ASD-TDR-62-539
Part II

ELECTRICAL AND ELECTRONIC PROPERTIES OF MATERIALS INFORMATION RETRIEVAL PROGRAM

TECHNICAL DOCUMENTARY REPORT NO. ASD-TDR-62-539, Part II

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Directorate of Materials and Processes
Aeronautical Systems Division
Air Force Systems Command
Wright-Patterson Air Force Base, Ohio

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by the Hughes Aircraft Company, Culver City, California
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NOTICES

FOREWORD

This report was prepared by Hughes Aircraft Company under Contract No. AF 33(616)-8438. This contract was initiated under Project No. 7381, Task No. 738103. The work was administered under the direction of the Directorate of Materials and Processes, Aeronautical Systems Division, with Mr. R. F. Klinger acting as project engineer.

This report covers work conducted from June 15, 1962 through December 14, 1962. The Contractor's Report Number is P63-15.

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:

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ABSTRACT

A documentation system has been established for abstracting, indexing, and retrieving data relative to the electrical and electronic properties of materials. That data and the literature are retrieved through a modified manual coordinate index highly adaptable to machine usage. Publications include data sheets, thesauri, property tables, and summary reviews. Methods and routines of the system have been described in the first final report, Technical Documentary Report No. ASD-TDR-62-539. This, the second final report, covers the additional effort expended during the first extension of the contract. Appended are a consolidated list of electrical and electronic properties and lists in the following categories of materials: Electroluminescent Materials, Thermionic Emitters, Ferroelectrics, Ferrites, Ferromagnetics, Super-conductors and Metals.

This technical documentary report has been reviewed and is approved.

D. A. Shinn
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ILLUSTRATIONS

I. INTRODUCTION

The exponential growth of research in recent years has brought with it what is commonly called the literature explosion. Although along with it have been informational problems that have plagued all areas of the physical and natural sciences, nowhere is the rise in generation of literature more evident than in electronics and its applications. When the transistor was invented in 1948, the whole area of solid state physics was stimulated, leading to developments that have evolved so fast that sometimes it seems impossible to say which came first, the theory or the new material.

Actually the accomplishment of technical endeavor would seem to be a process dependent first upon theoretical concept and later upon application. However, especially in the field of materials research, current effort often provides answers ahead of the problems, for creative empiricism appears frequently to lead theory. In general, one is forced to resort to the somewhat labored work of understanding before any final truth emerges.

Understanding this, the Directorate of Materials and Processes, Aeronautical Systems Division, has contracted the establishment of a program to collect, index and abstract the literature on the electrical and electronic properties of materials and to evaluate and compile the experimental data from this literature.

The program was initiated in June 1961 with the intention of covering ten major categories of materials: Semiconductors, Insulators, Ceramics, Ferroelectrics, Metals, Ferrites, Ferromagnetics, Electroluminescent Materials, Thermionic Emitters and Superconductors.

During the first year, a Phase I, study, and Phase II, implementation, was accomplished in the categories of Semiconductors and Insulators. During the six months covered by this report, the documentation effort has continued in these two categories and indexing-vocabulary studies have been tentatively established on Ferroelectrics, Metals, Ferrites, Ferromagnetics, Electroluminescent Materials, Thermionic Emitters and Superconductors. Ceramics has been discontinued as a separate category and is being subsumed under the other nine.

This report details the efforts during the six-month extension to the program from June 15, 1962, to December 14, 1962. The original routines, procedures and concepts of the program have been previously published in the final report for the first year of work. (ASD-TDR-62-539).

Manuscript released by the authors December 1962 for publication as an ASD technical documentary report.

II. DOCUMENTATION

Documentation comprises searching, acquiring, abstracting and indexing the literature. Establishment of a documentation system required studies to develop an appropriate vocabulary for material and property names and an indexing scheme capable of storing, identifying and rapidly retrieving the literature. It was thought desirable to develop an index both flexible and highly specific which would be contained in the final report for the first year.
methods of storage and retrieval.

The index as finally adopted can be called a modified coordinate index. The system, the philosophy behind the adoption of it, and a description of the punched card program for posting the descriptors is contained in the final report for the first year.

A. Searching the Literature

Since the beginning of the program, 6100 accession numbers have been assigned, representing almost that many items abstracted and indexed. This has involved searching over 50,000 titles, abstracts, or indexed entries up to the end of the report period.

Searching in the two categories of Semiconductors and Insulators can be said to be virtually complete. It has now broadened out from the usual, more remunerative sources into many of the more obscure sources. During the first year of the program it was largely concentrated in the following sources:

ASTIA Technical Abstract Bulletin

Ceramic Abstracts

Chemical Abstracts

Digest of Literature of Dielectrics

Engineering Index

Electrical Engineering Abstracts

Physics Abstracts

Semiconductor Abstracts

Semiconductor Electronics

Solid State Abstracts

U.S. Government Research Reports

At the present time, the searching in these two categories includes direct review of periodicals not indexed in these sources, primarily by citation following. Plans have also been laid for a systematic searching of the literature in the other seven categories and searching has begun. It is anticipated that a smaller percent of the articles in these categories can be readily searched in abstracting and indexing services and more will have to be searched through such techniques as use of citations. The proportion of lost effort will thus increase and for every piece of literature indexed into the system, a greater amount of time will be absorbed.

The period from June 15, 1962, to December 14, 1962, has been occupied in completing documentation as well as retrospective searching of literature for Semiconductor and Insulator materials to the year 1940. Although journals from the years 1940 to 1945 yielded valuable papers, the subject specialists and evaluators preparing data sheets showed strong preference towards data taken from 1955-1962 papers which reflect the most meaningful work and the latest instrumentation. Some materials, such as Silicon, inspired hundreds of papers containing data and studies so that the evaluator has faced a significant concern in choosing the best.

It may be well to consider here the impact of much literature as compared with pure data. In the acts of searching and abstracting, papers are found with all degrees of technical and scientific effort. In attempting to assay these works, the tendency is to include most everything on the grounds that it may be useful to a given user. He needs a wider range to build his case and is not satisfied with only single points clearly defined. A problem arises, of course, as with the limitations of any system selection of lists and names fails to account for the ones which may use non-standard symbols, compound names or author originality. Including these types of literature aggravates the false drop likelihood and yet papers such as these are selected after careful evaluation because they appear to have useful or significant data.

Our search efforts have definitely widened and methods have been introduced which have led to an even better coverage of the existing literature. The results can be seen from the following data (covering Semiconductor and Insulator materials only). It is felt that future activity in the added categories of materials contemplated will benefit from our added capability.

For sources of relevant information, we have screened the following abstract-indexes to the extent indicated. Search continues on the current input of technical literature by searching current issues and on the later issues not covered.

	Volumes	Period Covered
Solid State Abstracts	1-3	
(Semiconductor Electronics)		Jan. 1952-Sept. 1962
(Battelle Abstracts of Semiconducting Materials)	-	

		Volumes	Period Covered
Science Abstracts,	A. Physics	43-65	1940-Sept. 1962
	B. Electrical Engineering	43-65	1940-Sept. 1962
Chemical Abstracts		44-57	1947-June 1961
Technical Abstract Bulletin (ASTIA)		-	to May 1962
Ceramic Abstracts (American Ceramic Society)		33-45	1950-Oct. 1962
Applied Science and Technology Index		-	1958 - 1960
Engineering Index		-	1945 - 1961
Digest of Literature on Dielectrics		-	1957 - 1960
Resins, Rubber, Plastics Yearbooks		-	1957 - 1959
U. S. Government Research Reports		11-37	1949-April 1962

Another very productive source is an internal one in which references from the bibliographies of acquired articles are checked against the author index and information not already in the system is then searched for pertinent data.

In addition to the abstract-indexes, 26 of the most productive journals are being completely searched and selected articles checked against previous acquisitions to prevent duplications.

An analysis of the search activities in the two categories of Semiconductors and Insulators has yielded some interesting and useful information. For example, 6 percent of the sources which we have used have yielded 80 percent of our acquisitions. The source index file now includes 467 separate sources. Sixty sources have yielded 20 or more acquisitions each. Total pieces indexed at the time of the analysis were 5700.

Included in the analysis were articles covering 312 Semiconductor materials, 29 Semiconductor properties, 475 Insulator materials, and 12 Insulator properties. The 103 most productive sources in decreasing order of yield (to November 1962) are listed below. There have been 363 additional sources indexed which have yields of less than five articles each. The total articles acquired per source is in parenthesis.

1. Physical Review (940)
2. Technical Documents received from ASTIA (550)
3. Journal of Applied Physics (510)
4. Soviet Physics – Solid State (350)

5. American Physical Society, Bulletin (275)
6. Physical Society, Proceedings (244)
7. Physical Society of Japan, Journal (212)
8. Physics and Chemistry of Glasses, Journal (210)
9. Soviet Physics — Technical Physics (180)
10. Journal of Chemical Physics (150)
11. Academie des Sciences (Paris), Comptes Rendus (125)
12. Soviet Physics — Doklady (108)
13. Physica (100)
14. Zeitschrift für Naturforschung (90)
15. Electrochemical Society, Journal (85)
16. Nature (80)
17. American Institute of Chemical Engineers, Transactions (75)
18. Electrical Manufacturing (70)
19. Physical Review Letters (65)
20. American Ceramic Society, Journal (60)
21. Zeitschrift für Physik (50)
22. American Institute of Electrical Engineers, Proceedings (50)
23. Soviet Physics — JETP (46)
24. Optika i Spectroskopiia (45)
25. Canadian Journal of Chemistry (44)
26. Helvetica Physica Acta (42)
27. Czechoslovak Journal of Physics (40)
28. Dow Corning Corporation, Technical Publications (40)
29. Indian Journal of Physics (40)
30. Industrial and Engineering Chemistry (40)
31. Optical Society of America, Journal (40)
32. Royal Society of London, Proceedings (40)
33. Semiconductors and Phosphors (Proceedings of the International Colloquium held at Garmish-Partenkirchen, 1956) (40)
34. Institution of Electrical Engineers (London), Proceedings (38)
35. Materials in Design Engineering (35)
36. Insulation (34)

37. IRE Proceedings (34)
38. Journal of Electronics and Control (32)
39. Annalen der Physik (30)
40. American Chemical Society, Journal (30)
41. British Journal of Applied Physics (30)
42. Philips Research Reports (30)
43. Academy of Sciences of the USSR, Bulletin (25)
44. Canadian Journal of Physics (25)
45. Conference on Electrical Insulation, Annual Reports (25)
46. Elektrichestvo (25)
47. Elektrotechnik Zeitschrift (25)
48. Faraday Society, Transactions (25)
49. Journal of Electronics (25)
50. Modern Plastics (25)
51. National Bureau of Standards, Journal of Research (25)
52. Photoconductivity Conference, Atlantic City, 1954 (25)
53. Wire and Wire Products (25)
54. Zeitschrift für Physikalische Chemie (Frankfort) (23)
55. Zeitschrift für Angewandte Physik (22)
56. American Ceramic Society, Bulletin (21)
57. Journal of Physical Chemistry (20)
58. Naturwissenschaften (20)
59. Physica Status Solidi (20)
60. Product Engineering (20)
61. Solid State Physics in Electronics and Telecommunications (19)
62. Bell System Technical Journal (18)
63. British Intelligence Objectives Sub-Committee, Reports (17)
64. Electrical Engineering (17)
65. Zhurnal Tekhnicheskoi Fiziki (17)
66. Society of Glass Technology, Journal (16)
67. Tohoku U., Science Reports of the Research Institutes (16)
68. Journal of Polymer Science (15)

69. Kolloid Zeitschrift (15)
70. Journal de Chimie Physique (15)
71. Materials and Methods (15)
72. Review of Scientific Instruments (15)
73. Zeitschrift fur Elektrochemie (15)
74. Institution of Electrical Engineers, Journal (London) (14)
75. British Electrical and Allied Industries (13)
76. Ceramic Age (13)
77. Connecticut Hard Rubber Company (13)
78. RCA Review (13)
79. Revue Generale de L'Electricité (13)
80. ASTM Bulletin (12)
81. Akademiia Nauk SSSR. Instut Kristallografii. Trudy (11)
82. Electronics (11)
83. Faraday Society, Discussions (11)
84. Kunststoffe (11)
85. Optics and Spectroscopy (11)
86. Resins, Rubbers, Plastics Yearbook (11)
87. Electronic Engineering (10)
88. General Electric Company. Silicone Products Department Reports (10)
89. Applied Scientific Research (9)
90. Ceramic Industry (9)
91. Electrical Review (9)
92. Electrochemical Society, Transactions (9)
93. General Electric Review (9)
94. Progress of Theoretical Physics (9)
95. Rubber Age (9)
96. Union Carbide and Carbon Corporation, Data Sheets (9)
97. Research (8)
98. Reviews of Modern Physics (8)
99. Sylvania Technologist (8)
100. Abhandlungen der Braunschweigischer Wissenschaftlichen Gesellschaft (7)

101. Acoustical Society of America, Journal (6)

102. Annales de Physique (5)

103. Archiv für Physik (5)

The system content is being continually upgraded as a result of the evaluation and compilation efforts of high technical level personnel. Eliminated in the process are, (1) acquisitions of doubtful value, (2) errors in classification and (3) duplications. Subsequent replacement runs of descriptor cards reflect those corrections.

Favorable experience with the modified coordinate index system indicates that it is well suited for the variety and volume of reference material to be used. Current searching involves electronic data on 29 properties of 312 Inorganic and 250 Organic Semiconductor materials. Similarly sought is data on 12 electronic properties of 475 Insulator materials and searching has begun on the 7 additional categories of materials for the ensuing contract.

Boundary specifications for search in new fields such as these are very difficult to establish. It is expected that a better knowledge of user requirements will enable us to improve the quality of our output by tightening the specifications.

