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ASD-TDR-63-566
Part I

MECHANICAL PROPERTIES DATA CENTER DESIGN AND OPERATION

TECHNICAL DOCUMENTARY REPORT NO. ASD-63-566
Part I
May 1963

Aeronautical Systems Division
Air Force Materials Laboratory
Materials Application Division
Wright-Patterson Air Force Base, Ohio

Project No. 7381, Task No. 738103

(Prepared under Contract No. AF33 (657) 9149
by Technical Information Systems Division
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NOTICES

FOREWORD

This report was prepared by the Technical Information Systems Division of the Belfour Engineering Company, Suttons Bay, Michigan, under U.S.A.F. Contract No. AF 33(657)-9149. The work described herein was accomplished under Project No. 7381, Material Application, Task No. 738103, Data Collection and Correlation. This effort has been administered under the direction of the Aeronautical Systems Division, Information Processing Section, Materials Application Division, Air Force Materials Laboratory, Wright-Patterson Air Force Base, with R. F. Klinger as project engineer.

The report covers the work accomplished from 15 June 1962 to 15 May 1963.

ABSTRACT

This report discusses and describes the concepts and considerations as well as design details of a system capable of storing and retrieving mechanical properties information of metals and reinforced plastics. Included is a description of IBM card layout and codes utilized to store, retrieve, operate on and display the most pertinent numeric and alphabetic information necessary to the description of reported test procedures and results. Examples of graphic and tabular system output are also presented.

This Technical Documentary Report has been reviewed and is approved.

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I. Introduction

A. Purpose

This program is part of an effort to produce systems capable of storing and retrieving the wealth of technical information which exists today. Interested persons, including documentalists, library scientists, librarians, engineers, systems designers, and others have employed all manner of manual, electronic, and optical devices. The basic problem, to facilitate the use of existing knowledge, has basically not become more complex, just larger. The pro-offered solutions, and there are many, employ variations or combinations of two fundamental concepts. These are, to store and retrieve documents, or to extract, store, and retrieve the pertinent numbers, facts and ideas from documents. Herein lies the distinction between Document Centers and Data Centers. Document Centers are libraries. Data Centers are organizations designed to extract, store, operate on, and present merged information. The Data Center can operate like a Document Center, however the reverse is not true. These operations may, under a co-ordinated program, compliment each other and provide a network of Centers capable of efficiently acquiring, storing, evaluating, and presenting the significant technical information associated with all branches of science and technology. Specialization of Centers within a general area of interest is not only desirable but, at the Data Center level, vital.

The program which is the subject of this report has been a continuation of efforts to establish a Mechanical Properties Data Center capable of providing information and data on the mechanical properties of metal and reinforced plastics for application in aero-space and defense industries.

B. Scope

Specialized Data Centers, supported by Document Centers, seem to offer a most practical solution to the problems created by the continuous and inexhaustible flow of technical information that is created daily. In this association it is easy to visualize the mutual benefits involved. Document Centers can and do relieve Data Centers of extensive acquisition efforts. Data Centers can, in turn, minimize the search time devoted by Document Centers to answering specific and detailed information requests by providing data displays, evaluations, and source documents of very specific information. In such cases both Centers are performing in those areas for which they are primarily equipped. The potential of such unions are obvious

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Manuscript released by authors May 1963 for publication as an Summary Technical Report.

and most certainly compatible with the goals desired by all who are interested in the efficient use of available technical information. The efforts of this program have been influenced by that ultimate goal.

This project has been primarily a re-evaluation and refinement of procedures and techniques developed under previous contracts (AF33(616)-3301* and AF33(616)-7238**). Although the system and procedures described here have proven to be capable of successful and independent operation the emphasis has been directed toward those procedures and techniques most directly related to the extraction, storage, and retrieval of mechanical properties and associated definitive information. Reported here are the results of those efforts as applicable to the mechanical properties of metals and reinforced plastics.

II Discussion

The prototype mechanical properties information system developed and operated under Contract AF33(616)-7238 was evaluated in the early stages of this Contract AF33(657)-9149. This evaluation consisted of a review to determine if the important information that was encountered during encoding of documents was storable in a manner satisfactory for retrieval and processing. The review also scrutinized the prior search effort and output as compared to the questions asked of the system. The results clearly indicated that the basic approach was indeed satisfactory and that it was performing well in providing information from storage. There were detected, however, some areas which could be optimized to prevent trouble spots that might develop as the storage contents and inquiries increased. These potentially troublesome areas were primarily in the codes and in the ability to handle some of the developing new test conditions and procedures. It was apparent that these pockets of resistance could be wiped out by minor revisions and reinforcements as they developed. However, it was decided that a piecemeal attack would not be as satisfactory as a one time overhaul. The latter choice of a complete overhaul was not considered wasteful since the basic system would be retained and that which existed would continue in its usefulness, thus assuring that no waste of the past effort would result. In spite of the decision to modify, it was gratifying to find the prototype system operating most satisfactorily and to be so valuable in directing the design modifications. Furthermore the modified system as envisioned and designed retained the fundamental concepts of the prototype, resulting in complete compatibility of the two systems. This compatibility enables continued operation of the prototype side by side with the modified one.

*Belfour, A. J., Hyler, W.S. "A System For Automatic Processing of Fatigue Data", 1959, AF 33(616)-3301, WADC TR 58-461.

**Braden, R.C., Wright, C.S., "Development of a Materials Property Data Processing System", 1963, AF33(616)-7238, ASD TDR-63-128.

The total modified system from document acquisition through search output is best described in parts. Of the following five parts (paragraphs A through E), the first deals with the general concepts and methods that were considered and studied for the storage and retrieval portion because it is this portion of the total system about which all other functions revolve. The second part describes the efforts expended in acquisition of documents; the third discusses the work performed in extraction and storage of new data; the fourth explains the search activities; and the fifth discusses the routine dissemination program.

A. System Design Considerations

The basic philosophy upon which this entire approach to information storage and retrieval is based, has been discussed in detail in several publications (see References) and briefly in the Purpose of the Introduction of this report. It is seen from these references, presentations, and discussions that this system is designed to extract and store the actual data reported in the documents along with associated information which makes the data meaningful. This system concept and purpose differs from the conventional library (manual or mechanized) which is concerned principally with identifying documents that are known to contain or suspected of containing information on the subject being inquired.

Prior to modifying the prototype, the system purposes and design criteria for extracting and operating on data from existing literature were set forth as a basis for guiding the modification and are as follows:

1. System Purposes

a. To reduce duplication, loss of time, and product failures due to lack of suitable information by providing answers to inquiries and by routine dissemination of information via economical and rapid retrieving, analyzing, and displaying of stored mechanical property test measurements and other pertinent information.

b. To assist in analyzing large quantities of test measurements and associated information for a better understanding of the behavior and reactions of materials caused by variations in formulation, fabrication, environment and test procedures.

c. To assist, by inventory analysis of the stored data, in displaying available information and determining the need for initiating new or additional tests to fill gaps in the knowledge of mechanical properties of metals and plastics.

2. Design Criteria

The following requirements are the minimums that the system must meet:

a. Capable of storing test measurements along with other information about the material and testing procedure to make the stored measurements meaningful.

b. Capable of storing sufficient data and information to minimize the need for referring to the original documents.

c. Capable of operation with commercially available equipment.

d. Capable of machine conversion of the stored data to other types of storage media suitable for use on other types of mechanized processing equipment.

e. Provide means to refer the searcher to the original document for significant information which is not practicably storable in the system.

f. Economical in total operating cost (including machine rental, depreciation, or amortization, encoding, storing, retrieving, processing, decoding, and displaying operations) as compared with test programs or conventional literature searches.

g. Provide means for adding additional unforseen types of tests, and measurements to the system without upsetting existing storage usefulness.

h. Ability to allow the injection of human intelligence or logic at any stage in the retrieval and processing operations.

i. Capable of economical verification at all input or output stages.

j. Capacity to store principal property values with at least three significant figures.

k. Ability to machine process arithmetic operations on principal numeric information.

3. Data Processing Equipment and Storage Media

Specifications and costs of the various standard data processing equipment were studied. Computers, sorters, accounting machines, and equipment of the major data processing equipment manufacturers were evaluated. While many of these machines offered several advantages it was concluded that a special purpose electronic statistical machine together with other basic "accounting" machines and card operated plotters perform the necessary operations rapidly and at minimum cost. This was further supported by the successful use of this equipment with the prototype system. Also, conversion to many of the other machines is possible without an undue expenditure of effort if found desirable at a later date. This IBM equipment dictated the use of the 80 column punch card as the storage medium although due consideration was given to; microfilm, microfilm chips, aperature cards, and magnetic cards and tape, none of which completely satisfy the above requirements even though they offer possibilities for certain sub-system applications.

