NASA SP-7013

NASA PUBLICATIONS MANUAL 1974

Scientific and Technical Information Office 1974
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Washington, D.C.

For sale by the Superintendent of Documents, Government Printing Office
Washington, D.C., 20402

PREFACE

All scientific and technical programs of the National Aeronautics and Space Administration have a common ultimate purpose: the expansion and interpretation of scientific knowledge related to aeronautics and space exploration. This manual has been prepared to assist authors and editors engaged in recording this NASA-generated knowledge through the medium of scientific and technical reports. The objective is to establish uniform report standards for the agency. It is the intent that this manual, in establishing uniformity of presentation, will simplify the work of NASA in the production of reports and will provide reports of improved quality. These benefits are considered to overshadow the convenience to be found in a preference for presentation in a wide variety of styles. The standards presented here are merely a selection from many through which the same objectives could have been achieved; as the need arises, they may be updated and revised. Comments and suggestions are invited from NASA authors and editors, as well as from the grantees and contractors engaged in NASA-supported research and development.

Harold E. Pryor, Director
Scientific and Technical Information Office
National Aeronautics and Space Administration

CONTENTS

INTRODUCTION

The National Aeronautics and Space Act of 1958 established as one of the functions of the National Aeronautics and Space Administration the responsibility for providing "the widest practicable and appropriate dissemination of information concerning its activities and the results thereof." In accomplishing this objective, NASA has a need for uniform publication standards that will increase the utility, clarity, and quality of NASA reports. The purpose of this manual is to establish standards that will provide reports of maximum readability and ease of comprehension, written in a style that is both logical and familiar because of its wide acceptance in scientific writing.

As a Government agency with public responsibilities, NASA is governed by the publications policies established by Congressional act. Since 1895, the Public Printer has been authorized by Congress to determine the form and style of Government printing. The U.S. Government Printing Office (GPO) Style Manual (ref. 1) is issued periodically by the Public Printer and is subject to approval of the Joint Committee on Printing of the U.S. Congress. NASA therefore considers the rules provided by the GPO manual as authoritative wherever practical considerations do not intervene. The rules in any publications manual cannot, however, be regarded as rigid, since successful communication frequently demands flexibility, particularly in scientific works. With these limitations acknowledged, NASA offers the present manual for the assistance of personnel engaged in the various phases of its publications program.

This manual is arranged in sections to assist users in resolving various problems encountered in publication of scientific and technical reports. Certain types of reports to be issued under NASA sponsorship are first described. The second section, on format, is concerned with the physical appearance and reproduction procedures, and samples are provided. Subsequent sections advise authors and editors in matters relating to organization, content, and general style.

TYPES OF NASA PUBLICATIONS

Formal Series

NASA management has established (ref. 2) six formal series of NASA scientific and technical publications, as well as procedures for their approval. The series are these:

NASA Technical Reports include significant results of outstanding quality that are considered to be complete, comprehensive, and lasting contributions to existing knowledge. They are serially numbered, unclassified, referenceable, given broad initial distribution, and placed on public sale.

NASA Technical Notes include results of interest in continuing areas of research that may lack the same importance, permanence, or completeness ascribed to the Technical Report. They are serially numbered, unclassified, referenceable, given broad initial distribution, and placed on public sale.

NASA Technical Memorandums include information that may require or warrant limited distribution because of security classification or the preliminary or unconfirmed nature of their results. This series may also include conference proceedings. They are serially numbered, referenceable, and given the distribution appropriate to their content. If unclassified and unlimited, they are placed on public sale.

NASA Technical Translations of documents in languages other than English that are considered to merit formal publication are issued in English under NASA sponsorship. They are serially numbered, referenceable, given broad initial distribution, and placed on public sale.

NASA Contractor Reports include information generated under NASA contracts or grants considered to be useful contributions to existing knowledge. They are serially numbered, referenceable, and, except when security classified, given broad initial distribution and placed on public sale.

NASA Special Publications include information derived from or of value to the agency's programs, such as conference proceedings, mission results, monographs, data compilations, handbooks, and special bibliographies. They are serially numbered, referenceable, and, except when security classified, given broad initial distribution and placed on public sale.

Volume and reproduction constraints impose limits on the number of publications that can be physically printed. Accordingly, in three series of formal publications - Technical Memorandums, Technical Translations, and Contractor Reports - some documents are available only in duplicated or microfiche form. Identifiable by high serial numbers, these publications are nevertheless formal NASA reports, referenceable, and, unless security classified or limited, placed on public sale.

Contributions to External Publications

NASA scientists frequently prepare papers for release through other media. Most common are papers presented before technical societies or submitted to technical and scientific journals. In general, NASA contributors of papers to be released through outside media are provided with instructions regarding acceptable material by the organiza-

tions concerned. A representative example is the Style Manual of the American Institute of Physics (ref. 3). Contributors to such journals will adhere to the practices of the journal publisher; however, the fact that these reports are not to be released between NASA covers does not give license to contributors to ignore publication policies and standards established in this manual. For example, NASA policy concerning availability of references is the same for external contributions as for NASA formal publications.

Unclassified material released between NASA covers is in the public domain and may be reproduced by a journal without clearance. Professional ethics, as well as economy in publications procedures, dictates that NASA generally avoid the prior publication, as a formal NASA document, of a paper identical with one to be released by an outside organization in its journal or proceedings. However, when a report, more extensive in scope than the condensed outside contribution, is subsequently published as a formal NASA report, the title should be different and bibliographic information regarding the former presentation given on the technical report standard title page in item 15 and on page 1 in a footnote.

Informal Papers

Often certain phases of NASA research are reported in informal papers for the rapid exchange of information to selected groups. In many cases such papers are preliminary in character and have not had the extensive review of formal papers. As such they should not resemble regular NASA publications, should not carry display type on their covers, and should not bear the agency's seal or insignia. They are not referenceable in formal publications. Sometimes, however, they may warrant distribution on a request basis. When such release is authorized, these informal reports may be put into the NASA information system as high-number-series Technical Memorandums and become referenceable reports.

Supplementary Report Material

Supplementary report material (e.g., films, tables, etc.) poses certain problems that require special treatment and advance planning. A supplement considered to be of interest to a limited audience may be prepared under a separate cover with the same code number and date as the original report and made available only on request. Publications with supplements will include request information on the last page of the report (sample 1). A brief description of the supplement and the address of the center of origin of the report (NASA Headquarters for classified material) is given. An order form (not backed) printed on regular paper stock is also supplied on this page.

Motion-picture film supplement C-269 is available on loan. Requests will be filled in the order received.

The film (16 mm, 12 min, color, sound) consists of 11 separate collision sequences involving the polar target molecules CO, HCl, and CH_3CN. The collisions are single- and multiple-reflection types demonstrating mutual spiraling of the collision partners as well as hindering of the dipole by the incident ion.

Requests for film supplement C-269 should be addressed to:

Chief, Management Services Division (5-5)
National Aeronautics and Space Administration
Lewis Research Center
21000 Brookpark Road
Cleveland, Ohio 44135

CUT

Date _____

Please send, on loan, copy of film supplement C-269 to TN D-5747

_____
Name of Organization

_____
Street Number

_____
City and State Zip Code

Attention: Mr. _____
Title _____

SAMPLE 1

Supplements are mentioned in the Introduction of a report, as well as indicated in Item 15 of the standard title page. It is particularly important that this information be given in order that the supplement be noticed by bibliographic controllers and announced in STAR with the report.

Other types of supplements may be issued at later dates. Depending on the circumstances, these supplements may have the same code number as the original report (if not self-sufficient) with a dash number to identify the supplement (e.g., NASA TN D-146-I) or they may be (if self-sufficient) given new code numbers (e.g., NASA TM X-810, TN X-824, and TM X-899).

Some reports provide film supplements to give support to the results presented in the report proper. Film supplements are particularly useful in demonstrating behavioral characteristics of specimens undergoing tests. A film supplement will be identified by opening frames that provide the following information:

(1) National Aeronautics and Space Administration
(2) Center of origin, e.g., "Ames Research Center"
(3) Classification (if classified) and appropriate security markings
(4) Film serial number assigned by Center of origin
(5) Film supplement to NASA TN D-000
(6) Title and authors of report

Errata

Errata are issued to inform recipients of NASA publications of errors of sufficient importance to warrant correction. Minor typographical mistakes will not usually require errata. An errata is issued without a cover. The top of the first page includes the code number of the document, the title, authors, and data of original publication.

An errata should provide the page number and such other information as will assist the reader in locating the error. Equations may be identified by number, but in the text the error should be identified by line. If a page must be replaced, the corrected page should be printed on a separate sheet (not backed) to facilitate insertion in the report. The issue data of an errata appears at the bottom. A typical setup for an errata for a confidential report is shown in sample 2.

If an errata for a classified paper is not considered sufficiently informative to require classification when separated from the document and if the title is unclassified, the notation "This page is unclassified" should appear at the top and bottom of each page of the errata.

CONFIDENTIAL

ERRATA

NASA Technical Memorandum X-0000

FRICTION AND WEAR OF SELECTED METALS AND OF CARBONS IN LIQUID NATURAL GAS (U)

John E. Jones

December 1973

Page 14, figure 10: The abscissa scale should be 10, 20, 40, 60, 80, 100×10^3

Page 15, lines 31 and 32: The phrase "examination of the wear surfaces" should be deleted.

Page 29: Equation (B6) should be

$$C_d = 0.073\left[\frac{c}{R}\left(1 + \frac{c}{R}\right)\right]^{1/4} N_R^{-0.3}$$

Issued 2-14-74

CONFIDENTIAL

SAMPLE 2

FORMAT FOR NASA FORMAL SERIES

The remarks in this section are concerned chiefly with single reports such as Technical Reports, Technical Notes, or Technical Memorandums. Special Publications present different problems and must be handled individually.

Page Dimensions and Pagination

The outside dimensions of NASA formal reports (with the exception of those printed at GPO) are nominally fixed for a width of 8 inches and a length of $10\frac{1}{2}$ inches. The image area, which is defined as the area between margins, is limited to a maximum of $6\frac{5}{8}$ inches in width and $8\frac{5}{8}$ inches in length. (See sample 3.) If, as is sometimes necessary in tabulations and original figures, the copy provided exceeds the page dimensions, such copy may be reduced to fit the allowable dimensions. Most typewritten copy cannot, however, take a reduction of more than one-half, so that material requiring greater reduction must provide lettering sizes commensurate with the amount of reduction necessary.

