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COST-DRIVER ANALYSIS FOR COMPUTERIZED PRODUCTION PROCESS PLANNI--ETC(U)
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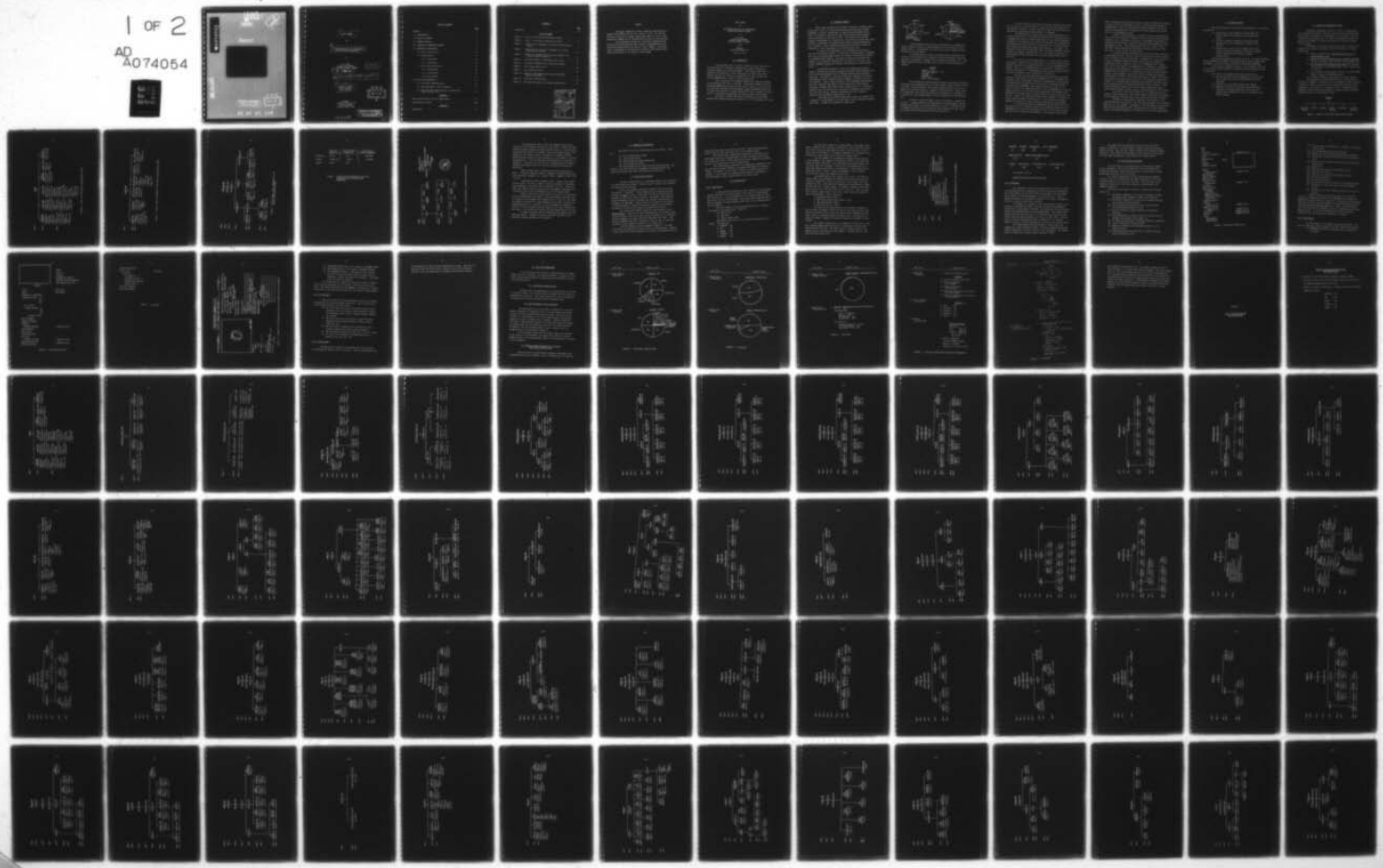

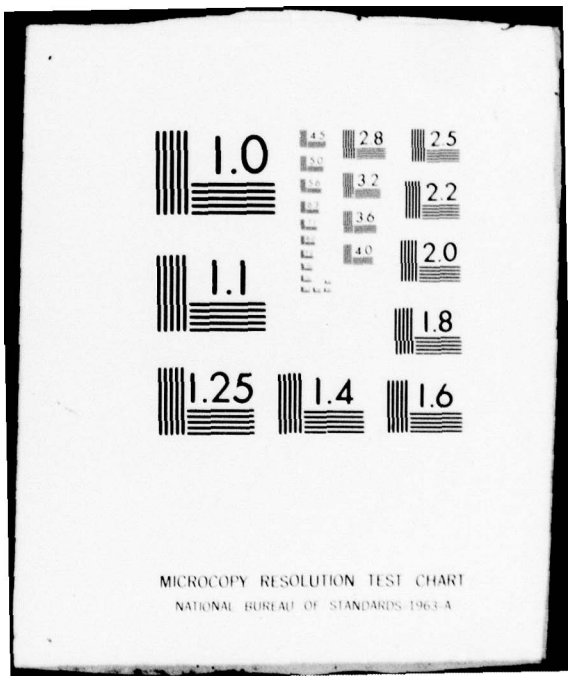
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Report

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(9) FINAL REPORT

on

(6) COST-DRIVER ANALYSIS FOR COMPUTERIZED PRODUCTION PROCESS PLANNING

to

U.S. ARMY
MISSILE R&D COMMAND
REDSTONE ARSENAL, ALABAMA

(12) 164 p.

(11) 20 July 1979

(15) DAAK40-77-R-0138

by

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By letter on file
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PREFACE

This report summarizes research conducted under Contract No. DAAK40-77-R-0138 from June 30, 1977, to May 31, 1979. The work was performed by Battelle's Columbus Laboratories (BCL) for the U.S. Army Missile R&D Command with Mr. Richard Kotler serving as Project Monitor.

This program was carried out in Battelle's Engineering and Manufacturing Technology Department through the Design/Manufacturing Interaction Program Office, Mr. Bryan R. Noton, Manager. The authors wish to acknowledge the contributions of Battelle staff members Wendy Freeze and Don Roop in the conduct of this program.

FINAL REPORT

on

COST-DRIVER ANALYSIS FOR COMPUTERIZED PRODUCTION PROCESS PLANNING

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U.S. ARMY
MISSILE R&D COMMAND
REDSTONE ARSENAL, ALABAMA

from

BATTELLE
Columbus Laboratories

July 20, 1979

1.0 INTRODUCTION

The spiraling costs of military systems in recent years reflect the high levels of technological sophistication needed to meet the ever increasing demands for system performance. These high systems costs have produced a new awareness in recent years within the DOD of the need to identify the high cost areas in the manufacture of these systems, and initiate MANTECH (MT) programs to reduce systems costs.

With a multitude of MT program possibilities, comes the problem of deciding which can yield the best ROI. Quantitative methods for determining how MANTECH money should be spent does not exist. To this end, the U.S. Army Missile Research and Development Command (MIRADCOM) entered into a contract with Battelle's Columbus Laboratories (BCL) to examine the potential for a quantitative methodology for assessing further MT programs.

This report outlines the results of Battelle's efforts toward meeting these objectives during the period July 1, 1977 through May 31, 1979.

ABSTRACT

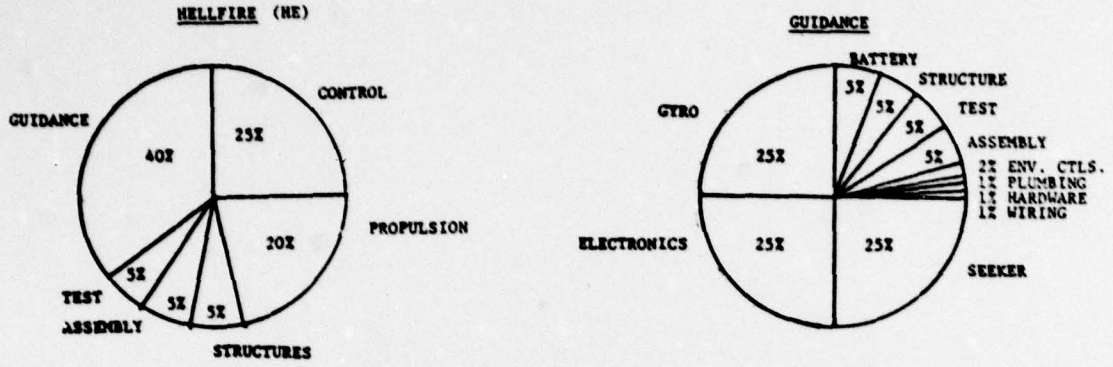
2.0 EXECUTIVE SUMMARY

This report describes the work done by Battelle's Columbus Laboratories (BCL) for the U.S. Army Missile Research and Development Command (MIRADCOM) to develop a methodology for examining missile manufacturing costs, cost drivers in manufacture, and future missile MANTECH programs from the standpoint of best ROI of funds. This objective has been met through the development of a missile parts classification system (MPCS) which provides a methodology for examining cost drivers in missile manufacture plus a variety of other interactive possibilities achievable through the availability of cost information at the discrete part level.

As devised, this methodology will accommodate both present as well as future missile systems. In other words, the methodology is designed such that as new technologies develop, the system is sufficiently flexible to accommodate these changes. Data would be stored and retrieved from a computer to allow general comparisons of costs which will identify cost drivers, MANTECH projects with high ROI, and estimates of future missile costs. ABSTRACT

The MPCS was developed in "tree" form drawing upon existing similar classification systems including MIL STD 881A "Work Breakdown Structure" and the proceedings of the 1975 Missile Manufacturing Technology Conference. The missile is initially divided into sections titled Structural System, Control, Guidance, Missile Assembly, Propulsion, and Test and Inspection. Each of these sections is then subdivided using descriptors that categorize the makeup of each section such as Wire Harness, Gyroscopes, Finishes, EMI Control, Seals, Flight Motor, etc. Further expansion of the tree evolves until six levels of breakdown yield discrete part data which reflect component characteristics such as material, physical size, performance characteristics, etc.

The system as now devised would use pie charts to indicate cost breakdowns and percentages at all levels down to and including the discrete part level. A sample cost breakdown is shown below.



This system would show costs as a percentage of an assembly cost which is some percentage of a larger assembly cost and finally the total missile itself. In this manner. the cost drivers will be evident as major divisions of the pie charts.

At the discrete part level, as indicated above, additional data could be stored relating cost to material, fabrication methods, production quantities, performance, component size, processing requirements, etc. The example below shows part data which could be used for missile design/cost analyses.

FAIRING

Length - 3 feet
Production Quantity - 500
Lot Size - 25
Aluminum
Formed Plate
Cost - 2.35 man-hours

This information would be gathered through a reporting system which contractors and subcontractors for a specific missile system would be required to provide. The availability of this type information would allow the designer of new missile systems to ultimately access this data, conduct trade-off comparisons, and obtain some relative cost comparisons to determine if a specific part can be manufactured, by what processes, from what materials, etc.

In order to access the MPCS, it will be necessary to computerize the data. A coding system was developed which is an alpha-numeric code and separates each branch of the parts classification tree. It allows the user to address any particular data location so that comparisons of part costs can be made within the same missile or between missiles.

The data stored at each point in the parts classification system will be set up in a similar format to allow quick and easy comparisons of any portion of interest. The data required to make the system useful was studied and an appropriate display method is recommended.

The MPCS with its coding system, data display techniques, and proposed incorporation of cost data and discrete part characteristics, can, if implemented, meet the proposed objectives that this program addressed. In addition, the possibility also exists that the MPCS, as a standardized reporting system, could be used for costs as well as the standardizing of parts numbers and engineering drawing identification. For example, all "actuators" would have the same basic MPCS code number regardless of manufacturer, performance characteristics, etc. with further coding used to differentiate between actuators and the relative manufacturing costs of each type.

As a result of this program effort, it is evident that an MPCS, if available, could have far reaching impact on cost data acquisition and analysis and missile part identification for all future MIRADCOM missile systems. Thus, it is recommended that the evolution of the MPCS be continued by development of an implementation plan and more detailed study of cost data availability, form, and methods of acquisition.

Now that the basic methodology has been developed and the MPCS devised to serve several functions if implemented, it is recommended that a further study be undertaken to develop an implementation plan/road map that would define the approach and time table for installing the MPCS as a working tool at MIRADCOM. This would be basically carried out by a review of current cost reporting practices, both at MIRADCOM and at selected missile contractors, along with detailed discussions with MIRADCOM staff responsible for present cost reporting practices and others within the Army and DoD. Present cost reporting systems would be examined to evaluate the scope, features, method of operation, etc., and to define any thread of commonality between the current reporting system and the proposed MPCS.

It is anticipated that the implementation plan would reflect the fact that any new cost reporting system of this magnitude would have to be implemented over a critical time period and only on those missile systems which are now in research and development or the advanced concept stage.

These considerations would define how best to apply the MPCS missile systems in various states of development in order to define the best approach to implementation. Thus, all non-production missile systems now at various stages of development would be examined and systems targeted which would best fit the implementation plan.

Based on this information, a prospectus would be developed which would outline the features of the MPCS, its short term and long term impact on missile costs, an estimate on the return on investment which might be realized once the system is operational, and make some assessment of total implementation costs. This prospectus would also, of course, contain a time table and key marketing and technical development activities which must occur in order to meet this time table.

A second important consideration and one which relates closely to an implementation plan, involves a study of the whole area of data acquisition. The MPCS as currently developed, if implemented in total, would constitute a tremendous undertaking in data acquisition and undoubtedly require many years to complete. Thus, it is recommended that an added effort as the first phase of implementation be to undertake to examine the whole area of data acquisition. Consultations would be held again with MIRADCOM staff involved with cost reporting, and selected missile manufacturers to obtain feedback on the various levels of detail that might be incorporated in the MPCS. What effect these levels of detail would have on data acquisition and collection practices by the contractors would also be studied. It is proposed that the guidance and propulsion sections be used as the target areas for examining the question of data collection. These areas represent the highest cost areas in missile manufacture and are sufficiently different in nature to give a broad prospective to the program.

The output of this effort would be a full understanding of the question of data acquisition, how the data might be collected, the mechanics of data collection, and what type of data reporting form would be needed.

The MPCS, as now developed, represents a new approach to part classification and cost analysis. The full potential impact of this development has yet to be assessed. Performance of the implementation plan development and cost acquisition efforts indicated above will provide important input to forthcoming assessment of the MPCS and its potential applications.

3.0 PROGRAM APPROACH

The initial approach to developing the methodology in this program consisted of:

(1) Establishing a work breakdown structure (WBS) for a missile system, its subsystems, and subsystem components

(2) Collect and analyze government and missile system manufacturer's cost information for insertion into the WBS

(3) Manipulation of cost data into formats which would display cost-driver information and provide a methodology for manufacturing technology program prioritization.

Five missile systems were selected for study. Two were air defense missiles (REDEYE and STINGER), two ground-to-ground combat missiles (TOW and DRAGON), and an air-to-ground missile in development (HELLFIRE).

As the program progressed, however, it was found that cost data in the form and detail necessary for meeting the above program plan were not available.

As a result, the program approach was altered in that

(1) The data available from the HELLFIRE missile system was used to define and refine the methodology as it was developed.

(2) Extensive cost acquisition efforts were stopped.

(3) Emphasis was placed on developing a methodology which could meet the program objectives plus be used for missile parts classification and cost estimating of new missile systems.

4.0 OVERVIEW OF METHODOLOGY DESIGN

Methodology development evolved as a result of establishing a parts classification system. The other portions of the methodology were then developed according to the requirements of that system. The parts classification development will be reviewed in subsequent sections that review the development of coding, data acquisition, and data storage/display systems.

Development of the parts classification system is based on the combination of applicable information from several sources. The main sources were:

(1) Military Standard 881A, Work Breakdown Structure for Defense Materiel Items

(2) Report of the Missile Manufacturing Technology Conference held at Hilton Head, South Carolina, 22-26 September 1975

(3) The Seventh Quarterly Design-to-Cost Report from Rockwell International on the HELLFIRE modular missile system dated 31 July 1978

(4) Data collected from the project offices on the TOW, DRAGON, REDEYE, STINGER, and HELLFIRE missiles.

(5) Catalogs, textbooks, and handbooks on various subjects.

The complete parts classification tree plus coding system is described in Appendix A. Evolution of its development is shown in Figures 1 through 6. Figure 1 shows the first level based on division of the missile into six sections. (A comparable tree for "command and launch equipment" could be developed and added to complete the major hardware-related portions of a total missile system.

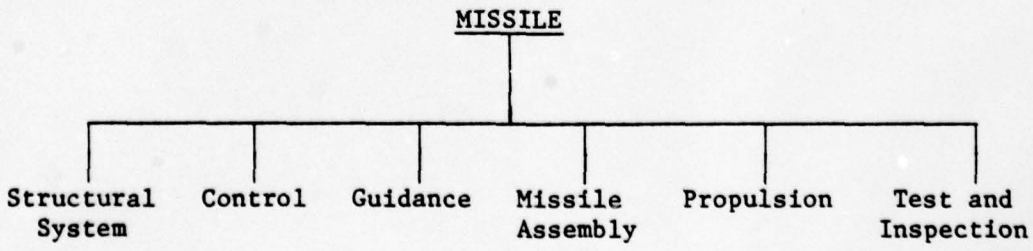


FIGURE 1. LEVEL 1 OF THE PARTS CLASSIFICATION SYSTEM

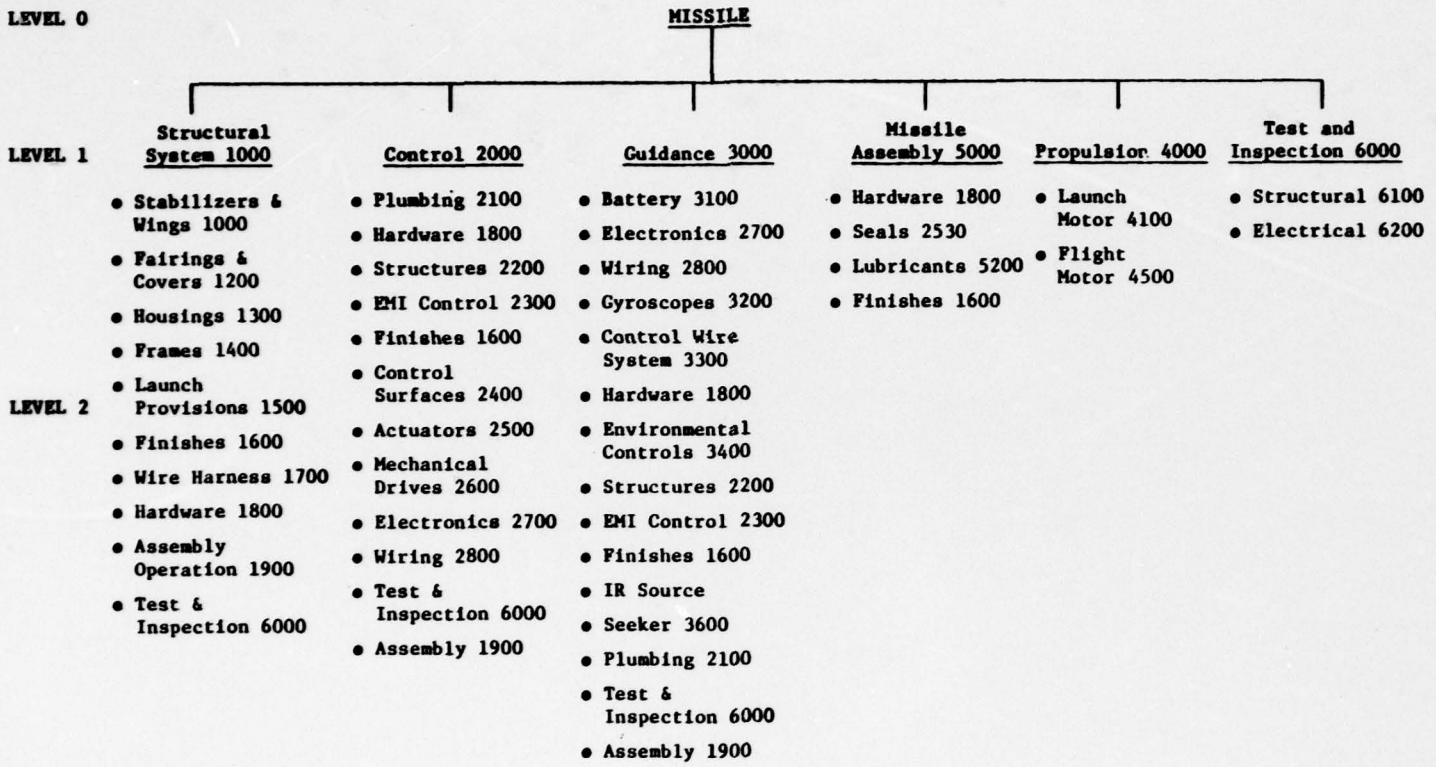


FIGURE 2. LEVEL 2 OF THE PARTS CLASSIFICATION SYSTEM

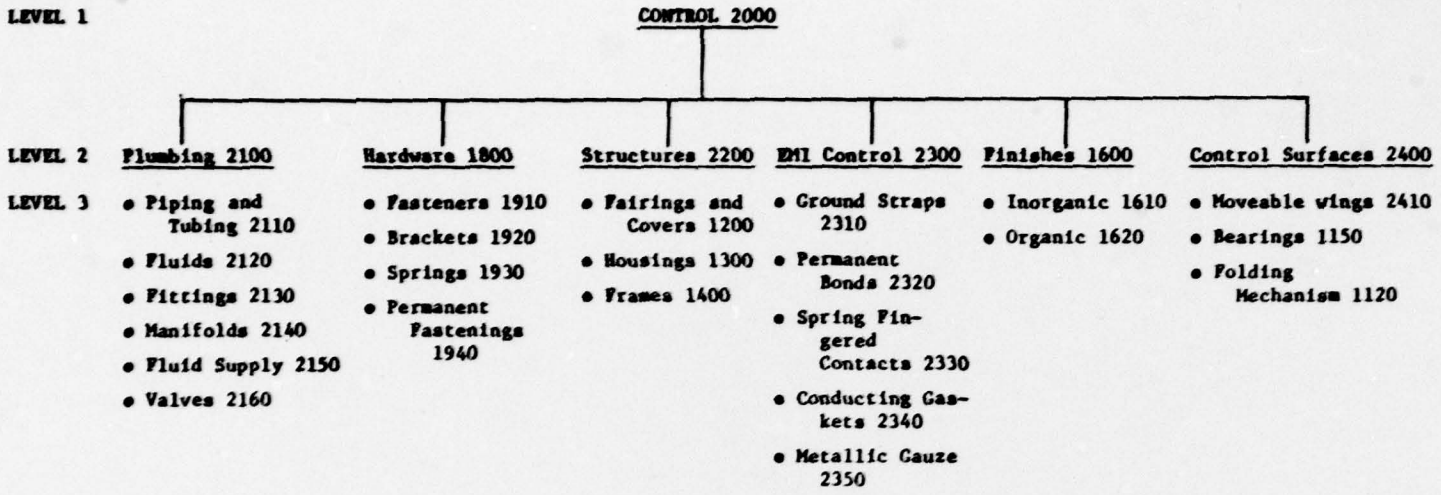


FIGURE 3. TYPICAL LEVEL 3 BREAKDOWN OF THE PARTS CLASSIFICATION SYSTEM

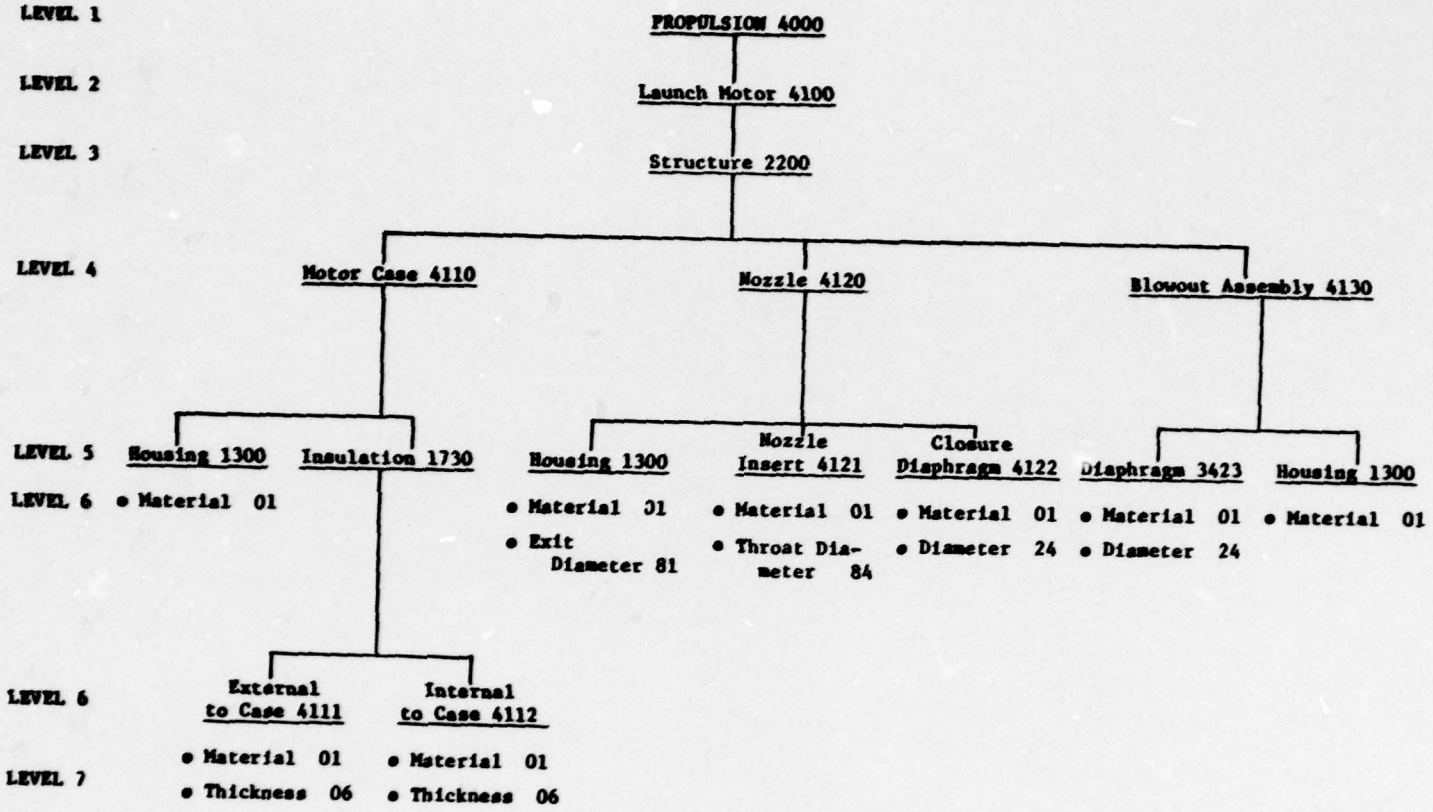


FIGURE 4. TYPICAL LEVEL 6 AND 7 BREAKDOWN OF THE PARTS CLASSIFICATION SYSTEM

	Collector Current 31	Collector-Emitter Voltage 32	Current-Gain Product Bandwidth
Transistor	<50 mA	<40 V	<100 MHZ
Bipolar	50-500 mA	40-80 V	>100 MHZ
Signal	>50 mA	>80 V	

FIGURE 5. TYPICAL PART CHARACTERISTICS AND COST CATEGORIES FOR A BIPOLAR SIGNAL TRANSISTOR

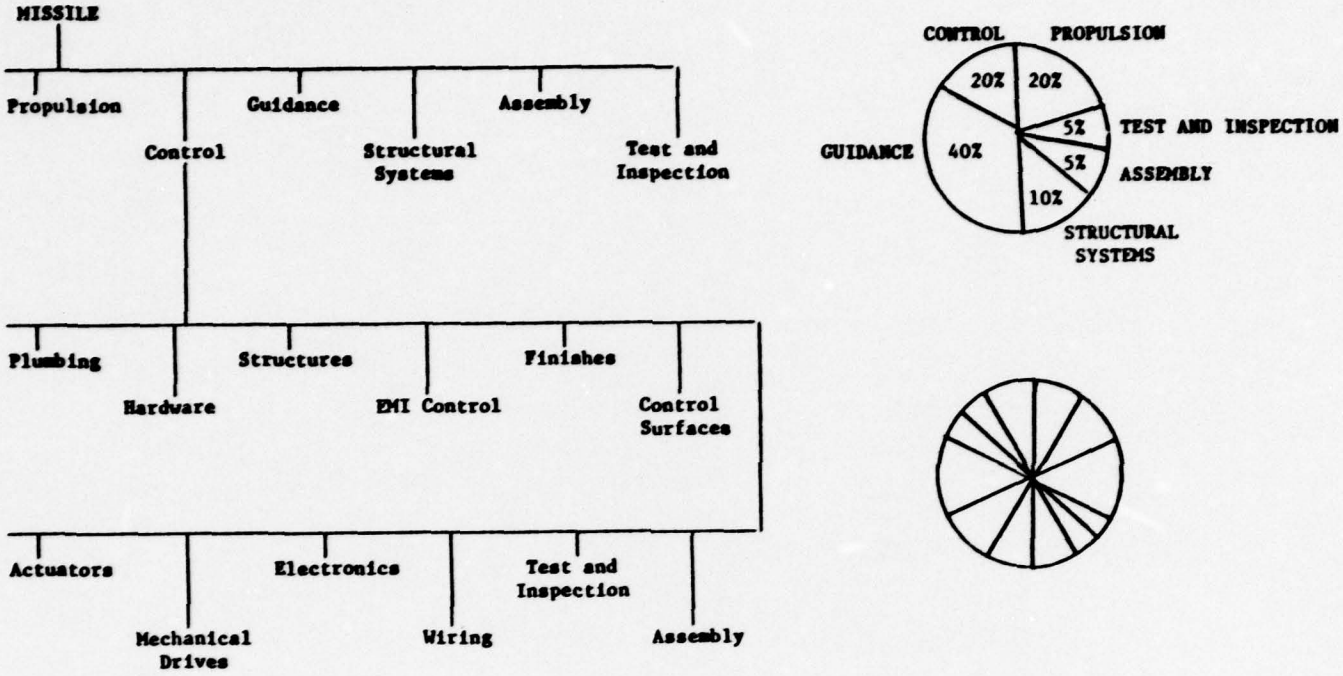


FIGURE 6. PIE CHART METHOD OF ILLUSTRATING COST DRIVERS

The descriptions used to define the component sections were selected to best illustrate the parts in that section. These terms sometimes have general meanings and some confusion arose as to where specific parts should be located. For example, does the gyroscope belong in the guidance or the control section? To address this problem, specific definitions were written for each descriptor as it was added to the parts classification. A list of terms with their definitions is contained in Appendix B. (The gyroscope is placed in the guidance section because it determines the missile direction but does not physically change that direction).

Figure 2 shows Level 2 descriptors for the six sections in Level 1. These may represent specific components or manufacturing steps such as finishes, assembly, etc. Figure 3 shows a segment of Level 3 for "control".

Continuing the level breakdown, Figure 4 shows a parts classification, which, at Level 6, begins to reflect the makeup of components, thus allowing for cost effects due to materials, size, etc. Along this same line, Figure 5 shows the variations in performance requirements for a transistor which can be accommodated and cost differences shown.

Figure 6 shows the pie chart method to be used for illustrating costs and highlighting cost drivers. This system depicts each part cost as a fraction of an assembly cost (graphically as a slice of a pie) which is likewise a fraction of a larger assembly cost and then a fraction of a complete missile cost. Each part cost can be graphically depicted as a portion of the total missile cost and compared to all other similar level part costs. Cost drivers then stand out as the largest slices of the pie.

The major references used for methodology development have been mentioned earlier. Appendix C contains a detailed reference list of pertinent documents received in this program.

5.0 METHODOLOGY DESCRIPTION

This missile cost driver methodology has four features. These are:

(1) Parts Classification System

(2) Parts Coding System

(3) Data Storage and Display Methodology

(4) Data Acquisition System.

Each is described and its unique features discussed below. The details of how these systems are integrated to determine missile cost drivers and perform other tasks are described in Section 6.0.

5.1 Parts Classification

The parts classification is a cataloging system for all the parts in a small missile air vehicle. Each part can be located in the system by its description and function.

As the tree expands, descriptors represent functions such as "propulsion" or "guidance". The succeeding levels become more specific and name the types of parts. These levels can then be characterized as separated by type with a similar function. For example, the functional section "Mechanical Drives" is divided into "Shafts", "End Connectors", "Linkage", and "Bearings". These parts all are related by the function of producing change in position by mechanical means but are separated according to the type of part needed to perform their function.

The lower levels further divide the types of parts by their characteristics. These are the last breakdown levels in the parts classification system. Each type of part such as "Fittings" in the functional section "Plumbing" are further divided by "Material" and "Size". This further breakdown allows for a variation in price of the size type part but made of a more expensive material or in a larger size.

This description has been necessarily vague as to the exact levels which are separated by function, type, or characteristic. Because of the variety and varying complexity of the parts, the breakdown does not

contain the same number of levels for each part. Even the simplest parts, however, have one level which fits each of the breakdown areas.

The current parts classification system has concentrated on the electronics area due to the large number of parts and because electronics are a known cost driver. Other areas have also been classified extensively but not to the same extent as the electronics area.

The classification system and the coding system (described in the next section) are easily adaptable to changing requirements of the methodology. For example, if a new type of actuator is invented and used in a missile, it can be added in as another section merely by expanding the tree and coding it with an unused number in the proper level.

5.2 Coding System

5.2.1 Description

A coding system was developed to give examples of the programmer/computer interaction in the description of the uses of the methodology (see Section 6.0). It is not intended to be an optimum system but shows what can be done and its advantages. The actual coding system used by the Army is dependent on several unknown factors such as the computer system and its software.

The code consists of three sections which make up a complete code number for any missile part. These are:

(1) Missile Code

(2) Part Code

(3) Characteristics Code.

The missile code consists of two letters which describe each missile. The codes are:

- HELLFIRE -- HE
- TOW -- TO
- DRAGON -- DR
- STINGER -- ST
- REDEYE -- RE.

The part code is made up of 4-digit numbers. Each number represents a separate word in the part classification. Where words are used in two or more places, the same number is used to allow retrieval of all of those parts in the missile. For example, "Fairings" are cataloged in five locations but each location can be retrieved by using "1200".

The code numbers can be combined to designate the precise part in the breakdown. For example, the "Fairings" section of the "Structural System" is coded "1000 1200". The "1000" means "Structural Systems" and the "1200" means the "Fairings". Each word in the breakdown has its 4-digit code number printed next to it in Appendix A, "Parts Classification and Coding System". Figure 7 shows the breakdown of the electronics system and the 4-digit code number for each area.

The characteristics code consists of two parts. The first is a 2-digit number which designates the characteristic area such as material (Code 01), length (07), collector current (31), time constant (60), and transmittance (81). The second part designates the characteristic element for that area with a 3-digit number. For example, aluminum is coded 002, formed plate is 145, .001-.015 inches is 227, and so on. Thus, to designate a specific characteristic for a part, the two codes are combined to form a 5-digit number. Some of these are:

- Material-Silicone = 01027
- Power Source-Electrical Actuator = 17357
- Word Capacity=16K = 48673
- Burn Time-<30 sec. = 77941.

The codes for the characteristics are contained in Appendix A. The first part of Appendix A lists the codes for the characteristic areas and the second lists each area with its characteristic elements and their codes. Each is in numerical order according to area. The elements are coded from lowest to highest for numerical elements and randomly for word elements.

The complete coding, then, is a combination of these three codes. The following example shows the code for a typical part with each code associated with each word. The slash is used to separate the part code numbers from the characteristics code numbers. A decimal point or other mark would work equally well.

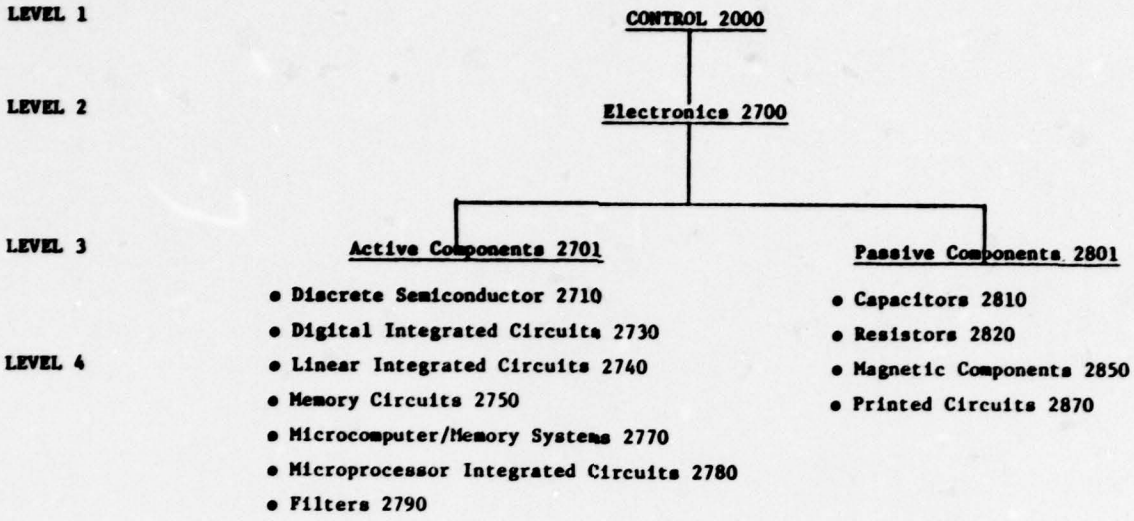


FIGURE 7. ELECTRONICS BREAKDOWN WITH 4-DIGIT CODE NUMBERS

```
HELLFIRE,   GUIDANCE,   ELECTRONICS,   ACTIVE COMPONENTS,
   |           |            |                |
   HE         3000         2700             2701

MEMORY CIRCUITS,   RANDOM ACCESS MEMORY-POLAR,
       |                        |
      2750                     2751

DIVIDER,   QUALITY-HIGH,   BIT CAPACITY-16K,   ACCESS TIME-<400S
   |           |               |                    |
   /         40616           43673                44685
```

The complete code is:

HE300027002701275027 51/406164367344685

5.2.2 Advantages

The advantage of this type of coding system is that it is useful in retrieving data from a breakdown tree such as the parts classification. The 4-digit number for each word allows the programmer to use one number when he wishes to retrieve information on one type of part. Then, by adding more numbers, he can become as specific as he likes in designating the part or parts he would like to retrieve.

For example, all the parts in the data bank made of steel can be retrieved by searching for 01001. Then all the parts in the HELLFIRE missile made of steel would be HE/01001. The steel parts in the structural system of the HELLFIRE missile would be HE1000/01001. The computer would compare that code with each code in its data bank and retrieve all parts with HE, 1000, and 01001 included, as a portion of their codes. Any code used to review the data should be able to manipulate it in a similar fashion in order to allow the methodology to be used to its fullest extent.

The coding numbers have been assigned to words, areas, and elements in a fiarly systematic fashion. The first breakdown levels have simpler numbers while the lower levels are more complicated. For example, control is 2000 while a fixed, nonlinear varistor is 2829.

The numbers have been assigned so that each area has spare numbers for additions. The characteristic areas are from 1-86 leaving 14 numbers unfilled. Each area has a range of numbers which designate elements that apply. Some elements are applicable to more than one area and retain the first number designated to them throughout the coding system.

5.3 Data Storage and Display

The third feature of the methodology is the system for display of cost information. The pie chart depiction of cost distribution has already been described, and the intent would be to develop these as shown subsequently in Section 6.0 of this report.

For future considerations, we have listed below and compiled in Figure 8 the type of data format that might ultimately be used in the system to develop a total history on each part. Input for much of this compilation would have to come from contractors, subcontractors, and component suppliers.

Cost factors which might be obtained to develop part characterization are:

(1) The physical dimensions of the part--an isometric drawing including overall dimensions, weight, and tolerances
(2) The specific material alloy used, such as aluminum 6061-T6, or an accurate material analysis
(3) Other materials which have been used to make this part and the resulting difference in cost
(4) Any heat treatment to improve physical and mechanical properties
(5) The specifications or characteristics of the parts such as wattage, time constant, output range, etc.
(6) Any chemical process such as painting, priming, or anodizing
(7) A list of the basic fabrication steps
(8) Whether the method is a new emerging process or an old, familiar process
(9) Other methods which have been used to fabricate this part and the difference in cost

NAME:
CODE:
TOTAL COST:
PURCHASED OR FABRICATED:
SCALE:
DIMENSION UNITS:
WEIGHT:
TOLERANCE:
REQUIRED FOR MISSILE:

DRAWING:

STANDARD MAN HOURS:

MATERIAL:
OPTIONAL MATERIAL: % CHANGE IN COST:
HEAT TREATMENT:
CHEMICAL TREATMENT:
SPECIFICATIONS:
FABRICATION STEPS:
OPTIONAL METHOD: % CHANGE IN COST:
PART STATUS:
TOOLING FAMILIES:
COST BREAKDOWN
RAW MATERIAL: %
RECURRING TOOLING: %
NON-RECURRING TOOLING: %
SUPPORT COSTS: %
LEARNING CURVE UNIT:
LOT SIZE:
OPTIONAL LOT SIZE: % CHANGE IN COST:
PRODUCTION RUN SIZE:
OPTIONAL RUN SIZE: % CHANGE IN COST:
SET UP TIME: STANDARD MAN HOURS
RUN TIME: STANDARD MAN HOURS
DATES
COSTS COMPUTED:
COSTS REPORTED:

FIGURE 8. DATA DISPLAY (BASIC PART)

(10) The part status--in production, a prototype, or a special one-of-a-kind

(11) The tooling families used in this process

(12) Whether the part was fabricated in-house or purchased

(13) The percent of the total cost which is the raw material costs

(14) The unit on the learning curve on which costs were based (usually 200)

(15) The lot size

(16) Other lot sizes used and the different in cost

(17) The production run size

(18) Other run sizes used and the difference in cost

(19) The set-up time per lot

(20) The run time per piece

(21) The percent of total cost which is the recurring tooling

(22) The percent of total cost which is the non-recurring tooling

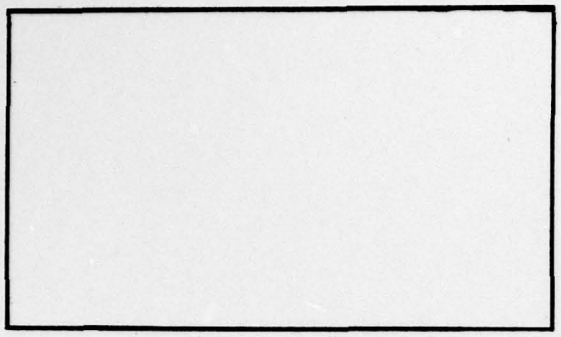
(23) The date the costs were computed and the date costs were reported.

A possible contractor reporting system as seen in Figure 9 represents a significant extension of the HELLFIRE D to C reports now generated (as shown typically in Figure 10). Discussions of this proposed reporting system were held with Rockwell International-Columbus Division staff associated with HELLFIRE manufacture. Their critique indicated that this form should be condensed in size and requested only on the most expensive parts. It was also recommended that process definition, learning curves, and tooling cost information be excluded.

5.3.1 Data Display

The data display for an assembly will be quite similar to the one for a basic part (shown in Figure 8) but will include these changes:

(1) MATERIAL--No material specification will be required for an assembly



DRAWING

NAME:

PART NO:

CODE NO:

REQUIRED FOR MISSILE:

REQUIRED FOR NEXT ASSEMBLY:

NEXT ASSEMBLY PART NO:

SCALE:

UNITS:

TOLERANCES:

PART WEIGHT:

PURCHASED OR FABRICATED?

FABRICATION STEPS: (1)
(2)
(3)
(4)

OLD OR NEW?

OPTIONAL METHOD: (1)
(2)
(3)
(4)

% CHANGE IN COST:

HEAT TREATMENT:

CHEMICAL TREATMENT:

MATERIAL:

OPTIONAL MATERIAL:

% CHANGE IN COST:

SPECIFICATIONS:

PART STATUS:

TOOLING FAMILIES:

LOT SIZE:

OPTIONAL LOT SIZE:

% CHANGE IN COST:

PRODUCTION RUN SIZE:

% CHANGE IN COST:

OPTIONAL RUN SIZE:

FIGURE 9. DATA ACQUISITION FORM

LEARNING CURVE UNIT:

SET UP TIME: RUN TIME:

TOTAL COST:

RAW MATERIAL: %

RECURRING TOOLING: %

NON-RECURRING TOOLING: %

SUPPORT COSTS: %

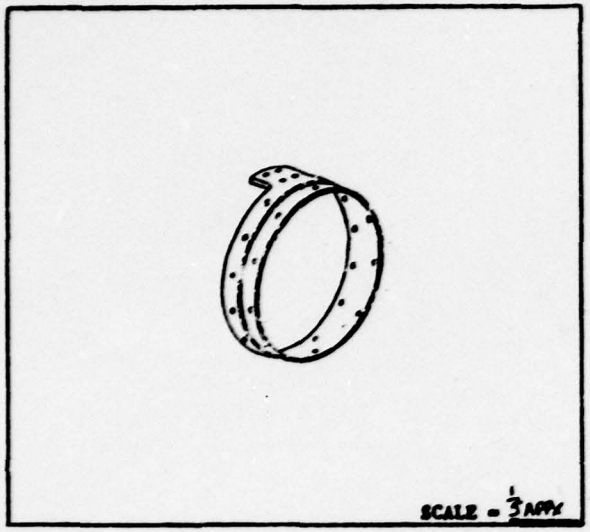
DATE COST COMPUTED:

DATE COST REPORTED:

FIGURE 9. (Continued)

PRODUCT DESCRIPTION: MISSILE

PART NUMBER: 13008302 PART NAME: FRAME FWD CONTROL WBS NO. 11200



SCALE = 1/3 APPX

QUANTITY PER NEXT ASSY: 1 QUANTITY PER END ITEM: 1

NEXT ASSEMBLY NAME: CONTROL SECTION ASSEM.

NEXT ASSY PART NUMBER: 13008360

MANUFACTURE [✓] PURCHASE [ ]

RAW MATERIAL: 7075-T6 AL. TUBING QQ-A-200/11

RAW MATERIAL TOLERANCE:

PROCUREMENT QA REQMT'S:

MANUFACTURING PROCESS:

1) LATHE
2) MILL
3) DRILL - TAP
DE-BURR - DE-GREASE - PROTECTIVE COAT

SET-UP HOURS _____ QUANTITY/RELEASE _____

MANUFACTURING TOLERANCE: +.000 - .005

IN-PROCESS QA REQMT'S: PER DWG

COSTS PER 1

MATERIAL:

LABOR:

MISC. HARDWARE: _____

TOTAL:

% OF WBS COST:

REALIZATION FACTOR _____

DTC COST REPORT & MFG. CODE _____

Form 434-C-46 6-77
REV. 12-77

RESPONSIBLE ENGINEERS-

DESIGN: L Richards

PRODUCTION: C. SHOEMAKER

QUALITY: M.L Beem

DATE: 12/31/77

REV: _____

REV: _____

FIGURE 10. EXAMPLE OF COST REPORTING FORM USED ON HELLFIRE MISSILE DEVELOPMENT

(2) FABRICATION STEPS--This will be changed to "ASSEMBLY STEPS".

(3) PART STATUS--This will be changed to "ASSEMBLY STATUS".

(4) COST BREAKDOWN--Instead of "Raw Material" and "Tooling", the total cost will be broken down by the next level of assemblies or parts which make up the assembly. The support costs will still be included.

The display will not always have each area as shown in Figure 9. If the data are unavailable or not relevant, then the item will not be shown. The computer should also be programmable to display only a portion of the data to save time and space when only one factor is being reviewed.

5.3.2 Ground Rules

Some cost factors will be specified before the data is reported to standardize the reporting between contractors. These factors will be called "Ground Rules" and are listed below:

(1) The total costs will include all hands-on-factory direct operations such as raw-stock, blank preparation, forging, heat-treatment, metal removal, priming, washing, tagging, and storing.

