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Increasing the Efficiency of a Surface Ionization Mass Spectrometer

Thomas Curtis Adams

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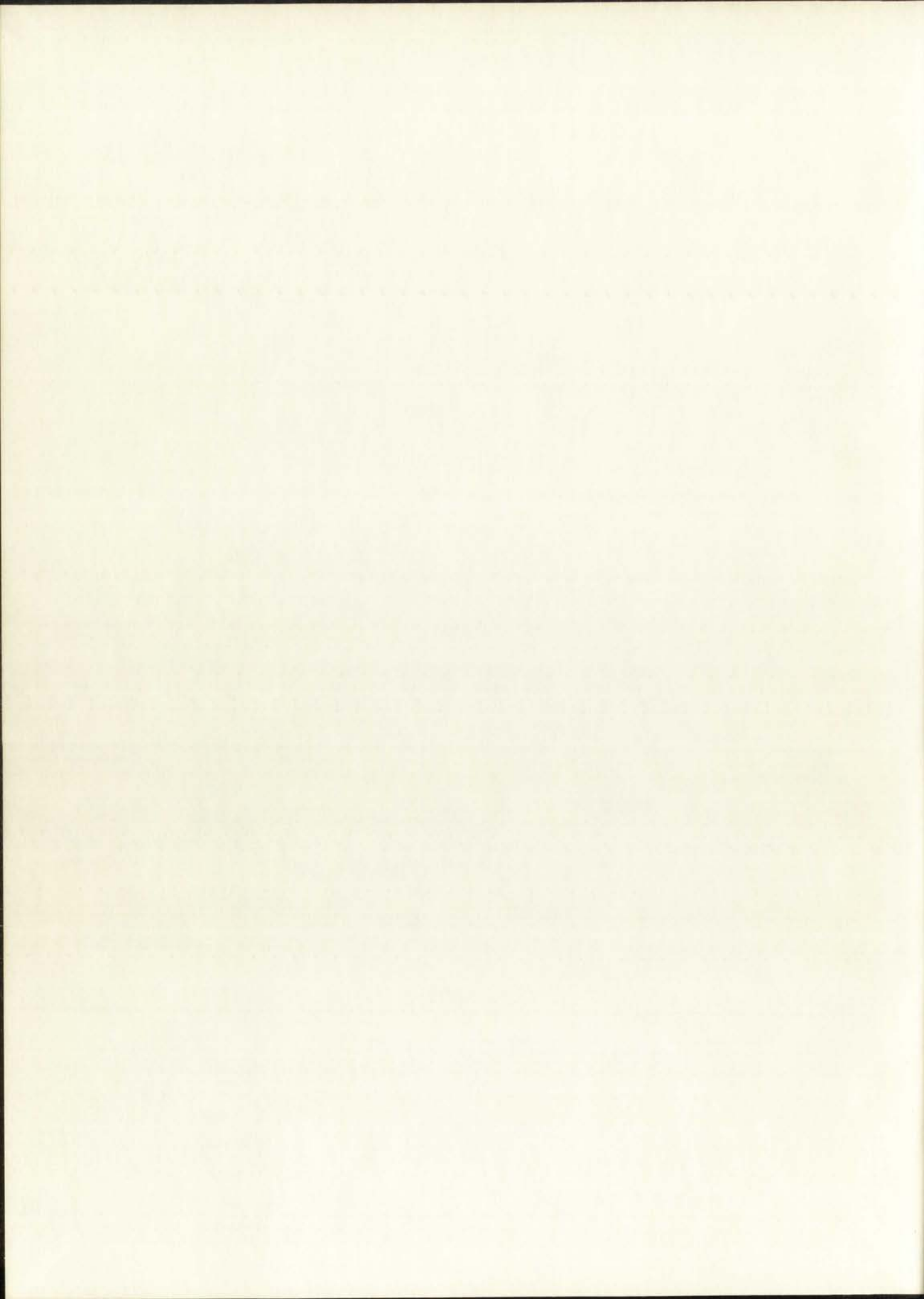


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This thesis, directed and approved by the candidate's committee, has been accepted by the Graduate Committee of The University of New Mexico in partial fulfillment of the requirements for the degree of

Master of Science in Physics

INCREASING THE EFFICIENCY

Title

OF A

SURFACE IONIZATION MASS SPECTROMETER

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INCREASING THE EFFICIENCY
OF A
SURFACE IONIZATION MASS SPECTROMETER

BY
THOMAS CURTIS ADAMS
B.S., University of Washington, 1956

THESIS

Submitted in Partial Fulfillment of the
Requirements for the Degree of
Master of Science in Physics
in the Graduate School of
The University of New Mexico
Albuquerque, New Mexico
October, 1970

INSTITUTIONAL REPORT

OF A

COMMISSION ON THE STATE OF TEXAS

BY
THE
COMMISSIONERS OF THE
STATE OF TEXAS, 1901

REPORT

Presented to the Legislature of the State of Texas at its Regular Session, 1901, in accordance with the provisions of the Act of the Legislature of 1899, Chapter 10, Section 1, and the Act of the Legislature of 1900, Chapter 10, Section 1.

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I wish to express my most sincere thanks to Dr. Richard M. Tisinger of the Los Alamos Scientific Laboratory, whose guidance and assistance throughout this project have been indispensable to the completion of a rather formidable task.

1870

Received of the Treasurer of the
Board of Directors of the
City of New York the sum of
Five Hundred Dollars (\$500.00)
for the purchase of the
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INCREASING THE EFFICIENCY
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ABSTRACT OF THESIS

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THE HISTORY OF THE

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INCREASING THE EFFICIENCY
OF A
SURFACE IONIZATION MASS SPECTROMETER

Thomas Curtis Adams
Department of Physics and Astronomy
The University of New Mexico, 1970

An Avco surface ionization mass spectrometer (model 90,000) was installed at the Los Alamos Scientific Laboratory in February, 1968. Since that date this machine has been used as a production instrument for the isotopic analysis of uranium and plutonium samples. During 1969, it was realized that a problem inherent in the ionization mechanism of the instrument was degrading the accuracy of results, and that the number of man-hours expended in reducing data had become excessive. As soon as this situation became apparent, corrective action was initiated to reduce the effect of the ionization problem and to decrease the amount of "people-time" required for data reduction. A relatively sophisticated computer program called "SPECTRE" was written which has improved the accuracy of published results, and which has released two people from the tedious labor of hand data reduction. This paper describes the steps leading to the successful conclusion of this effort, and analyzes the completed computer program in some detail.

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CHAPTER 1

THE INSTRUMENT

The number of types of mass spectrometers in existence is exceedingly large; therefore a rather comprehensive description of the Avco model 90,000 mass spectrometer with which this paper is concerned follows.

The Avco instrument utilizes a single magnetic analyzer to deflect an ion beam through 90 degrees with a 35 centimeter radius.¹ Figure 1 illustrates this ion path, and Figure 2 gives a reasonably good idea of the relative sizes of the ion source, flight tube and beam collector.

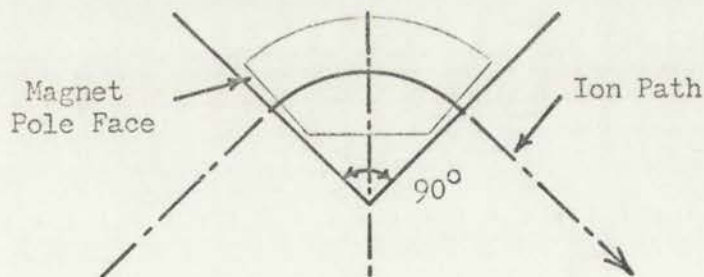


FIGURE 1. Ion optics of the Avco model 90,000 mass spectrometer.

The instrument at the Los Alamos Scientific Laboratory (LASL) is used for isotopic analysis of small quantities of uranium or plutonium. Elemental ions are generated and accelerated through an electrostatic

¹Avco Mass Spectrometers 90,000 Series, Avco Corporation Electronics Division, 2.



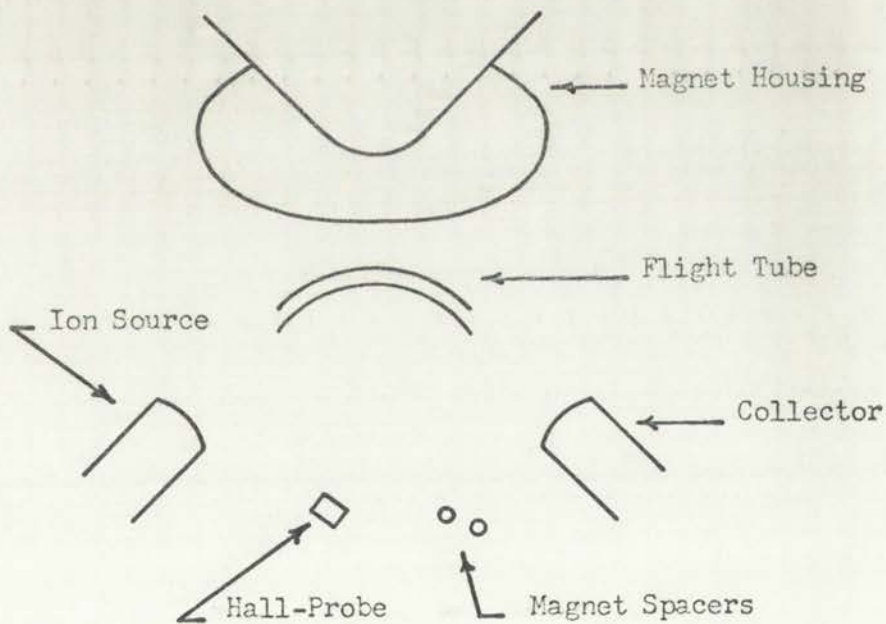
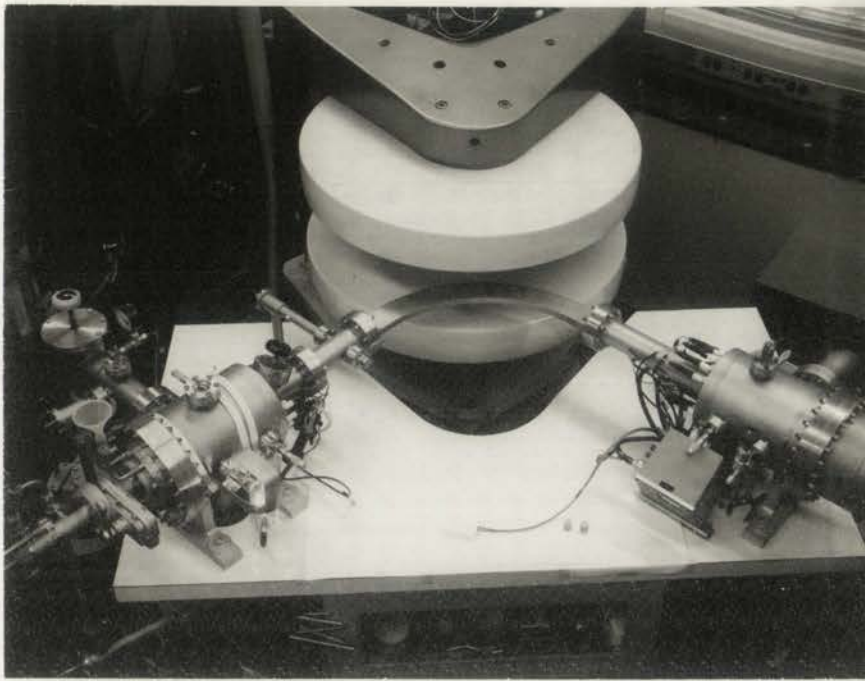
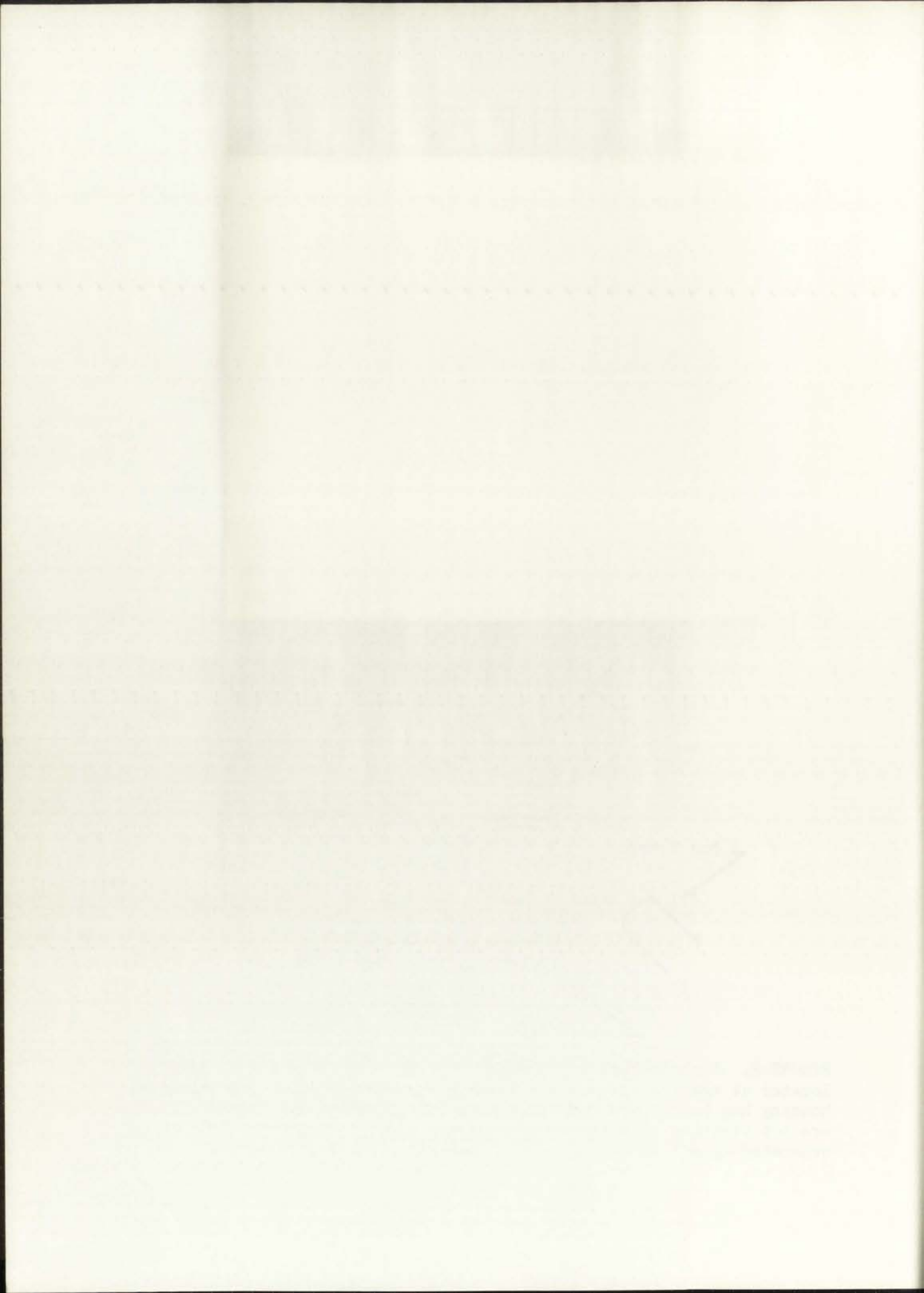


FIGURE 2. A photograph and a diagram of the Avco mass spectrometer located at the Los Alamos Scientific Laboratory (LASL). The magnet housing has been moved back to expose the flight tube. Magnet pole faces are not visible. The magnet spacers are used to keep the pole faces separated by a fixed distance when the magnet is in operation.



thick lensing system to produce a beam which is very nearly parallel. The ion beam is then passed through the magnetic analyzer with magnetic flux density adjusted and source and collector slits set so that only ions of a desired mass number reach the collector. Control during an experimental run is obtained by varying magnetic flux density to select different mass numbers.

As the title of this paper indicates, a surface ionization source is used. A solution of sample material in dilute nitric acid is prepared, and a known amount of this solution is then micropipetted onto two vaporizing filaments and evaporated to dryness. After placing the filaments in position, an electric current is passed through them, heating the sample material and evaporating elemental atoms and ions of this metal (U or Pu). These two side filaments are made of tantalum and serve to produce an atom vapor. A center filament made of rhenium is also used. It is not treated with sample material and serves to ionize a substantial portion of the atoms evaporated from the side filaments. Figure 3 illustrates the physical arrangement of these filaments.

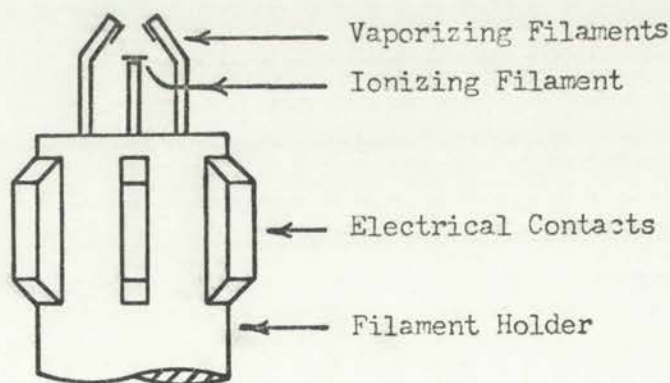


FIGURE 3. LASL filament arrangement.

Surface ionization offers 3 very real advantages over other methods of ion generation (such as electron bombardment):

1. Positive ions are produced with a small energy spread.
2. Sample preparation is relatively simple.
3. Essentially all ions produced are singly charged, which fact allows one to detect ions of a particular mass number rather than ions of a particular charge-to-mass ratio.

This method has the serious disadvantage that ion emission is not constant with time.

As mentioned earlier, an electrostatic lensing system is employed to form a parallel beam of accelerated positive ions. The effective potential through which these ions fall is held constant at a value of 10,000 volts.

The flight tube, a passage through which ions must move to reach the collector, is evacuated to reduce scattering collisions with resident particles. A gas pressure of approximately 5×10^{-8} torr is maintained by pumping during normal operation.

The magnet is water-cooled and is capable of flux densities up to 10,000 gauss. Hall-Probe control permits adjustment to 0.5 gauss over the whole range, and enables any given setting to be relocated within 2 gauss.²

At IASL, an 18-stage electrostatically focused electron multiplier is used as a detector (collector).³ Interstage voltage is held at 110 volts for each stage. A gain of approximately 1.3×10^5 has been measured,

²Ibid., 2.

³As in the literature, the terms "detector" and "collector" are used almost synonymously.

THE HISTORY OF THE UNITED STATES

The history of the United States is a story of growth and change. From the first European settlers to the present day, the nation has evolved through various stages of development. The early years were marked by exploration and the establishment of colonies. The American Revolution led to the birth of a new nation, and the subsequent years saw the expansion of territory and the growth of industry. The Civil War was a pivotal moment in the nation's history, leading to the abolition of slavery and the strengthening of the federal government. The 20th century brought significant social and economic changes, including the rise of the industrial revolution and the emergence of the United States as a global superpower. Today, the United States continues to play a leading role in the world, facing new challenges and opportunities.

THE HISTORY OF THE UNITED STATES
BY JAMES M. SMITH
NEW YORK: THE HISTORY COMPANY, 1900

which is sufficient to drive a vibrating reed electrometer. With this set-up, ion beam currents as small as 10^{-16} amperes can theoretically be examined with reasonable accuracy. Isotopic abundance ratios of the order of $10^4/1$ have been regularly measured. It should be noted that a small mass effect has been observed. That is, the average number of secondary electrons produced at the cathode of the electron multiplier varies slightly with the mass of the impinging ion. It has been found adequate to correct for this effect during data reduction.

Now that a general picture of the spectrometer has been established, it is perhaps appropriate to briefly inspect the basic equations involved (Gaussian form). Let the accelerating potential be V , thus allowing a singly charged ion to acquire a kinetic energy eV . This ion will enter the magnetic field with a discrete velocity which is given by

$$eV = \frac{1}{2} mv^2 \quad (1)$$

where m is the mass of the ion, e is the electronic charge, and v is the terminal velocity of the ion after acceleration. The magnetic flux density B is perpendicular to the velocity vector of the ion, therefore the ion under consideration will be deflected into a circular orbit.

Balancing forces yields

$$\frac{mv^2}{r} = \frac{e}{c} \left| \vec{v} \times \vec{B} \right| = \frac{evB}{c} \quad (2)$$

where c is the velocity of light and r is the radius of curvature of the ion path. Eliminating v from equations (1) and (2) yields a general expression relating the magnitude of the magnetic flux density to ion

The first part of the paper is devoted to the study of the
 asymptotic behavior of the eigenvalues of the Laplacian
 on a Riemannian manifold with boundary. The second part
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mass such that only ions of this mass will follow a path which passes through the collector slit:

$$B = \frac{c}{r} \sqrt{\frac{2V}{e}} \quad m^{\frac{1}{2}} \quad (3)$$

Substituting values of r and V for the LASL spectrometer and the accepted values of c and e yields

$$B \text{ gauss} = \frac{(3 \times 10^{10} \frac{\text{cm}}{\text{sec}})}{35 \text{ cm}} \sqrt{\frac{2 (10^4 \text{ volts}) (1.66 \times 10^{-24} \frac{\text{gm}}{\text{amu}}) (m \text{ amu})}{300 \frac{\text{volts}}{\text{statvolt}} (4.8 \times 10^{-10} \text{ statcoulomb})}}$$

$$B = 412 \text{ m}^{\frac{1}{2}} \quad (4)$$

where the units of m have been changed to atomic mass units. Thus we see that to pass an ion having mass number 235 requires a flux density $B = 412 \sqrt{235} = 6316$ gauss, and an ion of mass number 234 will reach the collector if the B field is set at $412 \sqrt{234} = 6302$ gauss. While these figures are not accurate to the number of places given, the difference between them ($6316 - 6302 = 14$ gauss) is quite representative of the change in flux density required to move from one mass number to an adjacent mass number.

Finite source and collector slit widths mean that ions traveling along paths other than the theoretical line path discussed thus far will also reach the detector. Within reason, this effect is desirable and results in an ion current of detectable magnitude at the collector. In operation the spectrometer is centered on a given mass number by varying magnetic flux density in the vicinity of the magnitude predicted by equation (4) until a maximum output is observed. By sweeping from mass number to mass number it has been well verified that proper velocity ions of adjacent mass number do not reach the collector when the

spectrometer is centered on a particular mass number. The term "proper velocity" is used in the preceding sentence because some ions will suffer energy and direction changing collisions with particles resident in the vacuum system during transit. Some of these will acquire a velocity just right to reach the collector even though they do not have the desired mass number. These unwanted ions are compensated for, to some extent, by ions of desired mass number which fail to reach the collector after experiencing collisions. It is important to keep the vacuum system operating efficiently to reduce collision frequency.

To complete a general understanding of the LASL mass spectrometer it is necessary to discuss the end result or product. With the instrument centered on a particular mass number, the electron multiplier will produce a current proportional to the number of atoms of that mass number present in the sample being analyzed. This current is passed through a resistor to create a d.c. voltage which is fed to a vibrating reed electrometer. The signal is then appropriately scaled and the output of the electrometer is graphically recorded on a moving strip chart. Such a recording is obtained for every mass number for which there are atoms present in the sample. One particular mass number is chosen as a reference, all recorded numbers are converted to a common scale, and atom abundance ratios are calculated by dividing the value associated with each mass number by the value determined for the reference. From this point it is a simple matter to compute the weight percent of the total sample represented by each isotopic species. Results are published (see Table 1) which state the atom ratio and the weight percent of each observed isotope.

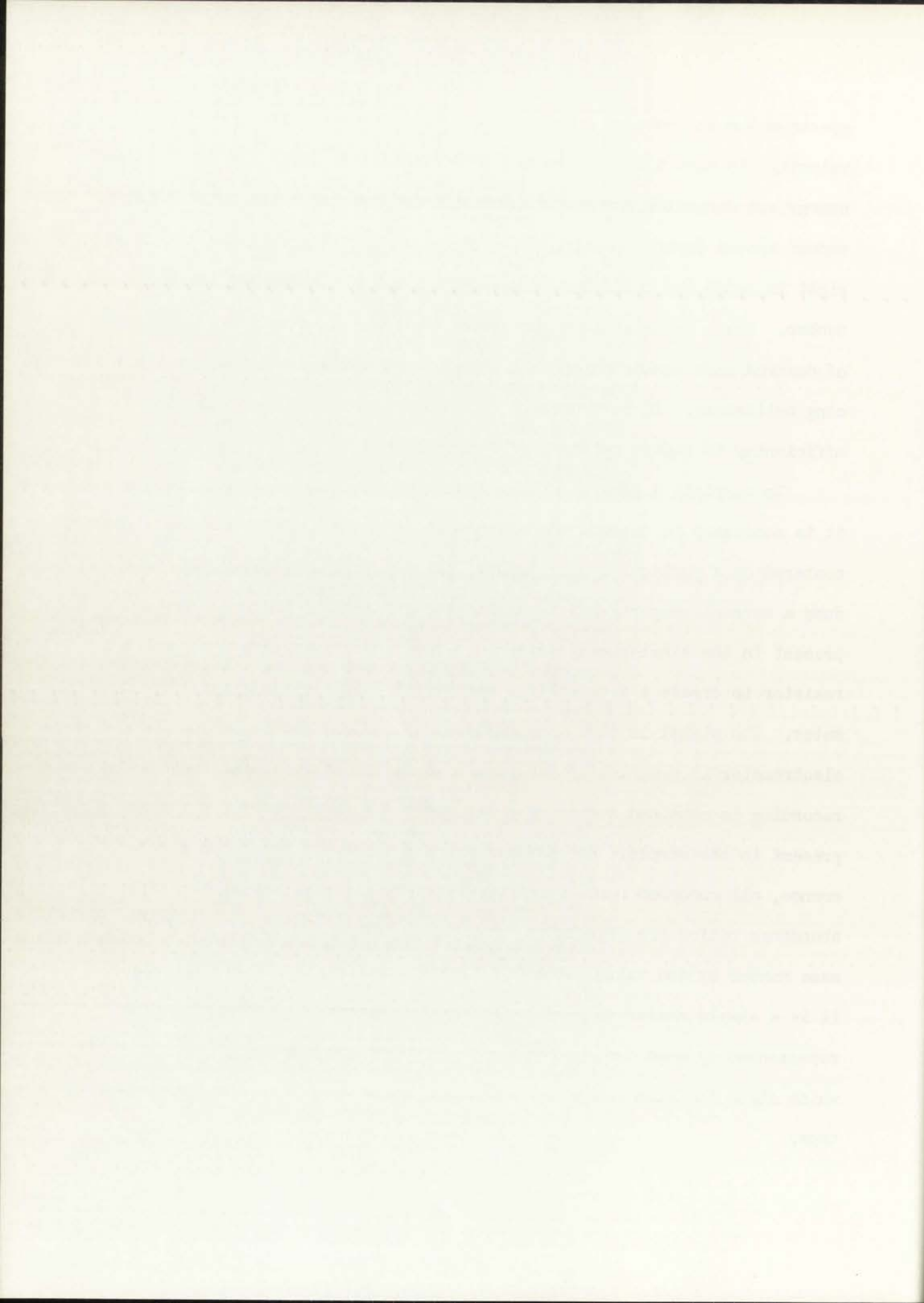


TABLE 1. Result of a Typical Analysis

Mass Number	Atom Ratio	Weight Percent
234	0.0116 ± 0.0004	1.08 ± 0.04
235 (reference)	1.00000 ± 0.00000	93.3 ± 0.2
236	0.00219 ± 0.00008	0.206 ± 0.007
238	0.057 ± 0.002	5.4 ± 0.2



CHAPTER 2

THE PROBLEM

As mentioned in Chapter 1, the only serious disadvantage inherent in the surface ionization method of ion generation is that ion emission is not constant with time. Total beam current falls off as time passes because of sample depletion. Irregular long term fluctuations (longer than 10 seconds) are often observed, and are attributed to complex heat transfer characteristics at the side filaments. A moment's reflection yields the inescapable conclusion that, if total beam current is not constant, then a measurement taken at some particular time is proportional to the atom abundance of the isotope in question only with respect to total beam current at that time. The ratio of such a measurement to another measurement made for the reference isotope at another time when beam current was different certainly does not give the atom abundance ratio of these two species!

One way to eliminate the problem of changing beam current is to build a dual collector. By measuring the ion currents contributed by two different isotopes simultaneously, it becomes a trivial job to calculate the relative abundance ratio. This method has drawbacks. An additional set of detecting, amplifying, and recording equipment is required. Calibration of the relative gain of each of the two channels can be troublesome. Physically mounting a second collector on an already established instrument requires careful planning and time.

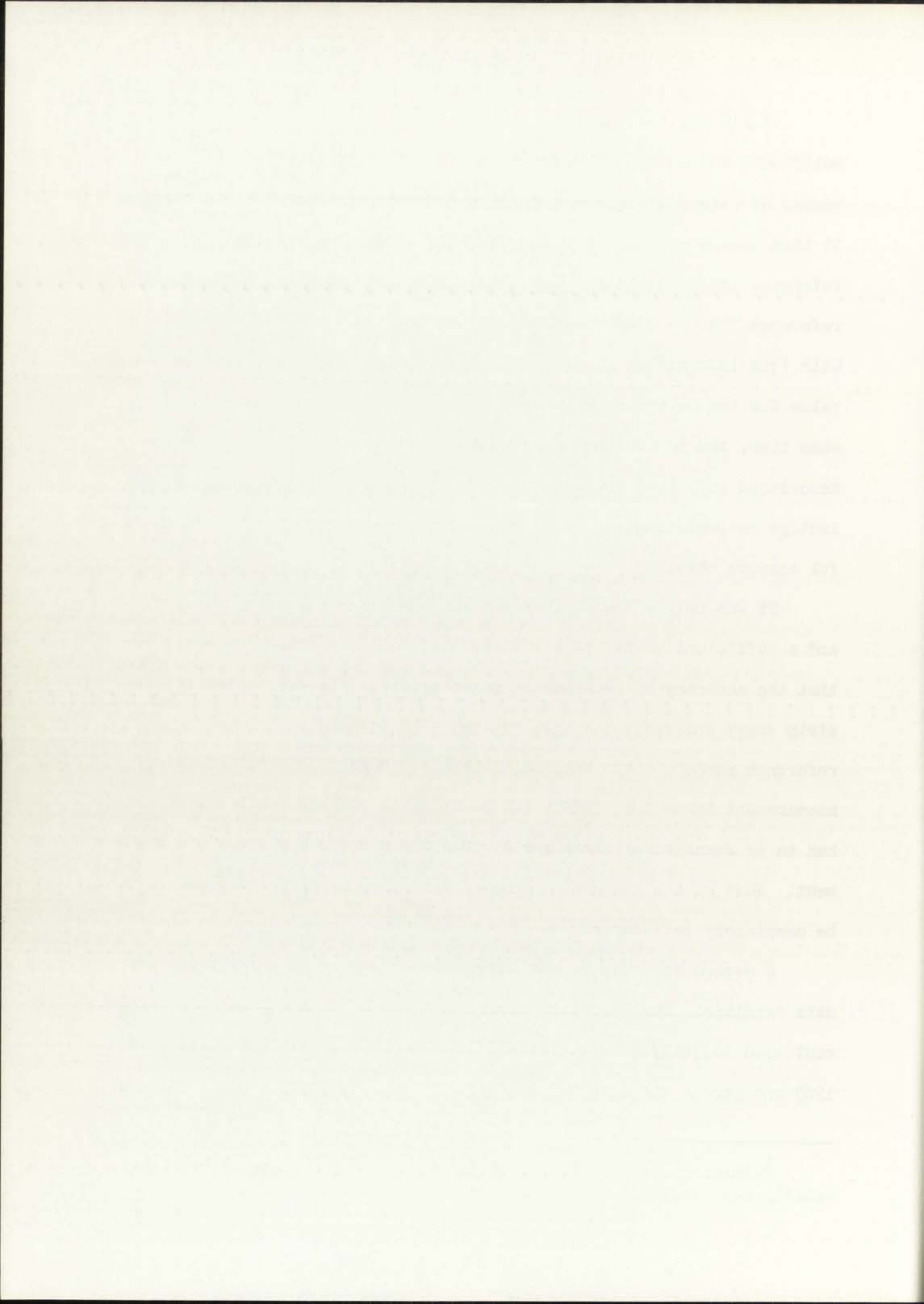


At LASL neither time nor funding was available to install a dual collector, and an alternate solution was initially adopted. A large number of reference isotope measurements were made during each analysis. It then became possible to infer from the strip chart, which showed the reference measurements in their proper time relationship, what the reference isotope measurement would have been at any time (see Figure 4). With this information it was possible to divide any measurement by the value for the reference isotope obtained from the strip chart for the same time, and to obtain a fairly accurate value for the isotopic ratio associated with that measurement. By repeating the measurement of each isotope several times (6 to 8) large errors were averaged out and meaningful answers obtained.

It was only after this system had been in use for about 6 months and a sufficient number of standards¹ had been run that it became clear that the accuracy of results was not adequate. The girl reducing the strip chart information simply was not able to draw in the complete reference isotope curve with sufficient accuracy. Also, a background measurement taken immediately before and after each isotopic measurement had to be averaged and graphically subtracted from the isotopic measurement. None of the background correction techniques attempted proved to be completely satisfactory.

A second and equally serious problem occurred in connection with data handling. The Avco mass spectrometer at LASL is a production instrument used to analyze approximately 800 samples a year. During most of 1969 one person was involved half-time in reading strip charts. During

¹Standards are isotopic samples of accurately known composition, usually supplied by the National Bureau of Standards (NBS).



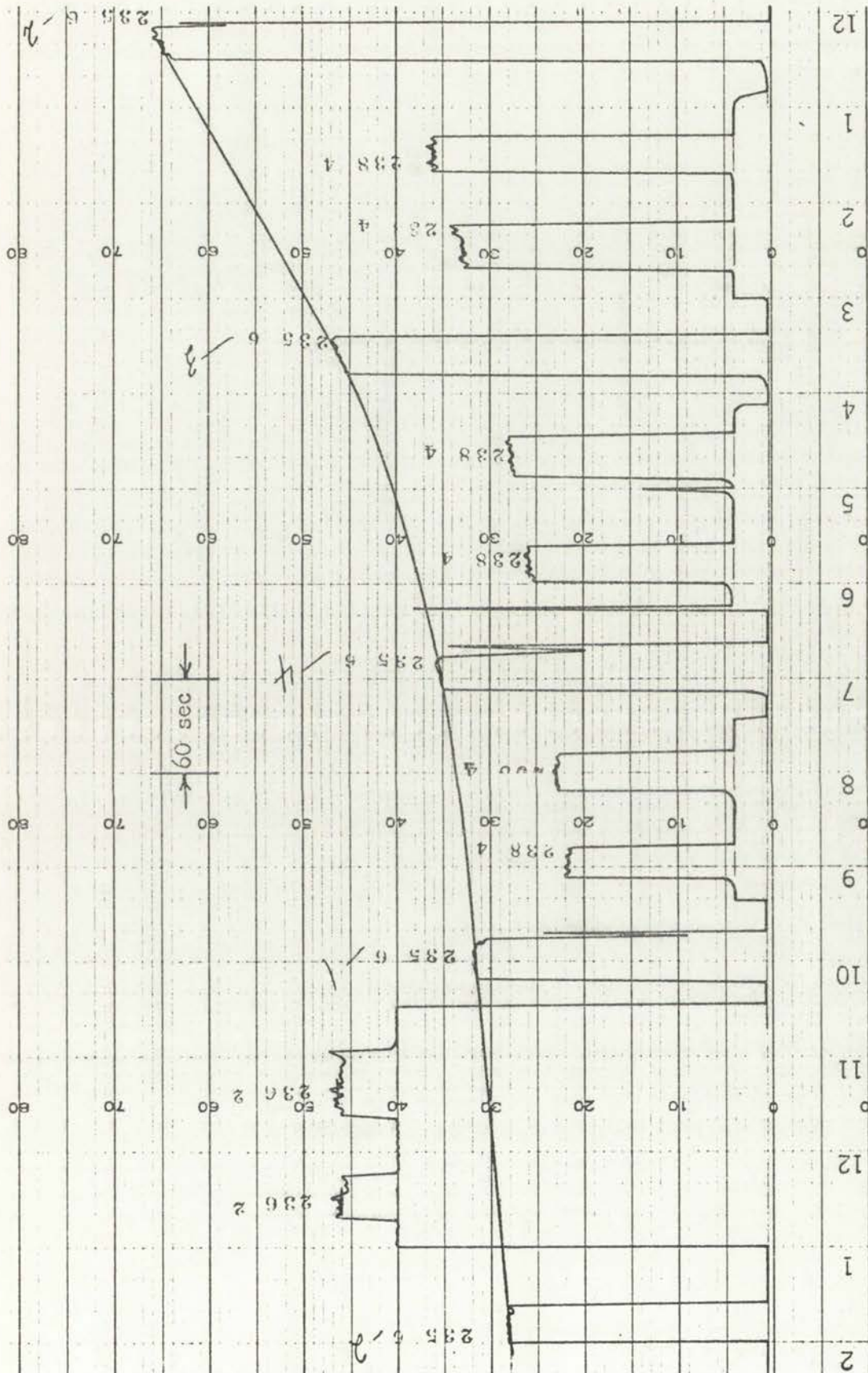


FIGURE 4. A portion of a strip chart. This particular chart was obtained at the same time as the data used in producing the material for Appendices E and F. A description of the sample material used may be found in Appendix F. Peak height is plotted in the vertical direction and time is measured from right to left (the result of chart drive direction). Five reference peaks (mass number 235) and 8 isotope peaks (6 for 238, 2 for 236) are illustrated. The number following each mass number (e.g., 238 4) is a scale factor.

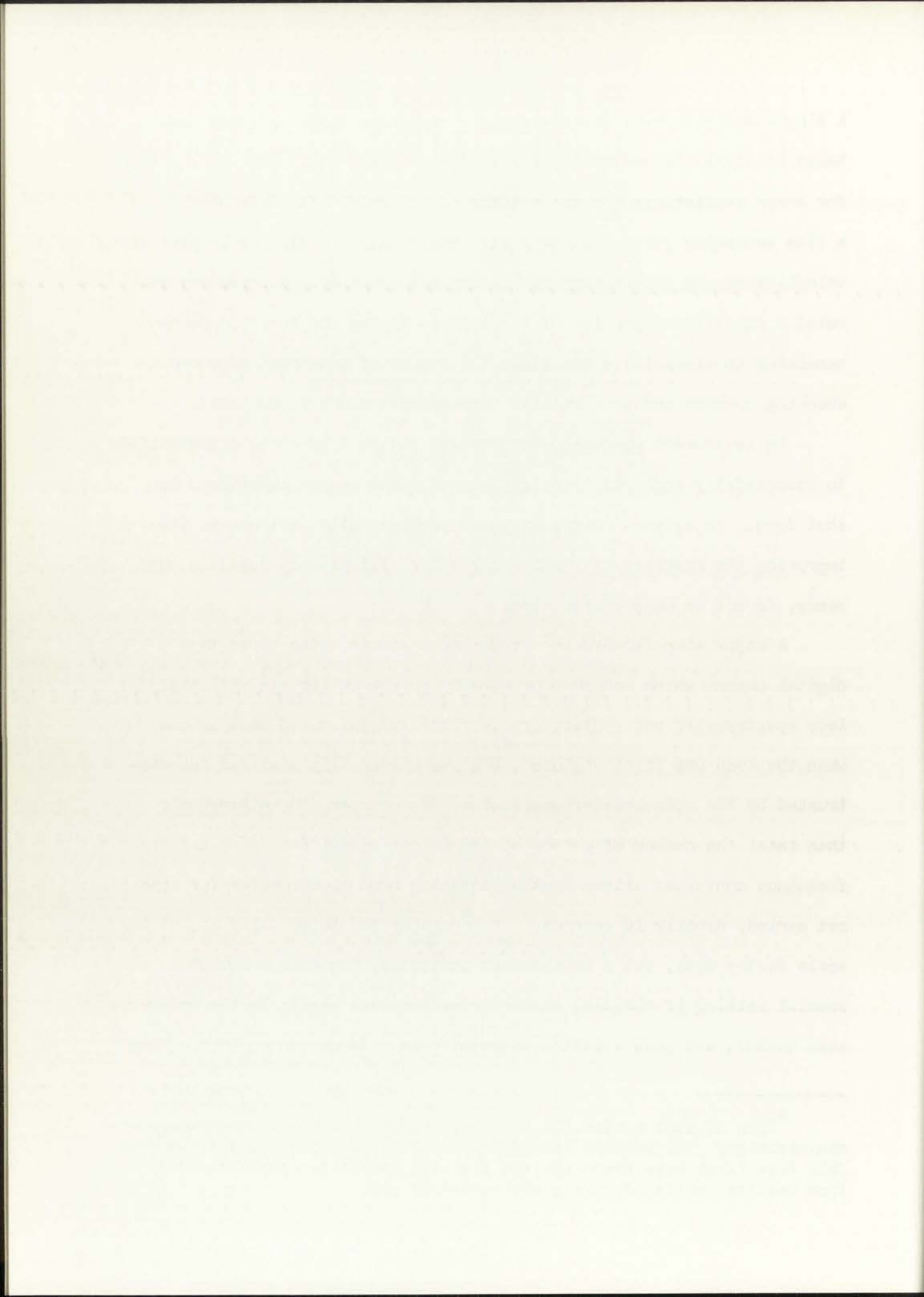


a single analysis many measurements of each mass number present were taken to eliminate bad measurements and to obtain sufficient information for error statistics; and the reading of the resultant strip charts was a time consuming job. Another person was employed full time in performing calculations and determining statistical uncertainty. A secretary devoted a significant portion of her time to typing the correspondence necessary to disseminate results. The number of man-hours expended in checking numbers and proofreading correspondence was appreciable.

