TO 4096.

RAMPIN.ASM CONTAINS THE FORTRAN CALLABLE ROUTINES SETUP,
ANA, AND TPLSR.

SETUP IS IS A UTILITY TO LOCATE ARRAYS IN MAIN.
ARGUMENTS OF SETUP ARE-

1....IGAIN; ADDRESS OF TABLE OF GAS GAIN VS VOLTAGE.
2....NBOT; STARTING(LOWEST) VALUE OF VOLTAGE IN TABLE.
3....NTOP; ENDING(HIGHEST) VALUE OF VOLTAGE IN TABLE.
4....LOGTB; ADDRESS OF 4096 CHANNEL TABLE OF LOG CHANNEL.
5....INLGTB; ADDRESS OF INVERSE LOG TABLE.
6....IDAT; ADDRESS OF 2-P X/Y BY LOG(Y/A) DATA ARRAY.
7....II; JOINT 512LOGY/A ADDRESS.
8....NVLT; 4096LOG(AMAX/A) FOR EVENT.
9....KBIT; SET TO UNITY WHEN END-OF-RAMP DETECTED.

.....
; DATA REQUIRED FOR QUAD TECHMAR INTERFACE.
; NEED BASE ADDRESS AND LOCATION OF PORTS RELATIVE TO BASE.

BASE EQU 240 ; BASE ADDRESS FOR UNIT #0.
PP EQU 0 ; CONTROL PORT ADDRESS.
PA EQU 3 ; A PORT ADDRESS.
PB EQU 2 ; B PORT ADDRESS.
PC EQU 1 ; C PORT ADDRESS.
EXP EQU 10000000B ; TOP BIT OF B BYTE FOR EXIT TEST.

.....
; DGROUP GROUP DATA
CODE SEGMENT 'CODE'
ASSUME CS:CODE,DS:DGROUP,SS:DGROUP

; SETUP ROUTINE LOCATES ADDRESSES OF DATA IN MAIN PROGRAM.
; ALSO, WITHIN SETUP, PROGRAM THE 8255-A DATA INPUT PORT.

SETUP PROC FAR
PUBLIC SETUP
PUSH BP
MOV BP,SP
MOV BX,[BP+38] ; ADDRESS OF GAS GAIN TABLE.
MOV IGAIN,BX ; PLACE IN IGAIN.
MOV BX,[BP+34] ; ADDRESS OF GAIN TABLE LOW LIMIT.
MOV AX,[BX] ; PLACE ADDRESS CONTENT IN NBOT.
MOV NBOT,AX

```

MOV     BX,[BP+30]    ;ADDRESS OF GAIN TABLE HIGH LIMIT.
MOV     AX,[BX]       ;PLACE ADDRESS CONTENT IN NTOP.
MOV     NTOP,AX
MOV     BX,[BP+26]    ;ADDRESS OF LOG CHANNEL TABLE.
MOV     LOGTB,BX      ;PLACE IN LOGTB.
MOV     BX,[BP+22]    ;ADDRESS OF INVERSE LOG TABLE.
MOV     INLGTB,BX     ;PLACE IN INLGTB.
MOV     BX,[BP+18]    ;ADDRESS OF 32X512 MAIN DATA ARRAY.
MOV     IDAT,BX       ;PLACE IN IDAT.
MOV     BX,[BP+14]    ;ADDRESS OF 512LOGY/A.
MOV     II,BX         ;PLACE IN II.
MOV     BX,[BP+10]    ;ADDRESS OF 4096LOGAMAX/A.
MOV     NVLT,BX       ;PLACE IN NVLT.
MOV     BX,[BP+6]     ;ADDRESS OF EXIT TEST.
MOV     KBIT,BX       ;PLACE IN KBIT.
;
; PROGRAM THE 8255-A I/O PORT.
MOV     AL,0B6H       ;MODE 1, OPTION 2.
OUT     BASE+PP,AL
;
POP     BP
RET     36             ;BACK TO MAIN.
;
SETUP   ENDP
;
; ENTRY FOR ANALYSIS ROUTINE ANA.
;
ANA     PROC          FAR
PUBLIC  ANA
;
; THREE PARAMETER ANALYSIS.
; ADC CONVERTS Y, X, AND HV TO 4096 FULL SCALE. CHECK TO SEE IF
; Y IS BELOW THE 896 CHANNEL DISCRIMINATION LIMIT (FOR MAXIMUM
; CHANNEL NUMBER OF 4096). MAKE SURE X IS LESS THAN Y. ALSO TEST
; TO VERIFY THAT HIGH VOLTAGE IS WITHIN TABLE LIMIT SETTINGS.
; IF ALL DATA OK, PROCEED TO FORM JOINT X/Y AND LOG(Y/A) ADDRESS.
;
; FIRST PRODUCE A RESET. THIS BIT TOGGLE SEQUENCE UNLOCKS THE
; ADC REGARDLESS OF STATUS AND ALLOWS ANALYSIS TO COMMENCE.
MOV     AL,0FH        ;LOAD RESET BIT HIGH.
OUT     BASE+PP,AL    ;SET BIT HIGH.
IN      AL,BASE+PA     ;INPUT A PORT AND CLEAR.
IN      AL,BASE+PB     ;INPUT B PORT AND CLEAR.
MOV     AL,0EH        ;LOAD BIT 7 LOW.
OUT     BASE+PP,AL    ;SET 7 LOW AND RESET.
JMP     STRT
;
BACK:   RET           ;RETURN TO MAIN PROGRAM IF BIT SET.
;
; RSET MAY BE USED TO FORCE A RESET WHENEVER OFF-NORMAL
; DATA IS ENCOUNTERED FOR THE Y CHANNEL (RSETY) OR FOR
; THE X CHANNEL (RSETX).
;
RSETY:  IN            AL,BASE+PA    ;FAST RESET WITHOUT BIT TOGGLE.
IN      AL,BASE+PB    ;X FINISHED, HV COMMENCES.

```

```

NOP
NOP
NOP
NOP
NOP
NOP
NOP
NOP
NOP
NOP
NOP
RSETX: IN      AL,BASE+PA      ;RESET HV AND TERMINATE.
        IN      AL,BASE+PB
;
STRT:   IN      AL,BASE+PC      ;GET C PORT DATA.
        TEST    AL,010B        ;TEST IF BIT 2 HIGH.
        JZ      STRT           ;LOOP TILL DATA READY.
        IN      AL,BASE+PA      ;INPUT LOW BYTE FROM A PORT.
        MOV     DX,AL           ;SAVE IN DX REGISTER.
        IN      AL,BASE+PB      ;INPUT HIGH BYTE FROM B PORT.
; ADC CAN NOW BEGIN CONVERTING X.
        MOV     DH,AL           ;DX HAS FULL Y VALUE.
        TEST    DH,EXB         ;TEST EXIT BIT.
        JNZ     BACK           ;IF UP, RETURN TO MAIN PROGRAM.
        INC     DX              ;TOP VALID Y = 4096.
        INC     DX
        CMP     DX,896          ;TEST IF Y EXCEEDS CHANNEL CUT OFF.
        JS      RSETX          ;IF NOT, START FROM BEGINNING.
        IN      AL,BASE+PA      ;INPUT X CHANNEL LOW BYTE.
        MOV     CL,AL           ;PLACE IN CX REGISTER.
        IN      AL,BASE+PB      ;INPUT X CHANNEL HIGH BYTE.
; ADC CAN NOW BEGIN CONVERSION OF HIGH VOLTAGE.
        MOV     CH,AL           ;CX HAS FULL X CHANNEL VALUE.
        INC     CX              ;TOP VALID X = 4096.
        INC     CX
        CMP     DX,4096         ;DON,T LET Y EQUAL OR EXCEED LIMIT.
        JNS     RSETX
        CMP     DX,CX           ;FAST RESET IF X SHOULD EXCEED Y.
        JS      RSETX
        IN      AL,BASE+PA      ;READ HV LOW BYTE.
        MOV     BL,AL           ;PLACE IN LOW BX.
        IN      AL,BASE+PB      ;READ HV HIGH BYTE.
; ADC NOW FREE TO ANALYSE ANOTHER PULSE.
        MOV     AH,AL           ;SWITCH TO AX HIGH.
        MOV     AL,BL           ;VOLTAGE VALUE STAYS IN AX.
        CMP     AX,NTOP ;VOLTAGE VALUE CAN'T EXCEED TABLE TOP.
        JNS     STRT           ;IF IT DOES, QUIT.
        SUB     AX,NBOT ;REMOVE THE LOW VOLTAGE TABLE LIMIT.
        JS      STRT           ;QUIT IF VOLTAGE LESS THAN LOW LIMIT.
;
; AT THIS POINT, AN EVENT HAVING ALL PARAMETERS WITHIN THE
; PRESCRIBED LIMITS EXISTS. HIGH VOLTAGE (A NUMBER LESS THAN
; 3000 IN EXCESS OF NBOT) IS IN AX. THE Y CHANNEL VALUE
; (1-4096) IS IN DX, AND THE X CHANNEL (1-4096) IS IN CX.
; NOW FIND THE ADDRESS IN THE 32X512 ARRAY IDAT AND INCREMENT.

```



```

    SAL     AX,1      ;FORM 2-BYTE WORD FOR VOLTAGE.
    MOV     BX,AX     ;PUT INTO BX FOR INDIRECT ADDRESSING.
    MOV     SI,IGAIN   ;LET SI HOLD THE IGAIN ADDRESS.
    MOV     AX,WORD PTR[BX+SI] ;PLACE GAS GAIN VALUE IN AX.
    MOV     SI,LOGTB   ;SI HOLDS LOG CHAN. TABLE ADDRESS.
    SAL     CX,1      ;FULL WORD FOR X.
    MOV     BX,CX     ;PUT INTO BX FOR ADDRESSING.
    MOV     CX,WORD PTR[BX+SI] ;CX HAS VALUE FOR LOG(X).
    SAL     DX,1      ;FULL WORD FOR Y.
    MOV     BX,DX     ;INTO BX FOR ADDRESSING.
    MOV     DX,WORD PTR[BX+SI] ;DX HAS VALUE OF LOG(Y).
;   SCALED VALUES FOR LOGX, LOGY, AND LOGA ARE NOW IN CX, DX, AND AX.
;   FORM X/Y. FIRST GET LOGX - LOGY + LOG32 = LOG(32X/Y).
    MOV     BX,CX     ;PLACE LOGX IN BX
    SUB     BX,DX     ;SUBTRACT LOG OF Y.
    ADD     BX,L32    ;NORMALIZE TO 32 CHANNELS MAXIMUM.
    JNS     PT1       ;NEGATIVE VALUES GO TO X/Y CHANNEL 0.
    MOV     BX,0
    JMP     PT2
PT1:   SAR     BX,1      ;SCALE TO 1024 FROM 4096 AND FORM
    AND     BX,07FFEH ;WORD ADDRESS FOR LOG(32X/Y).
;   LOOK UP X/Y FROM THE TABLE OF INVERSE VALUES.
    MOV     SI,INLGTB ;PLACE INVERSE TABLE ADDRESS IN SI.
    MOV     BX,WORD PTR[BX+SI] ;VALUE OF X/Y TO BX.
    SAL     BX,1      ;FULL WORD FOR ADDRESSING.
    AND     BX,03EH   ;RESTRICT ADDRESS.
;   FORM 4096*LOG((Y/LVL)*(GMAX/A))
PT2:   ADD     AX,DX     ;FORM 4096 * LOG OF SCALED ENERGY.
    AND     AX,011111111000000B ;CLEAR LOW 6 BITS FOR X/Y.
;   AX NOW HAS LOG(Y/A) ADDRESS SHIFTED TO HOLD X/Y IN LOW 6 BITS.
;   GET JOINT X/Y AND LOG(Y/A) ADDRESS.
    ADD     BX,AX     ;BX HAD X/Y VALUE. ADD AX FOR JOINT.
    MOV     SI,IDAT   ;PUT THE IDAT ARRAY ADDRESS INTO SI.
    INC     WORD PTR[BX+SI] ;INCREMENT COUNT AT ADDRESS.
    JMP     STRT      ;FINISHED. BACK FOR ANOTHER COUNT.

;
ANA     ENDP
;
CODE    ENDS
;
;.....
;
DATA    SEGMENT 'DATA' ;DEFINE ALL DATA AREAS NOW.
;
;   VARIABLES USED IN THE ROUTINE ANA.
;
L32     DW(14195)    ;=4096*LOG32 NORMALIZATION TO 32 CH. X/Y.
NBOT    DW(0)        ;LOW GAS GAIN TABLE LIMIT.
NTOP    DW(0)        ;HIGH GAS GAIN TABLE LIMIT.
;
;   ADDRESSES OF TABLES AND DATA ARRAYS.
;
IGAIN    DW(0)        ;ADDRESS OF GAS GAIN TABLE.
LOGTB    DW(0)        ;ADDRESS OF LOG CHANNEL TABLE.
INLGTB   DW(0)        ;ADDRESS OF INVERSE LOG TABLE.

```

```

IDAT    DW(0)    ;ADDRESS OF 32X512 MAIN DATA ARRAY.
II      DW(0)    ;ADDRESS OF JOINT 512LOGY/A NUMBER.
NVLT    DW(0)    ;ADDRESS OF 4096LOGAMAX/A NUMBER.
KBIT    DW(0)    ;ADDRESS OF EXIT TEST NUMBER.
;
DATA    ENDS
;
;-----
;
;  TEST ROUTINE USED IN TEST PULSE ONLY MODE TO RETURN JOINT
;  ADDRESS, LOG MULTIPLICATION, AND EXIT TEST.
;
CODE     SEGMENT 'CODE'
        ASSUME  CS:CODE,DS:DGROUP,SS:DGROUP
TPLSR    PROC     FAR
        PUBLIC  TPLSR
;  FIRST PRODUCE A RESET. THIS BIT TOGGLE SEQUENCE UNLOCKS THE
;  ADC REGARDLESS OF STATUS AND ALLOWS ANALYSIS TO COMMENCE.
        MOV     AL,0FH                ;LOAD RESET BIT HIGH.
        OUT     BASE+PP,AL            ;SET BIT HIGH.
        IN      AL,BASE+PA            ;INPUT A PORT AND CLEAR.
        IN      AL,BASE+PB            ;INPUT B PORT AND CLEAR.
        MOV     AL,0EH                ;LOAD BIT 7 LOW.
        OUT     BASE+PP,AL            ;SET 7 LOW AND RESET.
        MOV     AX,0
        MOV     SI,KBIT               ;INITIALIZE TERMINATION BIT.
        MOV     WORD PTR[SI],AX       ;INITIALIZE KBIT TO ZERO.
;
;  WAIT FOR Y DATA, THEN INPUT TO DX.
BEGIN:   IN      AL,BASE+PC            ;GET C PORT DATA.
        TEST    AL,010B               ;TEST IF BIT 2 HIGH.
        JZ      BEGIN                ;LOOP TILL DATA READY.
        IN      AL,BASE+PA            ;INPUT LOW BYTE FROM A PORT.
        MOV     DL,AL                 ;SAVE IN DX REGISTER.
        IN      AL,BASE+PB            ;INPUT HIGH BYTE FROM B PORT.
;  ADC CAN NOW BEGIN CONVERTING X.
        MOV     DH,AL                 ;DX HAS FULL Y VALUE.
P7:      IN      AL,BASE+PC            ;GET C PORT DATA.
        TEST    AL,010B               ;TEST IF DATA READY.
        JZ      P7                   ;LOOP TILL DATA READY.
        IN      AL,BASE+PA            ;INPUT X TO RESET MULTIPLEXER.
        IN      AL,BASE+PB
;  AFTER X READ-IN, VOLTAGE CONVERSION CAN COMMENCE.
P8:      IN      AL,BASE+PC            ;GET C PORT.
        TEST    AL,010B               ;SEE IF DATA READY.
        JZ      P8                   ;LOOP TILL READY.
        IN      AL,BASE+PA            ;READ HV LOW BYTE.
        MOV     BL,AL                 ;PLACE IN LOW BX.
        IN      AL,BASE+PB            ;READ HV HIGH BYTE.
;  ADC NOW FREE TO ANALYSE NEXT TIMER PULSE WHEN IT ARRIVES.
        MOV     AH,AL                 ;SWITCH TO AX HIGH.
        MOV     AL,BL                 ;VOLTAGE VALUE STAYS IN AX.
        TEST    DH,EXB               ;TEST EXIT BIT IN Y DATA.
        JNZ     OUT                   ;IF UP, RETURN TO MAIN PROGRAM.
        INC     DX                    ;TOP Y = 4096.

```

```

INC      DX
CMP      DX,896          ;Y MUST = OR EXCEED CHANNEL CUT OFF.
JS       BEGIN          ;IF NOT, START FROM BEGINNING.
CMP      DX,4096         ;DONT LET Y EQUAL OR EXCEED 4096.
JNS      BEGIN          ;IF HAPPENS, START OVER.
CMP      AX,NTOP         ;VOLTAGE VALUE CAN'T = OR EXCEED TABLE TOP.
JNS      BEGIN          ;IF IT DOES, QUIT.
SUB      AX,NBOT         ;REMOVE THE LOW VOLTAGE TABLE LIMIT.
JS       BEGIN          ;QUIT IF VOLTAGE LESS THAN LOW LIMIT.
;
; AT THIS POINT, AN EVENT HAVING ALL PARAMETERS WITHIN THE
; PRESCRIBED LIMITS EXISTS. HIGH VOLTAGE (A NUMBER LESS THAN
; 3000 IN EXCESS OF NBOT) IS IN AX. Y IS IN DX.
;
SAL      AX,1           ;FORM 2-BYTE WORD FOR VOLTAGE.
MOV      BX,AX          ;PUT INTO BX FOR INDIRECT ADDRESSING.
MOV      SI,IGAIN        ;LET SI HOLD THE IGAIN ADDRESS.
MOV      AX,WORD PTR[BX+SI] ;PLACE GAS GAIN VALUE IN AX.
MOV      SI,NVLT         ;ADDRESS OF NVLT INTO SI.
MOV      WORD PTR[SI],AX ;PUT LOG GAIN IN NVLT
MOV      SI,LOGTB        ;SI HOLDS LOG CHAN. TABLE ADDRESS.
SAL      DX,1           ;FULL WORD FOR Y.
MOV      BX,DX          ;INTO BX FOR ADDRESSING.
MOV      DX,WORD PTR[BX+SI] ;DX HAS VALUE OF LOG(Y).
; SCALED VALUES FOR LOGY, AND LOG(1/A) ARE NOW IN DX, AND AX.
; FORM 4096*LOG((Y/LVL)*(GMAX/A))
ADD      AX,DX          ;FORM 4096 * LOG OF SCALED ENERGY.
MOV      CL,6
SAR      AX,CL          ;SHIFT TO 512 CHANNELS.
AND      AX,01FFH       ;RESTRICT ADDRESS SPACE.
MOV      SI,II          ;ADDRESS OF II INTO SI.
MOV      WORD PTR[SI],AX ;PLACE RESULT IN II.
; II NOW HAS LOG(Y/A) ADDRESS SHIFTED TO 512 CHANNELS MAXIMUM.
; NVLT HAS THE 4096.LOG(GMAX/A) VALUE.
RET      ;FINISHED. BACK FOR ANOTHER COUNT.
;
OUT:     MOV      AX,1    ;SET TERMINATION BIT.
MOV      SI,KBIT        ;ADDRESS OF BIT TO SI.
MOV      WORD PTR[SI],AX ;SET KBIT NON ZERO TO INDICATE FINISH.
RET      ;BACK TO MAIN.
;
TPLSR    ENDP
;
CODE     ENDS
;
END