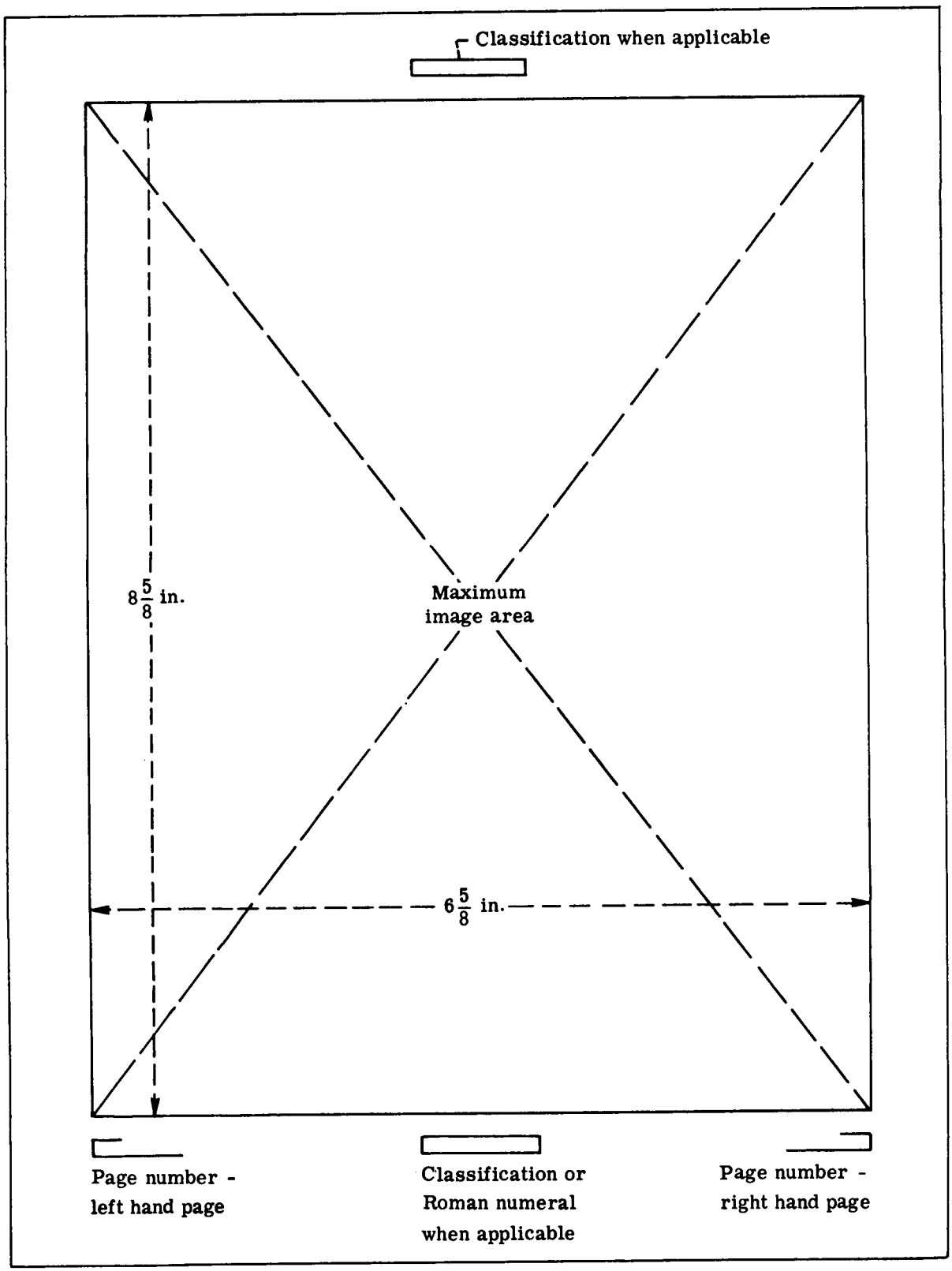
Pagination of front matter is in lower-case Roman numerals centered at the bottom of the page. Right-hand pages are given odd numbers; left-hand pages are given even numbers. The title page is considered to be page i, although no number appears on this page. Pagination of the report proper is in Arabic numbers, with page numbers positioned in the corners at the bottom of each page. The first page of text does not carry a number but is counted as page 1. Odd numbers, beginning with page 3, appear in lower right corners; even numbers appear in lower left corners. If pages are blank, they are counted as numbered pages, even though no number is shown.

Deviations from standard page size (such as foldouts or separate folded figures to be placed in envelopes) are not accepted unless they significantly enhance a report. They complicate operations so seriously that they can be provided only with the prior approval of NASA Headquarters. Since foldouts or gatefolds in papers require hand labor in most cases, they hold up the operations of the entire system and affect the scheduling of other documents that are being processed.

Typography

The typography to be used in texts of NASA publications depends specifically upon the type of publication selected.

NASA Special Publications are typeset through the Government Printing Office and reflect the quality that is obtainable from a variety of equipment and skilled technicians.


Classification when applicable
8 5/8 in.
Maximum image area
6 5/8 in.
Page number - left hand page
Classification or Roman numeral when applicable
Page number - right hand page

SAMPLE 3

One legible copy for the printer, either double- or triple-spaced, with original figures included, is all that is required of the Centers.

Other NASA formal publications are prepared at the originating Center in the form of "camera-ready copy." Contractors engaged in research and translating for NASA may be requested to supply reproducible copy as a part of their contracts. The master typewritten copies are used to prepare negatives for use in photo-offset equipment from which final copies are printed. Satisfactory reproduction requires clean copy typed with paper or plastic carbon ribbon that will not bleed or smear. Electric typewriters are available with proportional-spacing type faces and with changeable type bars providing special mathematical and other symbols often needed in scientific and technical reports.

As has been mentioned in the previous section, typewritten copy may be reduced. When copy is reduced, the textual material should be typed single-spaced to dimensions proportional to the image area allowed for each page, namely $6\frac{5}{8}$ by $8\frac{5}{8}$ inches. Adherence to these recommended practices will provide printed matter of neat and uniform appearance and will permit microfiche reproduction through several generations of copies.

Certain typing conventions are useful in improving the clarity, readability, and legibility of copy in scientific papers. A useful device in presenting symbolic expressions is to provide two spaces before and after symbols for physical concepts in a line of text; however, no extra spacing is used around the common chemical symbols. If an equation is simple, it may be typed within a line of text but should not be broken between two lines. A more complex equation in the reading text should be set on a separate line and indented or centered in the measure. Many of the familiar mathematical conventions (e.g., log, sin, cos, and tan) either in a line of text or in displayed equations are typed with one space before and after the notation. When symbols for differentials (d, ∂, and Δ) follow other symbols, they are separated from them by a space.

NASA scientists contributing to meetings and journals of technical and scientific societies will often be provided with specifications concerning the preparation of acceptable copy (e.g., ref. 3), and authors are urged to conform to their requirements. Many societies furnish the authors with forms to be used in preparing their preprints or printer's copies.

Color

The Government Printing and Binding Regulations (ref. 4) specify that "multicolor printing is prohibited except for classes of work wherein additional colors provide a functional value." Multicolor printing is not only costly but slow, and NASA therefore will allow color printing only after adequate justification is presented and approval is received from the printing officer at the originating Center.

Cover

Standard cover designs, each of a prescribed color, have been established for the following NASA formal series reports:

Type	Code	Color of cover stock
Technical Report	NASA TR R-	Granite
Technical Note	NASA TN D-	Buff
Technical Memorandum (low number)	NASA TM X-	Blue
Technical Translation (low number)	NASA TT F-	Terra cotta
Contractor Report (low number)	NASA CR-	Green

Final cover pages are prepared at the Langley Research Center after the report is approved and the print order is issued. High number reports, as stated before, do not carry a formal cover. The covers for Special Publications are individually designed by NASA Headquarters, and cover-stock color varies.

Technical Report Standard Title Page

The first right-hand page inside the cover is the COSATI technical report standard title page and is not numbered. It follows guidelines to format standards prepared by the Committee on Scientific and Technical Information (COSATI) of the Federal Council for Science and Technology. (See samples 4, 5, and 6.)

Detailed directions for preparing this page are given in the NASA July 1969 implementation edition of COSATI Guidelines to Format Standards for Scientific and Technical Reports Prepared by or for the Federal Government (ref. 5).

Front Matter

In single reports of moderate length, front matter (such as tables of contents, prefaces, or forewords) is rarely advantageous and is omitted. In long reports, a table of contents will often be helpful. In compilations of several papers, both a preface and a table of contents have advantages. These pages should be numbered with lower-case Roman numerals, beginning with iii on the first right-hand page behind the standard title page. The numbers are centered at the bottom of the page.

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
NASA TN D-7569		

4. Title and Subtitle	5. Report Date
ANALYSIS OF THE DYNAMICS OF A NUTATING BODY	October 1973
	6. Performing Organization Code

7. Author(s)	8. Performing Organization Report No.
William J. Anderson	E-7696
	10. Work Unit No.
	501-24

9. Performing Organization Name and Address	11. Contract or Grant No.
Lewis Research Center National Aeronautics and Space Administration Cleveland, Ohio 44135	
	13. Type of Report and Period Covered
	Technical Note

12. Sponsoring Agency Name and Address	14. Sponsoring Agency Code
National Aeronautics and Space Administration Washington, D.C. 20546	

15. Supplementary Notes

16. Abstract

The equations for the displacement, velocity, and acceleration of a point in a nutating body are developed. These are used to derive equations for the inertial moment developed by a nutating body of arbitrary shape. Calculations made for a previously designed nutating plate transmission indicate that that device is severely speed limited because of the very high magnitude inertial moment.

17. Key Words (Suggested by Author(s))	18. Distribution Statement
Mechanical drives Rotary drives Drives Power transmission Nutation dynamics	Unclassified - unlimited STAR Category 15

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price*
Unclassified	Unclassified	21	$3.00

* For sale by the National Technical Information Service, Springfield, Virginia 22151

SAMPLE 4

CONFIDENTIAL

Presented as sample only - no classified information included.

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
NASA TM X-1898		

4. Title and Subtitle	5. Report Date
PERFORMANCE AND STALL CHARACTERISTICS OF AN AFTERBURNING TURBOFAN ENGINE WITH STEADY-STATE INLET-FLOW DISTORTION (U)	July 1973
	6. Performing Organization Code
7. Author(s)	8. Performing Organization Report No.
David M. Straight and Charles M. Mehalic	E-5240
	10. Work Unit No.
9. Performing Organization Name and Address	720-03
Lewis Research Center National Aeronautics and Space Administration Cleveland, Ohio 44135	11. Contract or Grant No.
	13. Type of Report and Period Covered
12. Sponsoring Agency Name and Address	Technical Memorandum
National Aeronautics and Space Administration Washington, D.C. 20546	14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

The engine was tested at altitude with various patterns and levels of total-pressure distortion created by screens. High-frequency pressure probes provided data on stall lines and flow dynamics. The fan amplified the inlet distortion by amounts dependent on the pattern used, which, in turn, affected the core-compressor performance. Fan and core compressor maps including stall lines are presented. Dynamic core compressor stall data are compared with steady-state stall data, and oscillograph traces of pressures are shown following stalls from fan to core compressor and core compressor to fan. Fan inlet flow reversal near the duct wall occurred during stall. Sample data of fan rotating stalls generated by strong tip radial distortions are included. (U)

17. Key Words (Suggested by Author(s))	18. Distribution Statement
Inlet flow distortion Turbofan engine Engine stall characteristics	Available to U.S. Government Agencies and Their Contractors Only STAR Category 28

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Confidential	Unclassified	108	

"NATIONAL SECURITY INFORMATION"

Unauthorized Disclosure Subject to Criminal Sanctions.

CONFIDENTIAL CLASSIFIED
BY Edward A. Richley, LeRC Security Classification Officer
SUBJECT TO GENERAL DECLASSIFICATION SCHEDULE OF EXECUTIVE ORDER 11652 AUTOMATICALLY DOWNGRADED AT TWO YEAR INTERVALS AND DECLASSIFIED ON DEC. 31 1980

CONFIDENTIAL

SAMPLE 5

1. Report No. NASA CR-2357	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle FEASIBILITY STUDY OF A SATELLITE SOLAR POWER STATION		5. Report Date October 1973 6. Performing Organization Code
7. Author(s) Peter E. Glaser, Owen E. Maynard, John Mackovciak, Jr., and Eugene L. Ralph		8. Performing Organization Report No. ADL-3-74830 10. Work Unit No.
9. Performing Organization Name and Address Arthur D. Little, Inc. 20 Acorn Park Cambridge, Massachusetts 02140		11. Contract or Grant No. NAS 3-16804 13. Type of Report and Period Covered Contractor Report
12. Sponsoring Agency Name and Address National Aeronautics and Space Administration Washington, D.C. 20546		14. Sponsoring Agency Code

15. Supplementary Notes

Final Report. Project Manager, Ronald L. Thomas, Power Systems Division, NASA Lewis Research Center, Cleveland, Ohio

16. Abstract

A feasibility study of a stellite solar power station (SSPS) was conducted to (1) explore how an SSPS could be "flown" and controlled in orbit; (2) determine the techniques needed to avoid radio frequency interference (RFI); and (3) determine the key environmental, technological, and economic issues involved. Structural and dynamic analyses of the SSPS structure were performed, and deflections and internal member loads were determined. Desirable material characteristics were assessed and technology developments identified. Flight control performance of the SSPS baseline design was evaluated and parametric sizing studies were performed. The study of RFI avoidance techniques covered (1) optimization of the microwave transmission system; (2) device design and expected RFI; and (3) SSPS RFI effects. The identification of key issues involved (1) microwave generation, transmission, and rectification and solar energy conversion; (2) environmental-ecological impact and biological effects; and (3) economic issues, i.e., costs and benefits associated with the SSPS. The feasibility of the SSPS based on the parameters of the study was established.

