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The Argonne Code Center: A Decade of Computer Program Exchange\*

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I. INTRODUCTION AND HISTORICAL BACKGROUND

In October of 1955, A. Radkowsky and R. Brodsky published the first report of AEC-funded computer programming efforts. Their compilation, entitled "A Bibliography of Available Digital Computer Codes for Nuclear Reactor Problems" [1], contained information obtained from a survey of AEC installations. Each installation was asked to complete a standard form describing the programs which had been developed and the problem each was designed to solve. Over one hundred programs were included written for machines such as the AVIDAC; IBM CPC, 650, 701, and 702; and NAREC; NORC; SEAC; and UNIVAC.

At the second annual meeting of the American Nuclear Society in 1956 an informal organization known as the Nuclear Codes Group was formed. This group, composed of "persons interested in the development and use of computer codes for reactor design", held regular meetings in conjunction with the semiannual ANS meetings for the purpose of discussing current programming efforts. A periodic Newsletter [2] was published containing program abstracts submitted by group members. In 1959 the group became the Mathematics and Computation Division of the Society. One of the first acts of the Mathematics and Computation Division was to propose the establishment of a formal center for the collection and transfer of information on computer programs of interest to its membership. With the approval of the U.S. Atomic Energy Commission, Argonne National Laboratory accepted this responsibility and the Argonne Code Center was born.

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Initially the Center operated as an adjunct to the Laboratory's Applied Mathematics Division Applications Programming library. Attention was focussed on two categories of material--an abstract describing the computer program, its area of applicability and its availability, and a "program package" containing the material required to effectively transfer the program to another installation or computer for use. The submission of material to the Center was the responsibility of the author, usually an M&C Division member, who either transmitted it directly or through his installation's designated representative. The Center wrote or edited the program abstract and prepared and printed these for distribution [3] by the ANS office. In addition, the Center collected and reviewed the program package material, which was then dispatched to the appropriate computer manufacturer's representative, whose organization was responsible for maintaining and distributing the material upon request from the Code Center. The designated Cooperating Installation representatives at AEC laboratories, universities, and contractor organizations served as an information network. They relayed information to the Center concerning programs or requests originating within their installations and apprised their colleagues of the Center's program collection and operating procedures.

In September of 1962 a presentation on the operation of the Center was included in an ENEA-Argonne Seminar on "New Trends in the Use of Digital Computers in Atomic Energy Research and Development" held at Argonne [4]. As a result, the European Nuclear Energy Agency made plans to form a European counterpart of the Argonne Center, and this was established in May of 1964 at the Euratom Research Center in Ispra, Italy. Since that time the ENEA Computer Programme Library and the Argonne Code Center have, by international agreement, maintained each other's collection and handled code distribution in their respective geographic areas. In addition, since 1967 the IAEA has sponsored a staff member at the Ispra library to handle non-ENEA IAEA queries and requests.

It was not until 1965 that the Argonne Center became a separately-budgeted operation of the Reactor Physics Branch of the USAEC Division of Reactor Development and Technology, which is responsible for support of its current program.

## II. ACTIVITIES AND SERVICES

For descriptive purposes the Code Center's program may be treated as three parts. The first, *information services*, includes the preparation and publication of the computer program abstracts, the answering of technical inquiries, the reproduction and dissemination of the program documentation and other program package materials, and the compilation of bibliographies. The second, *computer activities*, encompasses the review and assimilation of programs into the computerized library, the maintenance and testing of the collection, and automation of the Center's service functions. The third part consists of *cooperative efforts* intended to cover those activities of joint interest undertaken with the Cooperating Installations, the Mathematics and Computation Division of the American Nuclear Society, and the ENEA Computer Programme Library.

### A. Information Services

Basic to this portion of our program is the preparation, editing, and publishing of the *program abstract* for each program resident in the

library collection. The purpose of the abstract is twofold. It serves initially to announce the acquisition of a program and later, as a reference to describe the program, the problems it is intended to solve, the machine versions available and the material obtainable from the Center on the program.