4. Sub-Divisions of a Mechanical Properties System

There are many ways in which the total set of metals and plastics mechanical properties can be sub-divided so that each part can be treated separately from the others. For instance no sub-dividing could be considered wherein all properties of all materials (metals and plastics) are stored on cards using one universal format. Another approach would divide the entire population into metals and plastics with all metal's data stored in a universal metal's format and all plastic's data stored in a separate and different format. In the latter case the metal's information cards would be stored separately from plastic's information cards and a machine program would exist for the metals and one for the plastics. However, the sub-division scheme of the prototype system was retained after review of these many possibilities. This consists of a sub-division for each material type-test type combination. In other words a card format exists for each type of test conducted on metals and similarly a card format exists for each type of test conducted on plastics. This sub-dividing appeared optimum for it allows the design of any one test type format to take full advantage of available space to store information normally associated with that type of test. Furthermore, inquiries normally are selective in that they ask for specific properties such as tensile strength, compression strength, or creep rupture strength, of a given material. Thus the storage system, in effect, consists of several sub-systems such as the sub-system for tensile tests of metals which, of course, carries all the associated information normally included with tensile tests (elongation, reduction of area, yield strength, notch factor, test environment, etc.). While this results in many sub-systems, all cards can be stored together in a non-ordered sequence since each card contains punched indicators which allows rapid sorting of the entire file. And while the formats differ between the sub-systems they are none the less basically similar so that little or no changes in the machine programs are required when shifting from one set to another. In actual practice this shifting is not apparent, as the punched indicators permit seeking specific information from the desired sub-set, while the entire population of cards is being scanned in one pass through the machines.

It is interesting to note that a universal format is not impossible, but impractical, since all test results are merely combinations of the units of time, force, and distance plus their derivatives (velocity or rate, etc.) and with perhaps some other units such as degrees fahrenheit.

Thus, compression tests are tensile tests with negative load application; creep tests are tensile or compression tests measured with the variable time, and tensile fatigue tests are tensile tests with the load varying with time. If Force (F) and Distance (L) are thought of in terms of their components in three mutually perpendicular directions (x,y & z) we can express:

Tensile Stress = $F_{x}/L_{y}\ L_{z}$

Compressive Stress = $-F_{x}/L_{y}\ L_{z}$

Shear Stress = $F_{z}/L_{y}\ L_{z}$ or $F_{y}/L_{z}\ L_{y}$

Poisson's Ratio = dL_{x}/dL_{y}

Etc.

While the above does not show how a universal format could be designed, it does indicate that "common grounds" exist for a single all inclusive format. This was explored but was not pursued because it would require a significant departure from the conventional and widely used test language, which could inhibit general use of the system.

5. Card Arrangement

Having retained the types of processing equipment, storage media, and main sub-divisions as used in the prototype system, the arrangement and number of cards for any one format was studied. It is here that the first departure (although minor) was made from the prototype. With 80 columns available per IBM card, decisions must be made as to how all information of a test type format is to be entered on a card or cards. A single card system with each card containing all information that its space will retain about one test could be established. This would require rejecting some "important" information from storage because of the limited space. Two or more cards can be chosen to be used for retaining the information for one test, or the most significant property for many specimens could be stored on one card with ancillary cards carrying associated data. In addition to and related to the decision of the number of cards and their arrangement there is the decision of how the information is to be represented on the cards. In other words, all context information can be punched so as to print out in the English language and the numerical data can be punched directly in numerical form or the context bits can be coded, or some can be coded and some entered in the natural language, etc.

The study concluded that for a given specimen tested in a particular type of test there should exist a single IBM card which stores all of the significant properties obtained from the test together with all of the major important information necessary to make the data meaningful. Thus a single card would "tell" for all practical purposes the complete history and test results of a test specimen. This single card is designated the A card. To store other information, particularly the exact chemical composition of the material, a second card (Card B) was designed and since several specimens usually have the same chemical composition only one B card will in most cases exist for several A cards. A serial number on both cards enables matching of a B card with its A cards (or vice-versa).

Finally, since in the process of obtaining end (failure) results, tests often record useful intermediate results such as stress-strain data, the third category of cards (A_n) was designed. The A_n card is associated with each specimen A card and carries the intermediate "behavior" data generated by the test in the process of reaching the failure point. Since a large number of intermediate points, such as in creep tests, may be generated, the A_n card is in reality an A_1, A_2, A_3 etc. card up to nine cards if needed. The serial number system enables a positive tie-up of an A card with each of its A_n cards and also indicates the sequence of the A_n cards and when the last has been reached or if any are in existence. Thus, three types of cards may exist to tell the complete story on any one specimen with one of the cards (A card) being the "king-pin" from which the large majority of questions can be answered. This line-up of three cards differs from the prototype by the addition of the A_n card for all types of tests and by a slightly different assignment of categories of information among the three cards. The modified system assignment is designed to make the A card principally independent by having all of the most important information contained in it, whereas, in the prototype this group of most important information was split between two cards. The desirability of this rearrangement came from experience gathered during prototype operation and was only possible after the prototype showed the way as to what was "most important" and how some information could be condensed.

One other significant storage addition was made over the prototype. This was the addition of an "Encoder's Card; which is merely a form containing comments by the encoder to clarify encoded information that could be misinterpreted; to describe the purpose of the test so that the data retrieved can be better judged as to its applicability for answering a specific question; and to store information judged pertinent, but for which there is no provisions in the punched cards. This Encoder's Card is not a machine processable card except for retrieving it, based on the document to which it belongs. There is only one Encoder's Card per document and experience to date shows that only four or five entries are required on the average. While this card may seem to be a discontinuity in the automation of the system, it is not, for it does not contain primary information on which a search would normally be made. Instead it is, in a sense, similar to a code sheet such that once a retrieval is made the appropriate Encoder's Card is consulted for additional information, much as a code book is consulted to decode some of the punched fields. The Encoder's Card has several advantages, among them are;

a. It increases encoding efficiency by giving the encoder a flexible storage bin to catch other information on which he might otherwise spend unnecessary time in trying to fit into a field of information on the card to which it does not truly belong.

b. It permits, by periodic review of the Encoder's Cards investigations aimed at finding similar information constantly appearing on the Encoder's Card. When such is found a judgement as to its significance can be made and if desired the punch card format can be modified to store that category of information.

c. It enables conveyance of the general purpose and/or accuracy of a test thus providing a basis for editing the retrieved data <u>if desired</u>.

d. It assists in keeping codes from becoming too specialized, detailed and single purposed. Thus rather broad category codes can be used with the punched card since minute detail can, when important, be stored in the Encoder's Card which in effect is a special code book for each document. Thus, instead of generating the code -

   "Butt welded - Heliarc followed by 975°F for 1 hour stress relief".

   the punch card code can be -

   "Butt welded - Heliarc followed by stress relief" with the 975°F and 1 hour stored in the Encoder's Card.

In this manner the latter example code is useable for many specimens even though their stress reliefs may vary in temperature and time. It is true that this prevents searching directly for butt welded Heliarc specimens stress relieved at 975°F for 1 hour. However, searching on the more general code will narrow down the possible so that a review of a few Encoder's Cards will find those that fit the exact question plus those that are in the near vicinity of the requirement. Obviously judgement in code assignment is needed to prevent assignment of codes that are too broad in scope and thus leave too much to the Encoder's Card. Experience to date has shown that a good and sensible balance is readily and easily obtained.

6. Data Arrangement

With the three basic types of cards (A, A_n, and B) established and with the general categories of information and data to be stored on each of them defined, the placement of the data within each card was reviewed. The prototype system conforms generally to a fixed format arrangement. This is, specific colums of the cards are designated to accept a certain type of information and only that type. These column groups are referred to as fields. This format for each card is thus fixed in that a particular type of information is always found in the same columns of all cards that have been assigned the same format. There are other possible methods such as flexible formats or restricted-flexible formats. The flexible format is one in which the information to be stored can be placed in any of the columns of the card but to enable their identification, index columns, either preceding each information column group or at some defined location in the card, are punched with a code so as to inform the searcher as to what kind of information exists in each group of columns. While a flexible format usually makes best use of available storage space it adds considerably to the searching effort. To overcome this added effort a restricted-flexible format is effective. A restricted-flexible format is identical to a flexible format with the exception that some column groups are used flexibly but only to the extent that each group is designated to store only a limited number of types of information. The index columns are still required. Thus if a certain type of information such as ultimate strength is desired it can be searched for in column group 60, 61 and 62, however, this group may also be permitted to contain yield strengths. An index column, say 59, exists and must be consulted to determine if the information is ultimate or yield strength.

After studying these various concepts and their combinations a selection of the fixed format combined with a restricted-flexible format was made. In general the prototype system while basically fixed, does contain some restricted-flexible column groups or fields. This restricted-flexible feature was achieved in the prototype by use of the "X" and "Y" zone punches in the flexible column groups. In the case of the above example particular patterns of the "X" and "Y" zone punches over column 60, 61 and 62 would be used to designate whether the data stored was ultimate or yield. These zone pattern punches were also used to indicate the units of the information (ksi, psi, pounds, minutes, hours, etc.). While this use of zone punches served well, it was obvious that, as the number of formats grew and new types of information were encountered, complexities and limited capacity in the zone punch patterns would result. The modified system, therefore, changed to using index columns preceding the restricted-flexible fields and reserved the overpunch patterns to act as specific modifiers to the data below them. The zone patterns were made common to all fields in all cards. The types of modification performed by the overpunch zone patterns are:

a. indicating decimal location

b. indicating whether the number is an average or extracted from a faired curve

c. indicating positive or negative value

d. indicating that additional information is available in the document pertaining to the field but cannot be stored in the system language

The modified system thus adopted a combination of a fixed and restricted-flexible format. In the metals system all B cards have the same format, all A cards of a specific test type have their common format and all A_n cards of a specific test type have a common format. Similarly, formats will exist for the plastics system.

