$10.00

PASCAL USERS GROUP

Pascal News

Communications about the Programming Language Pascal by Pascalers

- APL Scanner
- Computer Generated Population Pyramids
- Path Pascal
- Introduction to Modula-2
- Validation Suite Reports
- Announcements

Number
26
JULY 83

POLICY: PASCAL NEWS (Jan. 83)

- *Pascal News* is the official but *informal* publication of the User's Group.

Purpose: The Pascal User's Group (PUG) promotes the use of the programming language Pascal as well as the ideas behind Pascal through the vehicle of *Pascal News*. PUG is intentionally designed to be non political, and as such, it is not an "entity" which takes stands on issues or support causes or other efforts however well-intentioned. Informality is our guiding principle; there are no officers or meetings of PUG.

The increasing availability of Pascal makes it a viable alternative for software production and justifies its further use. We all strive to make using Pascal a respectable activity.

Membership: Anyone can join PUG, particularly the Pascal user, teacher, maintainer, implementor, distributor, or just plain fan. Memberships from libraries are also encouraged. See the COUPON for details.

- *Pascal News* is produced 4 times during a year; January, April, July October.
- ALL THE NEWS THAT'S FIT, WE PRINT. Please send material (brevity is a virtue) for *Pascal News* single-spaced and camera-ready (use dark ribbon and 15.5 cm lines!)
- Remember: ALL LETTERS TO US WILL BE PRINTED UNLESS THEY CONTAIN A REQUEST TO THE CONTRARY.
- *Pascal News* is divided into flexible sections:

POLICY — explains the way we do things (ALL-PURPOSE COUPON, etc.)

EDITOR'S CONTRIBUTION — passes along the opinion and point of view of the editor together with changes in the mechanics of PUG operation, etc.

APPLICATIONS — presents and documents source programs written in Pascal for various algorithms, and software tools for a Pascal environment; news of significant applications programs. Also critiques regarding program/algorithm certification, performance, standards conformance, style, output convenience, and general design.

ARTICLES — contains formal, submitted contributions (such as Pascal philosophy, use of Pascal as a teaching tool, use of Pascal at different computer installations, how to promote Pascal, etc.).

OPEN FORUM FOR MEMBERS — contains short, informal correspondence among members which is of interest to the readership of *Pascal News.*

IMPLEMENTATION NOTES — reports news of Pascal implementations: contacts for maintainers, implementors, distributors, and documentors of various implementations as well as where to send bug reports. Qualitative and quantitative descriptions and comparisons of various implementations are publicized. Sections contain information about Portable Pascals, Pascal Variants, Feature-Implementation Notes, and Machine-Dependent Implementations.

VALIDATION SUITE REPORTS — reports performance of various compilers against standard Pascal ISO 7185.

Pascal News

Communications about the Programming Language Pascal by Pascalers

JULY 1983 NUMBER 26

Charles Gaffney Publisher and Editor

The Pascal Newsletter is published by the Pascal Users Group, 2903 Huntington Rd., Cleveland, Ohio 44120. The Pascal Newsletter is a direct benefit of membership in PUG.

Membership dues in PUG are $25.00 US regular, other forms of membership please inquire. Inquiries regarding membership should be sent to the above address. Newsletter correspondence and advertising should be sent to the editor at the aforementioned address.

Advertising Rates: $300.00 Full Page. Please give your preference of magazine location: front, center, or back.

Hello,

Well, this is the third issue I am involved with and there have been many changes. I would like to write of Pascal first.

Pascal has enjoyed a jump in attention in the last year. One reason is that there are Pascal compilers available for many machines and, I am tempted to say, they are available for any machine. Most of the major main frames have Pascal either directly or from a third party.

One step down in size, I know of only one machine, the Tandem computer which is without a Pascal implementation. A Tandem representative here in Cleveland informed me they have a language called "TAL" and in many cases will execute a Pascal program with no changes.

A couple more steps down in size are the small Digital Equipment machines and compilers are available from about four sources. IBM has the Display writer and Datamaster. These were released without our language, but in the last year, UCSD Pascal has been made available through IBM. Apple Computer has been a strong and long supporter of Pascal. TRS 80 has UCSD Pascal.

The smallest machine with Pascal is the TI 99/4A. In this size, Commodore has promised Pascal for this summer on the "64" and "128" machines.

The small computer, that is, the home computers and small business computers, have exceeded $10 million in sales. This is according to Future Computing, a Richardson, Texas research firm.

With a guess, I would say that Pascal is implemented on at least 25% of these machines. If only 1% of these were being used to learn and program Pascal, then 25,000 people are presently involved. This is a lot of people looking for the best books from which to learn.

I am making an appeal to our members to submit comments and reviews of text books so that we all may benefit from your experience. I get calls from authors requesting information on Pascal. To these people, the best I can do is to send complete sets of *Pascal News*! With your comments and criticism, perhaps we could influence future text books.

Herb Rubenstein of Budget Computer in Golden, Colorado has sent a small article from *Popular Computing*. It seems that advanced placement test in computer science will use structure programming and the Pascal language. These tests allow up to one year of college level credits in computer science. The author of this article, Dan Watt, believes that the choice of Pascal in the testing may lead to Pascal as a defacto standard in high schools preparing students for college. Let me quote the last paragraph:

> "This situation illustrates the power of the testing establishment to influence the lives of students and teachers. Although the vast majority of high schools now offer Basic as the standard computer language for most programming and computer science classes, this action by the College Board may lead to the establishment of Pascal as a defacto standard for high school teaching and spawn an entire mini industry of curriculum to meet the new requirements. It may also offer significant school marketing advantages to microcomputer companies that already support Pascal — such as Apple, IBM and Texas Instruments."

I would like to see comments from you regarding this use of Pascal in a rite of passage.

In this issue, you will find a reprint of Dr. Srully Blotnick's column from *Forbes* magazine. I like this column because of the clever way he has made our economy dependent on you learning Pascal.

I enjoy *Forbes* magazine. They emphasize common sense and illustrate proven business practices. *Forbes* also takes a pulse of industries, and small computers is a fast growing industry. In a column called "Technology", edited by Stephen Kindel, on March 28, 1983, he noted that 2% of the households in the U.S.A. own computers of one form or another. There had been predicitions of 40% of households by 1990. This has been reduced to 20% in 1990 because there doesn't seem to be software that is useful in households.

Mr. Kindel ends this article with a quote from Seymour Papert, an MIT professor:

> "The real purpose of learning how computers work should be to improve human logic and thought processes, to make people more creative, not simply more dependent on machines."

Maybe this would be a good issue to review the tools available in our back issues. This issue contains the APL scanner. I am embarrassed to print this, not because of the program's quality, but because it was submitted four years ago. Well, no time like the present.

In issue #17 (yellow), Arthur Sale submitted "Referencer", a procedural cross reference. This program provides a printout of the heading of each procedure and function with indentation showing nesting. In issue #25, Mr. Yavner has improved on this program with "A Better Referencer". Mr. Yavner claims that *Pascal News* has been his sole source of instruction in Pascal. I believe this is a compliment to Andy Mickel and Rick Shaw for their efforts to maintain this newsletter. We should also thank our contributors, Mr. Sale for instance, for outstanding generosity. These people will appreciate your complements, criticisms and gifts of money. (Ho! Ho!)

Andrew Tandenbaum, in issues 21 and 22/23, provided us with "The EM1 Compiler". This is a good look at all that is necessary for a pseudo 32-bit machine pascal compiler.

The UCSD Pascal Project started with a 16-bit pseudo machine portable compiler. It was called P4 out of Zurich, Switzerland by Vrs Ammann, Kesav Nori and Christian Jacobi. I mentioned this because it has been published with critical commentary by S. Pemberton and M.C. Daniels in 1982. It is presented as a

case study of compiler design and is very interesting to read.

Pascal Implementation
S. Pemberton and M.C. Daniels
Ellis Horwood Limited Publishers
Distributed by:
John Wiley & Sons
605 Third Avenue
NY, NY 10016
USA

In #21 you will find Jeff Pepper's fine implementation of extended precision arithmetic.

Nicklaus Wirth, Pascal's creator, wrote Pascal S and we have it in #19 (mislabeled #17). This is a subset of Pascal and was intended as a teaching aid.

Also in #19 is a Lisp interpreter written in Pascal.

"MAP", a Pascal macro preprocessor for large program development, is published in #17.

Issue #16 contains the Validation Suite version 2.2. This is the compiler checker that Arthur Sale and Brian Wickman have now revised to version 3. This new version is available by using the Validation Suite coupon in the rear of this issue.

"Prose", a text formatter, by John Strait is the major program available in #15. A disclaimer in the instructions manual admits that it doesn't do everything, but I must say, it has a lot of capability.

In #13, two programs were printed that performed the same work. A sort of "Battle of Algorithms". "Pretty Print" and "Format" used any Pascal programs as input and printed it in a consistent style.

For those of you looking for other Pascal periodicals, there are four of which I know. "Pascal Market News", 30 Mowry Street, Mt. Carmel, CT. 06518. This is a nice quarterly for $9.

Another quarterly for Oregon Software users is the "Pascal Newsletter". Maybe this is too narrow in content, but you will know what Oregon Software is up to. Their address is 2340 SW Canyon Rd., Portland, OR. 97201.

A very slick magazine with good design is "Journal of Pascal and Ada." You can contact them at West Publishing Company, 898 South State Street, Orem, UT. 84057. The cost is $14 for six issues.

The USUS News and Report is more a system user's journal, but the system is based on Pascal. They also have a software library, seventeen floppy disks full, and all in source code and written in Pascal.

Now to the business of *Pascal News*. *Pascal News*, as the Pascal periodical granddaddy published since January 1974, has had its ups and downs. In 1979 our circulation was 7,000; now it is 3,600. Our biggest problem has been irregular publication. I am committed to four issues this year and I am considering six issues next year. I believe that regularity will supply us with growth and members and more software tools.

As I mentioned in the last issue, PUG (AUS) has stopped and I, in the USA, have taken over their area. Unfortunately, they have not sent me their mailing list and I fear that I have lost touch with our members there. This issue will be sent to those members listed as of 1979 and I hope they will "spread the word" and the subscription coupons!

Our PUG (EUR) has performed very nicely and I thank Helmut Weber and friends for their good work. But they have a problem concerning money. They have not charged enough for subscriptions and were pressed to send our #24. As a result, I will mail all issues directly and I hope you will not be inconvenienced. Please keep in touch with them as they are a strong group.

I have saved the worst for last. In November, 1982, I sent 300 copies of issue #24 to Nick Hughes in care of PUG (UK), Post Office Box 52, Pinnen, Middlesex HA5 3FE, United Kingdom. Using the phone number 866-3816, the air express shipper delivered these issues by mid-November. All well and good. The issues arrived before the cover date with plenty of time to post them to our English members. I called Nick at this number many times, but spoke to him only after many months. It was late April and I asked if I should use the same procedure in shipping #25 to him.

Nick said that the issues arrived properly and that method was efficient but wanted to know what was in #25. He told me that he did not like issue #24 and from the sound of it, did not like issue #25. He had disliked #24 so much, he decided not to send any of them out. Need I say more?

Nick will not supply his mailing list so I am sending this issue and #25 directly to the members of record in the United Kingdom as of 1979. If you feel a need to find out why Nick Hughes did not like issue #24 or would like to see it yourself, please call or write Nick at the above address and ask for your copy. He has 300 and I am sure he can spare one.

As a result of these difficulties, I will receive and service all subscriptions from here in Cleveland, Ohio. From now on, there will be only one person to blame if you have a complaint.

As of this issue, a year's subscription is raised in price to $25 a year and $50 for three years. These represent two sets of costs; production and organization. Production costs are typesetting, printing and mailing. Other activities of production are editing, reviewing, quality assurance and formatting. These tasks are performed by "yours truly" and presently I do them for free. (I'm real smart!)

Organization is a cost of servicing you and other members satisfactorily. This includes collecting and reviewing the mail, depositing checks, updating the mailing list, sending back issues to fill new subscriptions and sending sets of previous years back issues. In order to do this correctly, and in a timely fashion, I don't do it. I pay a firm to perform "fulfillment" and it takes one or two days per week. This cost is small compared to the bad feelings generated if not done correctly and quickly.

These are costs of which you are totally responsible. This newsletter has been a beneficiary of volunteerism. There are no volunteers now (save me). In many magazines, advertisements will pay for all production and organizational costs plus provide profits, sometimes large profits.

The cost of a full page ad in *Byte* or *PC* or *PC World* is over $2,000 and these are publications with 500 pages!

Now we may be able to keep our costs down and publish more often if we accept advertising. Three hundred dollars per page is not expensive. I will pursue

advertisers and I am asking for your help. If you are writing a book, have your publisher advertise with *Pascal News*. If you are making software packages, influence your boss in the virtues of an ad in *Pascal News*. If you manufacture or sell computers, sell your product from the pages of *Pascal News*. This is the oldest Pascal publication and, I proudly say, the most influential.

This newsletter help spread Pascal and our members were most influential in the standard efforts.

I believe *Pascal News'* new mission is to enable Pascal to be taught in the easiest way. This is in many forms. For instance, reviews of books and texts, discussion of what features to teach first as a foundation, how to teach advanced courses, discussions of extensions or standard program tools to include in every well written program as it is appropriate.

By the way, Andy Mickel tells me that the "Pascal User's Manual and Report" by Jensen and Wirth has sold 150,000 copies in 1982. This is interesting considering that in the previous seven years, it sold 175,000 copies. A very sharp jump in interest.

A new text book has been sent to me, "Pascal" by Dale/Orshalik, 1983 DC Heath. A nice title, short and to the point. The preface states a philosophy that I would like you to comment on.

> "In the past there have been two distinct approaches used in introductory computer science texts. One approach focused on problem solving and algorithm design in the abstract, leaving the learning of a particular language to a supplemental manual or a subsequent course. The second approach focused on the syntax of a particular programming language, and assumed that the problem-solving skills would be learned later through practice.
>
> We believe that neither approach is adequate. Problem solving is a skill that can and should be taught — but not in the abstract. Students must be exposed to the precision and detail required in actually implementing their algorithms in a real programming language. Because of its structured nature, Pascal provides an effective vehicle for combining these two approaches. This book teaches problem-solving heuristics, algorithm development using top-down design, and good programming style concurrently with the syntax and semantics of the Pascal language."