(2) The total costs will also include all support function modifiers such as planning, quality control, testing, inspection, etc.

(3) The total costs of assemblies will include the cost of joining, fastening, and other assembly operations.

(4) The units used to describe the parts will all be S.I. units.

(5) All costs will be reported in standard man-hours or a percent of the total part cost.

5.3.3 Data Storage

The data will be stored for each missile part and retrievable by specifying the specific code for that part. Data for similar parts will

be retrievable as a group to allow comparisons to be made. Each part or junction of the tree will also have a data set that can be retrieved. This will allow cost comparisons of assemblies from different missiles.

6.0 USE OF THE METHODOLOGY

It is the intent of this section to demonstrate what the methodology could do if developed. As already discussed, it provides for cost-driver identification through cost reporting and establishment of a parts classification system.

6.1 Cost-Driver Identification

A primary use of the methodology is to determine the cost drivers in a missile system. The technique used to determine the cost drivers is demonstrated in Figure 11. User input indicates the areas and descriptors of interest and the computer display shows the program output.

6.2 Cost Assessment of Future Missiles

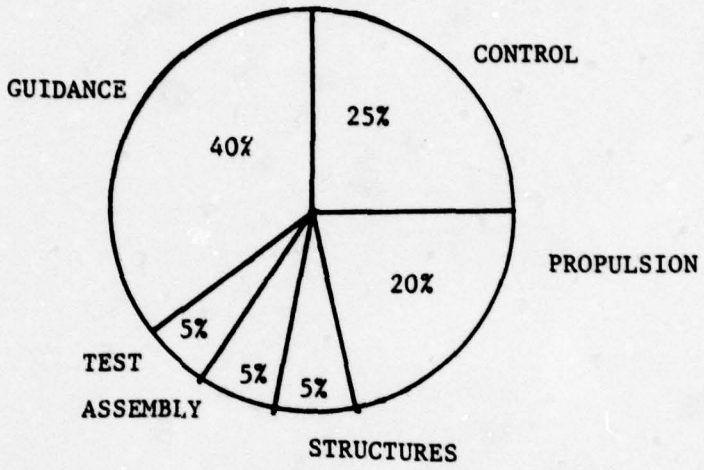
The methodology could also be used to estimate the cost of new missile components by comparing portions of the new design with similar portions of current missiles whose costs are known. More accurate predictions of a future missile's cost can be made because a more detailed comparison of parts and their costs is possible. Further, comparisons with parts of many different missiles can be made with equal ease instead of trying to make the cost prediction from one or two current missiles. An example of how this technique might be used to examine costs of a designed missile is illustrated in Figure 12.

In this example, three types of fairings designs are available in the system so the investigator can compare his concept with several designs and get at least some baseline data on that design which is closest to his requirement.

6.3 High Cost Ratio Between Parts of Varying Size, Value, Material, Etc.

Potential areas for manufacturing technology development could be suggested based on the difference in cost of similar parts of different

User Input	Computer Output
1. Identify Missile "HELLFIRE"	1. HELLFIRE (HE)



2. Identify Area "GUIDANCE"

2. GUIDANCE (HE3000)

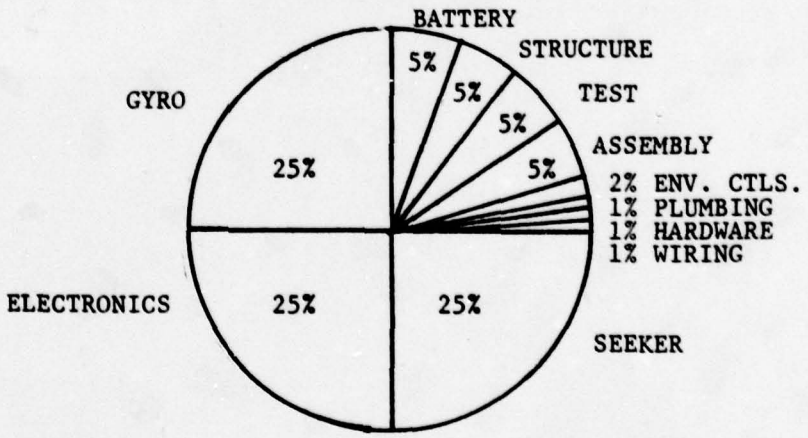
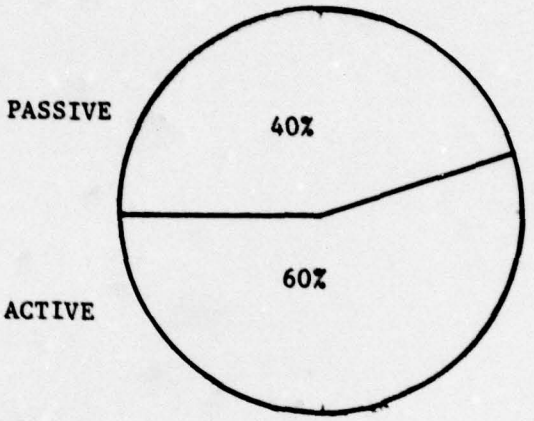


FIGURE 11. COST-DRIVER IDENTIFICATION

User Input	Computer Output
3. Identify Area "ELECTRONICS"	3. ELECTRONICS (HE30002700)



4. Identify Area "ACTIVE"	4. ACTIVE (HE200027002701)

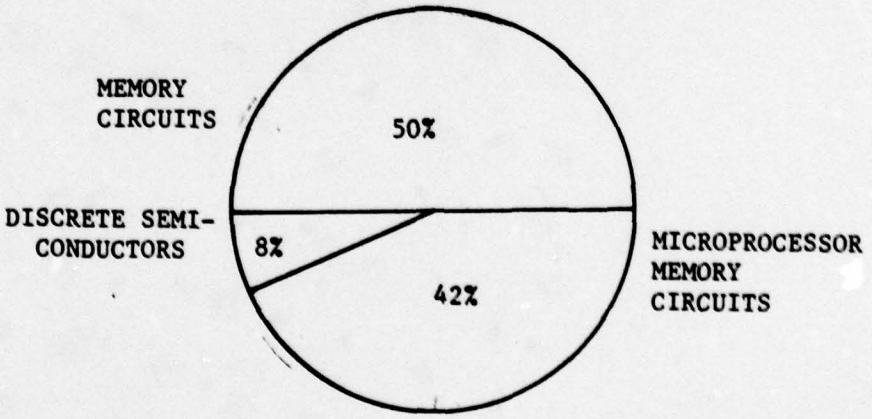
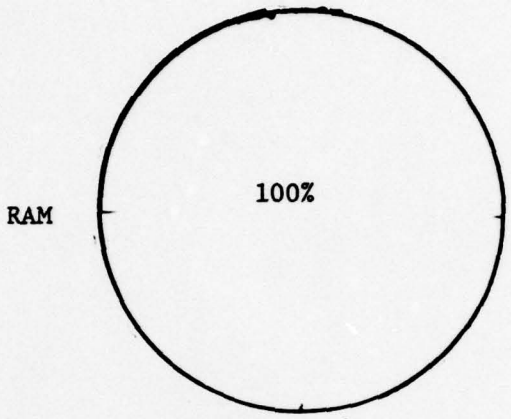


FIGURE 11. (Continued)

User Input	Computer Output
5. Identify Area "MEMORY CIRCUITS"	5. MEMORY CIRCUITS (HE3000270027012750)



6. Request Part Characteristics	6. RAM CODE (HE3000270027012750 2751/406164367344 685) Characteristics: Cost: 2.3 Manhours Quality: High Bit Capacity: 16K Access Time: <400s Cost Factors: Production Quantity: 50,000 Lot Size Quantity: 100 Time Frame: 6/75 - 8/78

FIGURE 11. (Continued)

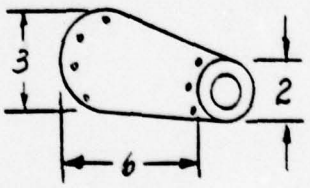
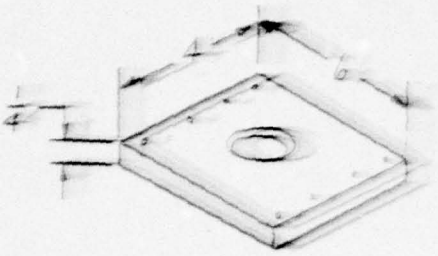
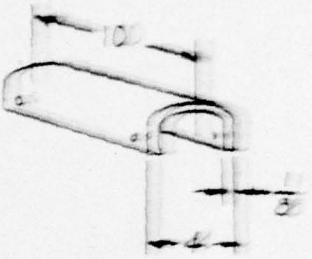
User Input	Computer Output
1. Enter Part "FAIRINGS"	1. Possible locations and code FAIRINGS • Structural Systems, Code 1000 • Control, Structures, Code 20001200 • Guidance, Structures, Code 30001200 • Propulsion, Launch Motor, Structures, Code 400041001200 • Propulsion, Flight Motor, Structures, Code 400042001200
2. Area of Interest "Code 1000"	MATERIALS 01 • Steel - 001 • Stainless - 003 • Aluminum - 002 • Composite - 004 • Plastic - 005
3. Material "Aluminum 002"	FABRICATION METHOD  • Missile: HELLFIRE Code No. HE10001200/01002 Material: Aluminum Fabrication: Rolled & Welded

FIGURE 12. COST DATA ACQUISITIONS FOR DESIGN CONSIDERATIONS

User Input | Computer Output



- Missile: STINGER
  Code No. STI0001200/01002
  Material: Aluminum
  Fabrication: Formed Plate



- Missile: TOW
  Code No. TOI0001200/01002
  Material: Aluminum
  Fabrication: Rolled

4. Part Closest to Designed Part "Code TOI0001200/01002"

4. Characteristics and Cost Factor Data on Selected Part

- Missile: TOW
  Part Code No. TOI0001200/01002

CHARACTERISTICS

Cost: 2.73
Material: Aluminum
Fabrication: Rolled
Weight: 1.8 lbs

Cost Factors

Production Quantity: 500
Lot Size: 25
Time Frame: 6/78 - 8/78

FIGURE 12. (Continued)

size, material, configuration, etc. For example, suppose the cost of three fairings, 1-, 2-, and 3-feet long, are compared. The 1-foot fairing costs $2, the 2-foot fairing costs $4, but the 3-foot fairing costs $15. One of several possible reasons for this difference is that some step in the manufacturing process for the large fairing is more costly than that used for the smaller fairings. A manufacturing technology project which upgrades the more efficient process or devises an alternate fabrication method for use with larger parts would reduce the cost of the large fairings.

APPENDIX A

PARTS CLASSIFICATION TREE AND CODING SYSTEM

NOTES FOR PARTS CLASSIFICATION TREE AND CODING SYSTEM

1. Each word in the tree is given a separate four-digit number.
2. No specific order is used but the simplest numbers are reserved for the highest breakdown levels in the tree.
3. Coding for a specific missile part is always preceded by its missile designator letters:

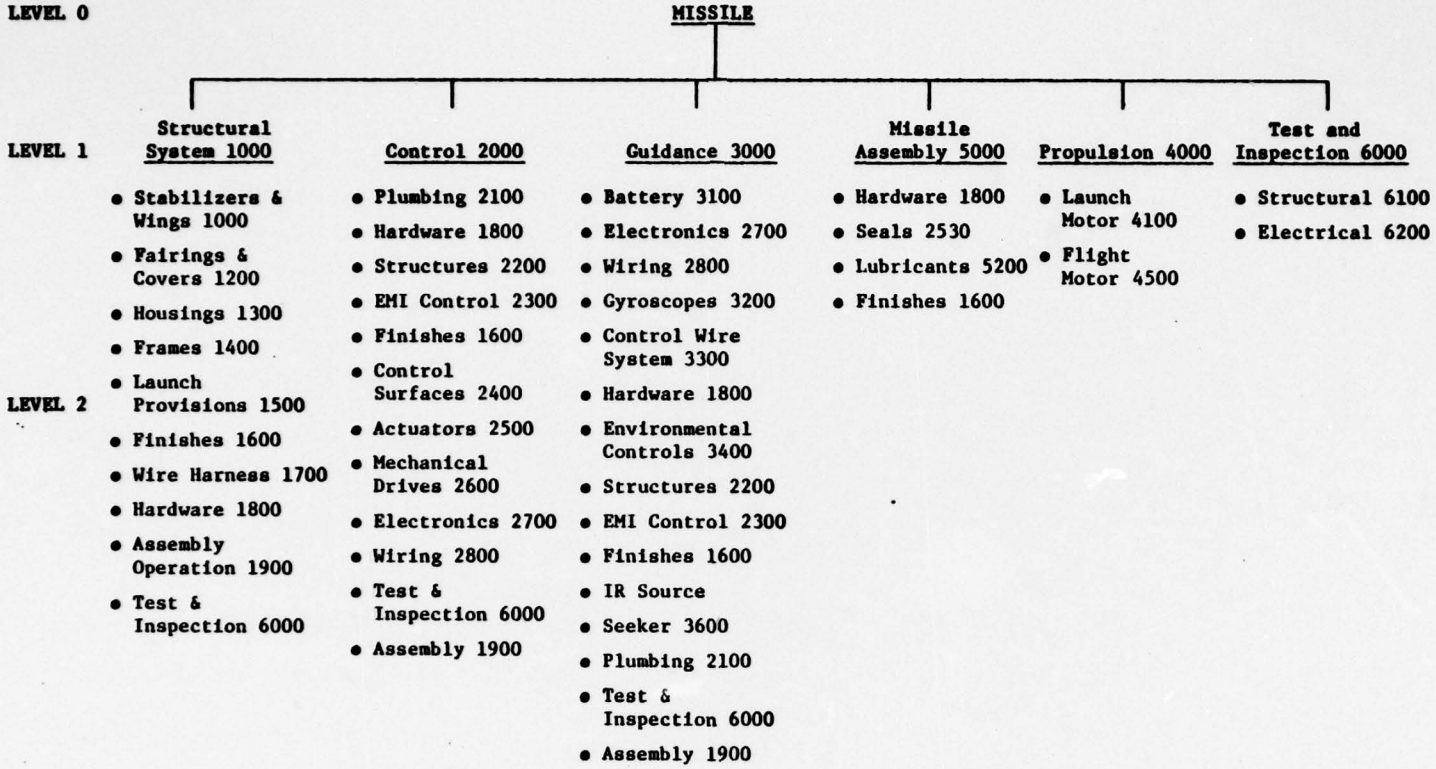
HELLFIRE -- HE

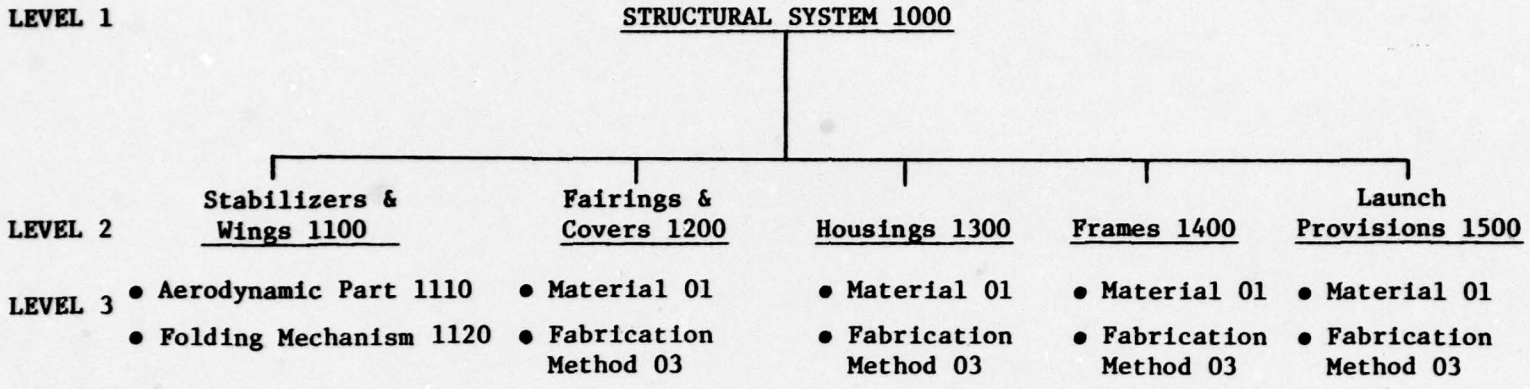
TOW -- TO

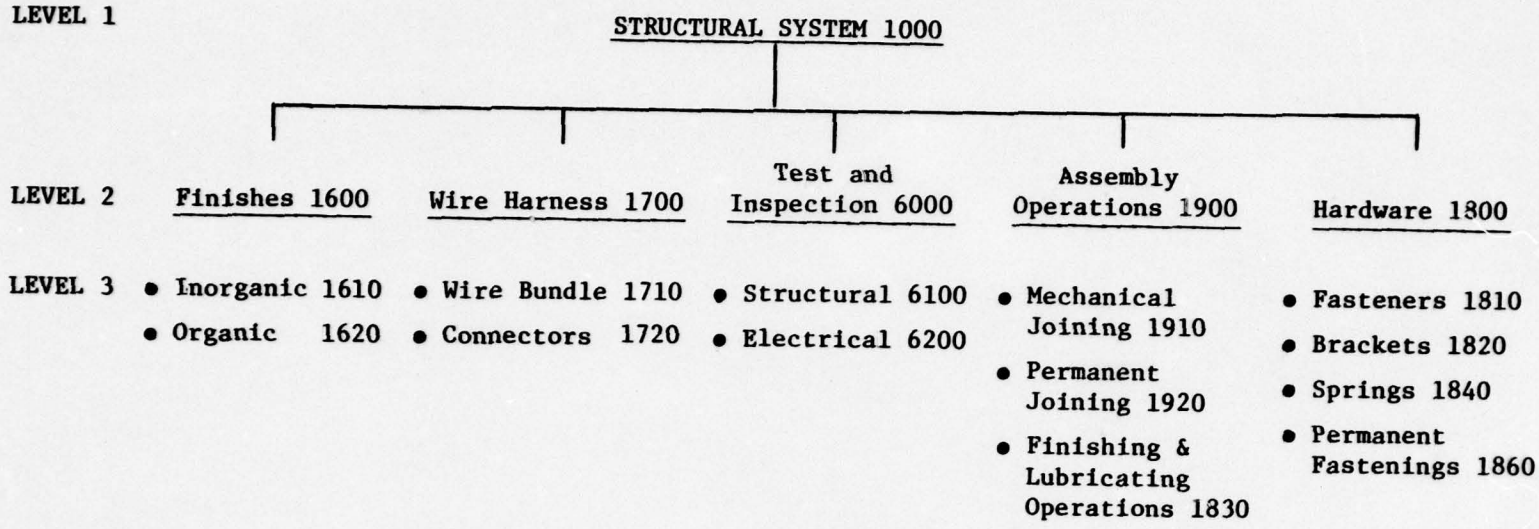
DRAWN -- DR

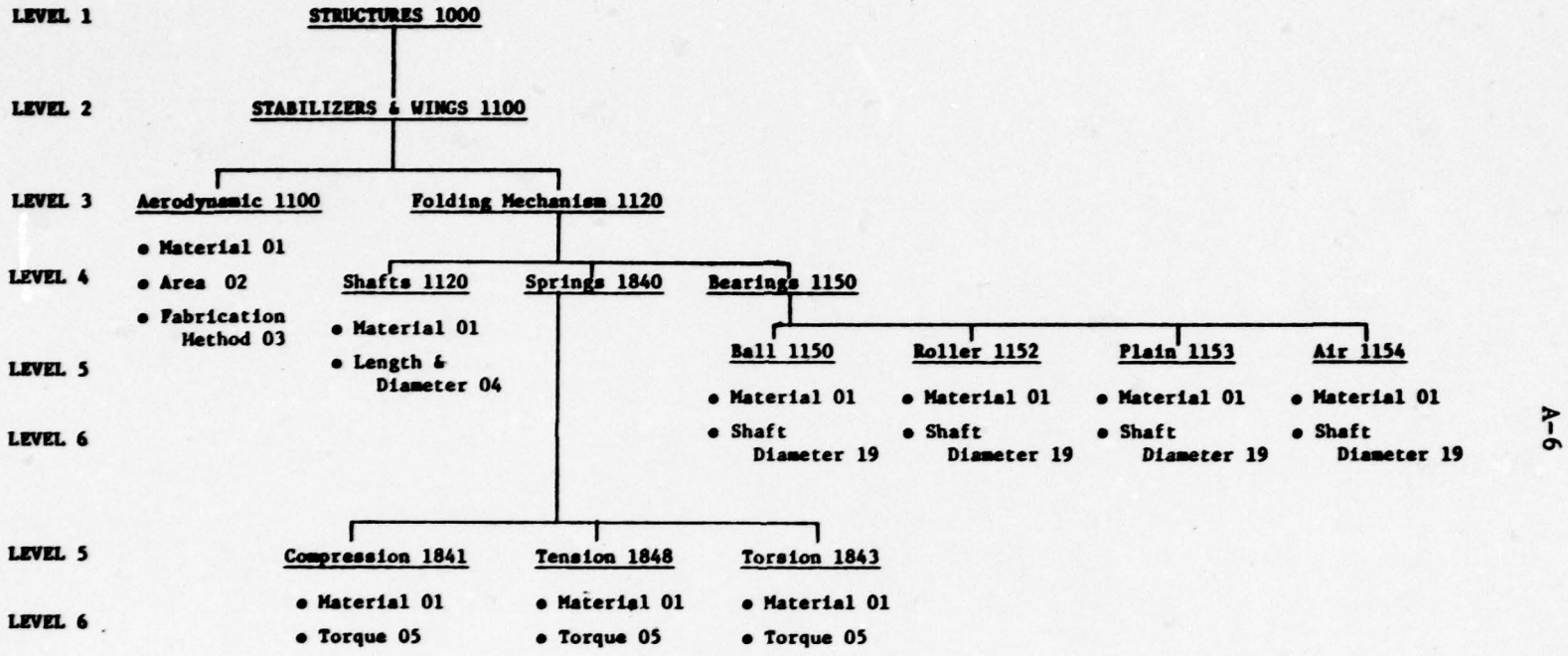
STINGER -- ST

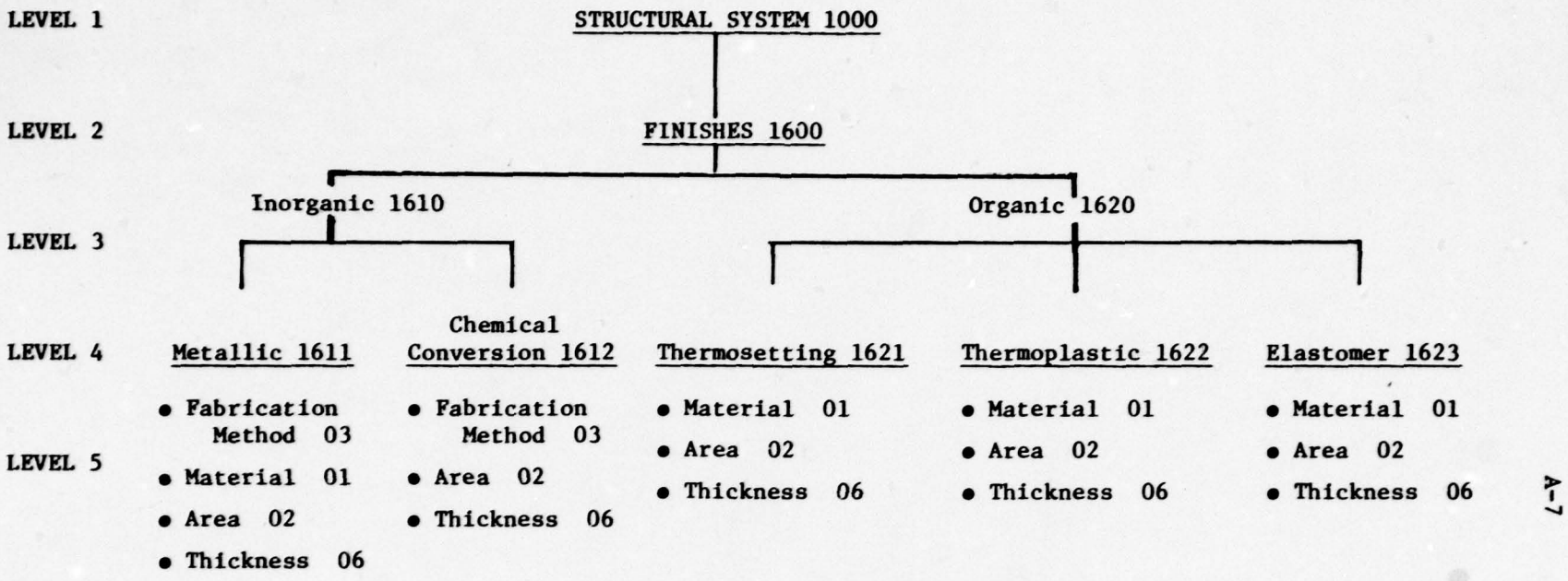
REDEYE -- RE

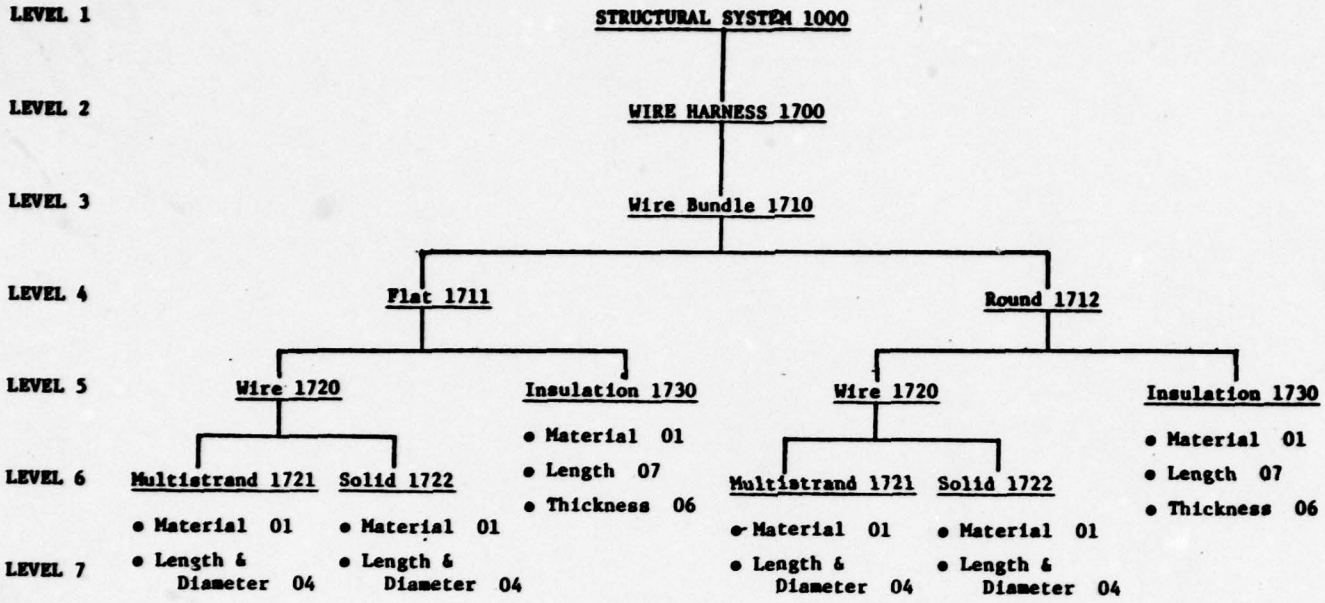

LEVEL 0
MISSILE
LEVEL 1
Structural System 1000
Control 2000
Guidance 3000
Missile Assembly 5000
Propulsion 4000
Test and Inspection 6000
LEVEL 2
• Stabilizers & Wings 1000
• Fairings & Covers 1200
• Housings 1300
• Frames 1400
• Launch Provisions 1500
• Finishes 1600
• Wire Harness 1700
• Hardware 1800
• Assembly Operation 1900
• Test & Inspection 6000
• Plumbing 2100
• Hardware 1800
• Structures 2200
• EMI Control 2300
• Finishes 1600
• Control Surfaces 2400
• Actuators 2500
• Mechanical Drives 2600
• Electronics 2700
• Wiring 2800
• Test & Inspection 6000
• Assembly 1900
• Battery 3100
• Electronics 2700
• Wiring 2800
• Gyroscopes 3200
• Control Wire System 3300
• Hardware 1800
• Environmental Controls 3400
• Structures 2200
• EMI Control 2300
• Finishes 1600
• IR Source
• Seeker 3600
• Plumbing 2100
• Test & Inspection 6000
• Assembly 1900
• Hardware 1800
• Seals 2530
• Lubricants 5200
• Finishes 1600
• Launch Motor 4100
• Flight Motor 4500
• Structural 6100
• Electrical 6200

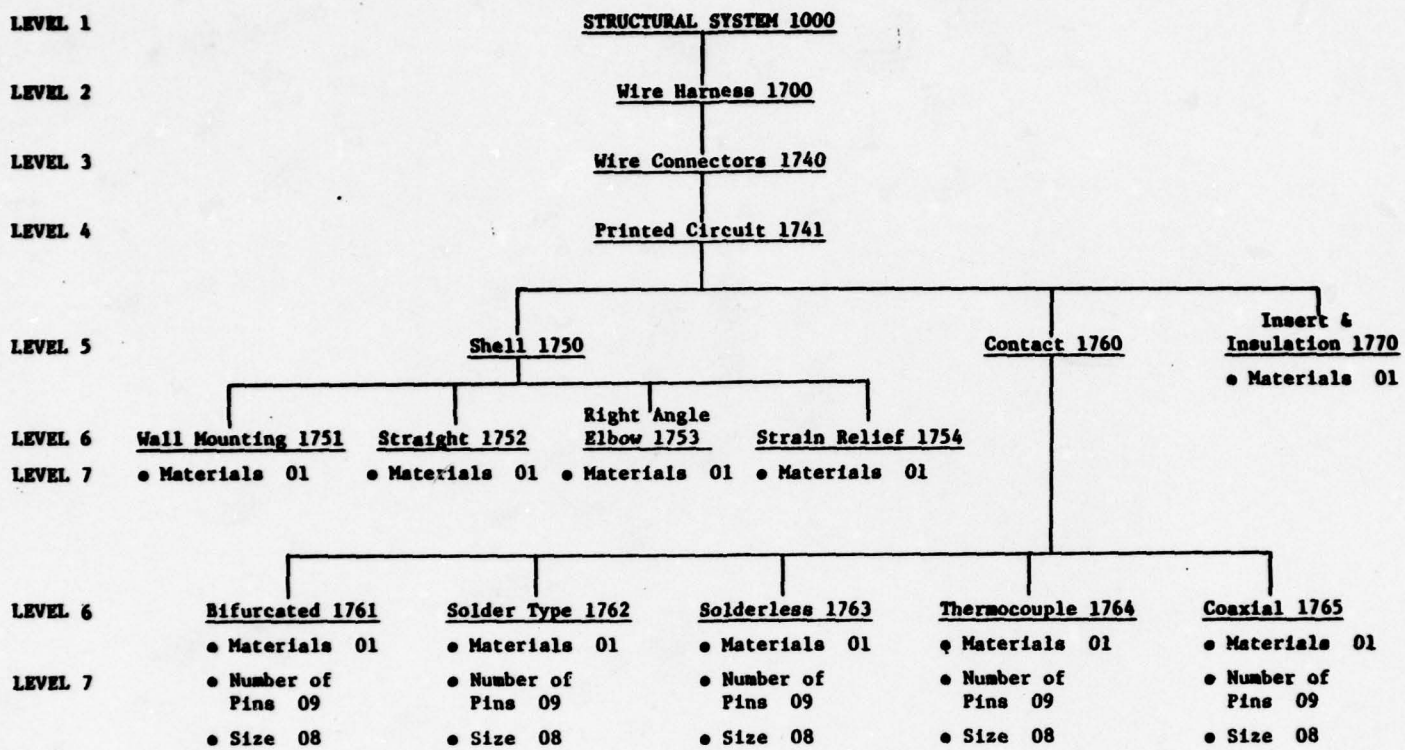

LEVEL 1
STRUCTURAL SYSTEM 1000
LEVEL 2
Stabilizers & Wings 1100
Fairings & Covers 1200
Housings 1300
Frames 1400
Launch Provisions 1500
LEVEL 3
• Aerodynamic Part 1110
• Folding Mechanism 1120
• Material 01
• Fabrication Method 03
• Material 01
• Fabrication Method 03
• Material 01
• Fabrication Method 03
• Material 01
• Fabrication Method 03

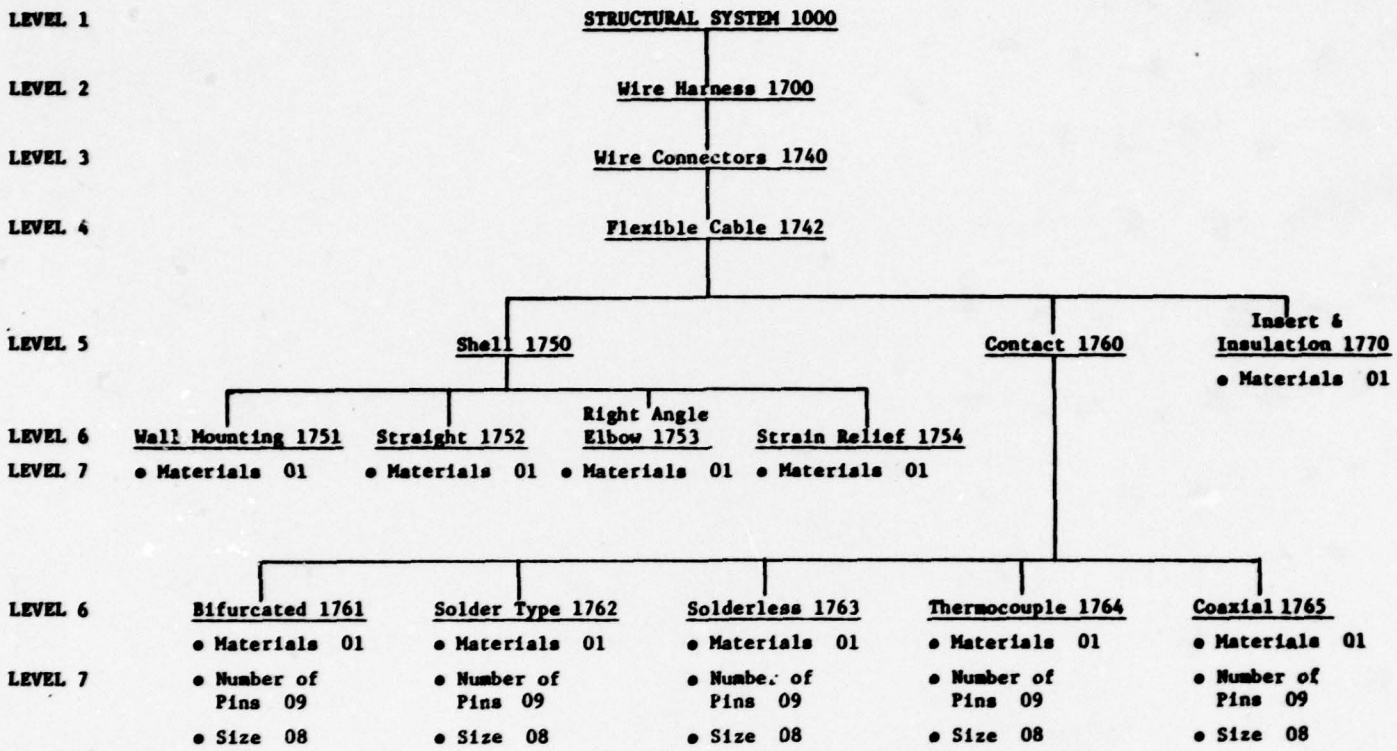

LEVEL 1
STRUCTURAL SYSTEM 1000
LEVEL 2
Finishes 1600
Wire Harness 1700
Test and Inspection 6000
Assembly Operations 1900
Hardware 1800
LEVEL 3
• Inorganic 1610
• Organic 1620
• Wire Bundle 1710
• Connectors 1720
• Structural 6100
• Electrical 6200
• Mechanical Joining 1910
• Permanent Joining 1920
• Finishing & Lubricating Operations 1830
• Fasteners 1810
• Brackets 1820
• Springs 1840
• Permanent Fastenings 1860

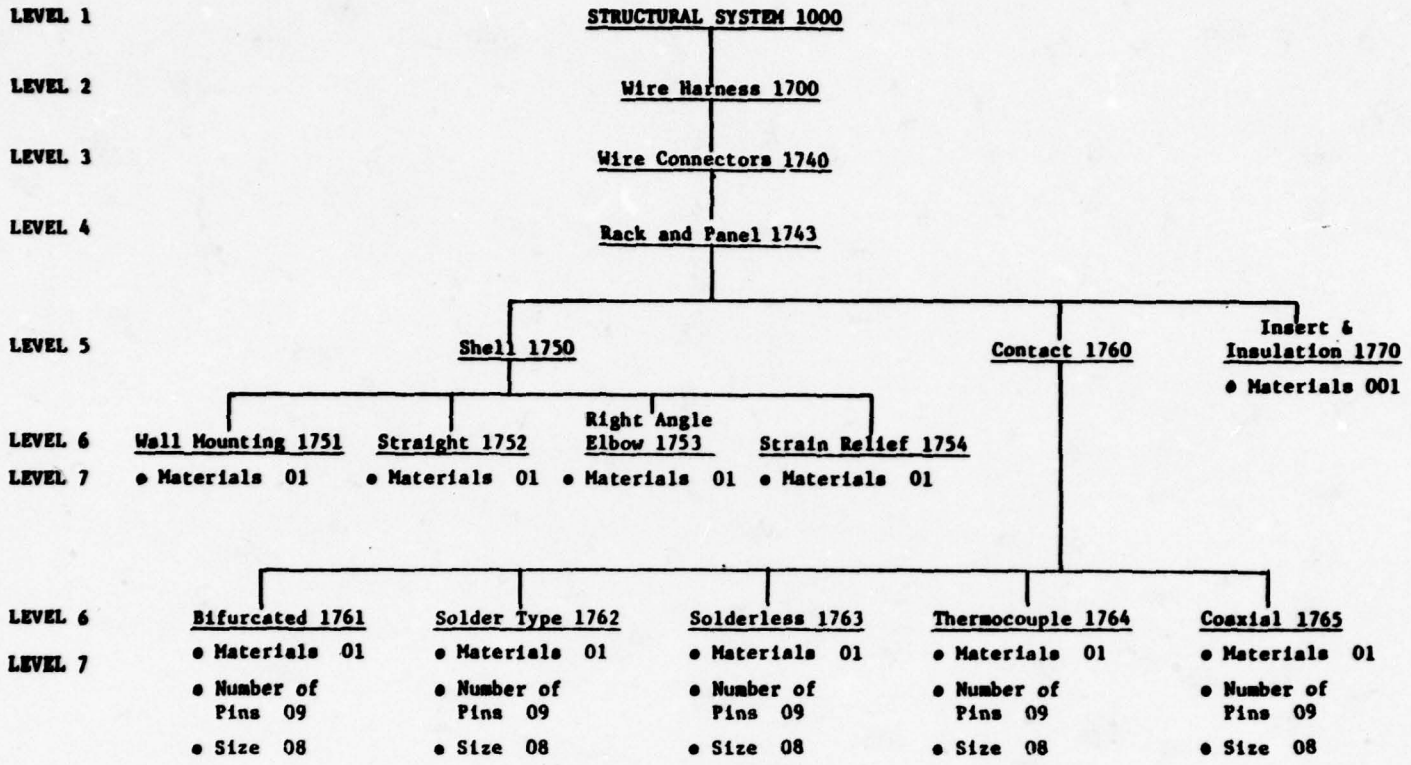

LEVEL 1
STRUCTURES 1000
LEVEL 2
STABILIZERS & WINGS 1100
LEVEL 3
Aerodynamic 1100
Folding Mechanism 1120
• Material 01
LEVEL 4
• Area 02
• Fabrication Method 03
Shafts 1120
Springs 1840
Bearings 1150
• Material 01
LEVEL 5
• Length & Diameter 04
Ball 1150
Roller 1152
Plain 1153
Air 1154
• Material 01
• Material 01
• Material 01
• Material 01
LEVEL 6
• Shaft Diameter 19
• Shaft Diameter 19
• Shaft Diameter 19
• Shaft Diameter 19
LEVEL 5
Compression 1841
Tension 1848
Torsion 1843
• Material 01
• Material 01
• Material 01
LEVEL 6
• Torque 05
• Torque 05
• Torque 05

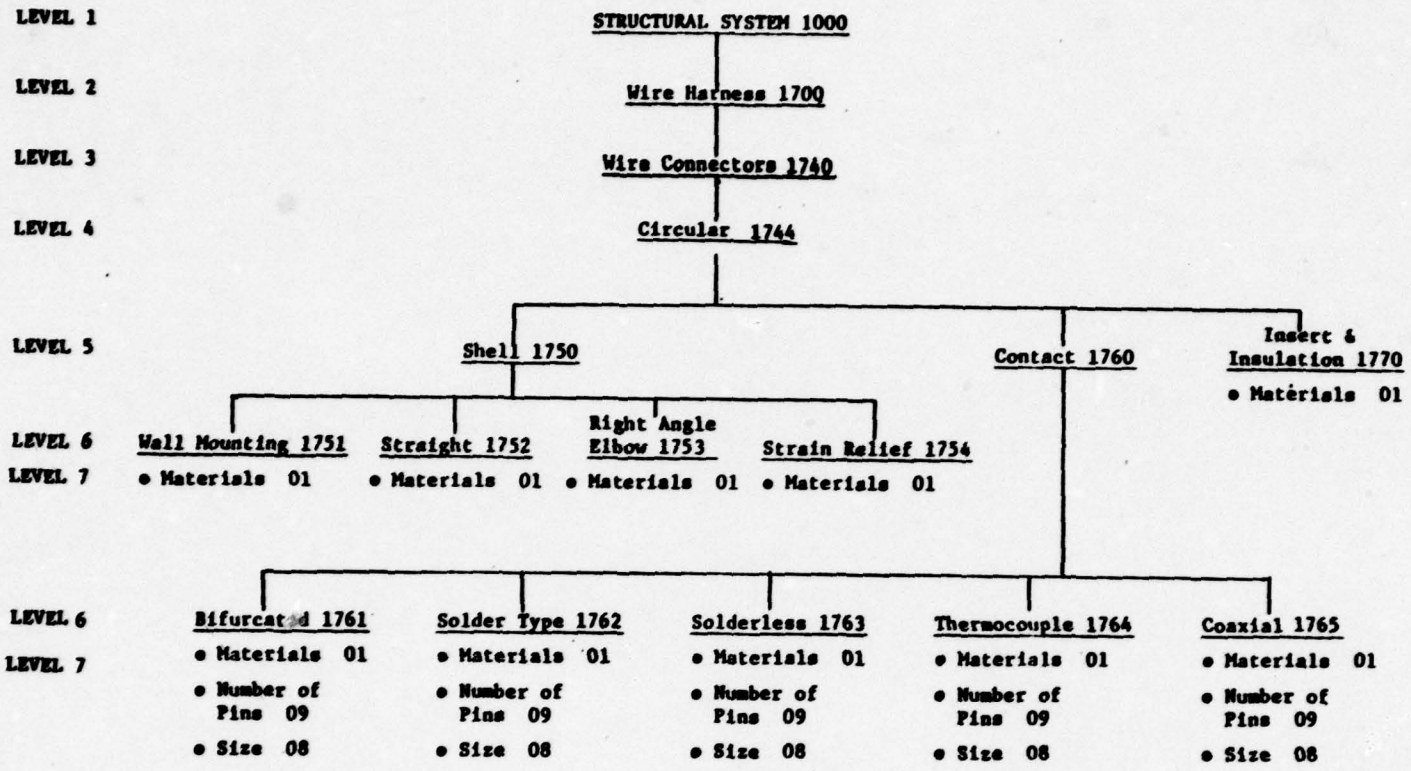

LEVEL 1
STRUCTURAL SYSTEM 1000
LEVEL 2
FINISHES 1600
LEVEL 3
Inorganic 1610
Organic 1620
LEVEL 4
Metallic 1611
Chemical Conversion 1612
Thermosetting 1621
Thermoplastic 1622
Elastomer 1623
LEVEL 5
• Fabrication Method 03
• Material 01
• Area 02
• Thickness 06
• Fabrication Method 03
• Area 02
• Thickness 06
• Material 01
• Area 02
• Thickness 06
• Material 01
• Area 02
• Thickness 06
• Material 01
• Area 02
• Thickness 06

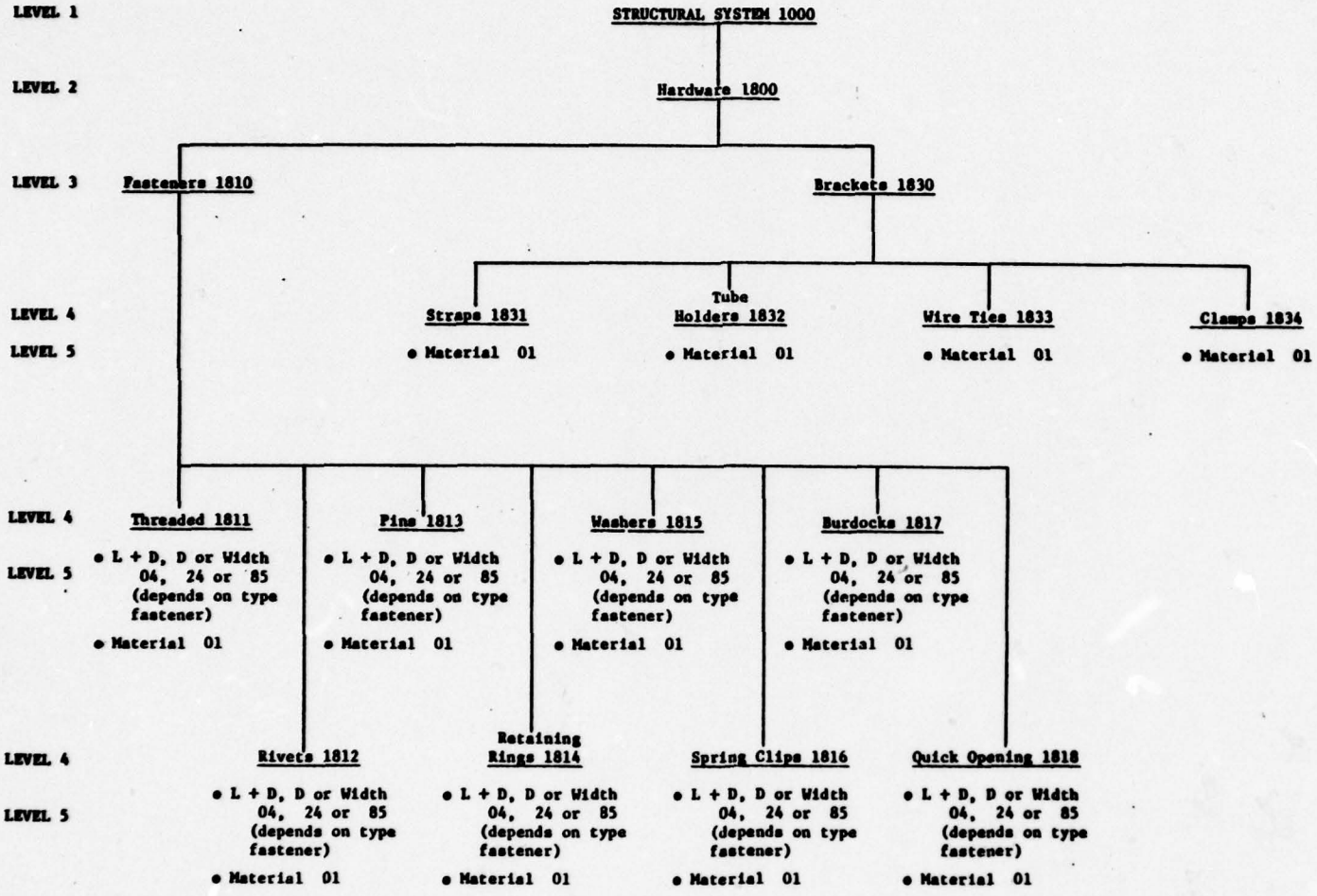

LEVEL 1
STRUCTURAL SYSTEM 1000
LEVEL 2
WIRE HARNESS 1700
LEVEL 3
Wire Bundle 1710
LEVEL 4
Flat 1711
Round 1712
LEVEL 5
Wire 1720
Insulation 1730
Wire 1720
Insulation 1730
• Material 01
• Length 07
• Thickness 06
• Material 01
• Length 07
• Thickness 06
LEVEL 6
Multistrand 1721
Solid 1722
Multistrand 1721
Solid 1722
LEVEL 7
• Material 01
• Length & Diameter 04
• Material 01
• Length & Diameter 04
• Material 01
• Length & Diameter 04
• Material 01
• Length & Diameter 04

