FINAL REPORT

on

SAMPLE DETECTION AND ANALYSIS TECHNIQUES FOR ELECTROPHORETIC SEPARATION

to

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
GEORGE C. MARSHALL SPACE FLIGHT CENTER
MARSHALL SPACE FLIGHT CENTER, ALABAMA 35812

June 12, 1975

by

Richard D. Falb, Kenneth E. Hughes,
and Thomas R. Powell

(Contract No. NAS8-29629)

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Attention EH34/Dr. R. E. Allen

Dear Dr. Allen:

Contract No. NAS8-29629

Enclosed are 6 copies of the corrected report on your project entitled "Sample Detection and Analysis Techniques for Electrophoretic Separation". In this report, we have incorporated the corrections which you gave me during our phone conversation of May 28 as well as several additional changes which we made after careful scrutiny of the draft copy.

In our recent conversation, you asked why we chose the topic "carrier proteins" in our Medline search (page 5). This topic was chosen because of the particular section headings available in the Medline data retrieval system. The only topic available under "proteins" was carrier proteins, and thus we had to choose this somewhat awkward title.

We were pleased to receive your report that the initial review of the report has been favorable, and we hope that our work will be of service to NASA researchers in the future.

Very truly yours,

Richard D. Falb

Richard D. Falb, Manager
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RDF:sad

Enc. (6)

Airmail

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SAMPLE DETECTION AND ANALYSIS TECHNIQUES FOR ELECTROPHORETIC SEPARATION

by

Richard D. Falb, Kenneth E. Hughes,
and Thomas R. Powell

INTRODUCTION

This document is the final report on your program entitled "Sample Detection and Analysis Techniques for Electrophoretic Separation". The purpose of this research program is to identify and evaluate methods for detection of biologically derived substances in an electrophoretic or other separation device used in a space laboratory. Previous in-flight demonstrations have indicated that electrophoresis in space is feasible and that separation is possible without supporting media. In subsequent space experiments, electrophoretic separation of various biological agents will be performed. During these experiments, it is desirable to measure quantitatively the degree of separation of the agents, to determine the performance limits of the separation methods, and to monitor the progress of the separation in order to tell when the experiment should be terminated.

In addition to monitoring techniques suitable for space experiments, it is also necessary in some cases to detect the biological agents in samples in a ground-based operation. For example, in a current method under study, the separated sample will be quick-frozen and transported back to earth for analysis. Because of the nature of these frozen samples, specialized analytical techniques will probably be essential to detect the separated zones.

The detection techniques which will be amenable to operation in the space laboratory are subject to a number of limitations including space, power, weight, fluid-handling problems, and other aspects of operation in a zero-g environment. This study was undertaken to examine methods of detection of biological agents which would be particularly suitable for space flight operation and to describe and define any modifications of existing techniques which would be required.

In this report, we have reviewed and selected appropriate analytical techniques and have described their principles of operation. We have also analyzed commercially available equipment with respect to several performance characteristics. The information contained in this report is designed primarily to serve as a handbook for researchers involved in NASA's space biological processing program. Hopefully, the researcher could determine from this report the best methods of detecting any given biological candidate material of interest to him. The explanations of the principles of operation and evaluation of the devices are simple and straight forward. A serious attempt has been made to avoid complicated technical language. Thus, this report is not designed to explain in detail the finer points of any of the analytical methods, but is designed to acquaint the scientist with broad, general principles. Included in the report are a number of suggestions of modifications of existing instruments which could be made to enable more facile detection of the biological candidate materials in space. We have contacted a large number of instrument manufacturers and they have indicated their general willingness to work with NASA in any way possible to adapt their instruments to NASA's needs.

OBJECTIVES

As stated in the Introduction, the primary objective of this program is to review available analytical techniques for detection of biological candidates. To obtain this overall objective, our contract with NASA has specified the following tasks.

> Task 1: Suggested classes of biologicals and a list of specific candidates of high interest to researchers shall be provided to the contractor by NASA. Established quantitative assay techniques that have proven to be the most sensitive for each class of candidates shall be listed by the contractor. The contractor shall supplement this list with advanced assay techniques derived from literature surveys and contact with scientific personnel.

Task 2: For each technique cited in Task 1, a detailed technical explanation shall be given to how the technique operates. This explanation will deal primarily with the technique employed, rather than the hardware, and the unique quality of the candidate which makes the technique specific. Specificity, quantity, quality, and state of the candidate shall be discussed in relation to the technique.

Task 3: For each technique described in Task 1, the contractor shall list and describe commercially available hardware, their vendors, and cost. The equipment listed shall be from a variety of manufacturers. The contractor shall describe and cross reference the technical discussion of Task 2 with each specific instrument. The contractor shall discuss the complexity of operation, sensitivity, ranges, weight, volume, and power requirements of the commercial equipment. Reliability of each unit shall be assessed by contacting at least three users operating the specific hardware under field conditions. The names, addresses, and phone numbers of persons consulted shall be listed along with how long the instrument has been in use.

Task 4: A summary evaluation shall be given by the contractor. It shall rank, in descending order, assay equipment and techniques most compatible with spacecraft operations. The ranking will consider small sample size and concentration, equipment sensitivity and reliability, availability, hardware modification requirements, and other manned spacecraft constraints in assessing space compatibility. Additional advanced techniques and equipment shall be discussed and compared with those techniques now being used.

The next section of the report outlines the methods of procedure adopted by Battelle in fulfilling these tasks.

METHODS OF PROCEDURE

At the outset of this research program, a meeting was held at Marshall Space Flight Center with representatives of NASA and Battelle to discuss the objectives and conduct of the research program. Present for Battelle at the meeting were Dr. David Marshall*, Principal Investigator, and Dr. Richard D. Falb, Co-Investigator. A list of potential biological candidates of interest to NASA for space separation techniques was presented by NASA and discussed in detail. It was emphasized at that time that we should review detection techniques for a very broad range of biological agents and not be confined to the specific candidates discussed at the meeting. The biological candidates ranged from proteins and polynucleic acids up through various kinds of cells. Particular emphasis was placed upon electrophoresis of cellular particles since a zero-g environment has certain advantages for this technique. The three prime biological candidates which were discussed with us at the meeting were B and T lymphocytes, cultured kidney cells, and aldehyde-fixed red cells. It was also emphasized at the meeting that the scope of the project should include, but not be limited to, electrophoresis. We were instructed to examine detection techniques for separation processes in general.

Based upon the initial meeting with NASA and the tasks outlined in our contract, we then devised methods of procedure as described in the following sections.

Literature Searches on Separation Processes

As a first step in reviewing detection techniques which were relevant to the objectives of this program, we conducted several automated literature searches which were focused primarily on cell separation techniques. The

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* Dr. Marshall left Battelle's employ in June, 1974, and was replaced by Dr. Falb as Principal Investigator.

literature on separation techniques served as a good source for analytical techniques because the vast majority of the references obtained described analytical techniques as well as separation processes. Battelle has access to several automated literature search services and these were utilized by referencing certain key words and topics. In order to obtain as broad a base of information as possible, several different sources were utilized for literature searches. In addition, a variety of key words and topics were used. Table 1 summarizes the automated searches that were conducted and the key words and topics used in the searches.

TABLE 1. AUTOMATED (MACHINE) LITERATURE SEARCHES

	Citations Reported	(Utilized)
(1) Medline	303	(95)
(a) Separation of lymphocytes by electrophoresis		
(b) Detection of electrophoresis		
(c) Separation of lymphocytes and kidney cells		
(d) Separation of carrier proteins		
(2) CIRC-II Database	900	(10)
(a) Separation of lymphocytes, or kidney cells, or proteins		
(b) Electrophoresis, isotachophoresis, and electroosmosis		
(3) Engineering Index	106	(9)
(a) Electrophoretic separation techniques		
(4) Chemcon	66	(21)
(a) Electrophoresis techniques		
(5) Nuclear Science Abstracts	107	(17)
(a) Electrophoretic separation		
(6) Defense Documentation Center	268	(20)
(a) Detection, electrophoresis		
(b) Electrophoresis		
(7) NASA RECON	126	(15)
(a) Electrophoretic separation		
(b) Particle Separation Techniques		
Total	1,876	(187)

As can be seen from the table, seven different automated searches were performed and these yielded a total of 1,876 citations. These citations contained information on the key words in the articles, the authors' names, the title of the article, and the reference.

In addition to the automated literature searches, we also manually reviewed several journals as a source of current information. The journals which were reviewed are as follows.

Separation Science
Analytical Chemistry
Review of Scientific Instruments
Instruments and Control Systems
Analytical Biochemistry
Science
Clinical Chemistry

In addition, background information on the principles of operation of the various detection techniques was obtained from several published tex These books will be referenced in the bibliography.

A final source of information from the literature was obtained from trade journals and publications by manufacturers of various instruments. Quite often these later publications contained excellent descriptions of the principles upon which the devices operate.

Analysis of Literature Searches

As a result of the automated and manual literature searches, a very large volume of potentially relevant information was obtained. The next task in the program was to analyze the sources of information, to sort out those which were relevant, and to abstract the necessary information. The citations from the automated searches were reviewed, and on the basis of title, key words, and information contained in abstracts, a number of references were selected for further study. Similarly, references obtained from the manual literature searches were reviewed and relevant articles selected.

Copies of the articles selected after the first review were then obtained for further analysis. In order to efficiently utilize the information in each of these papers, an information retrieval system was set up. This system was designed to enable us to correlate a large volume of information for utilization in our later surveys. The first step in the retrieval system was a bibliography worksheet* which was designed for the purpose of providing a convenient method of abstracting and categorizing information. Each of the articles was carefully read and the information relating to the detection method, assay technique, substance separated, supporting medium, and other information deemed important was abstracted on this worksheet.

As a second step, a cross-referencing system was set up to enable compilation of information from several different bases. In addition to the first author, each of the articles was cross-referenced with respect to (1) coauthor, (2) detection and assay technique, (3) particle separated or analyzed, and (4) authors' affiliation. This cross-referencing system enabled one to quickly scan the relevant work by one particular author or to quickly retrieve information on any particular detection or separation technique.

Classification of Detection Methods

As a third step in our work on this program, a general review of detection and analytical techniques was made. The sources for the review were information obtained from the literature searches and several compilations of analytical methods available in the current literature. From these sources, an overall classification of analytical techniques was developed. A summary of these techniques is contained in Table 2.

In the first category, primary methods were defined as analytical techniques based directly upon a given physical principle. Secondary techniques were classified as those which employed some physical principle to

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* A sample copy of a bibliography worksheet is contained in Appendix A.

TABLE 2. CLASSIFICATION OF DETECTION METHODS

Primary Detection Methods

- I. Photometric
  - A. Absorptive
    - 1. Infrared
    - 2. Visible
    - 3. Ultraviolet
    - 4. Atomic adsorption
  - B. Refractive
    - 1. Light scattering
    - 2. Nephelometry
    - 3. Pulsed laser scattering
    - 4. Interferometry
    - 5. Refractometry
  - C. Emissive
    - 1. Fluorometry
    - 2. Phosphorimetry
    - 3. Emission spectrography
  - D. Polarimetric
    - 1. Optical rotary dispersion
    - 2. Circular dichroism
    - 3. Polarimetry
- II. Electrometric
  - A. Potentiometry
  - B. Conductimetry
  - C. Coulometry
  - D. Flame ionization
  - E. Polarography
- III. Radiometric
  - A. Scintillation photometry
  - B. Autoradiography
  - C. Beta absorption
  - D. Mossbauer spectroscopy
  - E. Direct radiation counting
  - F. Neutron activation
- IV. Thermometric
  - A. Thermoconductivity
  - B. Microcalorimetry
  - C. Differential thermal analysis
  - D. Differential scanning calorimetry

TABLE 2. (continued)

V. Magnetic
- A. Nuclear magnetic resonance
- B. Electron spin resonance

VI. Ultrasonic

Secondary Techniques

I. Light microscopy
- A. Manual
  - 1. Light field
  - 2. Dark field
  - 3. Fluorescence
- B. Pattern recognition computer

II. Electron microscopy

III. Particle counting
- A. Optical
  - 1. Flow-through (photometry)
  - 2. Static (light microscopy)
- B. Electro-conductimetric

IV. Photography

V. Image enhancement techniques

Specific Detection Methods

I. Immunologically based
- A. Immunofluorescence
- B. Radioimmunoassay
- C. Agglutination

II. Enzymatically based
- A. Chromogenic substrates
- B. ATP photoluminescence
- C. Fluorogenic substrates

produce an image which was then further analyzed. In this category, microscopic and photographic techniques played an important role. The third classification of techniques was those which depended upon a specific biological reaction to detect particles. In this category are placed immunological and enzyme reactions.

The sheer volume of the techniques in this summary made it essential that we apply evaluative criteria for selection of optimum techniques fairly early in the research program. Accordingly, the primary criterion for selection of appropriate techniques was based upon the type of information obtained by the technique. If the information obtained related primarily to the molecular or subcellular structure of the biological material rather than its concentration, the method was eliminated from further consideration. Techniques such as nuclear magnetic resonance, Raman spectrometry, electron spin resonance, Mossbauer spectrometry, differential thermal analysis, circular dichroism, optical rotary dispersion, and differential scanning calorimetry were eliminated from consideration because these techniques give primarily information on molecular or cellular structure.

A second criterion for the inclusion of techniques was their general applicability to biological molecules. The range of particles under consideration begins with proteins as the lower limit of size and goes up to large cells 20 microns in diameter. These substances are dissolved or suspended in a buffered aqueous medium and must remain in this medium during the analysis. Thus, detection methods for the gas phase, such as flame ionization and thermal conductivity, were eliminated. Similarly, techniques which detect only elements, such as flame and emission spectrometry, and atomic adsorption, were eliminated from consideration. The criterion of broad applicability eliminated such methods as amperiometric titration and polarography.

A final criterion for selection of techniques was the sensitivity with which these techniques could detect biological agents. A number of these techniques eliminated by the criteria stated above required fairly concentrated samples and thus were eliminated for low sensitivity. A listing of those methods chosen for further analysis is shown in Table 3.

TABLE 3. REVISED LIST OF DETECTION METHODS

Primary Detection Methods

- I. Photometric
  - A. Absorptive (transmitted or reflected light)
    - 1. Infrared
    - 2. Visible
    - 3. Ultraviolet
  - B. Refractive
    - 1. Forward light scattering
    - 2. Nephelometry (side scattering)
    - 3. Refractometry
  - C. Emissive
    - 1. Fluorimetry
    - 2. Phosphorimetry
  - D. Polarimetric
- II. Electrometric
  - A. Potentiometry
  - B. Conductimetry
- III. Radiometric
  - A. Scintillation photometry
  - B. Gamma ray spectrometry
  - C. X-ray fluorescence
  - D. Beta absorption
- IV. Microcalorimetry
- V. Ultrasonic

Secondary Methods

- I. Multiparameter cell analysis
- II. Automated image analysis
- III. Particle counting
  - A. Optical
  - B. Electro-conductimetric (Coulter method)
- IV. Photography
- V. Light microscopy

TABLE 3. (continued)

Specific Methods
I. Immunologically based
A. Immunofluorescence
B. Agglutination
II. Enzymatically based
A. Chromogenic (color-generating) substrates
B. ATP photometry

After the final list shown in Table 3 was assembled, an analysis of the detection methods used for biological particle detection in the literature references was made. A summary of the citations is shown in Table 4.

TABLE 4. LITERATURE CITATIONS OF DETECTION TECHNIQUES

Assay Technique	No. of Citations
I. Primary methods	
Visible light absorption	44
Fluorometry	40
UV light absorption	36
Light scattering	32
Autoradiography	8
Infrared light absorption	6
Raman spectroscopy	6
Ultrasonics absorption	6
Nephelometry	4
Polarimetry	4
Potentiometry	4
Conductimetry	4
Scintillation photometry	4
Light reflection	4
Thermoconductivity	4
Phosphorometry	2
Mossbauer spectroscopy	2
II. Secondary methods	
Electro-conductimetric particle counting (Coulter method)	34
Flow-through optical particle counting	32
Light field microscopy	20
Pattern recognition computer	18
Photography	14
Fluorescence microscopy	8
Electron microscopy	8
Dark field and phase contrast microscopy	4
Manual particle counting (microscopic)	2
III. Specific methods	
Immunofluorescnece	6
Radioimmunoassay	2
Enzymatic reactions	2

Another very important aspect in evaluating all of the analytical techniques was the method of interface with the separation system. We defined the following three ways in which the detection methods would interface.

(1) _In situ_ detection

(2) Real-time eluate analysis (flow cell)

(3) Discrete sample analysis.

By _in situ_ detection, we mean a method capable of detecting the biological agents within the separation device itself. For example, in the electrophoretic separation of various types of red blood cells, an _in situ_ detection device would detect the various bands during the course of the separation. This first category of techniques would be valuable for inflight evaluation of the separation system.

The second category of detection systems would directly monitor the eluate from a separation device by a photocell. For example, in a continuous-flow electrophoresis system, flow cells could be mounted on the output tubes to detect the concentration of the separated particles.

In the third type of interface of the detection system with the separation device, discrete samples would be taken from the eluate and analyzed individually. This third type, of course, would represent the most remote interface with the separation device.

The analytical techniques which were chosen for further detailed study were evaluated according to the three above criteria. A number of the techniques could interface in all three of the above modes while others were limited to only one. In the evaluative data presented in a later section of this report, the interfacing modes are discussed in greater detail.

Interviews with Researchers and Instrument Manufacturers

A further source of information on the most recent developments in analytical instrumentation was interviews with individual researchers and development groups of instrument manufacturers. A compilation of these visits is shown in Table 5. In general, visits were made to discuss state-of-the-art developments which were not yet fully described in the available literature.

In the visit with Dr. Victor Hanson, use of an optical microscope to visually detect red-cell migration in an electric field was discussed. Dr. Hanson feels that this method should be applicable to a space electrophoresis experiment.

Several optical scanning systems for quantitation of proteins in gel columns were discussed with Dr. Gary Ackers at the University of Virginia.

An interview was held with Dr. Grant Barlow of Abbott Laboratories on the topic of electrophoretic separation of kidney cells. Dr. Barlow explained that only 5 percent of the kidney cells in his culture system produced urokinase and that he was investigating whether these cells could be separated from the inactive cells by an electrophoretic separation process in space. In this separation, the following requirements should be met.

(1) The cells must be viable and capable of further culture.

(2) The cells must be recovered in good yield.

(3) Sterility must be maintained.

In a typical separation experiment, 10^7 cells will be placed in the electrophoresis device. After separation, the entire contents of the electrophoresis cell will be frozen. Because the sample will be in a frozen state, Dr. Barlow felt that detection of the cells would be extremely difficult.

A visit was made in July to Dr. Milan Bier and his associate, Mr. J.O.N. Hinckley, at the Veterans Administration Hospital in Tucson, Arizona. Dr. Bier discussed his development of continuous-flow systems

TABLE 5. INTERVIEWS WITH RESEARCHERS AND INSTRUMENT DEVELOPERS

	Topics
(1) Victor Hanson Upstate Medical Center Syracuse, New York	Detection methods based on optical microscopy
(2) Gary Ackers University of Virginia	Optical scanning systems for proteins in gel columns
(3) Grant Barlow Abbott Laboratories North Chicago, Illinois	Electrophoretic separation of kidney cells
(4) J.O.N. Hinckley Milan Bier University of Arizona	Electrophoretic separation and detection systems
(5) C. J. van Oss P. E. Bigazzi University of New York at Buffalo	Fluorescent microscopic detection of lymphocytes
(6) Allen Strickler Beckman Instruments Anaheim, California	Methods of detection for continuous-flow electrophoresis
(7) M. J. Fulwyler P. F. Mullaney J. A. Steinkamp L. S. Cram J. M. Crowell G. C. Salzman Los Alamos Scientific Laboratory Los Alamos, New Mexico	Automated multiparameter cell detection and differentiation
(8) A.S.C.A.P. Exhibition Various instrument developers Gerhard Megla - Corning Instruments Rod Hilton - Scientific Products Melvin Miller - Geometric Data + 20 other mfg. reps.	Automated image analyzing systems
(9) Pittsburgh Conference on Analytical Chemistry and Applied Spectroscopy ~50 mfg. reps.	Analytical instruments in general

applied to electrophoresis, isotachophoresis, and isoelectric focusing. Dr. Bier also discussed methods of detection of biological agents as they were eluted from his electrophoresis devices. For proteins, he uses a UV flow cell which he feels has sufficient sensitivity for his purposes. For detection of cells, Dr. Bier recommends a chromogenic substrate which is mixed with the effluent stream and produces a color in the cells by virtue of enzymatic activity. He also recommends turbidimetric methods of analysis.

In September a visit was made to Drs. C. J. van Oss and P. E. Bigazzi at the State University of New York at Buffalo to discuss electrophoretic separation of lymphocytes. Dr. van Oss is currently separating B and T lymphocytes on an electrophoresis device in which the cells migrate upwards through a small column. As the cells reach the top of the column, they are aspirated and subsequently analyzed by incubation with fluoroscein isothiocyanate-conjugated rabbit antihuman immunoglobulin. Cells containing immunoglobulins on the surfaces bind the fluoroscein conjugate and can be detected in a UV microscope. Dr. van Oss pointed out that if enough cells were used in the experiment, the separation zones were visible to the naked eye.

We discussed with Dr. van Oss the possibility of incubating the cells with the fluoroscein-conjugated antibody before the separation process so that the separation could be followed _in situ_ by fluorimetry. Dr. van Oss felt that the fluorescent antibody may alter the electrophoretic mobility of the B cells.

We also suggested labelling with ^{51}Cr and detecting the separated bands with a gamma detector. Dr. van Oss was not familiar with chromium-labelling techniques but felt they might affect cell viability.

Mr. Allen Strickler of Beckman Instruments in Anaheim, California, was interviewed to discuss detection systems for the electrophoresis equipment being developed by Beckman. He was extremely helpful in this discussion and suggested several ways that biological materials could be detected within the electrophoresis cell. He pointed out that the electrophoresis cell developed by him possesses a window at a space just prior to the collection tubes. This window allows any number of detection methods including photography, UV absorption, visible absorption, and light scattering. On the current model of this device, a cross-section illuminator is provided. The optical arrangement forms a thin blade of light which traverses the calibrated window. Particles in this window scatter the light and can be detected visually or by a photographic process. Subsequent to our visit, several telephone conversations were held with Dr. Strickler. Beckman Instruments has a diverse background in biomedical and process analysis instruments including Schlieren optics, infrared, ultraviolet, and visible range spectrophotometry, radioactivity counting, fluorimetry, and various integrated computer systems applied to instrumentation.

One of the most productive visits in this program was held at Los Alamos Scientific Laboratory in Los Alamos, New Mexico. Discussions were held with the persons identified in Table 5 on automated multiparameter cell detection and differentiation. This group has developed a technique for cell analysis (described in a later section of this report) which should be extremely valuable to the NASA program. In this system, a suspension of cells passes through a detection chamber which simultaneously employs several methods of analysis. Cells pass through in such a way that each cell is analyzed individually. The methods of analysis include forward light scattering and two wavelengths of fluorescence detection. Integration of these methods enables information to be derived on the size, shape, and nuclear structure of the cells. This group is now working on a number of cell analysis systems including lymphocyte differentiation, analysis of cells from PAP smears, and detection of virus-infected cells. The system can analyze cells rapidly up to a rate of 10^5 cells per minute. Members of this group were interested in the objectives of the NASA program and enthusiastically indicated their willingness to apply their techniques to analysis of eluates from electrophoresis devices.

In addition to the laboratory visits, members of the project team attended two instrument shows being held in conjunction with scientific meetings. The first of these was the A.S.C.A.P. meeting in Washington, D.C., on October 8, 1974. Dr. Gerhard Megla of Corning Scientific Instruments discussed the possible application of their Leukocyte Automatic Recognition Computer (LARC) to the analysis of cell separation, especially B and T lymphocytes. The LARC consists of five small modules and automatically prepares the slides, applies stain, focuses the microscope, rapidly scans, locates, records, and classifies six types of white blood cells. The computer memory identifies cells by their morphological qualities such as nuclear size, shape, cytoplasm size, and color. The machine can be programmed to identify and classify any type of cell combination.

A similar machine was also demonstrated by Dr. Melvin Miller of Geometric Data Corporation. Dr. Miller is presently involved in trying to identify morphologic differences in lymphocytes. Based on data gathered so far, Dr. Miller felt there may be six to eight lymphocyte subcategories identifiable by image analysis.

The second meeting attended was the Pittsburgh Conference on Analytical Chemistry and Applied Spectroscopy. At this meeting, analytical instruments in general were reviewed and approximately 50 manufacturers' representatives were interviewed.

Selection of Manufacturers

The next successive step in our conduct of this research program was the selection of manufacturers to be contacted for information concerning their respective detection devices. In selecting these manufacturers, an attempt was made to obtain representatives from each of the detection methods outlined in Table 3. Several sources were used to obtain manufacturers' names, addresses, and range of products. The first of these sources was buyer guide directories and of these, the following three were the most helpful.

(1) Guide to Scientific Instruments (Science)

(2) Medical Electronics and Equipment News Dictionary and Buyers' Guide

(3) Instrument and Control Systems Buyers' Guide.

In addition to buyers' guides, advertisements of instruments in journals reviewed for the program provided a source for selection of manufacturers.

Several suggestions of manufacturers were obtained from scientific colleagues in our laboratories. We also obtained information on manufacturers from articles in trade journals relating to new analytical techniques. A final source of manufacturers was the literature search. In several of the articles, specific instruments used in analysis of biological agents were described.

After a list of appropriate manufacturers was compiled, a letter was written to each of these manufacturers requesting specific product information on instruments of interest to this program. In this aspect of the program, we contacted 148 manufacturers and received technical specifications on 271 instruments. When the product information was received, it was carefully evaluated as described in a succeeding section and filed for future reference.

In the selection of manufacturers and instruments for this survey, it was impossible to review all the instruments available in any one category. We have made a serious attempt to identify instruments which are representative of each particular category and to be as objective in our selection as possible. Omissions of certain instruments and manufacturers from our study does not imply that the instruments are not suitable or unacceptable.

User Survey

One of the important tasks on this research program was to establish the reliability, serviceability, and usability of the various analytical instruments. As a source of information for this assessment, users of each of the instruments identified by us were contacted and asked to provide information. The following steps were taken in organizing and implementing the user survey.

(1) The specifications from the product literature from each of the instruments obtained from the various manufacturers were reviewed. From this review, instruments of potential value to this program were selected.

(2) Manufacturers of each of the selected instruments were then contacted and asked to provide us with the names and addresses of users of the instruments.

(3) A letter was then written to each of the users requesting that they fill out a short information form relating to the use, reliability, accuracy, and complexity of operation of each particular instrument.*

(4) Many of the users were contacted either personally or by phone to request their participation in the project.

(5) Results of the user survey were analyzed by a system described in the next section.

In the course of this user survey, we requested user lists from 148 manufacturers and received 100. Very often, these lists were obtained through local manufacturers' representatives. From the user lists, contact was initiated with 516 individuals. At the time of writing this report, 343 users have completed and returned the forms to us. In general, response to our questionnaire was somewhat spasmodic and receipt of a completed questionnaire often required phone calls and reminder letters. Because of this rather poor response, we do not have responses from three users of each of the 271 instruments evaluated in this survey. However, most of the instruments have responses from at least two users.

* A copy of the user survey form is included in Appendix A of this report.

Analysis of Instruments

As a culmination of all the information-gathering work performed on this program, a comprehensive analysis was made of each of the analytical instruments. The technical data obtained from the manufacturers' literature and the results of the user survey were used in this evaluative process. Because of the very large amount of data which were obtained from these sources, a system for data abstraction and compilation was devised. For each instrument included in the analysis, a commercial equipment worksheet was filled out.* This equipment worksheet contained information on the power requirements, readout, size, sensitivity, accuracy, resolution, sample state, and available accessories for each instrument. It also contained any other miscellaneous information deemed relevant.

Point-Rating System

Because of the numerous criteria used in evaluation of each instrument, it was necessary to devise a numerical rating system as an evaluative tool. Such a system must, of necessity, be empirical and care must be taken so that the relative values given to each of the parameters are balanced. Development of this system required considerable deliberation and it must be understood that the numbers assigned should be regarded as evaluative tools and not as absolute values. The numerical rating system covers both physical factors and performance factors. Four basic physical factors considered were cost, power, volume, and weight. Point factors were then empirically derived so that average specifications resulted in approximately 10 points each. In order to normalize each of these factors and avoid having one factor outweigh another, inverse factors were used. For example, decreased weight would result in a higher point rating. It was found necessary to take values to the fourth root to eliminate a wide and unrealistic point spread. Table 6 describes these equations.

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* A copy of this worksheet is included in Appendix A.

TABLE 6. POINT-RATING SYSTEM FOR PHYSICAL FACTORS

Cost factor	$= \sqrt[4]{\frac{100}{C}}$	(C = cost in U.S. dollars)
Power factor	$= \sqrt[4]{\frac{40}{W}}$	(W = watts)
Volume factor	$= \sqrt[4]{\frac{6}{m^3}}$	(m^3 = cubic meters)
Weight factor	$= \sqrt[4]{\frac{30}{kg}}$	(kg = weight in kilograms)

The numerical ratings for the performance factors were obtained from the user survey. The response to objective multiple-choice questions in the user survey form permitted numerical evaluation of the comparative reliability of commercial instruments and their complexity of operation. Assignments of points were chosen according to the user survey protocol shown in Appendix A. Average ratings were arranged to yield about 10 points in each category. The ratings of the three questions under reliability were taken as a total. To reasonably account for time of instrument ownership, a time-in-use factor is used in computing total points. This factor is computed as the eighth root of the number of years the equipment has been in use.

Table 7 describes the point computations for reliability and complexity.

TABLE 7. POINT-RATING SYSTEM
FOR PERFORMANCE FACTORS

Reliability factor =	$\sqrt[8]{t}$ x points assessed for reliability
Complexity factor =	$\sqrt[8]{t}$ x points assessed for complexity

t = time of use in years.

Rating of Instruments

One of the requested tasks in this research program was the rating of the various instruments according to their performance and physical factors. Because of the large number of factors involved, a rating of this kind has certain inherent problems due to the difficulty of ascribing appropriate values to each of these factors. For example, if weight requirements are extremely critical for a given application, then the weight factor of a given instrument becomes highly important. The many factors of the instrument are related to the particular needs of the biological materials being assayed. Thus, a direct comparison between a technique which is capable of accurately measuring protein to a technique which can accurately measure suspended lymphocytes is not particularly meaningful. Several factors of the instrument such as sample size, temperature, flow-cell capability, ability to be rack mounted, the form of the output signal are not amenable to a comparative rating system. For these reasons, we have devised a rating system based on six factors (cost, power, volume, weight, complexity of use, and reliability). In compiling this rating, the data for each instrument were summarized on a commercial hardware description sheet. This sheet contains information on the assay principle, the vendor, the six rating factors, and the names and addresses of the users of the instruments who have been contacted. Data from each of these sheets are summarized in Table 8. Instruments in this table are listed in descending order according to total points. Please note that each instrument has a code number in this table which has been included for cross referencing.

In addition to this table, a rather extensive format was designed to assemble the performance data of each of the instruments. These data are compiled in Table 9. This table contains items such as sensitivity, resolution or bandwidth, accuracy, sample size, concentration, sample temperature, flow-cell capability, operating temperature, rack mount availability, wavelength, and other miscellaneous information where it is applicable.

TABLE 8. PHYSICAL AND PERFORMANCE DATA COMPARISON

A Weighted-Factors* Table
(Presented in descending order according to total points)

Inst. Code No.	Cost, $	Power, watts	Volume, m^3	Weight, kg	Complexity	Reliability	Total Points
15	292	–	0.0002	0.3	24.8	23.2	212.7
62	495	–	0.0005	0.3	22.6	20.1	194.5
173	198	–	0.001	0.3	10.0	10.0	170.9
19	495	–	0.0007	0.5	15.1	8.1	167.0
169	203	–	0.001	0.5	10.0	10.0	165.9
87	2,730	–	0.004	2.6	16.9	21.8	149.9
190	100	3	0.001	0.9	10.0	10.0	146.5
199	2,167	–	0.003	1.5	10.0	10.0	137.3
160	355	6	0.001	1.4	10.0	10.0	129.9
93	730	15	0.004	3.9	22.4	22.4	129.5
46	220	10	0.005	2.3	17.9	16.1	129.5
13	750	74	0.001	1.5	17.9	17.3	128.7
81	695	5	0.007	3.1	20.0	18.5	128.0
229	150	10	0.002	1.8	10.0	10.0	125.4
100	895	15	0.008	3.6	23.1	20.8	124.3
97	1,860	120-70	0.003	1.6	21.6	20.6	121.8
45	1,388	3	0.031	6.8	19.8	17.9	117.4
92	830	6	0.012	4.5	17.2	17.2	117.3
101	325	380	0.008	7.3	24.2	21.8	117.0
258	1,650	56	0.001	0.7	10.0	10.0	116.8
95	430	12	0.012	6.1	21.7	14.4	116.8
48	525	10	0.009	4.5	15.9	17.1	116.5
7	1,555	10	0.013	5.0	22.4	17.7	116.1

*See point system description.

TABLE 8. (continued)
A Weighted-Factors* Table
(Presented in descending order according to total points)

Inst. Code No.	Cost, $	Power, watts	Volume, m^3	Weight, kg	Complexity	Reliability	Total Points
2	2,400	4	0.007	8.2	15.2	19.2	115.4
37	350	35	0.009	6.4	20.2	17.1	115.2
111	2,439	14	0.009	5.7	20.4	20.3	114.5
71	2,359	17	0.008	6.4	22.4	18.5	113.9
61	2,400	4	0.007	8.2	17.1	15.8	113.9
238	1,320	8	0.015	5.8	16.7	20.1	113.6
30	1,995	15	0.007	3.9	18.9	17.0	113.2
133	2,375	120-70	0.008	3.9	20.5	24.6	112.9
1	800	990	0.008	4.1	24.0	21.6	112.7
192	359	12	0.005	2.0	10.0	10.0	112.3
131	650	10	0.013	9.1	19.5	14.7	111.6
33	795	50	0.012	3.6	19.9	17.9	111.5
231	275	14	0.006	2.3	10.0	10.0	111.1
197	1,053	2	0.012	4.5	10.0	10.0	109.9
120	2,450	20	0.015	1.9	16.1	17.9	109.8
60	935	60	0.009	4.5	15.5	21.6	109.7
22	757	30	0.003	5.4	13.3	19.0	109.5
91	2,390	17	0.014	5.7	15.1	22.9	108.8
114	1,850	65	0.018	13.5	25.9	21.2	108.4
96	5,500	24	0.015	5.4	21.4	20.5	108.4
112	1,726	12	0.009	4.8	17.7	13.7	108.2
77	1,375	70	0.004	9.1	15.4	20.9	107.6
230	450	27	0.004	2.3	10.0	10.0	107.4

*See point system description.

TABLE 8. (continued)

A Weighted-Factors* Table
(Presented in descending order according to total points)

Inst. Code No.	Cost, $	Power, watts	Volume, m^3	Weight, kg	Complexity	Reliability	Total Points
170	770	10	0.006	2.4	10.0	10.0	107.2
127	2,875	40	0.014	6.3	21.8	19.6	107.2
136	1,095	8	0.006	2.7	10.0	10.0	106.1
167	398	11	0.013	2.5	10.0	10.0	106.0
246	595	50	0.019	4.1	15.8	17.6	105.9
42	1,695	15	0.008	4.5	12.2	17.1	105.9
118	1,395	20	0.009	6.8	16.7	13.8	103.9
165	1,395	3	0.015	6.1	10.0	10.0	103.0
268	2,680	4	0.008	5.4	10.0	10.0	102.1
117	995	40	0.006	4.8	10.3	15.3	101.2
149	1,475	9	0.009	3.6	10.0	10.0	100.5
198	714	15	0.011	3.6	10.0	10.0	99.9
208	2,495	9-6	0.007	4.1	10.0	10.0	99.0
175	675	25	0.009	3.6	10.0	10.0	98.8
128	1,790	30	0.022	8.2	18.0	15.0	98.8
54	539	15	0.011	6.5	10.0	10.0	98.4
78	975	65	0.019	8.2	15.1	17.4	98.4
213	416	12	0.014	9.1	10.0	10.0	98.3
40	1,545	990	0.025	6.8	22.3	18.8	97.9
137	1,250	40	0.019	5.5	13.3	16.1	97.9
99	2,685	50	0.024	12.2	19.6	17.7	97.5
57	834	50	0.007	2.8	10.0	10.0	97.5
189	1,500	20	0.008	3.6	10.0	10.0	96.8

*See point system description.

TABLE 8. (continued)

A Weighted-Factors* Table
(Presented in descending order according to total points)

Inst. Code No.	Cost, $	Power, watts	Volume, m^3	Weight, kg	Complexity	Reliability	Total Points
124	2,695	60	0.018	13.2	18.4	16.6	95.4
108	3,936	52	0.011	10.7	18.7	14.0	95.3
241	1,385	10	0.015	6.0	10.0	10.0	95.2
126	1,495	20	0.022	10.4	13.4	14.2	94.9
115	1,795	115	0.027	11.3	16.4	19.6	94.8
74	2,750	50	0.016	9.1	16.4	14.8	94.2
12	5,600	100	0.024	12.7	20.4	18.3	93.9
132	4,095	100	0.020	14.9	20.3	16.7	93.4
129	2,495	28	0.037	21.8	16.8	17.3	93.2
266	3,500	100	0.021	18.1	18.3	19.0	93.2
14	595	30	0.014	6.9	10.0	10.0	93.2
200	1,830	20	0.012	4.3	10.0	10.0	93.1
24	4,995	150	0.046	20.4	23.7	19.0	93.1
75	2,450	25	0.027	5.0	14.0	12.0	92.9
257	2,225	120-70	0.006	2.3	10.0	10.0	92.6
171	450	28	0.033	5.9	10.0	10.0	92.4
5	2,250	40	0.056	15.0	16.6	17.8	92.3
64	550	35	0.015	7.7	10.0	10.0	92.1
20	2,375	100	0.044	13.6	19.6	16.8	92.0
182	1,344	50	0.006	6.8	10.0	10.0	91.6
113	640	100	0.010	5.0	10.0	10.0	91.5
157	1,495	55-24	0.017	4.2	10.0	10.0	91.4
63	675	35	0.015	7.7	10.0	10.0	91.1

*See point system description.

TABLE 8. (continued)
A Weighted-Factors* Table
(Presented in descending order according to total points)

Inst. Code No.	Cost, $	Power, watts	Volume, m^3	Weight, kg	Complexity	Reliability	Total Points
224	419	50-30	0.016	10.0	10.0	10.0	90.9
122	5,490	24	0.029	10.4	11.3	18.6	90.8
80	2,400	70	0.030	15.0	19.6	13.3	90.6
58	3,960	50	0.019	15.0	17.6	13.9	90.5
35	2,695	75	0.031	8.2	13.5	17.3	90.3
236	3,050	25	0.009	5.7	10.0	10.0	90.2
245	6,600	12	0.010	6.8	10.0	10.0	90.2
164	2,359	17	0.013	7.3	10.0	10.0	90.1
39	6,075	290	0.113	61.2	26.7	21.3	90.0
259	1,595	15	0.028	6.0	10.0	10.0	90.0
109	1,500	173	0.034	13.6	15.8	17.4	89.9
144	1,255	40	0.018	4.4	10.0	10.0	89.8
3	3,530	80	0.025	13.0	16.0	16.3	89.6
16	5,580	20	0.027	14.7	14.7	14.2	89.5
221	950	75	0.012	5.7	10.0	10.0	89.1
10	6,795	50-30	0.116	29.4	20.9	18.8	88.9
201	985	30	0.017	9.1	10.0	10.0	88.8
260	1,795	30	0.018	5.4	10.0	10.0	88.6
68	6,000	30	0.060	19.0	16.7	16.8	88.5
223	675	50-30	0.016	10.0	10.0	10.0	88.4
261	1,073	100	0.009	6.5	10.0	10.0	88.4
53	4,691	50-30	0.063	9.1	15.8	16.1	88.3
212	2,120	60	0.010	5.0	10.0	10.0	88.2

*See point system description.

TABLE 8. (continued)

A Weighted-Factors* Table
(Presented in descending order according to total points)

Inst. Code No.	Cost, $	Power, watts	Volume, m^3	Weight, kg	Complexity	Reliability	Total Points
180	995	60	0.013	6.5	10.0	10.0	88.0
151	1,550	50	0.010	8.2	10.0	10.0	87.6
227	1,360	200	0.020	2.3	10.0	10.0	87.4
181	1,395	60	0.013	6.5	10.0	10.0	87.4
191	735	50-30	0.025	8.2	10.0	10.0	87.0
106	1,290	48	0.018	6.8	10.0	10.0	86.9
76	7,100	100	0.075	18.1	18.1	18.6	86.2
55	2,600	175	0.053	15.9	17.6	15.9	86.0
193	1,375	100	0.012	6.8	10.0	10.0	85.7
184	1,460	50	0.015	9.3	10.0	10.0	85.5
254	5,500	35	0.014	5.4	10.0	10.0	85.1
41	2,950	300-250	0.055	22.2	18.7	16.8	84.8
70	5,978	100	0.091	18.1	20.0	15.1	84.5
143	1,920	50	0.015	8.2	10.0	10.0	84.4
119	2,800	120	0.041	27.2	14.8	16.7	83.7
177	5,145	96	0.044	31.8	12.7	20.6	83.6
153	1,435	65	0.018	10.0	10.0	10.0	83.6
159	1,385	32	0.042	12.2	10.0	10.0	82.4
263	1,670	55	0.025	10.8	10.0	10.0	81.9
84	6,875	100	0.094	22.7	19.5	14.2	81.8
94	5,874	230	0.066	20.0	20.0	13.5	81.2
222	4,785	300	0.088	31.8	18.6	17.3	81.1
146	4,000	15	0.040	18.1	10.0	10.0	80.8

*See point system description.

TABLE 8. (continued)
A Weighted-Factors* Table
(Presented in descending order according to total points)

Inst. Code No.	Cost, $	Power, watts	Volume, m^3	Weight, kg	Complexity	Reliability	Total Points
148	3,760	150	0.107	39.5	14.7	19.2	80.6
98	6,450	300-250	0.088	31.8	20.6	15.6	80.6
36	8,627	500	0.186	80.0	20.3	22.3	80.6
163	795	300	0.019	13.6	10.0	10.0	80.2
220	2,950	24	0.033	20.4	10.0	10.0	79.9
56	9,570	10	0.197	77.0	11.2	16.8	79.7
17	4,500	173	0.053	15.9	15.1	13.8	79.6
147	3,870	180	0.031	94.3	17.0	15.2	79.6
8	6,450	200	0.190	27.2	12.7	18.4	79.6
73	11,700	200	0.101	38.1	17.5	19.1	79.5
85	3,980	575	1.178	49.0	22.8	18.7	79.4
172	1,990	60	0.021	21 8	10.0	10.0	79.1
154	5,800	400	0.109	81.6	19.0	19.3	79.0
196	1,971	50	0.036	15.9	10.0	10.0	78.8
161	1,155	90	0.038	15.9	10.0	10.0	78.7
11	2,770	150	0.042	21.8	12.9	13.3	78.4
72	5,245	150	0.107	42.2	16.2	16.1	77.8
237	4,120	40	0.039	13.8	10.0	10.0	77.5
23	3,200	140-100	0.022	10.0	10.0	10.0	77.4
102	4,250	100	0.079	27.7	11.2	16.8	77.4
253	1,995	100	0.032	13.6	10.0	10.0	77.4
178	3,290	48	0.030	23.4	10.0	10.0	76.4
166	5,950	40-30	0.043	13.2	10.0	10.0	76.2

*See point system description.

TABLE 8. (continued)
A Weighted-Factors* Table
(Presented in descending order according to total points)

Inst. Code No.	Cost, $	Power, watts	Volume, m^3	Weight, kg	Complexity	Reliability	Total Points
271	3,000	50	0.039	20.4	10.0	10.0	76.1
202	1,735	150	0.029	17.7	10.0	10.0	76.0
162	2,195	100	0.034	17 2	10.0	10.0	75.9
67	6,580	345	0.249	40.8	18.9	15.4	75.1
267	3,120	110	0.039	13.6	10.0	10.0	74.9
232	3,750	85	0.030	20.4	10.0	10.0	74.5
255	3,995	100	0.039	13.6	10.0	10.0	74.3
82	6,000	360	0.117	56.7	14.5	17.4	73.7
205	2,600	173	0.037	19.7	10.0	10.0	72.9
176	6,405	75	0.041	16.8	10.0	10.0	72.8
103	17,000	150	0.389	144.0	18.4	18.0	72.8
43	13,900	165	0.078	37.6	13.0	15.7	72.6
188	5,400	50	0.063	23.2	10.0	10.0	72.4
168	2,790	100	0.051	25.4	10.0	10.0	72.4
264	2,995	100	0.142	11.3	10.0	10.0	72.3
130	13,500	520	0.706	270.0	22.8	17.9	72.3
242	6,800	100	0.047	13.6	10.0	10.0	72.1
88	16,826	600	0.150	68.0	20.0	15.1	72.0
123	13,045	351	0.118	95.7	21.0	12.6	71.9
243	8,490	115	0.036	16.0	10.0	10.0	71.4
185	2,990	140	0.054	22.0	10.0	10.0	71.3
270	7,500	140	0.034	15.9	10.0	10.0	71.3
66	20,790	110	0.290	39.5	14.8	14.7	70.4

*See point system description.

TABLE 8. (continued)

A Weighted-Factors* Table
(Presented in descending order according to total points)

Inst. Code No.	Cost, $	Power, watts	Volume, m^3	Weight, kg	Complexity	Reliability	Total Points
104	9,400	240	0.285	272.2	17.6	16.7	70.3
225	4,500	80	0.069	28.0	10.0	10.0	70.3
34	12,100	575	0.763	351.5	20.1	18.9	70.0
107	2,490	130	0.078	34.9	10.0	10.0	69.7
138	6,495	378	0.127	72.6	14.4	14.8	69.7
83	5,775	1150	0.116	61.7	14.4	15.4	69.2
141	8,000	200	0.040	18.1	10.0	10.0	69.1
59	2,995	75	0.095	58.0	10.0	10.0	68.8
186	3,350	140	0.092	34.0	10.0	10.0	68.0
139	5,225	250	0.044	29.5	10.0	10.0	67.8
50	8,000	250	0.040	22.7	10.0	10.0	67.7
240	10,960	230	0.219	39.9	15.8	11.0	67.7
4	9,900	360	0.471	113.4	11.2	20.8	67.6
248	5,400	100	0.093	38.0	10.0	10.0	67.3
209	4,800	500	0.045	22.7	10.0	10.0	67.1
49	11,325	100	0.035	60.8	10.0	10.0	66.9
110	17,250	575	0.403	136.1	16.0	17.7	66.9
125	20,500	500	1.444	90.7	17.6	17.1	66.6
194	3,990	340	0.066	34.5	10.0	10.0	66.1
90	8,500	85	0.134	27.7	10.0	10.0	66.0
207	7,500	200	0.075	27.2	10.0	10.0	65.9
252	8,795	100	0.107	40.0	10.0	10.0	65.3
44	13,500	650	0.757	136.1	15.9	16.9	65.2

*See point system description.

TABLE 8. (continued)

A Weighted-Factors* Table
(Presented in descending order according to total points)

Inst. Code No.	Cost, $	Power, watts	Volume, m^3	Weight, kg	Complexity	Reliability	Total Points
150	6,345	200	0.096	34.0	10.0	10.0	65.0
214	5,300	300	0.088	31.8	10.0	10.0	64.9
219	9,910	127	0.089	43.1	10.0	10.0	64.6
21	20,895	800	0.470	200.0	17.1	15.3	63.4
179	5,995	100	0.092	152.0	10.0	10.0	63.4
31	5 832	200	0.187	37.0	10.0	10.0	63.3
158	6,250	218	0.083	68.5	10.0	10.0	63.2
116	16,000	550	0.133	72.6	12.0	13.7	63.1
32	7,111	200	0.149	43.1	10.0	10.0	62.9
247	58,920	34	0.636	204.1	9.7	15.5	62.8
69	13,560	230	0.315	81.6	10.5	14.6	62.6
79	29,990	1265	1.125	249.5	18.3	16.5	62.4
51	9,950	500	0.283	13.6	10.0	10.0	62.3
142	7,950	350	0.094	45.4	10.0	10.0	62.2
226	10,500	500-350	0.078	33.0	10.0	10.0	62.1
204	4,400	403	0.144	54.0	10.0	10.0	62.0
195	2,950	1150	0.103	61.7	10.0	10.0	61.8
18	56,500	3510	1.878	499.0	22.7	15.9	61.7
152	5,795	625	0.108	42.6	10.0	10.0	61.7
251	6,710	200	0.145	69.8	10.0	10.0	61.7
262	9,940	350	0.095	50.0	10.0	10.0	61.3
239	10,379	750-500	0.063	43.5	10.0	10.0	61.2
215	6,990	350	0.089	81.6	10.0	10.0	61.1

*See point system description.

TABLE 8. (continued)
A Weighted-Factors* Table
(Presented in descending order according to total points)

Inst. Code No.	Cost, $	Power, watts	Volume, m^3	Weight, kg	Complexity	Reliability	Total Points
210	7,385	351	0.089	77.1	10.0	10.0	61.1
206	6,300	403	0.117	67.1	10.0	10.0	60.9
183	8,480	250	0.140	62.0	10.0	10.0	60.9
6	47,500	1500	1.160	281.6	18.2	16.5	60.8
28	49,500	175	2.240	204.1	14.9	15.1	60.5
29	16,000	66	0.078	36.3	10.0	10.0	60.4
105	7,000	175	0.180	112.0	10.0	10.0	60.3
265	4,900	345	0.142	113.4	10.0	10.0	60.3
156	4,750	345	0.142	113.4	10.0	10.0	60.3
135	13,400	100	0.280	79.0	10.0	10.0	60.2
187	6,740	297	0.142	90.7	10.0	10.0	60.1
25	9,470	600	0.120	40.8	7.4	11.9	59.6
155	6,975	400	0.117	104.3	10.0	10.0	59.4
134	13,200	100	0.484	93.0	10.0	10.0	58.8
65	27,800	330	0.537	113.0	11.5	13.9	58.7
9	33,900	2300	0.649	167.8	20.2	10.6	58.7
249	12,500	500	0.151	85.0	10.0	10.0	57.3
89	-	650-617	0.268	68.1	10.0	10.0	56.6
244	12,000	500	0.288	79.4	10.0	10.0	56.1
228	20,000	200	0.469	160.0	10.0	10.0	54.7
216	10,000	300	0.454	226.8	10.0	10.0	54.6
47	99,500	2300	1.790	226.8	15.6	14.2	54.1
203	25,950	590	0.262	136.1	10.0	10.0	53.3

*See point system description.

TABLE 8. (continued)

A Weighted-Factors* Table
(Presented in descending order according to total points)

Inst. Code No.	Cost, $	Power, watts	Volume, m^3	Weight, kg	Complexity	Reliability	Total Points
256	20,500	495	0.403	130.6	10.0	10.0	53.2
250	17,000	500	0.456	158.8	10.0	10.0	52.8
211	8,800	520	0.693	270.0	10.0	10.0	52.7
52	16,925	200	0.713	409.0	10.0	10.0	52.6
26	24,170	2325	0.240	100.8	7.4	11.9	51.2
145	40,000	800	0.343	147.4	10.0	10.0	51.0
174	35,000	1000	0.750	99.8	10.0	10.0	50.3
235	54,735	750	0.556	122.0	10.0	10.0	50.0
121	57,000	3000	0.819	226.8	12.9	10.4	49.2
27	29,825	2975	0.330	138.3	7.4	11.9	48.9
86	70,000	1970	0.535	194.4	8.0	13.2	48.3
234	74,070	1300	0.725	202.0	10.0	10.0	47.3
217	20,000	2500-1000	1.319	344.7	10.0	10.0	46.6
218	30,000	3000-1200	1.555	450.0	10.0	10.0	44.9
233	120,950	2550	0.919	300.3	10.0	10.0	44.3
269	45,000	5500	0.885	553.4	10.0	10.0	43.8
140	59,000	2300	2.416	635.0	10.0	10.0	43.0
38	75,000	2000	6.118	544.3	10.0	10.0	42.0

*See point system description.