In general, the newer articles are more specialized but carry more reliable data because of recent refinements in materials analysis. Therefore, future searching will require a closer analysis of the abstracting and the possible addition of properties only now becoming important.

B. Indexing and Abstracting

Few changes have been made in the routines of indexing and abstracting. These routines, as reported in the final report for the first year, are working competently and adequately. Work instead has been concentrated on aids to the index in the way of improved lists of indexing vocabularies and definitions and delineation of terms, synonyms and cross-references. To this end, work is continuing on the glossary as appended to the first final report.

One important addition to the routines of the system has been the use of a Change or Addition Notice (Figure 1). This form is used for any recommended change or addition and can be filled out by anyone working on the program. It is used for such varied additions and changes as adding new materials and properties, changes in routines, correcting of errors occurring in routine activities, and suggested re-indexing of articles into new categories.

All routines have now been established for indexing and abstracting in the new categories of materials. The index-abstract forms as now in use, appear as Figures 2 through 10. They are so arranged that the indexer-abstractor can write the materials appearing in an article down the left hand column and check the appropriate property. The properties that appear on each form are those usually considered as falling within that category of materials. Spaces are left to allow write in of other properties.

CHANGE OR ADDITION NOTICE - Electronics Properties Center

Operations Procedure

- Searching ☐
- Acquisition ☐
- Indexing ☐
- Abstracting ☐
- Evaluation ☐
- Data Sheets ☐
- Publications ☐

Priority

- Originator ☐
- Project Leader ☐

PROBLEM: ______________________________

PROPOSED SOLUTION: ______________________________

Change Requested By ____________ (Signature) ________ (Date) ____________ (Accession No. if involved)

Change Authorised By ____________ Signature (Project Leader) ________ (Date)

Change Introduced into EPC System ________ (Date)

Figure 1. Change or Addition Notice.

FERROELECTRIC MATERIALS	Curie Temperature	Dielectric Absorption	Dielectric Constant	Dielectric Strength	Dissipation Factor	Domain Structure	Electrical Hysteresis Loop Characteristics	Electrical Resistivity	Electromechanical Properties	Initial Dielectric Coefficient	Irradiation Effects	Lifetime	Loss Factor	Mobility	Piezoelectric Properties	Power Factor	Thermoelectric Properties			

AF33(616)-8438 Index - Abstract Form
Name: ____________ Hours: ________ Date: ____________
Revised October 1962

Figure 2. Index-Abstract Form-Ferroelectrics.

FERRITE MATERIALS	Curie Constant	Curie Temperature	Dielectric Absorption	Dielectric Constant	Dissipation Factor	Domain Structure	Electrical Resistivity	Gyromagnetic Effects	Irradiation Effects	Loss Factor	Magnetic Hysteresis Loop Characteristics	Magnetic Susceptibility	Magnetoelectric Properties	Magnetomechanical Effects	Thermomagnetic Properties		

AF33(616)-8438 Index - Abstract Form
Name: ____________ Hours: ________ Date: ____________
Revised October 1962

Figure 3. Index-Abstract Form-Ferrites

FERROMAGNETIC MATERIALS	Curie Constant	Curie Temperature	Domain Structure	Gyromagnetic Effects	Irradiation Effects	Magnetic Hysteresis Loop Characteristics	Magnetic Susceptibility	Magnetoelectric Properties	Magnetomechanical Effects	Thermomagnetic Properties		

AF33(616)-8438 Index - Abstract Form
Name:__________ Hours:______ Date:________
Revised October 1962

Figure 4. Index-Abstract Form-Ferromagnetics.

INSULATOR MATERIALS	Arc Resistance	Corona Effects	Dielectric Absorption	Dielectric Constant	Dielectric Strength	Dissipation Factor	Electrical Conductivity	Electrical Resistivity	Insulation Resistance	Irradiation Effects	Loss Factor	Power Factor			

AF33(616)-8438 Index - Abstract Form
Name: ____________ Hours: ________ Date: ____________
Revised October 1962

Figure 5. Index-Abstract Form-Insulators.

ELECTROLUMINESCENT MATERIALS	Absorption	Carrier Diffusion	Cross Sections	Dielectric Constant	Dielectric Strength	Electrical Conductivity	Electrical Resistivity	Emission	Energy Bands	Energy Gap	Energy Levels	Irradiation Effects	Lifetime	Luminescent Efficiency	Magnetic Susceptibility	Magnetoelectroluminescent Properties	Mobility	Photoelectroluminescent Properties	Photoelectronic Properties	Piezoelectric Properties	Surface Properties	Thermoelectroluminescent Properties	Work Function		

AF33(616)-8438 Index - Abstract Form
Name: ________________ Hours: ________ Date: __________
Revised October 1962

Figure 6. Index-Abstract Form-Electroluminescent Materials.

METAL MATERIALS	Electrical Conductivity	Irradiation Effects			

AF33(616)-8438   Index - Abstract Form
Name:____________ Hours:________ Date:________
Revised October 1962

Figure 7. Index-Abstract Form — Metals.

SUPERCONDUCTOR MATERIALS	Debye Temperature	Domain Structure	Electrical Conductivity	Electrical Resistivity	Electronic Specific Heat	Energy Gap	Irradiation Effects	Magnetic Susceptibility	Penetration Depth	Superconductive Transition Temperature	Thermal Conductivity	Thermomagnetic Properties	Threshold Field		

AF33(616)-8438 Index - Abstract Form Hours: ________ Date: ____________
Name: ________________

Revised October 1962

Figure 8. Index-Abstract Form-Superconductors.

SEMICONDUCTOR MATERIALS	Absorption	Carrier Diffusion	Cross Sections	Debye Temperature	Dielectric Constant	Effective Mass	Electrical Conductivity	Electrical Resistivity	Electroacoustic Properties	Emission	Energy Bands	Energy Gap	Energy Levels	Hall Coefficient	Irradiation Effects	Lifetime	Magnetic Susceptibility	Magnetoelectric Effects	Mobility	Photoelectronic Effects	Piezoelectric Effects	Piezoelectric Properties	Reflection	Refractive Index	Surface Properties	Thermal Conductivity	Thermoelectric Properties	Thermomagnetic Properties	Work Function		

AF33(616)-8438 **Index - Abstract Form**

Name: __________ **Hours:** ______ **Date:** ________

Revised October 1962

Figure 9. Index-Abstract Form-Semiconductors.

THERMIONIC EMITTERS MATERIALS	Cross Sections	Electrical Conductivity	Electrical Resistivity	Emission	Irradiation Effects	Lifetime	Richardson's Constant	Surface Properties	Surface Properties (Thin Film Characteristics)	Thermal Conductivity	Thermal Efficiency	Work Function				

AF33(616)-8438 Index - Abstract Form
Name: ____________________ Hours: __________ Date: ______________
Revised October 1962

Figure 10. Index-Abstract Form-Thermionic Emitters.

III. DATA COMPILATION AND EVALUATION

Since the beginning of the program, the compilation-evaluation of data has been one of the most difficult and crucial parts. As the literature has accumulated, it has been examined for its completeness within the field of the individual material being worked upon. In general, the most technically promising materials have been chosen first for evaluation and compilation after the literature has been judged complete within this area. The value of the results has depended upon the adequacy of the data as presented in the literature and upon the skill and knowledge of the subject specialist doing the work. Judgements have had to be made concerning the adequacy and comparative merits of experimental results, and the most probable values have had to be sought and chosen.

As much as possible, the information presented in the literature has been extracted. When not possible, the data has been synthesized, sometimes from several articles. In general, evaluation has been confined to primary source data except when only secondary citations have been available. If equally valid data has been available from more than one investigation, all are given. However, data are rejected when judged questionable because of faulty or dubious measurements, unknown sample composition, or if more reliable data are available from another source. Selection of data has been based upon that which is judged most representative, precise, and reliable, covering the widest range of variables. The addition of new data to a previously evaluated property requires a re-appraisal of the reported values and older data has been deleted if the new data has been judged to be more accurate or representative. During the course of the program, the quality of presentation in the data sheets has been improved to reflect suggestions made from both within the program group and outside of the group including the customer. The sheets have been expanded to include more data, and studies have been undertaken to present a more uniform selection. In addition, new equipment has been obtained to enable us to present the information surrounding the data sheet in a more uniform manner.

It is interesting to note the difference in compiling data sheets in the Semiconductor category and in the Insulator category. As we began to compile data in the Insulator category, these differences became noticeable. In contrast to the precise sample preparation in semiconductors with perhaps one part per million of impurity, Silicone Rubber, for example, requires format and detailed presentation which takes into consideration that industrial material is most often a batch. Quality control of such batches is adequate for its intended use, but raw materials and processing vary enough to make it necessary to show both them and the source of the ingredients in order to evaluate the measurement data for the applications engineer.

By this time it has become highly apparent that reducing the data to useful and workable data sheets requires great skill and knowledge. It is essential that objectives be formulated. Intelligent data compilation depends directly on the use to be made of it and the type of user. Current state of the art from all aspects must influence the choice of data, and since the evaluator cannot possibly be acquainted with all aspects, materials specialists, research scientists, and applications engineers must be available for consulting. Considerable work by the evaluator is necessary in rounding out an author's references and intentions. Experience, and even intuition frequently play an important part in weeding out incomplete works and selecting the best. Such parameters as symbols must be made understandable and as uniform as practical to assist the user in spite of the great degree of variance in these parameters as they appear in the literature. Data work sheets are used to compile the data in order that it might be reviewed for accuracy and completeness before being processed for data sheet layout. The data appear primarily as curves or in tabular form but they are not limited to these forms since it is felt that they must be presented in the optimum way. Where possible, graphs are adapted directly from the original sources. If this is not possible, they may be drawn from data compiled from the articles. In final form there is now an average of about 30 data sheets issued for each of the materials completed.

In evaluating the data and compiling it into data sheets technical problems lay in the areas of symbols, terminology, definitions, poor presentation of data and even poor writing. An interesting example has been the difference between a coefficient and a constant. This is frequently obscure. The property called dielectric constant is really a misnomer, it being subject to change by various parameters, for example, temperature, frequency and pressure. One article with valuable data detailed a fine, well-controlled experiment exhibited adequate presentation of the data, and then failed to give the name of the material involved in the experiment.

The following chart gives total information as to the number of data sheets issued or in process of being compiled, the number of properties for the materials involved, the number of pages of data sheets and the date of issue. The chart gives the status of these data sheets as of December 15, 1962.

Semiconductors	Number of Properties	Number of Pages	Date of Issue	Status 15 Dec 62
Indium Phosphide	17	24	June 1962	
Magnesium Selenide	5	9	June 1962	
Indium Telluride	10	22	June 1962	
Zinc Telluride	11	19	June 1962	
Cadmium Telluride	17	44	June 1962	
Indium Arsenide	23	52	July 1962	
Gallium Phosphide	14	18	Sept 1962	
Aluminum Antimonide	18	38	Sept 1962	
Magnesium Stannide	14	18	Oct 1962	
Lead Telluride	18	30	Oct 1962	
Gallium Antimonide	23	47	Oct 1962	
Gallium Arsenide				Final Review
Lead Selenide				Final Review
Zinc Oxide				Compiled
Silicon	1	29	Dec 1962	
Silicon	12	50		Evaluated
Insulators				
Polyethylene Terephthlate	9	32	June 1962	
Polytetrafluoroethylene Plastics	8	31	June 1962	
Polytrychlorofluoro-ethylene Plastics	7	14	June 1962	
Aluminum Oxide				Compiled
Steatite				Compiled
Rubber Silicone				Compiled

IV. ANALYSIS OF REQUESTS

During the initial phases of the contract, requests were discouraged as much as possible with the feeling that they could not be handled adquately until a representative amount of material had been entered into the system. However, the Semiconductor and Insulator categories are now virtually complete as far as documentation is concerned and it is felt that questions can be adequately answered in these two areas.

Some requests have been answered. Most of these requests have been of a single-point retrieval type. That is, the requester was interested in only one document or one item of information which could be easily located through the index and either the document or the information was given to him. However, other requests have required extensive effort to complete. These requests have centered about exhaustive searches in specific materials or properties with the compilation of a bibliography to submit to the requester. These requests and their answers have been carefully analyzed in order to obtain a measure of our indexing system efficiency. Although it has become obvious that errors have crept into the system, such as transposition of accession numbers and mis-posting, in general, the system has performed well, enabling us to readily find the information sought by the requester.

From March to December of 1962, 12 extensive answers were given in reply to requests. It might be appropriate to mention four of these as being representative. These four were requests from the Aeronautical Systems Division, Wright-Patterson Air Force Base, Ohio, Aeronutronics, Republic Aviation, and Hughes Aircraft Company. The first request was from R. F. Klinger (ASRCEM-1) and asked for specific information on the thermal properties of Beryllim Oxide. Two hours were spent in preparing literature references as well as specific data from these literature references by two of our subject specialists. The second request was in the form of a personal visit to the Center by a visitor from Aeronutronics. He was given complete access to the Center files on Semiconductors and he took notes and references for eight hours. After collecting his notes and references, he commented upon the excellent value of the Center files in the field and the usefulness of these notes and references to his work at Aeronutronics.

The third request was for information on the effects of ultra-high frequency on metallic and non-metallic materials (Plastics and Ceramics). Of particular interest was the effect in the mega-megacycle or teracycle range (10^{12}). Here again, a subject specialist was needed to compile the bibliography and to prepare information and data found in the collection.