An instrument producing information required by other organizations to successfully accomplish their assigned tasks cannot be allowed to shut down. To solve a severe manpower problem while at the same time improving the accuracy of published results, all without spending any money, is not an easy proposition.

A major step forward occurred when a counter with paper tape digital output which had been originally purchased for use with the Avco spectrometer was rediscovered.² This subsystem had been in use when the Avco was first employed, but was universally disliked and distrusted by the spectrometer operators. The counter did nothing more than total the number of pulses of the output signal from a voltage-to-frequency converter driven by the vibrating reed electrometer for some set period, usually 10 seconds. The operator had to manually adjust the scale factor dial, set a mass number indicator, position a switch to a special setting if the mass number being measured was to be the reference mass number, and push a button to print this information on tape. Then

²This digital system had been used under a previous supervisory administration. The reasons stated for its lack of success and subsequent fall from favor have been obtained from the operators themselves and from results published during the period of use.



the operator successively adjusted the magnetic field to record the first background, the mass number center measurement and the second background.³ Measurement times were automatically recorded.

The operator had to complete this procedure for each measurement of each mass number, while at the same time annotating the moving strip chart. Time between successive measurements averaged between 40 and 80 seconds.

When the digital output system was first used, occasional operator errors in positioning the many adjustable indicators destroyed both results and operator confidence. A straight line approximation was used to obtain reference isotope values corresponding to the times of measurement of other mass number isotopes. Results were poor, and the project was abandoned in favor of a return to the strip chart method.

Nevertheless, the rediscovery of this equipment was of the greatest importance. The obvious way to solve the existent manpower problem was to have the large computers at the LASL Central Computer Facility do all the calculational work, and computers require digital data. It remained necessary to figure out a procedure to make the operator's job tenable, and a method whereby the computer would produce more accurate results.

³One background would be taken at a mass number setting slightly less than that for the isotope being examined and the other at a setting somewhat higher than the setting for this isotope.

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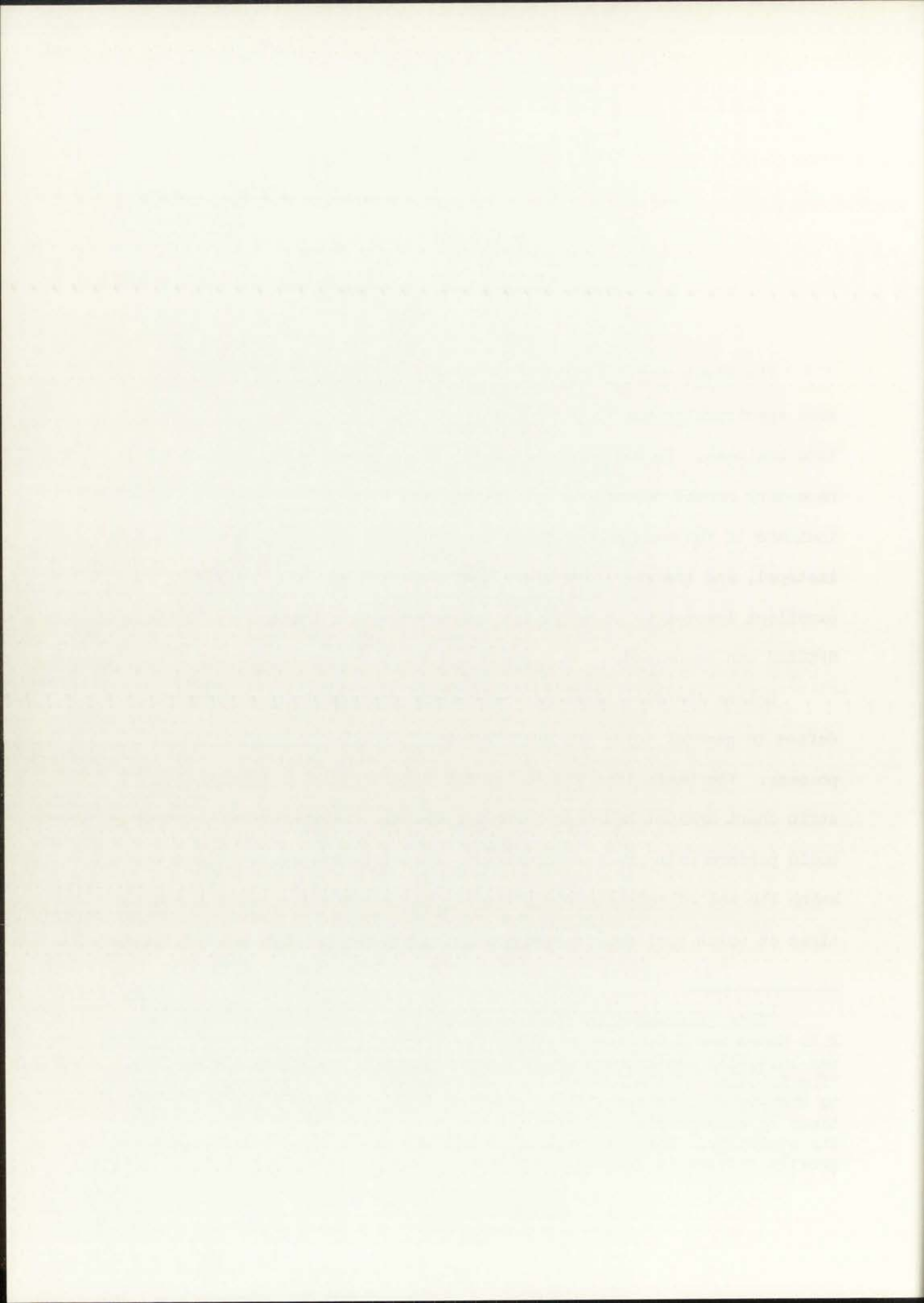
CHAPTER 3

EARLY ATTEMPTS AT A SOLUTION

The first step in solving the problems associated with the Avco mass spectrometer was to place the paper tape digital output system back into business. To make the operators' lives less hectic, several unnecessary manual operations were eliminated (e.g., positioning a switch to indicate if the mass number being measured corresponded to the reference isotope), and the remaining operations were ordered and simplified. An excellent least-squares curve fitting routine¹ was located, and program SPECTRE was conceived.

Before the first line of SPECTRE was written it was necessary to define in general terms the architecture the finished program was to possess. The basic idea was to let the computer do the same job the strip chart analyst had been doing graphically (hopefully the computer would perform with greater accuracy). That is, the computer would examine the set of measurements belonging to the reference isotope and the times at which each measurement was taken, and would then use the already

¹This least-squares routine was written on October 15, 1959, by R.H. Moore and R.K. Ziegler of the Los Alamos Scientific Laboratory. It was initially distributed as LASL Report Serial LA-2367 with the title, "The Solution of the General Least-Squares Problem with Special Reference to High-Speed Computers." The original routine has been modified many times by many people, and acquired the name "PACKAGE" at some stage of its evolution. For this application it was extensively modified and greatly reduced in length, thereby receiving the name "PARCEL."



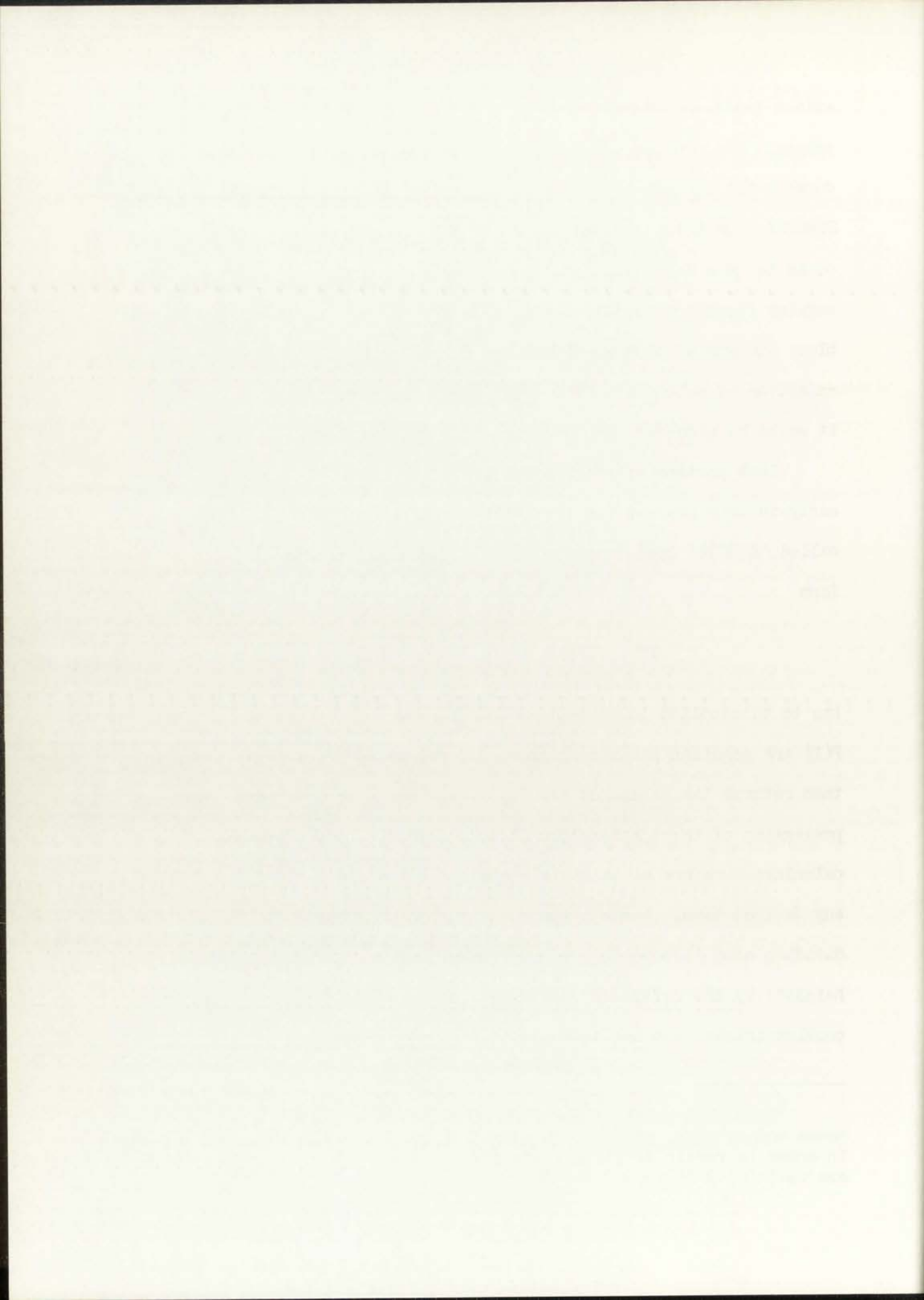
extant least-squares subroutine to fit a curve to these experimental points. The program would also examine the background readings and correct all isotope measurements accordingly. It was decided to break SPECTRE down into a relatively short parent program and several subroutines so as to make debugging and future change as simple as possible. The modular flowchart contained in Appendix C, section I, is essentially a block diagram of program SPECTRE as it was initially conceived, with the exception of subroutine MEMO which was a later addition. At this point it would be wise for the reader to look at Appendix C.

That portion of program SPECTRE which caused the greatest concern early in this project was the least-squares curve fitting subroutine, called "PARCEL" (see footnote, page 14). A mathematical function of the form

$$YT = f(P(1), P(2), P(3), P(4), Z) \quad (5)$$

has to be supplied to subroutine PARCEL, where YT is reference value, the P(i) are constant parameters to be determined and Z is time.² PARCEL then returns the values of the P(i) which yield the best fit. Once in possession of these parameters it is possible to use Equation (5) to calculate a reference value (also called a "reference peak height") for any desired time. Isotope abundance ratios can then be calculated by dividing each isotope measurement (often referred to as an "isotope peak height") by the reference peak height obtained for the same time. The problem arises when one attempts to pick a function.

²From this point on upper case letters are used for all variable names and symbols, even though occasionally contrary to standard practice, in order to remain in close accordance with the program listings which are restricted to upper case lettering (Appendices C through F).



Three sets of actual data were selected where measurements associated with the reference mass number (235) varied with time in the wildest manner ever observed. It was felt that if a function YT could be found such that a good curve fit would result for each of these three experimental runs, then that function would work for any experimental run. Numerous polynomial and exponential functions were tried. The $P(i)$ were allowed to become exponents as well as coefficients in many of the functions attempted. Some of the failures were spectacular (see Figure 5). For the most part, however, the fitted curves followed the experimental points fairly well. Fairly well was not good enough.

A brief digression is again in order. By this time everything possible was being done with the aid of the computer, including the print-out of all trial curves. A typewriter plotting routine was located

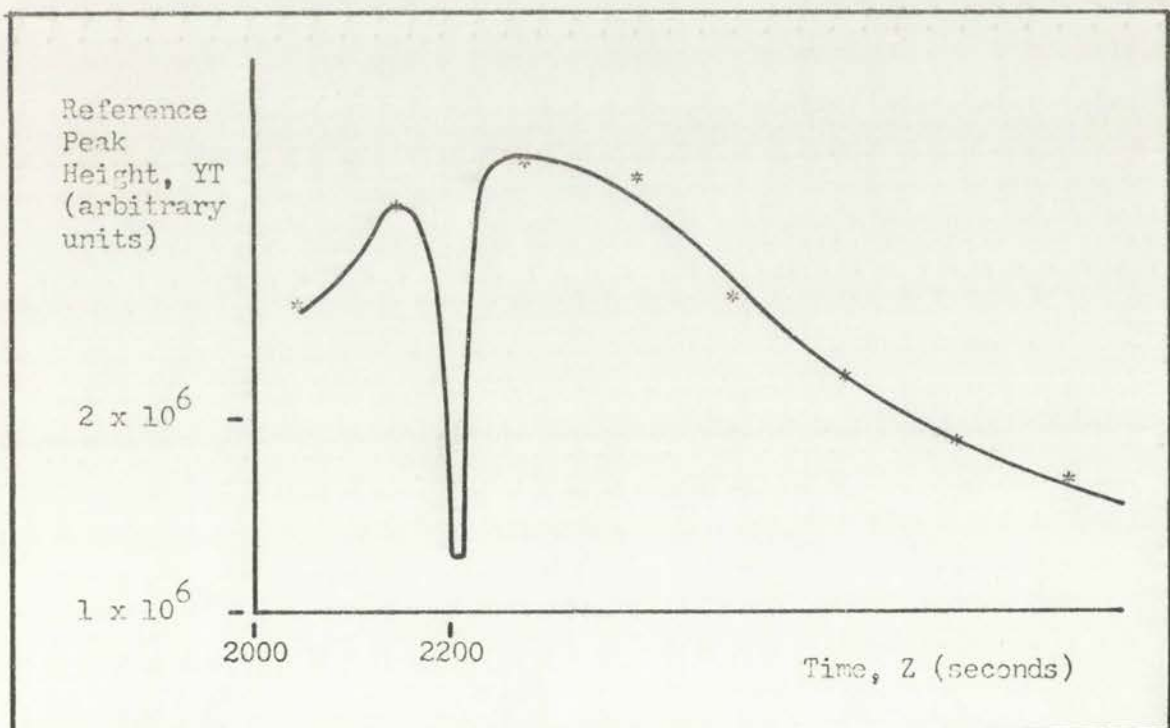


FIGURE 5. An unsuccessful reference curve fit.



and highly modified to plot both experimental points and the fitted curve.³ This code, called subroutine "Graphic", enabled trial curves to be seen and trial functions to be evaluated quickly without hand plotting (see Appendix F, pages 130, 132, and 134). Such typewriter plots are actually produced by high speed printer equipment attached to the computer and are available much more quickly than plots made on conventional x-y plotters or photographic plotting devices.

Meanwhile, the thought had occurred that if the reference isotope curve were fitted in smaller segments the fit should be better. Some segmented fitting was already being done. Occasionally during a run the beam current would fall to an unacceptably low level and the operator would increase the current through the two evaporative filaments to raise ion beam intensity. When this event occurred all measurements following the increase in filament temperature (FILTEMP) had to be considered separately when obtaining individual measurement ratios. A new program section was written which assigned synthetic FILTEMPS to each measurement so that the reference peak height curve would be fitted in sections of four to eight reference measurements each. The function (a modified Gaussian) which had been giving the best results to date was inserted and the refurbished source deck submitted to the computer. The results were very discouraging.

³This routine, by reputation, was plagiarized from a graduate student at Princeton who in turn had plagiarized it from some other source. Not knowing where credit belongs, the current version here at LASL is called "GRAPHIC" and is used without reference to antecedents or credit.



CHAPTER 4

SUCCESS AND THE LETTER

After considerable soul-searching, it was concluded that perhaps a polynomial might be more efficient at handling the shorter segments, many of which did not resemble any portion of a Gaussian curve. Almost immediately a number of functions were found which gave excellent results. Several weeks were required to arrive at a choice, and as arbitrary as the selected polynomial may appear, it gave the best overall fit for all data selections tested:

$$YT = P(1)Z^{-3/2} + P(2)Z^{-1/2} + P(3)Z^{1/2} + P(4)Z^{3/2} \quad (6)$$

Typical values for the $P(i), i=1,4$, may be found in Appendix F, pages 129, 131, and 133.

At this stage the "Weight Percent" column shown in Table 1 was not regularly included in the published report of a completed sample analysis. A survey of users revealed that several were performing the conversion from atom ratio to weight percent by hand, as they required this information on a routine basis.

During the survey just mentioned the group secretaries were asked to comment on procedural changes that might make their job easier or which might result in less delay in mailing the results. None of the relatively large number of suggestions received was of real value, but the volume caused one to ponder the possibility of having the computer write the

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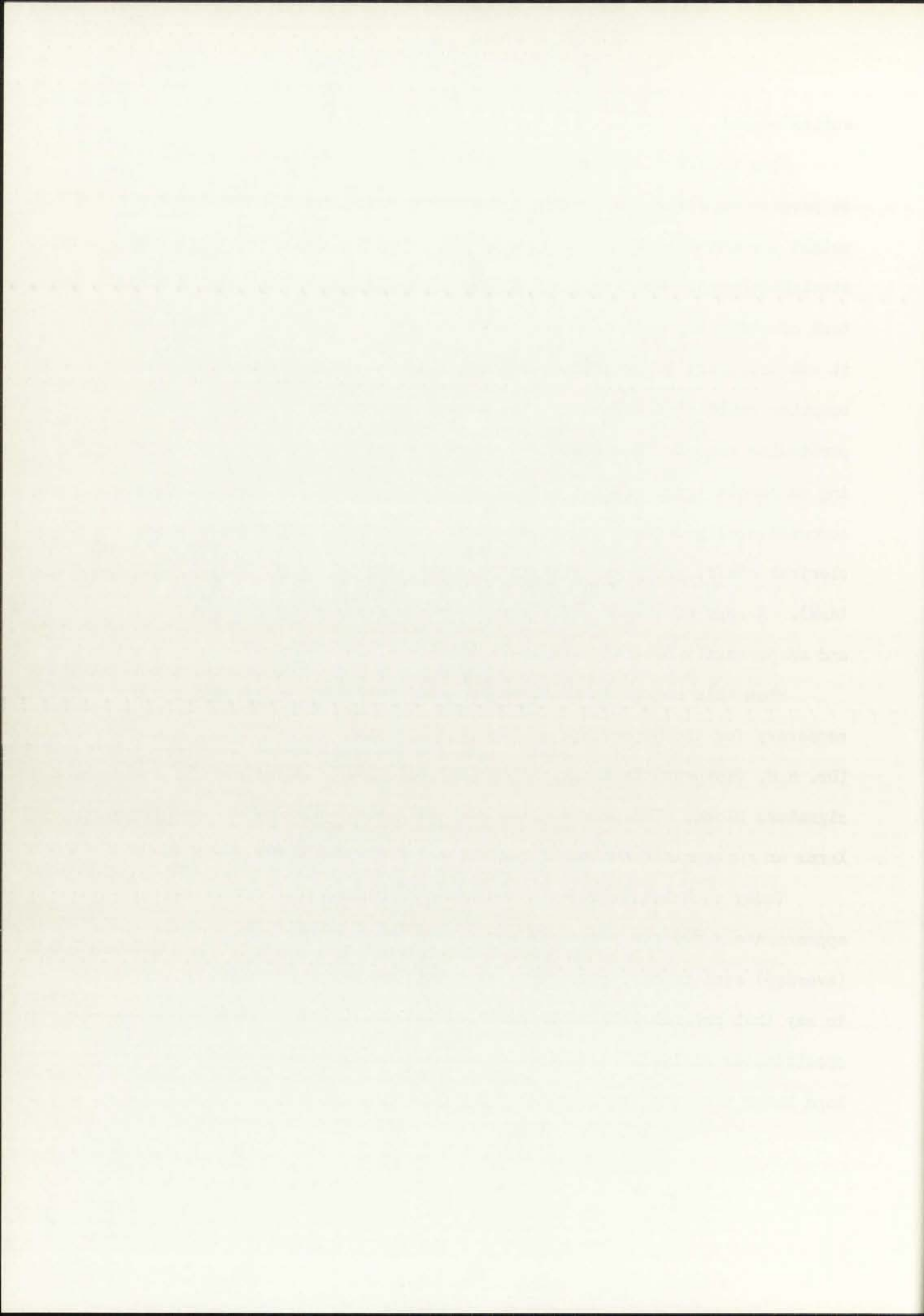
...

entire report.

As a result of this survey, subroutine MEMO was written and added to program SPECTRE. The coding necessary to have the computer calculate weight percent as well as atom ratio for each mass number examined was straightforward. Programming to have the computer write the letter report took considerably more effort. In having the computer draft a letter, it was necessary to program a good many logical decisions so that the computer could pick and choose the proper items to be included in any particular report. The distribution, for instance, varies widely depending on sample type. It was also necessary to ensure that the report was compositionally correct and consistently in a format acceptable to the clerical staff, group and division leaders, and to the users (no easy task). A copy of the computer report as programmed in subroutine MEMO and as presently used appears in Figure 6.

When this report is returned from the computer, it is only necessary for the Supervisor of the Mass Spectrometer Section (Dr. R.M. Tisinger) to indicate his approval by initialing the signature block. The secretary on duty will then add a group symbol, Xerox an appropriate number of copies, and send the report on its way.

Today such letter reports are being published at the rate of approximately 800 per year. If one counts the 6 copies of each report (average) sent to different users as separate reports, then it is fair to say that program SPECTRE produces almost 5000 highly accurate mass spectrometer analysis reports each year and requires essentially no hand labor once the spectrometer run has been completed.



OFFICE MEMORANDUM

TO : DISTRIBUTION
DATE: 4 SEP 70
FROM : R. M. TISINGER
SUBJECT: MASS SPECTROMETER ANALYSIS (SPECIAL)
(SAMPLE SERIAL NUMBER)
(NBS-930)
SYMBOL :

AN ANALYSIS OF THE SAMPLE DESCRIBED ABOVE WAS COMPLETED ON 31 AUG 70. THIS ANALYSIS WAS PERFORMED USING THE AVCC MASS SPECTROMETER. RESULTS ARE TABULATED BELOW WITH UNCERTAINTY EXPRESSED AT THE NINETY-FIVE PERCENT CONFIDENCE LEVEL. ATOM RATIO IS THE NUMERICAL RATIO OF THE NUMBER OF ATOMS OF SPECIFIED MASS NUMBER TO THE NUMBER OF ATOMS OF MASS NUMBER 235.

MASS NUMBER	ATOM RATIO	WEIGHT PERCENT
234	.01165 +- .00039	1.0822 +- .0361
235	1.00000 +- 0.00000	93.2936 +- .1672
236	.00219 +- .00008	.2055 +- .0073
238	.05735 +- .00186	5.4187 +- .1757

R. M. TISINGER
GROUP W-7

DISTRIBUTION:

W- 7 W. H. CHAMBERS
W- 7 R. M. TISINGER

FIGURE 6. The computer produced letter report of program SPECTRE. This particular example of the SPECTRE report was produced along with the material contained in Appendices E and F. A description of the sample material used may be found in Appendix F, pages 124 and 139.

MEMORANDUM FOR THE RECORD

DATE: 10/15/54

TO: SAC, NEW YORK

FROM: SA [Name], NEW YORK

SUBJECT: [Subject]

[Faded text block]

- [Faded list item 1]
- [Faded list item 2]
- [Faded list item 3]
- [Faded list item 4]

[Faded signature block]

[Faded text block]

CHAPTER 5

PROGRAM SPECTRE

The background for this program has been covered in preceding chapters. Program variables, flowcharts, a program listing, and an example of standard output are contained in appendices. Several important aspects of this program, however, remain to be discussed.

Program SPECTRE was not coded in the American Standards Association (ASA) FORTRAN IV programming language. It was coded in a version of FORTRAN IV espoused by the Control Data Corporation (CDC). While these two languages are essentially similar, several very important differences exist: ASA FORTRAN IV may be used on almost any computer. CDC FORTRAN IV is usable only on those few machines especially programmed to accept this language. The CDC version permits 7-character variable and routine names. The ASA version allows a maximum of 6 characters in such names. Buffer handling statements are not the same. The methods of writing and operating with logical arithmetic statements are quite different. Other differences exist.

This discrepancy is not fatal. If one were to attempt to compile a SPECTRE source deck on a machine other than the CDC-6600 or CDC-7600 machines at LASL, strange things would occur. Most other machines will truncate all names to 6 characters. All other machines will print diagnostic remarks to be identified with program statements which are not understood. A good program analyst could then correct the imperfect

statements and rename the variables and routines having names requiring changes. The corrected source program should then compile properly and the new user would have a viable program similar to SPECTRE.

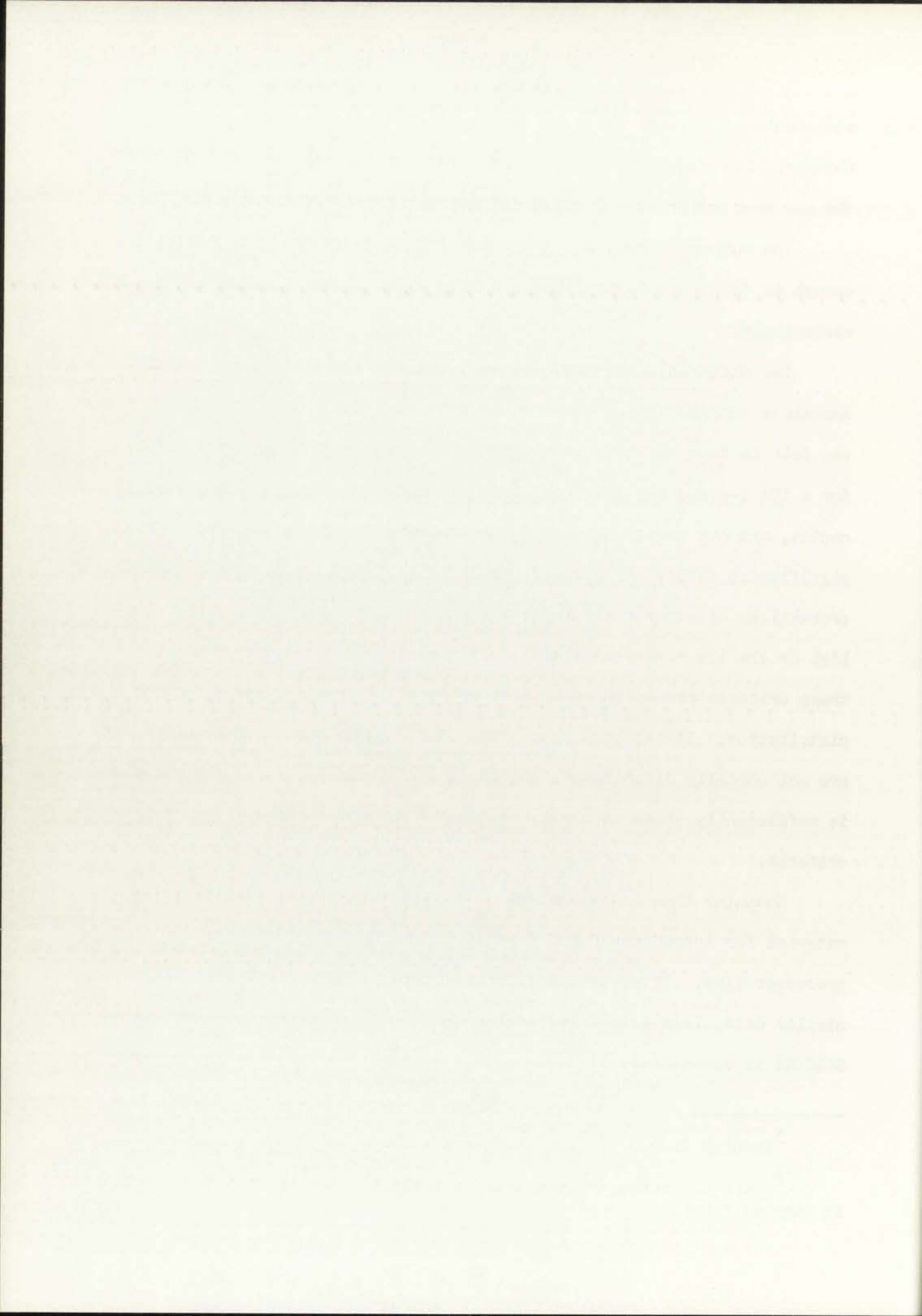
The author learned his programming from scratch, and now knows enough to do future coding with ASA standard programming languages exclusively.

Two different criteria have been used for the identification of anomalous measurements. Chauvenet's Criterion was initially applied, and was felt to have resulted in the elimination of good data.¹ Grubbs' table for a 10% 2-sided significance level has been used for the past several months, and has proven eminently satisfactory.² When using a 10% 2-sided significance table, the desired result is that there will be only a 10% probability of erroneously rejecting a good observation from either the high or the low measurement side. It should be pointed out that both of these criteria are based on an assumed normal (Gaussian) population or distribution. It has been recognized that mass spectrometer measurements are not normally distributed, but it is felt that the actual distribution is sufficiently close to normal so that it is reasonable to apply such criteria.

Computer time is expensive. The computer run made to obtain the material for Appendices E and F required exactly 8.8 seconds of central processor time. If program SPECTRE were run 800 times each year with similar data, less than 2 hours of computer time would be used annually. SPECTRE is economical.

¹Yardley Beers, Introduction to the Theory of Error, 23-24.

²Frank E. Grubbs, "Procedures for Detecting Outlying Observations in Samples," 2-5.



Initially it was decided that a basic 3% error plus a calculated statistical uncertainty (expressed at the 95% confidence level) would be shown for each isotope atom ratio listed on the published report. It was hoped that as experience was gained the magnitude and nature of non-statistical errors inherent in the procedure and material system would become apparent, and could perhaps be eliminated. It was intended that, when the magnitude of the actual irreducible nonstatistical error became known, the 3% arbitrarily assigned error should be accordingly reduced. While it was realized that assigning too large an uncertainty could be as bad as assigning too little, in this instance it was most important to the users that the accuracy of results be evaluated pessimistically. The numbers appearing in Figures 6 and 16 include the aforementioned arbitrary 3% error.

Recent checks against NBS standards have indicated that the non-statistical error is now less than 1% (compare the numbers stated for weight percent on page 138 with those given on page 139). The maximum uncertainty considered acceptable for Avco mass spectrometer results is 1%. SPECTRE is now producing consistently accurate and timely results.

The first part of the report deals with the general situation of the country and the position of the various groups. It then goes on to discuss the economic situation and the social conditions. The third part of the report is devoted to a detailed study of the various groups and their activities. The fourth part of the report is a summary of the findings and conclusions. The fifth part of the report is a list of references.

The second part of the report deals with the economic situation of the country. It discusses the various sectors of the economy and the role of each sector. It also discusses the economic policies of the government and the impact of these policies on the economy. The third part of the report is devoted to a detailed study of the various groups and their activities. The fourth part of the report is a summary of the findings and conclusions. The fifth part of the report is a list of references.

The third part of the report is devoted to a detailed study of the various groups and their activities. It discusses the various groups and their activities in detail. It also discusses the relationship between the various groups and the government. The fourth part of the report is a summary of the findings and conclusions. The fifth part of the report is a list of references.

CHAPTER 6

CONCLUSIONS

I shall use the first person throughout this chapter, as the opinions expressed are entirely my own.

There was a time when the mass spectrometer was almost exclusively a tool of the chemist. That time has passed. At Los Alamos, the Supervisor of the Mass Spectrometry Section, Dr. R.M. Tisinger, is a physicist, as is his principal assistant. The other national laboratories with which I am familiar have physicists, as well as scientists from other disciplines, attached to their mass spectrometer organizations. Today, the mass spectrometer must be considered, among many other things, as a research instrument for the physicist.

A report recently published by the National Academy of Sciences contains the following note:

Experience at Brookhaven and Berkeley has shown that a programmer [sic] can produce between 10 and 20 debugged and documented lines of program per day, depending on such factors as experience, when he is working on reasonably straight forward programming. When working on a complicated monitor system he would be considerably less productive.¹

A quick count of the number of lines in program SPECTRE, skipping comment statements and ignoring subroutines PARCEL and GRAPHIC which were not wholly written for use with SPECTRE, yields the figure 380. Assuming the

¹On-Line Data-Acquisition Systems in Nuclear Physics, 1969, National Academy of Sciences, 15.

I shall now proceed to discuss the various aspects of the problem which has been presented to me. It is a problem of great importance and one which has attracted the attention of many of our leading scientists. The first aspect which I shall discuss is the question of the nature of the forces which are involved in the process. It is generally assumed that the forces are of a purely electrostatic nature, but there is some evidence to suggest that they may be of a more complex character. The second aspect which I shall discuss is the question of the rate at which the process takes place. It is generally assumed that the rate is proportional to the square of the concentration of the reactants, but there is some evidence to suggest that it may be of a more complex character. The third aspect which I shall discuss is the question of the effect of temperature on the rate of the process. It is generally assumed that the rate increases with temperature, but there is some evidence to suggest that it may be of a more complex character. The fourth aspect which I shall discuss is the question of the effect of the nature of the solvent on the rate of the process. It is generally assumed that the rate is independent of the nature of the solvent, but there is some evidence to suggest that it may be of a more complex character. The fifth aspect which I shall discuss is the question of the effect of the nature of the reactants on the rate of the process. It is generally assumed that the rate is independent of the nature of the reactants, but there is some evidence to suggest that it may be of a more complex character.

The following table shows the results of the experiments which have been carried out. It will be seen that the rate of the process increases with temperature and with the concentration of the reactants. It is also seen that the rate is independent of the nature of the solvent and of the nature of the reactants. These results are in agreement with the generally accepted view that the process is of a purely electrostatic nature. The results also show that the rate is proportional to the square of the concentration of the reactants, which is in agreement with the generally accepted view that the process is of a second order nature. The results also show that the rate increases with temperature, which is in agreement with the generally accepted view that the process is of an activated nature. The results also show that the rate is independent of the nature of the solvent, which is in agreement with the generally accepted view that the process is of a purely electrostatic nature. The results also show that the rate is independent of the nature of the reactants, which is in agreement with the generally accepted view that the process is of a purely electrostatic nature.

I am, Sir, very truly yours,
 J. H. ...

statement quoted on the previous page is accurate, then an experienced programmer working at his maximum rate would have taken 19 full working days to write SPECTRE. I knew absolutely nothing about computers or programming when I started this project. It took me longer than 19 days. By the time modifications necessary to make PARCEL and GRAPHIC function with SPECTRE were completed and the entire program was put on-line as a tested and proven piece of production software, I should estimate the time expenditure as close to 6 man-months and the work involved as more than would have been required for 15 hours of course-work (exclusive of the time spent producing this report).

Six months of effort must be balanced against what was accomplished. The staff-member who was engaged full-time reducing data has now been assigned to another task which cannot be done by a machine. The girl who was working half-time reading strip charts was caught in the recent personnel reduction at LASL and was discharged. The secretaries who used to type 800 reports each year have expressed their appreciation on several occasions. The users have commented in writing that report accuracy is noticeably higher, that they are receiving results promptly for the first time, and that the weight percent column in the letter report has saved considerable "busy-work" on their part. I have become somewhat proficient in programming and in using a computer for data handling and analysis. I have also learned a great deal about mass spectrometers and their employment. It is perhaps also fair to say that I have gained some knowledge of technical report writing. I am more than satisfied.

SPECTRE is not the end. Improvement must continue. While program SPECTRE has placed the LASL Avco mass spectrometer on a par with the best of the dual collector machines, this instrument should be able to handle



a larger number of samples daily, and accuracy could be further improved. The next step will most probably be to change from magnetic field to electric field control. That is, instead of varying the magnetic flux density to determine which mass number reaches the collector, the ion accelerating electric field will be adjusted to accomplish the same result. The advantage in making this switch is that the change from one mass number to another can be made much more quickly without having to fight the tremendous inductance of the magnet coils. As soon as funding is available it is planned to interface the spectrometer to a small local computer. Rapid mass number selection under computer direction and control should greatly increase accuracy and sample through-put, and will have the additional advantage of allowing some degree of on-line data reduction.

I have enjoyed this project in all of its facets without reservation, and I look forward to the next.

APPENDIX A

FLOWCHART SYMBOLS

A flowchart is a diagram that shows the operations performed in an information processing system (usually a computer), and the sequence in which these operations are performed. Appendix C contains a modular flowchart for program SPECTRE, which stresses the logic flow of the program and its principal subroutines. Appendix D contains a detailed flowchart for program SPECTRE, which illustrates every step performed throughout the entire program.

It has long been recognized that uniformity in the meaning and use of symbols would enhance understanding and utility of the flowchart. To this end, the International Organization for Standardization (ISO) published a document entitled, Recommendation on Flowchart Symbols for Information Processing. The United States of America Standards Institute (USASI) has also promulgated a recommended set of flowchart symbols. Large companies in the business, such as IBM and CDC, have distributed manuals with their versions and their recommended extensions. All of these suggested groupings of flowcharting symbols are similar, but none are identical.