TABLE 9. PERFORMANCE SPECIFICATIONS

Note: Glossary of abbreviations at end of table

Inst. Code No.	Sensitivity	Resolution or Bandwidth	Accuracy	Sample Size	Concen-tration	Sample Temp.	Flow-Cell Capability	Ambient Temp.	Rack-Mount Available	Wavelength	Miscellaneous
1				1.4 ml			yes				
2	6×10^{-8} RI Units						yes				
3				0.1 ml (10 µl avail.)			yes	0-35 C		240/280 nm 2 channel diff.	0 - 100% T (auto. scale expansion)
4		0.2 nm		1-3 ml						190/800 nm	
5				up to 20 x 20 cm						254/366 nm 400-700 nm	fwd. or rev. scanning fiber optics w/CdS detect.
6											
7		4×10^{-5} RI		2 ml			yes			589.3 nm	1.30 - 1.74 RI
8		6 nm		up to 20 x 20 cm						190-720 nm	scans 4-8 nm/sec. auto return
9		0.001 A		3-50 µl diluted to 260-560 µl						290-720 nm	self-contained air, vac., water and waste services
10											auto. exposure control ASA 6-3200
11				10,50,32 and 150 µl						215-310 nm	0 - 100 % T 0 - 2.0 O.D.
12				10 µl diluted to 0.1 ml							counting time 7 sec
13								-15 to 40 C		250-1200 nm	
14				0.15-3.0 ml				5-40 C		360-720 filtered	0 - 2 A 0 - 100 % T
15				0.005-0.02 ml							
16		0.02 mm						0-43 C		360-700 nm	
17				scans up to 2 x 17 cm						525/360 nm	

TABLE 9. (continued)

Inst. Code No.	Sensitivity	Resolution or Bandwidth	Accuracy	Sample Size	Concen-tration	Sample Temp.	Flow-Cell Capability	Ambient Temp.	Rack-Mount Available	Wavelength	Miscellaneous
18				15-250 μl				4-50 C		325-800 nm	compressed air req.
19								5-40 C		400-700 nm	
20				0.4 ml						tungsten	
21		0.3 nm								200-825 nm	75 nm or greater increments
22				0.05 ml			yes			440/570 nm others avail.	
23				0.1/0.2 ml							auto. pipette, mag. stirring included
24				1 ml							
25	1-100 μ particles			0.3-5 ml						632.8 nm	fwd. scattering 1-19°
26	1-100 μ particles			0.3-5 ml						632.8 nm	fwd. scattering 1-19°
27	1-100 μ particles			0.3-5 ml					for storage display scope	632.8 nm	fwd. scattering 1-19°
28				film 24 cm wide slides 8x10 cm							
29		line sep. adj. 500-1um	± 0.8 μm per cm	up to 70x70 mm or cont roll film					yes		256 light density levels 0-4 O.D.
30				closed sample cont. avail.				0-50 C			sound velocity 400-2500 m/sec
31				up to 20x20 cm							exposure 1-60 min. carrier gas required 90 Argon/10 methane
32		2 mm		up to 20x20 cm							carrier gas required 98 Argon/2 Propane
33											counts to 99,999
34				5-20 ml							450 samples

TABLE 9. (continued)

Inst. Code No.	Sensitivity	Resolution or Bandwidth	Accuracy	Sample Size	Concen-tration	Sample Temp.	Flow-Cell Capability	Ambient Temp.	Rack-Mount Available	Wavelength	Miscellaneous
35	10^{-8} M		± 0.25 %	2-50 ml				0-50 C			scans 0.1-500 mV/se-
36	0.01 μg DHEA			up to 20x20 cm						200-700 nm	0-3 O.D. scans 10 cm/min.
37	0.25 V neg.										counts to 99,999
38	1-30 μ particles			up to 5 ml						465.8-515 nm	
39		0.8 nm		2 μl or 2 ml						200-700 nm	
40							yes			400-700 nm	
41				up to 15x20 cm						520/600 others avail	scans 1 - 14 cm 4 - 8 mm/sec
42				55 μl			yes			400-1100 nm 3 filters	0 - 2 O.D.
43		1/500 of image width						0-50 C	yes		0.5-2.25 O.D. 256 light density levels
44		0.03 O.D.									color display relates to opt. dens., 0-2 O.D.
45											
46			1-2 %					10-50 C			0-50,000 μm hos
47								20-32 C			50-800 cell count, video sens. to 3 colors
48							yes	-10 to 50 C			20,000 μm hos/cm to 1 mho/cm
49			± 0.002° angular	30 mm dia. up to 200 mm long						390-700 mm	rotation ± 90° angular or ± 130° ISS
50		0.001° 1-10 nm	0.002°	tubes up to 200 mm long						589 nm (546 opt.)	± 80° rotation auto. operation
51		0.001°		compartment 15x15x18 cm						365-589 (filtered)	± 999.99° rotation, incl. Hg and Na lamps

TABLE 9. (continued)

Inst. Code No.	Sensitivity	Resolution or Bandwidth	Accuracy	Sample Size	Concen-tration	Sample Temp.	Flow-Cell Capability	Ambient Temp.	Rack-Mount Available	Wavelength	Miscellaneous
52				7 ml							160 samples
53											auto. exposure control ASA 6-3200
54				0.2-100 ml						365-700 nm	
55										520 nm (filters)	
56		10 μ								[illegible]0-650 nm	0-4 log density 2.5-20 mm/min.
57	10^{-8} watts/ cm^2 full scale									235-320 nm	
58		5 nm		8 μl			yes, dual			200-450 nm	0.01-2.0 O.D. 0.100 % T
59								5-40 C		190-1100 nm	0 - 2 O.D. 0 - 110 % T
60				0.4 ml							
61	6×10^{-8} RI										
62					0-25 % solids						
63	± 0.5% full scale		± 2% full scale	2.5/25 ml							0 - 1000 NTU
64	0.04 FTU		± 2%	25ml							0 - 1000 FTU
65		0.05-0.3 nm								190-3000 nm	0 - 3.0 A
66											
67	counts photons			up to 20x20 cm						tungsten filters opt.	0 - 100% T, 0 - 3 O.D.
68				up to 12x20 cm						420-700 filters opt.	0 - 2.0 A, 0 - 100% T 1 - 6 cm/min. scan

TABLE 9. (continued)

Inst. Code No.	Sensitivity	Resolution or Bandwidth	Accuracy	Sample Size	Concen-tration	Sample Temp.	Flow-Cell Capability	Ambient Temp.	Rack-Mount Available	Wavelength	Miscellaneous
69	0.1 m cal. per sec			0.03 ml		50 to 725° C					0.1 - 20 m cal/sec gas purge req.
70	0.1°	0.05°		up to 25 mm dia.						546.1 nm	8 position compensator in 45° increments
71	10^{-7} RI			5 μl	>3 μg/ml sucrose		yes				1.31-1.44, 1.40-1.55 RI 10^{-5} to 1.28×10^{-3} diff. RI
72	7 mμ to 5μ particles							0-78 C		436/546 nm	angular range 0 ± 150°
73			± 40 min. angle	27 ml						514.5 nm tunable laser	0-178° scan, 5 speeds 11.3 to 180°/min.
74				20 μl							orifice size 100 μ
75										632.8 nm	64 detector elements in solid-state array
76		0.2° C		0.03 ml		-100 to 500 C					1-32 m cal/sec
77				0.25- 8 ml				15-30 C			
78		0.1 picoamp.							yes		input current 100 picoamp. to 1 mA full scale
79		0.1 nm	0.4 nm							186-2650 nm	0 - 100% T 0-2 A, cooling water req.
80		0.001 A 8 nm	0.5% A	0.7 ml			yes			340-700 nm grating	0-2 A sample aspiration system
81		20 nm		0.05 ml			yes			420-880 (filters)	fiber optic probe
82		0.5 nm								190-900 nm	
83				down to 2 μl			yes			220-700 nm	
84								10-40 C			pathlength <10 mm
85										356/254 nm 400-700 nm	

TABLE 9. (continued)

Inst. Code No.	Sensitivity	Resolution or Bandwidth	Accuracy	Sample Size	Concen- tration	Sample Temp.	Flow-Cell Capability	Ambient Temp.	Rack-Mount Available	Wavelength	Miscellaneous
86		stage moves in 5 μ steps		0.05 - 0.2 ml on micro slide				20-30 C			distilled H_2O required at 630 ml/min.
87											500 frame mag. avail. batteries ok for 1000 exp.
88	particle size 0.5-200 μ										16 channel size analysis
89				2 ml	0.01-1000 ppm						fully automatic,no microscope used
90				25 ml	0.5-1000 ppm					632.8 nm	+ 20 to -80 mV zeta potential
91	0.3 μ W/cm^2 full scale	25-50 nm								380-1350 nm	0-1000 μ W/cm^2 fiber optic probe
92				0.4-3.5 ml			yes				1.5-1500 m S. fsd 13 ranges
93				0.4-3.5 ml			yes				1.5 μ m hos - 500 mm hose 3 KHZ / 70 Hz sensor
94	particle size 0.5-800 μ										
95								-40 to +60 C			60/250 Hz sensor
96	10^{-13} g ATP			10 μl - 10 ml	10^{-9} to 1 mg ATP/ml						
97											frame rates to 60/sec with mod.
98		16nm								350-750 nm	0.3-2.0 O.D. scans 4-6 mm/sec.
99	2.10^{-4} O.D.			30 μl			yes			330-750 nm	0.01-2.0 O.D. 0-100% T
100										436, 546 and 640 nm	
101										420-640 nm filters	0-100% T
102											

TABLE 9. (continued)

Inst. Code No.	Sensitivity	Resolution or Bandwidth	Accuracy	Sample Size	Concen-tration	Sample Temp.	Flow-Cell Capability	Ambient Temp.	Rack-Mount Available	Wavelength	Miscellaneous
103		0.5 - 40 lines/mm		2-20 mm dia.						632.8 nm	
104							yes				
105		3 mm dia. flying spot		up to 20x20 cm						350-650 nm avail. to 200	Scans 0.5-6 cm/min.
106		8-12 nm					yes			360-620 and 620-1000 nm	0 - 2.0 A 0 - 100% T
107	$2x10^{-9}$ g/ml quinine SO_4									254-1000 nm	-0.4 to 2.0 A, 0-200% T 0.1 - 2000 conc.
108	10^{-14} W/cm^2 full scale	10^{-16} W.cm^2 0.2 nm								240-810 nm	
109										520 nm filtered	
110		0.3 nm.	0.001 A	down to 20 µl						185-800 nm	0.2 A, 0-12,000 conc. scans 0.005-5 nm/sec.
111	$2x10^{-4}$ A			25 µl			yes			254/280 nm diff.	0.03 - 4.26 A
112	$2x10^{-4}$ O.D.			8 µl			yes	0.25 C		254,280,350 440 or 550 nm	
113				2 ml							Nitrogen required Pt sample cell avail.
114		40 nm		0.05-0.3 ml			yes	0-30 C		254/280 nm	
115	10^{-4} A			4-76 µl			yes			254/280 nm	0-2 A 0-100% T
116				10-100 µl						340-650 nm	
117				8 or 50 µl			yes	0-30 C		254/280 nm	0-2.0 A
118							yes			254/280 nm	
119				up to 2.5 x 15 cm						500 - 600 nm	

TABLE 9. (continued)

Inst. Code No.	Sensitivity	Resolution or Bandwidth	Accuracy	Sample Size	Concen-tration	Sample Temp.	Flow-Cell Capability	Ambient Temp.	Rack-Mount Available	Wavelength	Miscellaneous
120		10 pico gram		5-100 ng	5×10^{-14} M						
121					up to 6 mm dia						binding energy range 0-1200 eV
122	10^{-11} g ATP/ml or 25 bacteria			10 μl + 90 μl reagent						350-600 nm	
123	0.001 A			1.1 ml up to 100 samples		25, 30, 32, 37 C				340-700 nm	0-2 A, auto incubation and reagent dispensing
124	-1 mV										energy range 0-2 MeV
125				up to 20x20 cm							spark chamber photography
126								20-25 C			12,800 counts at 1.0 ratio 0.000-1.900 fract. ratios
127			timer 0.001 min.								10-2200 KeV, 10^6 counts, 10^5 minutes
128				7.5 ml							present count 500-40,000
129				up to 48 mm dia.				12-45 C			25 KeV- 3 MeV gamma 1 μ curie - 999 m curies
130				3.5 ml			yes				3 channels
131											use Geiger - Mueller or scintillation detector
132				up to 6x25 cm							100-100 K counts/min. 12 scan speeds
133											1/50 - 1/2000 sec. shutter speeds
134	0.05 μV/μW		0.005°C	2-4 ml closed container		0-50 C					detect pulse 200 μJ detect heat effect 1 μW
135	0.05 μV/μW		0.005°C	0.5-0.7 ml		22-60 C	yes				detect puls 200 μJ detect heat effect 1 μW
136	10^{-11} watts										10^{-3} to 10^{+3} watts

TABLE 9. (continued)

Inst. Code No.	Sensitivity	Resolution or Bandwidth	Accuracy	Sample Size	Concentration	Sample Temp.	Flow-Cell Capability	Ambient Temp.	Rack-Mount Available	Wavelength	Miscellaneous
137			0.1 mV				yes				± 1000 mV 0-14 pH
138				0.7 ml		25, 30, 32, 37 C				340-700 nm	0-2 A includes sample aspirator
139				<1 ml	1:1200		yes	15-40 C			
140				3 ml	$2\text{-}4 \times 10^5$ cells/mm^3			20-32 C			deion. water and drain required 24 hr/day
141											
142	10 X scale expansion	0.14 nm		60 μl - 20 ml compartment 17 x 7 x 9 cm						185-3000 nm	0-2.7 A, 0-200% T 0-6000 conc.
143											0-3 A, 0-6000 conc. 0-900% T
144			0.05°	2.5 ml							0-360° range
145											
146	10^{-4} A			8 μl			yes			210-700 nm	0.01 - 2.56 A
147				3-45 ml						436/546 nm	0-135° scatter angle
148	7 mμ - 5μ							0-78 C		436/546 nm	angular range 0 ± 150° molecular wt. 300-10^9
149	0.1 μW/cm^2							0-45 C		450-950 nm	
150	5×10^{-4} A 0.2 nm		± 0.006 A at 1 A	8 μl			yes			210-780 nm	0-2 A
151	10^{-3} O.D.	15 nm		0.07 ml			yes	0-40 C		280 nm	0-3 O.D.
152		3×10^{-5} nm 8 nm		17 μl			yes			200-700 nm	0-2 A pressure feed mechanism
153				0.05-0.3 ml			yes	15-30 C		254 nm	

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TABLE 9. (continued)

Inst. Code No.	Sensitivity	Resolution or Bandwidth	Accuracy	Sample Size	Concentration	Sample Temp.	Flow-Cell Capability	Ambient Temp.	Rack-Mount Available	Wavelength	Miscellaneous
154		0.1 nm								185-750 nm	
155		0.1 nm								185-750 nm	
156							yes	-29 to 52 C		254-975 nm	0.5-4.0 A
157	0.0001 A	0.001 A 10 nm	0.002 A							366 nm (filtered)	0.0001-2.000 A
158	0.001 A	0.001 A	0.5% A	down to 0.025 ml		0-100 C				185-800 nm	0-3 A, scan speeds 0.5-10 cm/min
159				scans up to 14 cm						620 nm	0-3 O.D., scans 2.8-5.6 cm/min
160		7 nm								400-1100 nm	0-2 A
161		8 nm								325-925 nm	0-2 A 0-100% T
162		8 nm					yes			325-925 nm	0-2 A, 0-100% T 0-2000 conc.
163											
164	$5x10^{-8}$ RI units			8 µl			yes	0-100 C			
165	10^{-6} RI units							0-100 C			RI 1.30-1.71
166	0.1-1.0 ng				10^{-10} M		yes				
167			0.5%	8 ml		0-100 C	yes				0-140.000 µm hos/cm
168				110-145 ml	up to 50%						particle size to 1000 µ 0.1-100,000 µm hos/cm
169				12 ml							0-5 µm hos/cm x 0.1, 1, 10, 100, 1000
170			2%	2 µl			yes	20-40 C			1-1000 µm hos/cm at 3000 HZ

TABLE 9. (continued)

Inst. Code No.	Sensitivity	Resolution or Bandwidth	Accuracy	Sample Size	Concentration	Sample Temp.	Flow-Cell Capability	Ambient Temp.	Rack-Mount Available	Wavelength	Miscellaneous
171											
172											10-1010 counts/min. internal well crystal
173					0-10,000 ppm			10-20 C			
174				60 x 40 μm up to 13 x 18 cm							scans 625 lines 50 video frames/sec.
175	0.01 JTU			50 ml						400-1000 nm	0.5-500 JTU meas. scatter ratio
176									yes		count cap (data) 10^8 " " (time) 10^{12}
177								0-50 C			2 counters, each 10^7 cap. for time or input pulse
178											ditto
179	7×10^{-4} μCi of ^{137}Cs	<9%[b]		10 ml				0-50 C			
180	0.001A	0.2 nm		100 μl			yes			254 nm	0-2A
181	0.005A			8 μl			yes			254 nm	0-2.56A
182	10^{-9} W/cm^2									235-340 nm	
183		0.2 nm		0.5 or 0.12 ml			yes			190-850 nm	0-1.5A (attenuated to 3.5A)
184	10^{-5}T									160-320 nm	0-5 O.D. remote detector
185		10 nm								220-900 nm	0-2A 0-100% T 0-2000 conc.
186		2 nm								195-900 nm	0-2A, 0-100% T 0-2000 conc.
187		0.005A		0.7 ml (aspirated)						340-700 nm	0-2A scans up to 4.4 cm

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TABLE 9. (continued)

Inst. Code No.	Sensitivity	Resolution or Bandwidth	Accuracy	Sample Size	Concentration	Sample Temp.	Flow-Cell Capability	Ambient Temp.	Rack-Mount Available	Wavelength	Miscellaneous
188		aperture 1-3 mm	±0.02 O.D.	up to 30.5 x 28 cm							10^5 O.D. auto ranging scans up to 7.5 cm/sec.
189		10^{-10} watts		detector area 1 cm^2						450-950 nm	10^{-7} to 10^{-2} watts micro probes avail.
190			2%							350-660 nm (filters)	
191		9 nm	2%	4 ml or 75 µl			yes	up to 50 C		335-710 nm	
192								-20 to +50 C		200-850 nm	
193							yes				specifically designed for flow systems
194	5 PPT	15 nm	±0.2% DC output	1.8 or 2.2 ml						300-700 nm emission	high-low 30:1 + 7 ranges of sensitivity
195				compartment 9 x 15 x 10 cm						250-800 nm emission	0-2A 0-100% T
196	0.005%		0.05%	0.02-25 ml			yes				0-111, 111 ohms (2 ranges) bridge freq. 1000/3000 Hz
197	0.05%		0.25%	0.02-25 ml			yes				1 ohm - 1.1 meg ohm bridge freq. 100/1000 Hz
198								-5 to +65 C	yes		0-60,000 µMhos auto ranging
199											
200	0.01 pH or 1 mV										delay potentiometer, 10 - 60 sec.
201	particle size 0.5 - 4µ		±1% full scale							400-1000 nm	0.5-500 JTU, sensor remote to 30 m
202	3 PPB full scale		±0.5%	0.25-9 ml			yes			254-600 nm	
203	2 PPB full scale	0.5 nm		4.5 ml						200-1100 nm	0-2A, 0-200% T
204		0.5 nm								200-700 nm	

TABLE 9. (continued)

Inst. Code No.	Sensitivity	Resolution or Bandwidth	Accuracy	Sample Size	Concen-tration	Sample Temp.	Flow-Cell Capability	Ambient Temp.	Rack-Mount Available	Wavelength	Miscellaneous
205	0.1 PPB quinine SO_4										0 - 2 O.D. energy level adjustable
206	10^{-4} μg	0.5 nm		up to 4.5 ml			yes			200-700 nm	
207		display re-sol. 1 part in 1000						0-45 C	yes		time 1.10 M sec. 1024 channel memory
208				pulse input 0-10 V							count 99,999 x 128 chan-nels, time 10-1[illegible] K sec.
209								0-45 C	yes		time 10-100 K sec. x 5 count 100-1M x 256 channels
210											
211				3.5 ml			yes	10-25 C			3 channels
212			± 0.5%			0-60 C		0-50 C			0.2-200,000 μm hos 40/4000 HZ sensor
213											0-50,000 μm hos/cm
214	0.001 A	0.2 nm	±0.5 nm							190-900 nm	0-2 A, 0-200% T 0-8000 conc.
215											
216	-0.5 V					ambient only	yes	20-30 C			counts 100-1,000,000 time 0.01-100 min
217								-6 to 30 C			
218								0-30 C			for dual labeled samples
219				5 μl sample 250 μl reagent						340 650 nm (filtered)	wavelength pairs meas. 2 points in reaction
220				7.5 ml							counts to 99,999 time 0-100 min
221			± 0.001 pH			0-100 C					0± 1999.9 mV

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TABLE 9. (continued)

Inst. Code No.	Sensitivity	Resolution or Bandwidth	Accuracy	Sample Size	Concen-tration	Sample Temp.	Flow-Cell Capability	Ambient Temp.	Rack-Mount Available	Wavelength	Miscellaneous
222		0.2 nm					yes			190-900 nm	0-2.0 A 0-8000 conc.
223				1.5 ml			yes			340-800 nm (filters)	
224	bandpass 84-47 nm			1.5 ml			yes			415-640 nm	0-100% T 0-2 A
225				up to 14 cm scan length						40(00 filter wheel	0-3 O.D. scans 5/10 mm/sec.
226				25-200 μl 3 cells						340-630 filter wheel	sample is aspirated into sealed cuvette
227	10^{-7} R.I.			8 μl dissolved mati only			yes				R.I. 1,333 ± 0.02 for water solvent. Teflon 33 packing
228				5-50 ml		up to 100 C					2 independant titrations, samples taken at preset interval
229			± 2% full scale	5-40 ml	50-1000 ppm		yes	10-50 C	yes		0-10,000 μm hos, flow-cell 2.4 m remote
230			± 3% full scale								0 - 1200 FTU
231	0.5%		1%	dipping probe		0-50 C					0-50,000 um hos, sensor freq. 800 Hz
232			± 1%					25-50 C			count to 999,999
233	typical 0.7 μ	605,000 picture points in view field		microscope slide							0-2.52 A in increments of 0.01/0.02/0.04 O.D.
234				microscope slide							
235											for film densitometry and other macro appl.
236		0.05 μ					yes			2500 - 14,500 nm	0 - 2 A 0 -100% T
237								up to 60 C	yes		optical sensor 4.5 m remote
238				0.5-5 ml				0-45 C			-1600 to + 1200 mV 0-14 pH

TABLE 9. (continued)

Inst. Code No.	Sensitivity	Resolution or Bandwidth	Accuracy	Sample Size	Concen-tration	Sample Temp.	Flow-Cell Capability	Ambient Temp.	Rack-Mount Available	Wavelength	Miscellaneous
239			0.1 min. angle	0.2 - 2 ml				0-50 C		404-656 nm	15-100° angle
240			0.0025 A	1.0 - 3.6 ml 10-100 sample				18-28 C		340 nm	0.05 - 2.0 A time 1 - 9 min.
241				2.2 ml	9%					610 nm	
242		light emitting diode 1 mm beam	± 0.01 O. D.	up to 40x40 cm						670 nm	0 - 4 O.D.
243	0.0001%			up to 5 cm dia.				0-50 C			remote probe analyzer 2 elements simul.
244											locate & list 8 elements multiple element mapping
245	0.001%							0-50 C			1 element only, S to U
246								16-30 C			
247	ng/cm^2			1.2 cm dia. up to 6.4 cm high							may use 2 simul. transm. target tubes
248										2,500 to 25,000 nm	
249	0.05 PPB quinine SO_4	0.02 nm								200-900 nm	scan 15-480 nm/min.
250		0.2 nm		2 sample compt. 18x20x20 cm 4x20x20 cm						185-850 nm	0 - 1 A 0 - 100% T
251		0.1 nm	± 0.002 A	compartment 21x23x13 cm			yes			190-700 nm	0-2 A double-beam optics
252			± 1% T	compartment 26x16x13 cm						2,500 - 25,000 nm	0-100% T, focused light beam 2 x 8 mm
253		25 nm								400-700 nm	0-4 A 0-100% T
254	10^{-10} mg ATP									560-580 fixed	
255		0.0001 A 8 nm								330-700 nm	0-1.999 A

TABLE 9. (continued)

Inst. Code No.	Sensitivity	Resolution or Bandwidth	Accuracy	Sample Size	Concen-tration	Sample Temp.	Flow-Cell Capability	Ambient Temp.	Rack-Mount Available	Wavelength	Miscellaneous
256	0.0001 A 8 nm		1%	10-100 μl 56 samples		25,30, 32,37 C				340-700 nm	0-2 A mag. card input
257											1/250 - 1/6000 sec shutter speed
258								-30 to + 65 C			shutter correlation pulse 1.5 V, 1 msec, 500 ohms
259	cell size adjustable			25 μl							WBC 0-28,800 cells/mm^3 RBC 0-8,000,000 cells/mm^3
260				20 μl + diluent	WBC 1:800			15-40 C			
261			0.05°	13 ml						589 nm	0 ± 90° rotation
262			0.2% >1° 0.002% ≤ 1°							365-589 nm filters	0 ± 80° rotation
263	0.001° rotation										
264		0.01° rotation								400-700 nm	0 ± 99° rotation
265				flow rates up to 100 ml/min			yes	-29 to + 52 C		546 nm	TFE cells with quartz windows
266								4-50 C			4 channels
267								-28 to + 70 C			requires timer and pulse receiver
268								-18 to + 66 C	yes		freq. 0.4-10.0 MHz
269											cooling water req.
270										340-650 nm	keyboard operation 26,624 bit computer
271				7.5 ml							keyboard operation

Glossary of Abbreviations

A - ampere; also absorbance units, logarithm to the base 10 of the reciprocal of the transmittance. $A = \log_{10} (1/T)$.

ASA - relative film exposure index (photography).

ATP - adenosine triphosphate.

CI - curie(s).

conc. - concentration units; in absorption spectrometry, usually expressed in grams per liter.

exp. - exposures (in photography).

FTU - Formazin Turbidity Unit; refers to method of standard preparation; units interchangeable with JTU.

JTU - Jackson Turbidity Units.

O.D. - optical density units.

RBC - red blood cells; erythrocytes.

RI - refractive index.

T - transmittance (of light); expressed in percent. The ratio of the radiant power transmitted by a sample to the radiant power incident on the sample.

TFE - tetrafluorethylene.

WBC - white blood cells; leukocytes.

Another important factor in evaluating the instruments is the data display. This is summarized for each instrument in Table 10. In this table, the instruments are listed by the code number and the table indicates read-out methods which are built in and output signals which are generated by the equipment for purposes of information retrieval.

Thus, all of the factors relating to size, power requirements, performance, sensitivity, and output have been summarized in this section of the report. An additional requirement of our research program was to categorize the classes of biological compounds which could be detected. This primarily is a function of the physical principles underlying the detection method. The next section of this report contains a discussion and description of the principles of detection. In this section, the ability of each method to detect various biological candidate materials is summarized.

PRINCIPLES OF ANALYTICAL TECHNIQUES

Photometric Methods

By far the largest number of instrumental techniques for analysis described in this report are based upon photometric techniques. This is because of the great versatility, reliability, and rapidity of photometrically based methods. Photometric methods can be divided into the areas of adsorptive, refractive, and emissive techniques. These will be discussed below.

Adsorptive Methods

A ray of light coming in contact with a molecular species can interact with that species in such a way that the radiant energy is adsorbed by the species. Depending upon the frequency of the light, the absorption

TABLE 10. DATA DISPLAY METHODS

Instrument Code No.	Readout: Recorder	Readout: Meter	Readout: Digital	Readout: CRT	Readout: Printer	Output Signal: Recorder	Output Signal: Impedance Match, ohms	Output Signal: BCD
1		X				5/60 mV		
2						0-100 mV		
3						10/100 mV 300 uA	500, 100 K	
4	X							
5						± 2 V		
6				X	X			
7		scale						
8	X							
9			X	X				
10								
11	X							
12			X					X
13			X					X
14		X						
15		scale						
16			X			0-10 V	10 K	X
17	X							
18					X			
19		X				0-0.5 V	1 meg	
20	X							
21	X		X					
22						0-10 mV		
23	X							

TABLE 10. (continued)

Instrument Code No.	Readout: Recorder	Meter	Digital	CRT	Printer	Output Signal: Recorder	Impedance Match, ohms	BCD
24			X					
25			X	X				
26			X	X				
27			X	X	X			
28			X					
29					mag	± 10 V		
30						4 V pulse	300	
31								
32			X					
33			X					
34	X							
35		X				100 mV		
36			X			1V	7K	
37			X					
38			X	X				
39		X						
40		X				50/500 mV		
41	X							
42		X				0-10 mV		
43				X				
44				X				
45								
46		X				0-1 mA, 0-1 V		

TABLE 10. (continued)

Instrument Code No.	Readout: Recorder	Meter	Digital	CRT	Printer	Output Signal: Recorder	Impedance Match, ohms	BCD
47			X	X	X			
48		X				0-10 V		
49			X					X
50			X			± 5 V		
51			X					
52			X		opt.			
53								
54		X						
55	X							
56	X		X					
57		X				10/100 mV, 1 V	24/231, 1.6 K	
58						10 mV		
59								
60						0-10 mV	10 meg	
61								
62		scale						
63		X						
64		X						
65	X		X					
66								
67	X	X	X					X
68						0-1 V		
69			X			5/10 mV, 8-24 V		

TABLE 10. (continued)

Instrument Code No.	Readout: Recorder	Readout: Meter	Readout: Digital	Readout: CRT	Readout: Printer	Output Signal: Recorder	Output Signal: Impedance Match, ohms	Output Signal: BCD
70			X					
71		X				0-10 mV	25K	
72			X					X
73	X		X					X
74			X					
75			opt.			10 V		
76	opt.					5/10 mV, 8-24 V		
77						100/200/300 500/1000 mV		
78			X			10 mV, 1 V		
79	X							
80			X			0-100 mV		X
81		X				100 mV		
82			X			100 mV		
83		X						X
84			X					
85	X							
86			X	X	X			
87								
88	X		X	X	X			
89			X		X			X
90			X					
91		X				10 mV		
92		X				1000 mV		

TABLE 10. (continued)

Instrument Code No.	Readout: Recorder	Readout: Meter	Readout: Digital	Readout: CRT	Readout: Printer	Output Signal: Recorder	Output Signal: Impedance Match, ohms	Output Signal: BCD
93		X						
94			X	X				
95		X				0-1 V		
96			X			0-10 V	10 K	
97								
98	X				X			
99		X				10/100 mV	10 K	
100		X						
101		X						
102	X				X			
103				X				
104				X	X			
105						10/100 mV, 4 V		X
106			X			10/100 mV, 4 V		X
107			X			10/100 mV, 4V		
108			X			10/100 mV, 1 V	4/24/231	
109	X							
110	X		X					
111						0-10 mV	25 K	
112						0-10 mV	< 25 K	
113								
114						100 mV		
115	X					1 mA, 1 V		

TABLE 10. (continued)

Instrument Code No.	Readout					Output Signal		
	Recorder	Meter	Digital	CRT	Printer	Recorder	Impedance Match, ohms	BCD
116			X		X			
117		X						
118						1/10 mV		
119	X				opt.	500 mV		
120		X				100 mV		
121	X		X					
122			X			100 mV	1 K	
123			X		X	0.1 A, 100 mV		
124			X					
125				X				
126			X					
127			X			-1 V		
128			X					
129			X					
130					X			
131		X				1 mA, 10 mV		
132	X	X						
133								
134								
135								
136			X			0-100 mV		X
137			X					X
138			X		X	50 mV		X

TABLE 10. (continued)

Instrument Code No.	Readout					Output Signal		
	Recorder	Meter	Digital	CRT	Printer	Recorder	Impedance Match, ohms	BCD
139								
140			X	X	X	20 mA		
141								
142			X			1 V		X
143			X			1 V		
144		scale						
145								
146						10 mV		
147			opt.			5 mV		
148			X					X
149			X					X
150		X				100 ± 10 mV		
151						10/100 mV, 1 V		
152			X		X			X
153						100 mV		
154	opt.		X					
155	X		X					
156						0-10 mV		
157			X					X
158			X			0-6 V		X
159	opt.					0-50 mV	3K	
160		X						
161		X				0-1 V		

TABLE 10. (continued)

Instrument Code No.	Readout: Recorder	Readout: Meter	Readout: Digital	Readout: CRT	Readout: Printer	Output Signal: Recorder	Output Signal: Impedance Match, ohms	Output Signal: BCD
162			X			0-2 V		
163		X				0-100 mV		
164						0-10 mV	<25 K	
165		scale						
166						0-100 mV		
167		X				0-1 V		
168		X						
169		X						
170		X				10 mV		
171						1 mA, 10 mV		
172			X					
173		X						
174	X	X	X					X
175		X						
176		X	X			0 ± 1 V	1 K	X
177					X	100 mV, 10 V	100	X
178								X
179			X		X			
180						10 mV, 1 mA		
181						1 mA, 1/10 mV		
182			X			10/100 mV, 1 V	4/24/231	
183	X					10/15 mV, 1.5 V	5 K	
184		X				0-50 mV, 6 V	50	

TABLE 10. (continued)

Instrument Code No.	Readout					Output Signal		
	Recorder	Meter	Digital	CRT	Printer	Recorder	Impedance Match, ohms	BCD
185			X					X
186			X					X
187			X		X	50 mV		
188						1 V per cm, X-Y	1 K	
189			X					opt.
190		X						
191		X	X			0-1 V		
192		X				1 V	10	
193		X				5/50 mV		
194		X	X			0-1 V		
195		X						X
196			X	X				
197		X	X					
198		X				0-10 V	250 K	
199								
200			X					
201		X				0-10 V		
202						0-1 mA, 0-10 mV		
203	X							
204		X	opt.			10/100 mV		
205		X				0-100 mV		
206		X	opt.			10/100 mV		
207				X		0-1 V		X

TABLE 10. (continued)

Instrument Code No.	Readout: Recorder	Readout: Meter	Readout: Digital	Readout: CRT	Readout: Printer	Output Signal: Recorder	Output Signal: Impedance Match, ohms	Output Signal: BCD
208				X				
209				X				
210					X			
211					X			
212						250 mV		X
213		X				0-20 mA, 0-10 mV		
214			X					
215					X			
216			X		X			
217			X		X			
218			X					
219			X					
220			X					
221			X			100 mV, ± 15 V		X
222	opt.		X		opt.			
223		X						
224		X						
225	X							
226			X					
227						1/10 mV		
228	X							
229		X						
230		X						

TABLE 10. (continued)

Instrument Code No.	Readout: Recorder	Meter	Digital	CRT	Printer	Output Signal: Recorder	Impedance Match, ohms	BCD
231		X						
232						1 mA, 100 mV	100/1500	
233				X	X			X
234				X				X
235				X				X
236		X	opt.					
237						0-100 V		
238		X				500 mV		
239								
240						100 mV	100 K	
241		X						
242			X			1/10 V		
243			X					
244				X				
245			X					
246			X					
247			X					
248	X					10 mV, 1 V		
249			X			10 mV, 1 V		
250	X					10 mV, 4 V		
251			X			10 mV, 2 5 V		X
252	X							
253		X		X		12 V	25	

TABLE 10. (continued)

Instrument Code No.	Readout: Recorder	Readout: Meter	Readout: Digital	Readout: CRT	Readout: Printer	Output Signal: Recorder	Output Signal: Impedance Match, ohms	Output Signal: BCD
254			X				0-10 K	
255			X		opt.			X
256					X	100 mV		X
257								
258								
259		X						
260			X					
261		scale						
262			X			10 mV, 10 V		X
263			X					
264			X					
265						0-10 mV		
266		X						
267				X				
268				X				
269			X	X				
270			X		opt.			
271			X					

of the energy causes a change in the electronic, vibrational, and rotational energy levels of the molecule absorbing light. Light absorbed in the visible and ultraviolet regions causes a change in the electronic energy levels; absorption in the infrared region is a result of changes in vibrational and rotational energy levels. A close relation exists between the extent of absorption and the concentration of the absorbing substance. The change of the intensity of light with distance through an absorbing substance can be written as follows.

$$\frac{dI}{dx} = -KCI$$

where C is a concentration of the absorbing substance, I is the intensity of the light at the distance x, and K is the constant characteristic of the substance and the wavelength of the incident light. Since the intensity of the light decreases as it passes through the substance, the sign of the right-hand term is negative. This expression can be integrated to give the following expression.

$$\log \frac{I_o}{I} = ACd$$

where I equals the intensity of the radiation emerging from the sample cell, I_o the intensity of the incident radiation, and d the thickness of the sample. The quantity A is known as the molar extinction coefficient and is characteristic of a particular substance at a given wavelength. The quantity $\log \frac{I_o}{I}$ is known as the optical density, and it can be seen that this term is directly related to the concentration. The above equation, which describes the Lambert Beer law, indicates that the optical density measured should be directly proportional to the concentration of the unknown in solution. Under proper conditions, this is generally true and these conditions will be discussed in subsequent sections of this report.

The basic schematic diagram for a photometer is very simple and is shown on the next page. Light from the light source passes through a slit to the wavelength selector which can be either a filter, prism, or diffraction grating. It then passes through a second slit into the sample and the intensity of the light is measured by a photomultiplier tube. In the simplest types

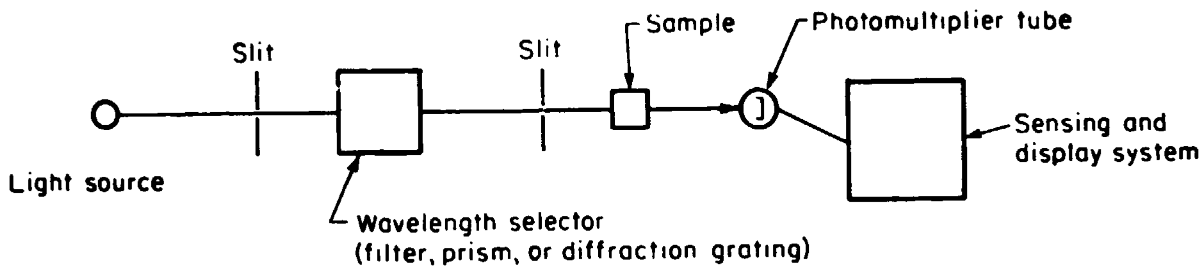

FIGURE 1. BASIC DIAGRAM OF A PHOTOMETER

of colorimeters, the light source is an incandescent lamp. The proper wavelength region is selected by a series of band-pass filters and the filtered light passes through the sample. It should be noted that the photomultiplier tube gives a signal directly proportional to the intensity of the radiation as it emerges from the sample. From the above equation, it can be seen that the relationship between the concentration of the sample and the emergent radiation is a reciprocal log function and is not related linearly. In photometers with simple electronics, the conversion from the voltage output of the photocell is accomplished by a nonlinear dial reading or by reference to a table relating 100 percent transmittance to concentrations. Because of this nonlinearity, simple photometers do not give accurate readings at high optical densities. In systems utilizing band-pass filters, deviation from Beer's law can occur if the band pass covers too broad an area of the absorption peak of the substance being analyzed.

In more complex spectrophotometers, further refinement of the simple diagram shown above are included. In order to compensate for voltage fluctuations and variations in intensity of the light source, the beam may be split into two components after it goes through the wavelength selector, as shown in the next figure. One of the beams traverses the sample and the other goes through a reference cell. Changes in volume current, source intensity can then be electronically compensated. The output signal from the photocell can be converted electronically to a logarithmic output which is directly proportional to concentrations.

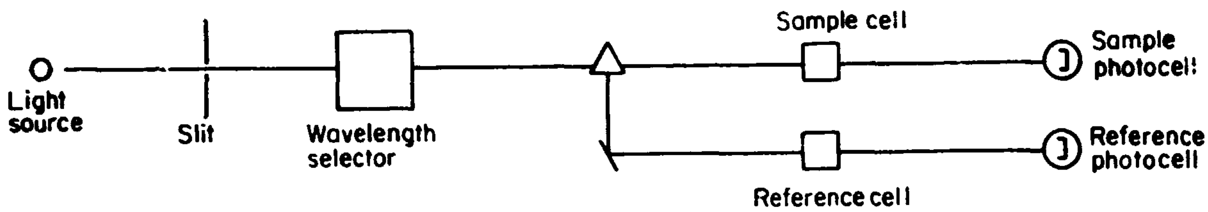

FIGURE 2. SIMPLIFIED DIAGRAM OF A DOUBLE-BEAM PHOTOMETER

Spectrophotometric methods can be further classified according to the type of measurements one desires on a given sample. In the first case, one may wish to obtain a scan of the abscrption of light of a given sample over a range of wavelengths starting from UV through the visible spectrum. To obtain such a scan, one needs an instrument which has a drive mechanism coupled with the wavelength selector and which operates on a double-beam principle. In precision instruments, the selection of wavelengths is performed by a diffraction grating and gratings are now available which can give a very accurate selection of wavelengths.

A second type of measurement which one makes with photometric equipment is the absorption of a given sample at discrete selected wavelengths in order to determine concentrations of constituents in the sample. In this case, one is not interested in a wavelength scanning function but is concerned with the ability to select wavelengths with as narrow as possible a band width. This type of photometer could be of special interest to the NASA program because many of the instruments of this type which are available are quite compact and simple in their operation. They operate at a few preselected wavelengths which are determined by the type of material being analyzed. For example, if one wishes to analyze proteins, a device would operate at a wavelength of 280 nm. Nucleotides in general can be detected at 260 nm and reduced NAD at 340 nm. A great many instruments of this type are available as can be seen from our instrument survey section of this report.

Spectrophotometric instruments are categorized by the region of wavelengths in which they are capable of operation. As mentiond before, the three categories are ultraviolet, 150-350 nm; visible, 350-1000 nm; and infrared, 1000-15,000 nm. In a general sense, infrared spectra are useful in determining information about the molecular structure. They would not be of great value in this present program for several reasons. First of all, the particles being analyzed would be suspended in an aqueous medium which would blank out the absorption spectrum of any species in solution. Second, the extinction coefficients in the infrared region are small compared to those in the visible and ultraviolet regions, and thus even if an aqueous solvent were not used, relatively high concentrations of the sample would be required.

Absorption of ultraviolet and visible light are a result of electronic transitions occurring within the sample molecules. Many spectrophotometers have capabilities of measuring absorbed light in both regions and several are included in this report. It should be noted that although the optical principles of UV and visible light spectrophotometers are the same, two differences exist on a practical level between these two light absorption regions. The first is the light source. A simple incandescent light source can be used in visible region. However, for UV measurements, the incandescent source is inadequate at the shorter wavelengths and one must use a hydrogen-deuterium lamp. The second difference is the type of materials used to contain the sample. In the visible region, one can use glass and various kinds of transparent polymers to contain the test solution. In the UV region, these materials absorb: thus, quartz must be used as a sample container.

Photometric instruments may be categorized from the standpoint of the physical form of the sample being analyzed. In the most common arrangement, the sample is contained in a discrete sample cell in a compartment within the instrument. The sample is thus removed from a solution being analyzed and is homogeneous. A number of photometric analysis systems have automated accessory equipment for placing samples in and out of the sample compartment. In addition, if a series of samples are measured over a time period to analyze a kinetic reaction, equipment is available to automatically move samples in and out of the photocell compartment at selected time intervals.

A second type of sample configuration which should be of definite value to this program is the flow cell. In this configuration, the sample is continuously flowed through the light beam of the instrument. The flow cell arrangement interfaces very well with separation processes and can be conveniently used to monitor the effluent from such processes. For example, many flow cell systems exist for monitoring proteins separated on chromatographic columns. In NASA's program on separation of biological macromolecules in space, UV and visible absorption flow cells could be used to monitor effluents from a wide variety of separation devices including both the batch and continuous-flow types.

A third type of photometric measurement configuration which is used to analyze samples which are nonhomogeneous is commonly referred to as optical densitometry. In this configuration, the sample traverses the light beam in one or two dimensions and the concentration of the various constituents of the sample in their respective zones can be detected. This method is commonly used to analyze disk, gel, flat gel, and strip electropherograms. Results from such a scan are obtained as a plot of the optical density as a function of distance in the X direction. A simplified diagram of a scanning densitometer is shown below.

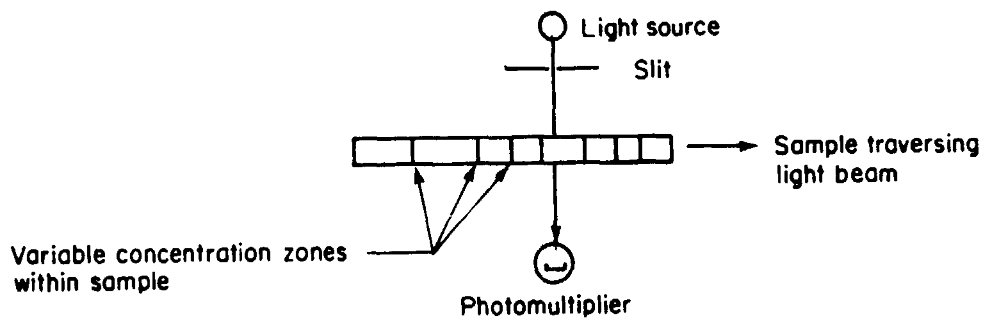

FIGURE 3. DIAGRAM OF SCANNING OPTICAL DENSITOMETER

Another variation of the optical densitometric procedures allows the sample to remain in a fixed position while the light beam moves over the sample. This can be accomplished by a fiber-optic light pipe which transmits the illuminating light to the surface of the sample. It is then reflected back and transmitted to the photomultiplier tube by another light pipe contained in this same probe. The probe can traverse a sample in the X and Y dimensions and is useful for scanning thin-layer chromatographic plates. A sketch of this device is shown below.

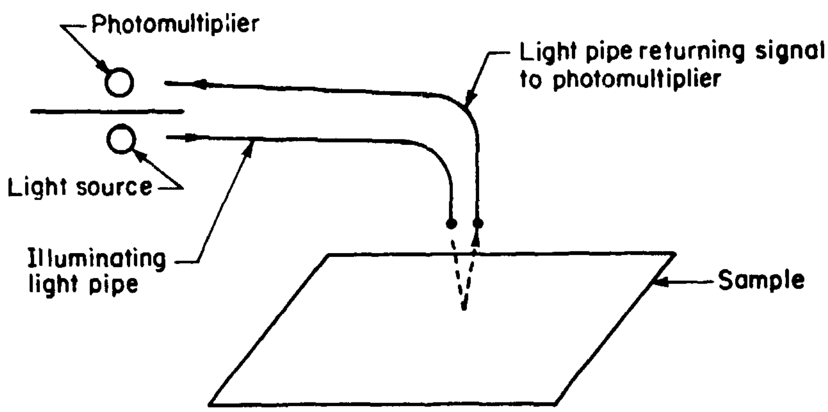

FIGURE 4. LIGHT PIPE SCANNING OPTICAL DENSITOMETER (REFLECTING)

A similar arrangement could be used in scanning a free-flow electrophoresis unit if the materials were transparent to the wavelength of light used and if a reflecting surface were used on the back side of the sample cell. In addition to reflected light, transmitted light can also be used with a fiber-optic probe. In this case, the return light pipe is placed on the other side of the sample. The two probes then move in conjunction with each other and traverse the sample.

Another modification employing fiber optics for monitoring concentrations of effluents in an electrophoresis system was developed by Hannig[(1)*] and is shown schematically on the next page.

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* References begin on Page 141.

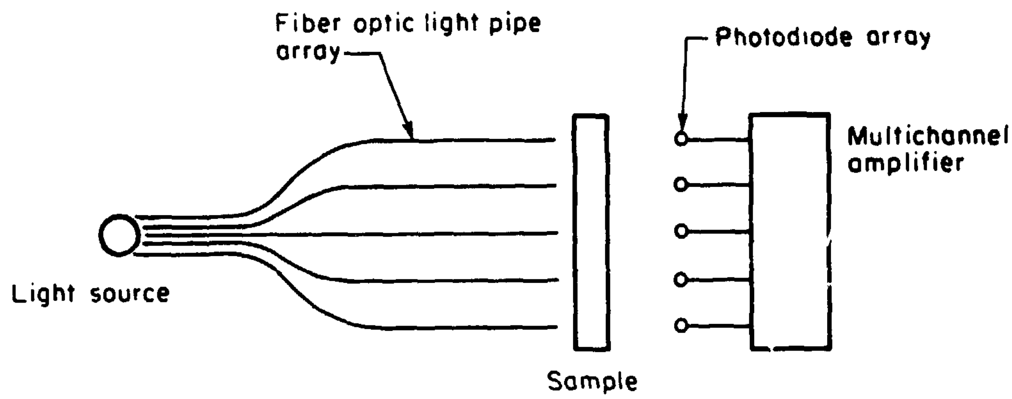

FIGURE 5. MULTIPLE LIGHT PIPE DENSITOMETER

In this system, an array of fiber-optic probes directs light to several channels of the effluent from the electrophoresis device. On the other side of each channel is a light-sensitive diode. In Dr. Hannig's arrangement, the signal from each of the diodes is scanned periodically and the data are then displayed on a television screen. This system enables the concentration of sample in several different effluent streams to be monitored simultaneously.

Photoemissive Methods

In addition to photoabsorptive methods, the emission of photon energy can be used as an analytical method for biologically derived species. Three types of photoemission are generally used for analysis and characterization of molecular species. These are fluorescence, phosphorescence, and Raman spectra. All of these result from the adsorption of light by a molecule at one wavelength and emission of light by the same molecule at another wavelength. Raman spectra occur when light interacts with molecules at a level insufficient to cause an electronic transition; rather the light causes a vibrational shift in the molecule and is reemitted at a slightly longer wavelength corresponding to the energy of the vibrational shift.

Raman spectra bear a great deal of resemblance to infrared spectra and are useful in elucidating functional groups and structural relationships in organic molecules. They are not as valuable in indicating the relative concentration of different constituents and therefore have not been considered in any detail in this report.

Fluorescence and phosphorescence result from the adsorption of UV or visible light by a molecular species. The adsorbed light is reemitted by the molecular species almost always at a slightly longer wavelength. The difference between phosphorescence and fluorescence is the time required for reemission of the adsorbed protons with fluorescence being more rapid by several orders of magnitude. For the detection of biological macromolecules, fluorescence is much more valuable than phosphorescence and will be discussed in further detail in this section of the report.

Fluorescence Spectra. As mentioned previously, fluorescence is described as the adsorption of ultraviolet or visible light by a molecular species followed by reemission of the light at a slightly longer wavelength. When the molecular species adsorbs the light, an electronic transition occurs placing the molecule in an excited state. In this excited state, the molecule then shifts to a slightly lower vibrational energy level and from this level a photon is emitted causing the molecule to return to the electronic ground state. Because some energy is lost in the shift to a lower vibrational or rotational energy state, the wavelength of the resulting emission is somewhat longer than that of the adsorbed light. Fluorescence, of course, can only occur in wavelength regions where the molecule adsorbs the incident light. Adsorption of visible or UV light by a molecular species certainly does not indicate that fluorescence will occur. Most molecules which adsorb light in this region dissipate the energy by rotational and vibrational modes and do not emit photons in the visible region. A number of biological molecules do exhibit fluorescence and thus this technique can be used in a wide number of applications.

A schematic diagram of the operation of a spectrofluorometer is shown below.

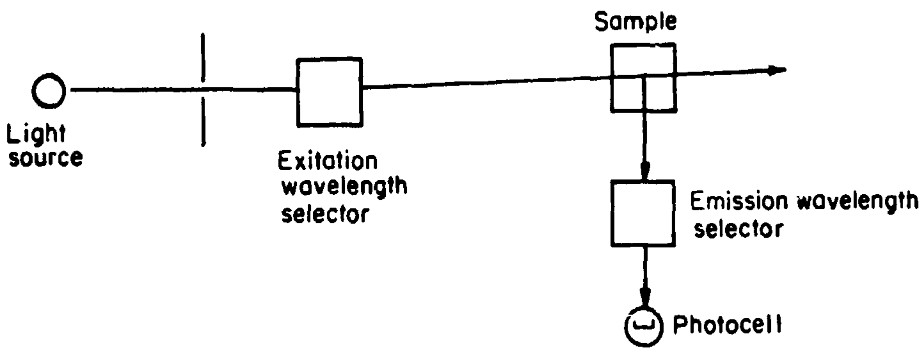

FIGURE 6. SIMPLIFIED DIAGRAM OF A SPECTROFLUOROMETER

Light from the light source goes through the monochromator for wavelength selection for excitation of the sample. It is adsorbed by the sample and reemitted as fluorescence in all directions. The emitted light is commonly measured at an angle of 90 degrees from the exciting light. This emitted light is passed through a second monochromator and is then detected by a photocell. In the design of such an instrument, care must be taken to avoid errors from scattered light since the intensity of the emitted light is much smaller than that of the incident light.

A molecular species which fluoresces has two characteristic spectra. These are the excitation spectrum and the emission spectrum. Excitation spectra are obtained by measuring the intensity of the emitted light at a fixed wavelength while varying wavelengths of the exciting light. The shape of the excitation spectrum is that of the absorption curve of the molecule. Emission spectra are obtained by fixing the exciting light at a given wavelength and measuring the intensity of the emitted light as a function of wavelength. The shape of the emission spectra is independent of the wavelength of the exciting light. Fluorescence measurements have some advantages over light adsorption measurements because of greatly increased sensitivity. In addition, fluorescence can sometimes distinguish between two different molecular species which adsorb light in the same wavelength regions.

The higher sensitivity of fluorometric methods as compared to absorptimetric methods is due to the fact that the fluorescence is a direct measure of the concentration of the fluorescing species. In absorptimetric measurements, the absorbing species reduces the intensity of the transmitted light in relation to its concentration in the sample solutions. For samples of low concentrations, the intensity of the transmitted light from the sample could be reduced very little in comparison to that of a blank and thus accuracy of the measurement could be severely compromised. In contrast to this, if the solutions were assayed by fluorometric methods (assuming the substance were fluorescent), the signal from the blank would be zero while the signal from the sample would be related to the concentration.

The increase in sensitivity which can be realized by fluorometric methods can be as high as three orders of magnitude greater than could be obtained with absorptimetric methods. In addition to greater sensitivity, fluorometry also has the advantage of higher versatility. Commonly, the working concentration range of fluorometry can vary a thousandfold. This versatility arises from the fact that the wavelength of the exciting, as well as the wavelength of the emitted light, can be varied. Quite often, this enables the analysis of a molecular species in the presence of an interfering substance which might have to be removed in a direct absorptimetric measurement.

In fluorometric analyses of complex solutions, interference can occur from compounds which quench the fluorescence of the substance being analyzed. In this case, these substances must be removed to ensure the accuracy of the assay. Fluorometric measurements are widely used in the analysis of biological mixtures and can be used to detect steroids, lipids, proteins, amino acids, enzyme activities, drugs (such as barbiturates, salicylates, tetracyclines, morphine, and many others). An excellent summary of the utilization of fluorescence in biology and medicine has been written by Udenfriend.[2] A number of biological constituents fluoresce naturally and can be directly detected by fluorometric procedures. However, the usefulness of these procedures is not limited to those materals which fluoresce naturally. For example, the presence and activity of enzymes can be assayed by using fluorogenic substrates for those enzymes. Proteins in free solution and in cells can be identified by coupling with a fluorescent dye containing a reactive functional group. For example, fluoroscein isothiocyanate is commonly used for this type of coupling. In addition, a host of fluorescent dyes are used in cytology to characterize various components of cells. Intracellular enzyme activities can also be detected by interaction with appropriate fluorogenic substrates. Finally, fluorescent antibodies can be used to identify a very large number of biological constituents. These antibodies are conjugated with fluorescent molecules such fluoroscein isothiocyanate. The fluorescent antibody then binds to its respective substrate and measuring the fluorescence constitutes an assay for that particular substrate.

Refractive Methods

When light passes from one medium to another medium of different density, the velocity of the light changes. The difference in velocity in the two mediums causes a shift in the direction of the beam. The change of direction is known as refraction and the refractive index of a given medium is defined as follows

$$N = \frac{\sin I}{\sin R}$$

where I equals the angle of incidence and R is the angle of refraction. By measuring the angles of incidence and refraction, the refractive index of any given substance can be determined. In a given solvent such as water, the refractive index increases with the concentration of a given solute. Therefore, with the appropriate instrumentation, measurement of the index of refraction can provide an analytical technique for concentrations of substances in aqueous solutions.

Detection methods based on refractive methods are of value to the NASA space program because of their relative simplicity and versatility. In this section, we will consider three types of effects based upon light refraction which can be utilized for detection of biological molecules. These are refractometry, light scattering, and nephelometry.

