AERONOMY REPORT
NO. 55

ANALYSIS OF PARTIAL-REFLECTION DATA FROM THE SOLAR ECLIPSE OF JULY 10, 1972

by
T. A. Bean
S. A. Bowhill

October 1, 1973

Supported by
National Aeronautics and Space Administration
Grant NGR 14-005-181

Aeronomy Laboratory
Department of Electrical Engineering
University of Illinois
Urbana, Illinois
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ABSTRACT

Partial-reflection data collected for the eclipse of July 10, 1972 as well as for July 9 and 11, 1972, are analyzed to determine eclipse effects on D-region electron densities. The partial-reflection experiment was set up to collect data using an on-line PDP-15 computer and DECTape storage. Except for a couple of changes, the experiment was the same setup as used by Birley and Sechrist [1971]. The electron-density profiles show good agreement with results from other eclipses. The partial-reflection programs were changed after the eclipse data collection to improve the operation of the partial-reflection system. These changes were mainly due to expanded computer hardware and have simplified the operations of the system considerably.
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1. INTRODUCTION

A solar eclipse can be thought of as the obscuration of solar radiation by the intervention of the moon between the sun and a point on the earth. This obscuring of the sun is a function of time which varies with the location on the earth, altitude, and the type of radiation. Depending on the wavelength of solar radiation and the ionospheric constituents, solar radiation can cause three chemical processes known as dissociation, ionization and excitation [Whitten and Poppoff, 1971]. The variation in solar radiation with time during a solar eclipse is given as an obscuration function and varies according to the different wavelengths of radiation. The obscuration function for visible light is easily calculated, being just that for the visible disk. Figure 1.1 shows this obscuration function for the eclipse of July 10, 1972 at 75 km altitude above the University of Illinois Aeronomy Field Station located near Urbana. At this location the eclipse was partial, with about 60% maximum obscuration. The obscuration functions for various other radiations during a total eclipse are shown in Figure 1.2 [Sears, 1972]. Notice the large difference between the obscuration functions for ultraviolet radiation and X-rays.

Solar radiation with wavelengths less than 2900Å causes various chemical reactions in the ionosphere [Whitten and Poppoff, 1971] with the most pronounced effects occurring in the D-region (50 to 90 km). For example, Turco and Sechrist [1970] show two orders of magnitude change in the electron density and more than three orders of magnitude change in CO₃⁻ and CO₄⁻ at 75 km during sunrise. Certain solar radiations greatly enhance the concentration of positive ions as well as the electron density so that during the daytime, except for during enhanced particle precipitation [Lauter and Knuth, 1967], the main ionization source above 70 km
Figure 1.1 The obscuration function of visible light at a height of 75 km for the eclipse of July 10, 1972, near Urbana, Illinois.
Figure 1.2 Obscuration functions for visible light (V), Lyman alpha (L\_\alpha), ultraviolet (UV), and X-ray (X) ionizing fluxes for the 1966 solar eclipse from Sears [1972].
is solar radiation as given in Section 2.1. Therefore by correlating the electron densities with the obscuration function for the ionizing radiation in a solar eclipse, values for the production and loss of positive ions and confirmation of the ionizing sources can be obtained.

Data from the D region have been obtained by both rocket measurements and ground-based techniques. Although rocket measurements seem to be more accurate [Mechtly, et al., 1967], the amount of data is limited by cost. Ground-based techniques can be set up anywhere and can gather large amounts of data, although the accuracy is not as great, and they are primarily limited to evaluating electron densities. One type of ground-based technique which is discussed in this paper is called the partial-reflection experiment. Data are collected using vertical incident radio waves which are partially reflected from the D region. The information obtained can be in one of two forms: differential absorption [Pirnat and Bowhill, 1968] and differential phase [Wiersma and Sechrist, 1972]. Partial-reflection data using the differential absorption method were collected from 1200 to 1700 CST for the solar eclipse of July 10, 1972, as well as July 9 and 11 as control days. The experiment was set up as described by Birley and Sechrist [1971] with two exceptions as described in Chapter 3. The solar and ionospheric conditions for this experiment are given in Chapter 2.
2. PRODUCTION AND LOSS OF THE D-REGION IONIZATION

Recently several papers have summarized the knowledge of the D region of the ionosphere. Thomas [1971] presents an overall review of the D region while theoretical models of the D region are presented by Sechrist [1972], Ferguson [1971], Donahue [1972], and Radicella and Stowe [1970]. The D region is perhaps the most complicated part of the ionosphere as well as the most difficult part from which to obtain accurate data. The chemical composition is dependent on height and solar zenith angle [Thomas, 1971]; although it consists of neutral constituents, positive ions, negative ions, and free electrons, this chapter is mainly concerned with the processes of formation and loss of free electrons during the daytime (solar zenith angles less than 90°) and during a solar eclipse. Using results obtained from measurements on other eclipses, the expected results from the partial-reflection experiment are given.

2.1 Ionization Sources

Although there is general agreement on what ionizes the neutral D-region constituents, there is some doubt as to the relative importance of each source. The ionization sources for the daytime D region at midlatitudes, as given by Mitra and Rowe [1972] and by Aikin [1972] are:

1) Lyman-α (1216Å) ionizing nitric oxide (NO)
2) 1-8Å X-rays ionizing all constituents
3) 1027-1118Å ultraviolet radiation ionizing metastable $\text{O}_2(\Delta_g)$
4) Galactic cosmic rays ionizing all constituents.

Along with these sources precipitating electrons may be considered another source of free electrons, but is of prime importance only in the polar regions, at night, or after a magnetic storm [Lauter and Knuth, 1967] and will not be considered in this paper.
The primary ionization source below 70 km is considered to be galactic cosmic rays [Sechrist, 1972], although its effect may extend as high as 75 km [Keneshea, 1967]. The primary ionization source above 70 km is either (1) or (3) depending upon the nitric oxide distribution adopted. Few measurements of nitric oxide have been made, so most distributions available are from theoretical models. Distributions measured by Barth [1966] and Pearce [1969] are at least an order of magnitude greater than distributions calculated from theoretical models of the ionosphere [Mitra, 1966], but distributions measured by Meira [1971] below 85 km are about the same as those calculated by Shimazaki and Laird [1970].

Using distribution by Barth [1966] for NO, the primary ionization source between 70 and 80 km is Lyman-α ionizing NO, but using nitric oxide distributions given by Shimazaki and Laird [1972] and photoionization rates for O₂(1Δg) given by Hunten and McElroy [1968], the main ionization source between 70 and 80 km is 1027-1118 Å UV radiation ionizing O₂(1Δg) [Thomas, 1971]. Somoyajulu and Avadbanulu [1972] pointed out that according to measurements by Huffman, et al. [1971], photoionization of O₂(1Δg) is important only above 80 km making Lyman-α the main ionization source. Figure 2.1 from Sechrist [1972] shows ion-pair production rates for various radiation during solar minimum.

In any case the distribution of NO is important to the rate of production of free electrons between 70 and 80 km, and the distribution by Meira [1971] is used in this paper.

The variation of ionization sources (1) and (3) with respect to solar activity is small [Thomas, [1971], but 2-8 Å X-ray flux can change by several orders of magnitude. Typical X-ray fluxes for different solar activity as given by Aikin [1972] are less than 4 x 10⁻³ ergs cm⁻² sec⁻¹ for a quiet sun, between 4 x 10⁻⁴ and 4 x 10⁻³ ergs cm⁻² sec⁻¹ for moderate sun, and greater than 4 x 10⁻³ ergs cm⁻² sec⁻¹ for an active sun. A solar flare on July 11 at
Figure 2.1 Ion-pair production rates from various D-region ionization sources as given by Sechrist [1972].
8:10 AM CST produced a 2-8 Å X-ray flux of $1.5 \times 10^{-2}$ ergs cm$^{-2}$ sec$^{-1}$. With an active sun or a solar flare 2-8 Å X-ray ionization can become the primary source of ionization. The 2-8 Å flux for July 9, 10, 11 in Figure 2.2 from the Solar Geophysical Data, 1973 (U. S. Department of Commerce) shows the solar activity to be quiet to moderate. The X-ray flux is expected to have little or no correlation with the electron density of the upper D region except for the X-ray burst near 1435 on July 11.

2.2 Formation of Ions in the D Region

The electron density between 70 and 85 km is dependent on the formation of positive ions. The three main ionization reactions for this region are:

A) $O_2 + h\nu \rightarrow O_2^+ + e$

B) $NO + h\nu \rightarrow NO^+ + e$

C) $N_2 + h\nu \rightarrow N_2^+ + e$

as seen in Figure 2.3 adapted from Mitra and Rowe [1972] and Donahue [1972], which is a block diagram of the positive-ion chemistry at 75 km. The main loss process for $N_2^+$ is by the charge-exchange reaction:

D) $N_2^+ + O_2 \rightarrow N_2 + O_2$.

This reaction is very fast ($1 \times 10^{-10}$ cm$^3$ sec$^{-1}$) [Fehsenfeld, et al., 1965]. Therefore concentrations of $N_2^+$ are small and the production of $O_2^+$ is either by photoionization or by charge transfer. Electron production, therefore can be determined by the production of $NO^+$ and $O_2^+$ minus the formation of $NO^+$ by charge exchange reactions shown in Figure 2.3. Since the production of $NO^+$ is dependent on NO distributions, the production rate of the free electrons also depends on the NO distribution which can differ by at least an order of magnitude (Section 2.1).

The main positive ions between 70 and 80 km are hydrated ions of the form $H^+(H_2O)_n^+$, $n$ being some number greater than zero [Narcisi and Bailey, 1965].
Figure 2.2 Average variations in 2-8 Å X-ray flux during which partial-reflection data were collected on July 9, 10, and 11, 1972.
Figure 2.3 Flow diagram of the formation of positive ions including conversion rates [Donahue, 1972]. Three-body rate constants are in units of $10^{-28} \text{ cm}^6 \text{ sec}^{-1}$; two-body rate constants are in units of $10^{-9} \text{ cm}^3 \text{ sec}^{-1}$. Rate constants not given by Donahue are from Good, et al. [1970].
Two basic reaction schemes for the formation of water cluster ions as presented by Fehsenfeld and Ferguson [1969] are from NO$^+$ and beginning with the reaction 

$$O_2^+ + O_2 + M + O_4^+ + M$$

where $M$ is a third body. Both schemes are given in Figure 2.3. Each scheme raised several questions which are dealt with by Donahue [1972]. According to Figure 2.3, NO$^+$ creates hydrates with masses of 55 and higher, yet 19$^+$ and 37$^+$ are the dominant hydrates detected. Also the first three reactions with NO$^+$ are too slow relative to the loss rate. Problems with the O$_2^+$ scheme are: it seems to ignore the large NO$^+$ concentration and the ionization of O$_2$(^1A_g) seems to be an overestimation according to Huffman, et al. [1971], but this may be the main source of water clusters between 77 and 85 km [Donahue, 1972]. Even with the large number of hydrated ions, the rapid recombination rate competes with the formation of hydrated ions [Thomas, 1971]. This recombination represents the main loss process for free electrons between 70 and 80 km.

The formation of negative ions would constitute a loss of free electrons by the attachment reaction:

$$E) \quad e + O_2 + O_2 \rightarrow O_2^- + O_2.$$

Figure 2.4 by Thomas [1971], giving a scheme for the daytime negative electrons at 65 km, shows reaction (E) to be fast, but the loss reactions

$$F) \quad O_2^- + O \rightarrow O_3 + e$$

$$G) \quad O_2^- + O_2(^1A_g) \rightarrow 2 O_2 + e$$

are much faster. Although the formation of O$_4^-$ is rapid, there is rapid return to O$_2^-$. The negative ion chemistry is dependent on atomic oxygen and O$_2$(^1A_g) concentrations. At night these concentrations decrease so that reaction (E) constitutes an important loss process for free electrons.

At eclipse totality free electron production is reduced to that comparable of nighttime electron production, and the production of atomic oxygen and metastable O$_2$(^1A_g) are also greatly reduced [Shimasaki and Laird, 1972]. By
Figure 2.4 Block diagram [Thomas, 1971] showing the negative ion chemistry during the day. The lifetimes of electrons and each ion are for a height of 65 km.
comparison of eclipse data, Mechty, et al. [1972] shows the possibility of attachment reactions as being the main loss process at totality. This would mean a large reduction in \( \text{O} \) and \( \text{O}_2(\Delta_g) \), but the reduction measured by Hunt [1965] during an eclipse shows less than an order of magnitude change in atomic oxygen. More measurements of atomic oxygen are needed during eclipses to determine more accurately the loss process for free electrons during totality of a solar eclipse.

2.3 Recombination

Above 70 km during the daytime, negative-ion chemistry is not important; so the main loss process of free electrons above 70 km is by recombination with positive ions. The continuity equation for electrons as given by Whitten and Popoff [1971] is:

\[
\frac{d[e]}{dt} = \frac{q}{1 + \lambda} - (\alpha_D + \lambda \alpha_i)[e]^2 - \frac{[e]}{1 + \lambda} \frac{d\lambda}{dt}
\]  

(2.1)

where \([e]\) is the electron density, \(\lambda\) is the ratio of negative ion concentrations to electron densities, \(q\) is the ionization rate, \(\alpha_D\) is the ion-electron recombination coefficient, and \(\alpha_i\) is the ion-ion recombination coefficient.

With the assumption that variation in \(\lambda\) is insignificant, then \(d\lambda/dt = 0\) and defining an effective recombination coefficient as \(\alpha_{\text{eff}} = \alpha_D + \lambda \alpha_i\), Equation (2.1) reduced to:

\[
\frac{d[e]}{dt} = \frac{q}{1 + \lambda} - \alpha_{\text{eff}}[e]^2
\]  

(2.2)

During a solar eclipse at totality, the electron production decreases by several orders of magnitude. Using an ionization rate of zero \((q = 0)\), \(\alpha_{\text{eff}}\) can be obtained from Equation (2.3) for short intervals of time.
\[ \alpha_{\text{eff}} = \frac{\Delta[e]}{\Delta t} [e]^2 \]  

(2.3)

With small changes in the electron density \( \alpha_{\text{eff}} \) can be obtained by the approximation [Mitra and Rowe, 1972]

\[ \alpha_{\text{eff}} = q/[e]^2 (1 + \lambda) \]  

(2.4)

Below 70 km the problem is complicated by the presence of negative ions [Mitra and Rowe, 1972] for which a time dependent analysis of the negative reaction scheme has to be used [Thomas, 1971]. As discussed in Section 2.2, there is the possibility of loss by attachment. Many problems about the loss process still remain unsolved including the question of the NO distribution.

### 2.4 Expected Results

Figure 1.2 by Sears [1972] gives the obscuration function for different D-region solar ionization sources from the eclipse of 1966. Lyman-\( \alpha \) and visible light have the same obscuration function but not so with UV and X-rays. The obscuration function for visible light at Urbana, Illinois for July 10, 1972 (Figure 1.1) is therefore expected to be different from the obscuration function for ultraviolet radiation and X-rays. Using the maps of the sun given in Solar-Geophysical Data, 1972 (U.S. Department of Commerce) and the moon's movement across the sun's disk, an idea of the obscuration function for different solar radiations can be obtained. Since the solar activity during the eclipse was quiet to moderate, the predominate ionization source between 70 and 80 km is expected to be Lyman-\( \alpha \).

The total obscuration is about 60\%, therefore data is used from previous eclipses with a similar obscuration and about the same solar zenith angle. The
solar zenith angle is shown in Figure 2.5 to be about 37°. Figure 2.6 by Deeks [1966] gives various electron densities for an eclipse during March equinox noon at sunspot minimum. Figure 2.7 by Smith, et al. [1965] gives electron density distributions for various obscurations of the eclipse of July 20, 1963. In Figure 2.6 the electron density for 60% obscuration shows little change until above 70 km. For Figure 2.7 at 40% obscuration the electron density at 75 km has no change while above and below this altitude show marked changes. Below 75 km the change is, therefore, expected to be no larger than above 75 km and the change is expected to be approximately 36% (from equation (2.4)). Due to the changing solar zenith angle, the magnitude of the slope of the changing electron densities before the maximum obscuration of the sun is expected to be greater than the slope after maximum obscuration.

2.5 Statement of the Problem

The purpose of this paper is to present the setting up, collection, and analysis of the partial-reflection data taken before, during and after a solar eclipse and to present changes made in the partial-reflection computer programs in order to simplify the operation and more effectively reject noise.
Figure 2.5 The variation of the solar zenith angle for July 10, 1972. The partial-reflection data collected period is shown as well as the time of maximum obscuration for the eclipse.
Figure 2.6 Variation of electron density during a solar eclipse at March equinox, mid-day, and sunspot minimum at middle latitudes [Deeks, 1966].
Profiles 1, 2, 3, and 4 refer to obscurations of 92%, 86%, 40%, and 2%, respectively. The solar zenith angle was 55° at totality and 61° at 40% obscuration.

Figure 2.7 Electron-density profiles for the eclipse of July 20, 1963 [Smith, et al., 1965]. Profiles 1, 2, 3, and 4 refer to obscurations of 92%, 86%, 40%, and 2%, respectively. The solar zenith angle was 55° at totality and 61° at 40% obscuration.
3. EXPERIMENTAL TECHNIQUE

The partial-reflection experiment was first performed by Gardner and Pawsey [1953]. Electron densities were deduced for 65 to 82 km from partially reflected, circularly polarized radio waves. The transmitter operated at 1 kw during each 30 µsec pulse with a center frequency of 2.28 MHz, and the partially reflected signals were displayed on an A-scan oscilloscope. Several improvements have been made in the experiment and are discussed by Pirnat and Bowhill [1968].

Gregory [1956] used an increase in transmitter power of 4 kw and a decrease in the transmitter pulse width to 9 µsec. These changes improved the amplitude and resolution of the partial reflections. Fejer and Vice [1959] developed an improved receiving and storing method using a dual-beam cathode-ray tube oscilloscope and camera. The system was operated at 1.83 and 2.63 MHz. Belrose and Burke [1964] also operated at two different frequencies (2.66 and 6.275 MHz) and transmitter power of 1 Mw, were able to obtain electron densities from the D and E region. Belrose and Burke [1964] were the first to use the generalized Appleton-Hartree formulas by Sen and Wyller [1960] for partial-reflection application.

Using the generalized Appleton-Hartree formulas and several approximations, the ratios of partially reflected extraordinary waves ($A_x$) to the partially reflected ordinary wave ($A_o$) for two heights can be used to calculate electron densities [Pirnat and Bowhill, 1968 and Reynolds and Sechrist, 1970]. The ratio $A_x/A_o$ at each height is inversely related to the absorption by the expression $\exp(2j\int_{0}^{h} k_x-k_o)$ from which the name differential absorption originates. At the University of Illinois the electron density was calculated directly from these ratios, and as seen in Chapter 4, small changes in these ratios can produce large variations in the electron densities.
Henry [1966] designed and built the hardware for the partial-reflection experiment at the University of Illinois. The transmitter that is presently being used was built for the purpose of making shipboard measurements. This transmitter operates at 40 kw during each 20 μsec pulse and with 5 pulses per second. The center frequency is 2.66 MHz with a 50-ohm unbalanced output. Figure 3.1 shows a block diagram of the transmitter. The reduction of power from the initial 50 kw used is to give longer life to the tubes used, and the pulse is shortened from 50 μsec used by Henry [1966] for better height resolution.

Figure 3.2 shows the two antenna arrays used to transmit and receive circularly polarized signals. Each array consists of 30 half-wave dipoles in the north-south direction and 30 in the east-west direction [Wiersma and Sechrist, 1972]. Each direction has matching networks that differ by 90° from the other direction of the same array to give a circularly polarized radio wave as shown in Figure 3.3. Each array gives approximately 22 dB gain with the main beam in the vertical direction. The first sidelobe is down 14 dB. Since both arrays are the same, this is a decrease of approximately 30 dB in the sidelobes relative to the main signal which has 44 dB gain. Further details on the antennas are given by Pirnat and Bowhill [1968] and Reynolds and Sechrist [1970].

3.1 Development of Receiving and Storing Data

The receiver, storage and timing controls have had two main changes in the development of the partial-reflection system. The experiment was originally set up using photographic film to store the partially reflected signals as displayed on an oscilloscope (see Figure 3.4). The controlling circuitry or pulser sent pulses of 30 volts to the transmitter, receiver, and camera. The pulser has remained the same with the exception of the addition of extra control circuitry depending on the storage method. The amplitudes of the received signals
Figure 3.1 Block diagram of the partial-reflection transmitter.
Figure 3.2 Partial-reflection antenna arrays for the Aeronomy Field Station.
Figure 3.3 Block diagram of the partial-reflection system.
Figure 3.4 Typical frame of data as collected by Henry [1966].
were later measured visually and electron densities were obtained. Pirnat and Bowhill [1968] shows that there is good correlation between electron densities calculated from the partial-reflection data and from rocket measurements with the transmitter operating at 25 kw of power during a 50 μsec pulse. This system of collection and storage is inexpensive, but the processing of the data to obtain electron densities is very slow and preparation and operation are complicated.

Reynolds and Sechrist [1970] set up data storage on paper tape. Ordinary and extraordinary samples were punched on paper tape for heights corresponding to 75 km and 80 km. Data can be stored at a rate of 30 values of each sample in one minute. From the paper tape the data can then be read into a computer and processed. This data on paper can be used to obtain an electron density for between 75 and 80 km. Reynolds and Sechrist [1970] show the results using paper tape compares favorably with results from rocket measurements and with the results published by Belrose and Burke [1964]. Although the system has a faster operation than the original system, it produces only one electron density and the added control circuitry is very complex.