The fourth request, the one from Hughes Aircraft, can be thoroughly evaluated. The Malibu Research Laboratories asked us to supply them with reprints of everything pertaining to the electronic properties of eight Semiconductor materials. These materials, with the number of properties of each are as follows: Cadmium Oxide (5), Cadmium Selenide (22), Cadmium Sulfide (25), Cadmium Telluride (24), Zinc Oxide (21), Zinc Selenide (16), Zinc Sulfide (24), Zinc Telluride (17). In total, 558 abstracts were involved, of which 452 were copied and sent to the Malibu Research Laboratories. These abstracts represented 1471 pages. Although this effort was charged directly to the Research Laboratories, it gave us a reading of the user viewpoint of our abstracting and the system, since Malibu agreed to give us their comments as to the adequacy of our work and to submit suggestions for its improvement. The total time required was 30 man hours of clerical work. The result shows that future estimates could be based upon about 50 pages per hour or 15 abstracts copied per hour. The number of abstracts for each material is known for over 200 materials and future estimates are likely to be fairly accurate. Since many of the abstracts cover two or more properties or materials, a check of the list obviated the making of duplicates, 105 in this case.

One qualifying factor applies in this situation and was accepted by Malibu. Our search on these particular materials was not considered fully complete in that we did not cross-check all the references given in each article to determine if we had overlooked any significant article or sources. These are being added as we complete the searches, our normal procedure to insure proper coverage of the literature.

The scientists at our research laboratories were very pleased with the search and the bibliography. They could offer very little in the way of suggestions for improvement of our system but on the contrary, were highly complimentary about our capability of providing them with information in the field of Semiconductors. It is interesting to note that very little technical effort was required to furnish the Research Laboratories with the information which they requested, but rather the hours of labor represented were clerical. This indicates the ease of use of our indexing system in obtaining this type of material.

In analyzing these representative requests, it becomes apparent that simple use of the system can be easily accomplished by the non-specialist, i. e., a librarian or even a clerk. However, the usefulness of a subject specialist in answering the more complex request cannot be minimized. No indexing system, regardless of how well conceived, can possibly cover all facets of the subject areas in every way they will be asked for. This fact will often mean that an interpolative function must take place that can be provided only by a person highly conversant with the subject.

One of the interesting aspects of the requests which have been received is the number of requests received from individuals engaged in research, an indication of the usefulness of this program to research as well as to applications. An example of a request of this nature was the request made by Mr. Jack Fraser, of the Santa Barbara Research Center of Hughes Aircraft Company. His request concerned information on materials data on infrared and semiconductor materials. Another item of interest has been the two requests for information on the use of Organic Semiconductors. Although a thesaurus was compiled on Organic Semiconductor materials, it was not expected that requests for information in this area would be very sudden or numerous. However, since the list of Organic Semiconductor materials was published in the last quarterly report, two requests have been received for information in this area. These two requests have come from Dr. C. A. Escoffery, of the Research and Development Division of the Aerospace Group, Hughes Aircraft Company and from Dr. Gary Carlson, of the Advanced Information Systems Company. In both instances, they were impressed with the work that we were doing in this field and encouraged us to continue on in Organic Semiconductors. It is anticipated that documentation will continue in Organic Semiconductors; however, it is felt that due to the urgent need for information in other areas, documentation will proceed only slowly.

V. OPERATIONS SUMMARY

In the six months some 16,000 titles and abstracts were searched with 3000 acquired. Of this number nearly 2200 were abstracted and indexed. Besides these, some 300 papers were indexed from work on hand at the start of the contract period. A similar situation exists for work on hand at present (185 items ready for coding). Retrospective documentation of the Semiconductor and Insulator categories was carried into the 1940 literature which of course extended the searches into the years before. About fifteen of the most productive journals are now being searched on a current basis. Papers from these are worked into the system. Some 600 papers in the new categories are printed, prepared and ready for abstracters.

As intended a considerable percentage of the abstracters' time during the subject period has been devoted to preparation for the coming year. Seven new cateogries of material had to be divided and assigned for detailed study in matters such as preparation of lists of materials, selection of properties lists and acquiring some background in the less familiar sections. Abstracters cover sheets have been prepared for Ferrites, Ferroelectrics, Ferromagnetics, Electroluminescents, Thermionic Emitters, Metals and Superconductors. No single author or source offered such analysis, and arrival at the properties selected represented much discussion with specialists in each field as well as practical decisions from our own staff.

VI. LISTS OF PROPERTIES

Since the beginning of the program, we have been faced with the problem of compiling properties in a consistent and organized fashion and yet categorizing electrical and electronic properties according to the main categories of materials (Semiconductors, Insulators, etc.). Some thought has even been given to eliminating the categories because the literature and the data therefrom does not always fit any preconceived plan of arrangement. Although categories can be useful, they can also present many problems. For example, how can the categories be defined? It's difficult to define them in terms of materials for many materials are useful in more than one category. In fact, some materials are known to change their characteristics so radically under certain conditions that they change categories.

It's even more difficult to define categories in terms of properties Many properties appear in several categories with no change in meaning. Electrical resistivity and electrical conductivity are in a sense synonymous, representing only a matter of degree rather than individual properties.

These considerations have led us to consider both a consolidated properties list and a consolidated materials list. The latter is still under consideration.

In consideration of a consolidated properties list the group members have weighted values both ways. Eighteen months of experience with thousands of articles has provided subject specialists with bias, mostly towards making the routines as simple and exact as possible. In this light, use of a consolidated properties list, introduces a long learning period and hence reduces initial output from the specialist. This is because he must be able to recognize and estimate the worth of any one of 95 to 100 properties in the articles he surveys. Few persons are willing or able to be so broad. Preference is towards taking one material category and learning it well enough to evaluate data within boundaries agreed upon in the contract assignment. We have found this to be true even among scientists actively engaged in the field of their specialty. As abstracters and evaluaters they tend to select among papers following their own local interests.

However, the case for a consolidated properties list is towards a more comprehensive coverage of what is found in an article. Authors do not confine themselves to any preconceived path of showing their experimental work. Often they find unexpected or compromised data which is nonetheless valuable or contributing to the sum of knowledge and so included. Often their work shades in and out of adjoining sciences, as from Chemistry to Physics, or from Metallurgy to Medicine.

On the other hand, there is a great need to retain the categories. Some users may want to retrieve all information on a single property or material but the average user will want only that portion of the literature or data dealing with the category he is interested in.

In view of offering better coverage of the literature and data in a more consistent fashion, the final decision has been to work from a single consolidated list of properties and to depend upon the inherent flexibility of the indexing system coupled with the IBM 1401 program to provide a categorization as useful to the user of the system. A complete evaluation of ways to do this is under study. As a first phase, a consolidated properties list follows. Following the list is a breakdown of the categories in which each individual property is useful.

INTERIM PROPERTIES LIST

Absolute Dielectric Constant
  See DIELECTRIC CONSTANT

ABSORPTION
  Absorption Coefficient
  Absorption Edge
  Absorption Spectrum
  Infrared Absorption
  Optical Absorption
  Spectral Absorption

Absorption Coefficient
  See ABSORPTION

Absorption Edge
  See ABSORPTION

Absorption Spectrum
  See ABSORPTION

Acoustoelectric Effect
  See ELECTROACOUSTIC PROPERTIES

Acoustomagnetoelectric Effect
  See ELECTROACOUSTIC PROPERTIES

Activation Energy
  See ENERGY GAP

Absorption
  See SURFACE PROPERTIES

Alpha Irradiation
  See IRRADIATION EFFECTS

Anistrophy Constants
  See ELECTROMECHANICAL EFFECTS
  MAGNETOMECHANICAL EFFECTS

ARC RESISTANCE
  Tracking

Band Gap
  See ENERGY GAP

Band Structure
  See ENERGY BANDS

Corona Resistance
    See CORONA EFFECTS

Cotangent θ
    See DISSIPATION FACTOR

Critical Electric Field
    See ELECTRICAL HYSTERESIS LOOP CHARACTERISTICS

Critical Frequency
    See PENETRATION DEPTH

Critical Magnetic Field
    See MAGNETIC HYSTERESIS LOOP CHARACTERISTICS

Critical Magnetic Field, Superconductive
    See THRESHOLD FIELD

Critical Temperature
    See SUPERCONDUCTIVE TRANSITION TEMPERATURE

CROSS SECTIONS
    Collision Cross Sections
    Equivalent Cross Sections
    Impurity Cross Sections
    Recombination Cross Sections
    Scattering Cross Sections
    Mean Free Path

CURIE CONSTANT

Curie Point
    See CURIE TEMPERATURE

CURIE TEMPERATURE
    Curie Point

Cyclotron Resonance
    See EFFECTIVE MASS

DEBYE TEMPERATURE

Decay Time
    See LIFETIME

De Haas – Van Alphen Effect
    See MAGNETIC SUSCEPTIBILITY

Dember Effect
    See MOBILITY

Diamagnetic Susceptibility
    See MAGNETIC SUSCEPTIBILITY

DIELECTRIC ABSORPTION

Dielectric Breakdown Voltage
    See DIELECTRIC STRENGTH

DIELECTRIC CONSTANT
    Absolute Dielectric Constant
    Complex Dielectric Constant
    Dielectric Relaxation Time
    Electric Susceptibility
    Polarization
    Relative Dielectric Constant
    Relative Capacitance
    Specific Inductive Capacity (S. I. C.)
    Permittivity

Dielectric Loss Angle
    See DISSIPATION FACTOR

Dielectric Loss Factor
    See LOSS FACTOR

Dielectric Loss Tangent
    See DISSIPATION FACTOR

Dielectric Relaxation Time
    See DIELECTRIC CONSTANT

DIELECTRIC STRENGTH
    Breakdown Voltage
    Dielectric Breakdown Voltage
    Electrical Strength
    Voltage Breakdown

Differential Susceptibility
    See ELECTRICAL HYSTERESIS LOOP CHARACTERISTICS

Diffusion Coefficient
    See CARRIER DIFFUSION

Diffusion Length
    See CARRIER DIFFUSION

DISSIPATION FACTOR

Contangent θ
Dielectric Loss Angle
Dielectric Loss Tangent
Loss Angle
Loss Tangent
Phase Angle
Phase Defect Angle
Quality Factor
Storage Factor
Tangent δ

Domain Boundary Growth Rate
See DOMAIN STRUCTURE

DOMAIN STRUCTURE

Characteristic Length
Domain Boundary Growth Rate
Domain Wall Energy
Domain Wall Mobility
Domain Wall Thickness

Domain Wall Thickness
See DOMAIN STRUCTURE

Domain Wall Energy
See DOMAIN STRUCTURE

Domain Wall Mobility
See DOMAIN STRUCTURE

Drift Mobility
See MOBILITY

Drift Velocity
See MOBILITY

EFFECTIVE MASS

Cyclotron Resonance
Minority Carrier Effective Mass

Effective Permeability
See THRESHOLD FIELD

Electric Strength
See DIELECTRIC STRENGTH

Electric Susceptibility
See DIELECTRIC CONSTANT

Electric Anisotrophy Constants
See ELECTROMECHANICAL EFFECTS

ELECTRICAL CONDUCTIVITY
Conductivity
Intrinsic Conductivity

ELECTRIC HYSTERESIS LOOP CHARACTERISTICS
Coercive Field, Electrical
Critical Electric Field
Differential Susceptibility
Initial Electrical Susceptibility
Maximum Coercive Field
Maximum Spontaneous Polarization
Output Voltage on Switching
Peaking Voltage
Peaking Time
Polarization Curves
Remanence Polarization
Small Signal Susceptibility
Switching Characteristics
Switching Time
Switching Voltage

Electric (al) Resistance
See INSULATION RESISTANCE

ELECTRICAL RESISTIVITY
Extrinsic Resistivity
Intrinsic Resistivity
Residual Electrical Resistivity
Resistivity (Electrical)
Specific Resistivity
Surface Resistance
Surface Resistivity
Te Value
Temperature Coefficient of Resistivity
Volume Resistivity

ELECTROACOUSTIC PROPERTIES
Acoustoelectric Effect
Acoustomagnetoelectric Effect
Phonon Drag
Phonon Energy Levels

Electromechanical Coupling Coefficient
See PIEZOELECTRIC PROPERTIES

ELECTROMECHANICAL EFFECTS (Does not include electroacoustic effects)
Anisotrophy Constants
Electrostriction

Electron Emission
See EMISSION

Electron Irradiation
See IRRADIATION EFFECTS

Electron Mobility
  See MOBILITY

ELECTRONIC SPECIFIC HEAT
  Heat Capacity

Electrostriction
  See ELECTROMECHANICAL EFFECTS

EMISSION
  Electron Emission
  Field Emission
  Ion Emission
  Photoemission
  Recombination Emission
  Secondary Emission

Emission Spectra
  See PHOTOELECTRONIC PROPERTIES

ENERGY BANDS
  Band Structure

ENERGY GAP
  Activation Energy
  Band Gap
  Forbidden Band Width
  Forbidden Energy Gap
  Forbidden Zone

ENERGY LEVELS
  Color Centers
  Exciton Levels
  F-Centers
  Ionization Energy
  Nuclear Magnetic Resonance
  Traps
  Zeeman Effect

Equivalent Cross Sections
  See CROSS SECTIONS

Ettingshausen Effect
  See MAGNETOELECTRIC PROPERTIES

Exciton Levels
  See ENERGY LEVELS

Extrinsic Resistivity
  See ELECTRICAL RESISTIVITY

F-Centers (Farben, i.e., "Color" Centers)
<u>See</u> ENERGY LEVELS

Faraday Rotation
<u>See</u> GYROMAGNETIC EFFECTS

Fatigue
<u>See</u> LUMINESCENT EFFICIENCY

Ferromagnetic Resonance Absorption
<u>See</u> GYROMAGNETIC EFFECTS

Field Effect
<u>See</u> SURFACE PROPERTIES

Field Effect Mobility
<u>See</u> MOBILITY

Field Emission
<u>See</u> EMISSION

Figure of Merit
<u>See</u> THERMOELECTRIC PROPERTIES

Fluorescence
<u>See</u> PHOTOELECTRONIC PROPERTIES

Forbidden Band Width
<u>See</u> ENERGY GAP

Forbidden Energy Gap
<u>See</u> ENERGY GAP

Forbidden Zone
<u>See</u> ENERGY GAP

Frequency Constant
<u>See</u> PIEZOELECTRIC PROPERTIES

Galvanomagnetic Properties
<u>See</u> MAGNETOELECTRIC PROPERTIES

Generation-Recombination Noise
<u>See</u> LIFETIME

GYROMAGNETIC EFFECTS
Faraday Rotation
Ferromagnetic Resonance Absorption
Gyromagnetic Ratio