The abstract format has evolved from the original form used in AECU-3078 on the basis of our experience at the Center and cooperative efforts with program authors, installation representatives, ENEA library personnel, and the ANS-10 Standards subcommittee members. It currently contains seventeen items, as follows:

<u>Program Abstract Number (Accession Number)</u>	<u>Date</u>
1. Name or Designation of Program	
2. Computer for which Program is Designed	
3. Nature of Physical Problem Solved	
4. Method of Solution	
5. Restrictions on the Complexity of the Problem	
6. Typical Running Time	
7. Unusual Features of the Program	
8. Related and Auxiliary Programs	
9. Status	
10. References	
11. Machine Requirements	
12. Programming Language(s) Used	
13. Operating System or Monitor under which Program is Executed	
14. Other Programming or Operating Information or Restrictions	
15. Name and Establishment of Author(s)	
16. Material Available (including transmittal requirements)	
17. Classification Category and Keywords	

Each author is asked to supply an abstract conforming to this standard format at the time he submits his program. If no abstract is received, the Center prepares one. In either case Center personnel assure that an abstract in the prescribed format, and as complete as possible, is prepared for each program prior to its inclusion in the collection. A copy of the proposed abstract is sent to both the author and his installation representative for review and approval prior to publication.

Up to mid-1967 abstracts of over 265 programs had been prepared and published in Argonne Code Center abstract distributions [3]. At that time a complete review and revision of the Center library was undertaken. Obsolete programs and those written for machines of the IBM 704 era and earlier were deleted. In January 1968 program abstracts for the Center collection were published for the first time as an Argonne National Laboratory report. This document, ANL-7411, was made available both in standard report form and in a specially-prepared looseleaf binder. The American Nuclear Society distributed copies to the members of its Reactor Physics and Mathematics and Computation Divisions upon request. Installation representatives received the looseleaf copies. A total of over 2500 copies was printed. Since that time two supplements have appeared, the first in October 1968, and the second in April of 1969. A third supplement went to press in November of 1969 covering Code Center programs through accession number 384. Many of these programs are available in two or three machine versions; one is packaged for five different machines.

A large fraction of Center effort is devoted to our second major information resource, the *program package*. Here, two distinct functions are involved--the preparation, modification, assimilation, and maintenance of the master program package, and the reproduction and distribution of copies of this master, or selected portions thereof, upon request. The first function is best described as a computer activity, the second fits into the information services category. The program package consists basically of two components: the computer-media, on cards or tape, and the traditional printed material or documentation. A list of recommended program package contents includes:

<u>Card and/or Tape Material</u>	<u>Documentation</u>
Source deck	Program report
Run deck	User's manual, i.e. information on input quantities, operating instructions and a description of the available output
Sample problem	Programmer's manual, e.g. allocation and use of memory and peripheral devices, program structure
Data libraries	Installation environment report
Auxiliary routines	
Environmental routines	

Each author is asked to supply 10 to 20 copies of the printed material portion of the program package. In practice, however, we frequently receive a single master copy from which multilith plates are prepared and distribution copies run by the Laboratory's Graphic Arts Department. This activity is scheduled routinely to ensure available documentation for each library program when it is requested.

When a request for a library program is received at the Center it is checked to see that the package has not previously been sent to that installation and that any necessary release forms have been completed and magnetic tapes required for the transmittal have been received. Next, the requestor's tapes are labelled and dispatched together with the appropriate Center master tapes and the necessary Computer Center operations forms to the appropriate computer scheduling area. The documentation portion of the requested package is assembled and when the machine processing is completed the output listing is checked to verify the job. Then tapes and documentation are dispatched with a standard letter of transmittal, at which time Center records are updated to show this transmittal. Average time from receipt of a request for a library program to dispatch of the program package material is about one week, varying, of course, with the amount of activity in the Code Center and the Computer Center and the number of programs included in the request. With additional personnel in the Code Center this could easily be reduced to about 48 hours. A histogram of program package distribution statistics is shown in Fig. 1.