Birley and Sechrist [1971] set up the partial-reflection experiment using a PDP-15 computer. The received signals were transmitted to the computer via an analog to digital converter and stored on DECTape to be processed later. The data consisted of four noise samples from 45 to 49.5 km and 21 data samples from 60 to 90 km in 1.5 km increments. The collection rate is 5 sets of 26 samples sec⁻¹. This collection is done alternating between ordinary partial reflection and extraordinary partial reflections. Electron densities obtained by Birley and Sechrist [1971] show good agreement with electron densities obtained from rocket measurements between 67.5 and 82.5 km. The other heights suffered
from too many rejections due to noise and saturation of the analog to digital converter, small signal to noise ratios, or inaccurate $A_x/A_o$ ratios. Computer storage offers several advantages:

1) A fast rate of data collection (presently limited to the transmitter speed)
2) Data can be stored more compactly and in much larger quantities
3) The controlling circuitry is greatly simplified
4) The data processing is faster
5) $[e]$ can be obtained for every 1.5 km

This type of system also poses several disadvantages:

1) High cost
2) Development of computer software
3) Loss of accuracy in digitizing the data
4) Development of new circuitry and modification of the old for adaption to the A/D converter
5) More complicated operations (operator must know computer operation)

These disadvantages have been reduced with additional equipment and development as given in Section 3.3.

3.2 Partial-Reflection Data Collection for the Solar Eclipse

The partial-reflection receiver was interfaced into the PDP-15 computer to obtain data to be processed as described by Birley and Sechrist [1971]. Several changes in the receiver and controlling circuitry and the addition of an analog-to-digital converter were required prior to using the computer. A block diagram of the original receiver is shown on page 18 of Aeronomy Report
No. 13, [Henry, 1966]. The analog-to-digital converter saturates with an input of one volt or greater and will be damaged with inputs greater than five volts. The maximum output of the receiver was therefore reduced from 10 volts to 1.5 volts by one of the IF amplifiers, and the full-wave bridge diode detector was replaced by a single diode to reduce the nonlinearity of the receiver. A second blanking gate was inserted with the mixer in the RF amplifier module to more completely remove the initial effects of the transmitter pulse. The polarity reversal circuitry was not used but was left intact while the differential amplifier and inverter were replaced by two DC amplifiers on integrated chips.

The block diagram of the modified receiver is shown in Figure 3.5. Figure 3.6 shows the RF module with the extra blanking gate and Figure 3.7 shows the IF amplifier/DC amplifier module with the revisions. Both modules were modifications of the RF-3 module and IF-6 module respectively, given by Henry [1966]. The receiver power supply was unchanged as set up by Henry [1966]. Encode pulses as shown in Figure 3.8 were used to control the operation of the A/D converter after Birley and Sechrist [1971]. The encode pulse circuitry consists of a 5-volt power supply and 4 monostable multivibrators (Figure 3.9) with a variable timing for length of noise and signal pulses and the delay of each.

Two main modifications were made in the software set up by Birley and Sechrist [1971]. For the first change D. R. Ward [private communication] set up a computer-controlled synchronization with the external pulser. The timing shown in Figure 3.9 is used to determine which radio wave mode has been received. The computer programs are set up to store only pairs of sets of 26 numbers read from the A/D converter. A set of numbers is read in and assumed to be from a radio wave of ordinary mode. The computer's clock is set for 150 usec and the computer waits for another set of numbers. If another set is not read in prior
Figure 3.5 Block diagram of the revised receiver used to operate with a PDP-15 computer.
Figure 3.6 The RF amplifier module for the receiver.
Figure 3.7 The IF and DC amplifier module.
Figure 3.8 The encode pulses as set up by Birley and Sechrist [1971] used to collect data during the eclipse, and the revised encode pulses used by the present programs.
Figure 3.9 The encode pulse circuitry used to produce the former and present encode pulses.
to the 150 μsec, the set was from an extraordinary radio wave and is rejected. Otherwise, both sets are accepted and the computer is synchronized with the pulser. This process is done only when the computer has a possibility of being out of synchronization with the pulser which are:

1) Beginning of every file
2) After the transfer of a block of data to disk
3) After collection is stopped and restarted by console control switch
4) During a timing error (no longer a terminal error, see Section 3.3)
5) When the computer "forgets to read" (discussed in Section 3.3)

The second change is to account for the nonlinearity of the receiver as seen in Figure 3.10 and was initially set up to adjust the data during processing [Wiersma and Sechrist, 1972]. Due to the time needed for the calibrating operation (approximately a half day), the computer is used which increases the speed of the process while making it possible to account for inaccuracies in the analog to digital converter. This process takes about 40 minutes (including 30 minutes for the receiver warm up). The adjustment to the data is done by using a table look-up method in the collection programs. Since the data stored on the disk are linearized data, the table is not needed after the collection is done and can be deleted after all the data are stored. The method is to convert the A/D converter output to the corresponding normalized receiver input. This is done by injecting a CW signal of a known value using an attenuator with one dB increments and storing the output in the computer using the set up shown in Figure 3.11. Straight line segment approximations to the curve in Figure 3.10 are obtained as shown in Table 3.1. Using outputs from 0 to 511 the corresponding inputs are determined normalized to 511 maximum, stored in a table as shown in
Figure 3.10 Graphs of the input versus output of the receiver used for eclipse data collection (old receiver) and the receiver presently being used. The input and output values have been normalized to the maximum of the A/D converter (511).
Figure 3.11  The wiring diagram used to calibrate the receiver. The voltmeter is used in setting the initial signal level prior to calibrating.
Table 3.1
Straight line segment approximation to the relationship of receiver input to receiver output.

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<tr>
<th>Slope</th>
<th>Input</th>
<th>Output</th>
<th>Attenuation</th>
<th>Used</th>
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<td>TU(1) = 0.000</td>
<td>TUO(1) = 4.786</td>
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<td>TUO(8) = 7.699</td>
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<td>TUO(13) = 12.389</td>
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<td>TUO(17) = 17.569</td>
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<td>TUO(33) = 39.789</td>
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<td>TUO(35) = 42.569</td>
<td>11DB</td>
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<td>S(36)</td>
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<td>TU(36) = 41.000</td>
<td>TUO(36) = 43.959</td>
<td>10DB</td>
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<td>TU(37) = 42.000</td>
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<td>TUO(39) = 48.129</td>
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<td>TU(41) = 46.000</td>
<td>TUO(41) = 50.899</td>
<td>5DB</td>
</tr>
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</table>
Table 3.2, and placed on a storage device (normally a disk). The program DLOGF (given in the Appendix in MACRO language) reads Table 3.2 into the computer, and the table is used during collection of the received partial-reflection signal. Using the table, the MACRO subroutine LIN does the linearization of the numbers read from the analog to digital converter. The programs responsible for the formation of these two tables are TBFORL (FORTRAN IV), LINAP (FORTRAN IV), RADC (MACRO), and TTM (MACRO).

The system as it has been described was used to collect and process the partial-reflection data for the three-day eclipse period of July 9, 10, and 11, 1972. The rest of this chapter will describe further changes and developments of the system. These changes have been due to an increase of 16 K core memory, the addition of 2 disk units capable of storing 262,144 words each, and the changing from a single user monitor system to a background/foreground monitor disk system.

3.3 Real-Time Data Storage and Automatic Processing

A computer operates on its own timing system and if this timing system operates along with events outside the computer that affect the operation of the computer, then the computer is said to be operating in real time. For instance, if the computer reads in a set of 26 samples and is able to manipulate or process them before the next set of samples is read in, the computer is doing real-time processing; as opposed to saving the data on tape and processing it later, as done by Reynolds and Sechrist [1970]. With high-speed access on the disk (16 msec access time), the background/foreground system made possible real-time collection and processing of partial-reflection data. Due to the complicated timing, slow print-out, and the noise algorithm (discussed in Section 3.4), processing of the data is postponed until after the file is stored on the disk.

The background/foreground monitor system is a double monitor, multi-priority level, software system. The two monitors are separate software systems
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</table>

Table 3.2

The output of the A/D converter are numbers between 1 and 511. The input for each output is given in this table.
sharing the same hardware with programs operating in the foreground system having priority. Each system has 8 automatic priority (API) levels and a mainstream level. There are four hardware levels which have highest priority. The software levels are labeled 4, 5, 6, 7, and 0 where 4 is the highest and 0 is the mainstream, the lowest. When a program initially starts running in either background or foreground, it begins on mainstream. Certain commands require a special subroutine called a real-time subroutine and is designated a priority level from 0 to 4 and stops all operation on lower priority levels (background is lower than foreground) until it exists from the level or performs an I/O operation.

With this system the partial-reflection collection and processing programs as mentioned could operate in real time, but due to several problems in the processing of data, the data could not easily be saved except in processed form. The solution used is to collect one file of data and process that file while the next file of data is being collected. After each file is collected, the operator is told what the next attenuator setting is. The collection program also checks the setting of the switches on the console to allow the operator to control parts of the collection program. Switch 0 acts as an on/off switch which causes collection to stop collecting and wait in a loop if set to 1. Switch 1 allows the background system to share the collection and processing storage device (1 disk) if the switch is set to 1. This sharing is necessary if the collected files are to be stored on DECTape. Switch 3 allows the processed data which are printed out onto the teletype to also be punched onto paper tape if the switch is set to 0. This option is presently used to allow for later plotting of the data using a programmable calculator. Switches 2 and 5 are not used at the present. The rest of the switches are used for determining the length of each file (default length is 513 pairs of sets of
26 numbers). The time of day is determined by using the clock within the computer to give the time in hours and minutes.

The flow diagram of the programs is shown in Figure 3.12. The programs are loaded into the computer and the computer's clock is set to the time of day. The operator is given the option of calibration of the receiver. The linearization table is stored on a disk and some initial information is read in. If the table read in is erroneous the operator must re-do the calibration procedures. The collection is started on priority level 6 and processing waits for the first file to be collected. After collection of the number of sets of samples set on the console switches and the operator changes the attenuator setting, the second file is collected while the first is processed and printed out. This process continues until stopped by the operator. Information used to calculate the noise threshold as described in Section 3.4 is transferred to the processing program after each file is collected and is not stored on the disk. The processing program therefore must remain faster than the collection or this information will be lost.

The processing of files involves rejecting sets of samples that are too noisy (discussed in Section 3.4), summing the squares of unsaturated data, subtracting off the sum of the squared acceptable data, and taking the square root. The resulting data are two sets of 21 samples, one of ordinary modes \((A_o)\) and one of extraordinary mode \((A_e)\) radio waves. This process is done in the main processing program PROC (given in the Appendix). The electron densities are calculated in CALC2 which is discussed in Section 3.5. The results are typed out on the teletype in tabular form as shown in Table 3.3.

The first line of the print-out of processed data is the heading. This gives the time the collection of the file stopped, the date, the reason for the run, and the attenuator setting for the file. The next line contains the noise threshold and the square of the multiplying constant used in the
Figure 3.12 A diagram of the control flow of the partial-reflection programs. The programs operate on the API level of the preceding program unless otherwise stated. The collection and processing program operated in parallel with the collection programs operating on API levels 5 and 6, whereas everything else operates serially.
### TABLE 3.3

Results of CALC2

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1215 8-14-73 10DB

#### 513 SAMPLES

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<th>AV. AX</th>
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maximum noise criterion discussed in Section 3.4. The next two lines are the ordinary and extraordinary mode noise before (number 1) and after (number 2) rejections due to excessive noise. The next line gives the number of pairs of sets of 26 samples collected and the number of these pairs rejected due to saturation. The first column of the table is the number of rejections due to both saturation and excessive noise for each height. The next column gives the height of the reflected signals for each row. The next two columns give RMS of the ordinary ($A_o$) and extraordinary ($A_e$) signals. The fifth column gives the ratios of extraordinary partial reflections to ordinary partial reflections from the fourth and third column respectively. The last column gives the electron density for between the heights. The last electron density is given as zero since only one height is available to calculate it.

The present method of collection and processing of partial-reflection data is fast, efficient, and easy to operate, but two problems needed to be removed. The increase of input/output operations have increased timing errors which are discussed by Birley and Sechrist [1971], and the A/D converter sometimes fails to respond to read commands.

The A/D converter transfers data to the computer using multicycle block transfer as described by Birley and Sechrist [1971]. The process is a three cycle operation for each word transferred. After each transfer, the A/D converter interface is tested for synchronization. If the timing between the interface and the I/O processor is altered, transfer is stopped resulting in a timing error. With the present system, this error can result from hardware malfunction or excessive I/O operation occurring. If the latter is the reason, the problem is only temporary and can be remedied by issuing another read. Care is taken to keep the computer synchronized with the pulser. If the error is a hardware problem, the condition will not clear up and collection must stop. The error
will usually occur when data are being collected, processed data are being printed out, and a tape is being copied onto the disk in background, all simultaneously.

The second problem has to do with the A/D converter's interface refusal to transmit data. The problem has been traced to failure in the A/D converter interface logic. The collection program will issue an A/D converter read, but not receive control back and no data are transferred. This problem occurs only with the background/foreground system and it occurs infrequently (once in about every 10,000 read commands). One solution is to issue a double read, but the problem could still occur. The solution used is for the processing to check for this stoppage, restart the collection in an orderly fashion if it has stopped and to ring the teletype bell to let the operator know of the stoppage. This solution does not prevent the failure of the A/D converter interface to transfer data, and the problem will have to be removed for faster ratio of collection, but presently the operator need not be concerned with this problem. The rest of the data is unaltered by this problem.

3.4 Noise Rejection

The partially reflected radio waves from the D region are usually small in amplitude on the order of 10 to 1000 mvolts at the output of the 80 dB gain receiver. Noise amplitudes vary between 30 to 1000 mvolts. For the purpose of the noise algorithm, noise is considered to be any interference which is part of the receiver output signal that is not attributed to the partially reflected waves from the vertically transmitted pulse. This noise is divided into two types: background noise and noise bursts. Background noise is noise caused by the receiver (14±3 mV) and general atmospheric noise which is always present (40±10 mV). Noise bursts are caused by lightning and other radio transmitters, and the amplitude of this noise is dependent on the location of the source. Lightning noise will usually last for the duration of one encode pulse while noise due to other
transmitters will last for at least 1/2 second which is several encode pulses (see Figure 3.8) and the noise will be increased usually by 10 to 1000 mvolts. Both types of noise are rejected in the processing program PROC(FORTRAN IV) as shown in the block diagram of this program in Figure 3.13.

Data are collected in pairs of sets of 26 numbers. Each set contains 5 noise samples and 21 samples of partially reflected signals. Each pair contains a set of ordinary mode samples and a set of extraordinary mode samples. In PROC a noise threshold is determined and the square of this multiplied by five is compared to the sum of the squares of the five noise samples of each set. This method of comparison is faster than comparing the RMS of the noise as set up by Birley and Sechrist [1971] since square root operations take approximately 1 msec and squaring takes 70 usec on the PDP-15, and the squaring need only be done once per file. If the noise of either mode is greater than the noise threshold, both sets of 21 signal samples are rejected and the next pair of sets are tested. If the noise of both modes is less than this threshold, the noise of both sets are considered acceptable and saved for later processing. The partially reflected signals with acceptable noise for each mode are checked for A/D converter saturation (.997 volts receiver output) at each height. If either of the two samples (one of each mode) is saturated at a height the two samples are rejected; otherwise the data are considered acceptable. This processing of pairs of 26 samples continues until the end of the file is reached. After the file of collected data has gone through this processing, the average of the sum of the squared acceptable noise for each mode is subtracted from the average of the sum of the squared acceptable partially reflected samples of the same mode at each height, and the square roots are printed out as shown in Table 3.3 and as described in Section 3.3.
Figure 3.13 A flow chart of the processing program PROC.
Originally, the noise threshold was determined by the operator typing in a value chosen by him as seen in the program PROC73 in the Appendix. This was later changed to an automatic determination based on the attenuator setting used as given at the beginning of a run. This method did not account for the day-to-day variation in noise nor in an erroneous attenuator setting. The noise threshold value is presently determined by the following equation:

\[ M = \left( \frac{K\left( \sum_{0}^{45} N \right)}{45} \right)^2 \]  

(3.1)

where \( M \) = maximum allowable noise value

\( K \) = arbitrary constant

\( N \) = certain noise samples collected as explained in the following paragraph.

In the collection programs RSUB and LIN, the maximum and sum of each group of 45 noise samples are stored, and the maximum values are compared. The sum of the group with the lowest maximum value is transferred to the processing program PROC and is used in equation (3.1). The constant \( K \) has been chosen by trial and error, and values between 2.5 and 3.5 seem to give the best results (equation 3.1 is being used).

Other algorithms have been tried, but none seem to give any obvious improvement in the resulting electron densities. One method is to split 5 noise samples collected with each set of data into 2 for comparison with the noise threshold value and 3 subtracted from the reflected signals. This method works on the theory that the noise within the 5 noise samples is not the same amplitude as the noise within the 21 data samples for each set of 26 data samples, but is statistically the same over the number of samples collected.
for one file. With the present system, when the number of rejections due to noise is large, (greater than 200 out of 513 pairs of sets of samples), the noise within the noise gate is restricted to a lower level than the noise in the data frame. Therefore, the noise in the data frame would not be completely subtracted off; as it would be with splitting the noise samples. The application of this technique using 4 noise samples showed no improvement in the results. Two possible causes are too few noise samples being used and the noise samples being too close together.

Another method has been developed and tested by D. R. Ward [private communication]. A CW signal is inputed into the receiver along with the received data from the antenna. The noise and partially reflected signals are each defined as $A \cos \theta$; where $A$ is the amplitude and $\theta$ is the phase. The noise is assumed to be random while the partially reflected signals are assumed to have only a small variation between two sets of samples. Using an algorithm developed by D. R. Ward [private communication], the phase and the amplitude of the noise portion of each signal average to zero while the phase and amplitude of the signals do not. This method is used to reject the noise from the partially reflected signals at each height. This method fails to reject interference caused by other transmitted signals since this type of noise does not have random phase. D. R. Ward [private communication] has obtained useful electron-density profiles from the method but generally found no improvement over the present system. Further study and development of either method may improve the processing and should not be discarded.

3.5 Converting $A_x/A_o$ Ratios to Electron-Density Profiles

The partial-reflection programs assume a constant collision frequency for each height with seasonal variation. The values used were determined from the
following equation [Birley and Sechrist, 1971]:

\[ V_m = Kp \]  \hspace{1cm} (3.2)

where \( K = \text{constant} = 7.3 \times 10^5 \)

\( p = \text{pressure in pascals} \)

\( V_m = \text{collision frequency in sec}^{-1} \)

The pressures used are from the mean atmospheric model from COSPAR International Reference Atmosphere (1965) with seasonal variations given by U. S. Standard Atmospheric Supplements (1966). Using these pressures, experimentally the values calculated for \( K \) vary by as much as \( 2 \times 10^5 \) [Lodato and Mechtly, 1971]. The seasonal variations in the collision frequency (Figure 3.14) can vary by as much as 20%. This 20% variation in \( V_m \) can cause the calculated \([e]\) to vary by a factor of 1.2. The electron densities are calculated using the refractive index equation given by Sen and Wyller [1960] and several approximations as discussed by Pirnat and Bowhill [1968]. The resulting equation given by Reynolds and Sechrist [1970] is:

\[ [e] = \ln \left( \frac{(A_x/A_o)}{(R_x/R_o)} \right)^{n_1} \left( \frac{(A_x/A_o)}{(R_x/R_o)} \right)^{n_2} / FD \]  \hspace{1cm} (3.3)

\[ FD = \left( \frac{5\Delta x e^2}{2\epsilon m \nu_m} \right) \left\{ \zeta_{5/2} \left( \frac{(\omega - \omega_L)}{\nu_m} \right) - \zeta_{5/2} \left( \frac{(\omega + \omega_L)}{\nu_m} \right) \right\} \]  \hspace{1cm} (3.4)

where

\[ \zeta_y(x) = \frac{1}{y^4} \int_0^\infty \frac{e^{-y}}{\epsilon^2 + x^2} e^{-\epsilon} d\epsilon \]

\( \epsilon = \frac{mv^2}{2kT} \)

\( [e] = \text{electron density} \)

\( e = \text{electron charge} = 1.6 \times 10^{-19} \text{ C} \)

\( m = \text{electron mass} = 9.1 \times 10^{-31} \text{ kg} \)

\( \epsilon_o = \text{permittivity of free space} = 8.85 \times 10^{-12} \text{ F m}^{-1} \)
Figure 3.14 The collision frequencies used in the program CALC to obtain electron-density profiles.
\( \omega = \) angular frequency of the transmitted wave

\( \omega_L = \) gyro-frequency of the electron

\( h_1 = \) lower height

\( h_2 = \) higher height

\( \Delta h = h_2 - h_1 \)

\( k = \) Boltzmann constant = 1.38 \( \times 10^{-23} \) J \( \circ K^{-1} \)

\( T = \) temperature

\( V = \) electron velocity

\( R_o = \) ordinary mode reflection coefficient

\( R_x = \) extraordinary mode reflection coefficient

This equation required a set of collision frequency constants which are given in the program CALC (FORTRAN IV). The ratio \((R_x/R_o)_{h_2} / (R_x/R_o)_{h_1}\) and FD (equation (3.4)) are calculated in ELDEN (FORTRAN IV). CAL2 (called by PROC) uses these values (which vary only with \( v_m \)) as constants for each pair of heights to calculate the electron densities according to Equation (3.5)

\[
[e] = \ln \left( \text{RATIO2} \times \frac{(A_x/A_o)_{h_1}}{(A_x/A_o)_{h_2}} \right) / \text{FD}
\]

(3.5)

where \( \text{RATIO2} = \frac{(R_x/R_o)_{h_2}}{(R_x/R_o)_{h_1}} \).