An effort has been made to use only those symbols common to all of the major recommended groupings. The flowchart contained in Appendix D was computer produced directly from a complete SPECTRE source program by a

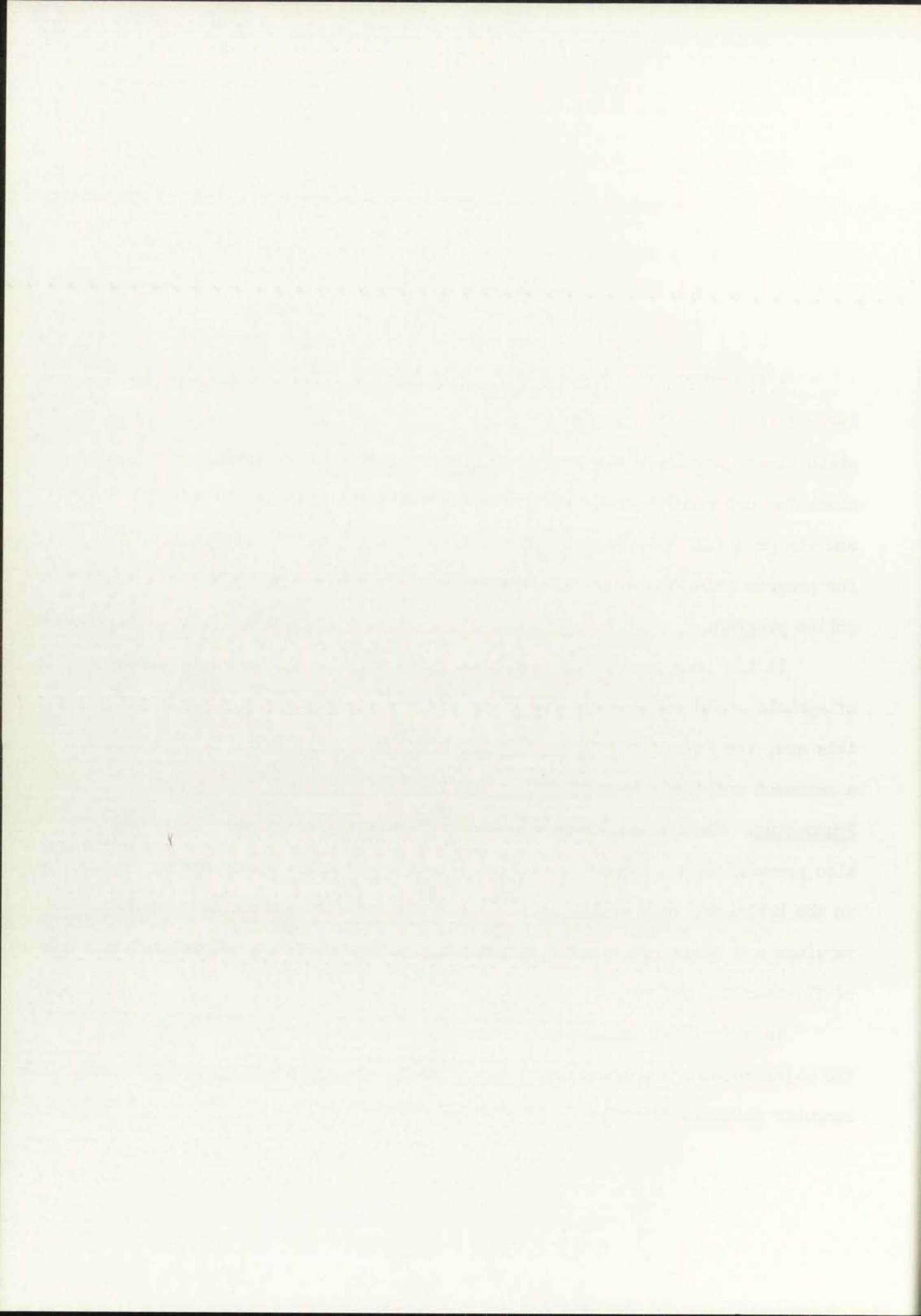
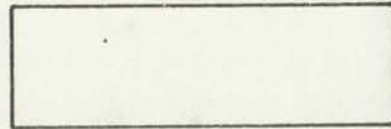
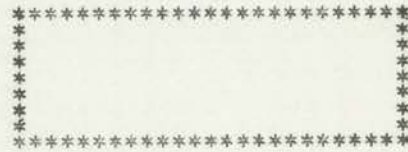


TABLE 2. Flowchart Symbols Used in Appendices C and D

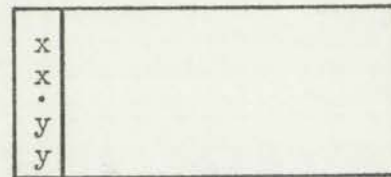
1. Process



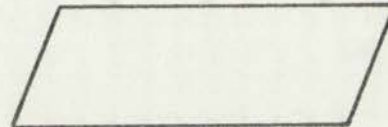
2. Comment/Annotation
(non-standard)



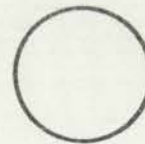
3. Predefined Process/Subroutine



4. Input/Output



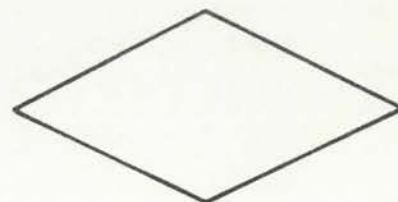
5. Connector/Transfer



6. Exit



7. Decision





standard flowcharting code called "AUTOFLOW."¹ It was impractical to remove one non-standard symbol from this flowchart; therefore, the comment/annotation symbol has been plainly marked "non-standard" in Table 2 and has been used in the flowcharts appearing in both Appendix C and Appendix D.

An illustrated listing of symbols to be used, such as appears in Figure 2, is really not sufficient for complete understanding of the use of these symbols. The remaining paragraphs of this Appendix will be employed to explain in detail the specific varieties of symbol usage.

Each flowchart symbol, except for certain unconditional transfers, has a symbol number which is printed above and to the right of the symbol. Within each flowchart page (in Appendix D each flowchart page takes up two physical pages), the symbols are numbered consecutively starting with 1. A symbol may also have a FORTRAN statement number associated with it. If so, the number is printed above and to the left of the symbol.

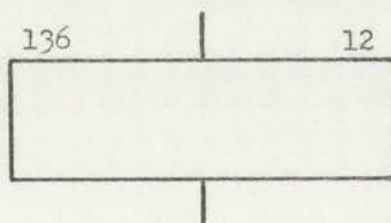


FIGURE 7. Symbol number 12. This symbol is associated with FORTRAN statement number 136.

If a symbol initiates a new path of flow, meaning that control does not pass down from the previous symbol, then the FORTRAN statement number associated with the symbol initiating the new path is printed in a small

¹AUTOFLOW was produced by Applied Data Research, Inc., of Princeton, New Jersey, for use at Goddard Space Center, Greenbelt, Maryland.



box above the symbol.

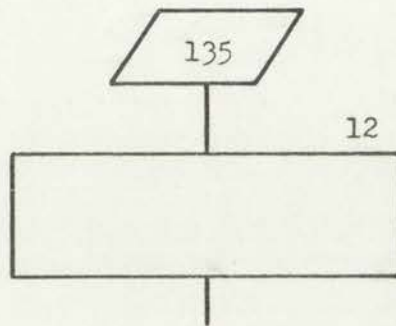


FIGURE 8. A symbol which begins a new path of flow. Symbol number 12 corresponds to FORTRAN statement number 135 in the source program.

Many references to symbols are shown in the form $xx.yy$ where xx is the flowchart page number² on which the symbol appears and yy is the number of the referenced symbol. If the symbol is on the current page, the xx is omitted and only the symbol number is printed.

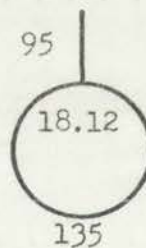


FIGURE 9. A connector or transfer. This transfer has been generated by FORTRAN statement number 95. Control is being transferred to symbol number 12 on flowchart page 18, which corresponds to FORTRAN statement number 135 in the source program.

When a call is made to a subroutine, the flowchart page and symbol number at which the subroutine flowchart begins are included within the

²In Appendix D the flowchart page number is assigned by the computer and is different from the usual physical page number.



FIGURE 2. A schematic diagram showing a vertical line connecting a trapezoidal shape at the top to a rectangular shape below it. The rectangular shape has a horizontal dashed line across its middle.

The vertical line connects the top of the trapezoidal shape to the top of the rectangular shape. The trapezoidal shape is wider at the top than at the bottom. The rectangular shape is wider than it is tall. The horizontal dashed line is positioned exactly halfway down the height of the rectangular shape.



FIGURE 3. A circular diagram with a vertical line extending upwards from its top center. The circle contains some faint, illegible text or markings.

The vertical line extends upwards from the top center of the circle. The circle itself is roughly circular in shape.

The diagram is centered on the page and is a simple line drawing.

predefined process/subroutine symbol generated by the call statement. If the word NONE appears instead, then a flowchart of the subroutine being called does not exist at the flowchart level under consideration.

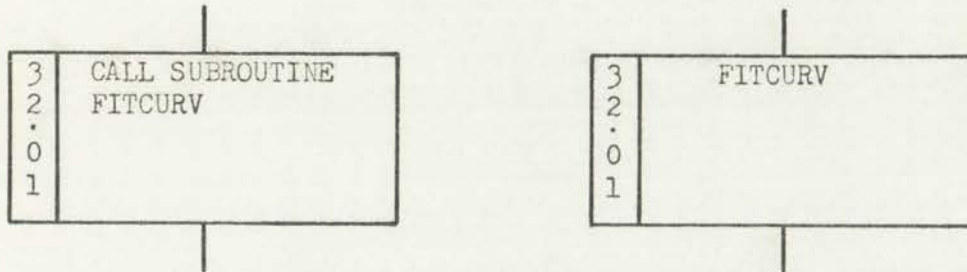


FIGURE 10. Symbols used to call a subroutine. A flowchart for subroutine FITCURV may be found starting with symbol number 1 on flowchart page 32.

An example of the decision symbol is shown in Figure 11. Each possible path leading from the decision is labeled according to the condition it represents (HIGH, LOW, EQUAL, YES, NO, etc.). If possible, a line is drawn to show the path to the specified destination. If a line cannot be drawn, then a connector/transfer symbol is used.

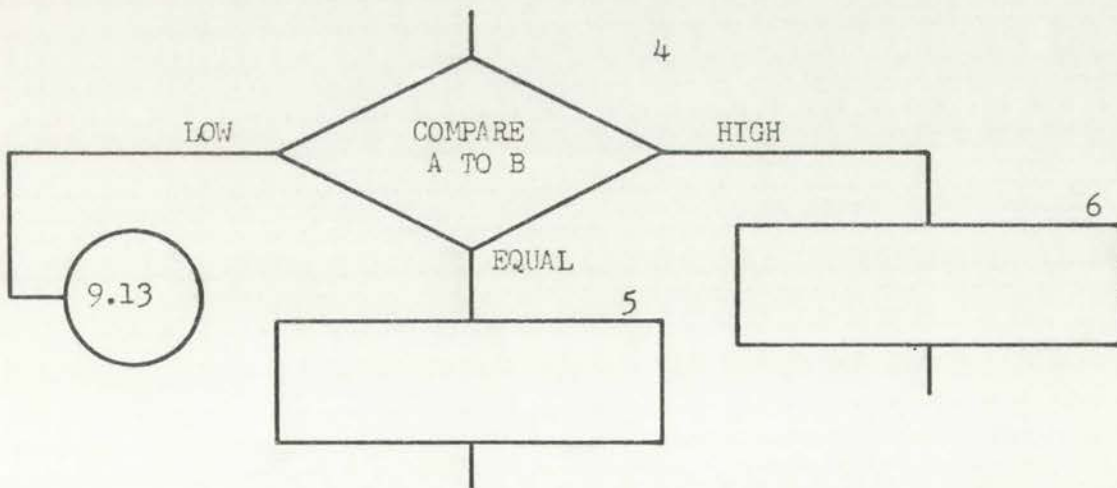


FIGURE 11. A decision wherein A is being compared to B. Note that, if A is low, then the path followed goes to the 13th symbol on flowchart page 9.

The first step in the process is to identify the key components of the system. This involves a thorough review of the existing architecture and the requirements for the new system. Once the components are identified, the next step is to design the system architecture. This includes defining the data flow, the user interface, and the underlying database structure.



The design phase is critical to the success of the project. It ensures that all requirements are met and that the system is scalable and maintainable. Once the design is complete, the next step is to develop the system. This involves writing the code, testing the system, and deploying it to the production environment.

After the system is deployed, it is important to monitor its performance and make any necessary adjustments. This includes regular updates, security patches, and performance tuning. The final step in the process is to evaluate the system's performance and user satisfaction. This helps to identify areas for improvement and ensures that the system is meeting the needs of the users.



In conclusion, the development of a system is a complex and multi-step process. It requires careful planning, design, and implementation. By following the steps outlined above, you can ensure that your system is built on a solid foundation and is capable of meeting the needs of your users.

Additional information is provided through the use of in-connectors. An in-connector indicates that there is a transfer of control to that symbol from the symbol specified by the in-connector.

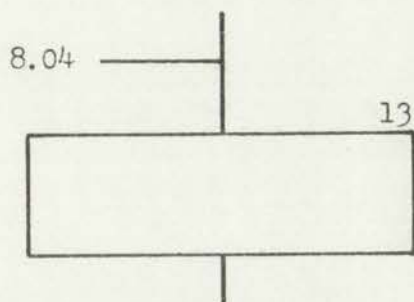


FIGURE 12. An in-connector. The in-connector illustrated indicates that control is transferred to this point from the fourth symbol on flowchart page 8.

The detailed flowchart contained in Appendix D uses asterisks to convey information. If there is more than one transfer to a given point, the in-connector at that point will contain an asterisk following information describing the first transfer. An asterisk found imbedded in a connecting line means that there are additional transfers to the terminal point of the connecting line besides that shown by the line itself. In both of these instances information describing the other transfers may be found in the cross reference listing immediately preceding the flowchart in Appendix D (a further discussion of this cross reference listing may be found on page 51, paragraph 1).



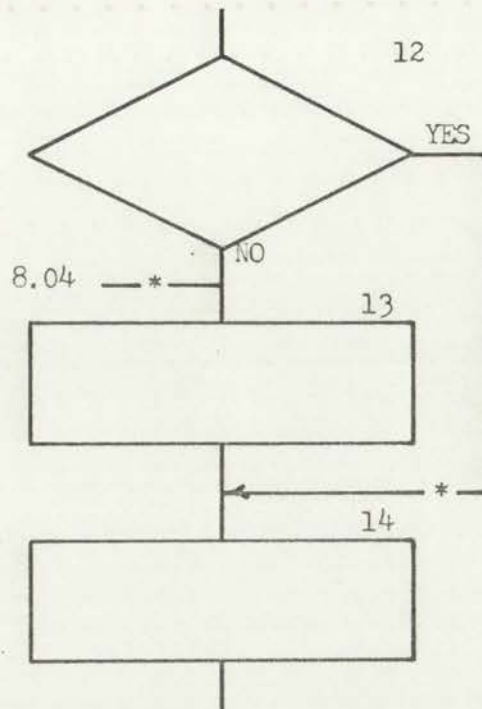


FIGURE 13. An example of the asterisk convention. The in-connector indicates that control is transferred to symbol 13 from symbol 4 on page 8. The right most connecting line indicates that for the YES condition control is transferred from decision symbol 12 to symbol 14. The asterisks found in each of these lines mean that there are transfers to symbols 13 and 14 other than those shown.

Column break indicators are used to show that the flow has been broken because the bottom of a column has been reached. In all such cases the flow is continued at the top of the next column.

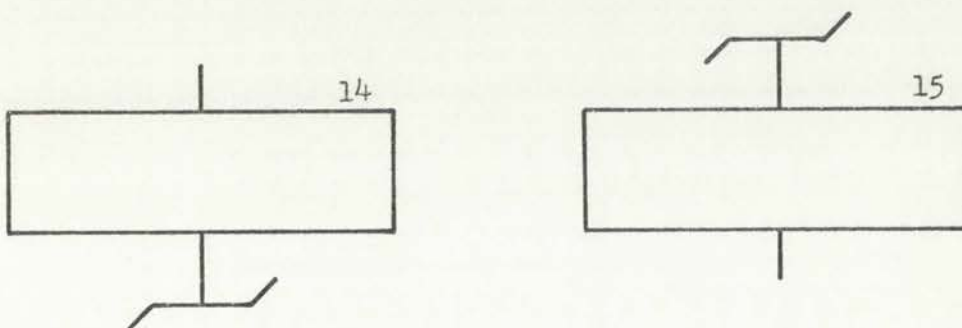


FIGURE 14. Column break indicators. These indicators show that control passes from the left to the right column.

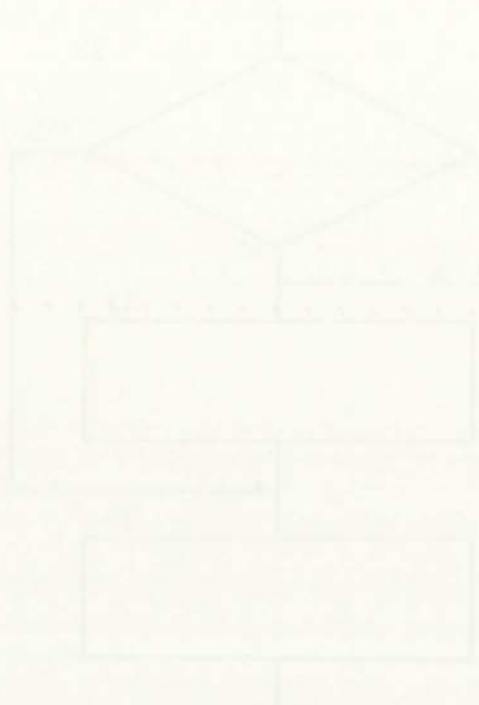


FIGURE 1. A schematic diagram of the experimental apparatus. The diamond-shaped element is a light source that is mounted on a vertical support. The rectangular box below it is a lens that focuses the light onto the second rectangular box, which is a detector. The detector is mounted on a horizontal support that can be moved along the vertical axis to measure the intensity of the light at different positions.

The detector is a photodiode that is sensitive to the wavelength of the light. The intensity of the light is measured as a function of the detector's position. The results of the measurements are shown in Figure 2.



FIGURE 2. A schematic diagram of the experimental apparatus. The two rectangular boxes are detectors that are sensitive to the wavelength of the light. The vertical lines represent the light paths that are measured as a function of the detector's position.

APPENDIX B

VARIABLE MEANINGS

Meanings for all of the variables used in program SPECTRE are given in the following list. This list is divided into four sections: one section for the parent program and a section for each of the subroutines FITCURV, ANALYZE and MEMO. In those cases where a particular variable is used in more than one routine, it is defined only in the section pertaining to the routine of first use. Several variables change meaning during the course of the program's logic flow. Such variables are redefined at the point in the list where the change takes place. Within a section, variables are defined in strict order of appearance in the detailed flowchart contained in Appendix D.

It should be noted that seven-character variable names are occasionally used, in direct conflict with the American Standards Association (ASA) standard for the FORTRAN IV computer language which specifies a maximum of six characters (see page 21, paragraph 2).

Section 1

Meaning for all of the purposes of this Act, the expression "the Commission" shall mean the Commission constituted under sub-section (1) of section 1 of the Commission of Enquiry Act, 1952, or any Commission constituted under that sub-section after the commencement of this Act, and "member" shall mean a member of the Commission so constituted.

It shall be lawful for the Commission to inquire into and report on the conduct of any person in relation to the discharge of his duties as a public servant, and to recommend the removal of such person from office or the imposition of any other penalty on him.

I. Parent Program Variables

Name	Meaning
1. TITLE (1)	is the date of the mass spectrometer run.
2. TITLE (2), (3), (4)	is the assigned serial number of the sample being analyzed.
3. TITLE (5)	is sample type (PRESHOT, POSTSHOT and SPECIAL are the only types permitted).
4. TITLE (6)	is shot name when a specific test shot is involved (e.g., TRINITY).
5. TITLE (7)	is the spectrometer used in the analysis (e.g., AVCO).
6. TITLE (8)	is the name of a person to be added to the distribution list (at present only ANDERSON or JAYNES are allowed).
7. FILTEMP (I)	is the sequence number of the filament temperature at which the Ith measurement was taken. That is, if the thirteenth measurement were made with the filament temperature adjusted to its second value, then $FILTEMP(13) = 2$.
8. SCALE (I)	is an integer which indicates the scale of the Ith measurement ($1 \leq SCALE(I) \leq 10$).
9. MASS (I)	is the mass number associated with the Ith measurement.

10. HOUR (I,J)
MINUTE (I,J)
SECOND (I,J) } * are the constituents of the time of the I,Jth measurement.
11. SUMTIME (I,J)* is the duration in seconds (integration time) of the counting period of the I,Jth measurement.
12. PEAK (I,J)* is the value of the I,Jth measurement (total pulse count or counts per second).
13. N is the total number of peak height measurements.
14. K, KA, KB, and KC are convenient indices used in connection with a data printout.
15. BACKGND (I) is a calculated background value for the time of the Ith peak height measurement.
16. PEAK (I) is the value of the Ith peak height. This value has been corrected for background and has been adjusted to a common scale.
17. TIME (I) is the time of the Ith peak height measurement normalized such that TIME (1) = 2000 seconds.
18. J is changed at this point to the sequence number (index I) of the first measurement belonging to the FILTEMP segment under consideration (see variable 24 on the following page).
19. L is the sequence number of the FILTEMP under consideration.
20. M is the sequence number of the synthetic FILTEMP segment under consideration.

* J = 1 refers to the preceding background measurement.

J = 2 refers to the peak height measurement.

J = 3 refers to the following background measurement.

The term "measurement" has been used somewhat ambiguously to refer in some instances to a group of two backgrounds plus a peak height (index I), and in other cases to refer to just one of these three (index I,J). This ambiguity soon disappears, as peak height is corrected for background immediately after data printout, and the term "measurement" refers to a unique peak height (index I) from that point on.

1. The first part of the report is devoted to a description of the work done during the period from 1/1/10 to 31/3/10.
2. The second part of the report is devoted to a description of the work done during the period from 1/4/10 to 31/6/10.
3. The third part of the report is devoted to a description of the work done during the period from 1/7/10 to 31/9/10.
4. The fourth part of the report is devoted to a description of the work done during the period from 1/10/10 to 31/12/10.
5. The fifth part of the report is devoted to a description of the work done during the period from 1/1/11 to 31/3/11.
6. The sixth part of the report is devoted to a description of the work done during the period from 1/4/11 to 31/6/11.
7. The seventh part of the report is devoted to a description of the work done during the period from 1/7/11 to 31/9/11.
8. The eighth part of the report is devoted to a description of the work done during the period from 1/10/11 to 31/12/11.
9. The ninth part of the report is devoted to a description of the work done during the period from 1/1/12 to 31/3/12.
10. The tenth part of the report is devoted to a description of the work done during the period from 1/4/12 to 31/6/12.

The work done during the period from 1/1/10 to 31/3/10 is described in the first part of the report. The work done during the period from 1/4/10 to 31/6/10 is described in the second part of the report. The work done during the period from 1/7/10 to 31/9/10 is described in the third part of the report. The work done during the period from 1/10/10 to 31/12/10 is described in the fourth part of the report. The work done during the period from 1/1/11 to 31/3/11 is described in the fifth part of the report. The work done during the period from 1/4/11 to 31/6/11 is described in the sixth part of the report. The work done during the period from 1/7/11 to 31/9/11 is described in the seventh part of the report. The work done during the period from 1/10/11 to 31/12/11 is described in the eighth part of the report. The work done during the period from 1/1/12 to 31/3/12 is described in the ninth part of the report. The work done during the period from 1/4/12 to 31/6/12 is described in the tenth part of the report.

21. NREF is a counter used to count the number of reference measurements processed at various program stages.¹
22. K is the sequence number (index I) of the last measurement belonging to the FILTEMP or FILTEMP segment under consideration.
23. KEEP is the total number of measurements taken at the FILTEMP under consideration.
24. KOUNT is the number of segments into which a group of measurements taken at the FILTEMP under consideration is to be divided. This division is programmed so that the reference peak height curve will be fitted in sections containing between 4 and 8 reference measurements each. When KOUNT equals 0 or 1 then the group of measurements is to be left undivided.
25. JUMP is an indicator which is set to value 5 whenever the next segment is to contain 5 reference measurements.
26. INVERT is a counter which counts from N down to J and is used only as an index for other variables.

¹From this point on a distinction is made between the terms "reference measurement" (or peak height) and "isotope measurement" (or peak height). "Isotope" is to be understood to apply to all mass numbers except the reference mass number. "Reference" is to be used only in connection with the reference mass number.

II. Subroutine FITCURV Variables

Name	Meaning
1. START	is the sequence number of the first measurement belonging to the FILTEMP under consideration.
2. FILNUM	is the sequence number of the FILTEMP under consideration.
3. K	is now the mass number index. The mass number associated with any value of K is $K + 230$ (i.e. $K = 1$ corresponds to mass number 231). K is restricted to integral values from $K = 1$ to $K = 15$.
4. TOTAL (K)	is a counter used to count the number of measurements of the Kth isotope processed through completion of the FILTEMP under consideration.
5. COUNT (K)	is a counter used to count the number of measurements of the Kth isotope processed through completion of the FILTEMP previous to the FILTEMP currently under consideration.
6. REFPEAK (I)	is the value of the Ith reference peak height belonging to the FILTEMP under consideration.
7. REFTIME (I)	is the time of the Ith reference measurement belonging to the FILTEMP under consideration.
8. M	is the value of TOTAL (K) and is used only as a do loop index.
9. ISOPEAK (K,M)	is the value of the Mth peak height for the Kth isotope.
10. ISOTIME (K,M)	is the time of the Mth measurement of the Kth isotope.
11. J	is the value of COUNT (K) + 1 and is used as a test element and as a do loop index.
12. REFVALU	is the calculated value of reference peak height based on the fitted reference curve at a time corresponding to one of the isotope measurements.
13. RATIO (K,I)	is the isotopic ratio of the Ith measurement of the Kth isotope belonging to the FILTEMP under consideration.

1	THE UNIVERSITY OF CHICAGO	1
2	THE UNIVERSITY OF CHICAGO	2
3	THE UNIVERSITY OF CHICAGO	3
4	THE UNIVERSITY OF CHICAGO	4
5	THE UNIVERSITY OF CHICAGO	5
6	THE UNIVERSITY OF CHICAGO	6
7	THE UNIVERSITY OF CHICAGO	7
8	THE UNIVERSITY OF CHICAGO	8
9	THE UNIVERSITY OF CHICAGO	9
10	THE UNIVERSITY OF CHICAGO	10
11	THE UNIVERSITY OF CHICAGO	11
12	THE UNIVERSITY OF CHICAGO	12
13	THE UNIVERSITY OF CHICAGO	13

14. XPLOT (I) is a time in seconds. The current FILTEMP curve is divided into 99 equal increments for smooth plotting. XPLOT (1), XPLOT (2), ..., XPLOT (100) are the boundary times of these increments.
15. YPLOT (I) is the calculated value of reference peak height based on the fitted reference curve at time XPLOT (I).
16. REFPILOT (I) is the calculated value of reference peak height based on the fitted reference curve at time REFTIME (I).
17. DIFFER (I) is the percentage difference between REFPEAK (I) and REFPILOT (I) (A measure of the quality of reference curve fit).

(1) [illegible]

(2) [illegible]

(3) [illegible]

III. Subroutine ANALYZE Variables

Name	Meaning
1. FUDGE	is a constant determined experimentally which is used in correcting for the mass effect (see page 4, paragraph 5).
2. ISOMASS	is the mass number of the isotope under consideration.
3. FACTOR	is a multiplicative correction applicable to the isotope under consideration.
4. BINGO	is an indicator which is set to value 99.0 whenever an isotopic ratio is statistically found to be an "outlier."
5. SUM	is the sum of the isotopic ratios for all measurements made of the isotope under consideration.
6. AVE	is the average isotopic ratio of the isotope under consideration.
7. SUMSQ	is the sum of squares of the statistical deviation in the isotopic ratios for all measurements made of the isotope under consideration.
8. DEV (K,I)	is the statistical deviation of the Ith isotopic ratio of the Kth isotope.
9. PERDEV (K,I)	is the percentage deviation in the Ith isotopic ratio of the Kth isotope.
10. SIGMA (K)	is the standard deviation (root mean square deviation) of the individual isotopic ratios calculated for the Kth isotope.
11. SIGBAR (K)	is the standard deviation of the average isotopic ratio of the Kth isotope (standard deviation of the sampling distribution).

12. UNRATIO* is an uncorrected isotopic ratio.
13. DSIGMA is the deviation of an isotopic ratio expressed in units of standard deviations. This quantity is immediately printed for record purposes.
14. RATIO (K) is a variable in common with the parent program and all other subroutines. It is therefore used briefly to pass the value of AVE on to subroutine MEMO.
15. RATIO (K,2) is used in the same manner as RATIO (K). It passes the value of SIGBAR (K) on to subroutine MEMO.
16. UNAVE* is an uncorrected average isotopic ratio.
17. UNSIGMA* is an uncorrected standard deviation of individual isotopic ratios for a particular mass number.
18. UNSIGBR* is an uncorrected standard deviation of an average isotopic ratio for a particular mass number.
19. REJECT (M) is the maximum number of standard deviations by which a given isotopic ratio may differ from the average isotopic ratio without being considered an "outlier" in a sample consisting of M ratios.¹
20. TEST is the value of REJECT (M) and is used as a test element.

*Variables marked with an asterisk are purposely returned to the uncorrected state with respect to the mass effect, and are immediately printed for record purposes.

¹Grubbs, "Procedures for Detecting Outlying Observations in Samples," 2-5.

10. 10/10/10
11. 10/10/10

12. 10/10/10

13. 10/10/10

14. 10/10/10

15. 10/10/10

16. 10/10/10

17. 10/10/10

18. 10/10/10

The first part of the document discusses the importance of maintaining accurate records of all transactions. It emphasizes that every entry should be supported by a valid receipt or invoice. The text also mentions the need for regular audits to ensure the integrity of the financial data.

In the second part, the author details the various methods used to collect and analyze data. This includes the use of specialized software and manual verification processes. The goal is to ensure that the data is both comprehensive and reliable.

The third section focuses on the challenges faced during the data collection process. It highlights the need for clear communication and coordination between different departments to avoid any discrepancies or missing information.

In the fourth part, the author discusses the results of the data analysis. It shows that there has been a significant increase in certain areas, while others remain stable. The findings are presented in a clear and concise manner.

The fifth section provides a detailed breakdown of the data, including a comparison of the current period with previous ones. This helps to identify trends and potential areas for improvement.

In the sixth part, the author offers recommendations based on the data analysis. These include suggestions for optimizing processes and improving data collection methods to ensure better results in the future.

The final part of the document is a conclusion that summarizes the key findings and the overall impact of the data analysis. It reiterates the importance of continuous monitoring and reporting to maintain the highest standards of accuracy and reliability.

Overall, the document provides a thorough and professional overview of the data collection and analysis process, highlighting the challenges and the successful outcomes achieved.

IV. Subroutine MEMO Variables

Name	Meaning
1. ATOMRAT (K)	is the average isotopic ratio of the Kth isotope.
2. ATOMERR (K)	is the uncertainty (expressed at the 95% confidence level) in ATOMRAT (K).
3. TFACTOR (M)	is the percentile value for Student's t (0.95) distribution with (M-1) degrees of freedom.
4. RATIO (K)	is changed in meaning early in this subroutine. The third statement following program statement number 30 is "RATIO(K)=ATOMRAT(K)*FLOAT(K+230)/MASS." From this statement on, RATIO (K) is the most probable mass ratio of the Kth isotope. "Mass ratio" is intended to mean the ratio of the mass of atoms of the Kth isotope to the mass of atoms of the reference isotope in any amount of sample material.
5. RATIO (K,2)	is changed in meaning at the same point as RATIO (K). From this point on RATIO (K,2) is the uncertainty (expressed at the 95% confidence level) in RATIO (K).
6. SUM	is used in subroutine MEMO as the sum of the mass ratios for all isotopes.
7. SUMSQ	is used in subroutine MEMO as the sum of squares of the uncertainties in the mass ratios for all isotopes.
8. ERROR1	is the root mean square uncertainty formed by taking the square root of SUMSQ.
9. ERROR (K)	is the uncertainty (expressed at the 95% confidence level) in PERCENT (K) (see immediately below).
10. PERCENT (K)	is the weight percent of the sample material contributed by the Kth isotope.
11. NUMBER	is the number of copies of the final written letter report which the computer is to prepare.

1	Introduction
2	Chapter I
3	Chapter II
4	Chapter III
5	Chapter IV
6	Chapter V
7	Chapter VI
8	Chapter VII
9	Chapter VIII
10	Chapter IX
11	Chapter X
12	Chapter XI
13	Chapter XII
14	Chapter XIII
15	Chapter XIV
16	Chapter XV
17	Chapter XVI
18	Chapter XVII
19	Chapter XVIII
20	Chapter XIX
21	Chapter XX
22	Chapter XXI
23	Chapter XXII
24	Chapter XXIII
25	Chapter XXIV
26	Chapter XXV
27	Chapter XXVI
28	Chapter XXVII
29	Chapter XXVIII
30	Chapter XXIX
31	Chapter XXX
32	Chapter XXXI
33	Chapter XXXII
34	Chapter XXXIII
35	Chapter XXXIV
36	Chapter XXXV
37	Chapter XXXVI
38	Chapter XXXVII
39	Chapter XXXVIII
40	Chapter XXXIX
41	Chapter XL
42	Chapter XLI
43	Chapter XLII
44	Chapter XLIII
45	Chapter XLIV
46	Chapter XLV
47	Chapter XLVI
48	Chapter XLVII
49	Chapter XLVIII
50	Chapter XLIX
51	Chapter L
52	Chapter LI
53	Chapter LII
54	Chapter LIII
55	Chapter LIV
56	Chapter LV
57	Chapter LVI
58	Chapter LVII
59	Chapter LVIII
60	Chapter LIX
61	Chapter LX
62	Chapter LXI
63	Chapter LXII
64	Chapter LXIII
65	Chapter LXIV
66	Chapter LXV
67	Chapter LXVI
68	Chapter LXVII
69	Chapter LXVIII
70	Chapter LXIX
71	Chapter LXX
72	Chapter LXXI
73	Chapter LXXII
74	Chapter LXXIII
75	Chapter LXXIV
76	Chapter LXXV
77	Chapter LXXVI
78	Chapter LXXVII
79	Chapter LXXVIII
80	Chapter LXXIX
81	Chapter LXXX
82	Chapter LXXXI
83	Chapter LXXXII
84	Chapter LXXXIII
85	Chapter LXXXIV
86	Chapter LXXXV
87	Chapter LXXXVI
88	Chapter LXXXVII
89	Chapter LXXXVIII
90	Chapter LXXXIX
91	Chapter LXXXX
92	Chapter LXXXXI
93	Chapter LXXXXII
94	Chapter LXXXXIII
95	Chapter LXXXXIV
96	Chapter LXXXXV
97	Chapter LXXXXVI
98	Chapter LXXXXVII
99	Chapter LXXXXVIII
100	Chapter LXXXXIX
101	Chapter LXXXXX

12. NDAY is used initially to contain a 6 digit date (i.e., 072470 corresponding to July 24, 1970). This variable is quickly emptied of all but the 2 day digits (i.e., 24). The exact date is supplied by the computer and corresponds to the day of processing.
13. NMONTH is a 2 digit month (i.e., 07).
14. NYEAR is a 2 digit year (i.e., 70).
15. MONTH (I) is the 3 letter month corresponding to NMONTH (i.e., JUL corresponds to NMONTH = 07).
16. MASSNUM is the mass number corresponding to a given value of K (i.e., 235 corresponds to K = 5).



APPENDIX C

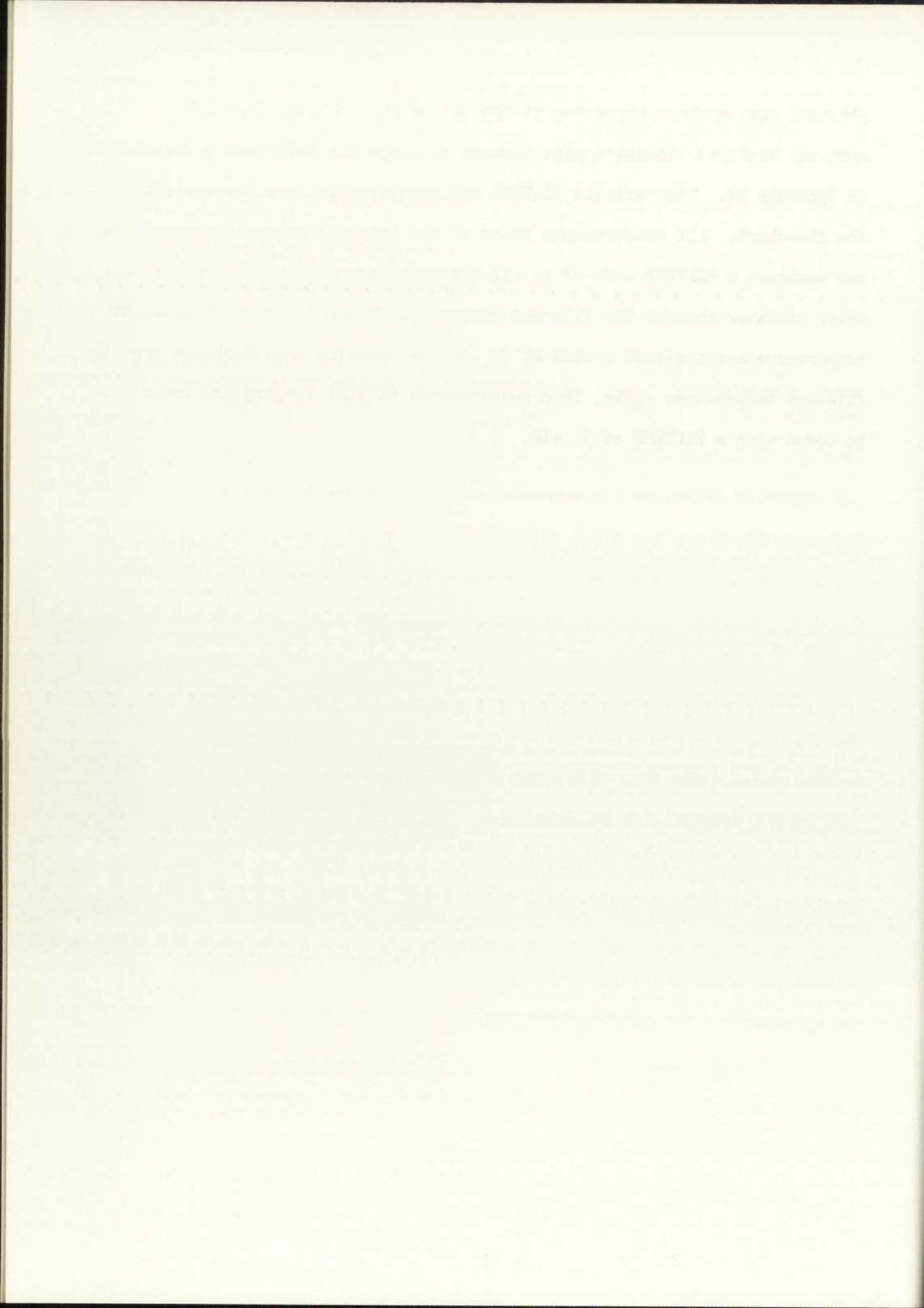
MODULAR FLOWCHART FOR PROGRAM SPECTRE

The following modular flowchart is perhaps the most important item appearing in this report. A detailed flowchart, such as that given in Appendix D, is excellent for correcting program "bugs" and evaluating the effect of individual statements, but is so complex as to be of questionable value to one not already familiar with the particulars of the program being considered. A modular program, on the other hand, stresses the logic flow of a program and allows one to quickly grasp the series of intended operations and desired results.

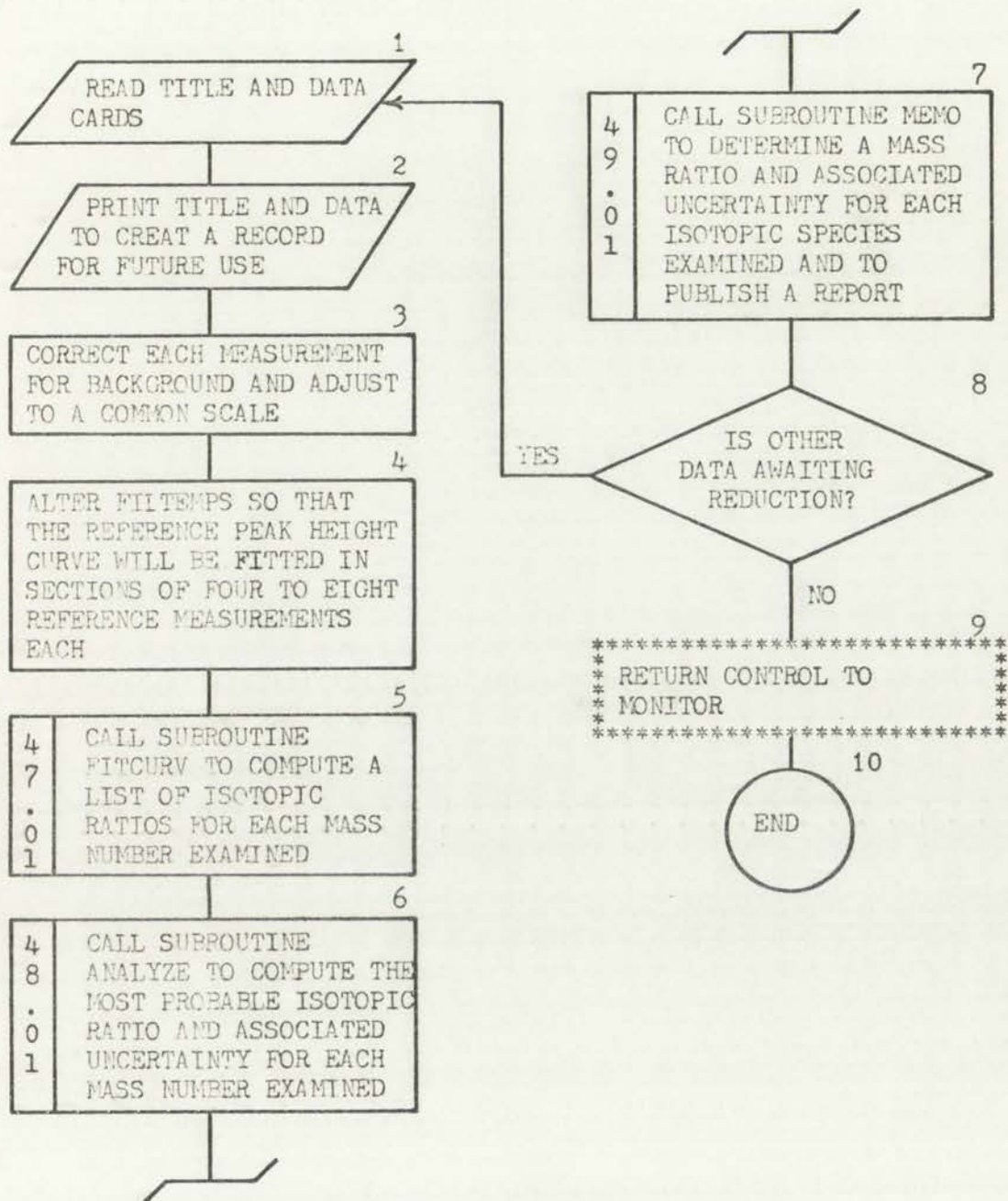
This flowchart has been broken into four self-sufficient parts. The flowchart for the parent program completely describes SPECTRE in modular terms. The flowcharts for subroutines FITCURV, ANALYZE and MEMO go one step further in detailing the methods used to perform those functions called for in the parent program flowchart. Subroutine FITCURV uses two other subroutines called PARCEL and GRAPHIC. Modular flowcharts for PARCEL and GRAPHIC are not included as these subroutines are adaptations of routines already in existence (see footnotes on pages 14 and 17), and the explanations of each appearing in the FITCURV flowchart are quite adequate to establish logic flow.