7. Code Schemes and Special Rules

With the design specified to the extent described so far there is only the need to establish the method of representing information and data by punched hole patterns in the cards.

The IBM card can be punched in any manner (within the limits of card strength) and many multiple punching positional array techniques have been developed. Many of these were studied and rejected in favor of the conventional punching system for which the IBM machines were originally designed. That is, the system where each of the 80 columns can be singly punched in any one of ten rows to represent any one of the numbers from 0 to 9 or can be punched in any one of the 1 through 9 positions together with any one of the three zone positions (commonly referred to as 0, X and Y) to represent an alphabetic character. A few other punch combinations are recognized as special characters such as &, -, $ etc. by some of the printout machines. Hence, fields that are designated to store numeric information are punched in this standard IBM decimal system. Binary, tertiary, etc. systems for numeric representation were considered but rejected principally due to the added conversion effort. All other pieces of information (other than serial numbers which are handled as above) are assigned codes which are punched into the cards. These codes may be either numeric, alphabetic or a combination of the two. Thus a field consisting of one column can contain 36 codes (not including the special characters) made up of A through Z and 0 through 9. A two column field has the capacity as follows:

Type of Code		
N	0 thru 99	100 codes
NA	0 thru 9 in first column with A thru Z in second column	260 codes
AN	A thru Z in first column with 0 thru 9 in second column	260 codes
AA	A thru Z in first column with A thru Z in second column	676 codes
	TOTAL	1296 codes

This alphabetic-numeric coding permits a condensed display of the codes in the NA and AN portions (see type of code above). This is accomplished by assigning in the NA type or portion of the code, information to each of the ten numbers (0-9) and by assigning information to each of the 26 alphabetic letters (A-Z). Thus 36 assignments enable the encoder to select combinations up to 260 in number while only viewing 36 assignments. Similarly the AN portion can have different assignments for the numbers and letters to yield 260 more combinations from only 36 assignments. In some cases utilization of the AN and NA portion of the code in this manner gives rise to combinations that are meaningless or not useful. In these cases the AN and/or NA portions can be used simply by assigning discreet codes to each of the 260 or 520 combinations.

Other coding techniques were studied, some of which are incorporated in the modified system. One of the most significant improvements was made in the Material Identification Code. The prototype system uses a four digit field in which the four digit AMS (Aeronautical Materials Spec.) number is punched. Only when the document referred to the material by its AMS number could this field be used in this manner. All other identifications were assigned a code number in the 0-2000 numbers not presently used by the AMS system. Operating experience showed that about only 25% of the documents reported the material in the AMS system. This led to the rapid growth of a large code in the 0-2000 number section. As a result, a particular material may be listed in the code book under some four or five numbers. As an example, one document may give the AMS number 6350 (4130 sheet and strip); another may refer to AISI 4130; another to SAE 4130; and another to MIL-S-18729; etc. Thus, to retrieve this alloy requires searching the code book for all 4130 types and then searching the cards for as many as five or six code numbers. Such a code becomes not only unnecessarily redundant but also inefficient. In analyzing this problem in detail, the obvious becomes apparent. That is, the entire systems usefulness is dependent upon an accurate representation of the material. For this reason the original system provided for storage of the materials chemistry. This feature is retained in the improved system. The chemistry, however, is not always reported and questions put to the system seldom define the material's chemistry. Documents and inquirers normally refer to a material by one of the specification numbers, trade names etc.. The best that a system can provide in the way of maintaining accuracy in describing a material is to use the description as reported in the document. With this as a requisite, several coding systems were devised and analyzed. They may be summarized briefly as follows:

a. Assign a code number to each material designation as encountered. From time to time rearrange the code book for use in searching so that similar or equivalent materials are listed together in blocks, each with their assigned code numbers. This requires searching for several code numbers to obtain all data on equivalent or similar material. As an example, the codes for 4130 may, after rearranging from the encoder's code book, appear as follows:

Code No.	Material Designation
0008	4130
0102	SAE 4130
3025	AMS 6350
4136	MIL S 18729

b. Use a Material Type field to place the material in a restrictive but rather broad category, and then proceed within that Material Type as above. Thus as an example the 4130 may appear in Material Type - "Iron Base-alloyed" and the code book for this Material Type would appear as in paragraph 7-a except it would contain only alloy steels. Material Types such as stainless steels or copper base would be thus separated. The IBM card, of course, would contain a column for the Material Type Code.

c. Punch AMS numbers directly into the card when the author reports the material in the AMS system. For other reported designations use the 0-2000 number (unassigned by AMS) as in paragraph 7-a or 7-b above. This is the procedure used in the prototype system with the possible addition of the post blocking.

d. A variation of paragraphs 7-a, 7-b, or 7-c by pre-blocking the code using MIL HDBK H-1B and other existing "equivalents" documents as guides.

e. Use the AMS numbering system and force all other reported designations into an AMS number. Thus when SAE 4130 is reported it would be encoded and punched with the equivalent AMS 6350 number. The Encoder's Card (which has been added as an improvement to the total system) would be used to record the actual designation reported in the document (in this case SAE 4130). What cannot be forced into AMS numbers would be assigned numbers in the 0-2000 series as in paragraph 7-c.

f. Pre-block with a Material Type column as in paragraph 7-b, and in the four digit field assign "as you go" with a code book arranged with columns to spread the materials horizontally opposite each assigned code number. Such a code book, as an example, would appear as follows.

Material Type 01 (Iron Base-Stainless Steel)

	1	2	3	4	5	6	7
Code No.	SAE No.	AISI No.	MIL Spec.No.	FED Spec.No.	AMS No.	ASTM No.	Trade Name or No.
0001	30301	301		QQ 5 682			
0002	304				5647	A 177-54	
0003					5644		17-7PH
0004	1010	C1010	5 11310A		5047		
0005	51410	410					ARMCO 12
0006							
0007							

The total information concerning the designation of the material is therefore found in seven columns used as demonstrated by the following example. In the fields assigned to material description, a seven digit number is punched, such as 01 0002 5. The first two numbers, 01, indicate that it is of the material Type, Iron Base Stainless Steel. The next four digits 0002 are found in the code book for Material Type 01. These show that it is one of the 304 designated stainless steel alloys. The last digit, 5, refers to the fifth column of the code book and shows that the material was designated AMS 5647 by the document author.

8. From the study of these various coding methods, plus a few others, the one of paragraph 7-f was selected and incorporated in the modified system. To further improve this code arrangement, a fifth IBM column is assigned, to indicate which of the columns in the code book contain the exact designation of the material used by the document author.

In summary, the modified storage system utilizes IBM 80 column punch cards for the storage medium with numerical data represented by standard IBM decimal punching and with other information coded with both numeric and alphabetic representation. The total system is sub-divided into metals and plastics with each of these further sub-divided by test types. In each of the major systems (metals and plastics) there are three types of punched cards, plus an Encoder's Card. There is one Encoder's Card generated per document. There is one B Card generated per unit or piece of material which may be common to many specimens. There is one A Card per specimen tested. And for each A Card there may exist up to 9 supplementary A_n Cards. The format or arrangement of information is identical for all B Cards in the metals system. The format is identical for all A Cards of the same type of metals test and the format for the metal's A_n Cards are likewise identical within any one test type. The plastic system formats are to be assigned in the same manner. In addition to the codes, a set of six universal rules is all that is needed to decode the stored information and data. Complete details of the system and formats are included in Belfour Engineering Company Report 121-2.

B. Acquisition and Document Handling

1. The source documents, from which mechanical properties data is being extracted, have been acquired from various sources including published reports from ASTIA, G.P.O., PLASTEC, NASA, and OTS. Trade journals, papers of technical societies, and announcements of research or development programs have provided leads to additional properties data. From these sources and the reports obtained from the Air Force unpublished data contracts, documents containing mechanical properties of metals and reinforced plastics were selected. Approximately, 90% of the effort was devoted to metals and 10% to reinforced plastics.

2. From this acquisition program a currently adequate backlog of properties reports have been accumulated. Future requirements and scheduling will necessitate a greater concentration of effort in this area to assure a continuous flow of properties data. A suggested alternative to individual acquisition efforts of Data Centers is the co-ordinated Data Center-Document Center relationship discussed briefly in the Introduction. As Data Centers acquire the easily obtainable reports (within their discipline) a point of diminishing returns is reached, and the duplicate efforts of individual centers become redundant and wasteful. Single organizations charged with the responsibility of acquiring pertinent reports within an identi-

fiable area of interest, say all properties of materials, and providing these documents to the appropriate Data Centers, could affect an efficient solution to acquisition problems. Data Centers could then redirect an appreciable amount of effort (see Table I and Figure 1) toward more productive areas.