One of the letters mentions high resolution graphics. I know of two texts that use Pascal as the illustrative language of their algorithms. They are "Principles of Interactive Computer Graphics" by Williams Newman and Robert Sproull, 1979 McGraw-Hill and "Fundamentals of Interactive Computer Graphics" by James Foley and Andries Van Dam, 1982 Addison-Wesley.

Two notes from members:

Steven Hull of Campbell, California, received a notice from me that #22/23 had been returned to us because the postal service will not forward bulk mail. His reply:

> "I guess this will teach me to move from Lakewood (a suburb of Cleveland, Ohio). Didn't know bulk mail wasn't forwardable. The Postal Diservice has been re-routing every piece of junk mail for a full year . . . I might have to file suit to stop it all!

And from Eric Eldred of New Hampshire who rewarded *Pascal News* with a three year subscription and dutifully filled the coupon with name and address and arrived at a request for "Date". Eric filled in "No! Married!". Thanks Eric, I needed that!

Charlie

To Charlie Gaffney,

I'm glad you have taken on *Pascal News*. I hope it works.

Perhaps, I should say what I would like to see published in *Pascal News*. The most valuable things are 1) Tools, and 2) Info on the various implementations. In my job we are using many computers. It is very helpful to know which compilers work well, meet standards, and produce efficient code. Apple Pascal is nearly bug free, and works as specified (with UCSD quirks). IBM Pascal VS is good — extensions are large presenting conversion problems if they are used. It has a good interface to FORTRAN. VAX Pascal is plain vanilla, appears to work well but we have not tested it in difficult situations. HP Pascal 1000 works fine but does not have a stack architecture and seems to compile slowly. Recent tests on HP Pascal 1.0 for the HP 200 computers seem to indicate it derives from UCSD although it is a native code 68000 compiler. It seems to work very well. We are interested in Pascal for the Data General Eclipse.

Good luck,
Dennis Ehn
215 Cypress Street
Newton Centre, MA 02159

Gentlemen:

Would you be so kind as to send information on the Pascal User's Group (PUG) and its official publication *Pascal News*. Recently we have acquired a microcomputer Pascal compiler and are very much interested in keeping up with current developments in Pascal.

Our system is based upon a SouthWest Technical Products Corporation S/09 computer, running the UniFLEX Operating System (similar to UNIX). If specific information is available for this unit, please let us know.

Additionally, the college has several (approximately 18) Apple computers which are capable of running the UCSD Pascal System. Once again, any special information here would be very helpful.

We look forward to hearing from you and hope that we can make a positive contribution to the Pascal User's Group.

Yours Truly,
Lawrence F. Strickland
Dept. of Engineering Technology
St. Petersburg Jr. College
P.O. Box 13489
St. Petersburg, FL 33733

Dear Sir,

I just received issue number 25 of *Pascal News* and was surprised to find an implementation note for our Pascal compiler. What makes it surprising is that to the best of my knowledge I have never sent in an entry, and the information provided is about a year and a half out of date.

In case you would like to provide your readers with valid information, I have enclosed an implementation note for the currently available compiler. I have also enclosed a copy of the ISO validation suite report from our language manual.

Work is currently being done on moving this compiler to the 68000 family of processors and should be available by the end of 1983.

On another note, I have received issues number 21, 22/23, and 25, but not issue 24. I am also enclosing a check for a 3 year membership — please see if you can determine what happened to number 24.

Sincerely,
Robert Reimiller
Owner, OmegaSoft
5787 Brandywine Ct.
Camarillo, CA 93010

December 1, 1982

I hope the letter referring to the possible end of the P.U.G. is wrong! I can be of some help if needed.

Allen Duberstein
Pine Instrument Co.
3345 Industrial Blvd.
Bethel Park, PA 15102

January 10, 1983

Dear Mr. Gaffney:

Enclosed is a check covering both the remailing cost of *Pascal News* #24 ($5) plus my membership renewal for two years ($18).

My apologies for getting out of synchronization with the Pascal Users Group. As the post office informed you, I recently moved to the address noted. Frankly, I hadn't received a *Pascal News* in so long that I simply forgot about it. It appears that I won't miss any issues — the enclosed All-Purpose Coupon is from issue #23.

Interestingly, after a long period (3 years) of not using Pascal, it looks like I will be using it once again. We have a couple of Convergent Technologies workstations in my office. These are very nice 8086-based machines; Burroughs sells them as the B-20s, and NCR sells them as WorkSavers. We will probably be getting a Pascal compiler, and I am looking forward to getting back into Pascaling in the near future.

Sincerely,

Read T. Fleming
144 Irving Avenue #B-3
Providence, RI 02906

November 30, 1982

I was surprised and pleased to receive issue number 24 of *Pascal News*. Thanks for taking it over. I do have one question, however, which you might be able to help me with. What year is it? My address label includes [82] on it but the previous issue I received was dated September, 1981. I notice that this issue is dated January, 1983. Should I send in another year's subscription money now? What happened to 1982? I never have managed to figure our *Pascal News'* subscription scheme. Maybe a note in the issues towards the end of a year saying "if your address label says [82] it's time to send in a renewal" would help.

Thanks for your help.

Richard Furuta
Computer Science, FR-35
University of Washington
Seattle, WA 98195

8 February 1983

Dear Sir,

I received your notification of renewal in the mail yesterday. I am slightly concerned that you may not have received the check which I mailed to you in December. I hope that it has only been a slight mix-up, and in fact, my subscription has been renewed for 3 years, as I requested.

I am currently using the Pascal implemented by Microsoft for the IBM Personal Computer. It has some non-standard features which were provided in order to allow programmers to access the full capabilities of the machine. This implementation is quite flexible, and was designed to allow users to produce systems programs, as well as application programs.

The greatest shortcoming to this product, however, is its lack of usable documentation. Even someone like myself, who has been programming in Pascal for 8 years, has difficulty in trying to locate the appropriate material in the 'reference manual'. Once this is overcome, the user is able to use this version for the production of some very powerful software.

I continue to look forward to the delivery of your fine newsletter. I enjoy the articles, and realize how difficult a task you have. Keep up the good work.

Regards,

Robert A. Gibson
1609 Lake Park Dr.
Raleigh, NC 27612

November 30, 1982

Pascal is being used for process control of laser trimming systems. We use Oregon Software Pascal.

Barbara Huseby, Training Dept.
Electro Scientific Industries
13900 N.W. Science Park Drive
Portland, OR 97229

March 3, 1983

Dear Mr. Gaffney:

I'm writing to let you know why I am not renewing my subscription to *Pascal News*. The main reason is that the price is now too high for the utility of the product (at least to me). I appreciate your efforts to keep PUG and *Pascal News* going, but I'm afraid they may have outlived their usefulness. Pascal is not really in need of promotion as it was when PUG was formed. The *Journal of Pascal & Ada* may be an appropriate successor.

As a long-time subscriber and occasional contributor, I wish you luck in your efforts.

Richard Leklanc
Assistant Professor
Georgia Institute of Technology
Atlanta, GA 30332

January 7, 1983

Hang in there, Charlie!

Andy Mickel
106 SE Arthur Avenue
Minneapolis, MN 55414

December 9, 1982

Dear Sirs:

Could you provide us with information on membership in your organization, both personal and institutional, as well as the subscription cost of your journal.

We are also interested in a rigorous comparison of the various PASCAL versions implemented by mini and microcomputer vendors. Do you know of any such comparative research? We are making plans to offer Advanced Placement Computer Science in the fall term of 1983, and wish to select an effective computer.

Very truly yours,

Charles McCambridge
Director
Instructional Materials Services
Niskayuna High School
1626 Balltown Rd.
Schenectady, NY 12309

December 25, 1982

Merry Xmas! Good luck, Charlie! Is your "acquisition" of PUG a sign that PUG and USUS will someday merge? I'm not sure I'd like that, but let's see.

Jim Merritt
P.O. Box 1087
Morro Bay, CA 93442

December 24, 1982

Please send me information on joining the Pascal

User's Group, I am a software project engineer at General Electric in Syracuse. I am currently in the process of selecting a high level language for internal programming of a 1024 × 1280 resolution raster display. Pascal is the leading candidate, therefore, I am very interested in the latest information regarding the language which I feel a user's group could provide.

My interest does transcend my work however as I do own a Commodore SuperPET which includes the University of Waterloo software package consisting of Pascal, APL, Fortran, Basic and a 6809 Assembler.

Sincerely,

Douglas W. MacDonald
4303 Luna Course
Liverpool, NY 13088

2/5/83

To Whom It May Concern:

I just received your notice to inform me that my membership is about to expire and that I should renew now.

I would like to tell you that I would consider renewing *if* I could be assured of getting my money's worth — this time!

When I first joined in 1981, I didn't hear from *Pascal News* for almost a year. Then a few months ago, I received a second issue, but that's been it.

Now I am a convicted Pascaler. I understand the difficulties of operating a non centralized club, but $20 should buy *some kind* of organization for things I feel.

Can you assure me of a better value this time around?

Cordially,

David Abate
Micro People
116 S. Bowdion St.
Lawrence, MA 01843

P.S. Question: Do you intend anything on UCSD-Pascal? This is my greatest interest.

7 January 1983

Hi,

This is a note in a bottle to: 1) find out if you're still out there, and 2) what's happening with Pascal. It doesn't seem to be taking the bite (or is that byte) out of Basic I thought it would.

We will start covering Pascal as soon as we have finished Basic programming — about five weeks from now. The extension program from Hocking Technical College in Nelsonville has provided seven Apple II and Apple III computers and two printers. By the end of the year, they will have installed a winchester disc and either a modem or a microwave link to their main campus computer. We'll need it by then to cover the Cobol and Fortran IV programs we'll be writing.

Most of my practical computer experience is in assembler language. I used it at Cincinnati Milacron's Process Controls Division (Mater's of the controls for the T^3 Industrial Robot).

I am interested in any literature you have to send me. In particular, I would like the titles of the books you consider best for teaching Pascal — either on the Apple II or on computers in general. Apple, Inc., sent me the Pascal Reference Manual (just a bit or a nibble over my head). I've also read copies of the DOS 3.2 Reference Manual and their Basic Programming Manual. I covered all these before classes started and wound up tutoring two other student/inmates.

Sincerely,

Brian Appleman 166-767
15802 St. Rt. 104
P.O. Box 5500
Chillicothe, OH 45601

P.S. If you need more on my background, just ask.

83-02-24

Dear Charlie:

I am a member of PUG (AUS) which has just folded, and I would like to re-enroll through PUG (US).

I don't share Arthur Sales view that PUG and PN have no purpose now that there is an ISO standard. The world still needs cheap, good software and PN (in a modest way) supplies some of it. Also, some organization is needed to defend and develop good programming language and style.

PUG (AUS) says I have a credit of 12 (old) issues and that the funds have been sent to you. Please will you accept my re-enrollment and advise me how many (new) issues I am now entitled to?

Finally, I, and I'm sure, many others appreciate your offer to keep PUG/PN going.

Thanks again.

Yours sincerely,

Peter Edwards
40 Davison St.
Mitcham, Vic.
Australia 3132

December 3, 1982

Best wishes in this venture, Charlie. I agree that *Pascal News* and P.U.G. are worth saving.

John W. Baxter
750 State Street, Apt. #224
San Diego, California 92101

February, 1983

You people have ripped me off for the last time!

By your own back order form (attached) you show that my renewal in 1981 paid for 3 issues mailed in 1982. But then, WHAT OF MY RENEWAL PAID IN 1982? ONLY ONE ISSUE #24 COUNTS??? AND THAT HAD TWO PREVIOUSLY PUBLISHED PRO-

GRAMS!! (That is, programs I had ALREADY received.) If you ran a decent organization, you'd make my 1982 renewal count for 1983 also.

David S. Bakin
Softech Inc.
360 Totten Pond Road
Waltham, MA 02154

December 24, 1982

We're indebted to you, Charlie!

Wayne N. Overman
3522 Rockdale Ct.
Baltimore, MD 21207

February 17, 1983

Dear Mr. Gaffney,

I am one of those folks who does not have a currently correct address with *Pascal News*.

Enclosed is a check for $5 for a copy of issue 19 which was returned to you.

Thank you on behalf of all the members of the user's group for the effort you are putting out. It is very much appreciated.

Tom Bishop
P.O. Box A
Kenmore, WA 98028

March 14, 1983

Dear Sir or Ms.:

We plan to offer Pascal at our school. I would appreciate receiving information on your group and, if possible, a sample copy of *Pascal News*.

Any suggestions or information you could send would be appreciated. We are particularly concerned that the new Apple 2-E does not support Pascal with one disk drive. We had hoped tht UCSD Pascal with one drive would work on the Apple 2-E.

Thanks for your help.

Sincerely,

Harold Baker
Director, Computer Science
Litchfield High School
Litchfield, CT 06759

February 11, 1983

Hi!

Here's my renewal. I really enjoy *Pascal News* and have been upset about what has happened with it the past 18 months or so. It has been of substantive value to me, particularly in the area of the style of Pascal coding among the community that have submitted articles.

I would like to see more articles on Modula 2, Wirth's follow on to Pascal and Ada in parallel. To me, this would seem a way of keeping PUG alive as well as providing a growth path to these languages for Pascal programmers.

I use Pascal/VS extensively at work and I have found its extensions the best of any other Pascal compiler for S/370 compatible machines. Almost all of its extensions are within the "spirit" of Pascal and uses a very good extension to STRING data. Of particular convenience is its READSTR and WRITESTR functions (they are procedures actually -unfortunately). I force the concept of function upon them by embedding their invocation within a function when required.

I never received issues 20 and 21 of *Pascal News* during the confusion, although I did mention this at times. I would certainly purchase them separately, but I am not prepared to purchase two sets to get them. Please advise.

Thanks for your work,

Bob Dinah
630 Alvarado St. #207
San Francisco, CA 94114

November 12, 1982

Dear Pascal User's Group:

The only source of information that I have on the Pascal User's Group came from "The BYTE Book of Pascal", according to an article written by Kenneth Bowles. An editor's note of July 1, 1979 listed the annual newsletter as $6.00 per year. I am enclosing $12.00 in case things have increased since that date. If this amount is insufficient, please make it up on back issues.

I am currently using an Apple /// with Apple computer's version of UCSD Pascal. There does not seem to be more than a dozen books written on Pascal, and just a few on UCSD.

