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THE ELECTRONIC PROPERTIES INFORMATION CENTER

H. Thayne Johnson and Donald L. Grigsby
Hughes Aircraft Company

TECHNICAL REPORT AFML-TR-65-68

March 1965

Air Force Materials Laboratory
Research and Technology Division
Air Force Systems Command
Wright-Patterson Air Force Base, Ohio

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NOTICES

AFML-TR-65-68

THE ELECTRONIC PROPERTIES INFORMATION CENTER

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FOREWORD

This report was prepared by Hughes Aircraft Company, Culver City, California, under Contract AF 33(615)-1235. The contract was initiated under Project No. 7381, "Materials Application," Task No. 738103, "Materials Information Processing and Retrieval." The work was administered under the direction of the Air Force Materials Laboratory, Research and Technology Division, with Mr. R. F. Klinger acting as Project Engineer.

This report covers work conducted from 1 February 1964 through 31 January 1965. The Contractor's Report Number is P65-12.

Many persons have contributed to the making of this report and the development of the program which it reflects. In addition to the authors, the most important contributors were:

J. W. Atwood
C. L. Blocher
M. Bloomfield
J. J. Grossman
D. H. Johnson
T. Lyndon
J. T. Milek
M. S. Neuberger
G. S. Picus
E. Schafer

Manuscript released by the authors January 1965 for publication as an R and D Technical Report.

This technical report has been reviewed and is approved.

D. A. Shinn
Chief, Materials Information Branch
Application Laboratory
Directorate of Materials and Processes

ABSTRACT

The function and use of the Electronic Properties Information Center is reviewed in this annual report covering 1 February 1964 through 31 January 1965. An overview of the development of the Center since its inception in June 1961 is included. The modified coordinate index, the indexing philosophy and vocabulary, data evaluation and compilation, and the development of data processing techniques are covered in some detail. Approximately 17,000 publications have been acquired and indexed, and 2000 data sheets issued. The Center has also published technical reports on individual materials of current interest.

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ILLUSTRATIONS

INTRODUCTION

The Electronic Properties Information Center (EPIC), as established and maintained by Hughes Aircraft Company under Air Force contract, is both unique and outstanding among the world's specialized information centers. From the beginning of the program in June 1961, Hughes has brought to the Center extensive experience in five fields: materials technology, information retrieval, library science, data processing, and systems engineering. EPIC has demonstrated these capabilities by developing an exhaustive, systematic, and organized approach to the literature on an international basis; by creating methods and files to control the large amount of literature; by using routines and procedures slanted toward maximum production; by planning an indexing system ideal to handle specialized materials information; by economically developing automated techniques to save both money and time and to enable publication and distribution of EPIC output cheaply and quickly; by building an indexing vocabulary and indexing philosophies in a unique fashion; and in evolving data evaluation and analysis techniques that have resulted in useful compilations of data sheets.

In general, the functions of EPIC can be described as: searching out all literature containing data on the electrical and electronic properties of materials; indexing and abstracting that literature for access; and extracting, evaluating, synthesizing and compiling the data into series of data sheets. In addition, special reports and bibliographies are published, copies of the index are distributed, and technical questions are answered.

Presently, EPIC can offer the following services:

1. A search of the lite ture to find specific data or information.
2. A bibliographic compilation on specific properties of specific materials.
3. A bibliographic compilation on specific materials.
4. Copies of EPIC publications, if still available.

Three annual reports have previously been published by EPIC, Parts I, II, and III of ASD Technical Documentary Report No. ASD-TDR-62-539. These were prepared under Contract No. AF 33(616)-8438.

This report, in general, supplements these. However, in order to give the reader an excellent overview of the Center and its present program, it also sometimes repeats the information contained in these three reports.

USE OF EPIC

The use of EPIC is increasing rapidly as indicated by the growth in both the distribution list and the number of requests for technical information. The distribution list now requires 268 copies of each publication we release. This includes data sheets and special reports. It is an international list containing two companies outside of the United States. Over the U.S., the list comprises all types of institutions within our scientific community, including universities, private industries, state and federal government agencies, and document centers, such as the Defense Documentation Center and the Scientific and Technical Information Center of NASA. Almost every state is represented.

Technical inquiries during this contract year numbered 342, coming to EPIC from a group of engineers and scientists as diversified as the distribution list. These inquiries varied from highly complex questions in which EPIC was required to act as a technical consultant, to simple questions which a data sheet, already compiled, could answer. A few have required over 100 man-hours to complete; others have been answered in just a few minutes.

Of the 342 questions, about 6 percent were outside of the scope of the Center, dealing primarily with devices or other than electrical or electronic properties (thermophysical, mechanical, optical, etc.). In many instances, the questioner was referred to other information centers. However, in every instance, EPIC was able to supply some technical information gathered either from the EPIC collection or from the excellent Hughes Library Services.

For some requests, the best answer has been a bibliography taken from our index. The computer printout of material properties has been consulted and accession numbers of relevant articles followed to the papers. If a check of these shows pertinency, they have been assembled as a bibliography and forwarded.

At times the inquiry is broader than the system, so the anchor has resorted to supplemental effort through the Hughes library system. This type of request calls for considerable effort on the part of qualified members of the technical staff to search the literature and assemble the data. A few requests have been so specific that direct point values of a property have been needed. These points may be assembled in tables from every facility in the company, or made available in Xerox copies from the original.

EPIC capability in answering these questions has resulted from the use of extensive Hughes abilities in the five fields mentioned in the INTRODUCTION. These have been demonstrated by the flexibility offered EPIC at Hughes by: (1) a permanent staff, able to provide routine or highly specialized answers; (2) the consultation with highly skilled materials engineers and researchers; (3) the cooperation of well equipped reproduction, microfilm, data processing, and similar groups, and (4) the availability of a large industrial library system in close proximity to EPIC and supervised by the same head.

Over 2000 data sheets have been published on 34 materials and many inquiries have been answered by sending copies of these. Because "hot" materials, determined in consultation with experts both at Hughes and those outside of Hughes using EPIC facilities, are compiled first, the chances of answering questions using data sheets are improving rapidly with each series issued.

The wisdom of a unique, systematic, and exhaustive approach to the experimental data in the literature can be seen in the following. For every 1000 titles examined by EPIC members for possible inclusion in the Center, about 100 are finally included and documented, and about 25 are used in compiling data sheets. By indexing and abstracting to this depth, EPIC is able to furnish technical answers of value beyond the experimental data, and yet improve the quality of the data sheet by being selective and evaluative. These statistics also point out how impossible it would be for an individual to go through this same process to get the data. The individual would not have access to our specialized knowledge of sources nor to the routines and philosophies which enable EPIC to accomplish their mission.

Every facet of EPIC is slanted toward the user. It is part of the philosophy of EPIC that the user needs a compilation that is as complete as possible. It is continually being demonstrated that this little bit of extra effort produces valuable data that outweighs the time involved.

EPIC is greatly advanced in the economical and practical use of data processing techniques. Indexes and bibliographies can now be cheaply published by machine. A technical question requiring a 500 document bibliography on a selected group of materials and properties, can now be answered at a cost of about $15.00, compared to a former manual cost of about $90.00. This includes giving the questioner both bibliographic entries and abstracts, divided by materials and properties. It also gives him a much neater, easier-to-read copy than our former method of reproducing our abstract cards by an electrostatic process.

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SEARCHING, SELECTING, AND ACQUIRING THE LITERATURE

In order to understand the full scope of our effort, EPIC has continually maintained an up-to-date survey of the literature. This has been done by counting random samplings of useful publications in indexing and abstracting services, bibliographies, citation lists, and similar sources.

At the beginning of the program, it was estimated that there were 27,000 publications of interest to EPIC, with a growth rate of 2500 per year. With the passage of over three years, and because it has been found desirable to include some documents not in that first count (e.g., some secondary sources and review articles), the counts now indicate about 40,000, with a growth rate of 3200 per year. There are now 17,000 documented into our system.

Searching is essential to establish the existence of these publications of interest to EPIC. Indexing and abstracting sources have been systematically explored for the data sought for the different categories of materials. In general, the procedure followed has been a year-by-year search, working backward in time from the most recent period in the most comprehensive abstract sources; then a further exploration is made of the bibliographies contained in the documents. The literature thought to contain data is recorded on 3" x 5" cards and checked for duplication against search and holdings records. It is then paged from Hughes Aircraft Company library shelves, borrowed from other libraries, or ordered from DDC, NASA, and other sources and then appraised by a subject specialist for relevant content. In addition, certain specialized bibliographies and DDC demand bibliographies have been searched.

Once the search for a category has been completed for the major indexing and abstracting sources, systematic exploration is initiated in the unindexed current issues of journals, serials, report series, and similar sources which are indicated to be remunerative through an examination of a cumulative source file maintained as an auxiliary aid to searching. A system of direct inquiry for information concerning current research programs is under development through leads furnished by the search results, contacts in the United States and abroad, Government and Defense agencies. Efforts are made to obtain the data developed under such programs on a current basis.

Indexes searched for retrospective material on a current basis are:

DDC Tecnnical Abstract Bulletin
Ceramic Abstracts
Chemical Abstracts
Digest of Literature on Dielectrics
Engineering Index
Electrical Engineering Abstracts
NASA Star
Nuclear Science Abstracts
Physics Abstracts
Review of Metal Literature
Solid State Abstracts
U.S. Government Research Reports

New issues of the following journals are being searched as they arrive:

Acedemie des Sciences. Comptes Rendus
Academy of Sciences. USSR Bulletin
American Ceramic Society, Bulletin
British Institute of Applied Physics
Canadian Journal of Physics
Czechoslovak Journal of Physics
Electrochemical Society, Journal
Electro-Technology
Helvetica Physica Acta
IEEE, Proceedings
Indian Journal of Physics
Insulation
Journal de Physique et le Radium
Journal of Applied Physics
Journal of Chemical Physics
Journal of Electronics and Control
Journal of Metals
Materials in Design Engineering
Nature
Optical Society of America, Journal
Philips Research Reports
Philips Technical Review
Physica
Physica Status Solidi
Physical Review
Physical Review Letters
Physical Society, Proceedings
Physical Society of Japan, Journal
Physics and Chemistry of Solids
Review of Modern Physics
Royal Society of London, Proceedings
Soviet Physics — Doklady

Soviet Physics — JETP
Soviet Physics — Solid State
Soviet Physics — Technical Physics
Zeitschrift fur Naturforschung
Zeitschrift fur Physik

Hughes Aircraft Company is also a member of the industrial associates programs of several large universities and receives their publications. These are also consistently screened.

The entire facilities of the library services of Hughes Aircraft Company is available which gives access to over 500,000 publications, growing at the rate of 5000 per month. EPIC and Hughes Aircraft Company appear on hundreds of automatic distribution lists issued by universities and companies throughout the world. As these publications are received, they are consistently examined.

Arrangements have been made to receive unpublished output of many companies outstanding in materials research. Members of the Air Force are also assisting us in obtaining many Department of Defense documents which could not otherwise be obtained. The result of this activity is that approximately 6000 items are considered each month for possible inclusion in the Center, 2000 of these are actually examined, and 500 are indexed and abstracted into the Center.

The Selection process is closely tied in with the mission of the Center, to acquire, index and abstract all publications which contain experimental data on the electrical and electronic properties of materials, or associated articles which would be helpful in evaluating and understanding this data. In addition, the program is slanted toward applications, rather than pure or basic research. However, in spite of this, approximately 50 percent of the use of the Center is by research scientists, with the remaining 50 percent by applications engineers. Because of this wide range of users, the tendency sometimes is to include material outside of our basic mission but which may be useful to a given user, for many users need a wide range of information rather than just single points.

Literature selected and acquired through the search procedures is reproduced or ordered directly for permanent retention. A large portion of this literature is available from the Hughes Aircraft libraries.

Literature not held by Hughes Aircraft Company libraries is purchased, borrowed or ordered from other libraries or issuing agencies. A continuing effort is made to be placed on distribution lists for reports issued on current research relevant to the project. Reports issued as part of Government contracts are ordered largely from DDC. Other reports are ordered directly from the issuing agency.

The ratio of acquisition to search is 1 to 10, with variety of influences causing the large spread. All articles in a selected periodical are searched, usually page by page, on the chance that usable charts or graphs may appear. Abstract services duplicate each other considerably. Translation services are likely to have translated mostly the outstanding foreign articles or entire journals, causing a small overlapping of search effort. None of the above are serious, but all point to the nature of searching.

EPIC ROUTINES AND PROCEDURES

The "Work Flow Chart" (Figure 1) presents a visual map of the path which a piece of literature takes on its road to becoming a part of the EPIC collection.

As has been stated, a piece of literature comes to the attention of a Member of the Technical Staff in any of several methods. Frequently the article is abstracted in one of several conventional abstracts. Such abstracts as Ceramic Abstracts, Chemical Abstracts, Metals Review, Science Abstracts (Section A: Physics Abstracts and Section B: Electrical Engineering Abstracts), Solid State Abstracts, Scientific and Technical Aerospace Reports (STAR) and Technical Abstract Bulletin (TAB) are searched systematically for references to articles worth including in the system. The technical staff, however, cannot depend solely on abstract services to lead them to all applicable literature, for all articles appearing in a given periodical are not necessarily abstracted by a given abstracting service. There is often a time lag between the publication of an article and a reference to it in an abstracting journal. Also, an abstract of an article does not always fully represent the article.

A second method by which an MTS can become cognizant of an article for possible inclusion in the system is through the study of the bibliographies, footnotes, and citations appearing in the literature itself. Every competent engineer and scientist gives full bibliographic credit to his peers in the field who have been engaged in exploring the same areas of knowledge as he. The bibliographies and other references appearing in their publications are, therefore, an excellent source of additional leads to material.

Still another type of material of interest is the technical information published by many chemical and electronics firms. This literature is often not available in the articles published in journals and other periodicals. Personal contacts, such as those furnished by attendance at professional meetings and conventions such as WESCON are frequently valuable sources of this type of literature. Being on a company's mailing list can be a helpful source of information.

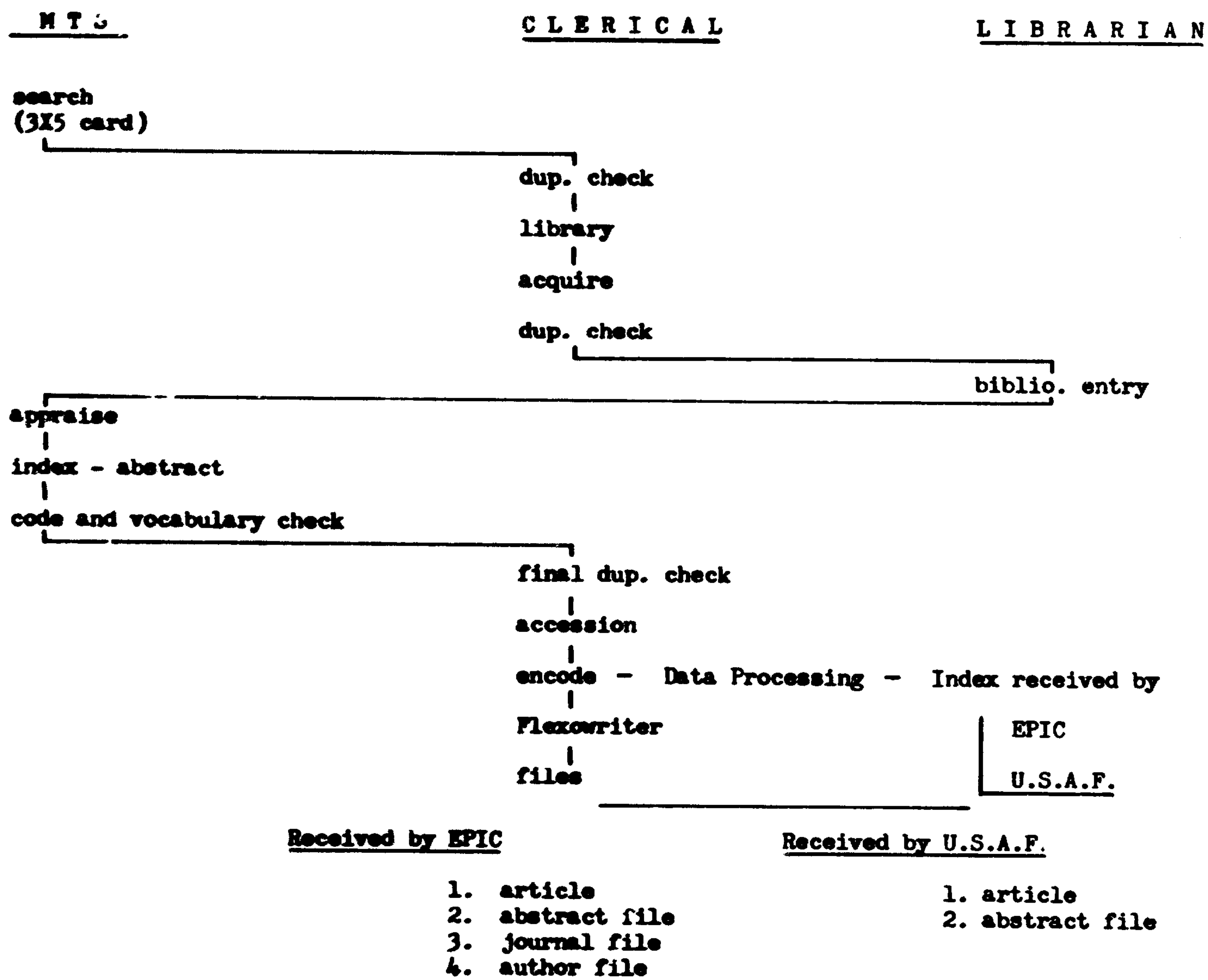

Figure 1. EPIC work flow chart.