Gyromagnetic Ratio
See GYROMAGNETIC EFFECTS

HALL COEFFICIENT
Hall Constant
Hall Effect
Hall Voltage

Hall Constant
See HALL COEFFICIENT

Hall Effect
See HALL COEFFICIENT

Hall Mobility
See MOBILITY

Hall Voltage
See HALL COEFFICIENT

Heat Capacity
See ELECTRONIC SPECIFIC HEAT

Hole Mobility
See MOBILITY

Hysteresis Loss
See MAGNETIC HYSTERESIS LOOP CHARACTERISTICS

Imaginary Dielectric Constant
See LOSS FACTOR

Impurity Cross Sections
See CROSS SECTIONS

Impurity Mobility
See MOBILITY

Infrared Absorption
See ABSORPTION

INITIAL DIELECTRIC COEFFICIENT

Initial Permeability
See MAGNETIC HYSTERESIS LOOP CHARACTERISTICS

Initial Electrical Susceptibility
See ELECTRICAL HYSTERESIS LOOP CHARACTERISTICS

Intrinsic Mobility
See MOBILITY

Intrinsic Resistivity
    See ELECTRICAL RESISTIVITY

Ion Emission
    See EMISSION

Ionization Energy
    See ENERGY LEVELS

INSULATION RESISTANCE
    Electric(al) Resistance
    Temperature Coefficient of Resistance

Intrinsic Conductivity
    See ELECTRICAL CONDUCTIVITY

IRRADIATION EFFECTS (Does not incl. electromagnetic radiation)
    Alpha Irradiation
    Beta Irradiation
    Electron Irradiation
    Neutron Irradiation
    Proton Irradiation
    Radiation Effects

Kelvin Effect
    See THERMOELECTRIC PROPERTIES

LIFETIME
    Decay Time
    Generation-Recombination Noise
    Minority Carrier Lifetime
    Recombination
    Recombination Centers
    Recombination Noise
    Relaxation Time

Loss Angle
    See DISSIPATION FACTOR

LOSS FACTOR
    Dielectric Loss Factor
    Imaginary Dielectric Constant

Loss Tangent
    See DISSIPATION FACTOR

Luminescence
    See PHOTOELECTRONIC PROPERTIES

LUMINESCENT EFFICIENCY
- Fatigue
- Quenching

Magnetic Anisotropy Constants
- See MAGNETOMECHANICAL EFFECTS

MAGNETIC HYSTERESIS LOOP CHARACTERISTICS
- Barkhausen Effect
- Coercive Field (Magnetic)
- Critical Magnetic Field
- Hysteresis Loss
- Initial Permeability
- Magnetization Decay
- Magnetizing Field for Optimum Squareness Ratio
- Maximum Permeability
- Optimum Squareness Ratio
- Output Voltage on Switching
- Peaking Time
- Remanence to Maximum Flux Density Ratio
- Remanent Flux Density
- Saturation Density
- Switching Characteristics
- Switching Time

MAGNETIC SUSCEPTIBILITY
- De Haas – Van Alphen Effect
- Diamagnetic Susceptibility
- Magnetization
- Paramagnetic Susceptibility

Magnetization
- See MAGNETIC SUSCEPTIBILITY

Magnetization Decay
- See MAGNETIC HYSTERESIS LOOP CHARACTERISTICS

Magnetizing Force for Optimum Squareness Ratio
- See MAGNETIC HYSTERESIS LOOP CHARACTERISTICS

Magnetoelastic Energy
- See MAGNETOMECHANICAL EFFECTS

MAGNETOELECTRIC PROPERTIES
- Corbino Effect
- Ettingshausen Effect
- Galvanomagnetic Properties
- Magnetoresistance

MAGNETOELECTROLUMINESCENT PROPERTIES

Nernst Effect
See THERMOMAGNETIC PROPERTIES

Nernst-Ettingshausen Effect
See THERMOMAGNETIC PROPERTIES

Neutron Irradiation
See IRRADIATION EFFECTS

Nuclear Magnetic Resonance
See ENERGY LEVELS

Optical Absorption
See ABSORPTION

Optimum Squareness Ratio
See MAGNETIC HYSTERESIS LOOP CHARACTERISTICS

Output Voltage on Switching
See ELECTRICAL HYSTERESIS LOOP CHARACTERISTICS
MAGNETIC HYSTERESIS LOOP CHARACTERISTICS

Parabolic Threshold Field Curves
See THRESHOLD FIELD

Paramagnetic Susceptibility
See MAGNETIC SUSCEPTIBILITY

Peaking Time
See ELECTRICAL HYSTERESIS LOOP CHARACTERISTICS
MAGNETIC HYSTERESIS LOOP CHARACTERISTICS

Peltier Coefficient
See THERMOELECTRIC PROPERTIES

PENETRATION DEPTH
Critical Frequency
Meissner (Ochsenfeld) Effect
Skin Depth

Permittivity
See DIELECTRIC CONSTANT

Phase Angle
See DISSIPATION FACTOR

Phase Defect Angle
See DISSIPATION FACTOR

Phonon Drag
See ELECTROACOUSTIC PROPERTIES

Recombination Spectra
See LIFETIME

REFLECTION
Reflectivity

Reflection Coefficients
See RICHARDSON'S CONSTANT

Reflectivity
See REFLECTION

Refraction
See REFRACTIVE INDEX

REFRACTIVE INDEX
Refraction

Relative Capacitance
See DIELECTRIC CONSTANT

Relative Dielectric Constant
See DIELECTRIC CONSTANT

Relaxation Time
See LIFETIME

Remanence Polarization
See ELECTRICAL HYSTERESIS LOOP CHARACTERISTICS

Remanence to Maximum Flux Density Ratio
See MAGNETIC HYSTERESIS LOOP CHARACTERISTICS

Remanent Flux Density
See MAGNETIC HYSTERESIS LOOP CHARACTERISTICS

Residual Electrical Resistivity
See ELECTRICAL RESISTIVITY

Resistivity
See ELECTRICAL RESISTIVITY

Resistivity (Thermal)
See THERMAL CONDUCTIVITY

RICHARDSON'S CONSTANT
Reflection Coefficients

Righi-Leduc Effect
See THERMOMAGNETIC PROPERTIES

Saturation Flux Density
See MAGNETIC HYSTERESIS LOOP CHARACTERISTICS

Saturation Susceptibility
See ELECTRICAL HYSTERESIS LOOP CHARACTERISTICS

Scattering Cross Sections
See CROSS SECTIONS

Secondary Emission
See EMISSION

Seebeck Coefficient
See THERMOELECTRIC PROPERTIES

Seebeck Effect
See THERMOELECTRIC PROPERTIES

Seebeck Voltage
See THERMOELECTRIC PROPERTIES

Skin Depth
See PENETRATION DEPTH

Small Signal Susceptibility
See ELECTRICAL HYSTERESIS LOOP CHARACTERISTICS

Specific Inductive Capacitance (S. I. C.)
See DIELECTRIC CONSTANT

Specific Resistivity
See ELECTRICAL RESISTIVITY

Specific Transition Temperature
See SUPERCONDUCTIVE TRANSITION TEMPERATURE

Spectral Absorption
See ABSORPTION

Spectral Response
See PHOTOELECTRONIC PROPERTIES

Storage Factor
See DISSIPATION FACTOR

Suhl Effect
See SURFACE PROPERTIES

Superconductive Critical Field
See THRESHOLD FIELD

Superconductive Temperature Interval
See SUPERCONDUCTIVE TRANSITION TEMPERATURE

SUPERCONDUCTIVE TRANSITION TEMPERATURE
Critical Temperature
Specific Transition Temperature
Transition Temperature

SURFACE PROPERTIES
Field Effect
Suhl Effect
Contact Potential

SURFACE PROPERTIES (THIN FILM CHARACTERISTICS)
Absorption
Poisoning

Surface Resistance
See ELECTRICAL RESISTIVITY

Surface Resistivity
See ELECTRICAL RESISTIVITY

Switching Characteristics
See ELECTRICAL HYSTERESIS LOOP CHARACTERISTICS
MAGNETIC HYSTERESIS LOOP CHARACTERISTICS

Switching Time
See ELECTRICAL HYSTERESIS LOOP CHARACTERISTICS
MAGNETIC HYSTERESIS LOOP CHARACTERISTICS

Switching Voltage
See ELECTRICAL HYSTERESIS LOOP CHARACTERISTICS

Tangent δ
See DISSIPATION FACTOR

Te Value
See ELECTRICAL RESISTIVITY

Temperature Coefficient of Resistivity
See ELECTRICAL RESISTIVITY

THERMAL CONDUCTIVITY
Conductivity
Resistivity (Thermal)
Thermal Resistivity

THERMAL EFFICIENCY

Thermal Emission
See EMISSION

Thermal Resistivity
See THERMAL CONDUCTIVITY

Thermionic Emission
See EMISSION

Thermoelectric Figure of Merit
See THERMOELECTRIC PROPERTIES

Thermoelectric Power
See THERMOELECTRIC PROPERTIES

THERMOELECTRIC PROPERTIES
Figure of Merit
Kelvin Effect
Seebeck Coefficient
Peltier Coefficient
Seebeck Effect
Seebeck Voltage
Thermoelectric Figure of Merit
Thermoelectric Power
Thomson Coefficient

THERMOELECTROLUMINESCENT PROPERTIES

THERMOMAGNETIC PROPERTIES
Nernst Effect
Nernst-Ettingshausen Effect
Righi-Leduc Effect

Thomson Coefficient
See THERMOELECTRIC PROPERTIES

Tracking
See ARC RESISTANCE

THRESHOLD FIELD
Critical Field, Superconductive
Effective Permeability
Parabolic Threshold Curves
Superconductive Critical Field

Transition Temperature
See SUPERCONDUCTIVE TRANSITION TEMPERATURE

Transport of Carriers
See MOBILITY

CATEGORY - PROPERTY CROSS INDEX

	Superconductors	Ferromagnetics	Semiconductors	Insulators	Ferrites	Ferroelectrics	Metals	Electroluminescent Materials	Thermionic Emitters
ABSORPTION			X					X	
ARC RESISTANCE				X					
CARRIER DIFFUSION			X					X	
CORONA EFFECTS				X					
CROSS SECTIONS			X					X	X
CURIE CONSTANT		X			X				
CURIE TEMPERATURE		X			X	X			
DEBYE TEMPERATURE	X		X						
DIELECTRIC ABSORPTION				X	X	X			
DIELECTRIC CONSTANT			X	X	X	X		X	
DIELECTRIC STRENGTH				X		X		X	
DISSIPATION FACTOR				X	X	X			
DOMAIN STRUCTURE	X	X			X	X			
EFFECTIVE MASS			X						
ELECTRICAL CONDUCTIVITY			X	X			X	X	X
ELECTRICAL HYSTERESIS LOOP CHARACTERISTICS						X			
ELECTRICAL RESISTIVITY	X		X	X	X	X		X	X
ELECTROACOUSTIC PROPERTIES			X						
ELECTROMECHANICAL PROPERTIES						X			
ELECTRONIC SPECIFIC HEAT	X								
EMISSION			X					X	X
ENERGY BANDS			X					X	
ENERGY GAP	X		X					X	

CATEGORY - PROPERTY CROSS INDEX (Continued)

	Superconductors	Ferromagnetics	Semiconductors	Insulators	Ferrites	Ferroelectrics	Metals	Electroluminescent Materials	Thermionic Emitters
ENERGY LEVELS			X					X	
GYROMAGNETIC EFFECTS					X				
HALL COEFFICIENT			X						
INITIAL DIELECTRIC COEFFICIENT						X			
INSULATION RESISTANCE				X					
IRRADIATION EFFECTS	X	X	X	X	X	X	X	X	X
LIFETIME			X			X		X	X
LOSS FACTOR				X	X	X			
LUMINESCENT EFFICIENCY								X	
MAGNETIC HYSTERESIS LOOP CHARACTERISTICS		X			X				
MAGNETIC SUSCEPTIBILITY	X		X					X	
MAGNETOELECTRIC PROPERTIES			X		X				
MAGNETOELECTRO-LUMINESCENT PROPERTIES								X	
MAGNETOMECHANICAL EFFECTS		X			X				
MOBILITY			X			X		X	
PENETRATION DEPTH	X								
PHOTOELECTRO-LUMINESCENT PROPERTIES								X	
PHOTOELECTRONIC PROPERTIES			X					X	
PIEZOELECTRIC PROPERTIES			X			X		X	
POWER FACTOR				X					

CATEGORY - PROPERTY CROSS INDEX (Continued)

	Superconductors	Ferromagnetics	Semiconductors	Insulators	Ferrites	Ferroelectrics	Metals	Electroluminescent Materials	Thermionic Emitters
REFLECTION			X						
REFRACTIVE INDEX			X						
RICHARDSON'S CONSTANT									X
SUPERCONDUCTIVE TRANSITION TEMPERATURE	X								
SURFACE PROPERTIES			X					X	X
SURFACE PROPERTIES (THIN FILM CHARACTERISTICS)									X
THERMAL CONDUCTIVITY	X		X						X
THERMAL EFFICIENCY									X
THERMOELECTRIC PROPERTIES			X			X			
THERMOELECTRO-LUMINESCENT PROPERTIES								X	
THERMOMAGNETIC PROPERTIES	X	X	X		X				
THRESHOLD FIELD	X								
WORK FUNCTION			X					X	X

VII. LISTS OF MATERIALS

Included in this section of the report are lists of materials in the seven new categories of materials under study during the six-month extension to the contract. Accompanying the lists are brief discussions of the rationale behind the adoption of the terms as an indexing vocabulary to be used in indexing the literature. The lists are tentative and will be modified as required as the literature is indexed. Also included is the list of Organic Semiconductor materials which first appeared in the Fourth Quarterly Progress Report.