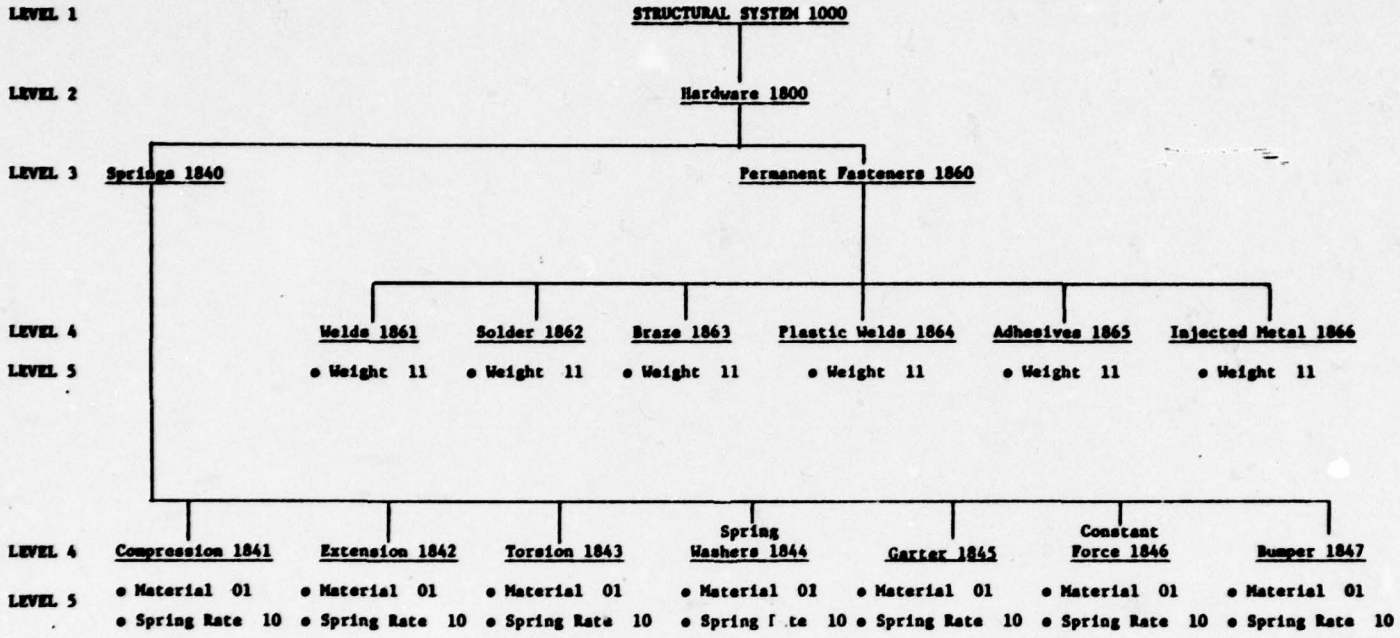

LEVEL 1
STRUCTURAL SYSTEM 1000
LEVEL 2
Wire Harness 1700
LEVEL 3
Wire Connectors 1740
LEVEL 4
Printed Circuit 1741
LEVEL 5
Shell 1750
Contact 1760
Insert & Insulation 1770
• Materials 01
LEVEL 6
Wall Mounting 1751
Straight 1752
Right Angle Elbow 1753
Strain Relief 1754
LEVEL 7
• Materials 01
• Materials 01
• Materials 01
• Materials 01
LEVEL 6
Bifurcated 1761
Solder Type 1762
Solderless 1763
Thermocouple 1764
Coaxial 1765
LEVEL 7
• Materials 01
• Number of Pins 09
• Size 08
• Materials 01
• Number of Pins 09
• Size 08
• Materials 01
• Number of Pins 09
• Size 08
• Materials 01
• Number of Pins 09
• Size 08
• Materials 01
• Number of Pins 09
• Size 08

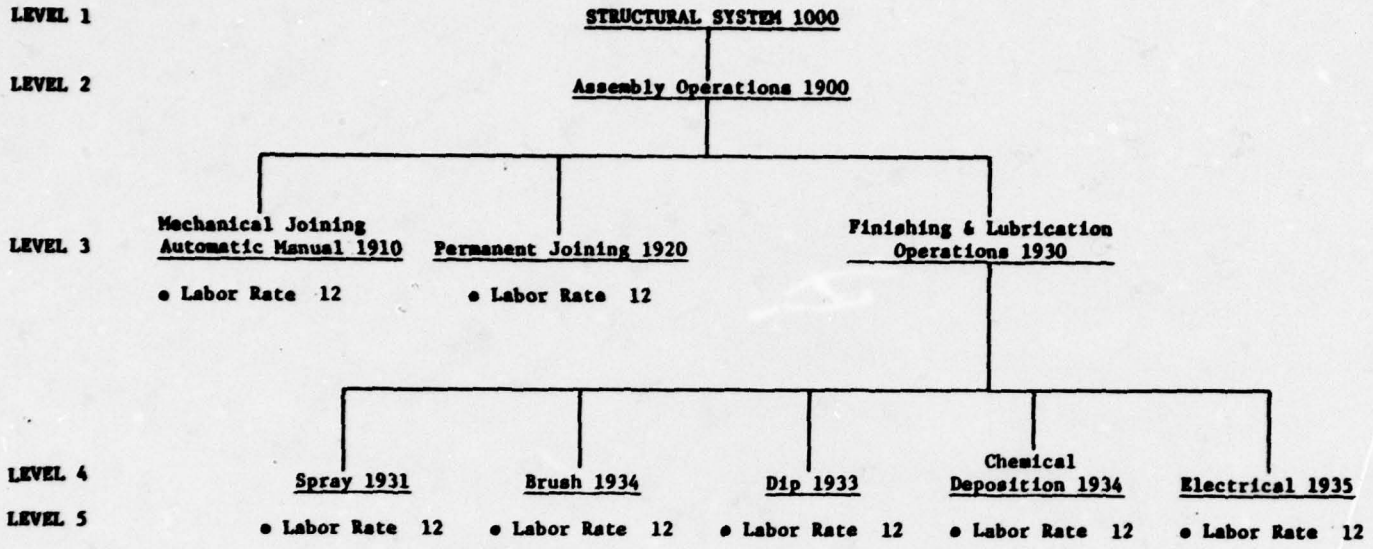

LEVEL 1
STRUCTURAL SYSTEM 1000
LEVEL 2
Wire Harness 1700
LEVEL 3
Wire Connectors 1740
LEVEL 4
Flexible Cable 1742
LEVEL 5
Shell 1750
Contact 1760
Insert & Insulation 1770
• Materials 01
LEVEL 6
Wall Mounting 1751
Straight 1752
Right Angle Elbow 1753
Strain Relief 1754
LEVEL 7
• Materials 01
• Materials 01
• Materials 01
• Materials 01
LEVEL 6
Bifurcated 1761
Solder Type 1762
Solderless 1763
Thermocouple 1764
Coaxial 1765
LEVEL 7
• Materials 01
• Number of Pins 09
• Size 08
• Materials 01
• Number of Pins 09
• Size 08
• Materials 01
• Number of Pins 09
• Size 08
• Materials 01
• Number of Pins 09
• Size 08
• Materials 01
• Number of Pins 09
• Size 08

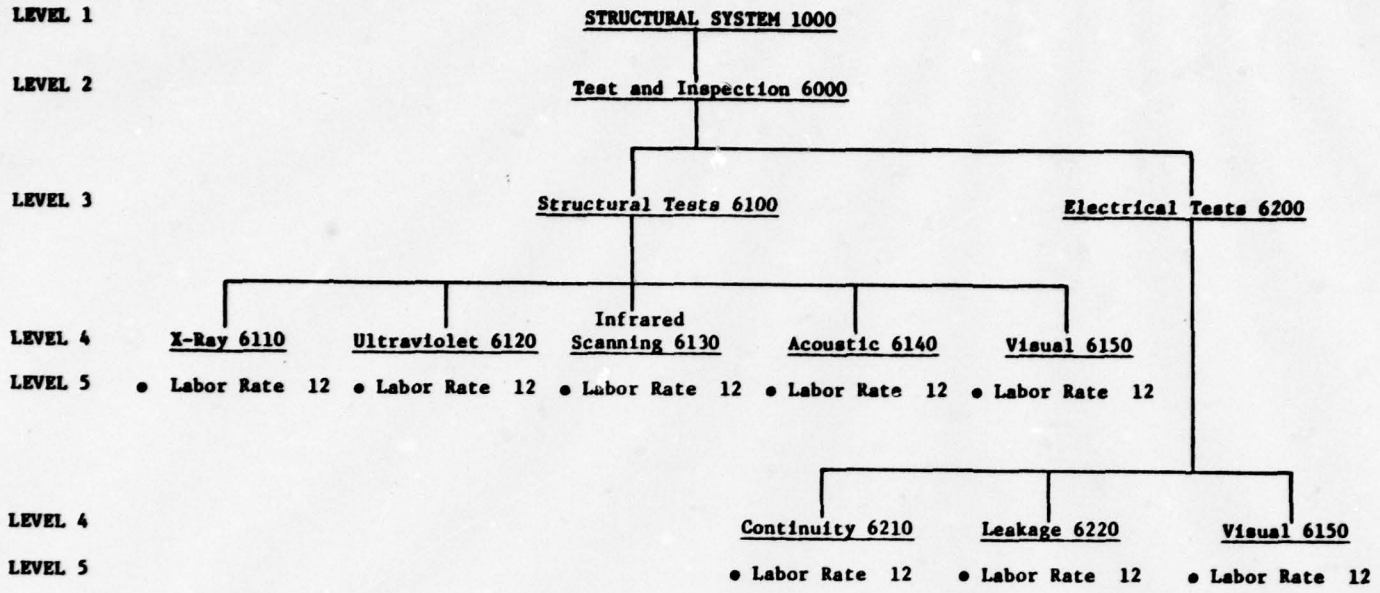

LEVEL 1
STRUCTURAL SYSTEM 1000
LEVEL 2
Wire Harness 1700
LEVEL 3
Wire Connectors 1740
LEVEL 4
Rack and Panel 1743
LEVEL 5
Shell 1750
Contact 1760
Insert & Insulation 1770
• Materials 001
LEVEL 6
Wall Mounting 1751
Straight 1752
Right Angle Elbow 1753
Strain Relief 1754
LEVEL 7
• Materials 01
• Materials 01
• Materials 01
• Materials 01
LEVEL 6
Bifurcated 1761
Solder Type 1762
Solderless 1763
Thermocouple 1764
Coaxial 1765
LEVEL 7
• Materials 01
• Number of Pins 09
• Size 08
• Materials 01
• Number of Pins 09
• Size 08
• Materials 01
• Number of Pins 09
• Size 08
• Materials 01
• Number of Pins 09
• Size 08
• Materials 01
• Number of Pins 09
• Size 08

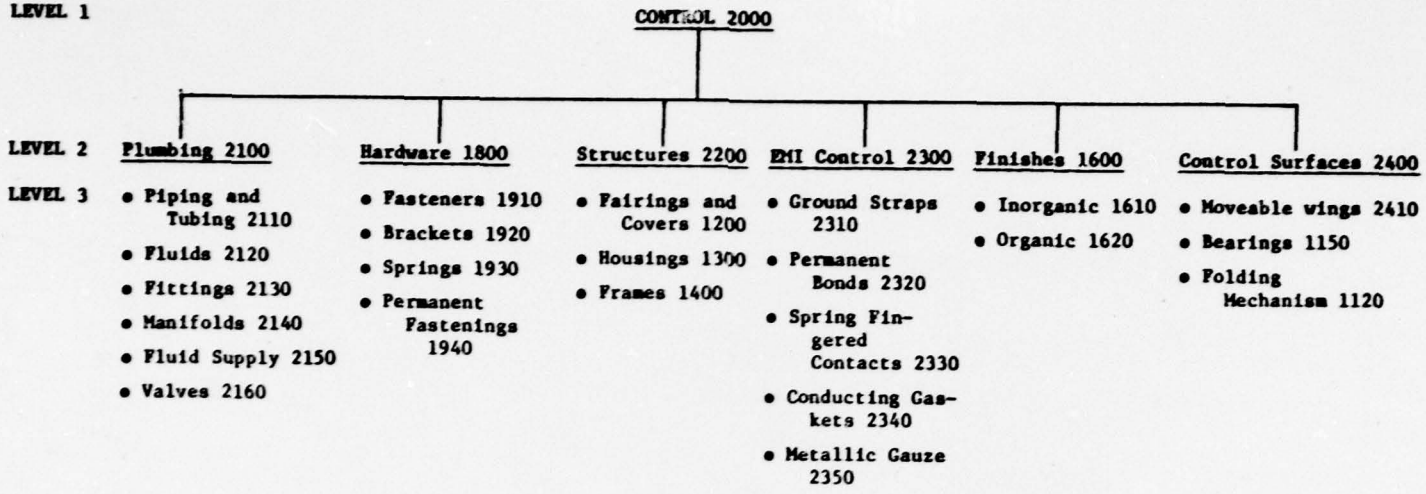

LEVEL 1
STRUCTURAL SYSTEM 1000
LEVEL 2
Wire Harness 1700
LEVEL 3
Wire Connectors 1740
LEVEL 4
Circular 1744
LEVEL 5
Shell 1750
Contact 1760
Insert & Insulation 1770
• Materials 01
LEVEL 6
Wall Mounting 1751
Straight 1752
Right Angle Elbow 1753
Strain Relief 1754
LEVEL 7
• Materials 01
• Materials 01
• Materials 01
• Materials 01
LEVEL 6
Bifurcated 1761
Solder Type 1762
Solderless 1763
Thermocouple 1764
Coaxial 1765
LEVEL 7
• Materials 01
• Number of Pins 09
• Size 08
• Materials 01
• Number of Pins 09
• Size 08
• Materials 01
• Number of Pins 09
• Size 08
• Materials 01
• Number of Pins 09
• Size 08
• Materials 01
• Number of Pins 09
• Size 08

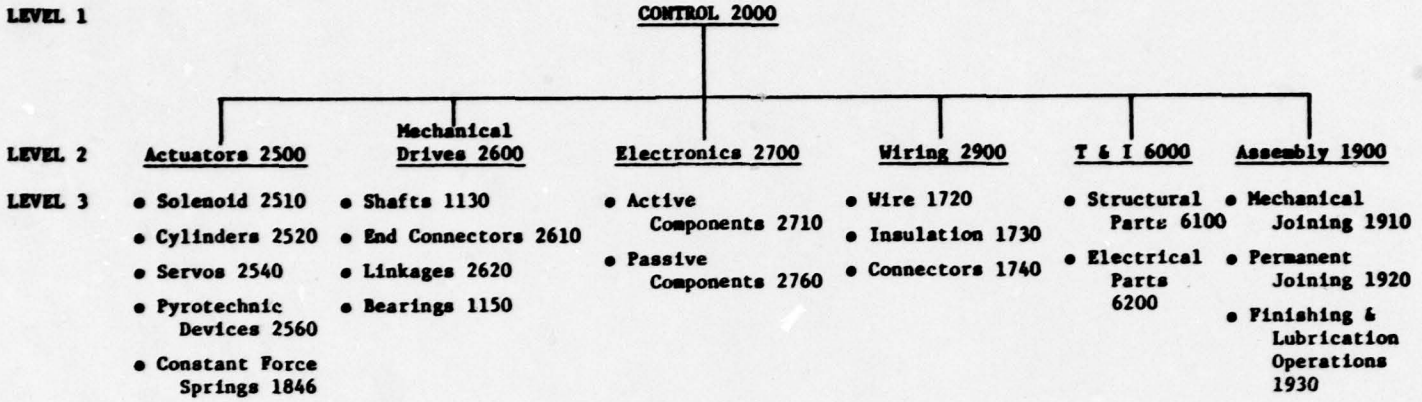

LEVEL 1
STRUCTURAL SYSTEM 1000
LEVEL 2
Hardware 1800
LEVEL 3
Fasteners 1810
Brackets 1830
LEVEL 4
Straps 1831
Tube Holders 1832
Wire Ties 1833
Clamps 1834
LEVEL 5
• Material 01
• Material 01
• Material 01
• Material 01
LEVEL 4
Threaded 1811
Pins 1813
Washers 1815
Burdocks 1817
LEVEL 5
• L + D, D or Width 04, 24 or 85 (depends on type fastener)
• Material 01
• L + D, D or Width 04, 24 or 85 (depends on type fastener)
• Material 01
• L + D, D or Width 04, 24 or 85 (depends on type fastener)
• Material 01
• L + D, D or Width 04, 24 or 85 (depends on type fastener)
• Material 01
LEVEL 4
Rivets 1812
Retaining Rings 1814
Spring Clips 1816
Quick Opening 1818
LEVEL 5
• L + D, D or Width 04, 24 or 85 (depends on type fastener)
• Material 01
• L + D, D or Width 04, 24 or 85 (depends on type fastener)
• Material 01
• L + D, D or Width 04, 24 or 85 (depends on type fastener)
• Material 01
• L + D, D or Width 04, 24 or 85 (depends on type fastener)
• Material 01

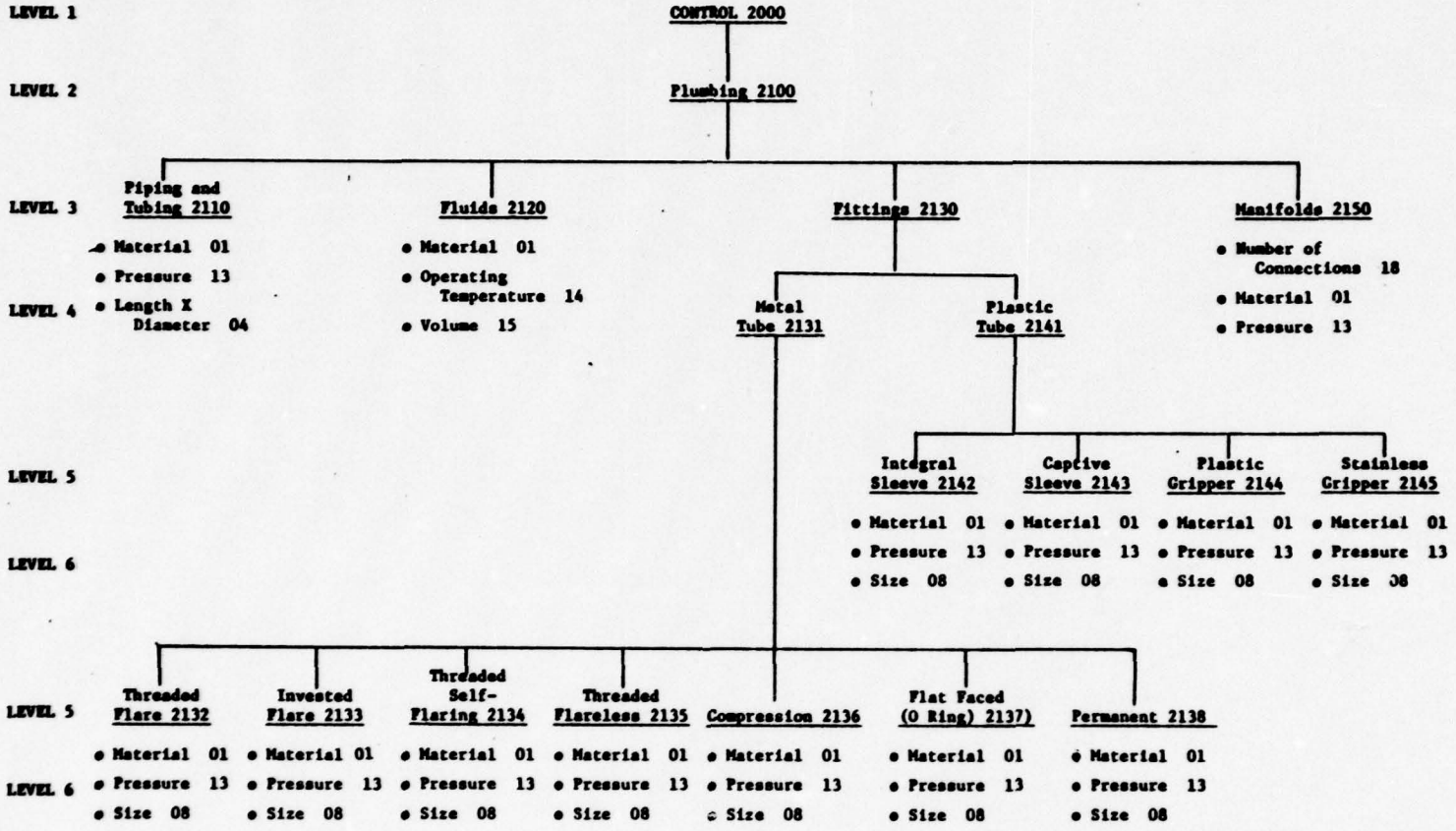

LEVEL 1
STRUCTURAL SYSTEM 1000
LEVEL 2
Hardware 1800
LEVEL 3
Springs 1840
Permanent Fasteners 1860
LEVEL 4
Welds 1861
Solder 1862
Braze 1863
Plastic Welds 1864
Adhesives 1865
Injected Metal 1866
LEVEL 5
• Weight 11
• Weight 11
• Weight 11
• Weight 11
• Weight 11
• Weight 11
LEVEL 4
Compression 1841
Extension 1842
Torsion 1843
Spring Washers 1844
Garter 1845
Constant Force 1846
Bumper 1847
LEVEL 5
• Material 01
• Spring Rate 10
• Material 01
• Spring Rate 10
• Material 01
• Spring Rate 10
• Material 01
• Spring Rate 10
• Material 01
• Spring Rate 10
• Material 01
• Spring Rate 10
• Material 01
• Spring Rate 10

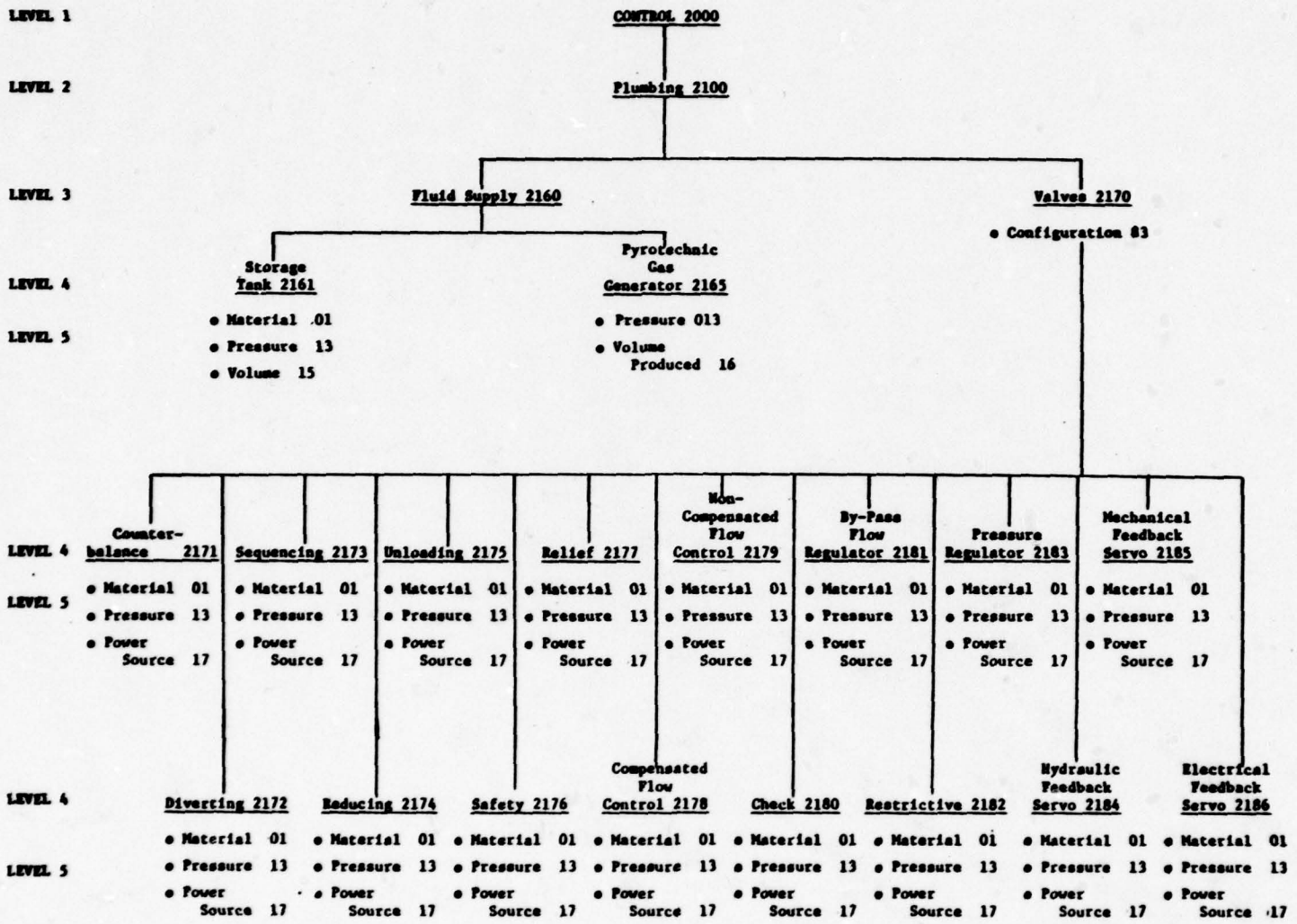

LEVEL 1
STRUCTURAL SYSTEM 1000
LEVEL 2
Assembly Operations 1900
LEVEL 3
Mechanical Joining Automatic Manual 1910
• Labor Rate 12
Permanent Joining 1920
• Labor Rate 12
Finishing & Lubrication Operations 1930
LEVEL 4
Spray 1931
Brush 1934
Dip 1933
Chemical Deposition 1934
Electrical 1935
LEVEL 5
• Labor Rate 12
• Labor Rate 12
• Labor Rate 12
• Labor Rate 12
• Labor Rate 12

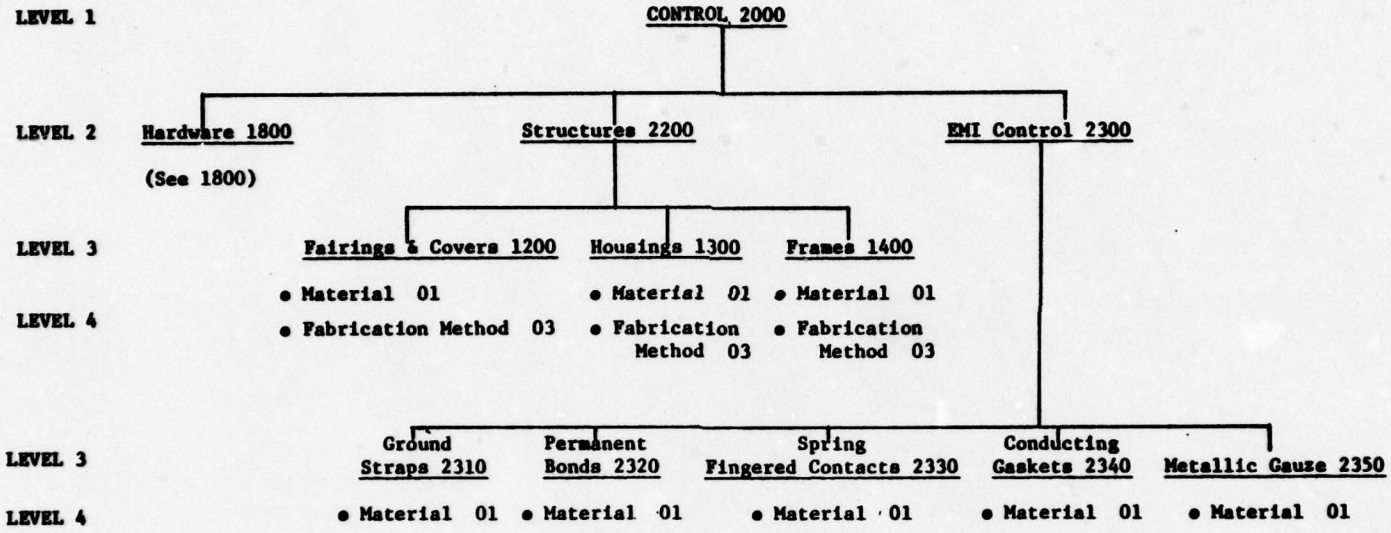

LEVEL 1
STRUCTURAL SYSTEM 1000
LEVEL 2
Test and Inspection 6000
LEVEL 3
Structural Tests 6100
Electrical Tests 6200
LEVEL 4
X-Ray 6110
Ultraviolet 6120
Infrared Scanning 6130
Acoustic 6140
Visual 6150
LEVEL 5
• Labor Rate 12
• Labor Rate 12
• Labor Rate 12
• Labor Rate 12
• Labor Rate 12
LEVEL 4
Continuity 6210
Leakage 6220
Visual 6150
LEVEL 5
• Labor Rate 12
• Labor Rate 12
• Labor Rate 12

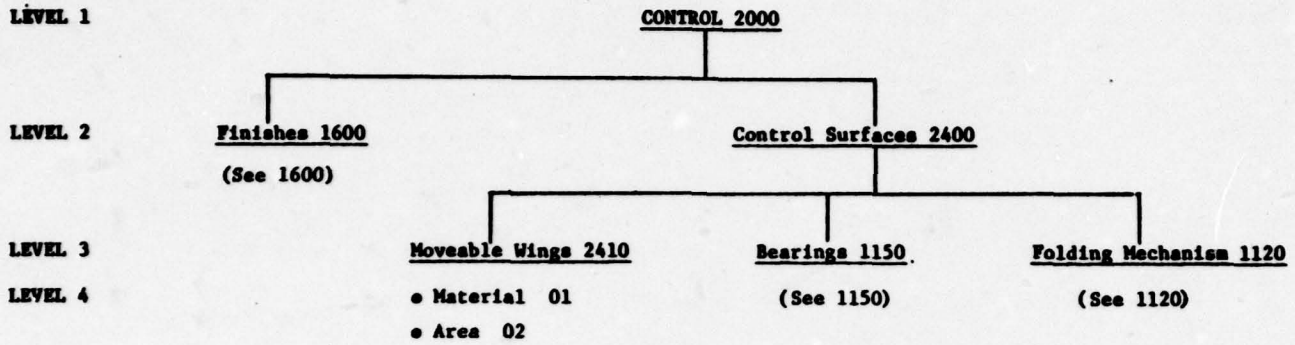

LEVEL 1
CONTROL 2000
LEVEL 2
Plumbing 2100
Hardware 1800
Structures 2200
EMI Control 2300
Finishes 1600
Control Surfaces 2400
LEVEL 3
• Piping and Tubing 2110
• Fluids 2120
• Fittings 2130
• Manifolds 2140
• Fluid Supply 2150
• Valves 2160
• Fasteners 1910
• Brackets 1920
• Springs 1930
• Permanent Fastenings 1940
• Fairings and Covers 1200
• Housings 1300
• Frames 1400
• Ground Straps 2310
• Permanent Bonds 2320
• Spring Fingered Contacts 2330
• Conducting Gaskets 2340
• Metallic Gauze 2350
• Inorganic 1610
• Organic 1620
• Moveable wings 2410
• Bearings 1150
• Folding Mechanism 1120

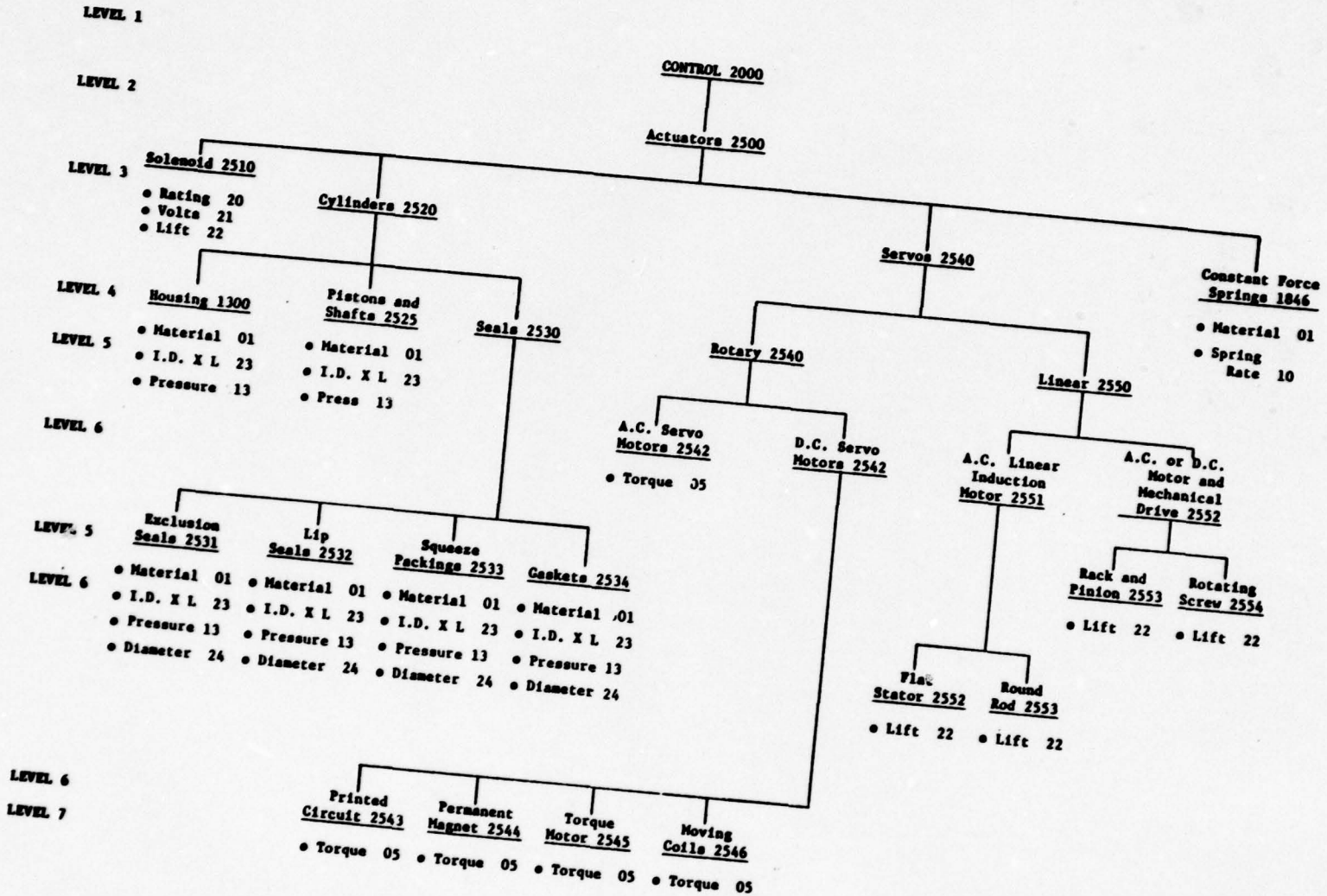

LEVEL 1
CONTROL 2000
LEVEL 2
Actuators 2500
Mechanical Drives 2600
Electronics 2700
Wiring 2900
T & I 6000
Assembly 1900
LEVEL 3
• Solenoid 2510
• Cylinders 2520
• Servos 2540
• Pyrotechnic Devices 2560
• Constant Force Springs 1846
• Shafts 1130
• End Connectors 2610
• Linkages 2620
• Bearings 1150
• Active Components 2710
• Passive Components 2760
• Wire 1720
• Insulation 1730
• Connectors 1740
• Structural Parts 6100
• Electrical Parts 6200
• Mechanical Joining 1910
• Permanent Joining 1920
• Finishing & Lubrication Operations 1930

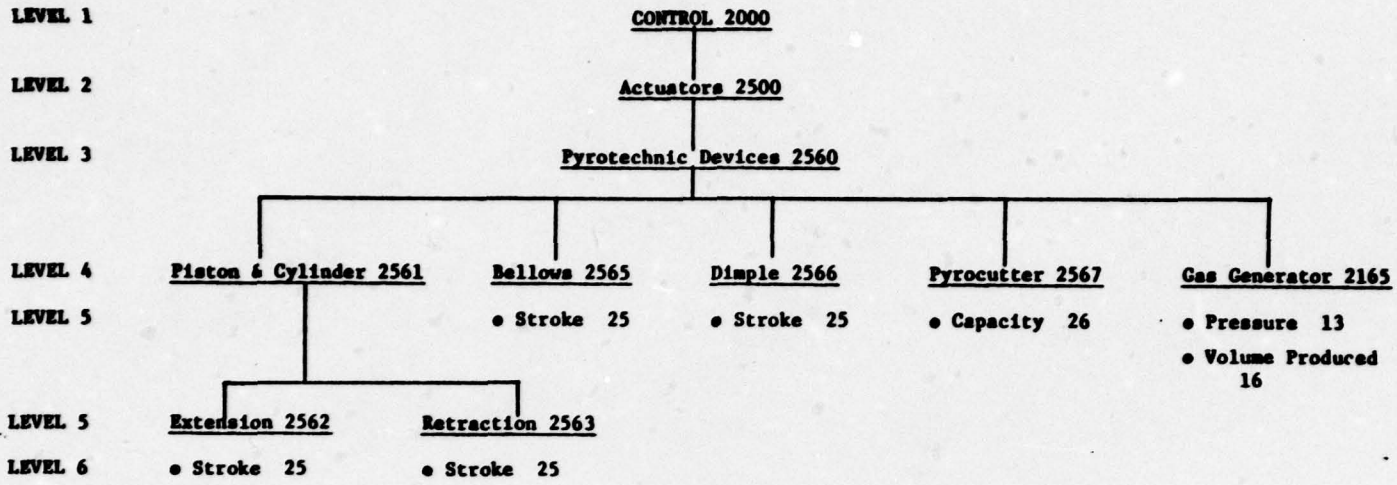

LEVEL 1
CONTROL 2000
LEVEL 2
Plumbing 2100
LEVEL 3
Piping and Tubing 2110
Fluids 2120
Fittings 2130
Manifolds 2150
• Material 01
• Pressure 13
LEVEL 4
• Length X Diameter 04
• Material 01
• Operating Temperature 14
• Volume 15
Metal Tube 2131
Plastic Tube 2141
• Number of Connections 18
• Material 01
• Pressure 13
LEVEL 5
Integral Sleeve 2142
Captive Sleeve 2143
Plastic Gripper 2144
Stainless Gripper 2145
• Material 01
• Pressure 13
• Size 08
LEVEL 6
LEVEL 5
Threaded Flare 2132
Invested Flare 2133
Threaded Self-Flaring 2134
Threaded Flareless 2135
Compression 2136
Flat Faced (O Ring) 2137)
Permanent 2138
LEVEL 6
• Material 01
• Pressure 13
• Size 08

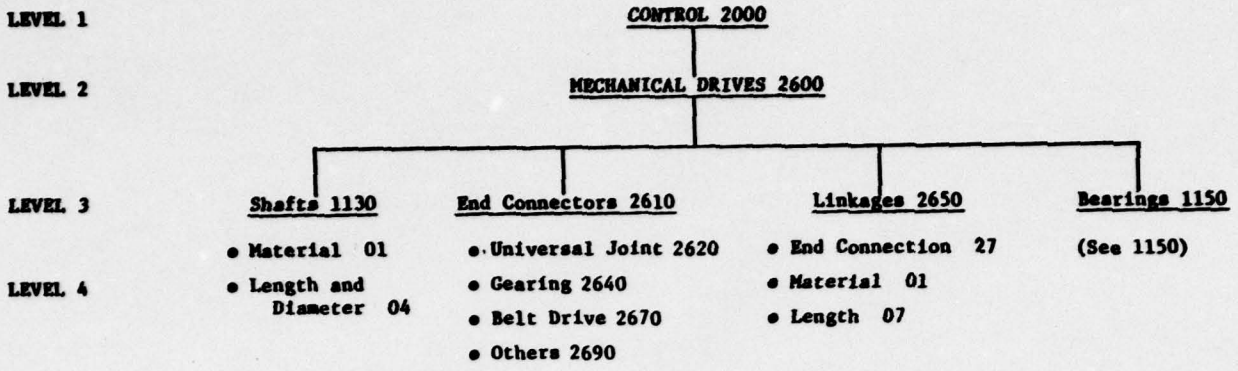

LEVEL 1
CONTROL 2000
LEVEL 2
Plumbing 2100
LEVEL 3
Fluid Supply 2160
Valves 2170
• Configuration 83
LEVEL 4
Storage Tank 2161
Pyrotechnic Gas Generator 2165
LEVEL 5
• Material 01
• Pressure 13
• Volume 15
• Pressure 013
• Volume Produced 16
LEVEL 4
Counter-balance 2171
Sequencing 2173
Unloading 2175
Relief 2177
Non-Compensated Flow Control 2179
By-Pass Flow Regulator 2181
Pressure Regulator 2183
Mechanical Feedback Servo 2185
LEVEL 5
• Material 01
• Pressure 13
• Power Source 17
LEVEL 4
Diverting 2172
Reducing 2174
Safety 2176
Compensated Flow Control 2178
Check 2180
Restrictive 2182
Hydraulic Feedback Servo 2184
Electrical Feedback Servo 2186
LEVEL 5
• Material 01
• Pressure 13
• Power Source 17

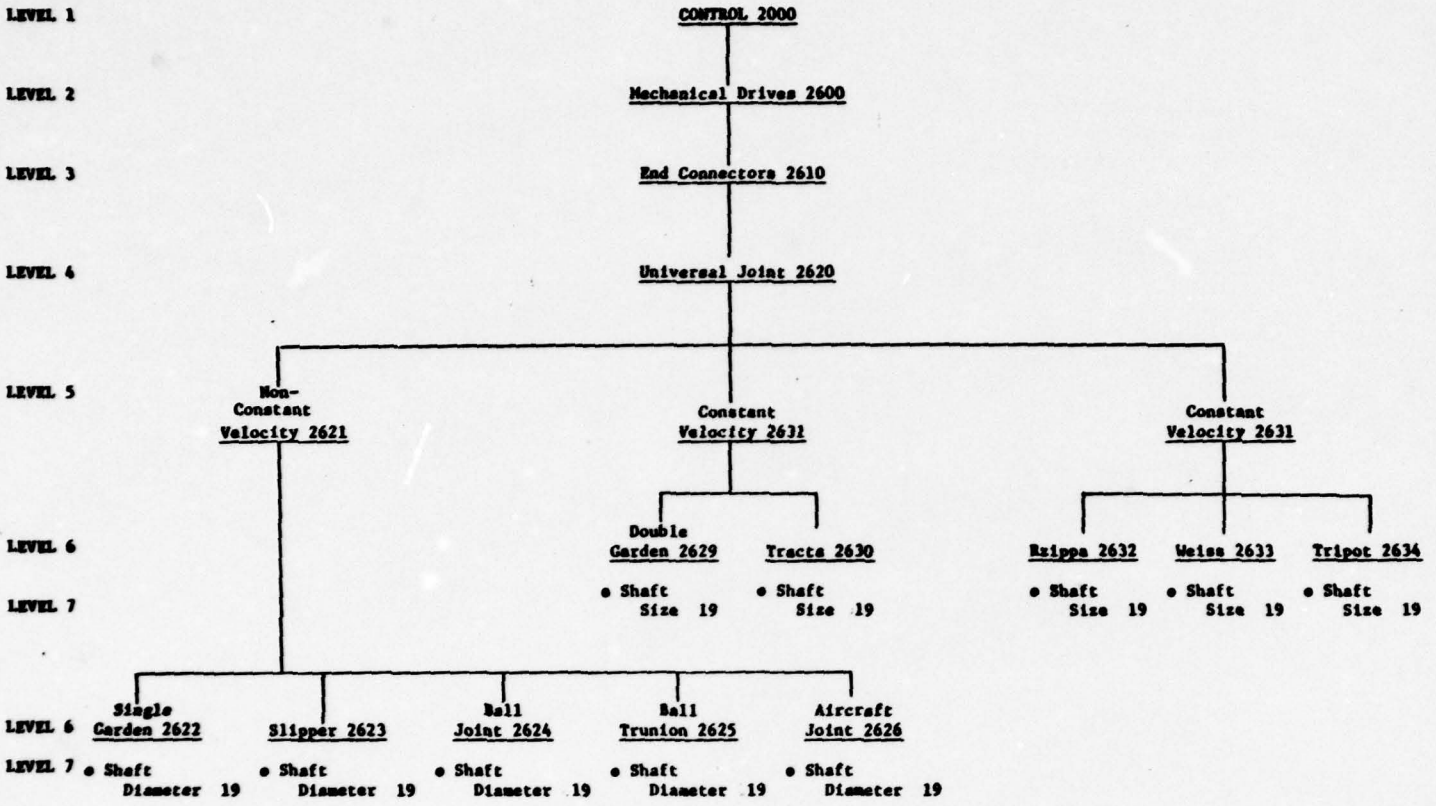

LEVEL 1
CONTROL 2000
LEVEL 2
Hardware 1800
(See 1800)
Structures 2200
EMI Control 2300
LEVEL 3
Fairings & Covers 1200
Housings 1300
Frames 1400
LEVEL 4
• Material 01
• Fabrication Method 03
• Material 01
• Fabrication Method 03
• Material 01
• Fabrication Method 03
LEVEL 3
Ground Straps 2310
Permanent Bonds 2320
Spring Fingered Contacts 2330
Conducting Gaskets 2340
Metallic Gauze 2350
LEVEL 4
• Material 01
• Material 01
• Material 01
• Material 01
• Material 01