```

APPENDIX III
LISTING OF THE CODE RMPRDN.FOR USED FOR DATA REDUCTION

LISTING OF THE CODE RMPRDN.FOR USED FOR DATA REDUCTION.

```

$NODEBUG
$NOFLOATCALLS
$LARGE
$STORAGE:2
C RMPRDN.FOR
C PROTON PEAK INTEGRATION FOR PROTON-RECOIL COUNTER SPECTRA.
C RMPRDN IS FOR RAMP-VOLTAGE MODE DATA ONLY.
C
  DIMENSION IDAT(32,512),NDAT(32,512),TVAL(512),ETVAL(512),
  XTPLSE(512),WIDE(512),PRTS(512),DVAL(512),EDVAL(512),GAMS(512),
  XDATI(32,511),DATN(32,511),D(32),RATEO(512),GMS(32)
  COMMON Y(512),X(512),B(9),W(512)
  DOUBLE PRECISION B,EVLV,DPI
C
  INTEGER*4 NSEC,NNSEC
  CHARACTER FNAME*16,PNAME*16,IDENT*72,JDENT*72
C
C ESTABLISH THE LOG OF ENERGY ELOG AT ANY CHANNEL
  ELOG(I)=FLOAT(I+NYMIN-1)/64. + CAL
C WHERE CAL = ALOG((LVL/GMAX)*FSEX/4096.).
C
  1 FORMAT(47H INPUT A 10 CHAR. FILE NAME FOR 2-P DATA ARRAY. )
  2 FORMAT(A)
  3 FORMAT(I3)
  4 FORMAT(50H INPUT POS TO SAVE ON DISC, OR NEG TO DELETE SAVE.)
  5 FORMAT(6E12.5)
  6 FORMAT(33H INPUT(I3) THE Y CHANNEL(1-NCHY). )
  7 FORMAT(16H PROTON VALLEY = I3, 14H TEST VALLEY = I3/
  X14H PROTON PEAK = I3,12H TEST PEAK = I3/
  X34H CHECK SPECTRUM BEFORE PROCEEDING. )
  8 FORMAT(/45H-----MAIN MENU-----/
  X49H ALL OPTIONS REACHED BY INPUTTING (I3) 1 TO 4). /
  X48H 1...PRINT RAW DATA BETWEEN ANY CHANNEL LIMITS. /
  X49H 2...DISPLAY AND PRINT 32-CHANNEL X/Y FOR ANY Y. /
  X42H 3...CARRY OUT GAMMA BACKGROUND ANALYSIS. /
  X49H 4...COMPLETE ANALYSIS AND OUTPUT FINAL RESULTS. /)
  9 FORMAT(///18X,27HLISTING OF ANALYSIS RESULTS //)
  10 FORMAT(I8,4F6.1,2F6.2,3E11.4)
  11 FORMAT(/9H J,5H DVAL,7H EDVAL,5H TVAL,7H ETVAL,6H LINE ,
  X8H RATIO ,9H GAMMAS ,11H PRTS ,9H TIME /)
  12 FORMAT(49H CAN'T FIND CONSISTENT SET OF DATA PEAKS/VALLEYS. /)
  13 FORMAT(8F8.0)
  14 FORMAT(32H INITIAL AVG PROTON LINE WIDTH = F7.2/
  X51H CHANNEL WHERE LINE BROADENS TO 1.5 TIMES INITIAL = I5/)
  15 FORMAT(16I5)
  16 FORMAT(43H INPUT A FILE NAME FOR THE PROTON SPECTRUM. )
  17 FORMAT(31H TOTAL POINTS AND START POINT = 2I5 )
  18 FORMAT(10F8.0)
  19 FORMAT(52H INPUT A FILE NAME FOR THE GAMMA BACKGROUND SPECTRUM )
  20 FORMAT(2I8)
  21 FORMAT(/41H TOTAL POINTS AND START POINT = 2I5 /
  X46H INITIAL AVERAGE PROTON LINE WIDTH = F7.2 /
  X36H N15 AND NBRK CHANNELS ARE 2I5 /
  X29H .90 WMAX CHANNEL = I5/
  X32H RUN TIME IN SECONDS = I8 /)

```

```

22 FORMAT(43H Y CHANNEL WHERE GAMMA RATIO = .90 OF MAX = I5)
23 FORMAT(50H Y CHANNEL WHERE X/Y PROTON CUT-OFF CHANNEL IS 1 = I5 )
24 FORMAT(43H INPUT A .DAT FILE NAME FOR 32 X/Y SPECTRUM )
26 FORMAT(35H THE ENERGY FOR THE X/Y SPECTRUM IS E12.5 )
25 FORMAT(53H INPUT(I3/I3) LOW AND HIGH Y LIMITS FOR DATA LISTING./)
27 FORMAT(53H INPUT NEGATIVE CHAN. NULL ABOVE AND SAVE FOR GRAPHER )
28 FORMAT(45H INPUT THE ENERGY SCALE FACTOR FSEX (E12.5). )
29 FORMAT(36H THE Y (OR LOG(E)) CHANNEL NUMBER IS I5 )
30 FORMAT(44H INPUT NEGATIVE TO DELETE LOW X/Y CORRECTION )
32 FORMAT(/33H X/Y DISTRIBUTION FOR Y CHANNEL = I3)

C
C NCHY, THE NUMBER OF Y (ENERGY) CHANNELS, IS LESS THAN 512.
C THIS RESTRICTS A FLOATING POINT ARRAY TO LESS THAN 1 PAGE.
C THE NUMBER OF X/Y CHNNELS IS FIXED AT 32.
    NCHY = 511
    NYMIN=1
    LTOT=NCHY
C NABS AND NORD ARE X AND Y POINT COUNT FOR PLOTTING ROUTINES.
    NABS=720
    NORD=348
    GO TO 203

C
C MAIN MENU. OPTIONS SELECTED HERE.
200 WRITE(*,8)
    READ(*,3) IGO
    IF(IGO)200,200,201
201 IF(IGO-4)202,202,200
202 GO TO(204,205,206,199),IGO

C
C INPUT A 32XNCHY CHANNEL DATA ARRAY FROM DISC.
C CONVERT TO FLOATING POINT.
C
203 WRITE(*,1)
    READ(*,2) FNAME
    OPEN(10,FILE=FNAME,FORM='UNFORMATTED',STATUS='OLD')
    READ(10) FNAME
    WRITE(*,2) FNAME
    READ(10) IDENT
    WRITE(*,2) IDENT
    READ(10) NSEC
    READ(10) LVL
    READ(10) GMAX
    READ(10) IDAT
    CLOSE(10)
    DO208 I=1,NCHY
    DO208 J=1,32
208 DATI(J,I)=FLOAT(IDAT(J,I)) + 32767.
    WCTOFF=.3
    WRITE(*,28)
    READ(*,5) FSEX
    CAL=ALOG((FLOAT(LVL)/GMAX)*FSEX/4096.)
    GO TO 200

C
C ONLY PRINT THE RAW DATA BETWEEN Y CHANNEL LIMITS AS INPUT.
C

```

```

204 WRITE(*,25)
    READ(*,3) ILO
    READ(*,3) IHI
    PAUSE 'PRINTER ON/OFF'
    WRITE(*,2) FNAME
    WRITE(*,2) IDENT
    DO152 J=ILO,IHI
    WRITE(*,15) J
152 WRITE(*,18) (DATI(I,J),I=1,32)
    GO TO 200

```

C
C DISPLAY THE 32 CHANNEL X/Y SPECTRUM FOR ANY Y AND ALSO
C PRINT THE 32 CHANNEL X/Y SPECTRUM. NULL VALUE FOR Y TERMINATES.
C

```

205 WRITE(*,6)
    READ(*,3) IYZ
    IY=IYZ-NYMIN+1
    IF(IY-LTOT)117,117,200
117 IF(IY)200,200,116
116 WRITE(*,32) IY
    DO610 I=1,LTOT
610 W(I)=EXP(ELOG(I))+WCTOFF
    WRITE(*,18) (DATI(I,IY),I=1,32)
    UMAX=1
    DO113 I=1,32
    IF(DATI(I,IY)-UMAX)113,113,114
114 UMAX=DATI(I,IY)
113 CONTINUE
    CALL PLTINIT
    CALL LINAX(NABS,NORD)
    DO115 I=1,32
    IX=IFIX((FLOAT(I))*FLOAT(NABS)/32.)-1
    JY=IFIX(.95*FLOAT(NORD)*DATI(I,IY)/UMAX)
    IXX=IX-3
    IF(JY)120,120,121
120 JY=0
121 CALL SPLT(IXX,JY,-1,6)
    LENGTH=2
    JYY=JY-1
    IF(JYY)112,112,115
112 JYY=0
    LENGTH=1
115 CALL SPLT(IX,JYY,1,LENGTH)
    CALL PLTOUT
    WRITE(*,29) IY
    WRITE(*,26) W(IY)
    WRITE(*,27)
    READ(*,15) IKO
    IF(IKO) 602,205,205
602 IKO=-IKO
    DO603 I=1,32
    IF(I-IKO) 600,600,601
601 D(I)=0.0
    GO TO 603
600 D(I)=DATI(I,IY)

```

```

603 CONTINUE
    WRITE(*,24)
    READ(*,2) FNAME
    OPEN(10,FILE=FNAME,FORM='FORMATTED',STATUS='NEW')
    DO605 I=1,32
    XI=FLOAT(I)
605 WRITE(10,5) XI,D(I)
    CLOSE(10)
    GO TO 205

C
C ANALYSE FOR DATA AND LIVE TIME USING BACKGROUND SUBTRACTION.
C COLLAPSE TO A SINGLE 32-CHANNEL SPECTRUM D(I), LOCATE THE
C VALLEY CHANNELS BEFORE PROTON PEAK (NVDAT) AND BEFORE LIVE
C TIME PEAK (NVTEST).
C
206 UMAX=0.0
    DO128 I=1,32
    UDUM=0.0
    DO129 J=1,NCHY
129 UDUM=UDUM+DATI(I,J)
    IF(UDUM-UMAX)128,128,127
127 UMAX=UDUM
128 D(I)=UDUM
C DERIVE THE TEST PULSER PEAK CHANNEL JTPK, AND THE TEST VALLEY JTVAL.
    DLTA=0.025*UMAX
    I=32
83 IF(D(I-1)-D(I)+DLTA)80,81,81
81 I=I-1
    IF(I-1)82,82,83
82 WRITE(*,12)
    GO TO 200
80 JTPK=I
86 IF(D(I-1)-D(I))84,84,85
84 I=I-1
    IF(I-1)82,82,86
85 JTVAL=I
C DERIVE THE PROTON PEAK JDPK AND ASSUME PROTON-GAMMA VALLEY
C NVDAT IS 5 CHANNELS BELOW THIS.
    I=I-1
89 IF(D(I-1)-D(I))88,88,87
87 I=I-1
    IF(I-1)82,82,89
88 JDPK=I
    NVDAT=JDPK-5
C NVTST BETTER VALUE FOR PROTON-TEST PULSE VALLEY VALUE.
    NVTST=IFIX(HILO(0,JDPK,JTPK,D))
C
C PLOT THE COLLAPSED X/Y SPECTRUM AND SHOW VALLEY CHANNELS.
    CALL PLTINIT
    CALL LINAX(NABS,NORD)
    DO165 I=1,32
    IX=IFIX((FLOAT(I))*FLOAT(NABS)/32.)-1
    JY=IFIX(.95*FLOAT(NORD)*D(I)/UMAX)
    IXX=IX-3
    CALL SPLT(IXX,JY,-1,6)

```



```

      LENGH=2
      JYY=JY-1
      IF(JYY)162,162,165
162  JYY=0
      LENGH=1
165  CALL SPLT(IX,JYY,1,LENGH)
      CALL PLTOUT
      WRITE(*,7) NVDAT,NVTST,JDPK,JTPK
      PAUSE ' CHECK PEAK/VALLEY DATA FOR CONSISTENCY '
C
C  DETERMINE NYMIN AND NYMAX WHICH ARE THE LEAST AND THE GREATEST
C  ENERGY CHANNEL TO RETAIN. REQUIRE THAT LIVE TIMES EXCEED TMCUT
C  OF MAX VALUE TO INCLUDE DATUM POINT.
C  ASSUME TMCUT TO BE 10% OF MAXIMUM TIME VALUE.
      TMCUT=.1
C  FIRST, PUT LIVE TIME SUM INTO TPLSE.
      NN1=NVTST-1
      DO408 I=1,NCHY
      UDUM=0.0
      DO409 J=NN1,32
409  UDUM=UDUM+DATI(J,I)
408  TPLSE(I)=UDUM
C  DETERMINE MIN AND MAX VALUES FOR DATA.
      TME=0.0
      DO400 I=1,NCHY
      IF(TPLSE(I)-TME)400,400,401
401  TME=TPLSE(I)
400  CONTINUE
      TME=TMCUT*TME
      I=1
404  IF(TPLSE(I)-TME)402,403,403
402  I=I+1
      GO TO 404
403  NYMIN=I
      I=NCHY
407  IF(TPLSE(I)-TME)405,406,406
405  I=I-1
      GO TO 407
406  NYMAX=I
C  READ A BACKGROUND SPECTRUM. CONVERT TO SAME CHANNEL LIMITS
C  AS FOR DATA.
      WRITE(*,19)
      READ(*,2) FNAME
      OPEN(10,FILE=FNAME,FORM='UNFORMATTED',STATUS='OLD')
      READ(10) FNAME
      WRITE(*,2) FNAME
      READ(10) JDENT
      WRITE(*,2) JDENT
      READ(10) NNSEC
      READ(10) NN11
      READ(10) GGGG
      READ(10) NDAT
      CLOSE(10)
      DO207 I=1,NCHY
      DO207 J=1,32

```

```

207 DATN(J,I)=FLOAT(NDAT(J,I)) + 32767.
C  SHIFT ORIGIN OF BOTH DATA AND BACKGROUND SO THAT NYMIN
C  CORRESPONDS TO FIRST DATA CHANNEL.
    LTOT=NYMAX-NYMIN+1
    DO410 I=1,LTOT
      II=I+NYMIN-1
      DO410 J=1,32
        DATN(J,I)=DATN(J,II)
410 DATI(J,I)=DATI(J,II)
C  DELETE TEST PULSES FROM BACKGROUND SPECTRUM.
    DO446 I=1,LTOT
      DO446 J=NN1,32
446 DATN(J,I)=0.0
C  GET PEAK CHANNEL FOR TEST PULSES. PUT INTO ARRAY TPLSE.
    DO340 I=1,LTOT
      DO341 J=1,32
341 D(J)=DATI(J,I)
340 TPLSE(I)=HILO(1,NN1,32,D)
C  DELETE ANY SPURIOUS COUNTS MORE THAN 4 CHANNELS ABOVE PEAK
C  OR IN FIRST CHANNEL. FORM COLLAPSED GAMMA SPECTRUM.
    KM=JTPK+4
    IF(KM-32)370,370,371
371 KM=32
370 DO372 I=1,LTOT
      DATI(1,I)=0.0
      DATN(1,I)=0.0
      DO372 J=KM,32
372 DATI(J,I)=0.0
      DO375 J=1,32
      UDUM=0.0
      DO376 I=1,LTOT
376 UDUM=UDUM+DATN(J,I)
375 GMS(J)=UDUM
    WRITE(*,17) LTOT,NYMIN
C
C  DETERMINE CHANNEL UPPER LIMIT N15 WHERE FWHM OF DATA EXCEEDS
C  1.5*AVERAGE WIDTH OVER FIRST 20 CHANNELS.
C  ALSO GET VALLEY CHANNELS TVAL BETWEEN PROTONS AND TEST PEAK.
    DO420 I=1,LTOT
      DO421 J=1,32
421 D(J)=DATI(J,I)
      TVAL(I)=HILO(0,JDPK,JTPK,D)
420 WIDE(I)=FWHM(NVDAT,NVTST,D)
C  INITIALIZE AVERAGE WITH FIRST 20 VALUES. THEN FIND 1.5*AVG POINT.
    AVFW=0.0
    DO422 I=1,20
422 AVFW=AVFW+WIDE(I)
    AVFW=AVFW/20.
    DO423 I=21,LTOT
      IF(WIDE(I)-1.5*AVFW)423,424,424
423 CONTINUE
424 N15=I
    WRITE(*,14) AVFW,N15
C  RE-DETERMINE X/Y COLLAPSED SPECTRUM OF DATA FOR Y BELOW N15.
C  THEN REDEFINE VALUES FOR INTEGRATION LIMITS.

```

```

DO412 J=1,32
UDUM=0.0
DO413 I=1,N15
413 UDUM=UDUM+DATI(J,I)
412 D(J)=UDUM
JDPK=IFIX(HILO(1,NV DAT,NVTST,D))
JTPK=IFIX(HILO(1,NVTST,32,D))
NVTST=IFIX(HILO(0,JDPK,JTPK,D))
NV DAT=JDPK-IFIX(1.5*FWHM(NV DAT,NVTST,D)+.5)
C FORM THE RATIO OF GAMMA COMPONENT IN PURE GAMMA RUN TO GAMMA
C COMPONENT IN DATA UP TO THE N15 CHANNEL NUMBER. FIT THIS
C RATIO AND USE TO CORRECT DATA ON A CHANNEL-BY CHANNEL BASIS.
DO530 I=1,N15
SM1=0.0
SM2=0.0
X(I)=FLOAT(I)
W(I)=1.0
DO531 J=1,NV DAT
SM1=SM1+DATI(J,I)
531 SM2=SM2+DATN(J,I)
530 Y(I)=SM2/SM1
MFIT=9
CALL LSQPOL(MFIT,N15)
C LET W(I)=RATEO BE THE EVALUATED RATIO OF PURE GAMMAS TO DATA GAMMAS.
DO532 I=1,N15
DPI=FLOAT(I)
EVLV=0.0
DO533 J=1,MFIT
533 EVLV=EVLV+B(J)*DPI**(J-1)
532 W(I)=EVLV
C W(I) WILL DECREASE AT HIGH I VALUES DUE TO DEGRADATION OF THE PROTON
C DATA INTO GAMMA INTEGRATION WINDOW. FIND MAXIMUM FOR W(I) AND THEN
C FIND THE CHANNEL KGL FOR WHICH W(I) IS LESS THAN 90% OF MAXIMUM.
C USE W AT KGL FOR ALL CHANNELS ABOVE KGL.
I=N15-10
WMAX=0.0
427 IF(W(I)-WMAX)425,425,426
426 WMAX=W(I)
I=I-1
IF(I-1)425,425,427
425 WMAX=.90*WMAX
I=N15-10
430 IF(W(I)-WMAX)429,428,428
429 I=I-1
IF(I-1)428,428,430
428 KGL=I
WRITE(*,22) KGL
C SUBTRACT THE BACKGROUND USING THE FITTED RATIO BELOW KGL
C AND THE RATIO AT KGL ABOVE KGL.
WASM=W(KGL)
DO538 I=1,LTOT
IF(I-KGL)535,536,536
536 WEIGHT=WASM
RATEO(I)=WASM
GO TO 537

```

```

535 WEIGHT=W(I)
    RATEO(I)=W(I)
537 DO534 J=1,32
534 DATI(J,I)=DATI(J,I)-DATN(J,I)/WEIGHT
538 CONTINUE
C
C MAY PROCEED BY USING THE COLLAPSED GAMMA SPECTRUM TO CORRECT FOR
C THE VERY SLOW X/Y COMPONENT IN THE SPECTRUM.
    WRITE(*,30)
    READ(*,3) IGO
    IF(IGO)200,200,230
230 LGPK=HILO(1,1,NVDAT,GMS)
    LGM1=LGPK-1
    LGP1=LGPK+1
    GNRM=0.0
    DO231 I=LGM1,LGP1
231 GNRM=GNRM+GMS(I)
    DO232 I=1,LTOT
    UDUM=0.0
    DO233 J=LGM1,LGP1
233 UDUM=UDUM+DATI(J,I)
    DO234 J=1,32
    DATI(J,I)=DATI(J,I)-UDUM*GMS(J)/GNRM
    IF(DATI(J,I))235,234,234
235 DATI(J,I)=0.0
234 CONTINUE
232 CONTINUE
    GO TO 200
C
C CHANGE THE ALGORITHM FOR PROTON PEAK WIDTH DETERMINATION BY SETTING
C THE LOWER CHANNEL LIMIT TO 1 FOR ALL CHANNELS ABOVE N15.
C DEFINE THE LOW CUTOFF CHANNEL FOR PROTON PEAK INTEGRATION TO BE
C 1.5*WIDE(I) BELOW THE PROTON PEAK CHANNEL.
C AT THE FIRST DEFAULT WHERE RESULT LESS THAN UNITY, DEFINE AS THE
C BREAK CHANNEL NBRK AND SET LOWER INTEGRATION LIMIT TO 1 SUBSEQUENTLY.
199 DO451 I=1,LTOT
    DO452 J=1,32
452 D(J)=DATI(J,I)
    IF(I-N15)453,453,454
453 DVAL(I)=HILO(1,NVDAT,NVTST,D)-1.5*FWHM(NVDAT,NVTST,D)
    GO TO 455
454 DVAL(I)=HILO(1,1,NVTST,D)-1.5*FWHM(1,NVTST,D)
455 IF(DVAL(I)-1.)456,451,451
451 CONTINUE
456 NBRK=I
    DO461 I=NBRK,LTOT
    EDVAL(I)=1.
461 DVAL(I)=1.
    WRITE(*,23) NBRK
C
C NOW HAVE GAMMA BACKGROUND-SUBTRACTED DATA AND VALUES FOR DVAL(I),
C THE INTEGRATION LIMIT BELOW PROTON PEAK, AND TVAL(I), THE
C INTEGRATION LIMIT ABOVE PROTON PEAK.
C DO AN ORDER 9 POLYFIT TO BOTH SETS OF VALLEY CHANNELS AND FROM THIS
C FIT, DERIVE RESIDUAL BACKGROUND GAMS, AS WELL AS PROTONS PRTS.