I am an ex-electrical engineer, turned to building construction. Previously, I worked for Westinghouse Research Center in Pittsburgh, and used the Burroughs B6500 main frame computer with ALGOL language. The B6500 used a number of formats and types that I miss; the Fixed Format was especially useful since it allowed the user to specify the number of total digits and the number of decimal digits combined. I would like to use this format in UCSD Pascal.

Thanks for taking the time to help me.

Very truly yours,

Larry J. Moorhead
5207 – 32nd Street East
Bradenton, Florida 33508

18 March 1983

Dear Sirs,

For the first time we have received a copy of *Pascal News*, and it has been read with great interest.

We would like to join your User Group but cannot find either a price or contact address for our region.

Please send us this information as soon as possible,

so that we can become members and start receiving your journal on a regular basis.

We have taken note of your abhorrance of paperwork (and endorse the sentiment) and will send the necessary prepayment once we receive the information.

Yours sincerely,

Bette Kun
Librarian
Control Data
P.O. Box 78105
Sandton, South Africa 2146

20 April 1983

Dear Mr. Shaw:

Enclosed is a check for $10.00 for a one-year subscription to the PASCAL Users' Group Newsletter. We have just recently acquired PASCAL-2 here at Villanova and our students are using it on LSI-11 systems running RT-11 V4.0 for applications involving real-time control, data acquisition, and computer communications.

Sincerely yours,

Richard J. Perry, Ph.D.
Villanova University
Dept. of Electrical Engineering
Villanova, PA 19085

15th February, 1983

Dear Mr Gaffney,

As a long PUG user the demise of PUG-AUS is a blow. Anyhow, as you can see from the attached letter I would *love to continue* and thus need your help.

Could you please detail the fees for 1983 for us ''down under'' for surface mail and air mail and as you can see I'm afraid I've not got issue number 21. Can you help?

For interest I use:

UCSD Pascal/p-System	ERA-50 Computer (8-bit, 8085 base)
Pascal MT+ under CP/M	ERA-50 Computer (8-bit, 8085 base)
and MP/M	ERA-50 Computer (8-bit, 8085 base)
Pascal MT+86 under CP/M-86	ERA-80 Computer (16 bit, 8086/8087 based)
and MP/M-86	ERA-80 Computer (16 bit, 8086/8087 based)

Regards,

Dr. William J. Caelli, F.A.C.S.
President
ERACOM Group of Companies
P.O. Box 5488, G.C.M.C.
Qld. 4217, Australia

1-8-82

Dear Sir/Madam,

This is the first letter I write to contact you. Let me introduce myself first. I am a student pursuing a computer course in the Hong Kong Polytechnic — a licensed user of your OMSI-PASCAL-2 V1.2. I don't know what your definition of user may be. May it be my Polytechnic or any student or programmer who use your OMSI PASCAL-1 under the Polytechnic, I venture to call myself a user in this letter, and would like to join the Pascal Users' Group and receive the newsletter.

In the past few months, I have been doing extensive programming using PASCAL, and find it very handy, especially in writing structured programs. However, until recently when I develop some system programs, I find problems. I discover that there is no source listing or documentation on the OMSI PASCAL-1 run time system (possibly in file FPP.RTS) and its relationship with RSTS/E, and I cannot interface with the low level I/O trap handlers without knowing their details. I find some problems on the RESET ODT mode, but I cannot deal with it in assembly level.

All in all, my problem is highly personal and does not in any way bear relation with the Hong Kong Polytechnic. However, as a student on computing, I don't want to leave problem unsolved. So, please send me any informational help, if possible.

Included please find a bank draft of $6 for subscription.

May I state once more my request. I need information on OMSI PASCAL-1 run time system especially the EMT trap handling.

Thank you very much in advance.

Yours faithfully,

Mr Kam Man-Kai
Flat 8
3/F Ting Yin House
Siu On Court
Tuen Mun – N.T.
Hong Kong

6th November, 1982.

Dear Mr. Mickel,

I am a student of computing studies in the H.K. Polytechnic. Recently, I got a chance to buy a Chinese version of 'A Practical Introduction to Pascal' by Wilson & Addyman from which I was informed that there is a PUG in States.

Briefly understanding the objectives of the PUG, I find myself in great interest in joining the group. Would youb be so kind as to provide me with further information as far as the PUG is concerned. I am eagerly looking forward to your reply.

Yours sincerely,

Alan Kwong
12, Boundary St.
Po Hing Bldg.
8/F, Block 'C'
Kln., H.K.

December 23, 1982

We have been using Oregon Software's RT-11 Pascal implementations for over three years with excellent results and complete satisfaction; Pascal is used for scientific "number crunching", program development, algorithm testing, etc.

Bob Schor
The Rockefeller University
1230 York Avenue
New York, NY 10021

December 30, 1982

A worthwhile journal.

George Williams
Union College
Schenectady, NY 12308

March 22, 1983

Dear Mr. Gaffney:

I have previously received *Pascal News* through University of Tasmania. Is it still published? If so, do I have any credit on my subscription dues? I would also be interested in information about USUS.

Yours sincerely,

M.J. Palmer
CSIRO
Private Bag
P.O. Wembley, W.A. 6014

February 3, 1983

Good job, Charlie! and good luck to the renewed *Pascal News*!

Norman W. Molhant
320 Principale
Tres-Saint-Redempteur, P.Q.
Canada J0P 1P0

May 1, 1983

A professor in Ithaca, NY told me there exists a public domain UCSD Pascal available for micro's.

I have a 60K Z-80 which uses memory map video, and a 63K 8085/8088 (both machines S-100 bus) which uses a TVI 950. I also have a H-29 terminal (like Z-19 but with a detached keyboard).

Is there really any way of getting this UCSD Pascal running on one of my systems? (I have UCSD on the Sage also Modula-2. Good stuff.)