3. As an aid to the control of data input (encoding and storage) and acquisition of mechanical properties source documents, a system of preliminary indexing for applicable properties reports has been instituted. This system provides for the identification of materials, properties, testing conditions, special atmosphere and other special information, by means of codes, in machine retrievable cards. In acquisition and data input, the preliminary indexing serves to supplement retrieved data with information from the back-log of documents which is desirable for a properly functioning data system. Since all documents considered for use in the system do receive this preliminary indexing, the machine processable card file which results provides a double check on the system's content.

4. This program has also included an effort in support of the indexing undertaken in behalf of the Aeronautical Systems Division Library. This effort included the indexing of approximately 200 documents, containing mechanical properties information, by the principals of links and roles. Although no appreciable direct benefits to the subject contract were achieved through this effort, a comparison can be made with other efforts of this type. Links and roles provide a means of retrieving documents wherein a search is made by seeking terms that have a stated or implied relationship (role) with each other. In searching such a system, these terms and relationships must be defined prior to retrieval. Conversely, the data storage system described in this report permits the storage and retrieval of units of information, including numeric values, associated with individual test procedures and results, without regard to the relationships between the units. Interestingly, this comparison points up a primary, but subtle, difference in the function of the two types of Centers.

C. Information Extraction and Storage

During the latter s'ages of the contract, a test quantity of documents were selected, from these the technical contents were extracted, encoded and keypunched into the cards, in accordance with the modifications. A total of over 20,000 cards were generated. This experience showed that more information could be stored than in the prototype system without becoming cumbersome. It also showed that, in many cases, the codes were easier to find. This, of course, was expected. The Encoder's Card concept has proven itself and the set of standard rules, with respect to zone overpunches, is a definite improvement and is less susceptible to error. Since (except for the use of zone punches in the Common Rules) all encoding is either numeric or alphabetic , the key punching operation has been simplified and is less prone to error. As in the prototype, encoding is first manually written on a standard form for each format. Keypunching is performed from these work sheets. The keypunching is duplicated from the forms by a second operator and the two decks of cards are machine compared to verify the keypunching. This also produces a second deck with its obvious usefulness. Studies and experiments are still being carried out on verification techniques. In the mean time, the punched data is further verified by machine plotting sets of data and comparing this output with the original documents and/or scrutinizing the graphs for obvious out of pattern points that indicate an error.

As the card file grows, inventories are continually updated. These inventories of the information are made by machine and presented in several ways. A typical inventory would list the number of test points for each of the test types of each of the materials. Other inventories based on other types of information, such as the number of tensile tests performed between 800 and 1000° F for each material, are also prepared, depending upon their need and usefulness.

Table II is a sample of part of an inventory.

These inventories have many uses and some of these are the time savings offered to searches by the act of first referring to the appropriate inventory, to determine if data exists in storage and the extent and type of other closely related information. Armed with this, the search can be initiated into the most fruitful areas first. The inventories are also helpful in guiding the encoding effort to keep a well balanced file.

The output from the system is either graphical or tabular. Both are produced by machines that are actuated and controlled by the cards. Standard calibration techniques are established for the plotting equipment and are exercised before and after each search. The calibrations are made to assure accuracy of plotted point position within ± 2%. (In normal operation, the percent of error is generally significantly less.) Further verification of overall accuracy is made by a final editing check of each search output.

The total number of cards in the entire file, including the fatigue and prototype system, now numbers in excess of 130,000. This represents approximately 119,000 individual tests with a total of over 2.3 million units of information and numerical data.

Table III lists the test type formats that have been released to encoding and also displays the general subject of the information and data stored in each test type Card A format. Table IV lists the subjects of the information stored in the Card B format for metals. Table V lists, as a typical example, the subjects of information stored in the A_n Cards of the "Constant Temperature-Constant Load Creep" format.

D. Data Retrieval Service

During the contract period, answers to inquiries were supplied from the data stored in both the fatigue file and the prototype mechanical properties file. This data retrieval service has been utilized by the defense industries from the time when the storage files reached a useable accumulation level. While no special large scale efforts have been made to advertise the service because of its infancy, a steady growth in the number of queries is experienced. This growth is attri buted to the awareness of the system created by referrals from Wright-Field; distribution of project reports; papers presented at symposiums; and through random referrals made by organizations that have used the service.

Inquiries are received by telephone and letters and, except for those coming from organizations that have had previous experience with the system, they are usually very broad in scope. When the inquirer is advised that the system can search for very detailed and specific requirements, he usually rephrases the question with more specific and unique descriptives of his problem. A search of the file is then made for data fulfilling the specified conditions. If a sufficient quantity is found that satisfies the question, no further search effort is expended. If not, closely related data is sought which will assist in answering the question.

Retrieved data is then machine plotted or tabulated with all associated descriptive information conveyed, to give a total comprehensive picture of the material and its performance.

In addition, the answer includes a list of references with each source related to its data by automatically printed indicators. The form of the display (plotted or tabulated) is made in accordance with the inquirer's choice.

Even though searches may and are performed for very specific questions, broad survey searches have been performed for some users. These are usually organized to find materials whose properties fall within certain broad limits. Such an output enables a designer to choose a material which is optimum from the standpoint of satisfying structural and non-structural dictates.

A search and presentation of its findings is accomplished in an elapsed time from as little as an hour to as much as several days. The time involved is dependent upon the complexity of the question, the amount of data retrieved, the final form of the display and whether any intermediate arithmetic operations such as statistical analyses are made on the data. The average elapsed time has been of the order of 2 to 3 days between receipt of the inquiry and return of the information by mail or telephone. Some studies were made during this contract activity to improve the organization of searches for the purpose of reducing the elapsed and expended time. Several approaches which for the most part constitute the addition of simple production aides show promise and are scheduled for development and incorporation.

Figures 2 and 3 are samples of graphic output displays plotted directly from cards, by the IBM 514 and Mosely, Model DY-6014 Digital Data Logarithmic Plotting System.

Table VII is a sample of a tabular output display achieved by the IBM 870 Document Writer.

Table VI Data Retrieval Search Log, is a listing of the search and retrievals made in answer to questions put to the system between 15 June 1962 and 15 May 1963.

E. Routine Information Dissemination

In addition to the output of the system used in answering specific questions, it has been the practice on previous contracts, to make routine dissemination of information via the medium of technical reports. These technical reports are prepared to disseminate information from the storage file on an unscheduled basis. The subjects of the technical reports are chosen on the merits of their probable timely interest to the defense industry complex. They generally deal with and are arranged to present data on the more recently applied materials or on the subjects of metal's behavior which are commanding the largest attention. Two such technical reports, (ASD TN 61-117, Part V and VI) were initiated during this contract. At this writing, Part V has been submitted to the printer's and will be disseminated in the near future. It is titled "Fatigue of Metals, Aluminum". Part VI entitled, "The Effect of Load Rate on the Ultimate Tensile Strength of Some Aluminum and Corrosion Resistant Alloys" is undergoing editing and after it is submitted to and approved by the Applications Laboratory of the Aeronautical Systems Division, it will be printed and distributed.

III Conclusions and Recommendations

The prototype system has proven that highly useful information is uncovered from the storage of material properties in a punched card system, at a fraction of the cost expended in the original test programs. A modification of the prototype has created a system with added advantages, while retaining the best features of the parent. Some of these advantages are:

a. Increased storage capacity in the codes without reverting to special methods of expansion.

b. Direct printout of code symbols.

c. Consistant use of zone punches in all formats (sub-systems) leading to simplicity in decoding and encoding.

d. Less likelihood of encoding and keypunching errors.

e. Ability to accept all data and information through the use of an Encoder's Card.

f. Confining search for the most part to the single major information A card.

g. Added fields of information and data have been provided in many of the formats, through a wider use of the restricted-flexible format principal with index columns.

h. The preliminary document indexing system achieves improved control of acquired documents, assists in directing acquisition and assures that searches do not overlook acquired data still in the early input stages.

The modified system maintains the essential elements of the prototype, thereby achieving compatibility, so that both systems are operable side by side. Thus the effort expended on the prototype is retained.

The following recommendations are made as a guide for continuation efforts to bring the total system to an optimum state of service.

a. Expand the storage file by increased input effort.

b. Provide for a closer relationship with Document Retrieval Centers to reduce acquisition duplication. The Document Centers might provide on an automatic basis all documents containing any material properties.

c. Continue studies and developments directed toward increased efficiency and reduction of elapsed time in providing answers to inquiries. Addition of production input and output aides, use of other standard data processing machines, and use of teletype and/or Facsimile transmission techniques are a few of the areas toward which further attention should be given.

d. Initiate format modifications for reinforced plastics.

e. Add formats for other types of test data that are being received. Some of those for which a backlog of data is beginning to exist are dynamic creep, bend tests (minimum radius forming) and rate of crack propagation in fatigue tests.

f. With the storage file now containing a large sum of materials' information, and increasing at a substantial rate, it is capable of supplying answers to a wide variety of questions. An organized effort starting on a small scale should be initiated to advertise the service so that its benefits are received industry wide. As part of this program the frequency of routine dissemination of Technical Notes should be increased.

g. Initiate studies of material behavior patterns, using the accumulated information for developing and checking theories and empirical relationships.

h. Find and exploit ways of encouraging authors to report more complete information about tests, without undue standardization and the associated possibility of damping creativity.

i. Require contractors to use Data Center information at the onset of programs, to eliminate costly test duplications. While some duplications are necessary by each contractor, so that he can verify his ability to achieve previously recorded results, these duplications can be considerably reduced by prior design of the contemplated tests using established data.