```

C AND THE TEST PULSE DISTRIBUTION TPLSE.

```

      DO348 I=1,LTOT
      X(I)=FLOAT(I)
348  W(I)=1.0
      MFIT=9
      DO349 I=1,LTOT
349  Y(I)=TVAL(I)
      CALL LSQPOL(MFIT,LTOT)
      DO350 I=1,LTOT
      DPI=FLOAT(I)
      EVLV=0.0
      DO351 J=1,MFIT
351  EVLV=EVLV+B(J)*DPI**(J-1)
350  ETVAL(I)=EVLV
      DO352 I=1,NBRK
352  Y(I)=OVAL(I)
      CALL LSQPOL(MFIT,NBRK)
      DO353 I=1,NBRK
      DPI=FLOAT(I)
      EVLV=0.0
      DO354 J=1,MFIT
354  EVLV=EVLV+B(J)*DPI**(J-1)
      EDVAL(I)=EVLV
      IF(EDVAL(I)-1.)356,353,353
356  EDVAL(I)=1.
353  CONTINUE

```

C

C USING THE FITTED CHANNEL VALUES, DERIVE A SPECTRUM FOR LIVE TIME
C AND PROTON RECOILS AND ALSO THE RESIDUAL BACKGROUND GAMS.

```

      DO251 I=1,LTOT
      DO252 J=1,32
252  D(J)=DATI(J,I)
      EV1=EDVAL(I)
      EV2=ETVAL(I)
      NV1=IFIX(EV1)
      NV2=IFIX(EV2)
      DIF1=EV1-FLOAT(NV1)
      C1H=(1.-DIF1)*D(NV1)
      DIF2=EV2-FLOAT(NV2)
      C2H=(1.-DIF2)*D(NV2)
      C2L=DIF2*D(NV2)
      NV2P1=NV2+1
      SUM1=C2H
      DO254 J=NV2P1,32
254  SUM1=SUM1+D(J)
      TPLSE(I)=SUM1
      NV1P1=NV1+1
      NV2M1=NV2-1
      SUM1=C1H+C2L
      DO255 J=NV1P1,NV2M1
255  SUM1=SUM1+D(J)
      SUM2=DIF1*D(NV1)
      NV1M1=NV1-1
      DO256 J=1,NV1M1

```

```

256 SUM2=SUM2+D(J)
   GAMS(I)=SUM2
251 PRIS(I)=SUM1
C
C  FINAL EDIT OF RESULTS.
   PAUSE 'PRINTER ON/OFF FOR FINAL EDIT'
   WRITE(*,9)
   WRITE(*,2) IDENT
   WRITE(*,21) LTOT,NYMIN,AVFW,N15,NBRK,KGL,NSEC
   WRITE(*,11)
   LCNTR=18
   I=1
280 WRITE(*,10) I,DVAL(I),EDVAL(I),TVAL(I),ETVAL(I),
   XWIDE(I),RATEO(I),GAMS(I),PRIS(I),TPLSE(I)
   I=I+1
   IF(I-LTOT)283,283,284
283 LCNTR=LCNTR+1
   IF(LCNTR-58)280,281,281
281 WRITE(*,282)
   LCNTR-1
282 FORMAT(/////////)
   GO TO 280
C  OPTION TO SAVE DATA ON DISC.
284 WRITE(*,4)
   READ(*,3) IGO
   IF(IGO)298,299,299
299 WRITE(*,16)
   READ(*,2) PNAME
   OPEN(10,FILE=PNAME,FORM='FORMATTED',STATUS='NEW')
   WRITE(10,2) PNAME
   WRITE(10,2) IDENT
   WRITE(10,20) NSEC
   WRITE(10,15) LTOT
   WRITE(10,15) NYMIN
   WRITE(10,20) LVL
   WRITE(10,5) GMAX
   WRITE(10,5) (PRIS(I),I=1,LTOT)
   WRITE(10,18) (TPLSE(I),I=1,LTOT)
298 CLOSE(10)
   STOP
   END
C
C  DERIVE THE FULL WIDTH AT HALF MAXIMUM OF THE DATA PEAK OVER
C  THE RANGE OF DATA FROM ICH1 TO ICH2 FOR THE D(I) ARRAY.
C
   FUNCTION FWHM(ICH1,ICH2,D)
   DIMENSION D(32)
C
   CMAX=0.0
   DO1 K=ICH1,ICH2
   IF(D(K)-CMAX)1,1,2
2  CMAX=D(K)
   IMAX=K
1  CONTINUE
   HALF=0.5*CMAX

```

```

      K=IMAX
5  IF(D(K)-HALF)3,3,4
4  K=K-1
   IF(K-ICH1)8,8,5
8  VLO=ICH1
   GO TO 9
3  U=D(K+1)-D(K)
   IF(U)11,11,10
11 VLO=FLOAT(K)+.5
   GO TO 9
10 VLO=FLOAT(K)+(HALF-D(K))/U
9  DO6 K=IMAX,ICH2
   IF(D(K)-HALF)7,6,6
6  CONTINUE
7  U=D(K-1)-D(K)
   IF(U)12,12,13
12 VHI=FLOAT(K)-.5
   GO TO 14
13 VHI=FLOAT(K)-(HALF-D(K))/U
14 FWHM=VHI-VLO
   RETURN
   END

```

C
C FUNCTION HILO (LH,ILO,IHI,D) RETURNS MAXIMUM (LH=1) OR MINIMUM(LH=0)
C COUNT CHANNEL NUMBER OF THE ARRAY D(I) IN THE INTERVAL ILO TO IHI.

```

C
      FUNCTION HILO(LH,ILO,IHI,D)
      DIMENSION D(32)

```

```

C
      IF(LH)1,1,2
1  U=1.E06
   GO TO 3
2  U=0.0
3  DO4 I=ILO,IHI
   IF(LH)5,5,6
5  IF(D(I)-U)7,4,4
7  U=D(I)
   LOHI=I
   GO TO 4
6  IF(D(I)-U)4,4,8
8  U=D(I)
   LOHI=I
4  HILO=FLOAT(LOHI)
   RETURN
   END

```

C
C SUBROUTINE SPLT(IX,IY,IHV,LNGTH) PLOTS ON THE STORAGE SCOPE A
C VERTICAL(IHV POSITIVE) LINE OR A HORIZONTAL(IHV NEGATIVE) LINE
C OF LENGTH LNGTH STARTING AT IX AND IY.

```

C
      SUBROUTINE SPLT(IX,IY,IHV,LNGTH)

```

```

C
      IF(IHV)1,2,2
1  NX=IX+LNGTH
   CALL QLINE(IX,IY,NX,IY,1)

```

```

        RETURN
2  NY=IY+LNGTH
    CALL QLINE(IX,IY,IX,NY,1)
    RETURN
    END
C
C  SUBROUTINE LINAX DRAWS LINEAR AXES, 32 CHANNEL TICS FOR ABSCISSA.
C
    SUBROUTINE LINAX(NABS,NORD)
C
    CALL SPLT(0,0,1,NORD)
    CALL SPLT(0,0,-1,NABS)
    DEL=FLOAT(NABS)/32.
    LNGTH=NORD/40
    IX=IFIX(DEL)
    I=1
1  CALL SPLT(IX,0,1,LNGTH)
    IX=IFIX(DEL*FLOAT(I+1))
    I=I+1
    IF(I-32)1,1,2
2  RETURN
    END
C
C  SUBROUTINE PLTINIT INITIALIZES PLOTTING ROUTINES.
C
    SUBROUTINE PLTINIT
C
    CALL QSMODE(6)
    RETURN
    END
C
C  SUBROUTINE PLTOUT RETURNS FROM PLOTTING ROUTINES.
C
    SUBROUTINE PLTOUT
C
    CHARACTER*1 CHAR
    CALL QINPUT(CHAR,0)
    CALL QSMODE(2)
    RETURN
    END
C
C  LEAST SQUARES POLYNOMIAL FIT. M(<=9) IS THE ORDER, N THE ARRAY SIZE.
C  SUBROUTINE LSQPOL(M,N)
C
    DIMENSION A(9,9),PIVOT(9),IPIVOT(9),INDEX(9,2),C(512,9)
    COMMON Y(512),X(512),B(9),W(512)
    EQUIVALENCE(AMAX,T,SWAP),(IROW,JROW),(ICOLUM,JCOLUM)
    DOUBLE PRECISION A,B,AMAX,XI,XN,PIVOT,DETERM,C,T,SWAP
C
    DO 520 I=1,N
520  C(I,1)=1.D 00
    DO530 J=2,M
    DO 530 I= 1,N
530  C(I,J)=C(I,J-1)*X(I)
    DO 560 I = 1,M

```



```

        B(I) = 0.0
        DO 550 J = 1,M
          A(I,J) = 0.0
          DO 550 K = 1,N
            550 A(I,J) = A(I,J) + C(K,I)*C(K,J)*W(K)
          DO 560 K = 1,N
            560 B(I) = B(I) + C(K,I)*Y(K)*W(K)
C
C  INITIALIZATION          (MATINV CALCULATIONS)
C
        DETERM=1.0
        DO 570 J = 1,M
          570 IPIVOT(J)=0
C
        DO 690 I=1,M
C
C  SEARCH FOR PIVOT ELEMENT
        AMAX=0.0
        DO 620 J=1,M
          IF (IPIVOT(J)-1) 580,620,580
          580 DO 610 K=1,M
            IF (IPIVOT(K)-1) 590,610,740
          590 IF(DABS(AMAX)-DABS(A(J,K))) 600,610,610
          600 IROW=J
            ICOLUM=K
            AMAX=A(J,K)
          610 CONTINUE
          620 CONTINUE
            IPIVOT(ICOLUM)=IPIVOT(ICOLUM)+1
C
C  INTERCHANGE ROWS TO PUT PIVOT ELEMENT ON DIAGONAL
C
        IF (IROW-ICOLUM) 630,650,630
          630 DETERM=-DETERM
            DO 640 L=1,M
              SWAP=A(IROW,L)
              A(IROW,L)=A(ICOLUM,L)
            640 A(ICOLUM,L)=SWAP
              SWAP = B(IROW)
              B(IROW) = B(ICOLUM)
              B(ICOLUM) = SWAP
          650 INDEX(I,1)=IROW
            INDEX(I,2)=ICOLUM
            PIVOT(I)=A(ICOLUM,ICOLUM)
            DETERM=DETERM*PIVOT(I)
C
C  DIVIDE PIVOT ROW BY PIVOT ELEMENT
C
        A(ICOLUM,ICOLUM)=1.0
        DO 660 L=1,M
          660 A(ICOLUM,L)=A(ICOLUM,L)/PIVOT(I)
            B(ICOLUM) = B(ICOLUM)/PIVOT(I)
C
C  REDUCE NON-PIVOT ROWS
C

```

```

        DO 690 L1=1,M
        IF(L1-ICOLUM) 670,690,670
670    T=A(L1,ICOLUM)
        A(L1,ICOLUM)=0.0
        DO 680 L=1,M
680    A(L1,L)=A(L1,L)-A(ICOLUM,L)*T
        B(L1) = B(L1) - B(ICOLUM)*T
690    CONTINUE
740    RETURN
C
    END

```

APPENDIX IV

LISTING OF THE RMPRDN OUTPUT DATA FOR THE HYDROGEN COUNTER IN THE JANUS NEUTRON SPECTRUM

APPENDIX IV

LISTING OF THE RMPECN OUTPUT DATA FOR THE HYDROGEN COUNTER IN THE 1 AND 3 MILLION SPECTRUM

POS 0 1.000 MON=222072(10 12). HYD. 3/24/88.

TOTAL POINTS AND START POINT = 475 28
INITIAL AVERAGE PROTON LINE WIDTH = 2.70
N15 AND NBRK CHANNELS ARE 321 376
.90 WMAX CHANNEL = 220
RUN TIME IN SECONDS = 19190

J	DVAL	EDVAL	TVAL	ETVAL	LINE	RATIO	GAMMAS	PRTS	TIME
1	15.9	16.4	24.0	24.0	2.92	.75	.1396E+03	.1788E+04	.2201E+04
2	16.0	16.3	24.0	24.0	2.71	.77	.1372E+03	.1785E+04	.2268E+04
3	16.0	16.3	24.0	24.0	2.84	.79	.1843E+03	.1852E+04	.2538E+04
4	16.0	16.2	24.0	24.0	2.90	.81	.1727E+03	.1973E+04	.2536E+04
5	16.3	16.2	24.0	24.0	2.57	.83	.1764E+03	.2016E+04	.2648E+04
6	16.9	16.2	24.0	24.0	2.99	.85	.1925E+03	.2088E+04	.2683E+04
7	16.2	16.2	24.0	24.0	2.64	.87	.1862E+03	.2194E+04	.2882E+04
8	16.2	16.1	24.0	24.0	2.66	.89	.1521E+03	.2356E+04	.2933E+04
9	16.0	16.1	24.0	24.0	2.83	.91	.1664E+03	.2372E+04	.3131E+04
10	16.2	16.1	24.0	24.0	2.71	.92	.2298E+03	.2433E+04	.3204E+04
11	16.1	16.1	24.0	24.0	2.72	.94	.2203E+03	.2521E+04	.3312E+04
12	16.9	16.1	24.0	24.0	2.93	.96	.1725E+03	.2613E+04	.3445E+04
13	16.3	16.1	24.0	24.0	2.56	.98	.2266E+03	.2620E+04	.3542E+04
14	16.1	16.1	24.0	24.0	2.66	1.00	.1969E+03	.2848E+04	.3648E+04
15	16.2	16.1	24.0	24.0	2.64	1.03	.1575E+03	.2760E+04	.3689E+04
16	16.2	16.1	24.0	24.0	2.60	1.05	.1550E+03	.2757E+04	.3865E+04
17	16.2	16.1	24.0	24.0	2.59	1.07	.1552E+03	.2933E+04	.4015E+04
18	16.3	16.2	24.0	24.0	2.59	1.09	.2326E+03	.3014E+04	.4156E+04
19	16.4	16.2	24.0	24.0	2.48	1.11	.2084E+03	.3122E+04	.4269E+04
20	16.2	16.2	24.0	24.0	2.58	1.13	.1454E+03	.3204E+04	.4427E+04
21	16.3	16.2	24.0	24.0	2.54	1.15	.2085E+03	.3219E+04	.4561E+04
22	16.3	16.2	24.0	24.0	2.53	1.17	.1610E+03	.3455E+04	.4731E+04
23	16.3	16.3	24.0	24.0	2.48	1.19	.1583E+03	.3500E+04	.4774E+04
24	16.4	16.3	24.0	24.0	2.49	1.21	.1710E+03	.3618E+04	.4951E+04
25	16.4	16.3	24.0	24.0	2.44	1.23	.2000E+03	.3600E+04	.5064E+04
26	16.3	16.3	24.0	24.0	2.55	1.26	.2152E+03	.3735E+04	.5192E+04
27	16.5	16.3	24.0	24.0	2.41	1.28	.1550E+03	.3821E+04	.5493E+04
28	16.4	16.4	24.0	24.0	2.45	1.30	.2133E+03	.3909E+04	.5501E+04
29	16.4	16.4	24.0	24.0	2.41	1.32	.2036E+03	.3928E+04	.5595E+04
30	16.4	16.4	24.0	24.0	2.45	1.34	.2025E+03	.4128E+04	.5866E+04
31	16.4	16.4	24.0	24.0	2.46	1.37	.1493E+03	.4239E+04	.6017E+04
32	16.3	16.5	24.0	24.0	2.51	1.39	.1608E+03	.4155E+04	.6152E+04
33	16.4	16.5	24.0	24.0	2.43	1.41	.1561E+03	.4335E+04	.6237E+04
34	16.5	16.5	24.0	24.0	2.35	1.43	.1297E+03	.4334E+04	.6443E+04
35	16.5	16.5	24.0	24.0	2.39	1.46	.1399E+03	.4535E+04	.6666E+04
36	16.4	16.6	24.0	24.0	2.43	1.48	.1055E+03	.4686E+04	.6705E+04
37	16.4	16.6	24.0	24.0	2.42	1.50	.2107E+03	.4781E+04	.6826E+04
38	16.5	16.6	24.0	24.0	2.35	1.52	.2214E+03	.4850E+04	.7088E+04
39	16.4	16.6	24.0	24.0	2.42	1.55	.1336E+03	.4785E+04	.7378E+04
40	16.6	16.7	24.0	24.0	2.30	1.57	.1322E+03	.4924E+04	.7355E+04