Thanks,

J. E. Pournelle, Ph.D.
12051 Laurel Terrace
Studio City, CA 91604

Program APLscanner

By Vincent Dichristofano, Alan Kaniss, Thomas Robinson, and John Santini
NADC, Philadelphia, PA

```
program APLscanner(input { + TERMINAL }, output , APLfile );

{
 * Purpose:
     This program is an implementation of APL in Pascal.

 * Authors:
     Vincent Dichristofano
     Alan Kaniss
     Thomas Robinson
     John Santini
          authors' affiliation - NADC

                                  Phil. PA. USA

     project leader:  Dr. Joseph Mezzaroba

     This program was written as part of an independent study
     course at Villanova University.

 * Submitted and accepted for Pascal News. DEC 1976.

 }
label
  100;

const
  prefix1 = 60;
  prefix2 = 62 { prefix for CDC ASCII 12-bit codes };
  MaxVarNameLength = 10;
  MaxINputLine = 132;
  InputArraySize = 134;
  NumberOfMessages = 100;
  MessageLength = 80;

type
  PackedString = packed array [1 .. MaxVarNameLength] of 0 .. 8191;
  TokenNoum =
    (FormRes, FormArg, GlobVar, MonadOper, ReductOper, DyadOper,
     SpecOper, constant, StatEnd);
  values = record
             RealVal: real;
             NextValue: ^values
           end;
  VarTab = record
             VarName: PackedString { v1 };
             FuncTabPtr: ^FuncTab { v2 - ftab };
             ValTabPtr: ^ValTab { v3 - vtab };
             DeferedValTabPtr: ^FParmTab;
             NextVarTabPtr: ^VarTab
           end;
  ValTab = record
             IntermedResult: Boolean;
             dimensions: integer;
             FirstDimen: ^DimenInfo;
             ForwardOrder: Boolean;
             FirstValue: ^values;
             NextValTabLink: ^ValTab
           end;
  TokenTable = record
                 NextToken: ^TokenTable;
                 case noun: TokenNoum of { p }
                   FormRes, FormArg, GlobVar: { vtab }
                               (VarTabPtr: ^VarTab);
                   MonadOper: (MonIndex: integer);
                   ReductOper: (RedIndx: integer);
                   DyadOper: (DOpIndx: integer);
                   SpecOper: (CharIndx: integer);
                   constant: (ValTabPtr: ^ValTab);
                   StatEnd: (EndAdj: integer)
               end;
  vfunc = record
            NextStmnt: ^TokenTable;
            NextVFunPrt: ^vfunc;
            StatLabel: PackedString
          end;
  OperatorTypr = (niladic, monadic, dyadic);
  FuncTab = record
              FuncName: PackedString { f1 };
              arity: OperatorType { f2 };
              result: Boolean { f3   true = explicit };
              ResultName: PackedString { f4 };
              LeftArg: PackedString { f5 };
              RightArg: PackedString { f6 };
              FirstStatement: ^vfunc;
              NextFuncTabPtr: ^FuncTab;
              NumOfStatements: integer
            end;
  FParmTab = record
               PtrVal: ^ValTab { sd1 and sd2 };
               LastParm: ^FParmTab { link to last }
                                   { sd1 or sd2 }
             end;
  DimenInfo = record
                NextDimen: ^DimenInfo;
                dimenlength: integer
              end;
  OpRecord = record
               OpIndex: integer;
               OpSymbol: integer
             end;
  OperandTab = record
                 OperPtr: ^ValTab { sval };
                 LastOper: ^OperandTab { link to last sval }
               end;
  SubrTab = record { sf }
              CalledSubr: ^FuncTab { s1 };
              TokenCallingSubr: ^TokenTable { s2 };
              StatemCallingSubr: ^vfunc { s3 };
              LastSubrPtr: ^SubrTab { link to last sf }
            end;
  OpTable = array [1 .. 16] of OpRecord;
  VarTabPtrType = ^VarTab;
  TypeValTabPtr = ^ValTab;
  TokenPtr = ^TokenTable;
  PtrFuncTab = ^FuncTab;
  TypeValuesPtr = ^values;
  APLcharSet =
    (asymbol, Bsymbol, CSymbol, DSymbol, ESymbol, FSymbol, GSymbol,
     HSymbol, ISymbol, JSymbol, KSymbol, LSymbol, MSymbol, NSymbol,
     OSymbol, PSymbol, QSymbol, RSymbol, SSymbol, TSymbol, USymbol,
     VSymbol, WSymbol, XSymbol, YSymbol, ZSymbol, OneSymbol, TwoSymbol,
     ThreeSymbol, FourSymbol, FiveSymbol, SixSymbol, SevenSymbol,
     EightSymbol, NineSymbol, ZeroSymbol, colon, RightArrow, LeftArrow,
     SmallCircle, period, LeftParen, RightParen, LeftBracket,
     RightBracket, semicolon, quadrangle, space, plus, minus, times,
     divide, asterisk, iota, rho, comma, tilde, equals, NotEqual,
     LessThne, LessOrEqual, GreaterOrEqual, GreaterThan, AndSymbol,
     OrSymbol, ceiling, floor, LargeCircle, ForwardSlash, DoubleQuote,
     negative, QuestionMark, omega, epsilon, UpArrow, DownArrow, alpha,
     UnderScore, del, delta, SingleQuote, EastCap, WestCap, SouthCap,
     NorthCap, ibeam, TBeam, VerticalStroke, BackwardSlash);

     text = file of char;

var
  XColonSym, XRightArrow, XLeftArrow, XLittleCircle, XPeriod, XLeftPar,
     XRightPar, XLeftBracket, XRightBracket, XSemicolon, XQuadSym:
     integer;
  character: array [APLcharSet] of integer;
  APLstatement: array [1 .. InputArraySize] of integer;
  digits: array [OneSymbol .. ZeroSymbol] of integer;
  ErrorMsgs: packed array [1 .. NumberOfMessages, 1 .. MessageLength] of
     char;
  APLfile: text;
  MOpTab, DOpTab, RedTab, CharTab, SpecTab: OpTable;
  SaveLabel: PackedString;
  name: PackedString;
  NewTokenPtr, OldTokenPtr, HoldTokenPtr, SaveTokenPtr: ^TokenTable;
  TestFuncPtr, NewFuncTabPtr, OldFuncTabPtr: ^FuncTab;
  NewVarTabPtr, OldVarTabPtr: ^VarTab;
  LeftValPtr, RightValPtr, ValPtr: ^values;
  NewValues, NewValPtr: ^values;
  NewDim: ^DimenInfo;
  DimPtr, NewPtr, LeftDimPtr, RigthDimPtr: ^DimenInfo;
  VarPointer: ^VarTab;
  OldVFuncPtr, NewVFuncPtr: ^vfunc;
  NewValTabLink, OldValTabLink: ^ValTab;
  position: integer;
  LineLength: integer;
  code, ColCnt: integer;
  FuncStatements: integer;
  TokenError, FirstFunction: Boolean;
  LineTooLong, HasLabel: Boolean;
  switch, FunctionMode, TokenSwitch, ItsAnIdentifier: Boolean;
  OperTabPtr: ^OperandTab { sv };
```

```
  PtrLastOper: ^OperandTab;
  SubrTabPtr: ^SubrTab;
  RParmPtr: ^FParmTab {  p1  };
  LParmPtr: ^FParmTab {  p2  };
  VFuncPtr: ^vfunc {  nl  };
  hold: ^TokenTable {  holds last symbol  };


procedure InitParser;

  begin
    OperTabPtr := nil;   SubrTabPtr := nil;   LParmPtr := nil;
    RParmPtr := nil;   VFuncPtr := nil;   hold := nil;   XColonSym := 1;
    XRightArrow := 2;   XLeftArrow := 3;   XLittleCircle := 4;
    XPeriod := 5;   XLeftPar := 6;   XRightPar := 7;
    XLeftBracket := 8;   XRightBracket := 9;   XSemicolon := 10;
    XQuadSym := 11;   new(OperTabPtr);   OperTabPtr^.LastOper := nil;
    PtrLastOper := OperTabPtr;
  end { initparser };


procedure InitializeCharacterSet
   { read installation character set from file };

  var
    TestForPrefix: integer;
    FileCharacter: char;
    SymbolIndex: APLcharSet;

  begin
    reset(APLfile);
    for SymbolIndex := asymbol to BackwardSlash do
      begin
        read(APLfile, FileCharacter);

  {  The following code would be removed for non-CDC installations  }

        TestForPrefix := ord(FileCharacter);
        if (TestForPrefix = prefix1) or (TestForPrefix = prefix2)
        then
          begin
            read(APLfile, FileCharacter);
            character[SymbolIndex] := 100 * TestForPrefix + ord(
               FileCharacter);
          end
        else

  {                                                              }
          character[SymbolIndex] := ord(FileCharacter)

      end
  end {  initializecharacterset  };

  procedure ReadInErrorMsgs;

    var
      MsgRow, MsgCol: integer;

    begin
      readln(APLfile);
      for MsgRow := 1 to NumberOfMessages do
        for MsgCol := 1 to MessageLength do
          ErrorMsgs[MsgRow, MsgCol] := ' ';  {  blank out error messages  };
      for MsgRow := 1 to NumberOfMessages do
        begin {  read in error messages from file  }
          MsgCol := 0;
          while not eoln(APLfile) do
            begin
              MsgCol := MsgCol + 1;
              read(APLfile, ErrorMsgs[MsgRow, MsgCol]);
            end;
          readln(APLfile);
        end
    end {  readinerrormsgs  };


  procedure FillUpTables;

    begin

       {          monadic operators            }

      MOpTab[1].OpSymbol := character[plus];   MOpTab[1].OpIndex := 2;
      MOpTab[2].OpSymbol := character[minus];   MOpTab[2].OpIndex := 3;
      MOpTab[3].OpSymbol := character[times];   MOpTab[3].OpIndex := 4;
      MOpTab[4].OpSymbol := character[divide];   MOpTab[4].OpIndex := 5;
      MOpTab[5].OpSymbol := character[asterisk];   MOpTab[5].OpIndex := 6;
      MOpTab[6].OpSymbol := character[iota];   MOpTab[6].OpIndex := 21;
      MOpTab[7].OpSymbol := character[rho];   MOpTab[7].OpIndex := 22;
      MOpTab[8].OpSymbol := character[comma];   MOpTab[8].OpIndex := 23;
      MOpTab[9].OpSymbol := character[tilde];   MOpTab[9].OpIndex := 1;

       {          dyadic operators            }

      DOpTab[1].OpSymbol := character[plus];   DOpTab[1].OpIndex := 52;
      DOpTab[2].OpSymbol := character[minus];   DOpTab[2].OpIndex := 53;
      DOpTab[3].OpSymbol := character[times];   DOpTab[3].OpIndex := 54;
      DOpTab[4].OpSymbol := character[divide];   DOpTab[4].OpIndex := 55;
      DOpTab[5].OpSymbol := character[asterisk];
      DOpTab[5].OpIndex := 56;   DOpTab[6].OpSymbol := character[iota];
      DOpTab[6].OpIndex := 87;   DOpTab[7].OpSymbol := character[rho];
      DOpTab[7].OpIndex := 88;   DOpTab[8].OpSymbol := character[comma];
      DOpTab[8].OpIndex := 89;   DOpTab[9].OpSymbol := character[equals];
      DOpTab[9].OpIndex := 71;
      DOpTab[10].OpSymbol := character[NotEqual];
      DOpTab[10].OpIndex := 72;
      DOpTab[11].OpSymbol := character[LessThne];
      DOpTab[11].OpIndex := 73;
      DOpTab[12].OpSymbol := character[LessOrEqual];
      DOpTab[12].OpIndex := 74;
      DOpTab[13].OpSymbol := character[GreaterOrEqual];
      DOpTab[13].OpIndex := 75;
      DOpTab[14].OpSymbol := character[GreaterThan];
      DOpTab[14].OpIndex := 76;
      DOpTab[15].OpSymbol := character[AndSymbol];
      DOpTab[15].OpIndex := 77;
      DOpTab[16].OpSymbol := character[OrSymbol];
      DOpTab[16].OpIndex := 78;

       {          special character            }

      CharTab[1].OpSymbol := character[colon];
      CharTab[2].OpSymbol := character[RightArrow];
      CharTab[3].OpSymbol := character[LeftArrow];
      CharTab[4].OpSymbol := character[SmallCircle];
      CharTab[5].OpSymbol := character[period];
      CharTab[6].OpSymbol := character[LeftParen];
      CharTab[7].OpSymbol := character[RightParen];
      CharTab[8].OpSymbol := character[LeftBracket];
      CharTab[9].OpSymbol := character[RightBracket];
      CharTab[10].OpSymbol := character[semicolon];
      CharTab[11].OpSymbol := character[quadrangle];
      CharTab[12].OpSymbol := character[space];
      SpecTab[1].OpSymbol := character[colon];
      SpecTab[2].OpSymbol := character[RightArrow];
      SpecTab[3].OpSymbol := character[LeftArrow];
      SpecTab[4].OpSymbol := character[LeftParen];
      SpecTab[5].OpSymbol := character[semicolon];
      SpecTab[6].OpSymbol := character[LeftBracket];

       {          reduction operator           }

      RedTab[1].OpSymbol := character[plus];   RedTab[1].OpIndex := 2;
      RedTab[2].OpSymbol := character[minus];   RedTab[2].OpIndex := 3;
      RedTab[3].OpSymbol := character[times];   RedTab[3].OpIndex := 4;
      RedTab[4].OpSymbol := character[divide];   RedTab[4].OpIndex := 5;
      RedTab[5].OpSymbol := character[asterisk];   RedTab[5].OpIndex := 6;
      RedTab[6].OpSymbol := character[equals];   RedTab[6].OpIndex := 21;
      RedTab[7].OpSymbol := character[NotEqual];
      RedTab[7].OpIndex := 22;
      RedTab[8].OpSymbol := character[LessThne];
      RedTab[8].OpIndex := 23;
      RedTab[9].OpSymbol := character[LessOrEqual];
      RedTab[9].OpIndex := 24;
      RedTab[10].OpSymbol := character[GreaterOrEqual];
      RedTab[10].OpIndex := 25;
      RedTab[11].OpSymbol := character[GreaterThan];
      RedTab[11].OpIndex := 26;
      RedTab[12].OpSymbol := character[AndSymbol];
      RedTab[12].OpIndex := 27;
      RedTab[13].OpSymbol := character[OrSymbol];
      RedTab[13].OpIndex := 28;
      RedTab[14].OpSymbol := character[ceiling];
      RedTab[14].OpIndex := 29;   RedTab[15].OpSymbol := character[floor];
      RedTab[15].OpIndex := 30;
      RedTab[16].OpSymbol := character[LargeCircle];
      RedTab[16].OpIndex := 31;   digits[OneSymbol] := 1;
      digits[TwoSymbol] := 2;   digits[ThreeSymbol] := 3;
      digits[FourSymbol] := 4;   digits[FiveSymbol] := 5;
      digits[SixSymbol] := 6;   digits[SevenSymbol] := 7;
      digits[EightSymbol] := 8;   digits[NineSymbol] := 9;
      digits[ZeroSymbol] := 0;
    end {  filluptables  };


  procedure PrintAPLStatement;

    var
      prefix, num: integer;
      index: integer;

    begin
      for index := 1 to LineLength do
        begin
          if APLstatement[index] > 6000
          then
            begin
              prefix := APLstatement[index] div 100;   write(chr(prefix));
              num := APLstatement[index] - 100 * prefix;
              write(chr(num))
            end
          else write(chr(APLstatement[index]))
        end;
      writeln
    end {  printaplstatement  };


  procedure SError(ErrorIndex: integer);

    var
      MsgCol: integer;

    begin
```

```
371     TokenError := true;
372     for MsgCol := 1 to MessageLength do
373       write(ErrorMsgs[ErrorIndex, MsgCol]);
374     writeln;   PrintAPLStatement {  echo statement to user  };
375     for MsgCol := 1 to(position - 1) do write(' ');
376     writeln(chr(character[UpArrow])) {  print pointer to user error  };
377   end {  error  };
378
379
380 procedure SkipSpaces;
381
382   begin
383     while (APLstatement[position] = character[space]) and (position <=
384        LineLength) do
385       position := position + 1
386   end {  skipspaces  };
387
388
389 procedure GetAPLstatement;
390
391   var
392     InputChar: char;
393     TestForPrefix: integer;
394     FirstTry: Boolean;
395
396   begin
397     for LineLength := 1 to MaxINputLine do
398       APLstatement[LineLength] := character[space] {  blank out line  };
399     LineLength := 0;   FirstTry := true;   position := 1;
400     LineTooLong := false;
401     APLstatement[InputArraySize] := character[omega];
402     APLstatement[InputArraySize - 1] := character[space]
403        {  set end-of-line  };
404     repeat
405       begin
406         if not FirstTry   then getseg(input) {  test for *cr* only  };
407         FirstTry := false;
408         while (not eoln(input)) and (not LineTooLong) do
409           if LineLength < MaxINputLine
410           then
411             begin
412               LineLength := LineLength + 1;   read(InputChar);
413
414   {  The following code would be removed for non-CDC installations  }
415               TestForPrefix := ord(InputChar);
416               if (TestForPrefix = prefix1) or (TestForPrefix = prefix2)
417               then
418                 begin
419                   read(InputChar);
420                   APLstatement[LineLength] := 100 * TestForPrefix + ord(
421                      InputChar);
422                 end
423               else
424
425   {                                                                   }
426
427                 APLstatement[LineLength] := ord(InputChar)
428             end
