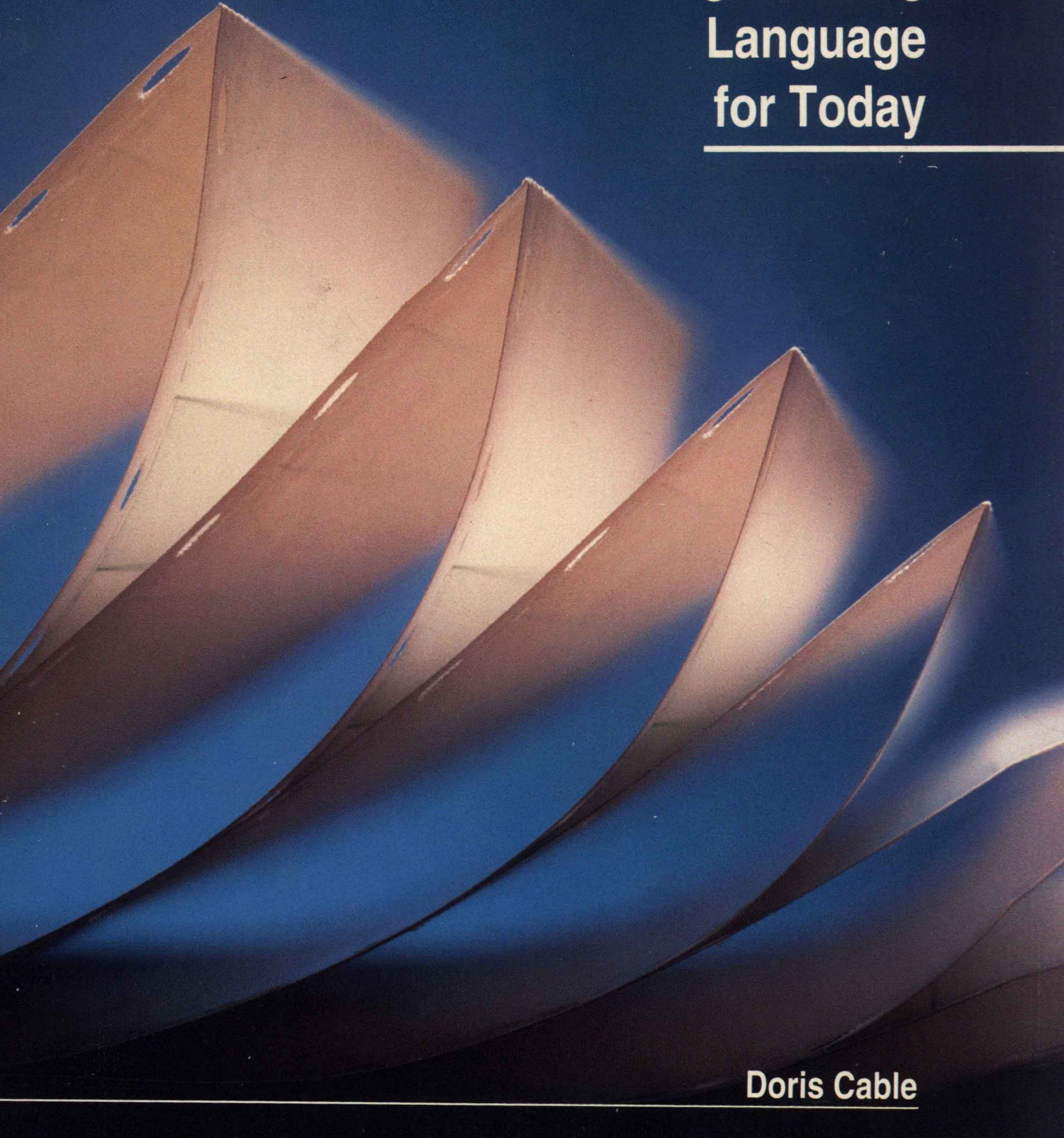
# RPG

# A Programming Language for Today



Doris Cable

# RPG

## A Programming Language for Today

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# Preface

This book is a text and learning guide for students for whom RPG will be a first introduction to programming languages. It is also a guide for the experienced programmer who wishes to add a useful tool to his or her knowledge base. The book will guide the reader through the differences between RPG II and RPG III. Finally, the book provides exercises and projects together with sample data to provide a sound basis for learning the language.

RPG II is available on a wide variety of minicomputers as well as mainframes and even personal computers. The fundamental concepts presented in this book apply equally to all forms of RPG, regardless of the hardware on which it will be run. The specific orientation will be toward RPG as it is run on IBM minicomputer hardware, but in general RPG II differs very little when used on different computer hardware.

The material on RPG III, however, is hardware-specific. RPG III, in its most complete form, is available only on the IBM System/38 and on the IBM AS/400. Some of the basic tools of RPG III, however, are available on the IBM System/36 and other hardware.

