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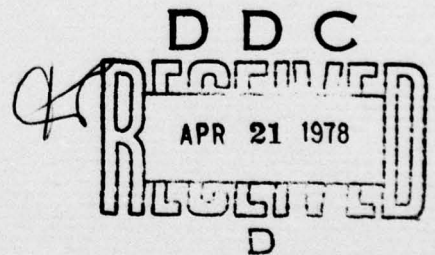
THIRTEENTH ANNUAL REPORT OF THE
MACHINABILITY DATA CENTER

MARCH 1978

JOHN F. KAHLES and JOHN L. KREBS
Metcut Research Associates Inc.
Cincinnati, Ohio

THIRTEENTH ANNUAL - CONTRACT DSA900-77-C-3197

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Prepared for

ARMY MATERIALS AND MECHANICS RESEARCH CENTER
Watertown, Massachusetts 02172

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ABSTRACT (cont.)

During the period, 4,680 data publications were sold, including 2,329 copies of the *Machining Data Handbook* (2nd Edition), 2,152 copies of recent publications, and 199 copies of other MDC publications developed under previous contracts. Seven computer programs and 20 programs for hand-held calculators, which are used to solve problems relating to the economics of machining, were also distributed.

MDC's seminar program "Practical Machining Principles for Shop Application" continued to be a highly successful means of information transfer. A total of 507 individuals attended the 12 scheduled seminars. Since the beginning of this program in 1974, 51 seminars have been presented to a total of 1,695 individuals representing 768 companies located in 40 states.

One new publication, entitled *Chemical Machining: Production with Chemistry*, was placed in distribution in accordance with MDC's current emphasis on publications relating to nontraditional machining methods. Two other publications, also related to nontraditional machining, are being prepared for distribution in calendar year 1978.

Technical inquiries processed during this contract period totaled 205. Of these, 61 were paid inquiries; the other 144 were no charge telephone type inquiries. Distribution of inquiries by type shows no significant pattern which would dictate special technical emphasis by MDC.

During the contract period, 1,674 documents were selected for inclusion to MDC's hard-copy document file from the source literature received relating to material removal. Hard-copy documents in storage at the end of this period totaled 37,535.

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SUMMARY

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The Machinability Data Center (MDC) is one of a number of Information Analysis Centers sponsored by the Department of Defense. The specific functions of MDC include the collection, evaluation, storage, and dissemination of information pertaining to machining technology with emphasis on machinability data. The objectives of MDC's efforts are to decrease the cost of machining and to increase the productivity and reliability of machined products in behalf of the Department of Defense and other U.S. Government Agencies and their contractors. Because there is a continuing need for the universal application of evaluated machining data, MDC services are also made available to private industry. ←

This is the Thirteenth Annual Report of the activities of the Machinability Data Center. This report covers the period from January 1, 1977, to December 31, 1977. MDC became operational in October 1964.

MDC's dissemination activities have been kept at a very high level during the period, particularly as a result of the sale of data publications and the sell-out attendance at the seminar sessions on "Practical Machining Principles for Shop Application." During this reporting period, 205 technical inquiries were processed. A total of 4,680 publications were sold including 2,329 copies of MDC's best-seller, the *Machining Data Handbook*. One new pamphlet was produced and placed in distribution: *Chemical Machining: Production with Chemistry*, MDC publication 77-102.

A total of 12 seminars was conducted during this reporting period. These sessions were attended by 507 individuals representing all phases of manufacturing management, engineering, and shop operations in private industry and Government. MDC plans to continue the seminar series as a permanent part of its total information transfer program as long as the need for such a program exists and user interest remains high. Twelve seminars have already been scheduled for calendar year 1978, six in the spring and six in the fall. It is important to note that since the seminar on "Practical Machining Principles for Shop Application" was first presented in 1974, 1,675 attendees have participated in the two-day sessions. These attendees came from 768 companies located in 40 states. Of these companies, 112 have sent 4 or more participants.

Income from MDC's programs during this reporting period resulted in a 72% cost recovery, which enabled the Center to achieve its contractual goals.

PREFACE

The Thirteenth Annual Report of the Machinability Data Center (MDC) covers work performed under Contract DSA900-77-C-3197 from January 1, 1977, to December 31, 1977.

MDC is operated by Metcut Research Associates Inc., 3980 Rosslyn Drive, Cincinnati, Ohio 45209. The MDC program is administered by the Defense Logistics Agency, and technical supervision is provided by the Army Materials and Mechanics Research Center, Watertown, Massachusetts.

The report was released by Dr. John F. Kahles, Director of the Machinability Data Center, in March 1978.

The Machinability Data Center wishes to acknowledge the significant contributions of the following individuals who have assisted MDC in carrying out this program:

Joseph L. Blue - DLA
Al M. Torain - DLA
Samuel Valencia - AMMRC
Frances Burke - DESC
Cincinnati Office - DCASMA

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INTRODUCTION

The Machinability Data Center (MDC) is one of a number of Information Analysis Centers sponsored by the Department of Defense. MDC is operated by Metcut Research Associates Inc., 3980 Rosslyn Drive, Cincinnati, Ohio 45209, under contract to the Defense Logistics Agency, Contract DSA900-77-C-3197, with technical monitoring by the Army Materials and Mechanics Research Center, Arsenal Street, Watertown, Massachusetts. The contract is issued by the Defense Electronics Supply Center, Dayton, Ohio, and administered by the Commander, DCASMA Cincinnati, Federal Office Building, 550 Main Street, Cincinnati, Ohio 45202.

The Machinability Data Center has been in continuous operation since 1964 and until 1972 operated as the Air Force Machinability Data Center under contract to the Air Force Materials Laboratory, Wright-Patterson Air Force Base, Ohio.

SCOPE

The Machinability Data Center collects, evaluates, stores and disseminates material removal information including specific and detailed machining data for the Department of Defense, other Government Agencies, their contractors and subcontractors, and for private industry in a manner that does not interfere with the required Government support. MDC's operation emphasizes engineering evaluation for the purpose of developing material removal parameters, such as speed, feed, depth of cut, tool material and geometry, cutting fluids and other significant variables which comprise a machining situation. Data is being processed for all types of materials and for all kinds of material removal operations, both traditional and nontraditional.

MDC has a hard-copy document file of over 37,000 selected and evaluated documents pertaining to material removal technology. This file has a supporting computerized index which permits immediate retrieval of selected documents according to a specific work material and machining operation.

SERVICES

Services provided by MDC are designed to assist its Users in Government and private industry by increasing productivity and reducing costs in all phases relating to the machining technology areas of manufacturing technology.

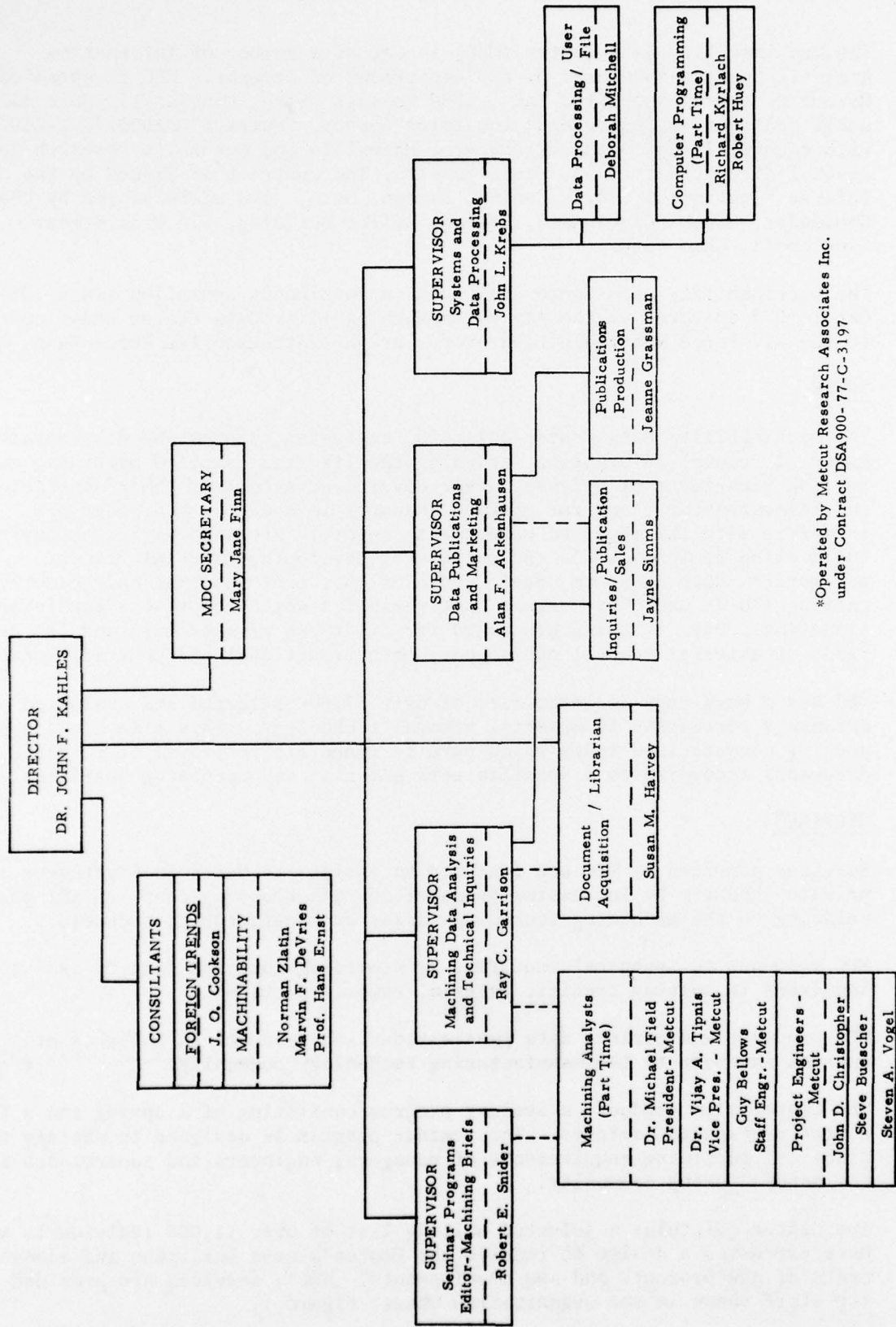
MDC responds to technical inquiries by providing analyzed data to assist inquirers in solving specific material removal problems.

MDC prepares and markets data publications and products on subjects of current interest to the manufacturing technology community.

The Center also conducts a seminar program consisting of a spring and a fall series of two-day seminars. The seminar program is designed to satisfy the practical machining requirements of managers, engineers and supervisors in the manufacturing community.

The Center maintains a selected mailing list of over 11,000 individuals who have expressed a desire to receive the Center's news bulletins and announcements of new products and new developments. MDC's services are provided by the staff shown in the Organization Chart, Figure 1.