The symbols and the numbering convention employed are the same as those used with the detailed flowchart of Appendix D (see Appendix A for symbol descriptions). Page references are to be applied to the usual

physical page numbers appearing at the bottom of each page (special computer assigned flowchart page numbers are used for reference purposes in Appendix D). The variable FILTEMP has been used by name throughout the flowchart. All measurements taken at the original filament temperature are assigned a FILTEMP code of 1; all measurements taken after the spectrometer operator changes the filament current to obtain a different filament temperature are assigned a code of 2. If the operator should change the filament temperature again, then measurements at that temperature would be coded with a FILTEMP of 3, etc.

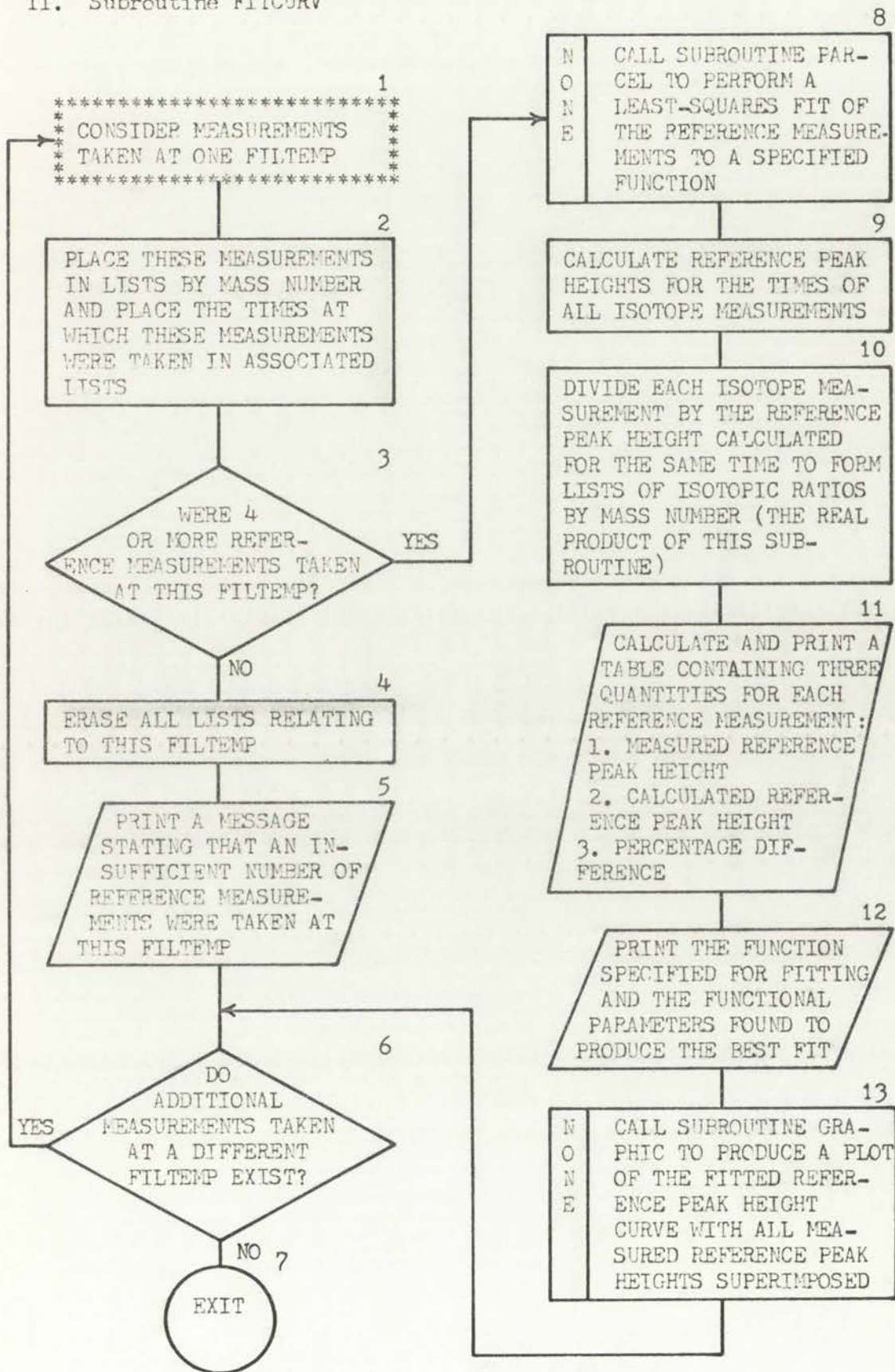


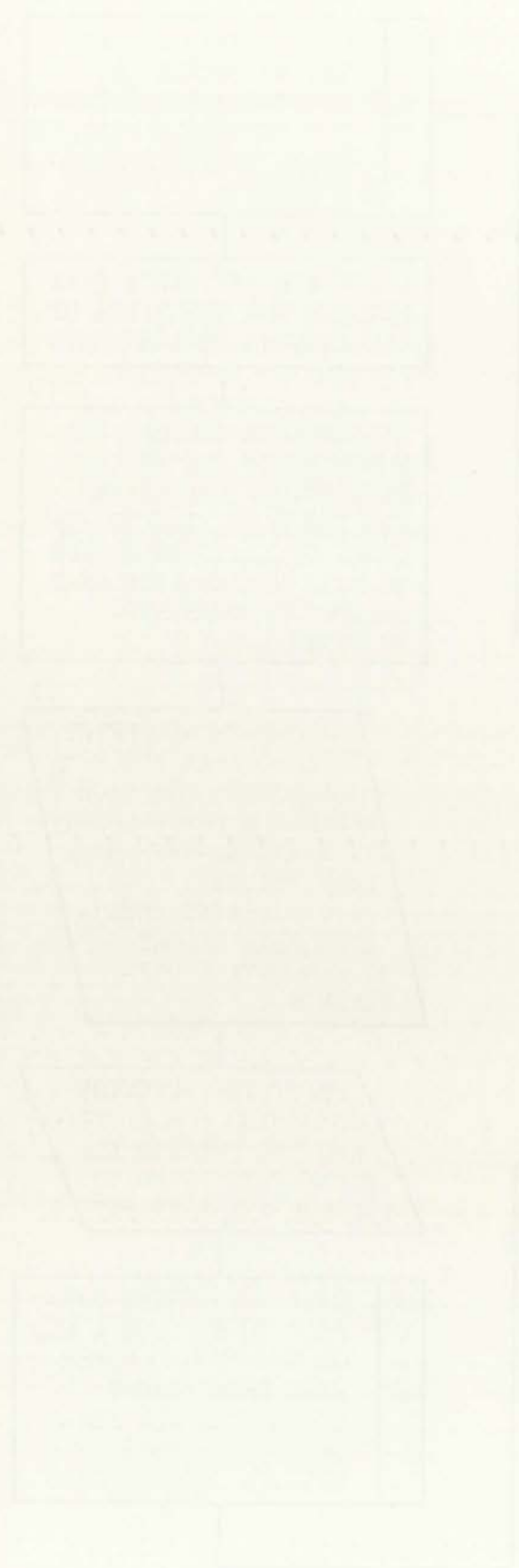
I. The Parent Program:



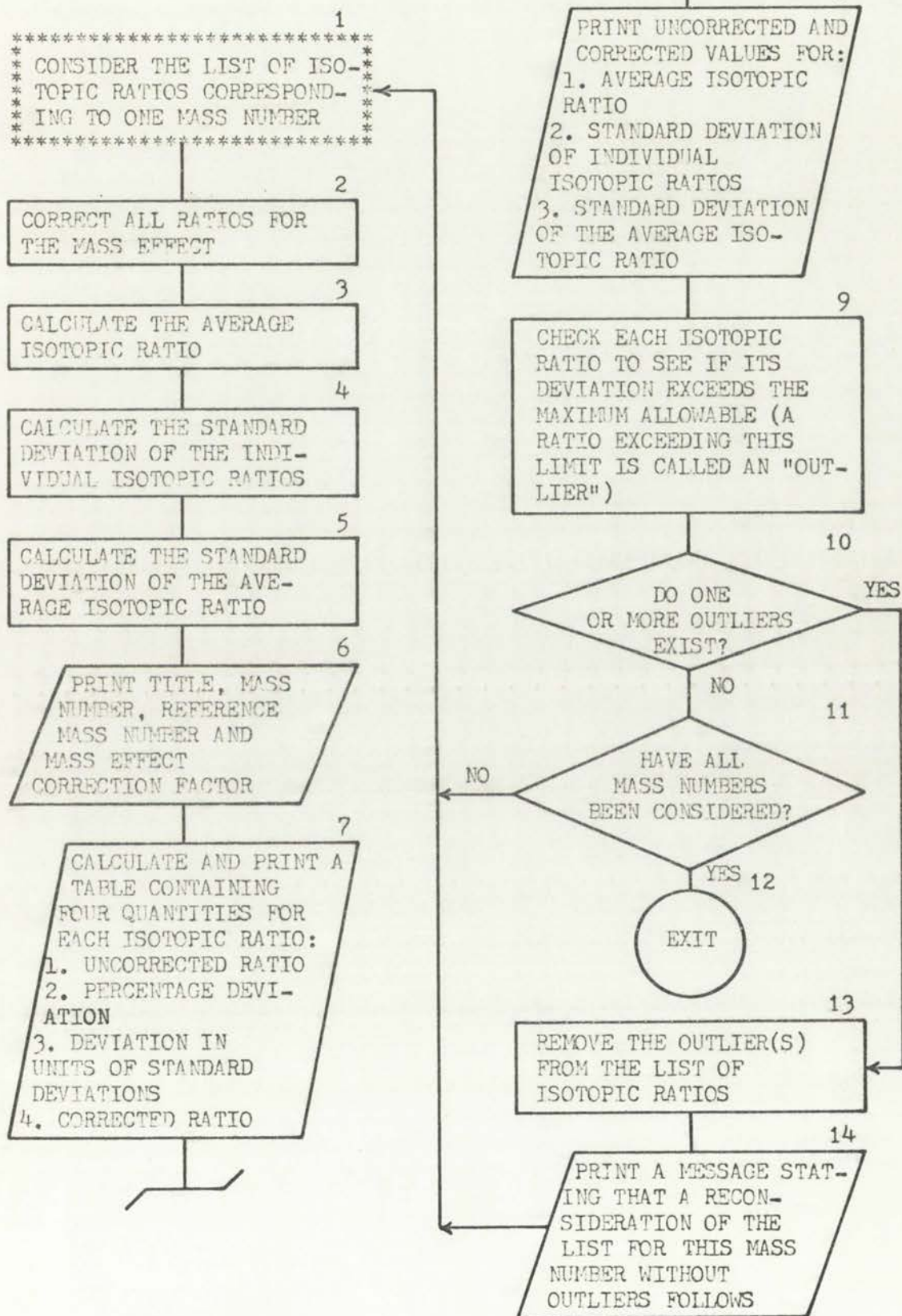


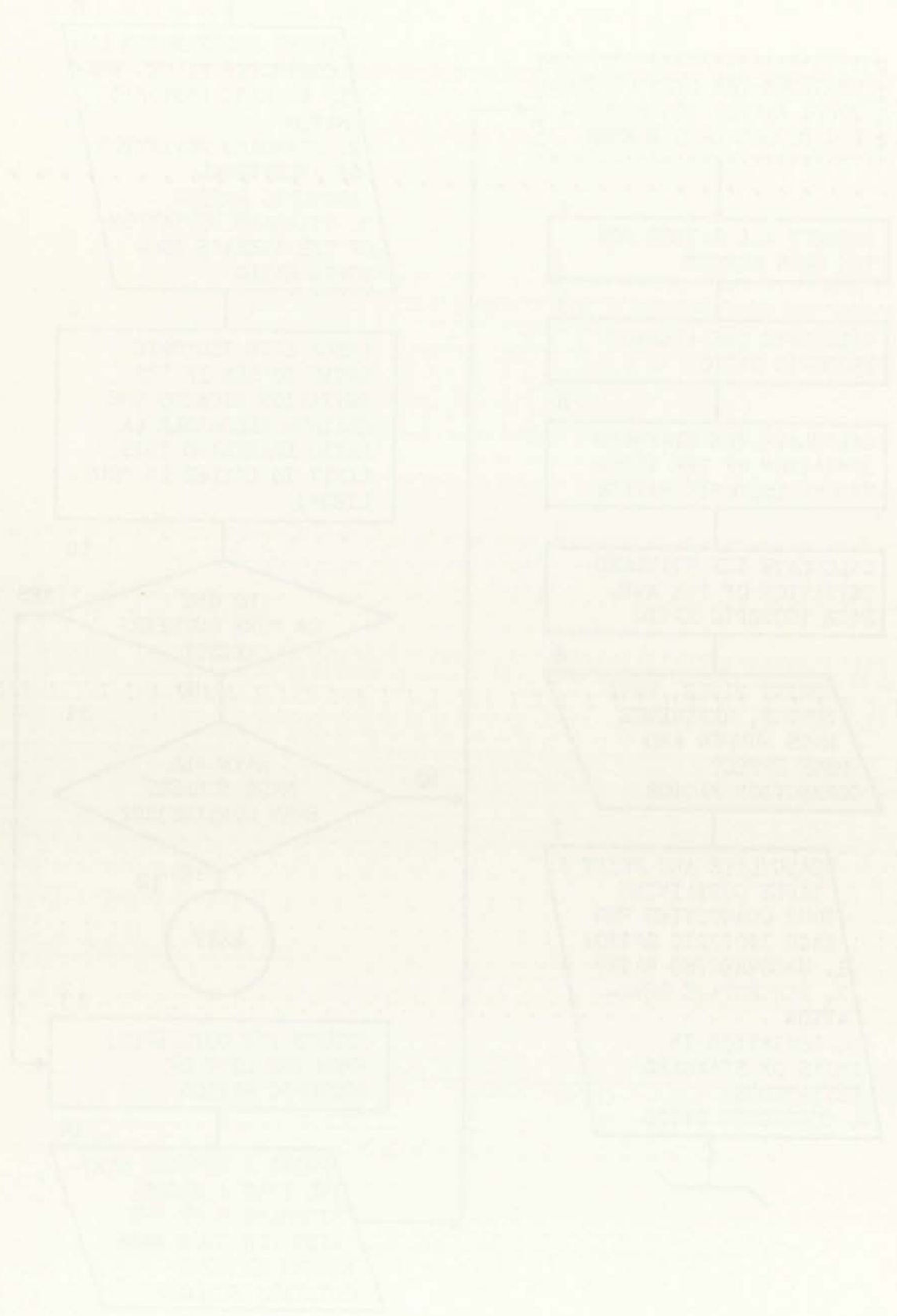
II. Subroutine FITCURV



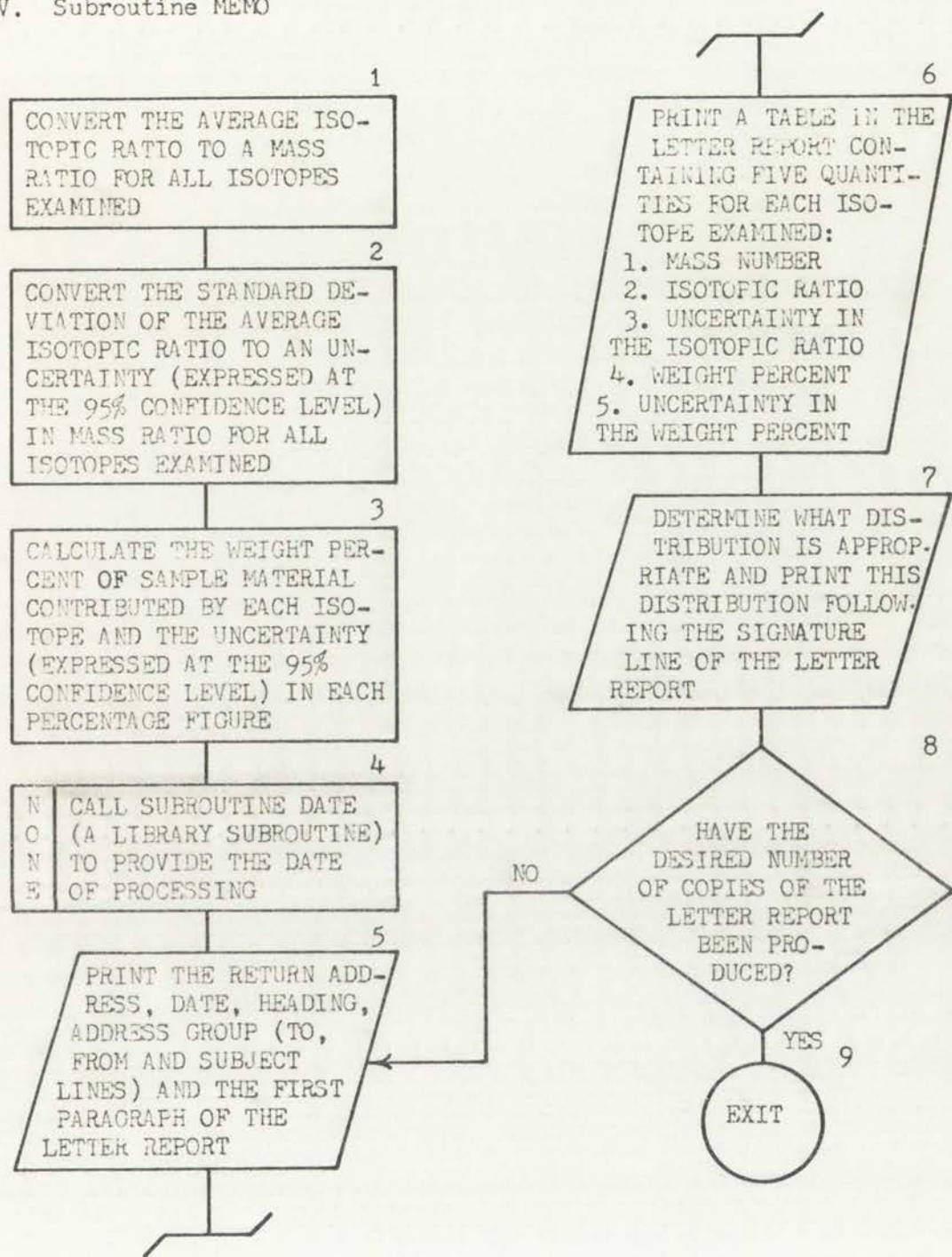


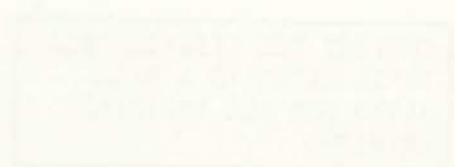
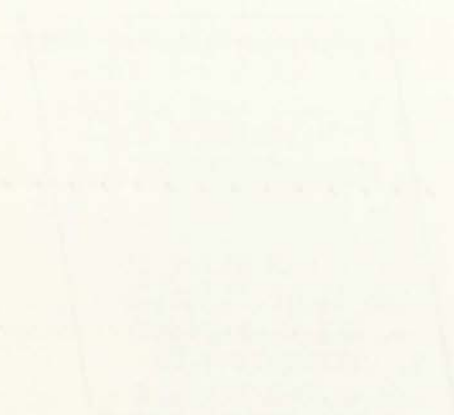
III. Subroutine ANALYZE





IV. Subroutine MEMO





APPENDIX D

DETAILED FLOWCHART FOR PROGRAM SPECTRE

This flowchart was produced directly from a complete SPECTRE source program by a standard flowcharting code called "AUTOFLOW" (see footnote page 29). Sections are included for subroutines PARCEL and GRAPHIC because they actually form an integral part of program SPECTRE, even though they were not wholly written for this application (PARCEL and GRAPHIC are also included in the complete listing appearing in Appendix E). With exception of subroutines PARCEL and GRAPHIC, every step and symbol of the entire flowchart has been checked for accuracy and proper usage. The flowchart is without a flaw!

Flowcharting is normally accomplished before a program is written as an aid for the coder. Many times, however, flowcharting is performed "after-the-fact" so as to allow a user to understand a program more thoroughly or to enable a program analyst to explain a program to others more efficiently. AUTOFLOW is so good that no-one familiar with its capability would consider flowcharting an already extant program by hand.

It is important to note that a flowchart page number is assigned by the computer and is placed in the upper right-hand corner of each flowchart page. Two physical pages are required to form one flowchart page. The computer assigned numbers are important in that all sequencing and referencing within the flowchart itself is keyed to these numbers. A normal page number appears at the bottom of each physical page.

The Council has received a report from the Commission on the progress of the work done in the various regions of the country during the year 1911. The report is contained in the enclosed report and is published in the form of a book. The report is divided into two parts, the first part dealing with the progress of the work done in the various regions and the second part dealing with the progress of the work done in the various departments of the country. The report is published in the form of a book and is available for sale at the price of 10/- per copy. The report is published in the form of a book and is available for sale at the price of 10/- per copy.

Confusion should not result as the physical page numbers in this Appendix are all larger than the largest of the flowchart page numbers.

Before the flowchart begins, a section called "Cross-Reference Listing" has been included. This listing gives the flowchart page and symbol or "box" number of all symbols corresponding to statements in the source program having a FORTRAN statement number (label). It also lists, in a column headed "References", all other symbols which transfer to each listed symbol. An example of such a listing is shown in Figure 15 below:

PAGE BOX		CROSS-REFERENCE LISTING LABEL	REFERENCES		
		DECK PARCEL			
		SUBROUTINE PARCEL			
7.01		PARCEL	4.25*		
7.14		1			
7.16			7.18		
7.24		2	7.21	9.25	9.27

FIGURE 15. A sample cross-reference listing. This listing describes subroutine PARCEL. Symbol 7.01 is the starting symbol of PARCEL and it is referenced by a call statement in symbol 4.25. The asterisk next to this reference indicates a subroutine call. Statement number 1 has been assigned page-and-symbol number 7.14 and there are no transfers to this symbol. Symbol 7.16 has no statement number, but is referenced by symbol 7.18 (a normal occurrence in do loops and logical IF statements). Statement number 2 has been assigned symbol 7.24 and is referenced by symbols 7.21, 9.25 and 9.27.

The parent program and subroutines are each preceded by a table of contents, which lists all FORTRAN statement numbers appearing in the source program in numerical order. The page and box number of the symbol corresponding to each statement number are also listed.

Faint, illegible text at the top of the page, possibly a header or introductory paragraph.

Section of faint, illegible text in the middle of the page.

Section of faint, illegible text at the bottom of the page.

CROSS-REFERENCE LISTING
REFERENCES

PAGE BOX

LABEL

1.03	5	3.15
1.06	10	
1.11		1.18
1.14	80	1.05
1.16	40	
1.20	50	1.13
1.22		1.25
1.23	52	
1.30	55	1.32
1.34	58	1.28
1.35		2.05
1.36		1.38
1.37	60	
2.04	70	
2.08	200	
2.09	210	3.10
2.11		2.14
2.14	220	2.12
2.17	230	2.11
2.18	240	2.16
2.21	250	2.19
2.24		3.21
3.01	260	3.01
3.03	270	2.24
3.04	300	2.26
3.05	310	2.21
3.13	75	3.06
3.16		3.08
3.17	320	3.18
3.21	330	
		2.27

1. The first part of the document is a list of names and their corresponding numbers. The names are arranged in a grid-like pattern, with some names appearing in multiple rows. The numbers are also arranged in a grid-like pattern, with some numbers appearing in multiple rows.

2. The second part of the document is a list of names and their corresponding numbers. The names are arranged in a grid-like pattern, with some names appearing in multiple rows. The numbers are also arranged in a grid-like pattern, with some numbers appearing in multiple rows.

3. The third part of the document is a list of names and their corresponding numbers. The names are arranged in a grid-like pattern, with some names appearing in multiple rows. The numbers are also arranged in a grid-like pattern, with some numbers appearing in multiple rows.

4. The fourth part of the document is a list of names and their corresponding numbers. The names are arranged in a grid-like pattern, with some names appearing in multiple rows. The numbers are also arranged in a grid-like pattern, with some numbers appearing in multiple rows.

5. The fifth part of the document is a list of names and their corresponding numbers. The names are arranged in a grid-like pattern, with some names appearing in multiple rows. The numbers are also arranged in a grid-like pattern, with some numbers appearing in multiple rows.

DECK FITCURY		
SURCUTINE FITCURY	FITCURY	3.13*
4.01		4.06
4.04	10	
4.05	20	6.14
4.08		4.17
4.10	40	4.10
4.12	50	
4.13	60	4.12
4.14	80	4.13
4.17	100	4.11
4.19	105	4.23
4.22	120	4.19
4.25	200	
4.26	205	4.30
4.27	220	4.28
5.03		5.07
5.04		5.09
5.06	230	
5.12	235	4.29
5.13		5.15
5.14	240	
5.19		5.21
5.20	250	
5.23	260	5.02
5.25	300	
6.01	306	5.25
6.02	310	6.04
6.07	324	
6.08	325	6.10
6.13	328	5.26
6.15	340	6.13

DECK PARCEL		
SURCUTINE PARCEL	PARCEL	4.25*
7.01		



CROSS-REFERENCE LISTING
REFERENCES

PAGE BOX

LABEL

7.05	2000	7.06	
7.10	2010	7.11	
7.14	1		
7.16		7.18	
7.17	10		
7.24	2	7.21	9.25
7.26		7.33	9.27
7.27		7.29	
7.28	20		
7.32	30		
7.35	3		
7.38		8.17	
8.05	4	8.06	
8.06	60		
8.10		8.15	
8.11	70	8.12	
8.14	80		
8.17	90		
8.20	7		
8.22	11		
8.24	12	9.02	
8.25	13	8.31	
8.28	14		
8.29	15	8.27	
9.01	16		
9.02	140	8.26	8.27
9.06	17		8.28
9.08		9.11	
9.10	18	9.08	
9.11	160	9.09	
9.16	19	9.04	9.09
9.17	170	9.18	9.13
9.24	21	9.20	
9.27	22	9.24	
			8.29

1. The first part of the document discusses the importance of maintaining accurate records of all transactions. This is essential for ensuring the integrity of the financial statements and for providing a clear audit trail.

2. The second part of the document outlines the various methods used to collect and analyze data. These methods include direct observation, interviews, and the use of specialized software tools.

3. The third part of the document describes the results of the data collection and analysis. It shows that there are significant differences in the way that different departments handle their data, which can lead to inconsistencies and errors.

4. The fourth part of the document discusses the implications of these findings. It suggests that a standardized approach to data collection and analysis is needed to ensure the accuracy and reliability of the financial statements.

5. The fifth part of the document provides a summary of the key findings and recommendations. It emphasizes the need for a clear and consistent approach to data collection and analysis, and for regular communication and collaboration between all departments involved.

6. The final part of the document concludes with a statement of the author's appreciation for the support and assistance provided by the various departments and individuals who participated in the study.

DECK GRAPHIC
SUBROUTINE GRAPHIC

10.01	GRAPHIC	6.12*
10.04	73	
10.05		10.07
10.06	75	
10.10		10.12
10.11	76	
10.17	1	10.26
10.19	2	
10.20	3	10.18
10.21	4	
10.22	5	10.20
10.23	6	
10.24	7	10.22
10.25	8	
10.26	9	10.24
10.27	10	
10.30		10.28
10.33		10.31
10.34	90	
10.35	12	
10.36	14	10.35
10.37	15	10.34
		11.01
10.40	17	
10.41	18	10.36
		10.39
		11.01
10.42	19	
10.43	20	
11.01	13	
11.02	21	10.42
11.03	22	10.41
		10.43
11.06	24	
11.07	25	10.43
		11.02
		11.05
11.09		11.11

CROSS-REFERENCE LISTING
REFERENCES

PAGE BOX LABEL	REFERENCES
11.10	600
11.14	11.19
11.15	11.17
11.16	
11.22	30
11.24	12.17
12.02	31
12.03	32
12.04	33
12.05	34
12.06	35
12.08	36
12.09	37
12.10	38
12.11	12.03 12.05 12.08
12.13	12.14
12.14	39
12.17	40
13.02	41
13.04	13.05
13.05	610
13.08	620
13.09	42
13.11	43
13.12	44
13.14	13.17
13.17	45
14.01	47
14.03	13.11
14.06	14.06
14.11	48
14.14	14.09
14.17	14.11
14.21	14.14
15.01	50
15.04	51
	13.21 14.18
	16.28
	15.01

15.05	53	13.08	14.23
15.07	54		
15.08	55	15.06	
15.10	56		
15.11	57	15.09	
15.13	58		
16.01	59	15.12	
16.02	60	15.13	
16.04	61	16.05	
16.09	62		
16.10	63	16.08	
16.12		16.26	
16.14	65	16.13	
16.15	66	16.29	
16.16	67	16.18	
16.18	68		
16.19	69	16.17	
16.21		16.23	
16.22	70		
16.25	71		
16.28	72	16.17	
16.29	64		

DECK ANALYZE

17.01	ANALYZE	3.14*	
17.04	20	17.07	18.15
17.05	30		
17.08	40	17.05	
17.09	45	17.10	
17.12	50	18.34	
17.14	60	17.15	
17.19		17.21	

CROSS-REFERENCE LISTING

PAGE BOX	LABEL	REFERENCES
17.20	70	
17.24	72	
18.01	74	17.23
18.02	80	17.24 18.10
18.07		
18.08	110	
18.13	220	18.12 18.33
18.15	230	17.06
18.22	140	
18.23	145	18.30 18.31
18.24	150	
18.26		18.28
18.27	160	
18.31	170	18.23
18.34	180	

DECK MEMO
SUBROUTINE MEMO

19.01	MEMO	3.15*
19.04	10	19.06 19.11
19.07	30	19.04
19.10	40	
19.13	42	19.05
19.15	45	19.17 20.03
20.01	60	19.15
20.02	70	
20.05	72	19.16
20.09	75	20.33
20.13	160	20.15 20.19
20.16	180	20.13
20.19	200	
20.21	210	20.14
20.25	230	20.22
20.26	250	20.23

Year	Month	Day	Time	Location	Remarks
1970	Jan	1	10:00	...	...
1970	Jan	2	10:00	...	...
1970	Jan	3	10:00	...	...
1970	Jan	4	10:00	...	...
1970	Jan	5	10:00	...	...
1970	Jan	6	10:00	...	...
1970	Jan	7	10:00	...	...
1970	Jan	8	10:00	...	...
1970	Jan	9	10:00	...	...
1970	Jan	10	10:00	...	...
1970	Jan	11	10:00	...	...
1970	Jan	12	10:00	...	...
1970	Jan	13	10:00	...	...
1970	Jan	14	10:00	...	...
1970	Jan	15	10:00	...	...
1970	Jan	16	10:00
1970	Jan	17	10:00
1970	Jan	18	10:00
1970	Jan	19	10:00
1970	Jan	20	10:00
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1970	Jan	27	10:00
1970	Jan	28	10:00
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1970	Jan	30	10:00
1970	Jan	31	10:00
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1970	Feb	3	10:00
1970	Feb	4	10:00
1970	Feb	5	10:00
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1970	Feb	11	10:00
1970	Feb	12	10:00
1970	Feb	13	10:00
1970	Feb	14	10:00
1970	Feb	15	10:00
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1970	Feb	17	10:00
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1970	Feb	19	10:00
1970	Feb	20	10:00
1970	Feb	21	10:00
1970	Feb	22	10:00
1970	Feb	23	10:00
1970	Feb	24	10:00	...	...
1970	Feb	25	10:00	...	...
1970	Feb	26	10:00
1970	Feb	27	10:00
1970	Feb	28	10:00
1970	Feb	29	10:00
1970	Feb	30	10:00
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1970	Mar	2	10:00
1970	Mar	3	10:00
1970	Mar	4	10:00
1970	Mar	5	10:00
1970	Mar	6	10:00
1970	Mar	7	10:00
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1970	Mar	9	10:00
1970	Mar	10	10:00
1970	Mar	11	10:00
1970	Mar	12	10:00
1970	Mar	13	10:00
1970	Mar	14	10:00	...	...
1970	Mar	15	10:00	...	...
1970	Mar	16	10:00	...	...
1970	Mar	17	10:00
1970	Mar	18	10:00
1970	Mar	19	10:00
1970	Mar	20	10:00
1970	Mar	21	10:00
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1970	Mar	27	10:00
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1970	Apr	3	10:00
1970	Apr	4	10:00
1970	Apr	5	10:00
1970	Apr	6	10:00
1970	Apr	7	10:00
1970	Apr	8	10:00
1970	Apr	9	10:00	...	...
1970	Apr	10	10:00	...	...
1970	Apr	11	10:00	...	...
1970	Apr	12	10:00	...	...
1970	Apr	13	10:00	...	...
1970	Apr	14	10:00	...	...
1970	Apr	15	10:00	...	...
1970	Apr	16	10:00	...	...
1970	Apr	17	10:00	...	...
1970	Apr	18	10:00	...	...
1970	Apr	19	10:00	...	...
1970	Apr	20	10:00	...	...
1970	Apr	21	10:00	...	...
1970	Apr	22	10:00	...	...
1970	Apr	23	10:00	...	...
1970	Apr	24	10:00	...	...
1970	Apr	25	10:00	...	...
1970	Apr	26	10:00	...	...
1970	Apr	27	10:00	...	...
1970	Apr	28	10:00	...	...
1970	Apr	29	10:00	...	...
1970	Apr	30	10:00
1970	Apr	30	10:00

1970-1971

20.29
20.31
20.34

270
300

20.27
20.24
20.24
20.29



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LABEL	PAGE BOX
5	1.03
10	1.06
40	1.16
50	1.20
52	1.23
55	1.30
58	1.34
60	1.37
70	2.04
75	3.13
80	1.14
200	2.08
210	2.09
220	2.14
230	2.17
240	2.18
250	2.21
260	3.01
270	3.03
300	3.04
310	3.05
320	3.17
330	3.21



```

*****
PROGRAM SPECTRE
  INPUT TAPE
  INPUT OUTPUT
  TAPE 2=OUTPUT
*****

```

```

*****
PROGRAM SPECTRE
  PRODUCES A SET OF
  1 OUTPUT WEIGHTS
  2 PERCENTAGES
  3 IN A SINGLE MASS
  4 SPECTRUM
  5 SAMPLE
*****

```

```

3.15
5
READ CARD
FORMAT 8

```

```

*****
I/O LIST IS
TITLE
*****

```

```

*****
EOF, 10
*****
CN
*****
OFF
*****

```

```

10
PRINT
FORMAT 12

```

```

80
*****
- END OF RUN -
RETURN CONTROL TO
*****

```

```

... 15
EXIT
...
```

```

40
READ CARD
FORMAT 45

```

```

*****
I/O LIST IS
(HOUR(I),J),MINUTE(I)
I,J),SECOND(I,J),
SUMTIME(I,J),
PEAK(I,J),J=1,3
*****

```

```

18
LO/EQ*
ADD 1 TO I
*COMPARE TO 100
*****
HIGH
*****

```

```

19
*****
END OF DD LOOP
VARIABLE I
*****

```

```

20
1.13
50
N = I - 1
K = N/4

```

```

21
BEGIN DD LOOP
52 I = 1, K
SET I = 1

```

```

22
KA = K + I $ KB = I
2 * K + I $ KC =
3 * K + I

```

```

27
I K = 4 * K + 1 I

```

```

26
TRUE *
N .LT. K *
IFALSE

```

```

29
BEGIN DC LOOP
55 I = K, N
SET I = K

```

```

30
PRINT
FORMAT 56

```

```

31
*****
I/O LIST IS
SCALE(I),
PEAK(I),
(MASS(I),
(HOUR(I),J),MINUTE(I)
SECOND(I,J))
SUMTIME(I,J),PEAK(I)
I,J=1,3)
*****

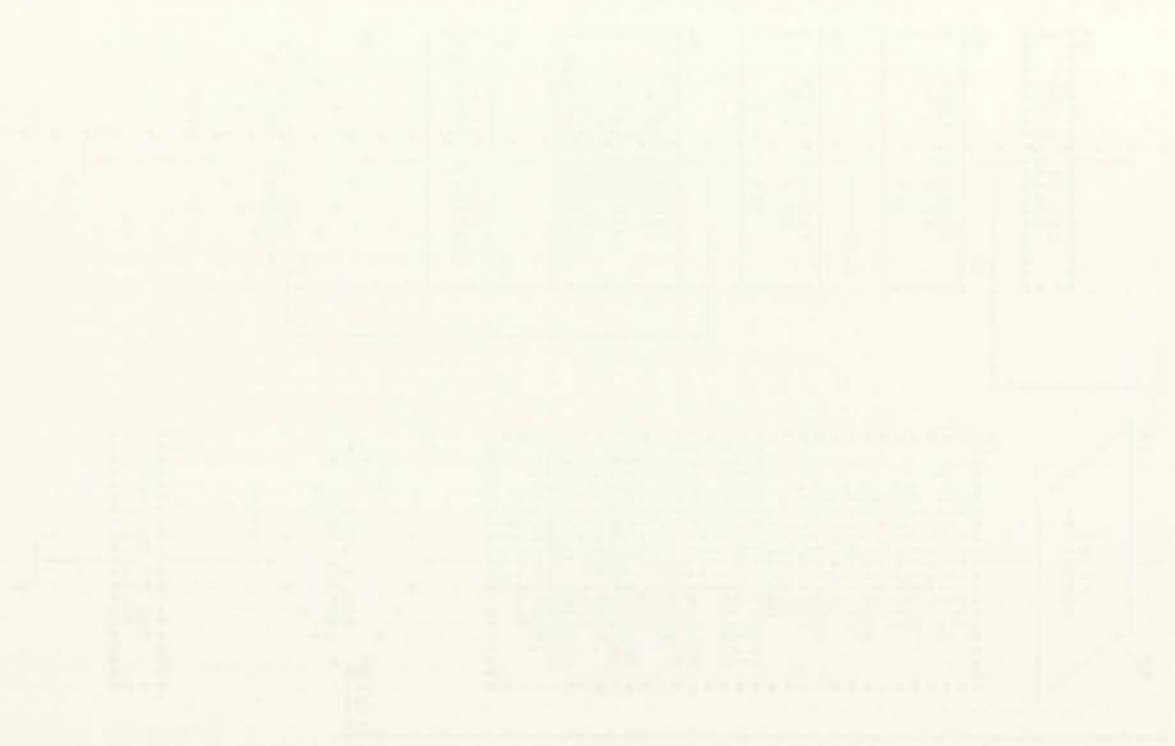
```