REFERENCE LIST

"A System for Automatic Processing of Fatigue Data", A. J. Belfour, Parsons Corporation, W. S. Hyler, Battelle Memorial Institute. WADC Technical Report 58-461, ASTIA Document No. 207792, Jan. 1959.

"Considerations and Recommendations for Developing a Materials Information Processing Capability", Albert J. Belfour, WADD Technical Report 60-867, December 1960.

"Development and Implementation of a Materials Information Processing System", Albert J. Belfour, WADC Technical Report 62-819, September 1962.

"A Practical Approach to Providing Materials Information", A. J. Belfour, presented at the Symposium on Materials Information Retrieval, November 28-29, 1962, Sponsored by Materials Information Branch, Applications Laboratory, Directorate of Material and Processes, Aeronautical Systems Division.

"Development of a Materials Property Data Processing System", R. C. Braden, C. S. Wright, WADC Technical Report 63-128, January 1963.

TABLE I

LABOR DISTRIBUTION
AF 33(657)-9149

Project Area	Distribution of Expended Time - Percentages by Area -			
	Engineering	Technical	Clerical	Total
1. Administration - All effort expended on administrative records, reports, correspondence, conferences, planning, etc.	10.3	0.3	1.8	12.4
2. Library & Literature Acquisition - Time expended acquiring, searching, sorting, cataloging, indexing and storing of all documents, books, papers, etc..	3.3	8.2	6.3	17.8
3. Data Input - All phases of data reduction-conversion from encoding through storage of unit records (cards) are included in this area of activity.	2.6	10.5	3.0	16.1
4. Data Output - All study, analysis, machine processing, tabulating, etc., necessary to produce an answer, solution or other end product such as a graph, tabulation, listing, discussion or any combination of these.	8.0	8.8	1.2	18.0
5. Dissemination - Non-technical work associated with the preparation, presentation and distribution of Output. Such efforts shall include typing, reproduction, binding or packaging of the Output.	2.1	0.8	6.7	9.6
6. Methods & Systems - This area of activity includes all efforts expended on study, evaluation, design and development of methods, routines or procedures necessary to the accomplishment of project goals. Formats, codes and any other rules, plans or practices.	19.7	1.8	1.5	23.0
7. Equipment & Facilities - Time spent on the study, evaluation, maintenance or repair, of equipment or facilities.	1.4	1.6	.1	3.1
TOTAL -	47.4	32.0	20.6	100.0

FIGURE 1

LABOR DISTRIBUTION

GRAPHIC DISPLAY

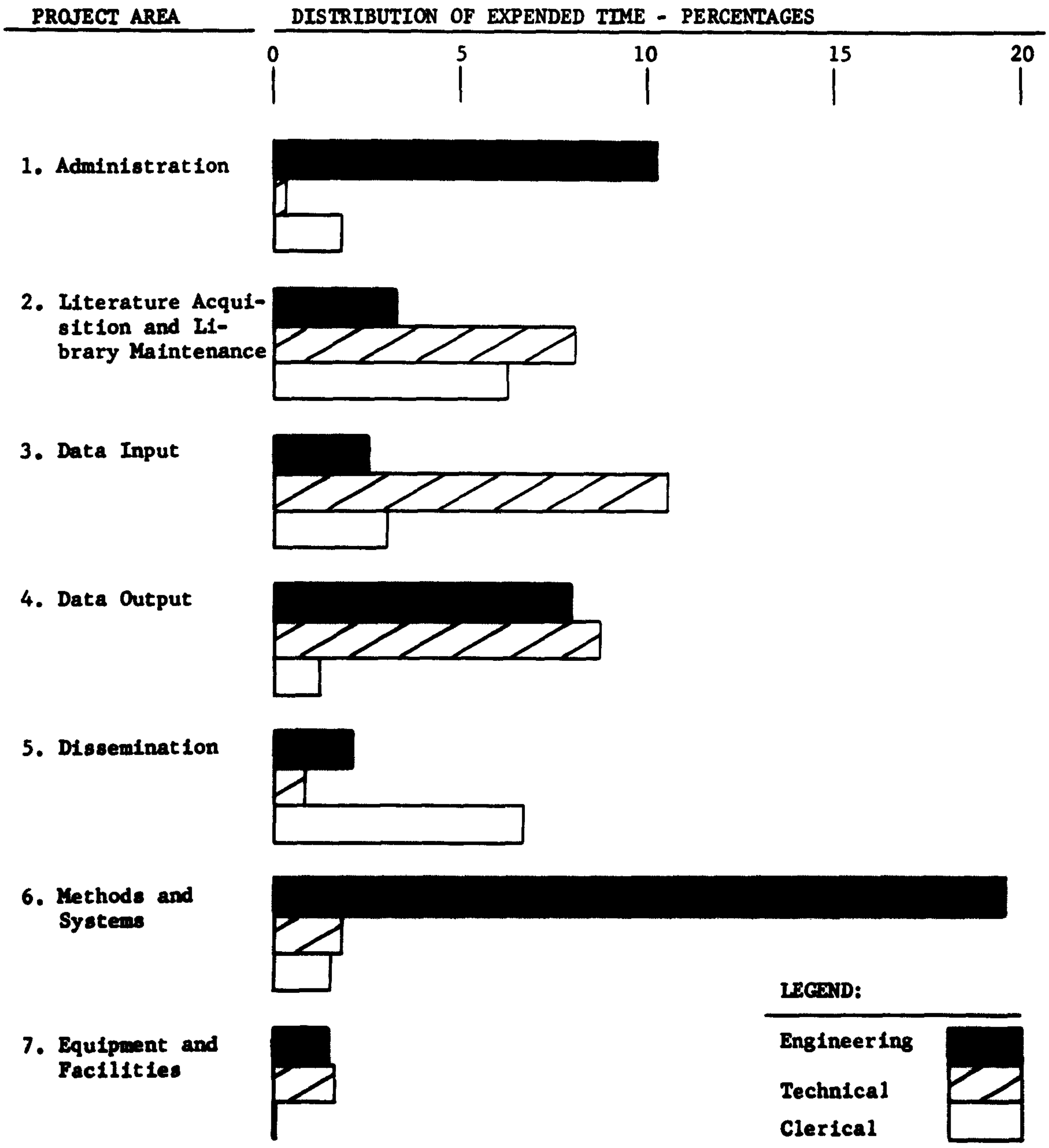

TABLE II

SAMPLE INVENTORY

SUMMARY INVENTORY-MECHANICAL PROPERTIES

Material Type	Material (Code) Identification	Total Unit Records	Single Specimens	Specimen Averages	Type of Test: Tension	Compression	Flexure	Shear	Bearing	Creep	Impact	Test Temperature: Sub-Room and Cryogenic	Room Temperature	Elevated Temperature	Pre-test Conditioning	No Pre-test Conditioning
CORROSION & HEAT RESISTANT	5510	29	29		29								10	19	19	10
	5515	10	10		6	2		1	1				10			10
	5516	10	10		10							7	3		4	6
	5517	6	6		2	2		1	1				6			6
	5518	71	71		67	2		1	1				19	52		71
	5519	130	130		126	2		1	1				19	111	56	74
	5520	550	550		304	68		44	134				203	347	434	116
	5524	10	10		10							5	5		4	6
	5525	532	532		199	63		69	164	37		2	51	479	452	80
	5526	5	5		2	2			1				5			5
	5527	5	5		2	2			1				5			5
	5528	979	979		701	224		2	4	48			478	501	159	820
	5529	73	73		49	12			12			1	48	24	30	43
	5532	213	213		102	67				44		8	33	172	152	61
	5538	10	10		4	4			2				10			10
	5542	54	54		35	2		1	16				21	33	24	30
	5547	15	15						15				3	12	12	3
	5548	262	253	9	213	47		1	1				198	64	96	166
	5549	15	15		15								3	12	12	3
	5570	25	25		25									25	25	
	5580	6	6		6								6			6
	5643	7	7		2	2		1	2				7			7
	5644	416	416		260					31	125		310	106	370	46
	5647	9	9								9	6	3			9
	5648	9	9								9	6	3			9
	5657	185	185		84	50		51					42	143	143	42
	5667	126	126		27	50		49					12	114	114	12
	5735	223	223		81	63		64	2	13			19	204	179	44
	5743	210	210		108	51		51					66	144	144	66

TABLE III

INFORMATION AND DATA STORED IN METALS "A" CARDS

FOR SEVERAL TEST TYPE FORMATS

TENSILE STANDARD

1. Material, Specimen Description and Fabrication and Test Environment*
2. Ultimate Tensile Stress
3. Yield and/or Proportional Limit Stress
4. Percent Offset
5. Gage Length
6. Elongation
7. Reduction in Area
8. Modulus of Elasticity
9. Poisson's Ratio
10. Failure Description

COMPRESSION

1. Material, Specimen Description and Fabrication and Test Environment*
2. Ultimate Compressive Stress
3. Yield and/or Proportional Limit Stress
4. Percent Offset
5. Gage Length
6. Deformation @ Failure
7. Modulus of Elasticity
8. Poisson's Ratio
9. Failure Description

*See end of table for information common to all tests.