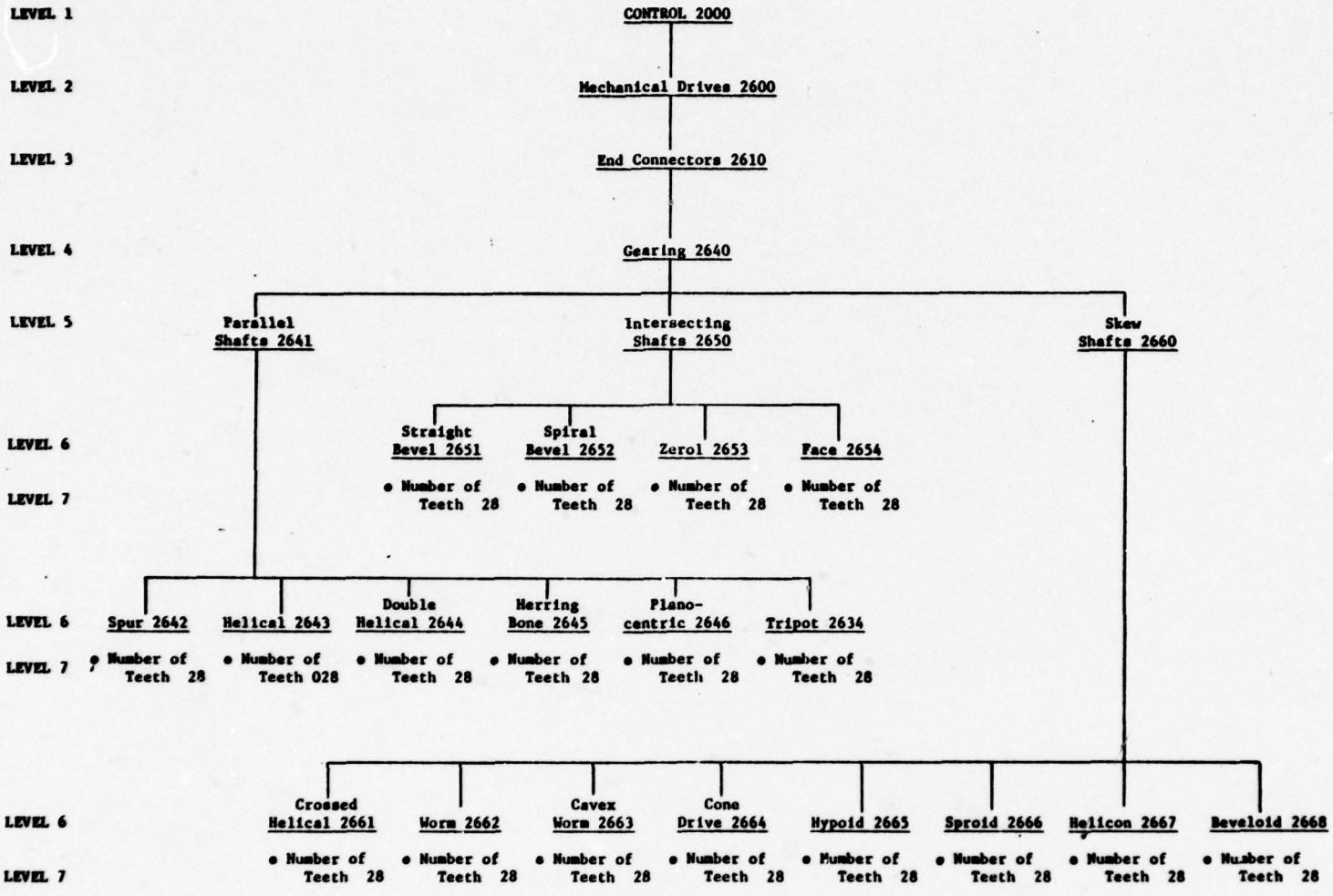

LEVEL 1
CONTROL 2000
LEVEL 2
Finishes 1600
(See 1600)
Control Surfaces 2400
LEVEL 3
Moveable Wings 2410
Bearings 1150
Folding Mechanism 1120
LEVEL 4
• Material 01
• Area 02
(See 1150)
(See 1120)

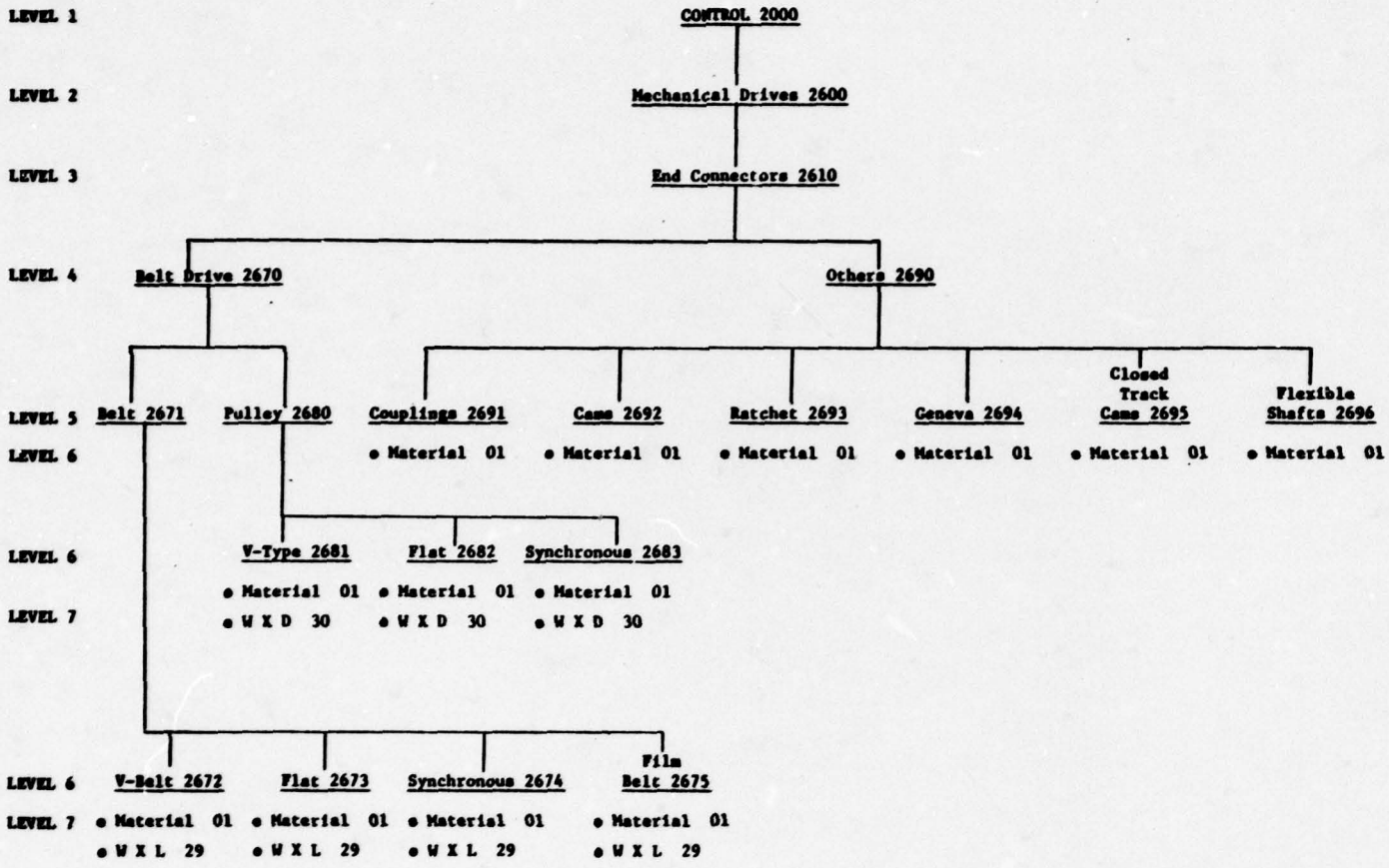

LEVEL 1
LEVEL 2
CONTROL 2000
Actuators 2500
LEVEL 3
Solenoid 2510
• Rating 20
• Volts 21
• Lift 22
Cylinders 2520
Servos 2540
Constant Force Springs 1846
• Material 01
• Spring Rate 10
LEVEL 4
Housing 1300
Pistons and Shafts 2525
Seals 2530
Rotary 2540
Linear 2550
LEVEL 5
• Material 01
• I.D. X L 23
• Pressure 13
• Material 01
• I.D. X L 23
• Press 13
LEVEL 6
A.C. Servo Motors 2542
• Torque 05
D.C. Servo Motors 2542
A.C. Linear Induction Motor 2551
A.C. or D.C. Motor and Mechanical Drive 2552
LEVEL 5
Exclusion Seals 2531
Lip Seals 2532
Squeeze Packings 2533
Gaskets 2534
LEVEL 6
• Material 01
• I.D. X L 23
• Pressure 13
• Diameter 24
• Material 01
• I.D. X L 23
• Pressure 13
• Diameter 24
• Material 01
• I.D. X L 23
• Pressure 13
• Diameter 24
• Material 01
• I.D. X L 23
• Pressure 13
• Diameter 24
Rack and Pinion 2553
• Lift 22
Rotating Screw 2554
• Lift 22
Flat Stator 2552
• Lift 22
Round Rod 2553
• Lift 22
LEVEL 6
LEVEL 7
Printed Circuit 2543
• Torque 05
Permanent Magnet 2544
• Torque 05
Torque Motor 2545
• Torque 05
Moving Coils 2546
• Torque 05


LEVEL 1
CONTROL 2000
LEVEL 2
Actuators 2500
LEVEL 3
Pyrotechnic Devices 2560
LEVEL 4
Piston & Cylinder 2561
Bellows 2565
Dimple 2566
Pyrocutter 2567
Gas Generator 2165
LEVEL 5
• Stroke 25
• Stroke 25
• Capacity 26
• Pressure 13
• Volume Produced 16
LEVEL 5
Extension 2562
Retraction 2563
LEVEL 6
• Stroke 25
• Stroke 25


LEVEL 1
CONTROL 2000
LEVEL 2
MECHANICAL DRIVES 2600
LEVEL 3
Shafts 1130
End Connectors 2610
Linkages 2650
Bearings 1150
• Material 01
• Length and Diameter 04
• Universal Joint 2620
• Gearing 2640
• Belt Drive 2670
• Others 2690
• End Connection 27
• Material 01
• Length 07
(See 1150)
LEVEL 4
LEVEL 4
LEVEL 5


LEVEL 1
CONTROL 2000
LEVEL 2
Mechanical Drives 2600
LEVEL 3
End Connectors 2610
LEVEL 4
Universal Joint 2620
LEVEL 5
Non-Constant Velocity 2621
Constant Velocity 2631
Constant Velocity 2631
LEVEL 6
Double Garden 2629
Tracta 2630
Rzippa 2632
Weiss 2633
Tripot 2634
LEVEL 7
• Shaft Size 19
• Shaft Size 19
• Shaft Size 19
• Shaft Size 19
• Shaft Size 19
LEVEL 6
Single Garden 2622
Slipper 2623
Ball Joint 2624
Ball Trunion 2625
Aircraft Joint 2626
LEVEL 7
• Shaft Diameter 19
• Shaft Diameter 19
• Shaft Diameter 19
• Shaft Diameter 19
• Shaft Diameter 19


LEVEL 1
CONTROL 2000
LEVEL 2
Mechanical Drives 2600
LEVEL 3
End Connectors 2610
LEVEL 4
Gearing 2640
LEVEL 5
Parallel Shafts 2641
Intersecting Shafts 2650
Skew Shafts 2660
LEVEL 6
Straight Bevel 2651
Spiral Bevel 2652
Zerol 2653
Face 2654
LEVEL 7
• Number of Teeth 28
• Number of Teeth 28
• Number of Teeth 28
• Number of Teeth 28
LEVEL 6
Spur 2642
Helical 2643
Double Helical 2644
Herring Bone 2645
Plano-centric 2646
Tripot 2634
LEVEL 7
• Number of Teeth 28
• Number of Teeth 028
• Number of Teeth 28
• Number of Teeth 28
• Number of Teeth 28
• Number of Teeth 28
LEVEL 6
Crossed Helical 2661
Worm 2662
Cavex Worm 2663
Cone Drive 2664
Hypoid 2665
Sproid 2666
Helicon 2667
Beveloid 2668
LEVEL 7
• Number of Teeth 28
• Number of Teeth 28
• Number of Teeth 28
• Number of Teeth 28
• Number of Teeth 28
• Number of Teeth 28
• Number of Teeth 28
• Number of Teeth 28


LEVEL 1
CONTROL 2000
LEVEL 2
Mechanical Drives 2600
LEVEL 3
End Connectors 2610
LEVEL 4
Belt Drive 2670
Others 2690
LEVEL 5
Belt 2671
Pulley 2680
Couplings 2691
Cams 2692
Ratchet 2693
Geneva 2694
Closed Track Cams 2695
Flexible Shafts 2696
LEVEL 6
• Material 01
• Material 01
• Material 01
• Material 01
• Material 01
• Material 01
LEVEL 6
V-Type 2681
Flat 2682
Synchronous 2683
LEVEL 7
• Material 01
• W X D 30
• Material 01
• W X D 30
• Material 01
• W X D 30
LEVEL 6
V-Belt 2672
Flat 2673
Synchronous 2674
Film Belt 2675
LEVEL 7
• Material 01
• W X L 29
• Material 01
• W X L 29
• Material 01
• W X L 29
• Material 01
• W X L 29

LEVEL 1

CONTROL 2000

LEVEL 2

Electronics 2700

LEVEL 3

Active Components 2701

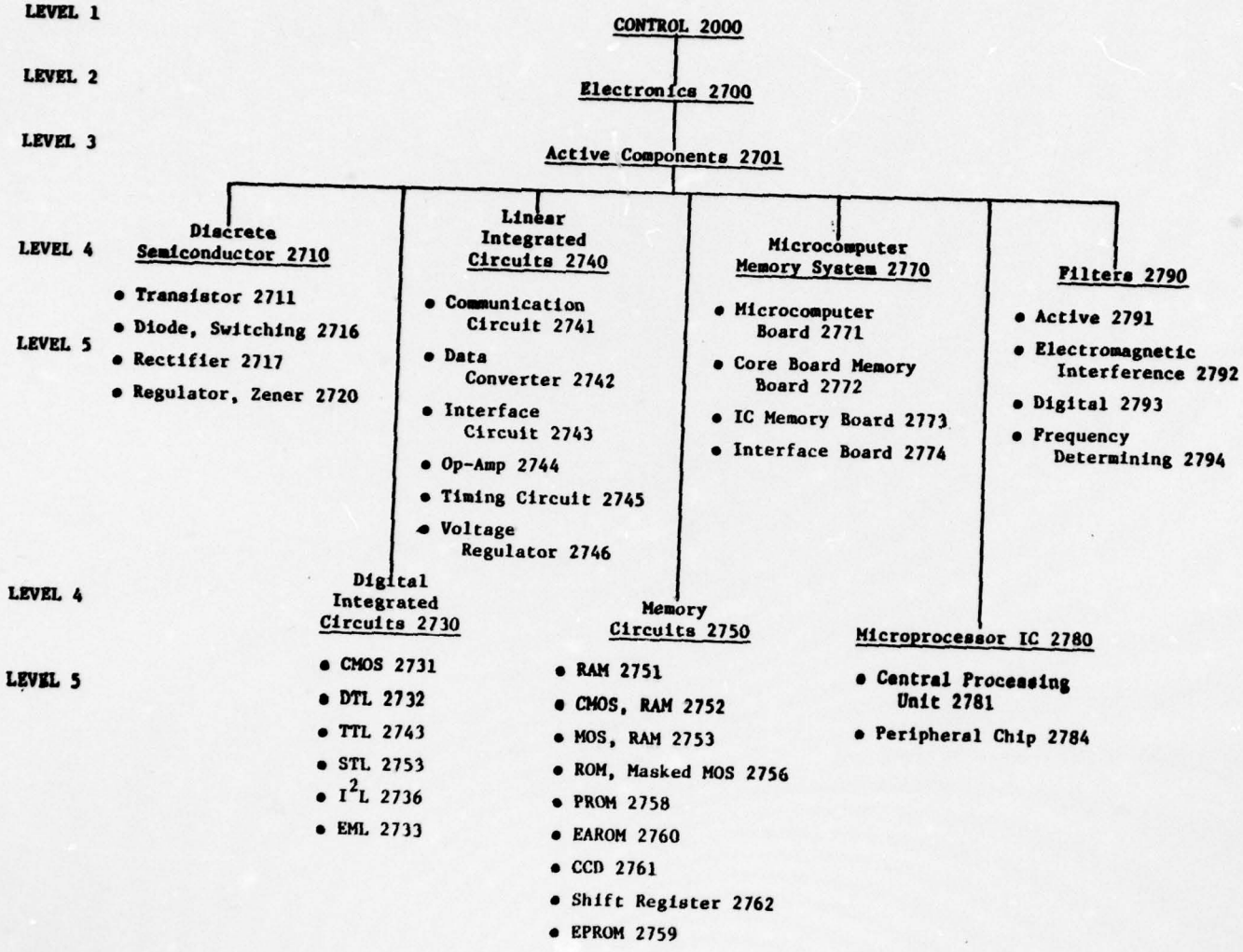
- Discrete Semiconductor 2710
- Digital Integrated Circuits 2730

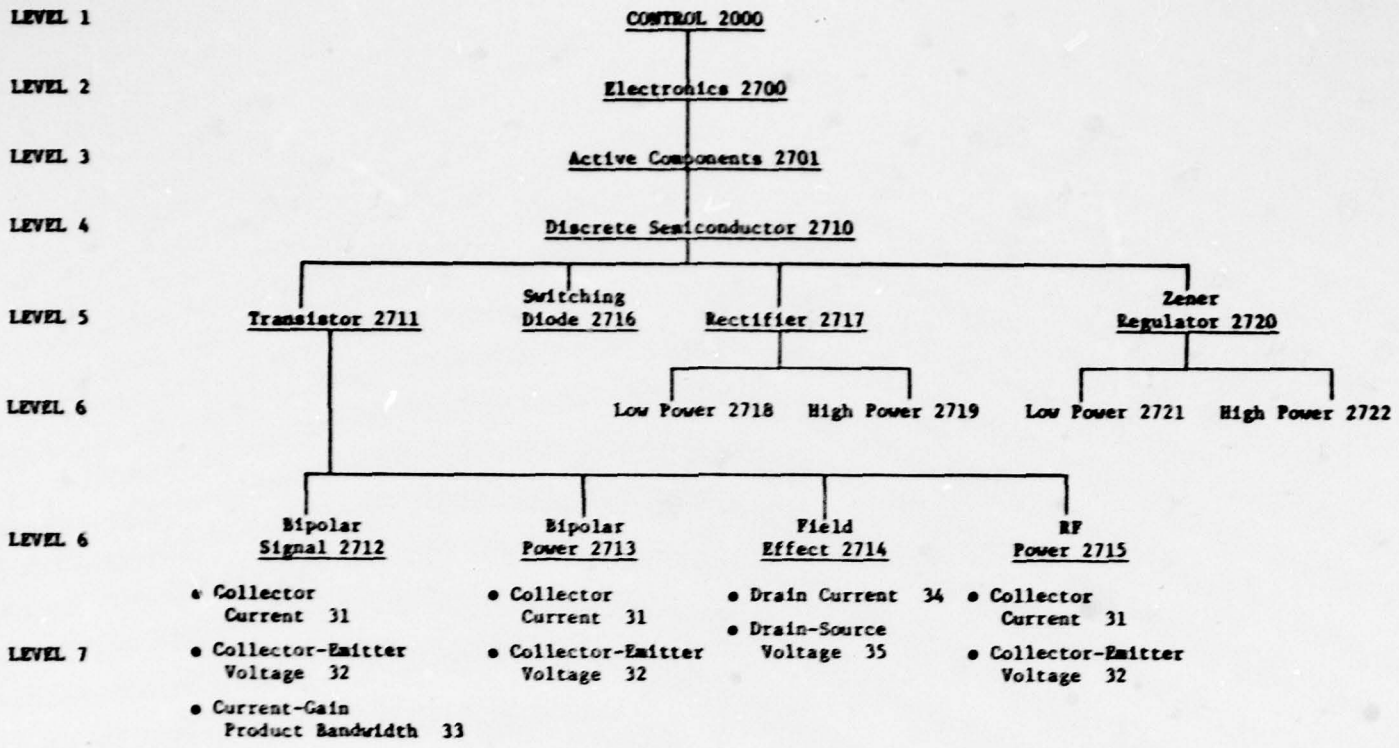
LEVEL 4

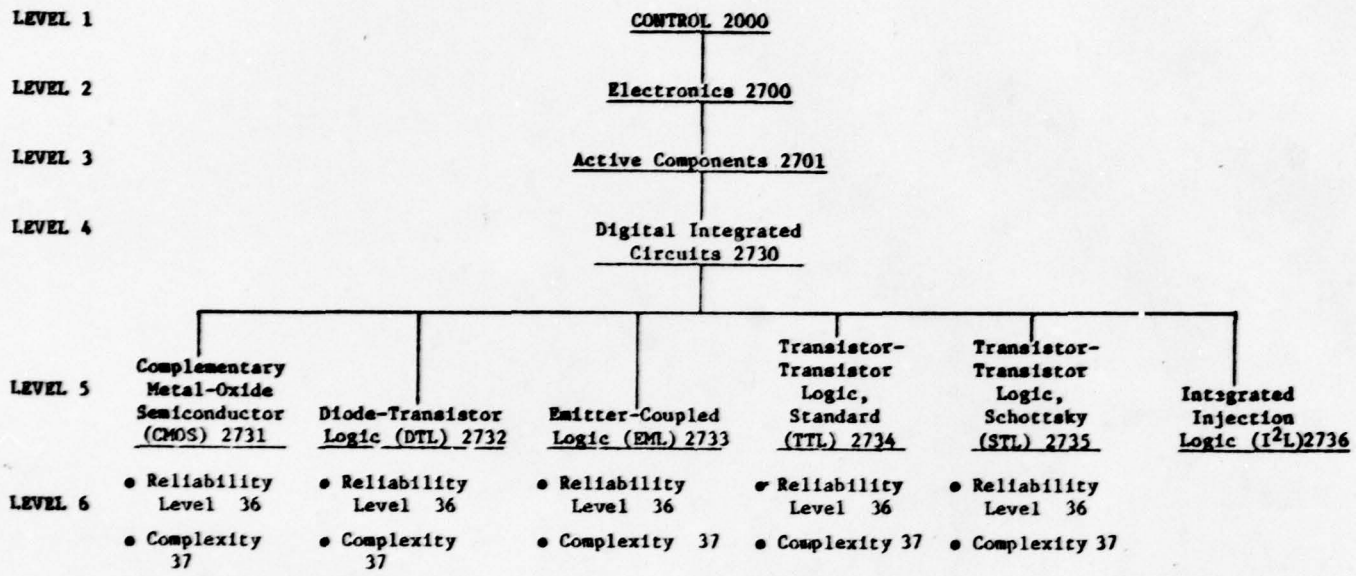
- Linear Integrated Circuits 2740
- Memory Circuits 2750
- Microcomputer/Memory Systems 2770
- Microprocessor Integrated Circuits 2780
- Filters 2790

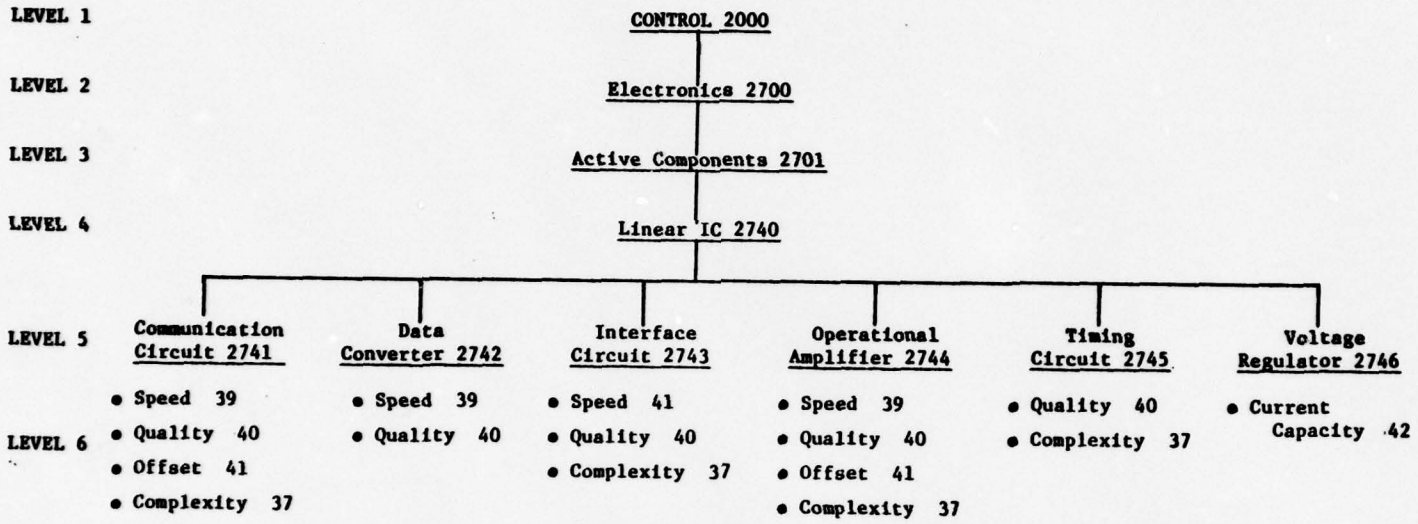
Passive Components 2801

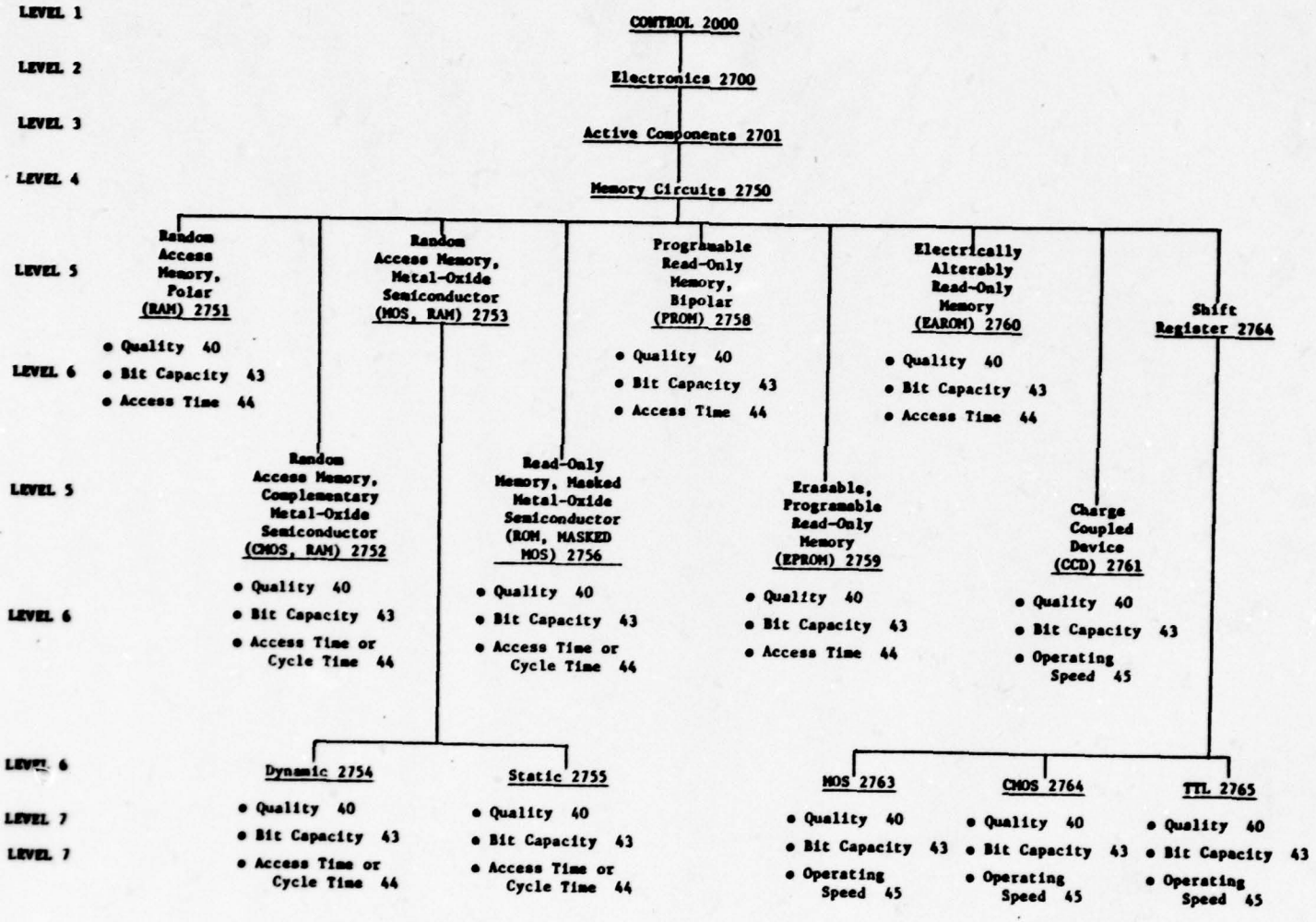
- Capacitors 2810
- Resistors 2820
- Magnetic Components 2850
- Printed Circuits 2870

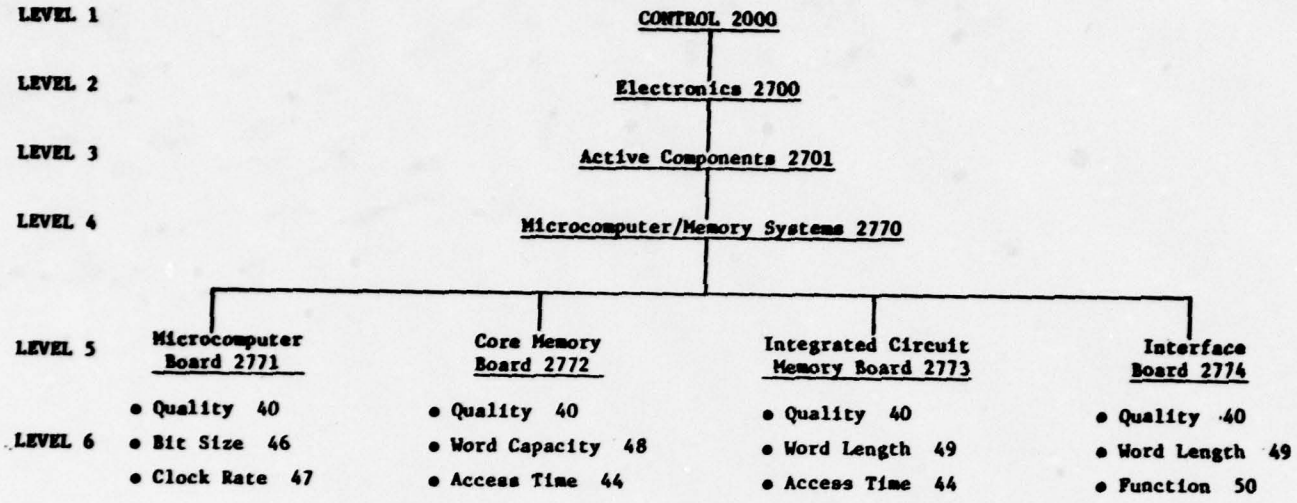

LEVEL 1
CONTROL 2000
LEVEL 2
Electronics 2700
LEVEL 3
Active Components 2701
LEVEL 4
Discrete Semiconductor 2710
Linear Integrated Circuits 2740
Microcomputer Memory System 2770
Filters 2790
LEVEL 5
• Transistor 2711
• Diode, Switching 2716
• Rectifier 2717
• Regulator, Zener 2720
• Communication Circuit 2741
• Data Converter 2742
• Interface Circuit 2743
• Op-Amp 2744
• Timing Circuit 2745
• Voltage Regulator 2746
• Microcomputer Board 2771
• Core Board Memory Board 2772
• IC Memory Board 2773
• Interface Board 2774
• Active 2791
• Electromagnetic Interference 2792
• Digital 2793
• Frequency Determining 2794
LEVEL 4
Digital Integrated Circuits 2730
Memory Circuits 2750
Microprocessor IC 2780
LEVEL 5
• CMOS 2731
• DTL 2732
• TTL 2743
• STL 2753
• I^2L 2736
• EML 2733
• RAM 2751
• CMOS, RAM 2752
• MOS, RAM 2753
• ROM, Masked MOS 2756
• PROM 2758
• EAROM 2760
• CCD 2761
• Shift Register 2762
• EPROM 2759
• Central Processing Unit 2781
• Peripheral Chip 2784

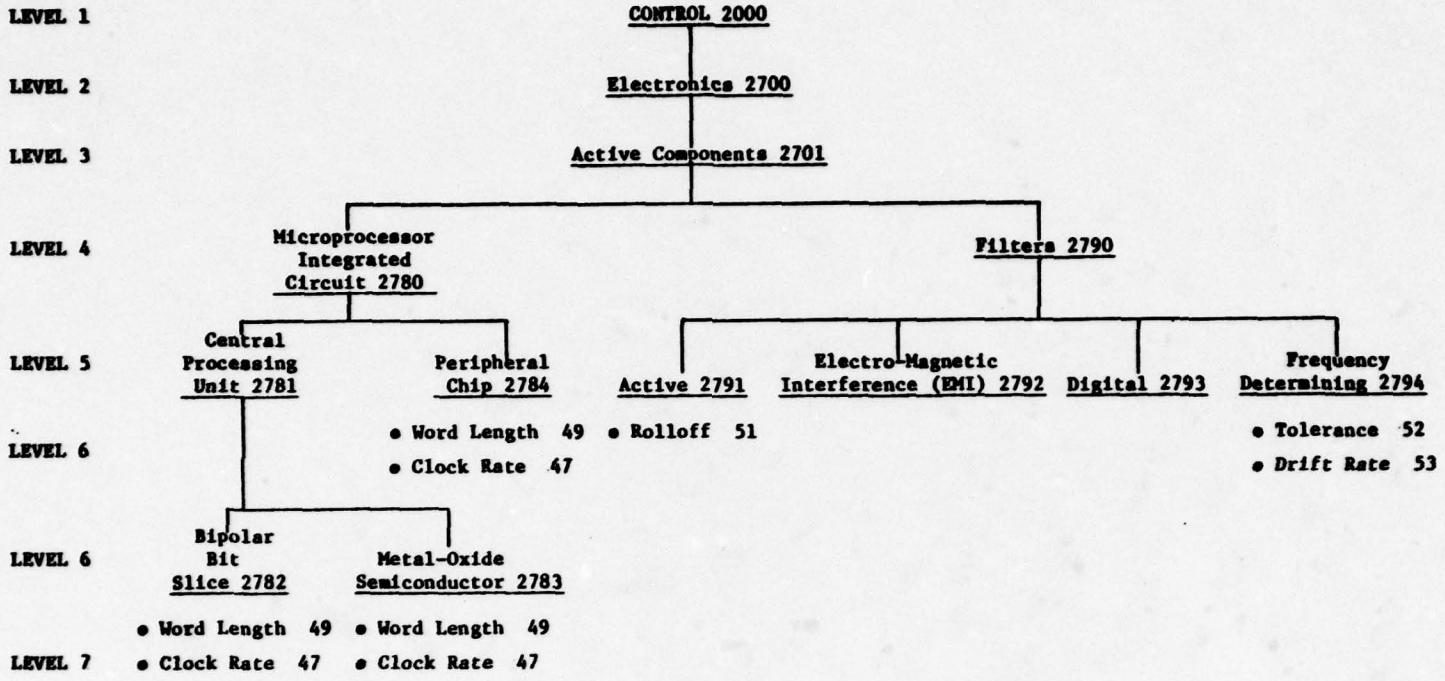

LEVEL 1
CONTROL 2000
LEVEL 2
Electronics 2700
LEVEL 3
Active Components 2701
LEVEL 4
Discrete Semiconductor 2710
LEVEL 5
Transistor 2711
Switching Diode 2716
Rectifier 2717
Zener Regulator 2720
LEVEL 6
Low Power 2718
High Power 2719
Low Power 2721
High Power 2722
LEVEL 6
Bipolar Signal 2712
Bipolar Power 2713
Field Effect 2714
RF Power 2715
LEVEL 7
• Collector Current 31
• Collector-Emitter Voltage 32
• Current-Gain Product Bandwidth 33
• Collector Current 31
• Collector-Emitter Voltage 32
• Drain Current 34
• Drain-Source Voltage 35
• Collector Current 31
• Collector-Emitter Voltage 32

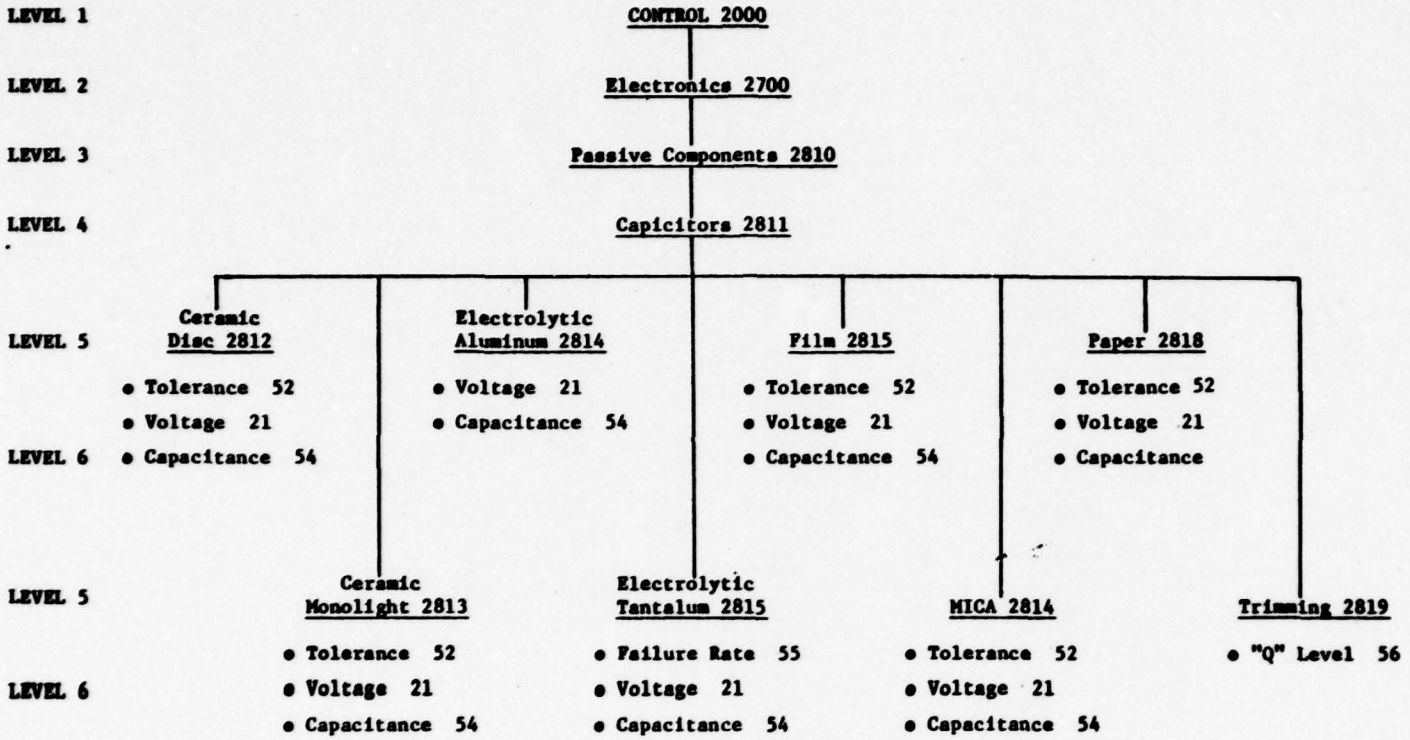

LEVEL 1
CONTROL 2000
LEVEL 2
Electronics 2700
LEVEL 3
Active Components 2701
LEVEL 4
Digital Integrated Circuits 2730
LEVEL 5
Complementary Metal-Oxide Semiconductor (CMOS) 2731
Diode-Transistor Logic (DTL) 2732
Emitter-Coupled Logic (ECL) 2733
Transistor-Transistor Logic, Standard (TTL) 2734
Transistor-Transistor Logic, Schottsky (STL) 2735
Integrated Injection Logic (I^2L)2736
LEVEL 6
• Reliability Level 36
• Complexity 37
• Reliability Level 36
• Complexity 37
• Reliability Level 36
• Complexity 37
• Reliability Level 36
• Complexity 37
• Reliability Level 36
• Complexity 37

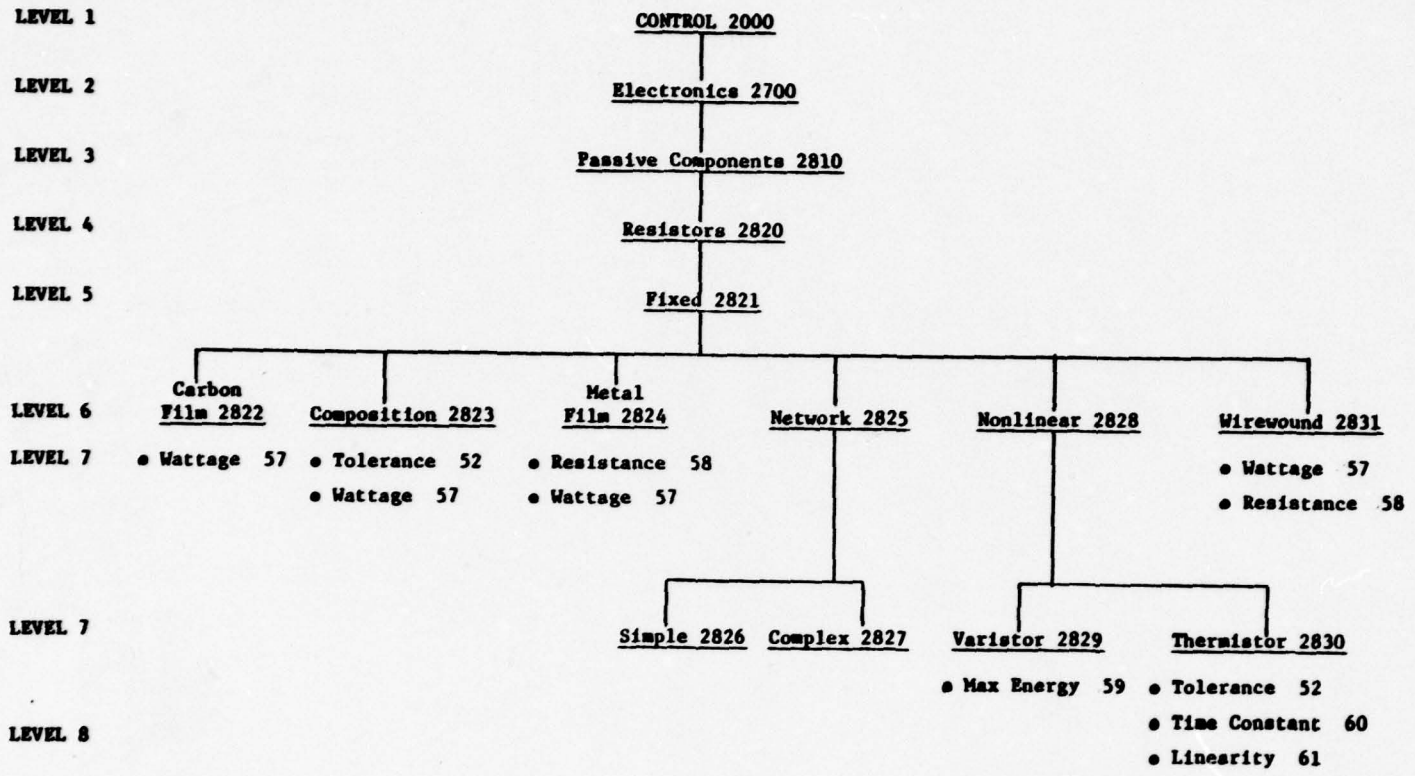

LEVEL 1
CONTROL 2000
LEVEL 2
Electronics 2700
LEVEL 3
Active Components 2701
LEVEL 4
Linear IC 2740
LEVEL 5
Communication Circuit 2741
Data Converter 2742
Interface Circuit 2743
Operational Amplifier 2744
Timing Circuit 2745
Voltage Regulator 2746
LEVEL 6
• Speed 39
• Quality 40
• Offset 41
• Complexity 37
• Speed 39
• Quality 40
• Speed 41
• Quality 40
• Complexity 37
• Speed 39
• Quality 40
• Offset 41
• Complexity 37
• Quality 40
• Complexity 37
• Current Capacity 42

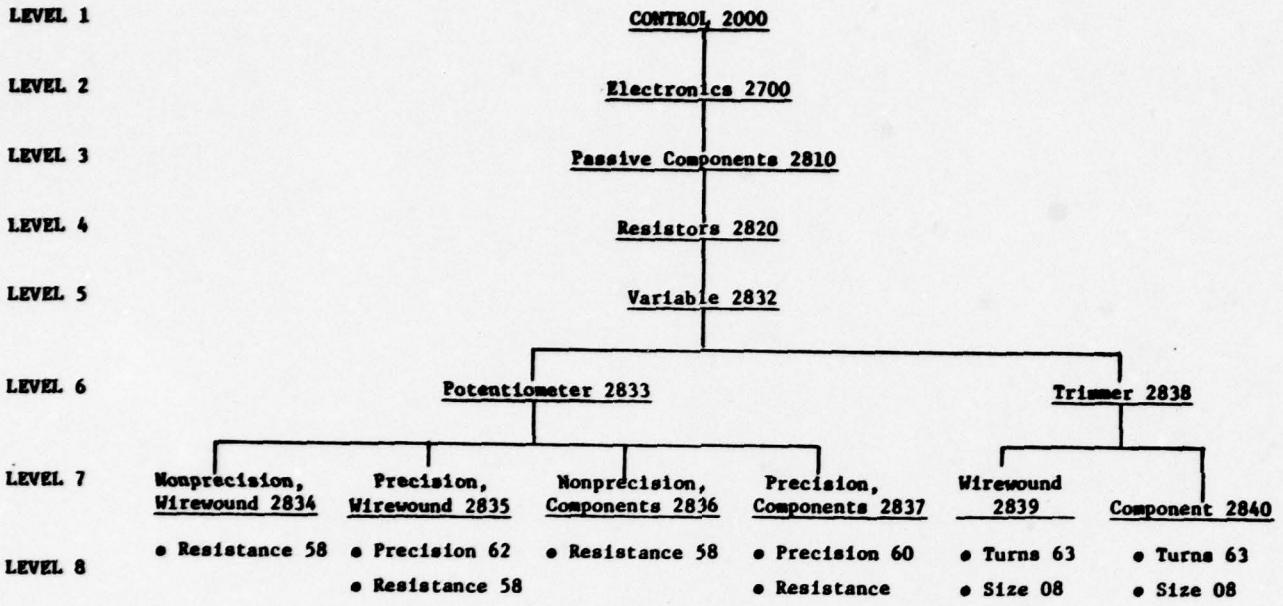

LEVEL 1
LEVEL 2
LEVEL 3
LEVEL 4
LEVEL 5
LEVEL 6
LEVEL 5
LEVEL 6
LEVEL 6
LEVEL 7
LEVEL 7
CONTROL 2000
Electronics 2700
Active Components 2701
Memory Circuits 2750
Random Access Memory, Polar (RAM) 2751
• Quality 40
• Bit Capacity 43
• Access Time 44
Random Access Memory, Metal-Oxide Semiconductor (MOS, RAM) 2753
Programable Read-Only Memory, Bipolar (PROM) 2758
• Quality 40
• Bit Capacity 43
• Access Time 44
Electrically Alterably Read-Only Memory (EAROM) 2760
• Quality 40
• Bit Capacity 43
• Access Time 44
Shift Register 2764
Random Access Memory, Complementary Metal-Oxide Semiconductor (CMOS, RAM) 2752
• Quality 40
• Bit Capacity 43
• Access Time or Cycle Time 44
Read-Only Memory, Masked Metal-Oxide Semiconductor (ROM, MASKED MOS) 2756
• Quality 40
• Bit Capacity 43
• Access Time or Cycle Time 44
Erasable, Programable Read-Only Memory (EPROM) 2759
• Quality 40
• Bit Capacity 43
• Access Time 44
Charge Coupled Device (CCD) 2761
• Quality 40
• Bit Capacity 43
• Operating Speed 45
Dynamic 2754
• Quality 40
• Bit Capacity 43
• Access Time or Cycle Time 44
Static 2755
• Quality 40
• Bit Capacity 43
• Access Time or Cycle Time 44
MOS 2763
• Quality 40
• Bit Capacity 43
• Operating Speed 45
CMOS 2764
• Quality 40
• Bit Capacity 43
• Operating Speed 45
TTL 2765
• Quality 40
• Bit Capacity 43
• Operating Speed 45