FIGURE 1
 MACHINABILITY DATA CENTER*
 ORGANIZATION CHART



*Operated by Metcut Research Associates Inc.
 under Contract DSA900-77-C-3197

MDC SERVICES

INQUIRY SERVICES

MDC processed a total of 205 inquiries during this reporting period. Of this number, only 61 were paid technical inquiries. The remainder were no-charge inquiries, whereby the inquirer was provided with the necessary machining information during the course of a short telephone conversation. Telephone inquiries are encouraged by MDC because they help to maintain effective communications between the User community and MDC.

The distribution of inquiries by type does not reveal any significant changes in subject areas from the last reporting period. The greater numbers of inquiries received, in both the paid and the no-charge categories, concerned the same areas in which MDC is either working on new publications or planning the revision of an existing publication. Prominent among these areas were the nontraditional machining processes and the materials and operations contained in the *Machining Data Handbook*.

Table 1 summarizes MDC's technical inquiry processing activity during the period of this report. It should be noted that of the 268 inquiries quoted, 207 were cancelled by the inquirer when the estimate of charges was provided. The income-to-cost ratio for processing inquiries and the percentage of total man-hours expended in answering inquiries appear satisfactory for the reporting period.

SEMINAR PROGRAM - "Practical Machining Principles for Shop Application"

MDC's seminar program is designed to emphasize the practical aspects of machining and to familiarize the User community with new technology and applications. This program complements the other information transfer activities of MDC, namely, the generation and sale of publications and computer programs and the technical inquiry services.

Since its inception in 1974, the seminar program "Practical Machining Principles for Shop Application" has been offered in two series each year - one in the spring and one in the fall. Generally, six two-day seminar sessions have been presented in each series, with nearly every session having capacity or overflow attendance.

The seminar program was initiated to provide updated machining information on a timely, person-to-person basis in an effort to decrease costs, increase productivity and improve the reliability of machined components. The program has been very well received by its attendees, among whom the following job types were represented: manufacturing engineers and managers, industrial engineers, process and methods engineers, tool engineers, NC programmers, estimators, production planners, and shop personnel. The continued popularity of this program and the demonstrated need within the User community has prompted MDC to make the seminar a regular part of its total information transfer activity. The subject content of the seminar has been carefully selected and is continually being revised in order to present the latest ideas and machining techniques. Dates are carefully selected so as not to interfere with other relevant conferences and symposia that might cause a conflict for potential attendees. The

current program covers two full working days and includes the following discussions and presentations:

1. An Introduction to Practical Machining Principles
2. Cutting Tools
3. Cutting Fluids
4. Work Materials (Characteristics Affecting Machinability)
5. Selection of Speeds and Feeds
6. Machine Tool Operations
7. Economics of Machining
8. Numerical Control Machining
9. Surface Finish, Surface Integrity and Accuracy
10. Advanced Material Removal and Manufacturing Techniques
11. Nontraditional Machining Processes
12. Tour of Metcut Research Associates Inc. and the Machinability Data Center

During the period of this report, two seminar series were conducted - one each in the spring and fall of 1977. During this time, a total of 12 two-day seminar sessions were conducted by MDC and attended by individuals representing Government and private industry. The value of the seminar program to the total information transfer process is enhanced by the ability of the individual attendees to further disseminate their new knowledge to other production engineers and supervisors throughout their own organizations.

The summary of the seminar program (Table 2-A) shows that 1,695 individuals representing 768 companies from 40 states have attended the 51 seminar sessions that have been held since the spring of 1974. Table 2-B lists the job titles of seminar attendees by percentage. Table 12-A lists organizations that have been represented at the seminar program thus far, and Table 12-B lists the 112 organizations which have sent four or more employees. Additionally, it is interesting to note that 24 companies have sent 10 or more employees, and 9 companies have sent 20 or more.

DATA PUBLICATIONS

During this reporting period, MDC continued its emphasis on the production and distribution of new data publications. Nearly 17 percent of total MDC man-hours during this reporting period was expended working on new data publications. This time included the initiation of work to revise and update the *Machining Data Handbook* and the preparation of publications which describe and provide data for the nontraditional machining processes.

One new publication was placed in distribution during the period of this report. It is entitled *Chemical Machining: Production with Chemistry*, Publication No. MDC 77-102. This publication, the third in the Machining Process Series, is a state-of-the-art review of the chemical and photo-chemical machining processes used in the manufacturing industries. It contains machinability, tolerance, surface integrity and producibility data. Guidelines are presented for design applications, manufacturing process plans and quality assurance, and machining data is provided for a wide range of materials.

Other publications are also being prepared, and two are tentatively scheduled for release during the calendar year 1978. One publication is entitled *Low Stress Grinding: For Quality Production*, Publication No. MDC 77-103; the other is entitled *Electrical Discharge Machining: A Spark for Production*, Publication No. MDC 78-104. These are the fourth and fifth publications in the Machining Process Series.

The publication on low stress grinding (MDC 77-103) describes the special combinations of grinding parameters which produce high integrity surfaces and discusses these parameters in relation to their impact on productivity. Practical combinations to achieve both productivity and high integrity are covered. Quality assurance checks and surface integrity results are detailed, and checklists for rapid fault diagnosis are included. This publication is intended principally for manufacturing, design or quality assurance engineers who wish to -

1. Avoid grinding cracks and burns.
2. Utilize high integrity abrasively ground components.
3. Grind high strength steels, superalloys or other sensitive alloys.
4. Reduce grinding manufacturing losses.
5. Reduce stresses in critical or highly loaded components.
6. Enhance the surface integrity obtainable by grinding.
7. Attain adequate producibility while assuring the quality of the ground surface being produced.

While labeled "low stress grinding," the designation actually encompasses all of the considerations for producing high integrity surfaces, with low surface residual stress being but one of the elements.

Electrical discharge machining (EDM) is the oldest and most widely used process of the nontraditional machining processes. The thermal and electrical nature of EDM introduces many new terms, concepts and operating possibilities to the machining scene. *Electrical Discharge Machining: A Spark for Production* (MDC 78-104) will cover the basic process description and operation, the practical applications, the characteristics of the parameters, and the quality assurance and surface integrity considerations. The manipulation of the operating (controllable) parameters to secure accuracy, shape, tolerance, finish and productivity will be detailed. The quality assurance-surface integrity concerns will include a description of the effects of thermally altered surface layers and the corrective action needed - if any. Equipment types and capabilities will be included with practical guides for the manufacturing, design or quality engineer.

Publications sales during this reporting period were most satisfactory. Distribution of the *Machining Data Handbook* continued at a high rate. At the end of 1977, a total of 21,584 copies of the Second Edition had been sold. Table 3 is a list of the MDC publications that are currently available for distribution. These publications are listed in sequence according to their publication dates.

Table 4 summarizes by title publication sales for the calendar year 1977.

COMPUTER PROGRAMS

The NCECO (NC ECONOMICS) computer program was developed by MDC and was first made available for sale to industry in 1973. A modified version of this program in the form of programmable calculator strips for use in hand-held calculators has been completed, and the strips are now available for use by shop and engineering personnel who may not have ready access to a computer.

Both NCECO and the calculator strips are applicable to NC and conventional machine tool. They facilitate the investigation and economic analysis of the many alternative machining conditions available for production use. Using these programs, economic machining conditions can be determined before a part is put into production; consequently, a machine tool producing a part can be operated to give the lowest part cost, or the maximum production rate, or some combination of both, depending upon production demands.

The computer program and calculator strips can also be used for estimating costs, preparing quotations and determining areas where cost-effective improvement should be directed in view of new developments, such as increased labor and overhead rates, new tool materials and alternative work materials. Sales of computer programs and calculator strips are shown in Table 5.

MDC'S CONTRIBUTIONS TO LITERATURE

In order to achieve cost recovery goals, MDC's services are generally subject to charges. On a no-charge basis, MDC full- and part-time personnel participate in the transfer of machining information by making contributions to technical literature. Table 6 lists items published in various sources during this reporting period.

INCOME FROM INFORMATION TRANSFER ACTIVITIES

Table 7 summarizes the income distribution from MDC's information transfer activities during the period of this report. This table itemizes the income from each type of activity, namely, handbooks and other publications, computer programs and calculator strips, inquiries, and the popular seminar program. A statistical summary of the Data Center's total activity during this reporting period is given in Table 12.

TABLE 1. - INQUIRY ACTIVITY
(January - December 1977)

Paid technical inquiries (268 quoted) 61
 No-charge (telephone) inquiries 144
 Total inquiries processed 205

Income from 61 paid technical inquiries \$ 6,869.10
 Average income per paid inquiry \$ 113.00
 Cost of inquiry services \$ 16,406.00
 % Cost recovery for inquiry processing 41.9
 Total cost recovery income from all sources . . . \$180,205.00
 % Income from inquiry services 3.8

Man-hours expended in inquiry processing 545
 Total man-hours for Center operation 11,799
 % Man-Hours for inquiry services 4.6

<u>INQUIRIES BY TYPE</u>	<u>Paid</u>	<u>No Charge</u>
High temperature alloys	9	11
Cutting fluids	1	3
Cutting tools	7	6
Surface integrity	10	21
Nontraditional machining processes	6	26
Cost	4	3
CAD/CAM	0	5
General machining	23	69
Bibliography	1	0
TOTAL	61	144

<u>INQUIRIES BY SOURCE</u>	<u>Paid</u>	<u>No Charge</u>
Government		
DoD	2	6
Non-DoD	1	3
Educational institutions	3	9
Private industry	55	126
TOTAL	61	144

TABLE 2-A. - SEMINAR PROGRAMS

	<u>During this Contract Period</u>	<u>1974 - 1977*</u>
Two-day seminars held	12	51
Attendees	507	1,695
Organizations represented	---	768
States represented	---	40

*Totals are cumulative from Spring 1974 through Fall 1977.

TABLE 2-B. - JOB TITLES OF SEMINAR ATTENDEES
(Spring 1974 through Fall 1977)

Shop Supervisors	15.3%
Manufacturing Engineers	14.3
Industrial Engineers	10.8
Process & Method Engineers	10.5
Manufacturing Managers	7.5
No Title	7.5
Tool Engineers & Designers	7.1
Superintendents & Plant Managers	5.9
NC Supervisors & Programmers	3.5
Presidents & Vice Presidents	2.7
Customer Service Engineers	2.3
Machinists	1.5
Time Study Engineers	1.3
Metallurgists.	1.2
Technical Specialists	1.2
Production Control Engineers	1.0
Miscellaneous (includes Estimators, Engineering Supervisors, Technical Staff, Teachers, Buyers, etc.)	6.4
	100.0%

TABLE 3. - LIST OF CURRENT MDC PUBLICATIONS
(in order by publication dates)

CHEMICAL MACHINING: Production with Chemistry, MDC 77-102, 76 pages, 5½ x 8½ in., paperbound, February 1977.

GROUP TECHNOLOGY: An Overview and Bibliography, MDC 76-601, 90 pages, 5½ x 8½ in., paperbound, August 1976.

NONTRADITIONAL MACHINING GUIDE: 26 Newcomers for Production, MDC 76-101, 74 pages, 5½ x 8½ in., paperbound, August 1976.

MACHINING: A Process Checklist, MDC 76-100, 20 pages, 5½ x 8½ in., paperbound, May 1976.