This book does not attempt to be all things to all people. It is not a general overview of computer programming languages. It is specific to the RPG language and its uses in a business environment.

## OBJECTIVES FOR THIS BOOK ■

This book was written to help the student learn RPG II, RPG III, and RPG/400. All three versions of the language are based on similar concepts and methods. Combining discussion of the three versions of RPG into one text makes it possible to demonstrate their differences and similarities.

The book is divided into two sections. The first section (Chapters 1–11) covers all the fundamental concepts of RPG II and is intended for the first-time programming student. It assumes no prior background in programming.

The second section (Chapters 12–18) is dedicated entirely to RPG III/400 and assumes a knowledge of the fundamentals of RPG II coding. It offers a modern approach to programming with the use of externally defined files and structured programming methods. This is one of the few texts available today that provides complete coverage of RPG III/400.

Besides the usual textbook rules of programming in RPG, there are many unwritten conventions used on a day-to-day basis by professional RPG programmers. These conventions are not required by any computer hardware or by any compiler. They are standards that are generally used across industry that make the programmer's job easier and are only learned on the job. They represent methods that programmers have discovered (sometimes the hard way) to be easier to implement, more user friendly, or more universally understood. These programming standards and conventions are included in this book so that the student can enter the working world with more than just the programming theory found in the manuals.

## OVERVIEW ■

This book is intended for the first-time programming student. The fundamental concepts are described in detail using a building-block approach. Each chapter presents a different type of problem that can be solved using the programming technique introduced in that chapter. Each chapter reinforces skills learned in earlier chapters. The student will be able to write a complete RPG program after completion of the first chapter. On completing the first section of the book, the student will be able to code programs proficiently in RPG II.

Each chapter begins with an outline listing the main topics to be covered in the chapter. At the end of each chapter, all new information is reviewed in a chapter summary. This summary lists new RPG rules, terms, and features. Students will find the summary useful when studying for tests.

Following the summary in each chapter are review questions. These questions relate to the chapter material and include fill-in answers which can provide a good basis to promote class discussion. These review questions also allow the student to review and study the concepts learned.

Program Debugging Exercises at the end of each chapter provide a means for the student to discover typical programming errors. Students are asked to find the errors, give possible explanations for their occurrence, and offer a solution. These projects may be assigned for outside study and are excellent for class discussion. Students who complete these exercises should be able to avoid making the same types of errors in their own programs. Program debugging is a skill that students will find useful in their future programming careers.

Provided at the end of each chapter is a programming project that allows the student to obtain "hands-on" experience with solving typical programming problems. These projects include such business applications as sales reports, employee lists, and inventory reports. Additional projects are provided in the Instructor's Manual.

Students are given an overview of the project, the input format, processing specifications, and the output format. The data for each program is included in Appendix D and is available on diskette. The appendixes also contain additional information concerning RPG programming.

## SUPPLEMENTS ■

Adopters of *RPG: A Programming Language for Today* receive an Instructor's Manual that will provide insights into the material covered in each chapter. The manual contains chapter outlines, teaching tips, more detailed descriptions of some of the more difficult concepts, answers to the Review Questions, and solutions to the Debugging Exercises and Programming Projects.

A test bank will be provided containing approximately 25 questions per chapter. These test questions are also available in computerized format, on Wm. C. Brown's TestPak 3.0. TestPak is a computerized testing service that provides you with a call-in/mail-in testing program and the complete test item file on diskette for use with your IBM PC. In addition to random test generation, TestPak allows for new questions to be added, or existing questions to be edited. TestPak 3.0 is available free to adopters of *RPG: A Programming Language for Today.*

All data needed for the programming assignments is available on an IBM 3.5- or 5.25-inch diskette. The data can easily be uploaded to your computer. This allows students to spend less time entering data and more time learning programming.

This text can be used for a single-semester class in RPG to give students a good overview of a programming language as it is used in business. Using this approach, all 18 chapters could be covered.

It is also possible to use the first 11 chapters in a first-semester class and use the second section of the book for advanced students in a second semester. This would allow time to cover each chapter thoroughly and to ensure a complete understanding of the material.

It is hoped that this text will provide a solid foundation for programmers and will prepare them for the next generation of minicomputers using RPG, the language for today and tomorrow.

### ACKNOWLEDGMENTS

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# Introduction to RPG and Programming

The data processing industry is relatively young and in many ways is still searching for guidelines and standards. Hardware has gone (and continues to go) through many changes in type and architecture. At the same time, software is experiencing similar changes and continues to evolve into something more accessible for the user.