A. Electroluminescent Materials

A material is considered to be electroluminescent if it exhibits luminescence when placed in an electric field. For each of the materials listed, experimental electroluminescent data have been found. The sources which yielded these data and materials were generally review and summary articles, and as the pertinent literature in this category is searched and abstracted the list will undergo revision.

Data other than luminescence as a function of field strength or current density is being accepted; for example, quenching of luminescence, luminescence efficiency and energy levels (see the list of electroluminescent properties). This type of data is included because of its direct relation to electroluminescence and is accepted even if it is from other types of experiments, i.e., photoluminescence or thermoluminescence experiments. It must be understood however, that pure thermoluminescence or photoluminescence data is not being included in this category, and that these other data are accepted only if they are from experiments performed on materials which are known to be electroluminescent. This restriction placed upon the materials list is necessary to ensure that the electroluminescent category is not lost in the wealth of general luminescent information.

There has been no attempt to consider the luminescent activators in this materials list. Their importance will not be minimized in this category, and they will receive full consideration in the compilation and in additional work in this category, but they will not be considered in the authority list of electroluminescent materials.

The lower case descriptors in the Electroluminescent and the Thermionic Emitter lists are included as cross references. When they are listed alphabetically, an upper case See reference is given.

ELECTROLUMINESCENT MATERIALS

ACRIDINE

ACRIFLAVINE
X - Euflavine
Trypaflavine neutral
Neutral acriflavine
Gonacrin
2,8-diamino-10-methyl acridinium Chloride

ALUMINUM NITRIDE

ALUMINUM OXIDE
X - Sapphire

ALUMINUM OXIDE-MAGNESIUM OXIDE SYSTEMS
X - Magnesium Aluminate

ALUMINUM PHOSPHIDE

ARSENIC-GALLIUM-PHOSPHORUS SYSTEMS

BARIUM OXIDE-TITANIUM OXIDE SYSTEMS
X - Barium Titanate

Barium Titanate
See BARIUM OXIDE-TITANIUM OXIDE SYSTEMS

BORON NITRIDE

CADMIUM-MANGANESE-SULFUR-ZINC SYSTEMS
X - Zinc Sulfide-Cadmium Sulfide-Manganese Sulfide

CADMIUM OXIDE

CADMIUM SELENIDE

CADMIUM SULFIDE

CADMIUM-SULFUR-ZINC SYSTEMS
X - Zinc-Cadmium Sulfide

CALCIUM OXIDE-TITANIUM OXIDE SYSTEMS
X - Calcium Titanate

CALCIUM OXIDE-TUNGSTEN OXIDE SYSTEMS
X - Calcium Tungstate

Calcium Titanate
  <u>See</u> CALCIUM OXIDE-TITANIUM OXIDE SYSTEMS

Calcium Tungstate
  <u>See</u> CALCIUM OXIDE-TUNGSTEN OXIDE SYSTEMS

CARBAZOLE

<u>Incl</u> Dibenzopyrrole
Diphenylenimine

CARBON (DIAMOND)

CESIUM ANTIMONIDE

2,8-diamino-10-methyl acridinium chloride
  See ACRIFLAVINE

Diamond
  <u>See</u> CARBON (DIAMOND)

Dibenzopyrrole
  <u>See</u> CARBAZOLE

Diphenylenimine
  <u>See</u> CARBAZOLE

Euflavine
  <u>See</u> ACRIFLAVINE

GALLIUM ANTIMONIDE

GALLIUM ARSENIDE

GALLIUM-INDIUM-PHOSPHORUS SYSTEMS

GALLIUM NITRIDE

GALLIUM PHOSPHIDE

GERMANIUM

Gonacrin
  <u>See</u> ACRIFLAVINE

INDIUM PHOSPHIDE

LEAD OXIDE-ZIRCONIUM OXIDE SYSTEMS
  X - Lead Zirconate

STRONTIUM SULFIDE

Strontium Titanate
See STRONTIUM OXIDE-TITANIUM OXIDE SYSTEMS

TITANIUM OXIDE

Trypaflavine, Neutral
See ACRIFLAVINE

Willemite
See SILICON OXIDE ZINC OXIDE SYSTEMS

Zinc-Cadmium Sulfide
See CADMIUM-SULFUR-ZINC SYSTEMS

ZINC FLUORIDE

Zinc Orthosilicate
See SILICON OXIDE-ZINC OXIDE SYSTEMS

ZINC SELENIDE

Zinc Selenium Sulfide
See SELENIUM-SULFUR-ZINC SYSTEMS

Zinc Silicate
See SILICON OXIDE ZINC OXIDE SYSTEMS

Zinc Silicate-Manganese Silicate
See MANGANESE OXIDE SILICON OXIDE ZINC OXIDE SYSTEMS

ZINC SULFIDE

Zinc Sulfide Cadmium Sulfide Manganese Sulfide
See CADMIUM MANGANESE SULFUR ZINC SYSTEMS

B. Thermionic Emitter Material

A material is considered a Thermionic Emitter if it emits electrons under increased temperatures. The procedure followed for this materials list was the same as in the Electroluminescent category. A material must first exhibit thermionic emission; that is the primary consideration. Other data such as thermal efficiency and poisoning are accepted even when they are obtained from experiments in field emission, photoemission, or secondary emission. These experiments must, however, be performed on materials which are known Thermionic Emitters, before the data is included. The sources were summary and review articles on thermionic emission, but in most cases it was necessary to return to the original article. This is not to say that the Electroluminescent materials were not studied carefully, but rather that the materials and experiments which yield thermionic emission data required more delineation than do the Electroluminescent materials and experiments.

The descriptors referred to as oxygen systems in this list do not refer to oxides. Rather, they refer to solid solutions of oxygen and the base material. There is little uniformity in the preparation of the cathodes used in thermionic emission experiments. (Thermionic emission experiments on cathodes are not considered device-oriented.) One such method of preparation is the oxygen coated cathode. This type cathode is prepared by the adsorption of oxygen onto the surface of the base material. This does not yield an oxide, but rather the solid solution which has been called the oxygen system. The only attempt to differentiate between film and bulk effect in this list of materials is in the lower case references. An example of this is Zirconium-Barium Oxide where zirconium is the base material and barium oxide is the emitting surface. Data on this cathode is indexed under BARIUM OXIDE and will be differentiated from bulk barium oxide in the evaluation and data sheet preparation.

THERMIONIC EMITTER MATERIALS

ALUMINUM

ANTIMONY

ARSENIC

BARIUM
- X-Tungsten-Barium
  - Strontium-Barium

BARIUM BORIDE

BARIUM OXIDE
- X-Zirconium-Barium Oxide
  - Tungsten-Barium Oxide
  - Tantalum-Barium Oxide
  - Platinum-Iridium-Barium Oxide
  - Platinum-Barium Oxide
  - Nickel-Barium Oxide
  - Molybdenum-Barium Oxide

BARIUM OXIDE-STRONTIUM OXIDE SYSTEMS

BARIUM OXIDE-STRONTIUM OXIDE-CALCIUM OXIDE SYSTEMS

BARIUM-OXYGEN-TUNGSTEN SYSTEMS

BARIUM SULFIDE
- X-Platinum-Barium Sulfide
  - Niobium-Barium Sulfide

BERYLLIUM

BISMUTH

BORON

BORON NITRIDE

CADMIUM

CALCIUM

CALCIUM BORIDE

STRONTIUM OXIDE

X-Tungsten-Strontium Oxide
Tantalum-Strontium Oxide
Platinum-Strontium Oxide
Platinum-Iridium-Strontium Oxide
Nickel-Strontium Oxide
Molybdenum-Strontium Oxide

TANTALUM

Tantalum-Barium Oxide
<u>See</u> BARIUM OXIDE

TANTALUM BORIDE

TANTALUM CARBIDE

TANTALUM NITRIDE

Tantalum-Strontium Oxide
<u>See</u> STRONTIUM OXIDE

Tantalum-Thorium
<u>See</u> THORIUM

TELLURIUM

THALLIUM

THORIUM

X-Tungsten-Thorium
Tantalum-Thorium
Molybdenum-Thorium

THORIUM BORIDE

THORIUM CARBIDE

THORIUM OXIDE

X-Iridium-Thorium Oxide
Tungsten-Thorium Oxide

THORIUM SULFIDE

X-Tungsten-Thorium Sulfide

TIN

TITANIUM

TITANIUM CARBIDE

C. Ferroelectric, Ferrite, Ferromagnetic and Superconductor Materials

The following lists of materials include Ferroelectric, Ferrites, Ferromagnetic, and Superconductors. They include no cross references. Each of the lists has been compiled from various secondary literature sources such as texts, summary reports or monographs. Although secondary sources were used a cursory check of the original sources was performed.

The naming systems in both the secondary and primary sources followed no uniformity, for example CNb_2 was listed as a superconductor in B. W. Roberts' report "Superconducting Materials and some of their properties". The original source of this information, [Hardy, G. F. and Hulm, J. K., Phys. Rev. 93, 1004 (1954)] cites the material as Nb_2C. Most of the superconductors in our list have been called systems. This denotes that they are either solid solutions or nonstiochiometric crystals which have been distorted from their original lattice structure. As the original sources are checked for each of these materials they will be named systems or compounds (such as Niobium Carbide in the above case) depending upon the original data.

Most of the materials in the Ferrite list are in reality the type of crystaline structure described above and are called oxide systems. Some ferrites however are stiochiometric compounds with undistorted crystaline structure. An example of this is Iron Oxide, but by and large these materials will use the oxide systems notation. The Ferromagnetic materials are recognized as alloys and because of their solid solution type structure they have also been named systems, so as to conform with our naming system. The Oxide compound system names have again been used.

The ferroelectric list of materials is the most conglomerate in types of names. The organic materials names have been used as they were found in the literature. Where possible the non-organic materials names have been changed to conform to our naming system. An example of this is the changing of Lead Bismuth Niobate to Bismuth Oxide-Lead Oxide-Niobium Oxide Systems, with a cross reference. In some non-organic materials where the generic name is in wide usage and is recognized as a Ferroelectric then it has been retained. Ammonium Alum is an example of this procedure. None of these Ferroelectric materials names contain any of the hydration notation and there has been no attempt to differentiate between the presence of hydrogen and deuterium.