Refractometry. As mentioned previously, the presence of a given solute in a solvent can be detected by the measurement of the refractive index of the solvent. In aqueous systems which are of the most interest in this particular program, the measurement of the index of refraction needs to be highly accurate in order to detect solutes at low concentrations. As in the case of absorption photometry, the sample may be measured in either a batch or a flow-through process. A number of refractometers are available which can measure refractive index of a batch sample. However, for this program, the flow refractometers are of the most use. For monitoring the effluent of a separation device, a differential refractometer can provide a highly sensitive detection means. This device continuously monitors the quantitative difference refractive index between the reference solution and the sample solution. A schematic diagram of the device is shown below.

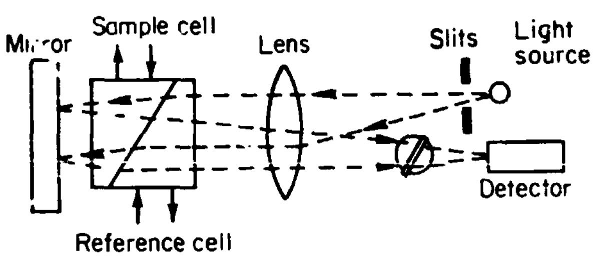

FIGURE 7. SCHEMATIC DIAGRAM OF DIFFERENTIAL REFRACTOMETER

A beam of light from the light source, which is an incandescent lamp, passes through the slit confining the beam to the region of the cell. The lens collimates the beam which then passes through the sample and reference cells. The beam is then reflected back through the sample and reference cells through the lens and focused upon the detector. The location of the focused beam is determined by the difference in refractive index between the sample and the reference cell. As the beam changes its location on the detector, an output signal is generated which is amplified and sent to a meter or corder. Another type of optical system for measuring differences in refractive index between the sample and reference cells utilizes two separate collimated beams of light. A difference in refractive index between these two cells affects the relative intensity of the light and is then detected by a dual photocell. This latter method is somewhat sensitive to dirt, air bubbles, and reflection due to the accumulation of films on the optical surfaces, and thus care must be taken to ensure these cells are absolutely clean.

Differential refractometry can provide a very sensitive method for detection of minute amounts of solute in aqueous systems. However, care must be taken to ensure that both the reference and sample fluid stream are at identical temperatures and under identical pressures since both of these affect the index of refraction. In addition, if buffer solutions are used, the composition of buffer in both sample and reference beams must be identical. To ensure uniform temperature between both streams, a heat exchanger can be employed.

Of particular interest to this program are the differential refractometers manufactured by Pharmacia Fine Chemicals and Waters Associates. The first instrument is capable of measuring differences of 5×10^{-8} refractive index units. It has a very broad range of sensitivity and can measure solute concentrations up to 25 percent (w/v). The cell volume is quite small (8 µl) and thus this instrument can interface with a wide variety of sepa ation devices. The flow rate through the sample cell can be varied over a wide range from 10 ml/hr to 500 ml/hr. The entire unit is a solid-state design with no moving parts. The minimal detectable solute concentrations are as ılow.

	Concentration, µg/ml
Dextran T40	0.3
Yeast RNA	0.2
Ovalbumin	0.4
Ribonuclease	0.2

The Waters instrument is capable of detecting differences in refractive index of 10^{-7} refractive index units and thus has slightly lower sensitivity. Both instruments can detect very sharp peaks of solute in the sample because of the small volume of the photocell detector.

Concentration gradients of biologically derived particles within the separation device itself can be detected also by refractometric methods by a technique described in the following section.

Schlieren Optics. Methods based on refractive index can be utilized to detect the separation of substances within a separation cell itself rather than from a sample eluted from the cell. Such techniques are used in electrophoresis, diffusion, and sedimentation separation devices to detect the various components as they are separated. As mentioned previously, a linear relation exists between the index of refraction of a solution and the concentration of the solute. Thus, any concentration gradient within a given solution will also result in a gradient in the refractive index. If a beam of light traverses a separation cell in which a solute or solutes have been separated in various bands, the refraction of the beam will increase as it passes through each band. The extent of the refraction will be related directly to the concentration of the particular solute in the band. By measuring the extent of refraction of the beam as it traverses the separation cell, one can then determine the location and concentration of solute in the various separated zones. A system for doing this has been developed and utilizes a type of optics known as Schlieren optics. A schematic diagram is shown below.

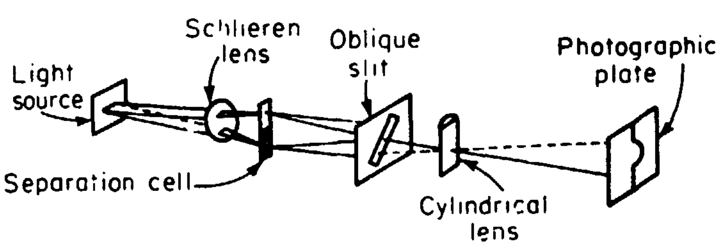

FIGURE 8. DIAGRAMMATIC SKETCH OF THE SCHLIEREN LENS SYSTEM TO OBTAIN THE CONTOUR OF THE INDEX OF REFRACTION GRADIENTS IN A SEPARATION CELL

The cylindrical lens has the property of focusing light horizontally but not vertically. In the presence of a concentration gradient, the line on the plate will be shifted horizontally to produce a hump. The amount of shift is proportional to the refractive gradient and thus the area under the hump is proportional to the concentration difference between the solution and the solvent.

Schlieren optics have been used for a great many years in determining the concentration gradients in electrophoretic, sedimentation, and diffusion cells. This system has the advantage of being generally applicable to a wide variety of solutes and is not dependent upon a particular adsorption band of the solute in question. A number of instruments employing Schlieren optics are commercially available. However, these usually include a Schlieren optic system which is integral with the separation device. For example, the Beckman ultracentrifuges, Models E and L, come equipped with Schlieren optic systems. In addition, the Beckman Model H electrophoresis apparatus also has a Schlieren optic system which is integral with the device. Beckman does make a system which can be purchased separately, but this is made for application to an ultracentrifuge. The major disadvantage of Schlieren optical systems is the precise alignment which is necessary for the system's proper functioning. The system also requires more space than other photometric devices, and this could be a disadvantage for in-flight operation.

Light-Scattering Photometry

When light passes through a medium of uniform refractive index, the beam continues undeflected in the direction of its propagation. However, when any discrete variations in the refractive index of the medium exist, such as those caused by the presence of particles, part of the light will be scattered in all directions. Light scattering is a commonplace phenomenon, and its most common illustration is the scattering of solar radiation in the upper atmosphere to produce the blue color of the sky. The turbidity of liquids and solids (and in some cases their color) is a result of the scattering of incident light. The theoretical bases for light scattering theory were developed by Lord Rayleigh from 1871 onward. With present-day scattering techniques, it is possible to determine the size distribution of particles in a colloidal suspension and the molecular weight and configuration of macromolecules in solution. Thus, the technique of light scattering can have broad applicability to the NASA program for detection of several types of particles.

The general theoretical bases for determination of the properties of particles from measurement of their light scattering are quite complex and will not be discussed in any detail in this report. For purposes of simplicity, we will divide the types of particles to be detected into two areas: particles of size considerably smaller than the wavelength of the incident light and particles equal to or considerably larger than the incident wavelength. The first category includes proteins, carbohydrates, and polynucleotides. In the second category are included bacteria, cellular organelles, and mammalian cells. Rayleigh derived an expression relating the intensity of scattered light of a given particle to the radius, wavelength, refractive index, and the angle of the scattered light. This expression is valid for macromolecules having a radius not exceeding about 1/20 of the wavelength of the incident light.

The basic components of a light-scattering photometer are shown below.

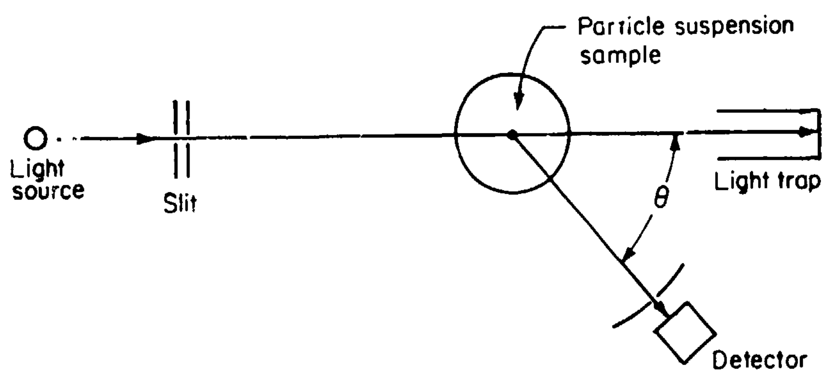

FIGURE 9. BASIC OPTICAL SYSTEM FOR LIGHT SCATTERING

The basic requirements are a monochromatic light source, beam-defining optics, a sample cell, a photodetection system, and a readout device. The photodetection system must be movable to measure the distribution of intensity as a function of the light-scattering angle. The intensity of the scattered light is very low compared to that of the incident light and thus extraneous light must be rigorously excluded from the system. This includes light from reflection of the vessel walls containing the sample, back scattering from the incident beam, and other extraneous light.

Detection and Analysis of Macromolecular Solute Molecules. As mentioned previously, light scattering can be used to determine the molecular weight and shape parameters of macromolecules such as proteins, polynucleotides, and high molecular weight carbohydrates in solution. From the intensity and angular distribution of the scattered light, the weight average molecular weight and the average radius of gyration can be determined. When the molecules in solution are much smaller than the wavelength of the incident light, scattering occurs uniformly in all directions and measurements of scattered light at a single angle will suffice to obtain the needed information about the species in solution. For larger particles, for example, viruses and polynucleotides, scattered light intensity varies with the angle due to interference between different parts of individual molecular chains. In this case, the intensity of the scattered light must be measured at varying angles and at different concentrations. The data must then be plotted in such a fashion that measurements are extrapolated to zero angle and infinite dilutions. Such a plot, called a Zimm plot, enables calculation of the radius of gyration from the slope of the line and molecular weight calculations from the intercept.

The technique of light scattering could be useful in the analysis of macromolecular particles such as proteins and nucleic acids separated by techniques included in the NASA space-processing program. For example, it could distinguish between proteins or nucleic acids of different molecular weights or varying shapes. However, other techniques of analysis based on immunologic or calorimetric methods may be preferred because of their simplicity. The time and effort involved in constructing a Zimm plot can be a drawback for this technique. For larger particles, recently developed methods discussed in the following section could be of considerable value.

Detection of Suspended Particles

Light-scattering techniques provide a highly versatile method for counting and quantifying properties of particles larger than 0.5 μ in suspension. Many types of particle-counting and detection instruments are based upon the principle of light scattering and use a variety of detection angles and cell configurations. For purposes of this discussion, we shall consider devices which detect light scattered from individual particles as they traverse a beam of incident light. Such instruments necessarily are flow instruments in which a diluted sample stream is passed continuously through a detection cell. A particle suspended in a medium which has an index of refraction different from the particle will scatter light by three different mechanisms. These are external reflection, refraction, and diffraction. The intensity of the reflected light is dependent upon the angle of reflection relative to the incident beam and the refractive index of the particle relative to the medium. Similarly, the intensity of the refracted component is dependent upon the angle of refraction and the relative index of refraction of the cell and transmittancy of the cell to the particular wavelength of the incident light. The diffraction component of the scattered light results from interference of light wavefronts produced by the total or particle obstruction of wavelengths by the particle. The intensity and size of the interference bands depend upon the angle with respect to the incident beam, the size of the object, and the wavelength of illumination.

It can be shown theoretically[3] that for certain size ranges of particles relative to the wavelength of illumination the intensity of the diffracted light at small angles of scattering is directly proportional to the volume of the suspended particles. Furthermore, the intensity is independent of variations in the refractive index of the particles and is very much greater than that of the reflected and refracted components. A very crude approximation which illustrates the relative intensities of these components is shown below.

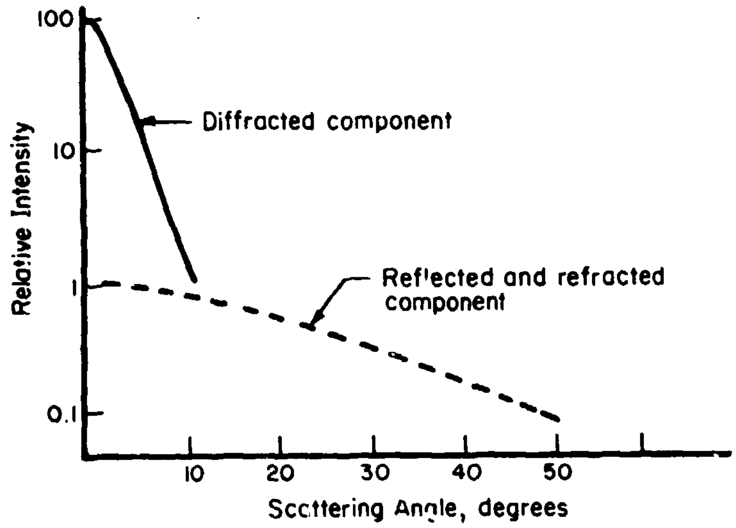

FIGURE 10. RELATIVE INTENSITIES OF DIFFRACTED, REFLECTED, AND REFRACTED LIGHT BY LARGE PARTICLES

It should be noted that this figure does not show any fine structure variations due to the internal structures of the particles in the refractive and reflective components.

One can readily surmise from this diagram that measurement of scattered light at [illegible]l angles greatly increases the potential sensitivity of the system since the intensity at 3° is roughly 100 times the intensity at 20°.

The refractive and reflective components of scattered light are dependent upon the refractive index of the particle and to changes in the refractive index within the particle itself. Therefore, measurement of the scattered intensity is a function of the angle of scattering and reveals features of the internal structure of the particle and can be used to distinguish one particle from another. For example, laser light scattering can be used in the classification of bacteria.[4] The size and the elements of the dielectric structure of a bacterium can be determined by examination of its light-scattering pattern over a range of angles from 0 to 90 degrees. In the above reference, the author studied the effect of various chemicals and therapeutic agents on the cells and was able to demonstrate membrane effects and changes in size induced by these agents. The bacterial cell may be regarded as a sphere with a uniform interior region (i.e., cytoplasm) surrounded by a shell-like structure (the cell wall). These two structures have different indices of refraction which results in a variation of scattered light intensity as the angle is changed. A particular type of cell can then have a characteristic fingerprint which can be used as a method of detection.

Applications of these principles will be discussed in a future section of this report entitled "Multiparameter Cell Analysis Systems".

<u>Light-Scattering Densitometry</u>. Another variation of light-scattering techniques to detect particle bands was described by Strickler.[5] This technique as originally described is used to detect bands either visually or photographically. A schematic diagram of this system is shown below.

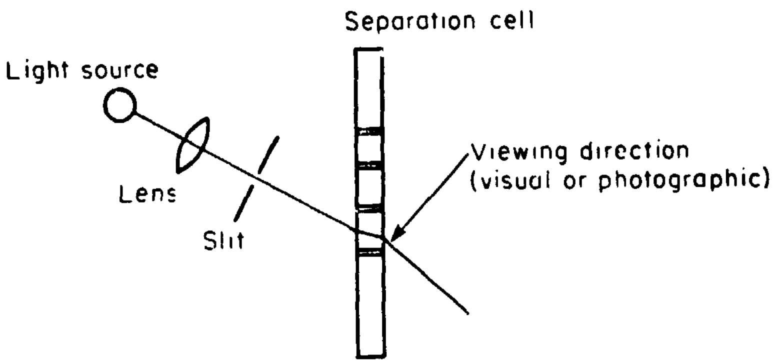

FIGURE 11. SCHEMATIC DIAGRAM OF CROSS-SECTION ILLUMINATOR

The separation cell is illuminated at an oblique angle by an incandescent lamp. The light then passes through a condensing lens and a slit into the separation cell. On the opposite side of the separation cell, the bands may be viewed at an angle of approximately 90 degrees to the incident light. Light scattered by the particles within the separation cell makes them appear brighter than the surrounding medium and thus they can be visualized. This technique can be used to scan an area of the separation cell approximately 2 cm in width. If one wishes to view a larger area, the light source and slit can be moved up and down accordingly. The lower limit of particles detectable by this method is 0.1 μ.[6] With larger particles (0.5 μ), the lower limit of sensitivity in terms of concentration is 0.. percent. The rather relatively low sensitivity of this system is due to the fact that the scattered light is visualized at an angle of 90 degrees from the incident light.

Greater sensitivity with this type of system could be attained by measuring the intensity of the scattered light at a very low angle relative to the incident beam. One could devise a light-scattering densitometer as shown in the diagram below.

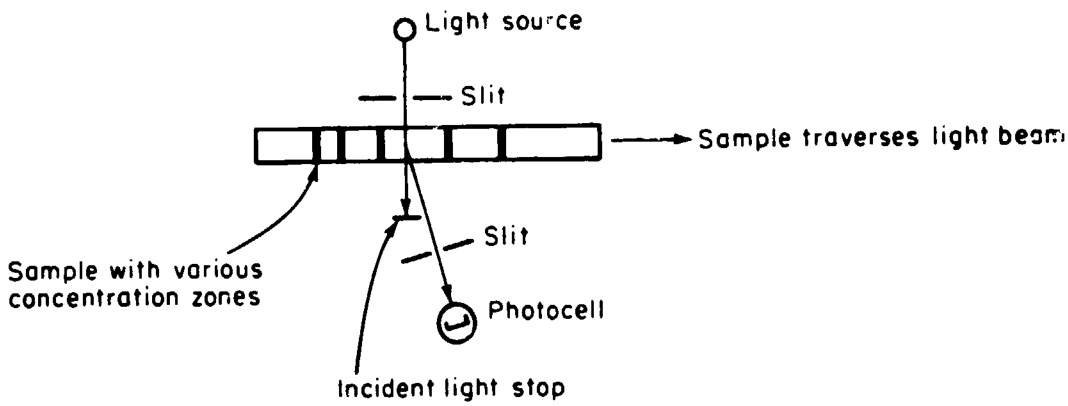

FIGURE 12. SCHEMATIC DIAGRAM OF LOW-ANGLE LIGHT-SCATTERING DENSITOMETER

The sensing system could be arranged to traverse the entire length of the separation cell and measure various concentration gradients within the cell. On one side of the cell, the light source and slit could be placed. On the opposite side, a transmitted light stop and photocell could be arranged to measure the intensity of the scattered light. The angle of the scattered light relative to the incident light could be measured at approximately 5°. By using an intense light source such as a laser, the sensitivity of this system could be improved by at least two orders of magnitude above that of Strickler's system. The light source and photocell could be designed to traverse the separation cell at the same rate. This system should have considera le sensitivity for particles . larger than 0.1 μ.

Nephelometry. Another variation of detection methods based upon light scattering can be grouped under the general headings of nephelometry. In essence, instruments of this type measure the scattered light usually at an angle of 90 degrees relative to the incident light. The schematic diagram of a nephelometer is shown below.

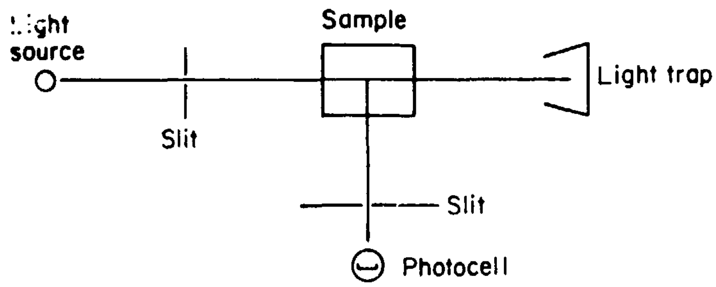

FIGURE 13. SCHEMATIC DIAGRAM OF A NEPHELOMETER

Nephelometry is used in a wide variety of applications which the concentration of suspended particles in matter is measured. T. technique is highly sensitive for relatively small concentration of suspended material and has the advantage that there is zero signal at zero concentration. A very broad range of particle concentrations can generally be measured with nephelometric methods. At higher concentrations, however, the sensitivity of the instrument can decline because the sample can become so opaque that sufficient light cannot enter it to produce a measurable readings. As in light scattering photometry, care must be taken to exclude all types of stray light which can come from the light trap, the lens, or the surface of the sample tube. A common source of error can be caused by bubbles in the sample and care must be taken to avoid such bubbles.

Synopsis of Light-Scattering Techniques

In the above sections, a number of measurement methods based on light scattering have been discussed with respect to their relevance to the NASA program. Each of the various methods has certain advantages and disadvantages for measurement of biologically derived particles. The table on the following page summarizes some of the points made in the text.

Polarimetry

A larg mber of biologically derived molecules in solution have the property of rotating the plane of plane-polarized light. The measurement of this rotation of polarized light is termed polarimetry and this technique can serve as a method of analysis under proper conditions. The principle of a polarimeter is quite simple. Monochromatic light is ssed through a polarizer and then through the sample. It then passes through an analyzer and finally impinges on a photocell. The analyzer consists of a polarizing crystal which can be rotated. As the analyzer is rotated to correspond to the polarization plane of the light emerging from the sample, the intensity of the light on the photocell increases. Using the optical null principle, the amount of rotation which occurred in the passage of light through the sample can then be determined. Several polarimeters are automated and

TABLE 11. FEATURES OF VARIOUS MEASUREMENT TECHNIQUES BASED ON LIGHT SCATTERING

Method	Sensitivity	Optimum Particle Size, μ	Correlation with Mass	Linearity	Interferences		
					Color	Stray Light	Bubbles
Low-angle forward scattering	High 1×10^{-8}	0.05-100	Fair	Good	None	Small	Small
Side scatter	Moderate 1×10^{-6}	0.01-1.0	Poor	Poor	Moderate	Moderate	Moderate
Back scatter	Moderate 1×10^{-6}	0.01-1.[illegible]	Poor	Poor	Moderate	Moderate	Moderate

present digital output data in the form of the degrees of rotation occurring in the sample.

Compounds which have the property of rotating plane-polarized light are those which possess molecular asymmetry. A great many biological molecules fall into this category and thus carbohydrates, amino acids, proteins, nucleic acids, vitamins, minerals, and other compounds will rotate light.

The extent of the rotation is related to the concentration of the rotating compound by the following expression.

$$\alpha = LC\ [\alpha]$$

where α is the observed rotation in degrees, $[\alpha]$ is the specific rotation of the compound, L is the length of the cell in decimeters, and C is the concentration of the compound in g/ml. The specific rotation of a given compound is dependent upon the wavelength of the light, the temperature, and the pH of the solution. Since the concentration term is expressed in g/ml, the unknown substance must be present in fairly high concentration. The most sensitive polarimeters are accurate to 0.002°. This would enable detection of amounts of solute in the range of 100 μg/ml depending, of course, on the magnitude of the specific rotation.

Polarimeters conventionally operate in a discrete sample mode but can be adapted to work in a flow-cell operation. Such a system is described in a paper by Saltzman[7] and should be adaptable to operation with a separation device. The usefulness of such a system would be limited, however, because of the large sample volume required, the high concentrations, and the relatively slow operation of the polarimeter.

In spite of the several drawbacks, polarimetry does have some advantages. The technique can tolerate a certain degree of turbidity and color background in the sample and is capable of detection of a wide range of compounds.

Flow Microcalorimetry

Flow microcalorimetry is a relatively new technique which may be of potential value for analyzing the separated products obtained from the NASA space-processing program. The technique is based upon the fact that almost every process, whether it be physical, chemical, or biological, is accompanied by heat evolution or absorption. The amounts of heat involved in any given process is related to the intrinsic properties of that process and on the amount of material undergoing a change. The use of flow microcalorimetry for analysis of biological systems has a particular advantage in nontransparent and impure solutions which are difficult to analyze by photometric methods. The flow microcalorimeter which is the basis for this technique was developed in 1969 by Monk and Wadso.[8] The apparatus is a twin calorimeter which utilizes a heat-conduction principle. Heat evolved in the reaction cell is conducted through the surrounding thermopile to a metal heat sink. The difference in potential generated by the thermopile surrounding the reaction cell and the reference thermopile is then used to quantitate the amount of heat involved in the process.

A diagram of the calorimeter is shown below.

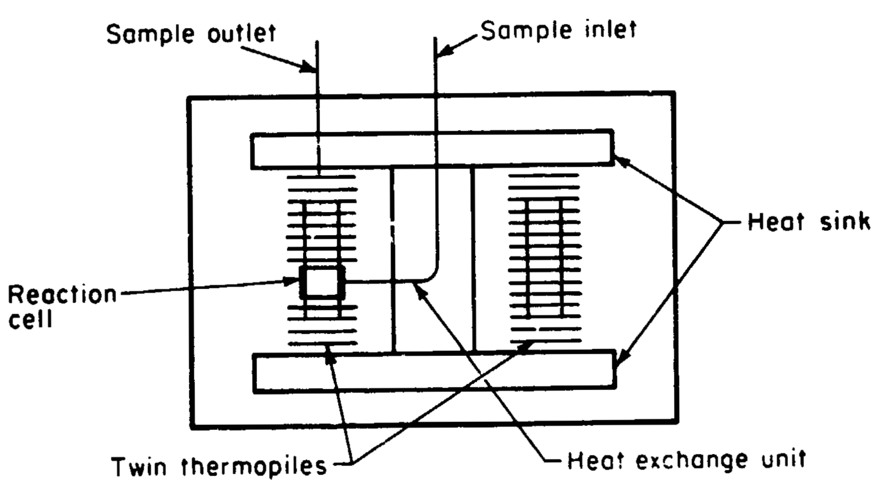

FIGURE 14. SCHEMATIC DIAGRAM OF FLOW MICROCALORIMETER

The biological applications of flow microcalorimetry have been described in a number of recent publications.[9,10] In these papers, the use of flow microcalorimetry for the determination of several enzyme concentrations and substrate concentrations is described. The process can also be used for the determination of antibody-antigen interactions and binding of substances to macromolecules. In essence, any interaction of the molecules being analyzed which adsorbs or evolves heat enables quantitation of that particular substance. The specificity of the technique depends upon the specificity of the biological interactions involved. For example, if one wishes to quantitate the presence of a certain enzyme, one adds to the solution a specific substrate for that particular enzyme. If the substrate is added in excess, the amount of heat evolved is related to the concentration of the respective enzymes. Conversely, one can measure the concentration of the substrate of a given enzyme by adding the appropriate enzyme to the reaction mixture. The usefulness of this technique is, of course, limited to those substances which can be made to undergo a specific interaction under the conditions of the flow cell.

The sensitivity of the flow microcalorimetry technique is quite high and can be used to detect micromolar quantities. The instrument is now available commercially as the LKB 10700-1 flow calorimeter and is described in the instrument section of this report.

Because this technique is still in its infancy and does not yet have a broad applicability, it is not likely to be of immediate usefulness for the NASA program. However, the potential of this method is sufficient to warrant its inclusion in this report.

Radioactivity Detection Methods

A given element is defined as radioactive when the nucleus of the element undergoes a spontaneous change accompanied by the emission of particles and the formation of the nucleus of a new element. Emission of particles is often accompanied by high energy electromagnetic radiation and the products of the decomposition process can be detected by a number of sensitive techniques. Because of the high sensitivity of detection, the use of radioactive tracers has been of tremendous use in chemistry, biology, and medicine in the last 25 years. In this section, we will describe the basic kinds of radioactivity, the detection of radioactivity, and the application to biologically derived systems.

Radioactive decay is a first-order process in which the integrated form can be described by the following

$$A = A_0 \, e^{-\lambda t}$$

where A_0 is the initial activity at the beginning of the decay period, t is the time of the decay period, λ is the decay constant, and A is the activity at that particular time. The unit of radioactivity is the curie (1 curie [Ci] is 3.7×10^{10} disintegrations per second). In experiments employing radioactive tracers, levels of radioactivity commonly employed are in the microcurie to millicurie region. The specific activity of a labelled compound is typically described in terms of µCi/mM.

Since radioactive decay is a first-order process, any given radioactive element may be characterized by its half-life. Radioisotopes are further characterized by the type and energy of the emitted radiation. The energy of the emitted radiation is usually expressed in terms of electron volts and runs in the range of 10×10^3 (keV) to 100×10^6 (MeV). Three types of radioactive decay will be considered in this discussion. These are alpha radiation, beta radiation, and gamma radiation. The characteristics of each of these types are discussed below.

Alpha Decay. Alpha decay occurs when an alpha particle (helium nucleus) is ejected from the radioactive nucleus. For each type of transition, monoenergetic particles are emitted and thus alpha radiation occurs in discrete lines. Alpha emission may or may not be accompanied by gamma emissions. Since alpha particles are positively charged, they interact with electrons of atoms along their path through matter. Since the cross-section of electrons is much greater than that of the nucleus, the interaction of alpha particles with matter occurs very frequently. From a practical aspect, this means that alpha particles cannot penetrate to any depth in matter and are significantly absorbed when passing through a gas. Because of this, alpha emitters are of very limited value in tracer studies and will not be discussed in further detail in this report.

Beta Decay. Three modes of beta decay exist and these are negatron emission (or beta - decay), positron emission (or beta + decay), and electron capture. In beta - decay, the atomic number increases by one unit. Most beta emitters also emit gamma radiation. In biological studies, the beta emitters used most frequently are ^{3}H, ^{14}C, ^{32}P, ^{35}S, ^{36}Cl, and ^{45}Ca because these elements are found frequently in biologically derived molecules. In contrast with alpha and gamma-ray emission, beta-ray spectra are continuous, and in counting, one chooses a rather broad window which is characteristic of the peak energy level. The isotopes referred to above have relatively low energies but can be distinguished from one another in most cases by proper selection of the appropriate windows. This will be described later in counting techniques.

When beta particles, both positively and negatively charged, pass through matter, they interact with the electrons of atoms in their path. Since they are of significantly smaller mass than alpha particles, their velocity is considerably greater. They can penetrate matter to a greater extent than can alpha particles. However, in a practical sense, when counting beta activity, one must essentially consider they cannot penetrate through the walls of a vessel such as a glass test tube. When a beta particle interacts while passing through matter, it can lose energy by emitting electromagnetic radiation in the X-ray spectral region. This radiation is referred to as Bremsstrahlung. High-speed beta rays also interact with matter to cause emission in the ultraviolet and short visible regions. This radiation is of lower intensity and is known as Cerenkov radiation. In certain systems, Cerenkov radiation can be used as a detection method for beta energy.

Because of the low penetration of beta particles through matter, the absorption of beta energy by the emitting medium itself can become a serious problem when low-energy beta emitters are utilized. For example, self-absorption losses for tritium are so great that solid sources are not practical for tracer experiments. A beta emitter such as ^{14}C which is 0.1 mm thick would self-absorb approximately 45 percent of its total energy. A source containing ^{32}P which has considerably higher energy of the same thickness would self-absorb only 5 percent. Two types of scattering of beta rays can complicate beta activity measurement. These are self-scattering by the source itself and back scattering. The latter is a reflection of beta rays from the material underlying the source. Beta rays which leave the source in the direction away from the detector can be scattered back toward the detector. This, of course, can increase the counting rate and increase the efficiency for any given counting method.

Gamma Decay. Gamma radiation occurs by a deexcitation of a nucleus without a change in atomic number. Gamma rays may be emitted promptly following alpha decay or beta decay or their emission may be delayed. In contrast to alpha and beta radiation, gamma particles possess no measurable mass. They are monoenergetic and thus their spectra consists of discrete lines. Since the gamma rays are not charged, when passing through matter they do not interact as frequently as do beta particles or alpha particles. Therefore, gamma rays can penetrate rather deeply into a substance along their pathway and this property has made them very valuable for biological and medical purposes. For purposes of this discussion, gamma rays interact with matter in three different ways. In the first effect, called the photoelectric effect, a gamma ray interacts with an atomic electron and transfers its entire kinetic energy to that electron. This electron then loses its energy by ion pair production and further excitation. The probability of an occurrence of the photoelectric effect varies approximately as the atomic number to the fifth number for the absorber atoms. Thus, materials of high atomic number, such as lead, are much more efficient absorbers of gamma radiation than materials of low atomic number.

A second interaction which gamma particles can undergo is known as the Compton effect and occurs when a gamma ray transfers a portion of its energy to a loosely bound electron. The excited electron can then expand its energy by causing excitation and ion pair formation. The probability for this type of interaction is approximately proportional to the atomic weight of the absorber.

A third type of interaction which occurs for higher energy gamma radiatin is the direct production of an ion pair. The probability of this interaction (which occurs only at energies greater than 1.2 MeV) is proportional to the atomic number squared of the absorber.

In contrast to the situation with beta rays, self-absorption of gamma rays is quite low and, except for very accurate work, does not cause a significant source of error.

Detectors of Nuclear Radiation

Detection of nuclear radiation can be accomplished by several means, and these are outlined in the sections that follow.

Ionization Chambers. An ionization chamber consists of a vessel which contains a gas and two electrodes. As the radiation from the source passes through the gas, ion pairs are produced which result in an electronic pulse between the two electrodes. The size of the pulse is proportional to the energy of the incident radiation.

Gas-Filled Proportional Counters. A gas-filled proportional counter operates on a principle similar to an ionization chamber in that ion pairs produced by the incoming radiation produce a current between two electrodes in the chamber. In contrast to the ionization chamber, however, the applied potential between the two electrodes is sufficient to cause amplification of the original interaction between the radiation and an electron. Typical amplification factors range from 10^2 to 10^4. The term proportional is used because the output current pulse is proportional to the energy of the incoming radiation. This characteristic of a gas-filled proportional counter makes possible the use of pulse-height discrimination to distinguish between radiation of different energy levels.

Geiger-Muller Tubes. The Geiger-Muller (G-M) tube operates on same principle as a gas-proportional counter except that the potential between the electrodes is even higher. It cannot distinguish between different energy levels of the incoming radiation and therefore is not a proportionality counter. The G-M tube requires little amplification and thus systems based on the G-M tube are relatively simple.

Scintillation Detectors. Nuclear radiation can interact with certain types of adsorber materials to produce a photon in the visible or ultraviolet regions. Such adsorbers are designated as scintillators. A scintillation detector consists of a scintillator which is optically coupled to a photomultiplier tube. Several types of scintillation detectors can produce output voltage pulses which are proportional to the energy of the incoming radiation and thus can discriminate between various energy levels. Scintillators can be placed in three categories: inorganic, organic, and gaseous. Inorganic scintillators are ionic crystals which can be excited by ionizing radiation. Fluorescence occurs when the entire crystal deexcites. Organic scintillators emit light as individual molecules undergo electronic deexcitation.

Semiconductor Detectors. Ionizing radiation reacts with semiconductor detectors by producing electron whole pairs in the solid. An electrical signal is obtained by separating and collecting the ion whole pairs and the number of such pairs is proportional to the energy level of the radiation. Such detectors are commonly made from germanium and silicon which are drifted with lithium. Lithium-drifted silicon detectors can be operated at room temperature. Germanium-lithium detectors must be cooled to liquid nitrogen storage for operation and storage as well. Semiconductor detectors have certain advantages over gas detectors in that they have better spectral resolution.

Photographic Emulsions. Ionizing radiation impinging upon a silver halide emulsion activates the silver halide and provides a permanent record of the interaction. Thus, by placing a photographic plate next to a radioactive source, one can determine the amount of radiation over a given period of time by measurement of the optical density of the developed photographic plate. In cases where a given sample may contain radioactive substances in different portions of its surface, the photographic plate can be used to determine the location of the radioactive source. The disadvantage of photographic emulsions is that they cannot give a real-time measurement and that they are less sensitive than the other methods mentioned above.

Thermoluminescent Detectors. A thermoluminescent detector emits light when it is heated after exposure to radiation. This light, which is in the visible spectral region and whose intensity increases with increased exposure to ionizing radiation, can be detected by a photomultiplier tube. Thermoluminescent detectors are frequently used in dosimetry because they can in effect integrate the total exposure of ionizing radiation at a given site over a period of time.

Characteristics of Radiation Measurement Systems

A number of factors are important in determining the sensitivity and accuracy of detection of nuclear radiation. One of the most important of these is the geometry factor. A radioactive source emits radiation in all directions. Thus, a detection system which would intercept every disintegration from the source would ideally be arranged in the form of a sphere around the source at the center. In common usage, the geometry factor refers to the fraction of the sphere around the source which is subtended by the sensitive volume of the detector. Detectors which subtend the entire sphere are referred to as having four-pi geometry; those subtending half the sphere are referred to as two-pi geometry. Below is an illustration of a detector with a low geometry factor.

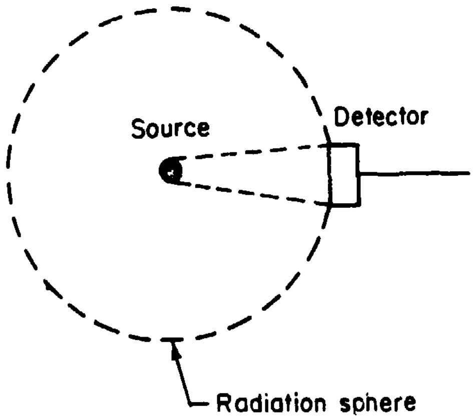

FIGURE 15. EXAMPLE OF DETECTOR WITH LOW GEOMETRY FACTOR

Another important factor which depends heavily upon the geometry is the efficiency of the detection system. Efficiency is defined as the percent of disintegrations from the source which are detected by the system. Efficiency is, of course, affected strongly by the geometry of the system. If only a small angle of the sphere is subtended, the efficiency will be relatively low. It also is affected by characteristics of the detector itself such as sensitivity and resolving time. Other factors which can lower the efficiency are absorption of the radiation by an intervening substance between the source and detector and self-absorption. On the other hand, efficiency can be increased by back scattering from the sample source. If pulse height selection is used in a counting procedure, counts below a certain selected level will be rejected and thus the efficiency of the process will be reduced.

Another important characteristic of a detection system using a pulse detector is its resolving time which is the minimum time required to detect two successive pulses separately. A Geiger-Muller tube, for example, is a relatively slow detector and requires 100 to 600 μsec to resolve two pulses. In comparison, scintillation detectors can resolve pulses from 10 nsec to a μsec.

For purposes of this report, we will discuss two kinds of instrumentation which can be coupled with the detector to provide a nuclear counting system. The first of these is a simple pulse-counting system. This system can provide either a total count of pulses over a measured period of time or can give an instantaneous average pulse rate. Such a system is not capable of analyzing various pulse heights but can have a pulse height selector which screens out pulses below a certain level. The components of a typical pulse-counting system are shown below.

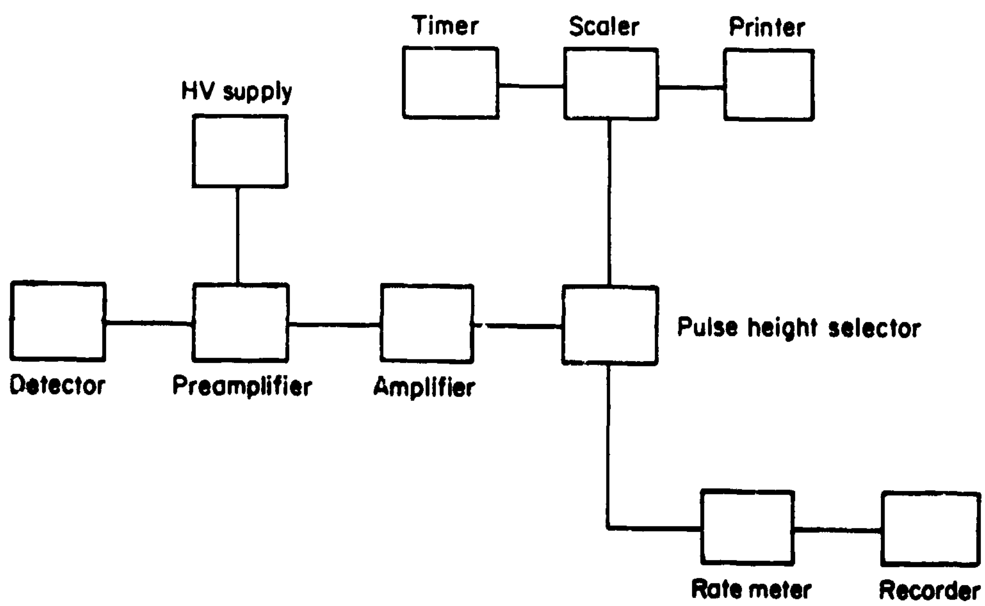

FIGURE 16. ELEMENTS OF A PULSE COUNTER

Pulse-counting systems are available as integral units or may be purchased in separate components. A large number of companies manufacture the separate components which are commonly referred to as nuclear instrument modules (NIM). These NIMS are standardized with respect to physical dimensions, connectors, and power requirements. The availability of these modules is of advantage to NASA because a system can be assembled from these components to meet the specific detection requirements of the NASA experiments.

A second type of detection system is a nuclear spectrometer which can measure and analyze the spectral distribution of nuclear radiation. Such a system analyzes the pulse heights received from the detector which are proportional to the energy of the incident radiation. It is also essential that the preamplifier and linear amplifier retain the proportionality of the pulses reaching the pulse-height analyzer.

Pulse-height analysis can be achieved by either a single-channel analyzer or a multichannel analyzer. A channel analyzer consists of a variable lower-level discriminator and a variable upper-level discriminator which defines an energy window. In radioisotope tracer studies, the value of a spectrometer lies in its ability to detect and discriminate several radioactive sources in the presence of each other. This is, of course, dependent upon the energy peaks of the various sources being sufficiently far apart to be detected independently of each other. In the case of gamma radiation in which the emitted energy is essentially a line, the window can be fairly narrow and still attain a good efficiency. In the case of beta radiation where the emitted energy is continuous rather than line, a rather broad window must be selected to attain good efficiency. If various isotopes are counted in the presence of each other, these windows can sometimes overlap. Instruments available today for radiotracer studies usually have three channels available for multiple counting.

Techniques for Beta Counting

The most popular method of measuring beta radiation in tracer studies is liquid scintillation counting. This technique is especially well suited for measuring the activity of the low-energy beta emitters, ^{3}H, ^{14}C, and ^{35}S, which are commonly used in biological experiments. The method is readily instrumented for automatic counting of large numbers of samples and can simultaneously measure three beta emitters in multiply labelled samples. A number of reviews on liquid scintillation counting have been prepared and the reader is especially referred to one by Kobayaski and Maudsley.(11)

Since the range of penetration of beta particles in any medium is very short, a primary requirement in scintillation counting for beta sources is that the scintillator be in intimate contact with the radioactive source. In liquid scintillation counting, the beta source is either dissolved or suspended in minute particles in a solvent which contains a scintillator which is also in solution. Typically, the solvent is toluene and contains a primary scintillator such as 2,5-diphenyloxazol (PPO) and a secondary scintillator such as 1,4-bis-(5-phenyloxazol-2-yl)-benzene (POPOP). Also, since the radioactive sample may not be stable in the organic solvent, a solubilizing or dispersing agent can be added to the solution. The secondary scintillator absorbs the light emitted by the primary scintillator and reemits it at a longer wavelength at which the photocells are more sensitive.

In a typical liquid scintillation counter, the sample is placed in a cylindrical glass vial of 10 to 20 ml approximate volume. The vial is then placed in a light-tight sample well between two photomultiplier tubes. Because of the high gain required for low-energy beta emitters, background from the photomultiplier is a problem. This background noise can be reduced by cooling the photomultipliers and by the use of two photomultipliers. The background noise can be distinguished between a scintillation arising from a beta particle by the coincident unit. In a practical sense, this means that many scintillation counters must operate at low temperatures and thus must have a refrigeration unit. Recent developments in photomultiplier electronics have led to liquid scintillation systems that can operate at room temperature. One of the problems with liquid scintillation counting is that the scintillators require an organic solvent for effective functioning. If the compound containing the radiolabel is not soluble in the organic solvent, a secondary solvent such as methanol or dioxane can be added. However, at higher concentrations of the secondary solvents, the efficiency of counting can be lowered. The elements of a scintillation counter are shown below.

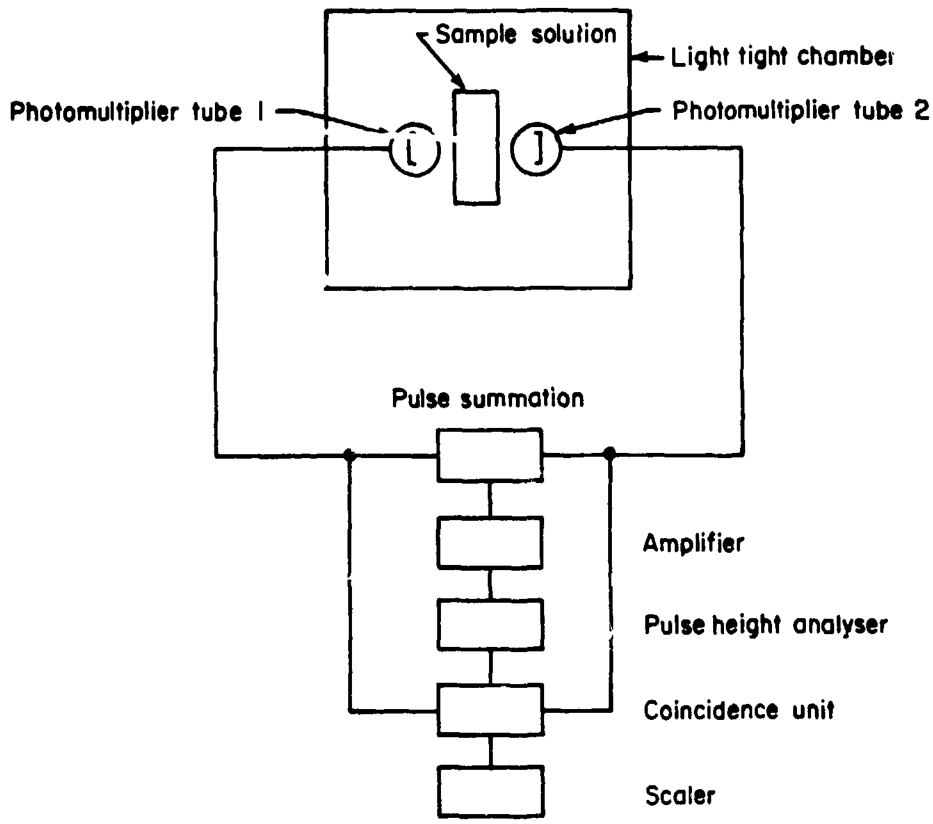

FIGURE 17. SCHEMATIC DIAGRAM OF LIQUID SCINTILLATION COUNTER

The major source of error in liquid scintillation counting systems is the quenching of the scintillation by the solution. Quenching is caused by molecules having strongly electronegative elements, such as water, ketones, and organic halides, which collide with scintillators and remove excitation energy. For accurate counting, the quenching of the scintillation solution must be evaluated. This can be done by an internal standard method in which a labelled compound of known activity is added to the sample and the counts per minute determined. A second method by which quenching is determined is by an external standard method. In this case, an external source of gamma rays can be used to introduce electrons into the scintillation mixture. This method can be automated so that the extrenal standard is removed from its shield and positioned near the vial at the appropriate time in the counting schedule. Many of the commercially available liquid scintillation counting systems have an automated external standardization method as part of their integral system.

The efficiencies commonly obtained in liquid scintillation counting for ^{14}C are as high as 90 percent. For tritium, efficiencies range from 30 to 50 percent. Another source of error which can occur in liquid scintillation counting, particularly in low-energy emitters such as tritium, is fluorescence and phorphorescence of the vial. To avoid this, the sample vials must be dark adapted for a few hours before counting.

The scintillation counting process described above is, of course, a discrete sample method of analysis and is not useful for a flowcell. Monitoring the activity of a beta source in a flowing liquid stream is difficult because of the extremely low penetration of the beta particles. Systems have been devised utilizing solid scintillation detectors in a number of different configurations. In one configuration, as shown on the next page, the walls of the flow cell chamber are coated with a solid scintillator such as naphthalene. In this case, the flow cell must be extremely thin to eliminate beta adsorption by the volume of solution. Even under the test of conditions, the efficiency of such a system is very low (less than 1 percent).

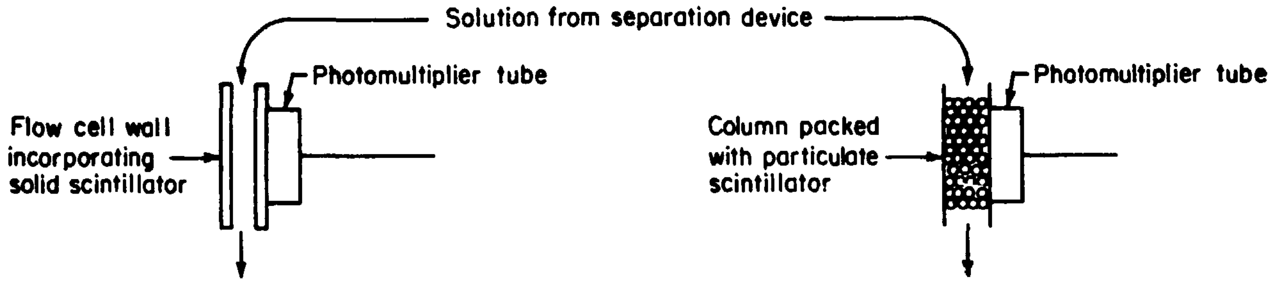

FIGURE 18. FLOW CELLS FOR DETECTION OF BETA EMITTERS

In a second configuration, the flow cell can be packed with particulate matter containing a solid scintillator such as naphthalene intermixed with a polymer such as polymethylmethacrylate. The solution then flows through the inters ices of the particulate matter which gives off scintillation detected by a photocell. Again in this configuration, the efficiency is quite low and this system can be used for relatively high amounts of radioactivity.

A flow cell with higher efficiency has been devised by Mechanic.[12] In this system, the effluent from a separation device is mixed with the organic solvent scintillation cocktail and the mixture is flowed directly into the well of a liquid scintillation detector. Even with the higher efficiency reported by this method, a relatively large amount of radioactivity is essential because the resident time in the counter is much shorter than is desirable.

The third mode of detector configuration of interest to the NASA program, i.e., detection within the separation cell itself, is not practical with beta emitters because of the low penetration of beta particles. The water phase used as a medium in the separation devices would in itself absorb most of the beta radiation contained in the sample. Second, the walls of the device would absorb any radiation reaching them. One possible way of detection of beta at very low efficiencies within a separation cell would be to coat the inner walls of the device with a solid scintillator responsive to beta radiation. Such a detector could respond to beta emitters in the fluid immediately next to the wall and with high levels of radioactivity could be used to detect concentration zones within the separation cells.

The discrete concentration zones of beta emitters can be detected in paper and thin-layer chromatographs and in paper or cellulose acetate electrophoretograms. A number of commercial instruments are available for this purpose and operate on the principle shown below.

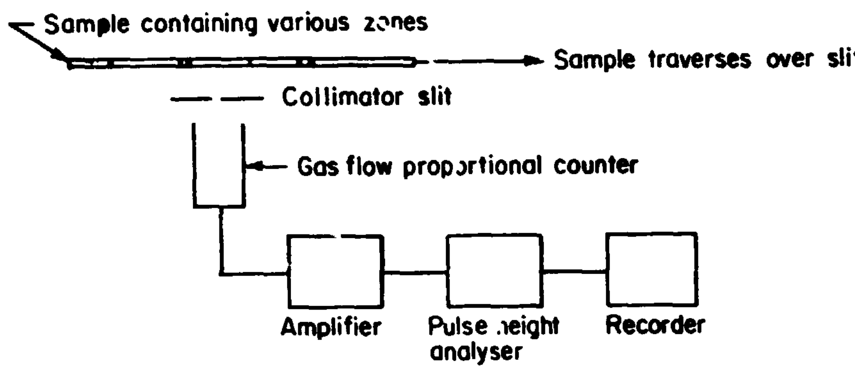

FIGURE 19. RADIOCHROMATOGRAPH SCANNERS FOR BETA EMITTERS

The sample passes over a collimator slit and radiation is detected in a glass gas-flow proportional counter. The detection cell utilizes a mixture of 90 percent argon and 10 percent methane for proportional counting. It should be emphasized that this method of counting works only with very thin samples and is not efficient for thicker samples such as gel electrophoretagrams. To obtain maximum efficiency, it is necessary to have the slit as close as possible to the surface of the sample. The resolution of the device is, of course, determined by the width of the slit opening.

An alternative for locating concentration zones on a chromatograph or electrophoresis strip is autoradiography. In this system, a silver halide photographic plate is laid directly on the chromatograph and developed after a predetermined exposure period. The photographic plate can then be scanned densitometrically to get a quantitative determination of the amount of beta emitter present in the various zones of the sample. A disadvantage of this method is the amount of time required. Often exposures of several weeks, and even months, are required with small amounts of radioactivity.

An alternative to the autoradiographic technique is a device called a beta camera. This device is described in a paper by Smith, et al.[13] This scanner produces a photograph in approximately 10 minutes and is thus much more rapid than the autoradiographic technique. The system consists of a spark chamber which lies directly above a chromatogram or electrophoresis strip and a camera mounted above the spark chamber. In the spark chamber is an electrode grid consisting of an anode and cathode. A radioactive disintegration causes a spark to jump the electrode gap. The sparks are then recorded on the photographic film by a time exposure. Exposure timing can vary from 5 seconds up to 1 hour, depending upon the amount of radioactivity present. After development of the film, the position and amounts of the radioactive substances can be quantitated by standard densitometric techniques. The spark chamber is flushed with a mixture of 10 percent methane in argon and is sensitive to low-energy beta up to gamma emitters. Resolution in the system, of course, depends upon the spacing of the electrode grid. Commercially available beta cameras are made by Baird Atomic and Picker, and an analysis of their performance is included in this report.

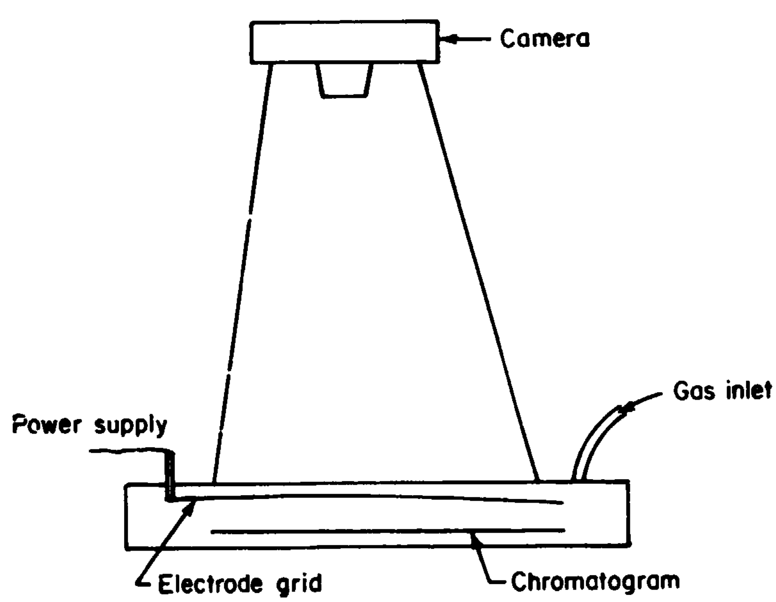

FIGURE 20. SPARK CHAMBER BETA CAMERA

Techniques for Gamma Counting

Gamma radiation can be detected by a variety of techniques such as gas proportional, thermoluminescence, and scintillation detectors. At present, the most widely used method is scintillation detection with a sodium iodide crystal doped with tantalum [NaI(Tℓ)]. Sodium iodide crystals of high uniformity can be grown to very large sizes, and this factor accounts for the wide use of the scintillation method. These crystals have a good intrinsic efficiency and provide pulses with heights proportional to the emitted energy over a wide range of gamma-ray energies.