It is essential to point out that these figures do not include distribution of Argonne Code Center programs made by the ENEA Computer Programs Library. Of interest also is the number of copies of library programs requested. Table I gives an indication of the "usefulness coefficient" of programs in the library collection. It should be noted that statistics are included for the 21 programs first announced in Supplement 2 which ANS did not distribute until July.

Answering mail and telephone inquiries occupies a fraction of the time of all Center personnel. While no attempt has been made to record statistics on this activity, the estimated daily average of telephone inquiries to the Center is 10 to 15 and the postman rings almost that frequently. Communications run the gamut from questions concerning information on Center procedures and activities, requests for programs or the abstract compilation, to inquiries on the appropriate program for the solution of a particular problem, on the availability of specific programs, and on problems of computer implementation and hardware and software system characteristics. Last year, in addition, we were surveyed almost weekly by persons engaged in tabulating the nation's information resources or computerized data collections.

Several attempts have been made to reduce the need for these special inquiries. The first was the inclusion in the abstract reports [5,6,7,8] of a section in which brief summaries of the programs appear classified according to the physical problem they were written to solve. The classification categories and the number of programs in each are indicated in Table II. The abstract compilations also include a KWIC index section designed to permit rapid selection of programs written at a given installation, in a particular compiler language, or packaged for a specific machine, as well as subject-index facilities. Publication of bibliographies of computer programs in the Center's nuclear physics, reactor design, operation, and engineering areas has been scheduled, as well. To keep abreast of computer code development a continuing literature search goes on. Card files of bibliographic information on relevant computer programs are maintained, classified both by program name and by "problem solved" category. These files are frequently consulted in answering individual inquiries. The material in these files will be published as KWIC bibliographies for distribution primarily to our Cooperating Installation Representatives. Initial bibliographies have been compiled covering references pertinent to the Center Collection and publications dated 1967 forward. Additional bibliographies will be issued on an annual basis.

#### B. Computer Activities

Computer activities are defined to include computer program acquisition --review, testing, and assimilation into the library, and maintenance of the library collection. The collection is composed of programs offered to the Center by authors or installation representatives, programs submitted in compliance with AEC contract provisions, and those solicited by the Center for inclusion because of outstanding requests or anticipated demands.

When received at the Center, the program package is logged in, reviewed, and checked for completeness. An attempt is made to see that all subprograms called for are available in either source or object form. Documentation is scanned for adequacy and, if found lacking, additional material is requested, or written, and added. Whenever possible the sample problem is executed at the Code Center to ensure its reproducibility. If installation routines or environment reports are necessary this is noted. The card or tape material is put into the Center library master format for later distribution to requestors and the package contents are defined for inclusion in the program abstract.

If the program submitted is a new version or a modification of an existing library program rather than a new program, the abstract for the program is amended accordingly. When a modification or replacement of a library program is received, an Argonne Code Center Note is written describing the situation and sent to all recipients of the original program. This notification is possible because the Center maintains for each program a list of all requestors and installations to whom copies of that program have been sent. In addition, the Installation Representative is advised of each transmittal to his installation. Such records permit us to keep all users of library programs up-to-date on the collection and to make effective use of our budget by minimizing duplicate distributions to the cooperating installations. Argonne Code Center Notes also inform recipients when errors are corrected or additional reference material is received. If someone other than the author or author's installation originates this information, it is verified with the author prior to publication and the necessary changes are made in the master library copy to ensure that future recipients get the best available information. To date 55 such notes have been issued.

Nine installations contributed 300 of the 459 program packages, or about two-thirds of the library collection, as of the end of the last fiscal year. These are Gulf General Atomic; Atomics International; the Argonne and Oak Ridge National Laboratories; the Bettis and Knolls Atomic Power Laboratories; the Los Alamos Scientific Laboratory; the Control Data Corporation; and General Electric's Advanced Products Operation. In contrast, the over 4000 packages distributed were sent to more than 400 different installations including government contractors and laboratories, universities, computer manufacturers and service bureaus, consulting firms, and interested individuals. Table III shows the program package additions to the library.