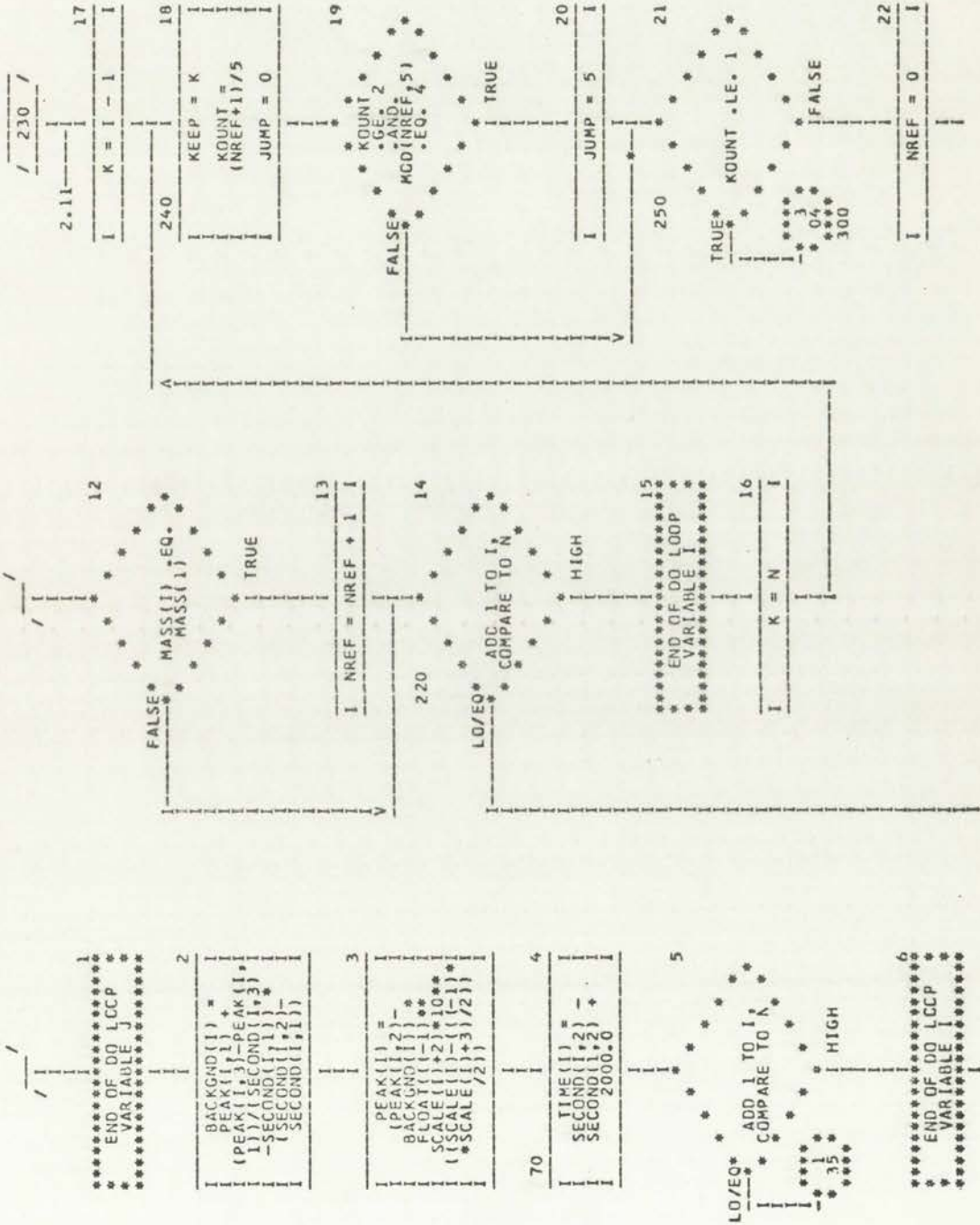
```

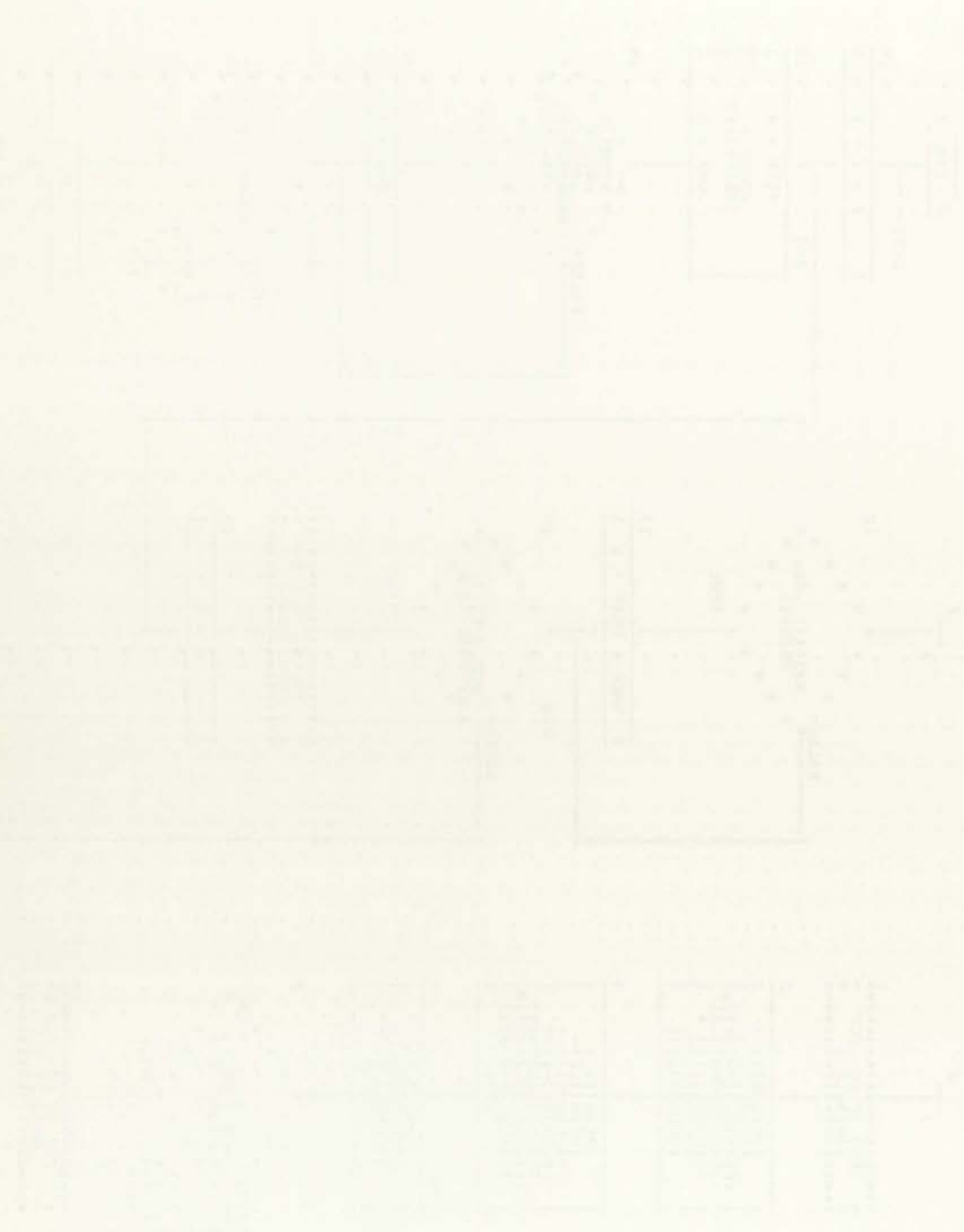
32
LO/EQ*
ADD 1 TO I
COMPARE TO N
*****
HIGH

```

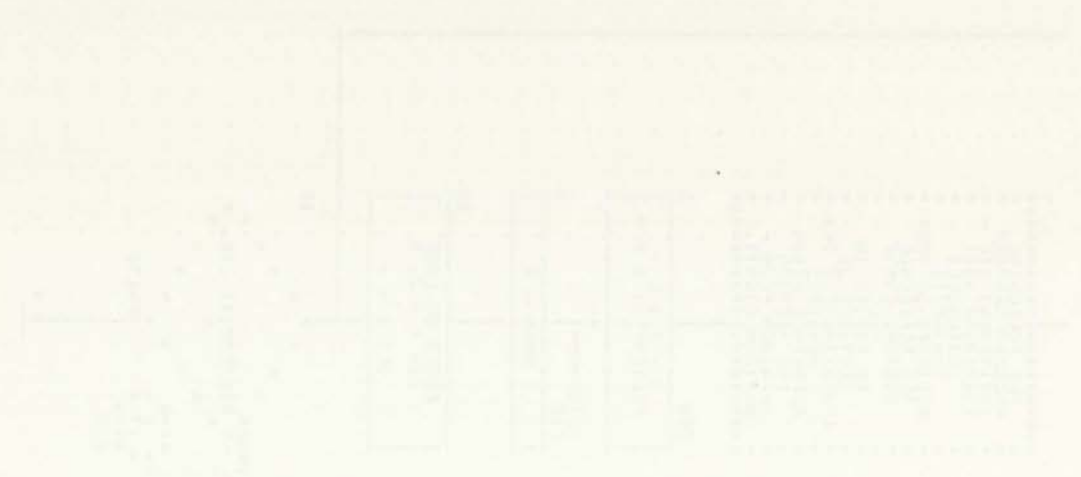








1000 1000 1000 1000



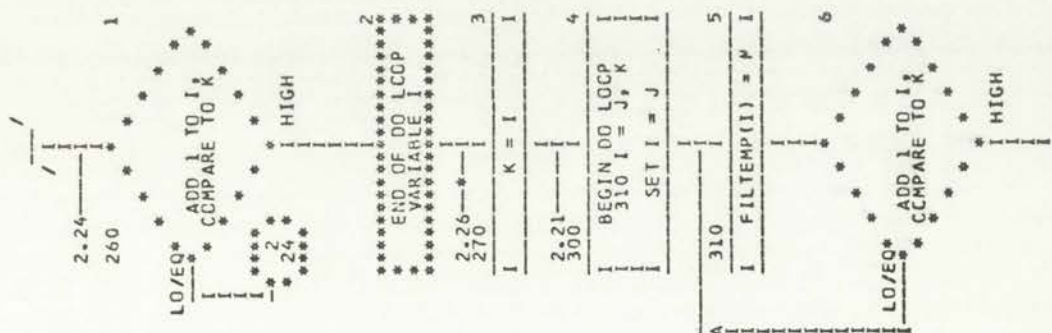
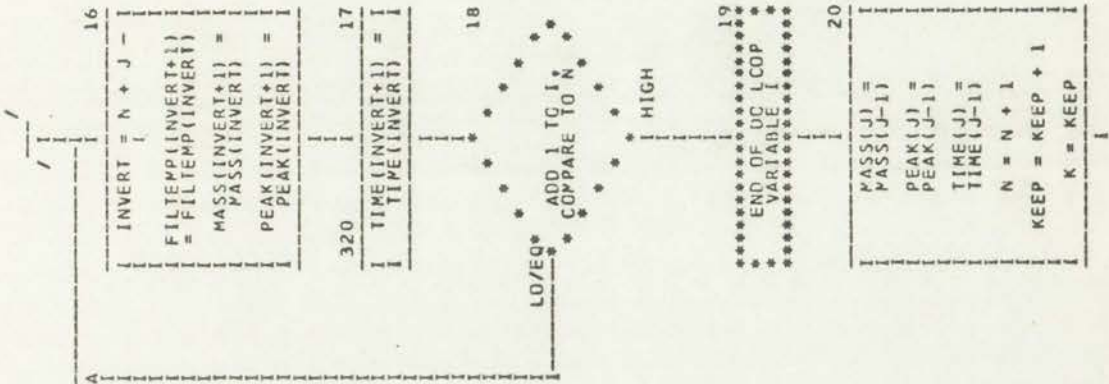


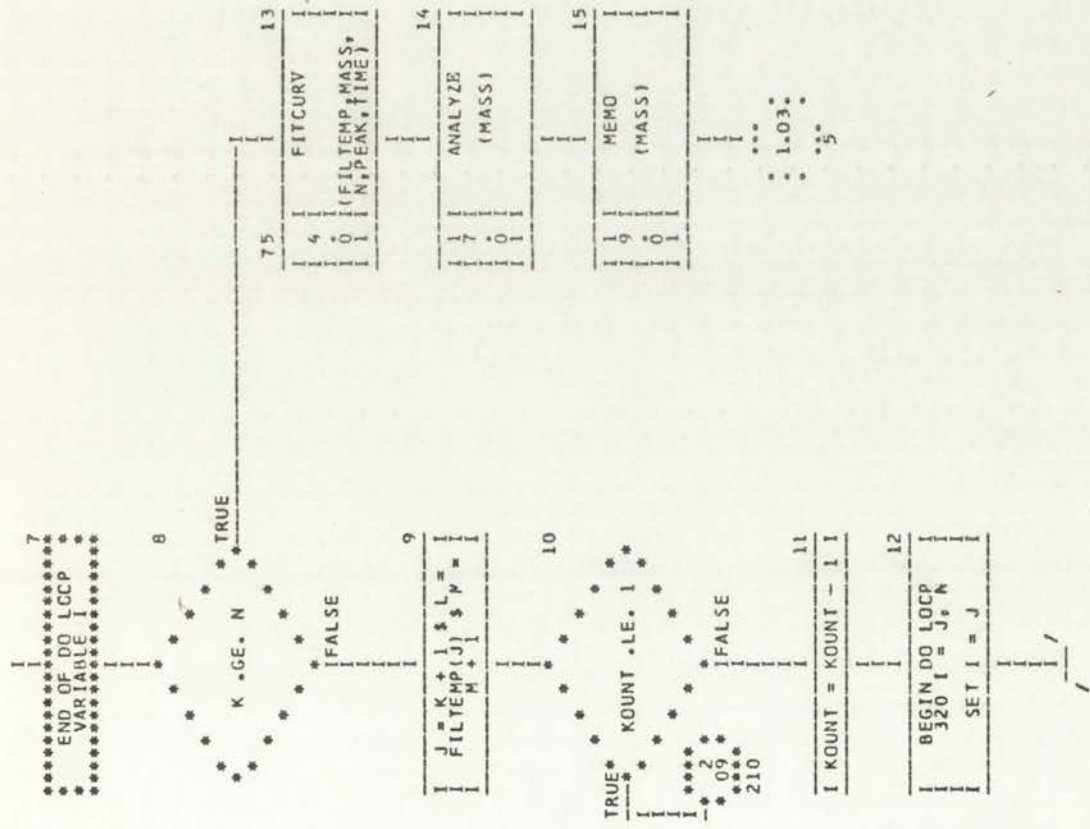


Figure 1. Block diagram of a control system.

```

330 1
      . . . 21
      : 2.21.
      :
      : 250

```



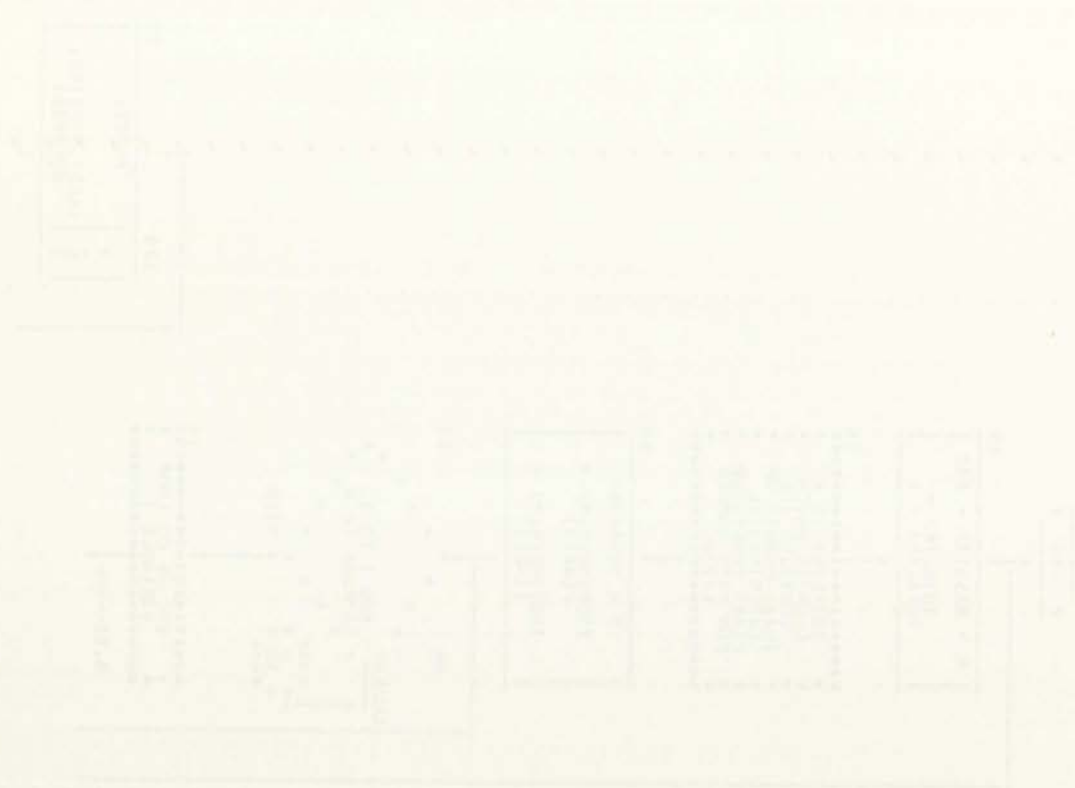
194
1945
1946



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LABEL	PAGE	UCX
FITCUR	4.01	
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20	4.08	
40	4.12	
50	4.13	
60	4.14	
80	4.17	
100	4.19	
105	4.22	
120	4.25	
200	4.26	
205	4.27	
220	5.03	
230	5.06	
235	5.12	
240	5.14	
250	5.20	
260	5.23	
300	5.25	
306	6.01	
310	6.02	
324	6.07	
325	6.08	
328	6.13	
340	6.15	

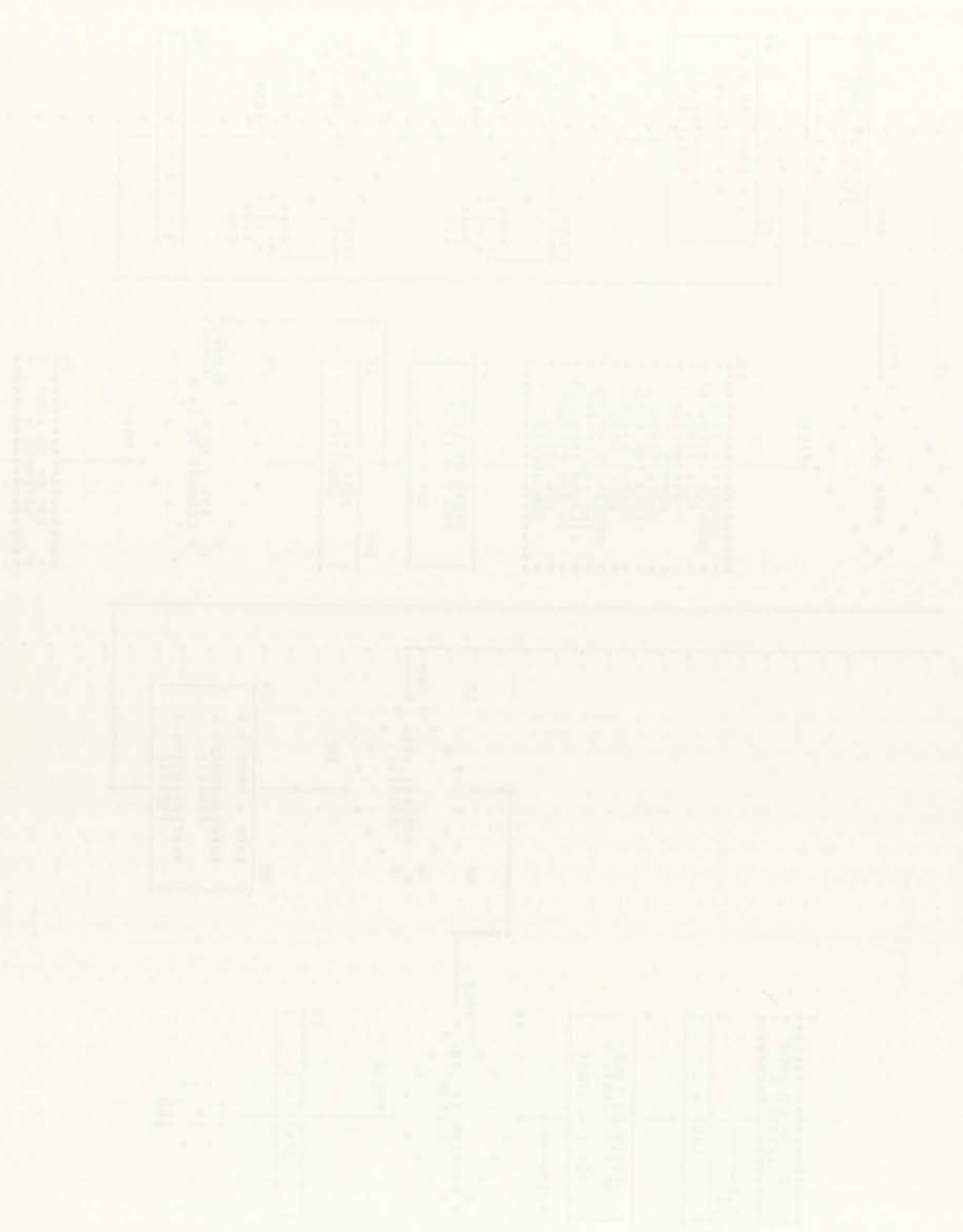




Control Systems - Feedback - 100



Control Systems - Feedback - 100





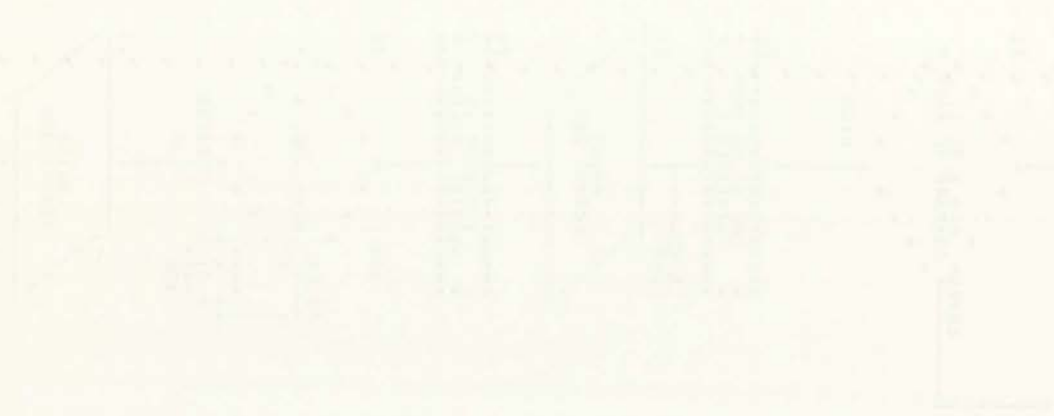
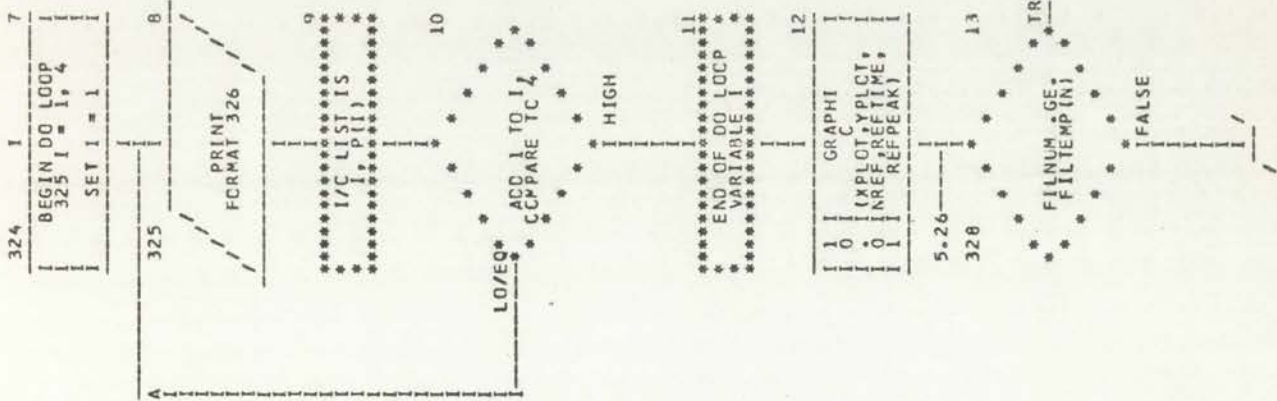




Figure 1: Block diagram of a control system.



Figure 2: Block diagram of a control system.



1. *Introduction*
 2. *Methodology*
 3. *Results and Discussion*
 4. *Conclusion*
 5. *References*

The first part of the report is an introduction to the topic. This is followed by a detailed description of the methodology used in the study. The results of the study are then presented and discussed in detail. Finally, the report concludes with a summary of the findings and a list of references.



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LABEL	PARCEL	PAGE BOX
	1	7.01
	2	7.14
	3	7.24
	4	7.35
	7	8.05
	10	8.20
	11	7.17
	12	8.22
	13	8.24
	14	8.25
	15	8.28
	16	8.29
	17	9.01
	18	9.06
	19	9.10
	20	9.16
	21	7.28
	22	9.24
	30	9.27
	60	7.32
	70	8.06
	80	8.11
	90	8.14
	140	8.17
	160	9.02
	170	9.11
	2000	9.17
	2010	7.05
		7.10



SUBROUTINE PARCEL

PARAMETERS (N,X,Y)

```

1  / PARCEL /
2  4.25
3  *****
4  SUBROUTINE PARCEL *****
5  *****
6  IK=NUMBER OF
7  PARAMETERS
8  M=NUMBER OF
9  INDEPENDENT
10 VARIABLES
11 ILLIM=MAXIMUM
12 NUMBER OF
13 ITERATIONS
14 IFG=CONTROLS THE
15 SIGNS OF THE
16 PARAMETERS (1)
17 OK TO CHANGE
18 SIGNS AFTER 5
19 ITERATIONS
20 (1) SIGNS ALWAYS
21 FREE TO CHANGE
22 (2) SIGNS NEVER
23 FREE TO CHANGE
24 *****
25 IK = 4
26 ILLIM = 25
27 M = 1
28 IFG = 1
29 TEST = 0.000001
30
31 BEGIN DO LOOP
32 2000 I = 1, N
33 SET I = 1
34
35 2000
36 I W(I) = 1.C
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
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97
98
99
100

```

```

13 *****
14 INITIALIZATION
15 FOR MAIN
16 *****
17 ITERATION LOOP
18 *****
19
20 KFREE = IK
21 KP = KFREE + 1
22 IDF = N - KFREE
23 DF = IDF
24 IT = 0
25
26
27 BEGIN DO LOOP
28 10 K = 1, IK
29 SET K = 1
30
31 DPI(K) = 0.0
32 SPI(K) = 0.0
33 PC(K) = PG(K)
34
35 10 P(K) = PG(K)
36
37
38
39
40
41
42
43
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86
87
88
89
90
91
92
93
94
95
96
97
98
99
100

```

```

27
28 AM(K,KK) = 0.0
29
30
31 BM(K,KK) = 0.0
32
33
34
35
36
37
38
39
40
41
42
43
44
45
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95
96
97
98
99
100

```



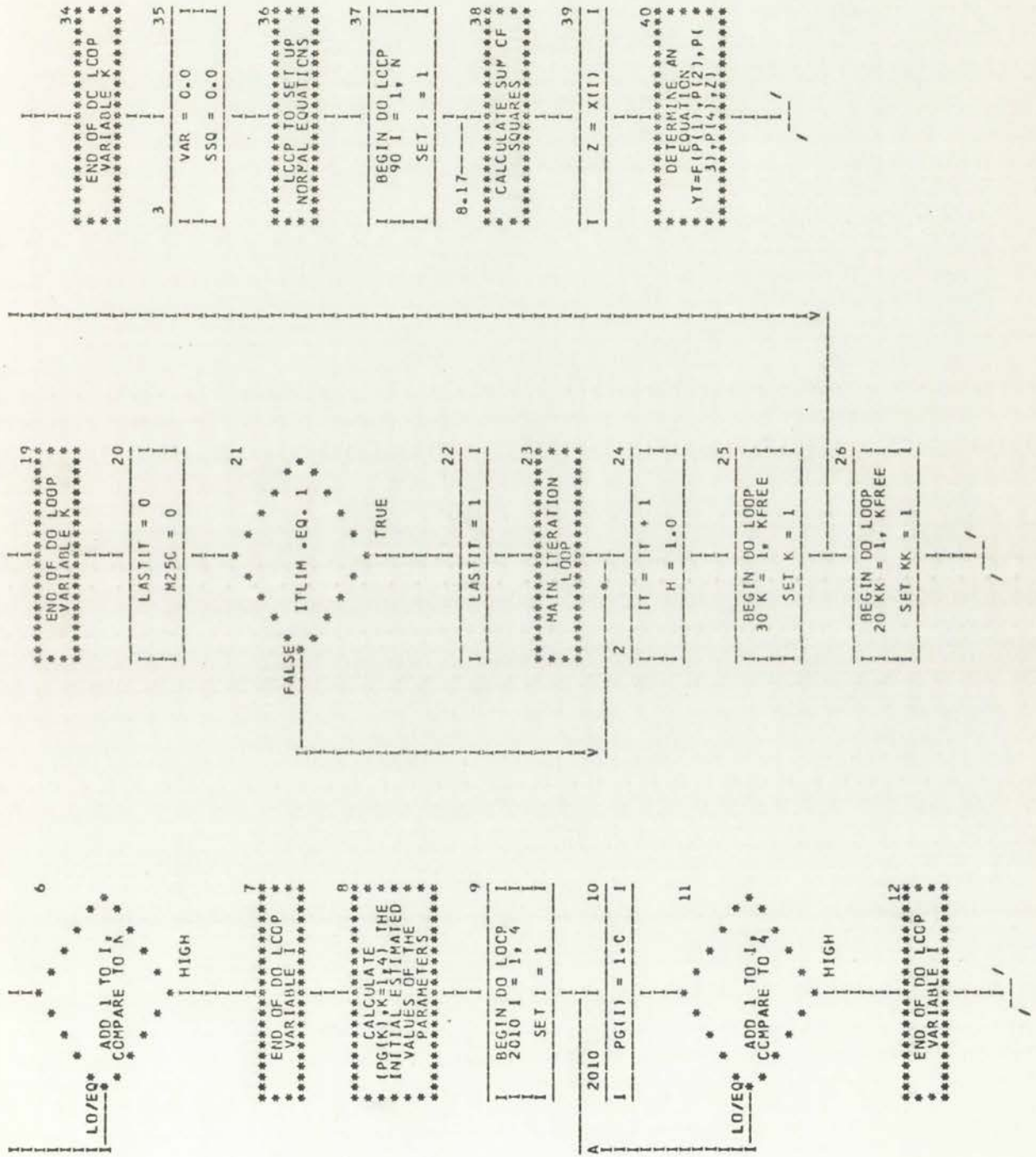


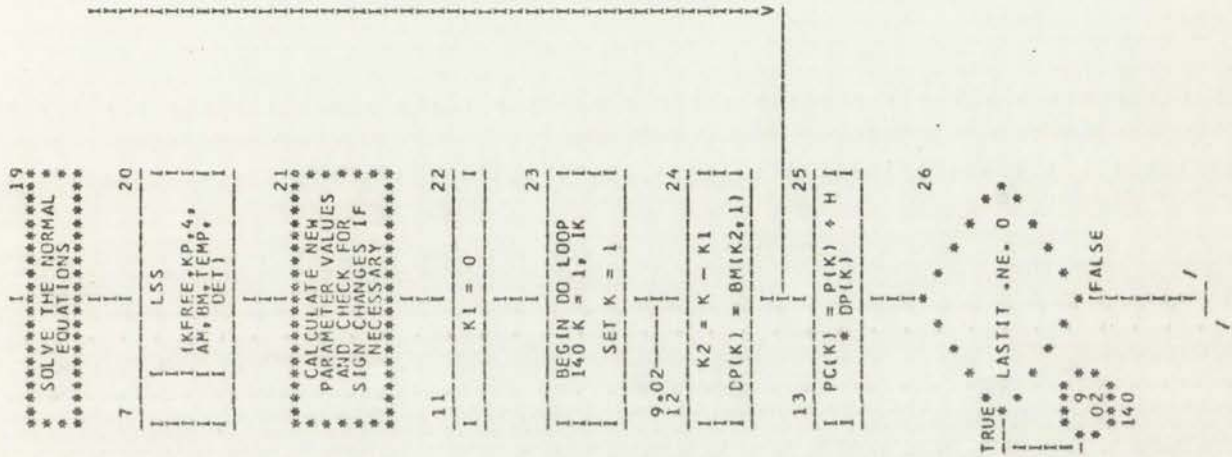
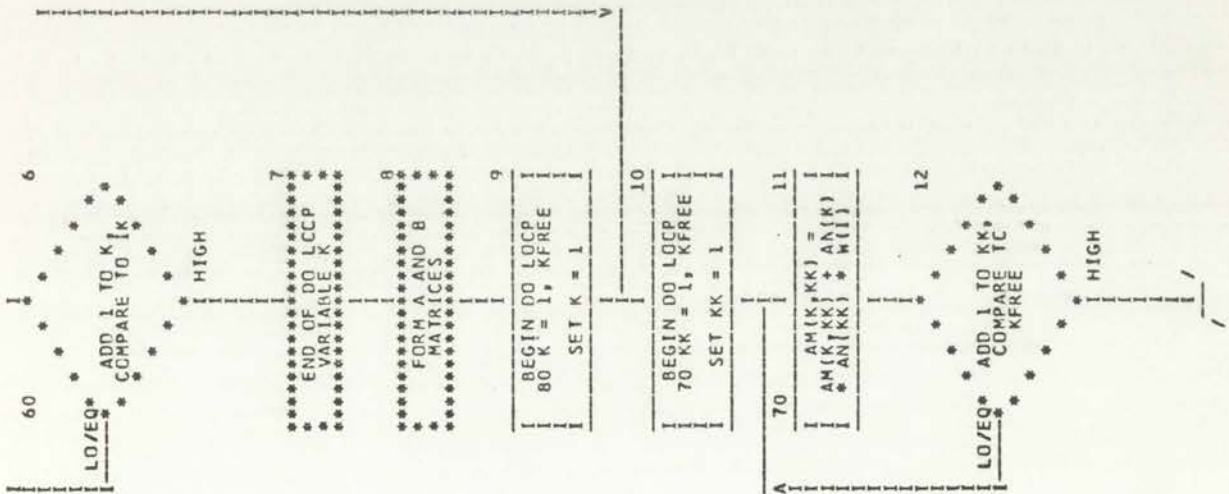




Diagram 1

Diagram 2

Diagram 3



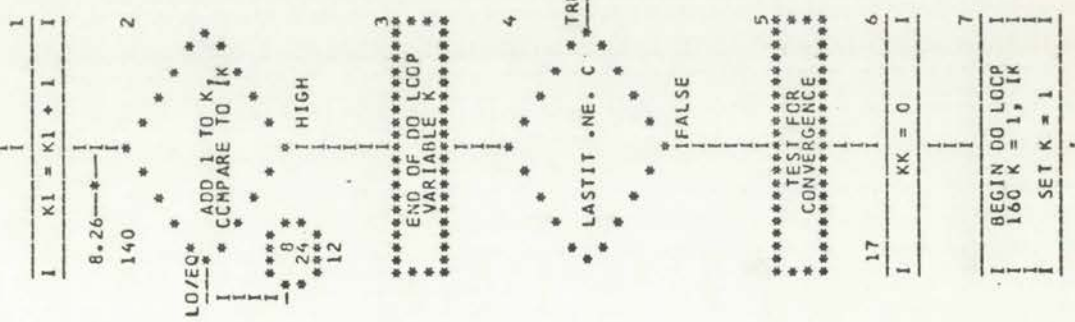
```

    *
    * 32
    *
    * EXIT*
    *
    *
  
```



SUBROUTINE PARCEL

/ 16 /



/ 18 /

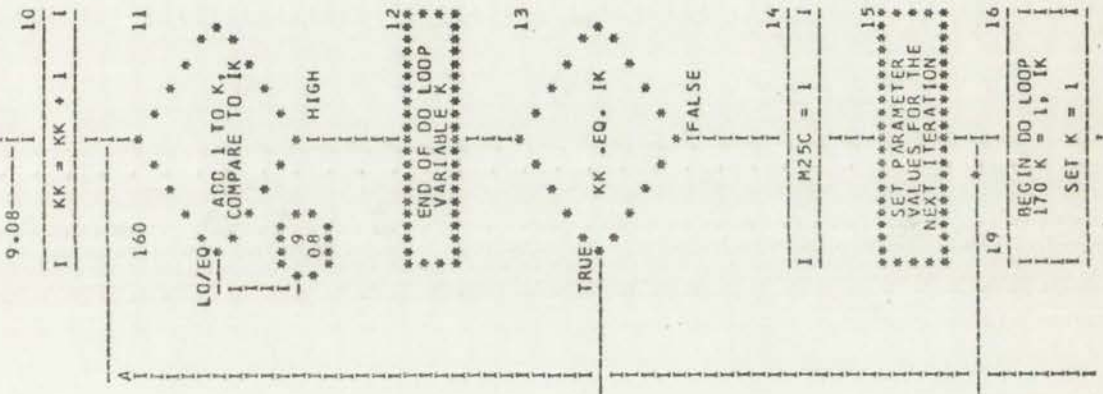






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7	10.24				
8	10.25				
9	10.26				
10	10.27				
12	10.35				
13	11.01				
14	10.36				
15	10.37				
17	10.40				
18	10.41				
19	10.42				
20	10.43				
21	11.02				
22	11.03				
24	11.06				
25	11.07				
26	11.16				
30	11.22				
31	12.02				
32	12.03				
33	12.04				
34	12.05				
35	12.06				
36	12.08				
37	12.09				
38	12.10				
39	12.13				

1000
 900
 800
 700
 600
 500
 400
 300
 200
 100
 0

1000
 900
 800
 700
 600
 500
 400
 300
 200
 100
 0

40	12.14
41	12.17
42	13.08
43	13.09
44	13.12
45	13.17
47	14.01
48	14.06
50	14.21
51	15.01
53	15.05
54	15.07
55	15.08
56	15.10
57	15.11
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63	16.10
64	16.29
65	16.14
66	16.15
67	16.16
68	16.18
69	16.19
70	16.22
71	16.25
72	16.28
73	10.04
75	10.06
76	10.11
9C	10.34
600	11.10
61C	13.04



SUBROUTINE GRAPHIC

PARAMETERS
(XPOINT,YPOINT,NREF,
REFTIME,REFPEAK)

/ GRAPHIC /

6.12

* SUBROUTINE GRAPHIC *

1
KROBGN = 1
KRDEND = 100
KONTRL = 1
INDGRD = 1
ISIZE = 2

3
ITAPE =
IAUS(ISIZE)

4
BEGIN DO LOOP
75 I = 1, 16
SET I = 1

5
I N4(I) = NN1(I)

6
I N4(I) = K4(I)

7
LO/EQ *
* ADD 1 TO I
* COMPARE TO 16 *
* HIGH

15

* SEARCH FOR
* MINIMUM AND
* MAXIMUM
* COORDINATES *

16
XFIRST =
XPOINT(KROBGN)
XFINAL =
XPOINT(KRDEND)
YFIRST =
YPOINT(KROBGN)
YFINAL =
YPOINT(KRDEND)
KRC = KROBGN

17
I KRD = KRD + 1

18
(0/+)* XPOINT(KRD) -
* XFIRST
* (-)

19
XFIRST =
XPOINT(KRD)

9
(-)* KRD - KRDEND
* (0/+)

10
MAXV
(REFPEAK,1,
INREF,1,YMAX)

28
FALSE *
YMAX -GT.
YFINAL *
TRUE

29
YFINAL = YMAX

30
MINV
(REFPEAK,1,
INREF,1,YMIN)

14
(0/-)*XFINAL/(XFINAL*
XFIRST) -
100000.0 *
* (+)

15
10.34
WRITE BCD
UNTIL TAPE
FORMAT 16

38
XFIRST = XFIRST -
ABS(10.005*XFIRST)
XFINAL = XFINAL +
ABS(10.005*XFINAL)

39
(+)* (XFINAL-XFIRST)
/100.0 *
* (0/-)



```

8 *****
  * END OF DO LOOP *
  * VARIABLE I *
  *****
9 BEGIN DO LOOP
  76 I = 1, 4
  SET I = 1
10 NN2(I) = NN5(I)
  N5(I) = K5(I)
11 I N2(I) = K2(I)
  76
12 *****
  * ADD 1 TO I *
  * COMPARE TO 4 *
  * HIGH *
13 *****
  * END OF DO LOOP *
  * VARIABLE I *
  *****
14 N3(01) = K3(01)
  N3(02) = K3(02)
  N5(01) = 4H +

```

```

3 (0/-) * XPOINT(KRD) - *
  * XFINAL *
  * (+) *
4 XFINAL = *
  XPCINT(KRD) *
  21
5 (0/+) * YPOINT(KRD) - *
  * YFIRST *
  * (-) *
6 YFIRST = *
  YPCINT(KRD) *
  23
7 YPOINT(KRD) - *
  * YFINAL *
  * (+) *
  24
  * (0/-) *
8 YFINAL = *
  YPCINT(KRD) *
  25

```

```

1 FALSE *
  * YMIN - YFIRST *
  * TRUE *
31
32 YFIRST = YMIN
  I
33 WRITE BCD
  UNIT TAPE
  FORMAT 11
34 (0/-) *
  * (XFINAL - XFIRST) *
  * /100.0 *
  * (+) *
  * 10 *
  * 37 *
  * 15 *
90
35 XFIRST + XFINAL *
  * (0/+) *
  * (-) *