17. Key Words (Suggested by Author(s))	18. Distribution Statement
Solar cells Satellite power system Microwave power Solar terrestrial power	Unclassified - unlimited STAR Category 31

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price*
Unclassified	Unclassified	199	$5.50

* For sale by the National Technical Information Service, Springfield, Virginia 22151

SAMPLE 6

Report Proper

First page of text. - The first page of text includes the title, the names of authors, and the Summary. (The Summary does not extend beyond page 1.) A typical format for this page is illustrated in samples 7 and 8. Certain problems associated with titles or authors and not indicated on the standard title page are resolved by use of footnotes on this page, e.g., when the author's affiliation is different from the source of research at the time of research.

Headings. - In general, NASA reports are subdivided into sections and subsections identified by appropriate headings. Because copy at most NASA centers is prepared with typewriters, the styles of heading illustrated in this section are in type faces generally available on typewriters; however, headings in other type faces are acceptable provided that the grades of heading are comparable.

Use of numbers with headings is not recommended as a standard practice in NASA publications, but numbered headings may be used if there is extensive referral to other parts of a report.

As in all standard outlines, coordinate headings should be in parallel construction. Each heading should have at least one additional corresponding heading; exceptions to this rule include such cases as an occasional short remark or a single example put in to illustrate a method.

The headings of a report are not an integral part of the text but are provided to assist the reader in finding specific information. Each paragraph below a given heading should therefore begin with an opening topic sentence which identifies the subject to be discussed and does not depend on the heading for clarity.

Headings are preferably limited to three grades, i.e., those indicated in the following sample by an asterisk. Others that will be used when extra grades of heading are necessary are also shown:

TRACKING AND DATA SYSTEM

*REQUIREMENTS AND CONFIGURATIONS

Mariner Project Requirements

*Near-Earth Phase

*Data-transmission requirements. - Xmxmxmxmxmxmxmxmxmxmxmxmxmxmxmx xmxmxmxmxmxmxmxmxmxmxmxmxmxmxmxmxmxmxmxmxmxmxmxmxmxm.

Launch-vehicle telemetry data: Xmxmxmxmxmxmxmxmxmxmxmxmxmxmxmx xmxmxmxmxmxmxmxmxmxmxmxmxmxmxmxmxmxmxmxmxmxmxmxmxmxmxmxmxm

PROPERTIES OF CRYSTALLINE BISMUTH SELENIDE AND ITS USE AS A HALL EFFECT MAGNETOMETER

John A. Woollam, Harry Beale,* and Ian L. Spain†

Lewis Research Center

SUMMARY

Single crystals of both n- and p-type Bi_2Se_3 grown by the Bridgman technique are found to make excellent Hall effect magnetometers. Plots of Hall resistivity ρ_{yx} against magnetic field B to 10[illegible] ...nity by less than 1 percent and show no Shunbnikov-[illegible] ...erature. The slope of [illegible]

...uations. Acc...

...s more difficult as higher fi... ...as ...loped. Nuclear magnetic resonance is very ... ...ity of the magnetic field is needed (ref. 2), and it is often difficult to ... a nuclear resonance measurement at the same time that other measurements are performed (ref. 3).

*Research Associate, University of California, Los Angeles, California.

†Associate Professor of Chemical Engineering, University of Maryland, College Park, Maryland.

SAMPLE 7

CONFIDENTIAL

IN-PILE AND OUT-OF-PILE TESTING OF A MOLYBDENUM - URANIUM DIOXIDE CERMET FUELED THERMIONIC DIODE (U)

Dominic C. DiIanni
Lewis Research Center

SUMMARY

The purpose of this program was to determine the irradiation effects on the fuel emitter stability and the thermionic performance. The fueled emitter consisted of a molybdenum- ...oxide ($Mo-UO_2$) cermet a... ...nd ex-

...it was difficult to follow a... ...metallography showed cermet remained intact and appeared to retain much of its strength while providing a path for fission gases to escape.

INTRODUCTION

The thermionic reactor offers the potential of achieving the compact, low specific weight power supply needed to meet future space power requirements. In the reactor many thermionic fuel elements are used to directly convert heat to electricity. In each fuel element are a number of unit cells or thermionic diodes which are electrically connected to provide the power output. Successful operation of a single, long life, reliable, thermionic diode is important in proving this direct conversion concept. Although

CONFIDENTIAL

SAMPLE 8

Numbered items. - The figures, references, tables, and equations in reports are numbered to facilitate their citation at various points in the text. Appendixes are identified by capital letters, except that a lone appendix is known simply as "the appendix." Figures, references, and equations are numbered with Arabic numerals. Either Arabic or Roman numerals may be used for tables, but Roman numerals for very high numbers are not recommended because of their complexity. The numbers for equations are set within parentheses but numbers for figures, tables, and references and letters for appendixes are not. The organization of a report should be such that the figures, references, and similar items are identified in a sequence to agree with the order in which they are introduced. Occasionally, an exception to this sequence may be justified if an incidental citation (e.g., in a symbol list) is included at a point not associated with the actual discussion of the item.

Proprietary identifications. - As a responsible agency operating in the public interest, NASA considers it improper to advertise, endorse, or criticize commercial products in its formal publications available to the general public. Cases in which trade names and similar identifications cannot be replaced by adequately descriptive generic terms should be extremely rare. Evaluations of proprietary products in a report may introduce delays in dissemination of the results to allow review by the manufacturers involved or may require special limitations on distribution of the report. Regardless of how convenient authors may find the use of commercial identifications, attention should in every case be given to their possible deletion for the following reasons:

(1) Use of commercial identifications serves, in effect, to publicize a product and could be interpreted by competitors as endorsement by NASA of another's product.

(2) Evaluations that show a commercial product in an unfavorable light may be objectionable to a manufacturer and could involve NASA in troublesome controversy.

Makeup. - The makeup of a report requires cooperative effort by authors, editors, typists, and illustrators for best results. Because most technical papers include tabulations and illustrative material, some thought as to the best mode of presentation is desirable. Some flexibility in the matter of makeup is considered necessary as a matter of convenience.

The accepted form of makeup places tabular and illustrative material in the text at a point immediately following its discussion, e.g, at the end of that paragraph or at the bottom of the page. Such a format is particularly desirable when the tables and figures are moderate in number and when their insertion does not unduly interrupt the continuity of the text.

When illustrative material is of such volume that its attempted insertion in the text would impair readability, tables and figures are assembled in proper sequence behind the main text, after the appendixes and the references. Usually, tables precede figures in arrangements of this type.

It is possible in a given paper to use a combination of these two types of makeup. If, for example, figures are relatively few, so that their insertion in text is desirable, but tables are voluminous, the tables may be assembled at the end and figures integrated with the discussion.

Terminal source and data line. - A "terminal closing" is provided at the end of most NASA formal reports. This closing includes the name and address of the originating Center and the date of completion of the final version of the report. The date used is roughly representative of the author's sign off on the completely edited manuscript submitted for final typing. The typist adds it, at the time of final typing, about three spaces below the last line of the concluding section (ahead of appendixes and references). A typical setup is as follows.

Lewis Research Center
National Aeronautics and Space Administration
Cleveland, Ohio 44135
July 12, 1973

The date in this formal closure is retained, irrespective of the publication date used on the cover, since publication procedures may introduce delays before final printing and distribution of reports, and this termination date may sometimes be significant in establishing prior work of NASA in a competitive field.

SECTIONS OF THE REPORT

NASA has a recommended organization to be used in most of its formal series reports. This format includes, in general, the following main headings, and their inclusion should be considered by authors in making an outline for their reports:

COSATI technical report standard title page

Summary

Introduction

Symbols (When a separate list is required.)

Main body of paper (This part will have such main headings and subheadings as are deemed useful.)

Concluding Section

Appendixes (When needed.)

References

Introduction

The primary function of the Introduction is to define the subject, the purpose, and the scope of the investigation. The Introduction should also include such information as the relation of the experiment to the general problem, the background and status of the problem, and the significance of the material treated.

The Introduction should include information concerning unusual aspects of a report; for example, such items as a film supplement, a supplementary report, or an appendix prepared by an author other than the author of the rest of the report should usually be mentioned in this section.

No separate section for acknowledgments is provided in the format for NASA publications. If acknowledgments are required for unusual assistance of a technical nature or for collaboration with another agency, such information should be included in the Introduction. Although many NASA employees, such as computer technicians, illustrators, and typists, contribute substantially to every NASA report, such services are considered routine to these employees' positions, and acknowledgments for their assistance are not in order. Neither should acknowledgments be made to supervisors or technical committees whose comments and advice result from regular work assignments.

Symbols and Units

Standards for letter symbols. - Scientists in special fields have over the years established standard letter and mathematical symbols to provide a common basis of understanding in their communications. In recognition of the existence and value of such standards, NASA has adopted the letter-symbol standards established in references 6 and 7 by the American Standards Association (ASA) for use in NASA publications. These two manuals are especially concerned with concepts associated with aeronautics and space studies and should be consulted first in selecting symbols for NASA reports. If conflicts occur or if concepts to be used are not found in these manuals, other standards, such as references 8 and 9, or the notations recommended by the International Union of Pure and Applied Physics (ref. 10) should be consulted. When no standards appear to have been established for other concepts used, the letter symbols found in the literature of a particular technical subject are recommended. The ASA (ref. 6) specifies that single-letter symbols (with subscripts when needed) are preferred over more cumbersome multiletter notations.

Defining symbols. - The writer in a given field of research might expect his audience to recognize without difficulty the symbols that he has chosen to represent the concepts which he uses. Usage is not as general, however, as the writer might suppose;

in addition, reports are sometimes used by workers in other fields. Accordingly, NASA has established the practice in its formal publications of including definitions of all symbols used therein with the exception of chemical symbols, which are discussed subsequently. If only a few symbols are used in a paper, each symbol may be defined where it is introduced. Such definitions may be run in the text or set off from the text in list form. If many symbols occur, they should be listed with their definitions and units as a separate section. This section usually follows directly after the Introduction but may sometimes be an appendix, e.g., when the list is extensive or interrupts the text. An excellent practice sometimes is to include a symbol list for reference and also to define the symbols when they are first introduced. When symbols are defined, either as they are introduced or in a separate section, explanatory information (such as formulas or units) follow the definitions. Unless units are very familiar in a given field, they should not be abbreviated in a symbol list. A separate symbol list is preferably set up alphabetically but may sometimes be arranged in some other logical order. If the list includes symbols from both the Latin and the Greek alphabets, the set of symbols in the Latin alphabet precedes that in the Greek. The list of subscript symbols follows the main symbol list. An example of a symbol list is shown in sample 9.

If it is necessary to use a long, involved expression that recurs frequently, it may be replaced by a single symbol after its first appearance. Symbols for which no standard typewriter keys are available should be avoided because of the difficulty of retaining uniformity when they are drawn in by hand.

When material is quoted or restated from outside sources, any symbols included in the quotation should be defined. Sometimes it may be desirable to change these quoted symbols to avoid conflicts with other symbols used in the report. Even if there are no conflicts, it may be advisable to change the symbols to standard notation if they are obviously nonstandard. Any change in the notation of quoted symbols should be acknowledged; e.g., "Brown has collected a large amount of empirical knowledge on n_h (called n_t in ref. 25)."

Chemical symbols. - No separate list to define symbols for the chemical elements is required in papers allied with the field of chemistry. Even in a chemical paper, however, the names of chemicals are preferably written out, except when formulas are presented or when the terms recur so frequently as to warrant use of symbols. In such cases symbols may be used if elements and compounds are identified at their first occurrence.

Standards for units of measurement. - For some years, efforts have been made in the world community toward the adoption of an international system of weights and measures. In 1960, a significant step was taken by the Eleventh General Conference on Weights and Measures, at which the United States was represented by Dr. A. V. Astin, Director of the National Bureau of Standards. (See ref. 11.) This Conference estab-

SYMBOLS

C_m	pitching-moment coefficient, $M_Y/q_\infty SL$ (see fig. 1)
$C_{m,\alpha=0}$	pitching-moment coefficient at $\alpha = 0^o$
$C_{m_\alpha} =$	$\partial C_m/\partial\alpha$ at $\alpha = 0^o$
F_D	drag force, N
$\vec{i}, \vec{j}, \vec{k}$	unit coordinate vectors
L	reference length, m
l	length of sharp conic bodies, m
M_Y	pitching moment, m-N
$m =$	$\tan\theta_{xz}/\tan\theta_{xy}$
S	projected wing area, m^2
x, y, z	rectangular Cartesian coordinates
α	angle of attack, deg
θ	body half-angle, deg
$\lambda =$	$\cos\alpha\cos\beta = \cos\epsilon$
Subscripts:	
b	conditions at base of body
max	maximum
xy	measured in horizontal plane
xz	measured in vertical plane
∞	free stream

SAMPLE 9

lished the International System of Units (Système International d'Unités, designated SI in all languages), in which the six units previously adopted by the Tenth General Conference were specified as the international basis for a practical system of measurements. In 1971 the Fourteenth General Conference adopted a seventh base unit. These seven base units are:

Physical concept	Measurement	Abbreviation
Length	meter	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Luminous intensity	candela	cd
Amount of substance	mole	mol

Two supplementary units are as follows:

Plane angle	radian	rad
Solid angle	steradian	sr

Practice guides for using SI are presented in references 12 and 13. Physical constants and conversion factors are given in reference 14.