Table III (Continued)

SHEAR (Fastener, Block, Sheet, Area Joint and Torsional)

1. Material, Specimen Description and Fabrication and Test Environment*
2. Ultimate Shear Stres
3. Proportional Limit Stress
4. Yield Stress
5. Percent Offset
6. Gage Length
7. Modulus of Rigidity
8. Failure Description

BEARING (Sheet or Plate in Bearing with Hardened Fixture Pin, Bolt, Pin or Rivet in Bearing with Hardened Fixture Plates, Fastener and Sheet or Plate Evaluated Together).

1. Material, Specimen Description and Fabrication and Test Environment*
2. Ultimate Bearing Stress
3. Yield Bearing Stress
4. Percent Offset
5. Gage Length
6. End Distance Ratio
7. Hole Diameter to Thickness Ratio
8. Specimen Width at Hole
9. Failure Description

*See end of table for information common to all tests.

Table III (Continued)

PRESSURE VESSEL BURST

1. Material, Specimen Description and Fabrication and Test Environment*
2. Burst Pressure
3. Yield Strength
4. Ultimate Strength or Strain
5. Other Reported Strengths or Strains
6. Biaxial Stress Ratio
7. Shear or Ductile Failure
8. Number of Pre-Burst Pressurizations
9. Failure Description

CONSTANT LOADING AND TEMPERATURE TENSILE CREEP

1. Material, Specimen Description and Fabrication and Test Environment*
2. Applied Stress
3. Time to Rupture or Test End
4. Gage Length
5. Room Temperature Permanent Elongation
6. Room Temperature Permanent Reduction in Area
7. Load and Temperature Application, Sequence, and Amount
8. Creep Deformation of Test End
9. Failure Description

*See end of table for information common to all tests.

Table III (Continued)

<u>INTERMITTENT LOAD AND/OR TEMPERATURE TENSILE CREEP</u>

1. Material, Specimen Description and Fabrication and Test Environment*
2. Applied Stress
3. Stress Cycling Details
4. Type of Creep and Time Measurements
5. Time to Rupture or Test End
6. Creep Deformation at Rupture or Test End
7. Elongation at Room Temperature
8. Reduction in Area at Room Temperature
9. Failure Description

IMPACT BENDING (<u>Charpy, Modified Charpy, Izod, Modified Izod, Vertically Dropped Weight on Simply Supported Specimen</u>).

1. Material, Specimen Description and Fabrication and Test Environment*
2. Energy Absorbed at Failure or Test End
3. Energy at Final Impact
4. Velocity at Final Impact
5. Type of Energy Corrections Made
6. Fixturing Dimensions
7. Fracture Appearance Measurement
8. Number of Blows Prior to Failing Blow
9. Failure Description

*See end of table for information common to all tests.

Table III (Continued)

TENSILE IMPACT

1. Material, Specimen Description and Fabrication and Test Environment*
2. Energy Absorbed at Failure of Test End
3. Energy at Final Impact
4. Velocity at Final Impact
5. Specimen Test Length (between grips)
6. Gage Length
7. Elongation in Gage Length
8. Reduction in Area
9. Lateral Contraction
10. Failure Description

TENSILE FRACTURE TOUGHNESS

1. Material, Specimen Description and Fabrication and Test Environment*
2. Gross Fracture Stress
3. Initial Net Fracture Stress
4. Toughness Index(es)
5. Fracture Appearance Measurement
6. Failure Description

*See end of table for information common to all tests.

Table III (Continued)

BENDING FRACTURE TOUGHNESS TEST

1. Material, Specimen Description and Fabrication and Test Environment*
2. Maximum Load Measurement
3. Load Measurement at Onset of Rapid Fracture
4. Deflection at Maximum Load
5. Deflection at Onset of Rapid Fracture
6. Toughness Index
7. Fracture Appearance Measurement
8. Failure Description

*COMMON INFORMATION

The following information is common to all the test types listed in the preceding portion of this table.

Bibliographic Identification
Test Type
Material Identification (Type, Designation)
Unit Number
Set Number
Number of Specimens in a Set
Specimen Number
Material Fabrication
Heat Treatment
Specimen Configuration and Dimensions
Specimen Notch Configuration and Stress Concentration Factor
Surface Treatment and Finish
Pretest Conditioning and Amount
Type of Hardness Test and Number
Orientation of Fibers, Grains, Crystals to Load
Test Load Rate
Test Environment and Amount
Card Sequence and Indicator

TABLE IV

INFORMATION AND DATA STORED IN METALS B CARDS
COMMON TO ALL TEST TYPE FORMATS

Bibliographic Identification

Unit Number

Material Identification (Type, Designation and Form)

8 Elements of Composition and Percentage for each

Amount and Type of Reduction (% Hot or Cold)

Starting and Finishing Temperature of Reduction

Grain Size and Other Metallurgical Properties Available in Document

Material Density

Principal and Other Test Types Reported for a Unit of Material

Card B Identification

TABLE V

INFORMATION AND DATA STORED IN CONSTANT TEMPERATURE

CONSTANT LOAD CREEP A_n CARDS

1st A_n Card Designated as A_1

- Bibliographic Identification
- Test Type
- Unit Number
- Set Number
- Specimen Number
- Test Temperature
- Yield Strength and/or Proportional Limit Stress
- Percent Offset
- Modulus of Elasticity
- Stress or Strain at Modulus
- Deformation Instrumentation
- Stress or Load and Strain or Deformation Measurements (8 entries)
- Card A_1 Indicator

2nd A_n Card Designated as A_2

- Bibliographic Identification
- Test Type
- Unit Number
- Set Number
- Specimen Number
- Applied Stress
- Test Temperature

Table V - continued

Extension Due to Load and/or Heat

Creep Deformation at Start of Second Stage

Time at Start of Second Stage

Second Stage Intercept with Zero Time Axis

Minimum or Average Second Stage Creep Rate

Creep Deformation at End of Second Stage

Time at End of Second Stage

Unstressed Deformation at Test Temperature

Room Temperature Hardness After Test

Card A_2 Indicator

3rd and Subsequent A_n Cards (A_3, A_4, A_5, etc.)

Bibliographic Identification

Test Type

Unit Number

Set Number

Specimen Number

Applied Stress

Test Temperature

Gage Length

Deformation Instrumentation

Extension Due to Load and/or Temperature

Time and Deformation Measurements (9 entries)