```

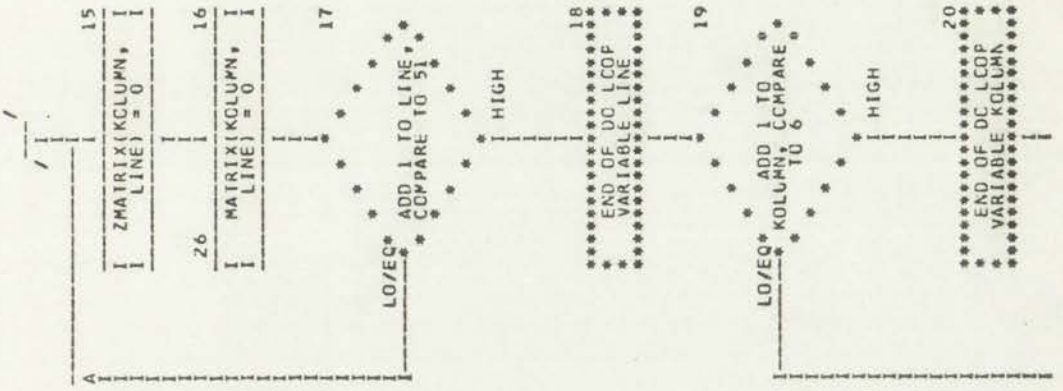
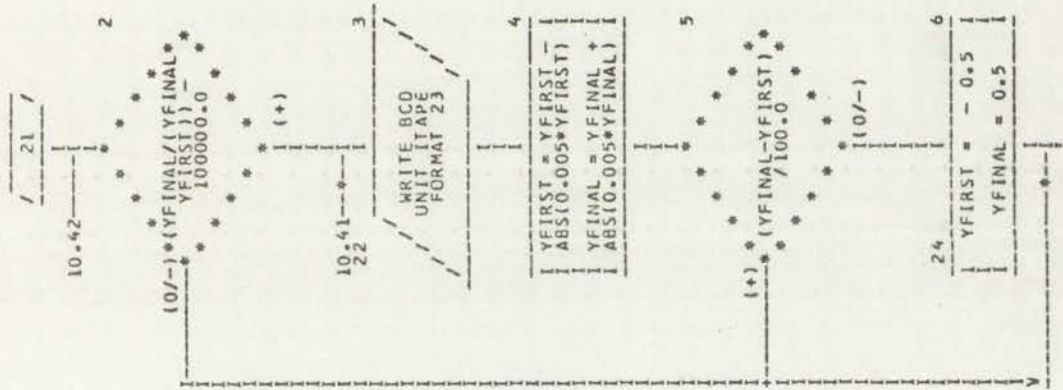
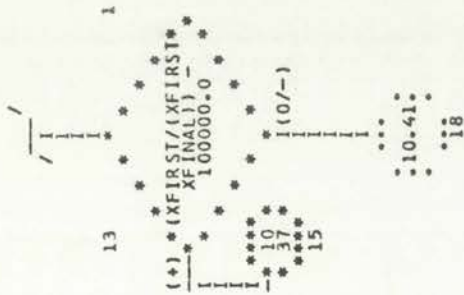
```

17 XFIRST = -0.5
  XFINAL = 0.5
  40
18 (0/-) *
  * (YFINAL - YFIRST) *
  * /100.0 *
  * (+) *
  * 11 *
  * 03 *
  * 22 *
19 YFIRST + YFINAL *
  * (0/+) *
  * (-) *
  * 11 *
  * 02 *
  * 21 *
20 (0/+) *
  * (YFIRST / (YFIRST *
  * YFINAL)) - *
  * /100000.0 *
  * (0/-) *
  * 11 *
  * 03 *
  * 22 *
  * 11.07 *
  * 25

```



SUBROUTINE GRAPHIC







SUBROUTINE GRAPHIC

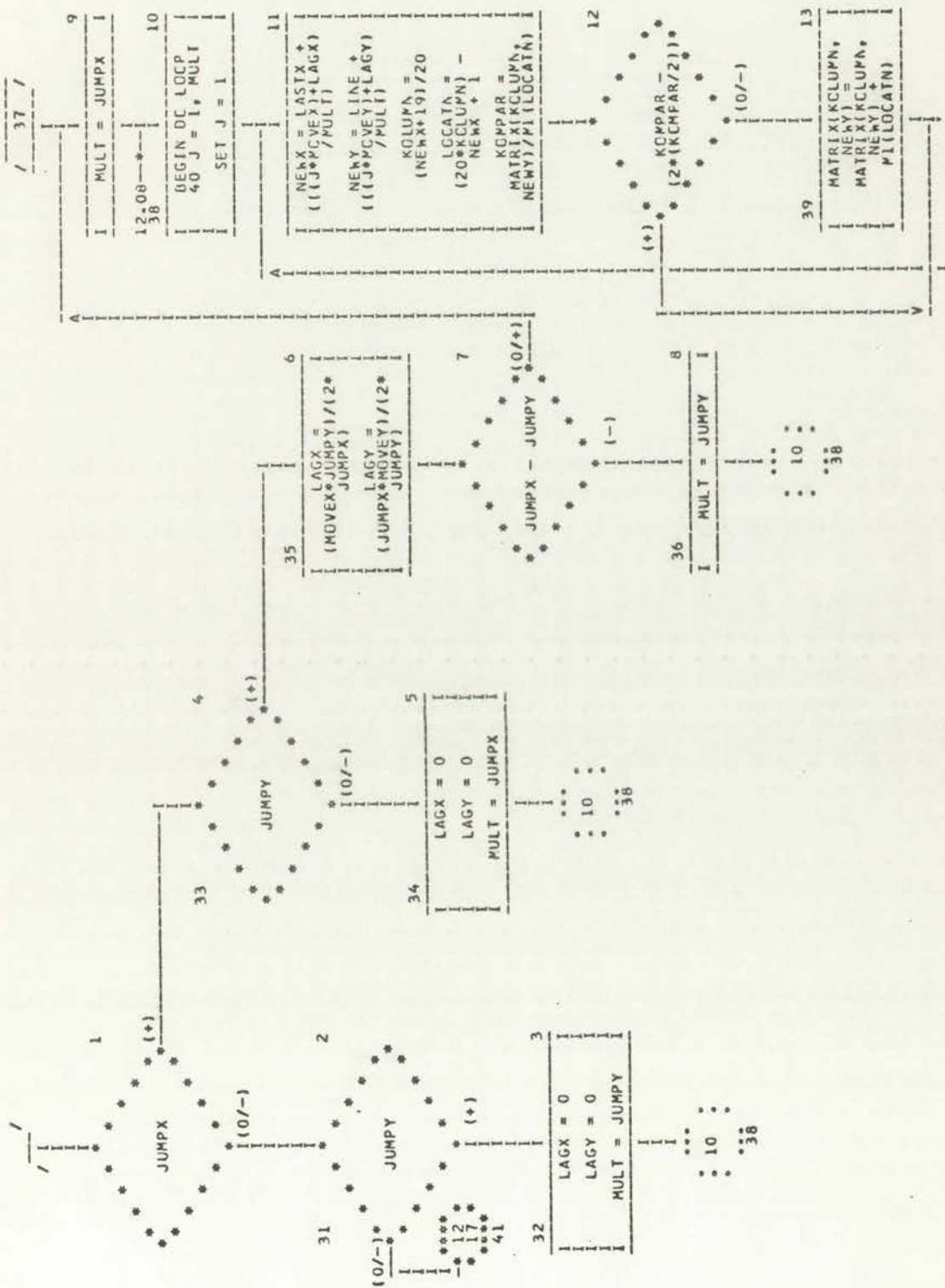




Fig. 1. Mechanical part.







1. Introduction
 2. Methodology
 3. Results
 4. Discussion
 5. Conclusion

1. Introduction
 2. Methodology
 3. Results
 4. Discussion
 5. Conclusion

1. Introduction
 2. Methodology
 3. Results
 4. Discussion
 5. Conclusion

1. Introduction
 2. Methodology
 3. Results
 4. Discussion
 5. Conclusion

1. Introduction
 2. Methodology
 3. Results
 4. Discussion
 5. Conclusion

1. Introduction
 2. Methodology
 3. Results
 4. Discussion
 5. Conclusion



Architectural drawing - floor plan



Architectural drawing - floor plan



SUBROUTINE GRAPHIC

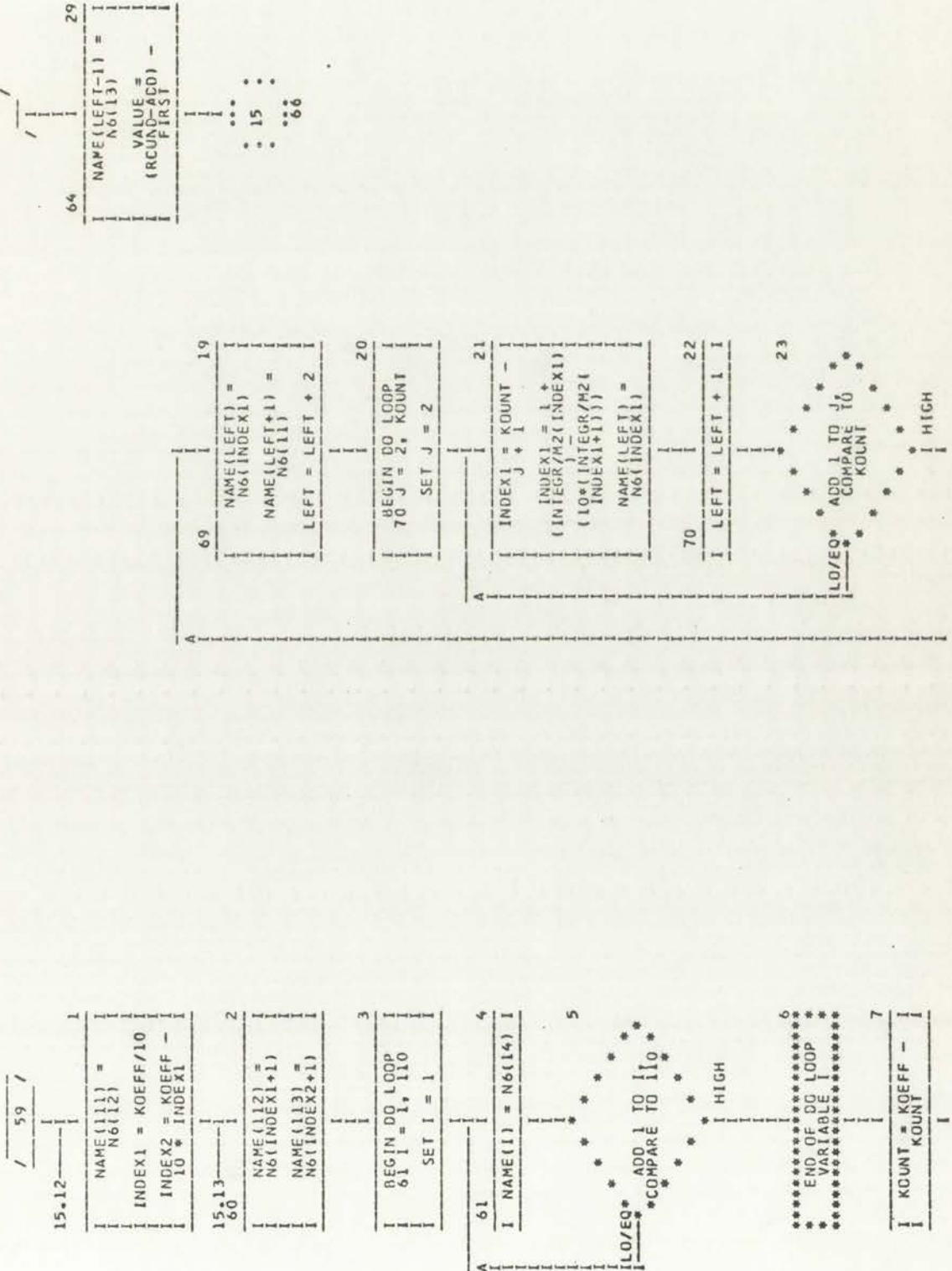




Figure 1: Block diagram of the image classification process.

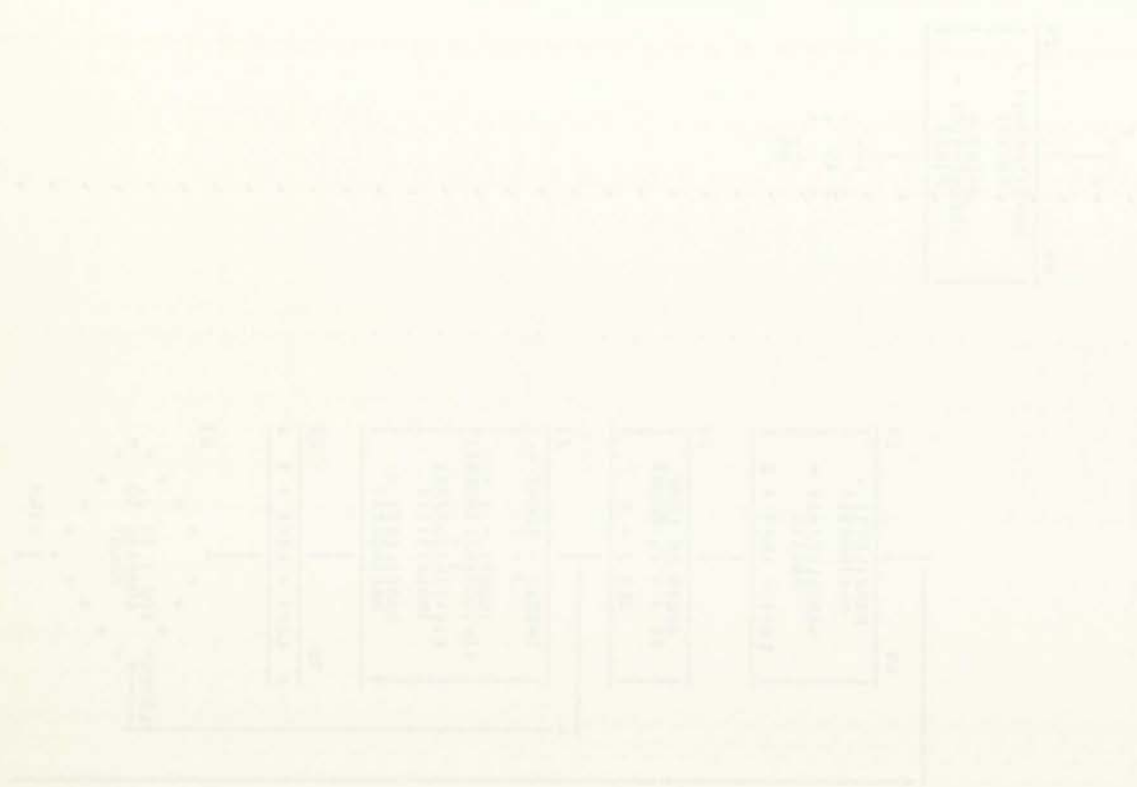
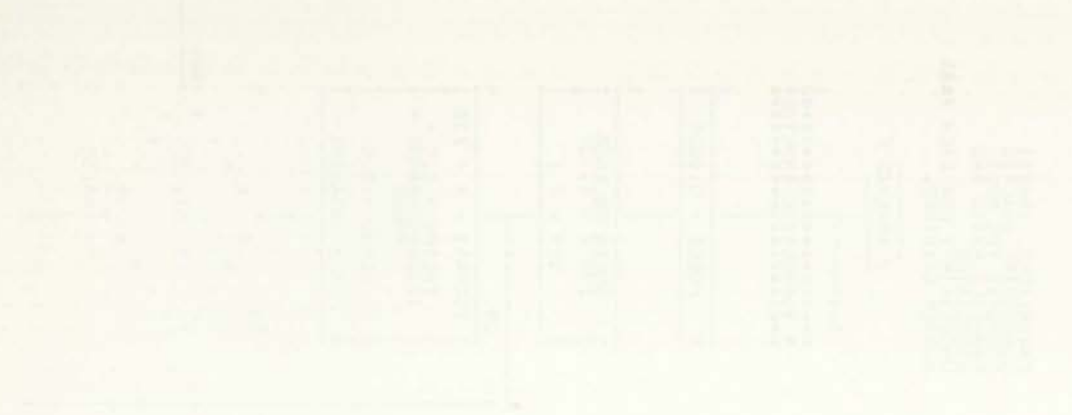


Figure 2: Block diagram of the image classification process.



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LABEL	PAGE	BOX
ANALYZE	17.01	
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30	17.05	
40	17.08	
45	17.09	
50	17.12	
60	17.14	
70	17.2C	
72	17.24	
74	18.01	
80	18.02	
110	18.08	
140	18.22	
145	18.23	
150	18.24	
160	18.27	
170	18.31	
180	18.34	
220	18.13	
230	18.15	



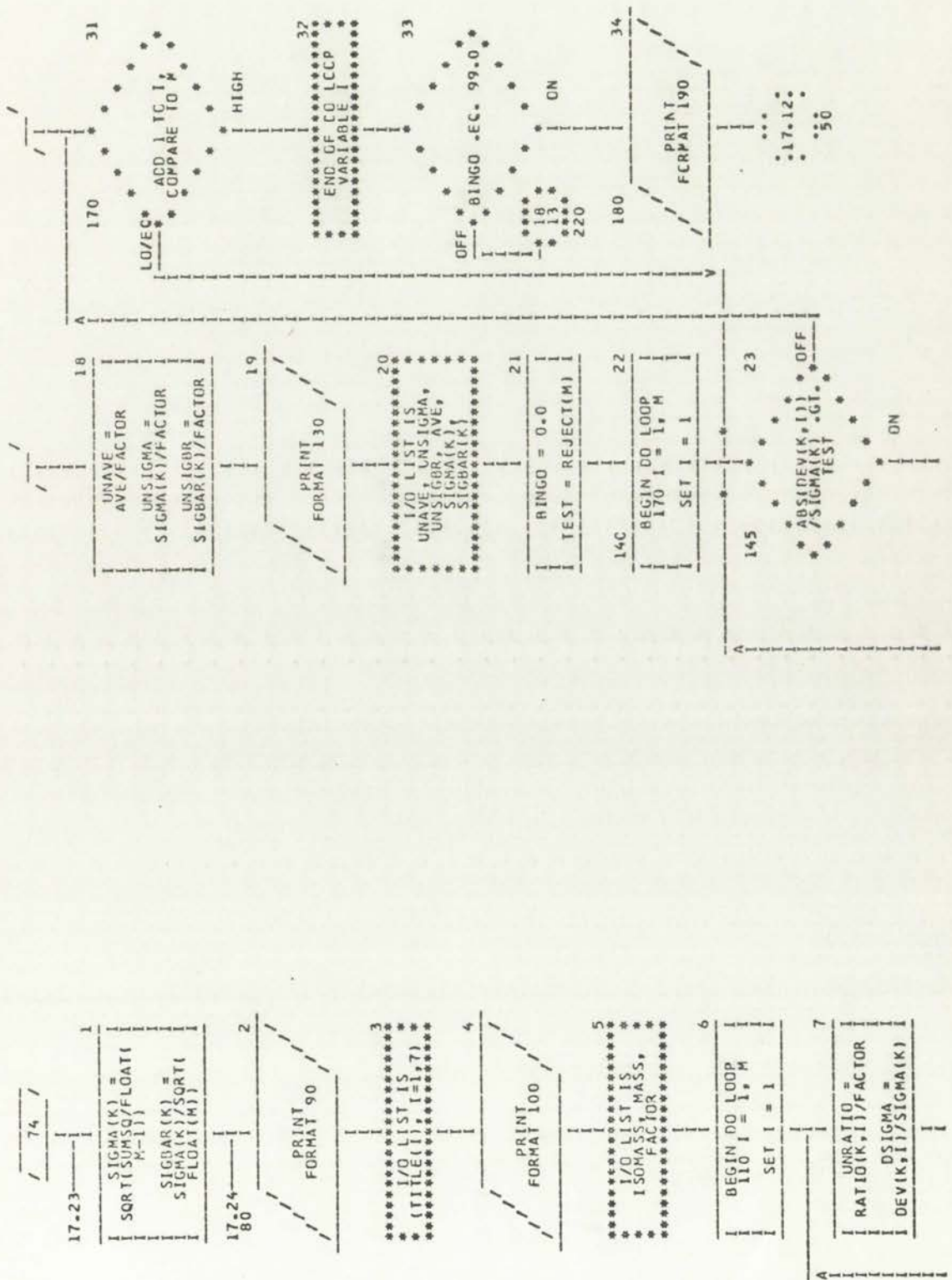
Page number: 100

Page number: 100

Page number: 100



SUBROUTINE ANALYZE





Flowchart illustrating the process flow.

Flowchart illustrating the process flow.

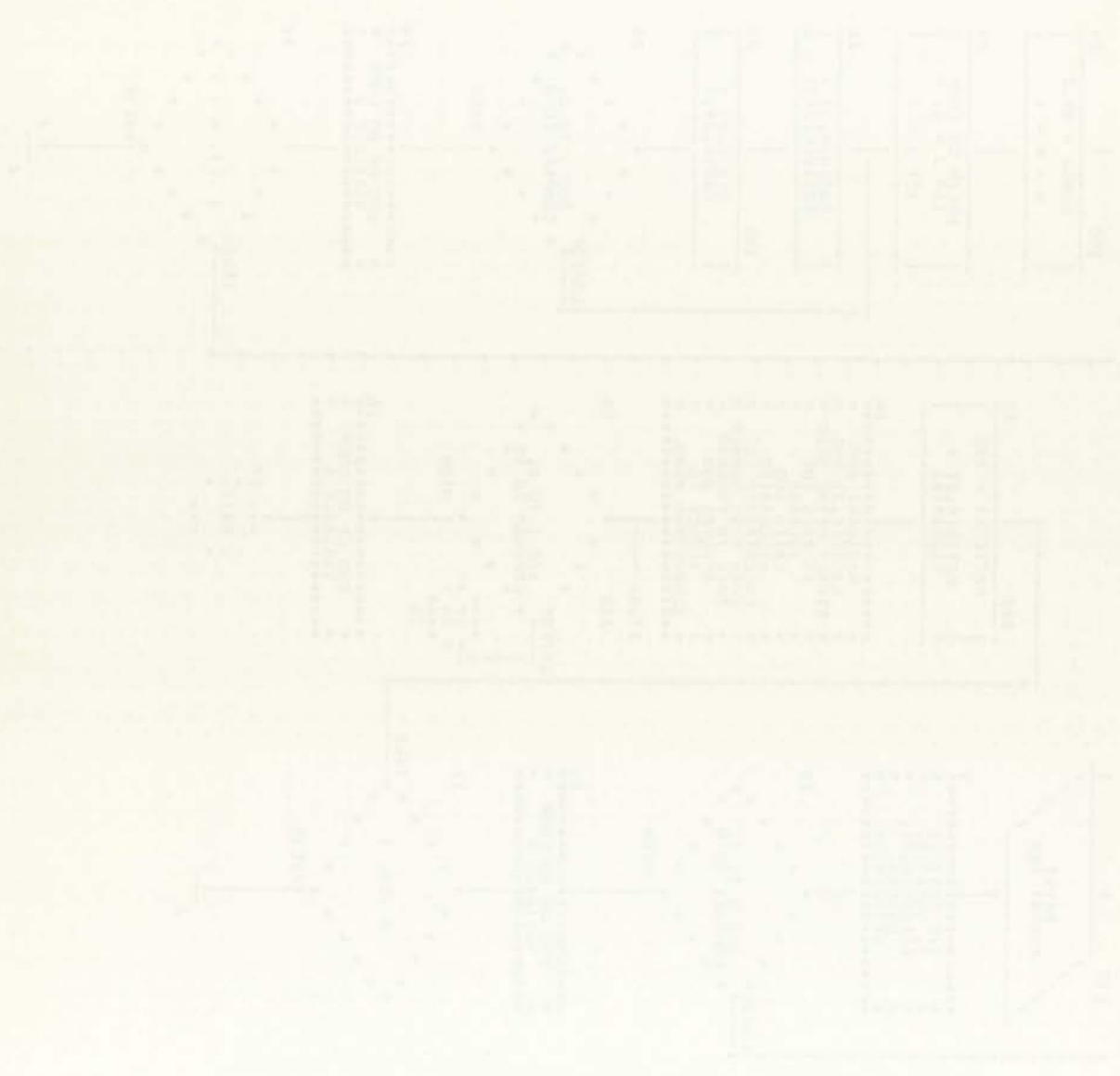


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10	19.04
30	19.07
40	19.10
42	19.13
45	19.15
60	20.01
70	20.02
72	20.05
75	20.09
160	20.13
180	20.16
200	20.19
210	20.21
230	20.25
250	20.26
270	20.31
300	20.34



SUBROUTINE MEMO

PARAMETERS (MASS)
 SUBROUTINE MEMO CONVERTS
 THE AVERAGE RATIO AND
 ASSOCIATED UNCERTAINTY
 FOR EACH MASS NUMBER
 EXAMINED TO A PERCENT OF
 TOTAL MASS
 WITH A RECALCULATED
 UNCERTAINTY, AND THEN
 PUBLISHES A REPORT
 CONTAINING THIS
 INFORMATION.

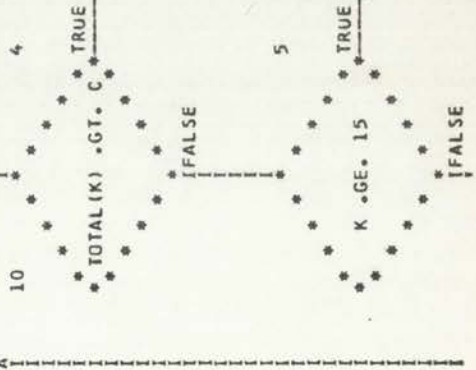
/ MEMO /

3.15

 * SUBROUTINE MEMO *

2
 SUM = 0.0
 SUMSQ = 0.0

3
 BEGIN DO LOOP
 40 K = 1, 15
 SET K = 1



RATIO(K) AND RATIO(K,2)
 CONTAIN THE AVERAGE RATIO
 AND ASSOCIATED
 UNCERTAINTY FOR EACH MASS
 NUMBER RESPECTIVELY.

/ 30 /

7
 ATOMRAT(K) =
 RATIO(K)
 M = TOTAL(K)
 ATOMERR(K) =
 SQRT((TFACOR(M)*
 RATIO(K,2)**2)+(
 0.03*ATOMRAT(K)**
 2))

8

 * THE FOLLOWING 2 *
 * STEPS CONVERT *
 * ATOMRAT(K) FROM *
 * AN ATOM RATIO TO *
 * A MASS *
 * RATIO AND ADJUST *
 * THE UNCERTAINTY *
 * IN THIS FIGURE *
 * ACCORDINGLY. *

9
 RATIO(K) =
 ATOMRAT(K) *
 FLOAT(K+230)/MASS
 RATIO(K,2) =
 ATOMERR(K) *
 FLOAT(K+230)/MASS
 SUM = SUM +
 RATIO(K)

10
 SUMSQ = SUMSQ +
 RATIO(K,2)**2





Diagram 1

Diagram 2

Diagram 3

PROBABILITY THEORY

CHAPTER I. THE THEORY OF PROBABILITY

SECTION I. THE THEORY OF PROBABILITY

SECTION II. THE THEORY OF PROBABILITY

SECTION III. THE THEORY OF PROBABILITY

SECTION IV. THE THEORY OF PROBABILITY

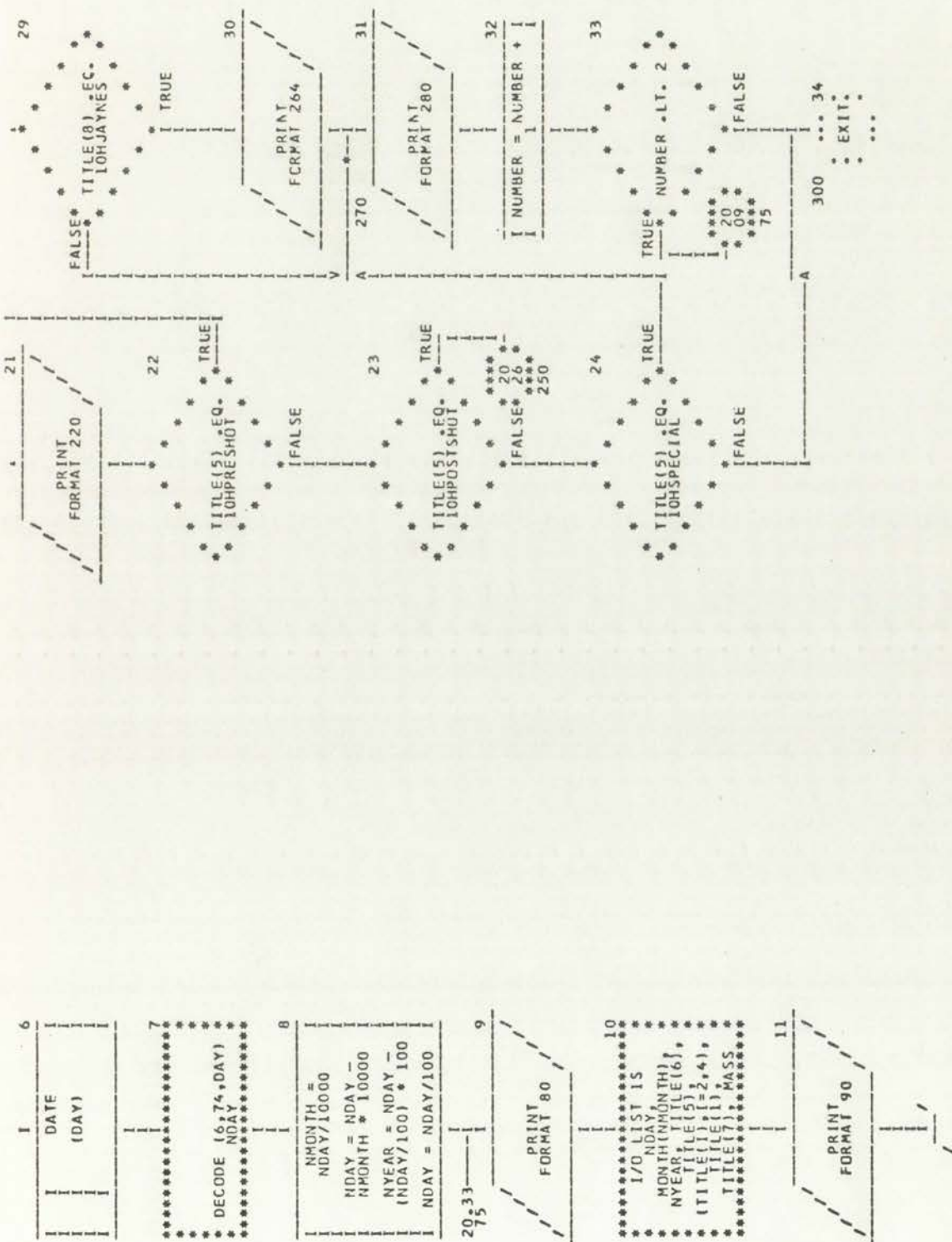
SECTION V. THE THEORY OF PROBABILITY

SECTION VI. THE THEORY OF PROBABILITY

SECTION VII. THE THEORY OF PROBABILITY

SECTION VIII. THE THEORY OF PROBABILITY



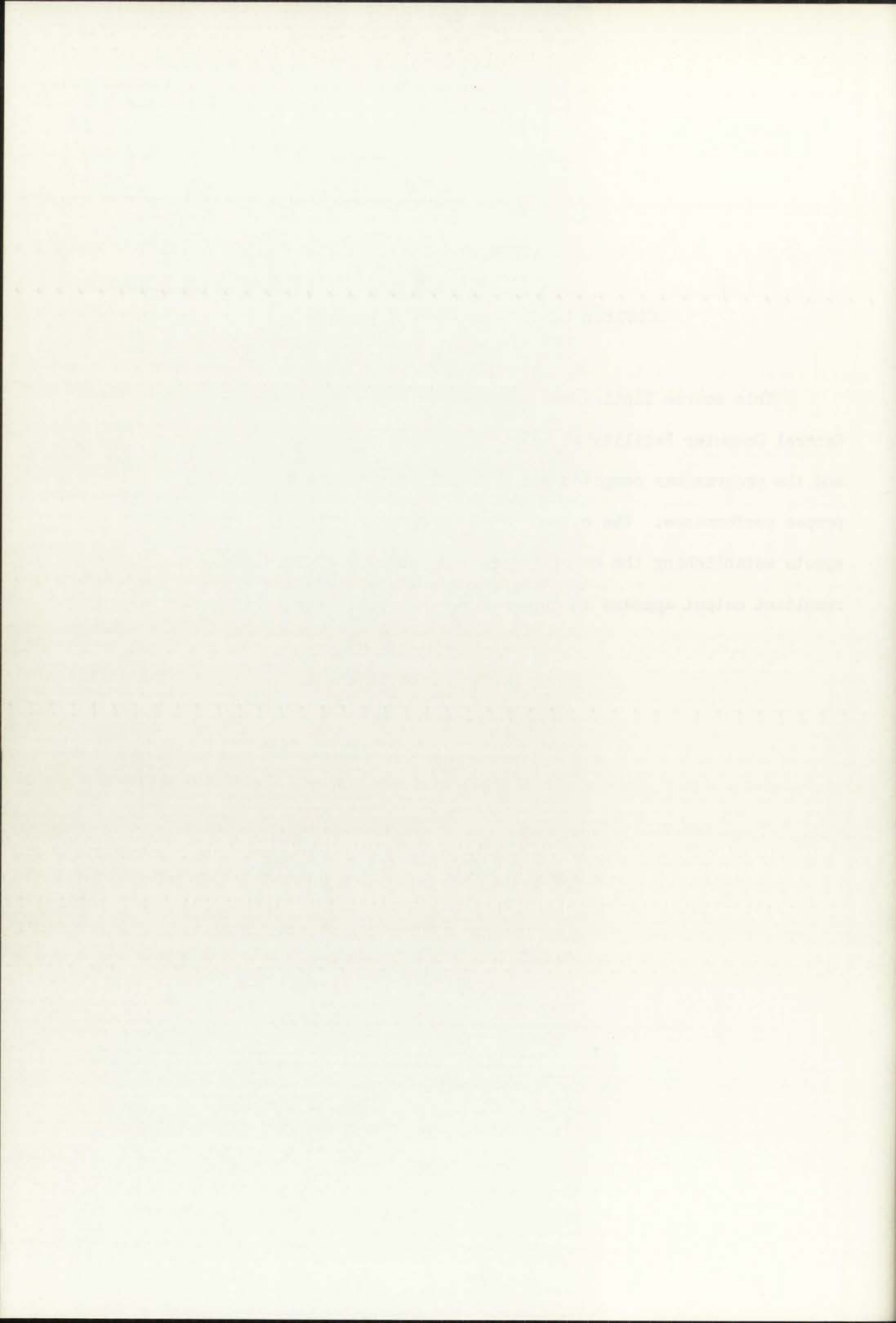




APPENDIX E

COMPLETE LISTING OF PROGRAM SPECTRE

This source listing was produced on September 4, 1970 at the Central Computer Facility at LASL. An actual data deck was included and the program was compiled and executed at the same time to ensure proper performance. The output of the program was correct in all respects establishing the completeness and accuracy of this listing. The resultant output appears in Appendix F.




```

PROGRAM SPECTRE (INPUT,TAPE 10=INPUT,OUTPUT,TAPE 2=OUTPUT)
C PROGRAM SPECTRE PRODUCES A SET OF ISOTOPE WEIGHT PERCENTAGES PRESENT
C IN A SINGLE MASS SPECTROMETER SAMPLE.
INTEGER FILTEMP(100),SCALE(100),MASS(100),TOTAL(15)
REAL HOUR(100,3),MINUTE(100,3),SECOND(100,3),SUMTIME(100,3),
C PEAK(100,3),BACKGND(100),TIME(100),RATIO(15,50),P(4)
COMMON TITLE(8),RATIO,TOTAL,P
EQUIVALENCE (HOUR,BACKGND),(MINUTE,TIME)
5 READ 8, TITLE
8 FORMAT (8A10)
IF (EOF,10) 80,10
10 PRINT 12, (TITLE(I), I=1,7),(TITLE(I),I=1,7)
12 FORMAT (1H12XA10,2X3A10,2XA10,2XA10,2XA10,5X11H* SPECTRE *)
PRINT 14, (TITLE(I),I=1,7)
14 FORMAT (1H12XA10,2X3A10,2XA10,2XA10,2XA10,5X11H* SPECTRE *//
C X2X11HINPUT DATA://
C X2X67HFILTEMP CODE, SCALE FACTOR, MASS NUMBER (FOLLOWED BY 3 DATA
C POINTS)/
C X2X55HHOUR:MINUTE:SECOND, INTEGRATION TIME (SEC), PEAK HEIGHT)
DO 40 I=1,100
READ 20, FILTEMP(I),SCALE(I),MASS(I)
20 FORMAT (I1,I2,I3)
IF (FILTEMP(I).EQ.9.AND.SCALE(I).EQ.99) GO TO 50
40 READ 45, (HOUR(I,J),MINUTE(I,J),SECOND(I,J),SUMTIME(I,J),
C PEAK(I,J),J=1,3)
45 FORMAT (F1,2F2,F3,F6)
50 N=I-1
K=N/4
DO 52 I=1,K
KA=K+I $ KB=2*K+I $ KC=3*K+I
52 PRINT 54, I, FILTEMP(I),SCALE(I),MASS(I),
C KA, FILTEMP(KA),SCALE(KA),MASS(KA),
C KB, FILTEMP(KB),SCALE(KB),MASS(KB),
C KC, FILTEMP(KC),SCALE(KC),MASS(KC),
C (HOUR(I,J),MINUTE(I,J),SECOND(I,J),SUMTIME(I,J),PEAK(I,J),
C HOUR(KA,J),MINUTE(KA,J),SECOND(KA,J),SUMTIME(KA,J),PEAK(KA,J),
C HOUR(KB,J),MINUTE(KB,J),SECOND(KB,J),SUMTIME(KB,J),PEAK(KB,J),
C HOUR(KC,J),MINUTE(KC,J),SECOND(KC,J),SUMTIME(KC,J),PEAK(KC,J),
C J=1,3)
54 FORMAT (1H02XI2,1H.2XI1,2XI2,2XI3,15XI2,1H.2XI1,2XI2,2XI3,
C 15XI2,1H.2XI1,2XI2,2XI3,15XI2,1H.2XI1,2XI2,2XI3/
C (X4XF1,1HOF2,1HOF2,2XF3,2XF6,10XF1,1HOF2,1HOF2,2XF3,2XF6,
C 10XF1,1HOF2,1HOF2,2XF3,2XF6,10XF1,1HOF2,1HOF2,2XF3,2XF6))
K=4*K+1
IF (N.LT.K) GO TO 58
DO 55 I=K,N
55 PRINT 56, I, FILTEMP(I),SCALE(I),MASS(I),(HOUR(I,J),MINUTE(I,J),
C SECOND(I,J),SUMTIME(I,J),PEAK(I,J),J=1,3)
56 FORMAT (1H092XI2,1H.2XI1,2XI2,2XI3/(X94XF1,1HOF2,1HOF2,2XF3,2XF6))
58 DO 70 I=1,N
DO 60 J=1,3
SECOND(I,J)=HOUR(I,J)*3600.0+MINUTE(I,J)*60.0+SECOND(I,J)
C -SUMTIME(I,J)/2.0
60 PEAK(I,J)=PEAK(I,J)/SUMTIME(I,J)
BACKGND(I)=PEAK(I,1)+(PEAK(I,3)-PEAK(I,1))/(SECOND(I,3)
C -SECOND(I,1))*(SECOND(I,2)-SECOND(I,1))
PEAK(I)=(PEAK(I,2)-BACKGND(I))*FLOAT((((-1)**SCALE(I)+2)*10**
C ((SCALE(I)-((((-1)**SCALE(I)+3)/2))/2))

```

Faint, illegible text, possibly bleed-through from the reverse side of the page. The text is arranged in several paragraphs and appears to be a formal document or report.

```

70 TIME(I)=SECOND(I,2)-SECOND(1,2)+2000.0
C THE FOLLOWING PROGRAM SEGMENT (STATEMENT 200 - STATEMENT 330)
C INTRODUCES SYNTHETIC FILTEMPS SO THAT THE REFERENCE ISOTOPE CURVE WILL
C BE FITTED IN SECTIONS OF APPROXIMATELY SIX MEASURED REFERENCE PEAKS
C PER SECTION (MINIMUM FOUR - MAXIMUM EIGHT).
200 J=1 $ L=FILTEMP(J) $ M=1
210 NREF=0
    DO 220 I=J,N
        IF (FILTEMP(I).NE.L) GO TO 230
        IF (MASS(I).EQ.MASS(1)) NREF=NREF+1
220 CONTINUE
    K=N
    GO TO 240
230 K=I-1
240 KEEP=K
    KOUNT=(NREF+1)/5
    JUMP=0
    IF (KOUNT.GE.2.AND.MOD(NREF,5).EQ.4) JUMP=5
250 IF (KOUNT.LE.1) GO TO 300
    NREF=0
    DO 260 I=J,K
        IF (MASS(I).NE.MASS(1)) GO TO 260
        NREF=NREF+1
        IF (NREF.GE.6) GO TO 270
        IF (KOUNT.EQ.2.AND.JUMP.EQ.5.AND.NREF.GE.5) GO TO 270
260 CONTINUE
270 K=I
300 DO 310 I=J,K
310 FILTEMP(I)=M
    IF (K.GE.N) GO TO 75
    J=K+1 $ L=FILTEMP(J) $ M=M+1
    IF (KOUNT.LE.1) GO TO 210
    KOUNT=KOUNT-1
    DO 320 I=J,N
        INVERT=N+J-I
        FILTEMP(INVERT+1)=FILTEMP(INVERT)
        MASS(INVERT+1)=MASS(INVERT)
        PEAK(INVERT+1)=PEAK(INVERT)
320 TIME(INVERT+1)=TIME(INVERT)
    MASS(J)=MASS(J-1)
    PEAK(J)=PEAK(J-1)
    TIME(J)=TIME(J-1)
    N=N+1
    KEEP=KEEP+1
    K=KEEP
330 GO TO 250
75 CALL FITCURV (FILTEMP,MASS,N,PEAK,TIME)
    CALL ANALYZE (MASS)
    CALL MEMO (MASS)
    GO TO 5
80 STOP
    END

```



```

SUBROUTINE FITCURV (FILTEMP,MASS,N,PEAK,TIME)
C SUBROUTINE FITCURV COMPUTES A LIST OF ISOTOPIC RATIOS FOR EACH
C ISOTOPIC MASS NUMBER EXAMINED. THIS RATIO IS THE RELATIVE ATOM
C ABUNDANCE OF A PARTICULAR MASS NUMBER COMPARED TO THE ATOM ABUNDANCE
C OF A PARTICULAR REFERENCE MASS NUMBER.
  INTEGER FILTEMP(100),MASS(100),START,FILNUM,TOTAL(15),COUNT(15)
  REAL PEAK(100),TIME(100),REFPEAK(50),REFTIME(50),ISOPEAK(15,50),
C ISOTIME(15,50),RATIO(15,50),XPLOTT(100),YPLOTT(100),XLABEL(9),
C YLABEL(9),REFPLOTT(50),DIFFER(50),X(50),Y(50),P(4)
  COMMON TITLE(8),RATIO,TOTAL,P
  EQUIVALENCE (ISOPEAK,RATIO)
  START=1
  FILNUM=1
  DO 10 K=1,15
  TOTAL(K)=0
10  COUNT(K)=0
20  NREF=0
  DO 80 I=START,N
  IF (FILTEMP(I).EQ.FILNUM) GO TO 40
  START=I
  GO TO 100
40  IF (MASS(I).EQ.MASS(1)) 50,60
50  NREF=NREF+1
  REFPEAK(NREF)=PEAK(I)
  REFTIME(NREF)=TIME(I)
  GO TO 80
60  K=MASS(I)-230
  TOTAL(K)=TOTAL(K)+1
C TOTAL(K) IS A COUNTER WHICH CONTAINS THE TOTAL NUMBER OF EXPERIMENTAL
C PEAKS PROCESSED FOR MASS NUMBER K+230.
  M=TOTAL(K)
  ISOPEAK(K,M)=PEAK(I)
  ISOTIME(K,M)=TIME(I)
  80  CONTINUE
100 IF (NREF.GE.4) GO TO 120
C COUNT(K) IS A COUNTER WHICH, AT THIS TIME, CONTAINS THE NUMBER OF
C EXPERIMENTAL PEAKS FOR MASS NUMBER K+230 WHICH WERE PROCESSED UP TO
C THE END OF THE FILTEMP PREVIOUS TO THE FILTEMP NOW BEING CONSIDERED.
  DO 105 K=1,15
105 TOTAL(K)=COUNT(K)
  PRINT 110, (TITLE(I), I=1,7)
110 FORMAT (1H12XA10,2X3A10,2XA10,2XA10,2XA10,5X11H* SPECTRE *///)
  GO TO 260
120 CALL PARCEL (NREF,REFTIME,REFPEAK)
200 DO 230 K=1,15
205 J=COUNT(K)+1
  M=TOTAL(K)
  COUNT(K)=TOTAL(K)
  IF (M-J.GT.-1) GO TO 220
  IF (K.GE.15) GO TO 235
  K=K+1
  GO TO 205
220 DO 230 I=J,M
C AT THIS POINT A QUANTITY CALLED REFVALU MUST BE OBTAINED.
  REFVALU=P(1)/ISOTIME(K,I)**1.5+P(2)/ISOTIME(K,I)**0.5
  C +P(3)*ISOTIME(K,I)**0.5+P(4)*ISOTIME(K,I)**1.5
230 RATIO(K,I)=ISOPEAK(K,I)/REFVALU
C AT THIS POINT YPLOTT(I) MUST BE CALCULATED.