Since assimilation of the computer-media portion of the program package into the Center library and the maintenance of this tape library absorbs a significant fraction of the available effort, plans were made to automate these processes along with the Center's statistical and record-keeping functions by use of the Argonne IBM 360/50-75 ASP System. Preliminary specifications were laid out for ACCESS, the Argonne Code Center Exchange and Service System, in November of 1967. Due to funding limitations, implementation of the system has been delayed, although some initial work in collaboration with the ENEA Computer Program Library was undertaken. The system is designed to provide storage, retrieval, modification, and display of Code Center information. This information is contained in six interrelated but dissimilar data bases utilized in the Center's operation:

- (1) requests to the Center for computer programs;
- (2) a listing of the existing program packages and their contents;
- (3) the collection of program abstracts;
- (4) the library program packages;
- (5) Center statistics on program package acquisition and transmittal;
- (6) cooperating installation information on computer facilities, representative's name and address, and institution's SDI profile.

This past year the establishment of three data bases was begun. These are numbers (2), (3), and (4) above, designated respectively as the table of contents file (TOC), the abstract file (ABS), and the package file (PKG). The table of contents file and the abstract file reside on the IBM 2314 disk storage facility; the package file is being set up on the IBM 2321 data cell. Programs have been specified and working versions written in the PL/I language to create, update, and maintain the abstract file and to prepare the abstract compilation supplements for publication. These versions are, however, restricted to card input and printer output. Display console or keyboard input and use of the IBM 2280 Film Recorder for publication are to be added. Implementation of ACCESS specifications will ultimately provide selective dissemination of abstract or package information on an installation profile basis and query-searching capabilities for the staff's use in handling questions and requests. ACCESS will also automatically post request and transmittal activity and maintain acquisition and distribution statistics.

### C. Cooperative Efforts

Growing as it did in response to the recognized needs of a cooperative group, the Center was organized as a cooperative venture. The work of the Center, while centralized at Argonne, is carried out with the assistance and advice of those individuals at the 127 cooperating installations who serve as their institution's Code Center representative. It is these people, along with the program authors and contributors, who make the Center a going concern. Non-routine activities undertaken with the Cooperative Installation Representatives include a survey of FORTRAN IV conversion plans for library programs and the "cooperating installation facilities report" compilation, which provides a minimum installation environment report for these participating institutions [9].

Work with the American Nuclear Society has been in two areas--standards and benchmark problems. In collaboration with the ANS-10 Standards Committee of the Mathematics and Computation Division, "A Code of Good Practices for the Documentation of Digital Computer Programs" was prepared [10]. A second standard, entitled "Recommended Programming Practices to Facilitate the Interchange of Digital Computer Programs," was developed and is awaiting approval and publication by the Society's Standards Committee. In February of 1968 the Center published, and currently maintains, a collection of benchmark problems prepared by an ANS Mathematics and Computation Division committee [11].

Since the establishment of the ENEA Computer Programme Library in Ispra, Italy, the two centers have collaborated in the development of program library procedures and automation of service functions. Some testing of library programs by ENEA staff at Argonne has been accomplished.

### III. STAFF AND BUDGET

Until fiscal 1966 the Center operated as an adjunct to the Applied Mathematics Division Applications Programming effort, consequently staff and budget figures are not available except from that time to the present; these are shown in Table IV.

During summers additional assistance has been obtained from the Laboratory's secretarial pool, and from June to August 1968 a member of the ANL Summer Student Training Program was assigned to the Center. Currently, a staff member from the National Tsing Hua University, Taiwan, is spending an eight-month period at the Center studying the use of computers to solve reactor physics problems and testing library programs.

#### IV. PROGRAM LIBRARIES AND THE FUTURE

Planning at the time of the formation of the Code Center called for use of the computer manufacturers' facilities for the storage and distribution of the program collection. Then, as now, each computer manufacturer maintained a library of programs written for his products. These libraries are organized to serve the user's groups, such as SHARE (IBM) and FOCUS (CDC); they also help to sell computers! Programs are available without charge to installations which own or rent the appropriate computer and are, thereby, members of that users group. These same members are the source of the collection. Users-group libraries have succeeded in handling the distribution of large volumes of programs effectively and economically. They have concentrated primarily in the areas of the frequently-used mathematical and statistical subroutines and general input/output and utility programs. These are often hardware-dependent. In contrast, the Center programs are large applications codes intended for use by colleagues with a different computer or even by the originating installation over more than one generation of computer. To make effective use of such programs requires a subject specialist as well as a hardware specialist.