MACHINING DATA HANDBOOK, Second Edition, 1029 pages, 8 x 10½ in., hardbound, 1972.

MACHINING OF HIGH STRENGTH STEELS WITH EMPHASIS ON SURFACE INTEGRITY, AFMDC 70-1, 268 pages, 8½ x 11 in., hardbound, 1970.

DETERMINATION AND ANALYSIS OF MACHINING COSTS AND PRODUCTION RATES USING COMPUTER TECHNIQUES, AFMDC 68-1, 124 pages, 8½ x 11 in., paperbound, August 1968.

1968 SUPPLEMENT TO MACHINING DATA FOR NUMERICAL CONTROL, AFMDC 68-2, 104 pages, 8½ x 11 in., paperbound, August 1968.

GRINDING RATIOS FOR AEROSPACE ALLOYS, AFMDC 66-2, 20 pages, 8½ x 11 in., paperbound, June 1966.

MACHINING DATA FOR BERYLLIUM METAL, AFMDC 66-3, 26 pages, 8½ x 11 in., paperbound, June 1966.

MACHINING DATA FOR TITANIUM ALLOYS, AFMDC 65-1, 56 pages, 5½ x 8½ in., paperbound, August 1965.

TABLE 4. - SALES OF MACHINING DATA PUBLICATIONS
(January - December 1977)

Machining Data Handbook, 2nd Edition	2,329
New data publications	
Machining: A Process Checklist	619
Nontraditional Machining Guide	525
Group Technology	701
Chemical Machining	<u>307</u>
	Total 2,152
Data publications (prior contracts)	<u>199</u>
	Grand Total 4,680

TABLE 5. - SALES OF COMPUTER PROGRAMS AND
PROGRAMMABLE CALCULATOR STRIPS
(January - December 1977)

NCECO (NC ECONomics) computer program	7
Calculator strips	20

TABLE 6. - CONTRIBUTIONS TO LITERATURE BY FULL- AND PART-TIME PERSONNEL
(January - December 1977)

Machinability Data Center - Data publications and services.

J. F. Kahles, *Materials Information Programs*, NBS special publication 463, Washington, DC: National Bureau of Standards, January 1977, pp. IV.5.1 - IV.5.8.

Chemical machining: Production with chemistry.

G. Bellows, Publication No. MDC 77-102, Cincinnati, OH: Machinability Data Center, Metcut Research Associates Inc., 1977.

Machinability data - Its present status and future need.

M. Field and S. A. Vogel, *Proceedings of CAM-I's Seminar on CAPP Applications*, Arlington, TX: Computer Aided Manufacturing - International, Inc., 1977, pp. 81-101.

The concepts and applications of the Metcut Machinability Processor for NC machining.

S. A. Vogel and V. A. Tipnis, *NC...From The User's Point of View: Proceedings of the Fourteenth Annual Meeting and Technical Conference*, Glenview, IL: Numerical Control Society, Inc., 1977, pp. 365-77.

Application of coated carbides and ceramics in face milling.

J. D. Christopher, *New Developments in Tool Materials and Applications*, Chicago, IL: Illinois Institute of Technology, 1977, pp. 89-93 (also published in *The Carbide Journal*, Vol. 9, May-June 1977, pp. 4-8).

Metallurgical damage in drilling and hole quality.

J. B. Kohls and G. Bellows, paper presented at the ASM Symposium, Influence of Metallurgy on Hole Making Operations, May 19-20, 1977, at Boston, Massachusetts.

Modern techniques for development, analysis and application of machinability data.

M. Field, *Proceedings of the 3rd International Conference on Production Engineering*, Tokyo, Japan: Japan Society of Precision Engineering, 1977, pp. 1-9.

Application of surface integrity in industry.

M. Field, *Proceedings of the 3rd International Conference on Production Engineering*, Tokyo, Japan: Japan Society of Precision Engineering, 1977, pp. 174-79.

Cutting rate-tool life functions (R-T-F), General theory and applications.

G. L. Ravnani, V. A. Tipnis and M. Y. Friedman, *Annals of the CIRP*, Vol. 26/1, 1977, pp. 295-301.

Mathematical models and algorithms for adaptive control of NC end milling operations.

V. A. Tipnis, *Proceedings of the International Conference on Production Engineering, New Delhi (Volume 1)*, Calcutta: The Institution of Engineers (India), 1977, pp. ii-37 to ii-47.

(continued - next page)

Table 6. (cont.)

Selection of economic machining conditions using programmable calculators.

S. C. Buescher, V. A. Tipnis and M. Field, *Proceedings of the International Conference on Production Engineering, New Delhi* (Volume 1), Calcutta: The Institution of Engineers (India), 1977, pp. iv-8 to iv-18.

Practical approaches to the management of numerical control job shops.

M. F. DeVries and V. A. Tipnis, *Proceedings of the International Conference on Production Engineering, New Delhi* (Volume 2), Calcutta: The Institution of Engineers (India), 1977, pp. xi-19 to xi-28.

Bearbeitungsdaten für das ACC- und ACO-Fräsen.

V. A. Tipnis, S. C. Buescher and R. C. Garrison, *Werkstatt und Betrieb*, Vol. 110, No. 9, 1977, pp. 589-96. (German translation of "Mathematically modeled machining data for adaptive control of end milling operations.")

A strategy for the development of improved machining steels.

V. A. Tipnis, *Proceedings, International Symposium on Influence of Metallurgy on Machinability of Steel*, Tokyo: The Iron and Steel Institute of Japan, 1977, pp. 1-14.

Deburring: A finishing checklist.

G. Bellows, Paper No. MRR77-440, Society of Manufacturing Engineers, Dearborn, MI, 1977.

TABLE 7. - INCOME DISTRIBUTION FROM MDC INFORMATION
TRANSFER ACTIVITIES
(January - December 1977)

Inquiries	\$ 6,573
Seminars	102,025
Machining Data Handbook	52,797
Other data publications	16,410
Computer programs and calculator strips	<u>2,400</u>
TOTAL	\$180,205

SOURCES OF MACHINING INFORMATION

MDC's operations are directly keyed to its hard-copy source document file, which is a collection of up-to-date and useful information relating to all phases of material removal technology. This file is kept current through a detailed screening procedure. Source publications from the United States and from the leading foreign industrial nations of the world are reviewed regularly for source data relating to MDC's area of interest. Meaningful data is identified, coded and indexed on the Center's computer for quick retrieval. This hard-copy document file, supported by the computer index, aids MDC's engineers by providing reference material for answering technical inquiries and for planning new technical publications or state-of-the-art reviews.

Table 8 summarizes MDC's activities relating to document acquisition in this reporting period. This table indicates that 422 documents were screened but contained no useful information for addition to MDC's document holdings. The apparent disparity between the number of documents judged significant and the total number of documents accessed arises from the fact that a single-screened source document often produces more than one independent secondary document for inclusion in the document file.

The status of the hard-copy document file is displayed in Table 9. The total number of documents by file type as well as by source category are depicted. A breakdown of the source file is also shown by the number of sources for each of the major source categories.

TABLE 8. - DOCUMENT ACQUISITION
(January - December 1977)

DOCUMENTS SCREENED*	
Significant	1,233
Nonsignificant	<u>422</u>
TOTAL	1,655
DOCUMENTS ACCESSED [†]	
Primary	621
Secondary	<u>1,414</u>
TOTAL	2,035
DOCUMENTS ENTERED INTO SYSTEM [§]	1,674

*Documents screened - refers to all types of publications, including periodicals, trade journals, conference proceedings, etc.

†Documents accessed - refers to those which have been selected for entry into MDC's document file. Secondary documents include such references as an article extracted from a periodical or an individual technical paper selected from a published volume of conference proceedings, etc. Primary documents include source data, such as contractor reports, which are entered into the system as received. Documents in this category are counted in the inventory of MDC's total data base.

§Documents entered into the system include primary and secondary documents which have been coded and referenced on the computer search files.

TABLE 9. - STATUS OF MDC DOCUMENT FILES
(as of December 31, 1977)

DOCUMENT FILE TOTALS*	
Regular file	26,703
Surface integrity file	3,124
Inquiry file	<u>7,708</u>
TOTAL [†] . .	37,535
BREAKDOWN OF SOURCE FILE	
DoD sources [§]	59
Educational institutions	96
Government, Non-DoD	17
Nongovernment open literature	
Domestic	904
Foreign	<u>476</u>
TOTAL . .	1,552
DOCUMENT TOTALS BY SOURCE	
DoD	1,463
Other Government	302
Nongovernment	
Domestic	27,470
Foreign	<u>8,300</u>
TOTAL . .	37,535

*Regular file - refers to the main document file which supports MDC's activities. Surface integrity file - refers to a segment of the main file pertaining to the special subject of surface integrity. Inquiry file - Inquiries are coded and filed in a similar manner to other documents and are used to assist in answering specific technical inquiries.

[†]The document file totals reflect the status of the files as of the reporting date after the addition of new source documents and the deletion of obsolete documents.

[§]DoD sources - includes DoD installations plus companies and educational institutions which generate source documents under Government contract and other source documents which result from their own research.

ECONOMIC ANALYSIS OF MDC'S OPERATIONS

Table 10 is a statistical analysis of the cumulative effect of the availability of the products and services of the Machinability Data Center towards cost savings to its Users. The numbers used in the computations include the total number of inquiries answered by the Data Center since its beginning and the total number of data publications sold and/or placed in distribution by the Data Center. The other input is the dollar savings per machining situation and the average number of machining situations serviced by each inquiry and/or individual data publication. These figures are then totaled to produce a dollar value which is the estimated total savings resulting from the operation of the Machinability Data Center.

Table 11 is an analysis of the cost of the metal cutting industry in the United States. These figures include the total number of metal cutting machine tools in use today and the average labor input plus the cost of labor and overhead for an average number of hours per individual working year. The estimates of the number of machine tools are extracted from the American Machinist Eleventh Inventory (1973). The other basic information is provided by U.S. Department of Commerce sources.

TABLE 11. - MACHINING COSTS IN THE U.S.A.

APPROXIMATE ANNUAL LABOR AND OVERHEAD COSTS FOR OPERATING METAL CUTTING MACHINE TOOLS IN INDUSTRIES IN THE UNITED STATES

Total number of metal cutting machine tools	= 2,692,000*
Average labor cost + overhead	= \$10-12 per hour
Average working day	= 8 hours
Number of working days per year	= 250
Average number of direct labor personnel per machine	= 1
Total cost of labor + overhead:	
2,692,000 x \$10 x 8 x 250 x 1	= \$53,840,000,000
2,692,000 x \$12 x 8 x 250 x 1	= \$64,608,000,000

It appears reasonable to conclude that the cost of labor + overhead for machining required for manufacturing in the U.S.A. is of the order of:

\$60,000,000,000 Annually

TOTAL SHIPMENTS INCLUDING EXPORTS OF METAL CUTTING TYPE METALWORKING MACHINERY (SIC Code 3541 only; in current dollars)†

<u>1973</u>	<u>1974</u>	<u>1975</u>	<u>1976 (estimate)</u>	<u>1977 (estimate)</u>
\$1,420,000,000	\$1,772,000,000	\$2,133,000,000	\$1,848,000,000	\$1,892,000,000

MACHINE TOOL ACCESSORIES INDUSTRY†

Metal cutting tools for machine tools and metalworking machinery in current dollars:

<u>1973</u>	<u>1974</u>	<u>1975 (estimate)</u>	<u>1976 (estimate)</u>
\$928,000,000	\$1,129,000,000	\$1,184,000,000	\$1,310,000,000

ANNUAL COST OF CUTTING FLUIDS FOR MATERIAL REMOVAL OPERATIONS§

\$160,000,000

NOTE: The statistics above provide perspective concerning the economic importance of metal cutting (machining and grinding) in the U.S.A.