41	16.5	16.7	24.0	24.0	2.39	1.59	.1011E+03	.5070E+04	.7609E+04
42	16.5	16.7	24.0	24.0	2.37	1.61	.1674E+03	.5209E+04	.7740E+04
43	16.5	16.7	24.0	24.0	2.37	1.64	.1684E+03	.5371E+04	.7978E+04
44	16.5	16.7	24.0	24.0	2.34	1.66	.2124E+03	.5490E+04	.8221E+04
45	16.4	16.8	24.0	24.0	2.40	1.68	.1310E+03	.5409E+04	.8368E+04
46	16.5	16.8	24.0	24.0	2.35	1.70	.1503E+03	.5539E+04	.8450E+04
47	16.5	16.8	24.0	24.0	2.36	1.73	.1412E+03	.5691E+04	.8764E+04
48	16.4	16.8	24.0	24.0	2.40	1.75	.1122E+03	.5914E+04	.8927E+04
49	16.5	16.8	24.0	24.0	2.35	1.77	.1312E+03	.6000E+04	.9277E+04
50	16.6	16.8	24.0	24.0	2.32	1.79	.9147E+02	.6053E+04	.9302E+04
51	16.6	16.9	24.0	24.0	2.26	1.81	.1559E+03	.6091E+04	.9580E+04
52	16.6	16.9	24.0	24.0	2.30	1.84	.1267E+03	.6293E+04	.9822E+04
53	16.6	16.9	24.0	24.0	2.29	1.86	.1647E+03	.6305E+04	.9965E+04
54	16.5	16.9	24.0	24.0	2.33	1.88	.1067E+03	.6549E+04	.1025E+05
55	16.6	16.9	24.0	24.0	2.30	1.90	.1347E+03	.6555E+04	.1042E+05
56	16.6	16.9	24.0	24.0	2.28	1.92	.1733E+03	.6731E+04	.1071E+05
57	16.5	16.9	24.0	24.0	2.34	1.95	.1587E+03	.6629E+04	.1088E+05
58	16.5	16.9	24.0	24.0	2.34	1.97	.1918E+03	.6897E+04	.1120E+05
59	17.5	16.9	24.0	24.0	2.33	1.99	.9448E+02	.7027E+04	.1124E+05
60	16.5	16.9	24.0	24.0	2.32	2.01	.1804E+03	.7105E+04	.1160E+05
61	16.5	16.9	24.0	24.0	2.35	2.03	.1474E+03	.7263E+04	.1184E+05
62	16.6	17.0	24.0	24.0	2.30	2.05	.1403E+03	.7350E+04	.1203E+05
63	17.5	17.0	24.0	24.0	2.34	2.07	.1489E+03	.7552E+04	.1234E+05
64	16.5	17.0	24.0	24.0	2.34	2.09	.1951E+03	.7764E+04	.1265E+05
65	17.5	17.0	24.0	24.0	2.34	2.11	.2361E+03	.7682E+04	.1281E+05
66	17.5	17.0	24.0	24.0	2.33	2.13	.1334E+03	.7915E+04	.1316E+05
67	17.5	17.0	24.0	24.0	2.32	2.15	.2402E+03	.8114E+04	.1332E+05
68	17.6	17.0	24.0	24.0	2.30	2.17	.1773E+03	.8071E+04	.1358E+05
69	17.6	17.0	24.0	24.0	2.30	2.19	.1374E+03	.8406E+04	.1396E+05
70	17.6	17.0	24.0	24.0	2.28	2.21	.2376E+03	.8499E+04	.1419E+05
71	17.6	17.0	24.0	24.0	2.28	2.23	.1569E+03	.8583E+04	.1448E+05
72	17.6	17.0	24.0	24.0	2.29	2.25	.1677E+03	.8668E+04	.1453E+05
73	17.6	17.0	24.0	24.0	2.28	2.27	.2116E+03	.8566E+04	.1447E+05
74	17.5	17.0	24.0	24.0	2.32	2.29	.1094E+03	.8638E+04	.1484E+05
75	17.6	17.0	24.0	24.0	2.29	2.30	.2254E+03	.8588E+04	.1463E+05
76	17.6	17.0	24.0	24.0	2.29	2.32	.2062E+03	.8560E+04	.1457E+05
77	17.6	17.0	24.0	24.0	2.30	2.34	.4212E+03	.8841E+04	.1447E+05
78	17.6	16.9	24.0	24.0	2.31	2.36	.5208E+03	.9075E+04	.1477E+05
79	17.6	16.9	24.0	24.0	2.28	2.37	.2932E+03	.8995E+04	.1465E+05
80	17.6	16.9	24.0	24.0	2.29	2.39	.2560E+03	.8997E+04	.1468E+05
81	17.6	16.9	24.0	24.0	2.29	2.41	.4360E+03	.9146E+04	.1441E+05
82	16.6	16.9	24.0	24.0	2.23	2.42	.5660E+03	.9170E+04	.1471E+05
83	17.5	16.9	24.0	24.0	2.33	2.44	.6732E+03	.9060E+04	.1450E+05
84	17.5	16.9	24.0	24.0	2.35	2.46	.5489E+03	.9173E+04	.1466E+05
85	16.5	16.9	24.0	24.0	2.31	2.47	.9212E+03	.9358E+04	.1473E+05
86	16.6	16.9	24.0	24.0	2.29	2.49	.1261E+04	.9326E+04	.1461E+05
87	16.5	16.9	24.0	24.0	2.32	2.50	.1232E+04	.9347E+04	.1447E+05
88	16.5	16.9	24.0	24.0	2.31	2.52	.1263E+04	.9374E+04	.1452E+05
89	16.6	16.9	24.0	24.0	2.30	2.53	.1343E+04	.9397E+04	.1444E+05
90	16.6	16.9	24.0	24.0	2.29	2.54	.1436E+04	.9494E+04	.1482E+05
91	16.6	16.9	24.0	24.0	2.30	2.56	.1580E+04	.9719E+04	.1440E+05
92	16.6	16.9	24.0	24.0	2.29	2.57	.1650E+04	.9676E+04	.1480E+05
93	16.6	16.9	24.0	24.0	2.29	2.58	.1838E+04	.9511E+04	.1468E+05
94	16.6	16.9	24.0	24.0	2.29	2.60	.1579E+04	.9730E+04	.1461E+05
95	16.6	16.8	24.0	24.0	2.26	2.61	.1735E+04	.9882E+04	.1453E+05
96	16.5	16.8	24.0	24.0	2.32	2.62	.1666E+04	.9896E+04	.1470E+05
97	16.6	16.8	24.0	24.0	2.30	2.63	.1603E+04	.9961E+04	.1466E+05

98	16.5	16.8	24.0	24.0	2.31	2.64	.1697E+04	.1001E+05	.1463E+05
99	16.6	16.8	24.0	24.0	2.30	2.66	.1875E+04	.1009E+05	.1455E+05
100	16.6	16.8	24.0	24.0	2.30	2.67	.1809E+04	.1026E+05	.1463E+05
101	16.6	16.8	24.0	24.0	2.26	2.68	.1408E+04	.1026E+05	.1473E+05
102	16.6	16.8	24.0	24.0	2.28	2.69	.2147E+04	.1019E+05	.1460E+05
103	16.6	16.8	24.0	24.0	2.27	2.70	.2144E+04	.1042E+05	.1460E+05
104	16.6	16.8	24.0	24.0	2.24	2.71	.1987E+04	.1061E+05	.1474E+05
105	16.6	16.8	24.0	24.0	2.27	2.72	.1534E+04	.1048E+05	.1466E+05
106	16.6	16.8	24.0	24.0	2.25	2.72	.1674E+04	.1047E+05	.1475E+05
107	16.6	16.8	24.0	24.0	2.25	2.73	.1341E+04	.1062E+05	.1458E+05
108	16.6	16.8	24.0	24.0	2.25	2.74	.1612E+04	.1102E+05	.1471E+05
109	16.6	16.7	24.0	24.0	2.25	2.75	.1339E+04	.1085E+05	.1464E+05
110	16.6	16.7	24.0	24.0	2.25	2.76	.1247E+04	.1085E+05	.1479E+05
111	16.6	16.7	24.0	24.0	2.26	2.76	.1394E+04	.1094E+05	.1464E+05
112	16.6	16.7	24.0	24.0	2.29	2.77	.9856E+03	.1085E+05	.1471E+05
113	16.6	16.7	24.0	24.0	2.30	2.78	.1257E+04	.1093E+05	.1488E+05
114	16.7	16.7	24.0	24.0	2.23	2.79	.9648E+03	.1131E+05	.1460E+05
115	16.7	16.7	24.0	24.0	2.22	2.79	.9921E+03	.1128E+05	.1489E+05
116	16.6	16.7	24.0	24.0	2.26	2.80	.8846E+03	.1138E+05	.1468E+05
117	16.6	16.7	24.0	24.0	2.25	2.80	.8648E+03	.1137E+05	.1494E+05
118	16.6	16.7	24.0	24.0	2.26	2.81	.9220E+03	.1143E+05	.1465E+05
119	16.7	16.7	24.0	24.0	2.24	2.81	.7538E+03	.1171E+05	.1468E+05
120	16.6	16.7	24.0	24.0	2.25	2.82	.7547E+03	.1170E+05	.1464E+05
121	16.7	16.7	24.0	24.0	2.22	2.82	.6551E+03	.1174E+05	.1501E+05
122	16.6	16.7	24.0	24.0	2.26	2.83	.1001E+04	.1167E+05	.1485E+05
123	16.6	16.7	24.0	24.0	2.24	2.83	.5846E+03	.1183E+05	.1462E+05
124	16.6	16.7	24.0	24.0	2.24	2.84	.5719E+03	.1208E+05	.1471E+05
125	16.6	16.7	24.0	24.0	2.25	2.84	.5629E+03	.1204E+05	.1479E+05
126	16.7	16.7	24.0	24.0	2.23	2.84	.5952E+03	.1195E+05	.1464E+05
127	16.7	16.7	24.0	24.0	2.23	2.85	.6452E+03	.1206E+05	.1477E+05
128	16.7	16.7	24.0	24.0	2.18	2.85	.6481E+03	.1203E+05	.1470E+05
129	16.7	16.7	24.0	24.0	2.17	2.85	.4534E+03	.1214E+05	.1475E+05
130	16.7	16.7	24.0	24.0	2.20	2.85	.5903E+03	.1244E+05	.1460E+05
131	16.7	16.7	24.0	24.0	2.20	2.85	.5093E+03	.1260E+05	.1495E+05
132	16.6	16.7	24.0	24.0	2.24	2.86	.8099E+03	.1245E+05	.1465E+05
133	16.8	16.7	24.0	24.0	2.16	2.86	.5765E+03	.1254E+05	.1496E+05
134	16.7	16.7	24.0	24.0	2.22	2.86	.3950E+03	.1270E+05	.1479E+05
135	16.7	16.7	24.0	24.0	2.19	2.86	.4989E+03	.1274E+05	.1486E+05
136	16.7	16.7	24.0	24.0	2.21	2.86	.7260E+03	.1295E+05	.1495E+05
137	16.7	16.7	24.0	24.0	2.20	2.86	.6716E+03	.1313E+05	.1490E+05
138	16.7	16.7	24.0	24.0	2.20	2.86	.6888E+03	.1316E+05	.1508E+05
139	16.7	16.7	24.0	24.0	2.20	2.86	.5336E+03	.1306E+05	.1479E+05
140	16.7	16.7	24.0	24.0	2.18	2.86	.6783E+03	.1332E+05	.1501E+05
141	16.7	16.7	24.0	24.0	2.20	2.86	.6882E+03	.1322E+05	.1474E+05
142	16.7	16.7	24.0	24.0	2.17	2.86	.1143E+04	.1336E+05	.1494E+05
143	16.7	16.7	24.0	24.0	2.22	2.86	.1004E+04	.1387E+05	.1497E+05
144	16.7	16.7	24.0	24.0	2.17	2.86	.1044E+04	.1379E+05	.1495E+05
145	16.7	16.7	24.0	24.0	2.18	2.86	.8896E+03	.1376E+05	.1486E+05
146	16.8	16.7	24.0	24.0	2.15	2.86	.7750E+03	.1402E+05	.1490E+05
147	16.8	16.7	24.0	24.0	2.15	2.86	.1008E+04	.1389E+05	.1489E+05
148	16.7	16.7	24.0	24.0	2.18	2.86	.1048E+04	.1403E+05	.1502E+05
149	16.8	16.7	24.0	24.0	2.14	2.86	.1089E+04	.1405E+05	.1496E+05
150	16.7	16.7	24.0	24.0	2.18	2.86	.1129E+04	.1417E+05	.1490E+05
151	16.8	16.7	24.0	24.0	2.15	2.86	.9457E+03	.1423E+05	.1498E+05
152	16.8	16.7	24.0	24.0	2.16	2.86	.8464E+03	.1426E+05	.1511E+05
153	16.7	16.7	24.0	24.0	2.17	2.85	.7037E+03	.1457E+05	.1499E+05
154	16.7	16.7	24.0	24.0	2.22	2.85	.8256E+03	.1456E+05	.1520E+05

155	16.8	16.7	24.0	24.0	2.15	2.85	.7606E+03	.1473E+05	.1520E+05
156	16.7	16.7	24.0	24.0	2.19	2.85	.9711E+03	.1477E+05	.1499E+05
157	16.7	16.7	24.0	24.0	2.17	2.85	.7170E+03	.1464E+05	.1505E+05
158	16.7	16.7	24.0	24.0	2.17	2.84	.1001E+04	.1487E+05	.1515E+05
159	16.8	16.7	24.0	24.0	2.16	2.84	.9110E+03	.1504E+05	.1500E+05
160	16.8	16.7	24.0	24.0	2.16	2.84	.9989E+03	.1511E+05	.1536E+05
161	16.7	16.7	24.0	24.0	2.19	2.84	.1309E+04	.1529E+05	.1502E+05
162	16.7	16.7	24.0	24.0	2.18	2.83	.7317E+03	.1528E+05	.1517E+05
163	16.7	16.7	24.0	24.0	2.18	2.83	.1082E+04	.1569E+05	.1504E+05
164	16.8	16.7	24.0	24.0	2.16	2.83	.1055E+04	.1564E+05	.1514E+05
165	16.7	16.7	24.0	24.0	2.18	2.83	.7702E+03	.1558E+05	.1530E+05
166	16.8	16.7	24.0	24.0	2.12	2.82	.8910E+03	.1571E+05	.1519E+05
167	16.7	16.7	24.0	24.0	2.17	2.82	.6965E+03	.1578E+05	.1513E+05
168	16.8	16.7	24.0	24.0	2.16	2.82	.8324E+03	.1587E+05	.1519E+05
169	16.8	16.7	24.0	24.0	2.13	2.81	.9849E+03	.1606E+05	.1517E+05
170	16.8	16.8	24.0	24.0	2.11	2.81	.1020E+04	.1573E+05	.1531E+05
171	16.8	16.8	24.0	24.0	2.13	2.81	.1048E+04	.1612E+05	.1534E+05
172	16.8	16.8	24.0	24.0	2.14	2.81	.9583E+03	.1627E+05	.1539E+05
173	16.8	16.8	24.0	24.0	2.14	2.80	.7457E+03	.1625E+05	.1525E+05
174	16.8	16.8	24.0	24.0	2.13	2.80	.9461E+03	.1649E+05	.1534E+05
175	16.8	16.8	24.0	24.0	2.12	2.80	.9535E+03	.1633E+05	.1538E+05
176	16.8	16.8	24.0	24.0	2.14	2.79	.7808E+03	.1660E+05	.1549E+05
177	16.8	16.8	24.0	24.0	2.15	2.79	.7702E+03	.1670E+05	.1534E+05
178	16.8	16.8	24.0	24.0	2.15	2.79	.7106E+03	.1654E+05	.1537E+05
179	16.8	16.8	24.0	24.0	2.12	2.78	.7278E+03	.1682E+05	.1556E+05
180	16.7	16.8	24.0	24.0	2.19	2.78	.7890E+03	.1688E+05	.1548E+05
181	16.8	16.8	24.0	24.0	2.14	2.78	.9289E+03	.1706E+05	.1536E+05
182	16.8	16.8	24.0	24.0	2.12	2.77	.7510E+03	.1711E+05	.1554E+05
183	16.8	16.8	24.0	24.0	2.13	2.77	.7986E+03	.1701E+05	.1550E+05
184	16.8	16.8	24.0	24.0	2.15	2.76	.9224E+03	.1723E+05	.1556E+05
185	16.8	16.8	24.0	24.0	2.14	2.76	.4716E+03	.1740E+05	.1536E+05
186	16.7	16.8	24.0	24.0	2.17	2.76	.7813E+03	.1741E+05	.1550E+05
187	16.8	16.8	24.0	24.0	2.14	2.75	.6486E+03	.1723E+05	.1572E+05
188	16.8	16.8	24.0	24.0	2.12	2.75	.8774E+03	.1759E+05	.1549E+05
189	16.8	16.8	24.0	24.0	2.15	2.75	.7211E+03	.1757E+05	.1554E+05
190	16.8	16.8	24.0	24.0	2.16	2.74	.7548E+03	.1760E+05	.1567E+05
191	16.8	16.8	24.0	24.0	2.12	2.74	.5967E+03	.1780E+05	.1551E+05
192	16.7	16.8	24.0	24.0	2.17	2.73	.6148E+03	.1785E+05	.1552E+05
193	16.8	16.8	24.0	24.0	2.14	2.73	.5917E+03	.1837E+05	.1577E+05
194	16.8	16.8	24.0	24.0	2.14	2.73	.8345E+03	.1822E+05	.1570E+05
195	16.8	16.8	24.0	24.0	2.10	2.72	.6691E+03	.1827E+05	.1567E+05
196	16.8	16.8	24.0	24.0	2.14	2.72	.7183E+03	.1862E+05	.1574E+05
197	16.8	16.8	24.0	24.0	2.13	2.71	.6821E+03	.1850E+05	.1572E+05
198	16.7	16.8	24.0	24.0	2.17	2.71	.6767E+03	.1850E+05	.1573E+05
199	16.7	16.8	24.0	24.0	2.17	2.70	.9483E+03	.1860E+05	.1586E+05
200	16.7	16.8	24.0	24.0	2.21	2.70	.8451E+03	.1883E+05	.1589E+05
201	16.8	16.8	24.0	24.0	2.15	2.69	.7740E+03	.1871E+05	.1558E+05
202	16.7	16.8	24.0	24.0	2.19	2.69	.6972E+03	.1891E+05	.1602E+05
203	16.8	16.7	24.0	24.0	2.15	2.68	.8259E+03	.1919E+05	.1577E+05
204	16.8	16.7	24.0	24.0	2.15	2.68	.6338E+03	.1914E+05	.1591E+05
205	16.8	16.7	24.0	24.0	2.16	2.67	.7662E+03	.1909E+05	.1571E+05
206	16.7	16.7	24.0	24.0	2.17	2.67	.7577E+03	.1918E+05	.1603E+05
207	16.7	16.7	24.0	24.0	2.18	2.66	.6873E+03	.1938E+05	.1601E+05
208	16.7	16.7	24.0	24.0	2.18	2.66	.6876E+03	.1987E+05	.1603E+05
209	16.7	16.7	24.0	24.0	2.17	2.65	.7094E+03	.1966E+05	.1607E+05
210	16.8	16.7	24.0	24.0	2.16	2.65	.7108E+03	.1965E+05	.1596E+05
211	16.7	16.7	24.0	24.0	2.17	2.64	.8069E+03	.2001E+05	.1621E+05