## PROGRAMMING LANGUAGES ■

Many programming languages, such as COBOL, FORTRAN, PL/1, and RPG, have been around for many years. Newer languages, such as fourth-generation languages, have been developed to make the programmer's job easier. These are all known as high-level languages because they are designed to be easy for the programmer to use (unlike low-level languages, such as assembly or machine languages, which are understood better by the computer). Most high-level languages share fundamental features such as the ability to read files, do computations, and write reports. They are nearly all compiled languages, which means that a programmer must first write the program and then compile (convert) it on the computer into machine language.

## OVERVIEW OF THE RPG LANGUAGE ■

Of the many programming languages used on computers today, RPG (for Report Program Generator) is unique. Although it originated as a mere report writer in the 1960s, it has grown up to become a powerful full-service language for use in business applications. It is more widely used than any other language on minicomputers today. Interestingly, RPG is programmed in English worldwide.

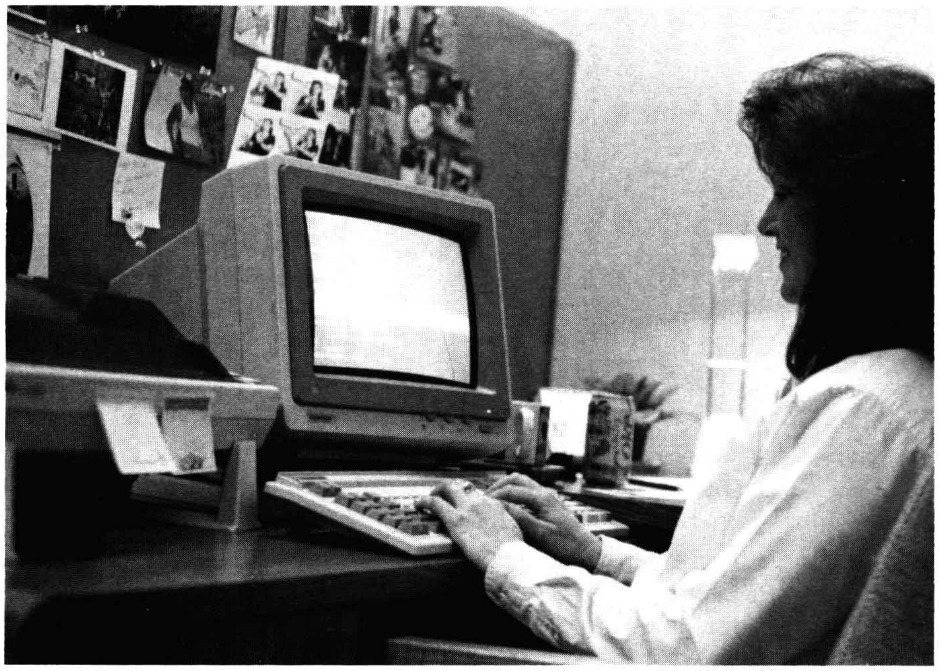
RPG is defined as a problem-oriented language. Multitudes of fourth-generation languages have been developed in recent years to achieve exactly what RPG has been doing all along—solving the problems of business with a minimum of programming effort or expertise.

### A Brief Glance Backward

In the early days of computers (circa 1950–1968) all business computers were large mainframes. (Minicomputers and personal computers had not yet been invented.) Programming languages were complicated, difficult to learn and to use. Often management needed only a report printed—perhaps just a listing of some file. In the languages available at that time, however, there was no such thing as a simple program.

At last, in the 1960s, IBM decided to create a language that could quickly meet the need for these simple reports. RPG was that language. It could read a data file, keep a few running totals, and write a nicely formatted report. This early version of RPG was simple to learn and easy to use,

**FIGURE I.1 A Programmer at Work**



but it had many limitations. It could not handle arrays of data, or make decisions, or update files. It could merely read and print. It did serve its purpose, but it was not a serious language.

Some people still think of RPG as this type of limited tool. On some mainframes, RPG remains in its original form doing only simple report writing.

### RPG II—Enter the Minicomputer

In 1969 IBM announced the first of its minicomputers for the business world—the System/3. Minicomputers had been around since 1964 for engineering uses, but none had been available for business applications. The System/3 was the right machine for small businesses that could not afford roomsful of expensive programmers. IBM, therefore, decided to introduce an easy language on the System/3. It would be a programming tool that anyone could learn and use quickly. That language was an updated version of RPG called RPG II.

Along with RPG II came many improvements over the original version of RPG. It became possible to make decisions, to control the actions of the program, to update files, and to use data arrays. RPG II could perform every function needed in the business environment at that time (using batch processing) and could do it faster, easier, and cheaper than any language of its time. Small businesses could have all the advantages of a large computer at far less cost.

Before long, other computer vendors realized that they would need to make versions of RPG II available for their customers if they were to compete with IBM. RPG II had become the standard of the minicomputer industry for business applications.