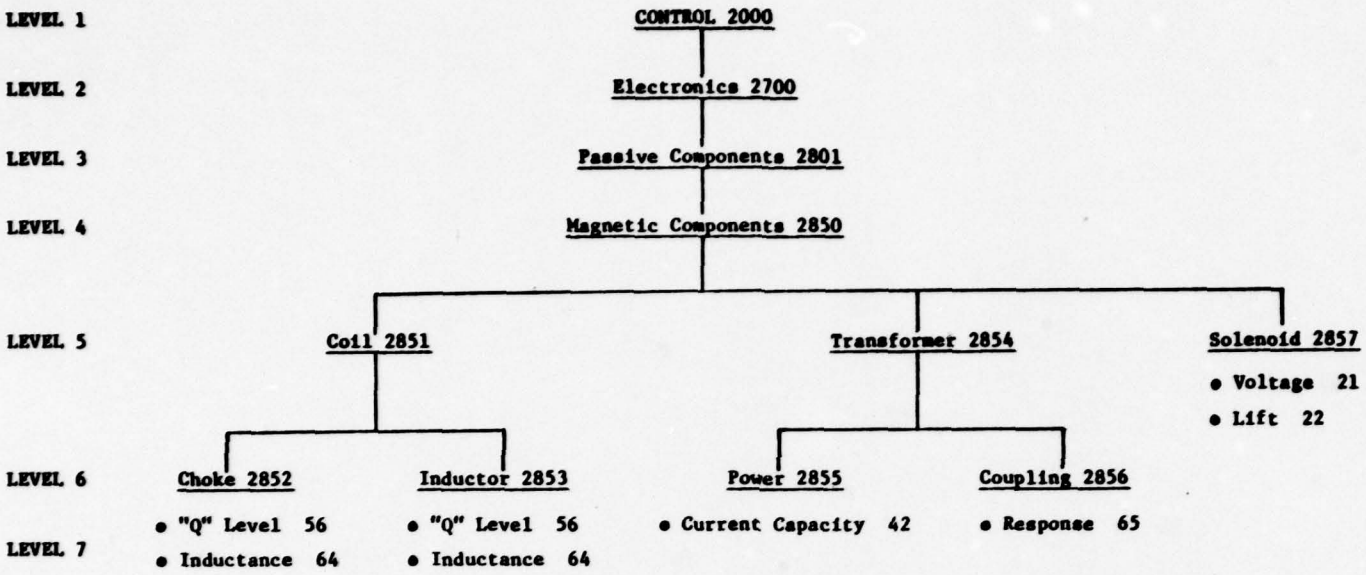

LEVEL 1
CONTROL 2000
LEVEL 2
Electronics 2700
LEVEL 3
Active Components 2701
LEVEL 4
Microcomputer/Memory Systems 2770
LEVEL 5
Microcomputer Board 2771
Core Memory Board 2772
Integrated Circuit Memory Board 2773
Interface Board 2774
LEVEL 6
• Quality 40
• Bit Size 46
• Clock Rate 47
• Quality 40
• Word Capacity 48
• Access Time 44
• Quality 40
• Word Length 49
• Access Time 44
• Quality 40
• Word Length 49
• Function 50

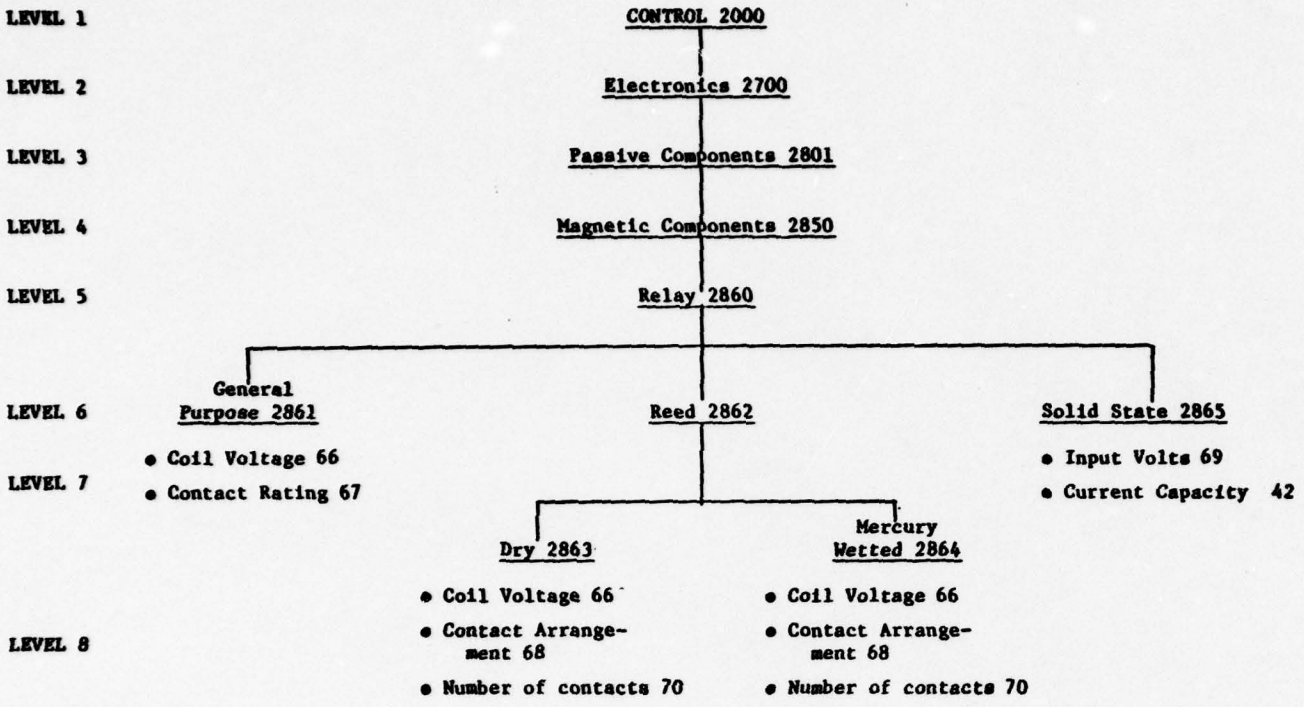

LEVEL 1
CONTROL 2000
LEVEL 2
Electronics 2700
LEVEL 3
Active Components 2701
LEVEL 4
Microprocessor Integrated Circuit 2780
Filters 2790
LEVEL 5
Central Processing Unit 2781
Peripheral Chip 2784
Active 2791
Electro-Magnetic Interference (EMI) 2792
Digital 2793
Frequency Determining 2794
LEVEL 6
• Word Length 49
• Clock Rate 47
• Rolloff 51
• Tolerance 52
• Drift Rate 53
LEVEL 6
Bipolar Bit Slice 2782
Metal-Oxide Semiconductor 2783
LEVEL 7
• Word Length 49
• Clock Rate 47
• Word Length 49
• Clock Rate 47

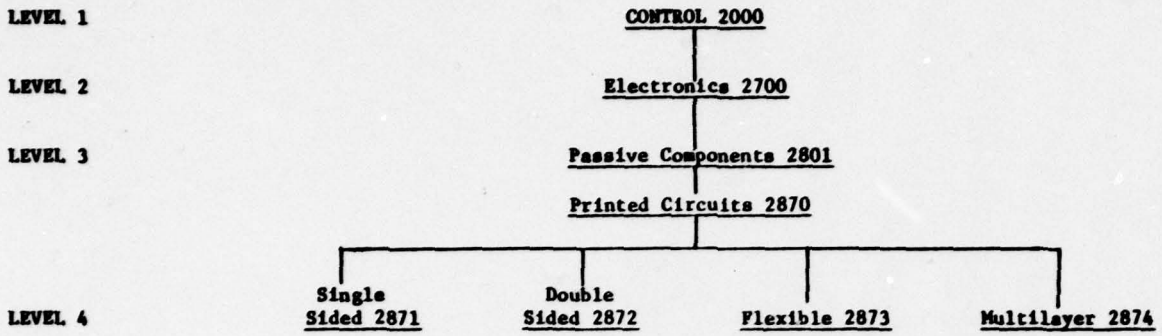

LEVEL 1
CONTROL 2000
LEVEL 2
Electronics 2700
LEVEL 3
Passive Components 2810
LEVEL 4
Capicitors 2811
LEVEL 5
Ceramic Disc 2812
• Tolerance 52
• Voltage 21
LEVEL 6
• Capacitance 54
Electrolytic Aluminum 2814
• Voltage 21
• Capacitance 54
Film 2815
• Tolerance 52
• Voltage 21
• Capacitance 54
Paper 2818
• Tolerance 52
• Voltage 21
• Capacitance
LEVEL 5
Ceramic Monolight 2813
• Tolerance 52
• Voltage 21
LEVEL 6
• Capacitance 54
Electrolytic Tantalum 2815
• Failure Rate 55
• Voltage 21
• Capacitance 54
MICA 2814
• Tolerance 52
• Voltage 21
• Capacitance 54
Trimming 2819
• "Q" Level 56

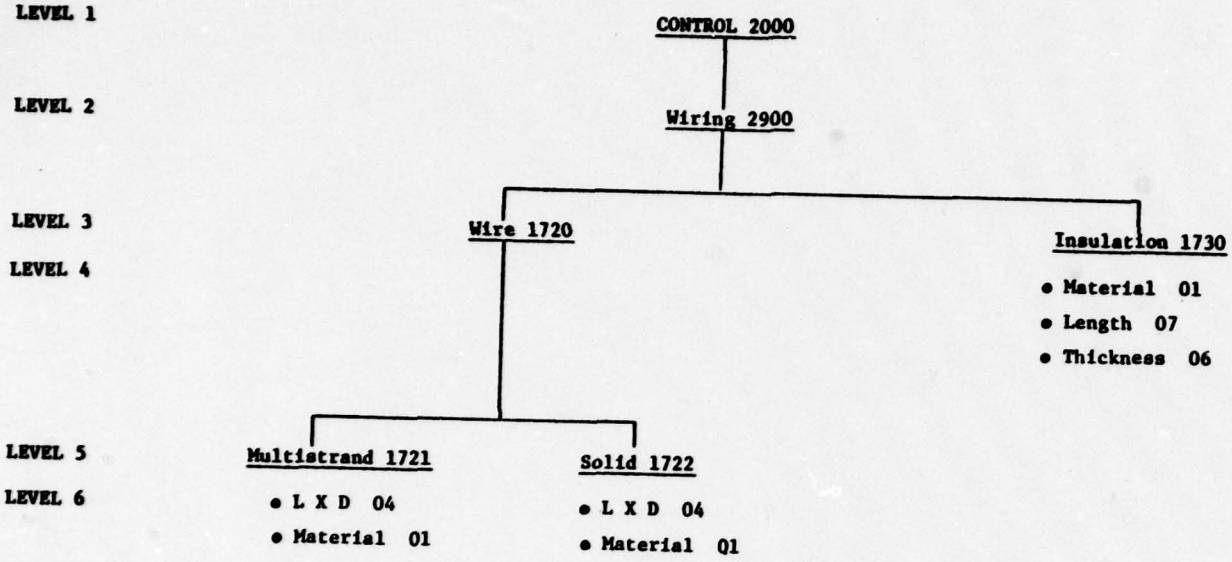

LEVEL 1
CONTROL 2000
LEVEL 2
Electronics 2700
LEVEL 3
Passive Components 2810
LEVEL 4
Resistors 2820
LEVEL 5
Fixed 2821
LEVEL 6
Carbon Film 2822
Composition 2823
Metal Film 2824
Network 2825
Nonlinear 2828
Wirewound 2831
LEVEL 7
• Wattage 57
• Tolerance 52
• Wattage 57
• Resistance 58
• Wattage 57
• Wattage 57
• Resistance 58
LEVEL 7
Simple 2826
Complex 2827
Varistor 2829
Thermistor 2830
• Max Energy 59
• Tolerance 52
• Time Constant 60
• Linearity 61
LEVEL 8

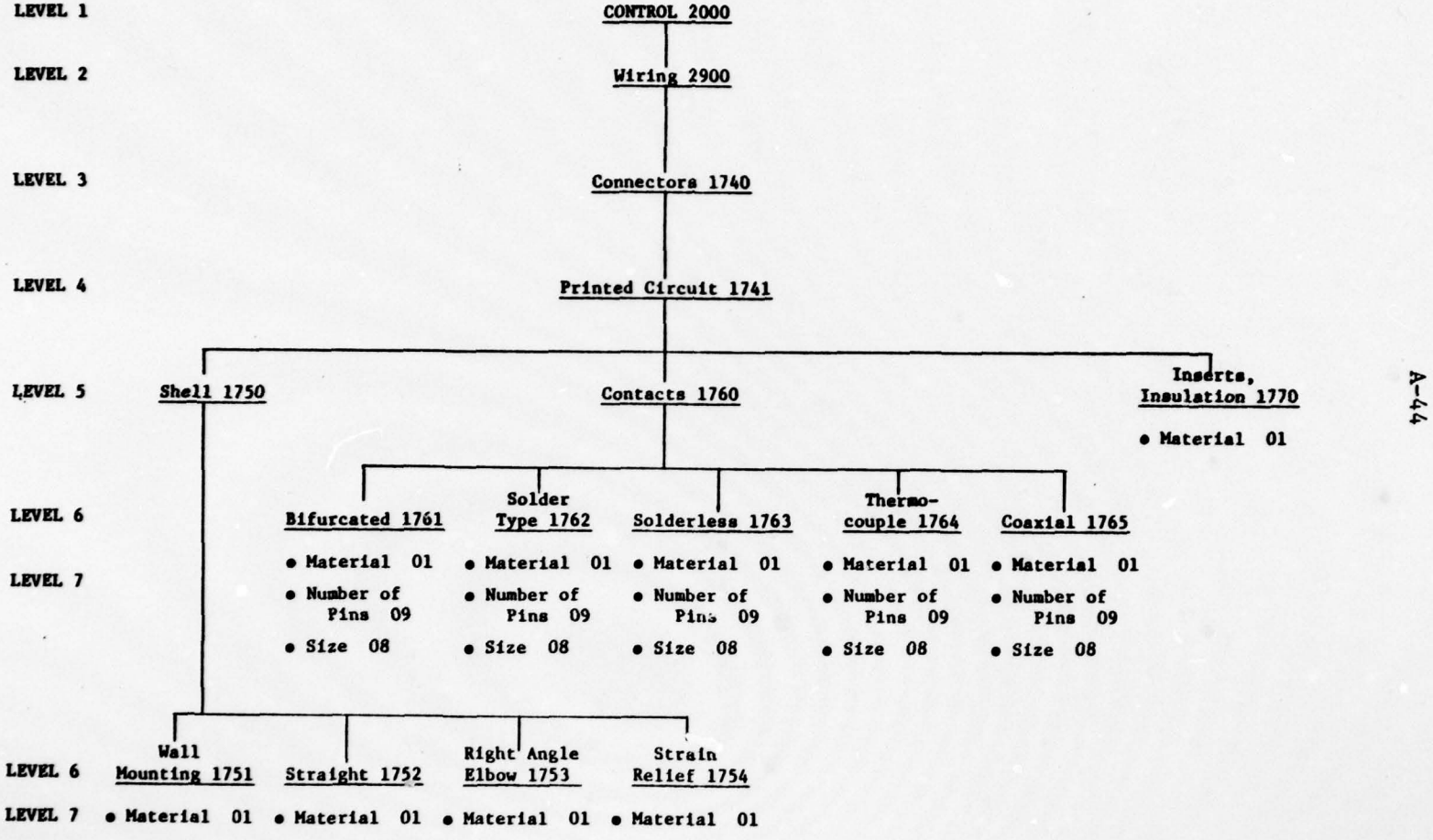

LEVEL 1
CONTROL 2000
LEVEL 2
Electronics 2700
LEVEL 3
Passive Components 2810
LEVEL 4
Resistors 2820
LEVEL 5
Variable 2832
LEVEL 6
Potentiometer 2833
Trimmer 2838
LEVEL 7
Nonprecision, Wirewound 2834
Precision, Wirewound 2835
Nonprecision, Components 2836
Precision, Components 2837
Wirewound 2839
Component 2840
LEVEL 8
• Resistance 58
• Precision 62
• Resistance 58
• Resistance 58
• Precision 60
• Resistance
• Turns 63
• Size 08
• Turns 63
• Size 08

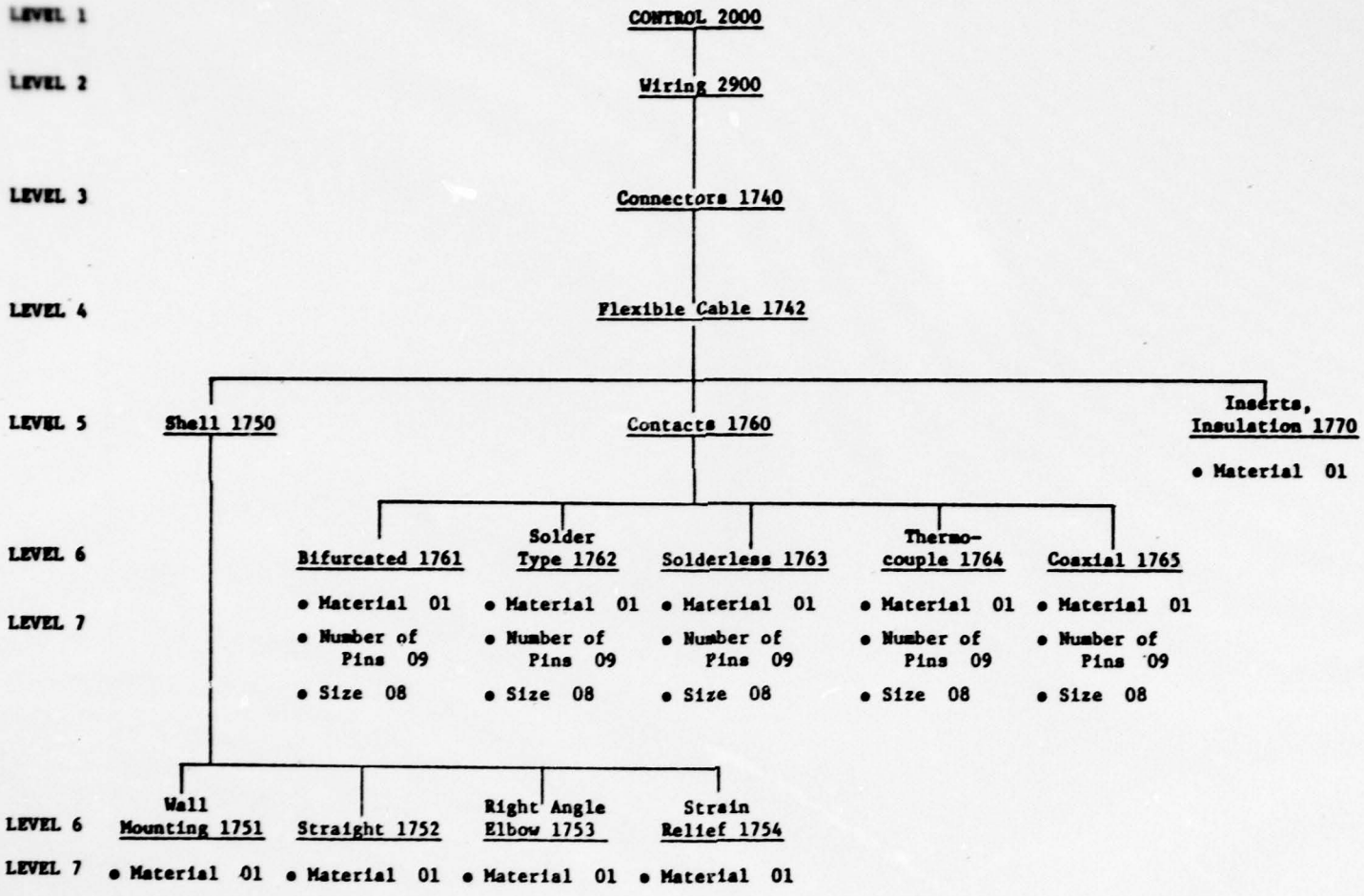

LEVEL 1
CONTROL 2000
LEVEL 2
Electronics 2700
LEVEL 3
Passive Components 2801
LEVEL 4
Magnetic Components 2850
LEVEL 5
Coil 2851
Transformer 2854
Solenoid 2857
• Voltage 21
• Lift 22
LEVEL 6
Choke 2852
Inductor 2853
Power 2855
Coupling 2856
LEVEL 7
• "Q" Level 56
• Inductance 64
• "Q" Level 56
• Inductance 64
• Current Capacity 42
• Response 65

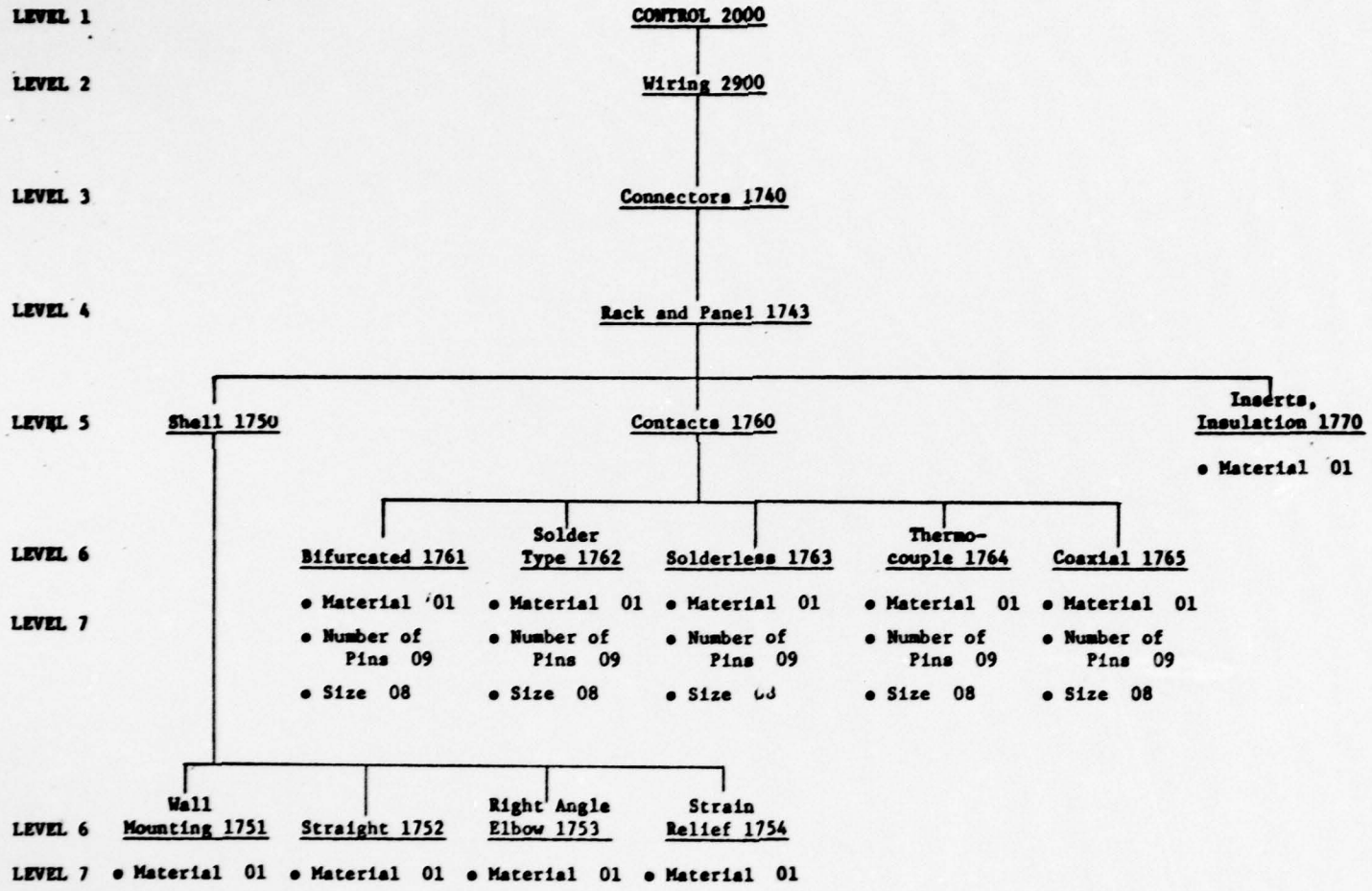

LEVEL 1
CONTROL 2000
LEVEL 2
Electronics 2700
LEVEL 3
Passive Components 2801
LEVEL 4
Magnetic Components 2850
LEVEL 5
Relay 2860
LEVEL 6
General Purpose 2861
Reed 2862
Solid State 2865
LEVEL 7
• Coil Voltage 66
• Contact Rating 67
• Input Volts 69
• Current Capacity 42
Dry 2863
Mercury Wetted 2864
LEVEL 8
• Coil Voltage 66
• Contact Arrangement 68
• Number of contacts 70
• Coil Voltage 66
• Contact Arrangement 68
• Number of contacts 70

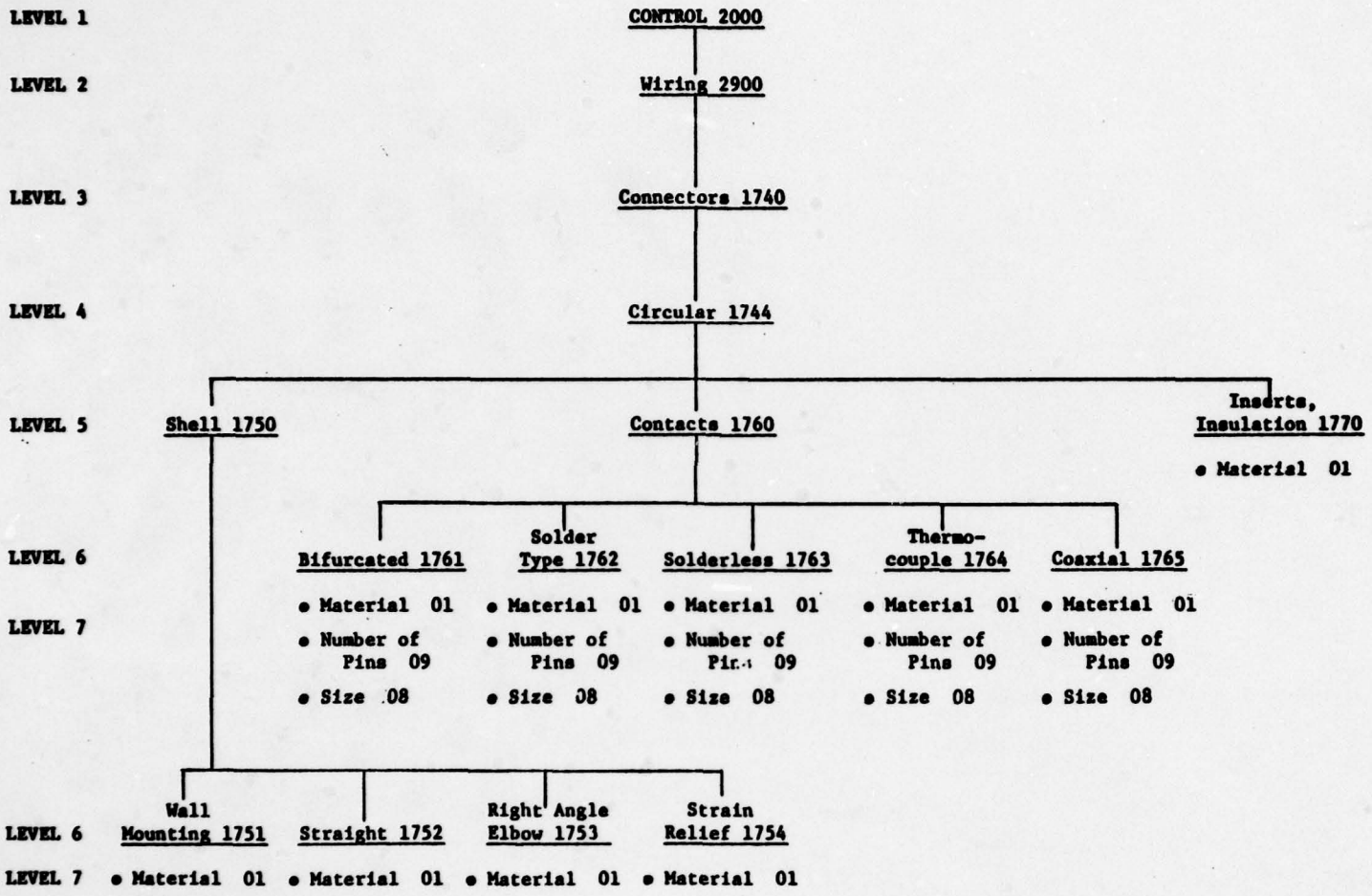

LEVEL 1
CONTROL 2000
LEVEL 2
Electronics 2700
LEVEL 3
Passive Components 2801
Printed Circuits 2870
LEVEL 4
Single Sided 2871
Double Sided 2872
Flexible 2873
Multilayer 2874

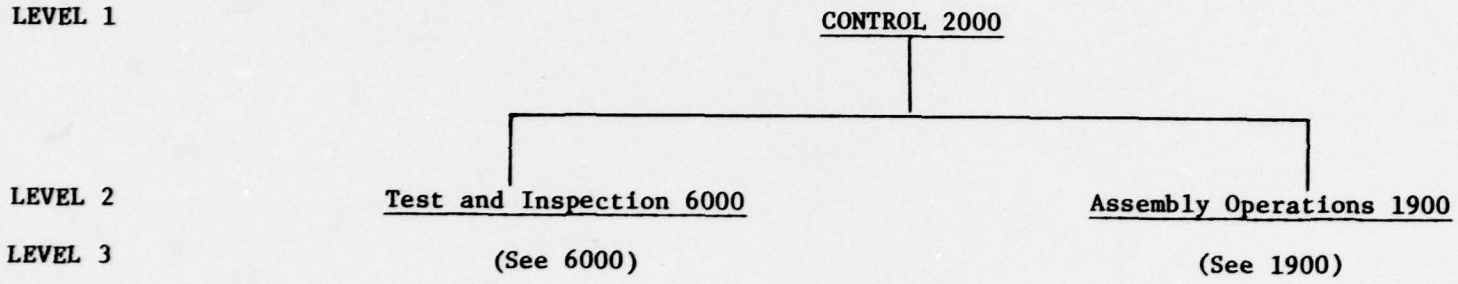

LEVEL 1
CONTROL 2000
LEVEL 2
Wiring 2900
LEVEL 3
Wire 1720
Insulation 1730
LEVEL 4
• Material 01
• Length 07
• Thickness 06
LEVEL 5
Multistrand 1721
Solid 1722
LEVEL 6
• L X D 04
• Material 01
• L X D 04
• Material 01

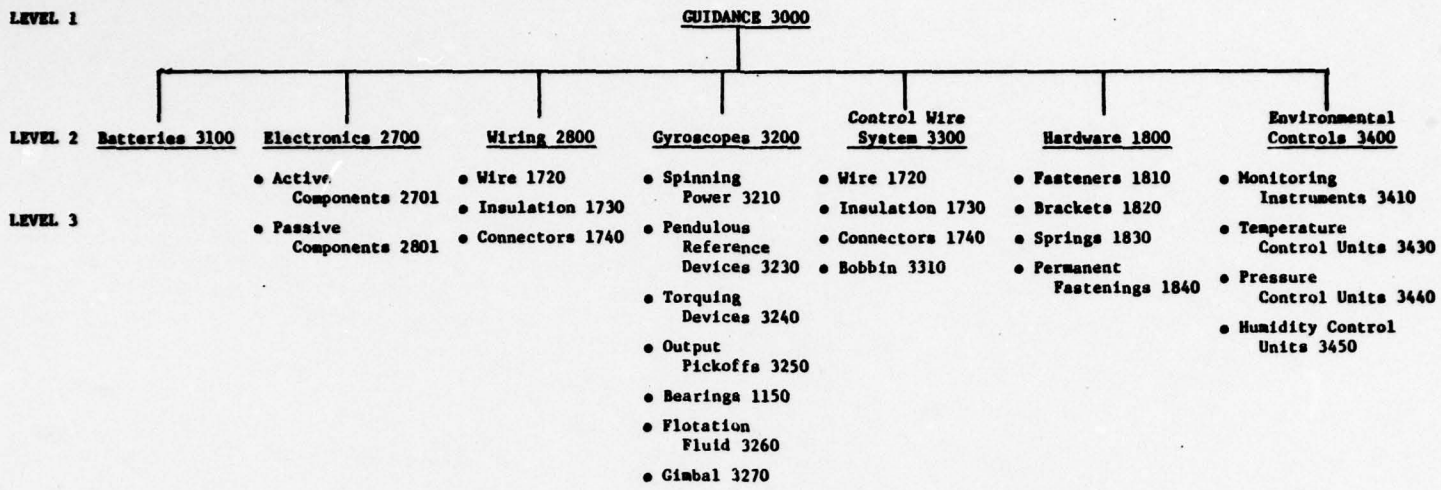

LEVEL 1
CONTROL 2000
LEVEL 2
Wiring 2900
LEVEL 3
Connectors 1740
LEVEL 4
Printed Circuit 1741
LEVEL 5
Shell 1750
Contacts 1760
Inserts, Insulation 1770
• Material 01
LEVEL 6
Bifurcated 1761
Solder Type 1762
Solderless 1763
Thermo-couple 1764
Coaxial 1765
LEVEL 7
• Material 01
• Number of Pins 09
• Size 08
LEVEL 6
Wall Mounting 1751
Straight 1752
Right Angle Elbow 1753
Strain Relief 1754
LEVEL 7
• Material 01

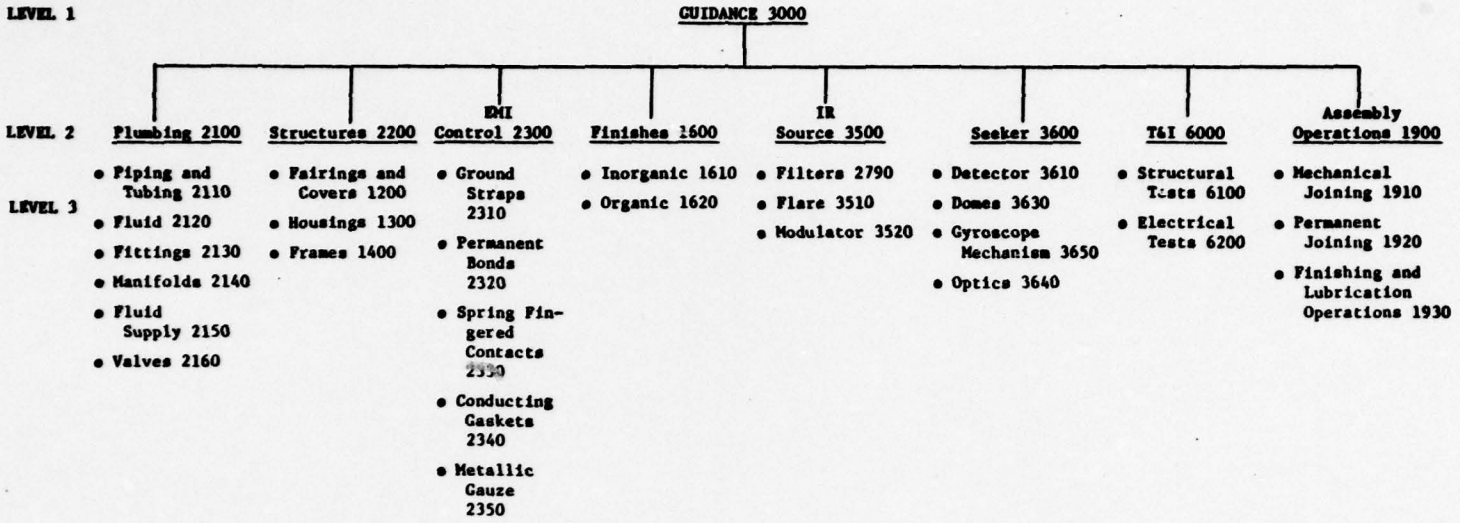

LEVEL 1
CONTROL 2000
LEVEL 2
Wiring 2900
LEVEL 3
Connectors 1740
LEVEL 4
Flexible Cable 1742
LEVEL 5
Shell 1750
Contacts 1760
Inserts, Insulation 1770
• Material 01
LEVEL 6
Bifurcated 1761
Solder Type 1762
Solderless 1763
Thermo-couple 1764
Coaxial 1765
LEVEL 7
• Material 01
• Number of Pins 09
• Size 08
LEVEL 6
Wall Mounting 1751
Straight 1752
Right Angle Elbow 1753
Strain Relief 1754
LEVEL 7
• Material 01

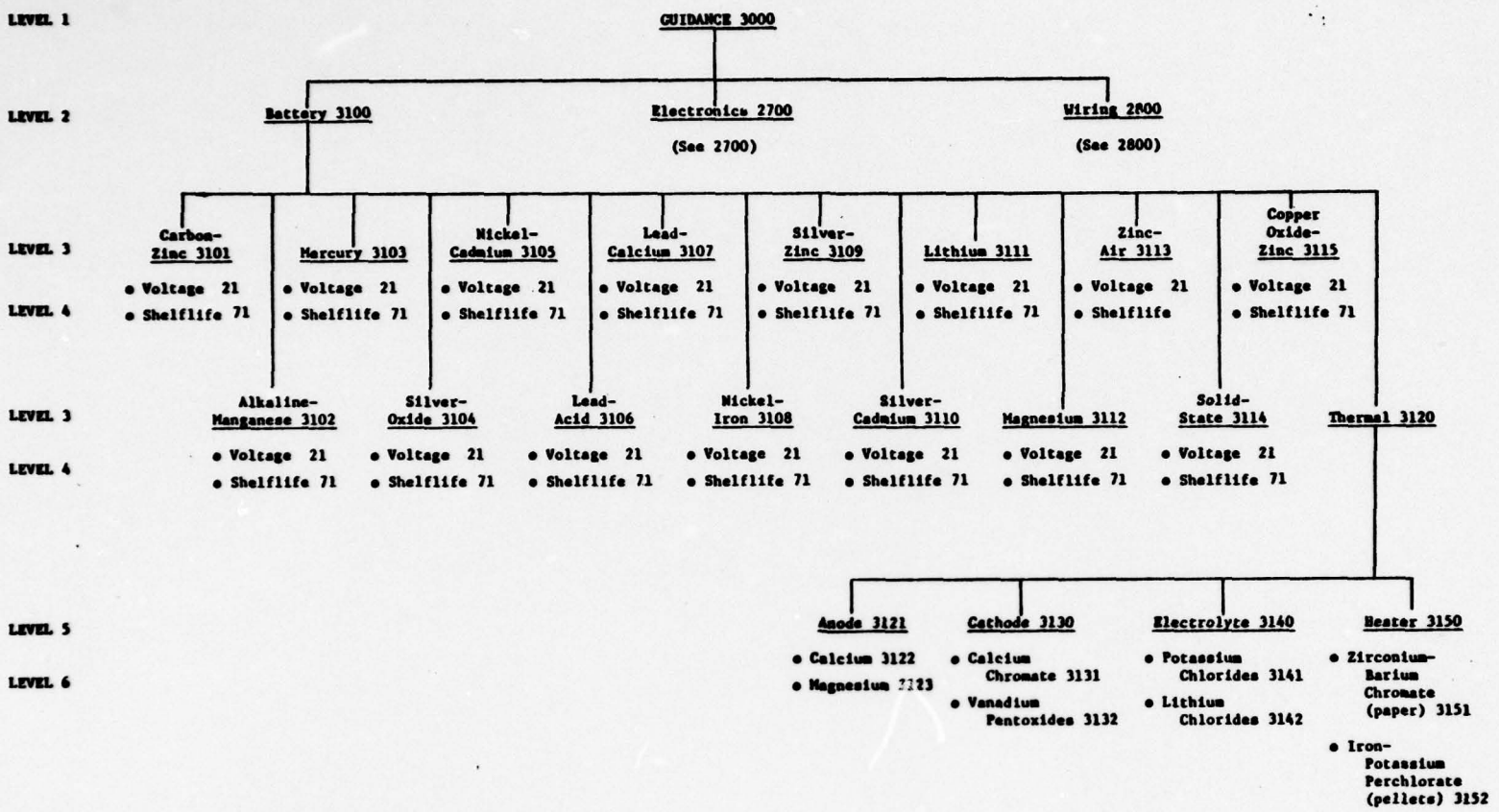

LEVEL 1
CONTROL 2000
LEVEL 2
Wiring 2900
LEVEL 3
Connectors 1740
LEVEL 4
Rack and Panel 1743
LEVEL 5
Shell 1750
Contacts 1760
Inserts, Insulation 1770
• Material 01
LEVEL 6
Bifurcated 1761
Solder Type 1762
Solderless 1763
Thermo-couple 1764
Coaxial 1765
LEVEL 7
• Material 01
• Number of Pins 09
• Size 08
• Material 01
• Number of Pins 09
• Size 08
• Material 01
• Number of Pins 09
• Size 08
• Material 01
• Number of Pins 09
• Size 08
• Material 01
• Number of Pins 09
• Size 08
LEVEL 6
Wall Mounting 1751
Straight 1752
Right Angle Elbow 1753
Strain Relief 1754
LEVEL 7
• Material 01
• Material 01
• Material 01
• Material 01

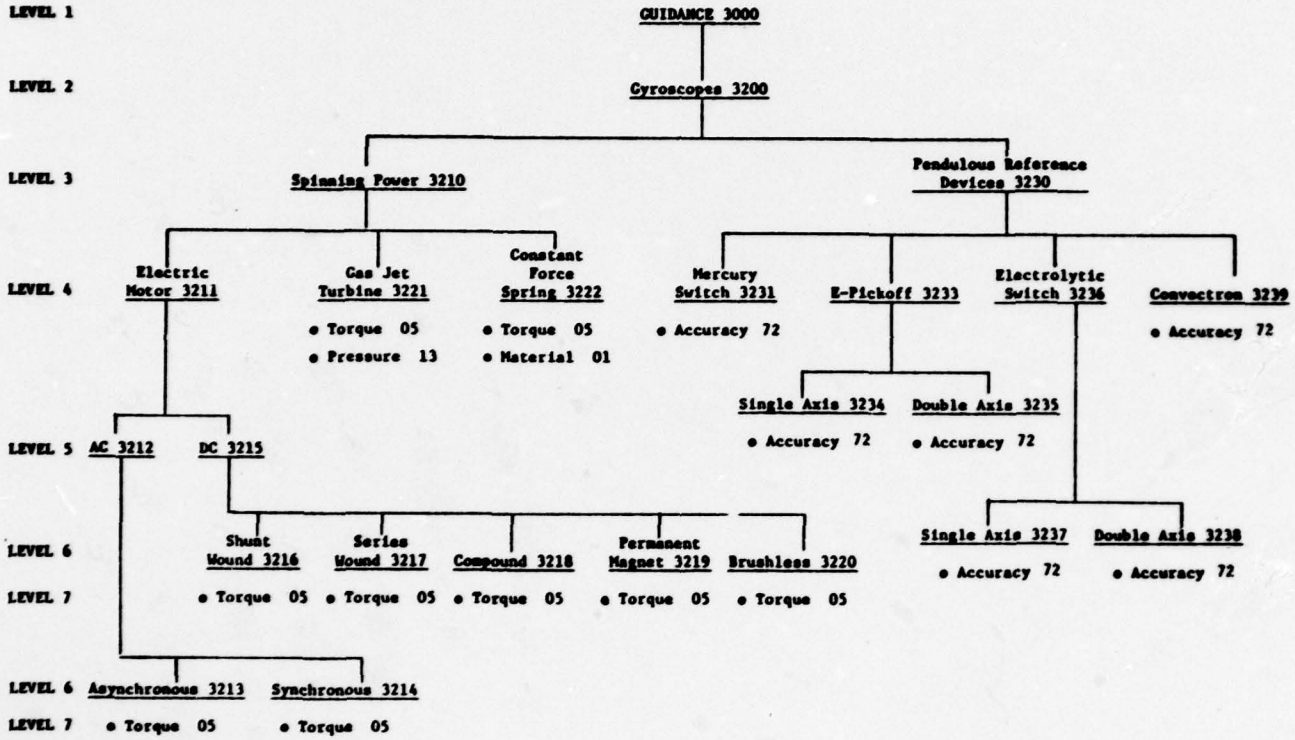

LEVEL 1
CONTROL 2000
LEVEL 2
Wiring 2900
LEVEL 3
Connectors 1740
LEVEL 4
Circular 1744
LEVEL 5
Shell 1750
Contacts 1760
Inserts, Insulation 1770
• Material 01
LEVEL 6
Bifurcated 1761
Solder Type 1762
Solderless 1763
Thermo-couple 1764
Coaxial 1765
LEVEL 7
• Material 01
• Number of Pins 09
• Size 08
LEVEL 6
Wall Mounting 1751
Straight 1752
Right Angle Elbow 1753
Strain Relief 1754
LEVEL 7
• Material 01

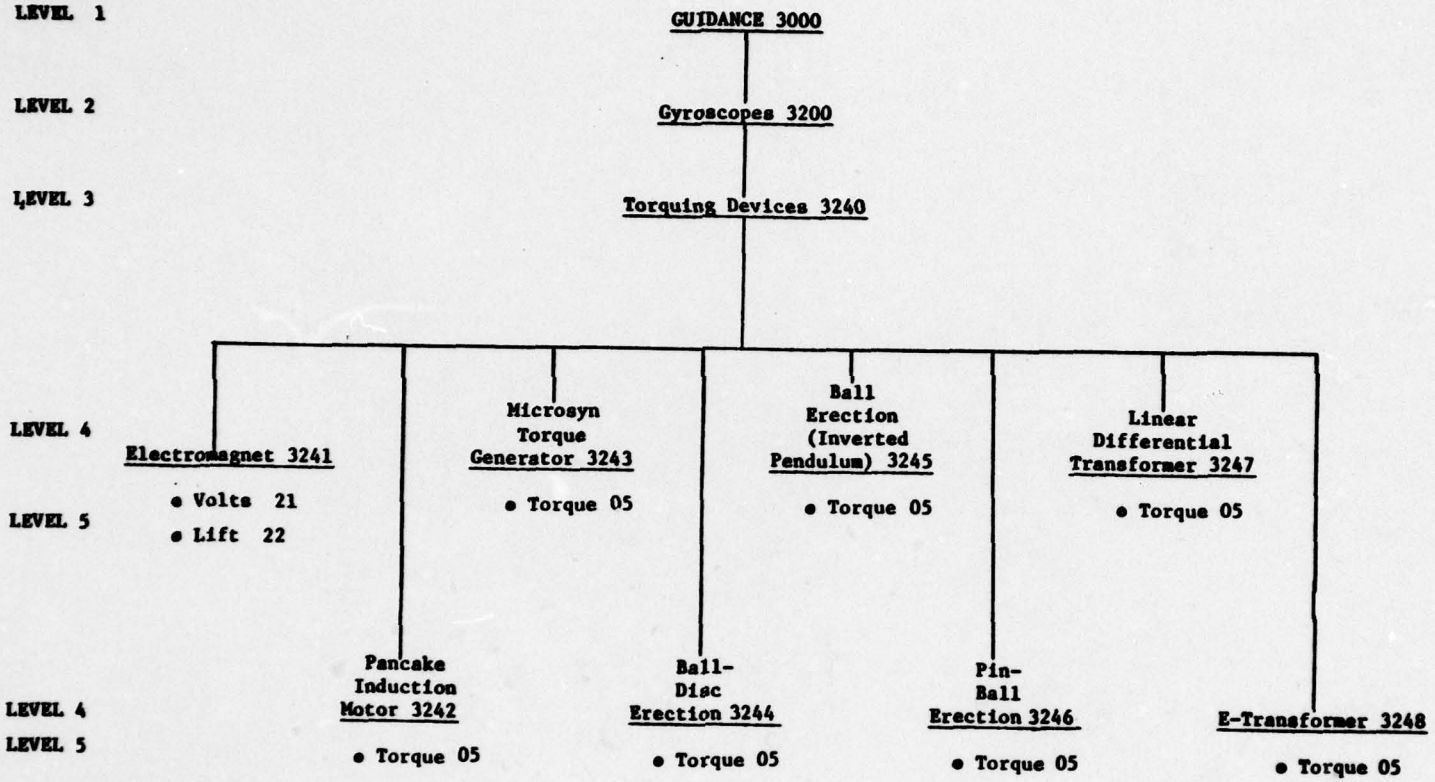

LEVEL 1
CONTROL 2000
LEVEL 2
Test and Inspection 6000
Assembly Operations 1900
LEVEL 3
(See 6000)
(See 1900)