Other program libraries currently in operation in addition to the users group variety are the installation libraries maintained at most large computer facilities; the shielding code collection at the Radiation Shielding Information Center at Oak Ridge; the NASA Manned Spacecraft Center ADP resource sharing operation for government contractors, and its private counterparts--COSMIC at the University of Georgia and the Aerospace Research Applications Center at Indiana University. A library has been proposed by Queen's University of Belfast to distribute the programs described in Computer Physics Communications, a North-Holland publication [12]. In addition, the United Kingdom maintains a National Computer Program Index at the National Computing Centre in Manchester [13] and the State of Israel recently requested our advice in the establishment of a state computer program library.

In view of this ever-increasing activity the future of such libraries and centers seems assured. After all, we are just at the threshold of the "computer age." A word of caution seems appropriate. Large-scale applications programs are an information resource; like scientific and technical papers they are the result of research and development activities. However, unlike such documents, they are not immediately useful to others working in the subject field, as are journals, reports, and other traditional library material. To be useful requires implementation on a computer system which may or may not be identical to that on which the program was created. It is essential that such program collections be maintained in a working environment, or center, encompassing both computer and subject specialists. To paraphrase the now-famous Weinberg report [14]--"the essence of a good computer program center is that it is operated by highly



competent working scientists and engineers," which rules out the "clearing-house" concept for this activity.

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**Table I. Cumulative Frequency Distribution of Number of Copies of Program Package Requested Showing Number of Library Programs Receiving Distribution Greater than Stated Number of Copies through June 1969**

<u>Number of Copies</u>	<u>Number of Programs</u>	<u>Per cent of Total</u>
3 or more	244	75.5
5 or more	196	61.9
7 or more	155	48.0
10 or more	112	34.7
15 or more	76	23.5
20 or more	48	14.9
25 or more	40	12.4
35 or more	15	4.6
45 or more	11	3.4
60 or more	5	1.5
75 or more	1	.3

Table II. Breakdown of Library Collection by  
Classification Category as of June 1969