```



```

235 DO 240 I=1,100
      XPLOT(I)=REFTIME(I)+FLOAT(I-1)*(REFTIME(NREF)-REFTIME(I))/99.0
240 YPLOT(I)=P(1)/XPLOT(I)**1.5+P(2)/XPLOT(I)**0.5
      C +P(3)*XPLOT(I)**0.5+P(4)*XPLOT(I)**1.5
C AT THIS POINT REF PLOT(I) MUST BE CALCULATED.
C REF PLOT(I) IS THE CALCULATED REFERENCE PEAK HEIGHT AT REFTIME(I).
      DO 250 I=1,NREF
      REF PLOT(I)=P(1)/REFTIME(I)**1.5+P(2)/REFTIME(I)**0.5
      C +P(3)*REFTIME(I)**0.5+P(4)*REFTIME(I)**1.5
250 DIFFER(I)=(REFPEAK(I)-REF PLOT(I))/REF PLOT(I)*100.0
260 PRINT 290, MASS(1),FILNUM
290 FORMAT (X20X22HREFERENCE MASS NUMBER I3,8X9HFILTEMP (I1,1H)//
      C X5X82HMEASURED REFERENCE PEAK          CALCULATED REFERENCE PEAK
      C PERCENT DIFFERENCE//)
300 IF (NREF.GE.4) GO TO 306
      PRINT 304
304 FORMAT (X77H***** LESS THAN FOUR REFERENCE PEAKS WERE MEASURED AT
      C THIS FILTEMP, THEREFORE/
      C X74H***** A REFERENCE CURVE HAS NOT BEEN CALCULATED AND ALL DATA
      C TAKEN AT THIS/
      C X31H***** FILTEMP HAS BEEN IGNORED.//)
      GO TO 328
306 DO 310 I=1,NREF
310 PRINT 320, I,REFPEAK(I),REF PLOT(I),DIFFER(I)
320 FORMAT (X12,1H.2XF18.1,13XF18.1,15XF10.2)
      PRINT 321
321 FORMAT(4(/)X100HTHE FUNCTION BEING FITTED IS: REFERENCE VALUE=P(1
      C)/T**1.5 + P(2)/T**0.5 + P(3)*T**0.5 + P(4)*T**1.5//)
324 DO 325 I=1,4
325 PRINT 326, I,P(I)
326 FORMAT (X5X2HP(I1,2H):1XE20.10)
      CALL GRAPHIC (XPLOT,YPLOT,NREF,REFTIME,REFPEAK)
328 IF (FILNUM.GE.FILTEMP(N)) GO TO 340
      FILNUM=FILNUM+1
      GO TO 20
340 RETURN
      END

```

1. The first part of the document discusses the importance of maintaining accurate records of all transactions. It emphasizes that proper record-keeping is essential for the success of any business and for the protection of the interests of all parties involved.

2. The second part of the document outlines the various methods and techniques used to collect and analyze data. It describes the process of identifying key variables, designing surveys, and using statistical tools to interpret the results. This section highlights the need for a systematic and unbiased approach to data collection.

3. The third part of the document focuses on the application of the collected data to solve real-world problems. It provides examples of how data analysis can be used to identify trends, predict future outcomes, and make informed decisions. This part also discusses the challenges of data interpretation and the importance of context in drawing conclusions.

4. The final part of the document concludes by summarizing the key findings and offering recommendations for further research and practice. It stresses the ongoing nature of data analysis and the need for continuous learning and adaptation in a rapidly changing environment.

```

SUBROUTINE PARCEL (N,X,Y)
  INTEGER TOTAL(15)
  REAL RATIO(15,50),X(50),Y(50),PG(4),W(50),DP(4),SP(4),PC(4),P(4),
  C AM(4,4),BM(4,5),YC(50),DY(50),AN(4),PART(4)
  COMMON TITLE(8),RATIO,TOTAL,P
C IK=NUMBER OF PARAMETERS. M=NUMBER OF INDEPENDENT VARIABLES.
C ITLIM=MAXIMUM NUMBER OF PERMISSIBLE ITERATIONS. IFG CONTROLS THE
C SIGNS OF THE PARAMETERS ((0) OK TO CHANGE SIGNS AFTER 5 ITERATIONS.
C (1) SIGNS ALWAYS FREE TO CHANGE. (2) SIGNS NEVER FREE TO CHANGE.).
  IK=4
  ITLIM=25
  M=1
  IFG=1
  TEST=0.000001
  DO 2000 I=1,N
2000 W(I)=1.0
C CALCULATE (PG(K),K=1,4) THE INITIAL ESTIMATED VALUES OF THE PARAMETERS
  DO 2010 I=1,4
2010 PG(I)=1.0
C INITIALIZATION FOR MAIN ITERATION LOOP
  1 KFREE=IK
  KP=KFREE+1
  IDF=N-KFREE
  DF=IDF
  IT=0
  DO 10 K=1,IK
  DP(K)=0.0
  SP(K)=0.0
  PC(K)=PG(K)
10 P(K)=PG(K)
  LASTIT=0
  M25C=0
  IF (ITLIM.EQ.1) LASTIT=1
C MAIN ITERATION LOOP
  2 IT=IT+1
  H=1.0
  DO 30 K=1,KFREE
  DO 20 KK=1,KFREE
20 BM(K,KK)=0.0
  BM(K,KP)=0.0
  K1=K+1
30 BM(K,K1)=1.0
  3 VAR=0.0
  SSQ=0.0
C LOOP TO SET UP NORMAL EQUATIONS
  DO 90 I=1,N
C CALCULATE SUM OF SQUARES
  Z=X(I)
C DETERMINE AN EQUATION YT=F(P(1),P(2),P(3),P(4),Z)
  YT=P(1)/Z**1.5+P(2)/Z**0.5+P(3)*Z**0.5+P(4)*Z**1.5
  PART(1)=1.0/Z**1.5
  PART(2)=1.0/Z**0.5
  PART(3)=Z**0.5
  PART(4)=Z**1.5
  YC(I)=YT
  DY(I)=Y(I)-YC(I)
  VAR=VAR+W(I)*DY(I)**2

```



```

SSQ=SSQ+DY(I)**2
C SET UP AN AS VECTOR OF PARTIAL DERIVATIVES
K1=0
DO 60 K=1, IK
  4 K2=K-K1
  AN(K2)=PART(K)
60 CONTINUE
C FORM A AND B MATRICES
DO 80 K=1, KFREE
DO 70 KK=1, KFREE
  70 AM(K, KK)=AM(K, KK)+AN(K)*AN(KK)*W(I)
  80 BM(K, 1)=BM(K, 1)+AN(K)*DY(I)*W(I)
90 CONTINUE
C SOLVE THE NORMAL EQUATIONS
  7 CALL LSS (KFREE, KP, 4, AM, BM, TEMP, DET)
C CALCULATE NEW PARAMETER VALUES AND CHECK FOR SIGN CHANGES IF NECESSARY
  11 K1=0
  DO 140 K=1, IK
    12 K2=K-K1
    DP(K)=BM(K2, 1)
    13 PC(K)=P(K)+H*DP(K)
    IF(LASTIT.NE.0)GOTO140
    IF(IFG-1)14, 140, 15
    14 IF(IT.GT.5)GOTO140
    15 IF(P(K)*PC(K).GE.0)GOTO140
    H=H/2
    IF(H.GE.1.0E-10)GOTO13
    RETURN
  16 K1=K1+1
  140 CONTINUE
  IF(LASTIT.NE.0)GOTO19
C TEST FOR CONVERGENCE
  17 KK=0
  DO 160 K=1, IK
    IF(P(K).EQ.0)GOTO18
    IF(ABS((PC(K)-P(K))/P(K))-TEST)160, 160, 19
  18 KK=KK+1
  160 CONTINUE
  IF(KK.EQ.IK)GOTO19
  M25C=1
C SET PARAMETER VALUES FOR THE NEXT ITERATION
  19 DO 170 K=1, IK
  170 P(K)=PC(K)
  IF(LASTIT.EQ.0)GOTO21
  PRINT 200, (TITLE(I), I=1, 7), IT
200 FORMAT (1H12XA10, 2X3A10, 2XA10, 2XA10, 2XA10, 5X11H* SPECTRE *////
  C X2X38HTHE NUMBER OF ITERATIONS REQUIRED WAS I2/)
  RETURN
C TEST WHETHER THE MAXIMUM NUMBER OF ITERATIONS HAS BEEN TAKEN
  21 IF(M25C.EQ.1)GOTO22
  IF(IT.LT.ITLIM-1)GOTO2
C GO BACK FOR LAST ITERATION
  22 LASTIT=1
  GOTO2
  END

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2008-2009

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```

1 KRD=KRD+1
  IF(XPOINT(KRD)-XFIRST)2,3,3
2 XFIRST=XPOINT(KRD)
3 IF(XPOINT(KRD)-XFINAL)5,5,4
4 XFINAL=XPOINT(KRD)
5 IF(YPOINT(KRD)-YFIRST)6,7,7
6 YFIRST=YPOINT(KRD)
7 IF(YPOINT(KRD)-YFINAL)9,9,8
8 YFINAL=YPOINT(KRD)
9 IF(KRD-KRDEND)1,10,10
10 CALL MAXV (REFPEAK,1,NREF,IT,YMAX)
  IF (YMAX.GT.YFINAL) YFINAL=YMAX
  CALL MINV (REFPEAK,1,NREF,IT,YMIN)
  IF (YMIN.LT.YFIRST) YFIRST=YMIN
  WRITE(ITAPE,11)
11 FORMAT(1H1)
90 IF((XFINAL-XFIRST)/100.0)15,15,12
12 IF(XFIRST+XFINAL)13,14,14
13 IF((XFIRST/(XFIRST-XFINAL))-100000.0)18,18,15
14 IF((XFINAL/(XFINAL-XFIRST))-100000.0)18,18,15
15 WRITE(ITAPE,16)
16 FORMAT(16X,51HPLOT ERROR, ZERO XPOINT HORIZONTAL COORDINATE RANGE)
  XFIRST=XFIRST-ABS(0.005*XFIRST)
  XFINAL=XFINAL+ABS(0.005*XFINAL)
  IF((XFINAL-XFIRST)/100.0)17,17,18
17 XFIRST=-0.5
  XFINAL=0.5
18 IF((YFINAL-YFIRST)/100.0)22,22,19
19 IF(YFIRST+YFINAL)20,21,21
20 IF((YFIRST/(YFIRST-YFINAL))-100000.0)25,25,22
21 IF((YFINAL/(YFINAL-YFIRST))-100000.0)25,25,22
22 WRITE(ITAPE,23)
23 FORMAT(16X,51HPLOT ERROR, ZERO YPOINT VERTICAL COORDINATE RANGE )
  YFIRST=YFIRST-ABS(0.005*YFIRST)
  YFINAL=YFINAL+ABS(0.005*YFINAL)
  IF((YFINAL-YFIRST)/100.0)24,24,25
24 YFIRST=-0.5
  YFINAL=0.5
25 XSCALE=100.0/(XFINAL-XFIRST)
  YSCALE=50.0/(YFINAL-YFIRST)
  DO 600 I=1,31
  LIST(I)=4H
600 ZLIST(I)=4H
  DO 26 KOLUMN=1,6
  DO 26 LINE=1,51
  ZMATRIX(KOLUMN,LINE)=0
26 MATRIX(KOLUMN,LINE)=0
C *****KONTRL = 1, GENERATE LINE PLOT*****
30 LASTX=1.5+(XSCALE*(XPOINT(KRDBGN)-XFIRST))
  LINE=51.5-(YSCALE*(YPOINT(KRDBGN)-YFIRST))
  KOLUMN=(LASTX+19)/20
  LOCATN=(20*KOLUMN)-LASTX+1
  MATRIX(KOLUMN,LINE)=M1(LOCATN)
  DO 41 KRD=KRDBGN,KRDEND
  MOVEX=IFIX(1.5+(XSCALE*(XPOINT(KRD)-XFIRST)))-LASTX
  MOVEY=IFIX(51.5-(YSCALE*(YPOINT(KRD)-YFIRST)))-LINE
  JUMPX=IABS(MOVEX)
  JUMPY=IABS(MOVEY)

```

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36. Innovation
37. Collaboration
38. Transparency
39. Accountability
40. Integrity
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42. Fairness
43. Justice
44. Equity
45. Inclusion
46. Diversity
47. Respect
48. Empathy
49. Compassion
50. Kindness
51. Generosity
52. Gratitude
53. Humility
54. Patience
55. Persistence
56. Perseverance
57. Determination
58. Resilience
59. Flexibility
60. Adaptability
61. Openness
62. Curiosity
63. Creativity
64. Innovation
65. Problem Solving
66. Critical Thinking
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68. Communication
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70. Leadership
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72. Networking
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92. Flexibility
93. Adaptability
94. Openness
95. Curiosity
96. Creativity
97. Innovation
98. Problem Solving
99. Critical Thinking
100. Analytical Skills


```

      IF(JUMPX)31,31,33
31  IF(JUMPY)41,41,32
32  LAGX=0
      LAGY=0
      MULT=JUMPY
      GO TO 38
33  IF(JUMPY)34,34,35
34  LAGX=0
      LAGY=0
      MULT=JUMPX
      GO TO 38
35  LAGX=(MOVEX*JUMPY)/(2*JUMPX)
      LAGY=(JUMPX*MOVEY)/(2*JUMPY)
      IF(JUMPX-JUMPY)36,37,37
36  MULT=JUMPY
      GO TO 38
37  MULT=JUMPX
38  DO 40 J=1,MULT
      NEWX=LASTX+(((J*MOVEX)+LAGX)/MULT)
      NEWY=LINE+(((J*MOVEY)+LAGY)/MULT)
      KOLUMN=(NEWX+19)/20
      LOCATN=(20*KOLUMN)-NEWX+1
      KOMPAN=MATRIX(KOLUMN,NEWY)/M1(LOCATN)
      IF(KOMPAN-(2*(KOMPAN/2)))39,39,40
39  MATRIX(KOLUMN,NEWY)=MATRIX(KOLUMN,NEWY)+M1(LOCATN)
40  CONTINUE
      LASTX=NEWX
      LINE=NEWY
41  CONTINUE
C *****KONTRL = 0, GENERATE POINT PLOT*****
      DO 620 KRD=1,NREF
      LASTX=1.5+(XSCALE*(REFTIME(KRD)-XFIRST))
      LINE=51.5-(YSCALE*(REFPEAK(KRD)-YFIRST))
      KOLUMN=(LASTX+19)/20
      LOCATN=(20*KOLUMN)-LASTX+1
      KOMPAN=ZMATRIX(KOLUMN,LINE)/M1(LOCATN)
      IF (KOMPAN-(2*(KOMPAN/2))) 610,610,620
610  ZMATRIX(KOLUMN,LINE)=ZMATRIX(KOLUMN,LINE)+M1(LOCATN)
620  CONTINUE
C *****PRINT THE PLOT STORAGE ARRAY*****
42  LOCK=0
      FIRST=YFIRST
      FINAL=YFINAL
      GO TO 53
43  IBGN=1
      DO 50 LINE=IBGN,51
      IF(LOCK)47,47,44
44  LOCK=LOCK-1
      DO 45 KOLUMN=1,5
      INDEX5=MATRIX(KOLUMN,LINE)/16
      INDEX4=INDEX5/16
      INDEX3=INDEX4/4
      INDEX2=INDEX3/16
      INDEX1=INDEX2/16
      INDEX6=MATRIX(KOLUMN,LINE)-16*INDEX5
      INDEX5=INDEX5-16*INDEX4
      INDEX4=INDEX4-4*INDEX3
      INDEX3=INDEX3-16*INDEX2

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INDEX2=INDEX2-16*INDEX1
LIST(6*KOLUMN) =N1(INDEX6+1)
LIST(6*KOLUMN-1)=N1(INDEX5+1)
LIST(6*KOLUMN-2)=N2(INDEX4+1)
LIST(6*KOLUMN-3)=N1(INDEX3+1)
LIST(6*KOLUMN-4)=N1(INDEX2+1)
LIST(6*KOLUMN-5)=N2(INDEX1+1)
INDEX5=ZMATRIX(KOLUMN,LINE)/16
INDEX4=INDEX5/16
INDEX3=INDEX4/4
INDEX2=INDEX3/16
INDEX1=INDEX2/16
INDEX6=ZMATRIX(KOLUMN,LINE)-16*INDEX5
INDEX5=INDEX5-16*INDEX4
INDEX4=INDEX4-4*INDEX3
INDEX3=INDEX3-16*INDEX2
INDEX2=INDEX2-16*INDEX1
ZLIST(6*KOLUMN)=NN1(INDEX6+1)
ZLIST(6*KOLUMN-1)=NN1(INDEX5+1)
ZLIST(6*KOLUMN-2)=NN2(INDEX4+1)
ZLIST(6*KOLUMN-3)=NN1(INDEX3+1)
ZLIST(6*KOLUMN-4)=NN1(INDEX2+1)
ZLIST(6*KOLUMN-5)=NN2(INDEX1+1)
45 CONTINUE
INDEX1=1+(MATRIX(6,LINE)/524288)
LIST(31)=N3(INDEX1)
INDEX1=1+ZMATRIX(6,LINE)/524288
ZLIST(31)=NN3(INDEX1)
WRITE(ITAPE,46)(LIST(I),I=1,31),(ZLIST(I),I=1,31)
46 FORMAT (1H+15X10(A2,2A4),A1/X15X10(A2,2A4),A1)
GO TO 50
47 LOCK=4
DO 48 KOLUMN=1,5
INDEX5=MATRIX(KOLUMN,LINE)/16
INDEX4=INDEX5/16
INDEX3=INDEX4/4
INDEX2=INDEX3/16
INDEX1=INDEX2/16
INDEX6=MATRIX(KOLUMN,LINE)-16*INDEX5
INDEX5=INDEX5-16*INDEX4
INDEX4=INDEX4-4*INDEX3
INDEX3=INDEX3-16*INDEX2
INDEX2=INDEX2-16*INDEX1
LIST(6*KOLUMN) =N4(INDEX6+1)
LIST(6*KOLUMN-1)=N4(INDEX5+1)
LIST(6*KOLUMN-2)=N5(INDEX4+1)
LIST(6*KOLUMN-3)=N4(INDEX3+1)
LIST(6*KOLUMN-4)=N4(INDEX2+1)
LIST(6*KOLUMN-5)=N5(INDEX1+1)
INDEX5=ZMATRIX(KOLUMN,LINE)/16
INDEX4=INDEX5/16
INDEX3=INDEX4/4
INDEX2=INDEX3/16
INDEX1=INDEX2/16
INDEX6=ZMATRIX(KOLUMN,LINE)-16*INDEX5
INDEX5=INDEX5-16*INDEX4
INDEX4=INDEX4-4*INDEX3
INDEX3=INDEX3-16*INDEX2

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1949-1950
1951-1952
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1955-1956
1957-1958
1959-1960
1961-1962
1963-1964
1965-1966
1967-1968
1969-1970
1971-1972
1973-1974
1975-1976
1977-1978
1979-1980
1981-1982
1983-1984
1985-1986
1987-1988
1989-1990
1991-1992
1993-1994
1995-1996
1997-1998
1999-2000
2001-2002
2003-2004
2005-2006
2007-2008
2009-2010
2011-2012
2013-2014
2015-2016
2017-2018
2019-2020
2021-2022

1947-1948
1949-1950
1951-1952
1953-1954
1955-1956
1957-1958
1959-1960
1961-1962
1963-1964
1965-1966
1967-1968
1969-1970
1971-1972
1973-1974
1975-1976
1977-1978
1979-1980
1981-1982
1983-1984
1985-1986
1987-1988
1989-1990
1991-1992
1993-1994
1995-1996
1997-1998
1999-2000
2001-2002
2003-2004
2005-2006
2007-2008
2009-2010
2011-2012
2013-2014
2015-2016
2017-2018
2019-2020
2021-2022

```

INDEX2=INDEX2-16*INDEX1
ZLIST(6*KOLUMN)=NN4(INDEX6+1)
ZLIST(6*KOLUMN-1)=NN4(INDEX5+1)
ZLIST(6*KOLUMN-2)=NN5(INDEX4+1)
ZLIST(6*KOLUMN-3)=NN4(INDEX3+1)
ZLIST(6*KOLUMN-4)=NN4(INDEX2+1)
ZLIST(6*KOLUMN-5)=NN5(INDEX1+1)
48 CONTINUE
INDEX1=1+(MATRIX(6,LINE)/524288)
LIST(31)=N3(INDEX1)
IF(INDGRD.EQ.1.A.MOD(LINE,5).EQ.1.A.INDEX1.NE.2) LIST(31)=4H+
IF(INDGRD.EQ.1.A.MOD(LINE,5).EQ.1.A.INDEX6.LE.7.A.ISIZE.LT.0.A.
1 KOLUMN.EQ.5) LIST(25)=4H+
IF(INDGRD.EQ.1.A.MOD(LINE,5).EQ.1.A.INDEX6.LE.7.A.ISIZE.EQ.0.A.
1 KOLUMN.EQ.5) LIST(13)=4H+
INDEX1=1+(ZMATRIX(6,LINE)/524288)
ZLIST(31)=NN3(INDEX1)
INDEX1=101-(2*(LINE-1))
INDEX2=INDEX1+9
IF(ISIZE.GT.0)
1WRITE(ITAPE,49)(NAME(I),I=INDEX1,INDEX2),(NAME(I),I=111,113),
2 (LIST(I),I=1,31),(ZLIST(I),I=1,31)
49 FORMAT(1H+10A1,1HE3A1,1X10(A2,2A4),A1/X15X10(A2,2A4),A1)
50 CONTINUE
FIRST=XFIRST
FINAL=XFINAL
GO TO 53
51 IF(ISIZE.GT.0)
1WRITE(ITAPE,52)(NAME(I),I=1,110),(NAME(I),I=111,113),J=1,11)
52 FORMAT(1H0,11X,110A1/9X,11(6X,1HE,3A1))
RETURN
C
C *****ALPHANUMERIC CODE SCALE NUMBER ARRAYS*****
53 STEP=(FINAL-FIRST)/10.0
KOUNT=ALOG10(1.01*STEP)-2.0
IF((1.01*STEP)-100.0)54,55,55
54 KOUNT=KOUNT-1
55 ROUND=5.0*(10.0**KOUNT)
IF(FIRST+FINAL)56,57,57
56 FINAL=-FIRST
57 FINAL=FINAL+ROUND
KOEFF=ALOG10(FINAL)
IF(FINAL-1.0)58,59,59
58 KOEFF=KOEFF-1
NAME(111)=N6(13)
INDEX1=-KOEFF/10
INDEX2=-KOEFF-10*INDEX1
GO TO 60
59 NAME(111)=N6(12)
INDEX1=KOEFF/10
INDEX2=KOEFF-10*INDEX1
60 NAME(112)=N6(INDEX1+1)
NAME(113)=N6(INDEX2+1)
DO 61 I=1,110
61 NAME(I)=N6(14)
KOUNT=KOEFF-KOUNT
IF(KOUNT-8)63,63,62
62 KOUNT=8

```

1. The first part of the document discusses the importance of maintaining accurate records of all transactions. It emphasizes that proper record-keeping is essential for the integrity of the financial system and for the ability to detect and prevent fraud. The text notes that without reliable records, it would be difficult to verify the accuracy of financial statements and to identify any discrepancies or irregularities.

2. The second part of the document outlines the specific requirements for record-keeping. It states that all transactions must be recorded in a clear, concise, and legible manner. The records should include the date, the amount, the nature of the transaction, and the names of the parties involved. It is also noted that records should be maintained for a minimum of seven years, unless otherwise specified by law or regulation.

3. The third part of the document discusses the role of internal controls in ensuring the accuracy of records. It explains that internal controls are designed to prevent errors and fraud by establishing a system of checks and balances. These controls should be implemented at all levels of the organization and should be regularly reviewed and updated to reflect changes in the business environment.

4. The fourth part of the document addresses the issue of data security. It highlights the need to protect sensitive financial information from unauthorized access, loss, or destruction. This can be achieved through the use of secure storage systems, encryption, and access controls. It is also recommended that employees be trained on data security best practices and that regular backups be performed to ensure the availability of records in the event of a disaster.

5. The fifth part of the document discusses the importance of transparency and accountability in financial reporting. It states that organizations should provide timely and accurate financial statements to their stakeholders, including investors, creditors, and regulatory authorities. This transparency is crucial for building trust and confidence in the organization's financial performance and for ensuring the long-term success of the business.

6. The sixth part of the document concludes by reiterating the key points discussed throughout the document. It emphasizes that maintaining accurate records, implementing strong internal controls, ensuring data security, and providing transparent financial reporting are all essential components of a sound financial management system. By following these principles, organizations can minimize the risk of errors and fraud and ensure the integrity of their financial data.

```

63 KOEFF=KOUNT-KOEFF-1
   ADD=0.0
   DO 71 I=1,11
   LEFT=(I*10)-9+((9-KOUNT)/2)
   IF(FIRST+ADD)64,65,65
64 NAME(LEFT-1)=N6(13)
   VALUE=(ROUND-ADD)-FIRST
   GO TO 66
65 VALUE=(ROUND+ADD)+FIRST
66 INTEGR=VALUE*(10.0**KOEFF)
67 INDEX1=1+(INTEGR/M2(KOUNT))
   IF(INDEX1-11)69,68,72
68 INTEGR=INTEGR-1
   GO TO 67
69 NAME(LEFT)=N6(INDEX1)
   NAME(LEFT+1)=N6(11)
   LEFT=LEFT+2
   DO 70 J=2,KOUNT
   INDEX1=KOUNT-J+1
   INDEX1=1+(INTEGR/M2(INDEX1))-(10*(INTEGR/M2(INDEX1+1)))
   NAME(LEFT)=N6(INDEX1)
70 LEFT=LEFT+1
71 ADD=ADD+STEP
72 IF(LOCK)43,43,51
   END

```



```

SUBROUTINE ANALYZE (MASS)
C SUBROUTINE ANALYZE COMPUTES THE MOST PROBABLE RATIO AND ASSOCIATED
C UNCERTAINTY FOR EACH MASS NUMBER EXAMINED.
  INTEGER TOTAL(15)
  REAL RATIO(15,50),DEV(15,50),SIGMA(15),SIGBAR(15),REJECT(20),P(4),
  C PERDEV(15,50)
  COMMON TITLE(8),RATIO,TOTAL,P
  FUDGE=0.0035
  DATA (REJECT(I),I=1,20)/1.15,1.15,1.15,1.46,1.67,1.82,1.94,2.03,
  C 2.11,2.18,2.23,2.29,2.33,2.37,2.41,2.44,2.47,2.50,2.53,2.56/
  DO 230 K=1,15
20  ISOMASS=K+230
  FACTOR=1.0+(ISOMASS-MASS)*FUDGE
  BINGO=0.0
  M=TOTAL(K)
30  IF (M.GT.0) GO TO 40
  IF (K.GE.15) GO TO 230
  K=K+1
  GO TO 20
40  DO 45 I=1,M
45  RATIO(K,I)=RATIO(K,I)*FACTOR
50  SUM=0.0
  DO 60 I=1,M
60  SUM=SUM+RATIO(K,I)
  AVE=SUM/FLOAT(M)
  SUMSQ=0.0
  DO 70 I=1,M
  DEV(K,I)=RATIO(K,I)-AVE
  PERDEV(K,I)=DEV(K,I)/AVE*100.0
70  SUMSQ=SUMSQ+DEV(K,I)**2
  IF (M.EQ.1) 72,74
72  SIGBAR(K)=0.0
  GO TO 80
74  SIGMA(K)=SQRT(SUMSQ/FLOAT(M-1))
  SIGBAR(K)=SIGMA(K)/SQRT(FLOAT(M))
80  PRINT 90, (TITLE(I), I=1,7)
90  FORMAT (1H12XA10,2X3A10,2XA10,2XA10,2XA10,5X11H* SPECTRE *////)
  PRINT 100, ISOMASS,MASS,FACTOR
100  FORMAT (X2X20HISOTOPE MASS NUMBER I3//
  C X2X22HREFERENCE MASS NUMBER I3//
  C X2X18HCORRECTION FACTOR F7.5///
  C X2X80HMEASUREMENT NO.      UNCORRECTED RATIO      DEVIATION
  C      CORRECTED RATIO/
  C X42X19H(PERCENT) (SIGMA)///)
  DO 110 I=1,M
  UNRATIO=RATIO(K,I)/FACTOR
  DSIGMA=DEV(K,I)/SIGMA(K)
110  PRINT 120, I,UNRATIO,PERDEV(K,I),DSIGMA,RATIO(K,I)
120  FORMAT (X2X12,1H.16XF10.5,12XF6.2,5XF6.2,6XF10.5)
  IF (M.EQ.1) GO TO 220
  UNAVE=AVE/FACTOR
  UNSIGMA=SIGMA(K)/FACTOR
  UNSIGBR=SIGBAR(K)/FACTOR
  PRINT 130, UNAVE,UNSIGMA,UNSIGBR,AVE,SIGMA(K),SIGBAR(K)
130  FORMAT (//X2X52HTHE UNCORRECTED AVERAGE RATIO=
  C F14.8/
  C X2X52HSTANDARD DEVIATION IN AN UNCORRECTED SINGLE RATIO= F14.8/
  C X2X52HSTANDARD DEVIATION IN THE UNCORRECTED AVERAGE RATIO=F14.8//

```



```

C X2X52HTHE CORRECTED AVERAGE RATIO= F14.8/
C X2X52HSTANDARD DEVIATION IN A CORRECTED SINGLE RATIO= F14.8/
C X2X52HSTANDARD DEVIATION IN THE CORRECTED AVERAGE RATIO= F14.8//
C /)
  BINGO=0.0
  TEST=REJECT(M)
140 DO 170 I=1,M
145 IF (ABS(DEV(K,I))/SIGMA(K).GT.TEST) 150,170
150 BINGO=99.0
  M=M-1
  DO 160 J=1,M
  RATIO(K,J)=RATIO(K,J+1)
160 DEV(K,J)=DEV(K,J+1)
  IF (I.LT.M+1) GO TO 145
170 CONTINUE
  IF (BINGO.EQ.99.0) 180,220
180 PRINT 190
190 FORMAT (X70H ***** THE FOREGOING TABLE CONTAINS ONE OR MCRE RATIO
  COS WHICH DEVIATE/
  C X77H ***** UNACCEPTABLY FROM THE AVERAGE. A RECCMPUTATION WITH
  COUT THESE RATIOS/
  C X17H ***** FOLLOWS:////)
  GO TO 50
220 RATIO(K)=AVE
  RATIO(K,2)=SIGBAR(K)
C RATIO(K) AND RATIO(K,2) ARE SIMPLY BEING USED TO PASS THE AVERAGE
C RATIO AND ASSOCIATED UNCERTAINTY FOR EACH MASS NUMBER BACK TO PROGRAM
C SPECTRE AND THENCE TO SUBPROGRAM MEMO.
230 CONTINUE
  RETURN
  END

```



```

SUBROUTINE MEMO (MASS)
C SUBROUTINE MEMO CONVERTS THE AVERAGE RATIO AND ASSOCIATED UNCERTAINTY
C FOR EACH MASS NUMBER EXAMINED TO A PERCENT OF TOTAL MASS
C WITH A RECALCULATED UNCERTAINTY, AND THEN PUBLISHES A REPORT
C CONTAINING THIS INFORMATION.
  INTEGER TOTAL(15),MONTH(12)
  REAL RATIO(15,50),ATOMRAT(15),ATOMERR(15),PERCENT(15),ERROR(15),
C P(4),TFACOR(20)
  COMMON TITLE(8),RATIO,TOTAL,P
  EQUIVALENCE (RATIO,PERCENT)
  SUM=0.0
  SUMSQ=0.0
  DATA (TFACOR(I),I=1,20)/1.00,12.7,4.30,3.18,2.78,2.57,2.45,2.36,
C 2.31,2.26,2.23,2.20,2.18,2.16,2.14,2.13,2.12,2.11,2.10,2.09/
  DO 40 K=1,15
10 IF (TOTAL(K).GT.0) GO TO 30
  IF (K.GE.15) GO TO 42
  K=K+1
  GO TO 10
C RATIO(K) AND RATIO(K,2) CONTAIN THE AVERAGE RATIO AND ASSOCIATED
C UNCERTAINTY FOR EACH MASS NUMBER RESPECTIVELY.
  30 ATOMRAT(K)=RATIO(K)
  M=TOTAL(K)
  ATOMERR(K)=SQRT((TFACOR(M)*RATIO(K,2))**2+(0.03*ATOMRAT(K))**2)
C THE FOLLOWING 2 STEPS CONVERT ATOMRAT(K) FROM AN ATOM RATIO TO A MASS
C RATIO AND ADJUST THE UNCERTAINTY IN THIS FIGURE ACCORDINGLY.
  RATIO(K)=ATOMRAT(K)*FLOAT(K+230)/MASS
  RATIO(K,2)=ATOMERR(K)*FLOAT(K+230)/MASS
  SUM=SUM+RATIO(K)
40 SUMSQ=SUMSQ+RATIO(K,2)**2
42 SUM=SUM+1.0
  ERROR1=SQRT(SUMSQ)
  DO 70 K=1,15
45 IF (TOTAL(K).GT.0) GO TO 60
  IF (K.GE.15) GO TO 72
  K=K+1
  GO TO 45
60 ERROR(K)=SQRT((1.0/SUM*RATIO(K,2))**2+(RATIO(K)/SUM**2*ERROR1)
C **2)*100.0
70 PERCENT(K)=RATIO(K)/SUM*100.0
72 K=MASS-230
  TOTAL(K)=1
  ATOMRAT(K)=1.0
  ATOMERR(K)=0.0
  PERCENT(K)=1.0/SUM*100.0
  ERROR(K)=1.0/SUM**2*ERROR1*100.0
  NUMBER=0
  CALL DATE (DAY)
  DECODE (6,74, DAY) NDAY
74 FORMAT (I6)
  NMONTH=NDAY/10000
  NDAY=NDAY-NMONTH*10000
  NYEAR=NDAY-(NDAY/100)*100
  NDAY=NDAY/100
  DATA (MONTH(I),I=1,12)/3HJAN,3HFEB,3HMAR,3HAPR,3HMAY,3HJUN,3HJUL,
C 3HAUG,3HSEP,3HOCT,3HNOV,3HDEC/
75 PRINT 80, NDAY,MONTH(NMONTH),NYEAR,TITLE(6),TITLE(5),
C (TITLE(I),I=2,4),TITLE(1),TITLE(7),MASS

```

THE UNIVERSITY OF CHICAGO
DEPARTMENT OF CHEMISTRY
5408 SOUTH DICKENS STREET
CHICAGO, ILLINOIS 60637
TEL: 773-936-5000
FAX: 773-936-5000
WWW: www.chem.uchicago.edu

1. Name of the donor: [Name]
2. Address: [Address]
3. City: [City]
4. State: [State]
5. Zip: [Zip]

6. Amount: [Amount]
7. Date: [Date]
8. Purpose: [Purpose]

9. Name of the recipient: [Name]
10. Address: [Address]
11. City: [City]
12. State: [State]
13. Zip: [Zip]

14. Name of the organization: [Name]
15. Address: [Address]
16. City: [City]
17. State: [State]
18. Zip: [Zip]

19. Name of the individual: [Name]
20. Address: [Address]
21. City: [City]
22. State: [State]
23. Zip: [Zip]

24. Name of the organization: [Name]
25. Address: [Address]
26. City: [City]
27. State: [State]
28. Zip: [Zip]

29. Name of the individual: [Name]
30. Address: [Address]
31. City: [City]
32. State: [State]
33. Zip: [Zip]

34. Name of the organization: [Name]
35. Address: [Address]
36. City: [City]
37. State: [State]
38. Zip: [Zip]

39. Name of the individual: [Name]
40. Address: [Address]
41. City: [City]
42. State: [State]
43. Zip: [Zip]

44. Name of the organization: [Name]
45. Address: [Address]
46. City: [City]
47. State: [State]
48. Zip: [Zip]

49. Name of the individual: [Name]
50. Address: [Address]
51. City: [City]
52. State: [State]
53. Zip: [Zip]

54. Name of the organization: [Name]
55. Address: [Address]
56. City: [City]
57. State: [State]
58. Zip: [Zip]

59. Name of the individual: [Name]
60. Address: [Address]
61. City: [City]
62. State: [State]
63. Zip: [Zip]

64. Name of the organization: [Name]
65. Address: [Address]
66. City: [City]
67. State: [State]
68. Zip: [Zip]

69. Name of the individual: [Name]
70. Address: [Address]
71. City: [City]
72. State: [State]
73. Zip: [Zip]

74. Name of the organization: [Name]
75. Address: [Address]
76. City: [City]
77. State: [State]
78. Zip: [Zip]

79. Name of the individual: [Name]
80. Address: [Address]
81. City: [City]
82. State: [State]
83. Zip: [Zip]

84. Name of the organization: [Name]
85. Address: [Address]
86. City: [City]
87. State: [State]
88. Zip: [Zip]

89. Name of the individual: [Name]
90. Address: [Address]
91. City: [City]
92. State: [State]
93. Zip: [Zip]

94. Name of the organization: [Name]
95. Address: [Address]
96. City: [City]
97. State: [State]
98. Zip: [Zip]

99. Name of the individual: [Name]
100. Address: [Address]
101. City: [City]
102. State: [State]
103. Zip: [Zip]