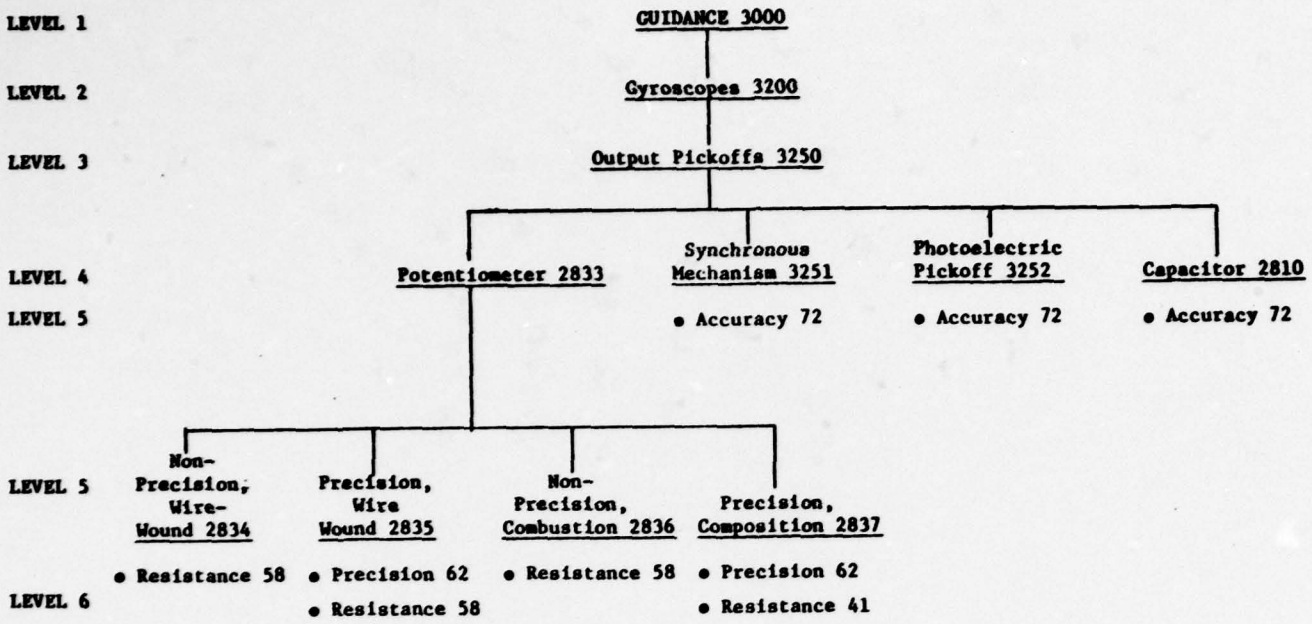

LEVEL 1
GUIDANCE 3000
LEVEL 2
Batteries 3100
Electronics 2700
Wiring 2800
Gyroscopes 3200
Control Wire System 3300
Hardware 1800
Environmental Controls 3400
LEVEL 3
• Active Components 2701
• Passive Components 2801
• Wire 1720
• Insulation 1730
• Connectors 1740
• Spinning Power 3210
• Pendulous Reference Devices 3230
• Torquing Devices 3240
• Output Pickoffs 3250
• Bearings 1150
• Flotation Fluid 3260
• Gimbal 3270
• Wire 1720
• Insulation 1730
• Connectors 1740
• Bobbin 3310
• Fasteners 1810
• Brackets 1820
• Springs 1830
• Permanent Fastenings 1840
• Monitoring Instruments 3410
• Temperature Control Units 3430
• Pressure Control Units 3440
• Humidity Control Units 3450

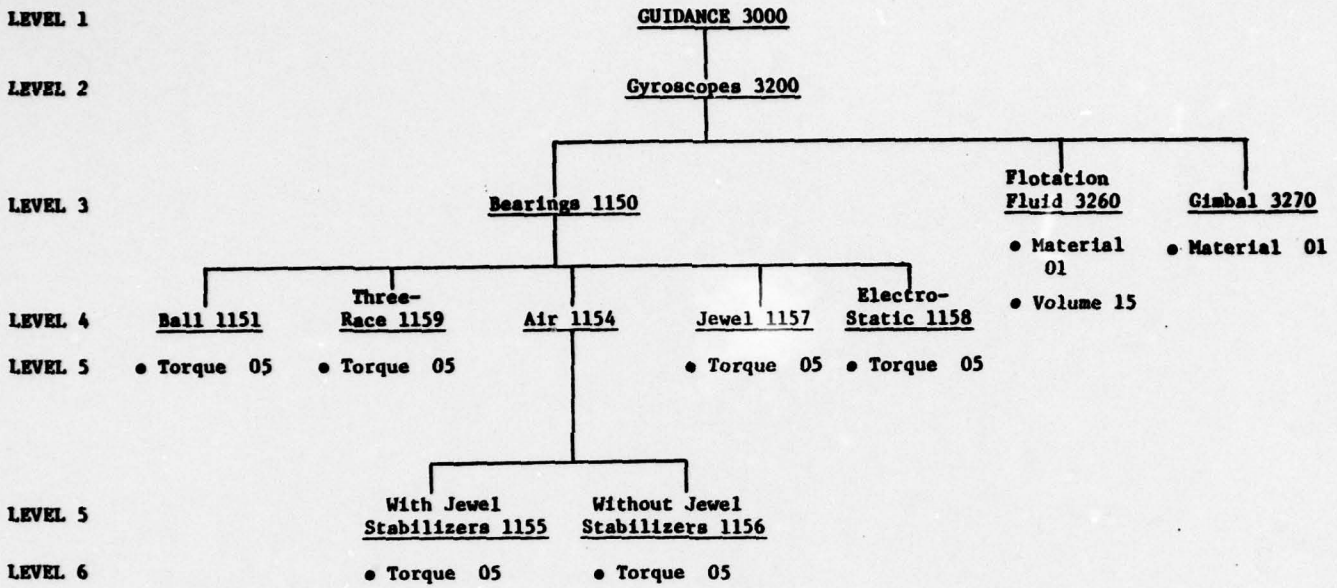

LEVEL 1
GUIDANCE 3000
LEVEL 2
Plumbing 2100
Structures 2200
EMI Control 2300
Finishes 1600
IR Source 3500
Seeker 3600
T&I 6000
Assembly Operations 1900
LEVEL 3
• Piping and Tubing 2110
• Fluid 2120
• Fittings 2130
• Manifolds 2140
• Fluid Supply 2150
• Valves 2160
• Fairings and Covers 1200
• Housings 1300
• Frames 1400
• Ground Straps 2310
• Permanent Bonds 2320
• Spring Fingered Contacts 2330
• Conducting Gaskets 2340
• Metallic Gauze 2350
• Inorganic 1610
• Organic 1620
• Filters 2790
• Flare 3510
• Modulator 3520
• Detector 3610
• Domes 3630
• Gyroscope Mechanism 3650
• Optics 3640
• Structural Tests 6100
• Electrical Tests 6200
• Mechanical Joining 1910
• Permanent Joining 1920
• Finishing and Lubrication Operations 1930

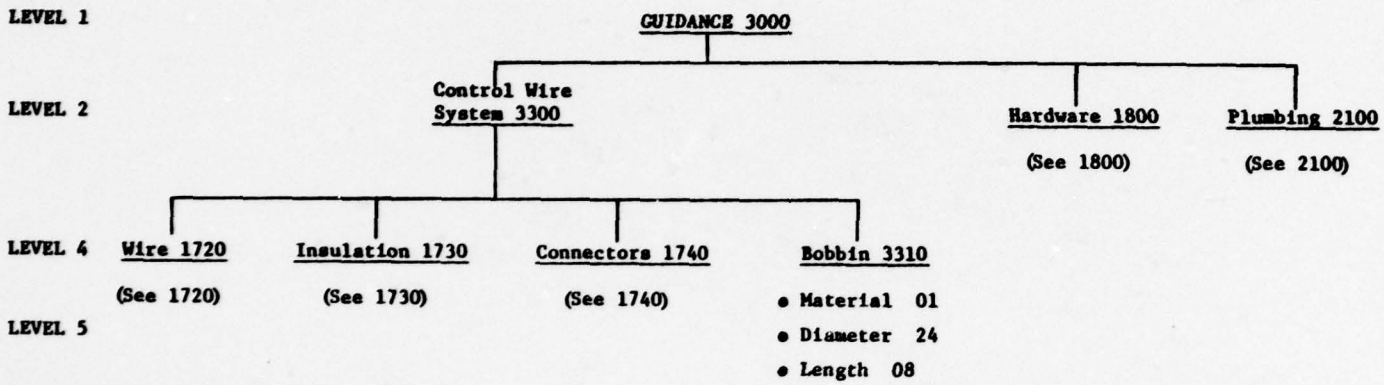

LEVEL 1
GUIDANCE 3000
LEVEL 2
Battery 3100
Electronics 2700
(See 2700)
Wiring 2800
(See 2800)
LEVEL 3
Carbon-Zinc 3101
Mercury 3103
Nickel-Cadmium 3105
Lead-Calcium 3107
Silver-Zinc 3109
Lithium 3111
Zinc-Air 3113
Copper Oxide-Zinc 3115
LEVEL 4
• Voltage 21
• Shelflife 71
• Voltage 21
• Shelflife
LEVEL 3
Alkaline-Manganese 3102
Silver-Oxide 3104
Lead-Acid 3106
Nickel-Iron 3108
Silver-Cadmium 3110
Magnesium 3112
Solid-State 3114
Thermal 3120
LEVEL 4
• Voltage 21
• Shelflife 71
LEVEL 5
Anode 3121
Cathode 3130
Electrolyte 3140
Heater 3150
LEVEL 6
• Calcium 3122
• Magnesium 3123
• Calcium Chromate 3131
• Vanadium Pentoxides 3132
• Potassium Chlorides 3141
• Lithium Chlorides 3142
• Zirconium-Barium Chromate (paper) 3151
• Iron-Potassium Perchlorate (pellets) 3152

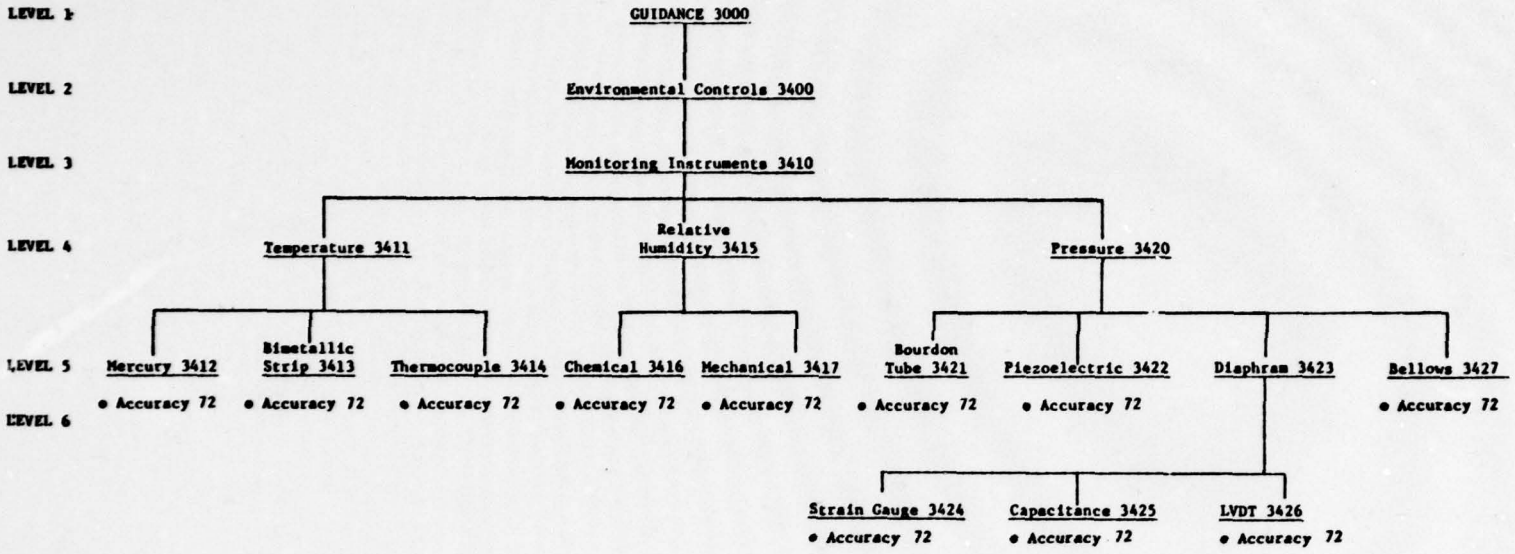

LEVEL 1
GUIDANCE 3000
LEVEL 2
Gyroscopes 3200
LEVEL 3
Spinning Power 3210
Pendulous Reference Devices 3230
LEVEL 4
Electric Motor 3211
Gas Jet Turbine 3221
• Torque 05
• Pressure 13
Constant Force Spring 3222
• Torque 05
• Material 01
Mercury Switch 3231
• Accuracy 72
E-Pickoff 3233
Electrolytic Switch 3236
Convectron 3239
• Accuracy 72
Single Axis 3234
• Accuracy 72
Double Axis 3235
• Accuracy 72
LEVEL 5
AC 3212
DC 3215
LEVEL 6
Shunt Wound 3216
Series Wound 3217
Compound 3218
Permanent Magnet 3219
Brushless 3220
LEVEL 7
• Torque 05
• Torque 05
• Torque 05
• Torque 05
• Torque 05
Single Axis 3237
• Accuracy 72
Double Axis 3238
• Accuracy 72
LEVEL 6
Asynchronous 3213
Synchronous 3214
LEVEL 7
• Torque 05
• Torque 05

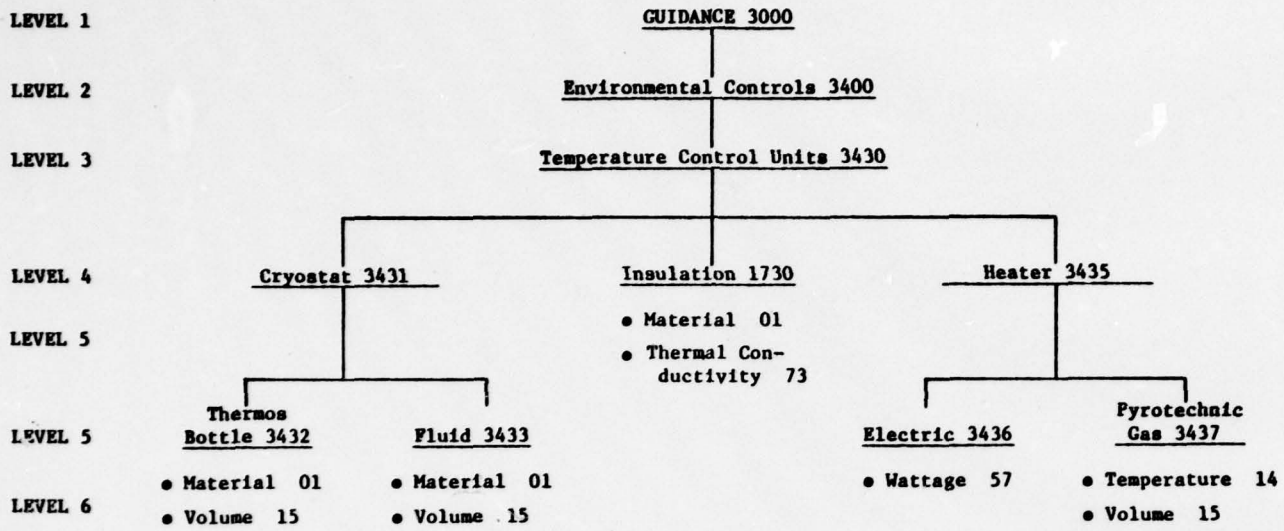

LEVEL 1
GUIDANCE 3000
LEVEL 2
Gyroscopes 3200
LEVEL 3
Torquing Devices 3240
LEVEL 4
Electromagnet 3241
• Volts 21
• Lift 22
LEVEL 5
Microsyn Torque Generator 3243
• Torque 05
Ball Erection (Inverted Pendulum) 3245
• Torque 05
Linear Differential Transformer 3247
• Torque 05
LEVEL 4
Pancake Induction Motor 3242
• Torque 05
LEVEL 5
Ball-Disc Erection 3244
• Torque 05
Pin-Ball Erection 3246
• Torque 05
E-Transformer 3248
• Torque 05


LEVEL 1
GUIDANCE 3000
LEVEL 2
Gyroscopes 3200
LEVEL 3
Output Pickoffs 3250
LEVEL 4
Potentiometer 2833
Synchronous Mechanism 3251
Photoelectric Pickoff 3252
Capacitor 2810
LEVEL 5
• Accuracy 72
• Accuracy 72
• Accuracy 72
LEVEL 5
Non-Precision, Wire-Wound 2834
Precision, Wire Wound 2835
Non-Precision, Combustion 2836
Precision, Composition 2837
LEVEL 6
• Resistance 58
• Precision 62
• Resistance 58
• Resistance 58
• Precision 62
• Resistance 41


LEVEL 1
GUIDANCE 3000
LEVEL 2
Gyroscopes 3200
LEVEL 3
Bearings 1150
Flotation Fluid 3260
• Material 01
• Volume 15
Gimbal 3270
• Material 01
LEVEL 4
Ball 1151
Three-Race 1159
Air 1154
Jewel 1157
Electro-Static 1158
LEVEL 5
• Torque 05
• Torque 05
• Torque 05
• Torque 05
LEVEL 5
With Jewel Stabilizers 1155
Without Jewel Stabilizers 1156
LEVEL 6
• Torque 05
• Torque 05

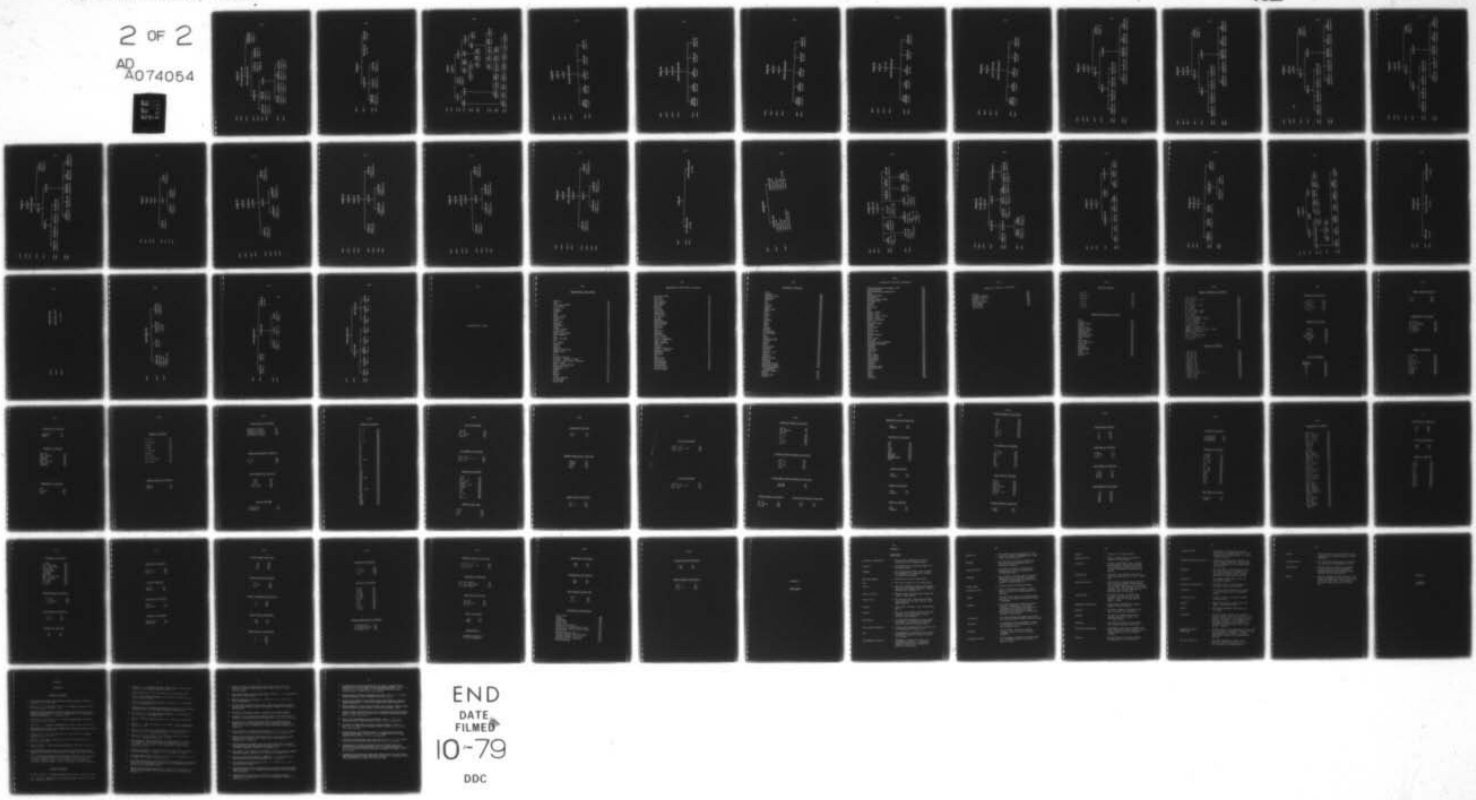

LEVEL 1
GUIDANCE 3000
LEVEL 2
Control Wire System 3300
Hardware 1800
(See 1800)
Plumbing 2100
(See 2100)
LEVEL 4
Wire 1720
(See 1720)
Insulation 1730
(See 1730)
Connectors 1740
(See 1740)
Bobbin 3310
LEVEL 5
• Material 01
• Diameter 24
• Length 08


LEVEL 1
GUIDANCE 3000
LEVEL 2
Environmental Controls 3400
LEVEL 3
Monitoring Instruments 3410
LEVEL 4
Temperature 3411
Relative Humidity 3415
Pressure 3420
LEVEL 5
Mercury 3412
Bimetallic Strip 3413
Thermocouple 3414
Chemical 3416
Mechanical 3417
Bourdon Tube 3421
Piezoelectric 3422
Diaphram 3423
Bellows 3427
LEVEL 6
• Accuracy 72
• Accuracy 72
• Accuracy 72
• Accuracy 72
• Accuracy 72
• Accuracy 72
• Accuracy 72
• Accuracy 72
Strain Gauge 3424
Capacitance 3425
LVDT 3426
• Accuracy 72
• Accuracy 72
• Accuracy 72


LEVEL 1
GUIDANCE 3000
LEVEL 2
Environmental Controls 3400
LEVEL 3
Temperature Control Units 3430
LEVEL 4
Cryostat 3431
Insulation 1730
Heater 3435
LEVEL 5
• Material 01
• Thermal Conductivity 73
LEVEL 5
Thermos Bottle 3432
Fluid 3433
Electric 3436
Pyrotechnic Gas 3437
LEVEL 6
• Material 01
• Volume 15
• Material 01
• Volume 15
• Wattage 57
• Temperature 14
• Volume 15

AD-A074 054 BATTELLE COLUMBUS LABS OH F/G 15/7
COST-DRIVER ANALYSIS FOR COMPUTERIZED PRODUCTION PROCESS PLANNI--ETC(U)
JUL 79 T E HILL, T G BYRER, B R NOTON DAAK40-77-R-0138
UNCLASSIFIED NL

2 OF 2
AD A074054



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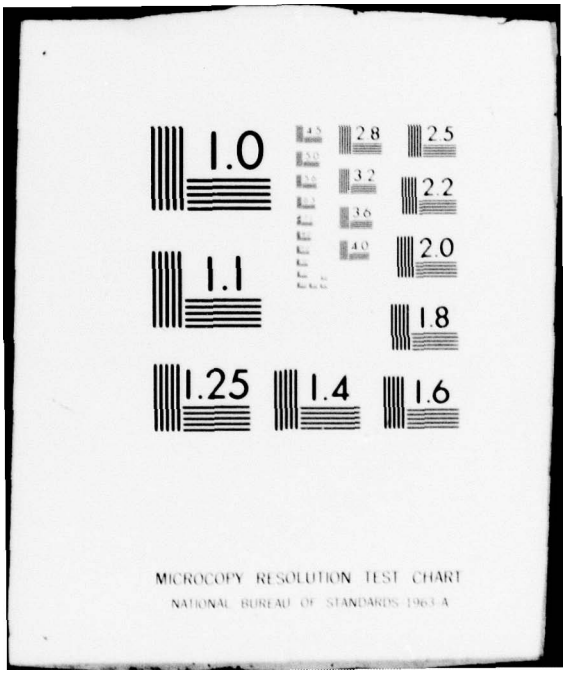
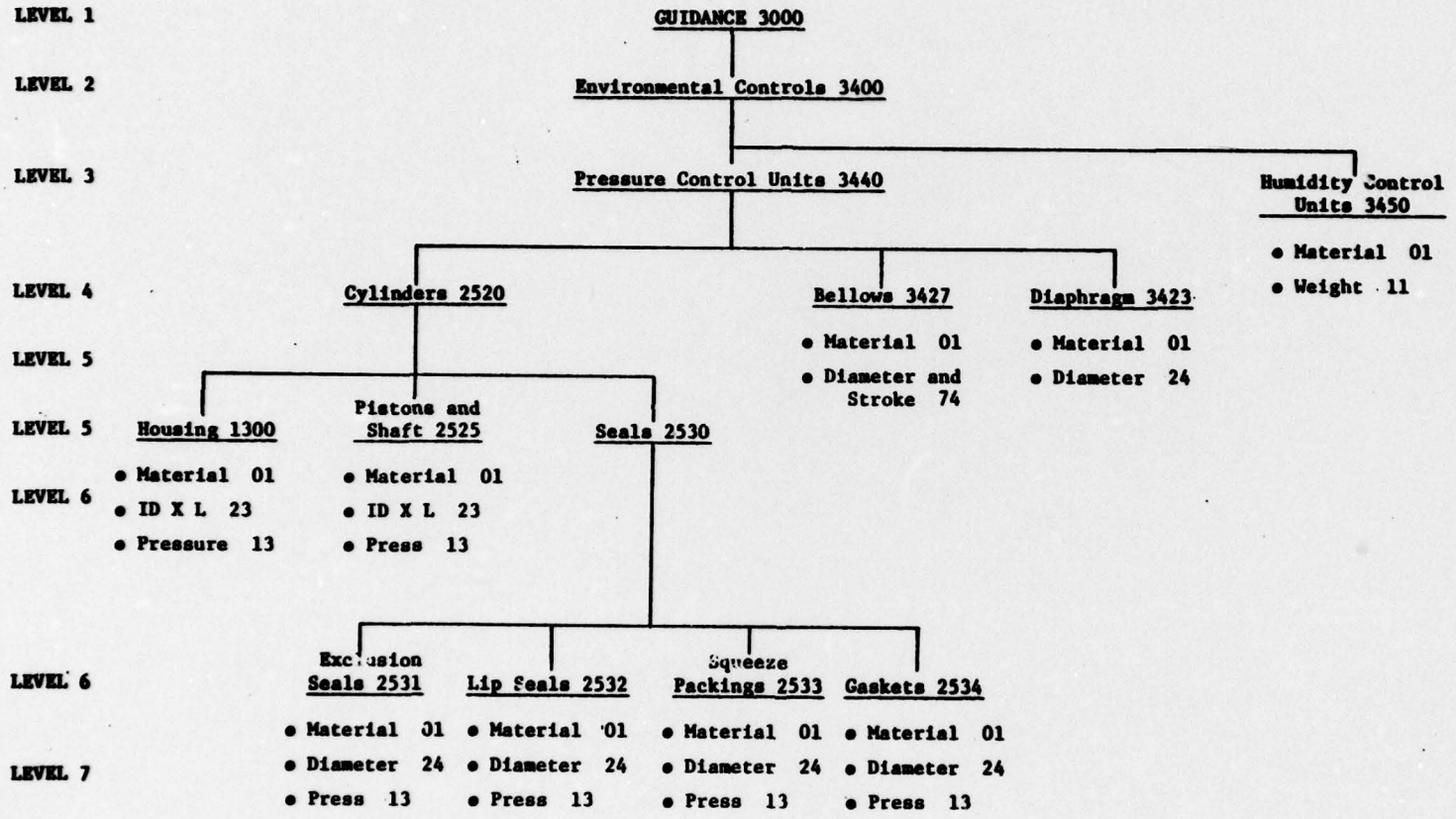
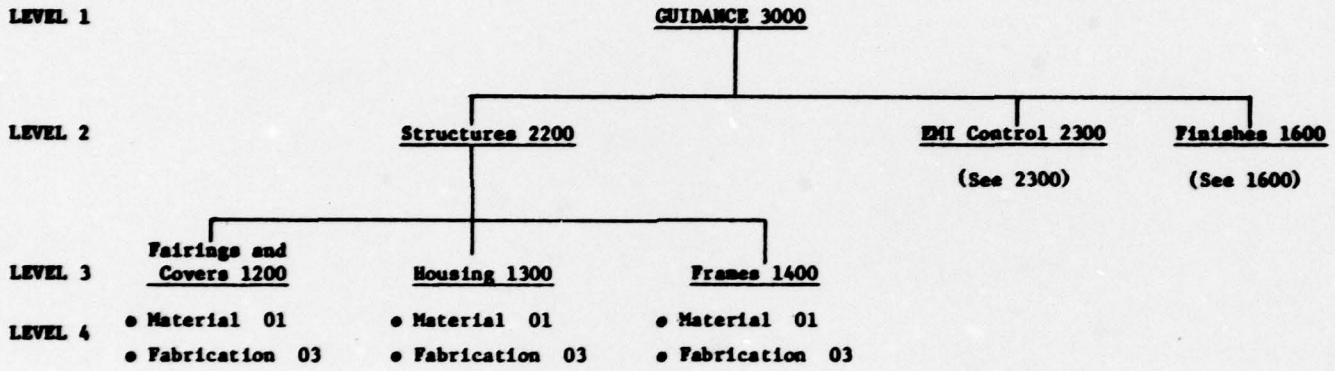
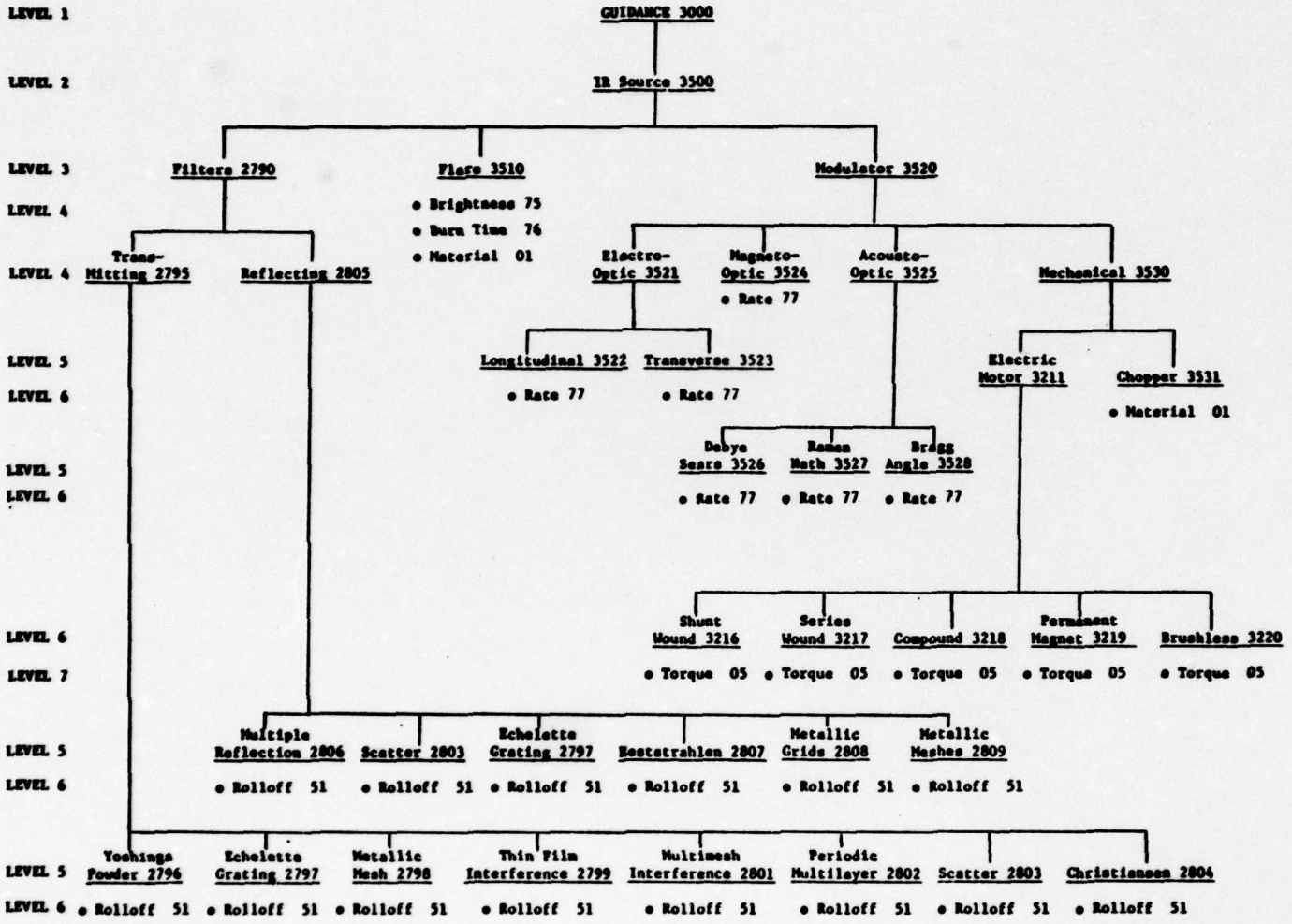
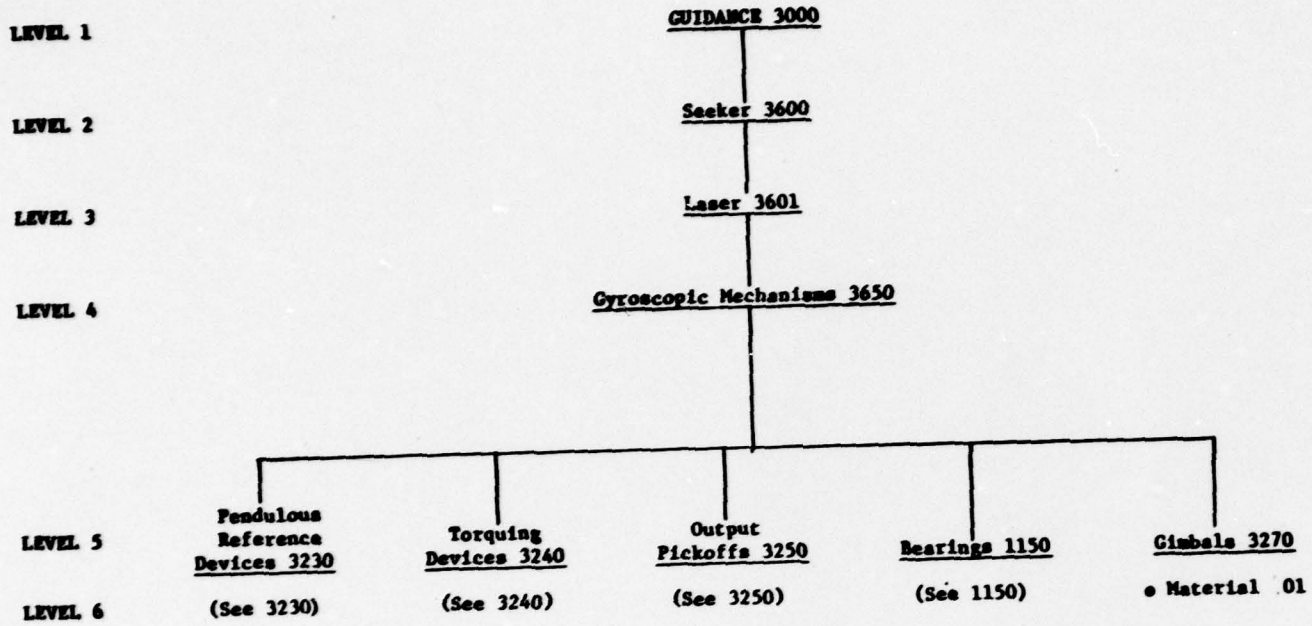
DATE FILMED
10-79
DDC

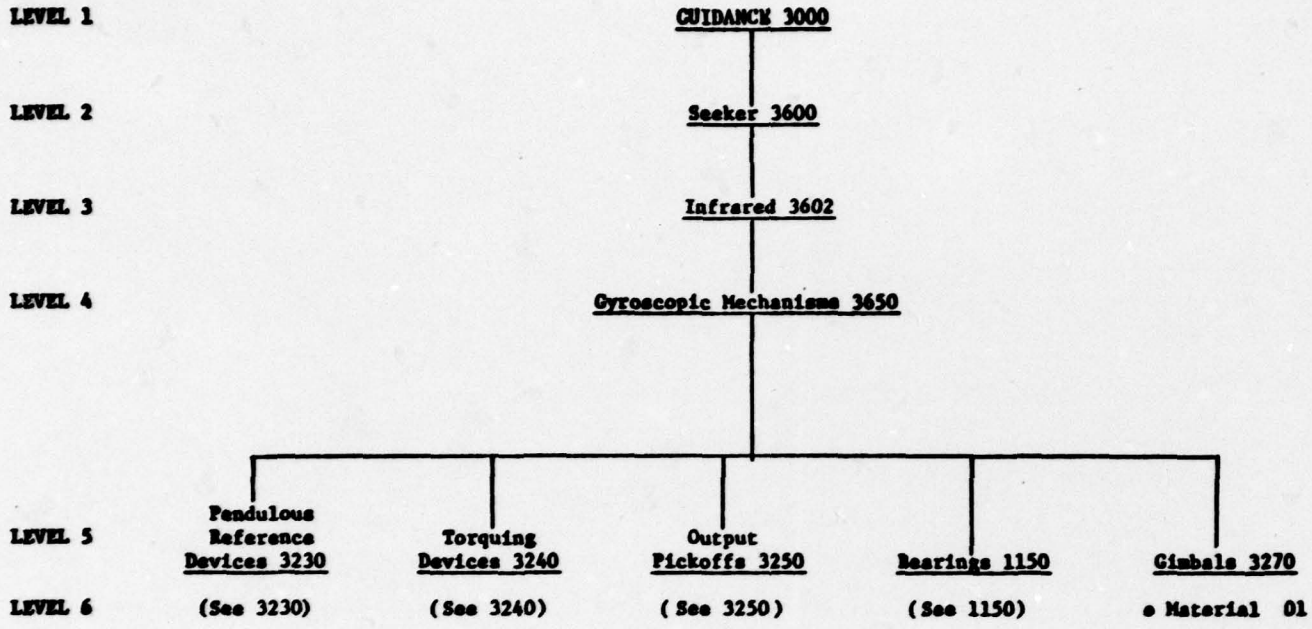

1.0
1.1
1.25
1.4
1.6
2.8
3.2
3.6
4.0
2.5
2.2
2.0
1.8
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A

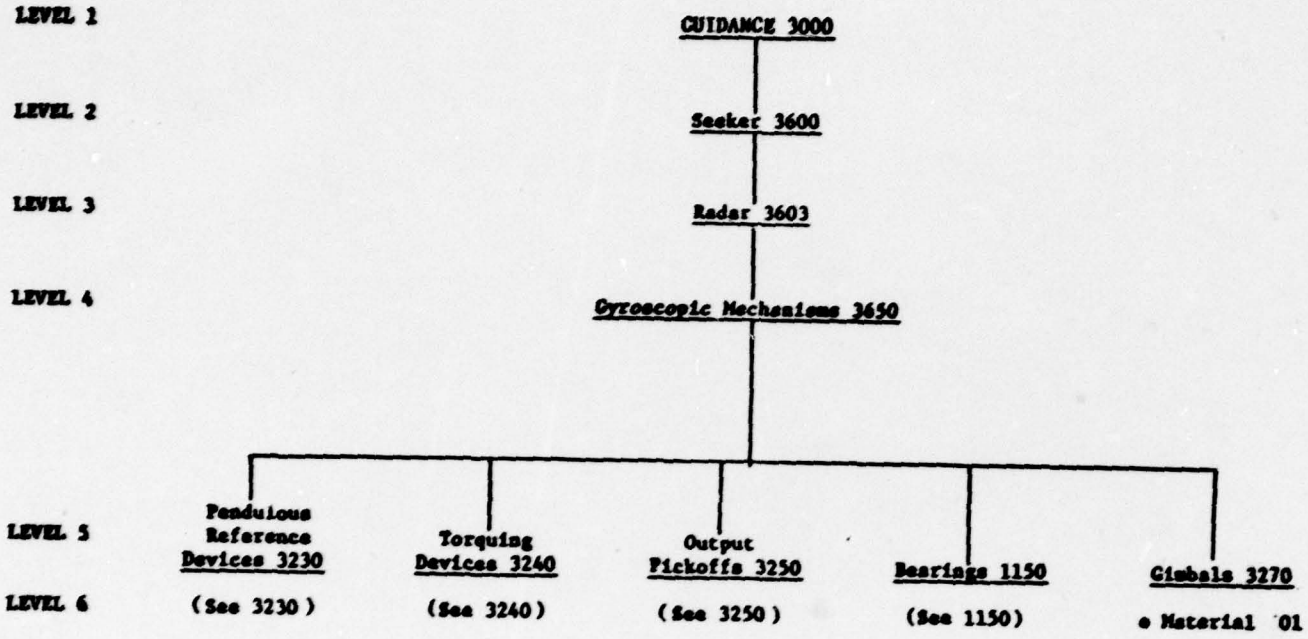

LEVEL 1
GUIDANCE 3000
LEVEL 2
Environmental Controls 3400
LEVEL 3
Pressure Control Units 3440
Humidity Control Units 3450
• Material 01
• Weight 11
LEVEL 4
Cylinders 2520
Bellows 3427
Diaphragm 3423
LEVEL 5
• Material 01
• Diameter and Stroke 74
• Material 01
• Diameter 24
LEVEL 5
Housing 1300
Pistons and Shaft 2525
Seals 2530
LEVEL 6
• Material 01
• ID X L 23
• Pressure 13
• Material 01
• ID X L 23
• Press 13
LEVEL 6
Exclusion Seals 2531
Lip Seals 2532
Squeeze Packings 2533
Gaskets 2534
LEVEL 7
• Material 01
• Diameter 24
• Press 13
• Material 01
• Diameter 24
• Press 13
• Material 01
• Diameter 24
• Press 13
• Material 01
• Diameter 24
• Press 13

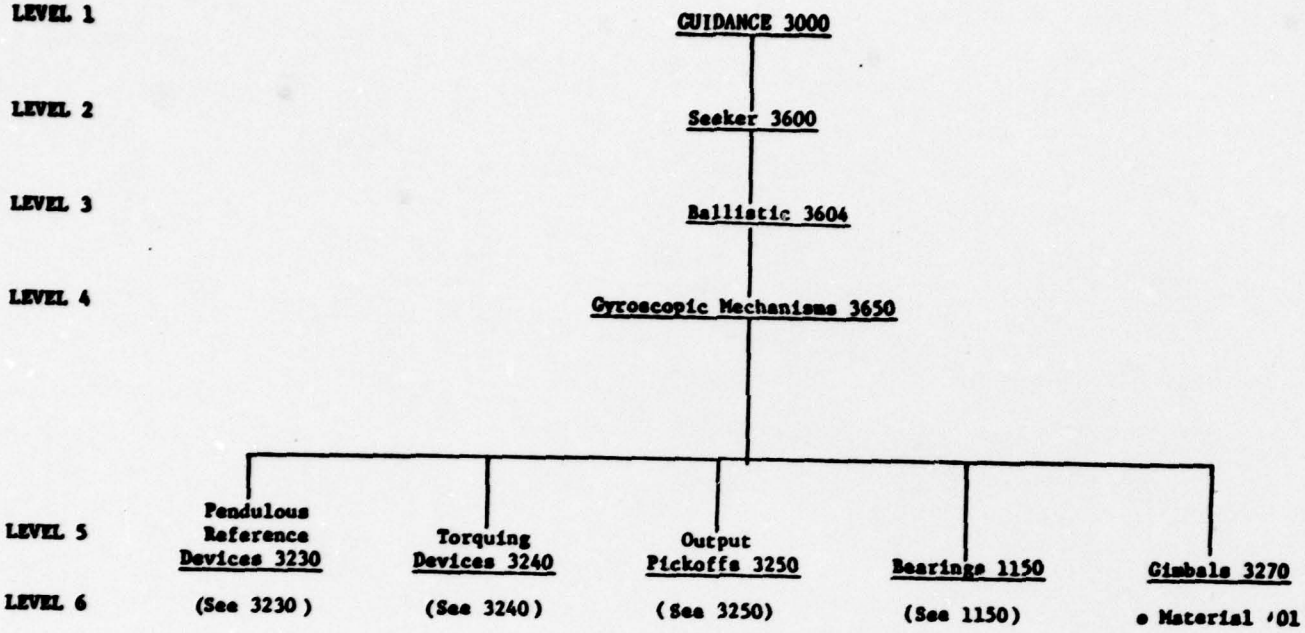

LEVEL 1
GUIDANCE 3000
LEVEL 2
Structures 2200
EMI Control 2300
(See 2300)
Finishes 1600
(See 1600)
LEVEL 3
Fairings and Covers 1200
Housing 1300
Frames 1400
LEVEL 4
• Material 01
• Fabrication 03
• Material 01
• Fabrication 03
• Material 01
• Fabrication 03

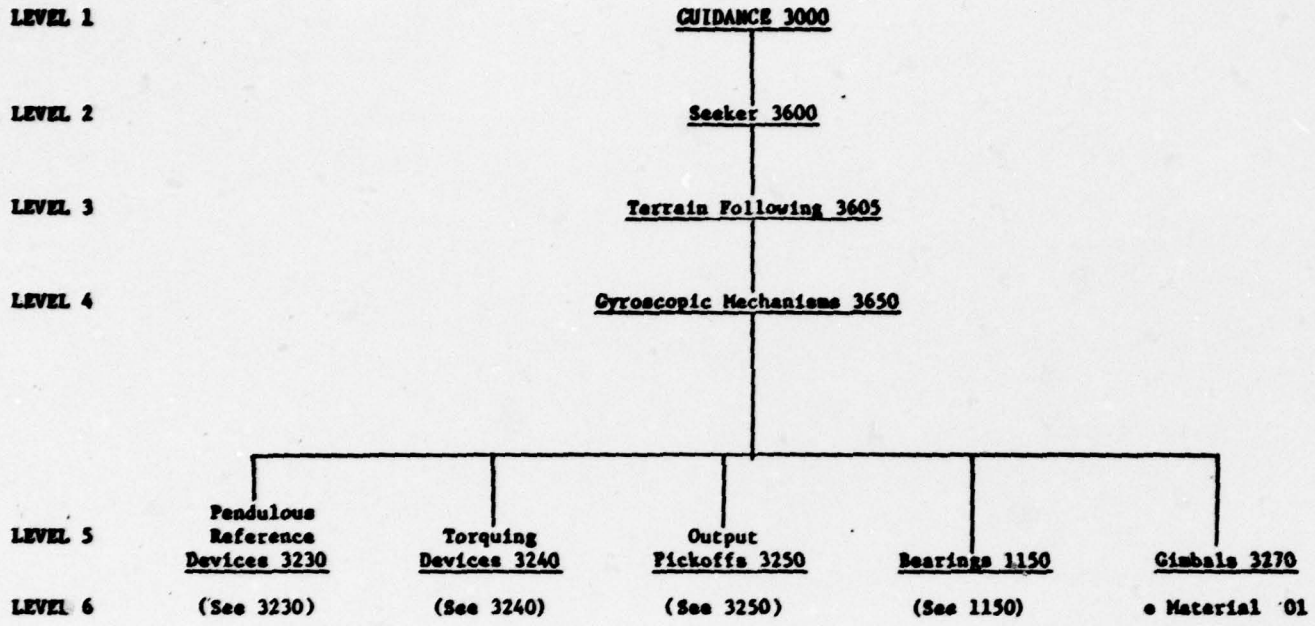

LEVEL 1
GUIDANCE 3000
LEVEL 2
IR Source 3500
LEVEL 3
Filters 2790
Flare 3510
Modulator 3520
LEVEL 4
• Brightness 75
• Burn Time 76
• Material 01
Trans-
Mitting 2795
Reflecting 2805
Electro-
Optic 3521
Magneto-
Optic 3524
• Rate 77
Acousto-
Optic 3525
Mechanical 3530
LEVEL 5
Longitudinal 3522
Transverse 3523
Electric
Motor 3211
Chopper 3531
LEVEL 6
• Rate 77
• Rate 77
• Material 01
Debye
Sears 3526
Raman
Nath 3527
Bragg
Angle 3528
LEVEL 5
LEVEL 6
• Rate 77
• Rate 77
• Rate 77
Shunt
Wound 3216
Series
Wound 3217
Compound 3218
Permanent
Magnet 3219
Brushless 3220
LEVEL 6
LEVEL 7
• Torque 05
• Torque 05
• Torque 05
• Torque 05
• Torque 05
Multiple
Reflection 2806
Scatter 2803
Echelette
Grating 2797
Reststrahlen 2807
Metallic
Grids 2808
Metallic
Meshes 2809
LEVEL 5
LEVEL 6
• Rolloff 51
• Rolloff 51
• Rolloff 51
• Rolloff 51
• Rolloff 51
• Rolloff 51
Yoshinga
Powder 2796
Echelette
Grating 2797
Metallic
Mesh 2798
Thin Film
Interference 2799
Multimesh
Interference 2801
Periodic
Multilayer 2802
Scatter 2803
Christiansen 2804
LEVEL 5
LEVEL 6
• Rolloff 51
• Rolloff 51
• Rolloff 51
• Rolloff 51
• Rolloff 51
• Rolloff 51
• Rolloff 51
• Rolloff 51