429           else LineTooLong := true
430       end
431     until LineLength <> 0 {  reject null lines  };
432     if LineTooLong   then SError(71)
433   end {  getaplstatement  };
434
435 function ItsADigit(TestChar: integer): Boolean;
436
437   var
438     DigitIndex: APLcharSet;
439   begin {  test to see if input character is a digit  }
441     ItsADigit := false;
442     for DigitIndex := OneSymbol to ZeroSymbol do
443       if TestChar = character[DigitIndex]   then ItsADigit := true
444   end {  itsadigit  };
445
446
447 function ItsALetter(TestChar: integer): Boolean;
448
449   var
450     LetterIndex: APLcharSet;
451
452   begin {  test to see if input character is a letter  }
453     ItsALetter := false;
454     for LetterIndex := asymbol to ZSymbol do
455       if TestChar = character[LetterIndex]   then ItsALetter := true
456   end {  itsaletter  };
457
458
459 function CharToNum(TestChar: integer): integer;
460
461   var
462     DigitIndex: APLcharSet;
463
464   begin {  chage a character to a number  }
465     for DigitIndex := OneSymbol to ZeroSymbol do
466       if TestChar = character[DigitIndex]
467       then CharToNum := digits[DigitIndex]
468   end {  chartonum  };
469
470
471
472 function NamesMatch(NameOne, NameToo: PackedString): Boolean;
473   var
474     index: integer;
475
476   begin {  see if two names (identifiers) are the same  }
477     NamesMatch := true;
478     for index := 1 to MaxVarNameLength do
479       if NameOne[index] <> NameToo[index]   then NamesMatch := false
480   end {  namesmatch  };
481
482
483 procedure TableLookUp(TestChar, TableLength: integer; table: OpTable;
484    var TableIndex: integer);
485
486   var
487     index: integer;
488
489   begin {  check for membership in a given table  }
490     TableIndex := 0;
491     for index := 1 to TableLength do
492       if TestChar = table[index].OpSymbol   then TableIndex := index
493   end {  tablelookup  };
494
495
496 procedure identifier(var name: PackedString; var ItsAnIdentifier:
497    Boolean);
498
499   var
500     NameLength: integer;
501     NameTooLong: Boolean;
502
503   begin
504     ItsAnIdentifier := false;   SkipSpaces;
505     if ItsALetter(APLstatement[position])
506     then
507       begin
508         NameTooLong := false;   ItsAnIdentifier := true;
509         for NameLength := 1 to MaxVarNameLength do {  blank out name  }
510           name[NameLength] := character[space];
511         NameLength := 0;
512         while (ItsALetter(APLstatement[position])) or (ItsADigit(
513            APLstatement[position])) do
514           begin {  build identifier  }
515             NameLength := NameLength + 1;
516             if NameLength <= MaxVarNameLength
517             then name[NameLength] := APLstatement[position]
518             else NameTooLong := true;
519             position := position + 1
520           end;
521         if NameTooLong
522         then SError(70) {  name greater than maxlength  }
523       end
524   end {  identifier  };
525
526
527 procedure MakeNumber(var RealNumber: real; var ItsANumber: Boolean);
528
529   var
530     sign, DigitCount: integer;
531
532   begin {  convert character input string to numerical representation  }
533     ItsANumber := false;   SkipSpaces;   sign := 1;   DigitCount := 0;
534     RealNumber := 0.0;
535     if (APLstatement[position] = character[negative]) or (ItsADigit(
536        APLstatement[position]))
537     then
538       begin
539         ItsANumber := true;
540         if APLstatement[position] = character[negative]
541         then begin sign := - 1;   position := position + 1 end;
542         if not ItsADigit(APLstatement[position])
543         then
544           begin
545             SError(1) {  digit must follow a minus sign  };
546             ItsANumber := false;
547           end
548         else
549           begin {  form whole number portion  }
551             while ItsADigit(APLstatement[position]) do
552               begin
553                 RealNumber := 10.0 * RealNumber + CharToNum(APLstatement
554                    [position]);
555                 position := position + 1
556               end;
557             if APLstatement[position] = character[period]
558             then
559               begin
560                 position := position + 1;
561                 while ItsADigit(APLstatement[position]) do
562                   begin {  form fractional portion  }
563                     RealNumber := RealNumber + CharToNum(APLstatement[
564                        position]) * exp((- 1.0 - DigitCount) * 2.3025851
565                        );
566                     DigitCount := DigitCount + 1;
567                     position := position + 1;
568                   end;
569                 if DigitCount = 0 then
570                   begin
571                     SError(2) {  digits must follow a decimal point  };
572                     ItsANumber := false;
573                   end
574               end;
```

```
575             RealNumber := RealNumber * sign
576           end
577       end
578   end {  makeanumber  };
579
580
581 function MonadicReference: Boolean;
582
583   var
584     SubPosition, TableIndex: integer;
585
586   begin {  see if operator is monadic within context of input line  }
587     MonadicReference := false;
588     if NewTokenPtr^.NextToken^.noun = StatEnd
589     then MonadicReference := true
590     else
591       begin
592         SubPosition := position - 1;
593         while (SubPosition > 0) and (APLstatement[SubPosition] =
594            character[space]) do
595           SubPosition := SubPosition - 1 {  get last non-blank  };
596         if SubPosition <> 0 then
597           TableLookUp(APLstatement[SubPosition], 6, SpecTab, TableIndex)
598           ;
599         if (TableIndex <> 0) or (SubPosition = 0)
600         then MonadicReference := true
601         else
602           if (NewTokenPtr^.NextToken^.noun <> FormRes) and (NewTokenPtr
603              ^.NextToken^.noun <> FormArg) and (NewTokenPtr^.NextToken ^
604              .noun <> GlobVar) and (NewTokenPtr^.NextToken^.noun <>
605              constant) and (APLstatement[SubPosition] <> character[
606              period]) and (APLstatement[SubPosition] <> character[
607              RightParen]) and (APLstatement[SubPosition] <> character[
608              RightBracket])
609           then MonadicReference := true
610       end
611   end {  monadicreference  };
612
613
614 procedure DyadicOpCheck;
615
616   var
617     TableIndex: integer;
618
619   begin
620     TableLookUp(APLstatement[position], 16, DOpTab, TableIndex);
621     if TableIndex = 0
622     then
623       begin
624         TableLookUp(APLstatement[position], 12, CharTab, TableIndex);
625         if TableIndex = 0
626         then
627           if APLstatement[position] = character[SouthCap]
628           then
629             begin
630               OldTokenPtr := SaveTokenPtr;   dispose(NewTokenPtr);
631               NewTokenPtr := SaveTokenPtr;   position := LineLength + 1;
632             end {  this was a comment - ignore remainder of line  }
633           else SError(4) {  invalid character encountered  }
634         else
635           begin {  special character encountered  }
636             NewTokenPtr^.noun := SpecOper;
637             NewTokenPtr^.CharIndx := TableIndex
638           end
639       end
640     else
641       if MonadicReference
642       then SError(74) { monadic reference to dyadic operator }
643       else
644         begin {  operator is dyadic  }
645           NewTokenPtr^.noun := DyadOper;
646           NewTokenPtr^.DOpIndx := TableIndex
647         end
648   end { dyadicopcheck };
649
650 procedure CheckOtherTables;
651
652   var
653     TableIndex: integer;
654     ChkIndex: integer;
655
656
657   function NextNonBlank: integer;
658
659     begin
660       ChkIndex := position + 1;
661       while (ChkIndex < LineLength) and (APLstatement[ChkIndex] =
662          character[space]) do
663         ChkIndex := ChkIndex + 1;
664       NextNonBlank := APLstatement[ChkIndex];
665     end {  nextnonblank  };
666
667
668   begin { checkothertables }
669     if NextNonBlank = character[ForwardSlash]
670     then
671       begin
672         TableLookUp(APLstatement[position], 16, RedTab, TableIndex);
673         if TableIndex = 0
674         then SError(72) {  invalid reduction operator  }
675         else
676           if not MonadicReference
677           then SError(73) {  dyadic reduction reference  }
678           else
679             begin {  operator is valid reduction operator  }
680               NewTokenPtr^.noun := ReductOper;
681               NewTokenPtr^.RedIndx := TableIndex;
682             end;
683         position := ChkIndex + 1;
684       end
685     else
686       begin
687         TableLookUp(APLstatement[position], 9, MOpTab, TableIndex);
688         if TableIndex = 0   then DyadicOpCheck
689         else
690           if not MonadicReference   then DyadicOpCheck
691           else
692             begin {  operator is monadic  }
693               NewTokenPtr^.noun := MonadOper;
694               NewTokenPtr^.MonIndex := TableIndex;
695             end;
696         position := position + 1;
697       end
698   end {  checkothertables  };
699
700
701
702 procedure TryToGetANumber;
703
704   var
705     NumberCount: integer;
706     RealNumber: real;
707     ItsANumber: Boolean;
708
709   begin
710     NumberCount := 0;   MakeNumber(RealNumber, ItsANumber);
711     if not ItsANumber   then CheckOtherTables
712     else
713       begin {  store values in value table  }
714         new(NewValTabLink);
715         NewValTabLink^.NextValTabLink := OldValTabLink;
716         OldValTabLink := NewValTabLink;
717         NewValTabLink^.ForwardOrder := true;
718         if FunctionMode   then NewValTabLink^.IntermedResult := false
719         else NewValTabLink^.IntermedResult := true;
720         switch := true;
721         while ItsANumber do
722           begin
723             NumberCount := NumberCount + 1;   new(NewValues);
724             if switch
725             then
726               begin
727                 switch := false;
728                 NewValTabLink^.FirstValue := NewValues
729               end
730             else NewValPtr^.NextValue := NewValues;
731             NewValues^.RealVal := RealNumber;   NewValPtr := NewValues;
732             MakeNumber(RealNumber, ItsANumber)
733           end;
734         NewValues^.NextValue := nil;
735         if NumberCount > 1
736         then
737           begin
738             NewValTabLink^.dimensions := 1 {  number is a vector  };
739             new(NewDim);   NewValTabLink^.FirstDimen := NewDim;
740             NewDim^.dimenlength := NumberCount;
741             NewDim^.NextDimen := nil
742           end
743         else
744           begin
745             NewValTabLink^.dimensions := 0 {  number is a scalar  };
746             NewValTabLink^.FirstDimen := nil
747           end;
748         NewTokenPtr^.noun := constant;
749         NewTokenPtr^.ValTabPtr := NewValTabLink;
750       end
751   end {  trytogetanumber  };
752
753
754 function NameInVarTable(name: PackedString; var VarPointer:
755    VarTabPtrType; TestFuncPtr: PtrFuncTab): Boolean;
756
757   var
758     found: Boolean;
759
760   begin
761     found := false;   VarPointer := OldVarTabPtr;
762     while (VarPointer <> nil) and (not found) do
763       begin
764         if (NamesMatch(name, VarPointer^.VarName)) and (VarPointer^.
765            FuncTabPtr = TestFuncPtr) {  test for global var  }
766         then found := true
767         else VarPointer := VarPointer^.NextVarTabPtr
768       end;
769     NameInVarTable := found;
770   end { nameinvartable };
773 procedure AddNameToVarTable(name: PackedString);
774
775     begin {  new variable name encountered  }
776       new(NewVarTabPtr);   NewVarTabPtr^.NextVarTabPtr := OldVarTabPtr;
777       OldVarTabPtr := NewVarTabPtr;   NewVarTabPtr^.VarName := name;
778       NewVarTabPtr^.ValTabPtr := nil;
```

```
    if NewTokenPtr <> nil
    then
      if (NewTokenPtr^.noun = FormRes) or (NewTokenPtr^.noun = FormArg
      )
      then NewVarTabPtr^.FuncTabPtr := NewFuncTabPtr
      else NewVarTabPtr^.FuncTabPtr := nil
  end {  addnametovartable  };


function FunctionAlreadyDefined(var NewFuncName: PackedString; var
    FuncIndex: PtrFuncTab): Boolean;

  var
    found: Boolean;

  begin
    found := false;   FuncIndex := OldFuncTabPtr;
    while (FuncIndex <> nil) and (not found) and (NewFuncTabPtr <>
      nil) do
      if NamesMatch(FuncIndex^.FuncName, NewFuncName)
      then found := true
      else FuncIndex := FuncIndex^.NextFuncTabPtr;
    FunctionAlreadyDefined := found
  end {  functionalreeadydefined  };


procedure MakeTokenLink;

  begin
    new(NewTokenPtr);   NewTokenPtr^.NextToken := OldTokenPtr;
    SaveTokenPtr := OldTokenPtr;   OldTokenPtr := NewTokenPtr
  end {  maketokenlink  };


procedure ProcessFuntionHeader;

  var
    DummyPtr: ^FuncTab;
    name1, name2, name3: PackedString;
    ItsAnIdentifier, FuncHeadError: Boolean;
    AriTyIndex: integer;

  begin
    FuncHeadError := false;   FunctionMode := true;
    FuncStatements := - 1;
    if FirstFunction
    then begin FuncStatements := 0;   FirstFunction := false; end;
    AriTyIndex := 1;   position := position + 1;
    identifier(name1, ItsAnIdentifier);
    if not ItsAnIdentifier
    then
      begin
        SError(7) {  unrecognizable function'argument name  };
        FunctionMode := false {  exit function mode  };
        FuncHeadError := true
      end
    else
      begin
        new(NewFuncTabPtr);   SkipSpaces;
        if APLstatement[position] = character[LeftArrow]
        then
          begin
            NewFuncTabPtr^.result := true {  explicit result  };
            NewFuncTabPtr^.ResultName := name1;
            position := position + 1;
            identifier(name1, ItsAnIdentifier);
            if not ItsAnIdentifier then
              begin
                SError(6)
                    { unrecognizable name to right of explicit res };
                FuncHeadError := true
              end
          end
        else NewFuncTabPtr^.result := false {  no explicit result  };
        SkipSpaces;
        if (position <= LineLength) and (not FuncHeadError)
        then
          begin
            identifier(name2, ItsAnIdentifier);
            if not ItsAnIdentifier
            then
              begin
                SError(7) {  invalid function'argument name  };
                FuncHeadError := true
              end
            else AriTyIndex := 2
          end;
        SkipSpaces;
        if (position <= LineLength) and (not FuncHeadError)
        then
          begin
            identifier(name3, ItsAnIdentifier);
            if not ItsAnIdentifier
            then
              begin
                SError(9) {  invalid function right argument name  };
                FuncHeadError := true
              end
            else AriTyIndex := 3
          end;
        SkipSpaces;
    if (position <= LineLength) and (not FuncHeadError) then
          begin
            SError(3)
                { extraneous characters to right of function header  };
            FuncHeadError := true
          end;
        case AriTyIndex of
          1:
            begin
              NewFuncTabPtr^.arity := niladic;
              NewFuncTabPtr^.FuncName := name1;