In practice, the sodium iodide crystal is coupled optically with a photomultiplier tube and a similar type of electronics can then be utilized for analyzing the output as is used in beta scintillation techniques. For discrete sample analyses, one of the most frequently used configurations is the well-type scintillation detector which is shown below.

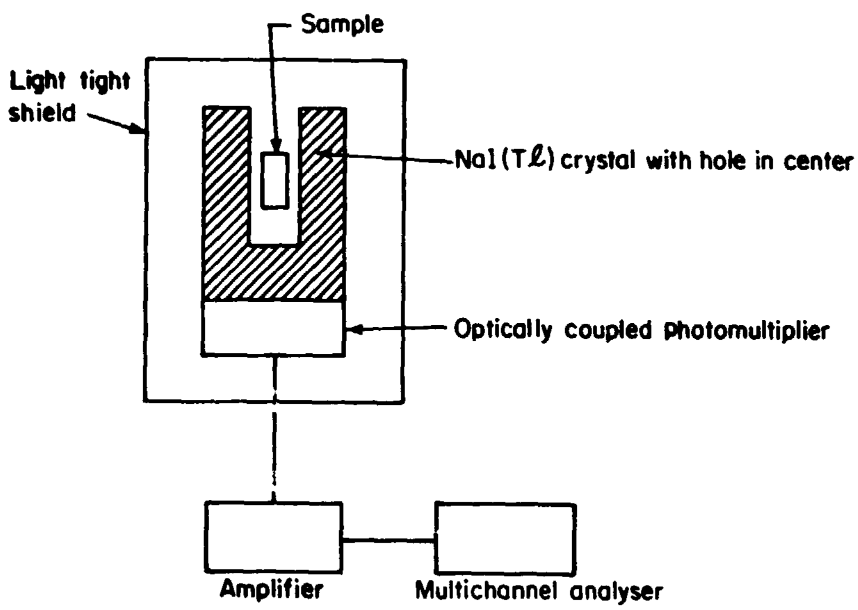

FIGURE 21. GAMMA SCINTILLATION DETECTOR

In this detector, a hole is drilled axially in the center of a sodium iodide crystal and the sample placed in the hole. This configuration supplies excellent geometry and results in good counting efficiency. A photomultiplier tube is coupled optically with the crystal and the system is enclosed in a light-tight box. Cylindrical crystals of sodium iodide are available in a wide range of diameters and thicknesses and have been made as large as 76 cm in diameter. Crystals 7.6 x 7.6 cm have now become the standard size used in a great many gamma-ray scintillation detector systems. A crystal of this size with a hole drilled axially is suitable for samples having a volume of 1:5 ml.

The efficiency of the sodium iodide detector depends upon its ability to intercept the gamma rays emitted by the sample. The higher the energy of the gamma radiation, the less efficient will the sodium iodide crystal be. Efficiencies of course can be improved by enlarging the size of the crystal. Because of weight, size, and cost considerations, crystals larger than 8 to 10 cm are not commonly used.

Semiconductor detectors such as lithium-drifted germanium and silicon types have much better resolution than sodium iodide detectors. However, their efficiency is less than sodium iodide and they must usually be cooled with liquid nitrogen. Thus, unless extremely high resolution of gamma ray spectra is desired, sodium iodide scintillation techniques are the method of choice. One of the disadvantages of the sodium iodide crystal detector is the fact that it is highly hygroscopic and must be carefully protected from moisture.

Flow cells for measurement of gamma radiation are not subject to the limitations of beta emitters because of the high penetration of gamma particles. Therefore, a number of flow gamma detectors are commercially available. The configuration of these detectors can vary widely, and one of the most common configurations is pictured on the next page.

A sodium iodide crystal with a hole drilled through the center is utilized as the scintillator in this configuration. The sample from the separation device flows through the center of the crystal and the scintillations are detected by an optically coupled photomultiplier tube. Care must

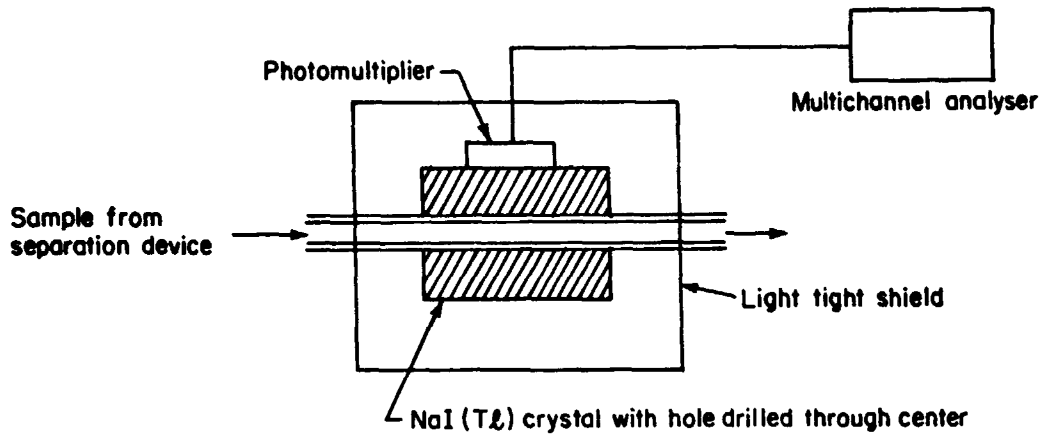

FIGURE 22. FLOW CELL FOR DETECTION OF GAMMA RADIATION

be taken with this system to exclude any stray light which may enter from the outside. Detectors of this type can have reasonably good counting efficiencies but fairly high activities are usually necessary because of the short residence time of the radioemitter within the scintillation area. As an alternative to the axially drilled sodium iodide crystal, the crystal may be placed to one side of the effluent stream from the separation device. In this configuration, of course, the efficiency is less because of the poorer geometry of the detectors. Gamma-detecting probes utilizing sodium iodide crystals in photomultipliers are available from a wide number of manufacturers. For specialized applications in gamma detection, scintillation detection probes employing sodium iodide crystals and photomultipliers can be developed according to the user's specifications. Crystals of all sizes and shapes can be purchased from the Harshaw Chemical Company in Cleveland, Ohio.

The high penetration of gamma rays makes possible the detection of mass concentration zones within the separation device itself. Ability to do this, however, is contingent upon there being sufficient levels of radioactivity within the concentration zones of the separation device. Scanners are commercially available for detection of concentration zones in chromatograph and electrophoretagrams from Packard Instrument Co., Inc., Downers Grove, Illinois.

In order to obtain resolution with a gamma-ray scanning apparatus, a collimator must be used which reduces significantly the subtended angle of radiation. As a result, the geometry of a gamma-ray scanner is very poor and this produces quite low efficiency (less than 1 percent). Thus, relatively high amounts of radioactivity must be present within the separation device in order to obtain sufficient activity for a gamma scan.

Radioisotopic Labelling Procedures

As mentioned previously, biologically derived molecules have no intrinsic radioactivity and thus employment of radiotracer techniques is dependent upon the incorporation of radiolabels. For small molecules, a very large number of isotopically labelled compounds can be purchased from supply houses such as New England Nuclear, Searle-Amersham, International Chemical and Nuclear Corporation, and Schwarz Bioresearch Corporation.

A very large variety of labelled compounds with beta emitters, such as ^{14}C, ^{3}H, ^{35}S , and ^{32}P, can be obtained. Compounds which can be purchased commercially include amino acids, vitamins, metabolites, carbohydrates, nucleosides, nucleotides, a large number of proteins, and polynucleotides. Beta-labelled proteins and polynucleotides are usually obtained from microorganisms or mammalian cells which have been cultured in media containing radiolabelled amino acids and nucleotides. If the protein or polynucleotide cannot be conveniently obtained from a culture, these may be directly labelled by a variety of compounds which contain functional groups capable of reacting with pendant groups. For example, proteins can be labelled with ^{3}H or ^{14}C compounds which contain isothiocyanate, diazo, activated carbonyl, and sulfhydryl groups.

Compounds labelled with gamma emitters are not nearly as numerous as beta emitters because very few of the elements contained in biologically derived compounds have isotopes which are gamma emitters. The most frequently used labels for biological compounds are ^{131}I, ^{125}I, and ^{51}Cr. Labelling of proteins with iodine can be accomplished in a straight forward process by a technique devised by Hunter and Greenwood.[14] In this method, the protein is incubated with sodium ^{131}I and a small amount of a mild oxidizing agent is added to produce molecular iodine. The iodine then reacts with tyrosyl residues in the protein to form a covalent bond. In this process, care must be taken to avoid damaging the function of the protein by excess oxidizing agents and/or overreaction with iodine. In addition to proteins, many other compounds can be labelled by simply reacting them with tyrosine if the appropriate amine or carboxyl groups are available. After the tyrosine adduct is formed, the iodination can be performed as described above.

Iodine labelling of cells and compounds can also be indirectly obtained by attaching an antibody to a particular cell or given hapten. Radiolabelling is then accomplished by the association of the antibody with its antigen.

One of the most convenient and effective methods of labelling intact cells is through the utilization of ^{51}Cr. Viable cells of a wide variety of types can be radiolabelled by simple incubation with chromate (^{51}Cr). The exact site of labelling or the mechanism of labelling is not known but data accumulated over the years indicate that the chromate enters the cell and becomes very tightly bound. Chromium labelling is the standard method utilized to determine the lifetime of red blood cells and platelets because of the irreversability of binding and the fact that the method allows the cells to remain completely viable. In addition to red cells, lymphocytes have been labelled with ^{51}Cr and used in subsequent studies of lymphocyte function.[15] Chromium labelling of cells allows a fairly high specific activity to be attained and thus minute quantities of cells can be readily detected by this method. This technique is utilized in Battelle's Columbus Laboratories on lymphocytes, and we regularly obtain activities of 5000 cpm/10^5 cell.

It should be noted that in any labelling experiment, one should take care to avoid incorporation of excessive amounts of radiolabel into compounds or cells. A very high amount of radioactivity incorporated into a compound can result in self-absorption and thus self-destruction of that compound. Thus, the results of the radiotracer experiment can be invalidated.

Application of Radioisotope Labelling to Determine Position of Cells in Electrophoresis Device. During the course of this research program, one of the questions asked us by NASA was related to the detection of separated bands of cells within a cylindrical electrophoresis tube. The frozen tube, which is approximately 18 cm in length and 1 cm in diameter, will be placed in an electrophoresis device during a space flight and suspensions of various types of cells will be electrophoresed during the flight. After each run, the buffer and cells in each tube will be frozen and maintained in a frozen state during the transport back to earth. The cylinder of ice will then be sectioned in such a way that discrete bands of cells can be contained within the sections. This necessitates a method of detection of the band of cells.

We suggest that radioisotopic labelling of the cells with ^{51}Cr would provide a good method of locating the various bands in the ice plug. For example, lymphocytes could be radiolabelled with ^{51}Cr to obtain an activity of 5000 cpm/10^5 cells. Assuming 70 percent counting efficiency, this amounts to 32×10^{-2} µCi/10^6 cells. We understand that the electrophoresis cell will contain approximately 10^7 to 10^9 cells. This would constitute a range of 0.32 to 32 µCi and would provide enough radioactivity for detection by a collimation device according to the calculations shown below.

Circumferential area of slit	1.1 cm^2
Area of radiation sphere	38.9 cm^2

$$\frac{1.1}{38.9} \times 100 = 2.9 \text{ percent}$$

For purposes of this calculation, we have assumed that the detection system should be able to resolve a band 1 mm in width. This could be done by use of a sodium iodide crystal optically coupled with a photocell. A suggested configuration is shown on the next page. The suggested configuration consists of a cylindrical sodium iodide crystal with an axial hole throughout the entire length of the crystal. Concentric with the crystal is

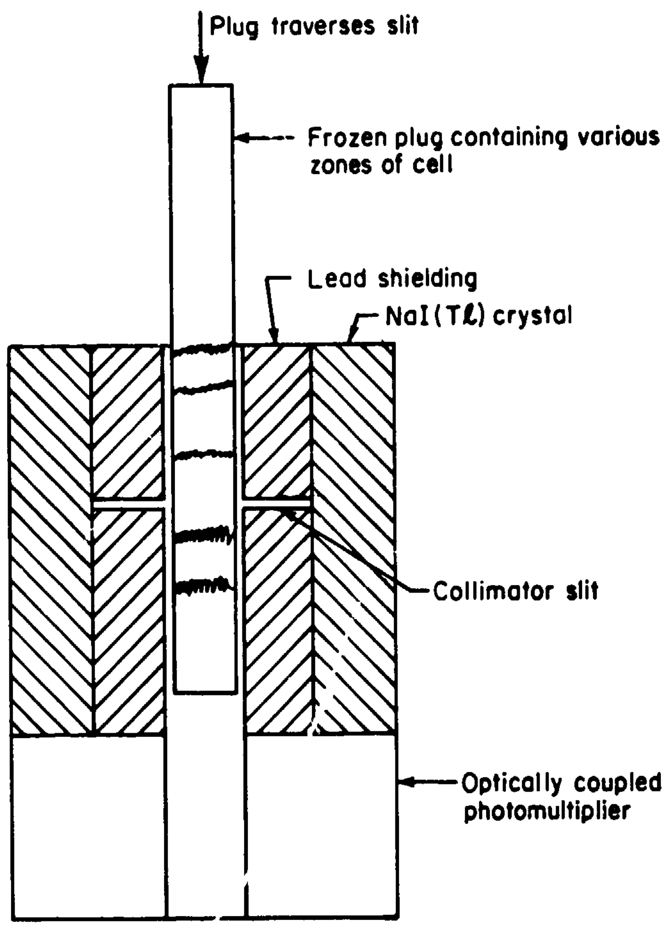

FIGURE 23a. CROSS-SECTION VIEW OF DETECTOR FOR CELLS IN FROZEN PLUG

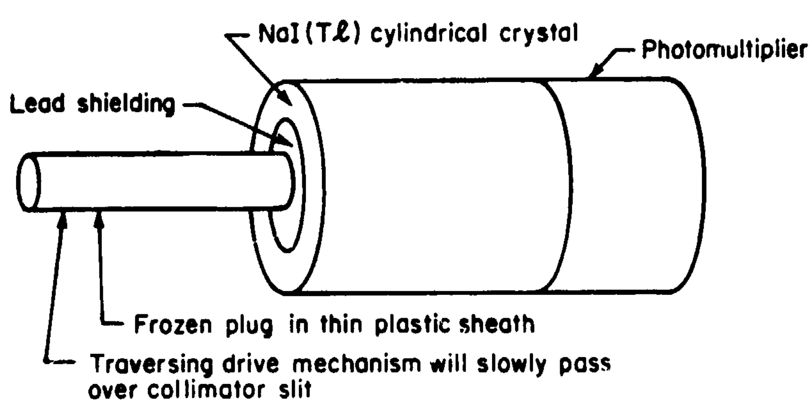

FIGURE 23b. SKETCH OF DETECTOR

a cylindrical lead shield which contains a radial slit around its entire circumference which serves as a collimator. The frozen plug fits inside the lead shield and traverses axially past the collimator slit. For purposes of this discussion, we have assumed that a slit width of 1 mm would provide sufficient resolution. This, of course, could be narrowed with resulting loss of counter efficiency. Optically coupled to the end of the sodium iodide crystal is a photomultiplier tube.

A series of rough calculations were made on the thickness of the lead shielding which would be required to obtain distinct peaks in the collimator. Ideally, the sodium iodide crystal should be very short in the axial direction to eliminate background noise from gamma-emitting cells not in frontof the slit. For this calculation, we have assumed that the shield should attenuate the gamma particles by a factor of 100:1. Using the mass attenuation coefficient of lead which is 0.32 cm^2/g, the thickness of lead required to attenuate 99 percent of the emission is 1.26 cm. If the diameter of the plug is 1 cm, then the cylinder of lead would be 3.5 cm in its outer diameter. Thus, a sodium iodide crystal 7.6 cm in diameter (which is a standard size) could serve well for this function.

The expected efficiency of such a system as depicted above can be calculated roughly from the geometry. If the lead cylinder is 3.5 cm in diameter and the collimator slit is 1 mm, the calculated efficiency is 2.9 percent.

As stated above, the level of labelling which one can obtain with ^{51}Cr is in the range of 3.2×10^{-2} $\mu Ci/10^6$ cell. If the frozen plug traverses past the slit at a rate of 1 mm/10 sec., then the average residence time for a band of cells 1 mm wide will be 10 seconds. The calculated total counts which could be obtained in a 10-second period are 345. These 345 counts would be approximately 15 times greater than the background. Thus, one would anticipate that this system would provide indication of concentration zones of cells. The configuration suggested may not be ideal and thicker lead shielding may be required to obtain sharp peaks. In addition, it may be desirable to place the sodium iodide crystal in just one side of the frozen column rather than having it surround the column. Because of the versatility and sizes and shapes available in sodium iodide crystals, a large number of configurations would be possible.

It should be noted that the detector system shown could be contained in a refrigeration unit to maintain it at a sufficiently low temperature to enable the plug to remain in a frozen sta[illegible] It may be desirable to allow the drive train of the traversing mec[illegible]m to be placed outside of the use temperature zone. However, the sodium [illegible]le crystal and the photocell are capable of operating at a low temperature.

Ultrasonic Analysis

Detection and measurement systems based upon ultrasound can best be viewed as analogs of light-based systems. Ultrasound is defined as sonic vibration at frequencies greater than 20,000 Hz. With ultrasound, the transmitting beam consists of sound waves rather than light waves. Sound waves can be focused, reflected, adsorbed, and detected by methods analogous to that in optical systems. In addition, sound waves can form interference patterns, and this property can be useful in analytical systems. Several different modes of ultrasound analysis can be used, and among these are reflective ultrasound, acoustic holography, and ultrasonic absorption.

The uses of ultrasound in medical diagnosis are currently expanding very rapidly. In these applications, ultrasound is generated by a piezoelectric transducer incorporated into a probe (see illustration on next page). Piezoelectric materials vibrate at high frequencies when a pulse of electricity is applied. The ultrasound then travels through the body and is reflected by interfaces between tissues with different acoustic properties. The reflected sound returns to the transducer which also serves as a detector during the time when it is not transmitting. Vibrations are then converted to electrical signals which can be processed and converted into an image. The time required for the reflected sound to return to the transducer depends upon the distance between the interface and the transducer and the properties of

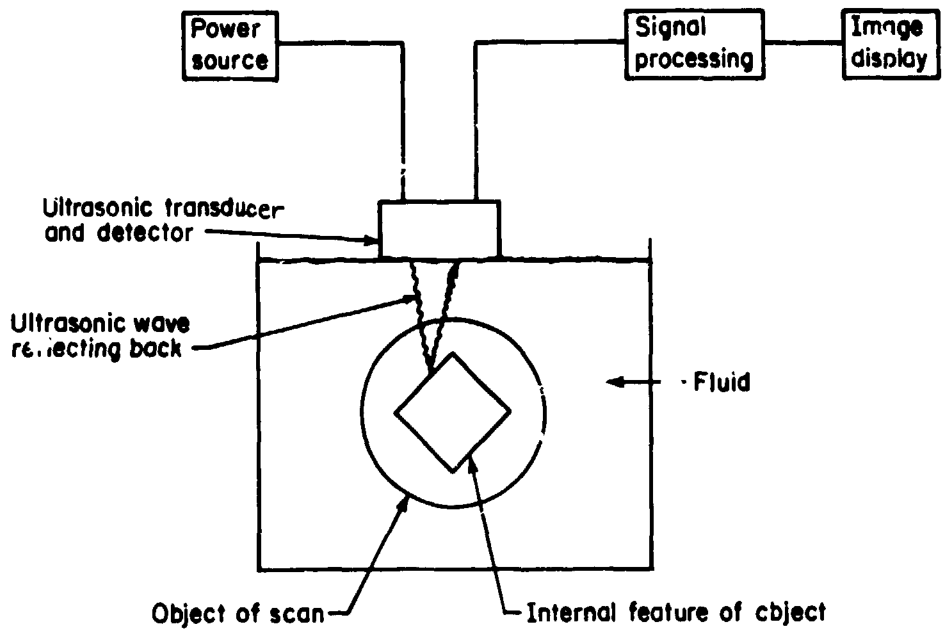

FIGURE 24. ULTRASONIC SCANNING SYSTEM

the structure through which it passes. Ultrasound is currently used in obstetrics and gynecology and in cardiology. Many applications are now under development, and these include locating tumors and differentiating between benign and malignant growth.

Of considerable interest also are developments of ultrasonic techniques for measuring blood flow through arteries to diagnose atherosclerotic plaques.

Acoustic holography, which is analogous to optical holography, is a method of extracting information in three dimensions from sound waves. An interference pattern is generated between a reference beam of ultrasound and the beam reflected from the sample. From the interference pattern, an image can be reconstructed.

The absorption of ultrasound can be used to detect and characterize biologically derived macromolecules in solution.[16] Absorption of ultrasound which is analogous to absorption of light is proportional to the concentration of biological macromolecules such as proteins and polynucleic acids. The absorption characteristics of the ultrasound are also a function of the orientation of the macromolecules as well as the concentration. For practical purposes of detection, however, ultrasound is not currently of value because of the concentrations necessary for a detectable signal are very high and thus the method has very low sensitivity.

In our literature search for applications of ultrasonics for particle detection, one article was uncovered in which impurities in fluids and gases were monitored by ultrasound.[17] This article describes the use of an ultrasonic particle counter manufactured by Sperry Corporation. The device was used to detect particulate matter in gas streams and in fluids such as liquid oxygen and hydraulic fluid. The ultrasonic particle counter was based on the phenomenon that solid particles in the fluid reflect the ultrasonic beam back to the source with the amplitude of the reflection being dependent upon the size of the particle. At the time of the writing, the authors reported that reliable counts could be made only with particles over 25 μ in size. Thus, this technique does not currently have relevance to the objectives of the NASA program.

Multiparameter Cell Analysis Systems

Considerable progress has been made in the field of multiparameter cell analysis in the last 5 years. Systems of this type simultaneously (or sequentially) measure several different parameters of individual cells and then correlate the assembled information to categorize each cell. Examples of measurements which are made include light adsorption, fluorescence, light scattering, and electrical conductivity. Multiparameter cell analysis systems are distinguishable from the cellular image analyzing systems described in another portion of this report in that the latter analyze a microscopic image of individual cells.

Several different research groups around the country are working on multiparameter cell analysis, and one of the groups in the forefront is at Los Alamos Scientific Laboratory in Los Alamos, New Mexico. This group has recently developed a new flow system instrument for quantitative analysis and sorting of microscopic particles, particularly biological cells.[18] The instrument has four separate modes of identification for cells. These are a Coulter counter for size distribution, low-angle light scattering for size and internal structure measurements, and two channels for fluorescence measurements. The cell suspension enters a flow chamber at a rate of 3-4 μl/min. from a pressurized reservoir. Flowing coaxially around the cell stream is a particle-free sheath fluid flowing at 1.2 ml/min. The sample stream flows through a volume-sensing orifice for particle counting by the standard Coulter method. It then flows through a viewing window which is traversed by a laser beam (0.5 watts at 488 nm). Forward light scattering is measured at an angle of 0.07 to 2 degrees. Fluorescence is measured at right angles to the incident laser beam and is split into two wavelength regions by a dichroic interference filter. Wavelengths are measured in the green and red fluorescence regions (520-570 nm and 620-800 nm). A diagram of the instrument is shown below.

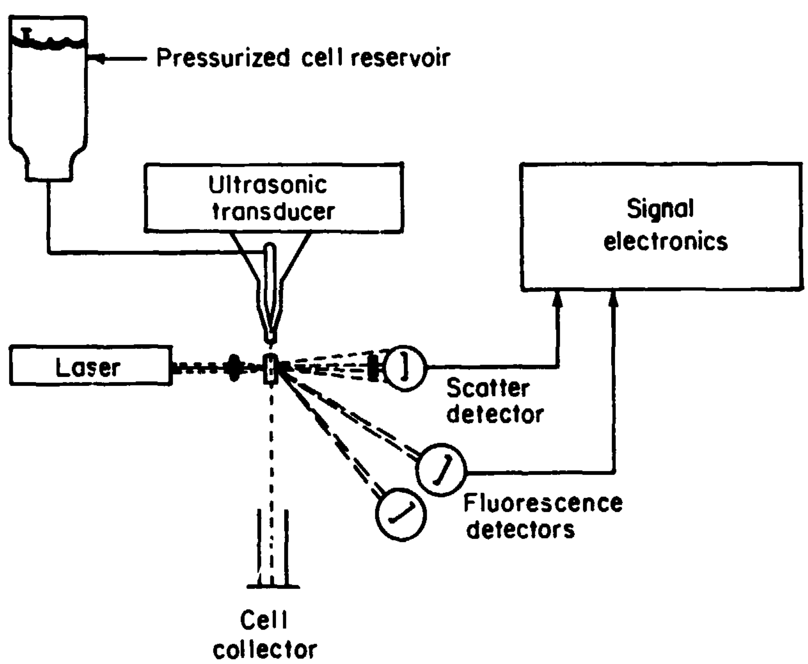

FIGURE 25. MULTIPARAMETER CELL ANALYZER

The fluorescence system has a disadvantage in that the cells require prestaining before analysis by the instrument. At present, this is done in a batch process, but there is no reason why it could not be done in a flow system. Cells are stained with propidium iodide for DNA quantitation and fluoroscein isothiocyanate for protein quantitation.

Multiparameter analysis of each individual cell as it passes through the sensing system can provide a great deal of information which can be used to identify and distinguish different types of cells from each other. In essence, three different parameters are measured: cell volume, protein, and DNA content. The electronics of the system provide gated single-parameter techniques, such as volume, which can be used to separate cells into various categories. In addition, one may obtain ratios of two different parameters which are characteristic of certain types of cells. For example, the protein:cell volume ratio, the DNA:cell volume ratio, or the protein:DNA ratios can be readily obtained by this instrument. Measurements of this type allow white cell differential counts to be made with quantitation of granulocytes, monocytes, and large and small lymphocytes.

A comparison of the Coulter method and the light-scattering method for determination of cell volume was made using uniform plastic microspheres. The results showed that for particle sizes less than 10 μ, the light scatter signal amplitude was directly proportional to the Coulter volume signal amplitude. However, the particles larger than 10.5 μ, this relationship does not hold. The Los Alamos group has presented several papers demonstrating the utility of this instrument in analyzing various kinds of mammalian cells. For example, they demonstrate that two distinct classes of human peripheral lymphocytes can be distinguished.[19] Lymphocytes are stained with acridine orange which results in a green fluorescence from the nucleus and a red fluorescence from the cytoplasmic granules. The authors were able to distinguish between large and small lymphocytes by both the volume measurements as well as the fluorescence ratio of these two types of cells.

A wide variety of different cell types has been examined by this group. For example, in another recent publication,[20] mammalian cells in suspension are passed through a flow chamber where they are lined up one at a time where they are exposed to the argon laser. As each cell crosses the beam, it produces an optical signal which is equal in duration to the cell transit time across the beam. The focus can be detected, amplified, and analyzed by techniques similar to those in gamma-ray spectroscopy. The rate of flow through the chamber is typically at a rate of 5×10^4 cells/min. The use of the laser in the system permits simplified optics since the beam is about 1 mm in diameter and has a very small divergence angle. This permits scattering measurements to be made at very small angles from the optical axis. As described before, the instrument measures cell volume by a Coulter system and by scattered light and has two channels for optical fluorescence. Electrical signals produced by the detectors are amplified and processed by a multichannel pulse analyzer to yield a frequency distribution histogram of the parameter under study.

Light-scattering techniques have considerable potential for distinguishing and identifying different types of cells. The work of Wyatt[21,22] gives theoretical and experimental evidence that various types of bacteria can be identified by light-scattering patterns. The cell can be regarded as a sphere immersed in a water-like medium. A typical cell with a diameter of around 10 μ and a refractive index relative to water of 1.03 to 1.05 can be used as a model. Scattering from such a cell can be considered to be composed of contributions from first-order Fraunhofer diffraction, transmission with refraction, and external reflections. Each reflection is independent of the refractive index and depends only on the gross silhouette of the cell. More than 80 percent of the diffracted light is contained within the main forward lobe which terminates at an angle of approximately 3.5 degrees. Thus, measurements in this angular range should reflect gross cellular size. The theory was confirmed with experiments in a paper published in 1972[23] using high-speed UV-sensitive film as the fluorescence detector.

The authors also discussed future applications and indicate that they are now working on a system which can take measurements at several different angles of the intensity of scattered light. They also intend to pursue adsorption of UV light by individual cells using UV lasers at appropriate wavelengths. In the area of fluorescence measurements, they intend to use an optical system which permits some spectroanalysis of the fluorescence emission. They also intend to explore excitation within 1 wavelength.

Future work is also planned with a host of different labelled antibodies which attach to different components of the cell, and thus can provide a distinctive and unique characterization of that particular cell.

We supplemented our literature review on this topic by a visit to Los Alamos Scientific Laboratory and by several subsequent telephone conversations. In a recent discussion with this laboratory, we requested information on light-scattering systems for cell characterization which did not require cell staining. The Los Alamos group has just published two papers[24,25] on a system for differential white cell count which involved no staining and was entirely dependent upon light scattering. This system is able to detect lymphocytes, monocytes, neutrophils, and eosinophils and does so by measuring size and shape of the nucleus for these cells. This can be done by measuring light scattering at just two angles in the forward scattering mode. Scattered light is detected with a hemispherical array of light-sensitive diodes which are manufactured by Recognition Systems, Inc. The diodes are arrayed in concentric rings inside a hemisphere of 30 mm diameter and are capable of picking up light scattering from zero to 75 degrees. A diagram of the system is shown on the next page.

This system can utilize a very low energy helium-neon laser (2 mw). For the analysis of any particular type of cells, one would first determine the optimal characteristic angles for light scattering between zero and 90 degrees. In addition to leukocytes, Los Alamos is also working on cells from PAP smears and is just beginning work on distinguishing T and B lymphocytes. Preliminary evidence indicates that there are several changes in the structure and cell surface of T and B lymphocytes which would enable them to be distinguished by light-scattering techniques.

Since this system counts cells one at a time as they pass through the laser beam, very dilute suspensions of cells are required. For purposes of analysis in space, only a small fraction of the output of a separation device would be needed for analysis. One should also point out that the wavelength of the laser is 632 nm and that any features of the cell smaller than this size would probably not be detectable by the light-scattering technique.

It should also be emphasized that the lasers used in these systems are of relatively low power and do not damage the cells. In a number of instances, the viability of the cells after analysis has been demonstrated.

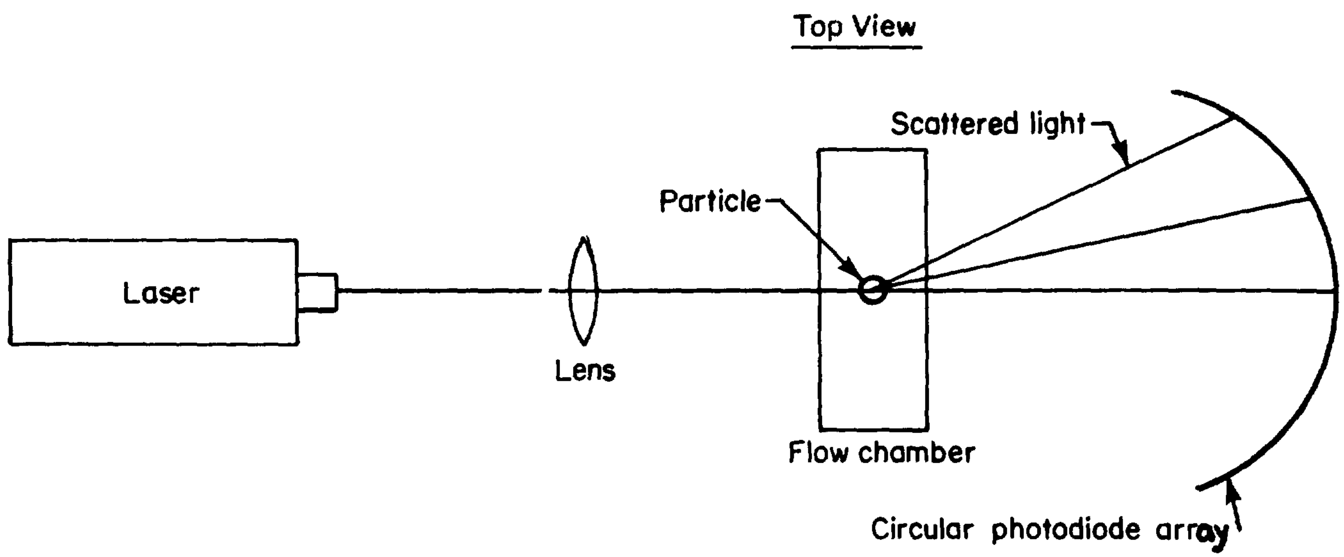

FIGURE 26. MULTIANGLE LIGHT-SCATTERING DETECTOR FOR CELLULAR ANALYSIS

Another sophisticated multiparameter cell-counting and differentiating device is manufactured by Technicon Instruments Corporation. The principles of operation and performance of this device have been recently described in a paper by Mansberg and co-workers.[26] This system, designated the Hemalog D, uses 0.4 ml of whole blood which is stained by an automated continuous-flow staining technique. The system can process a new sample each minute. Classification of the white cells is done through the optical methods of light scattering and light adsorption at appropriate wavelengths. The cells are sized by light scattering. Specific chemical reactions peculiar to each individual type of cell are used to differentiate the cells with light adsorption. Beta cells are stained with Alcian Blue. Monocytes exhibit an esterase activity which hydrolyzes α-naphthol butyrate. The α-naphthol is subsequently coupled with hexazonium pararosanilin. Lymphocytes and large mononuclear cells remained unstained in a peroxidase staining system and eosinophils stain very strongly. This system is capable of classifying 10,000 cells in less than 1 minute.

The system uses a single tungsten-halogen lamp which acts as a common light source for three individual optical systems. In two of the channels, a beam splitter divides the light collected from the flow cell for simultaneous measurement of dark-field forward-scattered light and full aperture light loss due to absorption by the stain of the cells. In the third channel, the interference beam is split into red and green spectral components to improve the signal:noise ratio.

It should be emphasized that the primary purpose of this instrument is to perform large numbers of differential white cell counts with high efficiency in a clinical laboratory. For purposes of the NASA program on particle separation in space, the primary objective is not the analysis of large numbers of samples over a short time period. However, the principles involved and the sensitivity of this instrument could be used to good advantage in evaluating separated cells because of its sensitivity to subtle differences in cell types.

Automated Image Analysis

In the last 5 years, dramatic advances have been made in the field of automated image analysis systems. Such systems will automatically scan, identify, quantitate, and/or differentiate selected elements present in a given optical field. The uses of image-analyzing and enhancement techniques are widespread and range from routine analysis of blood samples to analysis of photographs taken in space. A detailed explanation of image-analyzing and enhancement processes is beyond the scope of this report. Nevertheless, we shall describe a few of the instruments and techniques available which are relevant to the objectives of the NASA program.

Imaging processing systems can be broadly divided into two categories: (1) systems which automatically analyze given elements present in an optical field and categorize them with respect to density, size, shape, frequency, etc., and (2) image enhancement systems which process the image to make features distinguishable which were previously not detectable by visual observation. Several approaches to image enhancement are under development and of these, three are of most importance to this report. One approach is called coherent optical processing and makes use of the fact that coherent light of the laser can be sorted out readily into its spatial frequencies. Another approach is called digital processing and is based upon the manipulations by digital computer of a mathematical representation of the image. A third process converts an image to analog electrical signals and applies mathematical principles of enhancement and detection to these electrical analogs.

A number of image processing systems were reviewed in the course of this program and representatives of these are discussed below. The first class of devices are automated differential leukocyte classifiers. These are highly specialized image analysis systems and include methods for preparing and staining leukocytes as well as their analysis. A typical example of an instrument of this type is the Hematrak® produced by Geometric Data Corporation.

This device is a computerized electrooptical system which scans Wright-stained blood smears and was developed primarily for screening use in clinical hematology. It utilizes an advanced principle of pattern recognition and performs high-speed morphological analysis of nuclear shape, chromatin patterns, cytoplasm:nuclear ratio, and color of granules. Acceptable information on each of these features is included in the computer memory of the device. When an abnormal cell is detected, the scanner is designed to stop, permitting the technologist to interpret visually. The output of the instrument is a small card which logs the percentages of the cells in the various leukocyte populations.

Another such device is the Leukocyte Automatic Recognition Computer (LARC®) which is produced by the Corning Glass Works. This device automatically differentiates leukocytes from a peripheral blood smear stained by a Romanowski-type stain. The features used in the discrimination are nuclear shape, nuclear size, cytoplasm size, cytoplasm color, and nuclear density. A pierpheral blood smear is placed in a microscope and the microscope image is then focused on a television camera. The system is based on a doctoral thesis by Bacus.[27] A cell is analyzed by placing it in the center of the optical field. The television tube converts the optical image to a digitized electrical signal and the image is thus entered into the computer memory as a 50 x 50 point array. The image points are then histogrammed according to their optical density value.

An image-analyzing system with more versatility is the Omnicon® built by Bausch and Lomb. This system analyzes images from any number of sources such as optical microscopes, metallographs, electron microprobes, electron microscopes, photographs, micrographs, opaque prints, transparencies, and even gross specimens. The system operates by focusing the optical image on a Vidicon tube which then transforms the optical signal into a digitized electronic signal. The system can perform 23 direct measurements with images thus received. It can measure individual features or all the features in the field of measurement. Results can be printed out in numerical form as histograms or in several other formats. For example, the area, projected length, longest dimension, or any selected feature can be measured. The device can also perform particle counts of discrete particles in a particular field of measurement.

Another system of this type is the Quantimet®, manufactured by Image Analyzing Computers, Ltd. In this system, an image focused on a 720-line Vidicon scanner selects features for measurement in terms of their common gray level characteristics. The scanner output can also be coupled with a microdensitometer which assesses the optical density at each point in a feature and computes its integrated intensity. The scanning system is capable of detecting more than 30 separate gray levels to better than 1 percent accuracy over the entire field of view. Inputs to the device include photographic prints, plates, negatives, and cine film, as well as optical and electron microscopes. The basic measurements performed by the device are particle counting, area length and perimeter measurements, form factors, and optical density.

More sophisticated image processing computer systems are capable of enhancing and clarifying images to bring out details not discernible visually. Such a system is the Datacolor Image Enhancement System developed by Spatial Data Systems. This system analyzes films from photographs, radiographs, micrographs, and other sources and measures information not apparent to the naked eye. One of the techniques utilized is edge enhancement, which makes fine lines in an image much more distinct for visual analysis. Edge enhancement operates by producing a black line on the display when a normal image changes from white to black. Conversely, a white line is produced when a normal image changes from black to white. The width of the enhanced lines is adjustable from narrow to very thick for maximum visibility of fine details.

A second method of image enhancement involves a technique known as color enhancement. In this process, the photographic density is electronically analyzed and classified into as many as 32 discrete levels. Each level is then assigned a unique color which makes it visually distinguishable from the others. Borders between the colors indicate density contours. The operator may adjust the color enhancement to achieve visual effects that are best suited for a particular analysis. Colors can be switched in and out of the picture. The system may also be used as a densitometer. Color contours are then calibrated for quantitative measurement of film density which is read directly in terms of display color. This process may be of value to the forthcoming experiments on electrophoresis to be conducted by NASA. A photographic image of the electrophoresis tube may not reveal bands to the naked eye. However, analysis by an image enhancement system such as edge enhancement or color enhancement may make these zones discernible. The Spatial Data System also can provide a graphic display of the film density values along a vertical cross-section of the picture and thus can act as a microdensitometer.

Another image analyzing system which enhances details in an image is manufactured by Rank Precision Instruments. This system operates on a different principle than the ones discussed above, as shown in the following diagram.

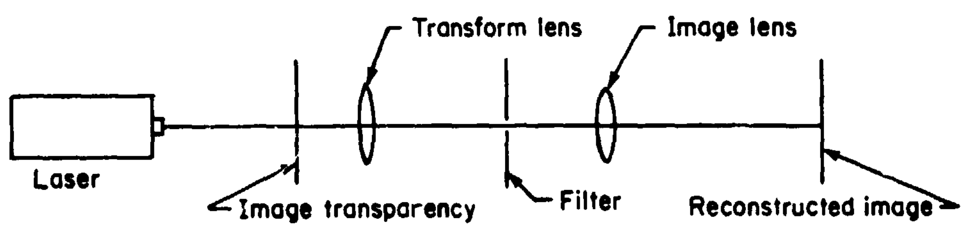

FIGURE 27. IMAGE ENHANCEMENT SYSTEM

The transparency is illuminated by coherent light from a laser. The light passing through the transparency is diffracted by the structure of the image and produces a Fourier transform. In this plane, certain transform spots can be masked off by the filter so that the reconstructed image contains only those spatial characteristics which are allowed through the filter. One of the advantages of this image analyzer is that it can separate random features from a background of a regularly repeated pattern. This has many applications in biology, particularly looking at the ultra-structure of cells. The output of the system is a television monitor or a photograph of the reconstructed image.

Particle-Counting Techniques

The detection methods discussed in the previous section are capable of deriving a considerable amount of information by combination of several different measurements. These methods can be of great value in detecting and analyzing complex mixtures of particles. In many cases, however, the amount of information obtainable by multiparameter analysis is not necessary and simpler methods would suffice. In this section, devices which automatically count and size particles will be described.

Two basic techniques of automated particle counting are currently in use. The first of these is the optical method which utilizes the adsorp-tion or scattering of light resulting from a particle intercepting a light beam. The second method, electroconduction, detects and counts cells by meas-uring the change in electrical conductance which occurs when a particle passes between two electrodes. This report has already described in some detail the principles of particulate analysis by light scattering. A review of particle-counting techn..ues written t Maisberg[28] provides a more detailed discussion of this top... Consequently, this section will deal primarily with the principle of electroconduction.

In the electroconductive technique, the sensing system consists of a small orifice through which the fluid containing the particles passes (see diagram on next page). On either side of the orifice electrodes are placed and a potential is applied across the electrodes. The particles are sus-pended in an electrolyte which is a good conductor. As an individual particle

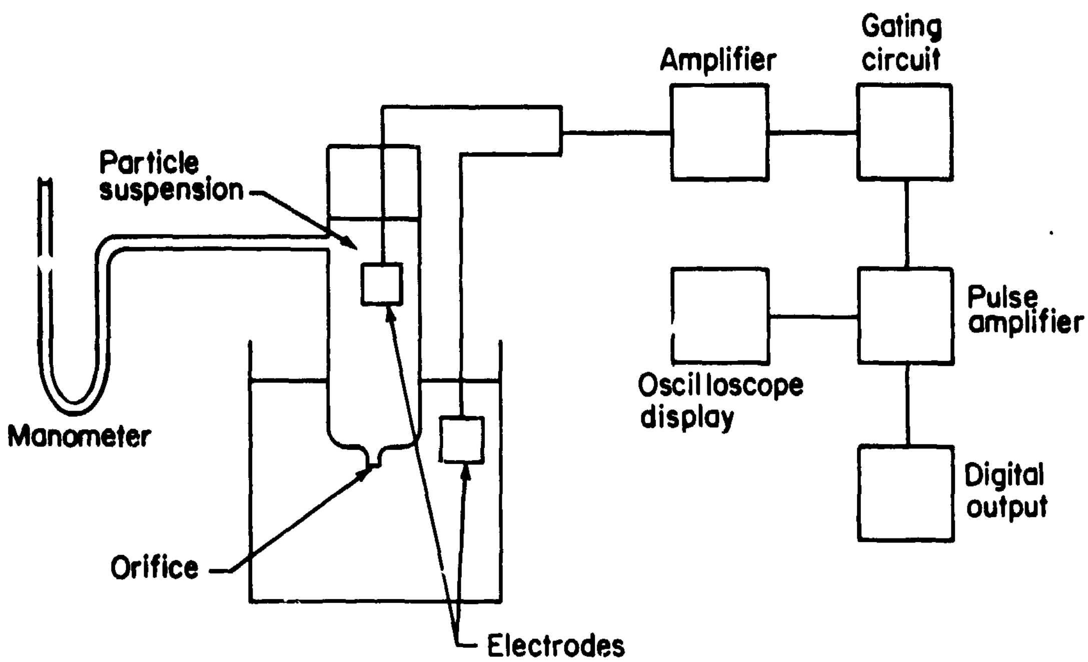

FIGURE 28. PRINCIPLE OF PARTICLE COUNTING BY ELECTROCONDUCTANCE

passes through the orifice, the cross-sectional area of the conducting fluid is reduced by the particle. Since the particles are not conductors, the conductivity is reduced in proportion to the volume of the particle. In a practical sense, this condition holds if the size of the orifice is in correct proportion to the size of the particles. Consequently, devices of this type have a range of orifice sizes which can be changed in response to the size ranges of particles being counted. In the operation of the counter, particles pass through the orifice at a high rate of speed. Because of the random distribution of the particles in the suspension, it is highly improbable that all of the particles will pass through the orifice one at a time. Some of the particles will pass through the sensing volume in pairs or even in greater number and a coincidence error will result. The coincidence error can be reduced theoretically by reducing the concentration of particles in suspension, but this can result in a higher background count due to dust particles in the diluent. Another method of reducing coincidence is by reducing the volume of the orifice, but there are practical limits to this approach.

Another consideration in determining the concentration of particles in the suspension is the ability of the electronic components to resolve one signal from the next concurrent one. If too many particles pass through the orifice in a given time period, another type of coincidence error can result. Typical instruments can resolve particles at a rate of 5000 particles/second.

As mentioned previously, the change in conductivity is in direct proportion to the volume of the particle. By analyzing pulse amplitude as particles pass through the orifice, particle counters can discriminate between various particle sizes. Particle sizes which can be detected and analyzed range from 0.5 to 800 μ. Particle counters can operate in several output modes. In one mode, the instrument can be gated at upper and lower size limits and then count particles within that size range. The particle counter can also be gated to count particles in several size ranges. Multichannel counters are now available which can perform a particle size distribution analysis. For this purpose, as many as 256 channels can be used. The output of the counter can be in the form of an oscilloscope display, a photographic recording, a XY plot of number versus size, or a tape.

A practical limitation for the conductometric particle analyzer with respect to operation in space is the method used to control the pressure driving the fluid through the orifice. Currently, a mercury manometer is used and this device would not function in a zero-g environment. A modification of this feature would be necessary and might be accomplished with a diaphragm to regulate pressure rather than a mercury column.

Particle-counting instruments are commonly used for analysis of discrete samples and as such would not interface directly with a separation device used in the NASA program. An adaptation of the device could be developed to effect a direct interface with a separation system having several effluent channels. This could be accomplished through the use of a rotary valve attached to the effluents of the separation device (see illustration that follows). Rotary valves suitable for this purpose are manufactured by J-Z Associates, Waltham, Massachusetts. The rotary valve could be programmed to sequentially and continuously sample each of the effluents. The major portion of each effluent would be diverted to a sample collector and only a small portion passed through the counter after appropriate dilution. We have discussed this concept with the particle detection group at Los Alamos, and they feel it is feasible. Care would have to be taken to ensure that the effluents from the device have the same buffer composition to avoid changes in conductivity from one sample to the next.

Photographic and Microscopic Methods

A number of detection techniques described in this report utilize photographic means as a method of recording data. For this reason, some photographic equipment has been included in the instrument survey. The available photographic equipment and techniques are very large in number and are beyond the scope of this report.

A discussion of the principles of microscopic methods used in scientific research is similarly broad and will not be presented in this report.

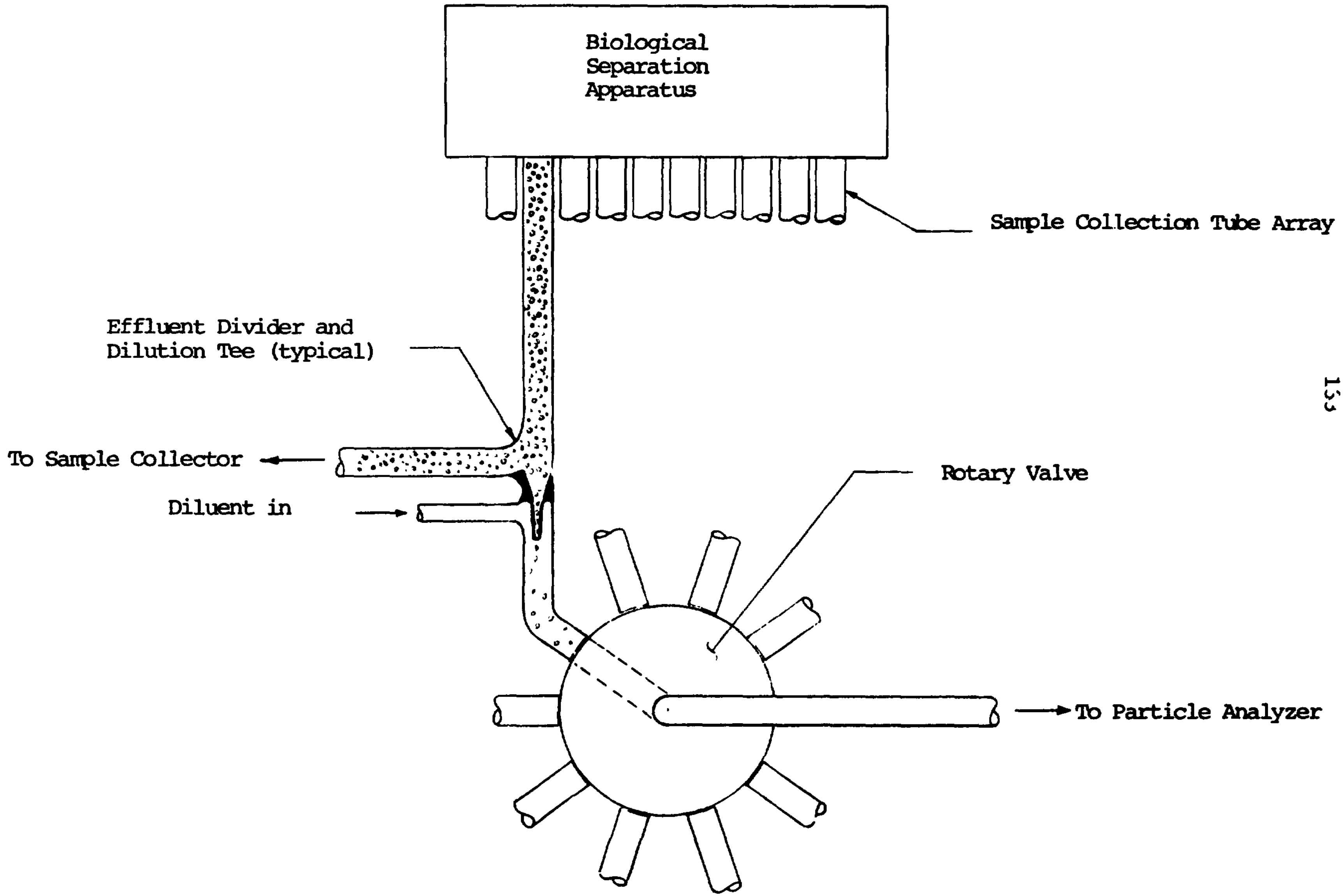

FIGURE 29. MULTI-CHANNEL ANALYZER FOR CONTINUOUS SEPARATION SYSTEMS

SUMMARY AND RECOMMENDATIONS

In the conduction of this research program, a large number of analytical methods were surveyed and evaluated for their relevance to the objective of particle detection in space. From these methods, certain were selected for further review. In the previous sections, the principles of these selected methods were outlined and the interface of the methods with separation devices was described. For purposes of comparing these methods with each other and evaluating their effectiveness, a summary table has been prepared (Table 12). The second column of the table lists the types of particles which can be detected according to size range. It should be understood that the individual methods can detect particles provided certain conditions are met. For example, photometric methods will detect only those substances which have adsorption peaks within the wavelength of the particular range of the method. The first two entries in the table, visible and ultraviolet photometry, refer to particles in solution and not suspensions of cells. Microphotometric methods do exist for detecting constituents and monitoring reactions within individual cells.

The results of the study indicate that many well-established detection techniques could be readily adapted to detect particles in space. In addition, certain newly emerging technologies such as multiparameter particulate analysis and image analyzers may be of value in particle detection and analysis.

As a result of this survey, we believe that the following specific techniques would be of the most value in monitoring electrophoretic or other types of separations in space. Most of the techniques will require some adaptation to interface adequately with the separation device.