212	16.7	16.7	24.0	24.0	2.21	2.63	.7191E+03	.2046E+05	.1620E+05
213	16.7	16.7	24.0	24.0	2.20	2.63	.8819E+03	.2035E+05	.1619E+05
214	16.6	16.7	24.0	24.0	2.24	2.62	.8661E+03	.2037E+05	.1610E+05
215	16.7	16.7	24.0	24.0	2.23	2.62	.8926E+03	.2063E+05	.1621E+05
216	16.8	16.7	24.0	24.0	2.14	2.61	.6697E+03	.2090E+05	.1616E+05
217	16.8	16.7	24.0	24.0	2.14	2.60	.1018E+04	.2089E+05	.1633E+05
218	16.7	16.7	24.0	24.0	2.18	2.59	.8827E+03	.2104E+05	.1620E+05
219	16.7	16.7	24.0	24.0	2.19	2.59	.7840E+03	.2094E+05	.1621E+05
220	16.7	16.7	24.0	24.0	2.19	2.58	.7349E+03	.2115E+05	.1643E+05
221	16.7	16.7	24.0	24.0	2.20	2.58	.8861E+03	.2143E+05	.1616E+05
222	16.6	16.7	24.0	24.0	2.26	2.58	.9100E+03	.2162E+05	.1656E+05
223	16.7	16.7	24.0	24.0	2.21	2.58	.8906E+03	.2178E+05	.1634E+05
224	16.7	16.6	24.0	24.0	2.22	2.58	.9970E+03	.2216E+05	.1651E+05
225	16.6	16.6	24.0	24.0	2.26	2.58	.9822E+03	.2195E+05	.1649E+05
226	16.6	16.6	24.0	24.0	2.27	2.58	.8966E+03	.2196E+05	.1619E+05
227	16.6	16.6	24.0	24.0	2.27	2.58	.9113E+03	.2235E+05	.1642E+05
228	16.6	16.6	24.0	24.0	2.25	2.58	.9331E+03	.2248E+05	.1653E+05
229	16.7	16.6	24.0	24.0	2.23	2.58	.9679E+03	.2258E+05	.1658E+05
230	16.5	16.6	24.0	24.0	2.32	2.58	.9080E+03	.2286E+05	.1654E+05
231	16.6	16.6	24.0	24.0	2.29	2.58	.9260E+03	.2288E+05	.1642E+05
232	16.6	16.6	24.0	24.0	2.26	2.58	.1034E+04	.2318E+05	.1667E+05
233	16.6	16.6	24.0	24.0	2.30	2.58	.9290E+03	.2278E+05	.1666E+05
234	16.5	16.6	24.0	24.0	2.33	2.58	.1032E+04	.2351E+05	.1681E+05
235	16.5	16.6	24.0	24.0	2.31	2.58	.1117E+04	.2378E+05	.1670E+05
236	16.5	16.5	24.0	24.0	2.32	2.58	.1071E+04	.2366E+05	.1674E+05
237	16.6	16.5	24.0	24.0	2.29	2.58	.1170E+04	.2390E+05	.1660E+05
238	16.4	16.5	24.0	24.0	2.37	2.58	.1139E+04	.2416E+05	.1674E+05
239	16.5	16.5	24.0	24.0	2.33	2.58	.1083E+04	.2394E+05	.1687E+05
240	16.4	16.5	24.0	24.0	2.40	2.58	.1113E+04	.2404E+05	.1692E+05
241	16.5	16.5	24.0	24.0	2.33	2.58	.1180E+04	.2437E+05	.1694E+05
242	16.5	16.5	24.0	24.0	2.36	2.58	.1056E+04	.2415E+05	.1681E+05
243	16.4	16.5	24.0	24.0	2.39	2.58	.1005E+04	.2465E+05	.1678E+05
244	16.4	16.5	24.0	24.0	2.38	2.58	.1102E+04	.2447E+05	.1689E+05
245	16.4	16.5	24.0	24.0	2.40	2.58	.1173E+04	.2488E+05	.1673E+05
246	16.4	16.5	24.0	24.0	2.39	2.58	.1184E+04	.2524E+05	.1717E+05
247	16.4	16.4	24.0	24.0	2.41	2.58	.1105E+04	.2517E+05	.1688E+05
248	16.4	16.4	24.0	24.0	2.42	2.58	.1309E+04	.2561E+05	.1697E+05
249	16.4	16.4	24.0	24.0	2.42	2.58	.1246E+04	.2587E+05	.1709E+05
250	16.4	16.4	24.0	24.0	2.42	2.58	.1303E+04	.2581E+05	.1722E+05
251	16.3	16.4	24.0	24.0	2.45	2.58	.1145E+04	.2596E+05	.1694E+05
252	16.4	16.4	24.0	24.0	2.43	2.58	.1249E+04	.2631E+05	.1706E+05
253	16.4	16.4	24.0	24.0	2.43	2.58	.1409E+04	.2613E+05	.1701E+05
254	16.4	16.4	24.0	24.0	2.43	2.58	.1487E+04	.2640E+05	.1718E+05
255	16.3	16.4	24.0	24.0	2.49	2.58	.1419E+04	.2671E+05	.1722E+05
256	16.3	16.3	24.0	24.0	2.46	2.58	.1520E+04	.2697E+05	.1721E+05
257	16.3	16.3	24.0	24.0	2.49	2.58	.1359E+04	.2690E+05	.1719E+05
258	16.3	16.3	24.0	24.0	2.47	2.58	.1491E+04	.2722E+05	.1733E+05
259	16.3	16.3	24.0	24.0	2.49	2.58	.1566E+04	.2737E+05	.1723E+05
260	16.2	16.3	24.0	24.0	2.53	2.58	.1464E+04	.2765E+05	.1728E+05
261	16.2	16.3	24.0	24.0	2.55	2.58	.1439E+04	.2808E+05	.1727E+05
262	16.3	16.3	24.0	24.0	2.50	2.58	.1546E+04	.2782E+05	.1732E+05
263	16.2	16.2	24.0	24.0	2.54	2.58	.1615E+04	.2803E+05	.1722E+05
264	16.1	16.2	24.0	24.0	2.57	2.58	.1650E+04	.2830E+05	.1758E+05
265	16.1	16.2	24.0	24.0	2.57	2.58	.1568E+04	.2863E+05	.1748E+05
266	16.1	16.2	24.0	24.0	2.57	2.58	.1654E+04	.2861E+05	.1752E+05
267	16.1	16.2	24.0	24.0	2.58	2.58	.1656E+04	.2899E+05	.1747E+05
268	16.1	16.2	24.0	24.0	2.63	2.58	.1618E+04	.2921E+05	.1759E+05

269	16.1	16.1	24.0	24.0	2.62	2.58	.1666E+04	.2939E+05	.1744E+05
270	16.0	16.1	24.0	24.0	2.65	2.58	.1643E+04	.2969E+05	.1764E+05
271	16.0	16.1	24.0	24.0	2.66	2.58	.1881E+04	.2959E+05	.1757E+05
272	16.1	16.1	24.0	24.0	2.62	2.58	.1899E+04	.2987E+05	.1763E+05
273	16.0	16.1	24.0	24.0	2.65	2.58	.1804E+04	.2985E+05	.1765E+05
274	16.0	16.0	24.0	24.0	2.64	2.58	.1844E+04	.3024E+05	.1774E+05
275	16.0	16.0	24.0	24.0	2.67	2.58	.1884E+04	.3061E+05	.1774E+05
276	15.9	16.0	24.0	24.0	2.71	2.58	.1854E+04	.3065E+05	.1773E+05
277	15.9	16.0	24.0	24.0	2.74	2.58	.1909E+04	.3082E+05	.1782E+05
278	16.0	16.0	24.0	24.0	2.67	2.58	.1965E+04	.3098E+05	.1786E+05
279	15.9	15.9	24.0	24.0	2.73	2.58	.1970E+04	.3103E+05	.1785E+05
280	15.9	15.9	24.0	24.0	2.72	2.58	.1935E+04	.3145E+05	.1799E+05
281	15.9	15.9	24.0	24.0	2.72	2.58	.2090E+04	.3144E+05	.1786E+05
282	15.9	15.8	24.0	24.0	2.74	2.58	.2058E+04	.3208E+05	.1785E+05
283	15.8	15.8	24.0	24.0	2.80	2.58	.2161E+04	.3212E+05	.1805E+05
284	15.8	15.8	24.0	24.0	2.81	2.58	.2124E+04	.3218E+05	.1813E+05
285	15.8	15.8	24.0	24.0	2.83	2.58	.2231E+04	.3238E+05	.1791E+05
286	15.7	15.7	24.0	24.0	2.83	2.58	.2020E+04	.3285E+05	.1821E+05
287	15.7	15.7	24.0	24.0	2.90	2.58	.2108E+04	.3279E+05	.1790E+05
288	15.7	15.7	24.0	24.0	2.89	2.58	.2118E+04	.3292E+05	.1791E+05
289	15.7	15.6	24.0	24.0	2.89	2.58	.2110E+04	.3345E+05	.1808E+05
290	15.6	15.6	24.0	24.0	2.95	2.58	.2233E+04	.3352E+05	.1816E+05
291	15.5	15.5	24.0	24.0	3.02	2.58	.2177E+04	.3372E+05	.1820E+05
292	15.5	15.5	24.0	24.0	3.00	2.58	.2195E+04	.3352E+05	.1805E+05
293	15.5	15.5	24.0	24.0	2.99	2.58	.2236E+04	.3398E+05	.1823E+05
294	15.5	15.4	24.0	24.0	3.00	2.58	.2256E+04	.3406E+05	.1840E+05
295	15.5	15.4	24.0	24.0	3.02	2.58	.2262E+04	.3449E+05	.1835E+05
296	15.4	15.3	24.0	24.0	3.05	2.58	.2271E+04	.3444E+05	.1806E+05
297	15.4	15.3	24.0	24.0	3.06	2.58	.2204E+04	.3480E+05	.1840E+05
298	15.3	15.2	24.0	24.0	3.13	2.58	.2205E+04	.3494E+05	.1851E+05
299	15.3	15.2	24.0	24.0	3.11	2.58	.2203E+04	.3497E+05	.1812E+05
300	15.2	15.1	24.0	24.0	3.17	2.58	.2266E+04	.3517E+05	.1845E+05
301	15.1	15.1	24.0	24.0	3.24	2.58	.2236E+04	.3532E+05	.1826E+05
302	15.2	15.0	24.0	24.0	3.19	2.58	.2271E+04	.3545E+05	.1841E+05
303	15.1	15.0	24.0	24.0	3.29	2.58	.2164E+04	.3528E+05	.1855E+05
304	15.0	14.9	24.0	24.0	3.32	2.58	.2221E+04	.3557E+05	.1847E+05
305	15.1	14.9	24.0	24.0	3.26	2.58	.2325E+04	.3597E+05	.1857E+05
306	14.9	14.8	24.0	24.0	3.42	2.58	.2191E+04	.3588E+05	.1854E+05
307	14.8	14.7	24.0	24.0	3.44	2.58	.2253E+04	.3619E+05	.1872E+05
308	14.8	14.7	24.0	24.0	3.46	2.58	.2234E+04	.3610E+05	.1868E+05
309	14.6	14.6	24.0	24.0	3.58	2.58	.2197E+04	.3684E+05	.1863E+05
310	14.7	14.5	24.0	24.0	3.55	2.58	.2299E+04	.3660E+05	.1871E+05
311	14.6	14.4	24.0	24.0	3.63	2.58	.2233E+04	.3673E+05	.1897E+05
312	14.5	14.4	24.0	24.0	3.66	2.58	.2156E+04	.3677E+05	.1863E+05
313	14.5	14.3	24.0	24.0	3.65	2.58	.2089E+04	.3758E+05	.1881E+05
314	14.5	14.2	24.0	24.0	3.66	2.58	.2115E+04	.3727E+05	.1868E+05
315	14.4	14.1	24.0	24.0	3.76	2.58	.2148E+04	.3736E+05	.1896E+05
316	14.3	14.0	24.0	24.0	3.77	2.58	.2163E+04	.3763E+05	.1892E+05
317	14.2	13.9	24.0	24.0	3.90	2.58	.2150E+04	.3779E+05	.1898E+05
318	14.2	13.8	24.0	24.0	3.89	2.58	.2116E+04	.3793E+05	.1902E+05
319	14.1	13.8	24.0	24.0	3.96	2.58	.2101E+04	.3839E+05	.1888E+05
320	14.0	13.7	24.0	24.0	3.97	2.58	.1966E+04	.3849E+05	.1871E+05
321	13.9	13.6	24.0	24.0	4.08	2.58	.2034E+04	.3867E+05	.1917E+05
322	13.7	13.4	24.0	24.0	4.18	2.58	.1984E+04	.3897E+05	.1920E+05
323	13.6	13.3	24.0	24.0	4.25	2.58	.1942E+04	.3924E+05	.1914E+05
324	12.6	13.2	24.0	24.0	4.30	2.58	.1998E+04	.3952E+05	.1895E+05
325	12.6	13.1	24.0	24.0	4.25	2.58	.1914E+04	.3969E+05	.1930E+05

326	13.5	13.0	24.0	24.0	4.36	2.58	.1904E+04	.3967E+05	.1933E+05
327	12.5	12.9	24.0	24.0	4.34	2.58	.1810E+04	.4005E+05	.1925E+05
328	12.3	12.8	24.0	24.0	4.50	2.58	.1734E+04	.4011E+05	.1927E+05
329	12.3	12.6	24.0	24.0	4.49	2.58	.1746E+04	.4022E+05	.1936E+05
330	12.2	12.5	24.0	24.0	4.57	2.58	.1795E+04	.4078E+05	.1959E+05
331	11.9	12.4	24.0	24.0	4.74	2.58	.1684E+04	.4103E+05	.1933E+05
332	11.9	12.2	24.0	24.0	4.72	2.58	.1529E+04	.4130E+05	.1944E+05
333	12.0	12.1	24.0	24.0	4.71	2.58	.1473E+04	.4136E+05	.1932E+05
334	11.6	12.0	24.0	24.0	4.95	2.58	.1467E+04	.4169E+05	.1942E+05
335	11.5	11.8	24.0	24.0	5.04	2.58	.1401E+04	.4171E+05	.1950E+05
336	11.5	11.7	24.0	24.0	6.01	2.58	.1239E+04	.4171E+05	.1953E+05
337	11.3	11.5	24.0	24.0	6.03	2.58	.1233E+04	.4181E+05	.1972E+05
338	11.2	11.4	24.0	24.0	5.99	2.58	.1223E+04	.4209E+05	.1951E+05
339	11.0	11.2	24.0	24.0	5.99	2.58	.1195E+04	.4243E+05	.1982E+05
340	10.9	11.0	24.0	24.0	5.99	2.58	.1045E+04	.4214E+05	.1968E+05
341	10.7	10.9	24.0	24.0	5.98	2.58	.9754E+03	.4233E+05	.1962E+05
342	10.6	10.7	24.0	24.0	5.95	2.58	.8854E+03	.4258E+05	.2006E+05
343	10.4	10.5	24.0	24.0	5.98	2.58	.8156E+03	.4301E+05	.1991E+05
344	10.1	10.3	24.0	24.0	5.92	2.58	.7538E+03	.4248E+05	.2009E+05
345	9.9	10.2	24.0	24.0	6.01	2.58	.6466E+03	.4350E+05	.1979E+05
346	9.9	10.0	24.0	24.0	5.96	2.58	.5476E+03	.4335E+05	.1994E+05
347	9.6	9.8	24.0	24.0	5.97	2.58	.5077E+03	.4309E+05	.1996E+05
348	9.5	9.6	24.0	24.0	5.94	2.58	.4967E+03	.4362E+05	.2007E+05
349	9.4	9.4	24.0	24.0	5.96	2.58	.3949E+03	.4408E+05	.2019E+05
350	9.2	9.2	24.0	24.0	5.94	2.58	.3905E+03	.4369E+05	.2014E+05
351	9.0	9.0	24.0	24.0	5.98	2.58	.2388E+03	.4388E+05	.2027E+05
352	8.7	8.8	24.0	24.0	5.96	2.58	.3047E+03	.4391E+05	.2017E+05
353	8.5	8.6	24.0	24.0	5.94	2.58	.3130E+03	.4406E+05	.2026E+05
354	8.3	8.4	24.0	24.0	5.98	2.58	.2876E+03	.4419E+05	.2049E+05
355	8.3	8.2	24.0	24.0	5.90	2.58	.3021E+03	.4408E+05	.2016E+05
356	8.1	8.0	24.0	24.0	5.90	2.58	.2835E+03	.4436E+05	.2041E+05
357	8.0	7.8	24.0	24.0	5.88	2.58	.3207E+03	.4448E+05	.2057E+05
358	7.8	7.5	24.0	24.0	5.89	2.58	.3298E+03	.4401E+05	.2053E+05
359	7.4	7.3	24.0	24.0	5.92	2.58	.3005E+03	.4437E+05	.2065E+05
360	7.3	7.1	24.0	24.0	5.90	2.58	.4140E+03	.4450E+05	.2057E+05
361	7.1	6.9	24.0	24.0	5.90	2.58	.4461E+03	.4453E+05	.2045E+05
362	6.8	6.6	24.0	24.0	5.90	2.58	.4015E+03	.4481E+05	.2047E+05
363	6.6	6.4	24.0	24.0	5.89	2.58	.3980E+03	.4441E+05	.2096E+05
364	6.2	6.2	24.0	24.0	5.94	2.58	.4477E+03	.4496E+05	.2085E+05
365	6.2	5.9	24.0	24.0	5.86	2.58	.3505E+03	.4451E+05	.2076E+05
366	5.9	5.7	24.0	24.0	5.88	2.58	.3373E+03	.4515E+05	.2105E+05
367	5.6	5.5	24.0	24.0	5.85	2.58	.2561E+03	.4468E+05	.2084E+05
368	5.4	5.2	24.0	24.0	5.84	2.58	.2027E+03	.4478E+05	.2086E+05
369	5.1	5.0	24.0	24.0	5.88	2.58	.1083E+03	.4493E+05	.2092E+05
370	4.9	4.7	24.0	24.0	5.86	2.58	.7782E+02	.4477E+05	.2120E+05
371	4.9	4.5	24.0	23.9	5.82	2.58	.5743E+02	.4451E+05	.2117E+05
372	4.4	4.3	24.0	23.9	5.85	2.58	.3614E+02	.4496E+05	.2119E+05
373	4.3	4.0	24.0	23.9	5.82	2.58	.1082E+02	.4469E+05	.2139E+05
374	4.0	3.8	24.0	23.9	5.82	2.58	.6592E+01	.4462E+05	.2128E+05
375	4.0	3.5	24.0	23.9	5.79	2.58	.2513E+00	.4471E+05	.2140E+05
376	1.0	3.3	24.0	23.9	5.79	2.58	.2364E+00	.4434E+05	.2152E+05
377	1.0	1.0	24.0	23.9	5.84	2.58	.0000E+00	.4442E+05	.2151E+05
378	1.0	1.0	24.0	23.9	5.77	2.58	.0000E+00	.4432E+05	.2153E+05
379	1.0	1.0	24.0	23.9	5.80	2.58	.0000E+00	.4438E+05	.2185E+05
380	1.0	1.0	24.0	23.9	5.76	2.58	.0000E+00	.4454E+05	.2181E+05
381	1.0	1.0	24.0	23.9	5.69	2.58	.0000E+00	.4393E+05	.2170E+05
382	1.0	1.0	24.0	23.9	5.71	2.58	.0000E+00	.4383E+05	.2165E+05