This method is used to reduce the amount of core memory required and increase speed of execution of the program. A new CALC2 can be obtained by revising the collision frequencies and running the program CALC which writes the program CALC2. The electron densities are printed out as shown in Table 3.3 and described in Section 3.3

3.6 Equipment Testing

The equipment needs to be tested periodically to determine if it is in operating order. The transmitter is tested by observing and keeping a log of
the voltage and current at various locations via meters and an oscilloscope. The antennas are tested by transmitting and receiving signals at various times during the day. At noon the extraordinary signal should be absorbed and at night the ordinary signal should be absorbed. By transmitting and receiving ordinary and extraordinary signals as described in Progress Report 73-1 [Edwards, 1973], the phase and attenuation of each antenna of each array can be set and checked for possible damage. This process is also a partial check for the transmitter and receiver. A spot check of 30 dB difference in ordinary and extraordinary reflections from the $E$ region at noon is done on a daily basis.

The program CHECK (FORTRAN IV) has proved valuable in checking the receiver and the analog to digital converter. CHECK performs a modified dump of the A/D converter as read by the computer. If the number 31 is typed, the output is in the form of partial-reflection data (ordinary and extraordinary pairs), patterned after the new encode pulse shown in Figure 3.8. If any other number is typed in an average of that number rounded to the next higher multiple of 50 is printed out. The 31 pairs of samples are printed out in millivolts only, while the averages are printed out in millivolts and as represented in the A/D converter. This program has had many applications; it showed the blanking gate on a new receiver to be too long. It was used to calibrate the A/D converter using an input from a standard source. Table 3.4 shows the accuracy of the A/D converter as the standard voltage source was varied from 1.0 volts to .1 in .1, .01, and .001 volt increments. It was used in comparing the paper punch system set up by Reynolds and Sechrist [1970] with the computer storing method presented in Section 3.3. CHECK has also been used to determine the number of samples required to have less than 10% error due to noise (at least 100 samples are required). The program is easy to operate and has become important in testing and checking the receiver and the analog to digital converter.
Table 3.4
The output of the A/D converter using a calibrated input source

<table>
<thead>
<tr>
<th>Average</th>
<th>Output Voltage</th>
<th>Input Voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>511.204</td>
<td>998.444 mV</td>
<td>1000 mV</td>
</tr>
<tr>
<td>460.558</td>
<td>899.527 mV</td>
<td>900 mV</td>
</tr>
<tr>
<td>409.625</td>
<td>800.050 mV</td>
<td>800 mV</td>
</tr>
<tr>
<td>358.528</td>
<td>700.250 mV</td>
<td>700 mV</td>
</tr>
<tr>
<td>307.057</td>
<td>600.050 mV</td>
<td>600 mV</td>
</tr>
<tr>
<td>256.020</td>
<td>500.050 mV</td>
<td>500 mV</td>
</tr>
<tr>
<td>205.252</td>
<td>400.050 mV</td>
<td>400 mV</td>
</tr>
<tr>
<td>154.082</td>
<td>300.050 mV</td>
<td>300 mV</td>
</tr>
<tr>
<td>102.787</td>
<td>200.050 mV</td>
<td>200 mV</td>
</tr>
<tr>
<td>51.076</td>
<td>100.050 mV</td>
<td>100 mV</td>
</tr>
<tr>
<td>46.349</td>
<td>90.050 mV</td>
<td>90 mV</td>
</tr>
<tr>
<td>40.843</td>
<td>80.050 mV</td>
<td>80 mV</td>
</tr>
<tr>
<td>35.208</td>
<td>70.050 mV</td>
<td>70 mV</td>
</tr>
<tr>
<td>30.844</td>
<td>60.050 mV</td>
<td>60 mV</td>
</tr>
<tr>
<td>25.769</td>
<td>50.050 mV</td>
<td>50 mV</td>
</tr>
<tr>
<td>20.222</td>
<td>40.050 mV</td>
<td>40 mV</td>
</tr>
<tr>
<td>15.022</td>
<td>30.050 mV</td>
<td>30 mV</td>
</tr>
<tr>
<td>10.200</td>
<td>20.050 mV</td>
<td>20 mV</td>
</tr>
<tr>
<td>4.830</td>
<td>10.050 mV</td>
<td>10 mV</td>
</tr>
<tr>
<td>3.857</td>
<td>9.050 mV</td>
<td>9 mV</td>
</tr>
<tr>
<td>3.233</td>
<td>8.050 mV</td>
<td>8 mV</td>
</tr>
<tr>
<td>3.010</td>
<td>7.050 mV</td>
<td>7 mV</td>
</tr>
<tr>
<td>2.847</td>
<td>6.050 mV</td>
<td>6 mV</td>
</tr>
<tr>
<td>2.443</td>
<td>5.050 mV</td>
<td>5 mV</td>
</tr>
<tr>
<td>2.054</td>
<td>4.050 mV</td>
<td>4 mV</td>
</tr>
<tr>
<td>1.404</td>
<td>3.050 mV</td>
<td>3 mV</td>
</tr>
<tr>
<td>0.659</td>
<td>2.050 mV</td>
<td>2 mV</td>
</tr>
<tr>
<td>0.125</td>
<td>1.050 mV</td>
<td>1 mV</td>
</tr>
<tr>
<td>0.010</td>
<td>0.050 mV</td>
<td>0 mV</td>
</tr>
</tbody>
</table>
3.7 Future Development

Several improvements are being made to the system. A new receiver is being made using a linear detector and new RF and IF stages to reduce the receiver noise. Figure 3.10 shows a comparison of the input versus output between the new receiver and the old one. With no input signal, the noise level of the new receiver is 2.5 mV and the level of the older receiver is 14 mV. The circuitry and discussion of it are given in the Aeronomy Progress Report 73-1 [Edwards, 1973].

A digital input/output device is presently being sought which would improve the calibration time and free the operator for other tasks as well as simplify the operation of the system. The purchase of such a device would also reduce the amount of paper presently required.

Another asset would be a line printer. One could reduce the processing time by at least half and allow for more sophisticated processing (with possibly better noise rejection) if such a line printer were purchased.

As mentioned by Birley and Sechrist [1971], an increase of transmitter power is also needed. This would improve the signal-to-noise ratio and give better data below 70 km.

The noise problem should be studied more carefully. Perhaps a combination of the method discussed in Section 3.4 would improve the results. Another possibility would be to reject extremely low values of reflected signals.

An additional program to transfer collected data to tape would be helpful. The original programs set up by Birley and Sechrist [1971] saved data on tape for future processing. With the present system, collected data can be stored on tape by using a system program called PIP. This requires knowledge in operation of the computer, and the transferring of files can get complicated.
This chapter describes the results from partial-reflection data which was collected and processed by the computer on July 9, 10, and 11, 1972. A solar eclipse occurred on July 10, 1972. The obscuration function shown in Figure 1.1 shows the first contact to be at 1319 CST and the last contact to be at 1536 CST with 60% of the solar disk obscured. The data were collected from 1200 to 1700 CST to show the effects of the solar eclipse on the electron density and collected between the same times on July 9 and 11 to be used as control data. Data were collected in blocks called files. Each file of data, consisting of 1026 sets of 26 numbers, was collected and stored on DECtape every 3.8 minutes. The signal prior to entering the receiver was attenuated with four attenuator settings (0, 10, 20, and 30 dB). Each file was collected beginning with the lowest attenuator setting of 0 dB with each subsequent file collected at the next attenuator settings; 10, 20, and 30 dB, respectively. This process was then repeated. This process was used to obtain the very small echoes as well as the very large ones. The files of data are divided into approximately 15 minute intervals, corresponding to the four attenuator settings.

The data between 1400 and 1430 on July 9 was lost due to an erasure of the disk before it could be processed. These data have been interpolated. The data from July 10 between 1200 and 1300 was erroneous and therefore has been eliminated from the results. The computer results were processed further combining the files with different attenuator settings.

4.1 Reduction of Data

Individual results shown in Figure 4.1 show valid electron densities but are limited height range; therefore, multiple attenuator settings were used to obtain usable data over a greater range of heights. The computer processes
Figure 4.1 Comparison of electron-density profiles on July 10 and 11, 1972. The data were taken at 1432 CST with the attenuator set at 30 dB.
only one file at a time; therefore, further processing was necessary to combine four files corresponding to the four attenuator settings into one set of results. Three methods have been developed to accomplish this. The first method was originally used but problems developed in determining acceptable data and method two was used. Using method two, some acceptable data were being ignored and the 20 and 30 dB settings were found to give similar results. Therefore, method three was developed to utilize much of this acceptable data that were being ignored.

1. In method one, the results with the lowest attenuator setting (0 dB) were used for 60 km up to the height where 5% of the ordinary and extraordinary data was rejected due to saturation (see Section 3.4). The electron densities for the higher heights were obtained from the next higher attenuator setting under the same restrictions of saturations. This process continued until the last electron density was obtained. The results of this method seemed to be satisfactory except for above 81 km and below 66 km.

2. Method two is the same as method one, but accounts for inaccuracies in the receiver by rejecting electron densities that used \( \frac{A_x}{A_0} \) ratios that were less than .09. Electron densities were rejected also if the signal to noise ratio was less than 1. These two revisions eliminated much of the results below 65 km and above 85 km.

3. Method three is similar to method two except for the way the multiple attenuators are combined. The electron densities are considered acceptable if the \( \frac{A_x}{A_0} \) ratios for both heights are greater than .08, the signal to noise ratio is above 1 for both heights, and the rejections due to saturations were less than 5% for both heights used to calculate the
electron density. If more than one attenuator setting had acceptable electron densities for between two heights, then the median of the acceptable electron densities was used. Using these three methods, the computer results were combined to give one electron-density profile for every 4 attenuator settings. Using either average or medians, electron densities of different heights or of different times were combined as discussed in Section 4.2.

4.2 Electron-Density Results

The results are presented in two forms: by the total differential absorption below each height ($A_x/A_0$ ratios) and by electron densities. The $A_x/A_0$ ratios given in Figures 4.2, 4.3, and 4.4 are plotted using a sixth order polynomial approximation of the ratio as calculated by method one. The eclipse shows a reduction in absorption which indicated a reduction in electron density as expected. The third day shows irregular absorption with a large increase in absorption. Referring to Figure 2.2, the increase in absorption is related to the X-ray flux burst. The electron density for above 75 km for the three days given in Figure 4.5 shows a good correlation between the large increase in electron density on July 11 and the burst of X-ray flux. Due to this obvious contamination, the second control day is not used for comparison during the burst period.

Figure 4.6 gives the $A_x/A_0$ ratios versus height. The ratios were determined using method one and taking the median of the groups within the hour corresponding to the maximum obscuration of the solar eclipse (1400-1500 CST). Due to the much larger absorption in the control days than during the eclipse, the electron densities above 81 km (approximately) are not valid according to method two and three, but with the eclipse day, the values should be acceptable up to 85 km.
Figure 4.2 Comparison of the $A_x/A_o$ ratio at 72 km for July 9, 10, and 11.
Figure 4.3 Comparison of the $A_x/A_o$ ratio at 75 km for July 9, 10, and 11.
Figure 4.4 Comparison of the $A_x/A_o$ ratio at 78 km for July 9, 10, and 11.
Figure 4.5 Median electron densities between 75 and 82.5 km.
Figure 4.6 Median $A_x/A_o$ profiles between 1400 and 1500 CST for each day.
Figure 4.7 gives the electron-density variation with time. The electron densities are averages between 70.5 and 78 km and between 78 and 87.5 km with the electron densities obtained by using method one for processing the computer result. Figure 4.5 and 4.8 give the electron-density median for 75 to 82.5 km and 67.5 and 75 km, respectively, as each varies with time. These electron densities were obtained using method three. At the lower altitudes, the median electron densities show no effect from the eclipse while the average electron densities do show a slight effect. This difference, though, is mainly attributed to the higher heights the averages were taken from rather than to the method used. The highest heights show large effects due to the eclipse. Figure 4.7 shows a minimum electron density near maximum obscuration of the eclipse while Figure 4.5 shows the minimum being delayed by half an hour. This is attributed to the variation in the data due to the inaccuracies in the partial-reflection equipment. The X-ray burst shown in Figure 2.2 seems to have no effect at the lower altitudes.

Median electron-density variations with height are given in Figure 4.9. These values are the median obtained by processing the computer results utilizing method two and finding the median value between 1400 and 1500 CST. Below 75 km the eclipse does not seem to have much effect on the electron density as shown in Figure 4.9, but above 75 km, the electron density decreases by 45 to 65%. The upper height for this comparison is 81 km due to the small $A_x/A_o$ ratios (shown in Figure 4.6). The electron-density profile shows some conformity to the expectation given in Section 2.4.

4.3 Theoretical Applications

Since the eclipse never reached totality, the electron production ($q$) cannot be assumed to be zero, but equation (2.4) can be used as an approximation
Figure 4.7 Average electron densities between the altitudes 78.0 - 87.5 km and 70.5 - 78.0 km.
Figure 4.8 Median electron densities between 67.5 and 75 km.
Figure 4.9 Median electron-density profiles between 1400 and 1500 CST.
to $[e]$ and $\alpha_{\text{eff}}$. Equation (3.1)

$$q = \sigma_i(\text{NO}) \, [\text{NO}] \, I_\infty \, e^{-\tau} \, P_o$$

(3.1)

where $q =$ electron production rate in cm$^{-3}$ sec$^{-1}$

$\sigma_i(\text{NO}) =$ ionization cross-section of nitric oxide $= 2 \times 10^{-18}$ cm$^2$

$[\text{NO}] =$ number density of nitric oxide in cm$^{-3}$

$I_\infty =$ incident Lyman-alpha flux at the top of the atmosphere $= 3.1 \times 10^{11}$ photons cm$^{-2}$ sec$^{-1}$

$P_o =$ the function of the unobscured solar disk

$\tau =$ optical depth

given by Sechrist [1966], was used to approximate the electron production rate and equation (3.2) was used to approximate the optical depth.

$$\tau = \sigma_a(O_2) \, [O_2] \, H \, \sec \chi$$

(3.2)

$[O_2] =$ number density of molecular oxygen in cm$^{-3}$

$H =$ scale height

$\chi =$ solar zenith angle

Figure 4.10 shows the variation of $q$ during the eclipse as compared to the variation without the eclipse. The electron production rates were used to obtain theoretical electron densities with $\alpha_{\text{eff}}$ being chosen to give the best fit to the experimental results. A value of $2 \times 10^{-6}$ for $\alpha_{\text{eff}}$ was determined for the eclipse day between 75 and 82.5 km and $1.77 \times 10^{-6}$ for the same height range on the control days. For the heights 78 to 87.5 km $\alpha_{\text{eff}}$ was found to be $8.46 \times 10^{-7}$. These values for $\alpha_{\text{eff}}$ are similar to ones given by Mitra [1968]. Figure 4.11 shows a comparison between the theoretical $[e]$ during the eclipse and without the eclipse using $\alpha_{\text{eff}}$ of $1.77 \times 10^{-6}$. 
Figure 4.10 Electron production rate between 75 and 82.5 km during the eclipse and during the control days. The NO distribution used is from Meira [1971].
Figure 4.11 Theoretical electron densities between 75 and 82.5 km for eclipse and control day; calculated using an $\alpha_{\text{eff}}$ of $1.77 \times 10^{-6}$.
The electron density of the eclipse was divided by average electron density of the control data and compared to the obscuration function as seen in Figure 4.12. The comparison of the experimental \([e]\) during the eclipse and the theoretical \([e]\) without the eclipse using equation (2.4) was also made and is shown in Figure 4.13.

The electron density for July 9 shows a good correlation with the solar zenith angle (Figure 4.14) and was therefore divided by the theoretical \([e]\) to eliminate the effects of the solar zenith angle and to determine the variability of the experimental \([e]\) (Figure 4.15). The same comparison is made with the eclipse \([e]\) (Figure 4.15) and shows a similar but greater variability.

Generally, the eclipse electron densities show a decrease that is greater than expected from the equation (2.4). Other than the possibility that this is caused by variabilities due to inaccuracies in the experiment, there are three reasons why this may occur:

1. The obscuration function of the ionization source (Lyman-\(\alpha\)) is different than the uniform-disk obscuration function used.
2. The \(a_{\text{eff}}\) increased during the eclipse. This could be caused by a change in the hydrated-ion composition between 75 and 81 km.
3. Loss by attachment is increased by the eclipse.

The electron-density profiles in Figure 4.10 show good comparison with the profile with 40% obscuration given in Figure 2.7 and with 60% obscuration shown in Figure 2.6. Smith, et al. [1965] described small changes below 70 km as the \(C\)-layer caused by cosmic rays which disappear as the eclipse reaches totality. The effect can be seen up to 69 km in Figure 4.9.

4.4 Summary

Comparing Figure 4.9 Figures 2.6 and 2.7, the electron-density profiles of this eclipse are similar to previous eclipses for the same obscuration. Generally, similar conclusions can be drawn. The difficulty in interpreting the
Figure 4.12 The ratio of electron densities for the average of the control day as compared to the unobscured sun.
Figure 4.13 The graph of the ratios of the theoretical \([e]\) for the unobscured sun to the experimental \([e]\) for the eclipse as compared to the unobscured sun. The \(\alpha_{\text{eff}}\) used for 75 to 82.5 km is \(1.77 \times 10^{-6}\) and for 78 to 87.5 km is \(8.46 \times 10^{-7}\).
Figure 4.14 Scatter plot correlating the electron density for July 9, 1972 between 75 and 82.5 km to the solar zenith angle.
Figure 4.15 The graph of the ratio of theoretical electron densities to the experimental electron densities for July 9, 10, 1972.
results lies in the variation of the electron density of the eclipse with time.
In Figures 4.12 and 4.13 a small decrease in electron density precedes the obscur-
ation of the sun. An error of 20% can be expected due to the equipment and 20% 
error can be expected in the collision frequencies. Errors due to collision fre-
quencies will cancel in Figure 4.12 but the errors due to the equipment will in-
crease. For Figure 4.13, the reverse is true, but there are also errors due to 
the approximations made in equations (2.4), (3.1), and (3.2). With these pos-
sibilities of errors and observing that the ratio after the eclipse can get as 
low as .8 in Figure 4.12, the initial decrease can be interpreted as experimen-
tal error. The errors in Figure 4.13 can be seen in the variations in Figure 4.15.

No correlation could be seen between the X-ray flux and the electron density 
on the third day except during the X-ray burst period. Therefore, Lyman-α is 
assumed to be the main ionization source and the theoretical calculations were 
made on that assumption.

Of the three reasons for the large decrease in [e], the effects due to 
changes in hydrated ions is the most likely. During the day electron loss by 
attachment is insignificant above 75 km. Since the obscuration of the sun was 
only 60% which corresponded to a production rate similar to that of 65° solar 
zenith angle, the loss process would still be by recombination.

The larger concentrations of Lyman-α on the solar disk were in the southern 
hemisphere and were not obscured and the intensity of 1-8 A X-ray flux was too 
small to have any large effect. Therefore, the obscuration function of the 
ionizing source would have the same obscuration or less. This leaves the only 
possibility for the larger decrease in free electron as being due to changes in 
the hydrated ions.
5. CONCLUSIONS

The solar eclipse provides a good opportunity to study several processes of the D region and to develop its theoretical model. Accurate interpretation of the eclipse data is required to determine exactly the D-region ion production and loss processes, the variation of $\alpha_{\text{eff}}$, formation of hydrated ions, and negative ion chemistry. A brief theory of the D-region chemistry is presented in Chapter 2 and used to analyze the data in Chapter 4. The equipment used in the collecting and processing of the partially reflected waves, as well as the refinements made in the collection process are given in Chapter 3. The newer partial-reflection system, discussed in Chapter 3, has been in use for the daily collection of data. Results from this newer system are given by Denny and Bowhill [1973]. This chapter reviews the results of the partial-reflection data taken during the eclipse and suggests further developments of the partial-reflection system.

5.1 Review of Results

The effect of the eclipse below 75 km is below the experimental errors. These errors are due to the variability of receiver gain caused by temperature fluctuations, the 40 µsec pulse width of the transmitter, inaccuracies in the collision frequencies, and inaccuracies in noise reduction. In comparing the $[\epsilon]$ profiles for July 9 and 10, 1972 in Figure 4.8, the beginning of the formation of a C layer can be seen resulting from cosmic rays. From Section 2.1, the main ionization source between 70 and 80 km is Lyman-α since the X-ray source effects were not observed below 81 km except when the X-ray flux increased above $1 \times 10^{-3}$ erg cm$^{-2}$ sec$^{-1}$.

The decrease between the electron density from July 9 and from July 10 is dependent on the height and is very marked between 79 and 81 km. Near 80 km,
this change in electron density is as much as 55% between the results of July 9 and 10, which was not expected according to equation (2.4). The most probably answer given in Chapter 4 is that it is due to an initial large decrease in hydrated positive ions which are the major ions between 75 and 80 km during the daytime (as seen in Figure 5.1 by Krankowsky, et al. [1972]).

The theoretical \( [e] \) were used to compare with the experimental \( [e] \) in Figure 4.13 to remove any electron density variability not due to the eclipse. The results in Figures 4.12 and 4.13 show unexpected initial decreases in \( [e] \) prior to the eclipse and larger decreases than would be expected during the eclipse, but allowing for 20% error in these results, these variations are within the error limits. In general, there is good agreement with the data from Smith, et al., [1927] and Deeks [1966].