TABLE 12. SUMMARY OF PRIMARY DETECTION TECHNIQUES

Technique	Types of Particles Detected	Modes of Detection: Discrete Sample	Flow Cell	*in situ*	Advantages of Use	Disadvantages of Use	Sensitivity
Visible photometry (other than cellular analysis)	Particles smaller than 0.1 μ (to avoid light scattering)	X	X	X	(1) Simplicity of operation-convenient light source (2) Can use glass or clear plastic optical systems (3) High stability (4) Versatility of operation	(1) Substances must have adsorption peaks in visible region (2) Affected by cloudiness of sample. bubbles	Depends on visible extinction coefficient
U.V. Photometry (other than cellular analytis)	Particles smaller than 0.1 μ (to avoid light scattering)	X	X	X (with quartz optics)	(1) Simplicity of operation (2) Versatility of of operation (3) Large number of substances possessing U.V. absorption peaks	(1) More sensitivity to cloudiness, bubbles, and other interference than visible (2) Requires quartz optics, hydrogen/derivatives light source	Proteins ~ 50 μg/ml Polynucleotides ~20 μg/ml
Fluorometry	Particles smaller than 0.1 μ	X	X	X	(1) Greater sensitivity than U.V. or visible (2) Ability to vary exciting and emitted frequency gives increased versatility (3) Scattered light effects are minimized	(1) Quenching of fluorescence can produce errors	Proteins ~ 4 μg/ml Polynucleotides ~5 μg/ml
Microfluorometry	Particles larger than 0.5 μ	X	X		(1) High sensitivity	(1) Staining or incubation of particles with fluorogenic substance is required	Any particles which can be stained or which react with a fluorogenic substance can be detected

TABLE 12. (continued)

Technique	Types of Particles Detected	Modes of Detection: Discrete Sample	Flow Cell	*in situ*	Advantages of Use	Disadvantages of Use	Sensitivity
Polarimetry	Particles smaller than 0.1 μ	X	X		(1) Ability to analyze closely, highly colored samples (2) Wide range of biological substances analyzed - most biological compounds possess biological activity	(1) Low sensitivity relatively high concentrations necessary (2) Slow response time of instrument	Proteins ~ 300 μg/ml Polynucelotides ~100 μg/ml Carbohydrates ~ 50 μg/ml
Refractometry	Particles smaller than 0.1 μ	X	X	X (with Schlieren)	(1) High sensitivity (2) Adaptability to several modes of operation (3) Broad applicability - not dependent on specific light adsorption peak - any solute causes change in R.I.	(1) Extreme sensitivity to changes in pressure, temperature, and ionic composition causes interference (2) Need for precise alignment in Schlieren optical systems	Proteins ~ 0.3 μg/ml Polynucleotides 0.2 μg/ml Carbohydrates 0.3 μg/ml
Nephelometry	Particles larger than 0.1 μ	X	X	X	(1) Simplicity of operation (2) High adaptability - many configurations can be used	(1) Interference by extraneous sources of scattered light (2) Nonlinearity of signal over wide concentration range	Depends on particle size and scattering angle Low angle ~0.1 μg/ml High angle ~1 μg/ml
Light scattering	Particles of all sizes[(a)]	X	X		(1) Large amount of information can be obtained on size, shape, and interval features of particles (2) Particles require no prestaining	(1) Nonlinearity of scattered intensity related to size in certain light regions	Can be done with either single particles or bulk suspensions for detection only, nephelometry should be used.

TABLE 12. (continued)

Technique	Types of Particles Detected	Modes of Detection: Discrete Sample	Flow Cell	*in situ*	Advantages of Use	Disadvantages of Use	Sensitivity
Radiometric							
Liquid scintillation (Beta)	All sizes of labeled particles	X			(1) Very high sensitivity-extremely small amounts of material may be detected - good counting efficiency (2) With appropriate labeling, different types of particles may be detected in presence of each other	(1) Cannot be efficiently used in flow cell or *in situ* because of low penetration of radioactivity (2) Particles must be labeled (3) Sample must be placed in non-aqueous scintillation fluid	
Gas proportional (Beta)	All sizes of labeled particles	X		X	(1) Can detect particles in electrophoresis strips, TLC plates (2) Very high sensitivity	(1) Limited applicability to NASA objectives	Depends on the amount of radioactivity which can be incorporated Typically 10^3 cells or 10^{-12} g protein
Crystal scintallation (gamma)	All sizes of labeled particles	X	X	X	(1) Very high sensitivity (2) Good versatility in use - discrete sample, flow, or *in situ* (3) Detector is very simple: crystal plus photo cell	(1) Particles must be labeled (2) Lead collimator must be used to get good spatial resolution	
Flow microcalorimetry	(not well characterized)	X	X		(1) Can analyze very turbid solutions	(1) Analysis depends upon chemical or physical transformation occurring (2) Slow response time	100 μg/ml

TABLE 12. (continued)

Technique	Types of Particles Detected	Modes of Detection: Discrete Sample	Flow Cell	*in situ*	Advantages of Use	Disadvantages of Use	Sensitivity
Ultrasonics	Particles larger than 25 μ	X			(1) Samples opaque to light can be analyzed	(1) Size of particles detected limits usefulness in biological systems	Not known

(a) It should be understood that different mechanisms of light scattering obtain as the particle sizes change with respect to the wavelength of the light.

(1) Visible Absorption Photometry

A simple and convenient detector for *in situ* analysis could be devised with a fiber-optic light pipe which traverses the separation cell. The light pipes could either be arranged opposite each other with the cell in between or could be mounted beside each other with a mirror placed on the opposite side. With the use of high-intensity sources, the cross-section of the light beam could be very small and thus the curvature of the electrophoresis tube would not be a problem. The particles being detected would, of course, have to absorb light in the visible region.

(2) Ultraviolet Photometry/Fluorescence

A simple and effective method combining UV and fluorescence[29] could detect the biological substances within the electrophoresis cell. The entire cell could be illuminated with a UV source. On the other side of the cell, a fluorescent glass plate could be mounted. A camera placed back of the plate could then photograph the glass plate. Bands of particles would appear on the photograph as dark bands. To accommodate this arrangement, one side of the electrophoresis cell would have to be made of quartz.

(3) Fluorescence

A simple fluorescence detector employing fiber optics could be constructed in a manner similar to the one described above for visible photometry. The return light pipe would be mounted at a 90° angle to the exciting light. The particles within the separation cell would have to exhibit fluorescence at the selected wavelengths. We would recommend that either fluorescent antibodies or fluorescent markers (fluorescein isothiocyanate, dansyl isothiocyanate) be used. These compounds adsorb and emit in the visible wavelength so quartz optics would not be necessary. Cells labelled with fluorescent antibodies can retain their viability and biological function although the electrophoretic mobility may be altered somewhat.

(4) Light Scattering

Light-scattering techniques have particular value for in situ detection and many configurations are possible. A narrow beam, low-power laser would be an ideal light source since the curvature of the electrophoresis tube would adversely affect the beam. A traversing system could be designed with the laser on one side and the photocell on the other. For the highest sensitivity, a small (<5°) angle from the incident light should be used.

(5) Radiometric Methods

Labelling of the particles with the gamma-emitting isotopes, ^{125}I and ^{51}Cr, is strongly recommended as the basis for a radiometric detection method. In situ detection could be accomplished by a traversing sodium iodide crystal mounted behind a lead shield containing a slit. Analysis of the effluents from a separation device can also be accomplished with a scintillation crystal.

(6) Multiparameter Cell Detection Systems

The multiparameter cell detection systems described previously in this report have much potential for analysis of effluents from separation devices. By combining the techniques of multiangle light scattering, fluorescence, and visible light adsorption, systems of this type are able to detect and distinguish many different types of particles. We recommend, therefore, that contact be maintained with the group at Los Alamos Scientific Laboratories.

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APPENDIX A

EXAMPLES OF INFORMATION RETRIEVAL TOOLS

PRECEDING PAGE BLANK NOT FILMED

A-1

BIBLIOGRAPHY WORKSHEET

ASSAY TECHNIQUE ______________

____

AUTHORS ______________________________

TITLE ______________________________

____

PUBLICATION ______________________________

Vol.________ No.________ Date______________________ Page(s)__________

SUBSTANCE SEPARATED ______________________ DETECTION METHOD ______________________

______________________ ______________________

______________________ ______________________

SUPPORTING MEDIUM ______________________________

Buffer pH ______________ Temperature ________ C

DISCUSSION:

ASSAY TECHNIQUE ____________________

A-2

COMMERCIAL EQUIPMENT WORKSHEET

Qualitative ☐

Quantitative ☐

VENDOR ____________________

INSTRUMENT

MODEL NO. __________ COST __________

ELECTRICAL INPUT __________ V __________ Hz __________ Watts

READOUT __________

or

OUTPUT VOLTAGE __________ V OUTPUT IMPEDANCE __________ Ohm

EQUIPMENT SIZE (__________ in) (__________ in) (__________ in)

Volume __________ m^3 (__________ in^3)

Weight __________ kg (__________ lb)

Mfgr. recommends for the following classes of candidates:

Sample State __________

Sample Size __________

Particle Size Range __________ u

Accuracy __________

Sensitivity __________

Concentration __________

Purity __________

Resolution __________

RANGES: Wavelength __________ nm Scan Speed __________

Operating Temperature __________ C

Absorbance __________ O .er __________

Compatibility with Spacecraft Operation __________

Complexity of Operation __________

ACCESSORIES AVAILABLE (not included in basic specifications above)

Cat. No.	Nomenclature	Size, in.	Weight, lb.	Add'l Watts	Cost

Date Mailed ____________

A-3

USER INFORMATION FORM

Equipment Nomenclature ____________

Model No. ____________

Manufacturer ____________

____

User's Name ____________ Phone (   ) ____________

Co. or Univ. Affiliation ____________

Address ____________

City ____________ State ____________ Zip ____________

(1) How is equipment used? (application) ____________

____

____

(2) How long has present equipment been in use? ____________

(3) Reliability:

Needs minor adjustment	- Rarely	6*	Occasionally	3	Often	1
Replacement parts required	- Rarely	6	Occasionally	3	Often	1
Reproducibility of results	- Good	6	Fair	3	Poor	1

(4) Complexity of Operation:

Extremely complex [2] Moderate skill required [10] Easily learned [20]

* point system protocol; e.g., "rarely" = 6 points.

APPENDIX B

BIBLIOGRAPHY

APPENDIX B

BIBLIOGRAPHY

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(513) 791-6530

(111) Process & Instruments Corp.
1943 Broadway
Brooklyn, New York 11207
(212) 452-8380
Mr. Greenspan
(Code 263)

(112) Rank Precision Industries, Inc.
411 Jarvis Avenue
Des Plaines, Illinois 60018
(312) 297-7720
Mr. Cresp
(Code 103)

(113) Raytheon Company
Medical Electronics Operation
P. O. Box 397
Fourth Avenue
Burlington, Ma 01803
(617) 272-7270
(Code 127)

Michael Farinacci
4550 Rainbow Road
South Euclid, Ohio 44121
(216) 461-1585

(114) Recognition System, Inc.
15531 Cabrito Road
Van Nuys, California 91406
(213) 785-2179
Harvey L. Kasdan, Ph.D.
(Code 28, 75)

(115) ROYCO Instruments, Inc.
141 Jefferson Drive
Menlo Park, California 94025
(415) 325-7811
Mr. Stanley Strobel
(Code 12, 74)

(116) Rudolph Instruments Engineering
Company, Inc.
61 Stevens Avenue
Little Falls, New Jersey 07424
(201) 256-1491
Mr. Hellmuth Rudolph
(Code 51, 184, 264)

(117) Rudolph Research
Pier Lane
Fairfield, New Jersey 07006
(201) 227-6810
Mr. Hans Ernesti
(Code 50, 70)

(118) SAI Technology Company
(Formerly JRB, Inc.)
8953 Complex Drive
San Diego, California 92123
(714) 459-2601
James T. Palmer, VP
Timothy Geiser, Product Mgr.
(Code 96)

(119) Sargent-Welch Scientific
7300 N. Linder Avenue
Skokie, Illinois 60076
(312) 677-0600
(Code 185, 186)

Ron Chain
10400 Toconic Terror
Cincinnati, Ohio 45215
(513) 771-3850

(120) Science Spectrum, Inc.
1216 State Street
Box 3003
Santa Barbara, California 93105
(805) 963-8605
James Hawes
(Code 73)

(121) Scientific Products
1430 Waukegan Road
McGaw Park, Illinois 60085
(312) 973-3600
(Code

(122) Schoeffel Instrument Corporation
24 Booker Street
Westwood, New Jersey 07675
(201) 664-7263
George O'Dom, Ph.D.
(Code 36, 58)

(123) Searle Analytic, Inc.
2000 Nuclear Drive
Des Plaines, Illinois 60018
(Code 216, 217, 218)

Edward J. Zurmuhlen
5643 Chevoit Road
Cincinnati, Ohio 45239
(513) 931-9100

(124) SHM Nuclear Corporation
570 Del Rey
Sunnyvale, California 94086
(408) 245-3136
Mr. Dave Reizes
(Code 242)

(125) SKAN-A-MATIC
P. O. Box S or Rt. 5 West
Elbridge, New York 13060
(315) 689-3961
(Sub-miniature light sources, photodetectors, scanners & assoc. electronics)

(126) Spatial Data Systems, Inc.
P. O. Box 249 or 500 S. Fairview
Goleta, California 93017
(805) 967-2383
Fred Clark
(Code 43, 44)

Daniel P. Ulrich
Electro Sales Associates
1635 Mardon Drive
Dayton, Ohio 45432
(513) 426-5551

(127) Technical Consulting Service
P. O. Box 141
Southampton, Pennsylvania 18966
(215) 947-2275
Horst K. Blume
(Code 99)

(128) Technicon Instruments Corp.
511 Benedict Avenue
Tarrytown, New York 10591
(914) 631-8000
(Code 139, 140)

(129) Tektronix, Inc.
P. O. Box 500
Beaverton, Oregon 97005
(503) 644-0161
(Code 13)

Thomas Edwards
Suite 5
12 West Shelby Blvd.
Worthington, Ohio 43085
(614) 888-4040

(130) Tracor, Inc.
6500 Tracor Lane
Austin, Texas 78721
(512) 926-2800
(Code 146)

(131) Transamerican Instrument Corp.
85 Kinderkamack Road
Emerson, New Jersey 07630
(201) 265-8906
Mr. Roland Kologrivov
(Code 14, 59)

(132) Transidyne General Corp.
903 Airport Drive
Ann Arbor, Michigan 48106
(313) 769-1900
Ms. Vickey Shallhorn
(Code 8, 41, 98)

(133) Tri-R Instruments, Inc.
48 Merrick Road
Rockville Centre, New York 11570
(516) 766-5134
(Code 212)

(134) G. K. Turner Associates
2524 Pulgas Avenue
Palo Alto, California 94303
(415) 324-0077
Charles Heltsley
(Code 191, 194, 200, 203)

(135) Union Carbide Corp.
Tarrytown Technical Center
Tarrytown, New York 10591
(Code 9)

Paul Orwick
120 S. Riverside Plaza
Chicago, Illinois 60606
(312) 822-7015

(136) United Detector Technology, Inc.
2644 30th Street
Santa Monica, California 90404
(213) 396-3175
Chris Hageman
(Code 136, also solid-state photo diodes)

Ed Boggs
Dietrich E. Associates, Inc.
333 West First Street
Dayton, Ohio 45402
(513) 223-6042

(137) Vactec, Inc.
2423 Northline Industrial Boulevard
Maryland Heights, Missouri 63043
(314) 872-8300
(Code 192)

Scott Electronics
Mr. Ted Chamberlain
2677-1/2 E. Main Street
Columbus, Ohio 43209
(614) 236-8619

(138) Vangard Systems, Inc.
Ten Price Street
Dobbs Ferry, New York 10522
(914) 693-6130
Mr. Herbert Rosenfeld
(Code 132)

(139) Varian Associates
611 Hansen Way
Palo Alto, California 94303
(415) 493-4000
Mr. Allen Shelton
(Code 79, 110, 150)

Dick Drotleff
2500 Euclid Avenue
Euclid, Ohio 44115
(216) 261-2115

(140) Vir Tis Company
Phoenix Precision Instruments
Rt. 208
Gardiner, New York 12525
(914) 255-5000
Jerry Bartholomew
(Code 22, 147)

(141) Vitatron Medical, Inc.
45 "A" Street
South Boston, Massachusetts 02127
(617) 269-8445
Anthony Featherstone
Lawrence H. Foley, Jr.
(Code 105, 106, 107)

(142) Volu-Sol Medical Industries, Inc.
1034 S. Commerce Street
Las Vegas, Nevada
(702) 384-1731
(Code 246)

(143) Waters Associates, Inc.
Maple Street
Milford, Massachusetts 01757
(617) 478-2000
(Code 2, 61)

Dick Goddard
John Sarruda
Pittsburgh, Pennsylvania
(412) 828-7728

(144) Wescan Instruments, Inc.
3018 Scott Boulevard
Santa Clara, California 95050
(408) 248-3519
(Code 170)

P. J. Navin Company
Mr. David Burge
P. O. Box 213
W. Carrollton, Ohio 46449

(145) Wilks Scientific Corp.
140 Water Street
P. O. Box 449
S. Noralk, Ct 06856
(203) 853-1616
Mr. Harold Jacobs
(Code 236)

(146) C. N. Wood Manufacturing Company
Newton Industrial Commons
Route 332
Newtown, Pennsylvania 18940
(215) 968-4268
Mr. Hunsberger
(Code 72)

(147) Carl Zeiss, Inc.
444 Fifth Avenue
New York, New York 10018
(212) 736-6070
(Code 141,142,143,144,145,174)

Robert Wenzel
1120 Morse Road
Columbus, Ohio 43229
(614) 846-1800

(148) Zena Company
2208A Hamilton Boulevard
S. Plainfield, New Jersey 07080
(201) 754-4109
Mr. Joe DelGaldo
(Code 54)

APPENDIX D

COMMERCIAL HARDWARE DESCRIPTION AND INDEX

APPENDIX D
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INSTRUMENT APPLICATIONS INDEX

Assay Technique	Instrument Code Nos.
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(3) Photometric/Absorption/Visible	3 4 5 8 13 14 16 17 18 19 20 21 22 36 40 41 42 54 55 56 59 65 68 79 80 81 82 85 91 98 99 100 101 102 105 106 107 108 109 110 112 115 116 119 136 142 143 146 149 150 152 154 155 156 157 158 159 160 161 162 183 185 186 187 188 189 190 191 192 203 214 222 223 224 225 237 242 250 251 253 270
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(25) Immunologically based/Immunofluorescence (see Photometric/Emissive/Fluorimetry)	
(26) Immunologically based/Agglutination	23 77
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(28) Enzymatically based/ATP Photometry	1 96 122 195 254

Code No. 1

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Enzymatic/ATP Photometry

VENDOR American Instrument Co.

Silver Springs, Maryland

INSTRUMENT Chem-Glow Photometer

MODEL OR CATALOG NO. 4-7441

Points*	Factor	Specifications
18.8	Cost	$800
7.1	Power required	115 V, 50/60 Hz, 990 watts
20.1	Volume (m^3)	0.008
21.1	Weight (kg)	4.1
24.0	Complexity of use	from user survey
21.6	Reliability	from user survey
112.7		

USER REFERENCES

(1) 2.5 yr Dr. Ivan Stern (312/965-4700)
Baxter Laboratories
6301 Lincoln Avenue
Morton Grove, Illinois 60053

(2) 7 yr Dr. Judy St. John (301/344-3471)
Agriculture and Environmental Quality Institute
Pesticide Action Laboratory
Building 001, BARC West
Bentsville, Maryland 20705

(3) 5 yr Dr. Grace Piccicco (301/982-2121)
National Aeronautics and Space Administration
Goddard Space Facility
Code 726
Greenbelt, Maryland 20771

*See point system description.

D-5 Code No. 2

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Refractive/Refractometry

VENDOR Waters Associates, Inc.

Milford, Massachusetts 01757

INSTRUMENT Differential Refractometer

MODEL OR CATALOG NO. R-403

Points*	Factor	Specifications
14.3	Cost	$2,400
28.3	Power required	115 V, 50/60 Hz, 4 watts
20.7	Volume (m^3)	0.007
17.7	Weight (kg)	8.2
15.2	Complexity of use	from user survey
19.2	Reliability	from user survey
115.4		

USER REFERENCES

(1) 18 mo Dr. C. G. Scott (201/235-3993)
Hoffmann-La Roche, Inc.
Kingsland Avenue
Nutley, New Jersey 07110

(2) 3 yr Jerry K. Miller (203/348-7331)
American Cyanamid Co.
1937 West Main Street
Stamford, Connecticut 06904

(3) 3 mo Walton Caldwell (201/574-5098)
Merck & Co., Inc.
Rayway, New Jersey 07065

*See point system description.

Code No. 3

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Ultraviolet

VENDOR LKB Instruments, Inc.
Rockville, Maryland 20852

INSTRUMENT Uvicord III UV Absorptiometer

MODEL OR CATALOG NO. 2089

Points*	Factor	Specifications
13.0	Cost	$3,530
13.4	Power required	115/220 V ± 10%, 50/60 Hz, 80 watts
15.1	Volume (m^3)	0.025
15.8	Weight (kg)	13.0
16.0	Complexity of use	from user survey
16.3	Reliability	from user survey
89.6		

USER REFERENCES

(1) 2 yr Dr. R. M. Robson (515/294-5036)
Iowa State University
Muscle Biology Group
Ames, Iowa 50010

(2) 3 yr Louis V. Avioli, M.D. (314/367-8060)
Washington University School of Medicine
The Jewish Hospital of St. Louis
216 South Kingshighway
St. Louis, Missouri 63110

(3) 1 mo Charles F. Schachtele (612/376-7577)
University of Minnesota
18-228 Health Sciences Unit A
School of Dentistry
Minneapolis, Minnesota 55455

*See point system description.

D-7 Code No. 4

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE: Photometric/Absorption/Ultraviolet

VENDOR: Beckman Instruments, Inc.
Irvine, California

INSTRUMENT: UV-Visible Spectrophotometer

MODEL OR CATALOG NO. ACTA III

Points*	Factor	Specifications
10.0	Cost	$9,900
9.2	Power required	120 V, 50/60 Hz, 360 watts
7.2	Volume (m^3)	0.471
9.2	Weight (kg)	113.4
11.2	Complexity of use	from user survey
20.8	Reliability	from user survey
67.6		

USER REFERENCES

(1) 2.5 yr
Melody K. Bean (614/299-3151, Ext. 2113)
Battelle, Columbus Laboratories
505 King Avenue
Columbus, Ohio 43201

(2) 15 mo
Dave Mitchell (216/593-1156)
General Electric Conneaut Base Plant
Rieg and Maple Avenue
Conneaut, Ohio 44030

(3) 4.5 yr
Dr. Nick Baumgartner (216/491-4911 or -4241, Ext. 22)
John Carroll University
Cleveland, Ohio 44118

*See point system description.

 Code No. 5

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Ultraviolet

VENDOR Kontes Glass Co.

Vineland, New Jersey 08360

INSTRUMENT Densitometer

MODEL OR CATALOG NO. K-495000

Points*	Factor	Specifications
14.5	Cost	$2,250
15.9	Power required	115 V, 60 Hz, 40 watts
12.3	Volume (m^3)	0.056
15.2	Weight (kg)	15.0
16.6	Complexity of use	from user survey
17.8	Reliability	from user survey
92.3		

USER REFERENCES

(1) 7 mo G. E. Carter, Jr. (803/656-3451 or -3450)
Clemson University
Department of Plant Pathology and Physiology
Clemson, South Carolina 29631

(2) 1 yr H. M. Stahr (515/294-1950)
Veterinary Diagnostic Lab
Veterinary College, Iowa State University
Ames, Iowa 50010

(3) 15 mo Prof. Joseph Sherma (215/253-6281, Ext. 274)
Department of Chemistry
Lafayette College
Easton, Pennsylvania 18042

*See point system description.

Code No. 6

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Radiometric/X-Ray Fluorescence

VENDOR Finnigan Corp.

Sunnyvale, California 94086

INSTRUMENT Energy Dispersive X-Ray Spectrometer

MODEL OR CATALOG NO. 800A

Points*	Factor	Specifications
6.7	Cost	$47,500
6.4	Power required	115V ± 10%, 60 Hz, 1500 watts
5.7	Volume (m^3)	1.160
7.3	Weight (kg)	281.6
18.2	Complexity of use	from user survey
16.5	Reliability	from user survey
60.8		

USER REFERENCES

(1) 3 yr William Reuter. Ph.D. 415/486-3342
Western Regional Research Center
U. S. Dept. of Agriculture
800 Buchanan Street
Berkeley, California 94710

(2) 1-1/2 yr T. M. Spittler 617/223-7337
US EPA, Region I Lab
240 Highland Avenue
Needham, Massachusetts 02194

(3) 2 yr Donald T. Carlton 219/482-4411
Magnavox Co, G&I Division
1700 Magnavox Way
Ft. Wayne, Indiana 46804

*See point system description.

D-10 Code No. 7

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Refractive/Refractometry

VENDOR Epic, Inc.

New York, New York 10038

INSTRUMENT Abbe 60 Refractometer

MODEL OR CATALOG NO. 60/ED

Points*	Factor	Specifications
15.9	Cost	$1,555
22.4	Power required	115V, 50/60 Hz, 10 watts
17.7	Volume (m^3)	0.013
20.0	Weight (kg)	5.0
22.4	Complexity of use	from user survey
17.7	Reliability	from user survey
116.1		

USER REFERENCES

(1) 1-1/2 yr
Dr. James E. Johnson 817/382-2990
Texas Woman's University
Chemistry Department
Denton, Texas 76204

(2) 2 yr
D. C. O'Shea 404/894-5256
Georgia Tech.
School of Physics
Atlanta, Georgia 30332

(3) 5 yr
Jack McEwan 219/724-2101
Central Soya Co., Inc.
1200 North Second Street
Decatur, Indiana 46733

*See point system description.

D-11 Code No. 8

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorptive/Ultraviolet

VENDOR Transidyne General Corp.

Ann Arbor, Michigan 48106

INSTRUMENT RFT Scanning Densitometer

MODEL OR CATALOG NO. 2950

Points*	Factor	Specifications
11.1	Cost	$6,450
10.6	Power required	110V, 60 Hz, 200 watts
13.7	Volume (m^3)	0.190
13.1	Weight (kg)	27.2
12.7	Complexity of use	from user survey
18.4	Reliability	from user survey
79.6		

USER REFERENCES

(1) 2 yr

Emanuel Epstein, Ph.D. 313/549-7000, Ext. 471
William Beaumont Hospital
3601 West 13 Mile Road
Royal Oak, Michigan 48072

(2) 2 mo

Bennie Zak, Ph.D. 313/577-1139
Wayne State University
School of Medicine
540 East Canfield
Detroit, Michigan 48201

(3) 3 yr

David E. Smith, M.D.
Methodist Hospital
Department of Pathology
1604 North Capitol Avenue
Indianapolis, Indiana 46204

*See point system description.

D-12 Code No. 9

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Enzymatic/Chromogenic Substrate

VENDOR Union Carbide Corp.

Tarrytown, New York

INSTRUMENT Centrifichem Analyzer

MODEL OR CATALOG NO. 3U 0100

Points*	Factor	Specifications
7.3	Cost	$33,900
5.7	Power required	115 ± 10V, 60 Hz, 2300 watts
6.6	Volume (m^3)	0.649
8.3	Weight (kg)	167.8
20.2	Complexity of use	from user survey
10.6	Reliability	from user survey
58.7		

USER REFERENCES

(1) 8 mo

Dick Mullen 216/998-3111, Ext. 2195
Ashtabula General Hospital
Clinical Labs
2420 Lake Avenue
Ashtabula, Ohio 44004

(2) 1-1/2 yr

James Sutton 216/585-5500
Richmond Heights General Hospital
27100 Chardon Road
Richmond Heights, Ohio 44143

(3) 15 mo

John Mulder 216/775-1211
Allen Memorial Hospital
200 West Lorain Street
Oberlin, Ohio 44074

*See point system description.

Code No. 10

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Light Microscopy

VENDOR Olympus Corp. of America

New Hyde Park, New York 11040

INSTRUMENT Vanox II Universal Research Microscope

MODEL OR CATALOG NO. AH-100A

Points*	Factor	Specifications
11.0	Cost	$6,795
15.0	Power required	120V, 60 Hz, 50-30 watts
10.3	Volume (m^3)	0.116
12.9	Weight (kg)	29.4
20.9	Complexity of use	from user survey
18.8	Reliability	from user survey
88.9		

USER REFERENCES

(1) 2 yr
Dr. Rainer, Pathologist 614/461-2030
Children's Hospital
561 South 17th Street
Columbus, Ohio 43205

(2) 1 yr
Dr. Alberosen 614/421-4321
Doctors Hospital North
1087 Dennison Avenue
Columbus, Ohio 43201

(3) 18 mo
Harvey L. Gibson, P.A. 513/228-5164
Montgomery County Coroner's Office
120 Zeigler Street
Dayton, Ohio 45402

*See point system description.

D-14 Code No. 11

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Ultraviolet

VENDOR Gilson Medical Electronics, Inc.

Middleton, Wisconsin 53562

INSTRUMENT Recording UV Spectrometer

MODEL OR CATALOG NO. M-UV-RP

Points*	Factor	Specifications
13.7	Cost	$2,770
11.4	Power required	115V, 60 Hz, 150 watts
13.2	Volume (m^3)	0.042
13.9	Weight (kg)	21.8
12.9	Complexity of use	from user survey
13.3	Reliability	from user survey
78.4		

USER REFERENCES

(1) 1 yr

Dr. Joel Rosenbloom 215/243-6662
University of Pennsylvania
Histology Department, Dental School
Philadelphia, Pennsylvania 19172

(2) 1 yr

M. D. Seymour 513/562-9462
Proctor and Gamble (Miami Valley Labs)
Box 39175
Cincinnati, Ohio 45247

(3) 4 mo

Dr. Robert Seinmeier 716/831-5845
State University of New York at Buffalo
Bioenergetics Lab, Room 168
Acheson Hall
Buffalo, New York 14214

*See point system description.

D-15 Code No. 12

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Particle Counting/Electro-conductimetric

VENDOR Royco Instruments, Inc.
Menlo Park, California 94025

INSTRUMENT Microcellcounter

MODEL OR CATALOG NO. 910

Points*	Factor	Specifications
11.5	Cost	$5,600
12.6	Power required	115/230V, 50/60 Hz, 100 watts
15.2	Volume (m^3)	0.024
15.9	Weight (kg)	12.7
20.4	Complexity of use	from user survey
18.3	Reliability	from user survey
93.9		

USER REFERENCES

(1) 2 yr
H. A. Woodson, Laboratory Manager 312/873-8200 Ext. 428
St. Bernard Hospital
6337 Harvard
Chicago, Illinois 60621

(2) 6 mo
Lila Friedman 415/497-6501
Stanford University Medical Center
Department of Pediatrics
Stanford, California 94305

(3) 1-1/2 yr
Gardner Community Health Clinic 408/998-2264
325 Willow Street
San Jose, California 95110

*See point system description.

D-16 Code No. 1

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Visible

VENDOR Tektronix Inc.

Beaverton, Oregon 97005

INSTRUMENT Photometer/Radiometer

MODEL OR CATALOG NO. J16 Option 3 with J6514 Probe

Points*	Factor	Specifications
19.1	Cost	$750
13.6	Power required	115V, 60 Hz, 74 watts
33.7	Volume (m^3)	0.001
27.1	Weight (kg)	1.5
17.9	Complexity of use	from user survey
17.3	Reliability	from user survey
128.7		

USER REFERENCES

(1) 8 mo

Philip E. Barnhart 614/882-6711
Otterbein College Physics Dept.
Westerville, Ohio 43081

(2) 4 mo

Guy London 614/421-1714
State of Ohio Educational TV Commission
2470 North Starr Road
Columbus, Ohio 43221

(3) 4 mo

H. L. Lazara 206/753-6092
Washington State Highway Department
Highway Administration Building
Olympia, Washington 98504

*See point system description.

D-17 Code No. 14

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Visible

VENDOR Transamerican Instrument Corp.

Emerson, New Jersey 07630

INSTRUMENT Spektromom

MODEL OR CATALOG NO. 402

Points*	Factor	Specifications
20.2	Cost	$595
17.1	Power required	220V, 50 Hz, 30 watts
17.4	Volume (m^3)	0.014
18.5	Weight (kg)	6.9
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
93.2		

USER REFERENCES

(1) Foreign Users Only

(Names not readily available)

(2)

(3)

*See point system description.

D-18 Code No. 15

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Refraction/Refractometry

VENDOR American Optical Corp.

Buffalo, New York 14215

INSTRUMENT AO-TS Meter

MODEL OR CATALOG NO. 10402

Points*	Factor	Specifications
24.2	Cost	$292
50.0	Power required	None
50.0	Volume (m^3)	0.0002
40.5	Weight (kg)	0.3
24.8	Complexity of use	from user survey
23.2	Reliability	from user survey
212.7		

USER REFERENCES

(1) 2 yr
Diane Metcalfe 614/299-3151, Ext. 3310
Battelle, Columbus Laboratories
505 King Avenue
Columbus, Ohio 43201

(2) 8 yr
Sandy Wolf 614/261-5263
Riverside Methodist Hospital
3535 Olentangy River Road
Columbus, Ohio 43214

(3) 10 yr
Duane Howell 614/461-2140
Children's Hospital
561 South 17th Street
Columbus, Ohio 43205

*See point system description.

D-19 Code No. 16

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Visible

VENDOR Photo Research

Burbank, California 91505

INSTRUMENT Specta 1980 Pritchard Photometer

MODEL OR CATALOG NO. 1980-OP with 1980-CDB control console and LMS-60B micro lens

Points*	Factor	Specifications
11.6	Cost	$5,580
18.9	Power required	117 ± 13 V, 50-400 Hz, 20 watts
14.8	Volume (m^3)	0.027
15.3	Weight (kg)	14.7
14.7	Complexity of use	from user survey
14.2	Reliability	from user survey
89.5		

USER REFERENCES

(1) 1 mo Wally Richardson 614/466-4843
State of Ohio, Dept. of Transportation
Bureau of Traffic
450 East Town Street
Columbus, Ohio 43215

(2) 10 mo Sgt. Robert Searle 513/255-3384
Air Space Medical Research Laboratory
Human Engineering Division
Wright-Patterson AFB, Ohio 45433

(3) 1 yr Alan G. King 216/641-8580, Ext. 605
Ferro Corporation Tech Center
6500 East Pleasant Valley Road
Independence, Ohio 44131

*See point system description.

Code No. 17

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Visible

VENDOR Helena Laboratories

Beaumont, Texas

INSTRUMENT Auto-Scanner Flur-Vis

MODEL OR CATALOG NO. 1202

Points*	Factor	Specifications
12.2	Cost	$4,500
11.0	Power required	115V, 50/60 Hz, 173 watts
12.5	Volume (m^3)	0.053
15.0	Weight (kg)	15.9
15.1	Complexity of use	from user survey
13.8	Reliability	from user survey
79.6		

USER REFERENCES

(1) 1 mo

Diane Huntress 916/456-7881, Ext. 731
Mercy Hospital
4001 J Street
Sacramento, California 95819

(2) 2 mo

Mr. C. E. Collins 602/263-1200, Ext. 374
Pathology Department
Phoenix Indian Medical Center
U. S. Public Health Service
4212 North 16th Street
Phoenix, Arizona 85016

(3) 1 mo

Mr. Jack Dickenson 305/565-6642
Damon Medical Lab
3290 N.E. 12th Avenue
Oakland Park, Florida 33306

*See point system descr' 'ion.

D-21 Code No. 18

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Visible

VENDOR Fisher Scientific Co.

Pittsburgh, Pennsylvania 15219

INSTRUMENT Programachem

MODEL OR CATALOG NO. 1040

Points*	Factor	Specifications
6.5	Cost	$56,500
5.2	Power required	117V, 60 Hz, 3510 watts
5.1	Volume (m^3)	1.878
6.3	Weight (kg)	499.0
22.7	Complexity of use	from user survey
15.9	Reliability	from user survey
61.7		

USER REFERENCES

(1) 2 yr
Jim Phillips 513/335-5624
Dettmer Hospital
3130 North Dixie Highway
Troy, Ohio 45373

(2) 3 yr
Bob Richards 216/746-8061, Ext. 209
Youngstown Osteopathic Hospital
1319 Florencedale Avenue
Youngstown, Ohio 44504

(3) 14 mo
Dr. John Fiskamp
Community Hospital
1500 North Ritter
Indianapolis, Indiana 46219

*See point system description.

Code No. 19

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Visible

VENDOR Bausch & Lomb, Analytical Systems Division

Rochester, New York 14625

INSTRUMENT Mini-Spec 20 Spectrophotometer

MODEL OR CATALOG NO. 33-10-02

Points*	Factor	Specifications
21.2	Cost	$495
50.0	Power required	Internal battery
36.9	Volume (m^3)	0.0007
35.7	Weight (kg)	0.5
15.1	Complexity of use	from user survey
8.1	Reliability	from user survey
167.0		

USER REFERENCES

(1) 1 mo

William F. Cowen 663-7237
U. S. Army Medical Bioengineering R&D Laboratory
Building 568, Ft. Detrick
Frederick, Maryland 21701

(2) 1 mo

David Kidd 505/277-2943
University of New Mexico
Biology Department
Albuquerque, New Mexico 87131

(3) 5 mo

Barbara Blaine 815/968-9691
Illinois Water Treatment Co.
840 Cedar Street
Rockford, Illinois 61105

*See point system description.

D-23 Code No. 20

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Visible

VENDOR Bio/Data Corp.

Hatboro, Pa. 19040

INSTRUMENT Platelet Aggregation Profiler

MODEL OR CATALOG NO. PAP-2

Points*	Factor	Specifications
14.3	Cost	$2,375
12.6	Power required	115 ± 10V, 60 Hz, 100 watts
13.1	Volume (m^3)	0.044
15.6	Weight (kg)	13.6
19.6	Complexity of use	from user survey
16.8	Reliability	from user survey
92.0		

USER REFERENCES

(1) 3 mo

Pat Campbell
Hematology Department
Trumbull Memorial Hospital
1350 East Market Street
Warren, Ohio 44482
216/399-6461, Ext. 2919

(2) 1-1/2 yr

Peter H. Levine, M.D.
New England Medical Center Hospital
171 Harrison Avenue
Boston, Massachusetts 02111
617/482-2800, Ext. 2244

(3) 1-1/2 yr

H. S. Weiss, M.D.
Roosevelt Hospital (Columbia University)
428 West 59th Street
New York, New York 10019
212/554-6641

*See point system description.

Code No. 21

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Ultraviolet

VENDOR American Instrument Co.

Silver Spring, Maryland

INSTRUMENT DW-2 Spectrophotometer

MODEL OR CATALOG NO. 4-9600

Points*	Factor	Specifications
8.3	Cost	$20,895
7.5	Power required	115V, 50/60 Hz, 800 watts
7.2	Volume (m^3)	0.470
8.0	Weight (kg)	200 (est.)
17.1	Complexity of use	from user survey
15.3	Reliability	from user survey
63.4		

USER REFERENCES

(1) 4 mo

Dr. Ted Sokoloski 614/422-6124
The Ohio State University
College of Pharmacy
Columbus, Ohio 43210

(2) 2 yr

Dr. Dennis Nelson 202/295-1520
Naval Medical Research Institute
Bethesda, Maryland 20014

(3) 3 yr

Dr. Ron Estabrook 214/688-3456
University Texas Health Science Center
Southwestern Medical School
Department of Biochemistry
5323 Harry Hines Blvd.
Dallas, Texas 75235

*See point system description.

Code No. 22

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Visible

VENDOR The Virtis Co.

Gardiner, New York 12525

INSTRUMENT Phoenix Micro Flow Colorimeter

MODEL OR CATALOG NO. 800

Points*	Factor	Specifications
19.1	Cost	$757
12.8	Power required	115V, 60 Hz, 30 watts
25.6	Volume (m^3)	0.003
19.7	Weight (kg)	5.4
13.3	Complexity of use	from user survey
19.0	Reliability	from user survey
109.5		

USER REFERENCES

(1) 7 yr

Calvin L. Long, Ph.D. 419/385-4661
Medical College of Ohio at Toledo
Department of Surgery
Arlington & Detroit Avenues
Toledo, Ohio 43614

(2) 9 yr

Dr. S. Nakai 604/228-4421
Department of Food Science
University of British Columbia
Vancouver, British Columbia, Canada
V6T 1W5

(3) 4 yr

Peter Mamunes, Ph.D. 804/770-3033
Medical College of Virginia
11th & Broad Streets
Medical Education Building
Richmond, Virginia 23298

*See point system description.

Code No. 23

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Immunological/Agglutination

VENDOR Linter Scientific Inc.

Millville, Massachusetts 01529

INSTRUMENT Colysagraph

MODEL OR CATALOG NO. L/S-2

Points*	Factor	Specifications
13.3	Cost	$3,200
11.6	Power required	115/230 V, 50/60 Hz, 140-100 watts
15.6	Volume (m^3)	0.022
16.9	Weight (kg)	10.0
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
77.4		

USER REFERENCES

(1) New instrument, no users available

(2)

(3)

*See point system description.

Code No. 24

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Particle Counting/Optical (Light Scatter)

VENDOR Fisher Scientific Co., Analytical Instrument Div.
Pittsburgh, Pennsylvania 15219

INSTRUMENT Autocytometer II Blood Cell Counter

MODEL OR CATALOG NO. 2-682

Points*	Factor	Specifications
11.9	Cost	$4,995
11.4	Power required	115V, 50/60 Hz, 150 watts
13.0	Volume (m^3)	0.046
14.1	Weight (kg)	20.4
23.7	Complexity of use	from user survey
19.0	Reliability	from user survey
93.1		

USER REFERENCES

(1) 4 yr

Bob Richards 216/746-8061, Ext. 209
Youngstown Osteopathic Hospital
1319 Florence Avenue
Youngstown, Ohio 44504

(2) 5 yr

Jim Phillips 513/335-5624
Dettmer Hospital
3130 North Dixie Highway
Troy, Ohio 45373

(3) 3 yr

Lew Diehle 513/492-4171
Wilson Memorial Hospital
915 West Michigan
Sidney, Ohio 45365

*See point system description.

D-28 Code No. 25

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Multiparameter Cell Analysis

VENDOR Bio/Physics Systems, Inc.

Mahopac, New York 10541

INSTRUMENT Cytograf

MODEL OR CATALOG NO. 6300A

Points*	Factor	Specifications
10.1	Cost	$9,470
8.1	Power required	115V, 50/60 Hz, 600 watts
10.2	Volume (m^3)	0.120
11.9	Weight (kg)	40.8
7.4	Complexity of use	from user survey
11.9	Reliability	from user survey
59.6		

USER REFERENCES

(1) 6 mo

Paul Hurtubise, Ph.D. 614/422-8310
Department of Pathology
The Ohio State University, Graves Hall
Columbus, Ohio 43210

(2) 2 yr

Fedor Medzihradsky, Ph.D. 313/764-1114
University of Michigan Medical School
Department of Biological Chemistry
Medical Science Building I
Ann Arbor, Michigan 48104

(3) 1 yr

Stephen L. Kimzey 713/483-4086
NASA Johnson Space Center
Code DB7
Houston, Texas 77058

*See point system description.

Code No. 26

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Multiparameter Cell Analysis

VENDOR Bio/Physics Systems, Inc.
Mahopac, New York 10541

INSTRUMENT Cytofluorograf

MODEL OR CATALOG NO. 6300A/4802A

Points*	Factor	Specifications
8.0	Cost	$24,170
5.8	Power required	115V, 50/60 Hz, 2325 watts
8.6	Volume (m^3)	0.240
9.5	Weight (kg)	100.8
7.4	Complexity of use	from user survey
11.9	Reliability	from user survey
51.2		

USER REFERENCES

(1) 6 mo
Paul Hurtubise, Ph.D. 614/422-8310
The Ohio State University
Department of Pathology, Graves Hall
College of Medicine
Columbus, Ohio 43210

(2) 2 yr
Fedor Medzihradsky, Ph.D. 313/764-1114
University of Michigan Medical School
Department of Biological Chemistry
Medical Science Building I
Ann Arbor, Michigan 48104

(3) 1 yr
Stephen L. Kimzey 713/483-4086
NASA Johnson Space Center
Code DB7
Houston, Texas 77058

*See point system description.

Code No. 27

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE: Multiparameter Cell Analysis

VENDOR: Bio/Physics Systems, Inc.
Mahopac, New York 10541

INSTRUMENT: Cytofluorograf

MODEL OR CATALOG NO. System 5

Points*	Factor	Specifications
7.6	Cost	$29,825
5.4	Power required	115V, 50/60 Hz, 2975 watts
7.9	Volume (m^3)	0.330
8.7	Weight (kg)	138.3
7.4	Complexity of use	from user survey
11.9	Reliability	from user survey
48.9		

USER REFERENCES

(1) 6 mo — Paul Hurtubise, Ph.D. 614/422-8310
The Ohio State University
Department of Pathology, Graves Hall
College of Medicine
Columbus, Ohio 43210

(2) 2 yr — Fedor Medzihradsky, Ph.D. 313/764-1114
University of Michigan Medical School
Department of Biological Chemistry
Medical Science Building I
Ann Arbor, Michigan 48104

(3) 1 yr — Stephen L. Kimzey 713/483-4086
NASA Johnson Space Center
Code DB7
Houston, Texas 77058

*See point system description.

 Code No. 28

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Refraction/Light Scattering

VENDOR Recognition Systems, Inc.

Van Nuys, California

INSTRUMENT Recording Optical Spectrum Analyzer

MODEL OR CATALOG NO. ROSA-3

Points*	Factor	Specifications
6.7	Cost	$49,500
11.0	Power required	115V, 60 Hz, 175 watts
4.9	Volume (m^3)	2.240
7.9	Weight (kg)	204.1
14.9	Complexity of use	} from user survey
15.1	Reliability	
60.5		

USER REFERENCES

(1) 6 mo
R. Schindler 206/773-1611
Boeing Aerospace Co.
P. O. Box 3999
Seattle, Washington 98124

(2) 2-1/2 yr
R. D. Leighty 703/664-6176
Research Institute
Engineer Topographic Laboratories
Fort Belvoir, Virginia 22060

(3) 11 mo
F. P. Kruger 213/746-2992
University of Southern California
Powell Hall of Engineering, Room 324
Los Angeles, California 90274

*See point system description.

Code No. 29

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Pattern Recognition Comput~~ (Image Analyzer)

VENDOR Photo Metrics, Inc.

Lexington, Massachusetts 02173

INSTRUMENT Raster Scanner

MODEL OR CATALOG NO. EDP

Points*	Factor	Specifications
8.9	Cost	$16,000
7.9	Power required	110V, 60 Hz, 660 watts
11.4	Volume (m^3)	0.078
12.2	Weight (kg)	36.3
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
60.4		

USER REFERENCES

(1) No users available

(2)

(3)

*See point system description.

Code No. 30

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE: Ultrasonics (Sound Velocity)

VENDOR: NUSonics, Inc.
Paramus, New Jersey 07652

INSTRUMENT: Laboratory Monitor

MODEL OR CATALOG NO. 6105

Points*	Factor	Specifications
15.0	Cost	$1,995
20.3	Power required	90-125V, 50/60 Hz, 15 watts
20.7	Volume (m^3)	0.007
21.3	Weight (kg)	3.9
18.9	Complexity of use	from user survey
17.0	Reliability	from user survey
113.2		

USER REFERENCES

(1) 1 yr — Roy Cox 513/642-7015
Westreco Co.
Marysville, Ohio 43040

(2) 2 mo — Wayne Ralph 513/562-6158
Proctor and Gamble Co.
Winton Hill Technical Center, PE 2N16
Cincinnati, Ohio 45224

(3) 2 yr — W. H. Rigby 614/587-0610
Owens Corning Fiberglas
Technical Center
Granville, Ohio 43023

*See point system description.

Code No. 31

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Radiometric/Misc. (Spark Imaging)

VENDOR Panax Nucleonics

Montreal, Quebec, Canada

INSTRUMENT Beta-Graph

MODEL OR CATALOG NO. (none)

Points*	Factor	Specifications
11.4	Cost	$5,832
10.6	Power required	115V, 60 Hz, 200 watts
9.1	Volume (m^3)	0.187
12.2	Weight (kg)	37 (est.)
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
63.3		

USER REFERENCES

(1) User list not available

(2)

(3)

*See point system description.

 Code No. 32

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Radiometric/Gamma Ray Spectrometry

VENDOR Panax Nucleonics

Montreal, Quebec, Canada

INSTRUMENT Radiochromatogram Scanner System

MODEL OR CATALOG NO. E. 0111/RRD-1

Points*	Factor	Specifications
10.9	Cost	$7,111
10.6	Power required	220 V, 50 Hz, 200 watts
9.7	Volume (m^3)	0.149
11.7	Weight (kg)	43.1
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
62.9		

USER REFERENCES

(1) User list not available

(2)

(3)

*See point system description.

 Code No. 33

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Radiometric/Scintillation Photometry

VENDOR Baird-Atomic

Bedford, Massachusetts 01730

INSTRUMENT Scaler

MODEL OR CATALOG NO. 955-150

Points*	Factor	Specifications
18.8	Cost	$795
15.0	Power required	110V, 60 Hz, 50 watts
18.1	Volume (m^3)	0.012
21.8	Weight (kg)	3.6
19.9	Complexity of use	from user survey
17.9	Reliability	from user survey
111.5		

USER REFERENCES

(1) 5 mo The Bendix Corporation 607/563-9511
Electrical Components Division
Sherman Avenue
Sidney, New York 13838

(2) 2 yr Charles W. Owens 603/862-1550
University of New Hampshire
Department of Chemistry
Durham, New Hampshire 03824

(3) 1 yr Mr. San Antonio College 213/ ED9-7331, Ext. 212
1100 North Grand Avenue
Walnut, California 91789

*See point system description.

Code No. 34

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Radiometric/Scintillation Photometry

VENDOR Packard Instrument Co., Inc.
Downers Grove, Illinois 60515

INSTRUMENT Tri-Carb Spectrometer

MODEL OR CATALOG NO. 2211

Points*	Factor	Specifications
9.5	Cost	$12,100
8.2	Power required	115/230 V, 50/60 Hz, 575 watts
6.4	Volume (m^3)	0.763
6.9	Weight (kg)	351.5
20.1	Complexity of use	from user survey
18.9	Reliability	from user survey
70.0		

USER REFERENCES

(1) 6 yr — Dr. Davie Imes 614/422-9475
The Ohio State University
Department of Biochemistry
Columbus, Ohio 43201

(2) 2-1/2 yr — Margaret A. Sheridan 614/299-3151, Ext. 2818
Battelle's Columbus Laboratories
505 King Avenue
Columbus, Ohio 43201

(3) 5 yr — Dr. George W. Wharton 614/422-7180
The Ohio State University
Department of Entomology
Columbus, Ohio 43201

*See point system description.

Code No. 35

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Electrometric/Potentiometry

VENDOR Princeton Applied Research Corp.

Princeton, New Jersey 08540

INSTRUMENT Polarographic Analyzer

MODEL OR CATALOG NO. 174A

Points*	Factor	Specifications
13.9	Cost	$2,695
13.6	Power required	115/230 V, 50/60 Hz, 75 watts
14.3	Volume (m^3)	0.031
17.7	Weight (kg)	8.2
13.5	Complexity of use	from user survey
17.3	Reliability	from user survey
90.3		

USER REFERENCES

(1) 2 yr

Jerry Colonel 513/684-3510
U. S. Food and Drug Administration
1141 Central Park Way
Cincinnati, Ohio 45239

(2) 9 mo

Dr. Bill Heineman 513/475-5325
Department of Chemistry
University of Cincinnati
Cincinnati, Ohio 45221

(3) 1 yr

Carter Olson 614/422-6794
The Ohio State University
500 West 12th Avenue
Columbus, Ohio 43210

*See point system description.

 Code No. 36

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Ultraviolet

VENDOR Schoeffel Instrument Corp.

Westwood, New Jersey 07625

INSTRUMENT Spectrodensitometer

MODEL OR CATALOG NO. SD-3000 with SDC 302

Points*	Factor	Specifications
10.4	Cost	$8,627
8.5	Power required	110/220 V, 50/60 Hz, 500 watts
9.1	Volume (m^3)	0.186
10.0	Weight (kg)	80 (est.)
20.3	Complexity of use	from user survey
22.3	Reliability	from user survey
80.6		

USER REFERENCES

(1) 7 yr

David S. Love, Ph.D. 216/368-2118
Case Western Reserve University
School of Medicine
Department of Anatomy
Cleveland, Ohio 44106

(2) 5 yr

Helen K. Berry 513/559-4451
Children's Hopsital Research Foundation
Elland and Bethesda Avenues
Cincinnati, Ohio 45229

(3) 2 yr

Mark D. Seymour 513/562-9462
Proctor & Gamble (Miami Valley Labs)
Box 39175
Cincinnati, Ohio 45247

*See point system description.

D-40 Code No. 37

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Radiometric/Scintillation Photometry

VENDOR The Nucleus, Inc.
Oak Ridge, Tennessee 37830

INSTRUMENT Nuclear Scaler

MODEL OR CATALOG NO. 500

Points*	Factor	Specifications
23.1	Cost	$350
16.4	Power required	105-125 V, 50/60 Hz, 35 watts
19.5	Volume (m^3)	0.009
18.9	Weight (kg)	6.4
20.2	Complexity of use	from user survey
17.1	Reliability	from user survey
115.2		

USER REFERENCES

(1) 7 mo — Donald G. Hopkins 815/725-6220, Ext. 53
Joliet West High School
401 North Larkin Avenue
Joliet, Illinois 60435

(2) 2 yr — Dr. James C. Wilkes 205/566-3000, Ext. 241
Troy State University
Department of Biology
Troy, Alabama 36081

(3) 1 yr — Barbara Reed 813/924-1351
Riverview High School
4850 Lords Lane
Sarasota, Florida 33581

*See point system description.

 Code No. 38

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Multiparameter Cell Analysis

VENDOR Becton Dickinson Electronics Laboratories

Mountain View, California

INSTRUMENT Fluorescence Activated Cell Sorter

MODEL OR CATALOG NO. FACS-1

Points*	Factor	Specifications
6.0	Cost	$75,000
6.0	Power required	1 ∅, 115V and 3 ∅, 208V; 60 Hz; 2000 watts
3.8	Volume (m^3)	6.118
6.2	Weight (kg)	544.3
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
42.0		

USER REFERENCES

(1) Users not available

(2)

(3)

*See point system description.

Code No. 39

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE: Photometric/Emission/Fluorometry

VENDOR: American Instrument Co.
Silver Spring, Maryland

INSTRUMENT: Aminco-Bowman Spectrophotofluorometer

MODEL OR CATALOG NO. 4-8202

Points*	Factor	Specifications
11.3	Cost	$6,075
9.7	Power required	115V, 50/60 Hz, 290 watts
10.3	Volume (m^3)	0.113
10.7	Weight (kg)	61.2
26.7	Complexity of use	from user survey
21.3	Reliability	from user survey
90.0		

USER REFERENCES

(1) 15 yr — Mr. Jim Seay 614/422-5326
The Ohio State University Hospital
Endocrinology Department
410 West 10th Avenue
Columbus, Ohio 43210

(2) 7 yr — Dr. Elizabeth Gross 614/422-9480
The Ohio State University
Department of Biochemistry
484 West 12th Avenue
Columbus, Ohio 43210

(3) 10 yr — Dr. Allen Burkman 614/422-7005
The Ohio State University
College of Pharmacy
500 West 12th Avenue
Columbus, Ohio 43210

*See point system description.

Code No. 40

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Emission/Fluorometry

VENDOR American Instrument Co.