Mention was made above of the use made of the commercially published abstracts, and the leads which these publications provide. A somewhat similar source of information is the bibliographies published by the Defense Documentation Center (DDC), formerly ASTIA, and NASA's information facility. These bibliographies and the other types of literature issued by DDC provide a valuable source of information and material for EPIC.

EPIC maintains subscriptions to all of the abstracting services listed in the second paragraph. It receives copies of STAR and TAB from the company's Technical Document Center which is responsible for the internal distribution of these two abstracts. When a copy of any of these abstracts is received in the EPIC office, it is routed to the desk of the MTS charged with the responsibility for searching this title for references to relevant articles. Each title, e.g., Chemical Abstracts or Electrical Engineering Abstracts, is always searched by the same MTS, who thus gains familiarity with the format and other physical arrangements of the abstract journal. This familarity contributes to speed and thoroughness in searching the abstracts. As the MTS goes through the pages of abstracts he indicates with a penciled check-mark or other means those articles he believes appropriate to the system. He then sends the complete abstract journal to the EPIC office where a member of the clerical staff clips out the citation and pastes it on a 3" x 5" card.

With over 17,000 articles in the system, careful attention must be paid to the matter of preventing duplications. This is more than a matter of keeping out two copies of the same articles; it is also a matter of the "quality" of an article. For example, an author or a group of authors might submit an article for publication in a professional journal. As their work and their knowledge progress, they will elaborate on the original article (frequently giving it the same title) and present it at a symposium or conference. Perhaps it is then published as a paper in the Proceedings of the Conference. Meanwhile, copies of the original periodical article might have been issued in reprints. The Defense Documentation Center will frequently issue these reprints after assigning an AD number. A similar situation exists, for example, in the case of an article being "reprinted" in the Bell Telephone System Technical Publications Monograph Series with some additional material being included in an appendix that did not appear in the original.

For the above reasons EPIC makes every effort to prevent duplications being entered into the system. The first "dup." check (as indicated in Figure 1) is, in a sense, the most important. It indicates whether or not any further efforts should be expended in acquiring the article. If it has been determined that the article is not in the system, the 3" x 5" search card becomes part of a collection which, when sufficiently large, is sent to the Company Library. As this Library adjoins the EPIC office, there is constant liaison and communication between the staff members of both sections. Should there be any question concerning the desired references, as happens when a misprint appears in a citation clipped from an abstract journal, this difficulty can be resolved on the spot, without the necessity of telephone calls or letters. The Company Library subscribes to approximately 900 periodicals and has a collection of 7000 bound periodical volumes.

Most of the desired items found through searching the abstract journals are contained in the collection of the Company Library. It has been mentioned above that " an abstract of an article is not the article." Regardless of the nature of the abstract it is still essential that an MTS examine the article before it is definitely accepted as being relevant to the EPIC system. For this reason, a member of the Library Staff pulls the desired periodicals from the periodical shelves and places them on a table to be examined by a member of the technical staff. Those that bear out the initial belief that the article is relevant are set aside to be reproduced on a Xerox 914 copier. As with the Library, the room containing the Xerox machine is next to the EPIC office and good liaison can be maintained.

Two copies of the desired article are reproduced on the Xerox 914 and sent to EPIC; the volume is returned to the Library. One of the copies is supplied to the Air Force as part of the contractual agreement; the other remains in the system as the file copy. Some journals and periodicals contain such an extensive number of relevant articles that EPIC maintains a subscription. In this case the original article is clipped from the journal and one copy is reproduced on the Xerox machine. When a periodical is received on an EPIC subscription it is always routed to the same member of the technical staff who indicates on a Search Form the desired pages to be reproduced from the journal. On the same form the member of the technical staff supplies information with a rubber stamp relating to the content of the article for future use that is, whether it is experimental, review, background, fabrication and application or technology. At the same time, the category (Semiconductor, Insulator, etc.) is indicated by the appropriate letter (S, I, etc.). The forms have been designed so that regardless of the source of the article - Library or EPIC subscription - the information relating to the content and the category can be noted.

Once an article has been acquired every effort is made to enter it into the system under as complete a bibliographic entry as possible. In the case of articles that have been acquired from journals the entry consists of the author's name, the title of the article, the name of the journal, as well as its volume, its number and the inclusive pages. In order to conform to the Flexowriter, great care must be given to the matter of abbreviations in the bibliographic entries. As the system is "user-oriented" the entry must be meaningful to the user yet be such that it can be accommodated to the Flexowriter.

The bibliographic entry for DDC items consists of the issuing agency, the title, the personal author, the report number, the contract number, the date, and the AD number as supplied by DDC.

The entries for vendor literature and company reports, or other reports in published form, bulletins, announcements, these and similar material consist of the name of the company or issuing agency, the title, the personal author, the bulletin or report number if one appears on the article. (If none appears, it is necessary to identify the article as a data sheet, report, technical report or other meaningful label.) Finally, the date of the article is added to the entry.

At this point, the article is returned to the member of the technical staff who makes a further appraisal of its relevancy to the system. If the article is worthy of retention, it is indexed and abstracted on an appropriate form (Figure 2). The indexing system and the indexing vocabulary are discussed elsewhere in this report and will not be discussed in this section.

After the article is indexed and abstracted, it is routed to the member of the technical staff who controls the indexing vocabulary. He determines whether the materials terms are already in the indexing vocabulary either as a primary term or a "cross-reference" term and makes appropriate changes. Then a final duplicate check is made.

At the time the bibliographic entry was being typed on the index-abstract (form) a carbon copy was typed on a 5" x 8" card. This card serves two purposes: it becomes the "in-process" file while the article is undergoing various steps in being processed and it is used as the original form from which two additional cards are made. These two cards are, the Author card and Journal card. Both cards are essential to the smooth functioning of the system. The Author file is, as the name indicates, an alphabetical listing of all personal and corporate authors who have written or published material that has been included in the system. A special mention should be made about the Journal File. It has demonstrated itself to be extremely valuable as a "control file." It provides a quick method of checking for duplicates. It provides a quick, visual exhibit of how thoroughly a given journal, e.g., Physical Review or Journal of Applied Physics, has been searched and incorporated into the system, and of how valuable a given journal is to EPIC. It also helps to control a journal title, particularly those which have frequently changed.

A last "routine" which should be discussed is the preparation of a data sheet. A Technical Illustrator is employed full time in EPIC to either accomplish the art work or to coordinate it through Hughes Art Services. Upon receiving instructions and information to compose a data sheet it is checked to see that all properties are in alphabetical order. The data processing code card may be used as a guide for any property name not appearing on the code card and should not be presented in the data sheet.

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CODE	MATERIAL	01 GENERAL	02 ABSORPTION	03 ARC RESISTANCE	05 CARRIER DIFFUSION	07 CORONA EFFECTS	09 CROSS SECTIONS	10 CURIE CONSTANT	11 CURIE TEMPERATURE	13 DEBYE TEMPERATURE	16 DIELECTRIC CONSTANT	18 DIELECTRIC STRENGTH	20 DISSIPATION FACTOR	22 DOMAIN STRUCTURE	24 EFFECTIVE MASS	25 ELECTRICAL CONDUCTIVITY	28 ELECTRICAL HYSTERESIS	30 ELECTRICAL RESISTIVITY	32 ELECTROACOUSTIC PROPERTIES	33 ELECTROMECHANICAL PROP.	34 ELECTRON FIELD EMISSION	35 ELECTRON PHOTOEMISSION	36 ELECTRON SECONDARY EMISS.	37 ELECTRON THERMIONIC EMISS.	39 ELECTRONIC SPECIFIC HEAT	40 ENERGY BANDS	41 ENERGY GAP	42 ENERGY LEVELS	44 GYROMAGNETIC PROPERTIES	46 HALL COEFFICIENT	50 INSULATION RESISTANCE	52 IRRADIATION PROPERTIES	54 LIFETIME	56 LOSS FACTOR	60 MAGNETIC HYSTERESIS	61 MAGNETIC SUSCEPTIBILITY	63 MAGNETOELECTRIC PROPERTIES	66 MAGNETOMECHANICAL PROP.	68 MOBILITY	70 PENETRATION DEPTH	71 PHOTOELECTRONIC PROPERTIES	72 PHOTON ELECTROLUMINESCENCE	73 PHOTON EMISSIVITY	74 PHOTON LUMINESCENCE	75 PHOTON MECH. LUMINESCENCE	76 PHOTON THERMOLUMINESCENCE	77 PIEZOELECTRIC PROPERTIES	78 POWER FACTOR	80 REFLECTION COEFFICIENT	81 REFRACTIVE INDEX	82 RICHARDSON'S CONSTANT	83 SUPERCOND. TRANS. TEMP.	88 THERMAL CONDUCTIVITY	92 THERMOELECTRIC PROPERTIES	94 THERMOMAGNETIC PROPERTIES	96 THRESHOLD FIELD	98 WORK FUNCTION			

EPIC Index Abstract Form
Revised October 1963

NAME __________ DATE __________

Figure 2. EPIC index abstract form.

Before any final work begins on the data sheet, all graphs, diagrams and charts being presented are ordered. The Technical Illustrator must determine if Xerox copies can be used, whether photostats must be ordered, art services work is needed, or if plotting is to be done by the illustrator.

The author has noted the graphs in order of appearance under each property throughout the data sheet, and must be kept in this order at all times. As each graph is ordered, in any of the four ways stated above, they must be labeled by the accession number of the article and property name.

Photostats may be needed for a clearer reproduction, enlarging or reducing the graph. When ordering the photostats the original sources of the article is checked out of the library and sent to the Photographic Laboratory. This may involve 10 to 15 journals and 20 to 25 graphs at each time. Each graph, when returned from the photo lab is numbered and placed in proper sequence. Should art services work be required for a single curve or a large number of graphs, an instruction sheet and an article containing the original graph are sent to the Art Services Group. When these graphs are returned they must be checked very carefully for any errors in spelling, copy wor[illegible] r deletions of curves ordered. Xerox copies may have to be inked for a better and darker reproduction and all spots removed that may have been reproduced on the graph by the Xerox machine.

After all graphs are received in final form, paste-up begins. Each graph and its accompanying note is laid out on the page, spacing graphs, centering note, and citing reference number. The illustrator must add greek symbols where needed, and standardize all captions for consistency. Graphs from different articles may have the same captions but be worded differently and the illustrator must type each caption in a consistent manner. Each graph may have varying sizes of lettering or numbers on the scales; these have to be changed and made the same size by the illustrator either by leroying or by typing. If the scale is changed by typing, the graph is lightly drawn on the paste-up page, measured to size, and typed before pasting. The illustrator must be sure there are no duplications of graphs or information in the same property or that a graph has been placed in the wrong property. Tables may be cited by the author to be typed within the data sheet, and must also have a reference number. Where possible, tables are typed before paste-up begins, so spacing can be determined.

When paste-up is complete, a Xerox copy is made and returned to the author for corrections, additions or deletions. During the time paste-up work is being done by the illustrator, new material pertaining to the material and property may have entered the system which the author will want to insert into the data sheet before publication. This may be a matter of adding pages, or it may change the entire layout of a property or section. Pages will have tc be retyped, pasted and in some cases graphs will have to be drawn.

When all is complete a list of all reference numbers is made and the abstract cards pulled from the abstract file. From this list a bibliography is typed.

The data sheet abstract, introduction, material identification, publications and title page are typed after all paste-up is completed. When the author has checked the data sheet for the last time a table of contents is typed and pages are numbered. It is then ready for publication.

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INDEXING AND ABSTRACTING

Usually a technical article contains a few central ideas each of which seems important enough for the author to expand and develop. It is to sort these that abstracting is done, and to arrange them in quickly accessible form that indexing is done. Experimental data which an author reports may be of great interest to a reader but it is useful only if he can get it readily. Indexing and abstracting are procedures used to enable one to scan myriads of documents selectively, eliminating those not useful to his search for information.

EPIC has utilized the skill of scientists and engineers to index and abstract literature for use by other scientists and engineers. No other way appears authentic. At first, the work was done by interested groups in several research-type divisions of the company, but as soon as the early study phases were reasonably complete the EPIC staff of chemists, physicists, and materials specialists took over.

Analysis of an article or report is both subjective and objective. Not only the subject matter is important but such factors as the prominence of the author and his agency have a subtle impact. The particular language it is written in is significant. The quality of reprints suggest interest attached to the publication. Of most importance to us, however, is the actual presentation and substantiation of data for these contribute most to our ability to compile data sheets and answer technical questions.

A guide sheet for abstractors has been composed and distributed so that essentials would consistently be sought out and indicated. This guide has been used as an aid in sorting out bibliographic, source, reference, and citation facts as well as emphasizing sample preparation and purity apparatus and conditions. Its primary aim, of course, was to see that properties data of the material were clearly and consistently noted.

Our method of storing and retrieving documents offers a way of obtaining property-material data but does not, as yet, reach into the ranges covered. Thus, abstracters do not seek out detailed numbers data but only make certain that articles will be indexed under the 56 properties on our list. Also, if a paper has 10 graphs on electrical resistivity, the indexer only checks that property once. Similarly, if energy gap data appears only one time it too is checked once.

Members of the Technical Staff who abstract and index scientific literature in foreign languages, or foreign languages translated into English, must watch carefully for local and national idiosyncracies and preferences. These are reflected in symbols used and choice for expressing the data parameters. Greek letters and abbreviations usually convey the same idea but not always. Material names are colored somewhat by national preference and significantly trade names play a large part. Insulators, alloys, ceramics and other products are frequently formulated for use with a registered composition and name.

The words used to convey the sense of a given article may be called an abstract. That name is used and understood differently by different services as special emphasis or interests are selected. Our abstracting technique is to select the author's abstract, select short phrases from the author's abstract, select phrases from the body of the article, the summary, or the conclusion, or composing our own if none of these meet our needs. It is implied and expected that the indexer-abstracter will have enough understanding of the principles involved to report upon them. With some of the world's outstanding scientists available for consultation there are few unresolved problems in theory.

As the abstractor goes through the article he spots electronic properties exhibited by experimental work. These are checked off in appropriate columns on the EPIC index-abstract form along with the material listed. The degree of analysis and care taken governs the quality and usefulness of the EPIC collection, since failure to see and indicate all properties reduces the total system value.

In the course of Abstracting-Indexing we have found it possible to record work not included in contract objectives but closely related. For instance, optical data of a specific nature has been listed. Also, citations by an author often lead to sources in other branches of the sciences such as Biology or Mechanics or Fabrication on which we have kept notes.

THE INDEXING SYSTEM

As the program began, several avenues of indexing were open for consideration, ranging from the general subject heading approach to the specificity of the unit term approach. At the beginning of the program, it was decided that a subject heading approach would be too unwieldy, for it would have to incorporate lengthy headings dealing with multiple material or property names (i.e., SODIUM PHOSPHIDE - ABSORPTION DUE TO IRRADIATION). To index to this degree of specificity would require an over-abundance of subject headings in the system, many of which would apply to only one or two articles.

For these reasons it was thought desirable to use headings of individual materials and/or properties. However, to simply do this and nothing more would make articles dealing with comparative properties of one material, or one property compared in several materials difficult to find. Therefore some kind of matching between these individual materials and property names had to be possible and the system would have to be one of "coordinate indexing."

Having chosen a coordinate indexing system, the question became one of whether or not to use unit terms (terms consisting of only one word, either a property or a material). If unit terms were used then coordination could take place between cards listing, individually, the desired material and property. However, there would be certain disadvantages to such an approach. For example, under a heading such as RESISTIVITY there would be hundreds of articles. To post these articles would probably require several cards. Then when it was desired to coordinate this property with a material, it would prove bulky and tedious to find the same article listed under both RESISTIVITY and the material. Also, imagine the number of times a user might take the trouble to coordinate a material term with a property term only to find no articles in the system.

To accomplish the specificity required and to eliminate the disadvantages of unit terms, a modified coordinate indexing scheme was chosen. The finalized system consisted of "precoordinated" descriptors of one material or one material and one property (i.e., INDIUM PHOSPHIDE-ABSORPTION). Advantages of the system over unit terms include quicker retrieval since usually only one card with the "precoordinated" descriptor has to be consulted. There is also a lower density of posted articles under any given term. For example, assume that there are 15 articles dealing with the property ABSORPTION of the material INDIUM PHOSPHIDE. If each of these articles is listed under both terms, the article (or its accession number) is posted 30 times. On the other hand, by "precoordinating" these terms into one descriptor (INDIUM PHOSPHIDE - ABSORPTION) the accession number is posted only 15 times. Thus posting and its attendant clerical errors is reduced by close to 50 percent.

The final index as chosen for the center was a manual modified coordinate index. It consisted of two card files. One, the Accession File, was arranged by an identifying or accession number assigned to each document entered into the system. Each card in the Accession File contained the bibliographic entry and property data. A second file, the Descriptor File, consisted of subject descriptor cards. The accession number was posted on the appropriate subject descriptor cards. For example, under a descriptor term such as INDIUM PHOSPHIDE - ABSORPTION were listed accession numbers of all the pieces of indexed literature containing data on that subject.

Retrieval on searches involving more than one property at a time was accomplished through matching the accession numbers on the relevant subject descriptor cards. Numbers found in common on the matched cards identified literature containing data on the two or more properties concerned. The same procedure would be followed in retrieving literature on two or more materials.