### On-Line Interactive Processing

By the mid-1970s, management was asking for more than RPG II could provide. They didn't like to wait for reports, and they didn't want mountains of paper on their desks. They wanted on-line, interactive, instant, available data on their terminals. Most languages had been designed long before terminals had become commonplace. No language made this type of programming easy.

As a temporary solution to this problem, IBM designed a utility called CCP which could be used in conjunction with RPG II to facilitate the writing of interactive application programs.

Everyone knew that this was not a complete answer to the problem, but they also knew that the System/3 was rapidly becoming obsolete. IBM then developed the System/34 and later the System/36 as further solutions. These machines used RPG II with an on-line capability—a big improvement over CCP.

### RPG III—A Truly On-Line Language

In 1979, with the System/38, IBM introduced RPG III, a language that was specifically intended to be used for programming interactive on-line applications. RPG III is a fully functional language, providing all the benefits of a completely modern structured programming language for use in the business environment. It continues to support all of the functions of RPG II with none of the aggravations of a limited language. RPG III is a language designed for communicating with terminals. It combines the best of the more modern languages (such as PASCAL) with the ease of use of a fourth-generation programming tool. Like PASCAL, it encourages the use of completely structured programming methods.

RPG III is native to the IBM System/38 architecture for which it was designed. This means that it cannot be readily adapted for use on other computers. Versions of RPG III are now available for other minicomputers (such as the IBM System/36), but there are certain limitations. The greatest benefits of RPG III can only be realized on the IBM System/38 and AS/400.

### The Future

With the announcement of IBM's AS/400 model in 1988, the functions of the System/36 and the System/38 are molded into a single framework. The language used on the AS/400 is RPG/400. RPG/400 is really RPG III with some additional operations and enhancements. With IBM's commitment to integrating the AS/400 into its planned system architecture for the 1990s, it is probable that RPG II, RPG III, and RPG/400 will share a united future in the 1990s and well into the twenty-first century.

## OVERVIEW OF PROGRAMMING ■

Programming consists of planning and designing the program, documenting the plan, writing the source code, compiling the code into object form, testing the program until it is free of errors, saving the final copy of the program, and finally documenting the program for future users or programmers.

Before a programmer begins writing a program, it is necessary to determine what the program is to do. The first step is to develop a plan. This may be done by a systems analyst or a programmer/analyst. It consists of discussing the project with the user (or manager) and finding out what is needed.

The second step will consist of documenting these findings by means of flowcharts, written narrative, and sample report formats so that the user can see what to expect. If all of this is acceptable, the programmer can then begin coding in the language available. Some typical documentation is shown in Figures I.2(a), I.2(b), I.2(c), and I.2(d).

### Coding the Program

The language in which programmers usually write their instructions for the computer is called a source language, or source code. It consists of words and phrases that are recognizable as human language (rather than binary symbols that have meaning only to the computer). The programmer must code with great attention to detail and accuracy to ensure that the final product will be free of errors. The programmer will write the entire program in this source language before submitting it to the computer to be compiled, or translated into machine language.

Program coding today is normally entered on a terminal using a special utility program called a text editor utility or source entry utility. Figure I.3 shows what a source program might look like on a display screen using a common utility.

**FIGURE I.2(a) Flowchart**

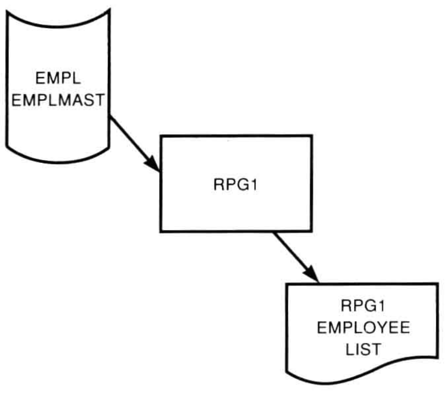


**FIGURE I.2(b) Record Layout**

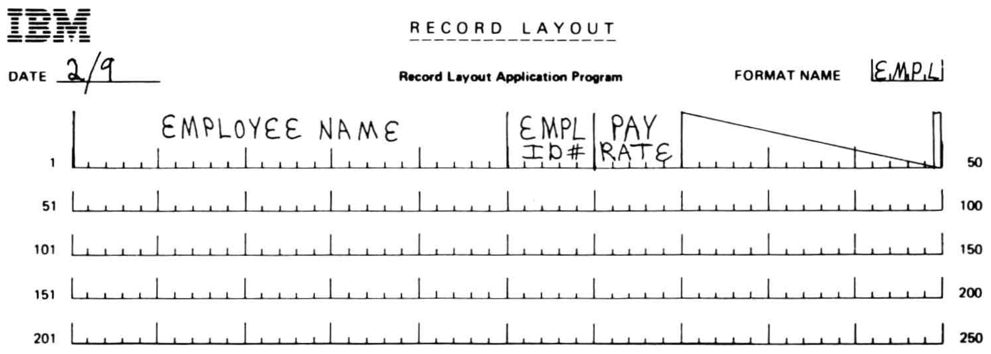


**FIGURE I.2(c) Program Narrative**

Program Narrative

Input: This program uses the following input files.