5.2 Suggestions for Further Work

The present partial-reflection system has proved invaluable in presenting variations in electron densities diurnally and from day-to-day as presented by Denny and Bowhill [1973]. The system has several limitations, though. Either the signal-to-noise-ratio should be increased or the rates of data collection increased. Both of these changes would require alterations in the transmitter. By doubling the peak power of the transmitter, meaningful partial reflections could be obtained at lower altitudes without excessively disturbing the ionosphere due to the slow pulse rate as is done in the cross modulation experiment. By increasing the pulse rate, more data could be collected in the same interval of time, allowing for a more accurate statistical evaluation of the noise.

A new receiver has been built as mentioned in Chapter 3. The initial results obtained using it show an improvement in the results, but the problem of eliminating atmospheric noise remains. The main problem lies in defining the noise.
Figure 5.1 Rocket measurements of the positive-ion chemistry by Krankowsky, et al. [1972].
A study should be done on the specific types of noise received and the algorithms required to reject each. This would include receiving and storing noise on DECTape for later evaluation of the amplitude and phase.

A digital input/output would increase the efficiency of the collection and process. Presently the system requires the assistance of the operator every 3-1/2 minutes and uses one page of computer paper for every page of data. With a digital input/output, the computer could set the attenuators and control other switching which would free the operator for other tasks. This would also improve the usefulness of taking differential phase measurements as described by Wiersma and Sechrist [1972].

Using a line printer for outputting the data would allow for more sophisticated and complicated processing of data. This would also be required if the rate of collection is increased. To collect one file of data takes 3.5 minutes, to process one, about 45 sec, but to print out the results on the teletype and paper tape takes 2.6 minutes. Therefore, the processing would not be able to keep up with a faster collection unless the speed of printing the results increased.
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APPENDIX

*TITLE DLOGFI
/DLOGFI IS A COMBINATION OF ALL THE PARTIAL REFLECTION
/MACRO PROGRAMS USED IN COLLECTING AND PROCESSING DATA. THE
/PROGRAMS CONTAINED IN THIS VERSION ARE:

/INITIALIZATION:
/INITILIZES COLL., & PROC. PARAM.
/READS UNFORMATTED CHAR. FROM TTY
/INCREMENTS THE TIME OF DAY
/READS SAMPLES FROM A/D CONVERTER
/FOR FORTHAN PROGRAM.
/Writes LIN. TABLE OUT ON DISK
/MAIN COLL. PROG. --- A REAL TIME
/ Subroutine API Level 6
/Gives Time to Lower API Level 5
/SETs UP DATA PACK & Checks Noise
/--- R-T SUB. AT API LEVEL 5
/Packs Data Double
/Writes Data on Storage Device
/Checks for Enough Data
/Sees if A & AO is in the Right
/Order and Are COLL. in Pairs---API 5
/LIN. DATA & DATA in #0 & Checks Noise
/PREPares A/D Converter Read
/A/D Interrupt Service Routine
/CHECKS INIT. DEV. & Checks for Coll. File
/Waits for File to Be Collected
/ALLOWS Time for Background
/Checks for Unwanted Coll. Stop
/USED to Switch Disks
/Reads Data Unpacks It & Puts
/It into a FORTAN Array

/ DATA IS COLLECTED ALTERNATELY ORDINARY AND EXTRAORDINARY
/ AS DESCRIBED BY BIRLEY (AERONOMY REPORT 42). THE TIMING OF THE
/ DATA IS DETERMINED BY AN EXTERNAL ENCODE PULSE. THE MODE OF THE
/ DATA INPUTED INTO THE COMPUTER IS DETERMINED BY A TIMING PROGRAM
/ (CHECK) SET UP BY D. WARD. ESSENTIALLY HOW IT WORKS IS AFTER A
/ FRAME OF DATA HAS BEEN READ IN THE COMPUTERS CLOCK IS SET FOR 9/64
/ OF A SECOND (9 PULSES). IF NO OTHER DATA IS READ IN BEFORE THE
/ TIME EXPIRES THE DATA FRAME IS EXTENDED TO AN EXTRAORDINARY MODE
/ AND IS REJECTED. OTHERWISE BOTH FRAMES ARE ACCEPTED. THIS CHECK IS MADE AT THE
/ BEGINNING, AFTER EACH DATA TRANSFER, AND WHENEVER THE COLLECTION
/ IS RESTARTED OR AN ERROR CONDITION EXISTS. THE PROGRAM IS SET SO
/ AS TO NOT OVER MAXIMUM STORAGE ON THE DISK.

TTI=4
TTO=6
THI=10
OUTPT=2
OUTPT#1=4
DATIN=5
DATIN#3=3
OUT#1=2
IN=2
ASC#2=2
IA=3
DUMP#2=2
SKAR#5=5
NSAM#1=7
TNSAM#1=37
NSAMP#1=NSAM#1=2+1
DATBLK#1=TNSAM#1=2
HTBLK#1=DATBLK#1
DTPBLK#1=DATBLK#1
DATSML#1=DATBLK#1
RTBLK#1=RTBLK#1
RBLK#1=DSAM#1
MNGO=11
MPAT=11
MNPG=2
NDPC=NSAM#1
DPR=NDPC+1
MAPD=509898/NSAMP
MAX= # OF DISKS TO BE USED
NDPR=1

*GLOB. CHNG. DA. AD DUMP. DLOGF. CKCOL. CKTN, PROC. RADC. TTM
*GLOB. TBPOL. PPT. VPP
*IDEV 12345678

THE FOLLOWING SUBROUTINE IS USED TO PREPARE THE
/COLLECTION AND PROCESSING PROGRAMS FOR MANIPULATION OF DATA.
/THE VARIABLES OF THE MACRO PROGRAMS ARE STORED IN THIS SUBROUTINE.
/THEORETICALLY, THIS SUBROUTINE IS EXECUTED IT IS WRITTEN OVER
/AND SHOULD NOT BE REENTERED (FOR IT WILL NOT EXIST).
MSGDB
MSGIl
MSG9
MSG8
LAST
ASCII
"SET SUBROUTINE PARAMETERS' ADDRESSES"
"JUMP AROUND PARAMETER LIST"
"ADDR. OF THE ADDR. OF THE DB SETTINGS"

MSG10
ASCII
"SAVE ID TO TEST FOR COLL. STOPAGE"
"SAVES AC DURING PROC. OPERATION"
"SAVES AC FOR API LEVEL 0"

TClO
LAW
-2
/STORES # OF FRAMES FOR ONE FILE

CN1
0
/STORES # OF FRAMES FOR ONE DISK

CNT
0
/OFF FOR 0-FRAMES, EVEN FOR X-FRAMES

CNT2
0
/SET TO 1 FOR O-FRAMES

DUM1
0
/GETS & STORES 1 LINEARIZED DATA WORD

DUM2
0
/STORES THE MAX. NOISE IN A FRAME

DUM3
0
/STORES THE SUM OF THE NOISE PER FRAME

DUM4
0
/STORES THE MAX. OF 45 NOISE SAMPLES

DUM5
0
/STORES THE SUM OF 45 NOISE SAMPLES

MAX
777
/STORES THE SMALLEST MAX. OF "DUM4"

TBUF
-DSA
BUF1
/STORES NAME OF BUF. TO BE OUTPUTED

IODOU
0
/STORES THE ID NUMBER

DUMP
0
/DATA IS TRANSFERRED WHEN NON-ZERO

COUNTP
LAW
-NDPC
/COUNTS # OF DATA PER FRAME TO PACK

DPOIN1
LAW
-NDPC
/POINTS TO UNPACK

ER2
0
/STORES TIMING ERROR FOR A-D CONVERTER

INSUB
0
/STORES R-T. SUB. & API LEVEL FOR A/D

TIME
0
/STORES TIME (RESET EVERY 1 MIN.)

TIME0
0
/STORES TIME USED IN DATA HEADER

HVAC
0
/STORES AC DURING EACH HOUR

MIN
0
/STORES THE MIN. IN DURING EACH HOUR

MCNTR
0
/STORES # OF MIN. OF RUN

LETCHG
-DSA
MBLK
/ADDRESS OF SUB."REALM" BUFFER

BUF11
-DSA
BUF1
/ADDRESS OF BUF1

BUF21
-DSA
BUF2
/ADDRESS OF BUF2

BUK31
-DSA
BUK3
/ADDRESS OF BUFI

SEV13
37
/133:3: LEADING:

-DEC

MIN
599
/MAX # OF .1 MIN.'S IN 1 HOUR

H1
33999
/1000-599

H2
1000-599
/USED TO INCREMENT H1 BY 1 HOUR

DBP
-DSA
D90
/POINTER FOR THE D93's

DBQ
0
/CPU'S STORAGE BLOCK

38548
/ASCII DEFAULT SETTINGS

31152
/ARE 0-16-25 (DEC)

LAW
1
/TELLS END OF DB SETTINGS

ST1
-BLOCK
1000
/LIN. TABLE

POINT
-DSA
SEV13
/POINTER FOR COLLECTION BUFFERS

BUF1
-BLOCK
DTMA=383
/FIRST COLLECTION BUFFER

STT
-SIXBIT
"TABLEDATA"
/NAME OF FILE TO BE READ IN

MSG7
2000

LAST
-ASCII
"SET CONSOLE SWITCHES, TURN ON PULSER AND ENCODE PU"
"ASCII "LSZ"<15>

MSG8
2000

-ASCII
"DISCONNECT WIRE FROM PULSED OSCILLATOR"<15>

MSG9
2000

-ASCII
"SET ATTENUATOR TO 0-DE"<15>

MSG10
2000

-ASCII
"TYPE # OF HOURS FOR THE RUN AND C.R."<15>

MSG11
2000

0
IAC DAC FDAT2 / TWO
IAC DAC FDAT3 / THREE
IAC DAC FDAT5 / FIVE
TAD CODE3A
DAC FDAT18 / EIGHT
LAC* FDAT2 /SET DAT SLOT 5 EQUAL
DAC* FDAT5 / TO DAT SLOT 2
LAC* FDAT3 /SET DAT SLOT 1 EQUAL
DAC* FDAT1 / TO DAT SLOT 3
*INIT OUTPT,OUT,INTIM /*PREPARE FIRST STORAGE DEVICE
.CLEAR OUTPT
LAV -2 /ARE TWO STORAGE
TAD CODE21 / DEVICES - REQUIRED?
JMP NDK11 /NO, OMIT FOLLOWING CODE
LAC MDUM1 /YES, CLEAR JUMP AROUND INSTRUCTIONS
DAC NDK2 / TO USE A SECOND DISK
DAC NDK3 / FOR STORAGE
*INIT DATIN8,OUT,INTIM /*PREPARE SECOND DEVICE FOR USE
.CLEAR DATIN9 /*REMOVE ALL FILES FROM IT
JMP +3
NDK11 LEM* FDAT1 /CLEAR DAT SLOTS FOR THE
LEM* FDAT3 / SECOND STORAGE DEVICE
LAS AND CODE40 / SWITCH #1
DAC SFPO /SET ADDR. TO THIS VALUE
LAV -1 /ARE TWO STORAGE
DAC* DMV3 /SET TO ACKNOWLEDGE I C
JMP /JUMP AROUND SECOND BUFFER

BUFF *BLOCK DTBLK-390 /SECOND COLLECTION BUFFER

*DEBK LAC CODE19 /INITIALIZE BCD
DAC HRC / POINTER
ISZ CTM1 / HAS FOUR NUMBERS BEEN
SKP / READ
JMP OTLP /YES, EXIT FROM ROUTINE
*WHITE TTO,ASC,NSGT-0 /NO, ASK FOR TIME
*WAIT TTO
JMS READM /READ IN TIME
DT 0 /CONTAINS THE ADDR. OF CHAN. READ IN
LAV -5 / INITIALIZE COUNTER TO EXIT THE
DAC CTM1 / ROUTINE AFTER FIVE #S
LAW -3 / INITIALIZE COUNTER TO GET
DAC CTM2 / THE MINUTES
UEM MIN / INITIALIZE LOC. THAT SAVE
DEM HI / THE TIME AND MINUTES
NXT1 JMS CHKN /GET NEXT NUMBER
JMS* +AD /MULTIPLY BY POWERS OF TEN
LAC HRC / TO SET BCD EQUIVALENT
DAC SAV2 /SAVE THE MINUTES
TAD HR /SETS UP THE NUMBERS READ IN
DAC HA / AS THE PRESENT TIME
ISZ CTM2 /IS THE NUMBER PART OF THE MIN. ?
JMP JPAR /NO, FIRST TWO #S ARE THE HOURS
LAW -1 /RESET COUNTER TO GET ALL THE
DAC CTM2 / MIN. (REST OF THE #S)
LAC SAV2 /SET MINUTES AND
TAD MIN / SET INTO AN ADDH.*
DAC MIN / WHICH SAVES MIN.*
JPAR ISZ HRC /GET NEXT MULTIPLYING #
ISZ CTM1 /OBTAINED 3 NUMBERS ?
JMP NWK1 /NO, GET NEXT NUMBER
LAC MMIN /CHECK THE MINUTES
TCA MIN / IS THE MINUTES GREATER THAN
TAD MIN / THE MAX. NUMBER OF MINUTES
SMA / IN AN HOUR ?
JMP ADEBR /YES, ASK FOR THE TIME AGAIN
LAC CHR /NO, CHECK THE TOTAL TIME
TCA /IS THE TIME OF DAY #
TAD HR / LARGER THAN THE BIGGEST #
SMA / ALLOW THE TIME OF DAY ?
JMP ADEHR /YES, ASK FOR THE TIME AGAIN
LAC HR /NO, PUT THE TIME INTO THE
DAC TIMH / ADDHR. WHICH GIVE THE
DAC TIME / TIME OF DAY
-TIMER 360*70D.5 /SET UP THE TIMING R.+ T. SUB.
JMS* CONTL /TRANSFER CONTROL TO CONTROL PROGRAM
JMP +2
SMA  / IS THE NUMBER < 8 ?
JMP  / NO, EXIT
 ISZ*  / YES, SET TIME OF YEAR LOC. TO SUM.
JMP  / EXIT

WINL  / GET SECOND NUMBER
AND  / IS THE NUMBER AN ASCII zero (60) ?
CODE26  / YES, EXIT
SAD  / NO, SET TIME OF YEAR.
CODE27  / TO WINTER
JMP  / EXIT
LAW  / SUM
-1  / EXIT
DAC*  / SUM
SUM4  / TO WINTER
JMP  / EXIT

LETMON  / IS THE FIRST LETTER
TAD  / AN "A" ?
CODE28  / YES, EXIT
SPA  / A "M" ?
JMP  / YES, WINTER MONTH
WINL  / EXIT
TAD  / A "F" ?
CODE29  / YES, EXIT
SPA  / A "J" ?
JMP  / YES, SUM
WINL  / EXIT

DAC*  / WINTER
DMV6  / GET LOC. OF THE *JOIN TABLE
DAC  / SAVE THE LOCATION
DUM2  / GO TO FOREGROUND DEVICES
TAD  / AND SAVE THAT LOC.
CODE11  / GET THE NEG. OF THE # FOREGROUND
DUM1  / DEVICES AND DOUBLE THE #
TAD  / (2 WORDS PER DEVICE USED)
CODE34  / AND USE AS THE COUNTER
HAL  / SET UP THE NEXT DUMMY
DUM2  / Name
TAD  / IS IT A 5 (DISK) ?
CODE13  / YES, CHECK WHICH DISK
JMP  / IS IT A 4 (DEC TAPE) ?
LK3  / YES, CHECK WHICH DEC TAPE
SAD  / IS IT A 7 (P. PUNCH) ?
CODE14  / YES, SAVE IT
JMP  / SAUNI
DCTP  / YES, SAVE IT
JMP  / CONTINUE
SAUNI  / NAME

DLTDS  / DELETE ALL OTHER DEVICES
LAC*  / BY INSERTING A DUMMY NAME
DUM1  / SET UP THE NEXT DUMMY
TAD  / NAME
CODE37  / TAD
DAC  / DUM1  / IS IT SECOND DUMMY
CODE22  / NAME INTO THE TABLE
DUM1  / TAD
ISZ  / IS IT SECOND DEVICE
DUM1  / HAS ALL THE DEVICES BEEN CHECK ?
CODE38  / CONTINUE
LAC*  / YES, RETURN
DUM1  / TAD
DUM1  / GO TO NEXT DEVICE
CODE20  / TAD
DUM1  / NAME INTO THE TABLE
DUM1  / IS IT NEXT DEVICE
CODE24  / NAME
DUM1  / HAS ALL THE DEVICES BEEN CHECK ?
CODE25  / CONTINUE
DUM1  / TAD
DUM1  / NAME INTO THE TABLE
DUM1  / TO NEXT DEVICE
CODE28  / NAME
DUM1  / TAD
CODE37  / TAD
LAC*  / TAD
DUM1  / SET FIRST WORD
CODE15  / IS IT A 1 ?
DUM1  / TO UNIT NUMBER
CODE16  / IS IT A 3 ?
DUM1  / TAD
DUM1  / YES, CHECK FOR DOUBLE DEVICE COLL.
DUM1  / TAD
SAUNI  / NO, SAVE THE TWO WORDS
SNA  DEFD8   /   
JNP   DEFDB   / NO, USE DEFAULT DB   
LAW   -1   / YES, ALLOW POSSIBLY ONE MORE   
DAC   DBCNT1   / DB SETTING   
LSE   DBCNT2   / IS ONE # STILL UNPROCESSED ?   
SNP   NUM1+8   / NO, CONTINUE THE EXIT   
DAC   DBP   / SET THE LAST LOC. TO A NEG. #   
LAC   DBCNT1   / SET THE FORTRAN COUNTER   
DAC   DBP   / TO THE # OF DB SETTINGS   
TAD   CODE5   / IF THERE IS ONLY ONE DB   
BAL   / SETTING SET THE LINK   
LAC   DMU1   / SET UP JUMP AROUND COLL* READ IN   
Szl   DMU1   / IS THERE MORE THAN ONE DB SETTING ?   
DAC   UPATI   / NO, INSERT JUMP AROUND   
DAC   +3   / USE INPUTED DB SETTINGs   
DEFD8   LAC   CODE6   / SET UP ASCII CODE FOR   
DAC   DBO   / ZERO DB SETTING   
---------------------------------------
LAC   CODE28   / NO, INITIALIZE MULTIPLIER   
DAC   MINEQC   / TO CONVERT #S TO MIN*   
DZM   TCI   / INITIALIZE STORAGE ADDR. FOR CONVERTING   
LAC   (DBO)   / INITIALIZE DB SETTINGS TO   
DAC   DBP   / THE BEGINNING   
DAC   +3   / SET UP COLLECTION'S DB   
DAC   MSG9+11   / MESSAGE   
CALTB   -SEEK   TBI, STT   
READ   TBI, DUMP, STI, 512   / READ TABLE IN   
*VAIT   TBI   
*CLOSE   TBI   
LAV   -775   / PREPARES COUNTER TO CHECK   
DAC   DUM2   / THE VALIDITY OF THE LIN. TABLE   
LAC   (STI+1)   / SET POINTER TO THE SECOND   
DAC   DUM3   / LOCATION OF THE TABLE   
LAC   STI   / GET THE FIRST NUMBER AND   
CALLP   TCA   / COMPLIMENT   
TAD*   DUM3   / IS THE PREVIOUS NUMBER   
SPA   / LARGE?   
JMP   CALER   / YES, ERRORNEOUS TABLE   
LAC*   DUM3   / GET PRESENT LIN. NUMBER   
ISZ   DUM3   / GO TO NEXT NUMBER   
ISZ   DUMP   / IS IT THE END OF THE TABLE ?   
JMP   CALLP   / NO, CHECK NEXT NUMBER   
DMA   DFM10   / YES, DELETE *DAT SLOT 10   
LAC   / GET THE # 1 DATA SWITCH FROM   
AND   CODE40   / CONSOLE   
SZA   / IS IT SET ?   
JMP   DLWT   / YES, SURPRESS PRINT OUT   
*WRITE   TTD*ASC*MS17,0   
*WRITE   TTD*ASC*MS18,0   
*WRITE   TTD*ASC*MS19,0   
*WRITE   TTD*ASC*MS20,0   
DLWT   / NUMBER OF HOURS   
*VAIT   TTD   
JMS   DBSUB   / SET UP NEXT DB SETTING   
JMS   HEADM   / READ IN # OF HOURS   
HUNTIM   / CONTAINS ADDRESS OF THE #''S READ IN   
*INITI   TTD*OUT*PSTART   / RESET THE IP RESTART   
*INITI   TTD*IN*PSTART   / ADDRESS   
LAC   CODE35   / DEFAULT VALUE FOR THE LENGTH   
DAC   TC3   / OF HOURS (20 HOURS)   
DZM   DOSTK   / CHECKS # OF #''S READ IN   
LAV   -3   / PREPARE TO USE NO MORE   
DAC   TC2   / THAN THREE NUMBERs   
JMP   TAD   / CHECK IF CHARACTER READ IN   
LAV   -49   / IS AN ASCII # OR PERIOD   
DAC   HUNTIM   / SET LOC. IN CHAR. BLOCK   
ISZ   HUNTIM   / GO TO NEXT CHARACTER   
SPA   / IS ASCII CHARACTER < 43 ?   
JMP   FNUM   / YES, EXIT   
SAD   CODE46   / NO, IS IT A DECIMAL POINT ?   
JMP   DSCPT   / NO, GO TO DECIMAL POINT NO TIME   
TAD   CODE17   / NO, CHECK FOR AN ASCII NUMBER   
SZA   / IS THE CHAR. < 72 ?   
JMP   GETGA   / NO, GET NEXT CHAR   
TAD   CODE12   / YES, IS CHARACTER GREATER   
SPA   / THAN 57 OCTAL ?   
JMP   GETHR   / NO, GET NEXT CHARACTER   
JMS*   +40   / YES, GET THE BINARY CODED DECIMAL   
LAC   MINEQC   / EQUIVALENT OF THE NUMBER   
TAD   TC1   / ADD TO THE PRECEDING NUMBERS   
DAC   TC1   / AND SAVE   
ISZ   MINEQC   / SET UP NEXT MULTIPLIER   
ISZ   DOSTK   / INCREMENT NUMBER COUNTER   
ISZ   TC3   / HAS ENOUGH #'S BEEN OBTAINED ?   
JMP   GETHR   / NO, GET NEXT NUMBER
DECPT  JMP  CNUM  /YES, EXIT
DECT  LAW  -1  /SET COUNTER TO GET ONLY
LAW  -1  /ONE MORE NUMBER
TAD  Dstor  /COUNTER
SMA  /HAS TWO NUMBERS BEEN OBTAINED?
JMP  GETHR  /YES, GET THE LAST NUMBER
LAC  TCI  /OFF BY A FACTOR OF TEN TOO HIGH
CLL  /THEREFORE REDUCE THE NUMBER BY A 10
DIV  /FACTORS OF TEN (ZERO IS UNAFFECTED)
LACQ  /GET THE QUOTIENT
DAC  TCI  /REPLACE WITH CORRECTED
LAC  CODE2  /SET THE BCD POINTER TO
DAC  MINSIG  /THE LAST MULTIPLIER
ISZ  Dstor  /INCREMENT NUMBER COUNTER
JMP  GETHR  /GET NEXT NUMBER