Figure 3 is an example of the descriptor cards. They were arranged within each category alphabetically by material name, and within material name by property name. The semiconductor alphabet was divided into elements, inorganic compounds and organic compounds. The insulation materials alphabet was not subdivided. The accession numbers identifying the pieces of literature were printed in columns under each subject name by terminal digit for easy matching.

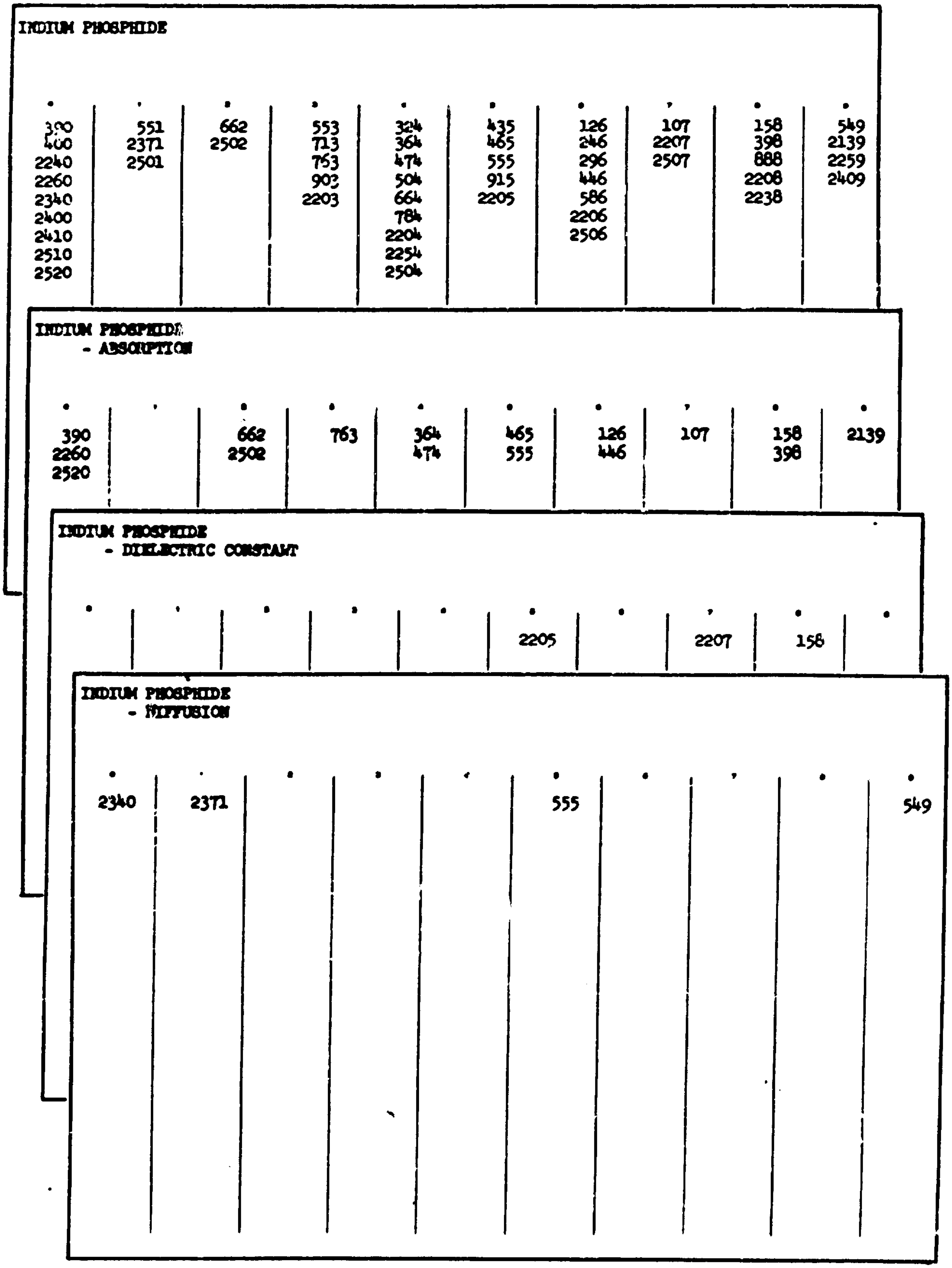

Figure 3. Descriptor cards.

This system was inherently more efficient than the other approaches. It minimized "false drops," both nonsignificant coordinations and those due to clerical errors. At the same time, the degree of specificity was more than adequate, allowing arbitrary control to suit the purposes of the program.

Along with the two card system, data processing and reproduction techniques were established to reproduce easily a few copies for external distribution, with one copy of both files delivered to the Air Force Contracting Agency. A third card file, the Extract File, was also established. This file consisted of extracts of the articles entered in the system to (1) use in compiling the data, and (2) reproduce for external distribution to both the Air Force and other agencies and institutions.

As the program advanced, two facts became quite obvious: (1) that more than just a few copies for external distribution were desirable, and (2) the Extract File was not worth the effort. It was taking an average of four pages to extract adequately articles that were averaging seven pages; also, the data sheet compiler seemed to always prefer using the full article.

With these factors in mind, both the data processing system and the Extract File were reconsidered. A new data processing system was prepared that gave greater flexibility in printing the output, and the Descriptor File was replaced by a master tab run of the index (Figure 4). The Extract File was eliminated entirely, and the Accession File was replaced by an Abstract File (Figure 5) consisting of a 5 x 8 card containing a full bibliographic entry and an abstract.

A punched paper tape machine was obtained to prepare the abstract cards. To obtain a "perfect" copy, the entry and abstract have first been typed upon paper while creating a paper tape. The paper copy is proofed and the tape corrected and then run back to type the card. As the run-back occurs, a second paper tape is created with just the bibliographic entry. The two tapes are now stored, with the latter being used when necessary to prepare and update an Accessions List of EPIC holdings, an easy way to prepare such a list for publication. The full tape has now been transferred to magnetic tape and a program prepared

ALLYL PLASTICS AL

ELECTRICAL RESISTIVITY — INSULATOR MATERIALS

5000

LOSS FACTOR — INSULATOR MATERIALS

4840

POWER FACTOR — INSULATOR MATERIALS

5000

ALUMINUM NITRIDE AL

INSULATOR MATERIALS

8676

DIELECTRIC CONSTANT — INSULATOR MATERIALS

8676

DISSIPATION FACTOR — INSULATOR MATERIALS

8676

ELECTRICAL RESISTIVITY — INSULATOR MATERIALS

8676

THERMAL CONDUCTIVITY — INSULATOR MATERIALS

8676

ALUMINUM OXIDE ALU

INSULATOR MATERIALS

1150	1261	1062	1353	1304	1955	1816	1677	1038	1119
1280	1901	1452	1773	1314	1965	1946	1927	1248	1769
1730	1941	1962	1963	1324	1975	1956	1957	1588	1909
1960	1961	1972	1973	1664	3435	1966	1967	1658	1929
1970	1971	4012	4063	1694	4055	1976	1977	1688	1959
4010	3341	4152	4153	1724	4065	3886	4007	1818	1969
4020	4011	4322	4163	1964	4155	4156	4057	1958	1989
4060	4071	4872	4323	1974	4325	4326	4157	1968	4009
4070	4221	5212	5033	4014	4835	4836	4217	1978	4069
4270	4291	5612	5713	4054	5035	5026	4267	4048	4159
4290	4301	5642	6283	4064	5065	5036	4297	4058	4259
4320	4311	5742	6653	4324	5625	5376	4317	4068	4269
4330	4321	5812	7503	4344	5695	7516	4327	4078	4289
4700	4331	6132	7513	4814	6295	7586	4837	4128	4319
4710	5341	10022	10083	4834	7505	10476	5007	4268	4329
5030	5691	10032	10563	5034	7515		5027	4328	4709
6180	5761	10472		5104	7735		5037	4708	5279
6200	6131			5704	7745		6167	5028	5389
6230	6181			6134	8695		7507	5048	5929
9550	7511			6294	8755		9577	5788	6149
10040	7571			7544	10035		10037	5998	6179
10240	10011			8604	10465		10087	[illegible]	6309
10460	10031			9534	10475			6298	6549
11210	10081			10474	10485			7518	7509
	11061				10785			10038	7519
	11291				11095			10478	7599
									9569
									10249

GENERAL — INSULATOR MATERIALS

									6549

ABSORPTION — INSULATOR MATERIALS

	7511	5212		10474	10465			10038	
					11095			10478	

ARC RESISTANCE — INSULATOR MATERIALS

1150		1452					1527	1818	1119
								1968	9569
								4708	

CARRIER DIFFUSION — INSULATOR MATERIALS

									1929

CORONA EFFECTS — INSULATOR MATERIALS

		1452						4708	

DEBYE TEMPERATURE — INSULATOR MATERIALS

								5998	5279

DIELECTRIC CONSTANT — INSULATOR MATERIALS

1150	1261	1452	1963	1304	1955	1946	1957	1038	1119
1280	1901	1962	1973	1314	1965	1966	1967	1248	1909
1970	1941	1972	4063	1324	1975	1976	1977	1658	1959
4010	1961	4152	4153	1664	4055	4156	4007	1958	1969
4060	1971	4322	4163	1964	4065	4326	4057	1968	1989
4070	4011	5212	4323	1974	4155	4836	4157	1978	4009
4270	4071	5642	5033	4014	4325	5026	4267	4048	4069
4290	4291	5742	7503	4054	4835	5036	4297	4058	4159
4320	4301	6132	10083	4064	5035	5376	4837	4078	4259
4700	4311	10022		4324	5625	7586	5007	4268	4269
4710	4321	10472		4344	5695	10476	5027	4328	4289
6180	4331			4814	7505		6167	5028	4319
6200	5691			4834	7745		7507	5048	4329
6230	6181			5034	8695		10037	5788	6149
9550	7571			5104	10035			6298	6179
11210	10031			5704	10465			7518	7509
	10081			6134	10475			10038	7519

Figure 4. Tab run index.

13901 AIR FORCE SYSTEMS COMMAND. FOREIGN TECHNOL. DIV. The Change in the Physico-Mechanical and Electro-Insulational Properties of Some Compressed Materials under the Influence of Temperature and other Factors, Moisture, Fuels and Oils. By, ZAKHAROV, V.A., et al. Rept. no. FTD-TT 62-1857/1 plus 2. ASTIA AD-415 667. SOURCE--STEKLOTEKSTOLITY I DRUGIYE KONSTRUKTSIONNYE PLASTIKI, Russian Book. 1960. p. 139-168.

In this article data is given which was obtained as a result of the influence of temperature on the principal physico-mechanical and electro-insulational properties of some compressed plastic masses, fiberglass AG-4, KMS-9, and TVFE-2, also asbestos fiber materials K41-5 and KMK-218 and powdered plastics KMK-9 and V4-70.

13902 GLASS FIBERS, INC. Development of Low Dielectric Constant Glasses. By, DUNN, W.A. Interim Eng. Rept. no. 4. Aug. 1959. DDC ATI-92 850.

Progress during this quarter included investigation of borosilicate glass compositions. Substitutions of divalent oxides for part of the monovalent oxides were made to test the effect of various ion combinations on the dielectric constant, loss tangent, and chemical stability.

Figure 6. Abstract cards.

for printing out from this tape in response to bibliographic searches. Further discussion about this program is contained in the section on data processing techniques.

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THE INDEXING VOCABULARY

Historically, one of the major problems of information storage and retrieval has been the selection of optimum indexing methods. This presents an especially difficult problem when the fields to be covered are as interdisciplinary as ours. The literature search, the indexing terms and the retrieval methods must be effective in many technical fields. Each has its own terminology, which may or may not conform to that of the others. Systems of nomenclature vary widely, sometimes even within a single discipline such as chemistry. An additional complication can be introduced by the author who may have his own concept of the proper name for a material. In the interest of complete and accurate retrieval, this confusion of various names for the same material must somehow be resolved.

Considerable difficulty has been experienced in delineating those to be included as indexing terms to the literature, and those to be included as cross-references. For example, semiconductor materials present an array of elements, compounds, mixtures and systems that have made it extremely difficult to correctly name and categorize the material at hand. A material composed of the elements Aluminum, Copper, and Sulfur might be a true compound, an Aluminum Copper Sulfide, a mixture of Aluminum Sulfide and Copper Sulfide, or a three-element system whose phase diagrams will indicate certain areas within which specific compounds exist.

Decisions have had to be made as to the order of various elements in a name. For example, would a compound of tin and antimony appear as antimony stannide (alphabetically) or as tin antimonide (by group in the periodic table) ?

Other problems have been encountered in binary alloys where some of these are intermetallic compounds and the atoms occur in stoichiometric ratios; in doping agents, where an impurity is introduced in a definite and controlled amount; and in materials not usually thought of as semiconductors or insulators, but which become so under certain conditions.

The materials list contains six kinds of descriptors. The first kind is the individual element names. The second kind is the compound name. The compounds include three different types of descriptors. First are the elemental compounds, ALUMINUM ANTIMONIDE or ZINC ARSENIDE. These are named in the usual manner by reference to the periodic table. The exception to this rule is, of course, in the borides, carbides, nitrides, oxides, and halides. If compounds of this first type are cited as containing gold, tungsten, germanium or other such names, the words such as <u>aurides</u>, <u>tungstides</u>, and <u>germanides</u> are avoided and these compounds are relegated to a system notation with the component elements in alphabetical order. There are no elemental compounds listed above the binary ones. Compounds such as mercury silver selenide are listed as systems (see below).

A second type of compound is an ionic salt. Primarily found in the ferroelectric materials, a compound of this type is a descriptor such as POTASSIUM HYDROGEN PHOSPHATE. Even when deuterium replaces the hydrogen in this salt the above notation is used, since no differentiation between isotopes is to be found in the list of descriptors.

A last type of compound is an organic material. Found primarily in the insulators and semiconductors, these descriptors are further delineated as plastics or laminates, and still further by their fillers or bases. Examples of these descriptors are AURAMINE; POLYSTYRENE LAMINATES, GLASS FABRIC BASE; and POLYSTYRENE PLASTICS, MINERAL FILLED. In some cases, the more common generic name is used in place of the specific chemical name. Where possible, numerical notation is avoided. Triglycine sulfate is indexed as GLYCINE SULFATE, and 7-acenaphthol appears as ACENAPHTHOL.

The third kind of descriptor is the system notation. These systems may range from two to six components and are either composed of elements, as in the case of MAGNESIUM SELENIUM SILVER SYSTEMS, or compounds, such as in IRON OXIDE-YTTRIUM OXIDE SYSTEMS. The components of these descriptors are arranged in alphabetical order, not by their order in the periodic table.

A fourth kind of descriptor is the element, compound, or system placed upon a substrate, as in the case of thermionic emitter cathodes.

Examples of this type of descriptor are CESIUM, TUNGSTEN OXIDE BASE, or BARIUM OXIDE-STRONTIUM OXIDE SYSTEMS, TUNGSTEN BASE.

A fifth kind of descriptor is the strictly generic term, such as ASBESTOS; GLASS, LEAD BORATE; or PAPER, KRAFT.

A sixth kind of descriptor is the categorical term, such as BENZENE COMPLEXES or GLASS. This type of descriptor is used when the author has given significant and pertinent data in his paper, but has omitted specific notation on the exact nature of the material.

To date, over 12,000 names of materials have been considered for use in the indexing vocabulary. Of these, approximately 4000 have now been entered into the primary vocabulary, and in addition, approximately 4000 others appear in the syndetic apparatus as "see-references."

To enable a broader use of our system we have compiled a cross-reference index of alternate names for materials as they have occurred in the literature we have abstracted. This gives many more points of entry into the system. Each name is referenced to the particular material name used in the "MATERIALS INDEX."

Briefly described, the supplemental index is comprised of proprietary (trademark registered) names, trade names and types, alloys, foreign material names, mineral names, and other names commonly used in identifying a material but which do not indicate its composition.

We maintain this cross-reference index in card file form which will later (when converted to magnetic tape) allow quick combining and print-out of all trade names applied to each individual material. Even in its present brief form it gives a quick and easy guide to composition (and source) from trade and similar names. The list includes some names which are no longer current but such "historical" information can be invaluable to anyone looking for the composition of, and data on, material mentioned in the older literature.

Some manufacturers in their commercial literature are forward looking enough to include composition information (even though approximate) along with electronic property data. This information is entered directly into the system and the source identified. In other cases we must depend on later materials survey articles which correlate composition and property data. This is a longer process but it is used where no other sources of composition information are available.

The MATERIALS CROSS-REFERENCE INDEX now contains about 4000 entries and is growing at about the same rate as the MATERIALS INDEX. New trade names of electronic or magnetic materials are entered as soon as EPIC can identify their compositions and have data on them. Examples of materials cross-references are included as Figure 6.

Similar problems were encountered with the properties. After compiling lists of properties, decisions had to be made as to which were synonyms and near-synonyms, and which would be subsumed under others. In semiconductors alone, for example, a list of 140 electronic properties was reduced to 29, with the rest subsumed under these.

The Indexing vocabulary is organized about the nine major categories of materials. These categories, while not mutually exclusive, tend to segregate materials by significant properties or characteristics. Although categorizing the materials can be a useful device to some users of EPIC, obviously, extremely arbitrary standards had to be developed. There is no material which is exclusively a metal, or a semiconductor, or a thermionic emitter. Under various environments and conditions, materials are observed experimentally, and the effects can be measured and perhaps explained theoretically. The observed and measured effects are the properties of the materials. In the process, one finds that there are ferroelectrics which are semiconductors, some metals which, at low temperatures, are superconductors, and that ferrites are a class of insulators having certain magnetic properties. The indexing method evolved, therefore, has been to ignore individualized concepts as to the categorization of specific materials and index a publication as it treats the material.