FERROELECTRIC MATERIALS

AMMONIUM BISULFATE

2-AMMONIUM 2-CADMIUM SULFATE

AMMONIUM FLUOBERYLLATE

AMMONIUM INDIUM ALUM

AMMONIUM IRON ALUM

AMMONIUM MONOCHLOROACETATE

AMMONIUM SULFATE

AMMONIUM VANADIUM ALUM

BARIUM LITHIUM OXYFLUOALUMINATE

BARIUM OXIDE BISMUTH OXIDE TITANIUM OXIDE SYSTEMS

BARIUM OXIDE CALCIUM OXIDE TITANIUM OXIDE SYSTEMS

BARIUM OXIDE MAGNESIUM OXIDE TITANIUM OXIDE SYSTEMS

BARIUM OXIDE STRONTIUM OXIDE TITANIUM OXIDE SYSTEMS

BARIUM OXIDE TANTALUM OXIDE SYSTEMS

BARIUM OXIDE TIN OXIDE TITANIUM OXIDE SYSTEMS

BARIUM OXIDE TITANIUM OXIDE SYSTEMS

BARIUM OXIDE ZIRCONIUM OXIDE SYSTEMS

BISMUTH OXIDE LEAD OXIDE NIOBIUM OXIDE SYSTEMS

BISMUTH OXIDE STRONTIUM OXIDE TITANIUM OXIDE SYSTEMS

BISMUTH OXIDE TITANIUM OXIDE SYSTEMS

CADMIUM OXIDE NIOBIUM OXIDE SYSTEMS

CADMIUM OXIDE TITANIUM OXIDE SYSTEMS

CALCIUM OXIDE BARIUM OXIDE SYSTEMS

CALCIUM OXIDE MAGNESIUM OXIDE TITANIUM OXIDE SYSTEMS

CALCIUM OXIDE NIOBIUM OXIDE SYSTEMS

CALCIUM OXIDE TANTALUM OXIDE SYSTEMS

CALCIUM OXIDE TITANIUM OXIDE SYSTEMS

CALCIUM OXIDE ZIRCONIUM OXIDE SYSTEMS

2-CALCIUM STRONTIUM PROPIONATE

CESIUM HYDROGEN ARSENATES

CESIUM HYDROGEN PHOSPHATE

3-GLYCINE FLUOBERYLLATE

2-GLYCINE MANGANOUS CHLORIDE

2-GLYCINE NITRATE

3-GLYCINE SELENATE

GLYCINE SILVER NITRATE

3-GLYCINE SULFATE

GUANIDINE ALUMINUM SELENATE

GUANIDINE ALUMINUM SULFATES

GUANIDINE CHROMIUM SELENATE

GUANIDINE CHROMIUM SULFATE

GUANIDINE GALLIUM SELENATE

GUANIDINE GALLIUM SULFATE

GUANIDINE VANADIUM SULFATE

IRON OXIDE LEAD OXIDE NIOBIUM OXIDE SYSTEMS

LANTHANUM OXIDE TITANIUM OXIDE SYSTEMS

LEAD OXIDE MAGNESIUM OXIDE NIOBIUM OXIDE SYSTEMS

LEAD OXIDE NIOBIUM OXIDE SYSTEMS

LEAD OXIDE TANTALUM OXIDE SYSTEMS

LEAD OXIDE TITANIUM OXIDE SYSTEMS

LEAD OXIDE ZIRCONIUM OXIDE SYSTEMS

LITHIUM AMMONIUM TARTRATE

LITHIUM HYDRAZINTUM SULFATE

LITHIUM HYDROGEN SELENITE

LITHIUM OXIDE NIOBIUM OXIDE SYSTEMS

LITHIUM OXIDE TANTALUM OXIDE SYSTEMS

LITHIUM THALLIUM TARTRATE

MAGNESIUM OXIDE NIOBIUM OXIDE SYSTEMS

MAGNESIUM OXIDE TANTALUM OXIDE SYSTEMS

MAGNESIUM OXIDE TITANIUM OXIDE SYSTEMS

MAGNESIUM OXIDE ZIRCONIUM OXIDE SYSTEMS

METHLAMMONIUM ALUMINUM ALUMS

METHYLAMMONIUM ALUMINIUM SELENATE

METHYLAMMONIUM CHROME ALUM

METHYLAMMONIUM GALLIUM ALUM

METHYLAMMONIUM INDIUM ALUM

METHYLAMMONIUM IRON ALUM

METHYLAMMONIUM VANADIUM ALUM

NIOBIUM OXIDE POTASSIUM OXIDE SYSTEMS

NIOBIUM OXIDE SODIUM OXIDE SYSTEMS

NIOBIUM OXIDE ZINC OXIDE SYSTEMS

NIOBIUM OXIDE ZIRCONIUM OXIDE SYSTEMS

POTASSIUM FERROCYANIDE

POTASSIUM HYDROGEN ARSENATES

POTASSIUM HYDROGEN PHOSPHATES

POTASSIUM NITRATE

POTASSIUM OXIDE SODIUM OXIDE TANTALUM OXIDE SYSTEMS

POTASSIUM OXIDE TANTALUM OXIDE SYSTEMS

POTASSIUM OXIDE TITANIUM OXIDE SYSTEMS

POTASSIUM TARTRATE

RUBIDIUM BISULFATE

RUBIDIUM HYDROGEN ARSENATES

RUBIDIUM HYDROGEN PHOSPHATES

RUBIDIUM SODIUM TARTRATE

SILICON OXIDE TITANIUM OXIDE SYSTEMS

SODIUM AMMONIUM TARTRATE

SODIUM HYDROGEN SELENITE

SODIUM NITRITE

SODIUM OXIDE TANTALUM OXIDE SYSTEMS

SODIUM OXIDE VANADIUM OXIDE SYSTEMS

SODIUM POTASSIUM TARTRATES

STRONTIUM OXIDE NIOBIUM OXIDE SYSTEMS

STRONTIUM OXIDE TANTALUM OXIDE SYSTEMS

STRONTIUM OXIDE TITANIUM OXIDE SYSTEMS

STRONTIUM OXIDE ZIRCONIUM OXIDE SYSTEMS

TANTALUM OXIDE ZINC OXIDE SYSTEMS

TITANIUM OXIDE ZIRCONIUM OXIDE SYSTEMS

TETRAMETHYLAMMONIUM 3-CHLOROMERCURIATE

THIOUREA

TUNGSTEN OXIDE

UREA CHROME ALUM

FERRITE MATERIALS

ALUMINUM OXIDE IRON OXIDE NICKEL OXIDE SYSTEMS

ALUMINUM OXIDE MAGNESIUM OXIDE SYSTEMS

ALUMINUM OXIDE NICKEL OXIDE SYSTEMS

BARIUM OXIDE COBALT OXIDE IRON OXIDE SYSTEMS

BARIUM OXIDE IRON OXIDE SYSTEMS

BARIUM OXIDE IRON OXIDE MAGNESIUM OXIDE SYSTEMS

BARIUM OXIDE IRON OXIDE MANGANESE OXIDE SYSTEMS

BARIUM OXIDE IRON OXIDE NICKEL OXIDE SYSTEMS

BARIUM OXIDE IRON OXIDE ZINC OXIDE SYSTEMS

BARIUM OXIDE LANTHANUM OXIDE MANGANESE OXIDE STRONTIUM OXIDE SYSTEMS

CADMIUM OXIDE IRON OXIDE SYSTEMS

CADMIUM OXIDE LANTHANUM OXIDE MANGANESE OXIDE SYSTEMS

CALCIUM OXIDE LANTHANUM OXIDE MANGANESE OXIDE SYSTEMS

CHROMIUM OXIDE IRON OXIDE SYSTEMS

CHROMIUM OXIDE IRON OXIDE LITHIUM OXIDE SYSTEMS

CHROMIUM OXIDE IRON OXIDE MAGNESIUM OXIDE SYSTEMS

CHROMIUM OXIDE MAGNESIUM OXIDE SYSTEMS

CHROMIUM OXIDE NICKEL OXIDE SYSTEMS

COBALT OXIDE IRON OXIDE SYSTEMS

COBALT OXIDE IRON OXIDE MANGANESE OXIDE SYSTEMS

COBALT IRON OXIDE MANGANESE OXIDE NICKEL OXIDE SYSTEMS

COBALT OXIDE IRON OXIDE NICKEL OXIDE SYSTEMS

COBALT OXIDE IRON OXIDE ZINC OXIDE SYSTEMS

COBALT OXIDE MANGANESE OXIDE SYSTEMS

COPPER OXIDE IRON OXIDE SYSTEMS

COPPER OXIDE IRON OXIDE ZINC OXIDE SYSTEMS

DYSPROSIUM OXIDE IRON OXIDE SYSTEMS

EUROPIUM OXIDE IRON OXIDE SYSTEMS

GADOLINIUM OXIDE IRON OXIDE SYSTEMS

HOLMIUM OXIDE IRON OXIDE SYSTEMS

IRON OXIDE

IRON OXIDE LITHIUM OXIDE ZINC OXIDE SYSTEMS

IRON OXIDE LUTETIUM OXIDE SYSTEMS

IRON OXIDE MAGNESIUM OXIDE SYSTEMS

IRON OXIDE MAGNESIUM OXIDE MANGANESE OXIDE SYSTEMS

IRON OXIDE MAGNESIUM OXIDE MOLYBDENUM OXIDE SYSTEMS

IRON OXIDE MAGNESIUM OXIDE ZINC OXIDE SYSTEMS

IRON OXIDE NICKEL OXIDE SYSTEMS

IRON OXIDE NICKEL OXIDE ZINC OXIDE SYSTEMS

IRON OXIDE SILICON OXIDE SYSTEMS

IRON OXIDE TELLURIUM OXIDE SYSTEMS

IRON OXIDE THORIUM OXIDE SYSTEMS

IRON OXIDE YTTRIUM OXIDE SYSTEMS

IRON OXIDE ZINC OXIDE SYSTEMS

LANTHANUM OXIDE MANGANESE OXIDE LEAD OXIDE SYSTEMS

MANGANESE OXIDE NICKEL OXIDE SYSTEMS

FERROMAGNETIC MATERIALS

ALUMINUM CARBON IRON SYSTEMS

ALUMINUM COBALT SYSTEMS

ALUMINUM COBALT COPPER IRON NICKEL SYSTEMS

ALUMINUM COBALT IRON NICKEL SYSTEMS

ALUMINUM COBALT IRON NICKEL TITANIUM SYSTEMS

ALUMINUM COBALT MANGANESE SYSTEMS

ALUMINUM COBALT NICKEL SYSTEMS

ALUMINUM COPPER IRON SYSTEMS

ALUMINUM COPPER IRON NICKEL SYSTEMS

ALUMINUM COPPER NICKEL SYSTEMS

ALUMINUM IRON SYSTEMS

ALUMINUM IRON MANGANESE SYSTEMS

ALUMINUM IRON NICKEL SYSTEMS

ALUMINUM IRON MANGANESE NICKEL SYSTEMS

ALUMINUM IRON NICKEL TITANIUM SYSTEMS

ALUMINUM IRON SILICON SYSTEMS

ALUMINUM MANGANESE NICKEL SYSTEMS

ALUMINUM MAGNESIUM SILICON SYSTEMS

ALUMINUM MANGANESE SILVER SYSTEMS

ALUMINUM NICKEL SYSTEMS

ANTIMONY CHROMIUM SYSTEMS

ANTIMONY COBALT SYSTEMS

ANTIMONY COBALT IRON SYSTEMS

ANTIMONY COPPER NICKEL SYSTEMS

ANTIMONY IRON SYSTEMS

ANTIMONY MAGNESIUM SYSTEMS

ANTIMONY NICKEL SYSTEMS

ARSENIC CHROMIUM SYSTEMS

ARSENIC COBALT SYSTEMS

ARSENIC COBALT NICKEL SYSTEMS

ARSENIC COPPER NICKEL SYSTEMS

ARSENIC IRON SYSTEMS

ARSENIC MAGNESIUM SYSTEMS

ARSENIC NICKEL SYSTEMS

BERYLLIUM COBALT SYSTEMS

BERYLLIUM COPPER NICKEL SYSTEMS

BERYLLIUM IRON SYSTEMS

BERYLLIUM IRON NICKEL SYSTEMS

BERYLLIUM NICKEL SYSTEMS

BISMUTH COBALT SYSTEMS

BISMUTH MAGNESIUM SYSTEMS

BISMUTH NICKEL SYSTEMS

BORON CARBON IRON SYSTEMS

BORON COBALT SYSTEMS

BORON IRON SYSTEMS

BORON MAGNESIUM SYSTEMS

BORON NICKEL SYSTEMS

CARBON CHROMIUM IRON TUNGSTEN SYSTEMS

CARBON COBALT SYSTEMS

CARBON COBALT IRON SYSTEMS

CARBON COPPER IRON SYSTEMS

CARBON COPPER NICKEL SYSTEMS

CARBON IRON SYSTEMS

CARBON IRON MANGANESE SYSTEMS

CARBON IRON MOLYBDENUM SYSTEMS

CARBON IRON SILICON SYSTEMS

CARBON IRON TIN ALLOYS

CARBON IRON TITANIUM SYSTEMS

CARBON IRON VANADIUM SYSTEMS

CARBON NICKEL SYSTEMS

CALCIUM MAGNESIUM SYSTEMS

CERIUM IRON SYSTEMS

CESIUM COBALT SYSTEMS

CHROMIUM COBALT SYSTEMS

CHROMIUM COPPER IRON SYSTEMS

CHROMIUM COPPER NICKEL SYSTEMS

CHROMIUM IRON SYSTEMS

CHROMIUM IRON MANGANESE ALLOYS

CHROMIUM IRON MOLYBDENUM SYSTEMS

CHROMIUM IRON MOLYBDENUM TUNGSTEN SYSTEMS

CHROMIUM IRON NICKEL SYSTEMS

CHROMIUM IRON TITANIUM SYSTEMS

CHROMIUM IRON TITANIUM TUNGSTEN SYSTEMS

CHROMIUM IRON TUNGSTEN SYSTEMS

CHROMIUM NICKEL SYSTEMS

CHROMIUM OXYGEN SYSTEMS

CHROMIUM PLATINUM SYSTEMS

CHROMIUM SELENIUM SYSTEMS

CHROMIUM SULFUR SYSTEMS

CHROMIUM THALLIUM SYSTEMS

COBALT

COBALT CHROMIUM IRON SYSTEMS

COBALT CHROMIUM IRON MOLYBDENUM SYSTEMS

COBALT CHROMIUM IRON TUNGSTEN SYSTEMS

COBALT COPPER SYSTEMS

COBALT COPPER IRON NICKEL SYSTEMS

COBALT COPPER MANGANESE ALLOYS

COBALT COPPER MOLYBDENUM SYSTEMS

COBALT COPPER NICKEL SYSTEMS

COBALT GOLD SYSTEMS

COBALT GERMANIUM SYSTEMS

COBALT HYDROGEN SYSTEMS

COBALT IRON SYSTEMS

COBALT IRON MANGANESE NICKEL SYSTEMS

COBALT IRON MANGANESE TUNGSTEN ALLOYS

COBALT IRON MANGANESE VANADIUM SYSTEMS

COBALT IRON MOLYBDENUM SYSTEMS

COBALT IRON MOLYBDENUM TUNGSTEN SYSTEMS

COBALT IRON NICKEL SYSTEMS

COBALT IRON NICKEL TITANIUM SYSTEMS

COBALT IRON SILICON SYSTEMS

COBALT IRON TANTALUM SYSTEMS

CHROMIUM PLATINUM SYSTEMS

CHROMIUM SELENIUM SYSTEMS

CHROMIUM SULFUR SYSTEMS

CHROMIUM THALLIUM SYSTEMS

COBALT

COBALT CHROMIUM IRON SYSTEMS

COBALT CHROMIUM IRON MOLYBDENUM SYSTEMS

COBALT CHROMIUM IRON TUNGSTEN SYSTEMS

COBALT COPPER SYSTEMS

COBALT COPPER IRON NICKEL SYSTEMS

COBALT COPPER MANGANESE ALLOYS

COBALT COPPER MOLYBDENUM SYSTEMS

COBALT COPPER NICKEL SYSTEMS

COBALT GOLD SYSTEMS

COBALT GERMANIUM SYSTEMS

COBALT HYDROGEN SYSTEMS

COBALT IRON SYSTEMS

COBALT IRON MANGANESE NICKEL SYSTEMS

COBALT IRON MANGANESE TUNGSTEN ALLOYS

COBALT IRON MANGANESE VANADIUM SYSTEMS