NASA requires the use of SI units in its formal reports (ref. 15). Where this ruling imposes difficulty, writers may consider including the U.S. Customary Units in parentheses following the SI quantity. Waivers are required for any formal report not adhering to this directive. Any report in which both the SI and the U.S. Customary Units are used may include information (in an appendix) explaining the relationships between the two systems.

Main Text

The central theme of a technical paper is developed in the main text. The organization of a report varies according to the type of subject matter. Experimental investigations contain comprehensive descriptions of specimens and apparatus. Theoretical investigations are concerned with abstract ideas and their application to scientific knowledge. Some of the details to be considered in the development of a report are discussed in the sections that follow.

Descriptive information. - A significant part of a research report is the descriptive information necessary to an adequate interpretation of the results.

Reports on experimental investigations should include a section on the apparatus used, the models tested, the materials employed, and the instruments for measurements. Generic terms instead of trade names should ordinarily be used in describing models and equipment. The discussion should be amplified by use of illustrative figures and tables. Information on equipment should be sufficient to provide the reader with an understanding of the techniques used; if details are available in previously published papers, references may be cited for the benefit of readers desiring further information. Quantitative data concerning dimensions and variables should be presented. The conditions imposed should be clearly defined. Previous publications containing related research of a similar type should be referenced. An evaluation of the precision of the equipment and of the data, either as percentages or as actual values, should be provided. This information may be presented when the specimens, instrumentation, and data are discussed or, if sufficiently important, in a separate section under a heading such as "Precision."

Descriptions in theoretical papers are confined to assumed configurations subjected to assumed conditions. The details to be considered must be specified with care.

Mathematical presentations. - Research results are closely associated with the conventions and uses established in mathematics. This discussion is concerned with the details of presenting information of this type. Short mathematical expressions or equations can be treated as a part of the text when it is convenient to do so. All numbered equations, however, regardless of length should be set off and indented or centered on a separate line. In a typed paper equations that cannot be broken and that are longer than the width of a page may be photographically reduced to page width and stripped into position. Punctuation is omitted after displayed equations, but introductory sentences leading into these equations should conform to correct grammatical usage. Instructions for equation setups are given in the GPO Style Manual and are recommended for use in all papers.

Equations needed for reference are numbered as (1), (2), (3), etc., throughout the text. Identifications such as (1a) and (1b) may be used for equivalent or derivative equations. A brace should be used to connect a group of equations with the same number. Equations in appendixes should be numbered either in consecutive order following the equations in the text or preferably as equations (A1), (A2), (B1), (B2), etc. The numbers for equations are usually set flush with the right margin at the end of the equation, with space left for separation from the equation. If space is insufficient to allow the number to be placed after a centered equation, the equation may be set off center. When necessary, the number may be set below the equation. The equation number is used to refer to an equation to avoid repeating it; however, if it is necessary to repeat a

numbered equation, it is given the same number as previously given. The parentheses are retained around the number when the equation is mentioned.

Equations are preferably given in such form that all the concepts involved are expressed by letter symbols. The use of words or phrases should be avoided unless practical considerations indicate them to be desirable; e.g., simple words like "Drag" and "Lift" might be used to avoid defining additional symbols which would otherwise not require definition. The first letter of each such word or phrase should be capitalized if it takes the place of a main symbol; it is not capitalized if it appears as a subscript to a symbol.

In lines containing fractions with horizontal bars, the bars of all fractions are alined and centered on other symbols and numbers not in fractions. A slant line instead of a horizontal bar may be used in equations to keep the terms to the same height and in simple fractions throughout the paper if no misinterpretation will result.

Values repeated in various parts of a paper should be given in the same form; i.e., 1/4, one-fourth, and/or 0.25 should not be used synonymously for one value. In fractions expressed in decimal form, an initial zero precedes the decimal point in the text.

Parentheses, brackets, and braces - in this order - should be used to enclose a part of a mathematical expression used as a unit. Exceptions are made to this order of introduction when special mathematical meaning is indicated such as matrices, functions, and limits.

Results and discussion. - An objective presentation of the results should be given. Tables and illustrations of the results are numbered consecutively as they are introduced. A tabular form for the results is more useful if the readers might want to use the data in a variety of forms; graphs are preferable in showing trends and comparisons. All statements about the results and any numerical values cited should agree precisely with information in the tables and figures.

If data from an investigation are considered of interest to only a few readers, such data may be omitted from a paper to save space and a statement inserted in the text concerning their availability as a supplement. (See section "Supplementary Report Material.")

In short papers the presentation of results may be combined with other sections, such as "Procedure" or "Discussion." The heading should be altered accordingly, e.g. "Tests and Results" or "Results and Discussion."

Discussion of the results, together with their analysis, to show that the conclusions are warranted is an important requirement in the paper. Each major conclusion should be clearly substantiated; any contradictory theories or results should be explored and differences clearly explained. Comparisons with results of similar work by other investigators should be presented when practical. If the results have an immediate appli-

cation, this point should be made in the discussion and, if suitable, an example to illustrate the method of application may be presented. Since NASA publications have an interdisciplinary readership, all statements should be clear to readers who may not be so well acquainted with the subject as the author.

Promises of NASA research to be published and reference to work in progress are to be avoided. Such suggestions in no way enhance the value of the report and might stimulate inquiries that could prove embarrassing, since redirection of a worker's activities often leaves such promises unfulfilled. If results are such as to indicate the need for further research, a simple statement to this effect should suffice. In some papers recommendations for future research may be presented apart from the discussion as a brief concluding section.

Concluding Section

Most formal NASA publications close with a separate concluding section. This section should be self-contained, because many readers will, after a brief glance at the Summary, turn to the concluding section to find out what was learned, and because parts of the concluding section are sometimes quoted verbatim in other documents. Therefore, undefined symbols are not used and reference is not made by number, e.g., to tables, illustrations, or references. The information in the concluding section is drawn from the results presented in earlier parts of the report; each conclusion is supported by the discussion in the main text. No new material is presented in this section.

The generally used headings for this section are Summary of Results, Conclusions, and sometimes Concluding Remarks. Each of these sections has a somewhat different content.

The Summary of Results simply states the major findings of the investigation. It begins with a brief paragraph stating the purpose and the method of accomplishment of the investigation. Frequently, brief itemized statements of the principal factual results are given. These results are obtained from experiment or theory; they are not deduced. The section is only a restatement of facts: All the material presented must have already appeared in the main body of the report.

The Conclusions section properly comprises the deductions, i.e., the conclusions reached from the facts presented. It, too, begins with a brief introductory paragraph. Ideally, conclusions are general; they do not depend on the particular apparatus or conditions of the investigation. If more than one conclusion is drawn, they are presented in order of importance. Already known facts should not be concluded, and conclusions should not be confused with factual results (Summary of Results).

A Concluding Remarks section may be used in place of a Conclusions section when

drawing adequate distinct conclusions is impossible. In this section the author may give opinions, make concise evaluations and appraisals, and give recommendations. The views expressed should, of course, be based on the information provided by the investigation.

Sometimes both Concluding Remarks and Summary of Results are used. This usage allows the concise summarization of the major results of the study, speculation on their meaning, or possible recommendations based on the results. When both sections are used, the Concluding Remarks usually precedes the Summary of Results as a "farther discussion" of the results.

Appendixes

Appendixes present supplementary information that does not logically fit into or might otherwise interfere with an orderly plan for presentation of the text. It is material that is important, but not essential, to the development of the report. Frequently, a report can be improved by relegating some material from long and detailed sections to an appendix. Particularly appropriate for appendixes are involved mathematical derivations; lengthy examples of an analysis described in the report; detailed descriptions of novel techniques, procedures, or equipment not essential to the main purpose of the report; symbol lists; and computer programs.

Each appendix must be referred to at some point in the text and must have a title. When more than one appendix is used, each is identified by a capital letter, A, B, C, etc., in the order mentioned in the report. If only one appendix is used, it carries no letter identification.

Appendixes follow the concluding section and precede the reference list. In general, each appendix begins on a new page, with the appendix designation on the first line and the title below it. The appendix may start on either a right- or a left-hand page, depending on the most desirable makeup achieved.

Appendixes may be written by authors different from those of the report. These appendixes are mentioned in the Introduction in a manner similar to the following statement: "Appendix B by John Doe describes the computer program used in the analysis." Such mention does not determine the letter designation of this appendix. The appendix is lettered in the sequence of its referral in the report proper.

Summary

As indicated in the section "Format for NASA Formal Series," the first main section in a formal NASA publication is the Summary. Although this section appears first in

the published document, it should, by reason of its content, be written last. This section is likely to be read independently of the report proper and should consequently be written as a concise recapitulation of information in the paper as a whole; it may well be picked up by abstractors for use in announcement journals or by reviewers. Its preparation should therefore be directed with this concept in mind. Because of its intended purpose, the Summary is not the place to use undefined symbols, nor to refer to tables, figures, and references by number.

Items to be considered in preparing a summary are the scope and purpose of the investigation, with an indication as to whether it is experimental, theoretical, or both; the range of variables; the important results or conclusions reached; and any limitations of which the reader should be advised. Results or conclusions given in the Summary should be in agreement with those in the concluding section. Redundancies introduced by comparison of these sections are irrelevant, since the Summary has a function independent of the other parts of the report.

The Summary need not be as lengthy as the concluding section but should nevertheless be sufficiently complete to indicate the significant contributions of the report. Except in rare instances, a Summary should be short enough to appear in its entirety on page 1 of the text.

Abstract

All NASA reports must have an abstract that is brief and independent of the text. The abstract appears on the standard title page and is used by library abstracting services and for indexing and retrieval purposes. The abstract briefly states the main features of the report such as the purpose, scope, and major findings; it is, in essence, a condensed form of the Summary. Although the brevity of the abstract may necessitate omission of important results, enough information should be included to assist a potential user in determining whether the report contains the type of information he is seeking. The abstract as well as the title of a classified report should be unclassified in order that the abstract will not be subject to the restrictions required by security regulations.

Title

An important asset to any document is a well selected title. Webster defines a title as "the distinctive designation of a written or printed production." This definition is a most appropriate statement concerning titles of technical publications. Much abstracting and indexing is based only on the title. For this reason alone, the title must be

carefully thought out and worded to convey the maximum amount of information in a minimum number of words. The most effective titles are both short and informative. Titles that begin "Investigation of," "Summary of," "Conference on," "Research on," "Study of," etc., should be avoided. These words unnecessarily lengthen the title and serve to bury the subject.

The final selection of a title should be deferred until the manuscript is finished. By that time, the author will have acquired his broadest viewpoint regarding the contribution and will be in the best position to choose a title that will be sufficiently descriptive of the contents to inform the potential audience of the subject matter.

Because of the cover design of NASA reports, title length should be kept to less than 116 typed spaces. Also, part numbers in titles (I, II, etc.) should be avoided unless at least two parts are published concurrently, or very nearly so. To include a part title is, in effect, a promise of another part, and if delays are encountered or other parts never materialize, such promises may become a nuisance if not an embarrassment. If reports in series are published with part numbers, the main title for all parts is the same and the subtitles are different.

NASA has established the practice of providing unclassified titles and abstracts for its classified publications whenever possible. This practice allows the citation of titles in unclassified documents, bibliographies, and other communications without jeopardy to the security of the documents. The classification of the title is indicated by the appropriate marking in parentheses ((U), (C), (S), (TS) for unclassified, confidential, secret, and top secret, respectively) following the title on the cover, standard title page, and page 1.