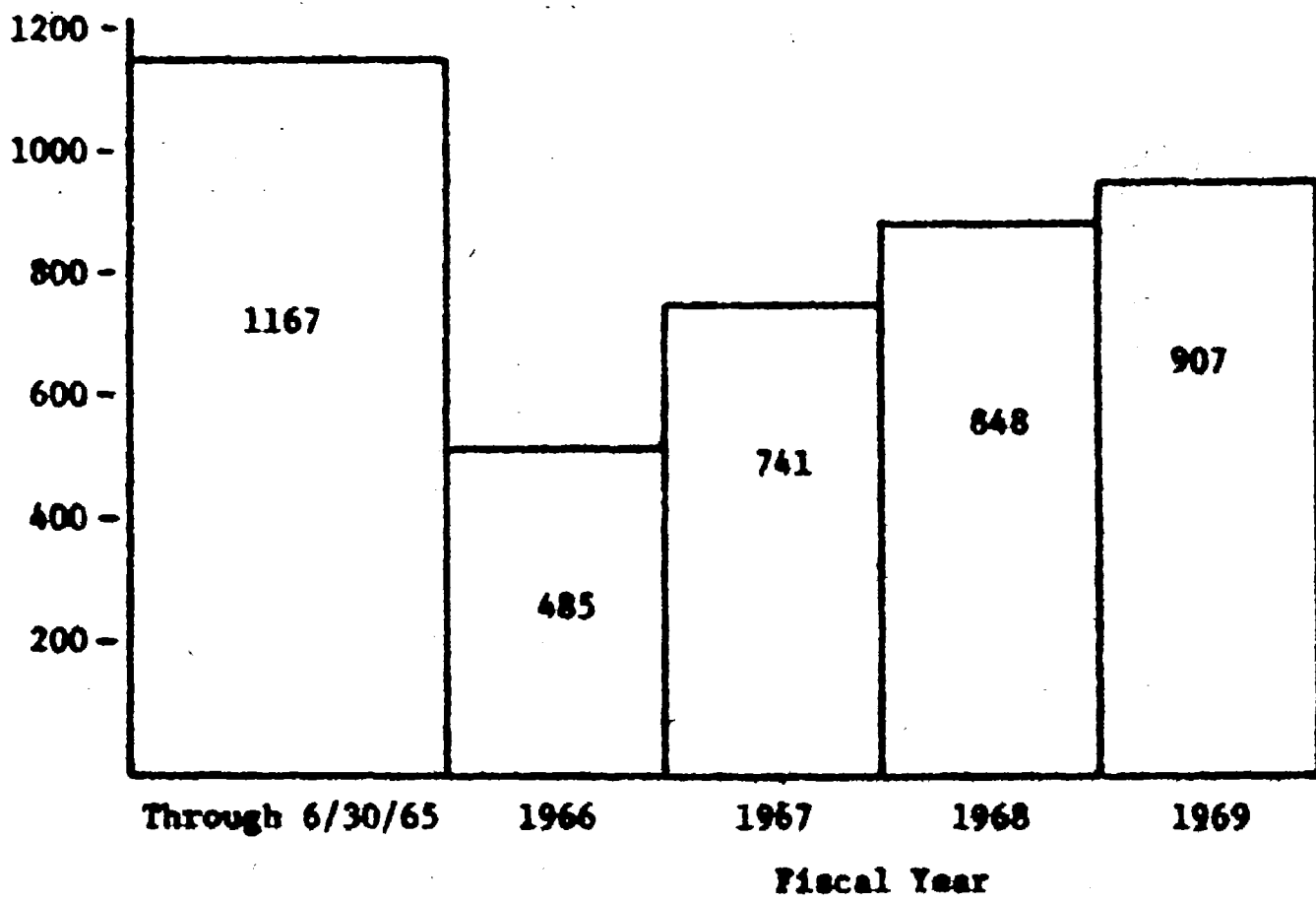
<u>Classification Category Identification and Definition</u>	<u>Number of Programs</u>
A. Cross-section and resonance-integral calculations	28
B. Spectrum calculations, generation of group constants, lattice and cell problems	38
C. Static design studies	42
D. Depletion, fuel management, cost analysis, and reactor economics	30
E. Space-independent kinetics	11
F. Space-time kinetics, coupled neutronics-hydrodynamics-thermodynamics and excursion simulations	13
G. Radiological safety, hazard and accident analysis	15
H. Steady-state and transient heat transfer	17
I. Deformation and stress distribution computations, structural analysis and engineering design studies	25
J. Gamma heating and shield design problems	12
K. Total systems analysis	1
L. Data preparation	7
M. Data management	7
N. Subsidiary calculations	4
O. Experimental data processing	10
P. General mathematical and computing system routines	6
Z. Nuclear data	1
Total	267

**Table III. Number of Program Packages Contributed to the Center Yearly, 1962-1969**

<u>Fiscal Year</u>	<u>Argonne Code Center Programs</u>	<u>ENEA Computer Programme Library Programs</u>	<u>Total</u>
1962	41		41
1963	40		40
1964	48		48
1965	39	14	53
1966	87	16	103
1967	52	43	95
1968	87	34	121
1969	65	34	99
<b>Total</b>	<b>459</b>	<b>141</b>	<b>600</b>

Table IV. Argonne Code Center Budget and Personnel Yearly, 1966-1970

<u>Fiscal Year</u>	<u>Budget Allocation</u>	<u>Man-year Allocation</u>	
		<u>Scientific Staff</u>	<u>Total</u>
1966	\$48,000	.5	1.9
1967	60,000	.5	2.6
1968	72,000	.5	2.5
1969	80,000	1.5	2.5
1970	90,000	1.5	2.5



**Fig. 1. Number of Program Packages Distributed, 1962-1969**