FNUM  LAW  -2  /CHECK THE NUMBER
TAD  Dstor  /COUNTER
SMA  /HAS 2 NUMBERS BEEN READ IN?
JMP  CNUM  /YES, IGNORE THE FOLLOWING CODE
IAC  /HAS EVEN ONE NUMBER BEEN
SZA  READ IN?
JMP  NONUM  /NO, USE THE DEFAULT VALUE (13.65 HH)
LAC  TCI  /YES, THERE IS ONE NUMBER BUT
CLL  /IT IS THE WRONG BCD
DIV  /EQUIVALENT SO REDUCE IT BY 10
LACQ  /GET THE INTEGER ANSWER
DAC  TCI  /SAVE CORRECTED
LAC  TCI  /GET LENGTH OF RUN NUMBER
TGA  /COMPLIMENT IT
DAC  TCJ  /AND SAVE THE NEGATIVE

NONUM  DZM  TCI  /INITIALIZE LOC. TO DETERMINE
DZM  TCI  /THE END OF THE RUN
DZM  MINTH  /INITIALIZE BINARY TIME OF DAY
LAC  CODE18  /SET UP MAX. STORAGE FOR
DAC  Dstor  /STORAGE DEVICE
JMS  FRTS  /FREE BACKGROUND DEVICES
*TMGR  *BEGIN+6  /SET UP MAIN REAL TIME SUB.
JMS*  *PROC  /START PROCESSING PHR.
JMP  *4+  /# OF PARAMETERS +1
+SZA  SUM4  /THE SEASON OF THE YEAR
+SZA  ALF  /LINE FEED
+SZA  TINR  /TIME AT THE END OF EACH FILE
*IDLE

END  2000
  0  *ASCI  <14="***END OF PROCESSING***"<15>
STPM  2000
  0  *ASCI  <7><7><15>
  /EJECT

/THIS SUBROUTINE IS USED TO READ IN CHARACTERS FROM THE
/TELETYPONE AT A TIME UNTIL A CARRIAGE RETURN IS FOUND.
The CHARACTERS ARE STORED IN "NBLK" (A BLOCK OF LENGTH 30). THE
/ADDRESS OF "NBLK" IS PUT INTO THE LOCATION AFTER THE "JMS READM"
/INSTRUCTION USED TO CALL THIS ROUTINE. THE PROGRAM CONTROL IS.
/THEN RETURNED TO TWO LOCATIONS AFTER THE CALLING INSTRUCTION.

/XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

READM  0
LAC  NUMB  /SET THE ADDR. OF THE BLOCK CONTAINING
DAC*  READM  /THE READ IN CHAR. INTO THE CALLING
ISZ  READM  /LOC.+1 AND RETURN TO LOC.*+2
CONR  .READ  TTI+IA+MTI.3  /READ IN ONE CHARACTER
.WAIT  TTI
LAC  MTI+2  /GET THE CHARACTER
DAC*  NUMB  /STORE IN THE CHAR. BLOCK
SAD  (177  /IS THE CHAR. A RUBOUT?
JMP  AOU  /YES, DELETE PREVIOUS CHAR.
ISZ  NUMB  /NO, PREPARE FOR NEXT CHAR.
SAD  (15  /IS THE CHAR. A +0?
JMP  DLT  /YES, DELETE THE LINE
SAD  (15  /NO, IS THE CHAR. A CARRIAGE RETURN?
SRP  /YES, EXIT FROM THE READ LOOP
JMP  CONR  /NO, GET NEXT CHAR.
LAC  (NBLK  /INITIALIZE CHARACTER BLOCK
DAC  NUMB  /POINTER
LAC  (18  /WRITE OUT ON TTY
DAC  RBOT+8  /A LINE FEED
DLT
LAC INBLK /RESET POINTER TO THE BEGINING
NUMB /OF THE BLOCK
LAC (180) /SET UP TO WRITE
JMP +11 /AN 0 CHAR.

ROU
LAC (15) /SET A CARRIAGE RETURN INTO THE
DAC* NUMB /PRESENT LOC. OF THE CHAR. BLOCK
LAW =1 /GO BACK TO WRITE OVER
TAD NUMB /THE PREVIOUS CHAR.
SAD NUMB /IS THE POINTER AT THE BEGINING?
JMP CONR /YES, DO NOT PRINT OUT ANYTHING
DAC NUMB /NO, RESET POINTER BACK 1 LOC.
LAC (124) /PREPARE TO WRITE A "RUBOUT" CHAR.
DAC RBOT+8 /SET IN OUTPUT ADDR.
JMS WRT /WRITE OUT THE ONE CHAR.
JMP CONA /READ NEXT CHAR.

WRT 0
*WRITE TTO IA, RBOT+3 /WRITE ONE IMAGE ALPHANUM. CHAR.
WAIT TTO /RETURN
RBOT 2003 /IMAGE A. OUT PUT
0 /MESSAGE
0 /LOC. TO STORE CHAR. TO OUTPUT
MTTI *BLOCK 3 /BLOCK CHAR. IS READ INTO.
NUMB *BLA NBLK /CHARACTER BLOCK POINTER
NBLK *BLA /BLOCK TO STORE ALL THE READ IN CHAR.

/*
  THE R.-T. SUBROUTINE THAT KEEPS TRACK OF THE TIME OF DAY
  THE SUBROUTINE IS INITIATED BY A "TIMER" WHILE STORING THE PRESENT
  "TIME" IN LOCATION "TIME" AND THE MINUTES * TEN IN "MIN". THE ROUTINE
  RESTARTS IT SELF STORING THE UPDATED TIME IN "TIME" AND THE UPDATED
  MINUTES TIMES TEN IN "MIN" USING BINARY CODED DECIMAL. THE BINARY
  REPRESENTATION OF THE NUMBER OF TENTHS OF MINUTES THAT HAS PAST IS
  GIVEN IN LOCATION "MONTH".
  */
TOD 0
DAC SVAC /SAVE AC FROM LOWER APL LEVELS
*TIMER 360+TOD+5 /RESTART CLOCK FOR ANOTHER 6 SECONDS
I3E MCNT /INCREMENT BINARY COUNTER
LAC MIN /CHECK THE MINUTE ADDR.
SAD MMIN /IS IT SET TO 59+9 MINUTES?
JMP CHN /YES, SET UP THE NEW HOUR
I3E MIN /NO, INCREMENT THE MINUTE COUNTER
I3E TIME /AND TIME OF DAY COUNTER
RESTOR LAC SVAC /RESTOR AC FOR LOWER LEVEL PROGRAM
*HLXIT TOD /EXIT FROM PHOS, AND API LEVEL
CHN DNM MIN /RESET MINUTES TO ZERO
LAC TIME /CHECK TIME OF DAY
SAD CHA /IS THE TIME AT THE END OF THE DAY?
JMP CTIME /YES, START A NEW DAY
TP NXHR /NO, CHANGE TO NEXT HOUR
DAC TIME /AND SAVE THE TIME
JMP RESTOR /EXIT
CTIME DNM TIME /RESTART TIME TO A NEW DAY
JMP RESTOR /AND EXIT

/*
  EXIT
  */
PSTART DNM BEGIN /RESET R.-T. SUB. BEGIN TO BE RENTERED
LAC MDUMI /PREPARE TO REINITIALIZE THE STORAGE
DAC START /DEVICE AND BEGIN A NEW FILE
LAC IDCOU /HAS THE COLLECTION FINISHED COLLECTING
SPA /THE PRESENT FILE?
JMP +3 /YES, LEAVE AS SET UP
DAC JMP RESTART /NO, PREPARE TO CLOSE THE
LAC (JMP RESTAR /OLD FILE
*TIMER 0 BEGIN 6 /RESTART THE COLLECTION
JMP DUM1+ /RESTART THE PROCESSING PROGRAMS

/*
  MAIN PROGRAM
  */
BEGIN 0
DAC SAVDAC /ENTERANCE TO THE MAIN REAL TIME SUB.
NOP /ST MNT.
CI *INIT OUTPT+OUTP+RESTAR /DT OUT
JMP INIT /GO TO INITIALIZING ROUTINE
ADO JMS ADREAD /PREPARE TO READ FROM A-D CONVERTER
TNSAM /# OF DATA NUMBERS TO READ
BUF ADDR. TO STORE DATA *#.
ERG /COMPLETION AND ERROR TIMING FLA3
50000+RSUB /PRIORITY LEVEL * R.-T SUBR. TO EXEC.
96

RET3 LAW -1 /LOAD -1 INTO MEMORY TO KEEP TRACK OF
DAC CNT2 / THE SAMPLE THAT HAS BEEN COLL.
LAC SAUDBL /RESTORE ACCUMULATOR
END1 +RLXIT BEIN /RELINQUISH CONTROL TO LOWER PRIORITY
ONCE NOP
PK0 JMS ADHEAD /A-D CONV. READ FOR X-SAMPLES
TNSAM /THE VARIABLES USED
BUF /ARE THE SAME ONES USED FOR
ERR / THE O-SAMPLE AND ARE
SAUDBL+RSUB /EXPLAINED ABOVE
LAC SAUDBL
END2 +RLXIT BEIN /RELINQUISH CONTROL
RET2 LAC THAVF /GET DECTAPE TRANSFER FLAG
SEA / AND TEST IT
JMS DTRANS /CLEAR AC TO READ CONSOLE SWITCHES
A CLAICLL
LAJ (JMP A SET UP TO RECHECK CONSOLE SWITCHES
LAC START / AND PUT INTO START
LAC SAUDBL /PUT CLOCK BACK INTO
+TIMER 00WTI+6 /LOWER LEVEL BEFORE RECHECKING SWITCH
WTI 0
DAC SAUDBL /PUT CLOCK BACK INTO
LAC MDUM1 /OPERATION
DAC ONCE /TELLS PROC. COLL. HAS STOPPED
DEM CNT /GET # FROM CONSOLE’S DATA SWITCHES
LAC (JMP A /PUT BIT 00 OF AC IN L
SNL /IS THE LINK A ZERO ?
+MP RDO /YES; L=9 COLLECT DATA
+TIMER 120WTI+6 /NO; STOP COLL. AND GIVE TIME TO A
+RLXIT BEIN / RELINQUISH CONTROL TO LOWER LEVEL BEFORE RECHECKING SWITCH

/ END OF MAIN PROGRAM

BUFF BLOCK DATBLK /BUFFER TO STORE AD SAMPLES
NAME *SIXBT "DATAPIDAT" /NAME OF FILE TO STORE DATA
/INITIALIZING ROUTINE
/INIT LAC (BUFI /POINTER IN DECTAPE BUFFER
DAC IBUF /NAME OF DECTAPE BUFFER IN USE
LAC IDCOU /SAVE THE ID # (THE #
DAC CNI / OF FRAMES PER FILE)
DEM IDCOU /ID NUMBER
DEM T-ANF /DECTAPE TRANSFER FLAG
DEM CNT /COUNTER FOR CLOCK
LAC MDUM1 /PUT CLOCK INTO OPERATION
DAC ONCE /TELLS PROC. COLL. HAS STOPPED
LAW -2 /SET BUFI AS THE FIRST
DAC CTT6 / BUFFER TO BE USED
LAC CTT7 /INIT; NOISE MAX.
DAC MAX4 /LOCATION
LAW MNCC /INITIALIZE COUNTER FOR MAXIMUM
DAC CTT8 /ALLOWABLE NOISE
LAC MONTH /GET THE LENGTH OF TIME REQUIRED
TAD TCI /COLLECT THE PREVIOUS FILE
DAC DBC /SAVE IT
TAD TCG /ADD TO ALL OTHER PREVIOUS TIMES TO
DAC TC2 /COLLECT THE OTHER FILES; SAVE AND
TAD TC3 /COMPARE TO THE MAXIMUM TIME
SMA /ARE THE FILE TIMES LARGER?
JMP EXTIP /YES, STOP COLLECTION
/DECTAPE FILE ROUTINE
/STORE DATA IN FILE ACCORDING TO RESPONSE
/UP +FSTAT OUTPT#NAME /CHECK FOR COLLECTED FILE
UP1 JMP UPDATE /REPLACED BY "SEA"IS FILE PRESENT?
WRITE LAC MCTR /YES; ACKNOWLEDGE THE PRESENCE
TCA /GET THE BEGINNING TIME FROM
DAC TCI /THE BINARY CLOCK COUNTER
DAC DBC /TO DETERMINE THE COLL. TIME
DAC TC1 /DETERMINE THE COLL. TIME
DAC TC2 /DETERMINE THE COLL. TIME
DAC TC3 /DETERMINE THE COLL. TIME
SMA /SAME TIME?
JMP EXTIP /YES, STOP COLLECTION
/C3 *ENTER OUTPT#NAME /DETERMINE THE COLL. TIME
JMS DTRANS /OPEN FILE
JMS DTRANS /WRITE DUMMY BLOCK
JMS DTRANS /WRITE DUMMY BLOCK
LAC MDUM2 /TELLS PROCESSING THAT COLLECTION
DAC REPL /HAS STARTED COLLECTING A FILE
JMP RDO /RETURN
UPDATE LAC TIME
/SETS THE TIME TO THE END
TAD CS
/ OF THE COLLECTED FILE AND
DAC TIMR
/ AND AROUNDS OFF TO THE NEAREST MIN.
*WRITE TTO ASC MSG1 0
/FILE PRESENT
*WAIT TTO

UPDATE NOP TTO ASC MSG 34
/REPLACED BY "JMP BLK2" FOR 1 DB SET.
*WAIT TTO

BLX1 JMS READM
/READ RESPONSE
COM 0
/ADDRESS OF THE RESPONSE
GETCH1 LAC* COM
/GET READ IN CHARACTER
DEZ* COM
/ AND ZERO THE LOC.
SAD (116)
/IS CHARACTER A "N"?
JMP STAGN
/CHECK IF NUM, IS LESS
TAD (-72)
/ THAN 78 OCTAL
SPA BLK3
/NO, CONTINUE
JMP BLK3
/YES, IS NUM, GREATER THAN
SPA
/ 75 OCTAL
JMP BLK3
/NO, CONTINUE
DAC* COM
/YES, SAVE
ISZ COM
/NEXT CHARACTER
JMP GETCH1
/REPEAT

BLK3 LAC GETCH1
/INITIALIZE THE BLOCK
DAC COM
/ CONTAINING THE INPUT CHAR.
LAC* COM
/GET FIRST CHAR.
SNA CONDB
/IS IT A ZERO?
JMP CH3
/PASS TO PROC THE DB CHANGE
DAC* <=1
/OFFSET THE # BY -1
CALLRAR
/DIVIDE BY TWO AND SAVE REMAINDER
TAD (60)
/SET UP AS ASCII CHA-
SPA
/PREPARE FOR MESSAGE
DAC* DBP
/SAVE NUMBER
LAC (140)
/ASCII FOR ZERO
SZL

LAC (152)
/ASCII FOR NUMBER 5
TAD* DBP
/Add TO OTHER DB SETTING
CALLRAR
/SET UP AS CHAR: 455 IN ASCII WORDS
DAC* DBP
/SAVE NEW DB SETTING
CONDB ISZ DBP
/GET NEXT CHAR.
LAC* COM
/SET UP NEXT CHAR.
SAD (-15)
/IS CHAR: A CARRIAGE RETURN?
JMP +4
/YES, EXIT
SZA
/NO, IS IT A ZERO?
DAC* CMULC
/NO, SET UP MUL. CONSTANT CHANGE
DEZ* COM
/CLEAR CHAR.
JMS DBSUB
/SET UP NEXT DB MESSAGE
DAC CN2
/GET STORAGE ALREADY USED
DAC CN2
/ADD STORAGE SIZE OF LAST
TAD CNI
/FIIE AND SAVE
DAC CN2
/ADD IT AGAIN AND CHECK--
TAD TEM1
/WILL ANOTHER FILE OF THE SAME
TAD DSTOH
/LENGTH OVERFLOW THE STORAGE ALLOW?
SMA

MDUM3 JMP RPT1
/YES, RESTART THE COUNTING
ISZ NAME+1
/NO, INCREMENT NAME
ISZ MS1+3
/INCREMENT TELETYPE
ISZ MSG1+3
/MESSAGE TWICE
JMP WRITE
/RETURN TO NEW FILE
STAGN LAC CN1
/HMOVE THE SIZE OF
TCA
/ THE LAST FILE
TAD CN2
/ FROM THE
DAC CN3
/STORAGE COUNTER
LAC DBC
/HMOVE THE AMOUNT OF
TCA
/ TIME USED
TAD TCA
/BY THE PRECEEDING
DAC TCB
/FILE
JMP WRITE
/RECOLLECT FILE
/DDBDDBDBDBDBDBDBDBDBDBDBDBDBDBDBDBDBDBDBDBDBDBDBDBDBDBDBDBDBDBDBDBDBDBDBDBDB
/ SUBROUTINE TO CHANGE THE DB MESSAGE TO BE PRINTED OUT

/ DBSUB 0
ISZ DBP
/GET NEXT DB
DAC DBP
/MESSAGE
SMA
/IS IT THE END OF THE DB MESSAGES?
JMP +4
/NO, USE THIS MESSAGE
LAC (DB0)
/YES, REPEAT THE
DAC DBP
/ FIRST DB
DAC* DBP
/SETTING GIVEN
DAC MSG1+11
/INSERT MESSAGF
JMP DBSUB
/RETURN
AN ID IS ASSIGNED AND 26 SAMPLES ARE PACKED WITHOUT WORD
A TOTAL OF 14 WORDS ARE PUT INTO A DECTAPE BUFFER FOR EACH CALL
HIGHEST ORDER BIT IS LOST AND NEG. NUMBERS ARE SET TO ZERO
ALTERNATES BETWEEN TWO DECTAPE BUFFERS-
WHEN ONE IS FULL THE OTHER IS USED FOR STORAGE
THE BUFFERS ARE LOCATED IN DLOGF AND WHITE OVER PART OF IT