While most of the terms are quite specific (e.g., CURIE TEMPERATURE, EFFECTIVE MASS, HALL COEFFICIENT, POWER FACTOR), there are many other terms which are really groupings or rather generalized terms (e.g., ELECTROACOUSTIC PROPERTIES, MAGNETIC

A-18 Alumina   Steatite-Magnesia A.G. (Germany)
SEE: ALUMINUM OXIDE

A-40 Titanium   Crucible Steel Co.-Titanium Div.
SEE: TITANIUM

A-40PD Titanium   Crucible Steel Co.-Titanium Div.
SEE: TITANIUM

A-55 Titanium   Crucible Steel Co.-Titanium Div.
SEE: TITANIUM

A-70 Titanium   Crucible Steel Co.-Titanium Div.
SEE: TITANIUM

A-95AT Titanium Alloy   Crucible Steel Co.-Titanium Div.
SEE: ALUMINUM TIN TITANIUM SYSTEMS

A-110AT Titanium Alloy   Crucible Steel Co.-Titanium Div.
SEE: ALUMINUM TIN TITANIUM SYSTEMS

A-303   Minneapolis-Honeywell Co.
SEE: ALUMINUM OXIDE

ABR   Acrylonitrile-Butadiene Rubber
SEE: RUBBER, NITRILE-BUTADIENE

ABS   Acrylonitrile-Butadiene-Styrene
SEE: ACRYLONITRILE-BUTADIENE-STYRENE PLASTICS

Acetal Copolymers
SEE: ACETAL PLASTICS

Acetate
SEE: CELLULOSE ACETATE PLASTICS

Acetate Butyrate Plastics
SEE: CELLULOSE ACETATE BUTYRATE PLASTICS

Acetate Cloth
SEE: CELLULOSE ACETATE PLASTICS

Acetate Fiber
SEE: CELLULOSE ACETATE PLASTICS

Acetate Film
SEE: CELLULOSE ACETATE PLASTICS

Acetate Propionate Plastics
SEE: CELLULOSE PROPIONATE PLASTICS

Acetate Rope Paper
SEE: PAPER, ROPE

Acetylated Paper
SEE: PAPER, ACETYLATED

Acrawax   Glyco Products Co
SEE: WAXES, STEARIN AND FATTY ACID

Acrylafil   Fiberfil, Inc.
SEE: POLYSTYRENE-ACRYLONITRILE COPOLYMER PLASTICS

Acrylate Plastics
SEE: ACRYLIC PLASTICS

Acrylic Copolymers
SEE: ACRYLIC PLASTICS

Acrylic Esters
SEE: ACRYLIC PLASTICS

Acrylic Fiber
SEE: ACRYLONITRILE FIBER

Acrylic Resins
SEE: ACRYLIC PLASTICS

Acrylic Rubber
SEE: RUBBER, ACRYLIC ESTER-ACRYLONITRILE COPOLYMERS

Acrylonitrile-Butadiene Rubber
SEE: RUBBER, NITRILE-BUTADIENE

Acrylonitrile-Polystyrene Copolymers
SEE: POLYSTYRENE-ACRYLONITRILE COPOLYMERS

Acrylonitrile Rubber
SEE: RUBBER, NITRILE-BUTADIENE

Acrylite   American Cyanamid Corp.
SEE: ACRYLIC PLASTICS

Acrylon Rubber, BA-12, EA-12, and EA-5   The Borden Co.
SEE: RUBBER, ACRYLIC ESTER-ACRYLONITRILE

Acrylux   Westlake Plastics Co
SEE: ACRYLIC PLASTICS

AD-94   Coors Porcelain Co
SEE: ALUMINUM OXIDE

ADP   Ammonium Dihydrogen Phosphate
SEE: AMMONIUM HYDROGEN PHOSPHATE

Adiprene L Rubber   E.I. du Pont Co
SEE: RUBBER, URETHANE

AI-200 Alumina   Coors Porcelain Co
SEE: ALUMINUM OXIDE

A-L 18 NICOMO-250   Allegheny Ludlum Steel Corp
SEE: COBALT IRON MOLYBDENUM NICKEL SYSTEMS

AL-300 Alumina   Western Gold and Platinum Works
SEE: ALUMINUM OXIDE

AL-600 Alumina   Western Gold and Platinum Works
SEE: ALUMINUM OXIDE

AL-995 Alumina   Western Gold and Platinum Works
SEE: ALUMINUM OXIDE

AL-1000 Alumina   Western Gold and Platinum Works
SEE: ALUMINUM OXIDE

Alberox A-962 Alumina   Alberox Corp
SEE: ALUMINUM OXIDE

Alcomax I   Permanent Magnet Association (England)
SEE: ALUMINUM COBALT IRON NICKEL SYSTEMS

Alcomax II   Permanent Magnet Association (England)
SEE: ALUMINUM COBALT COPPER IRON NICKEL SYSTEMS

Alcomax III   Permanent Magnet Association (England)
SEE: ALUMINUM COBALT COPPER IRON NICKEL NIOBIUM SYSTEMS

Alcomax IV   Permanent Magnet Association (England)
SEE: ALUMINUM COBALT COPPER IRON NICKEL NIOBIUM SYSTEMS

Alfer   Japan
SEE: ALUMINUM IRON SYSTEMS

Alfrax BI-K
SEE: ALUMINUM OXIDE

Alite A-212 Alumina   U.S. Stoneware Co.-Alite Div
SEE: ALUMINUM OXIDE

Alite A-216 Alumina   U.S. Stoneware Co.-Alite Div
SEE: ALUMINUM OXIDE

Alkali-Lead Glass
SEE: GLASS, LEAD ALKALI SILICATE

Alkali-Silicate Glass
SEE: GLASS, SODA LIME SILICA

Alkathene Plastics   Imperial Chemical Industries, Ltd.
SEE: POLYETHYLENE PLASTICS, CHLORINATED

Alkyd-Vinyl Varnish
SEE: VARNISHES, SOLVENTLESS

Allegheny Armature AISI M-43   Allegheny Ludlum Steel Corp
SEE: IRON

Allegheny Dynamo Special AISI M-22   Allegheny Ludlum Steel Corp
SEE: IRON SILICON SYSTEMS

Allegheny Dynamo AISI M-27   Allegheny Ludlum Steel Corp
SEE: IRON SILICON SYSTEMS

Allegheny Electric AISI M-36   Allegheny Ludlum Steel Corp
SEE: IRON SILICON SYSTEMS

Allegheny Electric Metal-4750   Allegheny Ludlum Steel Corp
SEE: IRON NICKEL SYSTEMS

Allegheny Moly Iron   Allegheny Ludlum Steel Corp
SEE: IRON MOLYBDENUM SYSTEMS

Allegheny Transformer-A   Allegheny Ludlum Steel Corp
SEE: IRON SILICON SYSTEMS

Allegheny Transformer-C   Allegheny Ludlum Steel Corp.
SEE: IRON SILICON SYSTEMS

Alloy 349
SEE: ALUMINUM IRON NICKEL SYSTEMS

Alloy 426
SEE: ALUMINUM COBALT IRON NICKEL TITANIUM SYSTEMS

Figure 6. Materials cross-references.

HYSTERESIS, PHOTOELECTRONIC PROPERTIES, THERMIONIC PROPERTIES). Thus, a person searching for values for the figure of merit of a particular material would look under thermoelectric properties. The reasons for this are several. Probably the most important is that the Index serves EPIC as a basis for gathering related data together to edit and compile into data sheets on a specific material.

A complete cross-reference list from over 400 secondary property terms to the 56 property terms used in the primary vocabulary has been compiled. A page from this list is included as Figure 7. The 56 property descriptors are as follows:

GENERAL
ABSORPTION
ARC RESISTANCE
CARRIER DIFFUSION
CORONA EFFECTS
CROSS SECTIONS
CURIE CONSTANT
CURIE TEMPERATURE
DEBYE TEMPERATURE
DIELECTRIC CONSTANT
DIELECTRIC STRENGTH
DISSIPATION FACTOR
DOMAIN STRUCTURE
EFFECTIVE MASS
ELECTRICAL CONDUCTIVITY
ELECTRICAL HYSTERESIS
ELECTRICAL RESISTIVITY
ELECTROACOUSTIC PROPERTIES
ELECTROMECHANICAL PROP.
ELECTRON FIELD EMISSION
ELECTRON PHOTOEMISSION
ELECTRON SECONDARY EMISS.
ELECTRON THERMIONIC EMISS.
ELECTRONIC SPECIFIC HEAT
ENERGY BANDS
ENERGY GAP
ENERGY LEVELS
GYROMAGNETIC PROPERTIES
HALL COEFFICIENT
INSULATION RESISTANCE
IRRADIATION PROPERTIES
LIFETIME
LOSS FACTOR
MAGNETIC HYSTERESIS
MAGNETIC SUSCEPTIBILITY
MAGNETOELECTRIC PROPERTIES
MAGNETOMECHANICAL PROP.
MOBILITY
PENETRATION DEPTH
PHOTOELECTRONIC PROPERTIES
PHOTON ELECTROLUMINESCENCE
PHOTON EMISSIVITY
PHOTON LUMINESCENCE
PHOTON MECH. LUMINESCENCE
PHOTON THERMOLUMINESCENCE
PIEZOELECTRIC PROPERTIES
POWER FACTOR
REFLECTION COEFFICIENT
REFRACTIVE INDEX
RICHARDSON'S CONSTANT
SUPERCOND. TRANS. TEMP.
THERMAL CONDUCTIVITY
THERMOELECTRIC PROPERTIES
THERMOMAGNETIC PROPERTIES
THRESHOLD FIELD
WORK FUNCTION

A brief review of our property indexing philosophy follows. It is suggested that technical reviewers also interested in solid-state physics examine the glossary mentioned above.

The study of solid-state physics involves a many-body problem. What happens when some 10^{23} atoms/cubic centimeter are brought together

Conductivity, electrical
See ELECTRICAL CONDUCTIVITY

Conductivity mobility
See MOBILITY

Corbino effect
See HALL COEFFICIENT

Corona discharge
See CORONA EFFECTS

CORONA EFFECTS
Breakdown field
Corona discharge
Corona onset field
Corona point voltage
Corona resistance
Corona starting gradient
Critical voltage gradient (corona)
Onset potential
Townsend's ionization coefficients

Corona point voltage
See CORONA EFFECTS

Corona onset field
See CORONA EFFECTS

Corona resistance
See CORONA EFFECTS

Corona starting gradient
See CORONA EFFECTS

Cosine θ
See POWER FACTOR

Cotangent θ
See DISSIPATION FACTOR

Coupling coefficients
See PIEZOELECTRIC PROPERTIES

Critical electric field
See ELECTRICAL HYSTERESIS

Critical field
See THRESHOLD FIELD

Critical frequency
See PENETRATION DEPTH

Critical temperature
See SUPERCONDUCTIVE TRANSITION TEMPERATURE

Critical voltage gradient (corona)
See CORONA EFFECTS

CROSS SECTIONS
Capture cross sections
Collison cross sections
Equivalent cross sections
Impurity cross sections
Partial scattering cross sections
Recombination cross sections
Scattering cross sections
Total scattering cross sections

CURIE CONSTANT
Curie-Weiss law
Weiss field constant

Curie point
See CURIE TEMPERATURE

CURIE TEMPERATURE
Antiferromagnetic Curie point
Curie point
Neél temperature

Curie-Weiss law
See CURIE CONSTANT
MAGNETIC SUSCEPTIBILITY

Current-wavelength characteristic
See ELECTRON PHOTOEMISSION

Cyclotron frequency
See Cyclotron resonance*
EFFECTIVE MASS

Cyclotron mass
See Cyclotron resonance*
EFFECTIVE MASS

Cyclotron resonance*
See EFFECTIVE MASS

Dark conductivity
See PHOTOELECTRONIC PROPERTIES

Debye frequency
See DEBYE TEMPERATURE

DEBYE TEMPERATURE
Debye frequency
Lattice specific heat
Specific heat

Decay time
See PHOTON LUMINESCENCE

Degenerate levels
See ENERGY LEVELS

de Haas - van Alphen effect*
See MAGNETIC SUSCEPTIBILITY

Demagnetization curve
See MAGNETIC HYSTERESIS

Demagnetization energy
See MAGNETOMECHANICAL PROPERTIES

Demagnetizing coefficients
See MAGNETOMECHANICAL PROPERTIES

Dember effect*
See PHOTOELECTRONIC PROPERTIES

Dember potential
See Dember effect*
PHOTOELECTRONIC PROPERTIES

Destriau effect
See PHOTON ELECTROLUMINESCENCE

Diamagnetic susceptibility
See MAGNETIC SUSCEPTIBILITY

Diamagnetism
See MAGNETIC SUSCEPTIBILITY

Dielectric breakdown voltage
See DIELECTRIC STRENGTH

DIELECTRIC CONSTANT
Absolute dielectric constant
Complex dielectric constant
Dielectric relaxation time
Permittivity
Relative capacitance
Relative dielectric constant
Relative permittivity
S. I. C. (Specific inductive capacity)
Specific inductive capacity (S. I. C.)

Dielectric dissipation factor
See DISSIPATION FACTOR

Dielectric hysteresis loop
See ELECTRIC HYSTERESIS

Dielectric loss angle
See DISSIPATION FACTOR

Dielectric loss factor
See LOSS FACTOR

Dielectric loss tangent
See DISSIPATION FACTOR

Dielectric power factor
See POWER FACTOR

Figure 7. Properties cross-references.

to make a crystal ? This has certain important consequences. For instance, it means that exact solutions cannot be expected, but rather that approximate models must be continually developed to fit the situation at hand. Thus, in making a theory it is essential to be aware of the experimental work in the phenomenon under consideration and vice versa.

In solid-state physics the particles are known and the forces between them are known, but all of human intelligence and insight are needed to understand the consequences of this interaction. Much of solid-state physics is interpreted in terms of certain elementary excitations, which react only weakly with one another. The important consideration about these excitations is that they are considered to have a finite lifetime.

In thermal equilibrium, the excitation may be characterized by a distribution function

$$f_p = \frac{1}{e^{E/kT} \pm 1} \qquad (1)$$

the plus sign applies if the excitation obeys Fermi-Dirac statistics the minus sign for Bose-Einstein statistics. $f_p(T)$ gives the probability of finding an excitation of momentum p, energy E, at the temperature T.

The basic Hamiltonian which describes a solid is of the form

$$H = H_{ion} + H_{electron} + H_{electron\text{-}ion} \qquad (2)$$

where H_{ion} describes a collection of ions (of a single species) which interact through a potential which depends only on the distance between the ions. By ion is meant the nucleus plus the closed-shell, or core, electrons, that is, those electrons which are essentially unchanged when the atoms are brought together to make a solid. $H_{electron}$ describes the valence electrons (the electrons outside the last closed shell), which are assumed to interact via a Coulomb interaction. Finally, $H_{electron\text{-}ion}$ describes the interaction between the electrons and the ions which is again assumed to be represented by a suitably chosen potential.

Equation (2) implies certain approximation in this treatment of a solid. For example, the interaction between ions is not well-represented when the coupling between closed-shell electrons on different ions begins to play an important role. The potential which represents the electron-ion interaction neglects the fact that the ions possess a structure (the core electrons). Also, where the Pauli principle plays an important role in the interaction between the valence electrons and the core electrons, that interaction may no longer be represented by a simple potential. In spite of all these approximations, however, the theory seems to fit experiments surprisingly well.

In general, only selected parts of the Hamiltonian (Equation 2) are studied. For example, the bond theory of solids is based on a model in which the equilibrium positions of the ions are regarded as fixed and the electrons are represented by a periodic (Hartree) potential. What are studied are the motion of a single electron in the periodic field of the ions and the Hartree potential, and the assignment of one electron state taking the Pauli principle into account. In this way other than the Hartree potential of the interaction between electrons is neglected. If the interaction between electrons in metals is of interest, it is useful to consider only $H_{electron}$, replacing the effect of the ion cores by a uniform distribution of positive charge. In this way, the role that electron interaction plays can be approximated without having present the additional complications introduced by the periodic ion potential. Of course, it is desirable finally to keep both the periodic ion potential and the electron interactions, and to include as well the effects associated with the departure of the ions from the equilibrium positions, since only in this way does one arrive at a generally adequate description of a solid.

The motions of a crystal lattice, in which each atom vibrates about an equilibrium point, may be resolved into normal modes, each mode generally representing a wave moving through the lattice. The system, from this standpoint, is simply a collection of harmonic oscillations, with one oscillator for each of the lattice waves. If the quantum commutation rules are imposed on the momenta, the harmonic-oscillator energy spectrum is obtained. These elementary units of lattice excitation are called phonons. They represent perhaps the simplest elementary excitation in a solid.

In the expansion of the ion Hamiltonian a description of completely independent phonons is obtained by keeping only the terms which are quadratic in the displacement of the ions from their equilibrium position. However, if the third-order or anharmonic terms in the expansion of the potential energy are included, the phonon-phonon interaction is obtained. This interaction gives rise to a scattering between phonons of different wave vectors which acts to limit the lifetime of a given phonon; it also acts to shift the phonon energy.

Despite the phonon-phonon and phonon electron interactions, both long-wavelength and short-wavelength phonons turn out to be well-defined excitations up to the melting point of a solid.

The electron-phonon interaction influences the properties of the quasi-particles in solids. In some metals that influence can be profound, since it gives rise to the phenomenon of superconductivity. In the BCS theory, it is shown that superconductivity can arise in metals as a consequence of an attractive phonon-induced, electron-electron interaction. For normal metals, the electron phonon interaction acts to change the quasi-particle energy and the specific heat. It also provides a quasi-particle damping mechanism and acts to limit the conductivity of metals at all temperatures.