COBALT IRON MOLYBDENUM SYSTEMS

COBALT IRON MOLYBDENUM TUNGSTEN SYSTEMS

COBALT IRON NICKEL SYSTEMS

COBALT IRON NICKEL TITANIUM SYSTEMS

COBALT IRON SILICON SYSTEMS

COBALT IRON TANTALUM SYSTEMS

COBALT IRON TIN SYSTEMS

COBALT IRON TITANIUM SYSTEMS

COBALT IRON TUNGSTEN SYSTEMS

COBALT IRON VANADIUM SYSTEMS

COBALT LEAD SYSTEMS

COBALT MAGNESIUM SYSTEMS

COBALT MANGANESE SYSTEMS

COBALT MERCURY SYSTEMS

COBALT MOLYBDENUM SYSTEMS

COBALT NICKEL SYSTEMS

COBALT NICKEL SILICON SYSTEMS

COBALT NIOBIUM SYSTEMS

COBALT NITROGEN SYSTEMS

COBALT OXYGEN SYSTEMS

COBALT PALLADIUM SYSTEMS

COBALT PHOSPHORUS SYSTEMS

COBALT PLATINUM SYSTEMS

COBALT SELENIUM SYSTEMS

COBALT SILICON SYSTEMS

COBALT SILVER SYSTEMS

COBALT SULFUR SYSTEMS

COBALT TANTALUM SYSTEMS

COBALT TELLURIUM SYSTEMS

COBALT THALLIUM SYSTEMS

COBALT TIN SYSTEMS

COBALT TITANIUM SYSTEMS

COBALT TUNGSTEN SYSTEMS

COBALT VANADIUM SYSTEMS

COBALT ZINC SYSTEMS

COBALT ZIRCONIUM SYSTEMS

COPPER GOLD NICKEL SYSTEMS

COPPER IRON SYSTEMS

COPPER IRON NICKEL SYSTEMS

COPPER MANGANESE NICKEL SYSTEMS

COPPER MANGANESE TIN SYSTEMS

COPPER IRON MOLYBDENUM SYSTEMS

COPPER IRON MOLYBDENUM NICKEL SYSTEMS

COPPER IRON NICKEL SYSTEMS

COPPER IRON NICKEL VANADIUM SYSTEMS

COPPER MOLYBDENUM NICKEL SYSTEMS

COPPER NICKEL SYSTEMS

GALLIUM NICKEL SYSTEMS

GERMANIUM NICKEL SYSTEMS

GOLD NICKEL SYSTEMS

HYDROGEN NICKEL SYSTEMS

HYDROGEN MAGNESIUM SYSTEMS

IODINE NICKEL SYSTEMS

IRON

IRON GADOLINIUM SYSTEMS

IRON GERMANIUM SYSTEMS

IRON HYDROGEN SYSTEMS

IRON LITHIUM SYSTEMS

INDIUM MAGNESIUM SYSTEMS

IRON MAGNESIUM NICKEL SYSTEMS

IRON MAGNESIUM ZINC SYSTEMS

IRON MANGANESE SYSTEMS

IRON MANGANESE MOLYBDENUM NICKEL SYSTEMS

IRON MANGANESE TITANIUM SYSTEMS

IRON MANGANESE VANADIUM SYSTEMS

IRON MANGANESE ZINC SYSTEMS

IRON MERCURY SYSTEMS

IRON MOLYBDENUM SYSTEMS

IRON MOLYBDENUM NICKEL SYSTEMS

IRON MOLYBDENUM VANADIUM SYSTEMS

IRON NEODYMIUM SYSTEMS

IRON NICKEL SYSTEMS

IRON NICKEL SILICON SYSTEMS

IRON NICKEL SILVER SYSTEMS

IRON NICKEL TANTALUM SYSTEMS

IRON NICKEL TIN SYSTEMS

IRON NICKEL TITANIUM SYSTEMS

IRON NICKEL TUNGSTEN SYSTEMS

IRON NICKEL VANADIUM SYSTEMS

IRON NIOBIUM SYSTEMS

IRON NITROGEN SYSTEMS

IRON OXYGEN SYSTEMS

IRON PALLADIUM SYSTEMS

IRON PHOSPHORUS SYSTEMS

IRON PLATINUM SYSTEMS

IRON SELENIUM SYSTEMS

IRON SILICON SYSTEMS

IRON SULFUR SYSTEMS

IRON TANTALUM SYSTEMS

IRON TIN SYSTEMS

IRON TITANIUM TUNGSTEN SYSTEMS

IRON TUNGSTEN SYSTEMS

IRON TUNGSTEN VANADIUM SYSTEMS

IRON URANIUM SYSTEMS

IRON VANADIUM SYSTEMS

IRON ZINC SYSTEMS

IRON ZIRCONIUM SYSTEMS

MANGANESE COPPER ALUMINUM SYSTEMS

MAGNESIUM

MAGNESIUM NICKEL SYSTEMS

MAGNESIUM NITROGEN SYSTEMS

MAGNESIUM OXYGEN SYSTEMS

MAGNESIUM PHOSPHORUS SYSTEMS

MAGNESIUM TIN SYSTEMS

MERCURY NICKEL SYSTEMS

MOLYBDENUM NICKEL SYSTEMS

NICKEL

NICKEL NIOBIUM SYSTEMS

NICKEL NITROGEN SYSTEMS

NICKEL OXYGEN SYSTEMS

NICKEL PALLADIUM SYSTEMS

NICKEL PHOSPHORUS SYSTEMS

NICKEL PLATINUM SYSTEMS

NICKEL SELENIUM SYSTEMS

NICKEL SILICON SYSTEMS

NICKEL SILVER SYSTEMS

NICKEL SULFUR SYSTEMS

NICKEL TANTALUM SYSTEMS

NICKEL TELLURIUM SYSTEMS

NICKEL THALLIUM SYSTEMS

NICKEL TIN SYSTEMS

NICKEL TITANTIUM SYSTEMS

NICKEL TUNGSTEN SYSTEMS

NICKEL VANADIUM SYSTEMS

NICKEL ZINC SYSTEMS

NICKEL ZIRCONIUM SYSTEMS

SUPERCONDUCTOR MATERIALS

ALUMINUM

ALUMINUM NIOBIUM SYSTEMS

ALUMINUM OSMIUM SYSTEMS

ALUMINUM SILICON VANADIUM SYSTEMS

ANTIMONY ARSENIC BISMUTH LEAD SYSTEMS

ANTIMONY BISMUTH LEAD SYSTEMS

ANTIMONY LEAD SYSTEMS

ANTIMONY MOLYBDENUM SYSTEMS

ANTIMONY PALLADIUM SYSTEMS

ANTIMONY PLATINUM SYSTEMS

ANTIMONY THALLIUM SYSTEMS

ANTIMONY TIN SYSTEMS

ANTIMONY TITANIUM SYSTEMS

ARSENIC BISMUTH LEAD SYSTEMS

ARSENIC LEAD SYSTEMS

ARSENIC NICKEL PALLADIUM SYSTEMS

ARSENIC TIN SYSTEMS

BARIUM BISMUTH SYSTEMS

BARIUM RHODIUM SYSTEMS

BERYLLIUM

BERYLLIUM GOLD SYSTEMS

BISMUTH

BISMUTH CADMIUM LEAD TIN SYSTEMS

BISMUTH CALCIUM SYSTEMS

BISMUTH CESIUM SYSTEMS

BISMUTH COPPER SYSTEMS

BISMUTH GOLD SYSTEMS

BISMUTH INDIUM SYSTEMS

BISMUTH LEAD SYSTEMS

BISMUTH LEAD TIN SYSTEMS

BISMUTH LITHIUM SYSTEMS

BISMUTH NICKEL SYSTEMS

BISMUTH PALLADIUM SYSTEMS

BISMUTH PLATINUM SYSTEMS

BISMUTH POTASSIUM SYSTEMS

BISMUTH RHODIUM SYSTEMS

BISMUTH RUBIDIUM SYSTEMS

BISMUTH SODIUM SYSTEMS

BISMUTH STRONTIUM SYSTEMS

BISMUTH THALLIUM SYSTEMS

BISMUTH TIN SYSTEMS

BISMUTH YTTRIUM SYSTEMS

BORON MOLYBDENUM SYSTEMS

BORON NIOBIUM SYSTEMS

BORON RHENIUM SYSTEMS

BORON RUTHENIUM SYSTEMS

BORON TANTALUM SYSTEMS

BORON TUNGSTEN SYSTEMS

BORON ZIRCONIUM SYSTEMS

BORON SILICON VANADIUM SYSTEMS

CADMIUM

CADMIUM LEAD SYSTEMS

CADMIUM MERCURY SYSTEMS

CADMIUM THALLIUM SYSTEMS

CALCIUM IRIDIUM SYSTEMS

CALCIUM LEAD SYSTEMS

CALCIUM RHODIUM SYSTEMS

CARBON MOLYBDENUM NIOBIUM SYSTEMS

CARBON MOLYBDENUM SYSTEMS

CARBON MOLYBDENUM TANTALUM SYSTEMS

CARBON NIOBIUM NITROGEN SYSTEMS

CARBON NIOBIUM SYSTEMS

CARBON NITROGEN NIOBIUM SYSTEMS

CARBON SILICON VANADIUM SYSTEMS

CARBON TANTALUM SYSTEMS

CARBON TANTALUM TUNGSTEN SYSTEMS

CARBON TUNGSTEN SYSTEMS

CERIUM GADOLINIUM RUTHENTIUM SYSTEMS

CERIUM LANTHANUM SYSTEMS

CERIUM PRASEODYMIUM RUTHENIUM SYSTEMS

CERIUM RUTHENIUM SYSTEMS

CHROMIUM SILICON VANADIUM SYSTEMS

CHROMIUM TITANIUM SYSTEMS

COBALT IRON SILICON SYSTEMS

COBALT NICKEL SILICON SYSTEMS

COBALT RHODIUM SILICON SYSTEMS

COBALT SILICON SYSTEMS

COBALT THORIUM SYSTEMS

COBALT TIN SYSTEMS

COBALT TITANIUM SYSTEMS

COBALT URANIUM SYSTEMS

COBALT ZIRCONIUM SYSTEMS

COPPER LEAD SYSTEMS

COPPER SULFIDE

COPPER THORIUM SYSTEMS

COPPER TIN SYSTEMS

DYSPROSIUM LANTHANUM SYSTEMS

ERBIUM LANTHANUM SYSTEMS

EUROPIUM LANTHANUM SYSTEMS

GADOLINIUM LANTHANUM OSMIUM SYSTEMS

GADOLINIUM LANTHANUM SYSTEMS

GADOLINIUM OSMIUM YTTRIUM SYSTEMS

GADOLINIUM RUTHENIUM THORIUM SYSTEMS

GALLIUM

GALLIUM MOLYBDENUM SYSTEMS

GALLIUM NIOBIUM SYSTEMS

GALLIUM VANADIUM SYSTEMS

GERMANIUM IRIDIUM SYSTEMS

GERMANIUM LANTHANUM SYSTEMS

GERMANIUM MOLYBDENUM SYSTEMS

GERMANIUM NIOBIUM SYSTEMS

GERMANIUM RHODIUM SYSTEMS

GERMANIUM SCANDIUM SYSTEMS

GERMANIUM SILICON VANADIUM SYSTEMS

GERMANIUM TANTALUM SYSTEMS

GERMANIUM VANADIUM SYSTEMS

GERMANIUM YTTRIUM SYSTEMS

GOLD LEAD SYSTEM

GOLD NIOBIUM SYSTEM

GOLD TELLURIUM SYSTEMS

GOLD THORIUM SYSTEMS

GOLD TIN SYSTEMS

GOLD ZIRCONIUM SYSTEMS

HAFNIUM

HAFNIUM MOLYBDENUM SYSTEMS

HAFNIUM OSMIUM SYSTEMS

HAFNIUM RHENIUM SYSTEMS

HAFNIUM RHODIUM SYSTEMS

HAFNIUM ZIRCONIUM SYSTEMS

HOLMIUM LANTHANUM SYSTEMS

HYDROGEN NIOBIUM SYSTEMS

HYDROGEN TANTALUM SYSTEMS

INDIUM

INDIUM LANTHANUM SYSTEMS

INDIUM LEAD SYSTEMS

INDIUM MERCURY SYSTEMS

INDIUM THALLIUM SYSTEMS

INDIUM TIN SYSTEMS

IRIDIUM MOLYBDENUM SYSTEMS

IRIDIUM NIOBIUM SYSTEMS

IRIDIUM OSMIUM YTTRIUM SYSTEMS

IRIDIUM SCANDIUM SYSTEMS

IRIDIUM STRONTIUM SYSTEMS

IRIDIUM THORIUM SYSTEMS

IRIDIUM TITANIUM SYSTEMS

IRIDIUM TUNGSTEN SYSTEMS

IRIDIUM VANADIUM SYSTEMS

IRIDIUM YTTRIUM SYSTEMS

IRIDIUM ZIRCONIUM SYSTEMS

IRON LANTHANUM SYSTEMS

IRON MANGANESE SILICON VANADIUM SYSTEMS

IRON NICKEL ZIRCONIUM SYSTEMS

IRON THORIUM SYSTEMS

IRON TITANIUM SYSTEMS

IRON TITANIUM VANADIUM SYSTEMS

IRON URANIUM SYSTEMS

IRON ZIRCONIUM SYSTEMS

LANTHANUM

LANTHANUM LUTETIUM SYSTEMS

LANTHANUM NEODYMIUM SYSTEMS

LANTHANUM OSMIUM SYSTEMS

LANTHANUM PRASEODYMIUM SYSTEMS

LANTHANUM RUTHENIUM SYSTEMS

LANTHANUM SAMARIUM SYSTEMS

MOLYBDENUM RUTHENIUM SYSTEMS

MOLYBDENUM SILICON SYSTEMS

MOLYBDENUM SILICON VANADIUM SYSTEMS

MOLYBDENUM TECHNETIUM SYSTEMS

MOLYBDENUM TITANIUM SYSTEMS

MOLYBDENUM URANIUM SYSTEMS

MOLYBDENUM VANADIUM SYSTEMS

NICKEL THORIUM SYSTEMS

NICKEL ZIRCONIUM SYSTEMS

NIOBIUM

NIOBIUM BORIDE

NIOBIUM CARBIDE

NIOBIUM NITROGEN SYSTEMS

NIOBIUM OSMIUM SYSTEMS

NIOBIUM PALLADIUM SYSTEMS

NIOBIUM PLATINUM SYSTEMS

NIOBIUM THENIUM SYSTEMS

NIOBIUM RHODIUM SYSTEMS

NIOBIUM SILVER SYSTEMS

NIOBIUM SILICON VANADIUM SYSTEMS

NIOBIUM TANTALUM SYSTEMS

NIOBIUM TANTALUM TIN SYSTEMS

NIOBIUM TECHNETIUM SYSTEMS

NIOBIUM TIN SYSTEMS

NIOBIUM TIN VANADIUM SYSTEMS

NIOBIUM URANIUM SYSTEMS

NIOBIUM ZIRCONIUM ALLOYS

NITROGEN OXYGEN TITANIUM SYSTEMS

NITROGEN OXYGEN VANADIUM SYSTEMS

NITROGEN RHENIUM SYSTEMS

NITROGEN TITANIUM SYSTEMS

NITROGEN VANADIUM SYSTEMS

NITROGEN ZIRCONIUM SYSTEMS

OSMIUM

OSMIUM RHENIUM YTTRIUM SYSTEMS

OSMIUM SCANDIUM SYSTEMS

OSMIUM TANTALUM SYSTEMS

OSMIUM THORIUM SYSTEMS

OSMIUM TUNGSTEN SYSTEMS

OSMIUM YTTRIUM SYSTEMS

OSMIUM ZIRCONIUM SYSTEMS

PALLADIUM RUBIDIUM ZIRCONIUM SYSTEMS

PALLADIUM SELENIUM SYSTEMS

PALLADIUM TELLURIUM SYSTEMS

PALLADIUM ZIRCONIUM SYSTEMS

PHOSPHORUS RHODIUM SYSTEMS

PHOSPHORUS TUNGSTEN SYSTEMS

PLATINUM TANTALUM SYSTEMS

PLATINUM VANADIUM SYSTEMS

PLATINUM YTTRIUM SYSTEMS

PLATINUM ZIRCONIUM SYSTEMS

RHENIUM

RHENIUM TANTALUM SYSTEMS

RHENIUM TITANIUM SYSTEMS

RHENIUM TUNGSTEN SYSTEMS

RHENIUM YTTRIUM SYSTEMS

RHENIUM ZIRCONIUM SYSTEMS

RHODIUM

RHODIUM SELENIDE

RHODIUM STRONTIUM SYSTEMS

RHODIUM SULFUR SYSTEMS

RHODIUM TANTALUM SYSTEMS

RHODIUM TELLURIDE

RHODIUM TITANIUM SYSTEMS