RSUB

DAC SAV /SAVE AC
MDUM1 NOP /INCREMENT COUNTER
DEM DUM2 /INITIALIZE THE VARIABLES USED
DEM DUM3 / TO DETERMINE THE NOISE
LAW NPFC /USE FIRST 5 NOISE SAMPLES TO SET DAC
DAC CTTI / MAX. ALLOWED NOISE FOR PROC.
LAC PAC /SKIP NOISE AFTER THE 5TH
DAC CIT5 / NOISE SAMPLE
LAW -1001 /IS THERE A DISK TIMING ERROR?
SAD EN3 / ERROR?
JMP EN5 /YES, PRINT MESSAGE
NOISE ISZ IDCOU /NO, INCREMENT ID NUMBER
LAC IDCN /ASSIGN ID NUMBER
DAC* POINT / TO BE PLACED ON STORAGE DEVICE
ISZ POINT /INCREMENT POINT TO NEXT LOCATION
DATA LAW -NPFC /COUNTER SO THAT 13 WORDS ARE PACKED
JMS PAC /GO TO PACKING ROUTINE
LAC DUM3 /SET SUM OF THE NEW 4 NOISE SAMPLES
TAD DUM5 / AND ADD TO THE 72 NOISE SAMPLE GROUP
LAC DUM5 /USE NEW SUM
LAC DUM2 /SET NEW MAX. FOR THE 4 NOISE SAMPLES
TCA /COMPARE NEW MAX.
TAD DUM4 / WITH OLD MAX.
SKP3 DAC SAV /YES, SET MAX. OF NEW 72 NOISE SAMPLES.
TAD MAX4 / AND COMPARE IT WITH THE MAX.
SKP3 DAC DUM4 / OF THE PREVIOUS 72 SAMPLES
LAC DUM4 / IS THE NEW ONE LESS THAN THE OLD ONE?
JMP SGP4 /ANO, PREPARE FOR ANOTHER COLLECTION
DAC CTT2 /NO, REPLACE THE OLD MAX.
DAC CTT2 / THE NEW MAX.
DAC DUM4 /REPLACE THE OLD SUM WITH
LAC DUM4 / THE NEW SUM
LAC DUM4 /RESET NOISE SAMPLING
SKP3 DUM DUM /LOCATIONS
SKP4 DAC DUM ONCE /PREPARE TO REENTER R-T SUB. "BEGIN"
LAC JMP RIT2 /BY INSERTING INTO LOG START
DAC RIT2 / A JUMP STATEMENT DEPENDING ON
LAC SAV / WHETHER 0=BEGIN OR 6
+HIXIT R52B /ENTER R-T SUB. "BEGIN"
PAC 0 /STORE WORD NUMBER BEING PACKED
DAC COT2P /BUF-1
LAC (BUF-1) /BUF POINTER
PAKING JMS LIN /GO TO TABLE ROUTINE
LAC DUM1 /STORE POINT
DAC* POINT /STORE
JMS LIN
LAC DUM1
TAD* POINT  /PACK INTO PREVIOUS ONE
DAC* POINT  /STORE IN BUF1
ISZ POINT  /MOVE POINTER UP ONE WORD
ISZ COUNT  /ONE WORD HAS BEEN PACKED
JMP* PAIN  /13 WORDS HAVE NOT BEEN PACKED
LAC* POINT  /13 WORDS HAVE BEEN PACKED
ISZ CTT8  /END OF BUFFER ?
JMP* PAC  /NO, CONTINUE COLLECTION
LAV -DATSTR  /YES, RESET THE BUFFER
DAC CTT8  /COUNT
LAC BUF01  /SET POINTER TO SECOND
DAC POINT  /BUFFER--BUF2
DAC BUF11  /GET FIRST BUFFER ADDRESS
ISZ CTT6  /JUST FINISHED FILLING BUF1 ?
JMP *+5  /YES, PREPARE TO STORE
DAC POINT  /BUFK2
LAW -DATSTR  /YES, RESET THE BUFFER
DAC CTT6  /COUNT
LAC Buf21  /END OF BUFFER ?
JMP* PAC  /CONTINUE COLLECTION
LAW -DATSTR  /YES* RESET THE BUFFER
DAC CTT8  /COUNTER
LAC BUF21  /SET POINTER TO SECOND
DAC point  /BUFFER--BUF2
LAC BUF11  /GET FIRST BUFFER ADDRESS
ISZ CTT6  /JUST FINISHED FILLING BUFI ?
JMP* PAC  /CONTINUE COLLECTION
LAW -DATSTR  /YES* RESET THE BUFFER
DAC CTT6  /COUNT
LAC Buf21  /END OF BUFFER ?
JMP* PAC  /CONTINUE COLLECTION

ERS1 *WRITE 70*ASC>*9<,0  /TIMING ERROR
LAC MDUMI  /PUT CLOCK OPERATION BACK
DAC ONCE  /IN PROGRAM
ISZ CNT  /PREPARE TO REJECT O-X PAIR
DAC JMP  /REJECT NEXT X-SAMPLE
LAC CNT2  /WAS THE LAST AN O-SAMPLE ?
DAC JMP  /NO, REJECT THE FORMER O-SAMPLE
DAC START  /YES, REJECT NEXT SAMPLE
*TIMER &BEGIN*  /RETURN TO COLLECTION
*NLXIT  &SUB

MSG5  2800
0  /ASCII "TIMING ERROR"<5>
/ $$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$%
/ ***********************************************************************
/ SUBROUTINE TRANSFERS 1 BLOCK OF DATA FROM A DESIGNATED BUFFER
/ TO THE STORAGE DEVICE BEING USED.
/ **********************
/ DTRANS  0
LAC TBUI  /PASS NAME OF BUFFER
DAC *+3  /TO WRITE
C4 *WRITE  OUTPT  DUMP  0,252
C5 *WRITE  OUTPT  DUMP  0,252
JMP* PAC  /CONTINUE COLLECTION

/***********************************************************************/
/ SUBROUTINE TO CHECK WHICH DATA CONSOLE SWITCHES ARE SET.
/ TOO LARGE SETTINGS AND TOO SMALL SETTINGS ARE GUARDED.
/ CKCNT  0
LAC TBUF  /PASS NAME OF BUFFER
DAC +*3  /TO WRITE
C4 *WRITE  OUTPT  DUMP  0,252
C5 *WAIT  OUTPT  DUMP  0,252
JMP* DTRANS

/***************************************************************************/
ROUTINE TO CLOSE FILE AND SET UP PARAMETERS FOR COLLECTION AND PROCESSING

RESTAR LAC TRANF /COMPLETE TRANSFER IF NECESSARY
MDUM2 SZA JMS DTHANS
C6 *WRITE OUTPT>DUM,>SEVN>2 /WRITE END OF FILE ID
C7 *CLOSE OUTPT
LAC MDUMI /INITIALIZE THE LOCATIONS
DAC START /"START" FOR COLLECTION
DAC REPL /AND "REPL" FOR PROCESSING
DAC SUM4 /GIVE THE SUMMATION OF THE LOWEST
DAC SUM5 /NOISE TO THE PROCESSING
DAC CHG /RESET DB CHANGER
LAC MDUM2 /IGNORE THE FIRST
DAC UP1 /FILE ONLY
JMP START /GO TO START

CLOCK INTERRUPT ROUTINE FOR AUTOMATIC 0-SAMPLE START

CHECK 0
DAC SAV /SAVE AC
DAC BEGIN /ZERO X-T SUB TO AVOID POSS. ERROR
DAC CNT /EXAMINE COUNTER
DAC LOW /LOWEST BIT OF CNT IN L
DAC BKP /L=I-CNT ODD-HALF FRAME DURING 9/60 SEC
DAC CONT /L=0-CNT EVEN-FULL FRAME DURING 9/60 SEC
DAC CNT /CLEAR HALF FRAME THAT WAS TAKEN
DAC BKUP /RESTORE LINK
DAC -1 /RESET IDCOU BACK ONE FRAME
DAC-IDCOU /BACK ONE
DAC CT18 /FRAME
DAC -BPK /RESET POINT BACK HALF FRAME
DAC CONT /PUT CLOCK BACK INTO OPERATION
DAC-EXT1 /PREPARE TO EXIT

DONM HAL
DAC-CONT /TESTORE THE LINK
DAC BPOINT /DATA STARTS AT BJF
DAC BPOINT /GET INPUT DATA WIND
DAC ERM /MASK ANY EXTRA BITS
DAC (+1333) /CHECK FOR NEG. #'S
DAC BKP /NEI # FOUND
DAC-C1777 /LOCATE # IN TABLE
DAC IDCOU /GET ADDRESS OF NUMBER
DAC DUMI /LOAD LINEARIZED # INTO AC

LIN 6
DAC CT11 /IS THIS THE FIFTH NOISE SAMPLE ?
DAC CT15 /IS IT A NOISE SAMPLE ?
DAC DUMI /STORE LINEARIZED #
DAC DUMI /IS THIS THE FIFTH NOISE SAMPLE ?

SUBROUTINE TO DO A TABLE LOOKUP FOR DATA LINEARIZATION.
ALSO SAVES SUM AND MAXIMUM OF EACH SET OF 5 NOISE SAMPLES,
SETS NEGATIVE NUMBERS TO ZERO, AND IF NECESSARY JUMPS AROUND "SKAR" NUMBER OF DATA NUMBERS BETWEEN THE NOISE AND DATA POINTS.

LIN 9
DAC BPOINT /DATA STARTS AT BJF
DAC BPOINT /GET INPUT DATA WIND
AND (1777) /MASK ANY EXTRA BITS
TAD (+1333) /CHECK FOR NEG. #'S
SMA
JMP ERM /VEI # FOUND
TAD (C1777) /LOCATE # IN TABLE
DAC DUMI /GET ADDRESS OF NUMBER
DAC* DUMI /LOAD LINEARIZED # INTO AC
DAC DUMI /RESTORE THE LIN. DATA #
DAC DUMI /RETURN TO POINT AT WHICH INTERRUPT
DAC* CT15 /COUNTER

/
**ADCR**+85
**ADCA=ADCR+1**

/ A-D WORD COUNT
/ AND CURRENT ADDRESS REGISTERS
/ S Com=100
/ MONITOR'S COMMUNICATION AREA
/ ADVI=783724
/ A-D CONVERTER WRITE INITIALIZ
/ ADSO=783701
/ ADST=783721
/ ADCO=783704
/ ADCT=783744
/
/ ENTRY POINT FOR A-D INTERFACE INITIALIZATION
/
/ ADREAD 0

JMP INSET

/ REPLACED BY "LAC* ADREAD"
/ TCA
/ DAC* (ADCR)
/ SET WORD COUNT
/ LAC* ADREAD
/ ISZ ADREAD
/ LAW -1
/ IA0* ADREAD
/ BUFFER ADDRESS -1
/ DAC* (ADCR)
/ TO CURRENT ADDRESS REG.
/ ISZ ADREAD
/ DAC INFLAG
/ DZM* INFLAG
/ LAC* ADREAD
/ LAC INSUB
/ ISZ ADREAD
/ POINT TO RETURN LOCATION
/ ADWI
/ INITIALIZE INTERFACE
/ JMP* ADREAD
/ RETURN
/
/ THE FOLLOWING CODE IS EXECUTED ONLY ONCE
INSET LAC* (+SCOM+55)
/GET ENTRY POINT ADDRESSES OF .SETUP
ADSVA DAC *
/ LAC* (+SCOM+51)
/ ENTRY POINT OF REALTP
REALTP DAC *
/ LAC (400010)
/RAISE THE API
ISA / LEVEL
JMS* ADSVA
/ CALL SET UP TO CONNECT
ADSI / THE API
DBK / DBREAK FROM API LEVEL
LAC (LAC* ADREAD)
/ MODIFY INSTRUCTION
DAC ADREAD+1
/ AND JMP TO IT
/
/ INTERRUPT SERVICE ROUTINE. EXECUTED IMMEDIATELY AFTER COMPLETION
/ OF DATA TRANSFER, DETERMINES STATUS OF A-D INTERFACE, SETS
/ COMPLETION FLAG AND ACTIVATES REAL-TIME SUBROUTINE.
/ HUNTS AT API LEVEL 0.
/
/ ADINT 0
DBA /PAGE ADDRESSING MODE
DAC ADSVA /SAVE AC
ADST /TIMING ERROR?
S K IPLAI LAC /NO-1 TO AC
LAW -1001
/YES, ERROR CODE
DAC* INFLAG /SET FLAG
ADCO
/ CLEAR
ADCT /INTERFACE FLAGS
LAC* (+SCOM+102)
/RAISE TO API
ISA / LEVEL 3 OR 1
LAC INSUB /REAL-TIME SUBROUTINE ADDRESS
SNA
JMP ADIXT /BYPASS MONITOR CALLS IF ZERO
JMS* REALTP /ACTIVATE REAL-TIME SUBROUTINE
ADIXT LAC (40000)
/REQUEST AN API INTERRUPT
ISA / AT SOFTWARE LEVEL 4
LAC ADSVA
/RESTORE AC
DBK /SET TO LEAVE HARDWARE API LEVEL
JMP* ADINT /RETURN TO INTERRUPTED PROGRAM
/
/**********************************************************************************
/ EJECT
/XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
/ PROCESSOR'S MACRO PROGRAMS, THEY INITIALIZE THE STORAGE
/ DEVICE, WAIT FOR FILE TO BE COLLECTED, CHECK FOR UNWANTED
/ COLLECTION, STOPPAGE, SWITCH STORAGE DEVICES IF NECESSARY, TELL
/ WHEN THE PROGRAMS HAVE REACHED THE END OF RUN, GIVES TIME TO
/ BACKGROUND AND READS IN DATA AND UNPACKS IT.
CHNG 0
JMS* DA /LOAD PARAM. ADDR. IN SMS AND CHG
JMP +4 /SKIP OVER PARAM. LIST
SUMS 0
CHG 0
CMULC 0
ISZ CTTI0 /LOGIC. TO CHANGE MUL. CONSTANT
SKP
JMP AGN /YES. RESET PARAMETERS TO BEGIN. OF DEV.
*+4
/NO
DU7 ISZ FIL+1 /CHECK IF COLLECTION IS FINISHED COLLECTING NEW FILE
LAC FIL+1 /IS THE COLLECTION
CMA NAME+1 /RECOLLECTING
TAD / THE FIRST FILE
SPA
LAW -1 /NO. SET THE COUNTER TO JUMP AROUND
DAC CTTI0 /YES. SET COUNTER TO A POS. #
LAW -1 /PREPARE TO READ
DAC CTT9 /DATA
LAC BUF31 /RESET BUF3 POINT WITH
DAC LOA / DUMMY BLOCKS
C13 INIT DATIN,IN=0
RT FSTAT DATIN,FIL /CHECK FOR PRESENTS OF NEW FILE
SNA JMP ENR3 /FILE NOT PRESENT
C11 SEEK DATIN,FIL /PREPARE TO READ
FIL* JMP CHNG /RETURN TO FORTRAN PROGRAM
ENR3 WRITE TIO+ASC,MSG6,0 /FILE NOT FOUND
S4 WRITE TIO+ASC,END,0 /FILE NOT FOUND LOOK FOR NEXT FILE
MS36 2000
0
ASCII "FILE NOT FOUND"<15>
AGN LAC API /INITIALIZE DATA=FILE
DAC FIL+1 /NAME
NDKR3 SKP /DETERMINES # OF STORAGE DEVICES
JMS SWIT /CHANGE STORAGE DEVICES
JMP DUM7+1 /NO, CONTINUE PROCESSING
ENDPH WRITE TIO+ASC,END,0 /END OF PROC. MESSAGE
WAIT TIO
JMS READM /WAIT FOR RESPONSE AND PUT
ANSE 0
LAS ANSE
SAO K120 /IS THE RESPONSE A "P" ?
JMP NSTA /YES, SET UP TO RESTART EVERYTHING
*+1
/NO, GIVE COMPLETE CONTROL TO BG.
KSTR CLEAR DATIN /CLEAR COLLECTION DEVICE
*+1 WRITE TIO+ASC,MSG2,0 /DB MESSAGE
SELECT TIO
JMS DBSUG /SET UP NEXT DA SETTING
JMS READM /WAIT FOR REPLY
STATE 0
ZER DZM MCNTR /ZERO BINARY TIMER
/RESTART COLLECTION
JMP AIN /RESTART PROC.
/ SUBROUTINE USED TO WAIT FOR FILE TO BE COLLECTED AND STORED
/ WHILE GIVING TIME TO BACKGROUND
STATE 0
STATE
LAC NAME+1 /COLLECTION'S FILE NAME
SAO FIL+1 /IS PROC.'S FILE NAME THE SAME ?
KSTR CONT,0 /YES, RETURN TO PROCESS FILE
JMS CTTI0 /END OF THE
SKP /JMP ?
JMP ENDPH /YES,EXIT
*+1 WRITE 30,WAIT,0 /YES, RELINQUISH TIME TO BG.
LAC SAVAC /STOCK AC
*+1 IDLE /WAIT FOR CLOCK INTERRUPT
/REAL TIME SUB** USED TO ALLOW TIME FOR BACKGROUND
WAI 0
DAC SAVAC /SAVE AC
ZER DZM WATT,0 /ZERO H-T SUB. ENTRY PT. TO ALLOW REENTRY
JMS CKCOL /CHECK FOR COLLECTION STOPPAGE
JMP +8 /CHECK FOR END OF COLL.
/ SUBROUTINE TO CHECK FOR UNATED COLL. STOPPAGE
CKCOL 0
LA+ -2 /HAS COLL. ENDED ALL COLLECTIONS
TAD CAT /FOR TODAY?
SPA* CKCOL /YES, RETURN
LAC TSTI /NO, HAS COLLECTION STOPPED
CCCCCCCCCCCCCCCCCC--CONT--CCCCC CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C PROGRAM SETS UP CALIBRATION AND THE HEADING FOR THE PRINT
C OUT OF THE PROCESSED DATA IN PROC. THE PROGRAM CALLS:
C TBFORL--CALIBRATION PROGRAM
C DLOGF--INITIAL MACRO PROGRAM
CCCCCCCCCCCCCCCCCC CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C
SUBROUTINE CONTL(ISURP)
INTEGER DB(4) DBC
REAL DATE(2), REAS(5)
COMMON /STAT/ DB, DATE, REAS, DBC, DBS, NCA
DATA NR/120784/
REWIND 4
C INITIALIZE THE DB SETTINGS USED
DBC=3
DB(2)=10
DB(3)=25
IF(ISURP.NE.0)GO TO 5
C GIVE PRECALIBRATION SETUP
WRITE(6,100)
100 FORMAT(46H TURN OFF PULSER AND ENCODE PULSE POWER SUPPLY/)
C SET UP CALIBRATION AND LINEARIZATION TABLE
CALL TBFORL
C ASK FOR AND GET THE DATE
WRITE(6,101)NH
101 FORMAT(5H DATE A2)
READ(4,201)DATE
201 FORMAT (8AS)
C ASK FOR AND GET THE REASON FOR THE RUN
WRITE(6,102)NH
102 FORMAT(16H REASON FOR DATA A2)
READ(4,202)REAS
202 FORMAT (8AS)
C PREPARE FOR COLLECTION AND PROCESSING
CALL DLOGF(DB, DBC, DATE)
RETURN
END

CTTTTTTTTTTTTTTTTTTTTTTTTTTTTTT---TBFORL---TTTTTTTTTTTTTTTTTTTTTTTTTTTTTT
C THIS PROGRAM SETS UP A LINEAR APPROXIMATION TO THE INPUT OF
C THE RECEIVER VERSUS THE OUTPUT OF THE A/D CONVERTER AS READ BY THE
C COMPUTER. FROM THIS LINEAR APPROXIMATION, A TABLE IS FORMED BY
C USING INPUTS FROM .5 TO 511.5 INCREMENTED BY 1. THE OFFSET OF .5
C IS USED FOR BETTER ACCURACY IN THE ROUNDOFF ERROR OF THE A/D CONVER-
C TER. ALL THE VALUES OF ZERO IN THE TABLE ARE CHANGED TO 1 SINCE
C 0 IS USED TO DESIGNATE NEGATIVE NUMBERS DURING THE COLLECTION.
C THE PROGRAM CALLS THE SUBROUTINES:
C RADC---READS #'S FROM THE A/D CONVERTER (MACRO)
C LINAP--CONVERTS INPUTS TO OUTPUTS FOR THE FORMATION
C OF THE LINEARIZATION TABLE
C TTM----WRITES LIN. TABLE ONTO A STORAGE DEVICE
CTTTTTTTTTTTTTTTTTTTTTTTTTTTTTT
SUBROUTINE TBFORL
INTEGER START(512), DLP0, STAT, IAS(44)
REAL KI
COMMON /TA/ SC(43), TU(44), TUO(44)
DATA C.CS.CN*NR/IHC, IHS, HN, 120784/

C DETERMINE IF CALIBRATION IS NEEDED AND WHICH PRINTOUT TO USE

WRITE(6,105) NR
105 FORMAT(1H WHICH CALIBRATION 5AH (5-SHORT, R-REGULAR, OR
13TH C-COMPLETE PRINT OUT OR N-NO CALIB.) A2)
READ(4,204)CAL
204 FORMAT(A) CAL
IERR=0
DLPO=0

C SET UP THE WANTED CALIBRATION
IF(CAL.EQ.CN) RETURN
IF(CAL.EQ.CS) DLP0=-1
IF(CAL.EQ.C) DLP0=1

C NUMBER OF A/D NUMBERS TO READ PER DB SETTING=NAV1*NAV
NAVI=5
NAV=500
AV=NAV*NAV
ICT=0

C NUMBER OF ATTENUATOR SETTINGS=NT1
NT1=42
NT2=NT1-1
NT3=NT1-2

C INPUT SIGNALS--FROM 0DB (OF 1000) TO INFINITY
TU(NT1)=562.34
TU(NT2)=501.19
TU(NT3)=446.68
TU(NT1-1)=395.11
TU(NT1-2)=354.82
TU(NT1-3)=316.23
TU(NT1-4)=281.84
TU(NT1-5)=251.19
TU(NT1-6)=223.87
TU(NT1-7)=199.53
TU(NT1-8)=177.83
TU(NT1-9)=156.49
TU(NT1-10)=137.25
TU(NT1-11)=119.93
TU(NT1-12)=104.76
TU(NT1-13)=91.51
TU(NT1-14)=79.73
TU(NT1-15)=71.28
TU(NT1-16)=63.30
TU(NT1-17)=56.34
TU(NT1-18)=50.12
TU(NT1-19)=44.67
TU(NT1-20)=39.81
TU(NT1-21)=35.48
TU(NT1-22)=31.62
TU(NT1-23)=28.18
TU(NT1-24)=25.12
TU(NT1-25)=22.39
TU(NT1-26)=20.10
TU(NT1-27)=18.34
TU(NT1-28)=16.70
TU(NT1-29)=15.19
TU(NT1-30)=13.85
TU(NT1-31)=12.70
TU(NT1-32)=11.82
TU(NT1-33)=10.58
TU(NT1-34)=9.91
TU(NT1-35)=8.91
TU(NT1-36)=7.96
TU(NT1-37)=7.08
TU(NT1-38)=6.31
TU(NT1-39)=5.62
TU(NT1-40)=4.93
TU(NT1-41)=4.30
TU(NT1-42)=3.70