383	1.0	1.0	24.0	23.9	5.79	2.56	.0000E+00	.4357E+05	.2196E+05
384	1.0	1.0	24.0	23.9	5.72	2.58	.0000E+00	.4286E+05	.2168E+05
385	1.0	1.0	24.0	23.8	5.69	2.58	.0000E+00	.4195E+05	.2183E+05
386	1.0	1.0	24.0	23.8	5.71	2.58	.0000E+00	.4121E+05	.2162E+05
387	1.0	1.0	24.0	23.8	5.65	2.58	.0000E+00	.4034E+05	.2162E+05
388	1.0	1.0	24.0	23.8	5.68	2.58	.0000E+00	.4016E+05	.2159E+05
389	1.0	1.0	24.0	23.8	5.69	2.58	.0000E+00	.3839E+05	.2156E+05
390	1.0	1.0	24.0	23.8	5.65	2.53	.0000E+00	.3812E+05	.2133E+05
391	1.0	1.0	24.0	23.8	5.66	2.58	.0000E+00	.3728E+05	.2127E+05
392	1.0	1.0	23.0	23.8	5.59	2.58	.0000E+00	.3642E+05	.2138E+05
393	1.0	1.0	24.0	23.8	5.64	2.58	.0000E+00	.3547E+05	.2120E+05
394	1.0	1.0	24.0	23.8	5.63	2.58	.0000E+00	.3477E+05	.2109E+05
395	1.0	1.0	24.0	23.7	5.57	2.58	.0000E+00	.3416E+05	.2100E+05
396	1.0	1.0	24.0	23.7	5.60	2.58	.0000E+00	.3315E+05	.2099E+05
397	1.0	1.0	23.0	23.7	5.50	2.58	.0000E+00	.3218E+05	.2090E+05
398	1.0	1.0	23.0	23.7	5.58	2.58	.0000E+00	.3146E+05	.2072E+05
399	1.0	1.0	24.0	23.7	5.53	2.58	.0000E+00	.3084E+05	.2088E+05
400	1.0	1.0	23.0	23.7	5.56	2.58	.0000E+00	.2966E+05	.2054E+05
401	1.0	1.0	23.0	23.7	5.46	2.58	.0000E+00	.2863E+05	.2058E+05
402	1.0	1.0	24.0	23.6	5.48	2.58	.0000E+00	.2767E+05	.2052E+05
403	1.0	1.0	24.0	23.6	5.45	2.58	.0000E+00	.2666E+05	.2028E+05
404	1.0	1.0	24.0	23.6	5.39	2.58	.0000E+00	.2580E+05	.2026E+05
405	1.0	1.0	23.0	23.6	5.39	2.58	.0000E+00	.2466E+05	.2029E+05
406	1.0	1.0	23.0	23.6	5.31	2.58	.0000E+00	.2374E+05	.1998E+05
407	1.0	1.0	24.0	23.6	5.37	2.58	.0000E+00	.2274E+05	.1993E+05
408	1.0	1.0	23.0	23.5	5.31	2.58	.0000E+00	.2139E+05	.1965E+05
409	1.0	1.0	23.0	23.5	5.29	2.58	.0000E+00	.2091E+05	.1983E+05
410	1.0	1.0	23.0	23.5	5.14	2.58	.0000E+00	.1980E+05	.1954E+05
411	1.0	1.0	24.0	23.5	5.22	2.58	.0000E+00	.1878E+05	.1945E+05
412	1.0	1.0	23.0	23.5	5.09	2.58	.0000E+00	.1787E+05	.1939E+05
413	1.0	1.0	24.0	23.4	5.06	2.58	.0000E+00	.1676E+05	.1920E+05
414	1.0	1.0	24.0	23.4	4.91	2.58	.0000E+00	.1588E+05	.1911E+05
415	1.0	1.0	24.0	23.4	4.97	2.58	.0000E+00	.1508E+05	.1915E+05
416	1.0	1.0	23.0	23.4	4.80	2.58	.0000E+00	.1407E+05	.1888E+05
417	1.0	1.0	24.0	23.4	4.67	2.58	.0000E+00	.1313E+05	.1876E+05
418	1.0	1.0	23.0	23.3	4.68	2.58	.0000E+00	.1230E+05	.1863E+05
419	1.0	1.0	23.0	23.3	4.52	2.58	.0000E+00	.1130E+05	.1859E+05
420	1.0	1.0	23.0	23.3	4.46	2.58	.0000E+00	.1073E+05	.1818E+05
421	1.0	1.0	23.0	23.3	4.36	2.58	.0000E+00	.9908E+04	.1793E+05
422	1.0	1.0	23.0	23.2	3.94	2.58	.0000E+00	.9415E+04	.1820E+05
423	1.0	1.0	24.0	23.2	3.95	2.58	.0000E+00	.8570E+04	.1803E+05
424	1.0	1.0	23.0	23.2	3.92	2.58	.0000E+00	.7923E+04	.1772E+05
425	1.0	1.0	23.0	23.2	3.69	2.58	.0000E+00	.7291E+04	.1760E+05
426	1.0	1.0	23.0	23.1	3.30	2.58	.0000E+00	.7034E+04	.1739E+05
427	1.0	1.0	23.0	23.1	3.17	2.58	.0000E+00	.6329E+04	.1717E+05
428	1.0	1.0	23.0	23.1	2.82	2.58	.0000E+00	.5913E+04	.1714E+05
429	1.0	1.0	24.0	23.0	2.88	2.58	.0000E+00	.5716E+04	.1676E+05
430	1.0	1.0	24.0	23.0	2.66	2.58	.0000E+00	.5635E+04	.1665E+05
431	1.0	1.0	23.0	23.0	2.51	2.58	.0000E+00	.5139E+04	.1658E+05
432	1.0	1.0	24.0	23.0	2.38	2.58	.0000E+00	.5035E+04	.1635E+05
433	1.0	1.0	22.0	22.9	2.25	2.58	.0000E+00	.4605E+04	.1614E+05
434	1.0	1.0	22.0	22.9	2.00	2.58	.0000E+00	.4419E+04	.1603E+05
435	1.0	1.0	23.0	22.9	1.76	2.58	.0000E+00	.4477E+04	.1566E+05
436	1.0	1.0	23.0	22.8	1.57	2.58	.0000E+00	.4242E+04	.1558E+05
437	1.0	1.0	22.0	22.8	1.61	2.58	.0000E+00	.4193E+04	.1529E+05
438	1.0	1.0	23.0	22.8	1.45	2.58	.0000E+00	.3918E+04	.1505E+05
439	1.0	1.0	23.0	22.7	1.36	2.58	.0000E+00	.4012E+04	.1485E+05

440	1.0	1.0	23.0	22.7	1.72	2.58	.0000E+00	.3806E+04	.1449E+05
441	1.0	1.0	22.0	22.6	1.50	2.58	.0000E+00	.3673E+04	.1460E+05
442	1.0	1.0	22.0	22.6	1.51	2.58	.0000E+00	.3675E+04	.1401E+05
443	1.0	1.0	23.0	22.6	2.19	2.58	.0000E+00	.3457E+04	.1376E+05
444	1.0	1.0	22.0	22.5	1.83	2.58	.0000E+00	.3478E+04	.1366E+05
445	1.0	1.0	22.0	22.5	1.28	2.58	.0000E+00	.3160E+04	.1352E+05
446	1.0	1.0	22.0	22.4	2.24	2.58	.0000E+00	.3096E+04	.1293E+05
447	1.0	1.0	22.0	22.4	1.74	2.58	.0000E+00	.2729E+04	.1286E+05
448	1.0	1.0	22.0	22.4	2.15	2.58	.0000E+00	.2902E+04	.1271E+05
449	1.0	1.0	23.0	22.3	2.15	2.58	.0000E+00	.2582E+04	.1220E+05
450	1.0	1.0	22.0	22.3	1.54	2.58	.0000E+00	.2220E+04	.1190E+05
451	1.0	1.0	22.0	22.2	2.38	2.58	.0000E+00	.2230E+04	.1174E+05
452	1.0	1.0	21.0	22.2	2.19	2.58	.0000E+00	.1934E+04	.1161E+05
453	1.0	1.0	24.0	22.1	.87	2.58	.0000E+00	.1758E+04	.1101E+05
454	1.0	1.0	22.0	22.1	1.50	2.58	.0000E+00	.1600E+04	.1080E+05
455	1.0	1.0	22.0	22.0	2.28	2.58	.0000E+00	.1462E+04	.1042E+05
456	1.0	1.0	22.0	22.0	2.13	2.58	.0000E+00	.1195E+04	.1024E+05
457	1.0	1.0	22.0	21.9	2.59	2.58	.0000E+00	.1136E+04	.9797E+04
458	1.0	1.0	23.0	21.9	1.50	2.58	.0000E+00	.9137E+03	.9609E+04
459	1.0	1.0	22.0	21.8	2.67	2.58	.0000E+00	.8394E+03	.9009E+04
460	1.0	1.0	22.0	21.8	.75	2.58	.0000E+00	.6771E+03	.8765E+04
461	1.0	1.0	22.0	21.7	1.50	2.58	.0000E+00	.5783E+03	.8337E+04
462	1.0	1.0	21.0	21.7	1.39	2.58	.0000E+00	.4759E+03	.8105E+04
463	1.0	1.0	22.0	21.6	4.25	2.58	.0000E+00	.4854E+03	.7602E+04
464	1.0	1.0	22.0	21.5	3.50	2.58	.0000E+00	.4531E+03	.7382E+04
465	1.0	1.0	22.0	21.5	.83	2.58	.0000E+00	.4382E+03	.6887E+04
466	1.0	1.0	20.0	21.4	1.63	2.58	.0000E+00	.3809E+03	.6530E+04
467	1.0	1.0	21.0	21.4	.67	2.58	.0000E+00	.3767E+03	.5972E+04
468	1.0	1.0	22.0	21.3	2.63	2.58	.0000E+00	.3410E+03	.5634E+04
469	1.0	1.0	21.0	21.2	.71	2.58	.0000E+00	.3093E+03	.5177E+04
470	1.0	1.0	22.0	21.2	.75	2.58	.0000E+00	.2377E+03	.4804E+04
471	1.0	1.0	22.0	21.1	1.29	2.58	.0000E+00	.2319E+03	.4286E+04
472	1.0	1.0	20.0	21.0	.50	2.58	.0000E+00	.1831E+03	.3915E+04
473	1.0	1.0	20.0	21.0	4.00	2.58	.0000E+00	.1392E+03	.3386E+04
474	1.0	1.0	22.0	20.9	3.00	2.58	.0000E+00	.1018E+03	.2927E+04
475	1.0	1.0	20.0	20.8	1.00	2.58	.0000E+00	.6403E+02	.2365E+04

INPUT POS TO SAVE ON DISC, OR NEG TO DELETE SAVE.

APPENDIX V

LISTING OF THE RMPRDN OUTPUT DATA FOR THE HYDROGEN/KRYPTON COUNTER
IN THE JANUS NEUTRON SPECTRUM

APPENDIX V

LISTING OF THE RMPROD OUTPUT DATA FOR THE HYDROGEN/KRYPTON
COUNTER IN THE JANUS NEUTRON SPECTRUM.

HYD/KR AT 0,0,100. 3HR,34 MIN. ATTN REMOVED(DOWN). 3/30/88.

TOTAL POINTS AND START POINT = 195 25
INITIAL AVERAGE PROTON LINE WIDTH = 3.57
N15 AND NBRK CHANNELS ARE 56 94
.90 WMAX CHANNEL = 46
RUN TIME IN SECONDS = 12840

J	DVAL	EDVAL	TVAL	ETVAL	LINE	RATIO-	GAMMAS	PRTS	TIME
1	14.7	14.6	25.0	25.0	3.51	7.39	-.9584E+02	.2200E+05	.3422E+04
2	14.8	14.7	25.0	25.0	3.49	7.38	-.1379E+03	.2258E+05	.3546E+04
3	14.8	14.8	25.0	25.0	3.47	7.37	.2375E+03	.2362E+05	.3728E+04
4	14.7	14.8	25.0	25.0	3.51	7.37	-.7095E+01	.2434E+05	.3773E+04
5	14.7	14.8	25.0	25.0	3.51	7.36	-.2743E+03	.2557E+05	.4174E+04
6	14.7	14.8	25.0	25.0	3.56	7.36	-.6349E+02	.2645E+05	.4211E+04
7	14.7	14.8	25.0	25.0	3.53	7.36	-.4494E+01	.2762E+05	.4391E+04
8	14.7	14.7	25.0	25.0	3.53	7.36	.1946E+02	.2846E+05	.4579E+04
9	14.7	14.7	25.0	25.0	3.56	7.36	-.2348E+03	.2925E+05	.4810E+04
10	14.8	14.7	25.0	25.0	3.47	7.36	-.2649E+03	.3027E+05	.5041E+04
11	14.6	14.6	25.0	25.0	3.61	7.37	.2160E+02	.3103E+05	.5266E+04
12	14.6	14.6	25.0	25.0	3.60	7.37	.7369E+02	.3229E+05	.5372E+04
13	14.6	14.5	25.0	25.0	3.57	7.37	-.1356E+03	.3303E+05	.5620E+04
14	14.5	14.5	25.0	25.0	3.64	7.38	-.1716E+03	.3401E+05	.5916E+04
15	14.5	14.5	25.0	25.0	3.64	7.38	-.9288E+02	.3540E+05	.6035E+04
16	14.6	14.5	25.0	25.0	3.63	7.38	-.2510E+03	.3622E+05	.6162E+04
17	14.6	14.4	25.0	25.0	3.62	7.38	-.5919E+02	.3712E+05	.6588E+04
18	14.5	14.4	25.0	25.0	3.65	7.38	-.4788E+03	.3809E+05	.6797E+04
19	14.4	14.4	25.0	25.0	3.76	7.38	-.4577E+02	.3886E+05	.6889E+04
20	14.5	14.4	25.0	25.0	3.65	7.38	-.3277E+03	.4015E+05	.7228E+04
21	14.3	14.4	25.0	25.0	3.80	7.38	-.2679E+03	.4077E+05	.7388E+04
22	14.4	14.4	25.0	25.0	3.74	7.38	-.2406E+03	.4215E+05	.7612E+04
23	14.3	14.3	25.0	25.0	3.80	7.37	-.4951E+03	.4271E+05	.7913E+04
24	14.2	14.3	25.0	25.0	3.84	7.36	-.4690E+03	.4347E+05	.8060E+04
25	14.2	14.3	25.0	25.0	3.88	7.36	-.2446E+03	.4537E+05	.8390E+04
26	14.2	14.3	25.0	25.0	3.88	7.35	-.1867E+03	.4639E+05	.8696E+04
27	14.2	14.2	25.0	25.0	3.89	7.34	-.2855E+03	.4693E+05	.8872E+04
28	14.0	14.2	25.0	25.0	4.00	7.33	-.2290E+03	.4809E+05	.9213E+04
29	14.0	14.1	25.0	25.0	3.97	7.32	-.6572E+03	.4923E+05	.9394E+04
30	14.0	14.1	25.0	25.0	4.02	7.30	-.6021E+03	.5024E+05	.9895E+04
31	13.9	14.0	25.0	25.0	4.07	7.29	-.6568E+03	.5080E+05	.1007E+05
32	13.8	13.9	25.0	25.0	4.11	7.27	-.6147E+03	.5274E+05	.1028E+05
33	13.8	13.9	25.0	25.0	4.10	7.26	-.5567E+03	.5317E+05	.1058E+05
34	13.7	13.8	25.0	25.0	4.20	7.24	-.9804E+03	.5430E+05	.1100E+05
35	13.7	13.7	25.0	25.0	4.23	7.22	-.9331E+03	.5534E+05	.1135E+05
36	13.5	13.6	25.0	25.0	4.33	7.20	-.7697E+03	.5591E+05	.1153E+05
37	13.6	13.5	25.0	25.0	4.28	7.18	-.7963E+03	.5713E+05	.1191E+05
38	13.5	13.4	25.0	25.0	4.33	7.15	-.1003E+04	.5810E+05	.1221E+05
39	13.4	13.3	25.0	25.0	4.38	7.12	-.1415E+04	.5914E+05	.1238E+05
40	13.3	13.1	25.0	25.0	4.48	7.09	-.1467E+04	.5996E+05	.1296E+05

41	13.4	13.0	25.0	25.0	4.42	7.05	-.1476E+04	.6105E+05	.1329E+05
42	13.2	12.9	25.0	25.0	4.55	7.00	-.1707E+04	.6172E+05	.1356E+05
43	13.0	12.8	25.0	25.0	4.64	6.95	-.1901E+04	.6343E+05	.1382E+05
44	12.9	12.6	25.0	25.0	4.70	6.89	-.1787E+04	.6446E+05	.1430E+05
45	12.9	12.5	25.0	25.0	4.74	6.82	-.2008E+04	.6490E+05	.1448E+05
46	12.8	12.3	25.0	25.0	4.82	6.74	-.2259E+04	.6639E+05	.1511E+05
47	11.7	12.2	25.0	25.0	4.85	6.74	-.2171E+04	.6701E+05	.1525E+05
48	11.5	12.1	25.0	25.0	4.97	6.74	-.2117E+04	.6773E+05	.1556E+05
49	11.5	11.9	25.0	25.0	4.97	6.74	-.2277E+04	.6895E+05	.1618E+05
50	11.5	11.8	25.0	25.0	5.01	6.74	-.2068E+04	.7012E+05	.1656E+05
51	11.4	11.6	25.0	25.0	5.09	6.74	-.1933E+04	.7087E+05	.1681E+05
52	11.3	11.5	25.0	25.0	5.17	6.74	-.1513E+04	.7234E+05	.1761E+05
53	11.2	11.3	25.0	25.0	5.21	6.74	-.1695E+04	.7301E+05	.1784E+05
54	11.1	11.2	25.0	25.0	5.30	6.74	-.1680E+04	.7392E+05	.1814E+05
55	11.1	11.0	25.0	25.0	5.29	6.74	-.1572E+04	.7512E+05	.1858E+05
56	10.8	10.9	25.0	25.0	5.48	6.74	-.1351E+04	.7596E+05	.1924E+05
57	10.7	10.7	25.0	25.0	5.53	6.74	-.1173E+04	.7634E+05	.1946E+05
58	10.7	10.6	25.0	25.0	5.57	6.74	-.9399E+03	.7753E+05	.1999E+05
59	10.4	10.4	25.0	25.0	5.75	6.74	-.9556E+03	.7809E+05	.2049E+05
60	10.3	10.2	25.0	25.0	5.82	6.74	-.9177E+03	.7911E+05	.2105E+05
61	10.1	10.1	25.0	25.0	5.94	6.74	-.6625E+03	.8032E+05	.2121E+05
62	9.9	9.9	25.0	25.0	6.08	6.74	-.7763E+03	.8056E+05	.2210E+05
63	9.7	9.7	25.0	25.0	6.19	6.74	-.4039E+03	.8176E+05	.2238E+05
64	9.6	9.5	25.0	25.0	6.28	6.74	-.3394E+03	.8348E+05	.2280E+05
65	9.5	9.3	25.0	25.0	6.37	6.74	-.2158E+03	.8437E+05	.2367E+05
66	9.3	9.1	25.0	25.0	6.45	6.74	-.1361E+03	.8548E+05	.2406E+05
67	8.9	8.9	25.0	25.0	7.65	6.74	-.2383E+02	.8613E+05	.2459E+05
68	8.9	8.7	25.0	25.0	7.63	6.74	.1694E+02	.8636E+05	.2523E+05
69	8.7	8.5	25.0	25.0	7.62	6.74	.1294E+03	.8734E+05	.2554E+05
70	8.3	8.3	25.0	25.0	7.66	6.74	.2164E+03	.8847E+05	.2626E+05
71	8.2	8.1	25.0	25.0	7.64	6.74	.2852E+03	.8920E+05	.2681E+05
72	7.8	7.8	25.0	25.0	7.66	6.74	.3810E+03	.9018E+05	.2746E+05
73	7.4	7.6	25.0	25.0	7.66	6.74	.2546E+03	.9114E+05	.2821E+05
74	7.3	7.3	25.0	25.0	7.68	6.74	.4163E+03	.9091E+05	.2854E+05
75	7.1	7.0	25.0	25.0	7.67	6.74	.4718E+03	.9176E+05	.2857E+05
76	6.8	6.8	25.0	25.0	7.65	6.74	.4534E+03	.9135E+05	.2913E+05
77	6.4	6.5	25.0	25.0	7.66	6.74	.4925E+03	.9151E+05	.2896E+05
78	6.2	6.2	25.0	25.0	7.61	6.74	.3551E+03	.9232E+05	.2933E+05
79	5.9	5.9	25.0	25.0	7.64	6.74	.3688E+03	.9203E+05	.2937E+05
80	5.4	5.6	25.0	25.0	7.69	6.74	.2686E+03	.9239E+05	.2970E+05
81	5.2	5.3	25.0	25.0	7.67	6.74	.2003E+03	.9243E+05	.2973E+05
82	4.9	4.9	25.0	25.0	7.69	6.74	.1608E+03	.9265E+05	.3006E+05
83	4.5	4.6	25.0	25.0	7.68	6.74	.1195E+03	.9247E+05	.3030E+05
84	4.2	4.3	25.0	25.0	7.66	6.74	.9687E+02	.9334E+05	.3009E+05
85	4.0	4.0	25.0	25.0	7.67	6.74	.4980E+02	.9392E+05	.3056E+05
86	3.6	3.7	25.0	25.0	7.71	6.74	.4507E+02	.9331E+05	.3065E+05
87	3.4	3.3	25.0	25.0	7.71	6.74	.3903E+02	.9406E+05	.3075E+05
88	3.2	3.0	25.0	25.0	7.69	6.74	.1495E+02	.9403E+05	.3122E+05
89	2.8	2.7	25.0	25.0	7.70	6.74	.1495E+02	.9371E+05	.3129E+05
90	2.5	2.4	25.0	25.0	7.76	6.74	.1286E+02	.9417E+05	.3130E+05
91	2.4	2.1	25.0	25.0	7.67	6.74	.1405E+01	.9456E+05	.3156E+05
92	1.1	1.8	25.0	25.0	7.72	6.74	.0000E+00	.9453E+05	.3194E+05
93	1.9	1.5	25.0	25.0	7.70	6.74	.0000E+00	.9460E+05	.3197E+05
94	1.0	1.2	25.0	25.0	7.73	6.74	.0000E+00	.9484E+05	.3237E+05
95	1.0	1.0	25.0	25.0	7.74	6.74	.0000E+00	.9503E+05	.3258E+05
96	1.0	1.0	25.0	25.0	7.68	6.74	.0000E+00	.9551E+05	.3262E+05
97	1.0	1.0	25.0	25.0	7.66	6.74	.0000E+00	.9483E+05	.3292E+05