Silver Spring, Maryland

INSTRUMENT Fluoro-Colorimeter

MODEL OR CATALOG NO. 4-7440

Points*	Factor	Specifications
16.0	Cost	$1,545
7.1	Power required	115V, 50/60 Hz, 990 watts
15.1	Volume (m^3)	0.025
18.6	Weight (kg)	6.8
22.3	Complexity of use	from user survey
18.8	Reliability	from user survey
97.9		

USER REFERENCES

(1) 2 yr — Dr. W. A. Wood 517/355-1605
Michigan State University
Biochemistry Department
East Lansing, Michigan 48824

(2) 6 yr — Dr. Clarence Goodnight 616/383-1674
Western Michigan University
Department of Biology
Kalamazoo, Michigan 49008

(3) 1 yr — Dr. Sal Fusari 313/567-5300, Ext. 5629
Park-Davis Laboratories
Analytical Development
Detroit, Michigan 48232

*See point system description.

D-44 Code No. 41

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Visible

VENDOR Transidyne General Corp.

Ann Arbor, Michigan 48106

INSTRUMENT Scanning Densitometer

MODEL OR CATALOG NO. TG 2970

Points*	Factor	Specifications
13.5	Cost	$2,950
9.6	Power required	115/220 V, 50/60 Hz, 300-250 watts
12.4	Volume (m^3)	0.055
13.8	Weight (kg)	22.2
18.7	Complexity of use	from user survey
16.8	Reliability	from user survey
84.8		

USER REFERENCES

(1) 7 mo Skipp Stensel 313/681-1027
Oakland Diagnostic Lab
2711 Pontiac Lake Road
Pontiac, Michigan 48054

(2) No more users available

(3)

*See point system description.

D-45 Code No. 42

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Visible

VENDOR Glenco Scientific Inc.

Houston, Texas 77007

INSTRUMENT Dual-Channel Differential Absorbance Monitor

MODEL OR CATALOG NO. 56-V

Points*	Factor	Specifications
15.6	Cost	$1,695
20.3	Power required	115V, 50/60 Hz, 15 watts
20.1	Volume (m^3)	0.008
20.6	Weight (kg)	4.5
12.2	Complexity of use	from user survey
17.1	Reliability	from user survey
105.9		

USER REFERENCES

(1) 1-1/2 yr Dr. J. H. Harrison 919/933-6193
Dept. of Chemistry
University of North Carolina
Chapel Hill, North Carolina 27514

(2) 2 mo Donald S. Kirkpatrick, Ph.D. 713/790-4638
Baylor College of Medicine
Dept. of Ophthalmology
1200 Moursund
Houston, Texas 77025

(3) 1 yr Dr. Roger L. Lundblad 919/966-1564
University of North Carolina
Chapel Hill, North Carolina 27514

*See point system description.

D-46 Code No. 43

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Pattern Recognition Computer

VENDOR Spatial Data Systems, Inc.

Goleta, California 93017

INSTRUMENT Computer Eye

MODEL OR CATALOG NO. 108-1A

Points*	Factor	Specifications
9.2	Cost	\$13,900
11.2	Power required	105-130 V, 60 Hz, 165 watts
11.4	Volume (m^3)	0.078
12.1	Weight (kg)	37.6
13.0	Complexity of use	from user survey
15.7	Reliability	from user survey
72.6		

USER REFERENCES

(1) 10 mo W. D. McFarland, Asst. Prof. 314/882-3078
University of Missouri - Columbia
Electrical Engineering, Room 339
Columbia, Missouri 65201

(2) 9 mo Dr. Thomas H. VonderHaar 303/491-8566
Colorado State University
Dept. of Atmospheric Science
Ft. Collins, Colorado 80523

(3) 1 yr B. K. P. Horn 617/253-6218
MIT A.I. Laboratory
545 Technology Square
Cambridge, Massachusetts 02139

*See point system description.

Code No. 44

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Pattern Recognition Computer

VENDOR Spatial Data Systems, Inc.

Goleta, California 93017

INSTRUMENT Datacolor Image Analyzer

MODEL OR CATALOG NO. T704-12A

Points*	Factor	Specifications
9.3	Cost	$13,500
7.9	Power required	117V, 60 Hz, 650 watts
6.4	Volume (m^3)	0.757
8.8	Weight (kg)	136.1
15.9	Complexity of use	from user survey
16.9	Reliability	from user survey
65.2		

USER REFERENCES

(1) 1 yr Dr. Rex Peterson 402/472-3471
Remote Sensing Center
University of Nebraska
Room 113, Nebraska Hall
Lincoln, Nebraska 68508

(2) 2 yr David Gaucher 315/330-2353
Calspan-Rome Air Development Center
Griffiss Air Force Base
Rome, New York

(3) 2 yr T. W. Gallagher 716/632-7500
Calspan Corp.
P. O. Box 235
Buffalo, New York 14221

*See point system description.

D-48 Code No. 45

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Light Microscopy

VENDOR Bausch and Lomb, Scientific Optical Products Div.
Rochester, New York 14602

INSTRUMENT Balplan Biological Microscope

MODEL OR CATALOG NO. BST 3 ZIH

Points*	Factor	Specifications
16.4	Cost	$1,388
30.4	Power required	115V, 60 Hz, 3 watts
14.3	Volume (m^3)	0.031
18.6	Weight (kg)	6.8
19.8	Complexity of use	from user survey
17.9	Reliability	from user survey
117.4		

USER REFERENCES

(1) 10 mo
Robert Rackley 919/966-1134
Medical Sciences Teaching Laboratories
School of Medicine
University of North Carolina
Chapel Hill, North Carolina 27514

(2) 8 mo
William A. Hawk, M.D. 216/229-2200
Cleveland Clinic
9500 Euclid Avenue
Cleveland, Ohio 44040

(3) 1-1/2 yr
Lee A. Drake 315/394-3500
Community College of Faiger Lake
120 N. Main Street
Canandaigua, New York 14424

*See point system description.

Code No. 46

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Electrometric/Conductimetry

VENDOR Leeds and Northrup Co.

North Wales, Pennsylvania 19454

INSTRUMENT Electrolytic Conductivity Monitor

MODEL OR CATALOG NO. 7075-1-152

Points*	Factor	Specifications
26.0	Cost	$220
22.5	Power required	120V $\pm$ 10%, 50/60 Hz, 10 watts
22.6	Volume (m^3)	0.005
24.4	Weight (kg)	2.3
17.9	Complexity of use	from user survey
16.1	Reliability	from user survey
129.5		

USER REFERENCES

(1)	8 mo	Stone Container Corp. North Fourth Street Coshocton, Ohio	614/622-6649
(2)	2 mo	Mr. Gordon Pridday Vistron Corp. Box 628 Lima, Ohio 45801	419/228-3232, Ext. 2394
(3)	7 mo	Hach Chemical Company P. O. Box 907 Ames, Iowa 50010	515/232-2533

*See point system description.

D-50

Code No. 47

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Pattern Recognition Computer

VENDOR Geometric Data Corp.

Wayne, Pennsylvania 19087

INSTRUMENT Hematrak Automated Differential Counter

MODEL OR CATALOG NO. ____________

Points*	Factor	Specifications
5.6	Cost	$99,500
5.8	Power required	115V, 60 Hz ± 10%, 2300 watts
5.2	Volume (m^3)	1.790
7.7	Weight (kg)	226.8
15.6	Complexity of use	from user survey
14.2	Reliability	from user survey
54.1		

USER REFERENCES

(1) 3 mo

Clinical Laboratory 202/981-6005
Malcolm Grow USAF Medical Center
Andrews Air Force Base, Maryland

(2) 4 mo

M. Homayouni, M.D. 202/574-6554
Greater S.E. Community Hospital
1310 Southern Avenue, S.E.
Washington, D.C. 20032

(3) 18 mo

John J. Egan, M.D. 302/652-4111
Wilmington Medical Center
Suite 5, Professional Bldg.
Wilmington, Delaware 19803

*See point system description.

Code No. 48

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Electrometric/Conductimetry

VENDOR Balsbaugh Laboratories, Inc.

South Hingham, Massachusetts 02043

INSTRUMENT Electrodeless Conductivity Monitor

MODEL OR CATALOG NO. 1200 with 1200-AT-C cell

Points*	Factor	Specifications
20.9	Cost	$525
22.5	Power required	105-125 V, 50/60 Hz, 10 watts
19.5	Volume (m^3)	0.009
20.6	Weight (kg)	4.5
15.9	Complexity of use	from user survey
17.1	Reliability	from user survey
116.5		

USER REFERENCES

(1) 2 mo

Mr. Oscar Koski 509/942-3581
Battelle, Pacific Northwest Laboratories
Building 305-B, 300 Area
Richland, Washington 99352

(2) 1 yr

Mr. Louis H. Johnson 904/968-6311, Ext. 7479
Monsanto Textiles Co.
P. O. Box 12830
Pensacola, Florida 32575

(3) 2 yr

D. W. McCoombs, Plant Engineer 617/668-0175
Kendall Co.
Northern Mfg. Div.
West Street
Walpole, Massachusetts 02081

*See point system description.

Code No. 49

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Refraction/Polarimetry

VENDOR Epic, Inc.
New York, New York 10038

INSTRUMENT Polarimeter

MODEL OR CATALOG NO. P70-4

Points*	Factor	Specifications
9.7	Cost	$11,325
12.6	Power required	110V, 50/60 Hz, 100 watts
13.9	Volume (m^3)	0.035
10.7	Weight (kg)	60.8
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
66.9		

USER REFERENCES

(1) Only foreign users; names not readily available

(2)

(3)

*See point system description.

Code No. 50

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Refraction/Polarimetry

VENDOR Rudolph Research

Fairfield, New Jersey 07006

INSTRUMENT Automatic Polarimeter

MODEL OR CATALOG NO. Autopol III

Points*	Factor	Specifications
10.6	Cost	$8,000
10.0	Power required	110V, 60 Hz, 250 watts
13.4	Volume (m^3)	0.040
13.7	Weight (kg)	22.7
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
67.7		

USER REFERENCES

(1) New instrument; users not yet available

(2)

(3)

*See point system description.

Code No. 51

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Refraction/Polarimetry

VENDOR Rudolph Instruments Engineering Co., Inc.

Little Falls, New Jersey 07424

INSTRUMENT Automatic Polarimeter

MODEL OR CATALOG NO. AP7 A41

Points*	Factor	Specifications
10.0	Cost	$9,950
8.5	Power required	115V, 60 Hz, 500 watts
8.2	Volume (m^3)	0.283
15.6	Weight (kg)	13.6
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
62.3		

USER REFERENCES

(1) Users list not available

(2)

(3)

*See point system description.

Code No. 52

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Radiometric/Gamma Spectrometry

VENDOR Panax Nucleonics

Montreal, Quebec, Canada

INSTRUMENT Automatic Gamma Spectrometer

MODEL OR CATALOG NO. C-0523/GTA-15

Points*	Factor	Specifications
8.8	Cost	$16,925
10.6	Power required	220V, 50 Hz, 200 watts
6.5	Volume (m^3)	0.713
6.7	Weight (kg)	409.0
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
52.6		

USER REFERENCES

(1) Only foreign users available

(2)

(3)

*See point system description.

Code No. 53

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Light Microscopy

VENDOR Olympus Corp. of America
New Hyde Park, New York 11040

INSTRUMENT Research Microscope

MODEL OR CATALOG NO. BHA-100 with PM-10-35A
and Polaroid camera attachments

Points*	Factor	Specifications
12.1	Cost	$4,691
15.0	Power required	120V, 60 Hz, 50-30 watts
12.0	Volume (m^3)	0.063
17.3	Weight (kg)	9.1
15.8	Complexity of use	from user survey
16.1	Reliability	from user survey
88.3		

USER REFERENCES

(1) 1 mo Christine H. Block 215/643-0200, Ext. 668
Rohm & Haas Co.
Norristown & McKean Roads
Spring House, Pennsylvania 19477

(2) 1 mo Dr. R. Quinton-Cox 503/225-8966
University of Oregon Health Sciences Center
611 S.W. Campus Drive
Portland, Oregon 97201

(3) 5 yr Rudolf Schmid 415/642-3506
Dept. of Botany
University of California
Berkeley, California 94720

*See point system description.

Code No. 54

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Visible

VENDOR Zena Corp.

South Plainfield, New Jersey 07080

INSTRUMENT Colorimeter

MODEL OR CATALOG NO. UK-VIII

Points*	Factor	Specifications
20.8	Cost	\$539
20.3	Power required	220V, 50/60 Hz, 15 watts
18.5	Volume (m^3)	0.011
18.8	Weight (kg)	6.5
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
98.4		

USER REFERENCES

(1) No users available

(2)

(3)

*See point system description.

D-58 Code No. 55

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Visible

VENDOR Helena Laboratories

Beaumont, Texas

INSTRUMENT Quick-Scan Densitometer

MODEL OR CATALOG NO. 1020

Points*	Factor	Specifications
14.0	Cost	$2,600
11.0	Power required	115V, 50/60 Hz, 175 watts
12.5	Volume (m^3)	0.053
15.0	Weight (kg)	15.9
17.6	Complexity of use	from user survey
15.9	Reliability	from user survey
86.0		

USER REFERENCES

(1) 18 mo Mrs. M. A. Renn 212/270-4621
Pathology - Sp. Chemistry
The Brooklyn Hospital
Brooklyn Cumberland Medical Center
121 Dekalb Avenue
Brooklyn, New York 11201

(2) 1-1/2 yr Dr. Lawrence L. Frost, M.D. 213/747-4261
Clinical Pathology Medical Group
1200 West Olympic Blvd.
Los Angeles, California 90015

(3) 2 yr Joe H. Zaletel 515/284-3371
Pathology-Clinical Chemistry
Mercy Hospital
6th - University
Des Moines, Iowa 50314

*See point system description.

Code No. 56

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Visible

VENDOR Gamma Scientific Inc.
San Diego, California 92123

INSTRUMENT Automatic Scanning Microdensitometer

MODEL OR CATALOG NO. 2900 HR with 700-10-90-13 and 700-10-5 conversions

Points*	Factor	Specifications
10.1	Cost	$9,570
22.5	Power required	95-125/190-250 V, 50/60 Hz, 10 watts
9.0	Volume (m^3)	0.197
10.1	Weight (kg)	77.0
11.2	Complexity of use	from user survey
16.8	Reliability	from user survey
79.7		

USER REFERENCES

(1) 1-1/2 yr Larry C. Anderson 312/647-8800, Ext. 2283
A. B. Dick Co.
5700 W. Touhy Avenue
Chicago, Illinois 60648

(2) 2 yr Vernon W. Dryden, Ph.D. 213/351-1270
Xerox Corp.
P. O. Box 5786
125 h. Vinedo Street
Pasadena, California 91107

(3) 5 yr P. M. Kay 216/587-6660
A-M Corporation
Multigraphics Development Center
19701 South Miles Road
Warrensville Heights, Ohio 44128

*See point system description.

D-60 Code No. 57

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Ultraviolet

VENDOR International Light, Inc.

Newburyport, Massachusetts 01950

INSTRUMENT UV Radiation Monitor

MODEL OR CATALOG NO. IL-530

Points*	Factor	Specifications
18.6	Cost	$834
15.0	Power required	115/230 V, 50/60 Hz, 50 watts (est.)
20.7	Volume (m^3)	0.007
23.2	Weight (kg)	2.8
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
97.5		

USER REFERENCES

(1) Users not available

(2)

(3)

*See point system description.

Code No. 58

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Ultraviolet

VENDOR Schoeffel Instrument Corp.
Westwood, New Jersey 07675

INSTRUMENT Spectroflow Monitor

MODEL OR CATALOG NO. SF-770

Points*	Factor	Specification
12.6	Cost	$3,960
15.0	Power required	115 +10V, 60 Hz, 50 watts
16.2	Volume (m^3)	0.019
15.2	Weight (kg)	15.0
17.6	Complexity of use	from user survey
13.9	Reliability	from user survey
90.5		

USER REFERENCES

(1) 6 mo John Bodenmiller 350/948-9111
Merrell-National Laboratories
110 East Amity Road
Cincinnati, Ohio 45215

(2) 1 mo Caesar Pilla 215/MU-8-4000 Ext. 554
Wyeth Laboratories
Box 8299
Philadelphia, Pennsylvania 19101

(3) 1 yr Dr. N. Neus 317/261-4073
Lilly Research
Indianapolis, Indiana 46206

*See point system description.

D-62

Code No. 59

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Ultraviolet

VENDOR Transamerican Instrument Corp.

Emerson, New Jersey 07630

INSTRUMENT Spektromom UV Spectrophotometer

MODEL OR CATALOG NO. 204

Points*	Factor	Specifications
13.5	Cost	$2,995
13.6	Power required	200 V + 10-15%, 50 Hz, 75 watts
10.8	Volume (m^3)	0.095
10.9	Weight (kg)	58.0
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
68.8		

USER REFERENCES

(1) Only foreign users available

(2)

(3)

*See point system description.

Code No. 60

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Refraction/Light Scatter

VENDOR Chrono-Log Corp.
Havertown, Pennsylvania 19083

INSTRUMENT Platelet Aggregometer

MODEL OR CATALOG NO. 300

Points*	Factor	Specifications
18.1	Cost	$935
14.4	Power required	115V, 60 Hz $\pm$ 5%, 60 watts
19.5	Volume (m^3)	0.009
20.6	Weight (kg)	4.5
15.5	Complexity of use	from user survey
21.6	Reliability	from user survey
109.7		

USER REFERENCES

(1) 5 yr — Linda Bowman 216/398-6000, Ext. 411[illegible]
Cleveland Metropolitan General Hospital
3398 Scranton Road
Cleveland, Ohio 44109

(2) 1-1/2 yr — Sue Granger 513/559-4268
Cincinnati Children's Hospital Research Foundation
Elland & Bethesda Avenue
Cincinnati, Ohio 45229

(3) 10 yr — Ms. Marianne Miller 513/872-4234
Cincinnati General Hospital
Dept. of Internal Medicine,
Hematology, Coagulation Lab
231 Bethesda Avenue
Cincinnati, Ohio 45267

*See point system description.

Code No. 61

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Refraction/Refractometry

VENDOR Waters Associates, Inc.

Milford, Massachusetts 01757

INSTRUMENT Differential Refractometer

MODEL OR CATALOG NO. R404

Points*	Factor	Specifications
14.3	Cost	$2,400
28.3	Power required	115 V, 50/60 Hz, 4 watts
20.7	Volume (m^3)	0.007
17.7	Weight (kg)	8.2
17.1	Complexity of use	from user survey
15.8	Reliability	from user survey
113.9		

USER REFERENCES

(1) 6 mo Dr. L. M. Beacham 919/549-8371
Burroughs Welcome
3030 Cornwallis Road
Durham, North Carolina 27709

(2) 2 yr B. P. Korzun 201/277-5292
Ciba-Geigy Corp.
Morris Avenue
Summit, New Jersey 07901

(3) 3 yr Joanna Fowler 516/345-4365
Brookhaven National Laboratory
Chemistry Dept.
Upton, New York 11973

*See point system description.

D-65 Code No. 62

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Refraccion/Refractometry

VENDOR Bausch and Lomb, Analytical Systems Div.

Rochester, New York 14625

INSTRUMENT Precision Hand Refractometer

MODEL OR CATALOG NO. 33-45-32

Points*	Factor	Specifications
21.2	Cost	$495
50.0	Power required	None
40.1	Volume (m^3)	0.0005
40.5	Weight (kg)	0.3
22.6	Complexity of use	from user survey
20.1	Reliability	from user survey
194.5		

USER REFERENCES

(1) 3 yr Alfred Clancy 617/531-1700, Ext. 60
Eastman Gelatine Corp.
227 Washington Street
Peabody, Massachusetts 01960

(2) 6 mo Bill Houston 513/868-51?
Champion Paper Division of Cham[illegible] International Corp.
Hamilton Mill
601 North B Street
Hamilton, Ohio 45013

(3) 10 yr Paul Rebit 615/266-7191
Brach Candy Company
P. O. Box 1407
1113 Chestnut Street
Chattanooga, Tennessee 37401

*See point system description.

Code No. 63

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Refraction/Nephelometry

VENDOR Hach Chemical Co.

Ames, Iowa

INSTRUMENT Analytical Nephelometer

MODEL OR CATALOG NO. 2424-20

Points*	Factor	Specifications
19.6	Cost	$675
16.4	Power required	95-135 V, 50/60 Hz, 35 watts
17.1	Volume (m^3)	0.015
18.0	Weight (kg)	7.7
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
91.1		

USER REFERENCES

(1) No user list available

(2)

(3)

*See point system description.

Code No. 64

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Refraction/Light Scatter

VENDOR Hach Chemical Co.

Ames, Iowa 50010

INSTRUMENT Laboratory Turbidimeter

MODEL OR CATALOG NO. 2100-10

Points*	Factor	Specifications
20.6	Cost	$550
16.4	Power required	95-135 V, 50/60 Hz, 35 watts
17.1	Volume (m^3)	0.015
18.0	Weight (kg)	7.7
10.0	Complexity of use	} from user survey
10.0	Reliability	
92.1		

USER REFERENCES

(1) No user list available

(2)

(3)

*See point system description.

Code No. 65

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Ultraviolet

VENDOR Beckman InstrumentsInc., Scientific Instrument Div.
Irvine, California 92664

INSTRUMENT ACTA M-VII UV-VIS-NIR Spectrophotometer

MODEL OR CATALOG NO. 133700

Points*	Factor	Specifications
7.7	Cost	$27,800
9.4	Power required	110V, 60 Hz, 330 watts
7.0	Volume (m^3)	0.537
9.2	Weight (kg)	113.0
11.5	Complexity of use	from user survey
13.9	Reliability	from user survey
58.7		

USER REFERENCES

(1) 3 mo Dr. V. A. Zeitler 713/238-3180
Dow Chemical USA
B-1219 Bldg., Texas Division
Freeport, Texas 77566

(2) 3 mo D. M. Fenstermacher 505/264-8739
Sandia Laboratories 2441
AEC/ERDA
P. O. Box 5800, KAFB east.
Albuquerque, New Mexico 87115

(3) 6 mo Ltc. Louis Hagler 414/561-4147
Letterman Army Institute of Research
Department of Medicine
Presidio of San Francisco
San Francisco, California 94129

*See point system description.

D-69 Code No. 66

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Pattern Recognition Computer (Image Analyzer)

VENDOR Bausch and Lomb, Analytical Systems Division

Rochester, New York 14625

INSTRUMENT Omnicon Feature Count System

MODEL OR CATALOG NO. 37-50-50-01

Points*	Factor	Specifications
8.3	Cost	$20,790
12.4	Power required	95-130 V, 50/60 Hz, 110 watts
8.2	Volume (m^3)	0.290
12.0	Weight (kg)	39.5
14.8	Complexity of use	from user survey
14.7	Reliability	from user survey
70.4		

USER REFERENCES

(1) 3 yr Dean Russell 205/453-2047
NASA
ES32, Marshall Space Flight Center
Huntsville, Alabama 35812

(2) 2 yr Gary Robertson 313/956-3597
Chrysler Corporation
P. O. Box 1118
Detroit, Michigan 48231

(3) 18 mo D. F. Lentz 513/425-2048
Armco Steel
703 Curtis Street
Middletown, Ohio 45042

*See point system description.

D-70 Code No. 67

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric (photon counting)

VENDOR Ortec, Inc.

Oak Ridge, Tennessee 37830

INSTRUMENT Scanning Densitometer

MODEL OR CATALOG NO. 4310-115

Points*	Factor	Specifications
11.1	Cost	$6,580
9.3	Power required	115/230 V, 50/60 Hz, 345 watts
8.5	Volume (m^3)	0.249
11.9	Weight (kg)	40.8
18.9	Complexity of use	from user survey
15.4	Reliability	from user survey
75.1		

USER REFERENCES

(1) 1 yr Dr. Stephen J. Mayor 419/385-7461, Ext. 726
Medical College of Ohio at Toledo
P. O. Box 6190
Toledo, Ohio 43614

(2) 3 mo Rakesh Goorha 901/525-8381, Ext. 265
St. Jude Children's Research Hospital
P. O. Box 318
Memphis, Tennessee 38101

(3) 1 yr W. R. Finnerty, Ph.D. 404/542-8902
University of Georgia
Department of Microbiology
Athens, Georgia 30602

*See point system description.

D-71 Code No. 68

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Visible

VENDOR Camag, Inc.

New Berlin, Wisconsin 53151

INSTRUMENT Electrophoresis Scanner

MODEL OR CATALOG NO. 80101

Points*	Factor	Specifications
11.4	Cost	$6,000
17.1	Power required	100-120 V, 60 Hz, 30 watts
12.1	Volume (m^3)	0.060
14.4	Weight (kg)	19.0
16.7	Complexity of use	from user survey
16.8	Reliability	from user survey
88.5		

USER REFERENCES

(1) 6 mo

Prof. Dr. G. Piekarski
University of Bonn
Institute of Medical Parasitology
D-53 Bonn-Venusberg
Fed. Republic of Germany

(2) 8 mo

Department of Clinical Chemistry
Kantonsspital Aarau
Aarau, Switzerland 5001

(3) 2 yr

Institut Dr. Viollier
Spalenring 147, Postfach
4002 Basel
Schweiz

*See point system description.

Code No. 69

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Microcalorimetry

VENDOR Perkin-Elmer Corp.

Norwalk, Connecticut 06856

INSTRUMENT DSC-2 Differential Scanning Calorimeter

MODEL OR CATALOG NO. 319-0001

Points*	Factor	Specifications
9.2	Cost	$13,560
10.3	Power required	115V, 60 Hz, 230 watts
8.0	Volume (m^3)	0.315
10.0	Weight (kg)	81.6
10.5	Complexity of use	from user survey
14.6	Reliability	from user survey
62.6		

USER REFERENCES

(1) 1 yr

Allen R. Tice 603/643-3200
USA CRREL
Box 282
Hanover, New Hampshire 03755

(2) 15 mo

Harvey E. Bair 201/582-2381
Bell Labs
Murray Hill, New Jersey 07974

(3) 2-1/2 yr

Anthony Wereta, Jr. (Capt.) 513/255-4685
Air Force Materials Laboratory
AFML/MBP
Wright-Patterson AFB, Ohio 45433

*See point system description.

D-73 Code No. 70

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Refraction/Refractometry

VENDOR Rudolph Research

Fairfield, New Jersey

INSTRUMENT Routine Ellipsometer

MODEL OR CATALOG NO. RR 100

Points*	Factor	Specifications
11.4	Cost	$5,978
12.6	Power required	115 V, 50/60 Hz, 100 watts
10.9	Volume (m^3)	0.091
14.5	Weight (kg)	18.1
20.0	Complexity of use	from user survey
15.1	Reliability	from user survey
84.5		

USER REFERENCES

(1) 15 mo Dale H. Wyker 215/439-5621
Western Electric Co., Inc.
555 Union Blvd.
Allentown, Pennsylvania 18103

(2) 1-1/2 yr C. T. Naber 612/853-3433
Control Data Corporation
P. O. Box 1249
Minneapolis, Minnesota 55440

(3) 6 mo Gene Johnson
Tau Labs
P. 904, Page Industrial Park
Poughkeepsie, New York 12603

*See point system description.

Code No. 71

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Refraction/Refractometry

VENDOR Laboratory Data Control

Riviera Beach, Florida 33404

INSTRUMENT Refract -Monitor

MODEL OR CATALOG NO. 1107

Points*	Factor	Specifications
14.3	Cost	$2,359
19.7	Power required	105-125 V, 60 Hz, 17 watts
20.1	Volume (m^3)	0.008
18.9	Weight (kg)	6.4
22.4	Complexity of use	from user survey
18.5	Reliability	from user survey
113.9		

USER REFERENCES

(1) 2 yr

P. W. Almquist 512/926-2800
Tracor Instruments
6500 Tracor Lane
Austin, Texas 78721

(2) 3 yr

Reed C. Williams 302/453-2711
DuPont
Instrument Products, Glasgow
Wilmington, Delaware 19898

(3)

*See point system description.

D-75 Code No. 72

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Refraction/Forward Light Scatter

VENDOR C. N. Wood Mfg. Co.

Newtown, Pennsylvania 18940

INSTRUMENT Duophotometer

MODEL OR CATALOG NO. 5200 with DMR 300 & BCD output

Points*	Factor	Specifications
11.8	Cost	$5,245
11.4	Power required	115V, 60 Hz, 150 watts
10.5	Volume (m^3)	0.107
11.8	Weight (kg)	42.2
16.2	Complexity of use	from user survey
16.1	Reliability	from user survey
77.8		

USER REFERENCES

(1) 2 yr

M. Tomozawa 518/270-6451
Rensselaer Polytechnic Institute
Materials Engineering Dept.
Troy, New York 12180

(2) 18 mo

Jerome Lichtenstein 201/469-1222, Ext. 299
Pharmacia Labs, Inc.
800 Centennial Avenue
Piscataway, New Jersey 08854

(3)

*See point system description.

D-76 Code No. 73

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Refraction/Forward Light Scatter

VENDOR Science Spectrum

Santa Barbara, California 93105

INSTRUMENT Light Scattering Photometer

MODEL OR CATALOG NO. Differential I with Argon Laser

Points*	Factor	Specifications
9.6	Cost	$11,700
10.6	Power required	110-120 V, 60 Hz, 200 watts
10.6	Vol (m^3)	0.101
12.1	Weight (kg)	38.1
17.5	Complexity of use	from user survey
19.1	Reliability	from user survey
79.5		

USER REFERENCES

(1) 2-1/2 yr S. E. Trifilette 302/57_-8372
ICI United States, Inc.
Murphy Road & Concord Pike - CRDL
Wilmington, Delaware 19897

(2) 4 yr Derry D. Cook 315/268-6630
Clarkson College
Potsdam, New York 13676

(3)

*See point system description.

Code No. 74

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE: Particle Counting/Electro-Conductimetric

VENDOR: Royco Instruments, Inc.
Menlo Park, California 94025

INSTRUMENT: Cell-Crit

MODEL OR CATALOG NO. 920

Points*	Factor	Specifications
13.8	Cost	$2,750
15.0	Power required	115/230 V ± 10%, 50/60 Hz, 50 watts
16.9	Volume (m^3)	0.016
17.3	Weight (kg)	9.1
16.4	Complexity of use	from user survey
14.8	Reliability	from user survey
94.2		

USER REFERENCES

(1) 3 mo — Lanny J. Keyston 408/293-0262, Ext. 491
Santa Clara Valley Medical Center
751 South Bascon Avenue
San Jose, California 95128

(2) 2 mo — Joseph A. Preston, M.D. 303/832-2237
1635 Marion
Denver, Colorado 80218

(3)

*See point system description.

Code No. 75

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Refraction/Forward Light Scatter

VENDOR Recognition Systems, Inc.

Van Nuys, California

INSTRUMENT Diffraction Pattern Sampling Unit

MODEL OR CATALOG NO. DPSU-1

Points*	Factor	Specifications
14.2	Cost	$2,450
17.9	Power required	115V, 60 Hz, 25 watts
14.8	Volume (m^3)	0.027
20.0	Weight (kg)	5.0
14.0	Complexity of use	from user survey
12.0	Reliability	from user survey
92.9		

USER REFERENCES

(1) 1 yr

G. E. Lukes 703/664-6176
Research Institute
Engineer Topographic Laboratories
Fort Belvoir, Virginia 22060

(2) 5 mo

Dr. Robert L. Bond 501/375-7247
University of Arkansas
Grad. Inst. of Tech.
P. O. Box 3017
Little Rock, Arkansas 72203

(3)

*See point system description.

D-79 Code No. 76

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Microcalorimetry

VENDOR Perkin-Elmer Corp.

Norwalk, Connecticut 06856

INSTRUMENT DSC-1B Differential Scanning Calorimeter

MODEL OR CATALOG NO. 219-0139

Points*	Factor	Specifications
10.9	Cost	$7,100
12.6	Power required	117V, 60 Hz, 100 watts
11.5	Volume (m^3)	0.075
14.5	Weight (kg)	18.1
18.1	Complexity of use	from user survey
18.6	Reliability	from user survey
86.2		

USER REFERENCES

(1) 10 yr H. E. Bair 201/582-2381
Bell Labs
Murray Hill, New Jersey 07974

(2) 3 yr Dr. Edward M. Bairall II 203/486-2441
IBM Research
IMS U-136 University of Connecticut
Storrs, Connecticut 06268

(3)

*See point system description.

D-80 Code No. 77

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Immunologically Based/Agglutination

VENDOR Payton Associates, Inc.
Buffalo, New York 14202

INSTRUMENT Single-Channel Aggregation Module

MODEL OR CATALOG NO. 300-D

Points*	Factor	Specifications
16.4	Cost	$1,375
13.8	Power required	105-125 V, 60 Hz ± 5%, 70 watts
23.8	Volume (m^3)	0.004
17.3	Weight (kg)	9.1
15.4	Complexity of use	from user survey
20.9	Reliability	from user survey
107.6		

USER REFERENCES

(1) 3 yr — E.J.W. Bowie, M.D. 507/282-2511
Mayo Clinic
200 First Street, SW
Rochester, Minnesota 55901

(2) 6 yr — W. Jean Dodds, D.V.M. 518/457-2663
Div. Labs & Research
New York State Department of Health
120 New Scotland Avenue
Albany, New York 12201

(3) 2 yr — Dale H. Cowan, M.D. 216/398-6000, Ext. 4115
Case Western Reserve Medical School
Cleveland Metro General Hospital
3395 Scranton Road
Cleveland, Ohio 44109

*See point system description.

D-81 Code No. 78

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric (general)

VENDOR Pacific Photometric Instruments

Emeryville, California 94608

INSTRUMENT Digital Photometer

MODEL OR CATALOG NO. 124

Points*	Factor	Specifications
17.9	Cost	$975
14.1	Power required	115/230 V, 50/60 Hz, 65 watts
16.2	Volume (m^3)	0.019
17.7	Weight (kg)	8.2
15.1	Complexity of use	from user survey
17.4	Reliability	from user survey
98.4		

USER REFERENCES

(1) 3 mo

Bob Anderson 507/285-5831
Mayo Clinic
200 First STreet, SW
Rochester, Minnesota 55901

(2) 2 yr

August H. Maki 916/752-6477
University of California at Davis
Davis, California 95616

(3)

*See point system description.

D-82 Code No. 79

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Inf:ared

VENDOR Varian

Palo Alto, California 94303

INSTRUMENT Cary 17 Automatic Recording Spectrophotometer

MODEL OR CATALOG NO. 01--700000-00

Points*	Factor	Specifications
7.6	Cost	$29,990
6.7	Power required	115/230 V, 50/60 Hz, 1265 watts
5.8	Volume (m^3)	1.125
7.5	Weight (kg)	249.5
18.3	Complexity of use	from user survey
16.5	Reliability	from user survey
62.4		

USER REFERENCES

(1) 6 mo

Allen D. Sawyer 214/749-2156
U. S. Food & Drug Administration
3032 Bryan
Dallas, Texas 75204

(2) 6 mo

Gregory L. Geoffroy 814/865-1924
Penn State University
152 Davey Lab
University Park, Pennsylvania 16802

(3)

*See point system description.

D-83

Code No 80

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Visible

VENDOR Gilford Instrument Laboratories, Inc.

Oberlin, Ohio 44074

INSTRUMENT Micro-Sample Spectrophotometer

MODEL OR CATALOG NO. 300-N

Points*	Factor	Specifications
14.3	Cost	$2,400
13.8	Power required	105-125V, 50/60 Hz, 70 watts
14.4	Volume (m^3)	0.030
15.2	Weight (kg)	15.0
19.6	Complexity of use	} from user survey
13.3	Reliability	
90.6		

USER REFERENCES

(1) 4 mo

Sharon Guthrie 614/299-3151, Ext. 3310
Battelle, Columbus Laboratories
505 King Avenue
Columbus, Ohio 43201

(2) 2 yr

Children's Hospital 614/261-2140
Clinical Chemistry Lab
(Dept. of Pediatrics, OSU)
561 South 17th Street
Columbus, Ohio 43205

(3)

*See point system description.

Code No. 81

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Visible

VENDOR Brinkmann Instruments, Inc.
Westbury, New York 11590

INSTRUMENT Probe Colorimeter PC/600

MODEL OR CATALOG NO. 20 23 000-2

Points*	Factor	Specifications
19.5	Cost	$695
26.7	Power required	110V, 50/60 Hz, 5 watts
20.7	Volume (m^3)	0.007
22.6	Weight (kg)	3.1
20.0	Complexity of use	from user survey
18.5	Reliability	from user survey
128.0		

USER REFERENCES

(1) 1 yr — Dr. William Spira 617/653-1000, Ext. 2900
U. S. Army Natick Development Cente-
Food Science Lab
Natick, Massachusetts 01760

(2) 1 yr — P. E. Cornwell, Ph.D. 205/934-2380
UAB, The Medical Center
University Station
Birmingham, Alabama 35294

(3)

*See point system description.

D-85 Code No. 82

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Ultraviolet

VENDOR Bausch and Lomb, Analytical Systems Division

Rochester, New York 14625

INSTRUMENT Spectronic 210 UV Spectrophotometer

MODEL OR CATALOG NO. 39-20-03

Points*	Factor	Specifications
11.4	Cost	$6,000
9.2	Power required	120V, 60 Hz, 360 watts
10.3	Volume (m^3)	0.117
10.9	Weight (kg)	56.7
14.5	Complexity of use	from user survey
17.4	Reliability	from user survey
73.7		

USER REFERENCES

(1) 5 mo

Justin G. Dane 716/882-8484
Westwood Pharmaceuticals, Inc.
468 DeWitt Street
Buffalo, New York 14213

(2) 1 mo

Arthur W. Smith 503/668-6634
City of Portland, Water Bureau
Rt. 3, Box 582
Sandy, Oregon 97055

(3)

*See point system description.

Code No. 83

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Emission/Fluorimetry

VENDOR Baird-Atomic

Bedford, Massachusetts 01730

INSTRUMENT Fluorispec Spectrofluorometer

MODEL OR CATALOG NO. SF-100

Points*	Factor	Specifications
11.5	Cost	$5,775
6.9	Power required	110V, 60 Hz, 1150 watts
10.3	Volume (m^3)	0.116
10.7	Weight (kg)	61.7
14.4	Complexity of use	from user survey
15.4	Reliability	from user survey
69.2		

USER REFERENCES

(1) 4 mo

Dr. Justin McCormick 313/8‾ -0710, Ext. 323
Michigan Cancer Foundation
110 East Warren
Detroit, Michigan 48201

(2) 1 yr

Dr. DeLyle Eastwood 203/445-8501, Ext. 255
U. S. Coast Guard R&D Center
Avery Point
Groton, Connecticut 06340

(3)

*See point system description.

 Code No. 84

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Radiometric/X-Ray Fluorescence

VENDOR Applied Research Laboratories

Sunland, California 91040

INSTRUMENT Non-Dispersive X-Ray Analyser

MODEL OR CATALOG NO. N 940

Points*	Factor	Specifications
11.0	Cost	$6,875
12.6	Power required	110V ± 15%, 50/60 Hz, 100 watts
10.8	Volume (m^3)	0.094
13.7	Weight (kg)	22.7
19.5	Complexity of use	from user survey
14.2	Reliability	from user survey
81.8		

USER REFERENCES

(1) 2 yrs

Mr. J. T. Harris
Ketton Portland Cement
Ketton, Stamford
Lincolnshire, England

(2) 3 mo

J. B. Rae
BP Refinery (Grangemouth) Limited
Bo'ness Road
Grangemouth, Stirlingshire FK3 9XQ

(3) 1 yr

G. A. Lee
ICI Australia Ltd.
Organic Factory, Denison Street
Matraville
Sydney, NSW 2036

*See point system description.

D-88 Code No. 85

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Visible

VENDOR Clifford Instruments, Inc.

Natick, Massachusetts 01760

INSTRUMENT Densicomp

MODEL OR CATALOG NO. 445-20

Points*	Factor	Specifications
12.6	Cost	$3,980
8.2	Power required	115V, 50/60 Hz, 575 watts
5.8	Volume (m^3)	1.178
11.3	Weight (kg)	49.0
22.8	Complexity of use	from user survey
18.7	Reliability	from user survey
79.4		

USER REFERENCES

(1) 4 yrs Augusto Aguirre, M D. 614/261-5526
Riverside Methodist Hospital
3535 Olentangy River Road
Columbus, Ohio 43214

(2) 2 yrs James J. Kennedy 513/872-2391
Good Samaritan Hospital
3217 Clifton Avenue
Cincinnati, Ohio 45220

(3)

*See point system description.

D-89

Code No. 86

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Pattern Recognition Computer

VENDOR Corning Scientific Instruments
Medfield, Massachusetts 02052

INSTRUMENT LARC Classifier

MODEL OR CATALOG NO. (none)

Points*	Factor	Specifications
6.1	Cost	$70,000
6.0	Power required	115V ± 10%, 60 Hz, 1970 watts
7.0	Volume (m^3)	0.535
8.0	Weight (kg)	194.4
8.0	Complexity of use	from user survey
13.2	Reliability	from user survey
48.3		

USER REFERENCES

(1) 2 mo James W. Bacus, Ph.D. 312/942-5874
Rush-Presbyterian-St. Luke's Medical Center
1753 West Congress Parkway
Chicago, Illinois 60612

(2) 2 mo Carol Strang 312/649-3200
Northwestern Memorial Hospital
303 East Superior Street
Chicago, Illinois 60611

(3)

*See point system description.

D-90

Code No. 87

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photography

VENDOR Paillard Inc.

Linden, New Jersey 07036

INSTRUMENT Hasselblad 70 mm SLR Camera

MODEL OR CATALOG NO. 500 EL with Magazine 70

Points*	Factor	Specifications
13.8	Cost	$2,730
50.0	Power required	Internal batteries
23.8	Volume (m^3)	0.004
23.6	Weight (kg)	2.6
16.9	Complexity of use	from user survey
21.8	Reliability	from user survey
149.9		

USER REFERENCES

(1) 10 yr

Garland L. Chambers 614/268-9994
Chambers Camera Service, Inc.
4608 North High Street
Columbus, Ohio 43214

(2) 6 yr

J. G. Stephan 614/299-3151
Battelle, Columbus Laboratories
505 King Avenue
Columbus, Ohio 43201

(3) 6 yr

Robert Parker 614/299-1101
Parker Photographs
2036 North High Street
Columbus, Ohio 43201

*See point system description.

D-91

Code No. 88

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Particle Counting/Electro-conductimetric

VENDOR Coulter Electronics, Inc.

Hialeah, Florida 33010

INSTRUMENT Coulter Counter TA II/PCA

MODEL OR CATALOG NO. 6600688

Points*	Factor	Specifications
8.8	Cost	$16,826
8.1	Power required	105-125 V, 50/60 Hz, 600 watts
9.6	Volume (m^3)	0.150
10.4	Weight (kg)	68.0
20.0	Complexity of use	from user survey
15.1	Reliability	from user survey
72.0		

USER REFERENCES

(1) 1-1/2 yr Dr. Charles A. Daniels 216/933-6181, Ext. 254
B. F. Goodrich Chemical Co.
Technical Center
P. O. Box 122
Avon Lake, Ohio 44012

(2) 8 mo Steve Shultz 614/224-2228
Ironsides Company
270 West Mound Street
Columbus, Ohio 43216

(3)

*See point system description.

D-92

Code No. 89

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Refraction/Light Scatter

VENDOR Pen Kem Co.

Croton-on-Hudson, New York 10520

INSTRUMENT Automatic Laser Zee Meter

MODEL OR CATALOG NO. 2003

Points*	Factor	Specifications
10.0	Cost	New instrument - cost not yet determined
7.9	Power required	105-125/205-230 V, 50/60 Hz, 650-617 watts
8.3	Volume (m^3)	0.268
10.4	Weight (kg)	68.1
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
56.6		

USER REFERENCES

(1) Instrument not yet marketed

(2)

(3)

*See point system description.

D-93 Code No. 90

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Refraction/Light Scatter

VENDOR Pen Kem Co.

Croton-on-Hudson, New York 10520

INSTRUMENT Laser Zee Meter

MODEL OR CATALOG NO. 400

Points*	Factor	Specifications
10.4	Cost	$8,500
13.2	Power required	105-125/205-230 V, 50/60 Hz, 85 watts
9.9	Volume (m^3)	0.134
13.1	Weight (kg)	27.7
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
66.0		

USER REFERENCES

(1) No users completed

(2)

(3)

*See point system description.

D-94 Code No. 91

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Visible

VENDOR ISCO

Lincoln, Nebraska

INSTRUMENT Spectroradiometer SR

MODEL OR CATALOG NO. 1050S

Points*	Factor	Specifications
14.3	Cost	$2,390
19.7	Power required	110-120 V, 50/60 Hz, 17 watts
17.4	Volume (m^3)	0.014
19.4	Weight (kg)	5.7
15.1	Complexity of use	from user survey
22.9	Reliability	from user survey
108.8		

USER REFERENCES

(1) 1 mo Jack C. Bailey 601/686-2311
ARS, USDA
P. O. Box 225
Stoneville, Mississippi 38776

(2) 3 yr Dr. J.W.A. Burley 215/895-2624, 2623
Department of Biological Sciences
Drexel University
32nd and Chestnut Streets
Philadelphia, Pennsylvania 19104

(3)

*See point system description.

D-95 Code No. 92

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Electrometric/Conductimetry

VENDOR The London Company

Cleveland, Ohio 44145

INSTRUMENT Conductivity Meter

MODEL OR CATALOG NO. CDM 3

Points*	Factor	Specifications
18.6	Cost	$830
25.6	Power required	110/220 V ± 10%, 47.5-63 Hz, 6 watts
18.1	Volume (m^3)	0.012
20.6	Weight (kg)	4.5
17.2	Complexity of use	from user survey
17.2	Reliability	from user survey
117.3		

USER REFERENCES

(1) 3 yr T. T. Kramer, D.V.M., Ph.D. 826-4539
Department of Veterinary Microbiology
Auburn University
Auburn, Alabama 36830

(2) 3 yr Dr. A. Scanu 312/947-5728
University of Chicago
950 East 59th Street
Chicago, Illinois 60637

(3)

*See point system description.

Code No. 93

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Electrometric/Conductimetry

VENDOR The London Company
Cleveland, Ohio 44145

INSTRUMENT Conductivity Meter

MODEL OR CATALOG NO. CDM 2

Points*	Factor	Specifications
19.2	Cost	$730
20.3	Power required	110/12//150/200/220/240 V, 50/60 Hz, 15 watts
23.9	Volume (m^3)	0.004
21.3	Weight (kg)	3.9
22.4	Complexity of use	from user survey
22.4	Reliability	from user survey
129.5		

USER REFERENCES

(1) 3 yr
Joseph Jarabak 312/947-5539
Department of Medicine
University of Chicago
Chicago, Illinois 60637

(2) 2 yr
Patrick Guire 816/561-0202
Midwest Research Institute
425 Volker Blvd.
Kansas City, Missouri 64110

(3)

*See point system description.

D-97 Code No. 94

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Particle Counting/Electro-Conductimetric

VENDOR Coulter Electronics, Inc.

Hialeah, Florida 33010

INSTRUMENT Coulter Counter ZBI

MODEL OR CATALOG NO. 6500051

Points*	Factor	Specifications
11.4	Cost	$5,874
10.3	Power required	105-125V, 50/60 Hz, 230 watts
11.8	Volume (m^3)	0.066
14.2	Weight (kg)	est. 20
20.0	Complexity of use	from user survey
13.5	Reliability	from user survey
81.2		

USER REFERENCES

(1) 1 yr Frances E. Scott 205/453-1341
National Aeronautics & Space Administration
Marshall Space Flight Center
Marshall Space Flight Ctr., Alabama 35812

(2) 1 yr Dr. W. Fred Hink 614/422-4943
The Ohio State University
Department of Entomology
1735 Neil Avenue
Columbus, Ohio 43210

(3)

*See point system description.

Code No. 95

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Electrometric/Conductimetry

VENDOR Leeds and Northrup Co.

North Wales, Pennsylvania 19454

INSTRUMENT Electrolytic Conductivity Monitor

MODEL OR CATALOG NO. 7073

Points*	Factor	Specifications
22.0	Cost	$430
21.5	Power required	120V, 50/60 Hz, 12 watts
18.1	Volume (m^3)	0.012
19.1	Weight (kg)	6.1
21.7	Complexity of use	from user survey
14.4	Reliability	from user survey
116.8		

USER REFERENCES

(1) 8 yr

Bob Wagner 614/299-4101, Ext. 49
American Smelting & Refining Co.
1363 Windsor Avenue
P. O. Box 327
Columbus, Ohio 43216

(2) 4 mo

William Beck 419/423-8123
Whirlpool Corp.
4901 North Main
Findlay, Ohio 45840

(3)

*See point system description.

D-99 Code No. 96

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Enzymatically based/ATP Photometry

VENDOR SAI Technology Co.

San Diego, California 92123

INSTRUMENT ATP Photometer

MODEL OR CATALOG NO. 2000

Points*	Factor	Specifications
11.6	Cost	$5,500
18.1	Power required	115/230 V $\pm$ 10%, 48-440 Hz, 24 watts
17.1	Volume (m^3)	0.015
19.7	Weight (kg)	5.4
21.4	Complexity of use	from user survey
20.5	Reliability	from user survey
108.4		

USER REFERENCES

(1) 5 yr Dr. Osmund Holm-Hansen 714/452-2339
Scripps Institution of Oceanography
University of California
Sverdrups Hall 2153
La Jolla, California 92037

(2) 6 mo Dr. Grace Lee Picciolo 301/982-2121
NASA-Goddard Space Center
Code /26
Greenbelt, Maryland 20771

(3)

*See point system description.

D-100 Code No. 97

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photography

VENDOR Charles A. Hulcher Co., Inc.

Hampton, Virginia 23361

INSTRUMENT 35 mm Sequence Camera

MODEL OR CATALOG NO. 112 with single-frame pulse

Points*	Factor	Specifications
15.2	Cost	$1,860
12.1	Power required	12/24 VDC, 120-70 watts
25.6	Volume (m^3)	0.003
26.7	Weight (kg)	1.6
21.6	Complexity of use	from user survey
20.6	Reliability	from user survey
121.8		

USER REFERENCES

(1) 4 yr Shannon L. Ball 214/455-3450, Ext. 6270
E-Systems, Inc.
Box 1056
Greenville, Texas 75401

(2) 8 yr Time-Life Photo Lab 212/556-2019
Time Inc.
1271 Avenue of the Americas
New York, New York 10020

(3)

*See point system description.

D-101 Code No. 98

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Visible

VENDOR Transidyne General Corp.

Ann Arbor, Michigan 48106

INSTRUMENT Programmable Scanning Densitometer

MODEL OR CATALOG NO. 2980

Points*	Factor	Specifications
11.2	Cost	$6,450
9.6	Power required	110/220 V, 50/60 Hz, 300-250 watts
11.0	Volume (m^3)	0.088
12.6	Weight (kg)	31.8
20.6	Complexity of use	from user survey
15.6	Reliability	from user survey
80.6		

USER REFERENCES

(1) 2 yr W. A. Foote Memorial Hospital 517/783-2771
205 North East Avenue
Jackson, Michigan 49201

(2) 9 mo Dr. G. Sherman 617/492-3500
Mount Auburn Hospital
330 Mount Auburn Street
Cambridge, Massachusetts 02138

(3)

*See point system description.

D-102 Code No. 99

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Visible

VENDOR Technical Consulting Services

Southampton, Pennsylvania 18966

INSTRUMENT Dual Wavelength Filter Photometer

MODEL OR CATALOG NO. 3000-C

Points*	Factor	Specifications
13.9	Cost	$2,685
15.0	Power required	110V, 50/60 Hz, 50 watts
15.2	Volume (m^3)	0.024
16.1	Weight (kg)	12.2
19.6	Complexity of use	from user survey
17.7	Reliability	from user survey
97.5		

USER REFERENCES

(1) 2 yr
Tsuyoshi Ohnishi, Ph.D. 215/448-7798
Biophysics Laboratory
Hahnemann Medical College
230 North Broad Street
Philadelphia, Pennsylvania 19102

(2) 4 mo
Toshiro Asakura 215/EV7-6000, Ext. 694
Children's Hospital of Philadelphia
University of Pennsylvania
34th Street, Civic Center Blvd.

(3)
Philadelphia, Pennsylvania 19104

*See point system description.

D-103 Code No. 100

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Visible

VENDOR Photronic Inc.

Jenkintown, Pennsylvania 19006

INSTRUMENT Tri-Colorphot

MODEL OR CATALOG NO. TC

Points*	Factor	Specifications
18.3	Cost	$895
20.3	Power required	110V, 60 Hz, 15 watts
20.0	Volume (m^3)	0.008
21.8	Weight (kg)	3.6
23.1	Complexity of use	from user survey
20.8	Reliability	from user survey
124.3		

USER REFERENCES

(1) 2 yr Aubrey D. Hibbard 314/882-2043
University of Missouri-Columbia
Department of Horticulture
1-43 Agriculture Building
Columbia, Missouri 65201

(2) 5 yr Barbara B. Aulenbach 301/344-3483
USDA, ARS
Horticultural Crops Marketing Lab
Room 6, Building 002, Agricultural Research Center-West
Beltsville, Maryland 20705

(3)

*See point system description.

D-104 Code No. 101

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Visible

VENDOR Photovolt Corp.

New York, New York 10010

INSTRUMENT Lumetron 401 Photoelectric Colorimeter

MODEL OR CATALOG NO. 4760

Points*	Factor	Specifications
23.6	Cost	$325
9.1	Power required	100-125V, 60 Hz (or 6 VDC), 380 watts
20.0	Volume (m^3)	0.008
18.3	Weight (kg)	7.3
24.2	Complexity of use	from user survey
21.8	Reliability	from user survey
117.0		

USER REFERENCES

(1) 2 yr

Quality Control Department 201/343-8703
Halocarbon Products Inc.
82 Burlews Court
Hackensack, New Jersey 07601

(2) 10 yr

Roll Coater, Inc. 317/462-7761
Arvin Industries
P. O. Box 787
Greenfield, Indiana 46140

(3)

*See point system description.

D-105 Code No. 102

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Visible

VENDOR Photovolt Corp.

New York, New York 10010

INSTRUMENT Densicord 552 Densitometer

MODEL OR CATALOG NO. 09-552-10

Points*	Factor	Specifications
12.4	Cost	$4,250
12.6	Power required	90-130 V, 50/60 Hz, 100 watts
11.3	Volume (m^3)	0.079
13.1	Weight (kg)	27.7
11.2	Complexity of use	from user survey
16.8	Reliability	from user survey
77.4		

USER REFERENCES

(1) 2 yr

Dr. H. B. Davidson 614/221-4171
Davidson Laboratories
267 East Broad Street
Columbus, Ohio 43215

(2) 3 yr

Robert Schmitt 513/221-2325- Ext. 400
Veterans Administration Hospital
Medical Service
3200 Vine Street
Cincinnati, Ohio 45220

(3)

*See point system description.