SOURCES: *Based on American Machinist Eleventh Inventory (1973)

†U. S. Department of Commerce, Bureau of Domestic Commerce

§MDC estimate (1976)

COVERAGE OF MACHINING TECHNOLOGY IN COUNTRIES OUTSIDE THE UNITED STATES

One of the more interesting and challenging facets of MDC's operation is the responsibility for assessing the relative position and rate of advancement of machining technology on a worldwide scale. In order to accomplish this task, a three-pronged approach has been adopted combining access to the basic literature sources, the use of foreign consultants and international personal contact by MDC full- and part-time personnel. Coverage of technology in other countries has currency as its guiding principle. Current research, new machine tools, new cutting tool materials and processes, economic approaches to machining, new applications and overall international trends all constitute areas of considerable interest.

Maximum exposure to machining technology in countries outside the U.S. is maintained through MDC's privileged association with CIRP (The International Institution for Production Engineering Research). CIRP is an international organization of limited size founded in Paris in 1951. Its members represent 27 countries and are elected on the basis of their technical contributions to the field of production engineering. Dr. Michael Field, President of Metcut Research and MDC Analyst, and MDC Director, Dr. John F. Kahles, are both members of this prestigious organization. Membership is reasonably distributed among educational institutions and private or public organizations within the mechanical engineering industries, including almost all the important metalworking research laboratories which in the 27 represented countries carry out valuable and continuous work in their respective field of activity.

Each year CIRP members meet at a General Assembly. On that occasion, the most important results of studies carried out in each country are presented and discussed. At the 27th Assembly, 1977, in New Delhi, India, 70 presentations were made, including one by MDC Analyst, Dr. Vijay A. Tipnis. From time to time, specially selected reports are compiled which stress principal problems of current interest, such as recent papers on in-process tool wear sensors, NC wire spark erosion, the grinding research program in Great Britain and trends in manufacturing toward the year 2000. Recently, more extensive reports have also been filed on subjects such as technology assessment of the computer-integrated automatic factory and the relationship of surface roughness and surface integrity to functional properties.

Characteristic of CIRP has been the creation of working groups whose principal tasks are the development of research in specific fields and the establishment of permanent liaison between members who are prepared to cooperate in specific research work. Currently, there are 8 such groups - Cutting, Physical and Chemical Machining Processes, Forming, Grinding, Machine Tools, Metrology, Surfaces and Optimization - and their activities are reported upon regularly. Active participation by Drs. Field and Kahles in the working groups in addition to their participation in the annual general assemblies brings about a level of personal exchange which permits MDC to gather valuable information which would otherwise be unavailable.

In the past, it has been the practice of MDC to follow machining trends in countries outside the United States with the aid of consultants who have both machining expertise and multi-language capability. Persons who have served MDC in this capacity include two internationally known manufacturing engineers - the late Dr. Max Kronenberg and the late Dr. Moshe Friedman.

During 1977 an agreement was reached with the Machine Tool Industry Research Association (MTIRA) of Great Britain to provide coverage of European foreign language literature and periodic discussions of machining trends as expressed in the literature and as seen at overseas exhibitions, in new commercial products, etc. Literature coverage is accomplished at MTIRA by monitoring foreign language journals and selecting certain relevant articles, preparing English language abstracts and sending these with the original articles to MDC, where they become part of the document collection. At MDC, certain abstracts are selected for periodic publication in MDC's newsletter, "Machining Briefs." Discussions of machining trends accompanied by references to applicable literature have also appeared in past issues of MDC's newsletter, "Machining Briefs."

At the present time, MDC document files contain information from a total of 476 individual open literature sources outside the United States as well as from a number of foreign universities, industrial research organizations, technical societies and companies. Access to many open literature sources is maintained through the use of major abstracting services, such as *Government Reports Announcements*, *Scientific and Technical Aerospace Reports*, *Metals Abstracts*, *Engineering Index* and the like. Supplementary smaller services, such as "Production Engineering Abstracts" (UK), "Industrial Diamond Abstracts" (UK), and a number of others that appear within or are inserted into journals and newsletters also provide valuable references to foreign literature in specific technological areas.

MDC recognizes that its three-pronged approach to covering machining technology in countries outside the United States is a compromise position. While certainly not exhaustive in scope, it does, nevertheless, enable MDC to identify within current budgetary limitations the important developments and differences in overseas research and practice as they affect the U.S. and as they contribute to the worldwide climate.

TABLE 12. - STATISTICAL SUMMARY FOR JANUARY 1 - DECEMBER 31, 1978

INFORMATION ANALYSIS CENTER CONTRACT STATUS REPORT	NAME OF INFORMATION ANALYSIS CENTER Machinability Data Center	QUARTER ENDING			CUMULATIVE THRU December 1977	
		OUTPUT UNITS PRODUCED	MANHOURS EXPENDED			TOTAL
			PRO- FESIONAL	NON-PRO- FESIONAL		
AREA TITLE			DIRECT	INDIRECT	TOTAL	INCOME
1. ACQUISITION AND INPUT OF SOURCE INFORMATION		2,046	33,220	48,161	81,381	
a. DOCUMENTS ACQUIRED	1,655					
b. DOCUMENTS REVIEWED	2,035					
c. DOCUMENTS CATALOGED	1,469					
2. TECHNICAL INQUIRY RESPONSES PROVIDED	204	492	6,253	10,153	16,406	6,573
3. BIBLIOGRAPHIC INQUIRY RESPONSES PROVIDED	1					
4. HANDBOOKS/DATA BOOKS COMPLETED		899	46,525	18,135	64,660	56,764
a. NEW CHAPTERS/PAGES COMPLETED						
b. REVISED CHAPTERS/PAGES COMPLETED						
c. DATA SETS COMPILED						
5. STATE-OF-THE-ART STUDIES COMPLETED		770	9,265	18,483	27,748	14,843
6. CRITICAL REVIEWS AND/OR TECHNOLOGY ASSESSMENTS COMPLETED						
7. CURRENT AWARENESS AND PROMOTION EFFORTS		1,593	52,707	29,973	82,680	
a. NUMBER NEWSLETTERS AND/OR ANNOUNCEMENTS PUBLISHED	6					
b. NUMBER MEETINGS, CONFERENCES, ETC. SUPPORTED	25					
8. OTHER		1,737	29,328	33,457	62,785	102,025
9. MANAGEMENT AND SUPPORT		1,409	23,473	39,157	62,630	
10. UNASSIGNABLE INDIRECT COSTS						
11. TOTAL		8,946	200,771	197,519	398,290	180,205

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TABLE 13-A.
 ORGANIZATIONS REPRESENTED AT MDC'S SEMINARS ON
 "PRACTICAL MACHINING PRINCIPLES FOR SHOP APPLICATION"
 (Spring 1974 - Fall 1977)

<u>Company</u>	<u>No. of Attendees</u>
AMP, Inc., Harrisburg, PA	1
A-Quality Machine Products, Mishawaka, IN	1
ARO, Inc., Arnold Air Force Station, TN	17
ASKO Inc., Homestead, OH	1
A-T-O Inc., Willoughby, OH	7
Abex Corp. (Research Center), Mahwah, NJ	1
Abex Corp., Marysville, OH	2
Acimet Manufacturing Corp., Cleveland, OH	1
Adams Tool & Engineering Co., Lansing, MI	2
Aero Nuclear Corp., Bentleyville, PA	2
Aeroquip Corp., Leslie, MI	1
Aeroquip Corp., Van Wert, OH	8
Aerospace Materials, Inc., Columbus, OH	1
Affiliated Hospital Products, St. Louis, MO	1
AiResearch Manufacturing Co., Phoenix, AZ	4
Ajax Forging & Casting Co., Ferndale, MI	1
Allen-Bradley Co., Highland Heights, OH	1
Allen-Bradley Co., Milwaukee, WI	1
Allis-Chalmers Corp., Cincinnati, OH	11
Allis-Chalmers Corp., Milwaukee, WI	3
Allis-Chalmers Corp., West Allis, WI	3
Allis-Chalmers Corp., York, PA	17
Aluminum Co. of America, Alcoa Center, PA	3
American Can Co., Geneva, NY	1
American Machinist, New York, NY	1
American Standard - WABCO, Lexington, KY	2
Anchor Coupling Co., Inc., Libertyville, IN	1
Anderson Greenwood, Bellaire, TX	2
Anderson Instrument Co., Inc., Fultonville, NY	1
Anderson Metal Industries Inc., Mercer, PA	1
Andrew Corp., Orland Park, IL	4
Ansul Co. (The), Marinette, WI	1
Apex Broach & Machine Co., Detroit, MI	2
Apollo Tool & Design, Dayton, OH	1
Applied Industries Inc., Center Line, MI	1
Aqua-Chem, Inc., Milwaukee, WI	1
Armco Steel Corp., Middletown, OH	1
Armstrong Machine Works, Three Rivers, MI	3
Ashland Oil, Inc., New Carlisle, IN	1
Atlas Crankshaft Corp., Fostoria, OH	3
Atlas Corp., Springfield, MA	1
Atwood & Morrill Co. Inc., Salem, MA	3
Atwood Vacuum Machine, Rockford, IL	1
Aurora Metal Co., Montgomery, IL	2