98	1.0	1.0	25.0	25.1	7.63	6.74	.0000E+00	.9532E+05	.3309E+05
99	1.0	1.0	25.0	25.1	7.54	6.74	.0000E+00	.9449E+05	.3345E+05
100	1.0	1.0	25.0	25.1	7.60	6.74	.0000E+00	.9419E+05	.3383E+05
101	1.0	1.0	25.0	25.1	7.47	6.74	.0000E+00	.9382E+05	.3388E+05
102	1.0	1.0	25.0	25.1	7.47	6.74	.0000E+00	.9326E+05	.3406E+05
103	1.0	1.0	25.0	25.1	7.44	6.74	.0000E+00	.9053E+05	.3389E+05
104	1.0	1.0	25.0	25.1	7.40	6.74	.0000E+00	.8859E+05	.3419E+05
105	1.0	1.0	25.0	25.1	7.38	6.74	.0000E+00	.8696E+05	.3403E+05
106	1.0	1.0	25.0	25.1	7.29	6.74	.0000E+00	.8525E+05	.3391E+05
107	1.0	1.0	25.0	25.1	7.35	6.74	.0000E+00	.8325E+05	.3348E+05
108	1.0	1.0	25.0	25.1	7.28	6.74	.0000E+00	.8133E+05	.3404E+05
109	1.0	1.0	25.0	25.0	7.27	6.74	.0000E+00	.7914E+05	.3383E+05
110	1.0	1.0	25.0	25.0	7.18	6.74	.0000E+00	.7757E+05	.3400E+05
111	1.0	1.0	25.0	25.0	7.22	6.74	.0000E+00	.7621E+05	.3360E+05
112	1.0	1.0	25.0	25.0	7.12	6.74	.0000E+00	.7379E+05	.3359E+05
113	1.0	1.0	25.0	25.0	7.17	6.74	.0000E+00	.7203E+05	.3359E+05
114	1.0	1.0	25.0	25.0	7.07	6.74	.0000E+00	.7044E+05	.3347E+05
115	1.0	1.0	25.0	25.0	7.04	6.74	.0000E+00	.6910E+05	.3374E+05
116	1.0	1.0	25.0	25.0	7.05	6.74	.0000E+00	.6711E+05	.3335E+05
117	1.0	1.0	25.0	25.0	6.98	6.74	.0000E+00	.6609E+05	.3316E+05
118	1.0	1.0	25.0	25.0	6.79	6.74	.0000E+00	.6390E+05	.3329E+05
119	1.0	1.0	25.0	25.0	7.02	6.74	.0000E+00	.6188E+05	.3330E+05
120	1.0	1.0	25.0	25.0	6.90	6.74	.0000E+00	.6067E+05	.3331E+05
121	1.0	1.0	25.0	24.9	6.72	6.74	.0000E+00	.5903E+05	.3296E+05
122	1.0	1.0	25.0	24.9	6.69	6.74	.0000E+00	.5718E+05	.3309E+05
123	1.0	1.0	25.0	24.9	6.80	6.74	.0000E+00	.5580E+05	.3272E+05
124	1.0	1.0	25.0	24.9	6.68	6.74	.0000E+00	.5451E+05	.3292E+05
125	1.0	1.0	25.0	24.9	6.50	6.74	.0000E+00	.5307E+05	.3264E+05
126	1.0	1.0	25.0	24.9	6.52	6.74	.0000E+00	.5195E+05	.3266E+05
127	1.0	1.0	25.0	24.8	6.65	6.74	.0000E+00	.5050E+05	.3242E+05
128	1.0	1.0	25.0	24.8	6.66	6.74	.0000E+00	.4926E+05	.3254E+05
129	1.0	1.0	25.0	24.8	6.38	6.74	.0000E+00	.4793E+05	.3236E+05
130	1.0	1.0	25.0	24.8	6.59	6.74	.0000E+00	.4672E+05	.3201E+05
131	1.0	1.0	25.0	24.7	6.23	6.74	.0000E+00	.4398E+05	.3228E+05
132	1.0	1.0	25.0	24.7	6.55	6.74	.0000E+00	.4258E+05	.3212E+05
133	1.0	1.0	25.0	24.7	6.62	6.74	.0000E+00	.4087E+05	.3201E+05
134	1.0	1.0	25.0	24.6	6.42	6.74	.0000E+00	.3981E+05	.3158E+05
135	1.0	1.0	25.0	24.6	6.47	6.74	.0000E+00	.3871E+05	.3167E+05
136	1.0	1.0	24.0	24.6	6.54	6.74	.0000E+00	.3764E+05	.3140E+05
137	1.0	1.0	25.0	24.5	6.10	6.74	.0000E+00	.3630E+05	.3148E+05
138	1.0	1.0	24.0	24.5	5.90	6.74	.0000E+00	.3543E+05	.3129E+05
139	1.0	1.0	24.0	24.5	5.82	6.74	.0000E+00	.3407E+05	.3109E+05
140	1.0	1.0	24.0	24.4	6.42	6.74	.0000E+00	.3290E+05	.3073E+05
141	1.0	1.0	24.0	24.4	6.22	6.74	.0000E+00	.3154E+05	.3098E+05
142	1.0	1.0	24.0	24.3	5.87	6.74	.0000E+00	.3071E+05	.3059E+05
143	1.0	1.0	24.0	24.3	5.96	6.74	.0000E+00	.2925E+05	.3025E+05
144	1.0	1.0	24.0	24.3	5.85	6.74	.0000E+00	.2838E+05	.3015E+05
145	1.0	1.0	25.0	24.2	5.79	6.74	.0000E+00	.2749E+05	.3009E+05
146	1.0	1.0	24.0	24.2	5.70	6.74	.0000E+00	.2647E+05	.2968E+05
147	1.0	1.0	24.0	24.1	5.45	6.74	.0000E+00	.2578E+05	.2928E+05
148	1.0	1.0	24.0	24.1	5.47	6.74	.0000E+00	.2438E+05	.2933E+05
149	1.0	1.0	24.0	24.0	5.36	6.74	.0000E+00	.2373E+05	.2913E+05
150	1.0	1.0	24.0	24.0	5.31	6.74	.0000E+00	.2269E+05	.2900E+05
151	1.0	1.0	23.0	23.9	5.11	6.74	.0000E+00	.2183E+05	.2875E+05
152	1.0	1.0	24.0	23.8	5.05	6.74	.0000E+00	.2094E+05	.2831E+05
153	1.0	1.0	25.0	23.8	4.85	6.74	.0000E+00	.2014E+05	.2813E+05
154	1.0	1.0	24.0	23.7	4.54	6.74	.0000E+00	.1916E+05	.2766E+05

155	1.0	1.0	24.0	23.7	4.31	6.74	.0000E+00	.1858E+05	.2758E+05
156	1.0	1.0	23.0	23.6	4.39	6.74	.0000E+00	.1742E+05	.2741E+05
157	1.0	1.0	23.0	23.5	3.98	6.74	.0000E+00	.1683E+05	.2697E+05
158	1.0	1.0	23.0	23.5	3.76	6.74	.0000E+00	.1625E+05	.2672E+05
159	1.0	1.0	24.0	23.4	3.50	6.74	.0000E+00	.1533E+05	.2636E+05
160	1.0	1.0	23.0	23.3	3.19	6.74	.0000E+00	.1456E+05	.2611E+05
161	1.0	1.0	23.0	23.3	3.38	6.74	.0000E+00	.1375E+05	.2552E+05
162	1.0	1.0	23.0	23.2	2.97	6.74	.0000E+00	.1300E+05	.2560E+05
163	1.0	1.0	23.0	23.1	2.60	6.74	.0000E+00	.1259E+05	.2490E+05
164	1.0	1.0	23.0	23.1	2.71	6.74	.0000E+00	.1181E+05	.2455E+05
165	1.0	1.0	23.0	23.0	2.40	6.74	.0000E+00	.1098E+05	.2437E+05
166	1.0	1.0	23.0	22.9	1.99	6.74	.0000E+00	.1039E+05	.2361E+05
167	1.0	1.0	22.0	22.8	1.93	6.74	.0000E+00	.9866E+04	.2340E+05
168	1.0	1.0	23.0	22.8	1.84	6.74	.0000E+00	.9365E+04	.2307E+05
169	1.0	1.0	24.0	22.7	1.55	6.74	.0000E+00	.8499E+04	.2268E+05
170	1.0	1.0	22.0	22.6	1.59	6.74	.0000E+00	.7941E+04	.2200E+05
171	1.0	1.0	23.0	22.5	1.44	6.74	.0000E+00	.7342E+04	.2156E+05
172	1.0	1.0	23.0	22.5	1.28	6.74	.0000E+00	.7062E+04	.2109E+05
173	1.0	1.0	22.0	22.4	1.62	6.74	.0000E+00	.6553E+04	.2064E+05
174	1.0	1.0	23.0	22.3	1.61	6.74	.0000E+00	.6014E+04	.2004E+05
175	1.0	1.0	21.0	22.2	1.28	6.74	.0000E+00	.5590E+04	.1954E+05
176	1.0	1.0	23.0	22.1	1.21	6.74	.0000E+00	.5059E+04	.1891E+05
177	1.0	1.0	24.0	22.1	1.08	6.74	.0000E+00	.4568E+04	.1838E+05
178	1.0	1.0	23.0	22.0	1.09	6.74	.0000E+00	.4225E+04	.1794E+05
179	1.0	1.0	22.0	21.9	1.52	6.74	.0000E+00	.3912E+04	.1702E+05
180	1.0	1.0	19.0	21.8	1.33	6.74	.0000E+00	.3487E+04	.1671E+05
181	1.0	1.0	23.0	21.7	1.75	6.74	.0000E+00	.3186E+04	.1580E+05
182	1.0	1.0	21.0	21.7	1.50	6.74	.0000E+00	.2792E+04	.1522E+05
183	1.0	1.0	22.0	21.6	.79	6.74	.0000E+00	.2506E+04	.1474E+05
184	1.0	1.0	20.0	21.5	1.89	6.74	.0000E+00	.2248E+04	.1380E+05
185	1.0	1.0	20.0	21.4	1.92	6.74	.0000E+00	.1965E+04	.1319E+05
186	1.0	1.0	22.0	21.3	2.00	6.74	.0000E+00	.1743E+04	.1231E+05
187	1.0	1.0	21.0	21.2	.83	6.74	.0000E+00	.1498E+04	.1146E+05
188	1.0	1.0	23.0	21.1	1.40	6.74	.0000E+00	.1258E+04	.1075E+05
189	1.0	1.0	20.0	21.1	.84	6.74	.0000E+00	.1106E+04	.1005E+05
190	1.0	1.0	24.0	21.0	1.75	6.74	.0000E+00	.8768E+03	.9123E+04
191	1.0	1.0	20.0	20.9	1.61	6.74	.0000E+00	.7979E+03	.8128E+04
192	1.0	1.0	19.0	20.8	1.17	6.74	.0000E+00	.6525E+03	.7250E+04
193	1.0	1.0	19.0	20.7	.72	6.74	.0000E+00	.5166E+03	.6368E+04
194	1.0	1.0	21.0	20.6	2.75	6.74	.0000E+00	.4112E+03	.5357E+04
195	1.0	1.0	22.0	20.5	1.50	6.74	.0000E+00	.2968E+03	.4230E+04

INPUT POS TO SAVE ON DISC OR NEG TO DELETE SAVE.

APPENDIX VI

LISTING OF THE CODE RMPSNS.FOR USED TO DERIVE THE NEUTRON SPECTRUM
FROM PROTON RECOIL DATA AND CALIBRATION MEASUREMENTS

APPENDIX VI

LISTING OF THE CODE RMPSNS.FOR USED TO DERIVE THE NEUTRON SPECTRUM FROM PROTON RECOIL DATA AND CALIBRATION MEASUREMENTS.

```

$ LARGE
$ NODEBUG
$ NOFLOATCALLS
C RMPSNS.FOR
C VERSION OF PSNS USED WITH THE 8088 COMPAQ AND RAMP VOLTAGE BIASING.
C CONVERT PROTON-RECOIL PULSE HEIGHT SPECTRA TO NEUTRON SPECTRUM.
C
      DIMENSION FLXL(512),ERFL(512),RES(512),RAPS(512),TIME(512),
      XENRGY(512),WHION(512),WHAMP(512),ETR(512),FRLV(512),
      XEGRF(1024),FLGRF(1024)
C
      CHARACTER FNAME*16,FLNAME*72,IDENT*72,JIDENT*72
C
C THE LOG OF ENERGY AT ANY CHANNEL I, ELOG(I), IS RELATED TO I, THE
C CHANNEL NUMBER, IBS, THE CHANNEL SHIFT FROM RMPRDN, AND THE
C CALIBRATION FACTOR, CAL, BY
      ELOG(I) = (FLOAT(I+IBS) -1.0 )/64. + CAL
C WHERE CAL = ALOG((LVL/GMAX)*FSEX/4096).
C ELOG IS THE "IONIZATION" ENERGY, NOT THE "TRUE" ENERGY.
C FSEX IS THE PRODUCT OF THE FULL-SCALE ENERGY AND MULTIPLICATION A.
C FSEX IS FIXED AND MUST BE IDENTICAL FOR ALL A VALUES.
C LVL IS THE ADC Y CHAN BIAS AND MAXG IS THE MAXIMUM GAS GAIN.
C
C THE INTRINSIC RESOLUTION(FWHM) OF THE NEUTRON SPECTRUM IS COMPUTED
C FROM THE ENERGY E AND THE SLOPE TAKING FULL FRACTIONAL WIDTH FW AS
      FWHM(E)=SQRT(FW*FW+0.17/E)
C
      1 FORMAT(37H INPUT FILE NAME FOR THE HEADER DATA. )
      2 FORMAT(6E12.5)
      3 FORMAT(8F8.0)
      4 FORMAT(10F8.1)
      5 FORMAT(///16H RMPSNS OUTPUT. //)
      6 FORMAT(41H INPUT FLUENCE NORMALIZATION FOR THE RUN. )
      7 FORMAT(10F8.0)
      8 FORMAT(//43H INPUT(I5) IGO NEGATIVE TO DELETE DISC SAVE /
      X57H OF THE NEUTRON AND PROTON SPECTRA IN NON-GRAPHER FORMAT. A)
      9 FORMAT(//9H ENERGY,10H FLUX,11H ERROR,10H RESLN. )
      10 FORMAT(I5)
      11 FORMAT(//32H TOTAL POINTS AND STARTING POINT 2I8/
      X17H ADC Y-BIAS LEVEL I8 /
      X19H MAXIMUM GAS GAIN = E12.5/
      X26H THE RUN TIME IN SECONDS = I8 /
      X34H THE CALIBRATION TIME IN SECONDS = I8 //)
      12 FORMAT(40H INPUT A 10 CHAR. HEADER DATA FILE NAME. )
      13 FORMAT(A)
      14 FORMAT(7H MAX= E11.4)
      15 FORMAT(47H INPUT A 10 CHAR. RECOIL-PROTON DATA FILE NAME. )
      16 FORMAT(18H FRST DEC = 1 KEV )
      17 FORMAT(51H INPUT(E12.5) THE REFERENCE CALIBRATION ENERGY ERF. /
      X53H THEN INPUT(D15.8/) THE TOP 5 POLYNOMIAL COEFFICIENTS /
      X60H IN AN M=6 LSQPOL FIT TO THE RATIO OF THE OBSERVED VARIATION /
      X52H OF NEUTRON SPECTRUM (PER LETHARGY) TO THE ERF VALUE /
      X36H AS A FUNCTION OF X=LOG(ENERGY/ERF). //)
      18 FORMAT(2I8)
      19 FORMAT(F10.3,E11.4,E10.3,F6.3)

```

```

20 FORMAT(45H INPUT A 10 CHARACTER FILE NAME FOR THE SAVED /
X24H FINAL NEUTRON SPECTRUM. )
21 FORMAT( ' INPUT THE FILE NAME FOR THE CALIBRATION SPECTRUM ' )
22 FORMAT(/51H LIST ENERGIES AND THEN LIST PROTON SPECTRA(/LETHY)//)
23 FORMAT(4D15.8)
24 FORMAT(10F8.3)
25 FORMAT(8E10.4)
375 FORMAT(53H INPUT POS. TO SAVE A .DAT FILE FOR NEUTRON PLOTTING.)
378 FORMAT(43H INPUT .DAT FILE NAME FOR GRAPHER NEUT SPC. )
381 FORMAT(53H INPUT POS. TO SAVE .DAT FILE OF PROTONS FOR GRAPHER.)
383 FORMAT(53H INPUT A .DAT FILE NAME FOR PROTONS FOR GRAPHER PLOT.)
950 FORMAT(37H INPUT(E12.5) THE ENERGY SCALE FSEX.)
951 FORMAT(45H INPUT(E12.5) THE HYDROGEN ATOM CONTENT HATM.)
952 FORMAT(35H THE LOGGED TEST PULSE COUNTS/SEC = E12.5 /
X28H INPUT(E12.5) CORRECT VALUE. )
953 FORMAT(43H INPUT(E12.5) UPPER ENERGY LIMIT IN OUTPUT. )
C
C INPUT THE SPECTRUM OF PROTON RECOILS RAPS AND THE TEST PULSER
C SPECTRUM TIME TOGETHER WITH OTHER DATA AS PRODUCED BY THE
C ANALYSIS OF THE RAW DATA IN RMPRDN.
165 PAUSE ' PROGRAM BEGINS HERE OR RETURNS AFTER COMPLETION. '
WRITE(*,15)
READ(*,13) FNAME
OPEN(10,FILE=FNAME,FORM='FORMATTED',STATUS='OLD')
READ(10,13) FNAME
READ(10,13) IDENT
WRITE(*,13) FNAME
WRITE(*,13) IDENT
C NPT AND IBS ARE THE TOTAL POINTS AND THE STARTING POINT.
READ(10,18) NSEC
READ(10,10) NPT
READ(10,10) IBS
READ(10,18) LVL
READ(10,2) GMAX
READ(10,2) (RAPS(I),I=1,NPT)
READ(10,7) (TIME(I),I=1,NPT)
CLOSE(10)
C
C READ THE CALIBRATION SPECTRA. THESE INCLUDE BOTH 'WHITE IONIZATION'
C WHION, AND 'WHITE AMPLITUDE' WHAMP AS DERIVED FROM THE SPECIAL
C TEST PULSE CALIBRATION RUN OPTION IN RAMPDA.
WRITE(*,21)
READ(*,13) FLNAME
OPEN(10,FILE=FLNAME,FORM='FORMATTED',STATUS='OLD')
READ(10,13) FLNAME
READ(10,13) JDENT
WRITE(*,13) FLNAME
WRITE(*,13) JDENT
READ(10,18) KSEC
READ(10,2) CPS
READ(10,18) NNII
READ(10,2) GGGG
READ(10,2) (WHION(I),I=1,512)
READ(10,3) (WHAMP(I),I=1,512)
CLOSE(10)