There are other elementary excitations which are encountered in solids. For example, in insulating crystals, an electron in the conduction band is strongly coupled to the optical mode of the lattice vibrations. As a result, when the electron moves, it is accompanied by a co-moving cloud of phonons, which may act to change its mass appreciably. The resultant quasi-particle is known as a polaron.

In insulators, or in certain semiconductors, in consequence of the electron-electron interaction, there may exist well-defined elementary excitations within the energy gap which separates the valence-electron band from the conduction-electron band. The excitations are known as excitons: They correspond to a bound electron-hole pair state. The energy of an exciton lies within the gap or a consequence of the attractive Coulomb interaction between an electron excited from the valence band and the hole it has left behind there.

In a ferromagnet, the low-lying excitations correspond to oscillations in the electron-spin-density fluctuations, and are known as spin waves. The quantized spin waves are called magnons.

The spectrum of elementary excitations in a solid is measured directly by means of various kinds of external probes. The ideal external probe is one which is only very weakly coupled to the solid, so that the system response can be experienced in terms of the properties of the excitations in the absence of the probe. The great strides which have been made in the purification of solids have enabled the experimentalist to use more and more sophisticated external probes, often involving a combination of both static and time-dependent magnetic and electric fields. A high degree of purity is required because even very small amounts of impurity may tend to mask the subtle resonance effects under investigation. One of the major consequences of the development of better probes and "better" solids is the vastly improved and by now quite detailed knowledge of the Fermi surface of a number of metals.

The "Properties" which are observed are simply the interactions of the "Particles" of the solid with the external probes of "Particles" and fields of several kinds. The "probe" may also be affected by several environmental parameters. What are recorded as "experimental data" are numerical values describing magnitudes, etc., of these various interactions which have been suitably separated from each other. Sometimes the Hamiltonian of a physical situation is only partially separable. This is interpreted as the Hamiltonian splitting into a sum of independent Hamiltonians plus some coupling terms. If these coupling terms are small, then the "particles" are regarded as "interacting." If the coupling terms are large, the "particles" are regarded as being "strongly-coupled." Sometimes a Hamiltonian can be "decoupled" by dividing it into sums of functions involving independent variables in a different way. The question as to what is and what is not a "particle" is, therefore, dependent to a large extent on its formulation. The modern viewpoint on solids, described briefly above, has been derived largely from a better understanding of how best to split up the Hamiltonian and thereby define the "particles."

In preparing a list of "property" terms suitable for indexing the various interactions found in the area called solid-state physics, and in particular those interactions which have come to be known as being descriptive of "electronic" or "electrical" properties, a good understanding of the elementary "particles" or excitations is highly to be recommended. This basic understanding is essential in the preparation of property terms encompassing specific interactions or broader classes of kinds or groups of related interactions. It is also most useful in delineating the relationships between the two.

Besides particles, defects in the lattice structure of crystals may act to limit the lifetime of "particles" or they may act to bind particles. By lifetime is meant the time the "particle" remains in some given energy state before being scattered into energy state.

Experiments provide the only direct demonstration of the reality of the elementary excitations of solids. Some of the physical phenomena which provide evidence for the existence of "particles" in solids are electromagnetic waves (used in light absorption, magnetic resonances), neutron scattering, electron beams, transport (charge, heat) properties, and acoustic absorption.

Light absorption is characterized by electron-photon and phonon-photon interactions. The photons of any given energy can only be absorbed if the solid has an energy transition of the correct size available. Absorption in a range appropriate for quasielectrons gives evidence for the existence of quasielectrons. This is especially true since quantum electrodynamics tells that electrons can emit and absorb light by changing their energy. In the system set up here some of these light absorption mechanisms are indexed under terms appropriate to the mechanism or to the quantity being measured by the mechanism, e.g., absorption, energy gap, energy levels, photoelectronic properties, etc.

Transport properties of solids deals with the capacity of solids to transport or conduct heat and charge. These properties are due almost entirely to the vibrations of the crystal lattice, and the motion of electrons through the crystal, together with the strong interactions between these two types of excitation. In a perfect metal lattice, the impediment to an electric current is due to electron-phonon interactions. The property known as electrical resistance is a measure of the nature and magnitude of these interactions.

In a magnetic field the transport properties of a solid are considerably altered. The phenomena of galvanomagnetism and thermomagnetism are important because of the insight they give on the electronic structure of solids. The introduction of the extra field vector resolves the degeneracy of a conductivity tensor with cubic symmetry. Some of the effects produce the change in the electrical resistance of a metal called magnetoresistance; a great variety of thermomagnetic phenomena is due to the bending of electron trajectories about the magnetic field lines; a number of effects in magnetic fields is so strong that an electron is able to make only several orbits about the lines of the field before being scattered; and other effects involve quantization of the electron orbits. Some of these "properties" are known and indexed within the present EPIC system as HALL COEFFICIENT, MAGNETOELECTRIC PROPERTIES, THERMOELECTRIC PROPERTIES, ELECTRICAL CONDUCTIVITY, etc.

An endeavor has been made during the periods covered by the EPIC contract(s) to prepare and define property terms based on an understanding of the elementary excitations involved and to build a system capable of coordinating and relating the physical phenomena identified as "properties." In addition, the system must be adaptable to incorporating new developments and interactions as they may arise. Two such developments of current interest, for example, are the possibility of energy storage in dielectrics by implanting or injecting electrons by irradiation with high energy electron beams. This produces a negative space charge layer inside the slab of material provided the thickness of the sample exceeds the mean free path of the electrons. Because of the extremely slow relaxation time of the trapped electrons, the dielectric may remain electrified for long periods of time. In this process there is a conversion of the incident kinetic energy of the electrons to electrostatic energy stored between the internal trapped electrons and the corresponding surface layer of positive charge. Recently, a way has been investigated to discharge the irradiated dielectric so that the trapped charge passes efficiently to a useful load.

Another interesting development has been the possibility of developing superconducting polymers, with superconducting transition temperatures in the region of room temperature. These and other developments must be planned for and included within the properties vocabulary as new developments occur in research involving "electronic properties" and interactions of materials. EPIC staff has, as one of its most important functions, this obligation to be aware of new developments and to incorporate the advances into the property (and material) nomenclature of the EPIC system.

EPIC DATA PROCESSING SYSTEM AND CAPABILITIES

A particularly good example of Hughes capabilities in the field of the specialized information center is the EPIC data processing system. The original RFP, which established the Center in 1961, did not call for "machine techniques." However, Hughes proposed a punched card system for generating the descriptor cards. This system, already well established in the Company Technical Document Center, had been shown to reduce the cost in posting accession numbers on descriptor cards by 17 percent. A by-product in EPIC was the immediate building of machine codes for the indexing vocabulary. As more sophisticated data processing techniques came to be considered, it was never necessary to build such codes. They were already in the system to be used for experimentation.

The original system used IBM equipment including sorters, collators, reproducers, interpreters, and card printers, with a 1401 doing the actual posting. The punched card file was well established numbering about 38,000 cards the first year (Figures 8 and 9) with each properly punched either as a master (material or material and property) or a detail (accession number - article) card. Quick visual distinction between these two could be made through the blue-lined top and clipped upper-left-hand corner for the master cards and plain, clipped upper-right-hand corner for the detail cards. Machine distinction was made through a punch on the masters in the X80 position (80th column above the zero).

The master card was to provide for the printout of the descriptor on the descriptor card. The detail cards represented the article in that the accession number of the article was punched on the card. For each descriptor card there was a punched master card. However, for each article there were several detail cards, one for each descriptor behind each of the appropriate master cards punched for the associated descriptor.

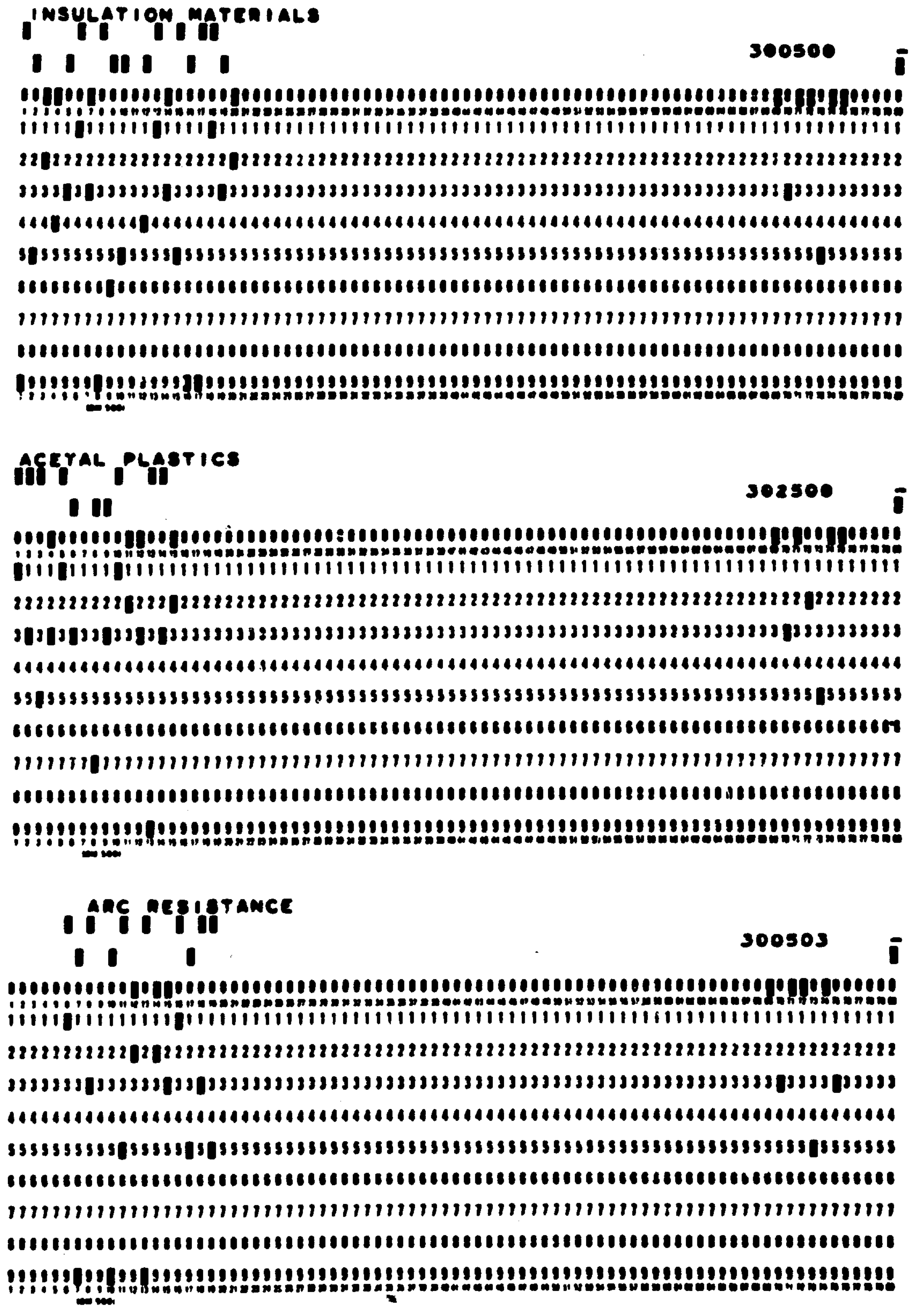
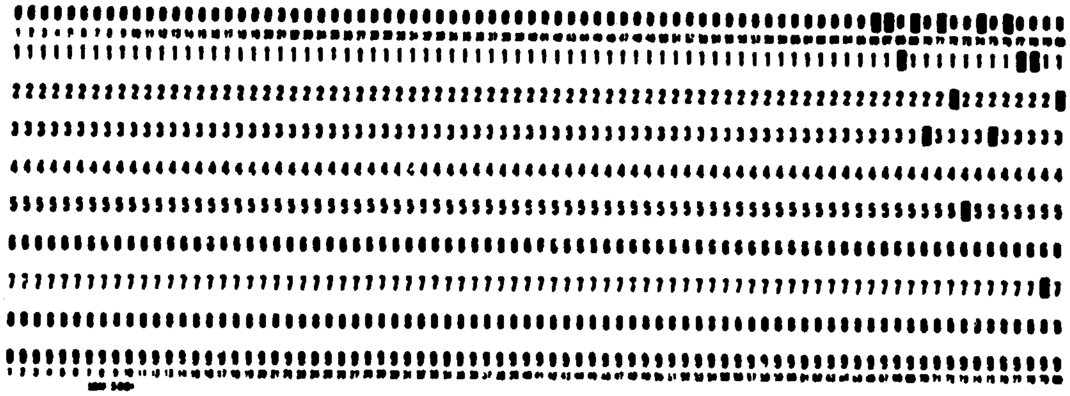
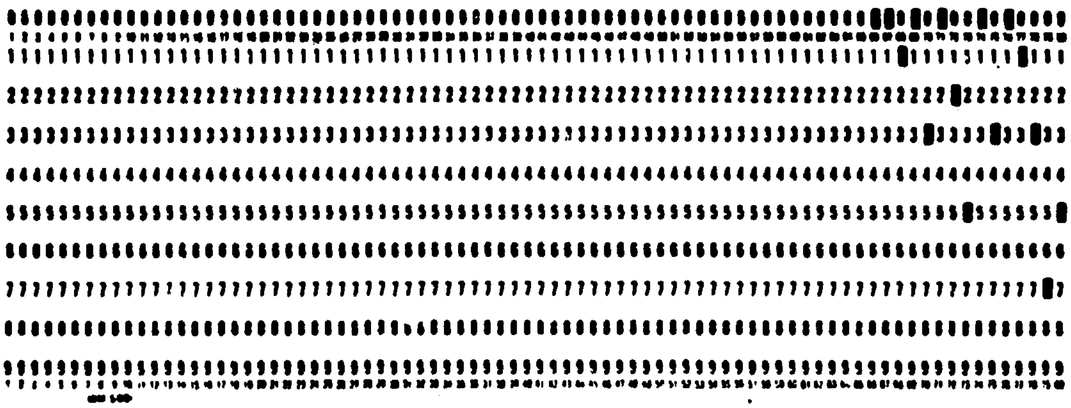


Figure 8. Master punched cards.

1030250301172



1030250301375



1030250301069

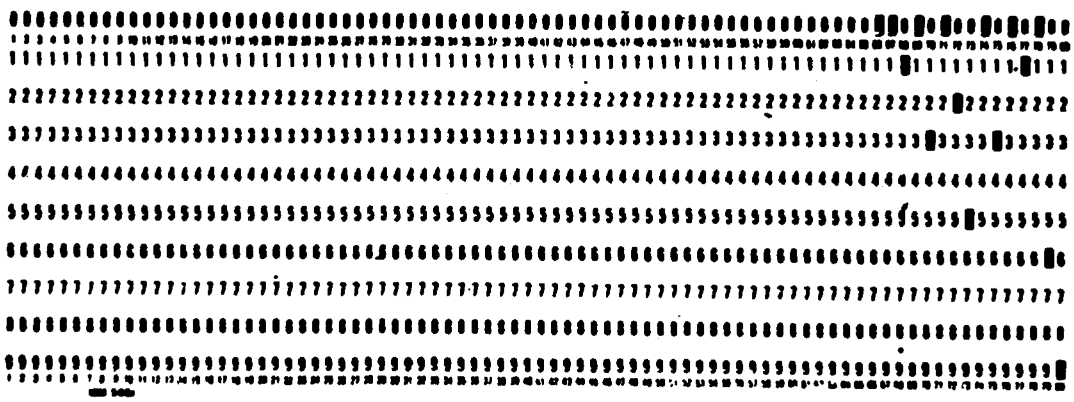


Figure 9. Detail punched cards.

The card deck for each of the major categories of materials (semiconductors, insulators, etc.) was filed separately and coded under that category. Master cards were coded at the left of the card for the printing of the material or property in the upper left-hand corner. They were also coded in columns 69 to 75 for the material and property, the material occupying 69 to 73 and the property 74 and 75. Thus, INSULATION MATERIALS, which was arbitrarily assigned the code number 03005, showed this number in columns 69 to 73 and showed 00 in 74 and 75 denoting no property. The number 0300500 was also printed above for visual use. Note that the first 0 was not printed but was punched in column 69. The property was coded in 74 and 75. INSULATION MATERIALS - ARC RESISTANCE was 0300503, CORONA EFFECTS 0300506, and so on through the properties for INSULATION MATERIALS.

The materials under the general category of INSULATION MATERIALS were coded in columns 71 and 72. While INSULATION MATERIALS was 03005, ACETAL PLASTICS becomes 3025. ACETAL PLASTIC - ARC RESISTANCE was 302503.

Continuing on through the deck all master cards continued to be coded in alphabetical fashion. This was to assure that all printouts (descriptor cards, master tab runs of materials, etc.) will be alphabetically arranged. Note that there was generous space allowed between the numbers assigned the properties and materials. For example, ARC RESISTANCE was 03, CORONA EFFECTS was 06 instead of 04. This space was to allow the addition of future materials and properties in alphabetical order without having to reassign any numbers.

The detail or article cards appeared in the deck behind the applicable master card. Columns 69 to 75 repeated the material and property. Columns 76 to 80 showed the accession number of the indexed article and columns 66 to 68 showed the horizontal line number to be printed on the descriptor card. While the terminal digit of the accession number indicated in which column on the descriptor card the number will appear, the line number determined its position (e.g., row within the column). Again note that zeros preceding the first digit do not appear printed on the tab card but are punched in. The total code appearing on a detail card would appear like this: 001030250301172: 001 - line number, 03025 - material, 03 - property, 01172 - accession number of the article.