C SET UP MESSAGES FOR TELLING WHICH ATTENUATOR SETTING TO DO
DO 11 I=1,NT3
11 IAS(I)=I+5
IAS(NT3)=99

C DO LOOP TO INPUT ALL THE OUTPUTED SIGNALS
DO 12 I=1,NT2
12 DUM=3
JUTE(6,15H) IAS(I),9A
100 FORMAT(6H SET T0 ,12,23DB ATTENUATION AND C.R,A2)
READ(4,200)F
200 FORMAT(F5.1)
C IF THE INPUTED NUMBER IS TWO DIGITS RESTART THE SETTINGS
IF(F.EQ.10) IN I TO 2.)
C ISSUE AN A/D CONVERTER READ "NAVI" TIMES
DO 10 J=1,NAVI
C READ "NAVI" NUMBERS FROM THE A/D CONVERTER
CALL RADCD(START,NAVI,STAT)
400 IF(STAT.EQ.0)GO TO 400
DO 1 J=1,NAVI
READ "NAV",NUMBERS FROM THE A/D CONVERTER
CALL RADC(START,NAVI,STAT)
400 IF(STAT.EQ.0)GO TO 400
DO 1 J=1,NAVI
C STORE THE INPUTTED NUMBERS IN A REAL VARIABLE
1 IDUM, DUM+FLOAT(START(J))
10 CONTINUE
C AVERAGE THE OUTPUTED NUMBERS AND GO TO THE NEXT SETTING
S(J)=((TUO(12)-TUO(11))/(TUO(12)-TUO(11))
102 FORMAT (4HSC(I2,2H)=*F6.3,5X*TU(12)=F8.3,S2X)
101 FORMAT (4HSC(I2,2H)=*F6.3,5X*TU(12)=F8.3,7H SDB///)
C OUTPUT LAST VALUES OF THE TABLE
WRITE(6,101)START,101
C OUTPUT THE LINEARIZATION TABLE FORMATION
XF=511.5
C GET THE INPUT VALUE AND STORE IN "XF"
CALL LINAP(XFNEXT)
XF=CXF*K1+1)/2
IF(XF.LE.12)XF=12
C STORE INPUT VALUE IN INTEGER LIN* TABLE
START(I)=IFIX(XF)
C ERROR CONDITION FOR LINEARIZATION TABLE
4 IF(START(I+1).LT.START(I-1))IERR2=IERR2+1
C LAST VALUE OF THE TABLE
START(512)=511
1 IF(DLPO.LT.)GO TO 6
C NEW PAGE
WRITE(6,103)
C WRITE LINEARIZATION TABLE ON A STORAGE DEVIVE (DUMP MODE)
C WRITE TABLE ON A STORAGE DEVIVE (DUMP MODE)
C WRITE OUT ANY ERROR AND ALLOW RECALIBRATION IF NEEDED
IF(IERR2.NE.0)GO TO 9
IF(IERR.EQ.3)RETURN
WRITE(6,106)
106 FORMAT (4H ****CHECK CALIBRATION FOR POSSIBLE ERRORS****///)
GO TO 7
9 WRITE(6,107)
C NEW PAGE
107 FORMAT (37H ++ERROR--BAD CALIBRATION TABLE ++)
GO TO 7
RETURN
END
***************SUBROUTINE LINAP**************
LINAP TRANSFORMS OUTPUT VOLTAGES INTO INPUT VOLTAGES OF
THE RECEIVER. THE CALIBRATION DATA IS CONTAINED IN SUB-
ROUTINE VALUE.

***************SUBROUTINE LINAP**************

C INPUT AND OUTPUT:
A IS THE OUTPUT VOLTAGE THAT IS TRANSFORMED INTO
INPUT VOLTAGE
NC5 IS THE NUMBER OF DB SETTNGS

SUBROUTINE LINAP(A,NC5)
COMMON /TA/ S(43),TU(44),TUO(44)

NC5=(NC5+2)/4
NC53=NC5+3/4
NC52=(NC5+1)/2

C FIND WHERE THE INPUTED NUMBER LIES
IF(A.GT.TUO(NC54)) N=NC54
IF(A.GT. TUO(NC52)) N=NC52
IF(A.GT.TUO(NC53)) N=NC53

C SET THE UPPER LIMIT OF THE SEARCH
K=N+NC54

C SEARCH FOR THE CORRECT LINE SEGMENT
DO 5 I=N+K
J=I+1
IF(A.GT.TUO(I).AND.A.LE.TUO(J)) GO TO 10
5 CONTINUE

C LINE SEGMENT COULDN'T BE FOUND
A=0.
RETURN

C SET THE VALUE OF THE CORRESPONDING OUTPUT
10 A=(A-TUO(I))*S(I)+TUO(I)
RETURN
END

CPPPPPPPPPPPPPPPPPPPPPPPPPPPP--PROC--PPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPP
C THIS PROGRAM OPERATES ALONG WITH DL03F1. IT TAKES DATA READ
C BY A SUBROUTINE AND CHECKS THE NOISE AND SATURATIONS
C FOR GOOD DATA. IT SUMS THE SQUARES OF THE DATA AT EACH HEIGHT
C AND THE ACCEPTABLE NOISE, SUBTRACTS THE ACCEPTABLE NOISE SQUARED
C FROM TH DATA, TAKES THE SQUARE ROOT OF THE DATA PRESERVING THE
C SIGN, TAKES THE SQUARE ROOT OF THE NOISE, AND PRINTS OUT THE RESULTS
C ON THE TELETYPE. THE RESULTS MAY ALSO BE PRINTED OUT ON PAPER TAPE
C IF NEEDED. THE PROGRAMS USED BY PROC ARE:
C CHNG---- INITIALIZES STORAGE DEVICE AND WAITS FOR FILE
C TO BE COLLECTED PLUS COMMUNICATING WITH COLL.
C DRD73--STORES DATA IN REAL ARRAY (FORTRAN)
C CALC2---CALCULATES ELECTRON DENSITIES (FORTRAN)
C CKCOL---CHECKS FOR UNWANTED STOPS IN COLLECTION
C PROGRAM (MACRO)
C PP7-----CHECKS DATA SWICHES ON THE CONSOLE TO ALLOW
C ON DISALLOW RESULTS TO BE PUT ON PAPER TAPE
CPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPPP

SUBROUTINE PROCIAPLFITIME)
COMMON /PPC/ A0(21),AX(21),AVA0(21),AVAX(21),ITIM(4),
1XO(21),IXJC1(1),BNQ(5),BNX(5),EL(21),
BANBMX*AVNO,BM0*AVNX,BMX*ID1R
COMMON /STAT/ IDB(4),RDATE(2),REAS(5),IDBRCXBSMXNC4,
SBMX#SBMX*SBMX
IWIN=-1
IEQU=0
ISUM=1
NC4=1

C INITIALIZE PAPER PUNCH
WRITE(7,150)
C INITIALIZE ALL VARIABLES NEEDED TO BE INIT.
10 SNO=0.
SMX=0.
IN=0
INW=0
BMO=0.
BMX=0.
DO 100 I=1,21
AVA0(I)=0.
AVAX(I)=0.
A0(I)=0.
AX(I)=0.
100 IF(J)=0
DO 110 I=1,4
BN0(I)=0.
BNX(I)=0.
110 INITIALIZE STORAGE DEVICE AND
C PREPARE TO READ DATA
CALL CHN(IMX,IBMX,IDBCH,IMC)
IF(IMCC.LE.0.OR.IMCC.GT.9)GO TO 80
IMCC=FLOAT(IMCC)*4.5
RMX=RMX*CMC*CMC*4.
DO 110 I=1,4
BN0(I)=0.
BNX(I)=0.
INITIALIZE STORAGE DEVICE AND
C PREPARE TO READ DATA
CALL CHN(IMX,IBMX,IDBCH,IMCC)
IF(IMCC.LE.0.OR.IMCC.GT.9)GO TO 28
CMC=FLOAT(IMCC)-4.5
RMX=RMX+CMC*CMC*4.
IF(IBMX.LT.1)IBMX=216
IMCC=0.
C NOISE CRITERION
IMX=THE SUM OF THE SET OF 45 NOISE SAMPLES WHICH HAS THE
MIN. MAXIMUM OF ALL THE MAXIMUMS OF EACH SET OF 45 NOISE SAMPLES
C THE AVERAGE NOISE FOR THE FIRST 5 IN EACH FRAME HAS
C TO BE LESS THAN SRBMX*IBMX/45. WHERE RBMX IS THE SUPPLIED CONSTANT.
C FOR SPEED RBMX*(IBMX/45.)*2*5. IS COMPARED TO THE SUM OF THE
SQUARES OF THE NOISE
DUMX=FLOAT(IBMX)/45.
IF(DUMX*SRBMX.GT.500.)DUMX=500./SRBMX
BMXNS=RBMX*DUMX*5.*DUMX
KE0F=0.
KEOFX=0.
ID=0.
C GET ORDINARY MODE DATA
CALL DRD73(A0,BN0,IBMX,ID,KE0F)
IF(KE0F.EQ.1)GO TO 80
C GET EXTRAORDINARY MODE DATA
CALL DRD73(A0,BNX,IBMX,ID,KEOFX)
IF(KEOFX.EQ.1)GO TO 80
C SET UP CHECK FOR REJECTION BECAUSE OF NOISE CRITERION
BMX=0.
BMEAN=0.
BMEAN+BN0(I)*BN0(I)
120 BMEANX=BMEANX+BNX(I)*BNX(I)
BMEAN=BMXNS/BID
BMEANX=BMXNS/BID
C NOISE USED TO SUBTRACT FROM DATA SAMPLES
BMX=BMX+DMEANX
BNX=BNX+DMEANX
BMX=BMXNS/BID
C SUM OF THE SQUARE OF THE UNSATURATED DATA AT EACH HEIGHT
DO 140 I=1,21
35 IF(AO(I).GE.510..OR.AX(I).GE.510.)GO TO 40
AVAO(I)=AVAO(I)+AO(I)*AO(I)
AVAX(I)=AVAX(I)+AX(I)*AX(I)
GO TO 140
C REJECTIONS DUE TO SATURATIONS OF DATA
40 IRJCI)=IRJCI)+1
140 CONTINUE
GO TO 60
C REJECTIONS FROM NOISE CRITERION
50 IR=IR+1
C SET UP AVERAGE NOISE USED IN REJECTION CRITERION
SNX=SN0+SNX
SNX=SNX+SNX
C NUMBER OF ACCEPTABLE DATA AT EACH HEIGHT
RSAM=ID-IRJCI)+IH
C AVERAGE SUM SQUARED OF ACCEPTABLE DATA FOR EACH HEIGHT MINUS THE
C AVERAGE SUM SQUARED OF THE ACCEPTABLE NOISE
AVOC=AVAO(I)/RSAM-BMO/RN
AVOX=AVAX(I)/RSAM-BMO/RN
XO(I)=0.
XO(I)=0.
IF(AVAO(I).LE.0..OR.AVAX(I).LE.0.)GO TO 150
XO(I)=AVAX(I)/AVA0(I)
GO TO 150
C NUMBER OF ACCEPTABLE DATA AT EACH HEIGHT
RSAM=ID-IRJCI)+IH
C AVERAGE SUM SQUARED OF ACCEPTABLE DATA FOR EACH HEIGHT MINUS THE
C AVERAGE SUM SQUARED OF THE ACCEPTABLE NOISE
AVOC=AVAO(I)/RSAM-BMO/RN
AVOX=AVAX(I)/RSAM-BMO/RN
XO(I)=0.
XO(I)=0.
IF(AVAO(I).LE.0..OR.AVAX(I).LE.0.)GO TO 150
XO(I)=AVAX(I)/AVA0(I)
CONTINUE
C THE RMS OF THE ACCEPTABLE NOISE
BMO=SQRT(BMO/RN)
BMX=SQRT(BMX/RN)
CALL CALC2(XO.120#EL*IA)

C GET THE TIME OF DAY
DO 155 I=1,4
   ITIME(I)=ITIME/I(13**I)
155 WRITE THE HEADING ON THE TELETYPewriter
WRITE(6,1050)ITIME,ITIME/10**II
1050 FORMAT(I4,14X*5A5,3X,5A5,3X,15HMULT. CONST.*F7.3/)
WRITE(6,1200)ITIME/(10**II)
1200 FORMAT(1H )
RETURN
END

C***********************SUBROUTINE DHDT3**************************
C DREAD READS 21 SAMPLES OF SIGNAL AND 5 SAMPLES OF NOISE
C FROM DECTAPE. THE OUTPUT VOLTAGES HAVE BEEN TRANSFORMED INTO
C INPUT VOLTAGES. THE PROGRAM USES SUBRHOUTINE DUMPT (MACRO) TO
C READ DATA FROM STORAGE DEVICE.
C********************************************************************
C SUBROUTINE DHDT3(A,BMEAN,ERK5,1D,K EOF)
DIMENSION A(21),IDAT(27),BMEAN(5)
KEOF=0
N=5
N1=N+1
N2=N+2
N3=N1+1
C GET ONE SET OF DATA (26 NUMBERS)
CALL DUMPT(I5,1E5)
C CHECK ID CONSECUTIVE
IF(IDAT(1).NE.130050) 10,15,10
C CHECK FOR END OF FILE
10 K EOF=1
C TELL PROC IT'S THE END OF THE FILE
15 RETJUN
C CHECK FOR CONSECUTIVE
C GET DATA SAMPLES INTO A REAL ARRAY
40 DO 42 MIN=N2,N3
   XM=13.0
   A(M+1)=IDAT(MIN)
42 CONTINUE
C GET NOISE SAMPLES INTO A REAL ARRAY
DO 133 J=1,N
   JSEL=J+1
   DATA(JSEL)=IDAT(JSEL)
133 RETURN
C THE ID IS CONSECUTIVE, IGNORE THE REST OF THE DATA
20 CALL(6,15,1D,IDAT(1),1D,1)
15 RETURN
END
CALC2 is a list of constants calculated from the programs CALC and ELDEN and contains the function that calculates the electron densities for the partial-reflection processing programs.*

SUBROUTINE CALC2(ARRAY.L,H#FD,IA)
DIMENSION ARRAY(21)*RATIO2(21)*FD(21)

C GET THE PREDETERMINED CONSTANTS FOR THE RIGHT SEASON
IF(IA)200300 100
C CONSTANTS FOR THE SUMMER
RATIO2( 1) = 1.0721158
RATIO2( 2) = 1.0778633
RATIO2( 3) = 1.0841143
RATIO2( 4) = 1.0909986
RATIO2( 5) = 1.0998918
RATIO2( 6) = 1.1001243
RATIO2( 7) = 1.1003032
RATIO2( 8) = 1.1006412
RATIO2( 9) = 1.1008597
RATIO2(10) = 1.1009432
RATIO2(11) = 1.10094014
RATIO2(12) = 1.1032614
RATIO2(13) = 1.1032646
RATIO2(14) = 1.1034602
RATIO2(15) = 1.10317923
RATIO2(16) = 1.10076428
RATIO2(17) = 1.10044388
RATIO2(18) = 1.10029128
RATIO2(19) = 1.10015084
RATIO2(20) = 1.10008443

FD( 1) = 0.170327E-03
FD( 2) = 0.243443E-03
FD( 3) = 0.329813E-03
FD( 4) = 0.427651E-03
FD( 5) = 0.532098E-03
FD( 6) = 0.627513E-03
FD( 7) = 0.699730E-03
FD( 8) = 0.744879E-03
FD( 9) = 0.753246E-03
FD(10) = 0.722645E-03
FD(11) = 0.660879E-03
FD(12) = 0.579908E-03
FD(13) = 0.492934E-03
FD(14) = 0.405772E-03
FD(15) = 0.326820E-03
FD(16) = 0.256820E-03
FD(17) = 0.201748E-03
FD(18) = 0.155429E-03
FD(19) = 0.118415E-03
FD(20) = 0.915812E-04
GO TO 400

C CONSTANTS FOR THE WINTER
RATIO2( 1) = 1.0862847
RATIO2( 2) = 1.0893572
RATIO2( 3) = 1.0899495
RATIO2( 4) = 1.08979884
RATIO2( 5) = 1.0898204
RATIO2( 6) = 1.0854859
RATIO2( 7) = 1.0778541
RATIO2( 8) = 1.0745673
RATIO2( 9) = 1.0665843
RATIO2(10) = 1.0531266
RATIO2(11) = 1.0458597
RATIO2(12) = 1.0339599
RATIO2(13) = 1.0266674
RATIO2(14) = 1.0167225
RATIO2(15) = 1.0127123
RATIO2(16) = 1.0076428
RATIO2(17) = 1.0046818
RATIO2(18) = 1.0023713
RATIO2(19) = 1.0019426
RATIO2(20) = 1.0007099

FD( 1) = 0.237897E-03
FD( 2) = 0.319960E-03
FD( 3) = 0.410827E-03
FD( 4) = 0.502861E-03
FD( 5) = 0.592594E-03
FD( 6) = 0.662825E-03
FD( 7) = 0.720342E-03
FD( 8) = 0.750909E-03
FD( 9) = 0.751034E-03
FD(10) = 0.720293E-03
FD(11) = 0.663644E-03
FD(12) = 0.588398E-03
FD(13) = 0.588587E-03
FD(14) = 0.418427E-03
FD(15) = 0.338916E-03
FD(16) = 0.256628E-03
FD(17) = 0.200210E-03
FD(18) = 0.156383E-03
FD(19) = 0.119390E-03
FD(20) = 0.899351E-04
GO TO 400

C CONSTANTS FOR EQUINOX
300 RATIO2( 1) = 1.0670392
RATIO2( 2) = 1.0803050
RATIO2( 3) = 1.0780858
RATIO2( 4) = 1.0912947
RATIO2( 5) = 1.0914300
RATIO2( 6) = 1.0917337
RATIO2( 7) = 1.0897806
RATIO2( 8) = 1.0825763
RATIO2( 9) = 1.0714581
RATIO2(10) = 1.0590323
RATIO2(11) = 1.0482722
RATIO2(12) = 1.0381881
RATIO2(13) = 1.0284035
RATIO2(14) = 1.0176469
RATIO2(15) = 1.0117923
RATIO2(16) = 1.0071480
RATIO2(17) = 1.0048179
RATIO2(18) = 1.0027836
RATIO2(19) = 1.0015986
RATIO2(20) = 1.0007970
FD( 1) = 0.188515E-03
FD( 2) = 0.261225E-03
FD( 3) = 0.347697E-03
FD( 4) = 0.421692E-03
FD( 5) = 0.538726E-03
FD( 6) = 0.633402E-03
FD( 7) = 0.705942E-03
FD( 8) = 0.747136E-03
FD( 9) = 0.752871E-03
FD(10) = 0.726456E-03
FD(11) = 0.661807E-03
FD(12) = 0.579908E-03
FD(13) = 0.492946E-03
FD(14) = 0.40839E-03
FD(15) = 0.32839E-03
FD(16) = 0.261536E-03
FD(17) = 0.236349E-03
FD(18) = 0.160150E-03
FD(19) = 0.124908E-03
FD(20) = 0.097959E-04

GO TO 13
IF(ARRAY(I).EQ.3 OR ARRAY(I+1).EQ.0.) GO TO 50

C THE FUNCTION FOR THE CALCULATION OF ELECTRON DENSITIES
FD(I) = ALOS((ARRAY(I)/ARRAY(I+1))*RATIO2(I))/FD(I)
GO TO 10
50 FD(I) = 1.1
CONTINUE
RETURN

C WHPP PUNCHES THE PROCESSED PARTIAL REFLECTION DATA
C ON PAPER TAPE
C
SUBROUTINE WHPP
COMMON /PPC/ AO(21),AX(21),AVAO(21),AVAX(21),TIM(4),
1XO(21),1XJ(24),BNOS(5),BNX(5),EL(21),
CHRMX,BHDW,BUX,BMIX,IDX,IR
COMMON /STAT/ IDB(4),KDATE(2),HEAS(5),IDBNC(4),BMXXS,HBMX,
1AUNG, shm, smx, im, id, ir
1050 FORMAT(1H1,4I,4X,2A5,3X,5A5,3X,12HDB/F7.1,F7.3,F8.1,
1F8.1,F8.1,F8.1,14.15)
DO 160 I=1,21
CALL CHKXL
WRITE(7,1400) ICH(I),AVAO(I),AVAX(I),XO(I),EL(I)
1400 FORMAT(1H1,14,F6.1,F6.1,F5.2,F6.0)
160 CONTINUE
RETURN
END
PROC73 EVALUATES COLLECTED PARTIAL-REFLECTION DATA AND
PRINTS OUT THE ELECTRON DENSITY. PROC73 USES THE FOLLOWING PROGRAMS:

- HEAD----SETS UP AND PRINTS THE HEADING (FORTRAN)
- DINIT---INITIALIZES THE STORAGE DEVICE (MACRO)
- FSTAT---LOCATES THE DATA FILE (MACRO)
- SEEK---FINDS THE FILE ON THE STORAGE DEVICE (MACRO)
- DRD73--SETS SAMPLES INTO THE REAL ARRAY (FORTRAN)
- CALC2---CALCULATES THE ELECTRON DENSITY (FORTRAN)