Code No. 103

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Pattern Recognition Computer (Image Analyzer)

VENDOR Rank Precision Industries, Inc.

Des Plaines, Illinois 60018

INSTRUMENT Image Analyzer

MODEL OR CATALOG NO. 3000

Points*	Factor	Specifications
8.7	Cost	$17,000
11.4	Power required	230-250 V, 50/60 Hz, 150 watts
7.6	Volume (m^3)	0.389
8.7	Weight (kg)	144.0
18.4	Complexity of use	from user survey
18.0	Reliability	from user survey
72.8		

USER REFERENCES

(1) 3 mo

Charles Oxnard 312/643-2606
University of Chicago
1025 East 57th Street
Chicago, Illinois 60637

(2) 1 yr

David J. Goodenough, Ph.D. 301/955-3350
Johns Hopkins University
615 North Wolfe Street
Baltimore, Maryland

(3) New

M. C. Bruce 301/443-2536
Dept. Health, Education, & Welfare
FDA/BRH
12720 Twinbrook Parkway
Rockville, Maryland 20852

*See point system description.

D-107

Code No. 104

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Radiometric/Scintillation Photometry

VENDOR Beckman Instruments, Inc.

Irvine, California 92664

INSTRUMENT Biogamma Analyzer

MODEL OR CATALOG NO. 167776

Points*	Factor	Specifications
10.2	Cost	$9,400
10.2	Power required	120V, 50/60 Hz, 240 watts
8.2	Volume (m^3)	0.285
7.4	Weight (kg)	272.2
17.6	Complexity of use	from user survey
16.7	Reliability	from user survey
70.3		

USER REFERENCES

(1) 2 yr Saint Thomas Hospital 216/379-1111
444 North Main Street
Akron, Ohio 44310

(2) 1 yr J. D. Clough, M.D. 216/229-2200
Cleveland Clinic
9500 Euclid Avenue
Cleveland, Ohio 44106

(3) 18 mo M. Saffran, Ph.D.
Department of Biochemistry
P. O. Box 6190
Medical College of Ohio at Toledo
Toledo, Ohio 43614

*See point system description.

Code No. 105

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Visible

VENDOR Vitatron Medical, Inc.

South Boston, Massachusetts 02127

INSTRUMENT Flying Spot Densitometer TLD 100

MODEL OR CATALOG NO. 811.100

Points*	Factor	Specifications
10.9	Cost	$7,000
11.0	Power required	110/240 V, 50/60 Hz, (est) 175 watts
9.2	Volume (m^3)	0.180
9.2	Weight (kg)	112.0
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
60.3		

USER REFERENCES

(1) No user list received

(2)

(3)

*See point system description.

D-109 Code No. 106

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Visible

VENDOR Vitatron Medical Inc.

South Boston, Massachusetts 02127

INSTRUMENT Digital Concentration Photometer

MODEL OR CATALOG NO. 951.000

Points*	Factor	Specifications
16.7	Cost	$1,290
15.2	Power required	110/220 V, 50/60 Hz, 48 watts
16.4	Volume (m^3)	0.018
18.6	Weight (kg)	6.8
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
86.9		

USER REFERENCES

(1) No user list received

(2)

(3)

*See point system description.

D-110 Code No. 107

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Ultraviolet

VENDOR Vitatron Medical Inc.

South Boston, Massachusetts 02127

INSTRUMENT Modular Photometer System

MODEL OR CATALOG NO. 940.100

Points*	Factor	Specifications
14.2	Cost	$2,490
11.8	Power required	110/220 V, 50/60 Hz, 130 watts
11.4	Volume (m^3)	0.078
12.3	Weight (kg)	34.9
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
69.7		

USER REFERENCES

(1) No user list received

(2)

(3)

*See point system description.

D-111 Code No. 108

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Visible

VENDOR International Light, Inc.

Newburyport, Massachusetts 01950

INSTRUMENT Spectroradiometer System

MODEL OR CATALOG NO. IL 700/IL 760/IL 780

Points*	Factor	Specifications
12.6	Cost	$3,936
14.9	Power required	115/230 V, 50/60 Hz, (est) 52 watts
18.5	Volume (m^3)	0.011
16.6	Weight (kg)	10.7
18.7	Complexity of use	from user survey
14.0	Reliability	from user survey
95.3		

USER REFERENCES

(1) 6 mo Dr. Edward A. Emmett 513/872-5284
University of Cincinnati
231 Bethesda Avenue, Room 5251
Cincinnati, Ohio 45267

(2) 8 mo R. R. Chance 201/455-4991
Allied Chemical
Materials Research Center
Morristown, New Jersey 07960

(3)

*See point system description.

D-112 Code No. 109

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Visible

VENDOR Helena Laboratories

Beaumont, Texas

INSTRUMENT Quick-Scan Jr. Densitometer

MODEL OR CATALOG NO. 1111

Points*	Factor	Specifications
16.1	Cost	$1,500
11.0	Power required	115V, 50/60 Hz, 173 watts
14.0	Volume (m^3)	0.034
15.6	Weight (kg)	13.6
15.8	Complexity of use	from user survey
17.4	Reliability	from user survey
89.9		

USER REFERENCES

(1) 1-1/2 yr Glen Berryman 419/244-3711
Flower Hospital Laboratory
3350 Collingwood Blvd.
Toledo, Ohio 43610

(2) 1-1/2 yr E. D. Slifer, M.D. 217/824-3331
St. Vincent Memorial Hospital
201 East Pleasant Street
Taylorville, Illinois 62568

(3)

*See point system description.

D-113 Code No. 110

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Abscrption/Ultraviolet

VENDOR Varian

Palo Alto, Califomia 94303

INSTRUMENT Cary 118C UV-Vis Spectrophotometer

MODEL OR CATALOG NO. 01-180000-00

Points*	Factor	Specifications
8.7	Cost	$17,250
8.1	Power required	115/230 V, 50/60 Hz, 575 watts
7.5	Volume (m^3)	0.403
8.9	Weight (kg)	136.1
16.0	Complexity of use	from user survey
17.7	Reliability	from user survey
66.9		

USER REFERENCES

(1) 18 mo Daniel L. Francis 216/232-3320
Ben Venue Labs
Bedford, Ohio 44146

(2) 2 yr John Tupa 216/771-3121
Glidden-Durkee, Div. S.C.M.
16651 Sprague Road
Strongsville, Ohio 44136

(3)

*See point system description.

Code No. 111

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Ultraviolet

VENDOR Pharmacia Fine Chemicals, Inc.
Piscataway, New Jersey 08854

INSTRUMENT Dual Wavelength UV Photometer

MODEL OR CATALOG NO. 200

Points*	Factor	Specifications
14.2	Cost	$2,439
20.7	Power required	115V, 60 Hz, 14 watts
19.5	Volume (m^3)	0.009
19.4	Weight (kg)	5.7
20.4	Complexity of use	from user survey
20.3	Reliability	from user survey
114.5		

USER REFERENCES

(1) 8 mo James S. Hagen 201/545-1300, Ext. 3447
E. R. Squibb
Georges Road
New Brunswick, New Jersey 08903

(2) 2 yr Dr. Lamanna 301/443-3036
FDA, BRH, DBE, XSB, MSS
HFX-120, 5600 Fishers Lane
Rockville, Maryland 20852

(3)

*See point system description.

D-115 Code No. 112

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Ultraviolet

VENDOR Pharmacia Fine Chemicals, Inc.

Piscataway, New Jersey 08854

INSTRUMENT UV-Visible Photometer

MODEL OR CATALOG NO. 140

Points*	Factor	Specifications
15.5	Cost	$1,726
21.5	Power required	105-125 V, 60 Hz, 12 watts
19.5	Volume (m^3)	0.009
20.3	Weight (kg)	4.8
17.7	Complexity of use	from user survey
13.7	Reliability	from user survey
108.2		

USER REFERENCES

(1) 2 yr C. A. Daniels, M.D., Ph.D. 919/684-2125
Duke University
Department of Pathology
Durham, North Carolina 77710

(2) 8 mo Mr. Terry L. Kaduce 319/353-6069
University of Iowa
Department of Biochemistry, 4-555 BSB
Iowa City, Iowa 52240

(3)

*See point system description.

D-116 Code No. 113

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Electrometric/Coulometry

VENDOR McKee Pedersen Instruments

Danville, California 94526

INSTRUMENT Electrocell-CPC

MODEL OR CATALOG NO. C-2000-1

Points*	Factor	Specifications
19.9	Cost	$640
12.6	Power required	117V, 50/60 Hz, (est) 100 watts
19.0	Volume (m^3)	0.010
20.0	Weight (kg)	5.0
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
91.5		

USER REFERENCES

(1) No users list received

(2)

(3)

*See point system description.

Code No. 114

D-117

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Ultraviolet

VENDOR LKB Instruments, Inc.

Rockville, Maryland 20852

INSTRUMENT Uvicord II UV Absorptiometer

MODEL OR CATALOG NO. 8300 A

Points*	Factor	Specifications
15.2	Cost	$1,850
14.1	Power required	115/230 V, 50/60 Hz, 65 watts
16.4	Volume (m^3)	0.018
15.6	Weight (kg)	13.5
25.9	Complexity of use	from user survey
21.2	Reliability	from user survey
108.4		

USER REFERENCES

(1) 4 yr Gene Myrano 313/577-1543
Wayne University (Medicine)
540 East Canfield
Detroit, Michigan 48201

(2) 15 yr Dr. M. D. Poulik 313/549-7000, Ext. 245
William Beaumont Hospital
Royal Oak, Michigan 48072

(3)

*See point system descri tion.

D-118 Code No. 115

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Ultraviolet

VENDOR ISCO

Lincoln, Nebraska 68505

INSTRUMENT Absorbance Monitor UA-5

MODEL OR CATALOG NO. 0721 U

Points*	Factor	Specifications
15.4	Cost	$1,795
12.2	Power required	110/120 V, 50/60 Hz, 115 watts
14.8	Volume (m^3)	0.027
16.4	Weight (kg)	11.3
16.4	Complexity of use	from user survey
19.6	Reliability	from user survey
94.8		

USER REFERENCES

(1) 2 yr John R. Shainoff, Ph.D. 216/229-2200, Ext. 1262
Research Division
Cleveland Clinic Foundation
9500 Euclid Avenue
Cleveland, Ohio 44106

(2) 2 yr James S. Marshall, M.D. 216/791-7300, Ext. 2150
Case Western Reserve University
2065 Adelbert Road
Cleveland, Ohio 44106

(3)

*See point system description.

 Code No. 116

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Visible

VENDOR Hycel, Inc.
Houston, Texas 77042

INSTRUMENT Desk Top Chemical Analyzer

MODEL OR CATALOG NO. HMA-1600

Points*	Factor	Specifications
8.9	Cost	$16,000
8.3	Power required	110V, 60 Hz, 550 watts
9.9	Volume (m^3)	0.133
10.3	Weight (kg)	72.6
12.0	Complexity of use	from user survey
13.7	Reliability	from user survey
63.1		

USER REFERENCES

(1) 2 mo Tony Piano 312/643-9200, Ext. 364
Illinois Central Community Hospital
5800 Stoney Island Avenue
Chicago, Illinois 60637

(2) 4 mo David Marrack, M.D. 713/524-7631 or 790-4661
Baylor College of Medicine
Pathology Department
1200 Moursund
Houston, Texas 77025

(3)

*See point system description.

D-120 Code No. 117

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Ultraviolet

VENDOR Glenco Scientific Inc.

Houston, Texas 77007

INSTRUMENT UV Absorbance Monitor

MODEL OR CATALOG NO. 5480

Points*	Factor	Specifications
17.8	Cost	$995
15.9	Power required	115V, 50/60 Hz, 40 watts
21.6	Volume (m^3)	0.006
20.3	Weight (kg)	4.8
10.3	Complexity of use	from user survey
15.3	Reliability	from user survey
101.2		

USER REFERENCES

(1) 6 mo Henry S. Kingdon 919/966-1540
University of North Carolina
Department of Medicine
Chapel Hill, North Carolina 27514

(2) 2 yr Melvin H. Keyes 419/242-6545
Owens-Illinois
1700 North Westwood
Toledo, Ohio 43666

(3)

*See point system description.

D-121 Code No. 118

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Ultraviolet

VENDOR Gilson Medical Electronics

Middleton, Wisconsin 53562

INSTRUMENT Dual Beam UV Monitor

MODEL OR CATALOG NO. 261

Points*	Factor	Specifications
16.4	Cost	$1,395
18.9	Power required	115/230 V, 50/60 Hz, 20 watts
19.5	Volume (m^3)	0.009
18.6	Weight (kg)	6.8
16.7	Complexity of use	from user survey
13.8	Reliability	from user survey
103.9		

USER REFERENCES

(1) 4 mo Dr. Roy Emery 517/355-8432
Michigan State University
Department of Dairy Science
East Lansing, Michigan 48842

(2) 2 mo Louis Adams 513/872-4701
University of Cincinnati
Division of Immunology
Medical Sciences Building
Cincinnati, Ohio 45267

(3)

*See point system description.

D-122 Code No. 119

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Visible

VENDOR Gelman Instrument Co.

Ann Arbor, Michigan 48106

INSTRUMENT Digiscreen-M

MODEL OR CATALOG NO. 39410

Points*	Factor	Specifications
13.7	Cost	$2,800
12.1	Power required	115V, 50/60 Hz, 120 watts
13.3	Volume (m^3)	0.041
13.1	Weight (kg)	27.2
14.8	Complexity of use	from user survey
16.7	Reliability	from user survey
83.7		

USER REFERENCES

(1) 2-1/2 yr Community Medical Laboratory 301/662-3860
801 Toll House Avenue
Frederick, Maryland 21701

(2) 6 mo Loudown Memorial Hospital 703/777-3300, Ext. 2685
Northern Virginia Commonwealth College
Route 7
Leesburg, Virginia 22075

(3)

*See point system description.

D-123 Code No. 120

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Electrometric/Potentiometry

VENDOR Environmental Sciences Associates, Inc.

Burlington, Massachusetts 01803

INSTRUMENT Single-Cell Anodic Stripping Voltammeter

MODEL OR CATALOG NO. SA-2011

Points*	Factor	Specifications
14.2	Cost	$2,450
18.9	Power required	110V, 60 Hz, 20 watts
17.1	Volume (m^3)	0.015
25.6	Weight (kg)	1.9
16.1	Complexity of use	from user survey
17.9	Reliability	from user survey
109.8		

USER REFERENCES

(1) 2-1/2 yr Steven Abbe 609/964-4000
Campbell Soup Co.
Campbell Place
Camden, New Jersey 08101

(2) 1-1/2 yr D. F. Craston 212/MU4-1600, Ext. 226
Chief Medical Examiner
New York City
New York University, Medical Center
520 First Avenue
(3) New York, New York 10016

*See point system description.

D-124 Code No. 121

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Radiometric/X-Ray Fluorescence

VENDOR DuPont Co., Instrument Products Division

Wilmington, Delaware 19898

INSTRUMENT Electron Spectrometer

MODEL OR CATALOG NO. 650

Points*	Factor	Specifications
6.5	Cost	$57,000
5.4	Power required	115V, 50/60 Hz, 3000 watts
6.3	Volume (m^3)	0.819
7.7	Weight (kg)	226.8
12.9	Complexity of use	from user survey
10.4	Reliability	from user survey
49.2		

USER REFERENCES

(1) 3 mo Richard W. Lauver 216/433-4000, Ext. 6174
NASA/Lewis Research Center
21000 Brookpark Road
Cleveland, Ohio 44135

(2) 4 mo Merle M. Millard 415/486-3496
USDA-ARS-WRRL
800 Buchannan Street
Berkeley, California 94710

(3)

*See point system description.

D-125 Code No. 122

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Enzymatically Based/ATP Photometry

VENDOR DuPont Co., Instrument Products Div.

Wilmington, Delaware 19898

INSTRUMENT Luminescence Biometer

MODEL OR CATALOG NO. 760

Points*	Factor	Specifications
11.6	Cost	$5,490
18.1	Power required	105-130 V, 50/60 Hz, 24 watts
14.5	Volume (m^3)	0.029
16.7	Weight (kg)	10.4
11.3	Complexity of use	from user survey
18.6	Reliability	from user survey
90.8		

USER REFERENCES

(1) 2 yr Dept. of Dairy Science 301/454-3928
University of Maryland
Animal Science Center
College Park, Maryland 20742

(2) 3-1/2 yr Hoffmann-LaRoche 201/475-5381
Sarepta Road
Belvidere, New Jersey 07823

(3)

*See point system description.

D-126 Code No. 123

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Enzymatically Based/Chromogenic

VENDOR Gilford Instrument Labs, Inc.

Oberlin, Ohio 44074

INSTRUMENT Dual Reagent Analyzer System

MODEL OR CATALOG NO. 3402

Points*	Factor	Specifications
9.3	Cost	$13,045
9.2	Power required	120V, 60 Hz, 351 watts
10.2	Volume (m^3)	0.118
9.6	Weight (kg)	95.7
21.0	Complexity of use	from user survey
12.6	Reliability	from user survey
71.9		

USER REFERENCES

(1) 3 yr

Department of Laboratory Medicine 513/369-2280
The Christ Hospital
2139 Auburn Avenue
Cincinnati, Ohio 45219

(2) 8 mo

H. Roger Barksdale 317/783-8240
St. Francis Hospital
1600 Albany
Beech Grove, Indiana 46107

(3)

*See point system description.

D-127 Code No. 124

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Radiometric/Direct Radiation Counting

VENDOR Picker Corp.

Cincinnati, Ohio 45246

INSTRUMENT Spectroscaler 4

MODEL OR CATALOG NO. 628-436

Points*	Factor	Specifications
13.9	Cost	$2,695
14.4	Power required	105-125 V, 50/60 Hz, 60 watts
16.4	Volume (m^3)	0.018
15.7	Weight (kg)	13.2
18.4	Complexity of use	from user survey
16.6	Reliability	from user survey
95.4		

USER REFERENCES

(1) 3 mo Steven G. Gerdes 614/422-7651
The Ohio State University Hospital
410 West 10th, Room N154
Nuclear Medicine
Columbus, Ohio 43210

(2) George S. Callendine, Jr.
Consulting Radiologic Physicist
931 Chatham Lane
Columbus, Ohio 43221

(3)

*See point system description.

D-128 Code No. 125

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Radiometric/Beta Imaging

VENDOR Baird-Atomic
Bedford, Massachusetts

INSTRUMENT Beta Camera

MODEL OR CATALOG NO. 986-000

Points*	Factor	Specifications
8.3	Cost	$20,500
8.4	Power required	115V, 60 Hz, (est.) 500 watts
5.5	Volume (m^3)	1.444
9.7	Weight (kg)	90.7
17.6	Complexity of use	from user survey
17.1	Reliability	from user survey
66.6		

USER REFERENCES

(1) 8 yr
Dr. Geno Marco 919/292-7100, Ext. 2532
Ciba-Geiby Corp.
P. O. Box 11422
Wing Road
Greensboro, North Carolina 27409

(2) 2 mo
Dr. Louis Malspeis 614/888-7175
The Ohio State University
500 West 12th Avenue
Columbus, Ohio 43210

(3) 4 yr
M. L. Sutherland 314/694-5033
Monsanto Agricultural Co.
800 North Lindbergh Blvd.
St. Louis, Missouti 63166

*See point system description.

D-129 Code No. 126

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Radiometric/Gamma Spectrometry

VENDOR Bio-Dynamics, Inc.

Indianapolis, Indiana 46250

INSTRUMENT THYROTEK

MODEL OR CATALOG NO. 0350

Points*	Factor	Specifications
16.1	Cost	$1,495
18.9	Power required	110V, 50/60 Hz, 20 watts
15.6	Volume (m^3)	0.022
16.7	Weight (kg)	10.4
13.4	Complexity of use	from user survey
14.2	Reliability	from user survey
94.9		

USER REFERENCES

(1) 6 mo Drs. Briggs and Russell 615/546-6852
1928 Alcoa Highway, Suite 307
Knoxville, Tennessee 37920

(2) 3 mo Ciro S. Tarta, M.D. 201/523-0521
220 Hamburg Turnpike
Wayne, New Jersey 07470

(3)

*See point system description.

D-130 Code No. 127

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Radiometric/Gamma Spectrometer

VENDOR Raytheon Co., Medical Electronics

Waltham, Massachusetts 02154

INSTRUMENT Sigma 2 Spectrometer

MODEL OR CATALOG NO. 210

Points*	Factor	Specifications
13.6	Cost	$2,875
15.9	Power required	117/235 V ± 10%, 60 Hz, 40 watts
17.4	Volume (m^3)	0.014
18.9	Weight (kg)	6.3
21.8	Complexity of use	from user survey
19.6	Reliability	from user survey
107.2		

USER REFERENCES

(1) 2 yr Darrell Miller, R.T.C.T. 216/264-4112, Ext. 221
Wooster Community Hospital
1761 Beall Avenue
Wooster, Ohio 44691

(2) 2 yr Joseph Huffman 216/494-6820
North Canton Medical Center
6046 Whipple Avenue
North Canton, Ohio 44720

(3)

*See point system description.

D-131 Code No. 128

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Radiometric/Scintillation Counting

VENDOR The Nucleus, Inc.

Oak Ridge, Tennessee 37830

INSTRUMENT Nuclear Analyzer

MODEL OR CATALOG NO. 1100

Points*	Factor	Specifications
15.4	Cost	$1,790
17.1	Power required	115/230 V, 50/60 Hz, 30 watts
15.6	Volume (m^3)	0.022
17.7	Weight (kg)	8.2
18.0	Complexity of use	from user survey
15.0	Reliability	from user survey
98.8		

USER REFERENCES

(1) 2 mo Norman D. Reed 406/994-4130
Montana State University
Microbiology
Bozeman, Montana 59715

(2) Joanna Schaefer
Diagnostics, Inc.
1618 Third Avenue North
Birmingham, Alabama 35203

(3)

*See point system description.

D-132 Code No. 129

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE: Radiometric/Scintillation Counting

VENDOR: Picker Corp.
Cincinnati, Ohio 45246

INSTRUMENT: Isotope Calibrator

MODEL OR CATALOG NO. 632-507

Points*	Factor	Specifications
14.1	Cost	$2,495
17.4	Power required	115V ± 10%, 60 Hz, 28 watts
13.7	Volume (m^3)	0.037
13.9	Weight (kg)	21.8
16.8	Complexity of use	from user survey
17.3	Reliability	from user survey
93.2		

USER REFERENCES

(1) 3 yr
James K. Green, R.T. NMT 513/271-8800, Ext. 277
Sister Mary Norbert Morgan
Our Lady of Mercy Hospital
Rowan Hills Drive
Cincinnati, Ohio 45227

(2) 8 mo
Children's Medical Center 513/461-4790
Department of Radiology
1735 Chapel Street
Dayton, Ohio 45404

(3)
George W. Callendine, Jr.
Consulting Radiologic Physicist
931 Chatham Lane
Columbus, Ohio 43221

*See point system description.

D-133 Code No. 130

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Radiometric/Scintillation Counting

VENDOR Beckman Instruments, Inc.

Irvine, California 92664

INSTRUMENT Liquid Scintillation System

MODEL OR CATALOG NO. LS-150

Points*	Factor	Specifications
9.3	Cost	$13,500
8.4	Power required	115V, 50/60 Hz, 520 watts
6.5	Volume (m^3)	0.706
7.4	Weight (kg)	270.0
22.8	Complexity of use	from user survey
17.9	Reliability	from user survey
72.3		

USER REFERENCES

(1) 8 mo

Nancy Hughes 614/422-2726
The Ohio State University
410 West 10th, Room N622
Columbus, Ohio 43210

(2) 4 yr

Ronald T. Borchardt 913/864-3427
University of Kansas
Department of Biochemistry
Lawrence, Kansas 66044

(3) 7 yr

Dr. W. W. Leavitt 513/872-5155
University of Cincinnati
College of Medicine
Department of Physiology
Cincinnati, Ohio 45267

*See point system description.

D-134 Code No. 131

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Radiometric/Direct Radiation Counting

VENDOR Baird-Atomic

Bedford, Massachusetts

INSTRUMENT Laboratory Monitor

MODEL OR CATALOG NO. 904-443

Points*	Factor	Specifications
19.8	Cost	$650
22.5	Power required	110V, 60 Hz, 10 watts
17.8	Volume (m^3)	0.013
17.3	Weight (kg)	(est.) 9.1
19.5	Complexity of use	} from user survey
14.7	Reliability	
111.6		

USER REFERENCES

(1) 5 yr Atomic Energy of Canada Ltd. 613/687-5581
Chalk River Nuclear Laboratories
Chalk River, Ontario KOJ 1J0

(2) 1 mo R. Gowe 617/762-1910, Ext. 320
Department of Nuclear Medicine
Norwood Hospital
800 Washington Street
Norwood, Massachusetts 02062

(3)

*See point system description.

D-135 **Code No.** 132

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Radiometric/Gamma Spectrometry

VENDOR Vangard Systems, Inc.

North Haven, Connecticut 06473

INSTRUMENT TLC Radiochromatogram Plate Scanner

MODEL OR CATALOG NO. 930

Points*	Factor	Specifications
12.5	Cost	$4,095
12.6	Power required	250V, 60 Hz, 100 watts
16.0	Volume (m^3)	0.020
15.3	Weight (kg)	(est.) 14.9
20.3	Complexity of use	from user survey
16.7	Reliability	from user survey
93.4		

USER REFERENCES

(1) 15 mo

Dr. Richard Ferrari 518/465-6251
Sterling-Winthrop Research Institute
Columbia Turnpike
Rensselaer, New York 12144

(2) 1 yr

Stanley Ulrek 212/367-7879
VA Hospital
130 West Kingsbridge Road
Bronx, New York 10468

(3)

*See point system description.

D-136 **Code No.** 133

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photography

VENDOR Charles A. Hulcher Co., Inc.

Hampton, Virginia 23361

INSTRUMENT 70 mm Sequence Camera

MODEL OR CATALOG NO. 123 with single-frame pulse

Points*	Factor	Specifications
14.3	Cost	$2,375
12.1	Power required	24-28 VDC, 120-70 watts
20.1	Volume (m^3)	0.008
21.3	Weight (kg)	3.9
20.5	Complexity of use	from user survey
24.6	Reliability	from user survey
112.9		

USER REFERENCES

(1) 1 yr

Gerald H. Bleedon 503/688-9483
W.A.C. Corp. Inc.
Rt. 1, Box 740
Eugene, Oregon 97402

(2) 15 yr

Henry DeWolf 716/482-5564
Aerial Surveys
106 Silverdale Drive
Rochester, New York 14609

(3)

*See point system description.

D-137 Code No. 134

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Microcalorimetry

VENDOR LKB Instruments Inc.

Rockville, Maryland 20852

INSTRUMENT Batch Microcalorimeter System

MODEL OR CATALOG NO. 2107-010

Points*	Factor	Specifications
9.3	Cost	$13,200
12.6	Power required	115/220 V ± 5%, 50/60 Hz, 100 watts
7.2	Volume (m^3)	0.484
9.7	Weight (kg)	93.0
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
58.8		

USER REFERENCES

(1) User list not received

(2)

(3)

*See point system description.

D-138 Code No. 135

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Microcalorimetry

VENDOR LKB Instruments, Inc.

Rockville, Maryland 20852

INSTRUMENT Sorption Microcalorimeter System

MODEL OR CATALOG NO. 2107-030

Points*	Factor	Specifications
9.3	Cost	$13,400
12.6	Power required	220V $\pm$ 5%, 50 Hz, 100 watts
8.2	Volume (m^3)	0.280
10.1	Weight (kg)	79.0
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
60.2		

USER REFERENCES

(1) New instrument - no users available

(2)

(3)

*See point system description.

D-139 Code No. 136

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Visible

VENDOR United Detector Technology, Inc.

Santa Monica, California 90405

INSTRUMENT Photometer/Radiometer

MODEL OR CATALOG NO. 11A

Points*	Factor	Specifications
17.4	Cost	$1,095
23.8	Power required	115/230 V, 50/60 Hz, 8 watts
21.5	Volume (m^3)	0.006
23.4	Weight (kg)	2.7
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
106.1		

USER REFERENCES

(1) No user list received

(2)

(3)

*See point system description.

D-140 Code No. 137

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Electrometric/Coulometry

VENDOR Orion Research, Inc.

Cambridge, Massachusetts 02139

INSTRUMENT 801A Research Digital Ionanalyzer

MODEL OR CATALOG NO. 080110

Points*	Factor	Specifications
16.8	Cost	$1,250
15.9	Power required	100-240 V, 50/60 Hz, 40 watts
16.2	Volume (m^3)	0.019
19.6	Weight (kg)	5.5
13.3	Complexity of use	from user survey
16.1	Reliability	from user survey
97.9		

USER REFERENCES

(1) 4 mo

Jack P. Fletcher 304/747-4133
Union Carbide Corporation
P. O. Box 8361
South Charleston, West Virginia 25303

(2) 6 mo

Dr. Michael J. Smith 513/426-6650, Ext. 669
Wright State University 873-2648 (after 4/28/75)
Department of Chemistry
Dayton. Ohio 45431

(3)

*See point system description.

D-141 Code No. 138

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Enzymatic/Chromogenic

VENDOR Gilford Instrument Labs, Inc.

Oberlin, Ohio 44074

INSTRUMENT Auto-Stat Analyzer

MODEL OR CATALOG NO. 3002-S

Points*	Factor	Specifications
11.1	Cost	$6,495
9.1	Power required	120V, 60 Hz, 378 watts
10.0	Volume (m^3)	0.127
10.3	Weight (kg)	72.6
14.4	Complexity of use	from user survey
14.8	Reliability	from user survey
69.7		

USER REFERENCES

(1) 2 mo C. Stephens, M.D. 606/292-3191
St. Luke Hospital
85 North Grand
Ft. Thomas, Kentucky 41075

(2) 3 mo Clayton McAvoy, M.T. 503/889-5331, Ext. 32
Holy Rosary Hospital Laboratory
351 SW 9th Street
Ontario, Oregon 97914

(3)

*See point system description.

Code No. 139

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Multiparameter Cell Analysis

VENDOR Technicon Instruments Corp.

Tarrytown, New York 10591

INSTRUMENT Autocounter Module

MODEL OR CATALOG NO. 139-A004-01

Points*	Factor	Specifications
11.8	Cost	$5,225
10.0	Power required	117V ± 5%, 60 Hz, 250 watts
13.1	Volume (m^3)	0.044
12.9	Weight (kg)	29.5
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
67.8		

USER REFERENCES

(1) User list not received

(2)

(3)

*See point system description.

D-143 Code No. 140

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Multiparameter Cell Analysis

VENDOR Technicon Instruments Corp.

Tarrytown, New York 10591

INSTRUMENT Automated Hematology Analyzer

MODEL OR CATALOG NO. Hemalog 8

Points*	Factor	Specifications
6.4	Cost	$59,000
5.8	Power required	105-125 V, 60 Hz, 2300 watts
4.8	Volume (m^3)	2.416
6.0	Weight (kg)	635.0
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
43.0		

USER REFERENCES

(1) User list not received

(2)

(3)

*See point system description.

D-144 Code No. 141

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Light Microscopy

VENDOR Carl Zeiss, Inc.

New York, New York 10018

INSTRUMENT Universal Microscope

MODEL OR CATALOG NO. (none)

Points*	Factor	Specifications
10.6	Cost	$8,000
10.6	Power required	115V, 60 Hz, 200 watts
13.4	Volume (m^3)	0.040
14.5	Weight (kg)	18.1
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
69.1		

USER REFERENCES

(1) User list not received

(2)

(3)

*See point system description.

D-145 **Code No.** 142

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Ultraviolet

VENDOR Carl Zeiss, Inc.

New York, New York 10018

INSTRUMENT Photometer

MODEL OR CATALOG NO. PMQ-3

Points*	Factor	Specifications
10.6	Cost	$7,950
9.2	Power required	115V, 60 Hz, 350 watts
10.8	Volume (m^3)	0.094
11.6	Weight (kg)	45.4
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
62.2		

USER REFERENCES

(1) User list not received

(2)

(3)

*See point system description.

 Code No. 143

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Visible

VENDOR Carl Zeiss, Inc.

New York, New York 10018

INSTRUMENT Digital Photometer Indicator

MODEL OR CATALOG NO. 93 00 38

Points*	Factor	Specifications
15.1	Cost	$1,920
15.0	Power required	115/230 V ± 10%, 50/60 Hz, 50 watts
17.1	Volume (m^3)	0.015
17.2	Weight (kg)	8.2
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
84.4		

USER REFERENCES

(1) User list not received

(2)

(3)

*See point system description.

D-147 Code No. 144

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Refraction/Polarimetry

VENDOR Carl Zeiss, Inc.

New York, New York 10018

INSTRUMENT Circle Polarimeter 0.05°

MODEL OR CATALOG NO. 55 01 97

Points*	Factor	Specifications
16.8	Cost	$1,255
15.9	Power required	110V, 50/60 Hz, 40 watts
16.4	Volume (m^3)	0.018
20.7	Weight (kg)	4.4
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
89.8		

USER REFERENCES

(1) User list not received

(2)

(3)

*See point system description.

D-148 Code No. 145

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Light Microscopy

VENDOR Carl Zeiss, Inc.

New York, New York 10018

INSTRUMENT Axiomat Microscope System

MODEL OR CATALOG NO. UTC

Points*	Factor	Specifications
7.1	Cost	$40,000
7.5	Power required	115V, 60 Hz, 800 watts
7.8	Volume (m^3)	0.343
8.6	Weight (kg)	147.4
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
51.0		

USER REFERENCES

(1) User survey not completed

(2)

(3)

*See point system description.

D-149 Code No. 146

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Ultraviolet

VENDOR Tracor Instruments

Austin, Texas 78721

INSTRUMENT 800D Tunable Absorption Detector

MODEL OR CATALOG NO. 58100

Points*	Factor	Specifications
12.6	Cost	$4,000
20.3	Power required	115V, 50/60 Hz, (est.)15 watts
13.4	Volume (m^3)	0.040
14.5	Weight (kg)	18.1 (est.)
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
80.8		

USER REFERENCES

(1) No user list received

(2)

(3)

*See point system description.

D-150 Code No. 147

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Refraction/Light Scattering

VENDOR The Virtis Company

Gardiner, New York

INSTRUMENT Brice-Phoenix Light Scattering Photometer

MODEL OR CATALOG NO. BP-2000

Points*	Factor	Specifications
12.7	Cost	$3,870
10.9	Power required	115V, 60 Hz, 180 watts
14.2	Volume (m^3)	0.031
9.6	Weight (kg)	94.3 (est.)
17.0	Complexity of use	from user survey
15.2	Reliability	from user survey
79.6		

USER REFERENCES

(1) 15 yr

J. Kratohvil 315/268-2353
Clarkson College of Technology
Department of Chemistry
Clarkson College of Technology
Potsdam, New York 13676

(2) 8 yr

R. J. Fiel 716/592-2834
Roswell Park Memorial Institute
Springville Laboratories
Springville, New York 14141

(3) 1 yr

Dr. Neil Wotherspoon 212/650-6615
Mt. Sinai School of Medicine
Environmental Sciences Laboratory
New York, New York 10029

*See point system description.

D-151 Code No. 148

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Refraction/Light Scattering

VENDOR C. N. Wood Mfg. Co.

Newtown, Pennsylvania

INSTRUMENT Monophotometer

MODEL OR CATALOG NO. 5000 with DM 300 and BCD output

Points*	Factor	Specifications
12.8	Cost	$3,760
11.4	Power required	115V, 50/60 Hz, 150 watts
10.5	Volume (m^3)	0.107
12.0	Weight (kg)	39.5
14.7	Complexity of use	from user survey
19.2	Reliability	from user survey
80.6		

USER REFERENCES

(1) 2 yr
Gilbert F. Pollnow, Ph.D. 414/424-1480
University of Wisconsin-Oshkosh
Department of Chemistry
800 Algoma Blvd.
Oshkosh, Wisconsin 54901

(2) 10 yr
Larry Pillepich 517/636-1547
Dow Chemical Co.
743 Building
Midland, Michigan 48640

(3) 1 yr
Theodore T. Herskovits 212/933-2233
Fordham University
Bronx, New York 10458

*See point system description.

D-152 Code No. 149

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Visible

VENDOR Gamma Scientific, Inc.

San Diego, California

INSTRUMENT Digital Photometer/Radiometer

MODEL OR CATALOG NO. 820 with 820-16C head

Points*	Factor	Specifications
16.1	Cost	$1,475
23.1	Power required	110/220 V, 50/60 Hz, 9 watts
19.5	Volume (m^3)	0.009
21.8	Weight (kg)	3.6
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
100.5		

USER REFERENCES

(1) 1 yr A. E. Froluvek 513/977-7050
Measurement & Control Section
Procter & Gamble
6300 Center Hill Road
Cincinnati, Ohio 45224

(2)

(3)

*See point system description.

D-153 Code No. 150

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Ultraviolet

VENDOR Varian

Palo Alto, California

INSTRUMENT 635M UV-Vis Spectrophotometer

MODEL OR CATALOG NO. 00-100056-01

Points*	Factor	Specifications
11.2	Cost	$6,345
10.6	Power required	110/115/220/240 V, 50/60 Hz, 200 watts
10.8	Volume (m^3)	0.096
12.4	Weight (kg)	34.0
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
65.0		

USER REFERENCES

(1) 6 mo Richard Lauver 216/433-4000
NASA/Lewis Research Center
21000 Brookpark Road
Cleveland, Ohio 44135

(2)

(3)

*See point system description.

D-154 Code No. 151

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Ultraviolet

VENDOR Searle Analytic, Inc., Buchler Instrument Div.
Fort Lee, New Jersey

INSTRUMENT Fracto-Scan

MODEL OR CATALOG NO. 3-5100

Points*	Factor	Specifications
15.9	Cost	$1,550
15.0	Power required	110-115 V, 50/60 Hz, 50 watts
19.0	Volume (m^3)	0.010
17.7	Weight (kg)	8.2
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
87.6		

USER REFERENCES

(1) 1 mo Robert T. Cook 216/368-2695
Case Western Reserve University
2085 Adelbert Rd.
Cleveland, Ohio 44106

(2)

(3)

*See point system description.

D-155 Code No. 152

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Ultraviolet

VENDOR Micromedic Systems, Inc.

Philadelphia, Pennsylvania

INSTRUMENT Spectrophotometer

MODEL OR CATALOG NO. MS-2

Points*	Factor	Specifications
11.5	Cost	$5,795
8.0	Power required	115/230 V $\pm$ 10%, 50/60 Hz, 625 watts
10.5	Volume (m^3)	0.108
11.7	Weight (kg)	42.6
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
61.7		

USER REFERENCES

(1) 2 mo Dr. A. Pollard 416/596-4459
University of Toronto
550 University Avenue
Mt. Sinai Hospital
Toronto, Ontario, Canada

(2)

(3)

*See point system description.

D-156 Code No. 153

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Ultraviolet

VENDOR LKB Instruments, Inc.

Rockville, Maryland

INSTRUMENT Uvicord I UV Absorptiometer

MODEL OR CATALOG NO. 4700 A-1

Points*	Factor	Specifications
16.2	Cost	$1,435
14.1	Power required	110/220 V, 60 Hz, 65 watts
16.4	Volume (m^3)	0.018
16.9	Weight (kg)	10.0
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
83.6		

USER REFERENCES

(1) 15 yr Dr. M. D. Poulik 313/549-7000, Ext. 245
William Beaumont Hospital
Royal Oak, Michigan 48072

(2)

(3)

*See point system description.

D-157 Code No. 154

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Ultraviolet

VENDOR GCA/McPherson Instrument

Acton, Massachusetts

INSTRUMENT UV Visible Spectrophotometer (single-beam)

MODEL OR CATALOG NO. EU-701-D

Points*	Factor	Specifications
11.4	Cost	$5,800
8.9	Power required	115/230 V, 50/60 Hz, 400 watts
10.4	Volume (m^3)	0.109
10.0	Weight (kg)	81.6
19.0	Complexity of use	from user survey
19.3	Reliability	from user survey
79.0		

USER REFERENCES

(1) 3 yr D. A. Fischman 312/753-2701
University of Chicago
1103 East 57gh Street
Chicago, Illinois 60637

(2) 1 yr Sarah C.R. Elgin
Harvard University
The Biological Laboratories
16 Divinity Avenue
Cambridge, Massachusetts 02138

(3)

*See point system description.

D-158 Code No. 155

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Ultraviolet

VENDOR GCA/McPherson Instrument

Acton, Massachusetts

INSTRUMENT UV Visible Ratio Recording Spectrophotometer (double-beam)

MODEL OR CATALOG NO. EU-707-D

Points*	**Factor**	**Specifications**
10.9	Cost	$ 6,975
8.9	Power required	115/230 V, 50/60 Hz, 400 watts
10.2	Volume (m^3)	0.317
9.4	Weight (kg)	104.3
10.0	Complexity of use	} from user survey
10.0	Reliability	
59.4		

USER REFERENCES

(1) 1 mo Charles E. Elson 608/262-2727
University of Wisconsin
1270 Linden Drive
Madison, Wisconsin 53706

(2)

(3)

*See point system description.

D-159 Code No. 156

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Ultraviolet

VENDOR DuPont Co., Instrument Products Div.

Wilmington, Delaware

INSTRUMENT Split-Beam Photometric Analyzer

MODEL OR CATALOG NO. 400

Points*	Factor	Specifications
12.0	Cost	$4,750
9.3	Power required	95-130 V, 60 Hz, 345 watts
9.8	Volume (m^3)	0.142
9.2	Weight (kg)	113.4
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
60.3		

USER REFERENCES

(1) 11 yr William H. Wagner 304/747-5352
Union Carbide Corporation
P. O. Box 8361
South Charleston, West Virginia 25303

(2)

(3)

*See point system description.

D-160 Code No. 157

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Ultraviolet

VENDOR Bio-Dynamics, Inc.

Indianapolis, Indiana

INSTRUMENT DIGITEK

MODEL OR CATALOG NO. 0900

Points*	Factor	Specifications
16.1	Cost	$1,495
17.7	Power required	100-120 V ± 12%, 50/60 Hz, 55-24 watts
16.6	Volume (m^3)	0.017
21.0	Weight (kg)	4.2
10.0	Complexity of use	} from user survey
10.0	Reliability	
91.4		

USER REFERENCES

(1) 4 mo Gary A. Nelson, M.D. 601/924-7994
University of Mississippi
418 Clinton Blvd.
Clinton, Mississippi 39056

(2)

(3)

*See point system description.

D-161 Code No. 158

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Ultraviolet

VENDOR Gilford Instrument Labs Inc.

Oberlin, Ohio

INSTRUMENT Spectrophotometer

MODEL OR CATALOG NO. 250

Points*	Factor	Specifications
11.2	Cost	$6,250
10.4	Power required	105-125 V, 50/60 Hz, 218 watts
11.2	Volume (m^3)	0.083
10.4	Weight (kg)	68.5
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
63.2		

USER REFERENCES

(1) 2 mo Amadeo J. Pesce 513/872-5371
University of Cincinnati
College of Medicine
Bethesda Avenue
Cincinnati, Ohio 45267

(2)

(3)

*See point system description.

D-162 Code No. 159

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Visible

VENDOR E-C Apparatus Corp.

St. Petersburg, Florida

INSTRUMENT Transmission Densitometer

MODEL OR CATALOG NO. EC 910

Points*	Factor	Specifications
16.4	Cost	$1,385
16.8	Power required	110/220 V, 50/60 Hz, 32 watts
13.2	Volume (m^3)	0.042
16.0	Weight (kg)	12.2
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
82.4		

USER REFERENCES

(1) 2 yr C. E. Dasch 614/826-8221
Muskingum College
New Concord, Ohio 43762

(2)

(3)

*See point system description.

D-163 Code No. 160

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Visible

VENDOR Glenco Scientific Inc.

Houston, Texas

INSTRUMENT Concentration Colorimeter

MODEL OR CATALOG NO. 53 A-FC

Points*	Factor	Specifications
23.0	Cost	$355
25.6	Power required	115V, 50/60 Hz, 6 watts
33.7	Volume (m^3)	0.001
27.6	Weight (kg)	1.4
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
129.9		

USER REFERENCES

(1) 9 mo

Phil Sulser 305/578-2598
Cordis Corp.
Laboratory Division
P. O. Box 370428
Miami, Florida 33137

(2)

(3)

*See point system description.

D-164 Code No. 161

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Visible

VENDOR Bausch & Lomb, Analytical Systems Div.

Rochester, New York

INSTRUMENT Spectronic 70 Spectrophotometer

MODEL OR CATALOG NO. 33-30-41

Points*	Factor	Specifications
17.1	Cost	$1,155
13.0	Power required	115/220 V, 50/60 Hz, 90 watts
13.6	Volume (m^3)	0.038
15.0	Weight (kg)	15.9
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
78.7		

USER REFERENCES

(1) 5 yr Paul M. Guter 412/537-5551
Teledyne-Vasco
P. O. Box 151
Latrobe, Pennsylvania 15650

(2)

(3)

*See point system description.

D-165 Code No. 162

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Visible

VENDOR Bausch & Lomb, Analytical Systems Div.

Rochester, New York

INSTRUMENT Spectronic 100 Spectrophotometer

MODEL OR CATALOG NO. 33-30-43

Points*	Factor	Specifications
14.6	Cost	$2,195
12.6	Power required	118V, 50/60 Hz, 100 watts
14.0	Volume (m^3)	0.034
14.7	Weight (kg)	17.2
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
75.9		

USER REFERENCES

(1) 4 yr Marlon Larsen, Ph.D. 503/255-1220, Ext. 222
ICN United Medical Lab, Inc.
Box 3932
Portland, Oregon 97208

(2)

(3)

*See point system description.

D-166 Code No. 163

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Emission/Fluorimetry

VENDOR Baird-Atomic

Bedford, Massachusetts

INSTRUMENT Fluorimet Filter Fluorometer

MODEL OR CATALOG NO. FM-200

Points*	Factor	Specifications
18.8	Cost	$795
9.6	Power required	110V, 60 Hz, 300 watts
16.2	Volume (m^3)	0.019
15.6	Weight (kg)	13.6
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
80.2		

USER REFERENCES

(1) 4 yr Dr. S. G. Schulman 904/392-3370
University of Florida
College of Pharmacy
Box 779
Gainesville, Florida 32610

(2)

(3)

*See point system description.

D-167 Code No. 164

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Refraction/Refractometry

VENDOR Pharmacia Fine Chemicals, Inc.

Piscataway, New Jersey

INSTRUMENT Differential Refractometer

MODEL OR CATALOG NO. 300L

Points*	Factor	Specifications
14.3	Cost	$2,359
19.7	Power required	105-125 V, 60 Hz, 17 watts
17.8	Volume (m^3)	0.013
18.3	Weight (kg)	7.3
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
90.1		

USER REFERENCES

(1) 2 yr C. A. Daniels, M.D., Ph.D. 919/684-2129
Duke University
Department of Pathology
Durham, North Carolina 27710

(2)

(3)

*See point system description.

D-168 Code No. 165

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Refraction/Refractometry

VENDOR Bausch & Lomb, Analytical Systems Div.

Rochester, New York

INSTRUMENT Abbe-3L Refractometer

MODEL OR CATALOG NO. 33-45-71

Points*	Factor	Specifications
16.4	Cost	$1,395
30.4	Power required	115V, 50/60 Hz, 3 watts
17.1	Volume (m^3)	0.015
19.1	Weight (kg)	6.1
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
103.0		

USER REFERENCES

(1) 7 yr

Roger W. Reiman 216/682-0015, Ext. 235
The J. M. Smucker Co.
Strawberry Lane
Orrville, Ohio 44667

(2)

(3)

*See point system description.

D-169 Code No. 166

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Electrometric/Potentiometry

VENDOR Environmental Sciences Assoc. Inc.

Burlington, Massachusetts

INSTRUMENT Multiple Anodic Stripping Analyzer

MODEL OR CATALOG NO. 2014

Points*	Factor	Specifications
11.4	Cost	$5,950
15.9	Power required	110/240 V, 50/60 Hz, 40-30 watts
13.2	Volume (m^3)	0.043
15.7	Weight (kg)	13.2
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
76.2		

USER REFERENCES

(1) 4 yr Nancy A. Shelhorse 804/441-2331
Norfolk Health Lab
401 Colley Avenue
Norfolk, Virginia 23507

(2)

(3)

*See point system description.

D-170 Code No. 167

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Electrometric/Conductimetry

VENDOR Markson Science, Inc.

Del Mar, California

INSTRUMENT Conductivity Analyzer

MODEL OR CATALOG NO. 4402

Points*	Factor	Specifications
22.4	Cost	$398
22.0	Power required	110V, 50/60 Hz, 11 watts
17.8	Volume (m^3)	0.013
23.8	Weight (kg)	2.5
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
106.0		

USER REFERENCES

(1) 8 mo

Dave Brookman 304/296-2554
Borg Warner Chemicals
P. O. Box 816
Morgantown, West Virginia 26505

(2)

(3)

*See point system description.

D-171 Code No. 168

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Electrometric/Conductimetry

VENDOR Micromeritics Instrument Corp.

Norcross, Georgia

INSTRUMENT Electrophoretic Mass-Transport Analyzer

MODEL OR CATALOG NO. 1202

Points*	Factor	Specifications
13.8	Cost	$2, 790
12.6	Power required	115V, 60 Hz, 100 watts
12.6	Volume (m^3)	0.051
13.4	Weight (kg)	25.4
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
72.4		

USER REFERENCES

(1) 4 mo

Prof. F. B. Brien 206/543-2620
University of Washington
Division of Metallurgical Engineering
Roberts Hall
Seattle, Washington 98195

(2)

(3)

*See point system description.

Code No. 169

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Electrometric/Conductimetry

VENDOR Myron L. Co.
Encinitas, California

INSTRUMENT DS Meter

MODEL OR CATALOG NO. EP

Points*	Factor	Specifications
26.5	Cost	$205
50.0	Power required	battery enclosed
33.7	Volume (m^3)	0.001
35.7	Weight (kg)	0.5
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
165.9		

USER REFERENCES

(1) 15 mo

Terry G. Kinner 714/487-3000, Ext. 321
Burroughs Corp.
16701 West Bernard Drive
San Diego, California 92127

(2)

(3)

*See point system description.

D-173 Code No. 170

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Electrometric/Conductimetry

VENDOR Wescan Instruments, Inc.

Santa Clara, California

INSTRUMENT Conductivity Meter

MODEL OR CATALOG NO. 210 with 219-200 cell

Points*	Factor	Specifications
19.0	Cost	$770
22.5	Power required	115V, 50/60 Hz, 10 watts
21.6	Vol (m^3)	0.006
24.1	Wei (kg)	2.4
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
107.2		

USER REFERENCES

(1) 7 mo L. N. Lightfoot 608/262-69 4 or 262- 8
University of Wisconsin
3018 Chemical Engineering Bldg.
Madison, Wisconsin 53706

(2)

(3)

*See point system description.

D-174 Code No. 171

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Radiometric/Direct Radiation Counting

VENDOR Picker Corp.

Cincinnati, Ohio

INSTRUMENT Labmonitor

MODEL OR CATALOG NO. 642-081

Points*	Factor	Specifications
21.7	Cost	$450
17.4	Power required	115V ± 10%, 60 Hz, 28 watts
14.1	Volume (m^3)	0.033
19.2	Weight (kg)	5.9
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
92.4		

USER REFERENCES

(1) 2-1/2 yr L. D. McCreary 513/562-9508
Procter and Gamble Co.
Box 39175
Cincinnati, Ohio 45239

(2)

(3)

*See point system description.

D-175 Code No. 172

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Radiometric/Gamma Spectrometry

VENDOR The Nucleus Inc.

Oak Ridge, Tennessee

INSTRUMENT Clinical Spectrometer

MODEL OR CATALOG NO. 1000

Points*	Factor	Specifications
15.0	Cost	$1,990
14.4	Power required	115V, 50/60 Hz, 60 watts
15.8	Volume (m^3)	0.021
13.9	Weight (kg)	21.8
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
79.1		

USER REFERENCES

(1) 1 yr Allen M. Webb 615/482-4939
Clinical Laboratory Associates
145 East Vance Road
Oak Ridge, Tennessee 37830

(2)

(3)

*See point system description.

D-176 Code No. 173

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Electrometric/Conductimetry

VENDOR Amstro Corp.

Hackettstown, New Jersey

INSTRUMENT Dissolved Solids Meter

MODEL OR CATALOG NO. DS-1

Points*	Factor	Specifications
26.7	Cost	$198
50.0	Power required	battery enclosed
33.7	Volume (m^3)	0.001
40.5	Weight (kg)	0.3
10.0	Complexicy of use	from user survey
10.0	Reliability	from user survey
170.9		

USER REFERENCES

(1) 5 mo

Mike Hrivnak 216/581-3000
Cleveland Cap Screw
4444 Lee Road
Cleveland, Ohio

(2)

(3)

*See point system description.

D-177 Code No. 174

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Pattern Recognition Compı (Image Analyzer)

VENDOR Carl Zeiss, Inc.

New York, New York 10018

INSTRUMENT Micro-Videomat

MODEL OR CATALOG NO. 47 76 00

Points*	Factor	Specifications
7.3	Cost	$35,000
7.1	Power required	115V, 60 Hz, 1000 watts
6.4	Volume (m^3)	0.750
9.5	Weight (kg)	99.8
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
50.3		

USER REFERENCES

(1) Users not completed

(2)

(3)

*See point system description.

D-178 Code No. 175

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Refraction/Light Scatter

VENDOR Monitor Technology, Inc.

Redwood City, California

INSTRUMENT Laboratory Turbidimeter

MODEL OR CATALOG NO. 150

Points*	Factor	Specifications
19.6	Cost	$675
17.9	Power required	110V, 60 Hz, 25 watts
19.5	Volume (m^3)	0.009
21.8	Weight (kg)	3.6 (est.)
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
98.8		

USER REFERENCES

(1) No users list

(2)

(3)

*See point system de cription.

D-179 Code No. 176

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Photon Counting

VENDOR Ortec, Inc.

Oak Ridge, Tennessee

INSTRUMENT Photon Counting System

MODEL OR CATALOG NO. 5C1

Points*	Factor	Specifications
11.1	Cost	$6,405
13.6	Power required	115V, 60 Hz, 75 watts
13.3	Volume (m^3)	0.041
14.8	Weight (kg)	16.8
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
72.8		

USER REFERENCES

(1) No user list

(2)

(3)

*See point system description.