<u>Company</u>	<u>No. of Attendees</u>
Auspro Manufacturing Co., Inc., Elkhart, IN	1
Automated Industries Inc., Oak Ridge, TN	1
Automatic Feed Co., Napoleon, OH	1
Avco Corp. (Lycoming Div.), Stratford, CT	2
Babcock & Wilcox Co., Barberton, OH	33
Babcock & Wilcox Co., Beaver Falls, PA	1
Babcock & Wilcox Co., Elkhart, IN	1
Babcock & Wilcox Co., Lynchburg, VA	6
Babcock & Wilcox Co., Paris, TX	1
Babcock & Wilcox Co., Rochester, MI	1
Badger-Powhatan, Ranson, WV	2
Baj Tool Co., Willoughby, OH	1
Baker Perkins Inc., Saginaw, MI	2
Baldwin-Gegenheimer, Stamford, CT	1
Ball Brothers Research Corp., Boulder, CO	1
Banta Machine Corp., Ridgefield, NJ	1
Barber-Coleman Co., Rockford, IL	2
Barnes Co., W. F. & John, Rockford, IL	5
Battelle-Northwest, Richland, WA	3
Beaird Poulan, Shreveport, LA	2
Bell Helicopter Co., Ft. Worth, TX	2
Bell Helicopter Co., Hurst, TX	2
Bell Telephone Labs., Holmdel, NJ	1
Bell Telephone Labs., Murray Hill, NJ	1
Beloit Corp. (Jones Div.), Dalton, MA	4
Bendix Corp. (I.T.D. Div.), Greenfield, MA	1
Bendix Corp., South Bend, IN	3
Bennett Pump Co., Muskegon, MI	2
Bepex Corp., Rosemont, IL	1
Berg Manufacturing Co., Des Plaines, IL	1
Berg Manufacturing Co., Iola, KS	2
Berkel Inc., La Porte, IN	1
Berkeley-Davis Inc., Danville, IL	2
Bethlehem Steel Corp., Baltimore, MD	1
Bettcher Industries Inc., Vermillion, OH	1
Bingham Willamette Co., Shreveport, LA	2
Black Clawson Co., Fulton, NY	1
Black Clawson Co., Middletown, OH	1
Black, Joseph E. (Consultant), Bellingham, WA	1
Bliss & Laughlin Industries, Evansville, IN	1
Bloom Engineering Co., Inc., Pittsburgh, PA	1
Boeing Co., Seattle, WA	2
Boeing Vertol Co., Philadelphia, PA	3
Booz-Allen Applied Research, Inc., Bethesda, MD	1
Boston Centerless Inc., Malden, MA	2
Brad Foote Gear Works, Inc., Cicero, IL	3
Brake Parts Co., McHenry, IL	1

<u>Company</u>	<u>No. of Attendees</u>
Brighton Corp., Cincinnati, OH	1
Brock Manufacturing Co., Crystal Lake, IL	1
Brothers Industries, Warren, MI	1
Brown & Sharpe Manufacturing Co., Centerdale, RI	1
Brown & Sharpe Manufacturing Co., No. Kingstown, RI	1
Browning, Victor R., & Co., Inc., Willoughby, OH	1
Brush Wellman, Inc., Elmore, OH	2
Buckeye Steel Castings, Columbus, OH	1
Bucyrus-Erie, Erie, PA	1
Budd Co. (The), Ashland, OH	4
Buehler Corp. (The), Indianapolis, IN	1
Bullard Co., Bridgeport, CT	1
Burgess-Norton Manufacturing Co., Geneva, IL	1
Burroughs Corp., Plymouth, MI	1
CBC Inc., Lubbock, TX	2
C-E Process Equipment Mfg. Facility, Enterprise, KS	1
C R M, Solon, OH	1
Cablecraft, Inc., Tacoma, WA	2
Cabot Corp., Kokomo, IN	2
Camcar Textron, Decorah, IA	1
Cameron Iron Works, Inc., Houston, TX	1
Carlton Machine Tool Co., Cincinnati, OH	1
Carlyle Compressor Co., East Syracuse, NY	4
Carmet Company, Lima, OH	1
Carmet Company, Madison Heights, MI	1
Carpenter Technology Corp., Reading, PA	4
Carr Tool Co., Cincinnati, OH	1
Carter Carburetor, St. Louis, MO	1
Case, J. I., Co., Racine, WI	1
Case, J. I., Co., Winneconne, WI	1
Caterpillar Tractor Co., East Peoria, IL	3
Cava Industries, Essington, PA	1
Chamberlain Mfg. Corp., New Bedford, MA	14
Champion Spark Plug, Toledo, OH	1
Chemetron Corp., Louisville, KY	6
Chemineer Inc., Dayton, OH	1
Cherry-Burrell Co., Cedar Rapids, IA	2
Chicago Pneumatic Tool Co., Utica, NY	1
Chromalloy American Corp. (Starline Div.), Harvard, IL	1
Chrysler Corp., Dearborn, MI	1
Chrysler Corp., Detroit, MI	1
Chrysler Corp., Kokomo, IN	6
Chrysler Corp., New Castle, IN	1
Cincinnati, Inc., Cincinnati, OH	5
Cincinnati Milacron Inc., Cincinnati, OH	5
Cincinnati Mine Machinery Co. (The), Cincinnati, OH	1
Cincinnati Metal-Blast, Inc., Cincinnati, OH	1

<u>Company</u>	<u>No. of Attendees</u>
Cincinnati Technical College, Cincinnati, OH	1
Cincinnati Tool, Cincinnati, OH	2
Cincinnati, University of, Cincinnati, OH	2
Clark Equipment Co., Buchanan, MI	1
Clark Equipment Co., Georgetown, KY	3
Clark Equipment Co., Rockingham, NC	1
Clayton Mark Co., Evanston, IL	1
Cleveland Hardware & Forging Co., Cleveland, OH	2
Cleveland Twist Drill Co., Cleveland, OH	1
Clow Corporation, Birmingham, AL	1
Clow Corporation, Oskaloosa, IA	2
Clow Corporation, Westmont, IL	1
Columbian Vise Manufacturing, Cleveland, OH	1
Columbus McKinnon Corp., Damascus, VA	2
Combustion Engineering, Inc., Chattanooga, TN	2
Commercial Machine Works, Elk Grove, IL	1
Comptrol Inc., Cleveland, OH	1
Conax Corporation, Buffalo, NY	2
Contraves-Goerz Corp., Pittsburgh, PA	8
Coolant Control, Inc., Cincinnati, OH	2
Cooper Bessemer Co., Mount Vernon, OH	1
Cooper Energy Services, Easton, PA	2
Cooper Energy Services, Mount Vernon, OH	1
Copeland Corp., Sidney, OH	1
Copperweld Specialty Steel Co., Warren, OH	3
Corning Community College, Corning, NY	1
Corning Glass Works, Corning, NY	1
Crane Co., Chicago, IL	2
Crepaco, Inc., Lake Mills, WI	2
Crosby Valve & Gage Co., Wrentham, MA	3
Cross Corp. (Fraser Div.), Fraser, MI	6
Cross Manufacturing Inc., Lewis, KS	2
Cummins Engine Co., Inc., Columbus, IN	12
Cummins Engine Co., Inc., North Charleston, SC	1
Cutler-Hammer, Inc., Bowling Green, KY	1
Cutler-Hammer, Inc., Milwaukee, WI	4
D.A.B. Industries Inc., Bellefontaine, OH	2
DRT Marketing Group, Inc., Troy, MI	1
Dana Corp., Chelsea, MI	7
Danly Machine Corp., Cicero, IL	1
Davis Manufacturing, Wichita, KS	1
Dean Machine Products, Inc., Manchester, CT	2
Dearborn, Howard, Inc., Berea, OH	12
Dearborn, Howard, Inc., Fryeburg, ME	1
Dearborn Machine Products Co., Taylor, MI	1
Deere & Company, Dubuque, IA	10
Deere & Company, Moline, IL	3

<u>Company</u>	<u>No. of Attendees</u>
Deere, John, Argentina, S.A.I.C., Granadero, Baigorria, Argentina	2
Deere, John, Des Moines Works, Des Moines, IA	3
*Defense Contract Admin. Management Area, Cincinnati, OH	5
Delaval Turbine Inc., Trenton, NJ	7
Delton Tool & Engineering, Inc., Delton, MI	1
Detroit Edge Tool Co., Detroit, MI	1
Deutsch Co. (The), (E.C.D. Div.), Banning, CA	1
Deutsch Co. (The), Oceanside, CA	2
DeVlieg Machine Co., Royal Oak, MI	1
DeZurik Corp., McMinnville, TN	2
DeZurik Corp., Sartell, MN	1
Diamond Chain Co., Indianapolis, IN	5
Digital Equipment Corp., Westfield, MA	1
Discharge Machining, Inc., Cleveland, OH	1
Dixie Tool Industries Co., Bridgeport, MI	2
DoAll Co., Des Plaines, IL	2
Dostal & Lowey Co., Menomonee Falls, WI	1
Dover Corp., Chattanooga, TN	2
Dover Corp., Cincinnati, OH	2
Dover Corp. (Cook Airtomic Div.), Louisville, KY	2
Dresser Industries (IVI), Alexandria, LA	1
Dresser Industries, Dallas, TX	1
Dresser Industries (Foote Jones), Downers Grove, IL	2
Dresser Industries (Clark Div.), New Orleans, LA	2
Dresser Industries, Waukesha, WI	2
DuBois Chemicals, Cincinnati, OH	1
Duff-Norton Co., Charlotte, NC	5
Dunmore Co. (The), Racine, WI	1
Dupps Co. (The), Germantown, OH	1
Duriron Co. (The), Dayton, OH	2
Duval Sierrita Corp., Sahuarita, AZ	1
Dyson, Joseph & Sons, Painesville, OH	1
East Chicago Machine Tool Corp., East Chicago, IN	1
Eaton Corp., Cleveland, OH	2
Eaton Corp., Glasgow, KY	2
Eaton Corp., Humboldt, TN	2
Eaton Corp., Louisville, KY	1
Eaton Corp., Marshall, MI	4
Eaton Corp., Richmond, IN	4
Eaton Corp., Roxboro, NC	1
Eaton Corp., Saginaw, MI	1
Eaton Corp., St. Louis, MO	1
Eccles Saw & Tool Co. Inc., Cincinnati, OH	1

*Department of Defense

<u>Company</u>	<u>No. of Attendees</u>
Edgewater Steel Co., Oakmont, PA	3
Elano Corp., Xenia, OH	2
Eldred Co. (The), Columbus, OH	1
Electric Machinery Mfg. Co., Minneapolis, MN	6
Electric Wheel Co., Quincy, IL	2
Elkhart Brass Manufacturing Co., Inc., Elkhart, IN	1
Elliott Corp., Irwin, PA	7
Emerson Electric Co. (Browning Mfg. Div.), Maysville, KY	1
Eonics, Inc., Detroit, MI	2
Erie Bolt Corp, Erie, PA	1
Essick Manufacturing Co., Los Angeles, CA	1
Evans Products, Plymouth, MI	1
Ex-Cell-O Corp., Howell, MI	1
Ex-Cell-O Corp., Walled Lake, MI	2
FAMA Inc., Monterrey, Mexico	3
FMC Corp., Englewood, NJ	1
FMC Corp., Houston, TX	1
FMC Corp., Indianapolis, IN	1
FMC Corp., Philadelphia, PA	2
Fairchild Industries, Manhattan Beach, CA	2
Falk Corp., Milwaukee, WI	3
Falon Co., Cleveland, OH	1
Fansteel Research Center, Salt Lake City, UT	1
Farrel Co.-Div. USM, Rochester, NY	2
Federal-Mogul Corp., Greensburg, IN	2
Federal-Mogul Corp., Macomb, IL	1
Federal-Mogul Corp., Malden, MO	1
Federal-Mogul Corp., Mooresville, IN	1
Federal Sign & Signal Corp., Shelby, OH	1
Fenn Manufacturing Co., Newington, CT	2
Fischer Special Manufacturing Co., Cincinnati, OH	1
Fisher Controls Co., Coraopolis, PA	5
Fisher Controls Co., Marshalltown, IA	4
Fisher Controls Co., McKinney, TX	2
Flodar Corp., Cleveland, OH	1
Ford Motor Co., Dearborn, MI	1
Ford Motor Co., Detroit, MI	1
Foremost Machining Builders, Inc., Fairfield, NJ	1
Foster Wheeler Energy Corp., Livingston, NJ	1
Freeport Machine Works, Freeport, IL	1
Fremont Manufacturing Co., Fremont, NB	1
French Oil Mill Machinery Co. (The), Piqua, OH	2
Frick Co., Waynesboro, PA	1
Gaishin Tool & Fixture Inc., Riverview, MI	1
Garden Way Manufacturing Co., Inc., Troy, NY	1
Garvin Brothers Inc., South Bend, IN	1