Authors

It is desirable for a scientist or technician to give attention early in his career to the name with which his works are to become associated. In a given field, the names of known scientists become meaningful, and a writer should, in the interest of establishing his identity, use his name consistently on his published works. Use by a writer of initials on one report and full given name on another introduces needless inconsistency that can be harassing to librarians and documentalists. Honors, titles, and similar information are not included in authors' bylines.

The author's name follows the report title on NASA covers, title pages, and first pages. Centers with which authors are affiliated are also usually included. If an author's affiliation is different from the responsible Center or other source indicated on the cover as the point of origin of the research, this is stated in a footnote to his name on page 1 of the text (see sample 7) and is noted on the cover and on the standard title page in item 15. No such indication is given for former employees who have resigned or

moved to other stations after having been actively affiliated with the research at the Center of origin of the report.

In papers of joint authorship, the authors' names appear in a sequence that will, in general, indicate the amount of responsibility assumed for the joint effort; that is, the first-named author should be the chief contributor, and other names should follow in the order corresponding to their respective contributions.

When the appendix to a paper is prepared by someone other than the author of the report, the name of the author of the appendix is added below the title of the appendix. This authorship is noted in the Introduction of the report and on the standard title page in item 15. Consideration might sometimes be given to making the author of an appendix a coauthor of the paper; however, if the material in the appendix is sufficiently important to warrant it, this information should probably be included in the main text.

References

Publications referred to in NASA publications are listed in the References section, which is located immediately after the concluding section of the report or, if the report has appendixes, after the last appendix. If the figures and tables are not interspersed throughout the text and are bound at the back of the report, the reference section appears ahead of the tables and figures. The references are numbered in the order of their mention in the text, tables, and figures. References used in a table or figure, if not cited elsewhere, may be mentioned in the text where the table or figure is discussed.

If a bibliography is presented in addition to or in place of the reference section, the publications in it are not numbered and are listed alphebetically according to author, listed chronologically, or grouped according to subject.

Only documents that the author has actually seen may be referenced. If he cannot obtain the original material and must use a secondary source, the citation given will be the secondary source. However, if mention of the original source is necessary, it may follow the secondary source in parentheses.

When surveying the literature for source material, the author should check the availability of the material. Material that is not obtainable must not be referenced. Similarly, limited-distribution documents must not be referenced unless absolutely necessary. If referencing any such material is necessary because the author is citing basic data that may not be repeated, written permission to reference the document must be obtained from the office controlling the report. If permission is granted, the source is given parenthetically with the reference. If the reference is available from the Defense Documentation Center, the AD number is given. Only formal documents may

be listed as references. Acknowledgment of other informal sources, such as private communications, if necessary, should be made in the text; e.g., "(private communication from John Doe, Blank Co., City, State)."

Unpublished NASA reports may not be cited in the reference lists of published NASA reports unless they are being processed as unlimited-distribution publications and have been assigned a report number by NASA Headquarters.

Articles that have been accepted (not merely submitted) by journals for publication may be cited, but the reference must be followed by a parenthetical note: "(To be published)."

Copyrighted material may be referenced without obtaining permission of the copyright holder, but permission must be obtained for direct quotation or reproduction of any part of such material. In order to avoid delaying the report, permission should be sought as soon as the decision is made to use the material.

Documents of higher classification than the report may be cited if the title of the reference is of no higher classification than that of the report. In addition, material or data discussed or quoted must not be of higher classification than that of the report.

Correct citation of a reference is an important responsibility of the author. In particular, the final draft of the report should be carefully checked to make certain no errors have crept into the reference list. Each reference should contain the following information in the order given:

1. Author: Surname, first name or initials as given on the reference. If anonymous, the listing is started with the title.

2. Title: Exact title as given.

3. Subtitle: If on separate line from main title, separate by a period; otherwise exactly as written.

4. Source: (a) Book: Volume number and subtitle, if any; edition; publisher; place of publication if publisher is foreign or not well known; date (use copyright date if no other date appears); page numbers (optional). (b) Periodical: Name of periodical; volume; number; month; year; inclusive pages. If title of periodical has changed, give correct title for issue cited. (c) Individual reports (e.g., NASA, NSF, etc.): organization report number; year. (If the name of the organization is not part of the report number, the name of the organization follows the report number.)

If several different parts of a publication are referred to at various places in a report, the page that the specific reference occurs on is given at the place of mention; e.g., "(ref. 12, p. 7)." These pages are not listed at the end of the reference.

Some typical reference forms are as follows:

Books

One edition:	Johnson, Leonard G.; The Statistical Treatment of Fatigue Experiments. Elsevier Publishing Co., 1964.
Revised edition:	Brewster, Ray Q.; and McEwen, W. E.: Organic Chemistry. Second ed. Prentice Hall, Inc., 1959.
One volume of a series:	Bowden, F. P.; and Tabor, D.: The Friction and Lubrication of Solids. Part II. Clarendon Press (London), 1964.
Foreign book:	Flügge, W.: Statik und Dynamik der Schalen. (Statics and Dynamics of Shells.) Julius Springer (Berlin), 1934.
Translation:	Jost, Wilhelm (Huber O. Croft, transl.): Explosion and Combustion Processes in Gases. McGraw-Hill Book Co., Inc., 1945.
Edited book:	Smithells, Colin J., ed.: Metals Reference Book. Vol. III. Fourth ed. Plenum Press, 1967.
One section of an edited collection:	Wiederhorn, S.: Effects of Environment on the Fracture of Glass. Environment-Sensitive Mechanical Behavior, A. R. C. Westwood and N. S. Stoloff, eds., Gordon & Breach Sci. Publ., Inc., 1966, pp. 293-317.
Section of a book:	Sasser, James H.: Photographic Summary of Apollo 11 Mission. Apollo 11 Preliminary Science Report, NASA SP-214, 1969, pp. 9-33.
Book compiled by a staff:	Battelle Memorial Institute: Prevention of the Failure of Metals Under Repeated Stress. John Wiley & Sons, Inc., 1941.
Book of anonymous authorship:	SAE Handbook. Soc. Automat. Eng., Inc., 1949.

Periodicals

Foreign:	De Haller, P.: Das Verhalten von Tragflügelgittern in Axialverdichtern und in Windkanal (The Behavior of Airfoil Grids in Axial Compressors and in a Wind Tunnel). Brennstoff-Wärme-Kraft, Bd. 5, Heft 10, Oct. 1953, pp. 333-336.

American:	Parker, R. J.; and Zaretsky, F. V.: Rolling Element Fatigue Lives of Through-Hardened Bearing Materials. J. Lub. Tech., vol. 94, no. 2, 1972, pp. 165-173.
Paper with discussion in same issue:	Beitler, S. R.: The Effect of Pulsations on Orifice Meters. Trans. ASME, vol. 61, no. 4, May 1939, pp. 309-312; discussion, pp. 312-314.
Paper with discussion in different issue:	Goland, Martin; and Luke, Y. L.: The Flutter of a Uniform Wing With Tip Weights. J. Appl. Mech., vol. 15, no. 1, Mar. 1948, pp. 13-20. (Discussion by R. H. Scanlan, vol. 15, no. 4, Dec. 1948, pp. 387-388.)

NASA-NACA Publications

Technical Report:	Miller, C. D.: Simultaneous Correction of Velocity and Mass Bias in Photography of Meteors. NASA TR R-280, 1968.
Technical Note:	Spalvins, Talivaldis; and Brainard, William A.: Effect of Surface Topography on Structural Growth of Thick Sputtered Films. NASA TN D-7577, 1974.
Technical Note with appendix by a different author	Akey, Norman D.; and Cross, Aubrey E. (appendix A by Thomas G. Campbell; appendix B by Fred B. Beck; appendix C by W. Linwood Jones, Jr.): Radio Blackout Alleviation and Plasma Diagnostic Results From a 25 000 Foot Per Second Blunt-Body Reentry. NASA TN D-5615, 1970.
Technical Memorandum:	Costakis, William G.: Analog Computer Implementation of Four Instantaneous Distortion Indices. NASA TM X-2993, 1974.
Contractor Report, low-number series:	Rohatgi, Upendra; and Reshotko, Eli: Laminar Flow Between Stationary and Rotating Disks With Inflow. NASA CR-2356, 1974.
Contractor Report, high-number series:	Kamotani, Yasuniro; and Greber, Isaac: Experiments on a Turbulent Jet in a Cross Flow. (FTAS/TR-71-62, Case Western Reserve Univ.; NASA Grant NGR-36-027-008.) NASA CR-72893, 1971.

Special Publication: Gunter, Edgar J., Jr.: Dynamic Stability of Rotor-Bearing Systems. NASA SP-113, 1966.

Tech Brief: Carter, Paul D.; Layton, Robert E.; and Stratton, Francis W.: New Concept in Brazing Metallic Honeycomb Panels. NASA Tech Brief B73-10358, 1973.

Report: Reissner, Eric: On the Theory of Oscillating Airfoils of Finite Span in Subsonic Compressible Flow. NACA Rep. 1002, 1950. (Supersedes NACA TN 1953.)

Research Memorandum: Wier, John E.; Pons, Dorothy C.; and Axilrod, Benjamin M.: Effects of Molding Conditions on Some Physical Properties of Glass-Fabric Unsaturated-Polyester Laminates. NACA RM 50J19, 1950.

Foreign-Government Publications

British R. & M.: Squire, H. B.; and Trouncer, J.: Round Jets in a General Stream. R. &. M. No. 1974, British A.R.C., 1944.

College or University Research Publications

Bulletin: Fried, Bernard; and Weller, Royal: Photoelectric Analysis of Two- and Three-Dimensional Stress Systems. Bull. 106, Eng. Exp. Station, Ohio State Univ. Stud. Eng. Ser., vol. IX, no. 4, July 1940.

Thesis: Krebs, Charles V.: Determination of Stress Concentration Factors for Hyperbolically Notched Tension Members. M. S. Thesis, Univ. of Notre Dame, 1950.

Research report: Prager, William: On Higher Rates of Stress and Deformation. Tech. Rep. 72, Brown Univ., 1961.

Commercial Publications

Industrial report: Garcia, R.; and Lewis, R. L.: Critical Loading Requirements for the SRE With Thorium-Uranium Fuel. NAA-SR-6608, North American Aviation, 1962.

Conference Publications

Proceedings: Sputtering and Ion Plating. NASA SP-5111, 1972.

Edited Proceedings: Clementel, E.; and Villi, C., eds.: Conference on Direct Interactions and Nuclear Reaction Mechanisms. Gordon & Breach Sci. Publ., Inc., 1963.

One paper from a conference: Mattox, Donald M.: Ion Plating - Concepts and Applications. Sputtering and Ion Plating. NASA SP-5111, 1972, pp. 11-40.

Hancock, J. F.; and Hinson, B. L.: Inlet Development for the L-500. AIAA Paper 69-448, June 1969.

Secondary Reference

Sternglass, Ernest J.: Backscattering of Kilovolt Electrons from Solids. Phys. Rev., vol. 95, no. 2, 1954, pp. 345-358. (Primary source - Palluel, Paul: The Mechanism of Electronic Rediffusion of Metals. Compt. Rend., vol. 224, June 2, 1947, pp. 1551-1553. (In French.))

Patent

Endrey, Andrew Laszlo: Aromatic Polyimides from Meta-Phenylene Diamine and Para-Phenylene Diamine. U.S. Patent 3,179,633, Apr. 1965. [Use case number when referencing a patent application title.]

Limited-Distribution Publication

Heathman: John H.: Hydrogen Tankage Application to Manned Aerospace Systems. Phases II and III. Vol. I. Design and Analytical Investigations. Rep. GDC-DCB68-008, Vol. I, General Dynamics/Convair, 1968. (Available from DDC as AD-833232.)

TABLES

Tables present information in an exact, highly concentrated form. The underlying principles in arranging tabular material are clarity and simplicity. Although there are rules which apply to tables generally, each table presents an individual problem which requires some thought as to arrangement.

For conciseness, commonly known abbreviations are used in tabular material. Units of measurement are always abbreviated.

In addition to simple tables, which are left unruled, there are ruled columnar tables, in which similar data are grouped under boxheads identifying appropriate parameters (sample 10), and leaderwork tables, in which dissimilar data are listed in rows with leaders connecting each parameter with the corresponding value (sample 11).