            end;
          2:
            begin
              NewFuncTabPtr^.arity := monadic;
              NewFuncTabPtr^.FuncName := name1;
              NewFuncTabPtr^.RightArg := name2;
              AddNameToVarTable(name2);
              NewVarTabPtr^.FuncTabPtr := NewFuncTabPtr;
            end;
          3:
            begin
              NewFuncTabPtr^.arity := dyadic;
              NewFuncTabPtr^.LeftArg := name1;
              NewFuncTabPtr^.FuncName := name2;
              NewFuncTabPtr^.RightArg := name3;
              AddNameToVarTable(name1);
              NewVarTabPtr^.FuncTabPtr := NewFuncTabPtr;
              AddNameToVarTable(name3);
              NewVarTabPtr^.FuncTabPtr := NewFuncTabPtr;
            end
        end {  case  };
        if FunctionAlreadyDefined(NewFuncTabPtr^.FuncName, DummyPtr)
        then
          begin
            SError(5) {  function already defined  };
            FuncHeadError := true;
          end;
        if FuncHeadError then
          begin
            dispose(NewFuncTabPtr) {  header no good  };
            FunctionMode := false {  exit function mode  };
            NewFuncTabPtr := OldFuncTabPtr;
          end
      end
  end {  processfuncheader  };


procedure DestroyStatement;

  var
    DumTokenPtr: ^TokenTable;
    AuxSubrTabPtr: ^SubrTab;

  begin
    if SubrTabPtr <> nil
    then
      begin
        while SubrTabPtr^.LastSubrPtr <> nil do
          begin
            AuxSubrTabPtr := SubrTabPtr;
            SubrTabPtr := SubrTabPtr^.LastSubrPtr;
            dispose(AuxSubrTabPtr);
          end;
        dispose(SubrTabPtr);
      end;
    DumTokenPtr := OldTokenPtr;
    while DumTokenPtr <> HoldTokenPtr do
      begin
        OldTokenPtr := OldTokenPtr^.NextToken;   dispose(DumTokenPtr);
        DumTokenPtr := OldTokenPtr
      end;
    NewTokenPtr := HoldTokenPtr;
    OldTokenPtr := HoldTokenPtr
       {  return pointer to end of last good line  }
  end {  destroystatement  };


procedure ReverseLinkList(var ArgPtr: TypeValTabPtr);

  var
    hold, TemPtr: ^values;

  begin {  reverselinklist  }
    ValPtr := ArgPtr^.FirstValue;   TemPtr := ValPtr^.NextValue;
    while TemPtr <> nil do
      begin
        hold := TemPtr^.NextValue;   TemPtr^.NextValue := ValPtr;
        ValPtr := TemPtr;   TemPtr := hold
      end;
    ArgPtr^.FirstValue^.NextValue := nil;
    ArgPtr^.FirstValue := ValPtr;
    if ArgPtr^.ForwardOrder
    then ArgPtr^.ForwardOrder := false
    else ArgPtr^.ForwardOrder := true {  toggle list order switch  }
  end {  reverselinklist  };


procedure parser(var TokenTabPtr: TokenPtr; var PtrToDa: TypeValTabPtr);

  var
```

```
    VFuncHold: ^vfunc {  hold while searching  };
    AuxOperTabPtr: ^OperandTab;
    AuxSubrTabPtr: ^SubrTab;
    AuxRParmPtr: ^FParmTab;
    AuxLParmPtr: ^FParmTab;
    ValidExp: Boolean {  true if valid expression  };
    cnt: integer;
    npv: integer {  number of indices  };
    assign, assign1: Boolean {  assign.in progress  };
    DoneSuccessor: Boolean;
    DoneParse: Boolean;


  procedure error(ErrorIndex: integer);

    var
      MsgCol: integer;

    begin
      write(' ', ErrorIndex, '  ');
      for MsgCol := 1 to MessageLength do
        write(ErrorMsgs[ErrorIndex, MsgCol]);
      writeln;   goto 100 {  return to scanner  };
    end {  error  };


  procedure release;

    begin {  releaseopertab  }
      OperTabPtr := PtrLastOper;
      while OperTabPtr^.LastOper <> nil do
        begin
          AuxOperTabPtr := OperTabPtr;
          OperTabPtr := OperTabPtr^.LastOper;   dispose(AuxOperTabPtr);
        end;
    end {  releaseopertab  };


  procedure expression(var ValidExp: Boolean);
    forward;


  procedure ReturnToCallingSubr;

    var
      NamePtr: ^VarTab;

    begin {  returntocallingsubr  }
      if SubrTabPtr^.CalledSubr^.result
      then
        begin {  place explicit result in opertab  }
          if not NameInVarTable(SubrTabPtr^.CalledSubr^.ResultName,
              NamePtr, SubrTabPtr^.CalledSubr)
          then error(11) {  'symbol not found'  }
          else
            begin
              AuxOperTabPtr := OperTabPtr;   new(OperTabPtr);
              OperTabPtr^.LastOper := AuxOperTabPtr;
              PtrLastOper := OperTabPtr;
              OperTabPtr^.OperPtr := NamePtr^.ValTabPtr;
            end;
        end;
    {  return to calling function  }
      VFuncPtr := SubrTabPtr^.StatemCallingSubr;
      TokenTabPtr := SubrTabPtr^.TokenCallingSubr^.NextToken;
      if SubrTabPtr^.CalledSubr^.arity <> niladic
      then
        begin {  monadic or dyadic  }
          AuxRParmPtr := RParmPtr;   RParmPtr := RParmPtr^.LastParm;
          dispose(AuxRParmPtr);
          if SubrTabPtr^.CalledSubr^.arity = dyadic then
            begin {  dyadic only  }
              AuxLParmPtr := LParmPtr;
              LParmPtr := LParmPtr^.LastParm;   dispose(AuxLParmPtr);
            end;
        end;
      AuxSubrTabPtr := SubrTabPtr;
      SubrTabPtr := SubrTabPtr^.LastSubrPtr;   dispose(AuxSubrTabPtr);
    end {  returntocallingsubr  };


  function SpecSymbol(sym: integer): Boolean;

    var
      ValidSym: Boolean;

    begin {  specsymbol  }
      ValidSym := false;
      if TokenTabPtr^.noun = SpecOper
      then
        if TokenTabPtr^.CharIndx = sym then
          begin
            hold := TokenTabPtr;
            TokenTabPtr := TokenTabPtr^.NextToken;   ValidSym := true;
          end;
      SpecSymbol := ValidSym;
    end {  specsymbol  };


  procedure CallSubr;

  var
    PtrToVarTab: ^VarTab;

  begin {  callsubr  }
    if SubrTabPtr^.CalledSubr^.arity <> niladic
    then
      begin
        if not NameInVarTable(SubrTabPtr^.CalledSubr^.RightArg,
            PtrToVarTab, SubrTabPtr^.CalledSubr)
        then error(32);
        if PtrToVarTab^.FuncTabPtr <> SubrTabPtr^.CalledSubr
        then error(32) {  program logic error, variable name of  };
      {  function argument not found in symbol table  }
        AuxRParmPtr := RParmPtr;   new(RParmPtr);
        RParmPtr^.LastParm := AuxRParmPtr;
        PtrToVarTab^.DeferedValTabPtr := RParmPtr;
        if SubrTabPtr^.CalledSubr^.arity = dyadic
        then
          begin {  if dyadic  }

              if not NameInVarTable(SubrTabPtr^.CalledSubr^.LeftArg,
                  PtrToVarTab, SubrTabPtr^.CalledSubr)
              then error(33);
              if PtrToVarTab^.FuncTabPtr <> SubrTabPtr^.CalledSubr
              then error(33) {  same as error(32)  };
              AuxLParmPtr := LParmPtr;   new(LParmPtr);
              LParmPtr^.LastParm := AuxLParmPtr;
              PtrToVarTab^.DeferedValTabPtr := LParmPtr;
              LParmPtr^.PtrVal := OperTabPtr^.OperPtr;
              AuxOperTabPtr := OperTabPtr;
              OperTabPtr := OperTabPtr^.LastOper;
              dispose(AuxOperTabPtr);   PtrLastOper := OperTabPtr;
            end;
          RParmPtr^.PtrVal := OperTabPtr^.OperPtr;
          AuxOperTabPtr := OperTabPtr;
          OperTabPtr := OperTabPtr^.LastOper;   dispose(AuxOperTabPtr);
          PtrLastOper := OperTabPtr;
        end;
      TokenTabPtr := SubrTabPtr^.CalledSubr^.FirstStatement^.NextStmnt;
      VFuncPtr := SubrTabPtr^.CalledSubr^.FirstStatement;
    end {  callsubr  };


  function FunctCall: Boolean;

    var
      PtrToFuncTab: ^FuncTab;
      NameOfFunc: PackedString;
      ValidFn: Boolean;

    begin {  functcall  }
      ValidFn := false;
      if TokenTabPtr^.noun = GlobVar
      then
        begin
          NameOfFunc := TokenTabPtr^.VarTabPtr^.VarName;
          if FunctionAlreadyDefined(NameOfFunc, PtrToFuncTab)
          then
            begin
              AuxSubrTabPtr := SubrTabPtr;   new(SubrTabPtr);
              SubrTabPtr^.LastSubrPtr := AuxSubrTabPtr;
              SubrTabPtr^.CalledSubr := PtrToFuncTab;
              SubrTabPtr^.TokenCallingSubr := TokenTabPtr;
              SubrTabPtr^.StatemCallingSubr := VFuncPtr;
              hold := TokenTabPtr;
              TokenTabPtr := TokenTabPtr^.NextToken;   ValidFn := true;
            end;
        end;
      FunctCall := ValidFn;
    end {  functcall  };


  procedure NunWrite(RealNo: real);

    var
      prefix, root: integer;
      SigDig, ColCnt: integer;

    begin {  output a number  }
      if RealNo >= 0.0
      then write(' ', RealNo: 12: 2) {  output positive number  }
      else
        begin {  output negative number  }
          RealNo := - 1.0 * RealNo;
          SigDig := trunc((ln(RealNo)) / (ln(10.0)));
          for ColCnt := 1 to(7 - SigDig) do write(' ');
          if character[negative] < 6000
          then write(chr(character[negative]))
          else
            begin
              prefix := character[negative] div 100;
              root := character[negative] - (100 * prefix);
              write(chr(prefix), chr(root));
            end;
          SigDig := SigDig + 5;   write(RealNo: SigDig: 2);
        end
    end {  numwrite  };


  procedure OutPutVal;
```

```
1182    var
1183      cnt: integer;
1184      AuxValuesPtr: ^values;
1185      DimHold, dimen1, dimen2, dimen3: integer;
1186      OutCnt1, OutCnt2, OutCnt3: integer;
1187      idimens: integer;
1188
1189    begin { outputval }
1190      cnt := 0;   writeln;   writeln;
1191      if not OperTabPtr^.OperPtr^.ForwardOrder
1192      then ReverseLinkList(OperTabPtr^.OperPtr);
1193      AuxValuesPtr := OperTabPtr^.OperPtr^.FirstValue;
1194      idimens := OperTabPtr^.OperPtr^.dimensions;
1195      if not (idimens in [0 .. 3])
1196      then
1197        begin
1198          for ColCnt := 1 to MessageLength do
1199            write(ErrorMsgs[60, ColCnt]);
1200          writeln;
1201        end
1202      else
1203        if AuxValuesPtr = nil
1204        then
1205          begin
1206            for ColCnt := 1 to MessageLength do
1207              write(ErrorMsgs[61, ColCnt]);
1208            writeln;
1209          end
1210        else
1211          if idimens = 0
1212          then begin NunWrite(AuxValuesPtr^.RealVal);   writeln; end
1213          else
1214            begin
1215              dimen1 := OperTabPtr^.OperPtr^.FirstDimen^.dimenlength;
1216              if idimens >= 2
1217              then
1218                dimen2 := OperTabPtr^.OperPtr^.FirstDimen^.NextDimen
1219                  ^.dimenlength
1220              else dimen2 := 1;
1221              if idimens = 3
1222              then
1223                dimen3 := OperTabPtr^.OperPtr^.FirstDimen^.NextDimen
1224                  ^.NextDimen^.dimenlength
1225              else dimen3 := 1;
1226              if idimens = 3 then
1227                begin { rotate dimensions }
1228                  DimHold := dimen1;   dimen1 := dimen2;
1229                  dimen2 := dimen3;   dimen3 := DimHold;
1230                end;
1231              for OutCnt3 := 1 to dimen3 do
1232                begin
1233                  for OutCnt2 := 1 to dimen1 do
1234                    begin
1235                      for OutCnt1 := 1 to dimen2 do
1236                        begin
1237                          cnt := cnt + 1;
1238                          if (((cnt - 1) mod 5) = 0) and (cnt <> 1)
1239                          then begin writeln;   write(' '); end;
1240                          NunWrite(AuxValuesPtr^.RealVal);
1241                          AuxValuesPtr := AuxValuesPtr^.NextValue;
1242                        end;
1243                      if idimens >= 2
1244                      then begin writeln;   cnt := 0; end;
1245                    end;
1246                  writeln;   writeln;
1247                end;
1248            { writeln; }
1249            end;
1250    end { outputval };
1251
1252
1253  function variable: Boolean;
1254
1255    var
1256      globOrDummy: Boolean { gord };
1257      PassedAdj: ^VarTab { k };
1258      rarg: Boolean { rd };
1259      ParmPtr: ^ValTab { pt };
1260      ValidVar: Boolean;
1261      ValidIndex: Boolean;
1262
1263
1264    procedure InputVal;
1265
1266      var
1267        AuxPtrToDa: ^ValTab;
1268        AuxValuesPtr: ^values;
1269        Aux2ValuesPtr: ^values;
1270        RealV: real;
1271        boolv: Boolean;
1272        ccntr, cnt: integer;
1273        AuxDimenFoPtr: ^DimenInfo;
1274
1275      begin { inputval }
1276        cnt := 0;   position := 1;   AuxPtrToDa := PtrToDa;
1277        new(PtrToDa);   AuxPtrToDa^.NextValTabLink := PtrToDa;
1278        AuxOperTabPtr := OperTabPtr;   new(OperTabPtr);
1279        PtrLastOper := OperTabPtr;
1280        OperTabPtr^.LastOper := AuxOperTabPtr;
1281        OperTabPtr^.OperPtr := PtrToDa;   new(Aux2ValuesPtr);
1282        PtrToDa^.FirstValue := Aux2ValuesPtr;
1283        for ccntr := 1 to MessageLength do write(ErrorMsgs[63, ccntr]);
1284        writeln;   readln;   GetAPLstatement;
1285        repeat
1286          MakeNumber(RealV, boolv);   SkipSpaces;
1287          if not boolv
1288          then
1289            begin
1290              for ColCnt := 1 to MessageLength do
1291                write(ErrorMsgs[62, ColCnt]);
1292              writeln;   position := 1;   cnt := 0;
1293              Aux2ValuesPtr := OperTabPtr^.OperPtr^.FirstValue;
1294              for ccntr := 1 to MessageLength do
1295                write(ErrorMsgs[63, ccntr]);
1296              writeln;   readln;   GetAPLstatement
1297            end
1298          else
1299            begin
1300              cnt := cnt + 1;   AuxValuesPtr := Aux2ValuesPtr;
1301              new(Aux2ValuesPtr);   AuxValuesPtr^.RealVal := RealV;
1302              AuxValuesPtr^.NextValue := Aux2ValuesPtr;
1303            end;
1304        until position > LineLength;
1305        dispose(Aux2ValuesPtr);   AuxValuesPtr^.NextValue := nil;
1306        PtrToDa^.IntermedResult := false;   PtrToDa^.dimensions := 1;
1307        PtrToDa^.ForwardOrder := true;
1308        PtrToDa^.NextValTabLink := nil;   new(AuxDimenFoPtr);
1309        PtrToDa^.FirstDimen := AuxDimenFoPtr;
1310        AuxDimenFoPtr^.dimenlength := cnt;
1311        AuxDimenFoPtr^.NextDimen := nil;
1312    end { inputval };
1313
1314
1315  procedure GetArrayPosition(var ValuesPtr: TypeValuesPtr);
1316
1317    var
1318      indice: real;
1319      kcnt: integer;
1320      sl: integer;
1321       AuxDimenFoPtr: ^DimenInfo;
1322
1323    begin { getarrayposition }
1324      if npv <> ParmPtr^.dimensions   then error(35);
1325      { 'wrong num. of subscripts' }
1326      sl := 0;   AuxOperTabPtr := OperTabPtr;
1327      AuxDimenFoPtr := ParmPtr^.FirstDimen;
1328      for kcnt := 1 to npv do
1329        begin
1330          if AuxOperTabPtr^.OperPtr^.dimensions <> 0
1331          then error(35) { 'non-scaler indices' };
1332          indice := AuxOperTabPtr^.OperPtr^.FirstValue^.RealVal;
1333          if indice - 1.0 * trunc(indice) <> 0.0
1334          then error(37) { 'non-integer indices' };
1335          if not (trunc(indice) in [1 .. AuxDimenFoPtr^.dimenlength
1336            ])
1337          then error(38) { 'out of range index' };
1338          sl := (sl * AuxDimenFoPtr^.dimenlength) + trunc(indice) -
1339            1;
1340          AuxOperTabPtr := AuxOperTabPtr^.LastOper;
1341          dispose(OperTabPtr);   OperTabPtr := AuxOperTabPtr;
1342          AuxDimenFoPtr := AuxDimenFoPtr^.NextDimen;
1343        end;
1344      ValuesPtr := ParmPtr^.FirstValue;
1345      while sl <> 0 do { determine which value in }
1346        { pt[sval(sv)][sval(sv-1)]...[sval(sv-npv+1)] }
1347        {          := sval(sv-npv)                    }