<u>Company</u>	<u>No. of Attendees</u>
Gay-Lee Co., Clawson, MI	1
Gehl Co., West Bend, WI	2
Generac Corp., Waukesha, WI	1
General Casting Corp. Waukesha, WI	1
General Dynamics, Avenel, NJ	1
General Dynamics, Ft. Worth, TX	5
General Dynamics, San Diego, CA	2
General Electric Co., Cincinnati, OH	4
General Electric Co., Ft. Wayne, IN	1
General Electric Co., Greenville, SC	1
General Electric Co., Hendersonville, NC	2
General Electric Co., Lynn, MA	1
General Electric Co., Merrimack, NH	1
General Electric Co., Philadelphia, PA	1
General Electric Co., Rome, GA	2
General Electric Co., St. Petersburg, FL	1
General Electric Co., San Jose, CA	2
General Electric Co., Schenectady, NY	3
General Electric Co., Southfield, MI	1
General Electric Co., Syracuse, NY	2
General Electric Co., Worthington, OH	2
General Motors Corp., Dayton, OH	4
General Motors Corp. (Detroit Diesel Allison), Detroit, MI	3
General Motors Corp. (Detroit Diesel Allison), Indianapolis, IN	2
General Motors Corp. (Delco Electronics), Kokomo, IN	1
General Motors Corp. (Harrison Radiator Div.), Lockport, NY	1
General Motors Corp., Rochester, NY	2
General Motors Corp. (Detroit Diesel Allison), Romulus, MI	2
General Motors Corp., Warren, MI	5
General Motors Overseas Operations, Detroit, MI	3
General Motors Technical Center, Warren, MI	2
General Signal Corp. (BIF Unit), West Warwick, RI	1
General Tool Co., Cincinnati, OH	1
Geo Space Corp., Houston, TX	2
Gerdes Products Co., Brookville, OH	2
Gettys Manufacturing Co., Racine, WI	1
Giddings & Lewis-Bickford Machine Co., Kaukauna, WI	1
Giddings & Lewis Machine Tool Co., Fond Du Lac, WI	2
Gleason Works, Rochester, NY	2
Gold Metal Products Co., Cincinnati, OH	1
Goodman Equipment Corp., Chicago, IL	2
Goodyear Aerospace Corp., Akron, OH	6
Gorham Tool Co., Detroit, MI	2
Gormac Products, Inc., Racine, WI	1
Gould Inc., Angola, IN	3
Gould Inc., McConnelsville, OH	2
Goulds Pumps, Inc., Lubbock, TX	1
Grapha Manufacturing Co., Hauppauge, NY	1

<u>Company</u>	<u>No. of Attendees</u>
Gray, G. A., Co., Cincinnati, OH	13
Grumman Aerospace Corp. Bethpage, NY	14
Gusmer Corp., Old Bridge, NJ	2
H & C Tool Supply Co., Rochester, NY	1
Hall Industries Inc., Pittsburgh, PA	1
Hamilton Caster & Mfg. Co., Hamilton, OH	1
Hamilton Standard, Windsor Locks, CT	3
Hamilton Technology Inc., Lancaster, PA	1
Hamilton Tool Co., Cincinnati, OH	1
Harley Tool & Machine Inc., Bogota, NJ	1
Harris Corp., Champlain, NY	1
Harvey Hubbell, Inc., Huntington, WV	2
Heil Co. (The), Arab, AL	2
Hendershot Tool Co., Oklahoma City, OK	1
Hesston Corp., Hesston, KS	3
Hewlett-Packard Co., Santa Rosa, CA	8
*Hill Air Force Base, Hill AFB, UT	3
Hillard Corp. (The), Elmira, NY	2
Hitachi, Ltd., Tokyo, Japan	7
Hobart Corp., Hillsboro, OH	5
Hobart Manufacturing Co., Troy, OH	1
Hoeganaes Corp., Riverton, NJ	1
Hollingsworth on Wheels, John D., Greenville, SC	2
Honeywell, Inc., Golden Valley, MN	1
Horix Manufacturing Co., McKees Rocks, PA	1
Houston Engineers Inc., Houston, TX	1
Howmet Corp., Whitehall, MI	2
Hubbell Machine Co., Inc., Cleveland, OH	1
Huber Corp., Marion, OH	2
Hughes Aircraft Co., Fullerton, CA	2
Hughes Helicopters, Culver City, CA	2
Huntington Alloys Inc., Huntington, WV	2
IBM Corp., Boulder, CO	4
IBM Corp., Endicott, NY	1
IBM Corp., Lexington, KY	2
IBM Corp., Research Triangle Park, NC	1
IBM Corp., San Jose, CA	1
IIT Research Institute, Chicago, IL	1
ITT Harper, Morton Grove, IL	1
ITW, Inc. (Shakeproof Div.), Elgin, IL	2
Illinois Tool Works, Chicago, IL	1
Indian Springs Mfg. Co. Inc., Baldwinsville, NY	1
Industrial Nut Corp., Sandusky, OH	2

*Department of Defense

<u>Company</u>	<u>No. of Attendees</u>
Industrial Tool Engineering Co., Detroit, MI	1
Ingersoll Manufacturing Consultants, Rockford, IL	1
Ingersoll-Rand Co., Athens, PA	2
Ingersoll-Rand Co., Mocksville, NC	2
Ingersoll-Rand Co., Painted Post, NY	5
Ingersoll-Rand Co., Phillipsburg, NJ	2
Ingersoll-Rand Co., Shippensburg, PA	2
Institute of Metal Cutting, Krakow, Poland	1
International Harvester Co., Canton, IL	10
International Harvester Co., East Moline, IL	1
International Harvester Co., Ft. Wayne, IN	8
International Harvester Co., Libertyville, IL	2
International Harvester Co., San Diego, C.	2
International Nickel Co., Huntington, WV	4
Interpace Corp. (Lapp Insulator Div.), LeRoy, NY	2
Iowa Industrial Hydraulics, Pocahontas, IA	1
Jeffrey Mfg. Co., Columbus, OH	4
Jeffrey Mfg. Co., Belton, SC	1
Jeffrey Mining Machinery, Columbus, OH	2
Jet Products, Inc., Braintree, MA	1
Johnson Foils Inc., Springfield, MA	2
Johnson Mold & Manufacturing, Muskegon, MI	1
Jordan Valve, Cincinnati, OH	3
Joslyn Stainless Steel, Ft. Wayne, IN	3
Jost Machinery Co., St. Ann, MO	1
Joy Manufacturing Co., Birmingham, AL	12
Judelson Industries Inc., Jersey City, NJ	1
KDI Precision Products, Inc., Cincinnati, OH	1
K-G Industries Inc., Rosemont, IL	2
KTS Industries Inc., Kalamazoo, MI	1
Kearney & Trecker Corp., Milwaukee, WI	2
Kelsey-Hayes (Axle and Brake Div.), Seminole, OK	1
Kelsey-Hayes, Springfield, OH	2
Kentucky, University of, Lexington, KY	1
Kewaunee Engineering Corp., Kewaunee, WI	2
Kingsbury Machine Tool Corp., Keene, NH	4
Kinsey, E.A., Co. (The), Cincinnati, OH	1
Klima, F. J., Inc., Virginia, MN	2
Koehring Co. (Speedstar Div.), Enid, OK	2
Koehring Co. (HPM Div.), Mt. Gilead, OH	4
Kollmorgen Corp (Inland Motor Div.), Radford, VA	1
Kometco Machining Co., Clermont, FL	1
Koppers-Sprout Waldron Inc., Muncy, PA	2
Kunkle Valve Co., Ft. Wayne, IN	2
Kyocera International, San Diego, CA	1

<u>Company</u>	<u>No. of Attendees</u>
LTV Aerospace Corp., Warren, MI	2
LaBour Pump Co. (The), Elkhart, IN	4
Ladish Co., Cudahy, WI	1
Lake Engineering Co., Long Lake, MN	1
Lamson Products Co., Seattle, WA	2
Lawrence Livermore Labs, Livermore, CA	9
LeBlond Inc., Cincinnati, OH	2
Ledex, Inc., Vandalia, OH	3
Lenape Forge Div.-Gulf + Western, West Chester, PA	3
Liberty Screw Machine Products, Inc., Chicago, IL	1
Lima Electric Co., Lima, OH	2
Lockheed-Georgia Co., Marietta, GA	4
Lockheed Missiles & Space Co., Inc., Sunnyvale, CA	2
Logansport Machine Co. Inc., Logansport, IN	1
Lord Corp. (Kinematics Div.), Erie, PA	3
Loyalist College, Belleville, Ontario, Canada	1
Lucas Machine, Cleveland, OH	2
MCC Marpac, Evanston, IL	3
MTS Systems Corp., Eden Prairie, MN	2
Machine Products Corp., Dayton, OH	1
Macon Machine Inc., Macon, GA	1
Madison Industries, Providence, RI	1
Madison-Kipp Corp., Madison, WI	2
Manufacturing Data Systems Inc., Ann Arbor, MI	1
Mark Controls Corp., Evanston, IL	2
Markem Corp., Keene, NH	2
Marlin Firearms Co., North Haven, CT	1
Marsh Stencil Machine Co., Belleville, IL	1
Martin Marietta Corp., Baltimore, MD	2
Martin Marietta Corp., Orlando, FL	3
Massey-Ferguson, Cuyahoga Falls, OH	1
Master Chemical Corp., Austell, GA	1
Master Chemical Corp., Kansas City, MO	1
Master Chemical Corp., Perrysburg, OH	1
Master Chemical Corp., Spring, TX	1
Mate Punch & Die Co., Anoka, MN	2
Maul Brothers Inc., Winchester, IN	1
McCorkle Machine Shop, Huntington, WV	2
McCrosky Tool Corp., Meadville, PA	2
McDonald, A.Y., Manufacturing, Dubuque, IA	2
McDonnell Douglas Corp., Grand Rapids, MI	2
McDonnell Douglas Corp., St. Louis, MO	4
McEvoy Oilfield Equipment Co., Houston, TX	1
McGraw-Edison Co., Cannonsburg, PA	2
M'Dionics Inc., Chicago, IL	1
Mechanical Mfg. Inc., Farmington, MI	4