```

80 FORMAT (1H144X32HLOS ALAMOS SCIENTIFIC LABORATORY/
C X48X24HUNIVERSITY OF CALIFORNIA/
C X46X28HLOS ALAMOS, NEW MEXICO 87544///
C X31X17HOFFICE MEMORANDUM50X11H* SPECTRE *///
C X2X22HTO : DISTRIBUTION24X6HDATE: 12,1XA3,1XI2//
C X2X24HFROM : R. M. TISINGER//
C X2X38HSUBJECT: MASS SPECTROMETER ANALYSIS (A10,1XA10,9X1H)/
C X39X32H(SAMPLE SERIAL NUMBER )//
C X39X1H(3A10,1H)//
C X2X8HSYMBOL : 4(//)
C X15X55HAN ANALYSIS OF THE SAMPLE DESCRIBED ABOVE WAS COMPLETED/
C X10X3HON A9,41H. THIS ANALYSIS WAS PERFORMED USING THE A10/
C X10X64HMASS SPECTROMETER. RESULTS ARE TABULATED BELOW WITH UNCE
CTAINTY/
C X10X60HEXPRESSED AT THE NINETY-FIVE PERCENT CONFIDENCE LEVEL. AT
COM/
C X10X64HRATIO IS THE NUMERICAL RATIO OF THE NUMBER OF ATOMS OF SPE
CCIFIED/
C X10X50HMASS NUMBER TO THE NUMBER OF ATOMS OF MASS NUMBER 13,1H.
C //)
PRINT 90
90 FORMAT (X10X60HMASS NUMBER ATOM RATIO WEIGH
CT PERCENT//)
DO 200 K=1,15
160 IF (TOTAL(K).GT.0) GO TO 180
IF (K.GE.15) GO TO 210
K=K+1
GO TO 160
180 MASSNUM=K+230
PRINT 190, MASSNUM,ATOMRAT(K),ATOMERR(K),PERCENT(K),ERROR(K)
190 FORMAT (X10X13,6XF11.5,4H +- F8.5,11XF7.4,4H +- F7.4//)
200 CONTINUE
210 PRINT 220
220 FORMAT (4(//)X48X14HR. M. TISINGER/
C X48X9HGROUP W-7 /
C X10X13HDISTRIBUTION://)
IF (TITLE(5).EQ.10HPRESHOT ) GO TO 230
IF (TITLE(5).EQ.10HPOSTSHOT ) GO TO 250
IF (TITLE(5).EQ.10HSPECIAL ) GO TO 270
GO TO 300
230 PRINT 240
240 FORMAT (X15X22H W- 1 J. J. WECHSLER)
250 PRINT 260
260 FORMAT (X15X17H W- 4 R. CANADA/
C X15X34H J-11 E. G. HANTEL / G. A. COWAN)
IF (TITLE(8).EQ.10HANDERSON ) PRINT 262
262 FORMAT (X15X22HCMB-11 J. W. ANDERSON)
IF (TITLE(8).EQ.10HJAYNES ) PRINT 264
264 FORMAT (X15X20HCMB- 6 G. E. JAYNES)
270 PRINT 280
280 FORMAT (X15X22H W- 7 W. H. CHAMBERS/
C X15X22H W- 7 R. M. TISINGER)
NUMBER=NUMBER+1
IF (NUMBER.LT.2) GO TO 75
300 RETURN
END

```


APPENDIX F

OUTPUT

The output pages contained in this Appendix are representative of the results regularly obtained with program SPECTRE. This particular output was produced on September 4, 1970 using an actual data deck during a computer run made for the purpose of generating the listing for Appendix E. The sample material was obtained from a supply of National Bureau of Standards' Standard Reference Material U-930 (NBS-930). The isotopic composition of NBS-930 has been carefully measured and the atom and weight percentage figures published by the National Bureau of Standards are stated in Figure 16. Figure 16 is located on page 139 for ease in comparison with the corresponding experimental figures on page 138.

The following output pages are complete and in the order produced. The first and last pages (title and letter report) are included only once, whereas they were actually printed twice. The letter report is the real product of program SPECTRE, and is disseminated according to the indicated distribution. The other output pages are reviewed to ensure that measurements were consistent and that nothing untoward occurred. These pages, along with a copy of the letter report, are then filed for record purposes.

TABLE 3. A Sequential Listing of Output Sections

Sequence Number	Section Name	Pages (inclusive)	Use
1.	Title page	126	for identification after filing
2.	Input data	127 - 128	to establish a permanent record
3.	Reference curves and calculations ¹	129 - 134	for verifying that smooth well-fitted curves have been found
4.	Isotope measurement data	135 - 137	to allow an examination of the data for each isotope
5.	Letter report	138	for immediate distribution

¹Reference curves are plotted with reference peak height in arbitrary units along the vertical axis and time in seconds along the horizontal axis.

31 AUG 70 NBS-930

SPECIAL

AVCO

* SPECTRE *



INPUT DATA:

FILTEMP CODE, SCALE FACTOR, MASS NUMBER (FOLLOWED BY 3 DATA POINTS)
 HOUR:MINUTE:SECOND, INTEGRATION TIME (SEC), PEAK HEIGHT

1.	1	7	235	10.	1	4	238	19.	1	2	236	28.	1	2	234	41368	
0	2	28	10	0	12	38	10	3988	0	22	54	10	0	32	28	10	69546
0	2	50	10	0	13	10	10	25832	0	23	12	10	0	33	2	10	41355
0	3	22	10	0	13	26	10	4005	0	23	26	10	0	33	24	10	
2.	1	4	238	11.	1	6	235	20.	1	6	235	29.	1	6	235	382	
0	3	40	10	0	13	46	10	371	0	23	44	10	0	33	44	10	23042
0	4	20	10	0	14	18	10	35428	0	24	12	10	0	34	12	10	384
0	4	38	10	0	14	36	10	376	0	24	28	10	0	34	30	10	
3.	1	4	238	12.	1	4	238	21.	1	2	236	30.	1	5	235	1199	
0	4	56	10	0	14	54	10	4002	0	24	52	10	0	34	48	10	68300
0	5	36	10	0	15	22	10	22843	0	25	20	10	0	35	18	10	1202
0	5	52	10	0	15	38	10	4007	0	25	38	10	0	35	40	10	
4.	1	7	235	13.	1	4	238	13.	1	4	238	31.	1	2	234	41429	
0	6	16	10	0	15	56	10	3993	0	25	56	10	0	36	4	10	65957
0	6	42	10	0	16	18	10	21898	0	26	18	10	0	36	42	10	41626
0	6	58	10	0	16	34	10	4000	0	26	34	10	0	36	58	10	
5.	1	6	235	14.	1	6	235	23.	1	6	235	32.	1	2	234	41413	
0	7	16	10	0	16	52	10	370	0	26	52	10	0	37	16	10	65248
0	7	38	10	0	17	22	10	31965	0	27	20	10	0	37	46	10	41426
0	8	0	10	0	17	40	10	376	0	27	36	10	0	38	10	10	
6.	1	4	238	15.	1	2	236	15.	1	2	236	33.	1	5	235	1201	
0	8	22	10	0	18	0	10	40361	0	27	56	10	0	38	30	10	57472
0	8	50	10	0	18	46	10	46868	0	28	20	10	0	38	56	10	1205
0	9	6	10	0	19	4	10	40345	0	28	36	10	0	39	16	10	
7.	1	4	238	16.	1	2	236	16.	1	2	236	34.	1	2	234	41504	
0	9	24	10	0	19	22	10	40352	0	28	54	10	0	39	34	10	61936
0	9	48	10	0	19	50	10	46491	0	29	16	10	0	40	6	10	41480
0	10	10	10	0	20	10	10	40236	0	29	32	10	0	40	24	10	
8.	1	6	235	17.	1	6	235	26.	1	6	235	35.	1	2	234	41527	
0	10	32	10	0	20	32	10	371	0	29	52	10	0	40	42	10	60731
0	10	58	10	0	21	10	10	28284	0	30	22	10	0	41	4	10	41510
0	11	18	10	0	21	26	10	376	0	30	40	10	0	41	24	10	
9.	1	4	238	18.	1	2	236	18.	1	2	234	36.	1	5	235	1204	
0	11	36	10	0	21	46	10	40443	0	31	0	10	0	41	42	10	45469
0	12	4	10	0	22	16	10	46331	0	31	50	10	0	42	36	10	1212
0	12	20	10	0	22	36	10	40398	0	32	10	10	0	42	56	10	

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0 43 14 10 41668
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0 43 58 10 41623

38. 1 2 234
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0 44 40 10 56195
0 44 58 10 41644

39. 1 5 235
0 45 16 10 1203
0 45 42 10 37590
0 46 10 10 1209

Year	1910	1920	1930
Population	1,000,000	1,500,000	2,000,000
Area (sq. mi.)	100,000	100,000	100,000
Population Density	10	15	20
Urban Population	500,000	750,000	1,000,000
Rural Population	500,000	750,000	1,000,000
Total Population	1,000,000	1,500,000	2,000,000

THE NUMBER OF ITERATIONS REQUIRED WAS 3

REFERENCE MASS NUMBER 235 FILTEMP (1)

	MEASURED REFERENCE PEAK	CALCULATED REFERENCE PEAK	PERCENT DIFFERENCE
1.	3750525.9	3749031.3	.04
2.	2188928.6	2198967.3	-.46
3.	1959900.0	1954699.3	.27
4.	1370239.6	1359482.4	.79
5.	1051614.0	1062733.5	-1.05
6.	947737.5	944031.8	.39

THE FUNCTION BEING FITTED IS: REFERENCE VALUE= $P(1)/T^{*1.5} + P(2)/T^{*0.5} + P(3)*T^{*0.5} + P(4)*T^{*1.5}$

P(1): .4549562729E+13
 P(2): -.4198884319E+10
 P(3): .1316134667E+07
 P(4): -.1351261508E+03

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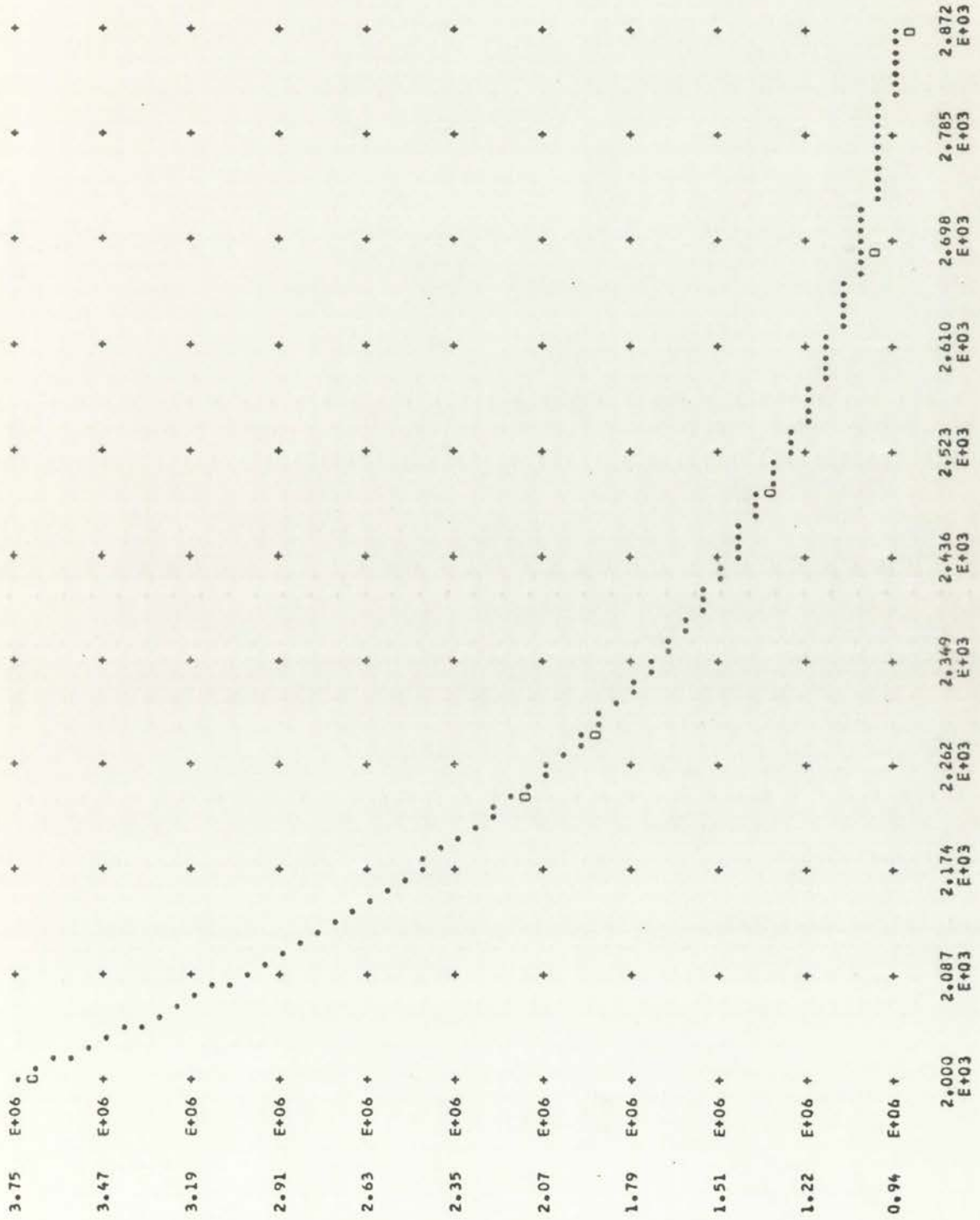
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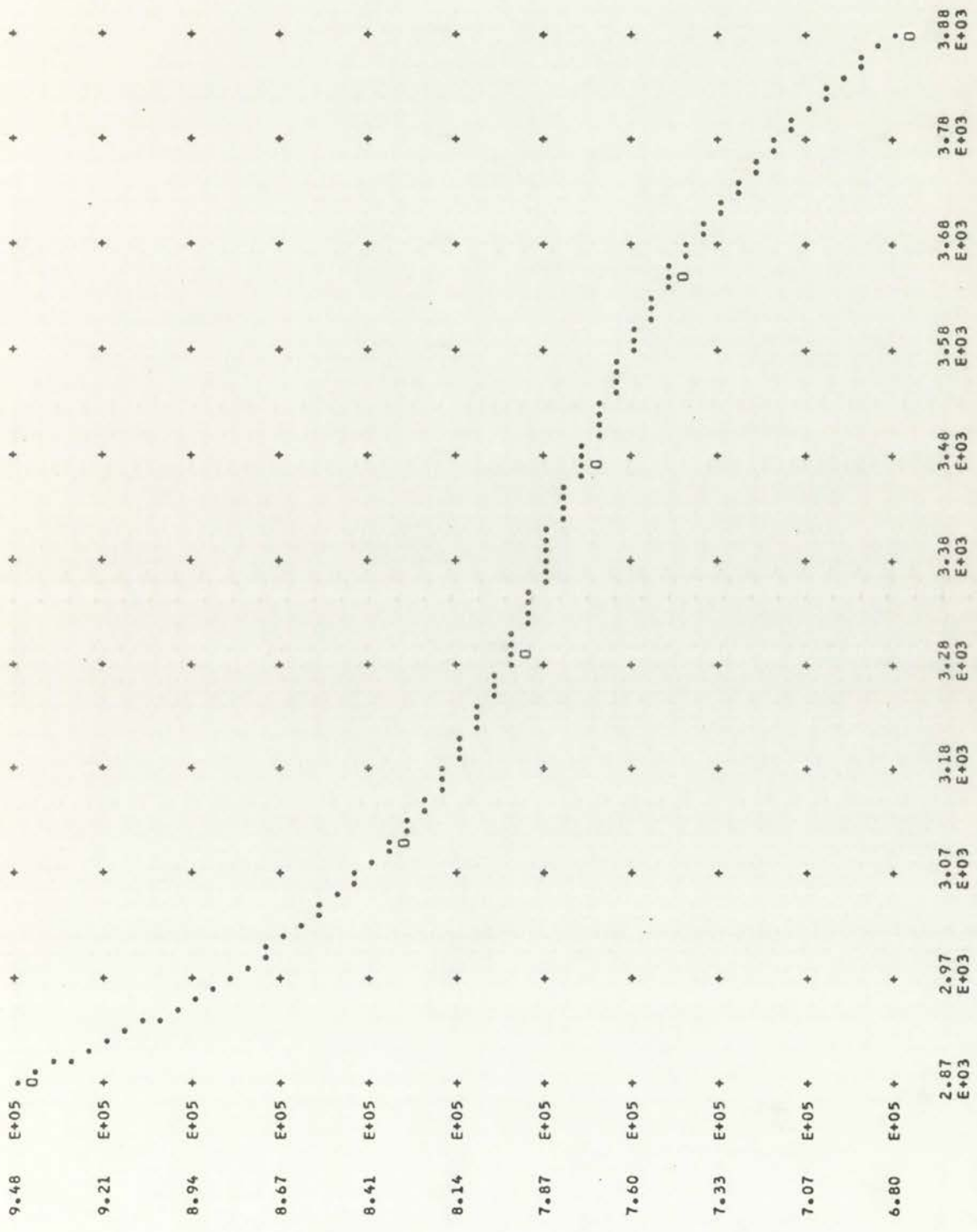
THE NUMBER OF ITERATIONS REQUIRED WAS 3

REFERENCE MASS NUMBER 235 FILTEMP (2)

	MEASURED REFERENCE PEAK	CALCULATED REFERENCE PEAK	PERCENT DIFFERENCE
1.	947737.5	947923.4	-.02
2.	837284.4	836342.2	.11
3.	798177.3	799541.3	-.17
4.	777234.5	776673.8	.07
5.	748241.2	748074.8	.02
6.	679763.5	679883.1	-.02

THE FUNCTION BEING FITTED IS: REFERENCE VALUE= $P(1)/T^{*1.5} + P(2)/T^{*0.5} + P(3)/T^{*0.5} + P(4)/T^{*1.5}$

P(1): .4166503420E+13
 P(2): -.3647590149E+10
 P(3): .1091309507E+07
 P(4): -.1074856525E+03





THE NUMBER OF ITERATIONS REQUIRED WAS 4

REFERENCE MASS NUMBER 235 FILTEMP (3)

	MEASURED REFERENCE PEAK	CALCULATED REFERENCE PEAK	PERCENT DIFFERENCE
1.	679763.5	681931.3	-.32
2.	670992.7	667307.3	.55
3.	562687.4	565528.1	-.50
4.	442591.6	440713.0	.43
5.	363841.1	364396.6	-.15

THE FUNCTION BEING FITTED IS: REFERENCE VALUE= $P(1)/T^{*1.5} + P(2)/T^{*0.5} + P(3)/T^{*0.5} + P(4)/T^{*1.5}$

P(1): -.2153889068E+14
P(2): .1535957577E+11
P(3): -.3601515619E+07
P(4): .2794379427E+03

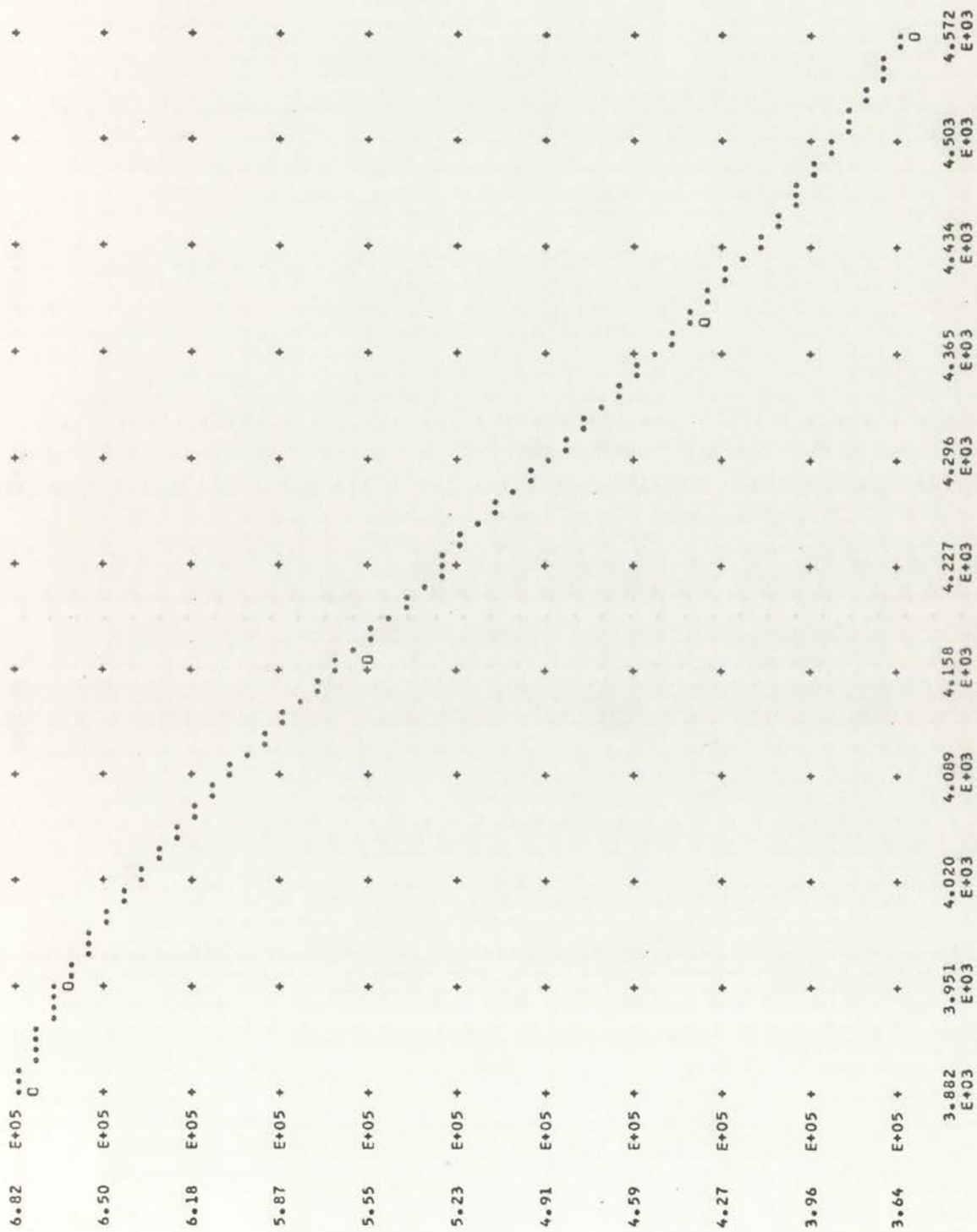
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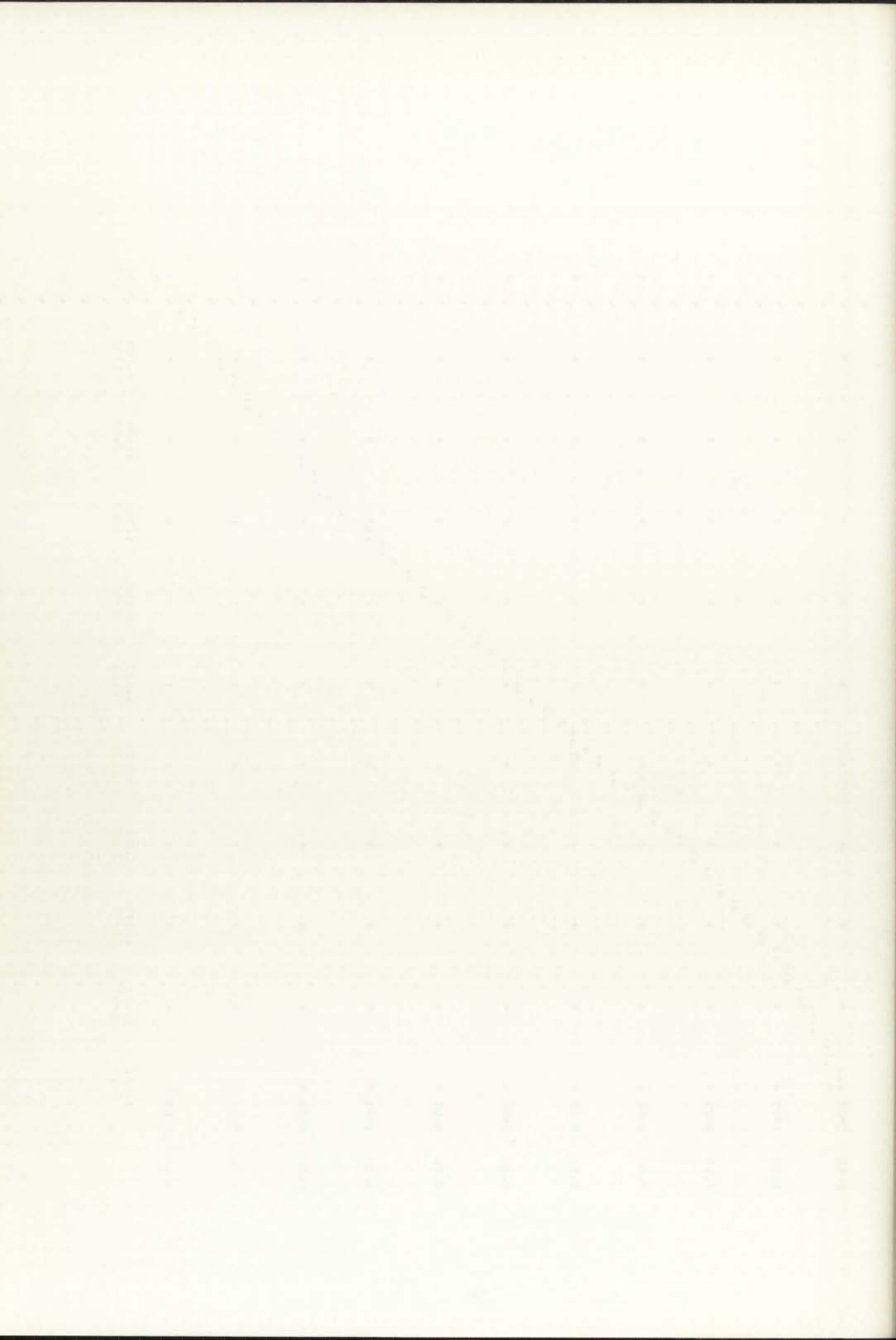
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ISOTOPE MASS NUMBER 234

REFERENCE MASS NUMBER 235

CORRECTION FACTOR .99650

MEASUREMENT NO.	UNCORRECTED RATIO	DEVIATION (PERCENT)	(SIGMA)	CORRECTED RATIO
1.	.01183	1.17	.68	.01179
2.	.01198	2.51	1.45	.01194
3.	.01152	-1.50	-.87	.01147
4.	.01183	1.23	.71	.01179
5.	.01169	-.03	-.02	.01165
6.	.01173	.38	.22	.01169
7.	.01159	-.83	-.48	.01155
8.	.01135	-2.93	-1.70	.01131

THE UNCORRECTED AVERAGE RATIO=
STANDARD DEVIATION IN AN UNCORRECTED SINGLE RATIO=
STANDARD DEVIATION IN THE UNCORRECTED AVERAGE RATIO=

.01169008
.00020152
.00007125

THE CORRECTED AVERAGE RATIO=
STANDARD DEVIATION IN A CORRECTED SINGLE RATIO=
STANDARD DEVIATION IN THE CORRECTED AVERAGE RATIO=

.01164916
.00020081
.00007100

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ISOTOPE MASS NUMBER 236

REFERENCE MASS NUMBER 235

CORRECTION FACTOR 1.00350

MEASUREMENT NO.	UNCORRECTED RATIO	DEVIATION (PERCENT)	DEVIATION (SIGMA)	CORRECTED RATIO
1.	.00219	.02	.01	.00219
2.	.00215	-1.43	-.64	.00216
3.	.00216	-.97	-.43	.00217
4.	.00212	-2.82	-1.26	.00213
5.	.00221	1.28	.57	.00222
6.	.00224	2.42	1.08	.00225
7.	.00214	-2.05	-.91	.00215
8.	.00226	3.55	1.58	.00227

THE UNCORRECTED AVERAGE RATIO=

.00218604

STANDARD DEVIATION IN AN UNCORRECTED SINGLE RATIO=

.00004905

STANDARD DEVIATION IN THE UNCORRECTED AVERAGE RATIO=

.00001734

THE CORRECTED AVERAGE RATIO=

.00219369

STANDARD DEVIATION IN A CORRECTED SINGLE RATIO=

.00004922

STANDARD DEVIATION IN THE CORRECTED AVERAGE RATIO=

.00001740

1. The first part of the document is a list of names and titles of the members of the committee.

2. The second part is a list of the names of the members of the committee who have been elected to the office of Secretary.

Name	Title	Year
John Doe	Secretary	1911
Jane Smith	Secretary	1912
Robert Johnson	Secretary	1913
Mary White	Secretary	1914
William Brown	Secretary	1915
Elizabeth Black	Secretary	1916
Thomas Green	Secretary	1917
Anna Gray	Secretary	1918
Charles Hall	Secretary	1919
Frances King	Secretary	1920

3. The third part is a list of the names of the members of the committee who have been elected to the office of Treasurer.

4. The fourth part is a list of the names of the members of the committee who have been elected to the office of Secretary-Treasurer.

ISOTOPE MASS NUMBER 238

REFERENCE MASS NUMBER 235

CORRECTION FACTOR 1.01050

MEASUREMENT NO.	UNCORRECTED RATIO	DEVIATION (PERCENT)	(SIGMA)	CORRECTED RATIO
1.	.05724	.86	.59	.05784
2.	.05650	-.45	-.31	.05709
3.	.05742	1.18	.81	.05803
4.	.05739	1.12	.77	.05799
5.	.05679	.06	.04	.05739
6.	.05750	1.32	.91	.05811
7.	.05602	-1.30	-.89	.05661
8.	.05517	-2.80	-1.92	.05575

THE UNCORRECTED AVERAGE RATIO = .05675377
 STANDARD DEVIATION IN AN UNCORRECTED SINGLE RATIO = .00082675
 STANDARD DEVIATION IN THE UNCORRECTED AVERAGE RATIO = .00029230

THE CORRECTED AVERAGE RATIO = .05734969
 STANDARD DEVIATION IN A CORRECTED SINGLE RATIO = .00083543
 STANDARD DEVIATION IN THE CORRECTED AVERAGE RATIO = .00029537

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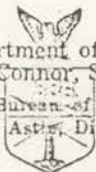
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Certificate of Analysis

Standard Reference Material U-930

Uranium Isotopic Standard

	²³⁴ U	²³⁵ U	²³⁶ U	²³⁸ U
Atom percent	1.0812	93.336	0.2027	5.380
	± 0.0020	± 0.010	± .0006	± 0.005
Weight percent	1.0759	93.276	.2034	5.445

The material consists of highly purified oxide, U₃O₈. The atomic weight of the material is calculated to be 235.197, using the nuclidic masses 234.0409; 235.0439; 236.0457; and 238.0508.

The values for ²³⁴U and ²³⁶U are calculated from measurements at the National Bureau of Standards. The samples were spiked with high-purity ²³³U to approximate the ²³⁴U concentration, the ratios ²³³U to ²³⁴U and ²³³U to ²³⁶U were measured on a triple-filament equipped surface ionization mass spectrometer with d-c amplifier circuits.

The values for ²³⁵U and ²³⁸U are derived from measurements made at the National Bureau of Standards, at Union Carbide Nuclear Co., Oak Ridge, Tenn., and at Goodyear Atomic Corp., Portsmouth, Ohio, each laboratory's value being given equal weight. Values obtained at NBS are the result of direct measurement of the ²³⁵U to ²³⁸U ratio using triple filament thermal ionization. The observed ratios were corrected for mass discrimination effects by determining the system bias from measurements on standards U-500 and U-900. Experience at NBS has shown, through intercomparison of the standards, and synthetic mixtures at the 10-, 50-, and 90-percent ²³⁵U level prepared from high-purity ²³⁵U and ²³⁸U isotopes, that a constant bias for a given procedure can be maintained over the range of 5- to 95-percent ²³⁵U. Values from Union Carbide and Goodyear Atomic are based on direct determinations of the ²³⁵U concentration by oxide dilution and UF₆ analysis, and then the ratio calculated using the NBS values for ²³⁴U and ²³⁶U, and the ²³⁵U value obtained by difference.

The limits indicated for the isotopic concentrations are at least as large as the 95-percent confidence level for a single determination. The ²³⁵U to ²³⁸U ratio for this standard, 17.349, is known to at least 0.1 percent; at the same time the pooled variance for the calibration system is significantly smaller.

Mass spectrometry measurements at NBS were made by Ernest L. Garner and William R. Shields on solutions prepared by Lawrence A. Machlan and Martha S. Richmond.

WASHINGTON, D.C. 20234
 February 11, 1966

W. Wayne Meinke, Chief
 Office of Standard Reference Materials

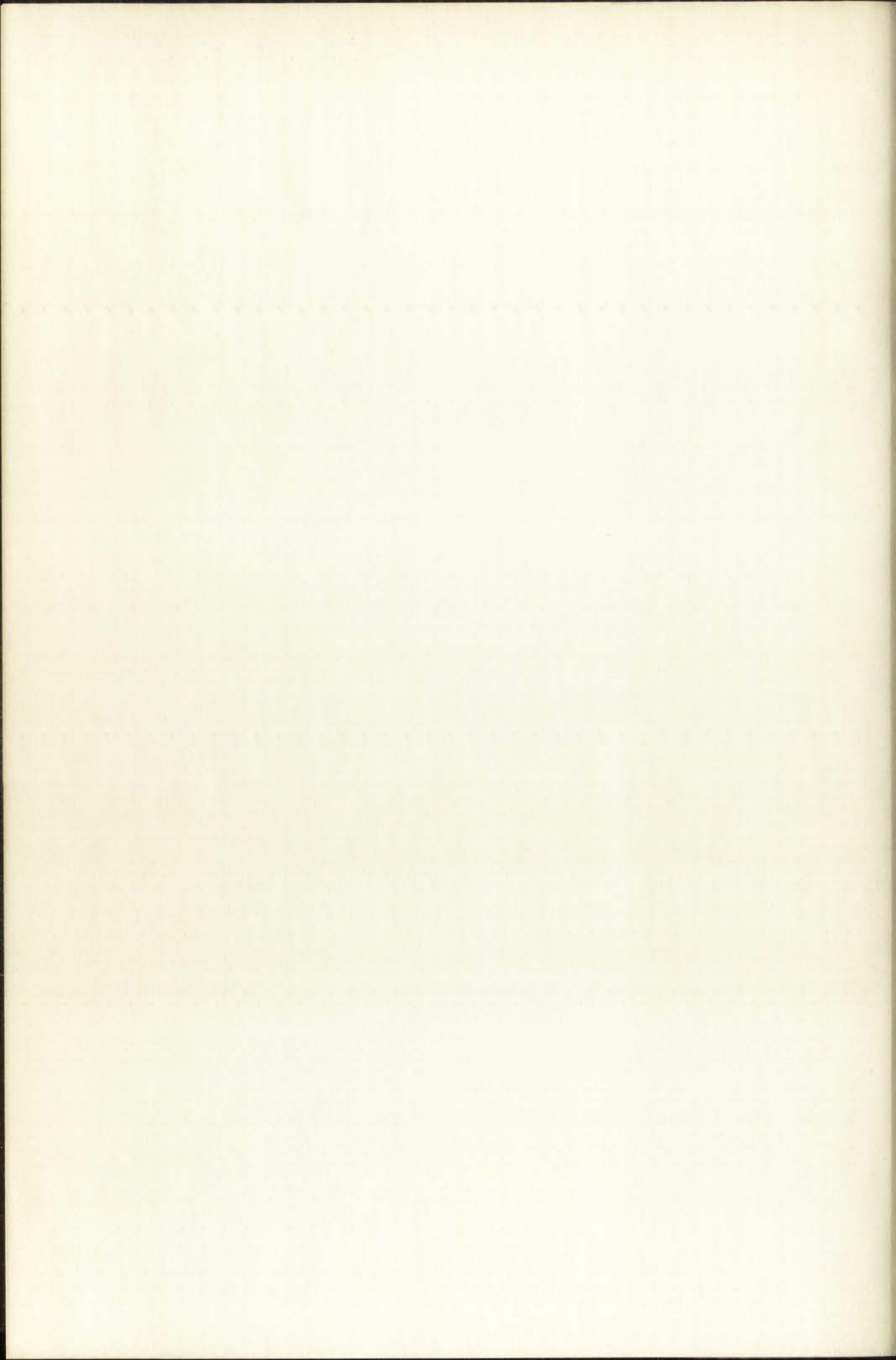
(This certificate supersedes certificate of 12-1-58)

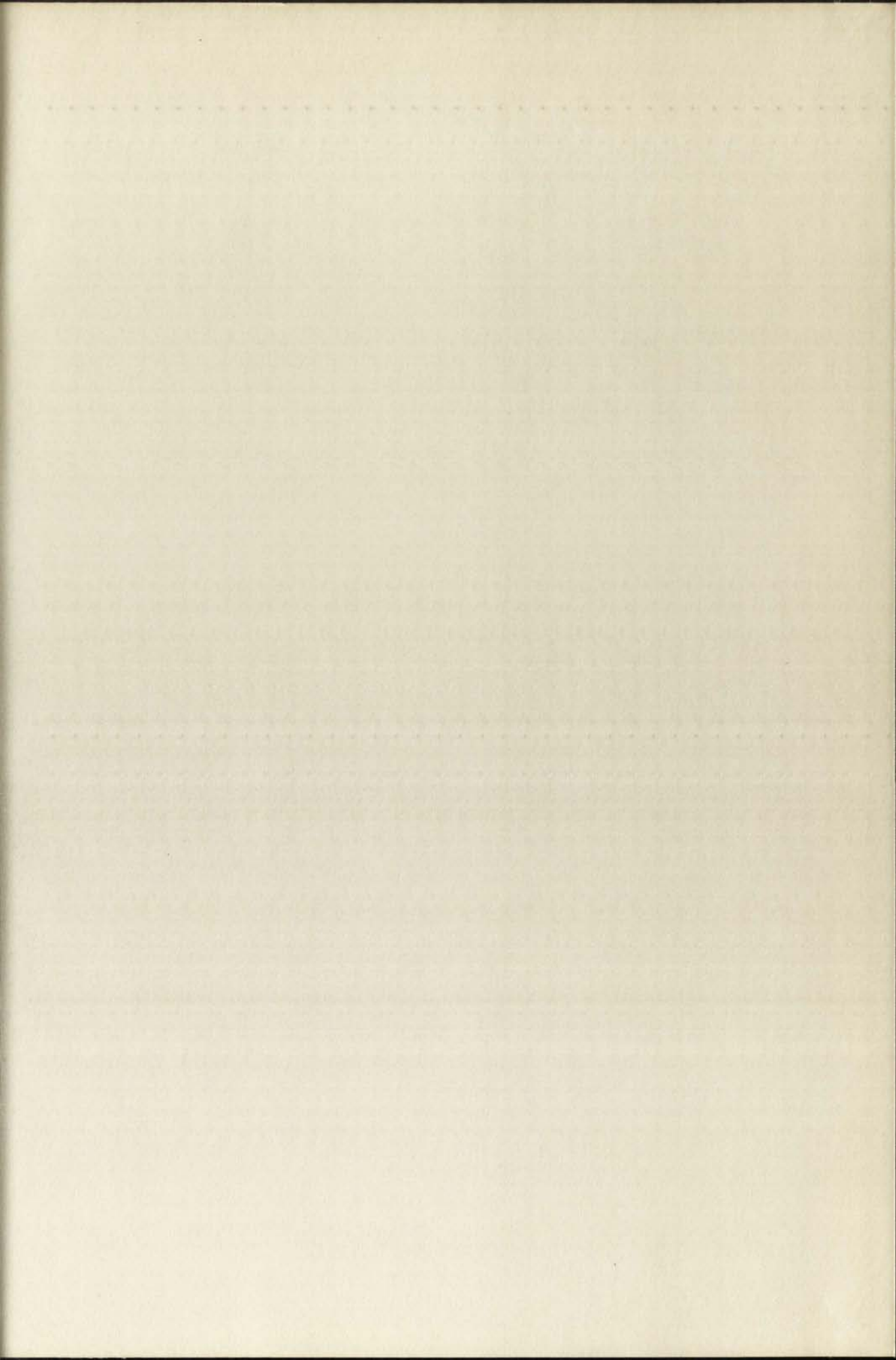
FIGURE 16. The provisional Certificate of Analysis for the NBS-930 uranium isotopic standard.

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- Beers, Yardley, Introduction to the Theory of Error, Addison-Wesley Publishing Company, Inc., Reading, Massachusetts, 1953.
- Grubbs, Frank E., "Procedures for Detecting Outlying Observations in Samples," Technometrics, II, No. 1, 1-21, 1969.
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- Beers, Yardley, Introduction to the Theory of Error, Addison-Wesley Publishing Company, Inc., Reading, Massachusetts, 1953.
- Grubbs, Frank E., "Procedures for Detecting Outlying Observations in Samples," Technometrics, II, No. 1, 1-21, 1969.
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- Roboz, John, Introduction to Mass Spectrometry Instrumentation and Techniques, Interscience Publishers (a division of John Wiley and Sons, Inc.), New York, 1968.
- Spiegel, Murray R., Theory and Problems of Statistics, Schaum's Outline Series, McGraw-Hill Book Company, New York, 1961.
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