| | |
|---|---|
| EMPLMAST | Employee Master List<br>File Length 128 |
| EMPL | Employee Time Transactions<br>File Length 50 |

Process:

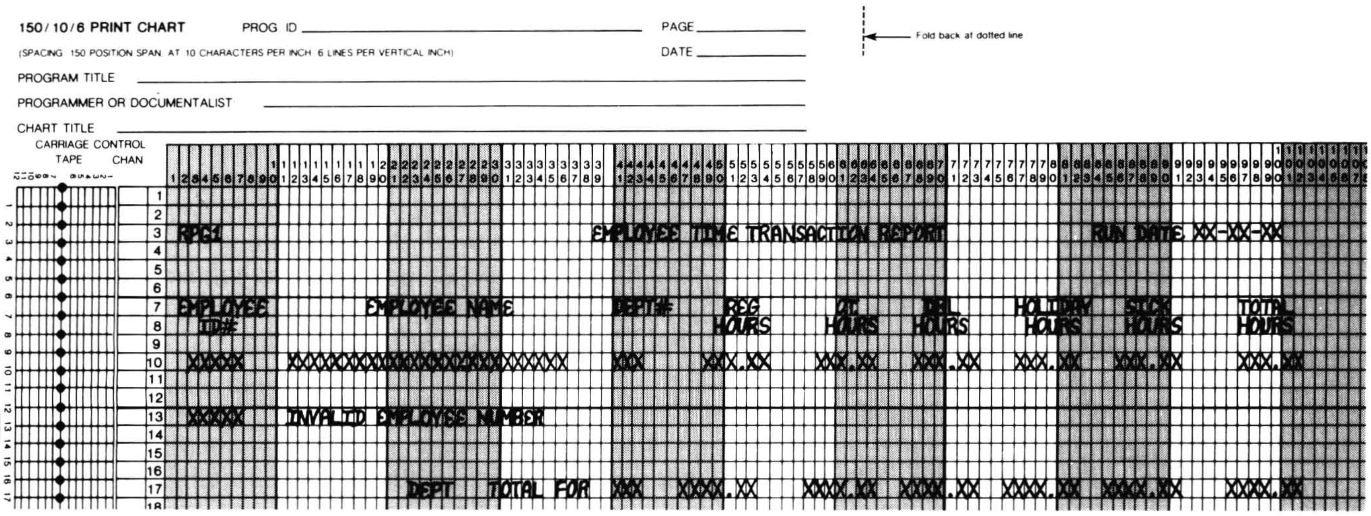
EMPL records are in sequence by department. Each EMPL record is read and the employee number compared with the EMPLMAST file to determine if it is a valid employee transaction. If the employee number is invalid, the hours in the record will not be added to the totals. The invalid employee number will be printed on the report with the message "Invalid Employee Number." Processing will continue with the next record.

If the employee number is valid, the record will be printed on the report showing department, employee name, regular hours, overtime hours, double-time hours, holiday hours, sick time hours, and a total of all hours. Total hours are computed from the hours in the input record by adding all the hour fields together.

Each type of hours is accumulated (i.e., all regular hours, all overtime hours, etc.) and a total is printed for each department. This total will be printed at the end of each group of records for a department after advancing one line.

A grand total for all departments will be printed at the end of the report.

**FIGURE I.2(d) Printer Spacing Chart**


150/10/6 PRINT CHART PROG ID ______ PAGE ______

(SPACING 150 POSITION SPAN AT 10 CHARACTERS PER INCH 6 LINES PER VERTICAL INCH) DATE ______

Fold back at dotted line

PROGRAM TITLE ______

PROGRAMMER OR DOCUMENTALIST ______

CHART TITLE ______

CARRIAGE CONTROL TAPE CHAN

```
 3  RPG1                                        EMPLOYEE TIME TRANSACTION REPORT            RUN DATE XX-XX-XX

 7  EMPLOYEE          EMPLOYEE NAME            DEPT#    REG       OT       DBL     HOLIDAY    SICK      TOTAL
 8    ID#                                                HOURS     HOURS    HOURS    HOURS     HOURS     HOURS

10   XXXXX   XXXXXXXXXXXXXXXXXXXXXXXXX          XXX    XXX.XX    XXX.XX   XXX.XX   XXX.XX    XXX.XX    XXX.XX

13   XXXXX   INVALID EMPLOYEE NUMBER

17                  DEPT    TOTAL FOR           XXX   XXXX.XX   XXXX.XX  XXXX.XX  XXXX.XX   XXXX.XX   XXXX.XX
```

## Program Compilation

After the RPG program has been completely entered and all obvious errors have been corrected, it must then be translated from the RPG source language into machine-language instructions which can be understood by the computer.