<u>Company</u>	<u>No. of Attendees</u>
Megadiamond Industries, New York, NY	9
Mercury Marine, Fond Du Lac, WI	1
Merkle Korff Gear Co., Franklin Park, IL	1
Mesta Machine Co., Pittsburgh, PA	1
Metalmasters, Inc. Lafayette, IN	1
Midland-Ross Corp., Owosso, MI	1
Mississippi State University, Mississippi State, MS	1
Missouri-Columbia, University of, Columbia, MO	1
Modernair Corp., Waterloo, IN	1
Monsanto Research Corp., Miamisburg, OH	2
Moog Automotive Inc., St. Louis, MO	5
Moog, Inc., Buffalo, NY	1
Moog, Inc., East Aurora, NY	1
Mosler Safe, Hamilton, OH	2
Motch & Merryweather Machinery Co., Cleveland, OH	1
Motor Machine Co., Inc., Edison, NJ	2
Mouck Machine Shop, Sandy Lake, PA	1
Murray Machinery, Inc., Wausau, WI	1
Muskegon Piston Ring Co., Muskegon, MI	1
Muskegon Piston Ring Co., Schofield, WI	3
NASA-Lewis Research Center, Cleveland, OH	1
NIBCO, Inc., Blytheville, AR	3
NIBCO, Inc., Elkhart, IN	4
NKR Precision Mfg. Co. Inc., Harriman, NY	1
NRM Corp., Columbiana, OH	2
Namco Controls, Jefferson, OH	3
National Acme, Cleveland, OH	3
National Bureau of Standards, Washington, DC	1
National Castings, Sharon, PA	1
National Radio Astronomy Observatory, Green Bank, WV	2
National Supply Co., Div.-Armco Steel Corp., Houston, TX	1
*Naval Avionics Facility, Indianapolis, IN	13
*Naval Research Laboratory, Washington, DC	2
New England Carbide Tool Co., Peabody, MA	1
New York Blower Co., LaPorte, IN	1
*Newark Air Force Station, Newark, OH	2
Newcomer Products, Inc., Latrobe, PA	2
Niagara Machine & Tool Works, Buffalo, NY	2
Nibco of Texas, Nacogdoches, TX	5
Nibco-Dayton, Dayton, OH	1
Nichols, W.H., Co., Waltham, MA	1
Niles Precision Co., Niles, MI	2
Noonan Machine Co., Inc. (Stanley H. Holmes Co.), Franklin Park, IL	2

*Department of Defense

<u>Company</u>	<u>No. of Attendees</u>
Nooter Corp., St. Louis, MO	2
Nordson Corp., Amherst, OH	2
Norris Industries, Los Angeles, CA	1
North American Clutch Corp., Milwaukee, WI	1
North American Products Co., Jasper, IN	1
North American Products Co., Lebanon, PA	1
North Carolina State University, Raleigh, NC	1
Northern Kentucky Vocational Technical School, Covington, KY	2
Northrop Corp., Hawthorne, CA	1
Northrop Corp., Norwood, MA	1
Norton Co., Worcester, MA	3
ORTEC, Inc., Oak Ridge, TN	1
Ohaus Scale Corp., Florham Park, NJ	1
Ohio Brass Co. (The), Barberton, OH	2
Ohio Brass Co. (The), Mansfield, OH	3
Ohio Nuclear Co., Solon, OH	5
Olin Corp., New Haven, CT	10
Olofsson Corp., Lansing, MI	3
Omark Industries, Milwaukie, OR	1
Omark Industries (KMS Div.), Moorestown, NJ	1
Otis Engineering Corp., Dallas, TX	1
Owingsville Industries, Owingsville, KY	1
Package Machinery Co., East Longmeadow, MA	2
Parker-Hannifin Corp., Clyde, NY	1
Parker-Hannifin Corp., Elyria, OH	1
Parker-Hannifin Corp., Grantsburg, WI	1
Parker-Hannifin Corp., Metamora, OH	2
Perfecto Tool & Engineering Co., Inc., Anderson, IN	1
Philadelphia Gear Corp., King of Prussia, PA	1
*Philadelphia Naval Shipyard, Philadelphia, PA	2
*Picatinny Arsenal, Dover, NJ	1
Pine Plating Co. Inc., Pine Island, MN	1
Pitney Bowes, Stamford, CT	4
Plymouth Foundry, Inc., Plymouth, IN	1
Porcelain Steel Bldgs. Co., Columbus, OH	1
Portage Machine Co., Akron, OH	2
Porter, H.K., Inc., Somerville, MA	1
Porter Precision Products Co., Cincinnati, OH	2
Pratt & Whitney Aircraft, East Hartford, CT	1
Pratt & Whitney Aircraft, West Palm Beach, FL	1
Pratt & Whitney Machine Tool Div.-Colt Inds., West Hartford, CT	1
Precision, Inc., Baton Rouge, LA	1
Preston Engravers, Inc., Windsor, CT	1

*Department of Defense

<u>Company</u>	<u>No. of Attendees</u>
Prince Corp., Holland, MI	1
Procter & Gamble, Cincinnati, OH	5
Pyromet Industries, Inc., Muncie, IN	1
Pyronics Inc., Cleveland, OH	1
R. B. Machine Shop Inc., Avenel, NJ	1
RCA Components, El Paso, TX	3
Ransburg Corp., Indianapolis, IN	2
Reamco Inc., Lafayette, LA	2
*Red River Army Depot, Texarkana, TX	1
Reece Corp. (The), Waltham, MA	4
RegO Co., Chicago, IL	2
Reliance Electric Co., (Dodge Mfg. Div.), Mishawaka, IN	2
Remington Arms Co., Inc., Ilion, NY	4
Remmele Engineering Inc., St. Paul, MN	4
Republic Steel Corp., Canton, OH	1
Republic Steel Corp. (Research Center), Independence, OH	1
Republic Steel Corp., Youngstown, OH	2
Resistance Welder Corp., Bay City, MI	1
Resistoflex Corp., Roseland, NJ	2
Reuland Electric Co., City of Industry, CA	4
Rexnord Inc., Downers Grove, IL	1
Rexnord Inc., Milwaukee, WI	3
Reynolds Metals Co., Bauxite, AR	2
Reynolds Metals Co., Corpus Christi, TX	1
Reynolds Metals Co., Richmond, VA	1
Reynolds, R. J., Tobacco Co., Winston-Salem, NC	5
Richards Industries, Inc., Cincinnati, OH	2
Richards, J. A., Co., Kalamazoo, MI	1
Robbins & Myers, Inc., Springfield, OH	2
*Rock Island Arsenal, Rock Island, IL	1
Rock Valley College, Rockford, IL	1
Rockland Manufacturing, Bedford, PA	1
Rockwell International, Allegan, MI	1
Rockwell International, Anaheim, CA	1
Rockwell International, Ashtabula, OH	8
Rockwell International, East Moline, IL	1
Rockwell International, Fairfield, CT	1
Rockwell International, Kenton, OH	4
Rockwell International, Los Angeles, CA	1
Rockwell International, New Castle, PA	15
Rockwell International, Newark, OH	12
Rockwell International, Pittsburgh, PA	2
Rockwell International, Raleigh, NC	1
Rockwell International, Troy, MI	3

*Department of Defense

<u>Company</u>	<u>No. of Attendees</u>
Rockwell International, Tupelo, MS	2
Rockwell International, Winchester, KY	7
Rollway Bearing Co., Syracuse, NY	1
Rosemount Inc., Eden Prairie, MN	1
Royer Foundry & Machine Co., Kingston, PA	3
Rucker/Atlas Bradford, Houston, TX	2
SKIL Corp., Chicago, IL	4
SKIL Corp., Skokie, IL	2
Saginaw Machine & Tool Co., Saginaw, MI	1
Sandia Laboratories, Albuquerque, NM	3
Sandy Hill Corp., Hudson Falls, NY	2
Sargent Industries, Odessa, TX	1
Schrader Automotive Products, Dickson, TN	1
Schwaner Tool Co., Inc., Amityville, NY	1
Schwitzer Engineered Components, Indianapolis, IN	30
Scot Industries Inc., Milwaukee, WI	1
Sea-Tac Industries, Inc., Seattle, WA	1
Sealed Power Corp., Rochester, IN	4
Senco Products, Inc., Cincinnati, OH	6
Setco Industries, Inc., Cincinnati, OH	3
Signode Corp., Florence, KY	5
Simplatrol Products-Formsprag Co., Webster, MA	1
Singer Co. (Link Div.), Binghamton, NY	1
Ski Way Machine Products Co., Euclid, OH	1
Smith, A. O., Corp., Erie, PA	2
Smith, A. O., Harvestore Products, Inc., Elkhorn, WI	2
Smith Meter Systems, Erie, PA	2
Smith Tool Co., Irvine, CA	2
Snyder Corp., Detroit, MI	3
South Bend Controls, South Bend, IN	2
Southwest Research Institute, San Antonio, TX	2
Spaulding Fibre Co., Inc., Gonic, NH	1
Sperry Flight Systems, Phoenix, AZ	1
Sperry-New Holland, Lexington, NB	1
Sperry Vickers, Omaha, NB	1
Sperry Vickers, Salem, OH	1
Sprout-Waldron-Koppers, Muncy, PA	1
Square D Co., Oxford, OH	1
Stallman Gear, Columbus, OH	1
Stamets, Wm. K., Co., Columbiana, OH	1
Standard Automotive Parts, Muskegon, MI	1
Standard Oil Co., Louisville, KY	1
Standard Steel, Burnham, PA	2
Stanford Linear Accelerator Center, Stanford, CA	1
Star Dental Manufacturing Co., Inc., Conshohocken, PA	1
Stark, Charles, Draper Labs., Cambridge, MA	3
Stark Industrial Inc., Canton, OH	1

<u>Company</u>	<u>No. of Attendees</u>
Stark Technical College, Canton, OH	1
Stedman Foundry & Machine Co., Inc., Aurora, IN	2
Steiger Tractor, Inc., Fargo, ND	1
Stewart Industries, Inc., Cincinnati, OH	3
Stewart Warner, Indianapolis, IN	1
Stinson Mfg. Co., San Antonio, TX	1
Stora Kopparberg Corp., Darien, CT	1
Storm-Vulcan, Inc., Dallas, TX	2
Sun Coolant Control, Inc., Philadelphia, PA	2
Sun Petroleum Products Co., Philadelphia, PA	1
Sundstrand Corp. (Hydro-Transmissions Div.), Ames, IA	2
Sundstrand Corp. (Aviation Div.), Rockford, IL	3
Super-Cut, Inc., Chicago, IL	6
Superior Die Set Corp., Oak Creek, WI	2
Superior Tube Co., Norristown, PA	1
Sutton Engineering Co., Bellefonte, PA	1
T.C. Industries Inc., Crystal Lake, IL	1
T.D.M. Corp., Fletcher, NC	1
T.K. International, Inc., Tulsa, OK	1
TRW Inc., Cleveland, OH	3
TRW Inc., Dayton, OH	7
TRW Inc., Redondo Beach, CA	1
TRW Mission Mfg. Co., Houston, TX	3
TRW Reda Pump Co., Bartlesville, OK	2
TRW-Wendt Sonis, Rogers, AR	3
Tate Model & Engineering Inc., Kokomo, IN	1
Taylor Forge Div.-Gulf + Western, Cicero, IL	2
Taylor Instrument Co., Arden, NC	1
Tek-O-Motive, Inc., La Moille, IL	2
Teledyne CAE, Toledo, OH	4
Teledyne Continental Motors, Mobile, AL	2
Teledyne Landis Machine Co., Waynesboro, PA	2
Teledyne Neosho, Neosho, MO	1
Teledyne Precision-Cincinnati, Cincinnati, OH	2
Texas A & M University, College Station, TX	1
Therm Inc., Ithaca, NY	1
Thermo Electron, Woburn, MA	2
Thiry Machine Co., Inc., Detroit, MI	1
3M Company, Cynthiana, KY	1
Thrush Products, Inc., Peru, IN	4
Timex Corp., Little Rock, AR	1
Tomkins-Johnson Co., Jackson, MI	4
Tompkins-Cortland Community College, Dryden, NY	1
Tool Crib, Inc. (The), Knoxville, TN	4
Townsend Co., Plymouth, MI	2
Trade Tool Corp., Youngstown, OH	1
Transtech, Sylvania, OH	1