The monthly updating program for the descriptor cards went as follows (see Figure 10). New master cards (2) were punched and sorted into order and then merged and sequenced (3) with the existing file (1). New detail cards (4) were also punched (except for columns 66 to 68) and sorted into order. These two files were then matched against each other (5) in columns 69 to 75 (materials and properties) and sorted into four groups. By the matching process with the new detail cards, the merged main file and new master cards were separated into those areas (master card plus associated detail cards) which do not require updating (6) and those areas to be updated (7). The new detail cards from block (4) were continued into block (8) except for those revealed by the matching process to have no masters in the file. These were sorted out (9) and discarded as errors or held until masters were made. The cards of (7) and (8) were then merged and sequenced into one file (10). Those cards from (7) were already in order by material, accession numbers, property, accession numbers, and so on. The detail cards from (8) were also in this order but without masters. Note that as the detail cards were filed behind the master they were filed first by the terminal digit, then by the rest of the number. Note also that, since accession numbers were being assigned by numerical order to the articles as they enter the indexing system, any new detail card would automatically file at the end of those cards with the same terminal digit because the rest of the accession numbers to be posted in that descriptor card column would be lower (i. e., the articles have previously entered the system). This simplified the next step (11) on the IBM 1401 where the vertical line number in that column on the descriptor card was automatically punched in and printed on the tab card in columns 66 to 68. For example, if that particular master card already had two subordinate detail cards with accession numbers ending in 1, the associated descriptor card would have two accession numbers in column 1. The detail card

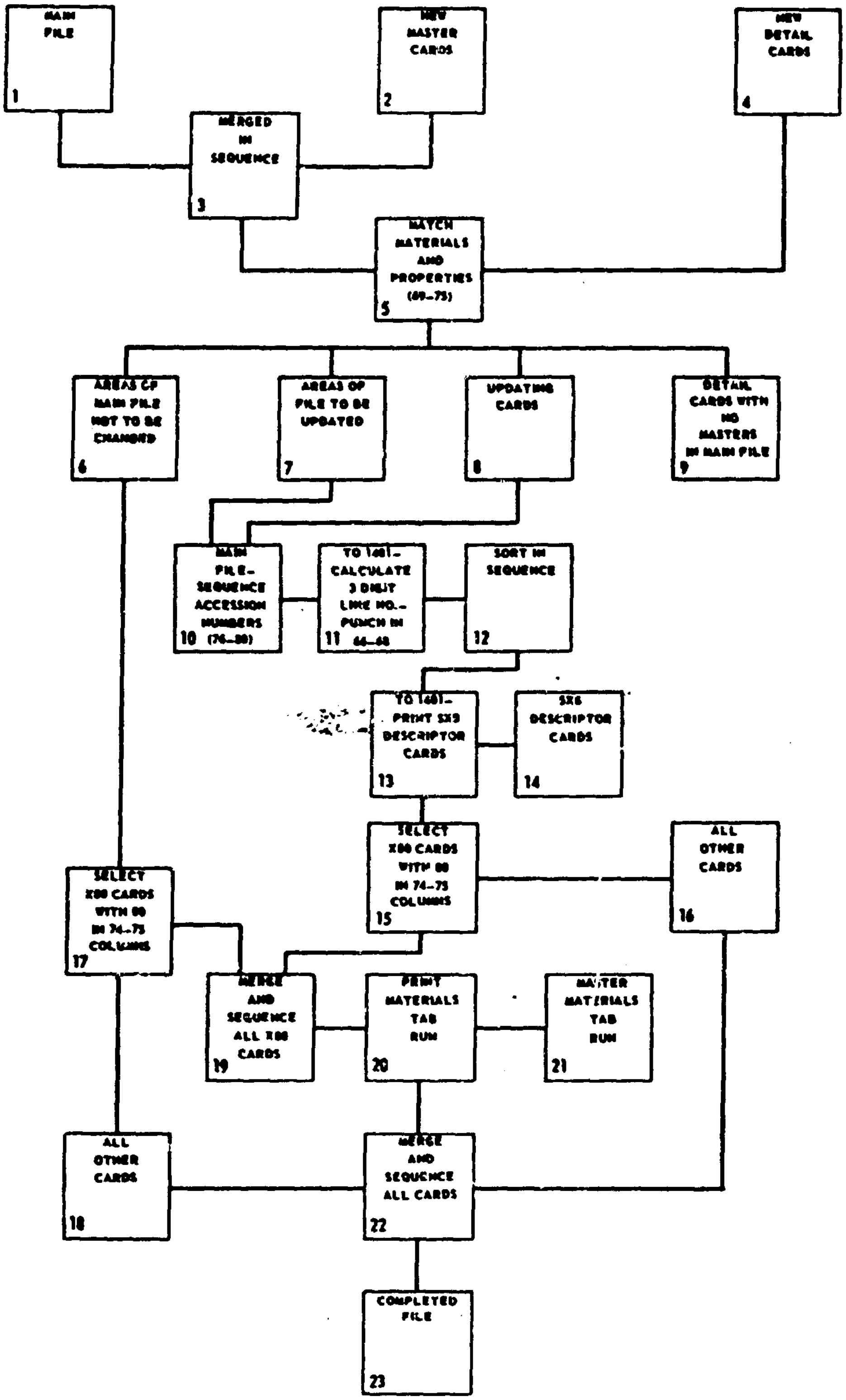


Figure 10. Punched card program for posting descriptor cards.

for the first accession number would show a line number (columns 66 to 68) of 001, the second 002, and the updating card would automatically be filed behind these two and then be punched by the IBM 1401 as 003 for the line number.

However, the detail cards filed after the masters were still not in the correct order to print the descriptor cards, since the 1401 would not print column 1 and then column 2 and on across, but rather would print the first line of accession numbers across all columns at once, then go to the second line, and on down the card. Each set of detail cards after each master had to be resorted to an order first by the line number and then by terminal digit of the accession number. This was accomplished in (12) and the cards were then ready to be taken to the 1401 for printout for the descriptor cards.

The printout (13) was as follows: Each master card represented a descriptor to be printed at the top of the descriptor card. The descriptor would be a material only (i. e., INDIUM PHOSPHIDE) or a material and a property in a precoordinated term (i. e., INDIUM PHOSPHIDE - ABSORPTION). The detail cards behind each master card represented the articles indexed under that descriptor by accession number. As the cards were run through the 1401, the master appeared first and the descriptor was printed at the top of the descriptor card. Then as the detail cards appear, the first line of accession numbers were printed across the descriptor card, then the second line, and on down the card. After the printout the 5x8 descriptor cards were ready to file since they were already in alphabetical order. The old cards which needed updating were pulled out of the descriptor file and the new ones inserted in their place.

An additional feature of the data processing system was the capability of the printing lists of materials and/or properties. Since the properties lists were not lengthy nor subject to frequent change, they were seldom printed but the monthly procedure of updating the descriptor cards included printing an up-to-date tab run of all materials in the system.

In order to do this all X80 (master) cards with 00 in the 74 and 75 columns (no property) were sorted from each of the two files (i. e., the updating file (15) and the rest of the main file (17)). These were merged in sequence (19) while the rest of the two files bypassed this step (16 and 17). These cards were then run through a printer to produce a master tab run of materials (21).

After the tab run of materials, all cards were merged and sequenced (22) for a single completed file (23).

There are many advantages to using a data processing system for updating descriptor cards. Some of these, such as the capability of producing tab runs of descriptors, are already implied. However, not only can tab runs of materials and properties be made, but also useful counts and comparisons, such as the average number of descriptors per article or total descriptors in the system, can be easily made. The accomplishment of such tasks from the manual file would be extremely cumbersome.

In addition, both clerical cost and clerical error are significantly reduced. This is particularly true where multiple copies are made and maintained. Since the punched deck is always maintained up-to-date, it provides a back-up file for the descriptor card catalog. A new catalog may be made any time either for an additional set or because of accidental destruction of the first, and at a much lower cost than clerical copying or reproduction. Yet, while a new catalog or part of an existing catalog is being run, it is unnecessary to remove any descriptor cards from the file, as is necessary with manual posting. The descriptor file is always intact for users of the system.

A by-product of posting through data processing is the generation of large numbers of punched cards individually coded to "connect" an accession number with a descriptor term. As it becomes feasible and desirable to automate the storage and retrieval of the indexed information accumulated in this project, these cards will provide an invaluable source of input information.

As stated previously, the Descriptor File is no longer used. Although this file and the data processing program just described served

EPIC well, it was felt that a need existed to publish copies of the index. Therefore, the descriptor cards were dropped in favor of a standard tab run at the same time that the magnetic tape replaced the punched cards.

At the time this occurred, the use of the Center was being assessed with the discovery that approximately 50 percent of the use was by research scientists. The original program had been slanted toward applications, with the maintaining of categories of materials. The applications engineer was interested in a material for a particular application, and did not want the results of a search submitted cluttered with the use of that material in some other manner. On the other hand, the research scientist usually wanted everything on a material, regardless of application.

With this knowledge, it was decided to build the flexibility into the new system to sort and printout with or without consideration of categories.

The electronic data processing procedures now used in EPIC are designed to facilitate the clerical operations of the Center, increase the Center's ability to answer technical requests and provide the capability of relating and comparing data in a manner not possible with human abilities. At present, all data processing techniques serve to replace tasks which could be accomplished manually at a higher cost and at a much higher tedium and error rate. The projected use of these techniques is to continue and improve existing routine tasks and to expand into other areas of such scope that they defy manual operations. The existing computer techniques involve two operations, 1) updating, and 2) emending and purging of the descriptor file which provides the indexes. This file has been in operation since the early days of EPIC and within the past year has been improved markedly.

As stated in the history of the data processing in EPIC, one of the prime reasons for adopting the use of the computer was the cost factor. Cost again has been the prime motive for all of the improvements that have been affected in this file. The most recent of these improvements has been the conversion to magnetic tape form. By the time accession numbers had reached the 11,600 figure, and the updating became necessary, it was evident that the file would contain approximately 85,000 individual master and detail records. Processing this many in card form was virtually prohibitive in both time and money, and so a conversion to tape was initiated. Very little savings were realized in that first tape updating because of the implementation costs. However, in the most recent updating, to accession number 13,600, enough time and money were saved to allow the analytical time necessary to yield an improved form of the index.

The description file contains two types of records, (1) material master records, and (2) detail records. Property master records that existed in the earlier file have been deleted. Analysis of the program showed that the amount of core storage necessary for the program itself left enough room to retain each of the 56 property names in storage and to call them out when needed. This improvement in the program allowed a reduction in the size of the file and reduced the length of the run time at that updating by 330 hours.

Even though all 104,000 records are now stored on tape, the input still remains the punched card. The form that these cards take is identical to the earlier cards except for the three digit line number field which will be explained later. Each year the number of accessions increases and correspondingly the data processing costs increase. Recognizing this, data processing funds are budgeted and subsequent improvement in the programs reduce operating costs and provide funds for additional capabilities. Because of these improvements, the data processing dollar in EPIC today buys the operation of the existing files as well as the necessary analysis for improved programs.

The original intent in going to EDP techniques was to alleviate the task of manually posting accession numbers under the precoordinated material-property index terms. This is still the primary role of the accessions file, but by using sound techniques and working closely with the analyst, this file now has capabilities far beyond just being an automated clerk. The primary purpose of this file is to provide an index to the accessions file and this it successfully has accomplished. Since the beginning of the data processing techniques, the format for this index has changed very little. The change to tab run form over the earlier card stock is but one example. A far more significant change is the nature of the index itself. When only two categories existed, insulators and semiconductors, the separate printouts for each file gave little trouble. Only a few of the materials were duplicated in the two files, but as the other seven categories were added, many more duplications occurred and the use of nine separate printouts proved to be rather cumbersome. To correct this situation, all nine categories have been sequenced into a single alphabetical materials index. This enables the user to go to only one index and determine the articles in the file that deal with that material and property, regardless of the category. This capability as well as many other advantages of this file will be discussed in a later section.

A significant difference exists between the updating and the emending-purging routines, but this difference is found primarily in the input and only slightly in the machine programs and printouts. The only indication that the descriptor file has been updated is a listing of a number larger than the last number of the previous updating. An accession number greater than 11,600 posted to any descriptor is evidence that the most recent updating to 13,600 has been completed. Emending and purging of the file is not so obvious, since the only way in which these operations can be detected is a comparison of the most recent index with a previous one. The machine sub-routines which emend or purge the file have an error listing of these transactions so that an accurate record of them may be retained. In the following discussion, each operation of the flow chart in Figure 11 and the corresponding text is numbered.

(1) There are two types of transmittals from EPIC to data processing, two updating forms and one emending-purging form. The updating form for detail records is a 4-1/4x 11 card. One of these cards is used for each material name as listed on the index-abstract form. During this phase of the EPIC routines the material name as listed on the index-abstract form is placed in the block labeled "Cat. Code," the

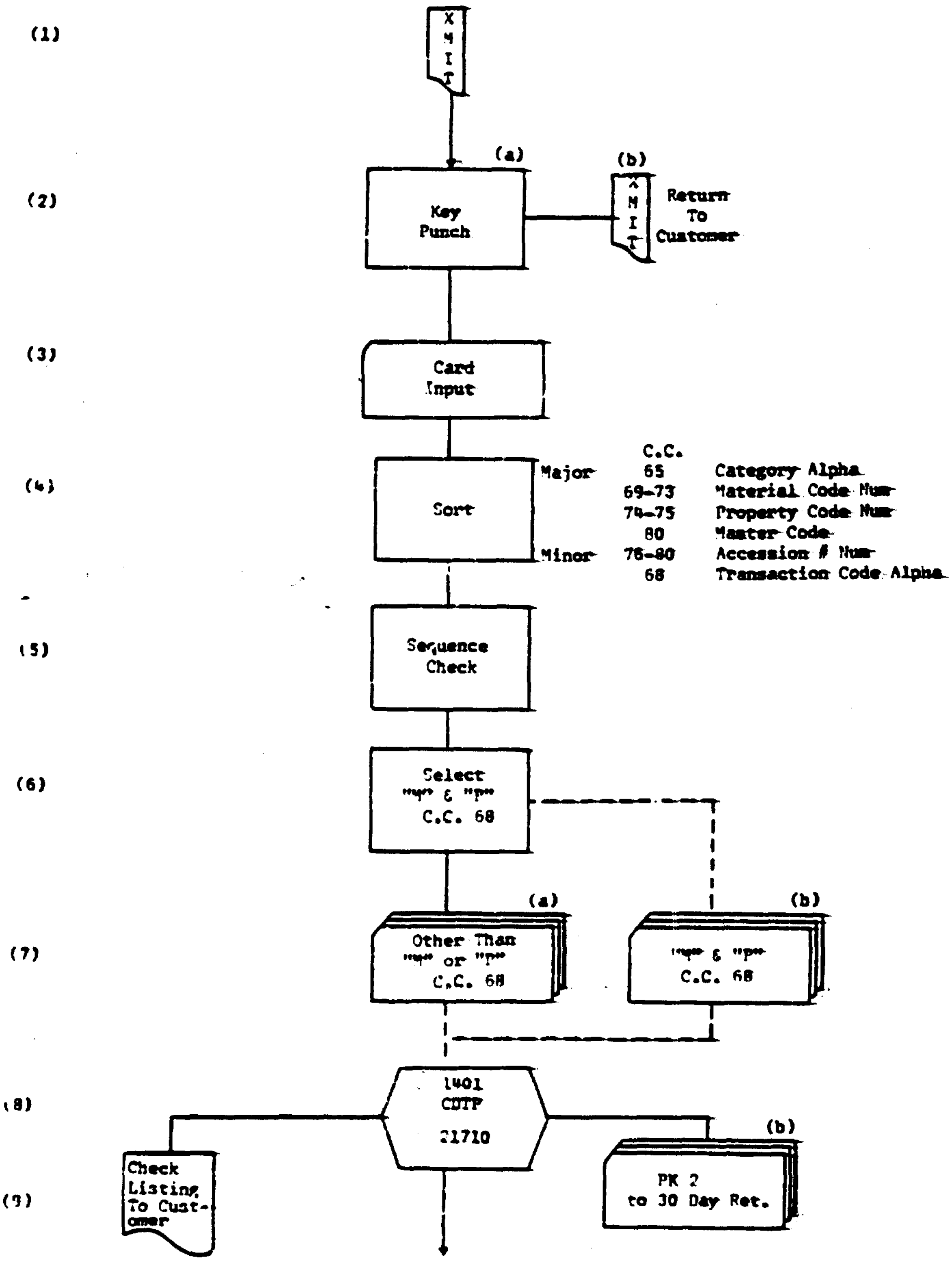


Figure 11. Data processing for producing index.