D-180 Code No. 177

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Photon Counting

VENDOR Ortec, Inc.

Oak Ridge, Tennessee

INSTRUMENT Photon Counting System

MODEL OR CATALOG NO. (typical system based on 401A/402A NIM-BIN)

Points*	Factor	Specifications
11.8	Cost	$5,145
12.8	Power required	103-129 V, 50-65 Hz, 96 watts
13.1	Volume (m^3)	0.044
12.6	Weight (kg)	31.8
12.7	Complexity of use	from user survey
20.6	Reliability	from user survey
83.6		

USER REFERENCES

(1) 2-1/2 John Kerins 201/757-0500
Medi-Physics, Inc.
900 Durham Avenue
South Plairfield, New Jersey 08830

(2) 5 yr D. Charleston 312/947-5056
University of Chicago
950 East 59th Street
Chicago, Illinois 60637

(3) 1 mo Dr. F. A. Grere 312/234-3100
Lake Forest Collete
Lake Forest, Illinois 60045

*See point system description.

D-181 Code No. 178

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Photon Counting

VENDOR Ortec, Inc.

Oak Ridge, Tennessee

INSTRUMENT Photon Counting System

MODEL OR CATALOG NO. (typical system based on 401M/402M NIM-BIN)

Points*	Factor	Specifications
13.2	Cost	$3,290
15.2	Power required	115/230 V, 47-65 Hz, 48 watts
14.4	Volume (m^3)	0.030
13.6	Weight (kg)	23.4
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
76.4		

USER REFERENCES

(1) 3 mo J. C. Widman 313/562-6000, Ext. 444
Veterans Hospital
Nuclear Medicine
Allen Park, Michigan 48101

(2)

(3)

*See point system description.

D-182 Code No. 179

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Radiometric/Scintillation Counting

VENDOR Ortec, Inc.

Oak Ridge, Tennessee

INSTRUMENT Shielded Well Counting System

MODEL OR CATALOG NO. 4801

Points*	Factor	Specifications
11.4	Cost	$5,995
12.6	Power required	110/220 V, 47-65 Hz, 100 watts
10.9	Volume (m^3)	0.092
8.5	Weight (kg)	152.0
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
63.4		

USER REFERENCES

(1) Users not completed

(2)

(3)

*See point system description.

D-183 Code No. 180

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Ultraviolet

VENDOR Altex Scientific, Inc.

Berkeley, California

INSTRUMENT Biochemical UV Monitor

MODEL OR CATALOG NO. 150-00

Points*	Factor	Specifications
17.8	Cost	$995
14.4	Power required	115/230 V, 50/60 Hz, 60 watts
17.8	Volume (m^3)	0.013
18.8	Weight (kg)	6.5 (est.)
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
88.0		

USER REFERENCES

(1) Users not completed

(2)

(3)

*See point system description.

D-184 Code No. 181

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Ultraviolet

VENDOR Altex Scientific

Berkeley, California

INSTRUMENT Analytical UV Detector

MODEL OR CATALOG NO. 153-00

Points*	Factor	Specifications
16.4	Cost	$1,395
14.4	Power required	115/230 V, 50/60 Hz, 60 watts
17.8	Volume (m^3)	0.015
18.8	Weight (kg)	6.5 (est.)
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
87.4		

USER REFERENCES

(1) Users not completed

(2)

(3)

*See point system description.

D-185 Code No. 182

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Ultraviolet

VENDOR International Light, Inc.

Newburyport, Massachusetts

INSTRUMENT Digital Actinic Radiometer

MODEL OR CATALOG NO. IL-730

Points*	Factor	Specifications
16.5	Cost	$1,344
15.0	Power required	115/230 V, 50/60 Hz (or 10-28 VDC), (est.) 50 watts
21.5	Volume (m^3)	0.006
18.6	Weight (kg)	6.8
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
91.6		

USER REFERENCES

(1) Users not completed

(2)

(3)

*See point system description.

D-186 Code No. 183

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Ultraviolet

VENDOR Perkin Elmer Corp.

Norwaik, Connecticut

INSTRUMENT 402 UV/VIS Spectrophotometer

MODEL OR CATALOG NO. 492-0001

Points*	Factor	Specification
10.4	Cost	$8,480
10.0	Power required	115V, 60 Hz, 250 watts
9.8	Volume (m^3)	0.140
10.7	Weight (kg)	62.0
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
60.9		

USER REFERENCES

(1) No users list

(2)

(3)

*See point system description.

D-187 Code No. 184

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE: Photometric/Absorption/Ultraviolet

VENDOR: Rudolph Instruments Engineering Co., Inc.
Little Falls, New Jersey

INSTRUMENT: Photometer

MODEL OR CATALOG NO. 1114

Points*	Factor	Specifications
16.2	Cost	$1,460
15.0	Power required	95-130 V, 60 Hz, (est.) 50 watts
17.1	Volume (m^3)	0.015
17.2	Weight (kg)	9.3
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
85.5		

USER REFERENCES

(1) Users not completed

(2)

(3)

*See point system description.

2-5

D-188 Code No. 185

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Ultraviolet

VENDOR Sargent-Welch Scientific Co.

Cincinnati, Ohio

INSTRUMENT Hitachi 102 Spectrophotometer

MODEL OR CATALOG NO. S-75616-20

Points*	Factor	Specifications
13.5	Cost	$2,990
11.6	Power required	105-125 V, 50/60 Hz, 140 watts
12.4	Volume (m^3)	0.054
13.8	Weight (kg)	22.0
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
71.3		

USER REFERENCES

(1) No users list

(2)

(3)

*See point system description.

D-189 Code No. 186

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Ultraviolet

VENDOR Sargent-Welch Scientific Co.

Cincinnati, Ohio

INSTRUMENT Hitachi 191 Spectrophotometer

MODEL OR CATALOG NO. S-75618-35

Points*	Factor	Specifications
13.1	Cost	$3,350
11.6	Power required	105-125 V, 50/60 Hz, 140 watts
10.9	Volume (m^3)	0.092
12.4	Weight (kg)	34.0
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
68.0		

USER REFERENCES

(1) No users list

(2)

(3)

*See point system description.

D-190 Code No. 187

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Visible

VENDOR Gilford Instrument Labs, Inc.

Oberlin, Ohio

INSTRUMENT Electrophoresis Analyzer

MODEL OR CATALOG NO. 3004

Points*	Factor	Specifications
11.0	Cost	$6,740
9.6	Power required	115/230 V ± 10%, 50/60 Hz, 297 watts
9.8	Volume (m^3)	0.142
9.7	Weight (kg)	90.7
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
60.1		

USER REFERENCES

(1) Users not completed

(2)

(3)

*See point system description.

D-191 Code No. 188

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Visible

VENDOR Artronix Instrumentation

St. Louis, Missouri

INSTRUMENT Isodensitometer

MODEL OR CATALOG NO. 1705

Points*	Factor	Specifications
11.7	Cost	$5,400
15.0	Power required	115/230 V $\pm$ 10%, 50/60 Hz, 50 watts
12.0	Volume (m^3)	0.063
13.7	Weight (kg)	23.2
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
72.4		

USER REFERENCES

(1) No users list

(2)

(3)

*See point system description.

D-192 Code No. 189

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Visible

VENDOR Electro Optical Industries, Inc.

Santa Barbara, California

INSTRUMENT Auto Ranging Photometer

MODEL OR CATALOG NO. A 425 D

Points*	Factor	Specifications
16.1	Cost	$1,500
18.9	Power required	100/115/200/230 V, 50-400 Hz, 20 watts
20.0	Volume (m^3)	0.008
21.8	Weight (kg)	3.6
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
96.8		

USER REFERENCES

(1) No user list

(2)

(3)

*See point system description.

D-193 Code No. 190

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Visible

VENDOR Markson Science, Inc.

Del Mar, California

INSTRUMENT Colorimeter

MODEL OR CATALOG NO. 7452

Points*	Factor	Specifications
31.6	Cost	$100
30.4	Power required	115V, 50/60 Hz (or 6/12 VDC), 3 watts
33.7	Volume (m^3)	0.001
30.8	Weight (kg)	0.9
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
146.5		

USER REFERENCES

(1) Users not completed

(2)

(3)

*See point system description.

D-194 Code No. 191

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Visible

VENDOR G. K. Turner Assoc.

Palo Alto, California

INSTRUMENT Spectrophotometer

MODEL OR CATALOG NO. 350-000

Points*	Factor	Specifications
19.2	Cost	$735
15.0	Power required	100-130 V, 50/60 Hz, 50-30 watts
15.1	Volume (m^3)	0.025
17.7	Weight (kg)	8.2
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
87.0		

USER REFERENCES

(1) No user list

(2)

(3)

*See point system description.

D-195 Code No. 192

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Visible

VENDOR Vactec, Inc.

Maryland Heights, Missouri

INSTRUMENT Portable Photometer

MODEL OR CATALOG NO. 3107 with 3109 probe

Points*	Factor	Specifications
23.0	Cost	$359
21.5	Power required	115V, 50/60 Hz, 12 watts (or internal batteries)
22.6	Volume (m^3)	0.005
25.2	Weight (kg)	2.0
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
112.3		

USER REFERENCES

(1) No user list

(2)

(3)

*See point system description.

D-196 Code No. 193

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Emission/Fluorometry

VENDOR American Instrument Co.

Silver Spring, Maryland

INSTRUMENT Fluoro-Monitor

MODEL OR CATALOG NO. J4-7461

Points*	Factor	Specifications
16.4	Cost	$1,375
12.6	Power required	115V, 60 Hz, 100 watts
18.1	Volume (m^3)	0.012
18.6	Weight (kg)	6.8
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
85.7		

USER REFERENCES

(1) Users not completed

(2)

(3)

*See point system description.

D-197 Code No. 194

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Emission/Fluorometry

VENDOR G. K. Turner Assoc.

Palo Alto, California

INSTRUMENT Spectroflurometer

MODEL OR CATALOG NO. 430-000

Points*	Factor	Specifications
12.6	Cost	$3,990
9.3	Power required	105-130 V, 48-65 Hz, 340 watts
11.8	Volume (m^3)	0.066
12.4	Weight (kg)	34.5
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
66.1		

USER REFERENCES

(1) No user list

(2)

(3)

*See point system description.

D-198 Code No. 195

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Emission/Fluorometry

VENDOR Baird-Atomic

Bedford, Massachusetts

INSTRUMENT Fluoripoint FP-100 Spectrofluorometer

MODEL OR CATALOG NO. 053687

Points*	Factor	Specifications
13.6	Cost	$2,950
6.9	Power required	110V, 60 Hz, 1150 watts
10.6	Volume (m^3)	0.103
10.7	Weight (kg)	61.7
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
61.8		

USER REFERENCES

(1) Users not completed

(2)

(3)

*See point system description.

D-199 Code No. 196

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Electrometric/Conductimetry

VENDOR Beckman Instruments, Inc., Cedar Grove Operations

Cedar Grove, New Jersey

INSTRUMENT Conductivity Bridge

MODEL OR CATALOG NO. RC-18A

Points*	Factor	Specifications
15.0	Cost	$1,971
15.0	Power required	115/230 V, 50/60 Hz, 50 watts
13.8	Volume (m^3)	0.036
15.0	Weight (kg)	15.9
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
78.8		

USER REFERENCES

(1) No user list

(2)

(3)

*See point system description.

D-200 Code No. 197

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Electrometric/Conductimetry

VENDOR Beckman Instruments, Inc., Cedar Grove Operations

Cedar Grove, New Jersey

INSTRUMENT Conductivity Bridge

MODEL OR CATALOG NO. RC-19

Points*	Factor	Specifications
17.6	Cost	$1,053
33.6	Power required	115/230 V, 50/60 Hz, 2 watts (or internal battery)
18.1	Volume (m^3)	0.012
20.6	Weight (kg)	4.5
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
109.9		

USER REFERENCES

(1) No user list

(2)

(3)

*See point system description.

D-201 Code No. 198

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Electrometric/Potentiometry

VENDOR Honeywell, Inc.

Fort Washington, Pennsylvania

INSTRUMENT Conductivity Signal Conditioner

MODEL OR CATALOG NO. 552022

Points*	Factor	Specifications
19.3	Cost	$714
20.3	Power required	100-130 V, 50/60 Hz ± 10%, 15 watts
18.5	Volume (m^3)	0.011
21.8	Weight (kg)	3.6
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
99.9		

USER REFERENCES

(1) Users not completed

(2)

(3)

*See point system description.

D-202 Code No. 199

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photography

VENDOR Nikon, Inc.

Garden City, New York

INSTRUMENT Nikon 35-mm Camera

MODEL OR CATALOG NO. F2 motor-drive camera with 250-exposure back and 55-mm Micro-Nikor PIC lens and ring

Points*	Factor	Specifications
14.6	Cost	$2,167
50.0	Power required	internal battery
25.6	Volume (m^3)	0.003
27.1	Weight (kg)	1.5
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
137.3		

USER REFERENCES

(1) No user list

(2)

(3)

*See point system description.

D-203 Code No. 200

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Electrometric/Potentiometry

VENDOR Brinkmann Instruments

Westbury, New York

INSTRUMENT Metrohm End-Point Titrator

MODEL OR CATALOG NO. E526

Points*	Factor	Specifications
15.3	Cost	$1,830
18.9	Power required	117V, 60 Hz, 20 watts
18.1	Volume (m^3)	0.012
20.8	Weight (kg)	4.3
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
93.1		

USER REFERENCES

(1) No user list

(2)

(3)

*See point system description.

D-204 Code No. 201

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Refraction/Nephelometry

VENDOR Monitor Technology, Inc.

Redwood City, California

INSTRUMENT Slip-Stream Turbidimeter

MODEL OR CATALOG NO. 160/131

Points*	Factor	Specifications
17.8	Cost	$985
17.1	Power required	110/220 V, 50/60 Hz, 30 watts
16.6	Volume (m^3)	0.017
17.3	Weight (kg)	9.1 (est.)
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
88.8		

USER REFERENCES

(1) No user list

(2)

(3)

*See point system description.

D-205 Code No. 202

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Emission/Fluorometry

VENDOR G. K. Turner Assoc.

Palo Alto, California

INSTRUMENT Filter Fluorometer

MODEL OR CATALOG NO. 111-000

Points*	Factor	Specifications
15.5	Cost	$1,735
11.4	Power required	117V, 60 Hz, 150 watts
14.5	Volume (m^3)	0.029
14.6	Weight (kg)	17.7
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
76.0		

USER REFERENCES

(1) No user list

(2)

(3)

*See point system description.

D-206 Code No. 203

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Emission/Fluorometry

VENDOR G. K. Turner Assoc.

Palo Alto, California

INSTRUMENT Spectrofluorometer

MODEL OR CATALOG NO. 210-0000

Points*	Factor	Specifications
7.9	Cost	$25,950
8.1	Power required	118V, 60 Hz, 590 watts
8.4	Volume (m^3)	0.262
8.9	Weight (kg)	136.1
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
53.3		

USER REFERENCES

(1) No user list

(2)

(3)

*See point system description.

D-207 Code No. 204

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Emission/Fluorometry

VENDOR Farrand Optical Co., Inc.

Valhalla, New York

INSTRUMENT Manual Spectrofluorometer

MODEL OR CATALOG NO. 135800

Points*	Factor	Specifications
12.3	Cost	$4,400
8.9	Power required	115V, 50/60 Hz, 403 watts
9.7	Volume (m^3)	0.144
11.1	Weight (kg)	54.0
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
62.0		

USER REFERENCES

(1) No user list

(2)

(3)

*See point system description.

D-208 Code No. 205

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Emission/Fluorometry

VENDOR Farrand Optical Co., Inc.

Valhalla, New York

INSTRUMENT Ratio Fluorometer-2

MODEL OR CATALOG NO. 143370

Points*	Factor	Specifications
14.0	Cost	$2,600
11.0	Power required	115V, 60 Hz, 173 watts
13.7	Volume (m^3)	0.037
14.2	Weight (kg)	19.7
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
72.9		

USER REFERENCES

(1) No user list

(2)

(3)

*See point system description.

D-209 Code No. 206

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Emission/Fluorometry

VENDOR Farrand Optical Co., Inc.

Valhalla, New York

INSTRUMENT MK 1 Spectrofluorometer

MODEL OR CATALOG NO. 129800

Points*	Factor	Specifications
11.2	Cost	$6,300
8.9	Power required	115V, 50/60 Hz, 403 watts
10.3	Volume (m^3)	0.117
10.5	Weight (kg)	67.1
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
60.9		

USER REFERENCES

(1) No user list

(2)

(3)

*See point system description.

D-210 Code No. 207

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Particle Counting (general)

VENDOR Nuclear Data, Inc.

Schaumburg, Illinois

INSTRUMENT ND 100 Multichannel Analyzer System

MODEL OR CATALOG NO. 88-0551 with 84-0215 memory

Points*	Factor	Specifications
10.7	Cost	$7,500
10.6	Power required	115/230 V, 50/60 Hz, 200 watts
11.5	Volume (m^3)	0.075
13.1	Weight (kg)	27.2
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
65.9		

USER REFERENCES

(1) No user list

(2)

(3)

*See point system description.

D-211 Code No. 208

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Particle Counting (general)

VENDOR Nuclear Data, Inc.

Schaumburg, Illinois

INSTRUMENT ND-555 Multichannel Analyzer

MODEL OR CATALOG NO. 88-0319

Points*	Factor	Specifications
14.1	Cost	$2,495
23.1	Power required	6/12 VDC, 9-6 watts
20.7	Volume (m^3)	0.007
21.1	Weight (kg)	4.1
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
99.0		

USER REFERENCES

(1) No user list

(2)

(3)

*See point system description.

D-212 Code No. 209

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Particle Counting (general)

VENDOR Nuclear Data Inc.

Schaumburg, Illinois

INSTRUMENT ND-1201 Multichannel Analyzer

MODEL OR CATALOG NO. 88-0552 with 84-0206 memory

Points*	Factor	Specifications
12.0	Cost	$4,800
8.4	Power required	115/230 V, 50/60 Hz, 500 watts
13.0	Volume (m^3)	0.045
13.7	Weight (kg)	22.7
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
67.1		

USER REFERENCES

(1) No user list

(2)

(3)

*See point system description.

D-213 Code No. 210

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Radiometric/Scintillation Counting

VENDOR Abbott Laboratories, Diagnostics Div.

North Chicago, Illinois

INSTRUMENT Logic 111 M with Auto Logic 100 sample changer

MODEL OR CATALOG NO. 7408-03

Points*	Factor	Specifications
10.8	Cost	$7,385
9.2	Power required	100/117/230 V, 50/60 Hz, 351 watts
11.0	Volume (m^3)	0.089
10.1	Weight (kg)	77.1
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
61.1		

USER REFERENCES

(1) No user list

(2)

(3)

*See point system description.

D-214 Code No. 211

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Radiometric/Scintillation Counting

VENDOR Beckman Instruments, Inc.

Irvine, California

INSTRUMENT Liquid Scintillation System

MODEL OR CATALOG NO. LS-100C

Points*	Factor	Specifications
10.3	Cost	$8,800
8.4	Power required	115V, 50/60 Hz, 520 watts
6.6	Volume (m^3)	0.693
7.4	Weight (kg)	270.0
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
52.7		

USER REFERENCES

(1) No user list

(2)

(3)

*See point system description.

D-215 Code No. 212

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Electrometric/Conductimetry

VENDOR Tri-R Instruments

Rockville Center, New York

INSTRUMENT DIGI 610 Digital Meter with Conductivity Plug-in

MODEL OR CATALOG NO. LF 610E (10010 with 30010)

Points*	Factor	Specifications
14.7	Cost	$2,120
14.4	Power required	110V, 50/60 Hz, 60 watts
19.0	Volume (m^3)	0.010
20.1	Weight (kg)	5.0
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
88.2		

USER REFERENCES

(1) No user list

(2)

(3)

*See point system description.

D-216 Code No. 213

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Electrometric/Conductimetry

VENDOR Leeds and Northrup Co.

North Wales, Pennsylvania

INSTRUMENT Electrolytic Conductivity Monitor

MODEL OR CATALOG NO. 7070

Points*	Factor	Specifications
22.1	Cost	$416
21.5	Power required	120V, 60 Hz, 12 watts
17.4	Volume (m^3)	0.014
17.3	Weight (kg)	9.1
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
98.3		

USER REFERENCES

(1) No user list

(2)

(3)

*See point system description.

D-217 Code No. 214

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Ultraviolet

VENDOR Beckman Instruments

Irvine, California

INSTRUMENT Spectrophotometer 26

MODEL OR CATALOG NO. 132600

Points*	Factor	Specifications
11.7	Cost	$5,300
9.6	Power required	115/230 V, 50/60 Hz, 300 watts
11.0	Volume (m^3)	0.088
12.6	Weight (kg)	31.8
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
64.9		

USER REFERENCES

(1) New instrument - no users available

(2)

(3)

*See point system description.

D-218 Code No. 215

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Radiometric/Scintillation Counting

VENDOR Abbott Laboratories, Diagnostics Division

North Chicago, Illinois

INSTRUMENT Auto Logic Scintillation System

MODEL OR CATALOG NO. 121 M

Points*	Factor	Specifications
10.9	Cost	$6,990
9.2	Power required	100/117/230 V, 50/60 Hz, 350 watts
11.0	Volume (m^3)	0.089
10.0	Weight (kg)	81.6 (est.)
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
61.1		

USER REFERENCES

(1) No users list

(2)

(3)

*See point system description.

D-219 Code No. 216

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Radiometric/Scintillation Counting

VENDOR Searle Analytic, Inc.

Des Plaines, Illinois

INSTRUMENT Delta 300 Liquid Scintillation System

MODEL OR CATALOG NO. 689

Points*	Factor	Specifications
10.0	Cost	$10,000 (est.)
9.6	Power required	115 ± 10 V, 50/60 Hz, 300 watts
7.3	Volume (m^3)	0.454
7.7	Weight (kg)	226.8
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
54.6		

USER REFERENCES

(1) No users list

(2)

(3)

*See point system description.

D-220 Code No. 217

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Radiometric/Scintillation Counting

VENDOR Searle Analytic, Inc.

Des Plaines, Illinois

INSTRUMENT Liquid Scintillation Counter

MODEL OR CATALOG NO. Mark II

Points*	Factor	Specifications
8.4	Cost	$20,000 (est.)
5.6	Power required	115 ± 10 V, 60 Hz, 2500-1000 watts
5.6	Volume (m^3)	1.319
7.0	Weight (kg)	344.7
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
46.6		

USER REFERENCES

(1) No users list

(2)

(3)

*See point system description.

D-221 Code No. 218

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Radiometric/Scintillation Counting

VENDOR Searle Analytic, Inc.

Des Plaines, Illinois

INSTRUMENT Liquid Scintillation Counter

MODEL OR CATALOG NO. Mark III

Points*	Factor	Specifications
7.6	Cost	$30,000 (est.)
5.4	Power required	115V, 60 Hz, 3000-1200 watts
5.4	Volume (m^3)	1.555
6.5	Weight (kg)	450.0
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
44.9		

USER REFERENCES

(1) No user list

(2)

(3)

*See point system description.

D-222 Code No. 219

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Enzymatic/Chromogenic

VENDOR Abbott Laboratories, Diagnostics Div.

Montreal, Quebec, Canada

INSTRUMENT Biochromatic Analyzer

MODEL OR CATALOG NO. ABA-50

Points*	Factor	Specifications
10.0	Cost	$9,910
11.9	Power required	115 ± 10 V, 60 Hz, 127 watts
11.0	Volume (m^3)	0.089
11.7	Weight (kg)	43.1
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
64.6		

USER REFERENCES

(1) No user list

(2)

(3)

*See point system description.

D-223 Code No. 220

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Radiometric/Scintillation Counting

VENDOR Dade Division, American Hospital Supply Corp.

Miami, Florida

INSTRUMENT Iso-Lect Well Counter

MODEL OR CATALOG NO. B 5627-1

Points*	Factor	Specifications
13.6	Cost	$2,950
18.1	Power required	120V, 60 Hz, 24 watts
14.1	Volume (m^3)	0.033
14.1	Weight (kg)	20.4
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
79.9		

USER REFERENCES

(1) No users list

(2)

(3)

*See point system description.

D-224 Code No. 221

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Electrometric/Potentiometry

VENDOR Beckman Instruments, Inc.

Irvine, California

INSTRUMENT 4500 pH meter

MODEL OR CATALOG NO. 123603

Points*	Factor	Specifications
18.0	Cost	$950
13.6	Power required	115V, 60 Hz, 75 watts
18.1	Volume (m^3)	0.012
19.4	Weight (kg)	5.7
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
89.1		

USER REFERENCES

(1) No users list

(2)

(3)

*See point system description.

D-225 Code No. 222

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Ultraviolet

VENDOR Beckman Instruments, Inc.

Irvine, California 92664

INSTRUMENT UV Spectrophotometer 25

MODEL OR CATALOG NO. 133101Y

Points*	Factor	Specifications
12.0	Cost	$4,785
9.6	Power required	115/230 V ± 10%, 50/60 Hz, 300 watts
11.0	Volume (m^3)	0.088
12.6	Weight (kg)	31.8
18.6	Complexity of use	from user survey
17.3	Reliability	from user survey
81.1		

USER REFERENCES

(1) 9 mo

Harry Grzeskowick 614/889-3333
Ashland CHemical Co.
5200 Blazer Parkway
Dublin, Ohio 43017

(2) 4 mo

Dr. Robert Mayer 614/422-1572
The Ohio State University
Johnson Laboratory, Department of Chemistry
140 West 18th Avenue
Columbus, Ohio 43210

(3) 8 mo

Dr. Randy Shull 614/422-1982
The Ohio State University
Genetics Department, 1735 Neal Avenue
Columbus, Ohio 43210

*See point system description.

D-226 Code No. 223

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Visible

VENDOR E. Leitz, Inc.

Rockleigh, New Jersey

INSTRUMENT 340-800 Photometer

MODEL OR CATALOG NO. 92300

Points*	Factor	Specifications
19.6	Cost	$675
15.0	Power required	115V, 60 Hz, 50-30 watts
16.9	Volume (m^3)	0.016
16.9	Weight (kg)	10.0
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
88.4		

USER REFERENCES

(1) No user list

(2)

(3)

*See point system description.

D-227 Code No. 224

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Visible

VENDOR E. Leitz, Inc.

Rockleigh, New Jersey

INSTRUMENT Photometer

MODEL OR CATALOG NO. 92320

Points*	Factor	Specifications
22.1	Cost	$419
15.0	Power required	115V, 50 Hz, 50-30 watts
16.9	Volume (m^3)	0.016
16.9	Weight (kg)	10.0
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
90.9		

USER REFERENCES

(1) No user list

(2)

(3)

*See point system description.

D-228 Code No. 225

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Visible

VENDOR Instrumentation Laboratory, Inc.

Lexington, Massachusetts

INSTRUMENT Densitometer

MODEL OR CATALOG NO. 377

Points*	Factor	Specifications
12.2	Cost	$4,500
13.4	Power required	100/115/220 V, 50/60 Hz, 80 watts
11.7	Volume (m^3)	0.[illegible]
13.0	Weight (kg)	28.0
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
70.3		

USER REFERENCES

(1) No user list

(2)

(3)

*See point system description.

D-229 Code No. 226

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Enzymatic/Chromogenic

VENDOR Instrumentation Laboratory, Inc.

Lexington, Massachusetts

INSTRUMENT Clinicard System 120/60

MODEL OR CATALOG NO. 368

Points*	Factor	Specifications
9.9	Cost	$10,500
8.4	Power required	100/120/230 V, 50/60 Hz, 500-350 watts
11.3	Volume (m^3)	0.078
12.5	Weight (kg)	33.0
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
62.1		

USER REFERENCES

(1) No user list

(2)

(3)

*See point system description.

Code No. 227

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Refraction/Refractometry

VENDOR GOW-MAC Instrument Co.

Madison, New Jersey

INSTRUMENT Christiansen Effect Detector

MODEL OR CATALOG NO. 80-100

Points*	Factor	Specifications
16.5	Cost	$1,360
10.6	Power required	115/220 V, 50/60 Hz, 200 watts
15.9	Volume (m^3)	0.020
24.4	Weight (kg)	2.3
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
87.4		

USER REFERENCES

(1) No user list

(2)

(3)

*See point system description.

D-231 Code No. 228

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Electrometric/Potentiometry

VENDOR Brinkmann Instruments, Inc.

Westbury, New York

INSTRUMENT Metrohm Multi-Titrator

MODEL OR CATALOG NO. E 440

Points*	Factor	Specifications
8.4	Cost	\$20,000 (est.)
10.6	Power required	110/220 V, 50 Hz (60 Hz opt.), 200 watts
7.3	Volume (m^3)	0.469
8.4	Weight (kg)	160.0
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
54.7		

USER REFERENCES

(1) No user list

(2)

(3)

*See point system description.

D-232 Code No. 229

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Electrometric/Conductimetry

VENDOR Myron L. Co.

Encinitas, California

INSTRUMENT Conductivity Monitor

MODEL OR CATALOG NO. 562 B

Points*	Factor	Specifications
28.6	Cost	$150
22.5	Power required	115V, 60 Hz, 10 watts
28.4	Volume (m^3)	0.002
25.9	Weight (kg)	1.8
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
125.4		

USER REFERENCES

(1) Users not completed

(2)

(3)

*See point system description.

D-233 Code No. 230

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Refraction/Nephelometry

VENDOR Ecologic Instrument Corp.

Bohemia, New York

INSTRUMENT Ecolab 104 Turbidimeter

MODEL OR CATALOG NO. 104-001

Points*	Factor	Specifications
21.7	Cost	$450
17.5	Power required	110V, 50/60 Hz (or internal batteries), 27 watts
23.8	Volume (m^3)	0.004
24.4	Weight (kg)	2.3
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
107.4		

USER REFERENCES

(1) No user list

(2)

(3)

*See point system description.

D-234 Code No. 231

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Electrometric/Conductimetry

VENDOR Ecologic Instrument Corp.

Bohemia, New York

INSTRUMENT Ecolab 103 Conductivity Meter

MODEL OR CATALOG NO. 5760-01-3

Points*	Factor	Specifications
24.5	Cost	$275
20.7	Power required	110V, 50/60 Hz (or internal batteries), 14 watts
21.5	Volume (m^3)	0.006
24.4	Weight (kg)	2.3
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
111.1		

USER REFERENCES

(1) No user list

(2)

(3)

*See point system description.

D-235 Code No. 232

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Radiometric/Scintillation Counting

VENDOR Baird-Atomic

Bedford, Massachusetts

INSTRUMENT Nuclear Spectrometer

MODEL OR CATALOG NO. 985-30A

Points*	Factor	Specifications
12.8	Cost	$3,750
13.2	Power required	110V, 60 Hz, 85 watts
14.4	Volume (m^3)	0.030
14.1	Weight (kg)	20.4
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
74.5		

USER REFERENCES

(1) 6 yr Lawrence General Hospital 617/683-4000
1 General St.
Lawrence, Massachusetts

(2)

(3)

*See point system description.

D-236 Code No. 233

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Pattern Recognition Computer

VENDOR Image Analysing Computers, Inc.

Monsey, New York

INSTRUMENT Pattern Recognition System

MODEL OR CATALOG NO. Quantimet 720

Points*	Factor	Specifications
5.4	Cost	\$120,950
5.6	Power required	110/240V, 50/60 Hz, 2550 watts
6.1	Volume (m^3)	0.919
7.2	Weight (kg)	300.3
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
44.3		

USER REFERENCES

(1) 2 yr Prof. R. F. Sekerka 412/621-2600, x-641
Carnegie-Mellon Univ.
Science Hall 2323
Pittsburgh, Pennsylvania 15213

(2)

(3)

*See point system description.

D-237 Code No. 234

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Pattern Recognition Computer (Image Analysis)

VENDOR Image Analysing Computers, Inc.

Monsey, New York

INSTRUMENT Microdensitometer

MODEL OR CATALOG NO. Quantimet 720D

Points*	Factor	Specifications
6.1	Cost	$74,070
6.7	Power required	110/240V, 50/60 Hz, 1300 watts
6.5	Volume (m^3)	0.725
8.0	Weight (kg)	202.0
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
47.3		

USER REFERENCES

(1) 10 mo Dr. Thomas R. Hakala 612/725-6767, x-6302
University of Minnesota
VA Hospital
Minneapolis, Minnesota 55417

(2)

(3)

*See point system description.

Code No. 235

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Pattern Recognition Computer (Image Analysis)

VENDOR Image Analysing Computer, Inc.

Monsey, New York

INSTRUMENT Macrodensitometer

MODEL OR CATALOG NO. Quantimet 720 D with Epidiascope

Points*	Factor	Specifications
6.5	Cost	$54,735
7.6	Power required	110/240V, 50/60 Hz, 750 watts
6.9	Volume (m^3)	0.556
9.0	Weight (kg)	122.0
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
50.0		

USER REFERENCES

(1) No user list

(2)

(3)

*See point system description.

D-239 Code No. 236

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Infra-Red

VENDOR Wilks Scientific Corp.

South Norwalk, Connecticut

INSTRUMENT MIRAN-I Analyzer

MODEL OR CATALOG NO. 5649

Points*	Factor	Specifications
13.4	Cost	$3,050
17.9	Power required	115/230V, 50/60 Hz, 25 watts
19.5	Volume (m^3)	0.009
19.4	Weight (kg)	5.7
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
90.2		

USER REFERENCES

(1) No user list

(2)

(3)

*See point system description.

D-240 Code No. 237

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Visible

VENDOR Milletron, Subsidiary of Capintec Inc.

Mt. Vernon, New York

INSTRUMENT Chrom-O-Scope

MODEL OR CATALOG NO. with 6-inch F 3.8 lens

Points*	Factor	Specifications
12.5	Cost	$4,120
15.9	Power required	115/230V, 50/60 Hz, -0 watts
13.5	Volume (m^3)	0.039
15.6	Weight (kg)	13.8
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
77.5		

USER REFERENCES

(1) No user list

(2)

(3)

*See point system description.

D-241 Code No. 238

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Electrometric/Potentiometry

VENDOR The London Co.

Cleveland, Ohio 44145

INSTRUMENT Potentiometric Titrator

MODEL OR CATALOG NO. TTT 2

Points*	Factor	Specifications
16.6	Cost	$1,320
23.8	Power required	115/220V ± 15%, 50/60 Hz, 8 watts
17.1	Volume (m^3)	0.015
19.3	Weight (kg)	5.8
16.7	Complexity of use	from user survey
20.1	Reliability	from user survey
113.6		

USER REFERENCES

(1) 2 yr Dr. S. Moore 201/235-4350
Hoffmann-La Roche
Kingsland St.
Nutley, New Jersey 07110

(2) 3 yr Dr. Norbert W. Tietz 312/542-2340
Mt. Sinai Hospital Med. Ctr.
Univ. of Health Sci./Chicago Med. School
California Avenue at 15th Street
Chicago, Illinois 60608

(3)

*See point system description.

D-242 Code No. 239

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Refraction/Refractometry

VENDOR International Micro-Optics

Fairfield, New Jersey

INSTRUMENT Pulfrich Refractometer

MODEL OR CATALOG NO. PR-2

Points*	Factor	Specifications
9.9	Cost	$10,379
7.6	Power required	220V, 50 Hz, 750-500 watts
12.0	Volume (m^3)	0.063
11.7	Weight (kg)	43.5
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
61.2		

USER REFERENCES

(1) No user list

(2)

(3)

*See point system description.

D-243 Code No. 240

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Enzymatically Based/Chromogenic Substrate

VENDOR LKB Instruments Inc.

Rockville, Maryland 20852

INSTRUMENT Reaction Rate Analyzer

MODEL OR CATALOG NO. 8600-5

Points*	Factor	Specifications
9.8	Cost	$10,960
10.3	Power required	115V ± 10%, 60 Hz, 230 watts
8.9	Volume (m^3)	0.219
11.9	Weight (kg)	39.9
15.8	Complexity of use	from user survey
11.0	Reliability	from user survey
67.7		

USER REFERENCES

(1) 3 yr B. Powers 914/967-7800
Union Carbide Corp.
401 Thes. Fremd. Avenue
Rye, New York 10580

(2) Dr. J. Karinattu
St. Therese Hospital
Waukegan, Illinois 60085

(3)

*See point system description.

D-244 Code No. 241

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Refraction/Nephelometry

VENDOR Nissei Sangyo Instruments Inc.

Mountain View, California

INSTRUMENT TGM-2020 Nephelometer

MODEL OR CATALOG NO. 2020-800

Points*	Factor	Specifications
16.4	Cost	$1,385
22.5	Power required	115V, 50/60 Hz, 10 watts
17.1	Volume (m^3)	0.015
19.2	Weight (kg)	6.0
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
95.2		

USER REFERENCES

(1) No user list

(2)

(3)

*See point system description.

D-245 Code No. 242

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Visible

VENDOR SHM Nuclear Corp.

Sunnyvale, California

INSTRUMENT Film Densitometer

MODEL OR CATALOG NO. None

Points*	Factor	Specifications
11.0	Cost	$6,800
12.6	Power required	115V, 60 Hz, 100 watts
12.9	Volume (m^3)	0.047
15.6	Weight (kg)	13.6
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
72.1		

USER REFERENCES

(1) No user list

(2)

(3)

*See point system description.

D-246 Code No. 243

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Radiometric/X-Ray Fluorescence

VENDOR Princeton Gamma Tech

Princeton, New Jersey

INSTRUMENT Chemical Analyzer

MODEL OR CATALOG NO. 100-2

Points*	Factor	Specifications
10.4	Cost	$8,490
12.2	Power required	105-125 V, 60 Hz, 115 watts
13.8	Volume (m^3)	0.036
15.0	Weight (kg)	16.0
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
71.4		

USER REFERENCES

(1) No user list

(2)

(3)

*See point system description.

D-247 Code No. 244

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Radiometric/X-Ray Fluorescence

VENDOR Princeton Gamma Tech

Princeton, New Jersey

INSTRUMENT X-Ray Analyzer

MODEL OR CATALOG NO. PGT 1000

Points*	Factor	Specifications
9.5	Cost	$12,000
8.4	Power required	115V, 50/60 Hz, 500 watts
8.2	Volume (m^3)	0.288
10.0	Weight (kg)	79.4
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
56.1		

USER REFERENCES

(1) No user list

(2)

(3)

*See point system description.

D-248 Code No. 245

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Radiometric/X-Ray Fluorescence

VENDOR Princeton Gamma Tech

Princeton, New Jersey

INSTRUMENT PORTA-LAB

MODEL OR CATALOG NO. 50

Points*	Factor	Specifications
11.1	Cost	$6,600
21.5	Power required	105-125 V, 60 Hz, 12 watts (also rechargeable battery)
19.0	Volume (m^3)	0.010
18.6	Weight (kg)	6.8
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
90.2		

USER REFERENCES

(1) No user list

(2)

(3)

*See point system description.

D-249 Code No. 246

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Refraction/Nephelometry

VENDOR Volu-Sol

Las Vegas, Nevada

INSTRUMENT Nephelometer

MODEL OR CATALOG NO. 300

Points*	Factor	Specifications
20.2	Cost	$595
15.0	Power required	110-130 V, 50/60 Hz, 50 watts
16.2	Volume (m^3)	0.019
21.1	Weight (kg)	4.1
15.8	Complexity of use	from user survey
17.6	Reliability	from user survey
105.9		

USER REFERENCES

(1) 1 yr Eastern Medical Labs 603/224-5343
85 South State
Concord, New Hampshire 03301

(2) 3 yr Polly Tilden 702/986-9943
Reynolds Elec. & Eng. Co.
P. O. Box 301
Mercury, Nevada 89023

(3)

*See point system description.

D-250 Code No. 247

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Radiometric/X-Ray Fluorescence

VENDOR Nuclear Semiconductor

Menlo Park, California

INSTRUMENT Spectrace 440 X-Ray Analyzer

MODEL OR CATALOG NO. 440A

Points*	Factor	Specifications
6.4	Cost	$58,920
16.6	Power required	110V, 60 Hz, 34 watts
6.7	Volume (m^3)	0.636
7.9	Weight (kg)	204.1
9.7	Complexity of use	from user survey
15.5	Reliability	from user survey
62.8		

USER REFERENCES

(1) 1 yr E. R. Bechtel 602/356-7811
Kennecott Copper Corp.
Ray Mines Division
Hayden, Arizona 85235

(2) 1 yr David C. Wherry 608/836-6511
Tracor Northern
2551 West Beltline Highway
Middleton, Wisconsin 53562

(3) 6 mo Dr. Peter Kalina
Sandoz AG, Werk Muttenz
Rothausstrasse 61
Schweizerhalle, Switzerland CH-4133

*See point system description.

Code No. 248

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE: Photometric/Absorption/Infrared

VENDOR: Perkin-Elmer Corp.
Norwalk, Connecticut

INSTRUMENT: 735 Infrared Spectrophotometer

MODEL OR CATALOG NO. 007-0206

Points*	Factor	Specifications
11.7	Cost	$5,400
12.6	Power required	105-125 V, 60 Hz, 100 watts
10.9	Volume (m^3)	0.093
12.1	Weight (kg)	38.0
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
67.3		

USER REFERENCES

(1) No user list

(2)

(3)

*See point system description.

D-252 Code No. 249

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Emission/Fluorometry

VENDOR Perkin-Elmer Corp.

Norwalk, Connecticut

INSTRUMENT Fluorescence Spectrophotometer

MODEL OR CATALOG NO. MPF-44

Points*	Factor	Specifications
9.4	Cost	$12,500
8.4	Power required	115/220 V, 50/60 Hz, 500 watts
9.6	Volume (m^3)	0.151
9.9	Weight (kg)	85.0
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
57.3		

USER REFERENCES

(1) No user list

(2)

(3)

*See point system description.

D-253 Code No. 250

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Ultraviolet

VENDOR Perkin-Elmer Corp.

Norwalk, Connecticut

INSTRUMENT Double-beam Double Wavelength UV-Vis Spectrophotometer

MODEL OR CATALOG NO. 356-0035

Points*	Factor	Specifications
8.7	Cost	$17,000
8.4	Power required	110V, 60 Hz, 500 watts
7.3	Volume (m^3)	0.456
8.4	Weight (kg)	158.8
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
52.8		

USER REFERENCES

(1) No user list

(2)

(3)

*See point system description.

D-254 Code No. 251

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Ultraviolet

VENDOR Philips Electronic Instruments

Mount Vernon, New York

INSTRUMENT Ultraviolet Spectrophotometer

MODEL OR CATALOG NO. SP-1700A

Points*	Factor	Specifications
11.0	Cost	$6,710
10.6	Power required	115/230V ± 10%, 50/60 Hz, 200 watts
9.7	Volume (m^3)	0.145
10.4	Weight (kg)	69.8
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
61.7		

USER REFERENCES

(1) No user list

(2)

(3)

*See point system description.

D-255 Code No. 252

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Infrared

VENDOR Philips Electronic Instruments

Mount Vernon, New York

INSTRUMENT Infrared Spectrophotometer

MODEL OR CATALOG NO. SP 1100

Points*	Factor	Specifications
10.3	Cost	$8,795
12.6	Power required	110/240V, 50/60 Hz, 100 watts
10.5	Volume (m^3)	0.107
11.9	Weight (kg)	40.0
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
65.3		

USER REFERENCES

(1) No user list

(2)

(3)

*See point system description.

D-256 Code No. 253

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Visible

VENDOR Broomer Research Corp.

Plainview, New York

INSTRUMENT SCF-1 Scanning Spectrocolorimeter

MODEL OR CATALOG NO. 5720

Points*	Factor	Specifications
15.0	Cost	$1,995
12.6	Power required	115V, 60 Hz, (est.) 100 watts
14.2	Volume (m^3)	0.032
15.6	Weight (kg)	(est.) 13.6
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
77.4		

USER REFERENCES

(1) No user list

(2)

(3)

*See point system description.

D-257 Code No. 254

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Enzymatic/ATP Photometry

VENDOR Lab-Line Instruments Inc.

Melrose Park, Illinois

INSTRUMENT ATP Photometer

MODEL OR CATALOG NO. 9140

Points*	Factor	Specifications
11.6	Cost	$5,500
16.4	Power required	115/230V, 50/60 Hz, 35 watts
17.4	Volume (m^3)	0.014
19.7	Weight (kg)	5.4
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
85.1		

USER REFERENCES

(1) Users not completed

(2)

(3)

*See point system description.

D-258 Code No. 255

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Enzymatic/Chromogenic

VENDOR Dow Diagnostics, The Dow Chemical Co.
Indianapolis, Indiana

INSTRUMENT Enzyme Spectrophotometer

MODEL OR CATALOG NO. 51791

Points*	Factor	Specifications
12.6	Cost	$3,995
12.6	Power required	105-130V, 60 Hz, 100 watts
13.5	Volume (m^3)	0.039
15.6	Weight (kg)	13.6
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
74.3		

USER REFERENCES

(1) Users not completed

(2)

(3)

*See point system description.

D-259 Code No. 256

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Enzymatic/Chromogenic

VENDOR Gilford Instrument Labs., Inc.

Oberlin, Ohio

INSTRUMENT Computer Directed Analyzer

MODEL OR CATALOG NO. 3500

Points*	Factor	Specifications
8.3	Cost	$20,500
8.5	Power required	105-125V, 60 Hz, 495 watts
7.5	Volume (m^3)	0.403
8.9	Weight (kg)	130.6
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
53.2		

USER REFERENCES

(1) 2 mo Dr. D. Buzzee 606/581-1322
St. Elizabeth Hospital
20th & Eastern Ave.
Covington, Kentucky 41014

(2)

(3)

*See point system description.

D-260 Code No. 257

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE: Photography

VENDOR: Charles A. Hulcher Co., Inc.
Hampton, Virginia

INSTRUMENT: 70 mm Sequence Camera

MODEL OR CATALOG NO. 108

Points*	Factor	Specifications
14.6	Cost	$2,225
12.1	Power required	24-28VDC, 120-70 watts
21.5	Volume (m^3)	0.006
24.4	Weight (kg)	2.3
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
92.6		

USER REFERENCES

(1) 3 yr Robert L. Kurtz 205/453-0941
MSFC/NASA
Huntsville, Alabama 35812

(2)

(3)

*See point system description.

D-261 Code No. 258

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photography

VENDOR Instrumentation Marketing Corp.

Burbank, California

INSTRUMENT Actionmaster 200 Miniature Cine Camera

MODEL CR CATALOG NO. 16 mm-1VN-100

Points*	Factor	Specifications
15.7	Cost	$1,650
14.6	Power required	28VDC, 56 watts
33.7	Volume (m^3)	0.001
32.8	Weight (kg)	0.7
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
116.8		

USER REFERENCES

(1) 1-1/2 yr Mr. George D. Wood 714/382-2911
HQ AAVS (MAC), DODC
Norton AFB
San Bernardino, California 92409

(2)

(3)

*See point system description.

D-262 Code No. 259

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Particle Counting/Electro-Conductimetric

VENDOR Clay Adams

Parsippany, New Jersey

INSTRUMENT ACCU-STAT Blood Cell Counter

MODEL OR CATALOG NO. 2401

Points*	Factor	Specifications
15.8	Cost	$1,595
20.3	Power required	95-135V, 60 Hz, 15 watts
14.7	Volume	0.028
19.2	Weight (kg)	6.0
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
90.0		

USER REFERENCES

(1) Users not completed

(2)

(3)

*See point system description.

D-263 Code No. 260

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Particle Counting/Electro-Conductimetric

VENDOR General Science Corp.

Bridgeport, Connecticut

INSTRUMENT MK-25/400 Haema-Count System

MODEL OR CATALOG NO. 69108

Points*	Factor	Specifications
15.4	Cost	$1,795
17.1	Power required	115V, 60 Hz, 30 watts
16.4	Volume (m^3)	0.018
19.7	Weight (kg)	5.4
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
88.6		

USER REFERENCES

(1) 10 mo William K. Young Jr. 202/245-1616
U.S.P.H.S.
PHS-OPC, 4th & C St., S. W.
Washington, D. C. 20201

(2)

(3)

*See point system description.

D-264 Code No. 261

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Refraction/Polarimetry

VENDOR Polyscience Corp.

Niles, Illinois

INSTRUMENT SR-5 Polarimeter

MODEL OR CATALOG NO. 3-310410 with Sodium Lamp 3-350703

Points*	Factor	Specifications
17.5	Cost	$1,073
12.6	Power required	115V, 50/60 Hz, 100 watts
19.5	Volume (m^3)	0.009
18.8	Weight (kg)	6.5
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
88.4		

USER REFERENCES

(1) 2 yr Fred Cramer 616/343-2603
A. M. Todd Co.
1717 Douglas, Box 711
Kalamazoo, Michigan 49005

(2)

(3)

*See point system description.

D-265 Code No. 262

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Refraction/Polarimetry

VENDOR Perkin-Elmer Corp.

Norwalk, Connecticut

INSTRUMENT Automation Polarimeter

MODEL OR CATALOG NO. 241

Points*	Factor	Specifications
10.0	Cost	$9,940
9.2	Power required	115/206/220/240V, 50/60 Hz, 350 watts
10.8	Volume (m^3)	0.095
11.3	Weight (kg)	50.0
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
61.3		

USER REFERENCES

(1) Users not completed

(2)

(3)

*See point system description.

D-266 Code No. 263

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Refraction/Polarimetry

VENDOR Process and Instruments Corp.

Brooklyn, New York

INSTRUMENT Digital Photoelectric Polarimeter

MODEL OR CATALOG NO. A

Points*	Factor	Specifications
15.6	Cost	$1,670
14.7	Power required	115V, 60 Hz, 55 watts
15.1	Volume (m^3)	0.025
16.5	Weight (kg)	10.8
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
81.9		

USER REFERENCES

(1) Users not completed

(2)

(3)

*See point system description.

Code No. 264

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Refraction/Polarimetry

VENDOR Rudolph Instruments Engineering Co., Inc.

Little Falls, New Jersey

INSTRUMENT Spectropolarimeter

MODEL OR CATALOG NO. 52A5

Points*	Factor	Specifications
13.5	Cost	$2,995
12.6	Power required	115V, 60 Hz, 100 watts
9.8	Volume (m^3)	0.142
16.4	Weight (kg)	11.3
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
72.3		

USER REFERENCES

(1) Users not completed

(2)

(3)

*See point system description.

D-268 Code No. 265

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Refraction/Polarimetry

VENDOR DuPont Co., Instrument Pr-lucts Div.

Wilmington, Delaware

INSTRUMENT Split-Beam Process Polarimeter

MODEL OR CATALOG NO. 402

Points*	Factor	Specifications
12.0	Cost	$4,900
9.3	Power required	95-130V, 60 Hz, 345 watts
9.8	Volume (m^3)	0.142
9.2	Weight (kg)	113.4
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
60.3		

USER REFERENCES

(1) 7 yr J. M. Vidito 317/261-4740
Eli Lilly and Company
P. O. Box 618
Indianapolis, Indiana 46206

(2)

(3)

*See point system description.

D-269 Code No. 2?6

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Radiometric/Gamma Spectrometry

VENDOR Analytical Development Assoc. Corp.

Cupertino, California

INSTRUMENT Multichannel Spectrometer/Scaler

MODEL OR CATALOG NO. ADAC MS-204

Points*	Factor	Specifications
13.0	Cost	$3,500
12.6	Power required	115V ± 10%, 60 Hz, 100 watts
15.8	Volume (m^3)	0.021
14.5	Weight (kg)	18.1
18.3	Complexity of use	from user survey
19.0	Reliability	from user survey
93.2		

USER REFERENCES

(1) 1 mo Mr. Gary Gallmore 201/775-5500
Jersey Shore Medical Center, Nuclear Medicine Dept.
1945 Carlies Ave.
Neptune, New Jersey 07753

(2) 2 yr Richard Thomason 513/853-4175
St. Francis Hospital, Nuclear Medicine Dept.
1860 Queen City Avenue
Cincinnati, Ohio 45214

(3)

*See point system description.

D-270 Code No. 267

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Ultrasonics

VENDOR Automation Industries, Inc., Sperry Div.

Danbury, Connecticut

INSTRUMENT Reflectoscope

MODEL OR CATALOG NO. UM 775

Points*	Factor	Specifications
13.4	Cost	$3,120
12.4	Power required	90-130V, 50/60 Hz, 110 watts
13.5	Volume (m^3)	0.039
15.6	Weight (kg)	13.6
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
74.9		

USER REFERENCES

(1) No user list

(2)

(3)

*See point system description.

D-271 Code No. 268

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE: Ultrasonics

VENDOR: Automation Industries, Inc., Sperry Div.
Danbury, Connecticut

INSTRUMENT: Ultrasonic Reflectoscope

MODEL OR CATALOG NO. UJ

Points*	Factor	Specifications
14.0	Cost	$2,680
28.3	Power required	115V, 50/60 Hz, 4 watts
20.1	Volume (m^3)	0.008
19.7	Weight (kg)	5.4
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
102.1		

USER REFERENCES

(1) No user list

(2)

(3)

*See point system description.

D-272 Code No. 269

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Radiometric/X-Ray Fluorescence

VENDOR Philips Electronic Inc.

Prairie View, Illinois

INSTRUMENT X-Ray Fluorescence System

MODEL OR CATALOG NO. EXAM IV

Points*	Factor	Specifications
6.8	Cost	$45,000 (est.)
4.6	Power required	175-265V, 50/60 Hz, 5500 watts
6.2	Volume (m^3)	0.885
6.2	Weight (kg)	553.4
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
43.8		

USER REFERENCES

(1) No user list

(2)

(3)

*See point system description.

D-273 Code No. 270

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Photometric/Absorption/Visible

VENDOR General Medical Systems, Inc.

Garland, Texas

INSTRUMENT Chemi-Computron

MODEL OR CATALOG NO. 2200

Points*	Factor	Specifications
10.7	Cost	$7,500
11.6	Power required	115/220V, 50/60 Hz, 140 watts
14.0	Volume (m^3)	0.034
15.0	Weight (kg)	15.9
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
71.3		

USER REFERENCES

(1) No user list

(2)

(3)

*See point system description.

D-274 Code No. 271

COMMERCIAL HARDWARE DESCRIPTION

ASSAY PRINCIPLE Radiometric/Scintillation Counting

VENDOR General Medical Systems, Inc.

Garland, Texas

INSTRUMENT Iso-Computron

MODEL OR CATALOG NO. 1200

Points*	Factor	Specifications
13.5	Cost	$3,000
15.0	Power required	115/220V, 50/60 Hz, 50 watts
13.5	Volume (m^3)	0.039
14.1	Weight (kg)	20.4
10.0	Complexity of use	from user survey
10.0	Reliability	from user survey
76.1		

USER REFERENCES

(1) No user list

(2)

(3)

*See point system description.