```

```

        WRITE(*,11) NPT,IBS,LVL,GMAX,NSEC,KSEC
C
C RE-ENTER CPS. VALUE FROM CALIBRATION MAY BE INCORRECT IF RAMP
C RANGE LIMITS EXCEED TABLE LIMITS.
        WRITE(*,952) CPS
        READ(*,2) CPS
C
C INPUT DATA WHICH INCLUDES THE FOLLOWING:
C 1) A VALUE FOR THE PRODUCT OF FULL-SCALE ENERGY AND
C    GAS MULTIPLICATION, FSEXA. FSEXA IS A CONSTANT FOR ALL A.
C    FROM IT, THE QUANTITY CAL IS DERIVED TO ALLOW CONVERSION OF THE
C    LOG CHANNEL SCALE APPROPRIATE TO THE RAW DATA TO LOG ENERGY.
C    USING FSEXA, CAN FORM THE "IONIZATION" ENERGY MESH, ENRGY(I).
C 2) HATM, WHICH IS THE HYDROGEN ATOM CONTENT OF THE COUNTER IN
C    UNITS OF 10**24 ATOMS.
C
        WRITE(*,950)
        READ(*,2) FSEXA
        WRITE(*,951)
        READ(*,2) HATM
        CAL = ALOG((FLOAT(LVL)/GMAX)*FSEXA/4096.)
C ASSUME A W CUTOFF, WCTOFF, OF .3 KEV FOR GAS.
        WCTOFF=.3
        DO705 I=1,NPT
705 ENRGY(I)=EXP(ELONG(I))+WCTOFF
C
        PAUSE ' PLOT RAPS '
        CALL PLARRAY(ENRGY,RAPS,NPT)
        PAUSE ' PLOT TIME '
        CALL PLARRAY(ENRGY,TIME,NPT)
C
C SHIFT THE CALIBRATION SPECTRUM TO CONFORM WITH IBS AS THE INITIAL
C POINT AND NPT AS THE POINT COUNT; SAME AS FOR THE DATA SPECTRUM.
C EDIT THE DATA USING PLOT ROUTINE.
        DO300 I=1,NPT
        II=I+IBS-1
        WHION(I)=WHION(II)
300 WHAMP(I)=WHAMP(II)
        PAUSE ' PLOT WHAMP '
        CALL PLARRAY(ENRGY,WHAMP,NPT)
C
C WEIGHT WHION USING AN ARBITRARY ENERGY-DEPENDENT TERM TO
C REDUCE DEPENDENCE UPON CHANNEL NUMBER I. THEN PLOT.
        DO288 I=1,NPT
        II=I+IBS-1
        AMUL=EXP(FLOAT(II)/64.)
288 WHION(I)=WHION(I)/AMUL
        PAUSE ' PLOT CHANNEL-WEIGHTED WHION '
        CALL PLARRAY(ENRGY,WHION,NPT)
C
C SMOOTH THE TIME SPECTRUM AND PLOT.
        CALL SMOOTH(TIME,NPT)
        PAUSE ' PLOT THE SMOOTHED TIME SPECTRUM '
        CALL PLARRAY(ENRGY,TIME,NPT)
C

```

```

C  NORMALIZE THE PROTON SPECTRUM TO SMOOTHED TIME SPECTRUM.
C  THEN PLOT THE TIME NORMALIZED PROTON SPECTRUM.
    DO286 I=1,NPT
1286 RAPS(I)=RAPS(I)/TIME(I)
    PAUSE ' PLOT THE TIME NORMALIZED PROTON SPECTRUM '
    CALL PLARRAY(ENRGY,RAPS,NPT)
C
C  FORM THE CALIBRATION RATIO WHION/WHAMP AND DENOTE BY FRLV.
C  SMOOTH AND PLOT.
    DO179 I=1,NPT
1179 FRLV(I)=WHION(I)/WHAMP(I)
    CALL SMOOTH(FRLV,NPT)
    PAUSE ' PLOT SMOOTHED CALIBRATION RATIO '
    CALL PLARRAY(ENRGY,FRLV,NPT)
C
C  FORM THE CALIBRATION-CORRECTED ABSOLUTE PROTON SPECTRUM PER UNIT
C  ENERGY. USE THE TEST PULSER COUNTS/SEC CPS TO SCALE FLUX TO AN
C  ABSOLUTE VALUE. ALSO REQUIRE ENERGY, FSE, CORRESPONDING TO ACTIVE
C  COUNTING REGION, WHICH IS 4096-LVL RATHER THAN FULL 4096.
    FSE=FSEXA*FLOAT(4096-LVL)/4096.
    DO189 I=1,NPT
1189 RAPS(I)=CPS*RAPS(I)/(FSE*FRLV(I))
    PAUSE ' PLOT NORMALIZED RAPS SPECTRUM WITH CHANNEL WEIGHTING '
    CALL PLARRAY(ENRGY,RAPS,NPT)
C  REMOVE WEIGHTING TO PRODUCE ABSOLUTE RAPS FOR SLOPE TAKING.
    DO186 I=1,NPT
    II=I+IBS-1
    AMUL=EXP(FLOAT(II)/64.)
    FRLV(I)=FRLV(I)*AMUL
1186 RAPS(I)=RAPS(I)/AMUL
C
C  DETERMINE SLOPES AND ERRORS OVER ABOUT 10% FWHM.
C  ANY OTHER FWHM COULD BE SPECIFIED IF NOT MORE THAN A FEW TIMES
C  THE INTRINSIC RESOLUTION OF THE COUNTER.
-----
C  LET FW BE THE FRACTIONAL LOG ENERGY INTERVAL FOR SLOPE TAKING.
    FW=.10
C  NSTHW IS THE SLOPE TAKING HALF WIDTH (CHANNELS) DERIVED FROM FW.
    NSTHW=IFIX(FW*64./2.)
    J=NSTHW
97  EDIT=ENRGY(J)
    IF(J-NSTHW)93,93,92
93  N1=1
    N2=2*NSTHW-1
    GO TO 89
92  IF(J-NPT+NSTHW-1)87,96,89
96  N1=NPT-(NSTHW+1)
    N2=NPT
    GO TO 88
87  N1=J-NSTHW
    N2=J+NSTHW
C  N1 AND N2 ARE THE LOWER AND UPPER SLOPE-TAKING CHANNEL VALUES.
88  L=N1
    T1=0.0
    T2=0.0

```

```

      T3=0.0
      T4=0.0
      T5=0.0
99  TCHEN=FLOAT(L)
      T1=T1 + TCHEN*RAPS(L)
      T2=T2 + TCHEN
      T3=T3 + RAPS(L)
      T4=T4 + TCHEN*TCHEN
      T5=T5 + RAPS(L)*TCHEN*TCHEN
      L=L + 1
      IF(N2-L)98,99,99
98  T2SQ=T2*T2
      V=FLOAT(N2-N1+1)
      SLOPE=(T1*V - T2*T3)/(T4*V - T2SQ)
      ERSI=SQRT((T5 *V*V+T3 *T2SQ-2.*T1 *T2*V)/(TIME(J)*FRLV(J)*FSE
      X/CPS))/(T4*V-T2SQ)
C   USING THE ESTABLISHED ENERGY SCALE TOGETHER WITH NORMALIZATION
C   FACTORS, CONVERT SLOPE TO NEUTRON FLUX SPECTRUM PER LETHARGY.
C   SIGE IS THE NEUTRON-PROTON SCATTERING CROSS SECTION.
      T1=-1.86+EDIT*(9.415E-5)+EDIT*EDIT*(1.306E-10)
      T2=0.4223+EDIT*(1.30E-4)
      SIGE=9.4248/(EDIT*(1.206E-3)+T1*T1)+
      X 3.1416/(EDIT*(1.206E-3)+T2*T2)
C   64 IS THE CONVERSION BETWEEN dN AND dLETHARGY.
      TEMP=EDIT*64./(HATM*SIGE)
      RES(J)=FWHM(EDIT)
      FLXL(J)=-TEMP*SLOPE
      ERFL(J)=TEMP*ERSI
      J=J+1
      GO TO 97

C-----
C   LET ETR CONTAIN THE ENERGIES APPROPRIATE TO RAPS.
C   NORMALIZE RAPS TO THE TOTAL H-ATOM NUMBER IN COUNTER AND /LETHY.
89  DO730 I=1,NPT
      RAPS(I)=RAPS(I)*ENRGY(I)/HATM
      ETR(I)=ENRGY(I)
730  CONTINUE
      KPTS=NPT

C
C   AVERAGE THE FLUXES OVER 3 ADJACENT POINTS.
C   REPORT FINAL DATA AT A SPACING OF 3 POINTS (ABOUT .05 LETHARGY).
      I=5
      K=1
84  IMIN=I-1
      IMAX=I+1
      IF(IMAX-NPT)85,85,86
85  DMM=0.0
      DO70 J=IMIN,IMAX
70  DMM=DMM+FLXL(J)
      FLXL(K)=DMM/3.
      ENRGY(K)=ENRGY(I)
      ERFL(K)=ERFL(I)
      RES(K)=RES(I)
      I=I+3
      K=K+1

```

```

      GO TO 84
      96 NPT=K-3
C -----
C  DELETE ALL DATA ABOVE AN INPUT LIMIT UPE.
      WRITE(*,953)
      READ(*,2) UPE
      DO715 I=1,NPT
      IF(ENRGY(I)-UPE)715,715,716
715  CONTINUE
      NPT=I
      GO TO 717
716  NPT=I-1
C
C  GET MAXIMUM VALUE OF NEUTRON SPECTRUM.
717  YMAX=0.0
      DO710 I=1,NPT
      IF(FLXL(I)+ERFL(I)-YMAX)710,710,711
711  YMAX=FLXL(I)+ERFL(I)
710  CONTINUE
C  PLOT THE NEUTRON SPECTRUM AND THE STATISTICAL ERROR.
      NABS=720
      NORD=348
      CALL PLTINIT
      NDEK=4
      CALL LINLOGAX(NABS,NORD,NDEK)
      I=1
712  DEL=ERFL(I)/YMAX
      Y=FLXL(I)/YMAX
      EE=ALOG10(ENRGY(I))/FLOAT(NDEK)
      IF(EE)731,731,713
713  LYY=IFIX(Y*FLOAT(NORD))
      IF(LYY)731,731,704
704  LXX=IFIX(EE*FLOAT(NABS))
      IDEL=IFIX(DEL*FLOAT(NORD))
      LLL=2*IDEL
      CALL SPLT(LXX,LYY-IDEL,1,LLL)
      CALL SPLT(LXX-3,LYY-IDEL,-1,6)
      CALL SPLT(LXX-3,LYY+IDEL,-1,6)
731  I=I+1
      IF(I-NPT)712,712,729
729  CALL PLTOUT
C
C  NORMALIZE NEUTRON SPECTRA AND PROTON RECOIL SPECTRA TO AN
C  APPROPRIATE VALUE OF FLUENCE MONITOR FOR THE RUN BEFORE
C  FINAL EDITING AND DISK SAVE.
      WRITE(*,6)
      READ(*,2) FLNRM
      DO740 I=1,NPT
      FLXL(I)=FLXL(I)/FLNRM
740  ERFL(I)=ERFL(I)/FLNRM
      DO741 I=1,KPTS
741  RAPS(I)=RAPS(I)/FLNRM
C
      PAUSE ' PRINTER IF WANT TO SAVE OUTPUT.
      WRITE(*,5)

```



```

        WRITE(*,13) FNAME
        WRITE(*,13) IDENT
        WRITE(*,9)
        DO723 I=1,NPT
723  WRITE(*,19) ENRGY(I),FLXL(I),ERFL(I),RES(I)
        WRITE(*,22)
        WRITE(*,25) (ETR(I),I=1,KPTS)
        WRITE(*,25) (RAPS(I),I=1,KPTS)
C
C  SAVE DATA ON DISC OR DELETE SAVE IF IGO NEG.
        WRITE(*,8)
        READ(*,10) IGO
        IF(IGO)380,718,718
718  WRITE(*,20)
        READ(*,13) FNAME
        OPEN(10,FILE=FNAME,STATUS='NEW')
        WRITE(10,13) FNAME
        WRITE(10,13) IDENT
        WRITE(10,10) NPT
        DO724 I=1,NPT
724  WRITE(10,19) ENRGY(I),FLXL(I),ERFL(I),RES(I)
        WRITE(10,10) KPTS
        WRITE(10,25) (ETR(I),I=1,KPTS)
        WRITE(10,25) (RAPS(I),I=1,KPTS)
        CLOSE(10)
C
C  OPTION TO SAVE A .DAT DISK FILE FOR GRAPHER PLOTTING OF THE
C  NEUTRON SPECTRUM WITH ERRORS
380  WRITE(*,375)
        READ(*,10) IGO
        IF(IGO)166,166,376
376  K2PT=2*NPT
        DO377 I=1,NPT
            J=2*I
            EGRF(J)=ENRGY(I)
            FLGRF(J)=FLXL(I)-ERFL(I)
            EGRF(J-1)=ENRGY(I)
            FLGRF(J-1)=FLXL(I)+ERFL(I)
            RES(J)=FLXL(I)
            RES(J-1)=FLXL(I)
377  CONTINUE
        WRITE(*,378)
        READ(*,13) FNAME
        OPEN(10,FILE=FNAME,STATUS='NEW')
        DO379 I=1,K2PT
379  WRITE(10,2) EGRF(I),FLGRF(I),RES(I)
        CLOSE(10)
C
C  OPTION TO SAVE THE FINAL PROTON SPECTRUM FOR GRAPHER PLOTTING.
166  WRITE(*,381)
        READ(*,10) IGO
        IF(IGO)165,165,382
382  WRITE(*,383)
        READ(*,13) FNAME
        OPEN(10,FILE=FNAME,STATUS='NEW')

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```

      DO384 I=1,KPTS
384  WRITE(10,2) STR(I),RAPS(I)
      CLOSE(10)

      GO TO 165
      END

C
C  THE ROUTINE SMOOTH(ASMTH,NPT) PRODUCES THE SMOOTHED ARRAY ASMTH
C  FROM THE INPUT ARRAY. ARRAY CONTAINS NPT POINTS.
C
      SUBROUTINE SMOOTH(ASMTH,NPT)
      DIMENSION ASMTH(512),RES(512)

C
C  SMOOTH THE ARRAY ASMTH TWICE OVER 5 ADJACENT POINTS.
      KKK=-2
184  DO179 I=1,NPT
179  RES(I)=ASMTH(I)
      ASMTH(1)=RES(1)
      ASMTH(2)=(RES(1)+RES(2)+RES(3))/3.
      ASMTH(NPT)=RES(NPT)
      ASMTH(NPT-1)=(RES(NPT)+RES(NPT-1)+RES(NPT-2))/3.
      I=3
173  IMIN=I-2
      IMAX=I+2
      IF(IMAX-NPT)170,170,180
170  DMM=0.0
      DO172 J=IMIN,IMAX
172  DMM=DMM+RES(J)
      ASMTH(I)=DMM/5.
      I=I+1
      GO TO 173
180  KKK=KKK+1
      IF(KKK)184,183,183
183  RETURN
      END

C
C  SUBROUTINE PLARRAY SCALES AND PLOTS THE ARRAY TEMP.
C  OPTION TO SAVE THE SPECTRUM FOR PLOTTING WITH GRAPHER.
C
      SUBROUTINE PLARRAY(ENRGY,TEMP,NPT)

C
      DIMENSION TEMP(512),ENRGY(512)
      CHARACTER FNAME*16
      1 FORMAT(27H INPUT (F8.1) ENERGY MARKER )
      2 FORMAT(F8.1)
      3 FORMAT(32H INPUT NEGATIVE TO SAVE ON DISC. )
      4 FORMAT(I3)
      5 FORMAT(36H INPUT FILE NAME FOR SAVED SPECTRUM. )
      6 FORMAT(A)
      7 FORMAT(2E12.5)

C  NABS AND NORD ARE X AND Y POINTS AVAILABLE FOR PLOTTING.
      NABS=720
      NORD=348

C  GET MAXIMUM VALUE OF SPECTRUM FOR PLOT NORMALIZATION.
      PMAX=0.0

```

```

      DO30 I=1,NPT
      IF(TEMP(I)-PMAX)30,30,31
31 PMAX=TEMP(I)
30 CONTINUE
C INITIALIZE TO PLOT THE CONTENTS OF THE TEMP ARRAY.
  EBOT=ENRGY(1)
  ETOP=ENRGY(NPT)
33 WRITE(*,1)
  READ(*,2) ENGY
  IF(ENGY)34,34,35
35 IF(ENGY-EBOT)33,36,36
36 IF(ENGY-ETOP)37,37,33
37 CALL PLTINIT
  NDEK=2
  CALL LINLOGAX(NABS,NORD,NDEK)
C PLOT THE TIME NORMALIZED PROTON SPECTRA.
  I=1
32 Y=IFIX(.95*TEMP(I)*FLOAT(NORD)/PMAX)
  LXX=IFIX(FLOAT(I)*FLOAT(NABS)/FLOAT(NPT))
  CALL SPLT(LXX,LYY,1,1)
  I=I+1
  IF(I-NPT)32,32,20
20 LXX=IFIX(FLOAT(NABS)*ALOG(ENGY/EBOT)/ALOG(ETOP/EBOT))
  CALL SPLT(LXX,0,1,NORD)
  CALL PLTOUT
  GO TO 33
34 WRITE(*,3)
  READ(*,4) IGO
  IF(IGO)41,40,40
41 WRITE(*,5)
  READ(*,6) FNAME
  OPEN(10,FILE=FNAME,STATUS='NEW')
  DO42 I=1,NPT
42 WRITE(10,7) ENRGY(I),TEMP(I)
  CLOSE(10)
40 RETURN
  END
C
C ROUTINE LINLOGAX(NABS,NORD) DRAWS A VERTICAL MARKER AND A
C HORIZONTAL LOGARITHMIC MARKER OVER NDEK DECADES.
C
  SUBROUTINE LINLOGAX(NABS,NORD,NDEK)
C
C FIRST DRAW VERTICAL TICKS.
  CALL SPLT(0,0,1,NORD)
  IDEL=NORD/10
  LENGTH=NABS/40
  IY=IDEL-1
  I=1
  1 CALL SPLT(0,IY,-1,LENGTH)
  IY=IY+IDEL
  I=I+1
  IF(I-10)1,1,10
C THEN DRAW HORIZONTAL LOGARITHMIC TICKS.
10 CALL SPLT(0,0,-1,NABS)

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```

      IDEL=NABS/NDEK
      SCL=FLOAT(IDEL)
      LNGTH=NORD/25
      IX=IDEL-1
      I=1
2  CALL SPLT(IX,0,1,LNGTH)
      IX=IX+IDEL
      I=I+1
      IF(I-NDEK)2,2,9
9  IX=IFIX(SCL*ALOG(2.)/ALOG(10.))-1.)
      LNGTH=LNGTH/2
      I=1
3  CALL SPLT(IX,0,1,LNGTH)
      IX=IX+IDEL
      I=I+1
      IF(I-NDEK)3,3,8
8  IX=IFIX(SCL*ALOG(4.)/ALOG(10.))-1.)
      I=1
4  CALL SPLT(IX,0,1,LNGTH)
      IX=IX+IDEL
      I=I+1
      IF(I-NDEK)4,4,7
7  IX=IFIX(SCL*ALOG(8.)/ALOG(10.))-1.)
      I=1
5  CALL SPLT(IX,0,1,LNGTH)
      IX=IX+IDEL
      I=I+1
      IF(I-NDEK)5,5,6
6  RETURN
      END

C
C  SUBROUTINE SPLT(IX,IY,IHV,LNGTH) PLOTS ON THE SCREEN A
C  VERTICAL(IHV POSITIVE) LINE OR A HORIZONTAL(IHV NEGATIVE) LINE
C  OF LENGTH LNGTH STARTING AT IX AND IY.
C
      SUBROUTINE SPLT(IX,IY,IHV,LNGTH)
C
      IF(IHV)1,2,2
1  NX=IX+LNGTH
      CALL QLINE(IX,IY,NX,IY,1)
      RETURN
2  NY=IY+LNGTH
      CALL QLINE(IX,IY,IX,NY,1)
      RETURN
      END

C
C  FUNCTION PLTINIT INITIALIZES PLOTTING ROUTINES.
C
      SUBROUTINE PLTINIT
C
      CALL QSMODE(6)
      RETURN
      END

C
C  FUNCTION PLTOUT RETURNS FROM PLOTTING ROUTINES.

```

```
C  
SUBROUTINE PLTOUT  
C  
CHARACTER*1 CHAR  
CALL QINPUT(CHAR,0)  
CALL QSMODE(2)  
RETURN  
END
```

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