Failure Description

Card Sequence and Indicator

FIGURE 2
GRAPHIC OUTPUT - S/N DIAGRAM

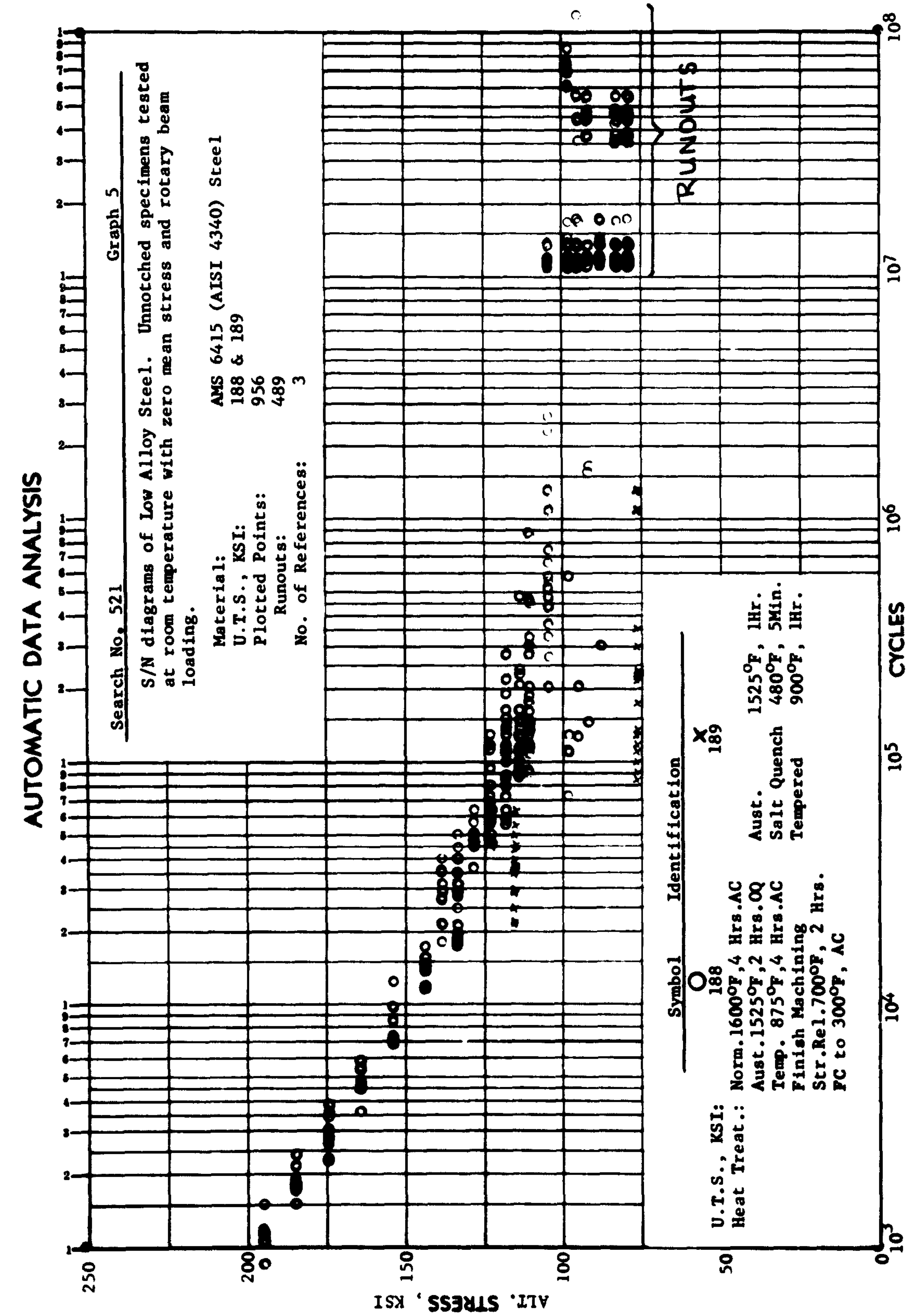

FIGURE 3

GRAPHIC OUTPUT - UTS vs TEMPERATURE & STRAIN RATE

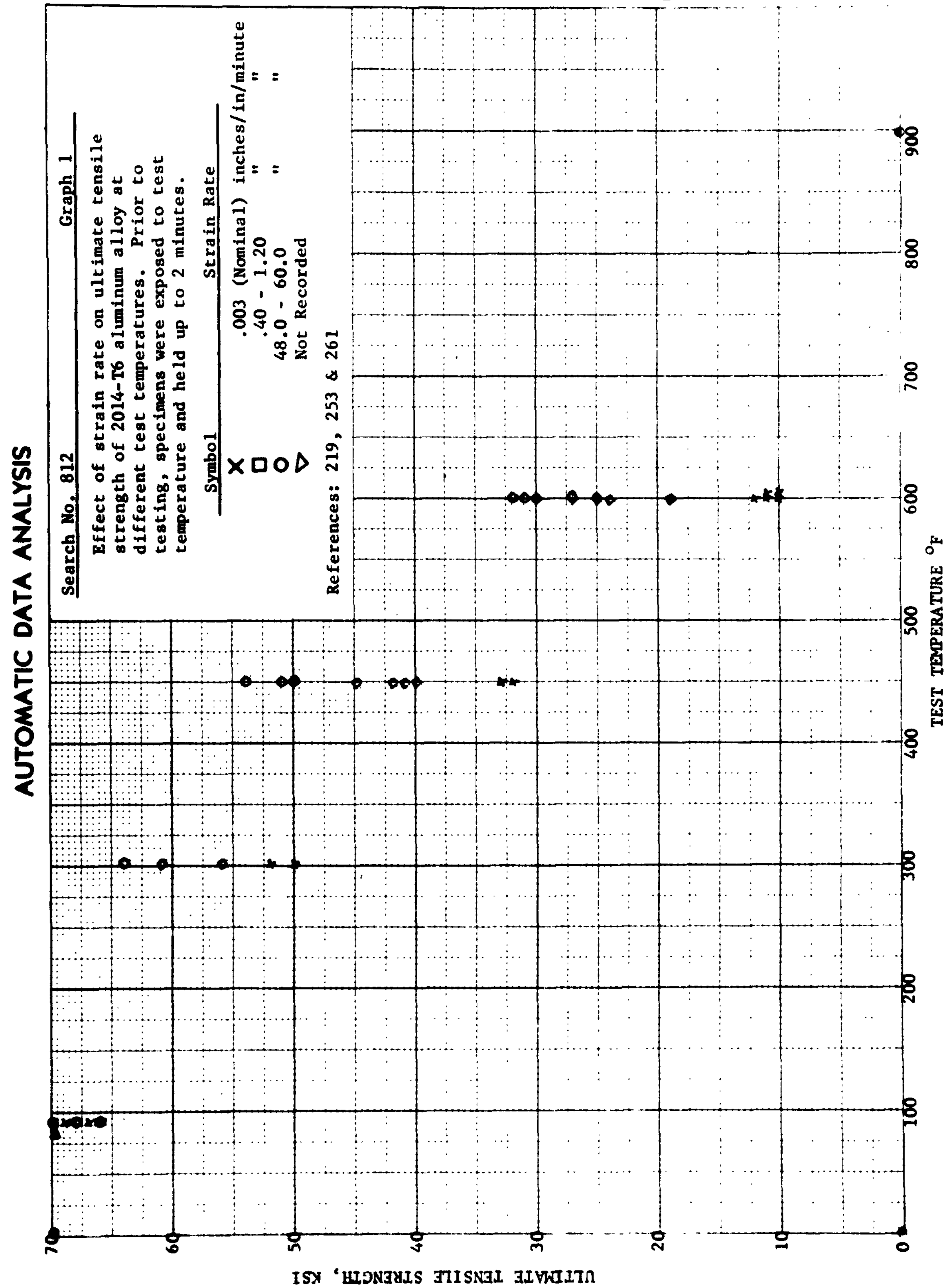

TABLE VI

DATA RETRIEVAL SEARCH LOG

15 June 1962 to 15 May 1963

SEARCH NO.	SEARCH PURPOSE	OUTPUT
411	Request for assorted properties information on L605, TZM, and columbium alloys B66, D36, and Cb752.	Copied portions of several references which included a variety of information on TZM and L605. Also, five other references cited which should contain useful information.
412	Request for fatigue data on 6Al, 4V, titanium alloy.	Two S/N displays (fifty-seven plotted points) with data sheets and reference list.
413	Request for hysteresis loop information on Beryllium-copper, spring steel and aluminum alloys 2024-T6 & 7075-T6.	Eight references cited which contain a variety of hysteresis loop information.

TABLE VI (Continued)

414	Request for Goodman Diagrams of Rene'41, Hastelloy X and aluminum alloys 2024 and 7075.	Thirty-two displays of Rene'41 and aluminum (2,503 plotted data points) with data sheets and reference list.
415	Request for information showing effect of strain rates (creep data) on Nimonic 80A at test temperature of $200^{o}C - 900^{o}C$.	Three references cited which contain properties information (at room and elevated temperatures) of Nimonic 80, 90 and 100.
416	Request for elevated temperature fatigue data of Rene'41. Notched and unnotched specimens, all stress ratios.	Three references which met the general requirements of the request and contain useful information.
417	Request for creep and/or creep rupture data (specifically rupture in 5 hours @ $2500^{o}F$) of 0.5 Titanium - Molybdenum Alloy.	Three references cited which contained applicable information.

TABLE VI (Continued)

418	Request for various displays of SAE 4340 (AMS 6415).	Eleven displays (approximately 3,272 plotted data points) including S/N Diagrams, Sa/F_{tu} vs fatigue life-time, F_{tu} vs Sa/F_{tu}. Also included was a supplementary data sheet and list of references.
419	Request for all available mechanical properties of titanium honeycomb brazed or welded and tested at $500^{o}F$ and over.	Five references cited which met the general requirements of the request.
420	Request for fatigue displays showing effect of notches and surface finish on 7075-T6 tested at room temperature.	Five fatigue displays (approximately 490 data points plotted) with summary data sheets.
421	Request for elevated temperature fatigue data of magnesium AZ 31B-0 (annealed).	One S/N diagram (approximately 15 plotted data points) with summary data sheet and list of supplementary references.

TABLE VI (Continued)

422	Request for a listing of references on the subject of stress corrosion of any metal.	List of 18 references.

TABLE VI

(Continued)

DATA RETRIEVAL SEARCH LOG

15 June 1962 to 15 May 1963

SEARCH NO.	SEARCH PURPOSE	OUTPUT
611	Search for availability of mechanical properties data of Rene'41.	Tabulation summarizing information available from mechanical properties data file.
612	Routine dissemination of mechanical properties information.	Technical Note 61-117, Part VI, "Effect of Strain Rates and Elevated Temperatures on the Tensile Properties of 4340, 17-7PH Steel and 7075 Aluminum". In Process - - - -

TABLE VI (Continued)

DATA RETRIEVAL SEARCH LOG

15 June 1962 to 15 May 1963

SEARCH NO	SEARCH PURPOSE	OUTPUT
811	Fatigue and creep data on selected alloys for ANC-5 Committee. (MIL Hdbk 5)	35 graphic displays (approximately 1100 plotted points) and Summary Data Sheets.
812	Tensile and yield strength of 2014-T6 Aluminum after exposure of room temperature to 800°F.	5 stress-temperature displays and list of references.
813	Fatigue of vacuum remelted or vacuum degressed steels tests in a corrosive atmosphere.	Approximately 500 fatigue displays with Summary Data Sheets. Also included was a list of applicable references.
814	Mechanical properties data on 2219 & 5456 Aluminum Alloy.	16 stress-temperature displays (approximately 512 data points). Also included was a list of supplementary references which contain applicable information.