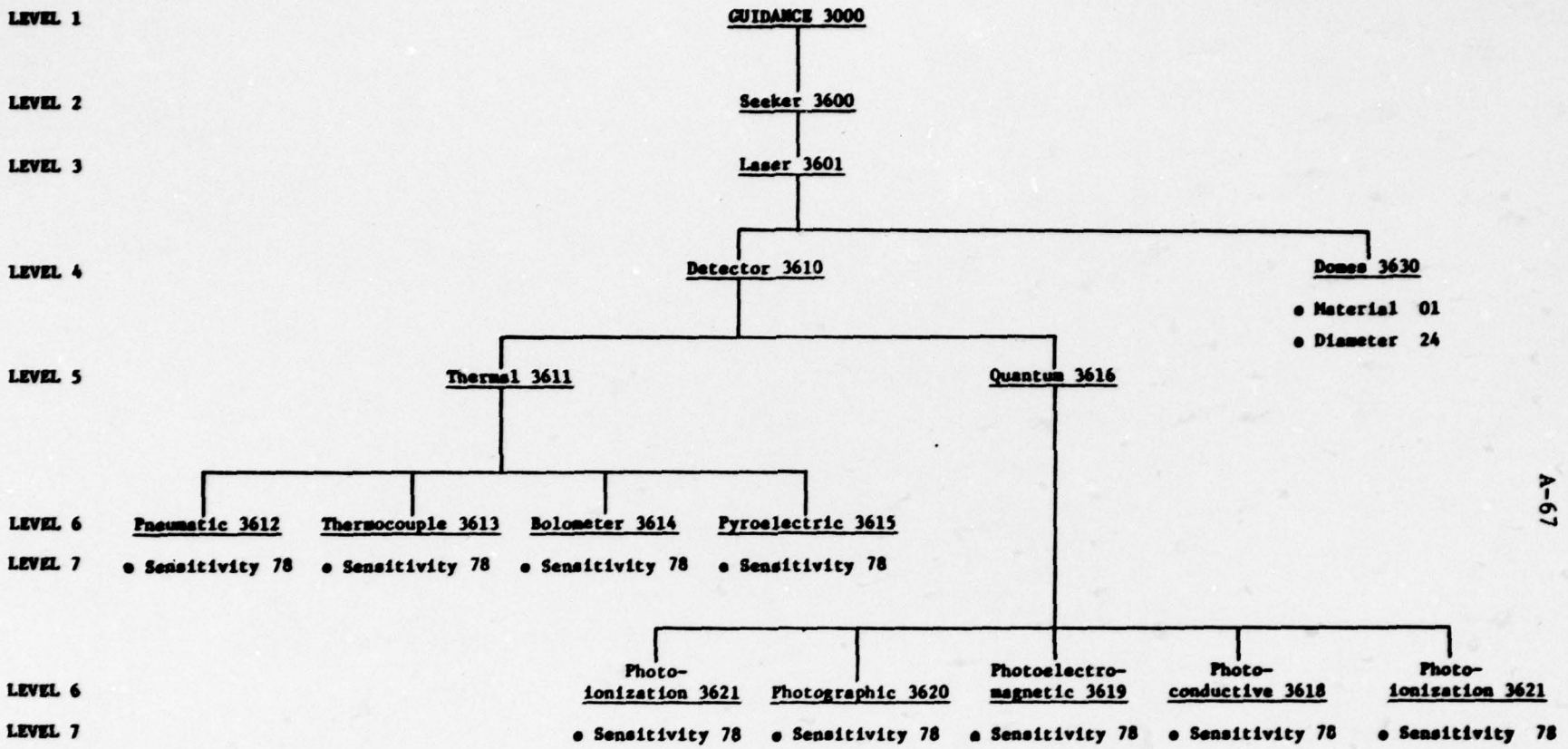

LEVEL 1
GUIDANCE 3000
LEVEL 2
Seeker 3600
LEVEL 3
Laser 3601
LEVEL 4
Gyroscopic Mechanisms 3650
LEVEL 5
Pendulous Reference Devices 3230
Torquing Devices 3240
Output Pickoffs 3250
Bearings 1150
Gimbals 3270
LEVEL 6
(See 3230)
(See 3240)
(See 3250)
(See 1150)
• Material 01

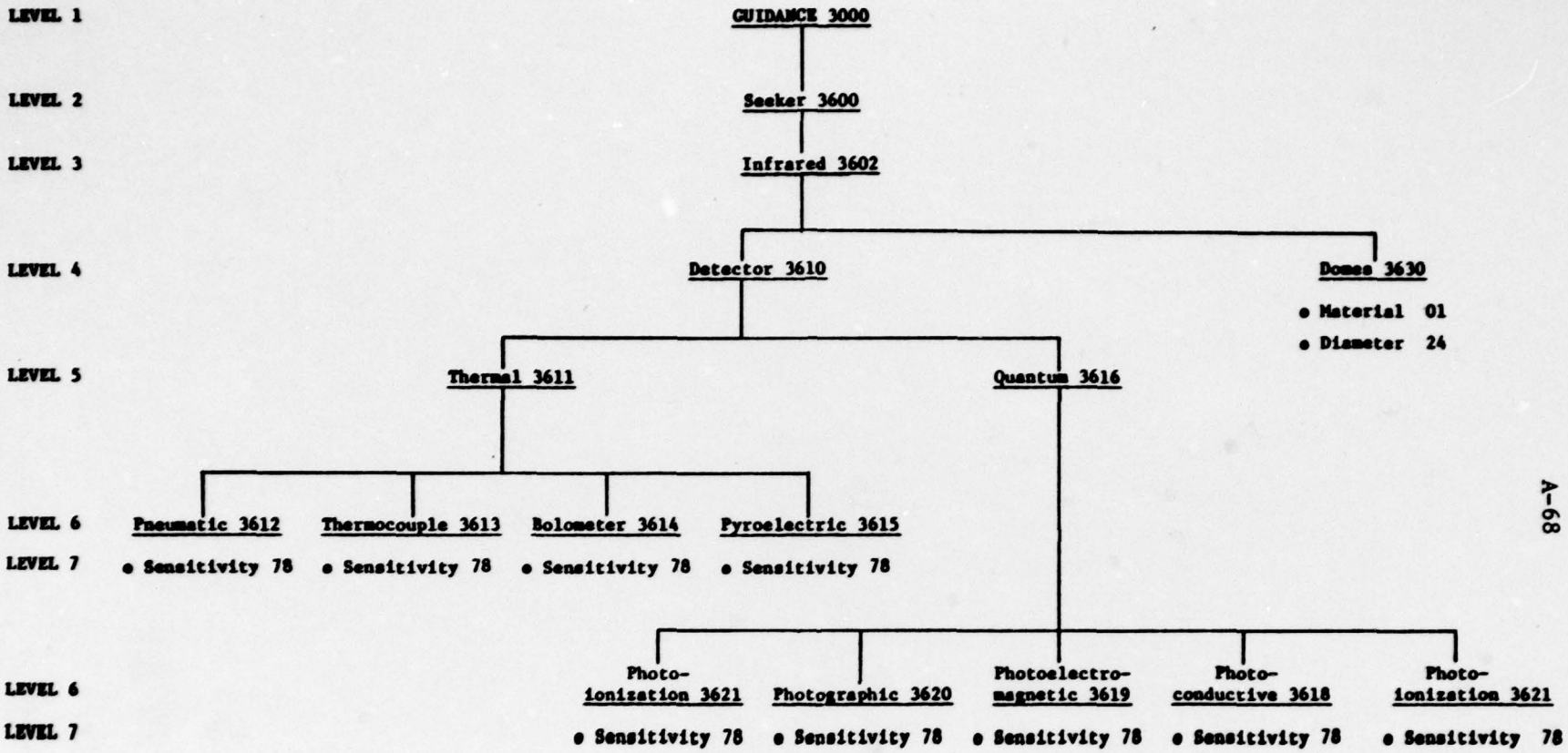

LEVEL 1
GUIDANCE 3000
LEVEL 2
Seeker 3600
LEVEL 3
Infrared 3602
LEVEL 4
Gyroscopic Mechanisms 3650
LEVEL 5
Pendulous Reference Devices 3230
Torquing Devices 3240
Output Pickoffs 3250
Bearings 1150
Gimbals 3270
LEVEL 6
(See 3230)
(See 3240)
(See 3250)
(See 1150)
• Material 01

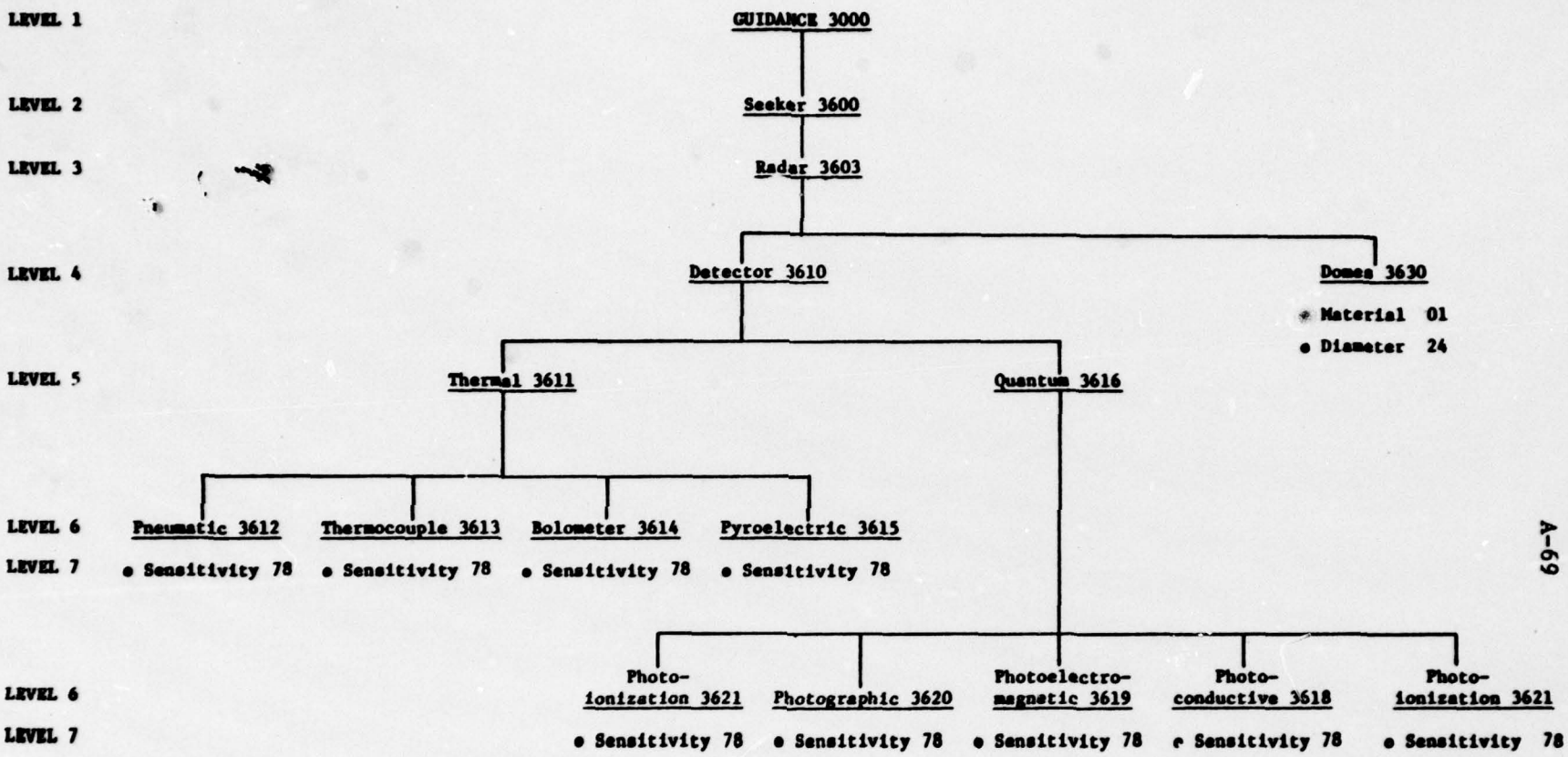

LEVEL 1
GUIDANCE 3000
LEVEL 2
Seeker 3600
LEVEL 3
Radar 3603
LEVEL 4
Gyroscopic Mechanisms 3650
LEVEL 5
Pendulous Reference Devices 3230
Torquing Devices 3240
Output Pickoffs 3250
Bearings 1150
Gimbals 3270
LEVEL 6
(See 3230)
(See 3240)
(See 3250)
(See 1150)
• Material 01

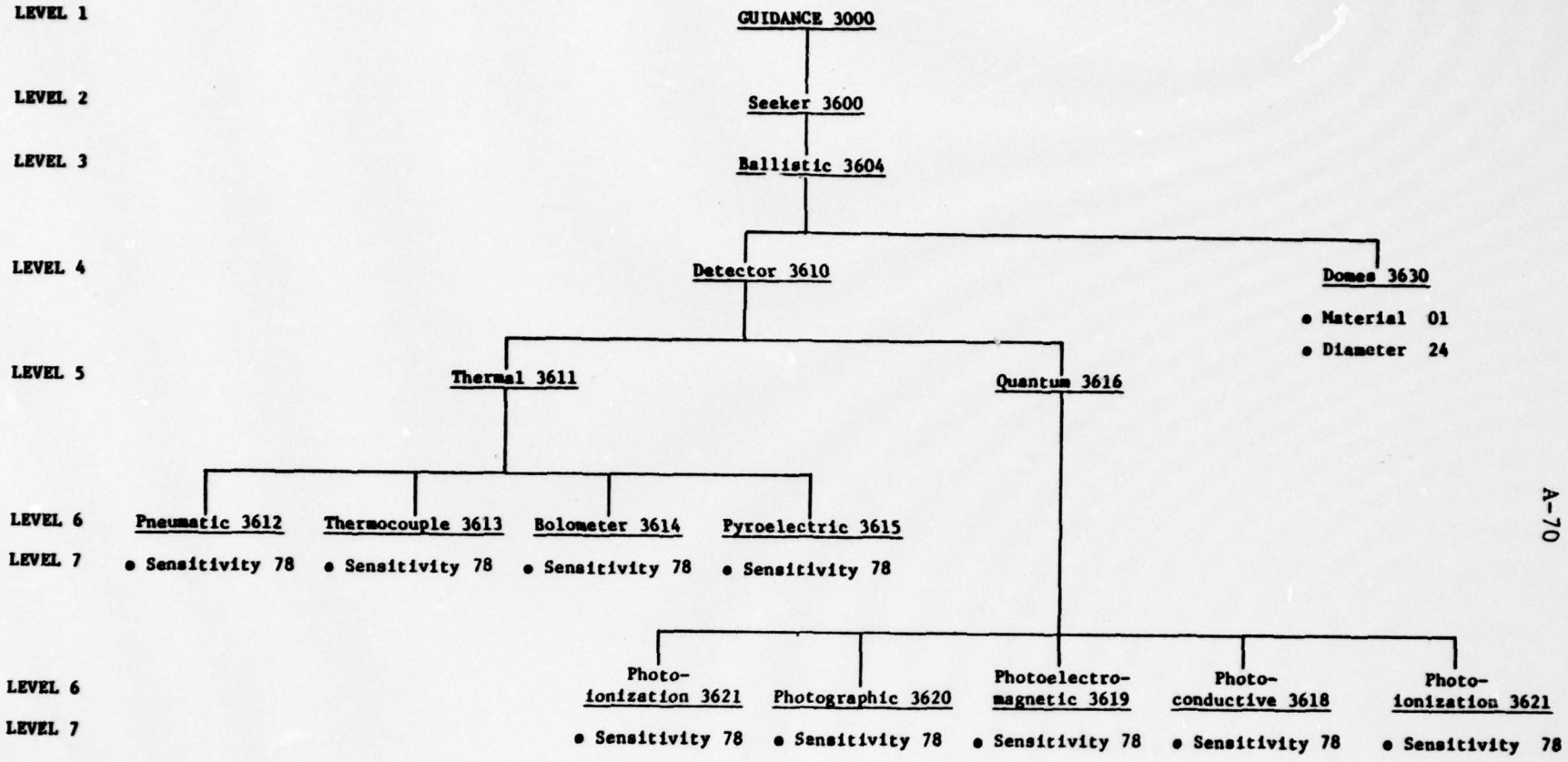

LEVEL 1
GUIDANCE 3000
LEVEL 2
Seeker 3600
LEVEL 3
Ballistic 3604
LEVEL 4
Gyroscopic Mechanisms 3650
LEVEL 5
Pendulous Reference Devices 3230
Torquing Devices 3240
Output Pickoffs 3250
Bearings 1150
Gimbals 3270
LEVEL 6
(See 3230)
(See 3240)
(See 3250)
(See 1150)
• Material '01

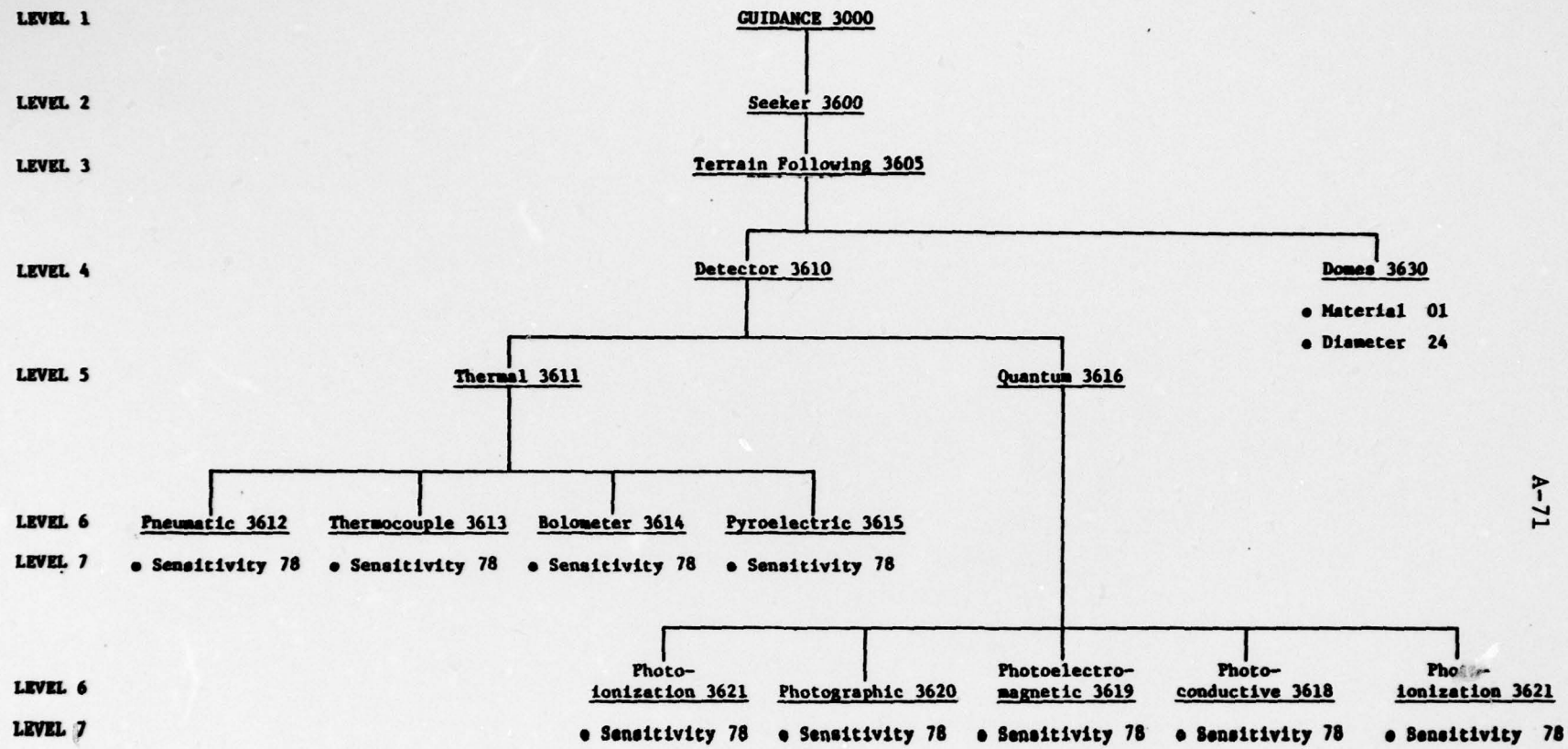

LEVEL 1
CUIDANCE 3000
LEVEL 2
Seeker 3600
LEVEL 3
Terrain Following 3605
LEVEL 4
Gyroscopic Mechanisms 3650
LEVEL 5
Pendulous Reference Devices 3230
Torquing Devices 3240
Output Pickoffs 3250
Bearings 1150
Gimbals 3270
LEVEL 6
(See 3230)
(See 3240)
(See 3250)
(See 1150)
• Material 01

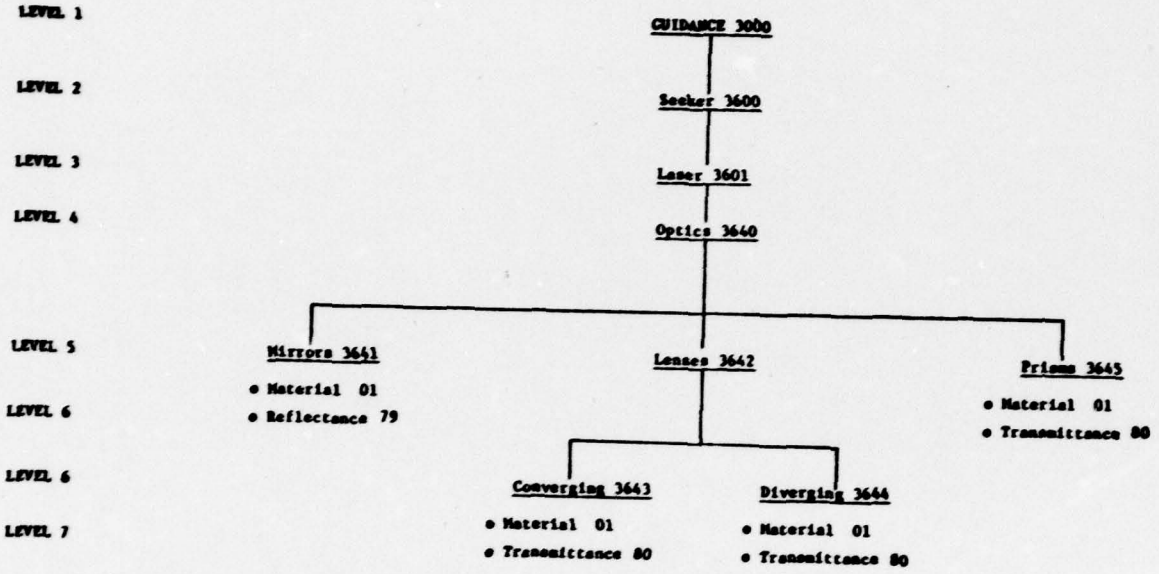

LEVEL 1
GUIDANCE 3000
LEVEL 2
Seeker 3600
LEVEL 3
Laser 3601
LEVEL 4
Detector 3610
Domes 3630
• Material 01
• Diameter 24
LEVEL 5
Thermal 3611
Quantum 3616
LEVEL 6
Pneumatic 3612
Thermocouple 3613
Bolometer 3614
Pyroelectric 3615
LEVEL 7
• Sensitivity 78
• Sensitivity 78
• Sensitivity 78
• Sensitivity 78
LEVEL 6
Photo-ionization 3621
Photographic 3620
Photoelectro-magnetic 3619
Photo-conductive 3618
Photo-ionization 3621
LEVEL 7
• Sensitivity 78
• Sensitivity 78
• Sensitivity 78
• Sensitivity 78
• Sensitivity 78

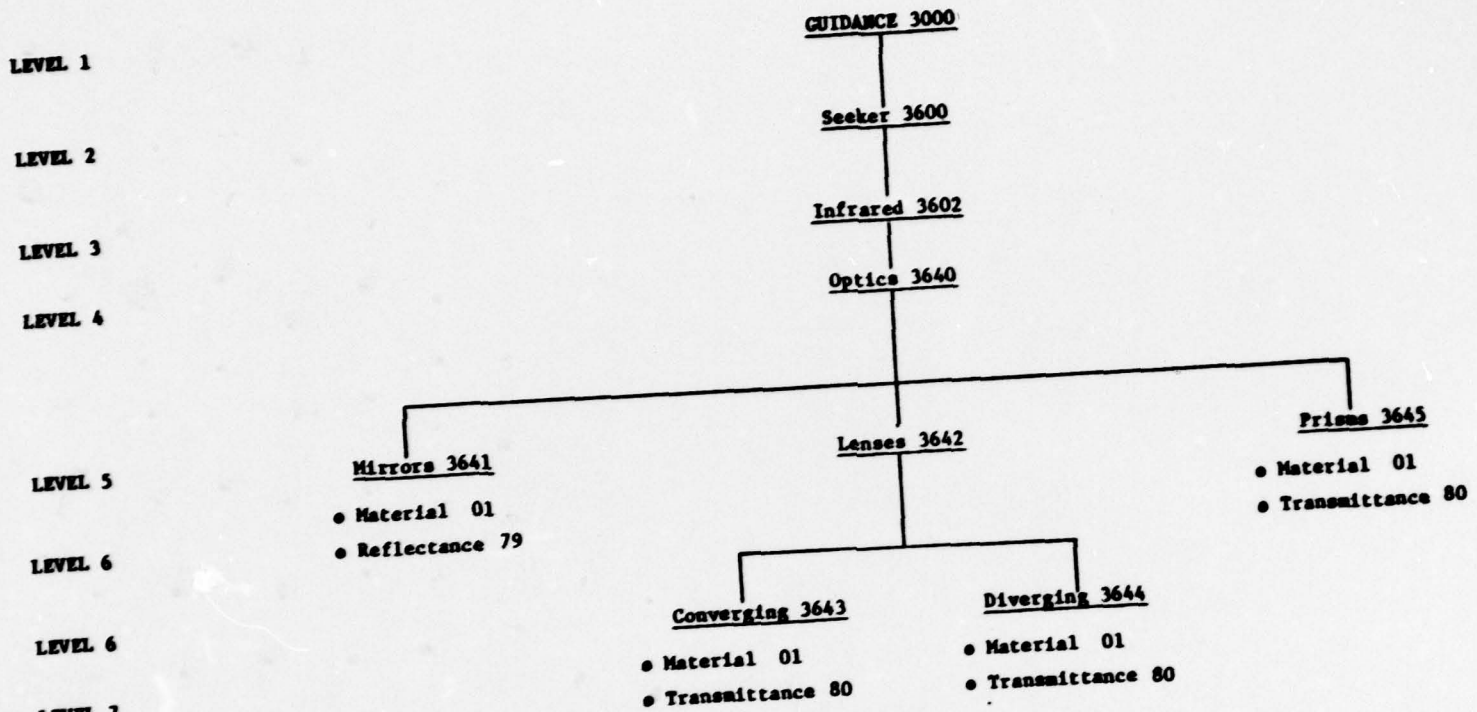

LEVEL 1
GUIDANCE 3000
LEVEL 2
Seeker 3600
LEVEL 3
Infrared 3602
LEVEL 4
Detector 3610
Domes 3630
• Material 01
• Diameter 24
LEVEL 5
Thermal 3611
Quantum 3616
LEVEL 6
Pneumatic 3612
Thermocouple 3613
Bolometer 3614
Pyroelectric 3615
LEVEL 7
• Sensitivity 78
• Sensitivity 78
• Sensitivity 78
• Sensitivity 78
LEVEL 6
Photo-ionization 3621
Photographic 3620
Photoelectro-magnetic 3619
Photo-conductive 3618
Photo-ionization 3621
LEVEL 7
• Sensitivity 78
• Sensitivity 78
• Sensitivity 78
• Sensitivity 78
• Sensitivity 78

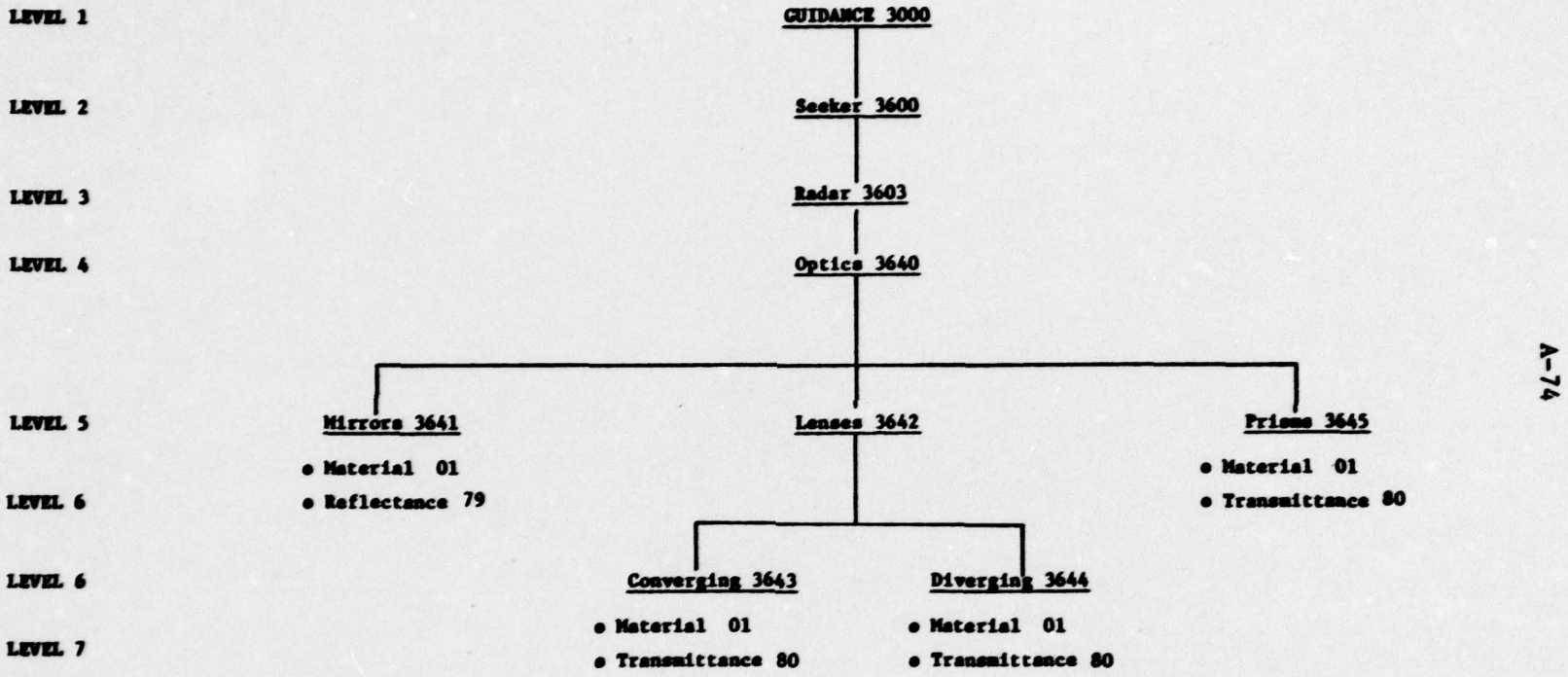

LEVEL 1
GUIDANCE 3000
LEVEL 2
Seeker 3600
LEVEL 3
Radar 3603
LEVEL 4
Detector 3610
Domes 3630
• Material 01
• Diameter 24
LEVEL 5
Thermal 3611
Quantum 3616
LEVEL 6
Pneumatic 3612
Thermocouple 3613
Bolometer 3614
Pyroelectric 3615
LEVEL 7
• Sensitivity 78
• Sensitivity 78
• Sensitivity 78
• Sensitivity 78
LEVEL 6
Photo-ionization 3621
Photographic 3620
Photoelectro-magnetic 3619
Photo-conductive 3618
Photo-ionization 3621
LEVEL 7
• Sensitivity 78
• Sensitivity 78
• Sensitivity 78
• Sensitivity 78
• Sensitivity 78

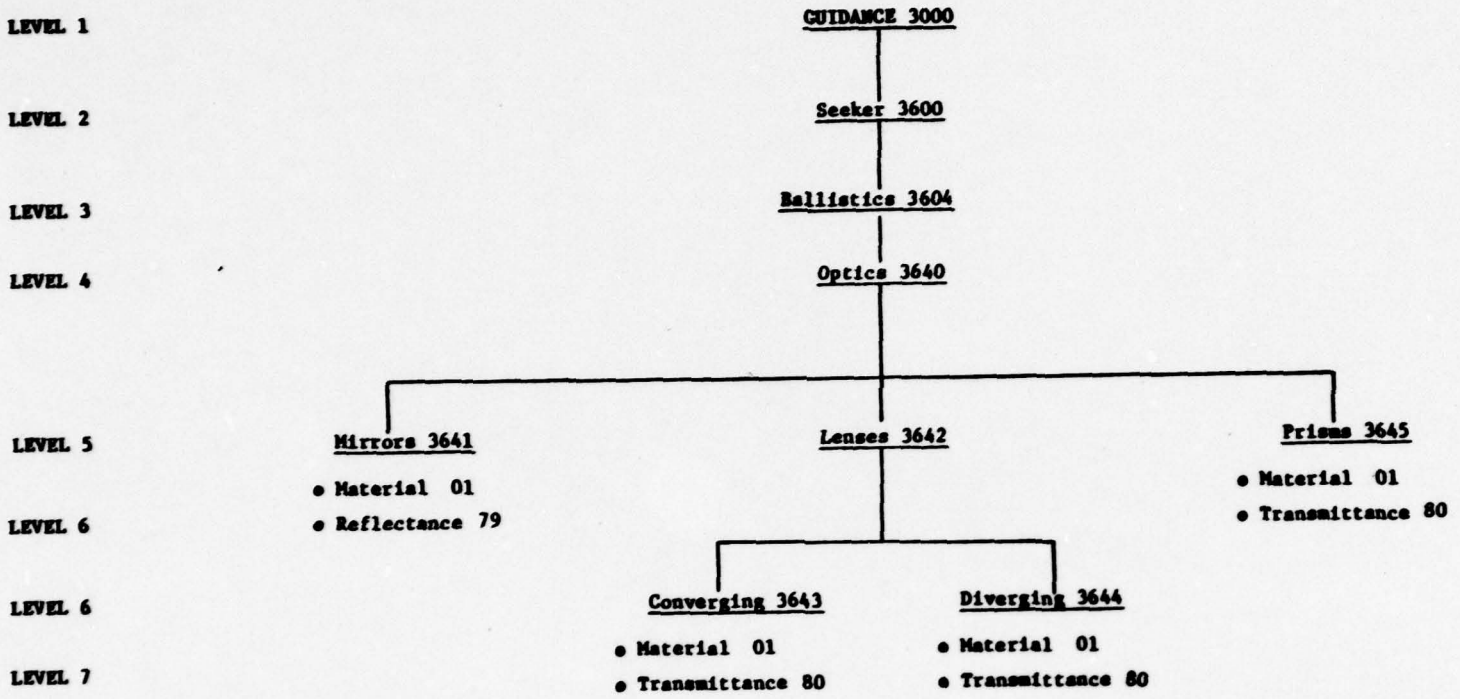

LEVEL 1
GUIDANCE 3000
LEVEL 2
Seeker 3600
LEVEL 3
Ballistic 3604
LEVEL 4
Detector 3610
Domes 3630
• Material 01
• Diameter 24
LEVEL 5
Thermal 3611
Quantum 3616
LEVEL 6
Pneumatic 3612
Thermocouple 3613
Bolometer 3614
Pyroelectric 3615
LEVEL 7
• Sensitivity 78
• Sensitivity 78
• Sensitivity 78
• Sensitivity 78
LEVEL 6
Photo-ionization 3621
Photographic 3620
Photoelectro-magnetic 3619
Photo-conductive 3618
Photo-ionization 3621
LEVEL 7
• Sensitivity 78
• Sensitivity 78
• Sensitivity 78
• Sensitivity 78
• Sensitivity 78

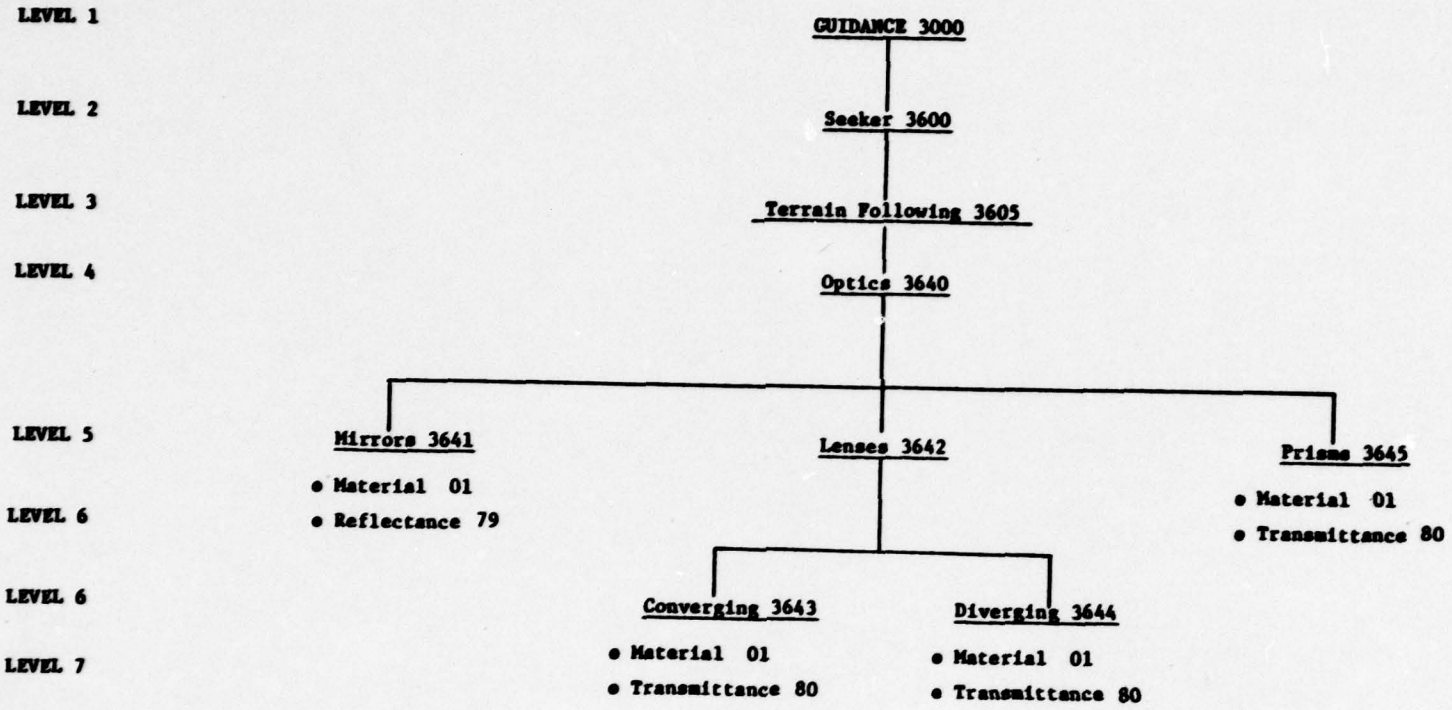

LEVEL 1
GUIDANCE 3000
LEVEL 2
Seeker 3600
LEVEL 3
Terrain Following 3605
LEVEL 4
Detector 3610
Domes 3630
• Material 01
• Diameter 24
LEVEL 5
Thermal 3611
Quantum 3616
LEVEL 6
Pneumatic 3612
Thermocouple 3613
Bolometer 3614
Pyroelectric 3615
LEVEL 7
• Sensitivity 78
• Sensitivity 78
• Sensitivity 78
• Sensitivity 78
LEVEL 6
Photo-ionization 3621
Photographic 3620
Photoelectro-magnetic 3619
Photo-conductive 3618
Photo-ionization 3621
LEVEL 7
• Sensitivity 78
• Sensitivity 78
• Sensitivity 78
• Sensitivity 78
• Sensitivity 78

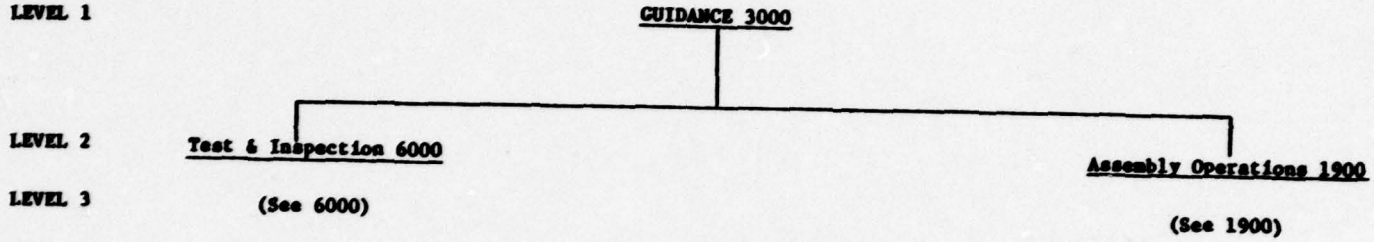

LEVEL 1
LEVEL 2
LEVEL 3
LEVEL 4
LEVEL 5
LEVEL 6
LEVEL 6
LEVEL 7
GUIDANCE 3000
Seeker 3600
Laser 3601
Optics 3640
Mirrors 3641
• Material 01
• Reflectance 79
Lenses 3642
Prisms 3645
• Material 01
• Transmittance 80
Converging 3643
• Material 01
• Transmittance 80
Diverging 3644
• Material 01
• Transmittance 80

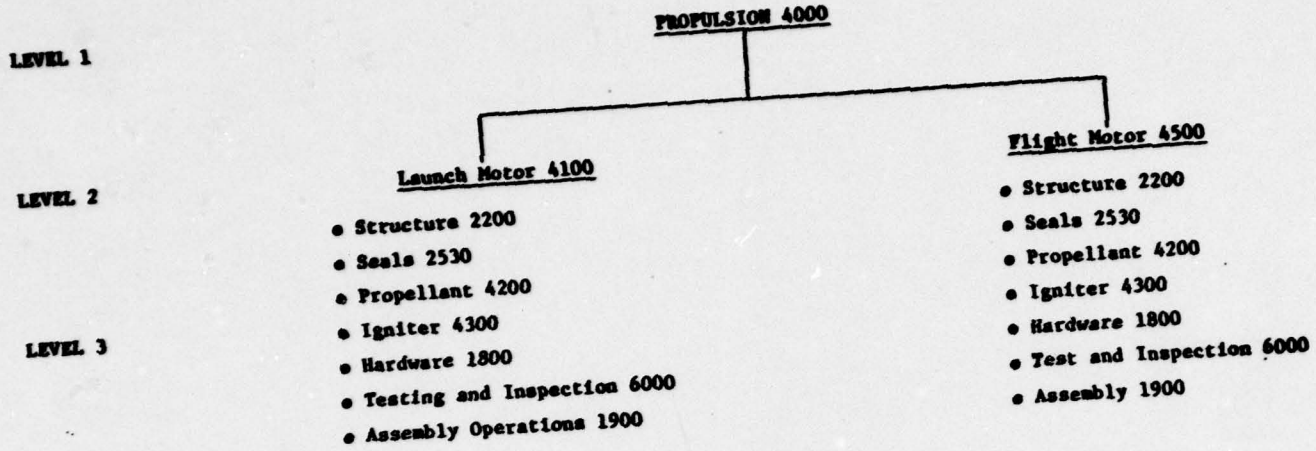

LEVEL 1
LEVEL 2
LEVEL 3
LEVEL 4
LEVEL 5
LEVEL 6
LEVEL 6
LEVEL 7
GUIDANCE 3000
Seeker 3600
Infrared 3602
Optics 3640
Mirrors 3641
• Material 01
• Reflectance 79
Lenses 3642
Converging 3643
• Material 01
• Transmittance 80
Diverging 3644
• Material 01
• Transmittance 80
Prisms 3645
• Material 01
• Transmittance 80

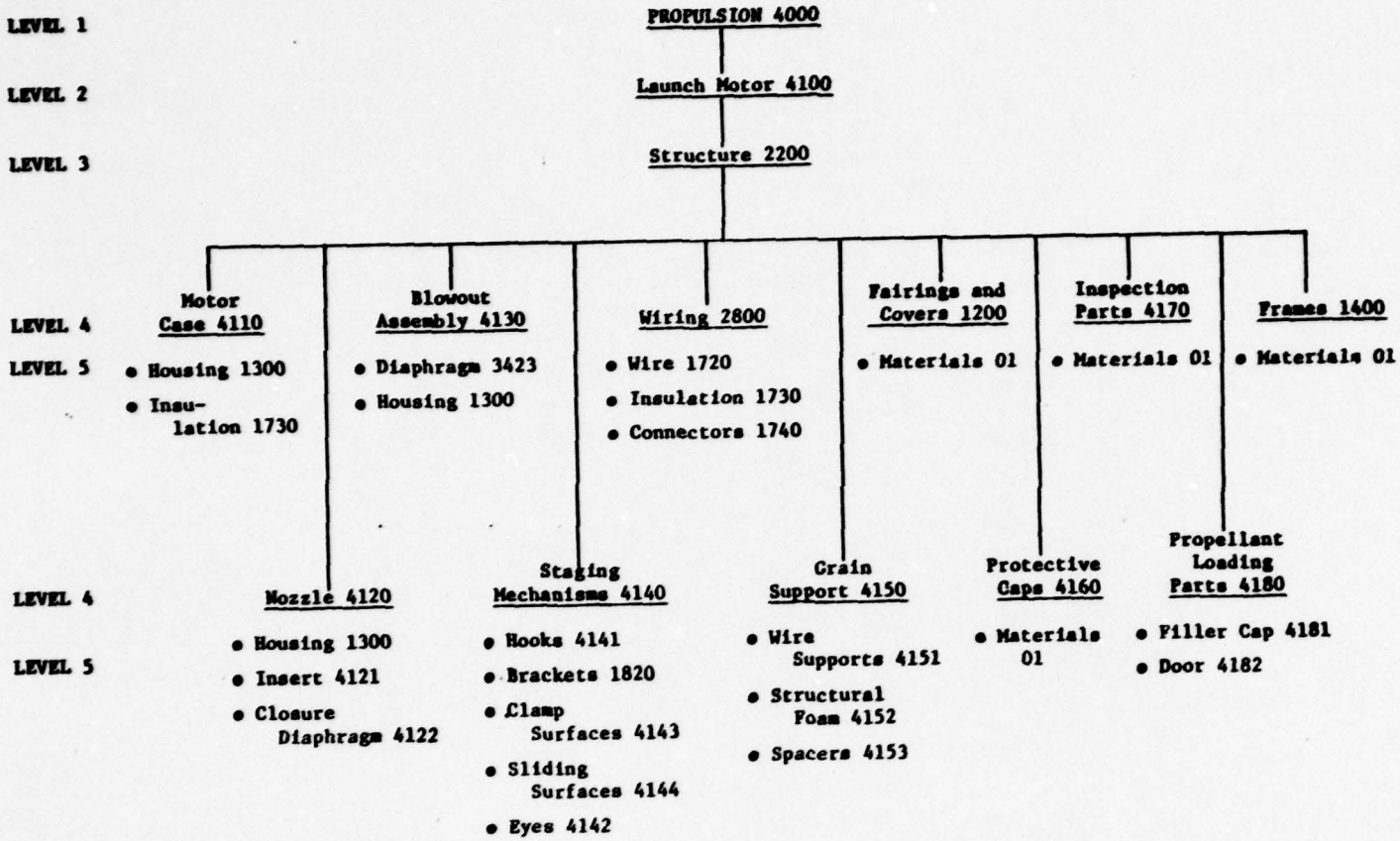

LEVEL 1
LEVEL 2
LEVEL 3
LEVEL 4
LEVEL 5
LEVEL 6
LEVEL 6
LEVEL 7
GUIDANCE 3000
Seeker 3600
Radar 3603
Optics 3640
Mirrors 3641
• Material 01
• Reflectance 79
Lenses 3642
Prisms 3645
• Material 01
• Transmittance 80
Converging 3643
• Material 01
• Transmittance 80
Diverging 3644
• Material 01
• Transmittance 80