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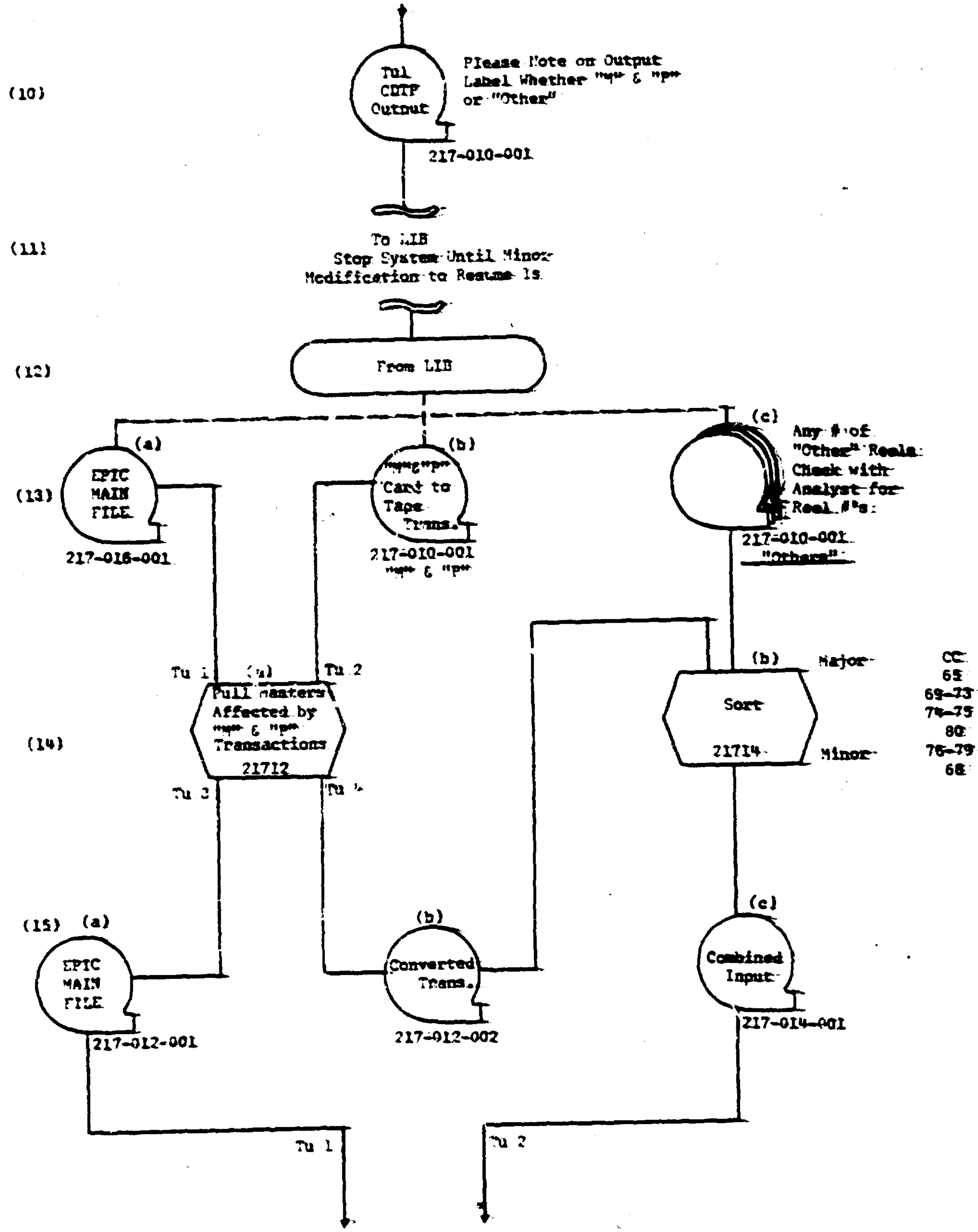


Figure 11. (Continued)

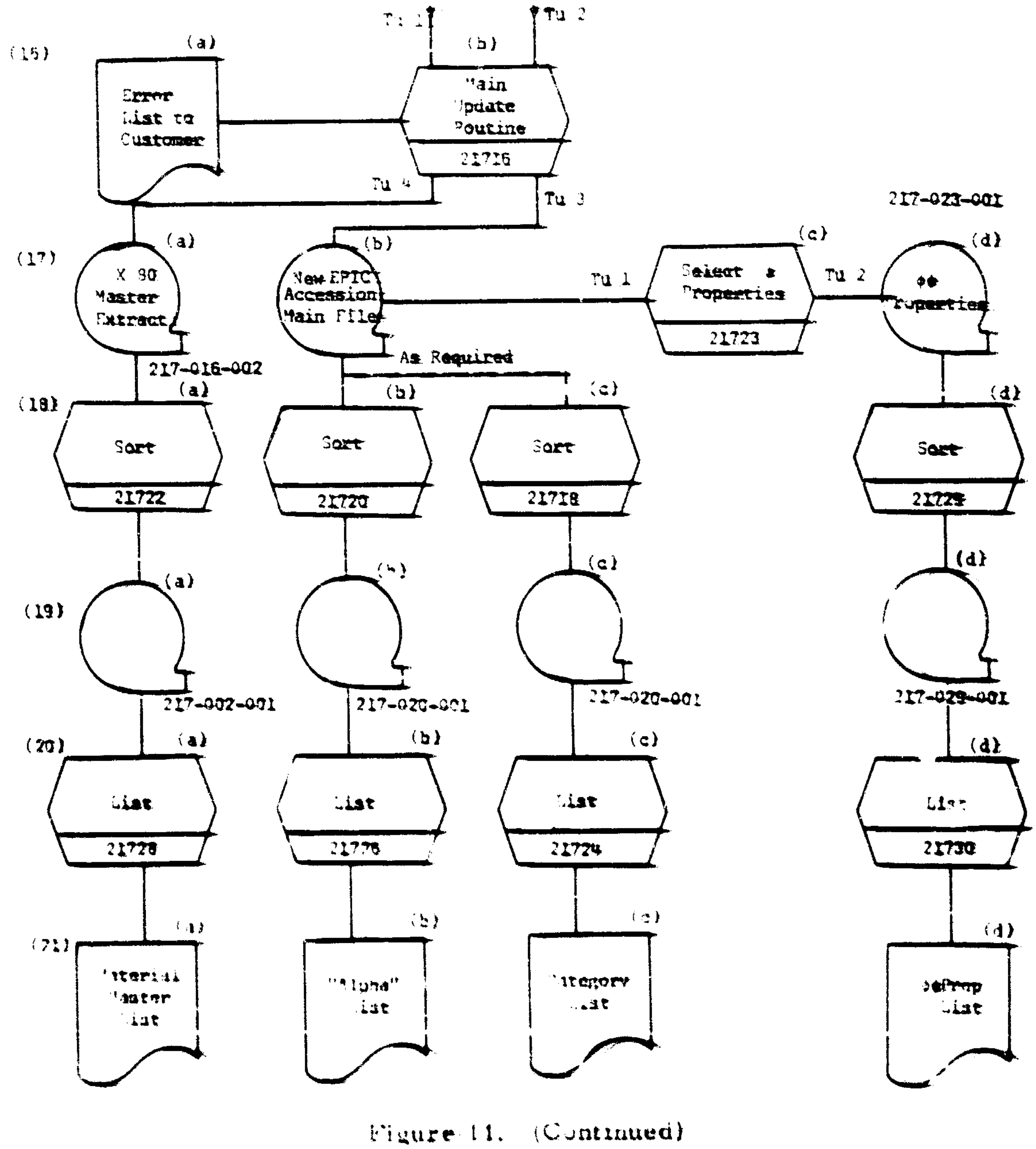


Figure 11. (Continued)

accessions number is placed under the label "Acc. #" and the numerical codes of the properties descriptors which are checked on the index-abstract form are circled.

These cards are then filed alphabetically until 1000 accessions numbers have been accrued. The material code number is then taken from the materials index and placed under the label "Code #" and the packet of cards is sent to the keypunch operation in the data processing section. These routines have one distinct advantage. The keypunch machine has a duplication capability which can be utilized. As these transmittal cards are grouped together with one material code and number and one category code letter applying to a bulk of them, these codes are duplicated by the keypunch operator with a savings of time and money. Each of these transmittal cards must have the 00 property code circled in addition to all of those checked on the index-abstract form. This procedure has a number of advantages which will be described in the next section.

The transmittals are used for updating the master records and are virtually duplications of the punched card itself. The new descriptor is spelled out in positions 1 to 64 and if this proves to be too long to fit the prescribed field, certain abbreviations are used. The word "System" is replaced by "Sys." "Oxide" is abbreviated by "Ox" and if after these efforts the descriptor is still too long, the chemical elements in the name are abbreviated. The remainder of the transmittal is coded as follows: the category code letter is placed in column 65; the transaction code N is placed in column 66, the material code number assigned to this new descriptor goes into columns 69 to 73. A property code of 00 is placed in columns 74 and 75 and a dash is coded into the x position of the 80 column to complete this transmittal.

Emending-purging transmittals are identical to the master-update form but vary in the coding methods and techniques. Six types of transactions are found in this operation. The first purging operation is the complete deletion of an entire material code. This is done when a material has been carried in the system and is no longer considered valuable. An example of this is the material descriptor "JUTE." This material was placed in the system early in the contract operations and has recently been deleted. This transaction is coded with a category code in column 65; an "A" transaction code in column 68 and the material descriptor code in columns 69 to 73.

The second type of purging operation is the deletion of a single entry. This type of transaction is used for detail records only and must be accompanied by at least one or more property codes. A transaction of this type does not need a material name spelled out in columns 1 to 64 but requires only a material number in columns 69 to 73, a category code in column 65; a "D" transaction code in column 68, an accession number in columns 76 to 80 and those property codes in columns 74 and 75 which are necessary. If all of the properties of a given material descriptor are deleted, the 00 property must also be deleted and if all material descriptors under a given accession number are deleted, then the document must be deleted from the files and replaced by a new document.

The last type of purging transaction is coupled with an emending operation. In some cases, the detail records need to be included, i.e., the postings under one or more material descriptors must be included with the postings under other material descriptors, with the original material master record being deleted. This type of transaction requires only a category code, the "P" transaction code in column 68, the original material code in columns 69 to 73, and the new material code to which the details are to be transferred in columns 76 to 80. No property code or accessions numbers are required since all details under the old material code number in Figure 4 are affected. In this type of transaction all of the details posted under Hydrocarbons, Fluorinated (54926) are transferred to Hydrocarbons, Halogenated (54927) and the 54926 master is deleted.

Another emending operation is the change single entry master transaction "C." This is used to change everything in the first 64 positions in master record. Regardless of what exists on the tape in this field for a given record this transaction will replace it with what is in columns 1 to 64 of the transmittal. The "00" property code in the

74 and 75 and the "-" in the 60 position are necessary since a master record is being corrected.

The third type of amending transaction is the complete change in material code "M." This is different from a "P" transaction in that the master is not deleted, nor is there an omission of the postings. This type of transaction is used when a material is completely out of alphabetical sequence, such as Barium Oxide-Uranium Oxide, Rhenium Base. No material name is needed in this transmittal and no property codes, only the incorrect material code number and the new number to make it sequentially correct.

The last type of amending transaction is the addition of an individual entry. This is an amending operation rather than an updating since this transaction is used on accession numbers not included in the regular updating. They are accession numbers that have already been processed and additional postings are necessary. (2a-2b) When the updating and amending-purging transmittals have been completed in EPIC they are sent to the keypunch operation of the data processing section, the cards are punched and verified and the transmittals are returned. The detail updating cards are now filed alphabetically and serve as an interim index to the body of the literature until the printout is available. This procedure gives access to the most recent accession numbers. The amending and purging forms and the updating forms are of no use, but are retained until the printout is available, then all transmittals are discarded.

(2-7) After the keypunch operation the cards are sorted first by category column 65; second by material code, 69 to 73; third by property codes, columns 74 and 75; fourth the master cards are separated by the X punch in the 60 position. The fifth sort is by accession number, columns 76 to 80, and finally they are sorted by transaction code, column 68. This deck is now checked for proper sequence. Because of the nature of the "M" and "P" transactions, they are separated from the other transactions. These two decks are kept separate for the card to tape operation.

[illegible]

[illegible] (25) [illegible] -12-01 [illegible] -12-01 [illegible] numbers [illegible] -14-01 [illegible] -12-01.

were the nine separate category printouts. These were obtained when the Main File was sorted (18c-21c) by program 21718 into the following sequence, first by category column 68, second by material code number 69 to 73 and finally by line number columns 66 to 68. The tape generated from this sort, 217-020-001 was listed by program 21724 and produced the nine separate categories.

(18b-21b) At the last updating, to accession number 13,600, it seemed desirable to printout first alphabetically the material, secondarily by property and finally be category. The main file was sorted by program 21720 which produces tape number 217-020-001 which in turn is listed by program 21726. The same type duplication exists in this printout as in the former one. This type duplication could have been eliminated, but would have given more rigid data processing techniques. And so to retain the capabilities of going back to the category type printout, the duplication is tolerated.

One other capability exists from this file at present, that is the selection of the 00 property codes and their printout by accession number order. This capability was first obtained when it was necessary to check the accession file for missing numbers. This subroutine works as follows: (17c) program 21723 selects the 00 properties and generates tape 217-023-001, (17d-21d) which is sorted on accession number columns 76 to 80 by program 21729 and generates tape 217-029-001, which is in turn listed by program 21730.

This new data processing system, designed to printout on master tab runs instead of descriptor cards, has great flexibility. It can printout: (1) alphabetically by category, then material, then property; (2) alphabetically by material, then category, then property; and (3) alphabetically by property, then category, then material. It also can produce descriptor runs of materials and/or properties with or without category notation. It is this flexibility that has allowed the commercial publication of the index in a unique and highly usable way (Plenum Press, February 1965).

DATA SHEET PREPARATION

Since the beginning of the program, part of our approach to the experimental data in the literature has been the compilation of data sheets (see Figure 12). These compilations have been issued with preference given to materials of immediate importance, and after consultation with "experts" in the field.

After a material is chosen, the first step is to determine with certainty that the literature on that material has been thoroughly searched and acquired. One of the methods employed as a check is to examine all citations appended to articles indexed to determine if these citations are also documented in the system. Some of the early EPIC data sheets were issued before all such citations could be included, in the interest of compiling what we could as soon as we could. Now, however, the data sheet compiler must satisfy himself that the EPIC collection of articles on a material is virtually complete before beginning to evaluate the data for compilation.

The EPIC staff member (or members) who is most knowledgeable about the material is assigned to prepare the data sheets. All articles on that material are pulled from the files, the compiler reads through them, gaining an overall view of the field, and then begins the evaluation of the data in the articles for possible inclusion.

In the meantime, an additional step is taken to help assure that the necessary articles are in the collection. All staff members are informed about the data sheets in preparation. In searching current journals, all germane material is referred at once to the appropriate staff member for immediate evaluation. In this way, data sheets are kept as current as possible. In one case, important energy level data that was published a few weeks after Silicon was finished, was issued as a supplementary sheet for distribution.

In evaluating the data in the articles for possible inclusion, the compiler begins by recording each paper on a work sheet. Review and secondary articles are so noted and used as additional sources for primary articles; however, data are compiled only from primary sources, except on very rare occasions when the primary source is not available.

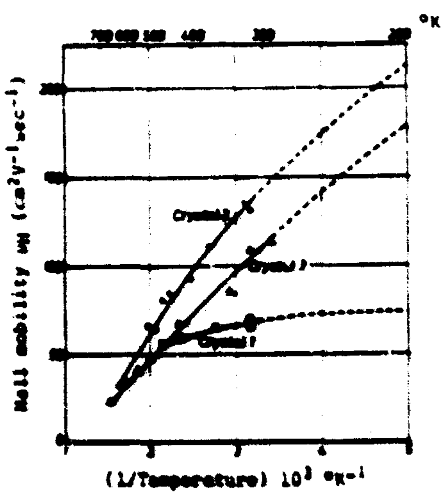
AIR FORCE MATERIALS LABORATORY
RESEARCH AND TECHNOLOGY DIVISION
AIR FORCE SYSTEMS COMMAND

PREPARED BY ELECTRONIC P... PERTIES INFORMATION CENTER · HUGHES AIRCRAFT COMPANY CULVER CITY CALIFORNIA

ZINC SULFIDE DECEMBER 1963

Mobility

Symbol	Value (cm^2/V sec)	Type	Ref.
μ	~10-100		3307
μ	~100	hexagonal or cubic	2586
μ_H	~120 (110-140)	hexagonal, some chlorine-doped $\sigma \sim 10^{-10}$ $(ohm\ cm)^{-1}$ T=300°K	2972
μ	~100	hexagonal, single crystal wurtzite	2525



Electron Hall mobility as a function of temperature for single crystal, hexagonal, chlorine-doped zinc sulfide samples.

[Ref. 2972]

Figure 12. Typical data sheet.

Two different philosophies have prevailed in compiling the data. The first which has been used in compiling on semiconductor, superconductor, and thermionic emitter materials, has been to retain as much as possible of the data as presented by the original author.

Under this philosophy, the first step is the evaluation of the single properties by one large lay-out of all graphs and information available. Selection is then made under the following considerations:

1. Date: Improvements in techniques and equipment in the past 20 years for producing pure single crystals, or those with controlled doping, suggest that the choice of papers written since approximately 1955, are preferable, all other factors being equal.
2. Parameters: Every possible environmental variation in experimental conditions is covered. In resistivity data we search for graphs showing the effect of a variety of dopants, a full range of temperature and field strength values, film vs bulk effects, pressure and stress applications and carrier concentration changes. In optical measurements we include, where available, the entire electromagnetic spectrum. In magnetic phenomena, we search out data showing a variety of magnetic field effects.

Internal evidence in the paper often indicates faulty or dubious measurements, unknown sample composition, and many other defects which reflect on the quality and value of the experimental data. Occasionally, where nothing better is available, such data may be included, with appropriate comments, showing at least some magnitude in the possible values. A considerable portion of the collected material is redundant, poorly presented and inexact. Poor quality articles in these categories are all set aside and the final selection of reliable data sources is made.