RHODIUM TUNGSTEN SYSTEMS

RHODIUM ZIRCONIUM SYSTEMS

RUTHENIUM

RUTHENIUM SCANDIUM SYSTEMS

RUTHENIUM SILICON VANADIUM SYSTEMS

RUTHENIUM THORIUM SYSTEMS

RUTHENIUM TITANIUM SYSTEMS

RUTHENIUM TITANIUM VANADIUM SYSTEMS

RUTHENIUM TUNGSTEN SYSTEMS

RUTHENIUM YTTRIUM SYSTEMS

RUTHENIUM ZIRCONIUM SYSTEMS

SILICON THORIUM SYSTEMS

SILICON TUNGSTEN SYSTEMS

SILICON VANADIUM SYSTEMS

SILICON TITANIUM VANADIUM SYSTEMS

SILICON VANADIUM ZIRCONIUM SYSTEMS

SILVER THALLIUM SYSTEMS

SILVER THORIUM SYSTEMS

SILVER TIN SYSTEMS

SILVER ZINC SYSTEMS

TANTALUM

TANTALUM BORIDE

TANTALUM CARBIDE

TANTALUM TIN SYSTEMS

TANTALUM TIN VANADIUM SYSTEMS

TECHNETIUM

TECHNETIUM ZIRCONIUM SYSTEMS

THALLIUM

THALLIUM TIN SYSTEMS

THORIUM

TIN

TIN VANADIUM SYSTEMS

TITANIUM

TITANIUM NITRIDE

TITANIUM VANADIUM SYSTEMS

TITANIUM ZIRCONIUM SYSTEMS

TUNGSTEN BORIDE

TUNGSTEN CARBIDE

TUNGSTEN NITRIDE

TUNGSTEN ZIRCONIUM SYSTEMS

URANIUM

VANADIUM

VANADIUM NITRIDE

VANADIUM ZIRCONIUM SYSTEMS

ZINC

ZIRCONIUM

ZIRCONIUM BORIDE

ZIRCONIUM NITRIDE

D. Metals and Alloys Materials List

By definition, a metal is an element capable of conducting an electrical current. This it does by virtue of its free electrons able to move throughout the lattice with minimum energy loss. We have accordingly determined to confine our selection of data to information concerning the variations of this basic ability, and limited to materials used in, or forming part of an electric circuit. If this seems too confining, one should realize that other properties are covered in other categories of materials where metals and alloys also frequently occur, e.g., semiconductors, ferromagnetics and superconductors (to name a few).

The initial list of materials covers 108 metals and alloys with the most used trade names of alloys where the composition is known. The list will be adjusted as experience indicates by frequency of occurrence of articles on any particular types of alloys. Where any grouping, for example "copper alloys", becomes too densely populated, it will be divided and indexed by composition, first by primary alloying element and, if necessary, then by percentage composition naming the constituent elements down to a 1% level.

METALS AND ALLOYS MATERIALS

Alumel
    See NICKEL ALLOYS

ALUMINUM

ALUMINUM ALLOYS

Aluminum Bronze
    See COPPER ALLOYS

ANTIMONY

ARSENIC

Balco
    See NICKEL ALLOYS

BARIUM

BERYLLIUM

Beryllium Copper
    See COPPER ALLOYS

BISMUTH

Brass
    See COPPER ALLOYS

Bronze
    See COPPER ALLOYS

CADMIUM

CALCIUM

CERIUM

CESIUM

Chromel
    See NICKEL ALLOYS

CHROMIUM

CHROMIUM ALLOYS

LEAD ALLOYS

LITHIUM

LUTETIUM

MAGNESIUM

MAGNESIUM ALLOYS

MANGANESE

Manganin
  See COPPER ALLOYS

MERCURY

MERCURY ALLOYS + AMALGAMS

MOLYBDENUM

MOLYBDENUM ALLOYS

Monel
  See NICKEL ALLOYS

NEODYMIUM

Nichrome
  See NICKEL ALLOYS

NICKEL

NICKEL ALLOYS

Nickel Silver
  See COPPER ALLOYS

NIOBIUM (COLUMBIUM)

NIOBIUM ALLOYS

OSMIUM

PALLADIUM

PALLADIUM ALLOYS

Phosphor Bronze
  See COPPER ALLOYS

PLATINUM

PLATINUM ALLOYS

PLUTONIUM

POTASSIUM

PRASEODYMIUM

RHENIUM

RHENIUM ALLOYS

RHODIUM

RHODIUM ALLOYS

RUBIDIUM

RUTHENIUM

RUTHENIUM ALLOYS

SAMARIUM

SCANDIUM

SELENIUM

SILICON

SILVER

SILVER ALLOYS

SODIUM

Stainless Steel
    See IRON ALLOYS

Steels
    See IRON

TANTALUM

TANTALUM ALLOYS

TELLURIUM

TERBIUM

THALLIUM

Thoriated Tungsten
See TUNGSTEN ALLOYS

THORIUM

THULIUM

TIN

TIN ALLOYS

TITANIUM

TITANIUM ALLOYS

TUNGSTEN

TUNGSTEN ALLOYS

URANIUM

URANIUM ALLOYS

VANADIUM

VANADIUM ALLOYS

WOLFRAM
See TUNGSTEN

YTTERBIUM

YTTRIUM

ZINC

ZINC ALLOYS

ZIRCONIUM

ZIRCONIUM ALLOYS

E. Organic Semiconductors Materials List

Development of a list of organic semiconductors involved the following sequence:

1. Investigation of the theory to determine the nature of an organic semiconductor.

2. Recognition of the unpredictable approach of authors writing in this field.

3. Selecting the list from texts, reports and articles considered authoritative.

4. Recognition of the nature of the organic compound from its name or formula. The structural formula is necessary to set up a generic compound and its derivatives. Some 400 names have been selected from the aromatic-ring compounds. The aliphatic-chain compounds are not semiconductors, so are not included.

It is essential to note that merely searching the literature for data on the various electronic properties of organic compounds is not satisfactory. The dielectric constant, in particular, has proven very efficient in the determination of organic structure, but since chain compounds (aliphatics) are not semiconductors, literature on them is useless for our purposes despite the enormous amount of it. The searcher must recognize the nature of the organic compound from its name or formula.

Organic naming, and chemical nomenclature in general, is in a considerable state of flux at the present. It seemed reasonable to show the true structure for each organic compound selected. This would define the compound exactly and leave no room for doubt or error. The job is not yet finished; however, eventually every compound will have a structural formula, if known.

The structural formula is necessary to set up a generic compound and its derivatives. However, in cases where the derivative is important in its own right, it is kept separately.

The first step in setting up a catalogue of names for the organic semiconductors was to investigate the theory and determine the nature of an organic semiconductor. It is a frequently unrecognized fact that data retrieval does not bear any resemblance to an assembly line production. A person's ability to write does not qualify him to select materials and properties according to a specific list. There are several reasons for this discontinuity. The most vital one is that every author is a distinct individual and therefore he usually presents his material in a unique manner. There are as many ways of plotting experimental data on a graph as there are investigators, and the extractor must know the possible parameters in any given region to reduce this material to intelligibility. For example, the exact nature of the sample is rarely specified directly, data is rarely tabulated and results are frequently rationalized. Only a thorough knowledge of the field allows the extractor to extract information efficiently.

Dimethylaniline Iodanil
See ANILINE COMPLEXES

m-Dinaphthdianthrene
See ANTHRENE

m-Dinaphthanthrone
See ANTHRONE

Diphenyl
See BIPHENYL

DIPHENYLENE

2, 2-DIPHENYL 1-PICRYL HYDRAZYL

a-a-DIPHENYL PICRYL HYDRAZYL

α, α-DIPHENYL-β-PICRYL HYDRAZYL

1, 4-Diphenyl Piperazine
See PIPERAZINE

4, 4'' Diphenyl Stilbene
See STILBENE

DIPYRROMETHENE

Distearyl-perylene
See PERYLENE

DURENE

DURENE HALOGEN COMPLEXES

EDESTIN

EOSIN

ERYTHROSIN (Na)

FERRIBEM

FERRIC ACETYLACETONATE

FLAVANTHRONE

Ferric Haem
See HAEM

FERROCENE

FIBRINOGEN

FLUORENE

FLUORENONE

FLUORESCEIN

FUCHSINE

GELATIN

GLOBIN

GLYCINE

Glycine Copper Chelate
See GLYCINE

GRAPHITE-PYROLYTIC

HAEM

Haemin
See PORPHYRINS

HEMOGLOBIN

Herring Sperm
See DNA

HYDROVIOANTHRONE

1-Hydroxyanthraquinone
See ANTHRANQUINONE

IMIDAZOLE

INDANTHRAZINE

INDANTHRONE

INDANTHRONE BLACK

INDIGO

NAPHTHODIANTHRENE

NAPHTHODIANTHRONE

m-Naphthodianthrone
See ANTHRONE

NAPHTHOL

NAPHTHOL ORANGE

Naphthalene Picrate
See NAPHTHALENE

NAPHTHYLAMINE

1-Naphthylamine
See NAPHTHYLAMINE

2-Naphthyl Phenyl Sulfone
See NAPHTHYL COMPLEXES

1-Naphthylamine Pierate
See NAPHTHYLAMINE

NAPHTHYL COMPLEXES

NEOFORMAZAN POLYMER

NICKEL PHTHALOCYANINE

NUCLEIC ACID

Octahydroviolanthrene
See VIOLANTHRENE

OVALENE

OXAMIDE

OXAZINE

Penicillum
See DNA

PENTACENE

Plasma Albumen
See ALBUMEN

PLATINUM PHTHALOCYANINE

Polyacetylene
See ACETYLENE

POLYACRYLIC ACID-DIVINYL BENZENE (Ni-doped)

Polyacrylacetylene
See ACETYLENE
ACRYLIC ACID

POLYACRYLONITRILE METAL FREE

POLYAMIDES

Polyaminoquinone
See Quinone

POLYCYCLOPENTADIENE

POLY 3-CYCLOPENTA 2', 4'/DIENYL CYCLOPENTANOL

POLYCYCLOPENTAMETHYLENE FULVENE

POLYCYCLOPENTENYL CHLORIDE

POLYDIVINYL BENZENE

Polydivinyl Benzene-chlorinated
See POLYDIVINYL BENZENE

Polydivinyl Benzene-oxidized
See POLYDIVINYL BENZENE

POLYFERROCENE

Polyferrocene Benzal
See POLYFERROCENE

Polyvinyl Ferrocene
See POLYFERROCENE

POLYPERCYANOETHYLENE

Polycercyanoethylene-copper Chelate
See POLYPERCYANOETHYLENE

PORPHYRINS

Potassium Anthracene
See ANTHRACENE, ALKALI DERIVATIVE

Pyradazine
See PYRIMIDINE

PYRANTHRENE

PYRANTHRONE

Pyrazine
See PYRIMIDINE

PYRAZOLE

PYRENE

PYRENE COMPLEXES

PYRIDINE

5, 6 (N)-pyridino-1, 9-benzanthrene
See BENZANTHRENE

PYRIMIDINE

PYRROLE

Pyrromethane-cobalt
See PYRROMETHANE COMPLEXES

PYRROMETHANE COMPLEXES

Pyrromethane-copper
See PYRROMETHANE COMPLEXES

Pyrromethane Hydrogen Bromide
See PYRROMETHANE COMPLEXES

Pyrromethane-nickel
See PYRROMETHANE COMPLEXES

Pyrromethane-zinc
See PYRROMETHANE COMPLEXES

QUINOLINE