This translation is accomplished by the use of an RPG compiler. The compiler is itself a program supplied by the computer manufacturer. Figure I.4 shows the steps that occur to convert source language into compiled machine language.

To convert the RPG source program into machine language, the compiler is read into the main memory of the computer. The compiler usually resides on disk when not in use. Next, the source code is read into main memory. The compiler then goes to work translating the source code into object code (machine language). A source listing is produced at the same time. This source listing

**FIGURE I.3 Display Screen Showing Source Program**

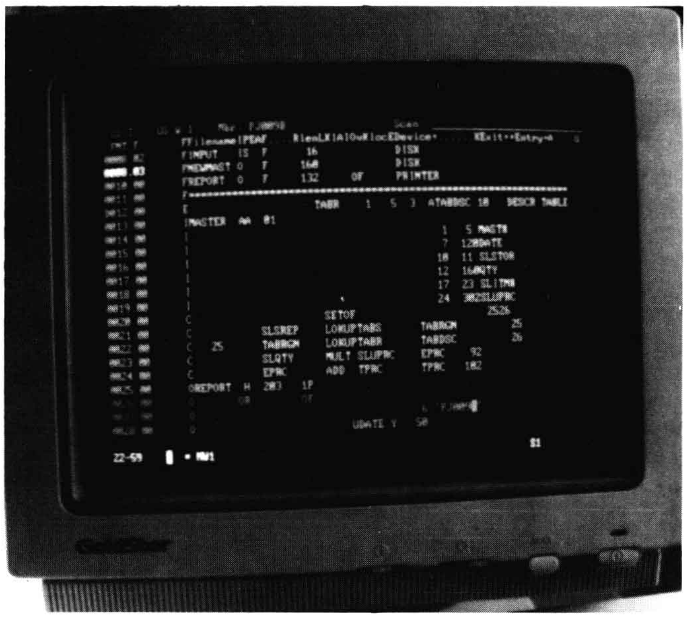

```
FFilename IPEAF ....RlenLK1AIOvKlocEDevice+ ......KExit++Entry+A
FINPUT    IS  F     16             DISK
FNEWMAST  O   F    160             DISK
FREPORT   O   F    132     OF      PRINTER
F*************************************************************
E                   TABR    1   5  3  ATABDSC 18   DESCR TABLE
IMASTER   AA  01
I                                              1   5 MASTR
I                                              7  12ODATE
I                                             10  11 SLSTOR
I                                             12  16ØQTY
I                                             17  23 SLITMN
I                                             24  302SLUPRC
I                                                  2526
C                       SETOF
C               SLSREP  LOKUPTABS      TABRGN       25
C       25      TABRGN  LOKUPTABR      TABDSC       26
C               SLQTY   MULT SLUPRC    EPRC    92
C               EPRC    ADD  TPRC      TPRC   102
OREPORT   H  203     1P
O         OR         OF
O                                   L  F.JAMP
O                    UDATE Y   58
                                                  01
22-59    ▌ • MW1
```

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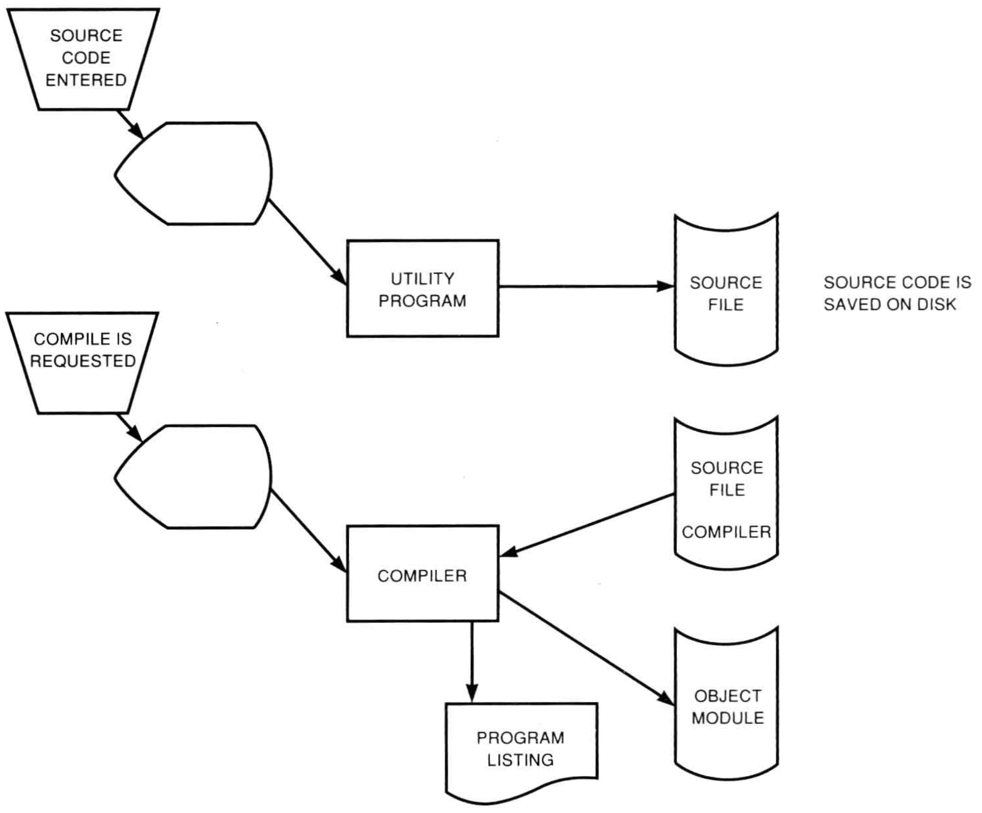
**FIGURE I.4 Compilation Flowchart**