1348        begin ValuesPtr := ValuesPtr^.NextValue;   sl := sl - 1; end;
1349    end { getarrayposition };
1350
1351
1352  procedure LinkResults;
1353
1354    var
1355      PtrToValues: ^values;
1356
1357    begin { linkresults }
1358      if npv = 0
1359      then
1360        begin
1361          if not globOrDummy
1362          then
1363            if rarg   then RParmPtr^.PtrVal := OperTabPtr^.OperPtr
1364            else LParmPtr^.PtrVal := OperTabPtr^.OperPtr
1365          else PassedAdj^.ValTabPtr := OperTabPtr^.OperPtr
1366        end
1367      else
1368        begin
1369          if globOrDummy   then ParmPtr := PassedAdj^.ValTabPtr
1370          else ParmPtr := PassedAdj^.DeferedValTabPtr^.PtrVal;
1371          GetArrayPosition(PtrToValues);
1372          if OperTabPtr^.OperPtr^.dimensions <> 0
1373          then error(36) { 'assigned expression not a scalar' };
1374          PtrToValues^.RealVal := OperTabPtr^.OperPtr^.FirstValue ^
1375            .RealVal;
1376        end;
1377      AuxOperTabPtr := OperTabPtr;
1378      OperTabPtr := OperTabPtr^.LastOper;   dispose(AuxOperTabPtr);
1379      PtrLastOper := OperTabPtr;
1380    end { linkresults };
1381
1382
1383  procedure StackPointers;
```

```
1384
1385    var
1386      AuxPtrToDa: ^ValTab;
1387      PtrToValues, AuxValuesPtr: ^values;
1388
1389    begin {  stackpointers  }
1390      ;
1391      if npv = 0
1392      then
1393        begin
1394          AuxOperTabPtr := OperTabPtr;   new(OperTabPtr);
1395          OperTabPtr^.LastOper := AuxOperTabPtr;
1396          OperTabPtr^.OperPtr := ParmPtr;
1397          PtrLastOper := OperTabPtr
1398        end
1399      else
1400        begin
1401          AuxPtrToDa := PtrToDa;   new(PtrToDa);
1402          PtrToDa^.NextValTabLink := AuxPtrToDa;
1403          PtrToDa^.IntermedResult := true;
1404          PtrToDa^.dimensions := 0;   PtrToDa^.FirstDimen := nil;
1405          PtrToDa^.ForwardOrder := true;   new(AuxValuesPtr);
1406          PtrToDa^.FirstValue := AuxValuesPtr;
1407          GetArrayPosition(PtrToValues);
1408          PtrToDa^.FirstValue^.RealVal := PtrToValues^.RealVal;
1409          PtrToDa^.FirstValue^.NextValue := nil;
1410          AuxOperTabPtr := OperTabPtr;   new(OperTabPtr);
1411          OperTabPtr^.LastOper := AuxOperTabPtr;
1412          OperTabPtr^.OperPtr := PtrToDa;
1413          PtrLastOper := OperTabPtr;
1414        end;
1415    end {  stackpointers  };
1416
1417
1418  function SimpleVariable: Boolean;
1419
1420    var
1421      ValidSv: Boolean;
1422
1423    begin {  simplevariable  }
1424      ValidSv := false;   rarg := false;   globOrDummy := false;
1425      if assign
1426      then
1427        begin
1428          if (TokenTabPtr^.noun = FormRes) or (TokenTabPtr^.noun =
1429            GlobVar)
1430          then
1431            begin
1432              globOrDummy := true;
1433              PassedAdj := TokenTabPtr^.VarTabPtr;
1434              hold := TokenTabPtr;
1435              TokenTabPtr := TokenTabPtr^.NextToken;
1436              ValidSv := true
1437            end
1438          else
1439            if TokenTabPtr^.noun = FormArg
1440            then
1441              begin
1442                if NamesMatch(TokenTabPtr^.VarTabPtr^.FuncTabPtr^.
1443                    LeftArg, TokenTabPtr^.VarTabPtr^.VarName)
1444                then rarg := true;
1445                PassedAdj := TokenTabPtr^.VarTabPtr
1446              end
1447        end
1448      else
1449        begin
1450          if (TokenTabPtr^.noun = FormRes) or (TokenTabPtr^.noun =
1451            GlobVar)
1452          then
1453            begin
1454              ParmPtr := TokenTabPtr^.VarTabPtr^.ValTabPtr;
1455              if ParmPtr <> nil then
1456                begin
1457                  hold := TokenTabPtr;
1458                  TokenTabPtr := TokenTabPtr^.NextToken;
1459                  ValidSv := true
1460                end
1461            end
1462          else
1463            begin
1464              if TokenTabPtr^.noun = FormArg
1465              then
1466                begin
1467                  if NamesMatch(TokenTabPtr^.VarTabPtr^.FuncTabPtr ^
1468                      .LeftArg, TokenTabPtr^.VarTabPtr^.VarName)
1469                  then ParmPtr := LParmPtr^.PtrVal
1470                  else ParmPtr := RParmPtr^.PtrVal;
1471                  hold := TokenTabPtr;
1472                  TokenTabPtr := TokenTabPtr^.NextToken;
1473                  ValidSv := true;
1474                end;
1475            end;
1476        end;
1477      SimpleVariable := ValidSv;
1478    end {  simple variable  };
1479
1480
1481  procedure index(var ValidI: Boolean);
1482
1483    var
1484      ValidE1, ValidE2: Boolean;
1485
1486    begin {  index  }
1487      ValidI := false;   expression(ValidE1);
1488      if ValidE1
1489      then
1490        begin
1491          npv := 1 {  no. of index expressions  };
1492          while SpecSymbol(XSemicolon) do
1493            begin
1494              npv := npv + 1;   expression(ValidE2);
1495              if not ValidE2   then error(39);
1496            {  'invalid index expression'  }
1497            end;
1498          ValidI := true;
1499        end;
1500    end {  index  };
1501
1502
1503  begin {  variable  }
1504    ValidVar := false;   npv := 0;
1505    if not assign
1506    then
1507      if SpecSymbol(XQuadSym)
1508      then begin InputVal;   ValidVar := true end
1509      else
1510        begin
1511          if SpecSymbol(XRightBracket)
1512          then
1513            begin
1514              index(ValidIndex);
1515              if (not ValidIndex) or (not SpecSymbol(XLeftBracket))
1516              then error(34) {  invalid index expression  };
1517            end;
1518          if SimpleVariable
1519          then begin StackPointers;   ValidVar := true end
1520        end
1521    else
1522      if SpecSymbol(XQuadSym)
1523      then begin OutPutVal;   ValidVar := true end
1524      else
1525        begin
1526          if SpecSymbol(XRightBracket)
1527          then
1528            begin
1529              index(ValidIndex);
1530              if (not ValidIndex) or (not SpecSymbol(XLeftBracket))
1531              then error(34) {  invalid index expression  };
1532            end;
1533          if SimpleVariable
1534          then begin LinkResults;   ValidVar := true; end;
1535        end;
1536    variable := ValidVar;
1537  end {  variable  };
1538
1539
1540  procedure primary(var valid: Boolean) {  recursive entry  };
1542    var
1543      ValidX: Boolean;
1544      assign: Boolean;
1545
1546
1547    function vector: Boolean;
1548
1549      var
1550        vec: Boolean;
1551
1552      begin {  vector  }
1553        vec := false;
1554        if TokenTabPtr^.noun = constant
1555        then
1556          begin
1557            AuxOperTabPtr := OperTabPtr;   new(OperTabPtr);
1558            PtrLastOper := OperTabPtr;
1559            OperTabPtr^.LastOper := AuxOperTabPtr;
1560            OperTabPtr^.OperPtr := TokenTabPtr^.ValTabPtr;
1561            hold := TokenTabPtr;
1562            TokenTabPtr := TokenTabPtr^.NextToken;   vec := true;
1563          end;
1564        vector := vec;
1565      end {  vector  };
1566
1567
1568    begin {  primary  }
1569      valid := true;
1570      if not vector
1571      then
1572        begin
1573          assign := false;
1574          if not variable
1575          then
1576            if SpecSymbol(XRightPar)
1577            then
1578              begin
1579                expression(ValidX);
1580                if not ValidX
1581                then error(14) {  'non-valid exp within parens'  }
1582                else
1583                  if not SpecSymbol(XLeftPar)
1584                  then
1585                    error(15)
1586                      {  'right paren not balanced with left paren'  }
1587                  else valid := true
```

```
1588            end
1589          else
1590            if not FunctCall   then valid := false
1591            else begin CallSubr;   primary(valid); end;
1592      end;
1593  end { primary };
1594
1595
1596 procedure expression { recursive };
1597
1598   var
1599     DoneExp, ValidPri, ValidFunc, ValidAssn: Boolean;
1600     code: integer;
1601
1602
1603   procedure assignment(var valida: Boolean);
1604
1605     begin { assignment }
1606       valida := false;
1607       if SpecSymbol(XLeftArrow)
1608       then
1609         begin
1610           assign := true;   assign1 := true;
1611           if variable   then valida := true
1612           else error(8) { result of an assn not a valid variable };
1613           valida := true;   assign := false;
1614         end;
1615     end { assignment };
1616
1617
1618   function mop: Boolean;
1619
1620     var
1621       ValidM: Boolean;
1622
1623     begin { mop }
1624       ValidM := false;
1625       if (TokenTabPtr^.noun = MonadOper) or (TokenTabPtr^.noun =
1626         ReductOper)
1627       then
1628         begin
1629           if TokenTabPtr^.noun = MonadOper
1630           then code := MOpTab[TokenTabPtr^.MonIndex].OpIndex
1631           else code := RedTab[TokenTabPtr^.RedIndx].OpIndex;
1632           hold := TokenTabPtr;
1633           TokenTabPtr := TokenTabPtr^.NextToken;   ValidM := true;
1634         end;
1635       mop := ValidM;
1636     end { mop };
1637
1638
1639   function dop: Boolean;
1640
1641     var
1642       ValidD: Boolean;
1643
1644     begin { dop }
1645       ValidD := false;
1646       if TokenTabPtr^.noun = DyadOper
1647       then
1648         begin
1649           code := DOpTab[TokenTabPtr^.DOpIndx].OpIndex;
1650           hold := TokenTabPtr;
1651           TokenTabPtr := TokenTabPtr^.NextToken;
1652           if (code > 80)   then ValidD := true
1653           else
1654             if TokenTabPtr^.noun = SpecOper
1655             then
1656               if SpecSymbol(XPeriod)
1657               then
1658                 begin
1659                   if TokenTabPtr^.noun = DyadOper
1660                   then
1661                     begin
1662                       if DOpTab[TokenTabPtr^.DOpIndx].OpIndex <= 80
1663                       then
1664                         begin
1665                           code := code + (100 * DOpTab[TokenTabPtr^.
1666                             DOpIndx].OpIndex);
1667                           hold := TokenTabPtr;
1668                           TokenTabPtr := TokenTabPtr^.NextToken;
1669                           ValidD := true
1670                         end
1671                       else error(27) { 'invalid inner product exp }
1672                     end
1673                   else
1674                     if TokenTabPtr^.noun = SpecOper
1675                     then
1676                       begin
1677                         if SpecSymbol(XLittleCircle)
1678                         then
1679                           begin code := 10 * code;   ValidD := true
1680                           end
1681                         else error(26) { 'inval outer prod exp' }
1682                       end
1683                     else error(26) { same as above }
1684                 end
1685               else ValidD := true
1686             else ValidD := true;
1687         end;
1688       dop := ValidD;
1689   end { dop };
1690
1691
1692 function ItsBoolean(test: real): Boolean;
1693
1694   begin
1695     if (test = 1.0) or (test = 0.0)   then ItsBoolean := true
1696     else ItsBoolean := false
1697   end { itsboolean };
1698
1699
1700 procedure DyadComp(var SFloat: real; value: real; code: integer);
1701 { compute result of dyadic operation }
1702
1703   begin
1704     case code of
1705       { left codes - reduction ops ' right codes - dyadic ops }
1706       2, 52: SFloat := value + SFloat { addition };
1707       3, 53: SFloat := value - SFloat { subtraction };
1708       4, 54: SFloat := value * SFloat { multiplication };
1709       5, 55:
1710         if SFloat = 0.0
1711         then error(20) { attempted division by zero }
1712         else SFloat := value / SFloat { division };
1713       6, 56:
1714         if value > 0.0
1715         then
1716           SFloat := exp(SFloat * ln(value))
1717             { number raised to a power }
1718         else SFloat := 1.0 / (exp(SFloat * ln(abs(value))));
1719       21, 71:
1720         if value = SFloat { equality }   then SFloat := 1.0
1721         else SFloat := 0.0;
1722       22, 72:
1723         if value <> SFloat { inequality }   then SFloat := 1.0
1724         else SFloat := 0.0;
1725       23, 73:
1726         if value < SFloat { less than }   then SFloat := 1.0
1727         else SFloat := 0.0;
1728       24, 74:
1729         if value <= SFloat { less than or equal to }
1730         then SFloat := 1.0
1731         else SFloat := 0.0;
1732       25, 75:
1733         if value >= SFloat { greater than or equal to }
1734         then SFloat := 1.0
1735         else SFloat := 0.0;
1736       26, 76:
1737         if value > SFloat { greater than }   then SFloat := 1.0
1738         else SFloat := 0.0;
1739       27, 77:
1740         if (ItsBoolean(value)) and (ItsBoolean(SFloat))
1741         then
1742           if (value = 1.0) and (SFloat = 1.0) { and }
1743           then SFloat := 1.0
1744           else SFloat := 0.0
1745         else error(19) { value not boolean };
1746       28, 78:
1747         if (ItsBoolean(value)) and (ItsBoolean(SFloat))
1748         then
1749           if (value = 1.0) or (SFloat = 1.0) { or }
1750           then SFloat := 1.0
1751           else SFloat := 0.0
1752         else error(19) { value not boolean };
1753       29:
1754         if value > SFloat { maximum or ceiling }
1755         then SFloat := value;
1756       30:
1757         if value < SFloat { minimum or floor }
1758         then SFloat := value;
1759       31:
1760         if (value * SFloat) < 0.0
1761         then error(50) { number and base of different sign }
1762         else
1763           SFloat := (ln(abs(SFloat))) / (ln(abs(value)))
1764             { log to a base }
1765     end { case }
1766   end { dyadcomp };
1767
1768
1769 procedure IndexGenerator(arg: TypeValTabPtr);
1770 { monadic iota operator }
1771
1772   var
1773     iotaIndex, TopValue: integer;
1774
1775   begin
1776     if arg^.dimensions <> 0
1777     then error(21) { argument not a scalar }
1778     else
1779       if arg^.FirstValue^.RealVal < 0.0
1780       then error(22) { argument is negative }
1781       else
1782         if (arg^.FirstValue^.RealVal) - (1.0 * trunc(arg^.
1783           FirstValue^.RealVal)) <> 0.0
1784         then error(23) { argument is not an integer }
1785         else
1786           begin
1787             new(NewValTabLink);
1788             OldValTabLink^.NextValTabLink := NewValTabLink;
```

```
          NewValTabLink^.NextValTabLink := nil;
          NewValTabLink^.ForwardOrder := true;
          NewValTabLink^.IntermedResult := true;
          NewValTabLink^.dimensions := 1 { result is a vector };
          new(NewDim);   NewValTabLink^.FirstDimen := NewDim;
          TopValue := trunc(arg^.FirstValue^.RealVal)
             { last index generd };
          NewDim^.dimenlength := TopValue;
          NewDim^.NextDimen := nil;   iotaIndex := 1;
          switch := true;
          while iotaIndex <= TopValue do
            begin
              new(NewValues);   NewValues^.RealVal := iotaIndex;
              if switch
              then
                begin
                  switch := false;