<u>Company</u>	<u>No. of Attendees</u>
Troyke Manufacturing Co., Cincinnati, OH	2
Tweco Products, Inc., Wichita, KS	2
Tyson Bearing Co., Glasgow, KY	2
Tyson Bearing Co., Massillon, OH	2
*U.S. Army Tank Automotive Command, Warren, MI	4
U.S. Department of Commerce, Washington, DC	1
U.S. Steel Corp., Garland, TX	1
*USAF, Wright-Patterson AFB, OH	3
Union Carbide Corp., Chicago, IL	1
Union Carbide Corp., Oak Ridge, TN	8
Union Chain Co., Sandusky, OH	2
Union Pump Co., Battle Creek, MI	9
United Nuclear Corp., Uncasville, CT	2
Upson Machine Products Inc., Painesville, OH	6
VRC Corp., Olmsted Falls, OH	1
Valeron Corp., Battle Creek, MI	8
Valeron Corp., Cincinnati, OH	1
Van Wood Mfg. Co. Inc., Cherry Hill, NJ	1
Varco, International, Orange, CA	1
Ventura Industries, Inc., Detroit, MI	1
Vibrac Corp., Chelmsford, MA	1
Vogt, Henry, Machine Co., Louisville, KY	1
Vought Corp., Sterling Heights, MI	1
Vulcan Mfg. Co., Cincinnati, OH	1
WABCO (Union Switch & Signal Div.), Pittsburgh, PA	2
Wade & Sons Inc., Independence, MO	2
Wallace & Tiernan, Belleville, NJ	1
Walworth Co., Greensburg, PA	1
Ward Machinery Co., Cockeysville, MD	1
Warnecke Electron Tubes Inc., Des Plaines, IL	2
Warner Electric Brake & Clutch Co., South Beloit, IL	4
Warner Gear Div., Muncie, IN	2
Warner & Swasey Co., Cleveland, OH	7
Warner & Swasey Co., Worcester, MA	1
Washington Mould, Machine & Foundry Co., Washington, PA	5
Waupaca Foundry Inc., Waupaca, WI	1
Wayne Novelty Inc., Decatur, IN	1
Weatherhead Co., Antwerp, OH	4
Weatherhead Co., Syracuse, IN	1
Weaver, W. R., Co., El Paso, TX	2
Webster Manufacturing Co., Tiffin, OH	3
Wedler Brothers, Inc., Cleveland, OH	1

*Department of Defense

<u>Company</u>	<u>No. of Attendees</u>
West Milton Precision Machining & Tool, Inc., Vandalia, OH	2
Western Gear Corp., Lynwood, CA	1
Western Gear Corp., Jamestown, ND	5
Westhoff Tool & Die Co., Inc., St. Louis, MO	5
Westinghouse Electric Corp., Baltimore, MD	1
Westinghouse Electric Corp., Charlotte, NC	2
Westinghouse Electric Corp., Cheswick, PA	1
Westinghouse Electric Corp., Hunt Valley, MD	1
Westinghouse Electric Corp., Madison, PA	1
Westinghouse Electric Corp., Orville, OH	1
Westinghouse Electric Corp., Sunnyvale, CA	13
Wheelabrator-Frye, Inc., Mishawaka, IN	1
Wilton Corp., Schiller Park, IL	1
Windsor Mfg. Co. (The), Windsor, CT	2
Woolley Tool & Manufacturing, Odessa, TX	1
Worcester Controls Corp., Worcester, MA	1
Worthington Compressors Inc., Buffalo, NY	1
Worthington Marine & Industry Products, Harrison, NJ	1
Worthington Pump Corp., Harrison, NJ	3
Wyman-Gordon Co., Harvey, IL	3
Wyman-Gordon Co., Worcester, MA	3
Wysong & Miles Co., Greensboro, NC	2
Xerox Corp., Webster, NY	2
Xtek, Inc., Cincinnati, OH	23
York Industries Inc., Emigsville, PA	1
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TOTAL NO. OF COMPANIES 768	TOTAL ATTENDEES 1,695

TABLE 13-B.
 ORGANIZATIONS REPRESENTED BY
 4 OR MORE ATTENDEES AT MDC'S SEMINARS ON
 "PRACTICAL MACHINING PRINCIPLES FOR SHOP APPLICATION"
 (Spring 1974 - Fall 1977)

<u>Company</u>	<u>No. of Attendees</u>	<u>Company</u>	<u>No. of Attendees</u>
ARO, Inc.	17	FMC Corp.	5
A-T-O Inc.	4	Federal Mogul Corp.	6
Aeroquip Corp.	9	Fisher Controls Co.	11
AiResearch Mfg. Co.	4		
Allis-Chalmers Corp.	34	General Dynamics	8
Andrew Corp.	4	General Electric Co.	24
		General Motors Corp.	25
Babcock & Wilcox	43	Goodyear Aerospace Corp.	6
Barnes Co., W.F. & John	5	Gould Inc.	5
Bell Helicopter Co.	4	Gray, G.A., Co.	13
Beloit Corp.	4	Grumman Aerospace Corp.	14
Bendix Corp.	4		
Boeing Co.	5	Hitachi, Ltd.	7
Budd Co. (The)	4	Hobart Corp.	6
Carlyle Compressor Co.	4	IBM Corp.	9
Carpenter Technology Corp.	4	Ingersoll-Rand Co.	13
Chamberlain Mfg. Corp.	14	International Harvester Co.	23
Chemetron Corp.	6	International Nickel Co.	4
Chrysler Corp.	9		
Cincinnati Inc.	5	Jeffrey Mfg. Co.	5
Cincinnati Milacron Inc.	5	Joy Manufacturing Co.	12
Clark Equipment Co.	5		
Clow Corp.	4	Koehring Co.	6
Contraves-Goerz Corp.	8		
Cross Corp.	6	LaBour Pump Co.	4
Cummins Engine Co.	13	Lawrence Livermore Labs	9
Cutler-Hammer, Inc.	5	Lockheed	6
Dana Corp.	7	Martin Marietta Corp.	5
Dearborn, Howard, Inc.	13	Master Chemical Corp.	4
Deere & Co.	10	McDonnell Douglas Corp.	6
Deere, John	5	Mechanical Mfg. Inc.	4
Defense Contract Admin. Serv. Management Area	5	Megadiamond Industries	9
Delaval Turbine Inc.	7	Moog, Inc.	7
Diamond Chain Co.	5	Muskegon Piston Ring Co.	4
Dover Corp.	6		
Dresser Industries	8	NIBCO, Inc.	7
Duff-Norton	5	Naval Avionics Facility	13
Eaton Corp.	18	Ohio Brass Co.	5
Electric Machinery Mfg. Co.	6	Ohio Nuclear Co.	5
Elliott Corp.	7	Olin Corp.	10

Organizations Represented by 4 or More Attendees (Spring 1974 - Fall 1977)

(continued)

<u>Company</u>	<u>No. of Attendees</u>
Parker-Hannifin Corp.	5
Pitney Bowes	4
Procter & Gamble	5
Reece Corp.	4
Republic Steel Corp.	4
Reuland Electric Co.	4
Rexnord Inc.	4
Reynolds Metals Co.	4
Reynolds, R.J., Tobacco Co.	5
Rockwell International	59
SKIL Corp.	6
Schwitzer Engineered Components	30
Sealed Power Corp.	4
Senco Products, Inc.	6
Signode Corp.	5
Smith, A.O.	4
Sperry Vickers	4
Sundstrand Corp.	5
Super-Cut, Inc.	6
TRW	19
Teledyne	11
Thrush Products, Inc.	4
Tomkins-Johnson Co.	4
Tool Crib, Inc. (The)	4
Tyson Bearing Co.	4
U.S. Army Tank Automotive Command	4
Union Carbide Corp.	9
Union Pump Co.	9
Upton Machine Products Inc.	6
Valeron Corp.	9
Warner Electric Brake & Clutch Co.	4
Warner & Swasey Co.	8
Washington Mould, Machine & Foundry Co.	5
Weatherhead Co.	5
Western Gear Corp.	6
Westhoff Tool & Die Co.	5
Westinghouse Electric Corp.	20
Wyman-Gordon Co.	6
Xtek, Inc.	23

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Thermophysical and Electronic Properties
Information Analysis Center
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Purdue University
2595 Yeager Road
West Lafayette, Indiana 47906

Plastics Technical Evaluation Center
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Picatinny Arsenal
Dover, New Jersey 07801

Chemical Propulsion Information Agency
Attn: Dr. P. L. Nichols, Group Supv.
The John Hopkins University
Applied Physics Laboratory
John Hopkins Road
Laurel, Maryland 20810

Nondestructive Testing
Information Analysis Center
Attn: R. T. Smith, Director
Southwest Research Institute
8500 Culebra Road
P. O. Drawer 28510
San Antonio, Texas 78284

Concrete Technology Information
Analysis Center
Attn: Bryant Mather
U. S. Army Engineers Waterways Exp. Sta.
P. O. Box 631
Vicksburg, Mississippi 39180

Defense Nuclear Agency Information
Analysis Center
Attn: Warren Chan
General Electric - TEMPO
816 State Street, P. O. Drawer QQ
Santa Barbara, California 93102

Reliability Analysis Center
Attn: Harold Lauffenberger
Rome Air Development Center
RBRAC
Griffiss AFB, New York 13440

Aerospace Structures Information
Analysis Center
Attn: G. Maddux, AFFDL/FBR
Wright-Patterson AFB, Ohio 45433

Infrared Information & Analysis Center
Attn: Dr. G. J. Zissis
Environmental Research Institute
of Michigan
P. O. Box 618
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WATERLOO, MASSACHUSETTS 02172
THIRTEENTH ANNUAL REPORT OF THE MACHINABILITY
DATA CENTER - John F. Kahles, John L. Krebs
Metcon Research Associates Inc.
Cincinnati, Ohio 45209
Technical Report AMMC TR 78-13, March 1978,
52 pp. - tables, Contract D54900-77-C-3197
Annual Report, 1 January 77 - 31 December 77

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UNCLASSIFIED
UNLIMITED DISTRIBUTION
KEY WORDS
Technical Information Center
Machining - Information Retrieval
Costs - Operation
Reviews - Data Processing Systems

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