will show every line of code as it was coded by the programmer. The source listing will also note any errors and show them at the bottom of the listing. Note that the compiler will find only syntax errors or errors in spelling of key words or placement of the fields. It is not capable of finding errors in logic. If the errors are too severe to permit compilation, then it will say so and no object code will be produced at all. If all goes well, the source listing will state that, and the object code (an object module) will be created.

Once the object module is created, it should be saved on disk and the program will be ready for testing. The source code should probably also be saved on disk so that changes can be made later if needed.

In learning environments, it is often useful to do a test run immediately after the compiler has finished. This is referred to as a "load and go" method. Figure I.5 shows a source listing of an RPG program with its accompanying error messages.

## Program Testing

Once the program is compiled successfully, it must be tested to determine whether it will produce the desired results. Acceptance by the compiler does not necessarily mean the output will be correct. Steps in testing are as follows:

1. *Preparing Test Data.* When a program is to be tested, it should be tested with data which was prepared for testing the various routines within the program. Test data should contain every possible combination of bad and good data to be sure all functions of the program are exercised. It is better to find the problems before the program goes into "live" productive use than to wait and let the errors be found by users, bosses, or instructors. Program testing should be extensive and thorough. The preparation of good test data is a difficult and tedious task, but it is an important part of programming.

2. *Desk Checking.* Sometimes problems are not easy to find. Sometimes the most careful programmer will find an obscure bug or error in the program that refuses to allow the program to perform correctly. The only solution to this dilemma is for the programmer to sit down with a listing of the program and "think" some data through the program line by line. This process, called "playing computer," is slow, but it is one of the best ways to discover what has gone wrong with the program.
3. *Program Debugging.* Programs containing bugs (or errors) should never be released into a production environment. Nothing will give computers a bad name faster than invalid data showing up on someone's report or screen. Unexpected program failures greatly reduce the credibility of the data processing department. It is the responsibility of every programmer to make certain that no program is released until it has been completely and thoroughly tested and found to be absolutely bug free.