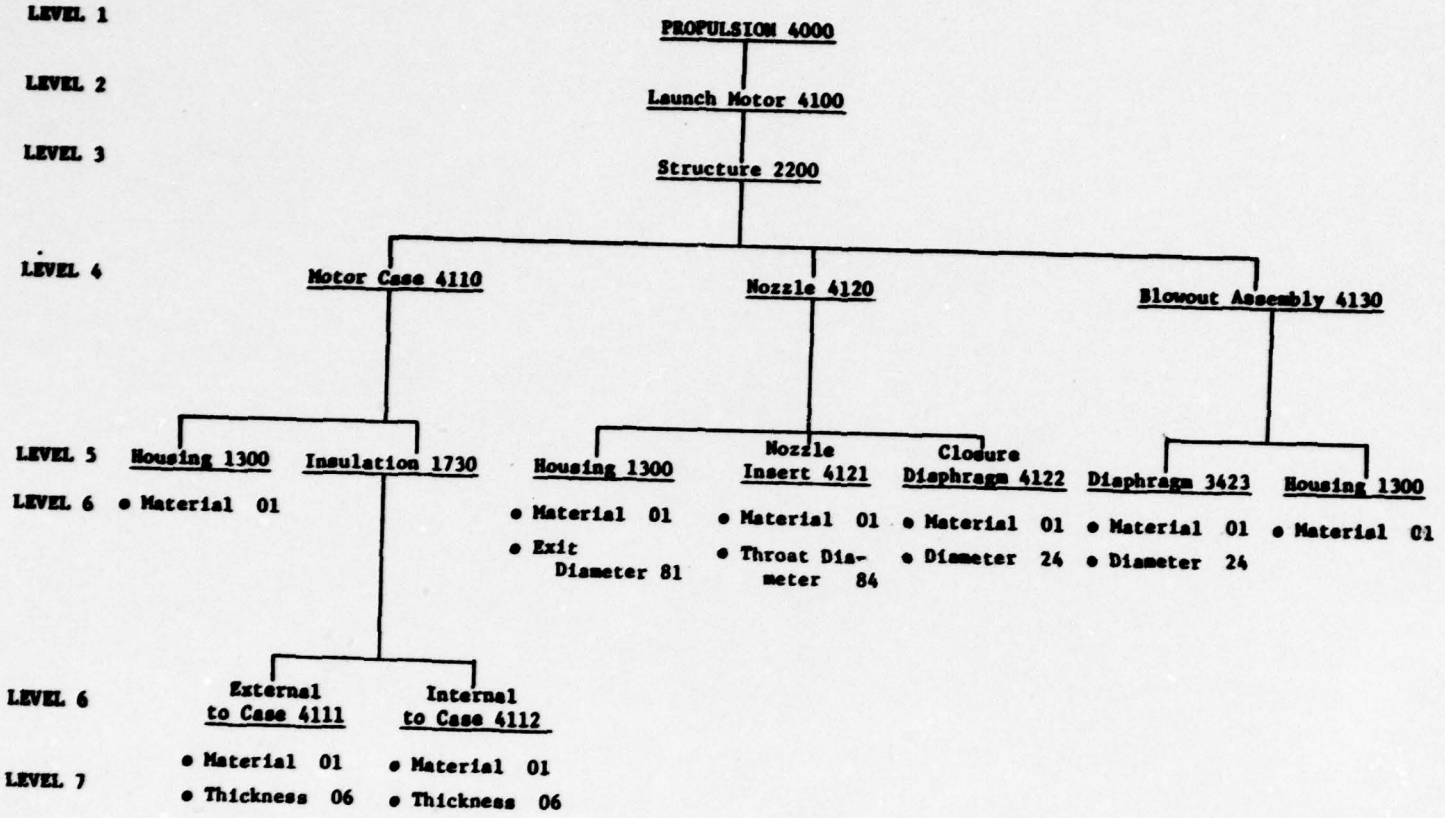

LEVEL 1
LEVEL 2
LEVEL 3
LEVEL 4
LEVEL 5
LEVEL 6
LEVEL 6
LEVEL 7
GUIDANCE 3000
Seeker 3600
Ballistics 3604
Optics 3640
Mirrors 3641
• Material 01
• Reflectance 79
Lenses 3642
Converging 3643
• Material 01
• Transmittance 80
Diverging 3644
• Material 01
• Transmittance 80
Prisms 3645
• Material 01
• Transmittance 80

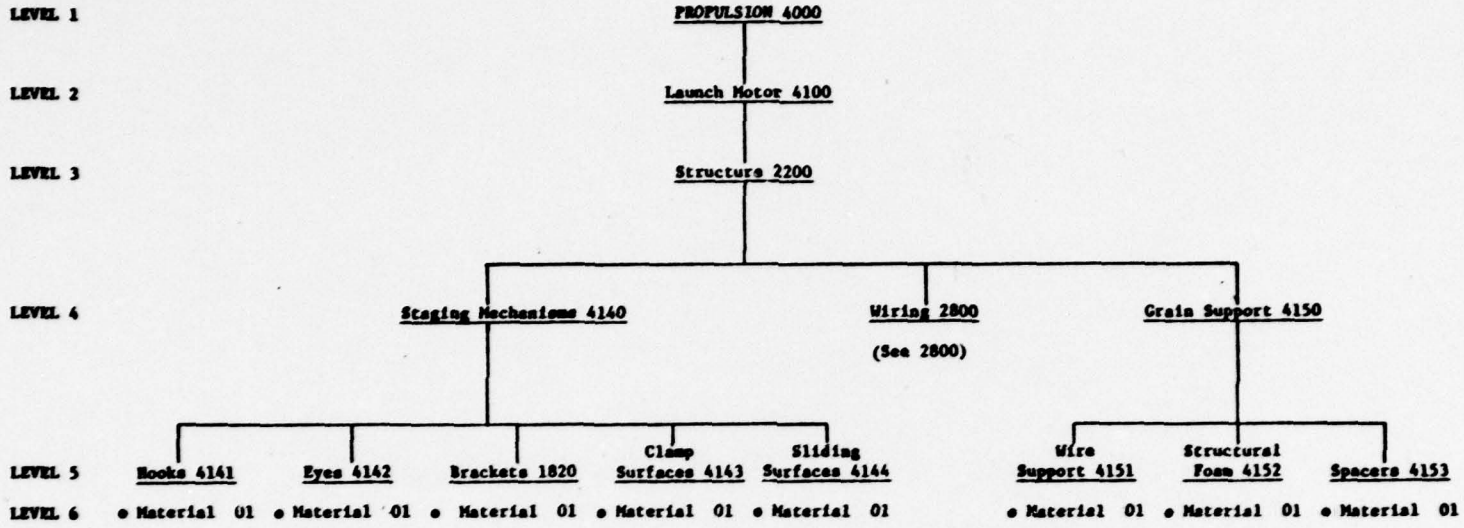

LEVEL 1
LEVEL 2
LEVEL 3
LEVEL 4
LEVEL 5
LEVEL 6
LEVEL 6
LEVEL 7
GUIDANCE 3000
Seeker 3600
Terrain Following 3605
Optics 3640
Mirrors 3641
• Material 01
• Reflectance 79
Lenses 3642
Converging 3643
• Material 01
• Transmittance 80
Diverging 3644
• Material 01
• Transmittance 80
Prisms 3645
• Material 01
• Transmittance 80

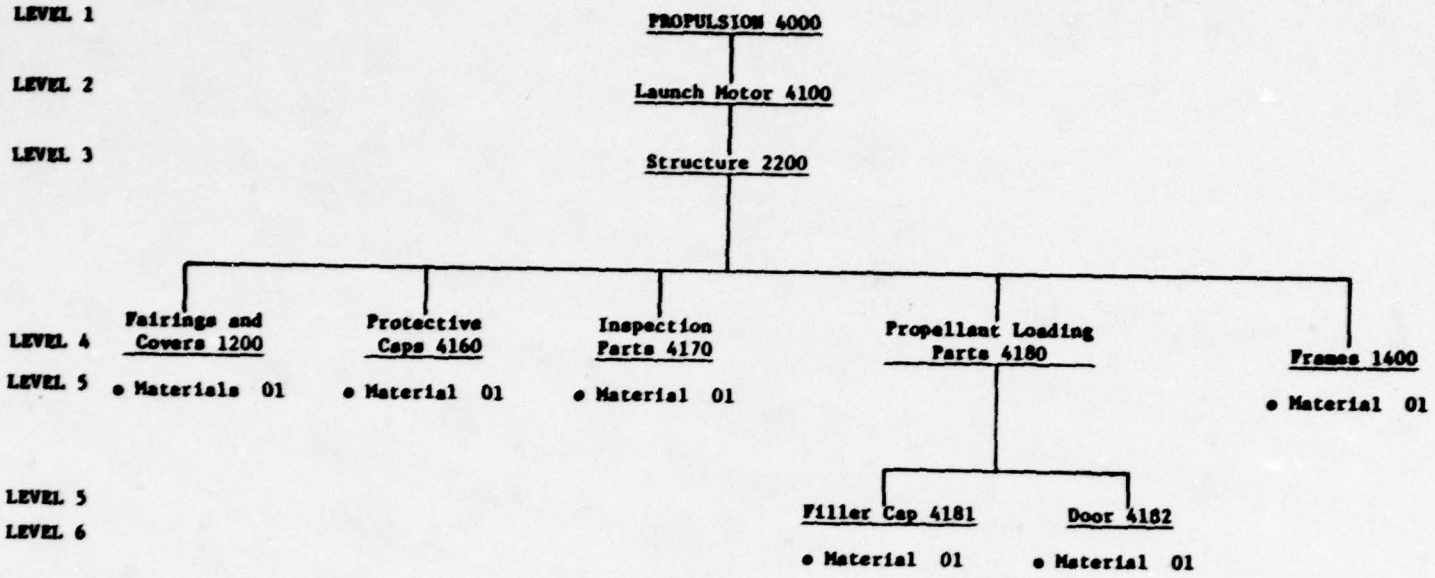

LEVEL 1
GUIDANCE 3000
LEVEL 2
Test & Inspection 6000
Assembly Operations 1900
LEVEL 3
(See 6000)
(See 1900)

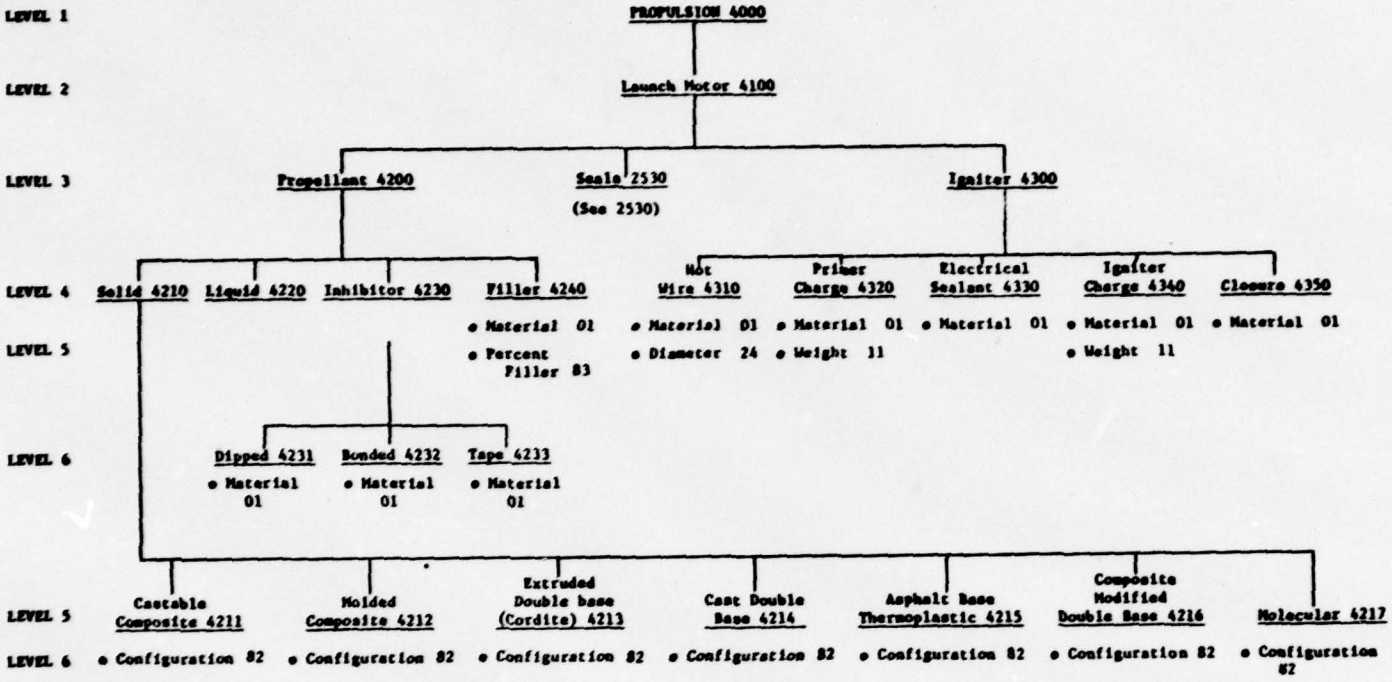

LEVEL 1
PROPULSION 4000
LEVEL 2
Launch Motor 4100
Flight Motor 4500
LEVEL 3
• Structure 2200
• Seals 2530
• Propellant 4200
• Igniter 4300
• Hardware 1800
• Testing and Inspection 6000
• Assembly Operations 1900
• Structure 2200
• Seals 2530
• Propellant 4200
• Igniter 4300
• Hardware 1800
• Test and Inspection 6000
• Assembly 1900

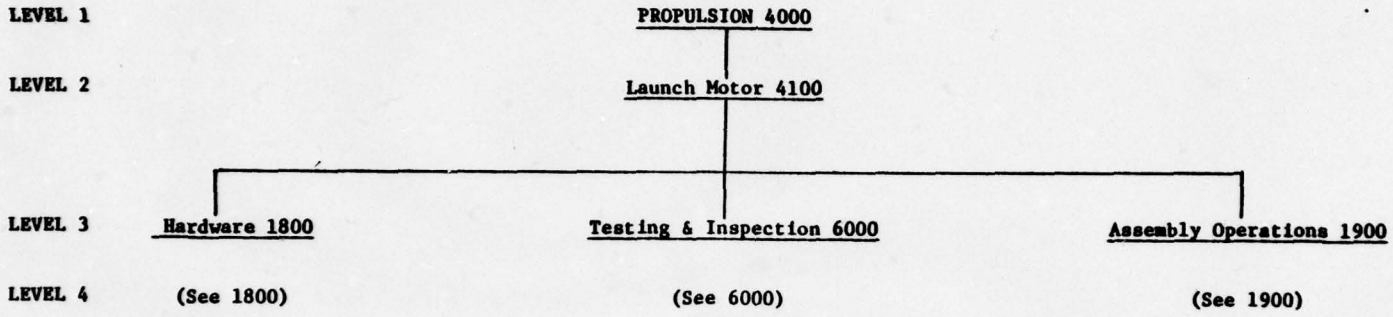

LEVEL 1
PROPULSION 4000
LEVEL 2
Launch Motor 4100
LEVEL 3
Structure 2200
LEVEL 4
Motor Case 4110
Blowout Assembly 4130
Wiring 2800
Fairings and Covers 1200
Inspection Parts 4170
Frames 1400
LEVEL 5
• Housing 1300
• Insulation 1730
• Diaphragm 3423
• Housing 1300
• Wire 1720
• Insulation 1730
• Connectors 1740
• Materials 01
• Materials 01
• Materials 01
LEVEL 4
Nozzle 4120
Staging Mechanisms 4140
Grain Support 4150
Protective Caps 4160
Propellant Loading Parts 4180
LEVEL 5
• Housing 1300
• Insert 4121
• Closure Diaphragm 4122
• Hooks 4141
• Brackets 1820
• Clamp Surfaces 4143
• Sliding Surfaces 4144
• Eyes 4142
• Wire Supports 4151
• Structural Foam 4152
• Spacers 4153
• Materials 01
• Filler Cap 4181
• Door 4182


LEVEL 1
PROPULSION 4000
LEVEL 2
Launch Motor 4100
LEVEL 3
Structure 2200
LEVEL 4
Motor Case 4110
Nozzle 4120
Blowout Assembly 4130
LEVEL 5
Housing 1300
Insulation 1730
Housing 1300
Nozzle Insert 4121
Closure Diaphragm 4122
Diaphragm 3423
Housing 1300
LEVEL 6
• Material 01
• Material 01
• Exit Diameter 81
• Material 01
• Throat Diameter 84
• Material 01
• Diameter 24
• Material 01
• Diameter 24
• Material 01
LEVEL 6
External to Case 4111
Internal to Case 4112
LEVEL 7
• Material 01
• Thickness 06
• Material 01
• Thickness 06


LEVEL 1
PROPULSION 4000
LEVEL 2
Launch Motor 4100
LEVEL 3
Structure 2200
LEVEL 4
Staging Mechanisms 4140
Wiring 2800
(See 2800)
Grain Support 4150
LEVEL 5
Hooks 4141
Eyes 4142
Brackets 1820
Clamp Surfaces 4143
Sliding Surfaces 4144
Wire Support 4151
Structural Foam 4152
Spacers 4153
LEVEL 6
• Material 01
• Material 01
• Material 01
• Material 01
• Material 01
• Material 01
• Material 01
• Material 01


LEVEL 1
PROPULSION 4000
LEVEL 2
Launch Motor 4100
LEVEL 3
Structure 2200
LEVEL 4
Fairings and Covers 1200
Protective Caps 4160
Inspection Parts 4170
Propellant Loading Parts 4180
Frames 1400
LEVEL 5
• Materials 01
• Material 01
• Material 01
• Material 01
LEVEL 5
LEVEL 6
Filler Cap 4181
Door 4182
• Material 01
• Material 01

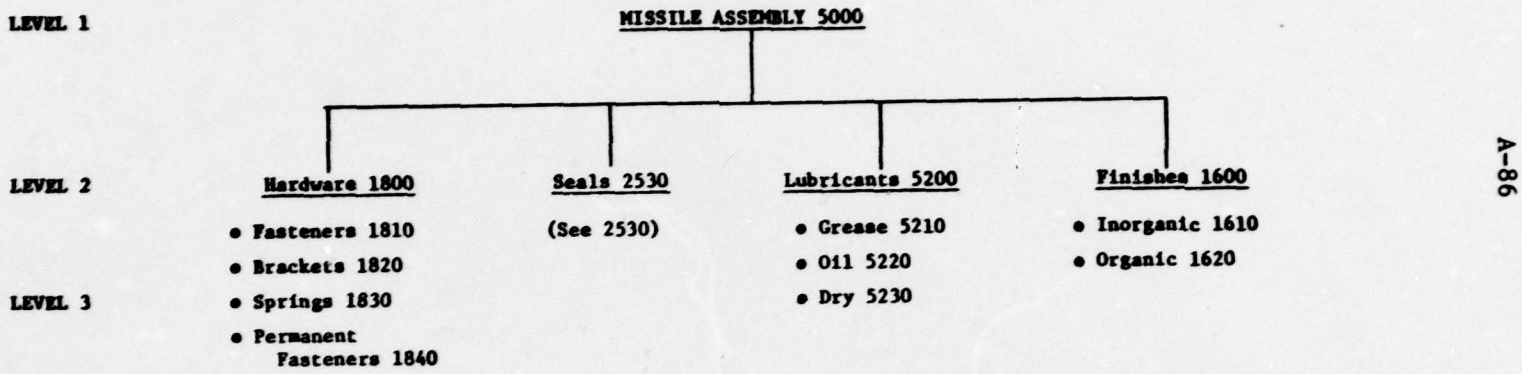

LEVEL 1
PROPULSION 4000
LEVEL 2
Launch Motor 4100
LEVEL 3
Propellant 4200
Seals 2530
(See 2530)
Igniter 4300
LEVEL 4
Solid 4210
Liquid 4220
Inhibitor 4230
Filler 4240
Hot Wire 4310
Primer Charge 4320
Electrical Sealant 4330
Igniter Charge 4340
Closure 4350
• Material 01
• Percent Filler 83
• Material 01
• Diameter 24
• Weight 11
• Material 01
• Material 01
• Weight 11
• Material 01
LEVEL 5
LEVEL 6
Dipped 4231
Bonded 4232
Tape 4233
• Material 01
• Material 01
• Material 01
LEVEL 5
Castable Composite 4211
Molded Composite 4212
Extruded Double base (Cordite) 4213
Cast Double Base 4214
Asphalt Base Thermoplastic 4215
Composite Modified Double Base 4216
Molecular 4217
LEVEL 6
• Configuration 82
• Configuration 82
• Configuration 82
• Configuration 82
• Configuration 82
• Configuration 82
• Configuration 82

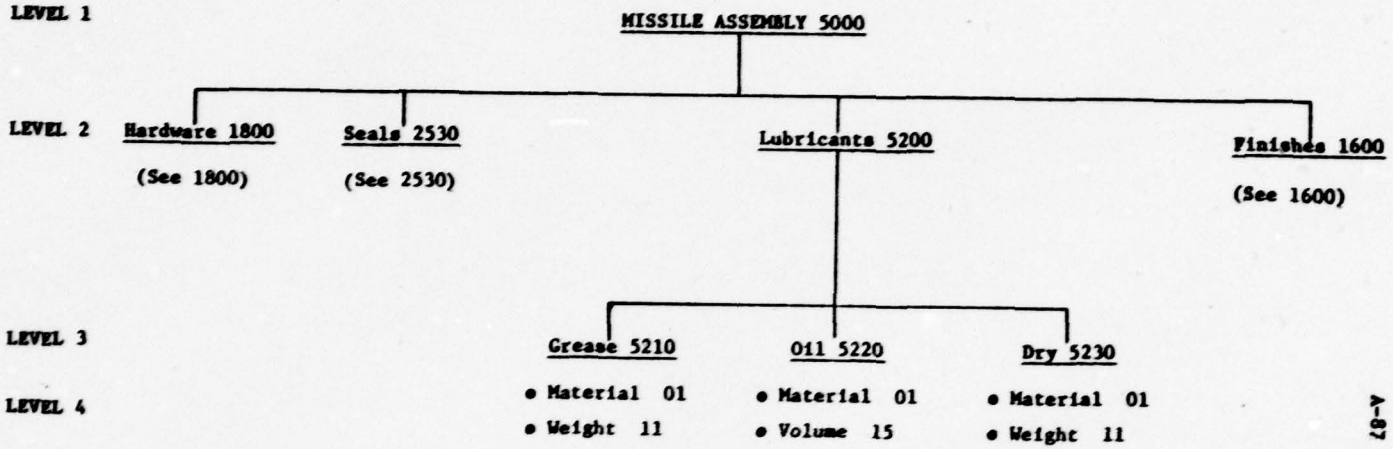

LEVEL 1
PROPULSION 4000
LEVEL 2
Launch Motor 4100
LEVEL 3
Hardware 1800
Testing & Inspection 6000
Assembly Operations 1900
LEVEL 4
(See 1800)
(See 6000)
(See 1900)

LEVEL 1 PROPULSION 4000

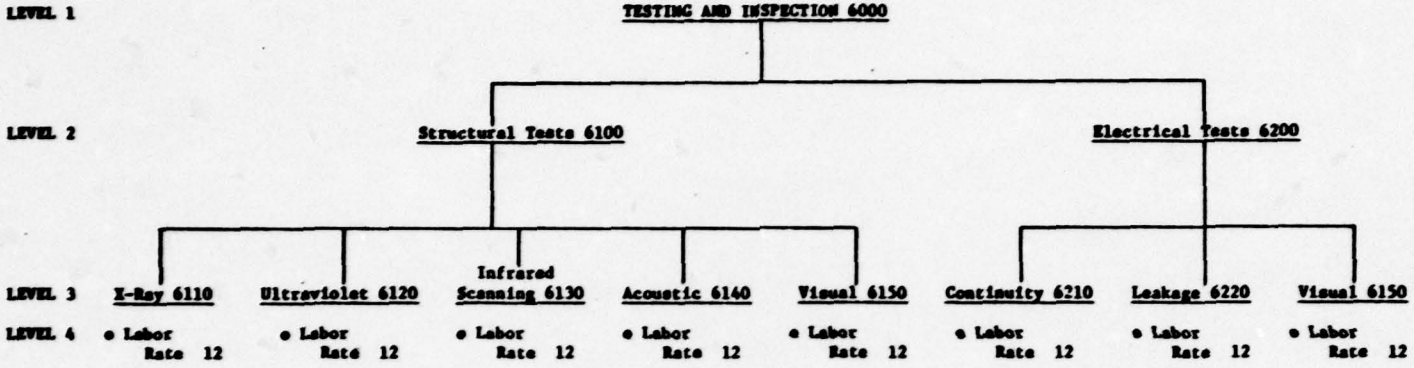
LEVEL 2 Flight Motor 4500

LEVEL 3 (See 4100)


LEVEL 1
MISSILE ASSEMBLY 5000
LEVEL 2
Hardware 1800
Seals 2530
Lubricants 5200
Finishes 1600
• Fasteners 1810
• Brackets 1820
LEVEL 3
• Springs 1830
• Permanent Fasteners 1840
(See 2530)
• Grease 5210
• Oil 5220
• Dry 5230
• Inorganic 1610
• Organic 1620


LEVEL 1
MISSILE ASSEMBLY 5000
LEVEL 2
Hardware 1800
(See 1800)
Seals 2530
(See 2530)
Lubricants 5200
Finishes 1600
(See 1600)
LEVEL 3
Grease 5210
011 5220
Dry 5230
LEVEL 4
• Material 01
• Weight 11
• Material 01
• Volume 15
• Material 01
• Weight 11

A-87


LEVEL 1
TESTING AND INSPECTION 6000
LEVEL 2
Structural Tests 6100
Electrical Tests 6200
LEVEL 3
X-Ray 6110
Ultraviolet 6120
Infrared Scanning 6130
Acoustic 6140
Visual 6150
Continuity 6210
Leakage 6220
Visual 6150
LEVEL 4
• Labor Rate 12
• Labor Rate 12
• Labor Rate 12
• Labor Rate 12
• Labor Rate 12
• Labor Rate 12
• Labor Rate 12
• Labor Rate 12

CHARACTERISTIC CODING

CHARACTERISTIC AREA CODING

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Material 01 (001-125)

Steel	001
Aluminum	002
Stainless Steel	003
Composites	004
Plastics	005
Tin	006
Lead	007
Chromium	008
Copper	009
Copper Alloy	010
Nickel	011
Zinc	012
Cadmium	013
Gold	014
Silver	015
Platinum	016
Vinyl	017
Rubber	018
Nylon	019
Varnish	020
Neoprene	021
Polyethylene	022
Polypropylene	023
PVC	024
Teflon	025
Cadmium Plating	026
Silicone	027
Furane	028
Epoxy	029
Polyurethane	030
Polyester	031
Phenolic	032
Inorganic Zinc	033
Acrylic	034
Asphaltic	035
Sodium Nitrate	036
Manesium	037
Polyamide	038
Butadiene Styrene	039
Chlorinated Rubber	040
Chlorosulfonated Polyethylene	041
Chromate Plating	042
Rhodium	043
Alumina Oxide	044
Ceramic	045

Material 01 (001-125) (Continued)

Ethylene propylene terpolymer (EPT)	046
Fluoroelastomer	047
Glass-reinforced thermoplastic	048
Brass	049
Berrylium Copper	050
Polyallomer	051
Ethylene vinyl acetate	052
Petroleum base	053
Nitrogen	054
Helium	055
Silica Gel	056
Buna - N	057
Felt	058
Rubber + Fabric	059
Rubber + Cord	060
Rubber + Cord + Fabric	061
Rubber + Nylon	062
Rubber + Polyamide	063
Cast Iron	064
Molecular Seives	065
Laminac	066
Glass/Silver	067
Quartz	068
Di-electrics	069
Spinel	070
Silicon Nitride	071
Pyrex	072
Fused Silica	073
Petroleum	074
Synthetic (oil or grease)	075
Molybdenum Disulfide	076
Graphite	077
Titanium	078
Glass Fiber	079
Ablative	080
Buna - S	081
Butyl Rubber	082
Polysulfide	083
Polyisoprene	084
Polyacrylic	085
Tungsten	086
Carbide	087
Molybdenum alloy	088
Inorganic salts	089
Oils	090
Resins	091
Waxes	092
Silica	093
Asbestos	094

Material 01 (001-125) (Continued)

Carbon	095
Inorganic Hydrate	096
Polassium titanate	097
Phenolic cork	098
Potassuin nitrate	099
Black powder	100
Fluorocarbon	101
Silicon Oil	102

Area 02 (126-140)

<10 in^2	126
10-100 in^2	127
>100 in^2	128
<1 ft^2	129
1-10 ft^2	130
>10 ft^2	131

Fabrication Method 03 (141-165)

Cast	141
Forged	142
Machined Sheet	143
Molded	144
Formed Plate	145
Rolled & Welded	146
Seamless Tube	147
Combination	148
Electrdeposition	149
Flame sprayed	150
Clad	151
Hot dipped	152
Vapor deposition	153
Diffusion	154
Anodized	155
Phosphatized	156
Chromatized	157
Oxide	158
Glass coated	159
Rolled	160

Length x Diameter 04 (166-200)

<2" x 1/4"	166
2 - 4" x 1/4" - 1/2"	167
>4" x 1/2"	168
3 x <1/4"	169
3 - 5 x 1/4" - 1/2"	170
5" x >1/2"	171
3" x <3/8"	172
3 - 5" x 3/8" - 1/2"	173
5 - 6" x 1/2" - 7/8"	174
6" x >7/8"	175
1 ft x <0.010 in	176
1 - 5 ft x 0.010 - 0.050 in	177
5 ft x >0.050 in	178
<1 ft x <0.25 in	179
1 - 5 ft x 1/4" - 1/2"	180
>5 ft x >1/2"	181
<3000 ft x <0.001 in	182
3000 ft - 5000 ft x 0.001 - 0.005"	183
>5000 ft x >0.005 in	184
1/2" x <1/8"	185
1/2 - 1" x 1/8" - 1/4"	186
1 - 2" x 1/4 - 1/2"	187
2" x >1/2"	188

Torque 05 (201-220)

<0.1 in. oz	201
>0.1 in. oz	202
<0.1 in. oz	203
>0.1 in. oz	204
<4 in. - oz	205
>4 in. - oz	206
>10 in. - oz	207
<10 in. - oz	208
<40 in. - oz	209
>40 in. - oz	210
<0.25 in. - lb	211
>0.25 - 2.5 in. - lb	212
>2.5 in. - lb	213
<1 in. - lb	214
>1 in. - lb	215

Thickness 006 (226-235)

<0.001"	226
0.001 - 0.15"	227
>0.015"	228
<0.25 in.	229
0.25 - 1 in.	230
1 in.	231

Length 007 (236-250)

<1 ft	236
1 - 5 ft	237
>5 ft	238
<3000 ft	239
3000 - 5000 ft	240
>5000 ft	241
<6"	242
>6"	243

Size 08 (251-265)

Standard	251
Miniature	252
20	253
16	254
12	255
8	256
4	257
0	258

Number Pins 09 (266-275)

1 - 4	266
5 - 20	267
>20	268

Spring Rate 10 (276-290)

<1/4 lb/in.	276
1/4 - 2 1/2 lb/in.	277
>2 1/2 lb/in.	278
<1 lb/in.	279
1 - 10 lb/in.	280
>10 lb/in.	281

Weight 11 (291-310)

<0.1 oz	291
0.1 - 1 oz	292
>1 oz	293
<0.1 lb	294
0.1 - 0.25 lb	295
>0.25 lb	296
<1 lb	297
1 - 10 lb	298
>10 lb	299
<5 lbs	300
>5 lbs	301

Labor Rate 12 (511-515)

Automatic	511
Manual	512

Pressure 13 (311-325)

<100 psi	311
100 - 2500 psi	312
>2500 psi	313
<500 psi	314
500 - 2599 psi	315
<1000 psi	316
>1000 psi	317

Temperature 14 (326-335)

<0°F	326
0 - 150°F	327
>150°F	328

Volume 15 (335-350)

<4 $in.^3$	336
4 - 20 $in.^3$	337
>20 $in.^3$	338
<1 SCF	339
1 - 10 SCF	340
>10 SCF	341
<0.1 liter	342
0.1 - 0.5 liter	343
>0.5 liter	344

Volume Produced 16 (351-355)

<1000 cc	351
>1000 cc	352

Power Source 17 (356-365)

Pneumatic actuator	356
Electrical actuator	357
Mechanical actuator	358
Pyrotechnic actuator	359

Number Connections 18 (366-375)

2 - 5	366
5 - 10	367
>10	368

Shaft Diameter 019 (221-225)

<1/2"	471
>1/2"	472
<1/8"	221
1/8 - 1/4"	222
1/4 - 1/2"	481

Duty 20 (376-380)

Intermittent	376
Continuous	377

Voltage 21 (381-450)

0 - 25	381
<1	382
1 - 3	383
3	384
3 - 6	385
6	386
6 - 12	387
10	388
12	389
>12	390
15	391
16	392
20	393
24	394
>24	395
25	396
25 - 100	397
35	398
50	399
>50	400
<75	401
75	402
>75	403
<100	404
100	405
>100	406
100 - 300	407
120	408
150	409
200	410
250	411
300	412
300 - 100	413
350	414
400	415
>400	416
600	417
800	418
>1000	419
1200	420
1600	421

Lift 22 (451-460)

<10 oz	451
10 - 50	452
50 - 100 oz	453
>100 oz	454

ID x Length 23 (461-470)

<1/2" x <3"	461
1/2" - 2" x 3" - 6	462
>2" x >6"	463

Diameter 24 (481-500)

<1/2"	471
>1/2"	472
1/4 - 1/2"	481
<0.001"	482
0.001 - 0.01"	483
>0.01"	484
<1/4"	485
<1"	486
>1"	487
1 - 3"	488
>3"	489
1/2 - 1"	490

Stroke 25 (471-480)

<1/2"	471
>1/2"	472
<1"	473
>1"	474

Capacity 26 (516-520)

<1/2"	471
>1/2"	472

Linkage Connections 27 (531-540)

Pinned	531
Sliding	532
Screw	533
Ball	534

Number Teeth 28 (521-530)

<30	521
30 - 50	522
>75	523

W x L 29 (541-550)

<1/2" x 6"	541
1/2" - 1" x 6 - 20"	542
>1" x 20"	543

W x D 30 (551-560)

<1/2" x 6"	551
1/2 - 1" x 6 - 10"	552
>1" x 10"	553

Collector Current 31 (561-575)

<50 mA	561
50 - 500 mA	562
>500 mA	
<1 A	563
1 - 5 A	564
>5 A	565
<3 A	566
3 - 10 A	567
>10 A	568

Collector emitter voltage 32 (576-590)

<30 v	576
30 - 80 v	577
<40 v	578
40 - 80 v	579
>80 v	580

Current-gain product bandwidth 33 (591-600)

<100 MHz	591
>100 MHz	592

Drain current 34 (601-610)

<20 ma	601
20 - 150 ma	602
>150 ma	603

Drain-source voltage 35 (611-615)

<30 v	576
>30 v	612

Reliability Level 36 (616-620)

High	616
Standard	617

Complexity 37 (621-635)

SSI	621
MSI	622
LSI	623
VLSI	624
High	625
Low	626
ROM only	627
ROM/RAM	628
ROM/RAM/TIMER	629
Other	630

Speed 39 (636-640)

High	616
Standard	617

Quality 40 (641-645)

High	616
Standard	617

Offset 41 (646-650)

High	616
Standard	617

Current Capacity 42 (651-665)

>5a	565
>10a	568
1a	651
3a	652
<5a	653
5a	654
5 - 10	655
<10a	656
10 - 25	657
>25	658

Bit Capacity 43 (666-680)

8 - 64	666
64 - 256	667
256 - 1	668
<1K	669
1K	670
4K	671
8K	672
16K	673
>16K	674

Access Time 44 (681-695)

<60 ns	681
>60 ns	682
<200 ns	683
200 - 500 ns	684
<400 ns	685
>400 ns	686
500 ns - 1 μs	687
>1 μs	690

Operating Speed 45 (696-700)

<5 MHz	696
>5 MHz	697

Bit Size 46 (701-710)

4	701
8	702
16	703
18	704

Clock Rate 47 (711-715)

<1 MHz	711
1 - 10 Mz	712
>10 Mz	713

Word Length 49 (716-720)

4 bit	716
8 bit	717
16 bit	718
32 bit	719

Word Capacity 48 (721-725)

1K	670
4K	671
8K	672
16K	673
32K	721
64K	722

Rolloff 51 (726-730)

40 dB/decade	726
80 dB/decade	727
120 dB/decade	728

Tolerance 52 (31-750)

<0.001%	731
>0.001%	732
±0 - 2%	733
2 - 5%	734
±2 - 20%	735
<5%	736
5%	737
5 - 10%	738
±0 - 10%	739
±>10%	740
>10%	741
10%	742
<1.5%	743
>1.5%	744
>5%	745
±>20%	746

Drift Rate 53 (751-755)

>1 ppm/°C	751
<1 ppm/°C	752

Capacitance 54 (756-800)

<0.01 µF	756
0.01 - 0.02 µF	757
0.02 - 0.05 µF	758
0.05 - 0.1 µF	759
0.1 - 0.22 µF	760
>0.22 µF	761
≤0.02 µF	762
>0.02 µF	763
<0.1 µF	764
≥0.1 µF	765
<10 pF	766
10 - 250 pF	767
250 - 1500 pF	768
0.0015 - 0.01 µF	769
>0.01 µF	770
<0.25 µF	771
0.25 - 0.5 µF	772
0.5 - 2.0 µF	773
>2.0 µF	774
<0.04 µF	775
0.04 - 0.25 µF	776
0.25 - 1.0 µF	777
>1.0 µF	778
0.01 - 0.05 µF	779
0.05 - 0.22 µF	780
0.22 - 1.0 µF	781
<15 µF	782
15 - 50 µF	783
100 - 200 µF	784
200 - 500 µF	785
500 - 1500 µF	786
1500 - 5000 µF	787
5000 - 10,000 µF	788
>1000 µF	789
<50 pF	790
50 - 100 pF	791
100 - 250 pF	792
>250 pF	793
10 - 100 pF	794
100 - 1000 pF	795
>1000 pF	796

Failure Rate 55 (801-805)

>2%	801
2%	802
1%	803

Q Level 56 (806-810)

High	616
Low	646

Wattage 57 (811-830)

1/8 w	811
1/4 w	812
1/2 w	813
1 w	814
2 w	815
5 w	816
10 w	817
>10 w	818
20 w	819
<25 w	820
25 w	821
>25 w	822
50 w	823
>50 w	824

Resistance 58 (831-845)

10 ohms	831
10 - 1000" ohms	832
1000 - 5000" ohms	833
<10,000 ohms	834
>10,000 ohms	835
<20K ohms	836
>20K ohms	837
5000 - 50,000 ohms	838
10K - 50K ohms	839
>50K ohms	840
1 - 1 meg	841
>1 meg	842

Maximum energy 59 (846-850)

<1 joule	846
1 - 10 joule	847
>10 joule	848

Time Constant 60 (851-855)

<2 sec	851
>2 sec	852

Linearity 61 (856-860)

<1%	856
>1%	857

Precision 62 (861-865)

0.1%	861
0.1 - 0.25%	862
0.25%	863

Turns 63 (866-870)

Single	866
Multiple	867

Inductance 64 (871-875)

Fixed	871
Adjustable	872

Response 65 (876-880)

Narrow band	876
Wide band	877

Coil Voltage 66 (881-885)

6v	386
12v	389
24v	394
> 24v	395

Contact Rating 67 (886-890)

<10a	568
5 - 10a	655
>1a	886

Contact arrangement 68 (891-895)

A	891
B	892
C	893

Input Voltage 69 (895-900)

<30v	576
>30v	612

Number Contacts 70 (901-905)

1	901
2	902
3	903
4	904

Shelflife 71 (906-910)

<1 yr	906
1 - 3 yr	907
3 - 5 yr	908
>5 yr	909

Accuracy 72 (911-925)

<3 min	911
>3 min	912
<±2 min	913
>±2 min	914
<0.5 min	915
>0.5 min	916
<±1°F	917
>±1°F	918
<±2%	919
>±2%	920
<±5 psi	921
>±5 psi	922

Thermal Conductivity 73 (926-930)

<.02 BTU/hr-ft-°F	926
.02-.05 BTU/hr-ft-°F	927
>.05 BTU/hr-ft-°F	928

Diameter x Stroke 74 (931-935)

<0.5 in. x 1"	931
0.5 - 1.0" x 1 - 3"	932
>1.0" x 3"	933

Brightness 75 (936-940)

<0.1 foot lambert	936
0.1 - 1.0 foot lambert	937
>1.0 foot lambert	938

Burn Time 76 (941-945)

<30 sec	941
30 - 60 sec	942
>60 sec	943

Rate 77 (946-950)

<60Hz	946
>60Hz	947

Sensitivity 78

Displayed graphically
for each instrument

Reflectance 79 (951-955)

<98%	951
>98%	952

Transmittance 80 (956-957)

<98%	956
>98%	957

Exit Diameter 81 (958-960)

<1/2"	471
>1"	487
1/2 - 1"	958

Configuration 82 (966-999)

Spool valve	966
Poppet	967
Diaphragm	968
Shear value	969
Rotary valve	970
Restricted (Inhibitor)	971
Unrestricted, Single Hollow charge	972
Unrestricted, Multiple Hollow charge	973
Rod & Tube	974
Internal Burning, Star	975
Internal Burning, Multiperforated	976
Internal Burning, clover leaf	977
External buring - cruciform	978
Multi-propellant	979

Percent Filler 83 (964-965)

<20%	964
>20%	965

Throat Diameter 84 (961-963)

>1/2"	472
1/4 - 1/2"	481
<1/4"	485

APPENDIX B

DEFINITIONS

APPENDIX B

DEFINITIONS

Acoustooptic Modulation	--	Varies light transmitted by varying ultrasonic waves through material.
Actuators	--	Any mechanism for converting energy into mechanical motion.
Assembly	--	Any joining action where a set of parts are premanently or temporarily attached in building the missile.
Blow Out Assembly	--	Relief built into the rocket motor.
Case	--	The outer container of the rocket motor.
Control	--	Parts which physically adjust the missile direction including moving fins, actuators, power sources, linkage, etc.
Control Surfaces	--	Moveable wings and flaps which change the course of the missile.
Control Wire	--	The trailing wire, connections and insulation which are the data link in a wire guided missile.
Cryostat	--	System which provides a very cold environment.
Detector	--	The unit in the seeker which receives and deciphers the target energy from all external noise energies.
Electronics	--	All electrical components, circuit cards, instruments, and systems not including wiring and connectors between units.
Electrooptic Modulation	--	Varying light transmitted by a material due to varying electric field in it.
EMI	--	Electromagnetic interference here used as equipment to reduce the noise in electrical circuits
Environmental Controls	--	Equipment to monitor and control any environmental variable (temperature, humidity, pressure etc.) around any portion of the missile.

Fabrication	--	Any operation using raw material to form a part--as opposed to assembly which forms a part from other parts.
Fairings	--	Any covering or enclosure primarily for reduction of wind resistance and not structural integrity.
Filter (Optical)	--	An optical part used to eliminate all frequencies except those desired from the generated light.
Finishes	--	Any coating or covering layer of material added to any part to prevent corrosion, to disguise the missile, to identify the missile, to prevent EMI, etc.
Flight Motor	--	The motor used for sustained flight.
Floatation Fluid	--	Fluid surrounding the gimbals in some gyros to reduce the torques generated by bearings.
Frames	--	Any part which connects or supports major portions of the missile which are enclosed in housings.
Guidance	--	Parts determining the missile direction of travel, comparison of the actual direction to the desired direction, and producing the required error signal. Electrical power supplies are arbitrarily located in this section.
Gyro-Optics	--	Gyro type bearings and gimbals which keep the detector optics pointed toward the target.
Gyroscope	--	Any instrument which determines a change in attitude and is stabilized by one or more spinning rotors.
Hardware	--	The extraneous fasteners, brackets, springs, clips, etc. used in general assembly.
Housings & Covers	--	Any container, covering or enclosure used as a structural support for any part or group of parts.

Igniter	--	Starter for the rocket motor.
Inspection Ports	--	Doors or windows used to internally inspect the rocket motor.
IR Source	--	Usually a pyrotechnic flare, filtered and modulated to flash infrared light at the frequency required to allow an accurate fix between the launcher and missile.
Launch Motor	--	The motor o gas generator used only to eject the missile from the tube or launch rack.
Launch Provisions	--	Those parts on a missile whose function is to provide stability and protection for the missile while it is in the launch tube or rack. Also included are all hooks, releases, and tie-downs that must be disconnected to allow launch.
Lift Surfaces	--	Any wing, airfoil, or lifting body surface which provides lift to the missile. Does not include moveable wings or flaps.
Magnetooptic Modulator	--	Varies light transmitted by varying magnetic field in material.
Material	--	The basic elements or compounds from which the parts are fabricated.
Missile	--	The part of a missile system which becomes airborne at launch, i.e., the flight vehicle.
Modulator	--	Controller to pulse the light beam at the required frequency and pattern.
Monitoring Instruments	--	Measurement device which determines the error between the desired reading and the actual reading of an environmental variable.
Nozzles	--	The exit point for the high pressure gas generated in the rocket motor.

Output Pickoffs	--	Any device to indicate when the gyro moves from its standard position. It is connected to a torquing device to correct the gyro position.
Pendulous Reference Devices	--	Units which indicate the vertical direction by using a pendulum. The gyro can then be referenced to the average pendulum position.
Plumbing	--	All parts which provide storage, transport, and control of a working fluid. This includes piping, fluid, fittings, manifolds, storage tanks and valves.
Propellant	--	The chemical which burns to form the high pressure gases.
Propellant Loading Parts	--	Mechanical parts to allow entrance to the case to load the propellent.
Propulsion	--	All parts of the rocket motor or motors or gas generators used for propulsive force.
Protective Caps	--	Covers for nozzles and other openings in rocket motor.
Quantum	--	Photon type detectors which count the number of incident photons.
Seeker	--	Unit which determines the direction to the target.
Structures	--	All parts whose function is to support, enclose, protect, and cover the rest of the parts in the missile. For example, frames, housings, fairings. Also included are parts whose function is too general to be included in another section such as wire harness, finishes.
Temperature Control (Gyroscope)	--	Precise control of the temperature of the fluid in a gyroscope is necessary to maintain a constant viscosity and thereby a constant relationship between torque generated and velocity.
Test and Inspection	--	Any check, inspection, test or other action to determine the quality of the part, material, or assembled parts.

Thermal	--	Detectors which sense the change in temperature due to the absorption of incident radiation.
Torquing Devices	--	Any unit which applies torque to the axis of a gyroscope to compensate for drift.
Wire Harness	--	System of wire and connectors complete and installed as a unit as opposed to single wires which are cataloged in the sections they are connected to.
Wiring	--	The wire, insulation, and connections that connect different electronic units to themselves and other parts. The wiring is cataloged under the section it is used in.

APPENDIX C

REFERENCES

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REFERENCES

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