Whenever possible in columnar tables, the author should give all comparable values to the same number of decimal places; however, such forms as 0.00 are usually unnecessary. Tabular decimal values such as 2.300 should not be changed to 2.30 or 2.3 if the degree of accuracy of the values might be affected. The minus sign is given with all negative values; no space is left between the minus sign and the value. Plus signs are not used to indicate positive values but may be used to indicate such information as direction. If a column of values has a multiplying factor, the factor should be placed after the top value (other than zero) and not in the boxhead. If the first number in a column or under a cross rule is wholly a decimal, a cipher is added at the left. Initial zeros and multiplying factors are repeated under a cross rule. When an explanation is offered for a missing value in a column, a footnote is added and the footnote reference mark is given in parentheses at the proper place. If identical values are obtained as test values, either they are repeated or the value is given once and an arrow is drawn down the column to the next different value. If test conditions are identical for several test values, the conditions are given only once for a group of values to which they correspond. This grouping within columns may be shown by single horizontal rules or by spaces. If rules or spaces are impracticable, connected data may be indicated by braces.

If a table has subdivisions for different conditions, the heading for the first condition is inserted directly after the lower cross rule of the boxheads. (See sample 10.) It is centered and separated from the data by a complete horizontal rule. Vertical rules do not cross subdivisions. Comparable subdivision headings are written in the same style. Boxheads and units are not repeated if they are alike for all conditions, but the columns are alined.

Column headings and rows in tables should not be numbered except when necessary for reference. The numbers should then be placed above the columns or in the stub of a row in parentheses or circles and set off by a cross rule.

Leaderwork tables usually do not have rules or column headings. (See sample 11.) This type of table presents a list of different conditions pertaining to a particular subject.

TABLE I. - TENSILE PROPERTIES OF RECRYSTALLIZED[a] TUNGSTEN AND MOLYBDENUM

[From ref. 2.]

Temperature, K	Specimen type (b)	Ultimate tensile strength, Pa	Elongation between buttonheads, cm	Reduction of area, percent
Tungsten				
1700	1	$220\ 019 \times 10^3$	1.57	95
1900	1	131 280	1.60	75
2060	1	98 736	.69	36
2260	1	67 433	.51	25
Molybdenum				
1650	2	$93\ 013 \times 10^3$	0.95	96
1922	2	40 680	1.55	99
2255	2	14 720	1.75	99

[a]Recrystallized at 2370 K for 1/2 hr in vacuum.
[b]Specimen types are shown in fig. 6.

SAMPLE 10

TABLE V. - PERTINENT PHYSICAL CHARACTERISTICS AND DIMENSIONS OF THE TEST AIRPLANE

Total wing area, S, m^2	130
Wing span, b, m	35
Wing aspect ratio, A	9
Wing thickness ratio, t/c	0.12
Wing taper ratio, λ	0.42
Wing mean aerodynamic chord, $\bar{c}$, m	4
Wing sweepback (25-percent-chord line), Λ, deg	35
Total horizontal-tail area, S_t, m^2	24
Horizontal-tail span, b_t, m	10
Horizontal-tail mean aerodynamic chord, c_t, m	2.6
Horizontal-tail sweepback (25-percent-chord line), Λ_t, deg	35

SAMPLE 11

Frequently, a quantity, its symbol, and unit (or such information as is applicable) are given on the left with the values of the quantity given on the right. The space between the quantity and value is filled with leader dots.

Insofar as possible, each table should be self-explanatory, a unit independent of the text. Tables are numbered consecutively with Roman or Arabic numerals in order of their mention in the text. Exceptions to this are short tables which are part of the text and which follow an introductory statement, such as "Results of this test are given in the following table:". These tables are not numbered, do not have titles, and are not referred to elsewhere in the text.

The title is an integral part of the table and should be as exact and descriptive as possible. Additional information that applies to all the data in the table is given in a bracketed headnote beneath the title. (See sample 10.) Tables presented on more than one page are titled "TABLE IV. - Continued."; the actual title is not repeated. For the last page of a continued table, the word "Concluded" is used instead of "Continued." If subtitles are necessary they are centered beneath the title or beneath the bracketed headnote and designated by letters in parentheses.

Boxheads should be brief; if necessary they may be amplified by footnotes. Boxheads usually contain such information as quantity, symbol, and unit, separated by commas. Only the initial letter of the first word is capitalized. Material in boxheads is set up horizontally if possible. Periods are not used following boxheads but a dash (or, sometimes, a colon) is used if boxhead material reads into the following matter.

Footnotes may be used to explain or amplify a title, boxhead, or value. (See sample 10.) Footnote reference marks are lowercase letters and begin anew for each table. If a footnote pertains to an entire column, the reference mark is enclosed in parentheses and placed at the bottom of the boxhead, just above the column rule. Footnote reference marks are placed before numbers and after words and are introduced in a table from left to right and from top to bottom. The reference mark for a footnote referring to the entire title of a table is placed at the end of the title; the mark for a footnote referring to a part of the title is placed with that part.

Where practicable, tables should be inserted in the text as near (preferably following) their first mention as possible. A table may be placed on a page upright (preferably) or sideways. The typed text may run above, below, or around a small table, or several tables may be grouped together on a page. Where tables are voluminous or their insertion unduly interrupts the flow of the text, they may be grouped in proper sequence following the text. (See "Makeup.")

For large typewritten tables, attention must be given to the relative dimensions of the printed page. Ideally, typewritten letters and numbers should not be reduced more than one-half. Tables which would require a reduction greater than one-half should be rearranged. Large tables requiring excessive reduction may be run across facing pages.

Single rules are used in tables except for special cases. Long narrow tables may be

divided into halves, thirds, etc., and doubled up with two vertical rules separating the parts. In such doubled-up tables, the boxheads are repeated.

Sketches may be part of a table, if the combination causes no makeup difficulties. A sketch that is part of a table is never considered a numbered figure.

Electronically tabulated data are not typed but are printed directly from the printout sheet. If possible, authors should have the headings and setup checked by an editor before obtaining printouts to ensure that there are no production problems. No changes (such as adding initial ciphers to decimal fractions) are made in printout data. It is most important that printouts be clear and sharp for readability on microfiche.

FIGURES

Layout

Figures (photographs, drawings, and graphs) are numbered with Arabic numerals in the order of their mention, unless the mention is clearly incidental. They are either inserted in the text near (preferably following) their first mention or grouped together at the back of the report. Exceptions to the requirement for numbering figures are permissible for small sketches which are part of the text and which follow an introductory statement such as ". . . shown in the following sketch:". Such unnumbered sketches do not have a legend and are not referred to elsewhere in the text. Under no circumstances should the arrangement of figures or parts of one figure be out of sequence. Figures arranged in a group are in sequence from top to bottom or from left to right.

The size of the printed figure including the legend cannot exceed the dimensions of the report image area. Within these limits, various sizes, proportions, and arrangements of figures are possible. Two or more figures may be grouped on a page, upright (preferably) or sideways, or the typed text may run above, below, or around a small figure.

Report figures should be prepared with consideration for their appearance in the final printed version. Because figures in final reports cannot be reproduced larger than page size, an effort should be made to keep the lettering scale of original figures to a suitable size. It is important that all lettering and lines be large and heavy enough for legibility after the contemplated reduction. The complexity of a drawing or graph determines the size of the printed figure.

All lettering and numbers in a figure should read according to the position of the legend on the page when possible. Sidewise labels should be positioned to read from the bottom of the figure upward.

Oversize figures requiring gatefolds in the printed copy are to be avoided. Consideration should be given to presenting such a figure in parts on separate pages or running the figure broadside across facing pages. Large-scale charts of interest to a limited

audience may be prepared for distribution on request, as suggested in the section "Supplementary Report Material," and a simplified or reduced-size figure inserted in the report to indicate the content of such a chart, if appropriate.

Photographs

The photographs used in a report should be selected for the purpose of clarifying the text. Unnecessary and repetitious photographs are to be avoided. In many cases simple sketches are more informative than photographs.

Rules for labeling photographs are the same as those given for drawings. Although a photograph should have no superfluous details in the background, a familiar object or a scale may be included to show comparative dimensions.

If a photograph shows a magnified object, the magnification is indicated in the legend or on the photograph. Such a figure should be reproduced without reduction or enlargement to maintain this magnification.

Photographs submitted for reproduction must be glossy prints, clear in detail, of good tone gradation, and unmarred by marks or scratches. Photographs that may be difficult to reproduce should be accompanied by additional prints with the important areas encircled for special attention by the printer in reproduction.

Drawings

Particulars of a drawing are designated directly on the drawing by labels. The first word of a label is capitalized and no period is used at the end. Block form may be used for labels. When space limitations require that the particulars be identified by letters or numbers rather than words, these identifying labels should begin with A or 1 in the upper left part of the figure and proceed from left to right in horizontal rows whenever practicable. These numbers or letters should be identified either in a key (see "Keys," p. 43) or in the legend.

When parts of a drawing must be differentiated, shading rather than color is used. Commercial adhesive overlay material with variously sized and spaced black dots or lines is available for this purpose.

Graphs

Because line graphs are the type of chart most often used to present data in NASA papers, the rules and examples in this section apply primarily to that type; however, other types of chart such as bar graphs may be used if the data are best presented in such a manner. The rules are as follows for the various parts of a line graph.

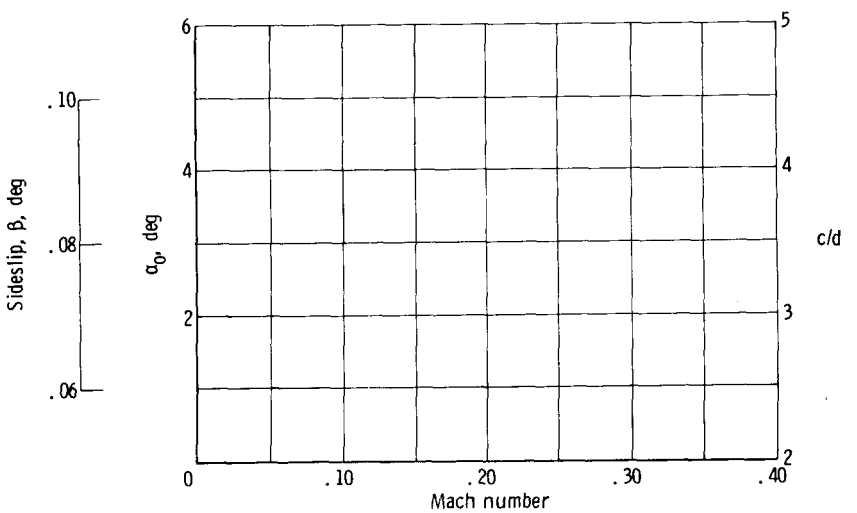
Grid. - When line graphs are prepared on grid paper as reproducible copy, green,

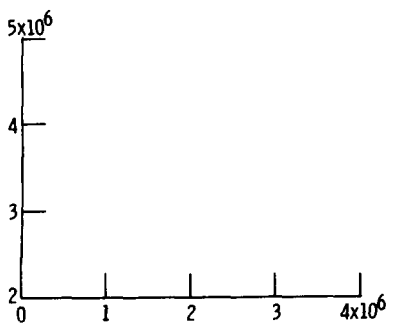
blue and black, or orange grid paper may be used. Blue and black grid paper is specially prepared to be used when only coarse grid is to be retained. Green grid paper should be used for showing trends and comparisons when no grid lines are to be retained. Tick marks or grid lines must be drawn on the green grid paper. If data are to be read precisely from the figure and the retention of all grid is desired, orange grid paper should be used. Special care must be taken in plotting on orange grid paper because erasures will show. Also all labels, keys, etc., should be on white paper pasted neatly over the grid.

Except for logarithmic plots and other such special plotting systems, grid blocks should be squares whenever possible. Scale values should be selected with this in mind. Unless extra grid blocks are desirable for correct proportions or for possible extrapolation of curves, grid blocks should extend to include only the limits of the curves.

Scales and scale labels. - Scales are usually set up in standard form; that is, positive scale values apply to the first quadrant. Scale intervals should be such that interpolation is simplified.

Scale labels and values are placed outside the grid. If a figure has two scales, both may be placed on one side of the figure, or they may be placed on opposite sides. Although ordinate scales have been used for illustration, these rules apply also to abscissa scales.