**FIGURE I.5 Source Listing**

```
SEQUENCE        1         2         3         4         5         6         7
NUMBER     67890123456789012345678901234567890123456789012345678901234567890123 4


      100  F* TITLE: SALES ANALYSIS REPORT
      200  F* DATE:   3/11              AUTHOR: D.CABLE
      300  F* DESCRIPTION:  PRINT REPORT OF ALL SALES FOR MONTH
      400  F*******************************************************************
      500  F* MODIFICATIONS:
      600  F* NO.      DATE      INIT          DESCRIPTION
      700  F*        XX/XX/XX    XXX      XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
      800  F*******************************************************************


NAME OF PROGRAM WILL BE ILL05 IN LIBRARY CABLE

           H
* 1019              ALL DECIMAL DATA ERRORS IGNORED
      900  FSALEMASTIP  F       512              DISK
     1000  FREPORT  O   F       132              PRINTER
     1100  F*******************************************************************


     1200  ISALEMASTAA   01
     1300  I                                                 1   2 SACMPY
     1400  I                                                 3   50SALOC
     1500  I                                                 6   6 SATYPE
     1600  I                                                 7  21 SAPNO
     1700  I                                                22  230SAMTH
     1800  I                                                24  280SAQTY
     1900  I                                                29  352SAPRC


     2000  C                          TIME          TYME     60


     2100  OPRINT    H  101         1P
* 6001 6001-********  .
* 6035          6035-******

     2200  O                                          6 'ILL005'
     2300  O                                         75 'P.C. SOLUTIONS'
     2400  O                                        124 'PAGE'
     2500  O                            PAGE        132
     2600  O         H  2           1P
* 6001 6001-********  .
* 6035          6035-******

     2700  O                                          8 'RUN DATE'
     2800  O                            UDATE Y      17
     2900  O                            TYME         26 '  :  :  '
     3000  O                                         60 'MONTHLY SALES ANALYSIS'
     3100  O         H  2           1P
* 6001 6001-********  .
* 6035          6035-******
```

```
 SEQUENCE       1         2         3         4         5         6         7
 NUMBER     678901234567890123456789012345678901234567890123456789012345678901234

     3200  O                                      10 'COMPANY'
     3300  O                                      20 'LOCATION'
     3400  O                                      26 'MONTH'
     3500  O                                      33 'QUANT'
     3600  O                                      42 'TOTAL SALES'
     3700  O         0  1     01
* 6001 6001-********  .
* 6035            6035-******

     3800  O                            SACMPY    12
     3900  O                            SALOC     20
     4000  O                            SAMTH     25
     4100  O                            SAQTY K   32
     4200  O                            SAPRC K   42
 * * * * * E N D   O F   S O U R C E * * * * *


* 7086        900    RPG PROVIDES BLOCK/UNBLOCK SUPPORT FOR FILE SALEMAST.
* 7064       1000    REPORT FILE NOT REFERENCED FOR OUTPUT



   CROSS-REFERENCE LISTING



        FILE/RCD     DEV/RCD     REFERENCES (D=DEFINED)

        PRINT         **UNDEF**  2100
     02 REPORT       PRINTER     1000D
     01 SALEMAST     DISK         900D 1200


        FIELD        ATTR         REFERENCES (M=MODIFIED D=DEFINED)

        PAGE         P(4,0)   2500
        SACMPY       A(2)     1300D 3800
        SALOC        P(3,0)   1400D 3900
        SAMTH        P(2,0)   1700D 4000
* 7031  SAPNO        A(15)    1600D
        SAPRC        P(7,2)   1900D 4200
        SAQTY        P(5,0)   1800D 4100
* 7031  SATYPE       A(1)     1500D
        TYME         P(6,0)   2000D 2900
        UDATE        P(6,0)   2800

        INDICATOR  REFERENCES (M=MODIFIED D=DEFINED)

        LR           900D
        01           1200M 3700
        1P           2100   2600   3100


  MESSAGES

   MSGID     SEV  NUMBER    TEXT

* QRG1019    00     1       IGNDECERR(*YES) SPECIFIED ON COMMAND. NO DECIMAL DATA ERRORS
* QRG6001    40     4       FILE/RECORD NAME NOT VALID, NOT DEFINED, IGNORED, OR MISSING.
                            VALID TYPE FOUND
* QRG6035    20     4       SPACE OR SKIP MUST BE SPECIFIED ONLY FOR PROGRAM DESCRIBED FI
                            ASSUMED.
* QRG7031    00     2       NAME OR INDICATOR NOT REFERENCED.
* QRG7064    40     1       PROGRAM FILE NOT REFERENCED. FILE IGNORED
* QRG7086    00     1       RPG WILL HANDLE BLOCKING FUNCTION FOR THE FILE. INFDS CONTENT
                            ARE TRANSFERRED.
```

**FIGURE I.5** ***Continued***

```
 MESSAGE  SUMMARY

 TOTAL      00        10        20        30        40        50
  13         4         0         4         0         5         0

    42 RECORDS READ FROM SOURCE FILE
 SOURCE RECORDS INCLUDE     33 SPECIFICATIONS,      0 TABLE RECORDS, AND      9 COMMENTS


 QRG0008 COMPILE TERMINATED. SEVERITY 40 ERRORS FOUND IN PROGRAM

 * * * * * E N D   O F   C O M P I L A T I O N * * * * *
* QRG1020                  ERROR OCCURRED CREATING OR UPDATING DATA AREA RETURNCODE. COMPIL
```

## Documentation

Documentation is the process of recording all information related to a given program (or system of programs) in such a way that users, managers, other programmers, or data processing auditors will be able to quickly understand exactly what it is that your program is supposed to be doing. At a minimum it should include:

1. Record layout forms
2. Printer (or screen) layouts
3. A program narrative describing the routines used in the program
4. A flowchart and/or pseudocode outline of the program logic
5. The final copy of the source listing (produced at final compilation time)
6. Sample reports (or screens)
7. User instruction manual

Documentation is an often-neglected part of a programmer's job but a crucial one if a company is to continue to function successfully over a period of time.

## CONCLUSION ■

RPG is a programming language that can serve as an excellent introduction to programming. It is a language that is best suited for business applications and is widely used on mid-range computers. RPG has been used as a business programming language since the early 1960s and is predicted to remain popular with mid-range users for many years to come.

This text presents an introduction to both RPG II and RPG III. It explains the fundamentals of programming along with standard conventions practiced in a business programming environment.

# Contents