The graphs are copied photographically; occasionally they may be enlarged or reduced, and then they are arranged on the data sheet form. Every available piece of information about the sample and the experiment is extracted from the article and included in the caption of the graph. The axis legends are standardized with respect to nomenclature (e.g., Peltier or Seebeck effects will be given on the ordinate as thermoelectric values, and then more exactly described in the caption). The original legend units are always retained, but standard units are also added. In the semiconductor and superconductor data sheets, no changes are made in the graphs and they are presented unaltered.

The arrangement of the graphs generally shows pure single crystal material followed by the effect of dopants, with the latter in alphabetic order. They are grouped by such parameters as temperature, field, pressure, etc., bulk and film data, and then such miscellany as occurs.

In tabular data, much the same arrangement obtains. At times, the values from one reference may be given in a block for simple comparison of the variant parameter. Each data entry shows by its reference number the EPIC accession number of the article from which it is extracted. These numbers are given with full bibliographic information at the end of the data sheets. This list of titles, then, represents the experimental literature for a particular material. For this reason, we spread out our selection of graphical data to include a wide range of articles, in order that the latter may be represented in the bibliography.

The inclusion of certain non-electronic properties, such as optical data, thermal conductivity and magnetic effects, has been discussed in the section on THE INDEXING VOCABULARY, but some amplification of the peculiar role of optical data in the field of solid state physics should be given.

The data presented in the compilation of electronic phenomena may be divided into three classes:

1. Direct measurements of electrical properties in the classic sense. These included dielectric measurements, conductivity, Hall coefficient, magnetoresistance, magnetic susceptibility, and the various listed properties that may be calculated from these data, such as mobility.
2. Non-electronic measurements, on the other hand, are used to explain the energy states that influence and determine the

directly measured electrical properties. Among these non-electronic properties are optical values, which include absorption, transmission, reflection, and refractive index. Thermoelectric and thermomagnetic data and the various emission and photoelectronic values are important in themselves, but also are a tool to handle the theoretical basis of solid state physics.

5. The basically physical properties of crystal structure. These factors give rise to magnetic and electrical anisotropies and the resultant piezo effects.

It is essential in the evaluation of experimental data, that the compiler understand the significance of the variations in data produced as a result of differing methods of measurement. The earliest energy gap values were generally obtained by optical means, for under certain conditions, the optical absorption edge is a measure of the energy gap. This whole body of data is supplemented by electrical measurements, such as the thermal change in conductivity and Hall coefficient from which the energy gap may also be calculated. These measurements on pure and doped materials, including data on thermal emf, photoconductivity and photovoltaic phenomena, indicate further the energy levels of the dopant in the host band gap. Pressure or temperature curves for electrical phenomena show changes in the band gap itself, or, as in the deformation potential, shifts in the valence and conduction bands. Irradiation can also act as a dopant, to change the electronic properties of a material by altering its energy states.

The application of other ranges of the electromagnetic spectrum, such as microwaves, probes still more deeply into the inner transition levels of the atomic structure. These new methods represent the introduction into the experiment of a variety of influences and effects from the photons, electrons, and phonons which are active in the crystal lattice under various conditions of temperature and pressure.

Even though all these data are valid, it is evident that the variety of methods used cannot give identical data for the same physical phenomena. Therefore, every value must also show the method by which it was obtained. When more than one value exists, the compiler is required to present all values that have been found by valid experiments, in order that the scientist or engineer may sort out the requisite data for himself.

The importance of crystal lattice and phase diagram information is as unquestioned now as are the energy data, for both the research scientist and the applications engineer. Magnetic and electrical anisotropy is a direct result of crystal structure and important changes in the Curie point of ferroelectrics, ferrites and ferromagnetics arise as a result of phase changes in the compound stoichiometry. These data, therefore, are given in a few introductory paragraphs at the beginning of the data sheets and the references are appended directly to the page.

The second data compilation philosophy has been utilized for the insulator materials and involves integrating as many data points as possible from different authors or sources. This leads to a spread in point values for any property at a specific temperature, frequency, voltage, etc. Such information or data presentation is of great value to a designer, since materials procured from different sources could not possibly possess a single valued property in view of the use of different raw materials by different manufacturers and laboratories. The raw materials generally contain different distributions of impurity contents and grain sizes. Further, varied fabrication methods or processes, firing temperatures and times, and heat treatments differ from supplier to supplier. All these procedures may not be uniform from batch to batch. Different measuring apparatus and methods of measurement also account for variables in data values. In addition, it is well known that different technicians or operators will read dials and instruments differently, thus giving a scatter in values. Recognizing that all these variables will exist and enter into raw data, the resulting compiled data sheet must of necessity indicate the type and amount of scatter.

Single crystal data, oftentimes, are different from polycrystalline data, because grain boundaries have a marked influence on some properties and are insensitive on others.

In the individual EPIC data sheets, every attempt is made to segregate differences in materials composition, in order to prevent mixing "apples with oranges." To cite an example, aluminum oxide -- which is an indexed material -- can cover a wide range of chemical and physical products. When the compiler evaluates the pertinent literature indexed under this descriptor code material, he finds that aluminum oxide ceramic materials can range from 70 percent to 100 percent in chemical composition as well as from sintered to single and polycrystalline forms. Hence, the compiler segregates the data values by percentage of aluminum oxide. Such arrangement of aluminum oxide data has more significance to a designer, as he is made aware of the effect of chemical composition on the electronic properties. This is reemphasized in the general discussion on aluminum oxide which precedes the data. The effect of density on the dielectric properties, where such data are available, is also shown.

Property values will vary with the type of measurement, and such methods are specified (e.g., d-c or a-c) when given in the original source.

In a number of data sheets, master materials identification charts are prepared for the compiled products to relate manufacturer, tradename designation of products, density, porosity, color, crystallinity, chemical purity, and type of fabrication.

As the data sheet compilation activity progressed, improvements were sought at every opportunity. These improvements led ultimately to the preparation of a Style Guide, in which the improvements were detailed. This has subsequently resulted in many benefits: standardization and uniformity of data presentation, plus lower cost of data sheet presentation.

Another example of data sheet compilation not mixing "apples and oranges" is the segregation of dielectric strength property data points by electrode geometry or configuration. In the compilation of sulphur hexafluoride dielectric strength data, the following segregation of graphs and tables was made

a. Sphere-to-Sphere Geometry

b. Sphere-to-Point Geometry

c. Sphere-to-Rod Geometry

d. Sphere-to-Plane Geometry

e. Plane-to-Plane Geometry

f. Plane-to-Rod Geometry

g. Plane-to-Point Geometry

h. Rod-to-Rod Geometry

i. Coaxial Cylinder Geometry

All the dielectric strengths were plotted as functions of gas pressure and gap spacing for the above geometries.

By arranging the dielectric strength data in these sections, a designer can readily find his desired information for a specific application, and also compare it with another electrode configuration, if necessary. Further, he would also be immediately appraised if data were lacking for any specific electrode geometry configuration.

The following is a list of data sheet publications issued to date. In addition to these, data sheets are being prepared on Germanium.

DS-101 Cadmium Telluride -- Data Sheets. M. Neuberger. June 1962.

DS-102 Indium Phosphide -- Data Sheets. M. Neuberger. June 1962.

DS-103 Indium Telluride -- Data Sheets. M. Neuberger. June 1962.

DS-104 Magnesium Silicide -- Data Sheets. M. Neuberger. June 1962.

DS-105 Polyethylene Terephthalate -- Data Sheets. J. T. Milek. June 1962.

DS-106 Polytetrafluoroethylene Plastics -- Data Sheets. Emil Schafer. June 1962.

DS-107 Polytrifluorochloroethylene Plastics -- Data Sheets. Emil Schafer. June 1962.

DS-108 Zinc Telluride -- Data Sheets. M. Neuberger. June 1962.

DS-109 Indium Arsenide -- Data Sheets. M. Neuberger. July 1962.

DS-110 Aluminum Antimonide -- Data Sheets. M. Neuberger. September 1962.

DS-111 Gallium Phosphide -- Data Sheets. M. Neuberger. September 1962.

DS-12. Gallium Antimonide --Data Sheets. M. Neuberger. October 1962.

DS-13. Lead Telluride --Data Sheets. M. Neuberger. October 1962.

DS-14. Magnesium Stannide --Data Sheets. M. Neuberger. November 1962.

DS-15. Gallium Arsenide --Data Sheets. M. Neuberger. December 1962.

DS-16. Lead Selenide --Data Sheets. M. Neuberger. December 1962.

DS-21. Indium Antimonide --Data Sheets. M. Neuberger. February 1963.

DS-22. Steatite --Data Sheets. J. T. Milek. February 1963.

DS-23. Beryllium Oxide --Data Sheets. J. T. Milek. March 1963.

DS-24. Cadmium Sulfide --Summary Review and Data Sheets. M. Neuberger. April 1963.

DS-25. Magnesium Oxide --Data Sheets. J. T. Milek. June 1963.

DS-27. Silicone Rubber --Data Sheets. J. T. Milek. June 1963.

DS-28. Cordierite --Data Sheets. J. T. Milek. June 1963.

DS-29. Forsterite --Data Sheets. J. T. Milek. August 1963.

DS-30. Pyroceram --Data Sheets. J. T. Milek. August 1963.

DS-31. Germanium --Data Sheets. M. Neuberger. September 1963.

DS-32. Zinc Selenide --Data Sheets. M. Neuberger. September 1963.

DS-33. Zinc Oxide --Data Sheets. M. Neuberger. October 1963.

DS-34. Cadmium Selenide --Data Sheets. M. Neuberger. November 1963.

DS-35. Zinc Sulfide --Data Sheets. M. Neuberger and D. L. Grigsby. December 1963.

DS-36. Aluminum Oxide --Data Sheets. J. T. Milek. March 1964.

DS-37. Silicon --Data Sheets. M. Neuberger. May 1964.

DS-38. Borosilicate Glasses --Data Sheets. J. T. Milek. June 1964.

DS-39. Aluminosilicate Glasses --Data Sheets. J. T. Milek. July 1964.

DS-40. Sulfur Hexafluoride --Data Sheets. J. T. Milek. October 1964.

DS-41. Niobium --Data Sheets. D. L. Grigsby. November 1964.

DS-42. Fluorocarbon Gases --Data Sheets. J. T. Milek. November 1964.

FUTURE PLANS

[illegible] its inception [illegible] has been [illegible] advancing the state-of-the-art [illegible] seeking new ways to improve [illegible] users. [illegible] because [illegible] necessary [illegible] keep abreast [illegible] scientists and engineers [illegible].

Future plans [illegible] encompass almost every phase [illegible]. However, [illegible] better ways to serve the user [illegible]. [illegible] plans underway [illegible] regular [illegible] needs. [illegible] also publish other types [illegible] reports. Recent [illegible] summary report [illegible] reports [illegible] summarize [illegible] research [illegible]. Bibliographies are now being [illegible]. [illegible] bibliographic [illegible]. This [illegible] will [illegible] answers [illegible] engineers [illegible] bibliographic [illegible] will allow [illegible] bibliographies.

Plans have now been [illegible] of the system [illegible] and the [illegible] secondary [illegible]. These will include processes, such as EPITAXIAL DEPOSITION, [illegible] THIN FILMS. The inclusion of these terms will allow [illegible] searches [illegible] thin film development [illegible] deposition. [illegible] these [illegible] terms will be in process [illegible] this contract year.

Other types of terms will be considered [illegible] year. [illegible] will be [illegible] parameters and ranges. [illegible] will [illegible] between [illegible] properties, [illegible] ranges of temperatures, pressures, and similar [illegible].

The indexing systems and files as they now exist, are more than sufficient for the efficient operation of EPIC. Some recent technical request have shown areas where a further delineation of the descriptors would yield a reduction of manual operations of the file. An example of this is found in the descriptor TITANIUM OXIDE. Clearly, this descriptor does not differentiate between the various types of titanium oxides and so an effort is being made to alleviate this problem. With the present coding capabilities in the descriptor file, further delineation of the descriptors is possible where it is warranted. The necessary efforts to effect these changes will result in a savings of time and money and make the files even more accessible to the user.

Another type of coding problem that can easily be solved is the inclusion of the trade names and other cross-references into the index. The coding problems with this procedure will be handled in much the same manner as the indexing procedures listed above. The difference, however, will be found in the nature of the printouts. These cross-references will not always be desirable within the indexes as will the other descriptors already mentioned. The nature of the coding of these descriptors will enable them to be included or treated separately. This is just one further step to ensure flexibility in the data processing routines in EPIC.

One further improvement is planned for the accessions file. As the file exists today, materials descriptors are in alphabetical as well as numerical sequence. The retention of this characteristic has on occasion necessitated a reshuffling of the numbers, when a new descriptor must fit between two others alphabetically, but cannot numerically. Within the next year the sort routines will be changed from numerical in columns 69 to 75 to alphabetical in columns 1 to 64. Because of the tape form of the file, this can be accomplished with little additional cost. This procedure will enable a random assignment of the descriptor numbers, which will result in an immediate savings, offsetting the cost of sort routines by ensuring that large banks of descriptor numbers will never have to be changed again. Another advantage of this type of descriptor encoding can be effected in the input form. To date, the punched card had been the only entry to the file, but with alphabetical sequencing of the records, the punched paper tape may now become the input.

The last of the projected plans for this file is its use as a source of addresses to future files which will be described below.

One of the files mentioned above already exists, and is operational.

The file was first generated on paper tape as the abstract cards were being typed. Non-printable codes were used to separate the bibliography from the abstract and to separate each entry from the others. This paper tape was then converted to magnetic tape and printed out for checking. The file at this time consists of 13,000 entries, with an average of two 125-character lines for each bibliography, and an average of four of these lines per abstract. Two types of corrections are being made to this file. First are the errors in the control codes, such as the carriage return code and incorrect or omitted non-printable control codes separating the entries. Second, corrections are being made in typographical and technical errors in both the bibliography and abstract.

The retrieval programs on this file are being checked out now. Two types of retrievals are possible at this time. First is a printout of bibliographical entries only, or bibliography and abstracts both when a list of individual accession numbers are submitted. These entries are called out of the file and printed in numerical sequence. The second type of retrieval calls out the same type of entry, but uses the descriptor file to do it. This is an example of using the descriptor file to supply addresses to the bibliography file. The requestor submits a material, or a pre-coordinated material-property descriptor code, and the accession numbers posted under this description code are called out from the descriptor index, sorted, and in turn serve to call out the entries from the bibliography file. These are also printed out in numerical sequence.

At present, these are the only capabilities of this file, but programs are already being written which will allow this file to be searched and printed in any of the following orders: (1) Author, (2) Title, (3) Journal, (4) Entry within the journal, and (5) Date. This file will be operational for complete machine search capabilities of all EPIC holdings before the end of this contract year.

Further capabilities of this file will include the use of it in certain clerical routines in the Center to reduce time and error rates. One such routine that may be assigned to machine techniques is the duplication check. A paper tape of the "selections" produced in the search operation can be generated, converted to magnetic tape, and matched against the file printout of the documents which should be reviewed for acquisition is obtained. Other capabilities of this file may be found in statistical counts on author, journal, and date correlations between any or all of these elements in the bibliographical entry will give a very powerful retrieval tool. The possibilities of this file when coupled with the descriptor file and the proposed files as listed below will be almost beyond comprehension.

The first of the projected future files is being established at this time. It is a file of generic terms. This will consist of a list of master terms, such as the master materials list for the descriptor file and also a list of these generic terms with accession numbers posted to them such as the material-property descriptors in the descriptor file. These terms contain descriptors such as "thin films," "epitaxial deposition," etc. At least two uses may be realized from this file, first, as an address to the bibliography file and/or descriptor file, and second, as a source of coordination between the descriptor file and other type of indexing file such as the parameter-ranges file described below. The primary advantage is the greater depth of indexing to the literature that it provides.

Finally, there is at least one more new file in the planning stages, the parameter-ranges file. The exact format and nature of this file is not clear at this time, and only a few of its purposes and capabilities are defined. There will be at least two types of indexing terms, first, the parameter descriptors against which the properties in the descriptor file are measured, and second, the range of measured values of either or both the property and parameter. The postings in this file will be a coded form of the actual individual datum or groups of data as recorded in the article. The possibilities of this file almost out-strip the imagination. Immediately this file would be coordinated with at least the descriptor file and probably a combination of the descriptor and all other files. It would certainly serve as a source of addresses for the bibliography file. The establishment of this data handling capability would again allow for a further depth of indexing and data processing.

In all of the present and projected computer uses, two criteria must be met, first, the data processing routines must reduce time, effort, error rate or cost of some EPIC routine, and second, they must provide added flexibility and capability in data handling. All of these data processing efforts allow EPIC to provide a greater service to its user.

Unclassified

Security Classification

DOCUMENT CONTROL DATA - R&D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) Hughes Aircraft Company Culver City, California	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

The Electronic Properties Information Center

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Summary Report. 1 February 1964 - 31 January 1965.

5. AUTHOR(S) (Last name, first name, initial)

Johnson, H. Thayne
Grigsby, Donald L.

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13. ABSTRACT

The function and use of the Electronic Properties Information Center is reviewed in this annual report covering 1 February 1964 through 31 January 1965. An overview of the development of the Center since its inception in June 1961 is included. The modified coordinate index, the indexing philosophy and vocabulary, data evaluation and compilation, and the development of data processing techniques are covered in some detail. Approximately 17,000 publications have been acquired and indexed, and 2000 data sheets issued. The Center has also published technical reports on individual materials of current interest.

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14 KEY WORDS	LINK A ROLE	LINK A WT	LINK B ROLE	LINK B WT	LINK C ROLE	LINK C WT
Electronic Properties Information Center						
Information Analysis Center						
Electronic Properties - Theory						
Electronic Properties - Experimental Data						
Information Retrieval						
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