If the scale values are so large that they are best shown by a multiplying factor, the factor should be written after the highest value and not after the scale label; on the ordinate scale this factor should be placed as shown in the example. When scale values are decimal values, the initial zeros are omitted.

When the ordinate and abscissa scales intersect at the point (0, 0), only one zero is used. The zero is alined horizontally with the other abscissa values and vertically with the right-hand numeral of the other ordinate scale values. When an ordinate scale is given on the right-hand side of a figure, the zero value is alined with the left-hand numeral of the other ordinate scale values.

A quantity, its symbol, and its unit (or as much of this information as is desirable and appropriate) are given in a scale label and are separated by commas. The first letter of the first word of the label is capitalized and no period is used at the end. The unit is abbreviated. When simple fractions occur in both abscissa and ordinate scale labels, they should be set up similarly.

Scale labels are placed on the outer side of scale values. For easy reading, ordinate scale labels are preferably written horizontally; however, long ordinate labels are written vertically. The second and succeeding lines of a label are usually centered under the first.

When separate graphs are made for the multiple parts of a figure, using a common set of scales for these parts may be desirable. The scales and labels need not be repeated for the parts of a figure on a given page:

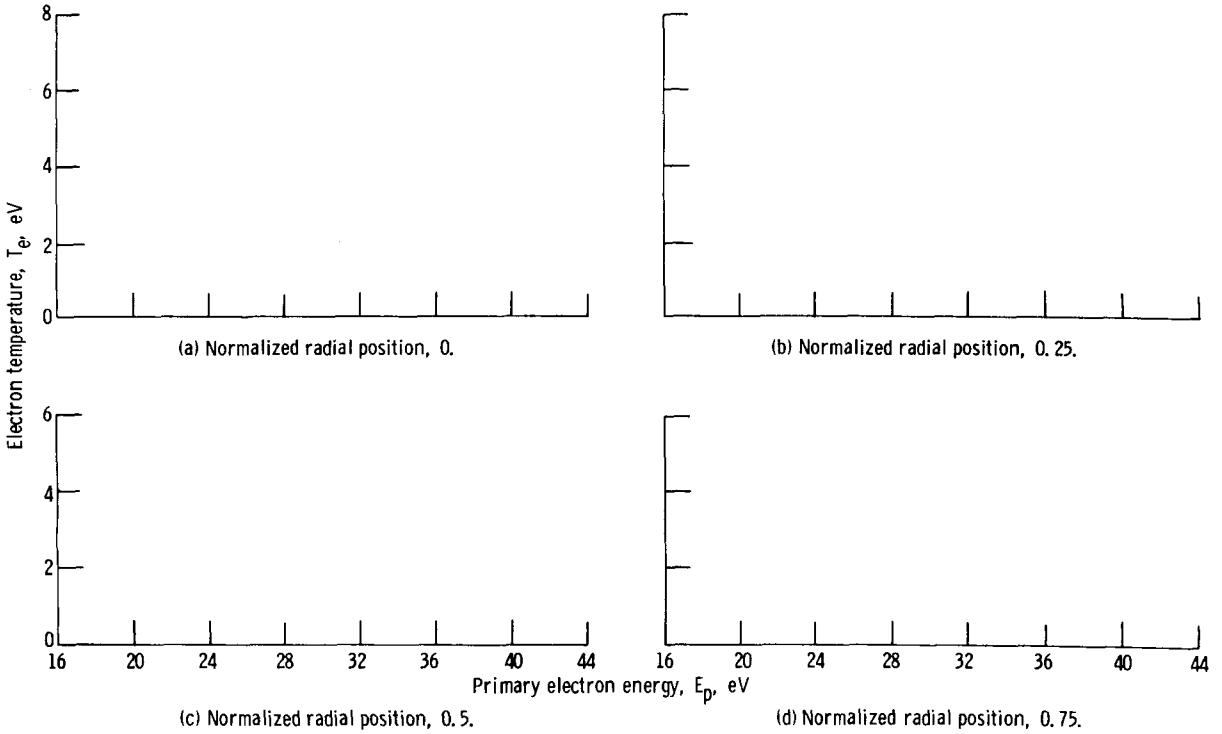
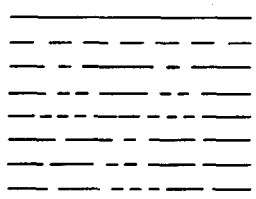


Figure 14. - Variation of electron temperature with primary electron energy.

Curves and curve labels. - Dashed and solid lines are used to differentiate curves. Colored lines are not used. In any one report the same line should be used to represent the same condition in related figures. The preferred line order for the introduction of different kinds of curves in a figure is as follows:



Curves are usually not broken for any reason other than to indicate a gap in the data. All labels must be placed outside the path of the curve and must not interfere with possible extrapolation. Curves adjoin, but do not cross, test-point symbols.

Curves presenting experimental test data ordinarily are substantiated by test points. No test points should show on curves resulting from cross-plotting or on curves showing purely mathematical relationships.

When identification of curves is needed, labels should be used unless there are so many curves that the lettering would cause difficulty in reading the curves. In such cases keys may be used. Whenever practicable, curve labels are preferably grouped together and headed by their quantity and unit. Word labels have the first letter capitalized and no period at the end. When curve labels are decimal fractions, initial zeros are used only with the value on the first curve. When equations are used for curve labels, an initial zero is used.

If they add to the clarity of the graph, leaders may be used from curve labels to curves. Leaders should be as short as possible. Preferably, they are angled slightly, composed of very short dashes, and positioned so that they cannot be mistaken for data curves.

Test-point symbols. - The following order for introduction of symbols is suggested:

If data for more test conditions are to be plotted, these may be oriented in different directions to furnish more symbols The symbols + and × should not be used and solid or partly filled-in symbols should be avoided if there is any overlapping of symbols. Flags may be added in different positions to all the given symbols. Such symbols should be plotted so that the flags do not coincide with curves, grid lines, or other symbols. All symbols within one figure should be the same size.

In any one report, the same symbol should be used to represent the same condition in related figures or in a group of curves within one figure. If it is desirable to use similar symbols for different sets of data, the following types of differentiation may be applied to the symbols:

Keys. - When keys, instead of labels, are used in figures, the following setups are typical for identification of lines, test-point symbols, or both:

Propeller speed, rpm		Propeller speed, rpm		Propeller speed, rpm
———	1000	○	1000	—○— 1000
– – – –	1350	□	1350	—□— 1350

The heading is centered over the values rather than the entire key and the second and succeeding lines are usually centered under the first. When the items within the key are word labels instead of values, hanging indention may be used if space is available. Setups of keys in general follow the rules for tabular material and should be uniform for similar figures in any one report.

Whenever possible, keys are placed within the grid. If necessary, keys may be placed at the side or at the top of the figure outside the grid. If several parts of a figure are grouped together on a page, only one key is necessary for the group. However, if a figure consists of several parts that are each page size, they should have individual keys.

Figure legends. - Figure legends should be concise, but adequately descriptive. All explanatory matter and test conditions that are not a part of the key or labels should follow the main legend. A series of similar figures may be made into a composite figure with each part given an appropriate sublegend. The sublegends, designated by (a), (b), (c), etc., should be centered under the parts of the figure to which they refer. If several parts of a figure are on separate pages, the main legend is given once on the first page. On the following pages, the main legend (with the sublegend centered above it) is written "Figure 2. - Continued." and on the last page, "Figure 2. - Concluded."

GRAMMAR AND ENGLISH USAGE

The capabilities of scientists are reflected in the quality and lucidity of their writing. A researcher has an obligation not only to develop new scientific concepts but also to inform others of them; and to accomplish his aims, he should be able to write with clarity. No special literary talent is needed for good technical reports. The more important ingredients of clear writing are logical thinking, accurate use of English, and a continuing effort to avoid ambiguity and involved sentences or discussions.

Authoritative reference works on the use of language should be as much a part of the research writer's library as are the commonly used handbooks on science and technology. The GPO Style Manual (ref. 1), however, is the NASA authority in matters concerning variant spellings and contains, as well, comprehensive chapters on compounding and punctuation. No purpose will be served in listing the commonly accepted rules of grammar and punctuation, but a few rules that represent desirable conventions are specified here in the interest of establishing uniformity in NASA reports.

A sentence should not begin with a letter symbol or with a numeral. The concept for the symbol or the number for the numeral should be spelled out or the sentence should be recast. For example, "The frequency ω is replaced by its equivalent as given in equation (1)." not "ω is replaced by . . . ."

Government Printing Office rules for compounding should be followed in most cases. Prefixes are generally closed up unless omission of the hyphen introduces ambiguity.

The comma should be retained before "and" and "or" in constructions connecting words or phrases in series.

A space will be used instead of a comma in numbers of five or more digits to separate digits in groups of three, e.g., 6000, 40 000, 3 000 000. In four-digit numbers neither a space nor a comma is used, except in columns with larger numbers. This usage is in compliance with the SI.

ABBREVIATIONS

Usage

The principles to be followed in use of abbreviations in NASA reports are essentially those recommended in the GPO Style Manual; namely, "to conserve space and to avoid distracting the mind of the reader by needlessly spelling out repetitious words and phrases." Indiscriminate use of abbreviations in the text of a report when space is not a consideration should be avoided. The abbreviations presented in the GPO Style Manual should be followed except where at variance with the lists presented here. The abbreviation forms adopted in the SI (ref. 11) and by the International Union of Pure and Applied Physics (ref. 10) are in general agreement, and NASA has consequently given them

preference over the forms listed in the GPO Style Manual. For abbreviations of U.S. Customary Units, forms given by ASA (refs. 16 and 17) are used. These forms omit internal and terminal punctuation, except where such omission may introduce ambiguity.

Abbreviations for government agencies and other names that recur frequently in a paper may be used after the full name has been given once, together with the abbreviated form in parentheses.

The degree sign is used with numerals to indicate either angles or temperatures; for example, an angle of 40°, 10° of wing sweep, or a temperature of 120° C. (Note, however, that the degree sign is not used with K (kelvin).) The abbreviation "deg" is used in scale labels and column headings for angles but the degree sign is used with temperature designations. Examples: Angle of attack, α, deg; Temperature, T, $^{\circ}$C.

Abbreviations such as e.g., etc., cf., i.e., and viz may be used in the text if desired. Abbreviations for mention of numbered equations, figures, references, or sections of references are used only within parentheses. Except for the noted abbreviations, parenthetical material follows the usage of the rest of the text. In tables, figures, and footnotes, abbreviations are used for economy of space except in titles and legends.

In reference lists, abbreviations are used for all source material cited after the title of a cited reference. The forms presented in Chemical Abstracts (ref. 18) are accepted as authoritative for periodical abbreviations.

Lists

Words in the following lists are preferably abbreviated as shown, in accordance with the rules prescribed in the preceding section. Nonstandard abbreviations are allowable in rare cases when the text explains their use. Additional abbreviations should be selected from recognized authorities in accordance with these and other principles exemplified by the abbreviations listed.