TABLE VI (Continued)

815	Request for fatigue properties of cast 17-4PH stainless steel.	S/N diagram of 17-4PH stainless steel (34 plotted points) with data selected reference. Also, copied portions of two other applicable references. Four additional references listed which contained miscellaneous information on 17-4PH.
816	Request for information showing effect of fretting corrosion on 4340 steel (ultimate tensile strength of approximately 150ksi), and on 2024-T3 and T4.	Two applicable references located and forwarded to Enstrom Aircraft.
817	Request for fatigue information on sheet Rene' 41.	S/N display (10 data points plotted) with data sheet and reference.

TABLE VI (Continued)

818	Request for fatigue information (all values of R) on low alloy steels.	Information sent in three parts as follows: Part I - Eleven S/N displays (approximately 113 data points plotted) with data sheets and reference list. Part II - Eighteen S/N displays with data sheets and reference list. Part III - Twenty-eight S/N displays (1,734 data points plotted) with data sheet and reference list.
819	Request for axial load fatigue data on aluminum alloys 7079-T6 and 7079-T651. All available stress ratios for notched, riveted, and bolted joints.	Copied portions of four references which contain a variety of information on both 7079-T6 and 7079-T651. Also 13 other references.

TABLE VI (Continued)

820	Request for fatigue data (tension-tension) and fracture toughness of welded SAE 4330 Vanadium modified, SAE 4335 and Vascojet 1000 (H-11 tool steel). Notched and unnotched specimens with F_{tu} of 200-240 ksi.	Eight references cited which include data pertinent to the materials and properties requested.
821	Fatigue and Stress rupture properties of IN-100 or other nickel base casting materials.	Two fatigue and stress rupture displays (approximately 80 plotted data points) of GMR-235 with summary sheets. Also copied portions of 6 documents detailing fatigue and stress rupture properties of nickel base alloys GMR-235, Inconel 713C, Udimet N-155, Nicrotung, R-41, and IN-100.

TABLE VI (Continued)

822	Request for general information on fatigue of aluminum.	Copies of two technical notes on the Fatigue of Metals - Aluminum. TN 61-117, Parts I and IV.
823	Request for fatigue data on 410 stainless steel (approximate F_{tu} of 170 ksi) and 6Al-4V Titanium (approximate F_{tu} of 155 ksi). Of most interest - notched specimens of approximate K_t 2.8 and failures at about one million cycles.	Three fatigue displays (approximately 30 data points plotted) with summary sheets and copied portions of six documents which contained applicable information.
824	Request for list of materials meeting the following requirements: 1) F_{ty} 55 ksi or more @ 600°F after 5 minute exposure. 2) Ductility of 5% or more. 3) Coef. thermal expansion 8.6-10.0 x 10^{-6}@R.T.& 9.4-11.5x10^{-6}@500°F.	Listing of 43 materials meeting one or more of the specified requirement and associated reference list.

TABLE VI (Continued)

825	Request for any $600^{\circ}F$ - $1200^{\circ}F$ strength properties of beryllium. Also, names of companies, researches, etc. investigating beryllium joining methods.	List of seven references supplied.
826	Request for any or all materials having less than 3% short transverse ductility and less than 10% longitudinal ductility.	Information not available at this time.
827	Request for fatigue data on clear (non-reinforced) plastic materials for use in designing hemispherical vessels subject to cycled internal pressure.	Selection of materials meeting or nearly meeting the requirements was made and information phoned.
828	Request for fatigue displays (tabulations) comparing 6Al-4V-Titanium and 4340 steel. Specimens and test conditions to be similar.	Two tabulations (one/material) with Summary Data Sheets. Approximately 220 tests described.

TABLE VI (Continued)

829	Request for list of materials meeting the following requirements: 1) Tension yield of 60 to 200 ksi @ $500^{\circ}F$ 2) Coef. of thermal expansion of 8.5 to 10.5 in/in/$^{\circ}F$ @ R.T. 3) Coef. of thermal expansion of 9.3 to 11.8 in/in/$^{\circ}F$ @ $500^{\circ}F$. 4) Elongation of 10-100%.	Tabulation listing materials and properties meeting the requirements of the request.
830	Request for mechanical properties information displays on welded and unwelded 6061-T6.	Two fatigue displays (approximately 108 data points) and Summary Data Sheets. Also included was a list of references which contain applicable information.
831	Request for list of references describing applications and requirements involving graphite, either by itself or in conjunction with metals or plastics.	Thirteen references cited which contain applicable information.

TABLE VI (Continued)

832	Request for mechanical properties information (fatigue and fracture toughness) of D6aC. Heat treat histories and information on the weldability of this material also desired.	Eleven references cited which contain information meeting the general requirements of the request.
833	Request for available mechanical properties information on sheet Beryllium.	Three fatigue displays (approximately 47 data points plotted) with summary sheets. Also, 14 references cited which contain applicable information.
834	Request for tabulation of plastics information available from mechanical properties data card file.	8 pages, 4 of which identify type of information available and 4 displaying plastics inventory.

TABLE VI (Continued)

835	Request for room and elevated fatigue data of Inconel 713 C.	3 pages copied from one reference. Additional information on this material was sent previously.
836	Request for titles of BEC generated Technical Notes (ASD TN 61-117, I through V) and copies of those containing fatigue data on low alloy steels.	Complete listing of titles, TN numbers, and ASTIA Accession numbers sent along with two technical notes containing displays and information on low alloy steels.

TABLE VII

TABULAR OUTPUT - FATIGUE TEST DATA

SAE 4340 STEEL

REFERENCE NO.*	HEAT TREATMENT*	YIELD STRENGTH, KSI	ULTIMATE TENSILE STRENGTH, KSI	% ELONGATION IN 4 DIA.	SURFACE CONDITION*	SURFACE FINISH MICROINCHES, RMS	PRIMARY FABRICATION*	SECONDARY OPERATION*	SECONDARY OPERATION OR NOTCH FACTOR*	SPECIMEN TYPE*	CYCLIC SPEED, CPS	TEST TEMPERATURE °F ÷ 10	MEAN STRESS, KSI	ALTERNATING STRESS, KSI	FATIGUE LIFETIME
009	19	147	159	15	68	10	4	51	51	11	038	008	075	075	4,500
009	19	147	159	15	68	10	4	51	51	11	038	008	070	070	43,000
009	19	147	159	15	68	10	4	51	51	11	038	008	065	065	120,000
009	19	147	159	15	68	10	4	51	51	11	038	008	060	060	900,000
009	19	147	159	15	68	10	4	51	51	11	038	008	058	058	2,500,000
009	19	147	159	15	68	10	4	51	51	11	038	008	057	057	20,000,000 ‡
009	19	147	159	15	68	10	4	51	51	11	038	080	065	065	2,200
009	19	147	159	15	68	10	4	51	51	11	038	080	063	063	10,000
009	19	147	159	15	68	10	4	51	51	11	038	080	060	060	18,000
009	19	147	159	15	68	10	4	51	51	11	038	080	058	058	55,000
009	19	147	159	15	68	10	4	51	51	11	038	080	055	055	140,000
009	19	147	159	15	68	10	4	51	51	11	038	080	053	053	400,000
009	19	147	159	15	68	10	4	51	51	11	038	080	051	051	1,500,000
009	19	147	159	15	68	10	4	51	51	11	038	080	050	050	1,,600,000
009	19	147	159	15	68	10	4	51	51	11	038	080	047	047	2,800,000
009	19	147	159	15	68	10	4	51	51	11	038	080	043	043	400,000
009	19	147	159	15	68	10	4	51	51	11	038	080	041	041	18,000,000 ‡
009	19	147	159	15	68	10	4	51	51	11	038	008	000	090	18,000
009	19	147	159	15	68	10	4	51	51	11	038	008	000	090	25,000
009	19	147	159	15	68	10	4	51	51	11	038	008	000	082	69,000
009	19	147	159	15	68	10	4	51	51	11	038	008	000	076	85,000
009	19	147	159	15	68	10	4	51	51	11	038	008	000	078	130,000

‡ INDICATES RUNOUT

* CODED - SEE CODE SHEET

Aeronautical Systems Division, AF Materials Laboratory, Materials Application Division, Wright-Patterson AFB, Ohio.
Rpt No. ASD-TDR-63-566, Pt. I. MECHANICAL PROPERTIES DATA CENTER -- DESIGN AND OPERATION. Final report, May 63, 50p., incl tables, illus., 5 refs.

Unclassified Report

This report discusses and describes the concepts and considerations as well a- design details of a system capable of storing and retrieving mechanical properties information of metals and reinforced plastics. Included is a description of IBM card layout and codes utilized to store, retrieve, operate

(over)

on and display the most pertinent numeric and alphabetic information necessary to the description of reported test procedures and results. Examples of graphic and tabular system output are also presented.

1. Information Retrieval
2. Materials Information
3. Data Storage & Devices
4. Computer Storage & Devices
5. Integrators

I. AFSC Project 7381, Task 738103
II. Contract No. AF 33(657)-9149
III. Belfour Engineering Co., Suttons Bay, Michigan
IV. Stulen, F. L.
V. Aval fr OTS
VI. In ASTIA Collection.

Aeronautical Systems Division, AF Materials Laboratory, Materials Application Division, Wright-Patterson AFB, Ohio.
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