The program initializes variables, reads in data, and calculates the electron density. It includes checks for valid data files and noise levels.
C SUM OF THE SQUARED GOOD AO AND AX SAMPLES
    AVAO(I)=AVAO(I)+AO(I)*AO(I)
    AVAX(I)=AVAX(I)+AX(I)*AX(I)
    GO TO 47
C THE TOTAL # OF REJECTIONS DUE TO SATURATION
C PLUS NOISE ABOVE THE GIVEN MAXIMUM
   IRJ(I)=IRJ(I)+1
47 CONTINUE
   GO TO 520
500 \( \text{IF}(I)=I\text{RJ}(I)+1 \)
520 SNO=BMEO+SN0
    SNX=BMEXX+SNX
    GO TO 48
49 \( \text{IF}(I)=I\text{D}-1 \)
50 \( \text{IF}(I)=I\text{D}/2 \)
    BID=I\text{D}-5
    BMXSNSBMXNS/\text{DUM4}
C THE RMS OF ALL NOISE SAMPLES TAKEN
    AVNO=SQRT(SNO/BID)
    AVNX=SQRT(SNX/BID)
C THE NUMBER OF THE ACCEPTABLE NOISE SAMPLES
   RN=4*(ID-I)\text{R}
    \text{DO 52 I=1,21}
C NUMBER OF REJECTED DATA AT EACH HEIGHT
   IRJ(I)=IRJ(I)+IH
C NUMBER OF ACCEPTABLE DATA AT EACH HEIGHT
   RSAM=ID-I\text{RJ}(I)
C ACCEPTABLE NOISE IS SUBTRACTED OFF
    AVOC=AVAL(I)/RSAM-BMO/\text{RN}
    AVXC=AVAX(I)/RSAM-BMX/\text{RN}
C RMS OF GOOD DATA WITH THE SIGN PRESERVED
    AVAO(I)=(ABS(AVOC)/AVOC)*SQRT(ABS(AVOC))
    AVAX(I)=(ABS(AVXC)/AVXC)*SQRT(ABS(AVXC))
    EL(I)=\text{N}
    XO(I)=\text{N}
    IF(AVO(I).LE.0.0.OR.AVX(I).LE.0.0)GO TO 52
52 CONTINUE
C RMS OF ACCEPTABLE NOISE
    BMO=SQRT(BMO/\text{RN})
    BMX=SQRT(BMX/\text{RN})
C GET ELECTRON DENSITIES
    CALL CALCL8(XO.,EL,1A)
C WRITE THE HEADING
    CALL HEAD(J)
    WRITE(6,100) BMXSNS,AVNO,BMO,AVNX,BMX
100 FORMAT (25H MAXIMUM ALLOWABLE NOISE=F6.1/16H 0-NOISE AV.(I)=F5.1/16H 0-NOISE AV.(I)=F5.1/16H X-NOISE AV.(I)=F5.1/16H X-NOISE AV.(I)=F5.1)
    WRITE(6,54)ID,IN
54 FORMAT (12H 1X,14,8H SAMPLES,5X,15,12H REJ.(NOISE)\text{/BH REJECTS},
          12X 64HEIGHT,2X 6HAU, AO.2X,6HAU, AX.2X,5HAU/4X,8HED)
    HT=SB.5
C WRITE OUT TABLE
    \text{DO 53} I=1,21
    HT=HT+I.5
53 \text{WRITE(6,58)IRJ(I),HT,AVAO(I),AVAX(I),XO(I),EL(I)
      \text{FORMAT(3X 14,3X.F5.* 3X,F6.1 2X F6. 12XF5.2,3X.F6.0)
      \text{CONTINUE}
58 \text{TO} 10
STOP
END
.TITLE READ DATA IN DUMP MODE

/READ DUMP MODE FROM DECTAPE ON A VARIABLE .DAT SLOT
/FILLS 252 DEC WORD BUFFER AND OUTPUTS 26
/WARDS TO ARRAY IDAT EVERY TIME CALLED.
/THERE ARE UNPACKED FROM 18 WORDS OF THE BUFFER.
/IDAT: WORD 1  1+4#  /WORD 2-6 NOISE SAMPLES
/WORD 7-27 DATA
/NDFP1   SET IF A NEGATIVE NUMBER WAS IN THE DATA

/DUMP=4 /TYPE OF I/O MODE
/DATIN=2 /DAT SLOT TO READ DATA FROM
/NSAM=32  # OF SAMPLES PER SET
/NSAMP=NSAM/2+1  # OF SETS PER ONE BLOCK OF STORAGE
/DTBLK=374  # SIZE OF ONE SET PACKED DOUBLE
/DATSTR=Dtblk/NSAMP  # OF SETS PER ONE BLOCK OF STORAGE
/NDPC=NSAM/2  # NUMBER OF STORED DATA PAIRS PER SET

.LOOP: DIGIN, DUMP, DA

DIGIN    /INITIALIZE DEVICE STORING THE DATA
/INIT DIGIN, DIGIN /PREPARE TO READ
/LAW = -1 /IN ONE BLOCK OF DATA
/LAC CTT9 /RESET THE BUFFER POINTER WITH
/LAC COUNT  /THE ADDR. OF BUF3
/LAC ISZ SWITC /PREPARE TO READ TWO
/LAC DUMP, LCA /DUMMY BLOCKS
/JMP DIGIN /END OF INITIALIZATION

DUMP 0  /PICKUP ADDR OF ADDR
/JMP +3 /OF ARRAY

A2 0  /SET ON NEG #
/LAC* = A2 /SET ADDR.
/LAC* A2  /OF ARRAY
/LAW = -NDPC /SET COUNTER OF DATA TO BE
/LAC COUNT  /PROCESSED
/LAC ISZ SWITC /GET POINTER
/JMP LBB /CONTINUE WITH PRESENT SET OF DATA
/LAW = DATSTR /RESET COUNTER TO THE NUMBER
/LAC CTT9 /OF SETS PER BLOCK OF STORAGE
/LRA = READ DATIN, DUMP, BUF3, DTBLK /GET 1 BLOCK OF DATA
/C14 = WAIT DATIN

LCA ISZ SWITC /INITIALLY READ TWO DUMMY BLOCKS
/JMP LBA
/LAW = -3 /RESET CONTROL TO READ
/LAC SWITC /TWO DUMMY BLOCKS
/LAC (JMP LCB /READ ONE BLOCK OF DATA
/LAC LCA /AT A TIME
/LCB LAC BUF31 /GET ADDRESS OF BUF3
/LAC COUNT  /POINTS TO BUF3
/LAC* POINT2 /GET THE ID (FIRST WORD IN DATA SET)
/LAC* SADV /END OF FILE ID?
/JMP ENV /YES, RESET PARAM'S AND CLOSE FILE
/LAC* POINT2 /GET ID AND PUT
/LAC* A2 /INTO THE FORWARD ARRAY
/LISZ A2 /GO TO NEXT ADDR. OF THE ARRAY

LOOP ISZ POINT2 /GO TO NEXT DATA WORD
/LAW = -2 /PREPARE TO UNPACK
/LAC TC10 /252 DATA WORDS
/LAC* POINT2 /GET DATA WORDS FROM BUF3
/SWHA AND (7777 /SAVE ONE DATA WORD
/SWB /CHECK FOR NEG. NUMBER
/LISZ = FLA3 /SET IF NEG. NUMBER FOUND
/LAC* A2 /LOAD # INTO FORWARD ARRAY
/LAC* POINT2 /GET DATA WORD AGAIN
/LISZ A2 /GO TO NEXT LOC. IN ARRAY
/LISZ TC10 /UNPACED TWO WORDS?
/JMP UNPLP /NO LOOP AROUND
/LISZ COUNT /YES, HAS 34 DATA WORDS BEEN UNPACKED?
/JMP LOOP /NO, REPEAT UNPACKING PROCESS
/OCTA ISZ POINT2 /YES, GO TO NEXT ID
/JMP DUMP /RETURN

SWITC LAW = -3
/COUNT LAW = -NDPC
/CTT9 LAW = DATSTR
/SENV 375002
/TC10 0
/POINT2 = DSA BUF3
/BUF3 = DSA BUF3
/BUF0 = BLOCK DTBLK

/...
CALC

C FROM GIVEN COLLISION FREQUENCIES, CALC ALONG WITH ELDEN
C CALCULATES THE CONSTANT VALUES USED IN THE ELECTRON DENSITY
C EQUATION GIVEN BY PIMAT IN AERONOMY REPORT 29 AND WRITES THE
C PROGRAM CALC2 WHICH CALCULATES THE ELECTRON DENSITIES FOR THE
C PARTIAL-REFLECTION PROGRAMS.

C******************************************************************
DIMENSION ARRAY(21), P(21), H(3), CFFC3), ELC20), CALC2(2)

DATA CALC2(4), CALC2(2)/5HCALC2*4H SRC/

I DAT=1
LABL=0

C COLLISION FREQUENCY PROFILES
C COLLISION FREQUENCY PROFILE FOR THE SUMMER
100 P(1)=192.3
P(2)=156.9
P(3)=137.5
P(4)=132.7
P(5)=85.37
P(6)=66.25
P(7)=52.53
P(8)=41.66
P(9)=32.91
P(10)=25.84
P(11)=20.1
P(C13)=15.53
P(14)=11.89
P(15)=9.057
P(16)=6.917
P(17)=5.399
P(18)=3.827
P(19)=2.562
P(20)=2.124
P(21)=1.563

C WRITE THE PROGRAM HEADING ONTO TAPE
CALL ENF(DAT,CALC)

WRITE(I DAT,10)

10 FORMAT(69H CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC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C CONSTANTS FOR THE WINTER
GO TO 400
C CONSTANTS FOR THE EQUINOX
GO TO 400

C SET THE COLLISION FREQUENCIES TO THE RIGHT ORDER OF MAGNITUDE
DO 401 I=1,21
P(I)=PCI)*(1+I.**5)
401 CONTINUE

C STATEMENT LABEL FOR THE NEW PROGRAM
LABL=LABEL\#100
J=J+4
K=0
DO 23 I=1,23
K=K+I
CF(I)=P(K)
CF(2)=P(K+1)
23 CONTINUE

C CALCULATE CONSTANTS FOR THE ELECTRON DENSITY EQUATION
CALL ELDEN(RCFARHAY(I)AHRAY(I+1),EL(I))
AHRAY(I)=AHRAY(2)/ARRAY(I)
C WRITE FIRST CONSTANT WITH A STATEMENT LABEL
WRITE(IDAT,405)LABL,ARRAY(1)
405 FORMATCH,13,12H RATIO2(1)=F10.7)
C WRITE THE REST OF THE RO AND RX CONSTANTS
DO 25 I=2,20
AHRAY(I)=AHRAY(I+1)/AHRAY(I)
WRITE(IDAT,410) I,ARRAY(I)
25 CONTINUE
C WRITE THE CONSTANT DENOMINATORS
DO 38 I=1,28
WRITE(IDAT,420) I,EL(I)
38 CONTINUE
C CALCULATE THE REST OF THE CONSTANTS
IF(J+L.T.5)GO TO 200
IF(J+L.LT.10)GO TO 300
C WRITE THE REST OF THE PROGRAM TO CALCULATE ELECTRON DENSITIES
WRITE(IDAT,48)
48 FORMATCHH 480 DO 10 I=LL,LH/48H IF(ARRAY(I).EQ.0.OR.
ARRAY(I+1).EQ.0)GO TO 59/59H C THE FUNCTION FOR THE CALCULATION OF ELECTRON DENSITIES/
35I FD(I)=ALOG((AHRAY(I)/AHRAY(I+1))*RATIO(I))/FD(I)
41H GO TO 10/12H 59 FD(I)=0./12H 10 CONTINUE/8H RETURN
CALL CLOSE(IDAT)
STOP
END

SUBROUTINE ELDEN

DURING DATA PROCESSING THERE ARE ONLY 2 VARIABLES
C FOR EACH HEIGHT (AO AND AY). THE EQUATION FOR THE
C ELECTRON DENSITY AS GIVEN BY BIRLY (1971) IS:
C ED=LN(((AY(I)/AO(I))/(RX(I)/RO(I)))/((AY(2)/AO(2))/(RX(2)/RO(2))))/FD
C WHERE LN IS THE NATURAL LOG AND 1 AND 2 ARE HEIGHT 1 AND 2
C SUBROUTINE ELDEN CALCULATES THE CONSTANTS RX,RO,AND FD
C FOR EACH HEIGHT.
SUBROUTINE ELDEN(AXBYAO,GNU,RXROI,RXRO2,FD)
DIMENSION AXBYAO(3),RXBYRO(3),RX(3),RO(3),GNU(3),RATIO(3)

C APPROX INTEGRAL PARAMETERS
A4=2.3983474E-2
A3=1.1287513E+1
A2=1.1394160E+2
A1=2.4653115E+1
B6=1.806412E-2
B5=9.387732
B4=1.4921254E+2
B3=2.8958085E+2
B2=1.2849512E+2
B1=6.4093464E+1
B0=6.9205405E+1
D3=6.945939
D2=6.690102
D1=4.36015732
D0=6.945939
C GNU(3) IS MEAN COLLISION FREQUENCY AT THE INTERMEDIATE HEIGHT
C CALCULATE C INTEGRALS AT BOTH HEIGHTS AND FOR AVERAGE GNU
DUM=GNU(1)+GNU(2)
GNU(3)=.5*DUM
DO 22 K=I,3
X=(2.59614E+7)/GNU(K)
X=7.3PR6E+6/GNU(K)
CTN=O*(O*(O+AI)+A2)+A3)+A4
CTD=O*(O*(O*(O+B1)+B2)+B3)+B4)+B5)+B6
CT=CTN/CTD

C CALCULATE RATIOS
RX(K)=SQRT((X*CTX)**2+(2.5*CFX)**2)
RO(K)=SQRT((O*CTO)**2+(2.5*CFO)**2)
RXBYRO(K)=RX(K)/RO(K)
RATIO(K)=AXBYAO(K)/RXBYRO(K)
CONTINUE
22
C CALCULATE FD FROM FINAL VALUES OF DO LOOP
FO=(5.*3.12E+3*CFX)/(4.*3.0E+3*GNU(3))
FX=(5.*3.12E+3*CFX)/(4.*3.0E+3*GNU(3))
FD=(FX-FO)*3.E+9
RXROI=RXBYRO(1)
PYRO2=RXBYRO(2)
RETURN
END

C******************************************************************
C PROGRAM READS IN THE NUMBER OF SAMPLES ASKS FOR BY OPERATOR.
C IF THE NUMBER IS ZERO, 31 NUMBERS ARE READ IN AND SET UP AS PARTIAL
C REFLECTION DATA IS (I.E 5 NOISE SAMPLES AND 26 DATA POINTS & 5 EXTRA
C DATA IS PRINTED OUT IN THE FORM OF ONE NUMBER PER HEIGHT AFTER EACH
C GROUP OF 26 SAMPLES ARE READ IN. THIS HAS BEEN USED TO CHECK THE
C RECEIVER AND A/D CONVERTER AGAINST THE REYNOLDS SYSTEM AND TO SEE
C IF EVERYTHING IS OPERATING AS IT SHOULD. IF THE NUMBER READ IN IS
C NOT ZERO, THAT NUMBER OF SAMPLES ARE READ FROM THE A/D CONVERTER
C AND AN AVERAGE OF ALL THE NUMBERS ARE TAKEN AND PRINTED OUT.
C******************************************************************

C DIMENSION IA(50),RAI(50),RA2(50)
MAX=50
IIN=31
WRITE (6,110)
110 FORMAT(1AH ADC CHECK)
C DEFAULT VALUE FOR THE # OF SAMPLES = 31
4 NR=31
C READ # OF SAMPLE TO BE READ FROM A/D CONVERTER
5 READ (4,210) IDV
210 FORMAT(15)
IF(IDV.NE.3) NR=IDV
IF(NR.NE.31) GO TO 50
C FOR 31 NUMBERS READ IN, THE FORM USED IS 2 SETS OF 31 SAMPLES
C AS IN THE PARTIAL REFLECTION COLLECTION
II=0
25  ICH=0
   II=I+1
   CALL INPAD(IA,NS,ICH)
   IF(ICH.EQ.9) GO TO 6
   IF(II.GT.II) NO TO 11
   DO 13 II=1,111
C CONVERSION ALGORITHM FOR A/D CONVERTER NEG. #'S TO COMPUTER
C NEGATIVE NUMBERS
   IF(IA(I).LT.511) IA(I)=3072+(4096+32768)*7+IA(I)
13  RAI(I)=FLOAT(IA(I))/SII
   GO TO 25

11  WRITE(6,101)
C DO LOOP FOR SECOND SET OF NUMBERS READ IN
   DO 15 I=1,131
C CONVERSION ALGORITHM FOR A/D CONVERTER NEG. #'S TO COMPUTER
C NEGATIVE NUMBERS
   IF(IA(I).GT.511) IA(I)=3072+(4096+32768)*7+IA(I)
   HT=45.+FLOAT(I-1)*.5
   IF(I.EQ.6.OR.I.EQ.1) WRITE(6,105)
   IF(I.EQ.11) WRITE(6,106)
   RA2(I)=FLOAT(IA(I))/SII
   GO TO 15

15  WRITE(6,110)
C WRITE OUT THE NUMBERS IN AN ORDERLY WAY
   WRITE(6,110) HT,RAI(I),RA2(I)
   101  FORMAT(3X,F4.1,4HKM,F5.0,4HKM,F5.0,2HKM)
   105  FORMAT(25H -----------------------------------)
   106  FORMAT(5H DATA)
   GO TO 5

C THE FOLLOWING DUMPS THE AVERAGE OF THE A/D CONVERTER NUMBERS
C AND ALSO GIVES THE VALUE IN MILLIVOLTS
50  INS=(NS+MAX-1)/MAX
   TNS=INS/
   DO 60 J=1,INS
   ICH=8
   CALL INPAD(IA,MAY,ICH)
   IF(ICH.EQ.9) GO TO 29
   DO 55 I=1,MAY
   IF(IA(I).LT.511) IA(I)=3072+(4096+32768)*7+IA(I)
55  AV=AV+FLOAT(IA(I))
   CONTINUE
   AV=AV/TNS
   AVV=AV/.512
   WRITE(6,120) AVAVV
   120  FORMAT(9H AVERAGE:,F7.3,12H VOLTAGE:,F7.3,H MV)
   GO TO 5
   STOP
   FND

.TITLE A/D CONVERTER SERVICE ROUTINES FOR RG-FOG
RFKMIS USA SERVICE ROUTINES FOR THE HP 5610A A TO D
CONVERTER. THESE ROUTINES PERMIT INPUT OF ANY SPECIFIED
NUMBER OF SAMPLES INTO A CORE BUFFER. INPUT MAY BE OVER-
LAPPED WITH PROGRAM EXECUTION, AND CONTROL MAY BE PRIORITY
TO LOWER PRIORITY PROGRAMS WHILE DATA TRANSFER TAKES PLACE.
MACRO-15 CALLING SEQUENCE:
JMS INPAD
NUMBER OF SAMPLES REQUIRED
BUFFER ADDRESS
COMPLETION FLAG ADDRESS
REAL-TIME SUBROUTINE ADDRESS, PRIORITY LEVEL IN BITS 0-2
(EXAMPLE: 500000+RTSURA)
(RETURNS HERE IMMEDIATELY)
IF THE 4TH WORD AFTER THE JMS IS 0, NO REAL-TIME SUBROUTINE
WILL BE ACTIVATED. NOTE: THE PRIORITY CODE FOR MAINSTREAM IS 1
THE COMPLETION FLAG IS CLEARED BY THE CALL TO INPAD,
AND SET TO +1 FOR NORMAL COMPLETION OR -100 IF A DATA
TIMING ERROR OCCURS.

ADVCR=2E
ADCA=ADVCR+1
LCOM=120
/A-D WORD COUNT
/MONITOR'S COMMUNICATION AREA
/A-D CONVERTER WRITE INITIALIZE
/SKIP ON WORD COUNT OVERFLOW
/SKIP ON DATA TIMING ERROR
/CLEAR OVERFLOW FLAG
/CLEAR TIMING FLAG
ENTRY POINT FOR A-D INTERFACE INITIALIZATION

```
ENTRY POINT FOR A-D INTERFACE INITIALIZATION

GLOBL INPAD,.DA

INPAD m
  JMS* .DA
  JMP +4

INAP m
  INPAD
  JMP INSET
    /REPLACED BY "LAC* INWC"
    TCA
    DAC* (ADWCR)
    LAW -1
    TAD* INAR
    DAC* (ADCAR)
    DZM= INFLAG
    DZM INSUB#
    ADVI
    /INITIALIZE INTERFACE
    JMP= INPAD
    /RETURN

THE FOLLOWING CODE IS EXECUTED ONLY ONCE

INSET LAC* (.SCOM+55)
  /GET ENTRY POINT ADDRESS OF .SETUP
ADSVA DAC
  JMS# .-1
  /CALL .SETUP TO CONNECT ADINT TO API
ADSO ADINT
DZM* (204

LAC (LAC* INWC
  /MODIFY INSTRUCTION
  JMP INR
  /AND JUMP TO IT

/INTERRUPT SERVICE ROUTINE. EXECUTED IMMEDIATELY AFTER COMPLETION
/ OF DATA TRANSFER. DETERMINES STATUS OF A-D INTERFACE, SETS
/ COMPLETION FLAG AND ACTIVATES REAL-TIME SUBROUTINE.
/ RUNS AT API LEVEL m.

ADINT m
  DRA
  DAC ADST
  /PAGE ADDRESSING MODE
  SKPICLAAIC
  /TIMING ERROR?
  LAW -1001
  /YES, ERROR CODE
  DAC* INFLAG
  /SET FLAG
  ADCO
  /CLEAR
  ADCT
  /INTERFACE FLAGS

ADTV LAC ADST
  /RESTORE AC
  DDB
  /SET TO LEAVE HARDWARE API LEVEL
  JMP= ADINT
  /RETURN TO INTERRUPTED PROGRAM
```

120