General scientific terms. - Some items in the list on general scientific terms will be noted to have more than one abbreviation given. The different forms are ascribed to differences in usage in different scientific areas and among different groups. Although the forms established in the SI are favored, their use is sometimes confusing. For example, in a scale label a notation such as "Time, t, s" will attain greater clarity if written "Time, t, sec" or "Time, t, seconds." It should be noted that some changes in abbreviations heretofore commonly used in American literature have been changed in accordance with SI usage. The principal change is associated with the use of capital letters to abbreviate the units named for famous scientists; examples are V for volt, A for ampere, P for poise, and dB for decibel.

abridged	abr.
aerodynamic center	a.c.
alternating current	ac
altitude	alt
American Standards Association	ASA
ampere	A
angstrom	Å
anonymous	anon.
approximate	approx
atmosphere	atm
atomic mass units	amu
atomic weight	at. wt.
audiofrequency	af
average	av
astronomical unit	AU
balance	bal.
barn	b
bits per second	bps
body-centered cubic	bcc
calculated	calc
center of gravity	c.g.
center of mass	c.m.
center of pressure	c.p.
centipoise	cP
chapter, chapters	ch., chs.
chemically pure	cp
circular	cir.
coefficient	coeff
cologarithm	colog
copyright	c.
coulomb	C
counts per second	counts/sec
critical	crit.
cycle	spell out
cycles per minute	cpm
cycles per second (hertz)	Hz
debye	D
decibel	dB
degree (separated from numbers)	deg
degree (with numbers)	^{o}
degrees Celsius	^{o}C
degrees Fahrenheit	^{o}F
degrees Rankine	^{o}R
diameter	diam
direct current	dc
disintegrations per second	dis/sec
eastern standard time	EST
efficiency	eff.
electric, electrical	elec.
electromagnetic units	emu
electromotive force	emf
electron volt	eV
entropy unit	eu
equation, equations	eq., eqs.
experiment, experimental	exp.
exponential	exp
exponential integral	Ei
external	ext.
face-centered cubic	fcc
feet per second	fps or ft/s
figure, figures	fig., figs.
Greenwich mean time	GMT
government	govt.
gravitational unit	g
henry	H
hexagonal close packed	hcp
hour	h or hr
inch (but in^2, in/hr, in-lb)	in.
intermediate frequency	i.f.
internal	int.
international	int.
International Critical Tables	ICT

International Standards Association	I.S.A.
joule	J
kelvin	K
kinetic energy	KE
kips per square inch	ksi
latitude	lat
leading edge	L.E.
lens aperture (of 8)	f/8
limit	lim
linear	lin.
liter (but kl, ml)	spell out
logarithm (common)	log
logarithm (natural)	$\log_e$ or ln
magnetomotive force	mmf
magnified 50 times	X50
maximum	max.
mean aerodynamic chord	M.A.C.
mean effective pressure	mep
melting point	mp
microampere	μA
mile	spell out
miles per hour	mph
milliampere	mA
milli-mass-units	mmu
million electron volts	MeV
minimum	min.
minute (time)	min
minute (angular measure)	'
molar	M
mole	spell out
nautical mile	n. mi.
newton	N
nuclear magneton	nm
number, numbers	no., nos. or No., Nos.
observed	obs
ohm	spell out or Ω
page, pages	p., pp.
percent	spell out or %
pounds per square inch	lb/in^2 or psi
pounds per square inch absolute	psia
radian	rad
radiofrequency	rf
radius (no period when a unit)	rad.
reference, references	ref., refs.
revised (spell out if confusing)	rev.
revolutions per minute	rpm
revolutions per second	rps
root mean square	rms
Saybolt Universal (or Furol) Seconds	SUS, SFS
second	sec or s
second (angular measure)	''
section	sec
specific fuel consumption	sfc
specific heat	sp. ht.
temperature	temp.
tesla	T
theoretical	theor.
thousand pounds	kip
trailing edge	T.E.
ultraviolet	uv
university	univ.
velocity	vel.
versus	vs
volume, volumes	vol., vols.
watt	W
weight	wt

Abbreviations for periodicals and similar sources. - The preferred forms of abbreviations for periodicals and similar sources for use in NASA reports have been selected from Chemical Abstracts (ref. 18). These forms (except for a few trivial differences) agree with those adopted in the American Standards for Periodical Abbreviations (refs. 19 and 20). Some of the sources frequently cited by NASA authors, together with their recommended abbreviations, are given in the following list.

Source	Abbreviation
Acta Crystallographica	Acta Crystallogr.
Acustica	Acustica
Aerospace Engineering	Aerosp. Eng.
Aeronautical Quarterly	Aeronaut. Quart.
AGARD (Advisory Group for Aeronautical Research and Development, North Atlantic Treaty Organization)	AGARD
AIBS Bulletin	AIBS Bull.
Aircraft Engineering	Aircraft Eng.
American Institute of Aeronautics and Astronautics	AIAA (journal) or American Inst. Aeronaut. & Astronaut. (publisher)
American Journal of Physics	American J. Phys.
Annalen der Physik	Ann. Phys.
Annales de Physique	Ann. Phys. (Paris)
Applied Scientific Research	Appl. Sci. Res.
ARS Journal	ARS J.
Astronautics and Aeronautics	Astronaut. & Aeronaut.
Astronautics and Aerospace Engineering	Astronaut. & Aerosp. Eng.
Astronomical Journal, The	Astron. J.
Astrophysical Journal	Astrophys. J.
Australian Journal of Physics	Australian J. Phys.
Australian Journal of Scientific Research	Australian J. Sci. Res.
British Journal of Applied Physics	British J. Appl. Phys.
Bulletin of the American Mathematical Society	Bull. American Math. Soc.
Bulletin of the American Meteorological Society	Bull. American Meteorol. Soc.
Bulletin of the American Physical Society	Bull. American Phys. Soc.
Bulletin of the Atomic Scientists	Bull. At. Sci.
Bulletin of the Bureau of Standards	Bull. Bur. Stand.
Canadian Journal of Physics	Canadian J. Phys.

Source	Abbreviation
Chemical Reviews	Chem. Rev.
Communications on Pure and Applied Mathematics	Commun. Pure & Appl. Math.
Discussions of the Faraday Society	Discuss. Faraday Soc.
Electronics	Electronics
Engineer	Engineer
General Electric Review	Gen. Elec. Rev.
Industrial and Engineering Chemistry	Ind. & Eng. Chem.
Institute of Electrical and Electronics Engineers	IEEE (journal) or Inst. Elec. & Electron Eng. (publisher)
Institute of Electrical and Electronics Engineers Transactions on Automatic Control	IEEE Trans. Automat. Contr.
Instrument Society of America	ISA or Instrum. Soc. America
Jet Propulsion	Jet Propulsion
Journal of the Acoustical Society of America, The	J. Acoust. Soc. America
Journal of the Aeronautical Sciences	J. Aeronaut. Sci.
Journal of the Aerospace Sciences	J. Aerosp. Sci.
Journal of the American Ceramic Society	J. American Ceram. Soc.
Journal of the American Chemical Society	J. American Chem. Soc.
Journal American Helicopter Society	J. American Helicopter Soc.
Journal of Applied Mechanics	J. Appl. Mech.
Journal of Applied Physics	J. Appl. Phys.
Journal of Chemical Physics, The	J. Chem. Phys.
Journal of Fluid Mechanics	J. Fluid Mech.
Journal of the Franklin Institute	J. Franklin Inst.
Journal of Geophysical Research	J. Geophys. Res.
Journal of Mathematics and Physics	J. Math. & Phys.
Journal of Meteorology	J. Meteorol.
Journal of the Optical Society of America	J. Opt. Soc. America
Journal of Physical Chemistry	J. Phys. Chem.
Journal of the Physical Society of Japan	J. Phys. Soc. Japan
Journal of Research of the National Bureau of Standards	J. Res. Nat. Bur. Stand.
Journal of the Royal Aeronautical Society	J. Roy. Aeronaut. Soc.
Journal of Scientific Instruments	J. Sci. Instrum.

Source	Abbreviation
Journal of the Society of Motion Picture and Television Engineers	J. SMPTE
Journal of Spacecraft and Rockets	J. Spacecraft & Rockets
Mechanical Engineering	Mech. Eng.
Nature	Nature
Philosophical Magazine	Phil. Mag.
Philosophical Transactions of the Royal Society of London	Phil. Trans. Roy. Soc. London
Photographic Journal	Phot. J.
Physica	Physica
Physical Review, The	Phys. Rev.
Physical Review Letters	Phys. Rev. Letters
Physics of Fluids, The	Phys. Fluids
Physics Today	Phys. Today
Proceedings of the American Society for Testing Materials	Proc. American Soc. Testing Mater.
Proceedings of the Cambridge Philosophical Society	Proc. Cambridge Phil. Soc.
Proceedings of the Institute of Radio Engineers	Proc. IRE
Proceedings of the Institution of Mechanical Engineers (London)	Proc. Inst. Mech. Eng. (London)
Proceedings of the National Academy of Sciences	Proc. Nat. Acad. Sci. U.S.
Proceedings of the Physical Society (London)	Proc. Phys. Soc. (London)
Proceedings of the Royal Society (London)	Proc. Roy. Soc. (London)
Quarterly Journal of Mechanics and Applied Mathematics	Quart. J. Mech. & Appl. Math.
Quarterly Journal of the Royal Meteorological Society	Quart. J. Roy. Meteorol. Soc.
Quarterly of Applied Mathematics	Quart. Appl. Math.
Review of Scientific Instruments, The	Rev. Sci. Instrum.
Reviews of Modern Physics	Rev. Mod. Phys.
Science	Science
Society of Automotive Engineers	SAE (journal) or Soc. Automot. Eng. (publisher)
SOUND - Its Uses and Control	SOUND

Source	Abbreviation
Soviet Astronomy - AJ (English transl. of Astronomicheskii Zhurnal)	Soviet Astron. - AJ
Soviet Physics - JETP (English transl. of Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki)	Soviet Phys. - JETP
Soviet Physics - Technical Physics (English transl. of Zhurnal Technicheskoi Fiziki)	Soviet Phys. - Tech. Phys.
Transactions of the American Institute of Electrical Engineers	Trans. AIEE (journal) or American Inst. Elec. Eng. (publisher)
Transactions of the American Institute of Mining, Metallurgical, and Petroleum Engineers	Trans. AIME (journal) or American Inst. Mining Met. & Petrol. Eng. (publisher)
Transactions of the American Society of Mechanical Engineers	Trans. ASME, Ser. A: J. Eng. Power (journal) or American Soc. Mech. Eng. (publisher)
Transactions of the American Society for Metals	Trans. ASM (journal) or Trans. American Soc. Metals (publisher)
Transactions of the Faraday Society	Trans. Faraday Soc.
Zeitschrift für Astrophysik	Z. Astrophys.
Zeitschrift für Physik	Z. Physik

REFERENCES

1. U.S. Government Printing Office Style Manual. Revised ed., Jan. 1973.
2. NASA Scientific and Technical Publications. NASA Notice NN 2220, Nov. 17, 1971.
3. Style Manual. Pub. R-128, Second ed., American Inst. Phys., 1959. (Revised Nov. 1968.)
4. Government Printing & Binding Regulations. No. 22, Joint Committee on Printing, Congress of the United States, Dec. 1972.
5. COSATI Guidelines to Format Standards for Scientific and Technical Reports Prepared by or for the Federal Government. NASA Implementation Edition, July 1969.
6. American Standard Letter Symbols for Aeronautical Sciences. ASA Y10.7-1954, American Soc. Mech. Eng., c. 1954.
7. American Standard Letter Symbols for Rocket Propulsion. ASA Y10.14-1959, American Soc. Mech. Eng., c. 1960.
8. Letter Symbols for Heat and Thermodynamics. ASA Y10.4-1957, American Soc. Mech. Eng., c. 1957.
9. Letter Symbols for Meteorology. ASA Y10.10-1953, American Soc. Mech. Eng., c. 1953.
10. Symbols, Units and Nomenclature in Physics. Doc. U.I.P. 11(S.U.N. 65-3), Int. Union Pure & Appl. Phys. (Amsterdam), 1965.
11. Comptes Rendus des Séances de la Onzième Conférence Générale des Poids et Mesures. Gauthier-Villar & Cie (Paris), 1960. (Available as NASA TT F-217.)
12. Page, C. H.; and Vigoureux, P., eds.: The International System of Units (SI). NBS Special Publ. 330, 1972.
13. ASTM Standard Metric Practice Guide. E380-72, American Soc. Testing & Mater., June 1972.
14. Mechtley, E. A.: The International System of Units of 1960 - Physical Constants and Conversion Factors. Second Revision. NASA SP-7012, 1973.
15. Use of the International System of Units (SI) in NASA Publications. NASA Policy Directive NPD 2220.4, Sept. 14, 1970.
16. Abbreviations for Scientific and Engineering Terms. ASA Z10.1-1941, American Soc. Mech. Eng., c. 1941.
17. Letter Symbols for Units Used in Science and Technology. ANSI Y10.19-1969, American Soc. Mech. Eng., c. 1970.
18. Access - Key to the Source Literature of the Chemical Sciences. American Chem. Soc., c. 1969.
19. Revised and Enlarged Word-Abbreviation List for American National Standard for Periodical Title Abbreviations. Z39.5-1963, National Clearinghouse for Periodical Title Word Abbreviations (Columbus, Ohio), Dec. 31, 1966.
20. American National Standard for the Abbreviation of Titles of Periodicals. ANSI Z39.5-1969, American Nat. Stand. Inst., Inc., c. 1970.

*U.S. GOVERNMENT PRINTING OFFICE:1974 625-915/59 1-3