                  NewValTabLink^.FirstValue := NewValues
                end
              else NewValPtr^.NextValue := NewValues;
              NewValPtr := NewValues;
              iotaIndex := iotaIndex + 1
            end;
          if switch
          then
            NewValTabLink^.FirstValue := nil
               { result is vector of length 0 }
          else NewValues^.NextValue := nil
        end
  end {  indexgenerator  };


procedure ravel(arg: TypeValTabPtr);
{  monadic comma operator  }

  var
    elements: integer;

  begin
    new(NewValTabLink);
    OldValTabLink^.NextValTabLink := NewValTabLink;
    NewValTabLink^.NextValTabLink := nil;
    NewValTabLink^.IntermedResult := true;
    NewValTabLink^.ForwardOrder := arg^.ForwardOrder;
    NewValTabLink^.dimensions := 1 { result is a vector };
    new(NewDim);   NewValTabLink^.FirstDimen := NewDim;
    NewDim^.NextDimen := nil;   switch := true;
    ValPtr := arg^.FirstValue;   elements := 0;
    while ValPtr <> nil do
      begin { duplicate values into result }
        new(NewValues);   NewValues^.RealVal := ValPtr^.RealVal;
        elements := elements + 1;
        if switch
        then
          begin
            switch := false;
            NewValTabLink^.FirstValue := NewValues
          end
        else NewValPtr^.NextValue := NewValues;
        NewValPtr := NewValues;   ValPtr := ValPtr^.NextValue
      end;
    NewDim^.dimenlength := elements;
    if switch   then NewValTabLink^.FirstValue := nil
    else NewValues^.NextValue := nil
  end {  ravel  };


procedure ShapeOf(arg: TypeValTabPtr);
{  monadic rho operator  }

  begin
    new(NewValTabLink);
    OldValTabLink^.NextValTabLink := NewValTabLink;
    NewValTabLink^.NextValTabLink := nil;
    NewValTabLink^.IntermedResult := true;
    NewValTabLink^.ForwardOrder := true;
    NewValTabLink^.dimensions := 1 { result is a vector };
    new(NewDim);   NewDim^.dimenlength := arg^.dimensions;
    NewValTabLink^.FirstDimen := NewDim;
    NewDim^.NextDimen := nil;   switch := true;
    DimPtr := arg^.FirstDimen;
    while DimPtr <> nil do

      begin { argument dimensions become result values }
        new(NewValues);
        NewValues^.RealVal := DimPtr^.dimenlength;
        if switch
        then
          begin
            switch := false;
            NewValTabLink^.FirstValue := NewValues
          end
        else NewValPtr^.NextValue := NewValues;
        NewValPtr := NewValues;   DimPtr := DimPtr^.NextDimen
      end;
    if switch
    then
      NewValTabLink^.FirstValue := nil
         { result is a vector of length 0 }
    else NewValues^.NextValue := nil
  end {  shapeof  };
```

```
procedure reduction(arg: TypeValTabPtr);

  var
    counter, RowLength: integer;
    SFloat: real;

  begin
    if (arg^.dimensions = 0) or (arg^.FirstValue = nil)
    then
      error(24) { argument is a scalar or vector of length zero }
    else
      if (arg^.dimensions = 1) and (arg^.FirstDimen^.dimenlength
         = 1)
      then error(51) { argument is a vector of length one }
      else
        begin
          new(NewValTabLink);
          OldValTabLink^.NextValTabLink := NewValTabLink;
          NewValTabLink^.NextValTabLink := nil;
          NewValTabLink^.IntermedResult := true;
          if arg^.ForwardOrder   then ReverseLinkList(arg);
          NewValTabLink^.ForwardOrder := false;
          NewValTabLink^.dimensions := arg^.dimensions - 1;
          DimPtr := arg^.FirstDimen;   switch := true;
          while DimPtr^.NextDimen <> nil do
            begin { build dimensions of result }
              new(NewDim);
              if switch
              then
                begin
                  switch := false;
                  NewValTabLink^.FirstDimen := NewDim
                end
              else NewPtr^.NextDimen := NewDim;
              NewDim^.dimenlength := DimPtr^.dimenlength;
              NewPtr := NewDim;   DimPtr := DimPtr^.NextDimen
            end;
          if switch
          then
            NewValTabLink^.FirstDimen := nil
               { arg is vector,result is scalar }
          else NewDim^.NextDimen := nil;
          RowLength := DimPtr^.dimenlength;
          ValPtr := arg^.FirstValue;   switch := true;
          while ValPtr <> nil do
            begin { perform reduction }
              SFloat := ValPtr^.RealVal
                 { sfloat gets last value in row };
              ValPtr := ValPtr^.NextValue;
              for counter := 2 to RowLength do
                begin
                  DyadComp(SFloat, ValPtr^.RealVal, code);
                  ValPtr := ValPtr^.NextValue
                end;
              new(NewValues);   NewValues^.RealVal := SFloat;
              if switch
              then
                begin
                  switch := false;
                  NewValTabLink^.FirstValue := NewValues
                end
              else NewValPtr^.NextValue := NewValues;
              NewValPtr := NewValues
            end;
          NewValues^.NextValue := nil
        end;
  end { reduction };


procedure monadic(arg: TypeValTabPtr; token: TokenPtr);
{  operations with codes between 1 and 31  }

  begin
    if token^.noun = ReductOper   then reduction(arg)
    else
      if code > 20
      then
        case code of
          21: IndexGenerator(arg);
          22: ShapeOf(arg);
          23: ravel(arg)
        end { case }
      else
        begin
          new(NewValTabLink);
          OldValTabLink^.NextValTabLink := NewValTabLink;
          NewValTabLink^.NextValTabLink := nil;
          NewValTabLink^.IntermedResult := true;
          NewValTabLink^.ForwardOrder := arg^.ForwardOrder;
          NewValTabLink^.dimensions := arg^.dimensions;
           switch := true;   DimPtr := arg^.FirstDimen;
           while DimPtr <> nil do
             begin { duplicate dimensions of arg into result }
               new(NewDim);
               NewDim^.dimenlength := DimPtr^.dimenlength;
               if switch
               then
                 begin
                   switch := false;
                   NewValTabLink^.FirstDimen := NewDim
                 end
```

```
            else NewPtr^.NextDimen := NewDim;
            NewPtr := NewDim;   DimPtr := DimPtr^.NextDimen
          end;
        if switch
        then
          NewValTabLink^.FirstDimen := nil { result is a scalar }
        else NewDim^.NextDimen := nil;
        switch := true;   ValPtr := arg^.FirstValue;
        while ValPtr <> nil do
          begin
            new(NewValues);
            if switch = true
            then
              begin
                switch := false;
                NewValTabLink^.FirstValue := NewValues
              end
            else NewValPtr^.NextValue := NewValues;
            NewValPtr := NewValues;
            case code of
              1:
                if ItsBoolean(ValPtr^.RealVal)
                   {  logical negation  }
                then
                  NewValues^.RealVal := 1.0 - ValPtr^.RealVal
                else error(19) { value not boolean  };
              2:
                NewValues^.RealVal := ValPtr^.RealVal
                   {  no-op  };
              3:
                NewValues^.RealVal := 0.0 - ValPtr^.RealVal
                   {  negation  };
              4:
                if ValPtr^.RealVal > 0.0 {  signum  }
                then NewValues^.RealVal := 1.0
                else
                  if ValPtr^.RealVal < 0.0
                  then NewValues^.RealVal := - 1.0;
              5:
                if ValPtr^.RealVal = 0.0 {  reciprocal  }
                then error(54) { attempted inverse of zero }
                else
                  NewValues^.RealVal := 1.0 / ValPtr^.RealVal;
              6: NewValues^.RealVal := exp(ValPtr^.RealVal)
            end { case };
            ValPtr := ValPtr^.NextValue
          end;
        if switch   then NewValTabLink^.FirstValue := nil
        else NewValues^.NextValue := nil
      end
end {  monadic  };


procedure catenate(LeftArg, RightArg: TypeValTabPtr);
{  dyadic comma operator - joins 2 arguments  }

  var
    ResultLength: integer;

  begin { catenate }
    if (RightArg^.dimensions > 1) or (LeftArg^.dimensions > 1)
    then error(53) { argument(s) with rank greater than 1 }
    else
      begin
        new(NewValTabLink);
        OldValTabLink^.NextValTabLink := NewValTabLink;
        NewValTabLink^.NextValTabLink := nil;
        NewValTabLink^.IntermedResult := true;
        if not LeftArg^.ForwardOrder
        then ReverseLinkList(LeftArg);
        if not RightArg^.ForwardOrder
        then ReverseLinkList(RightArg);
        NewValTabLink^.ForwardOrder := true;
        NewValTabLink^.dimensions := 1 { result is a vector };
        new(NewDim);   NewValTabLink^.FirstDimen := NewDim;
        NewDim^.NextDimen := nil;   ResultLength := 0;
        if LeftArg^.dimensions = 0
        then
          ResultLength := ResultLength + 1 { left arg is a scalar }
        else
          ResultLength := ResultLength + LeftArg^.FirstDimen^.
              dimenlength;
        if RightArg^.dimensions = 0
        then
          ResultLength := ResultLength + 1 { right arg is a scalar }
        else
          ResultLength := ResultLength + RightArg^.FirstDimen^.
              dimenlength;
        NewDim^.dimenlength := ResultLength;   switch := true;
        if ResultLength = 0
        then
          NewValTabLink^.FirstValue := nil
              { result is vector of length 0 }
        else
          begin { transfer values to result }
            LeftValPtr := LeftArg^.FirstValue;
            while LeftValPtr <> nil do
              begin { transfer left arg values (if any)  }
                new(NewValues);
                if switch
                then
                  begin
                    switch := false;
                    NewValTabLink^.FirstValue := NewValues
                  end
                else NewValPtr^.NextValue := NewValues;
                NewValues^.RealVal := LeftValPtr^.RealVal;
                NewValPtr := NewValues;
                LeftValPtr := LeftValPtr^.NextValue
              end;
            RightValPtr := RightArg^.FirstValue;
            while RightValPtr <> nil do
              begin { transfer right arg values (if any)  }
                new(NewValues);
                if switch
                then
                  begin
                    switch := false;
                    NewValTabLink^.FirstValue := NewValues
                  end
                else NewValPtr^.NextValue := NewValues;
                NewValues^.RealVal := RightValPtr^.RealVal;
                NewValPtr := NewValues;
                RightValPtr := RightValPtr^.NextValue
              end;
            NewValues^.NextValue := nil
          end { transfer of values }
      end
end {  catenate  };


procedure IndexOf(LeftArg, RightArg: TypeValTabPtr);
{  dyadic iota operator  }

  var
    MapIndex, icount, TestLength, OneMore: integer;

  begin {  indexof  }
    if LeftArg^.dimensions <> 1
    then error(29) {  left argument is not a vector  }
    else
      begin
        new(NewValTabLink);
        OldValTabLink^.NextValTabLink := NewValTabLink;
        NewValTabLink^.NextValTabLink := nil;
        NewValTabLink^.IntermedResult := true;
        if not LeftArg^.ForwardOrder
        then ReverseLinkList(LeftArg);
        NewValTabLink^.ForwardOrder := RightArg^.ForwardOrder;
        NewValTabLink^.dimensions := RightArg^.dimensions;
        if RightArg^.dimensions = 0
        then
          NewValTabLink^.FirstDimen := nil
              { right argument is a scalar }
        else
          begin { build dimensions of result }
            switch := true;   DimPtr := RightArg^.FirstDimen;
            while DimPtr <> nil do
              begin
                new(NewDim);
                if switch
                then
                  begin
                    switch := false;
                    NewValTabLink^.FirstDimen := NewDim
                  end
                else NewPtr^.NextDimen := NewDim;
                NewDim^.dimenlength := DimPtr^.dimenlength;
                NewPtr := NewDim;   DimPtr := DimPtr^.NextDimen
              end;
            NewDim^.NextDimen := nil
          end;
        switch := true;   RightValPtr := RightArg^.FirstValue;
        while RightValPtr <> nil do
          begin
            new(NewValues);
            if switch
            then
              begin
                switch := false;
                NewValTabLink^.FirstValue := NewValues
              end
            else NewValPtr^.NextValue := NewValues;
            icount := 1;   LeftValPtr := LeftArg^.FirstValue;
            TestLength := LeftArg^.FirstDimen^.dimenlength
               { length of left arg };
            OneMore := TestLength + 1
               { length of left arg plus one };
            MapIndex := OneMore;
            while (icount <= TestLength) and (MapIndex = OneMore) do
              begin
          { try to match value in right arg with one in left arg }
                if LeftValPtr^.RealVal = RightValPtr^.RealVal
                then MapIndex := icount { value match };
                icount := icount + 1;
                LeftValPtr := LeftValPtr^.NextValue
              end;
            NewValues^.RealVal := MapIndex;
            NewValPtr := NewValues;
            RightValPtr := RightValPtr^.NextValue
          end
  { if no match, index becomes one more than length of left arg }
      ;
```

```
        NewValues^.NextValue := nil
      end
  end {  indexof  };


procedure reshape(LeftArg, RightArg: TypeValTabPtr);
  {  dyadic rho operator - change dimensions of  }

    var
      ResultLength, elements: integer;
      DimPtr: ^DimenInfo;
      NewPtr: ^values;

    begin {  reshape  }
      if LeftArg^.dimensions > 1
      then error(56) {  left argument not a vector or a scalar  }
      else
        begin
          new(NewValTabLink);
          OldValTabLink^.NextValTabLink := NewValTabLink;
          NewValTabLink^.NextValTabLink := nil;
          NewValTabLink^.IntermedResult := true;
          if not LeftArg^.ForwardOrder
          then ReverseLinkList(LeftArg);
          if not RightArg^.ForwardOrder
          then ReverseLinkList(RightArg);
          NewValTabLink^.ForwardOrder := true;
          if LeftArg^.FirstDimen = nil
          then NewValTabLink^.dimensions := 1
          else
            NewValTabLink^.dimensions := LeftArg^.FirstDimen^.
               dimenlength;
          ResultLength := 1;   LeftValPtr := LeftArg^.FirstValue;
          switch := true;
          while LeftValPtr <> nil do
              { left arg values are dimensions of result }
            begin { build result dimensions }
              ResultLength := ResultLength * trunc(LeftValPtr^.
                 RealVal);
              new(NewDim);
              NewDim^.dimenlength := trunc(LeftValPtr^.RealVal);
              LeftValPtr := LeftValPtr^.NextValue;
              if switch
              then
                begin
                  switch := false;
                  NewValTabLink^.FirstDimen := NewDim
                end
              else DimPtr^.NextDimen := NewDim;
              DimPtr := NewDim
            end;
          NewDim^.NextDimen := nil;
          RightValPtr := RightArg^.FirstValue;   elements := 0;
          switch := true;
          while elements < ResultLength do
            begin { duplicate right arg values into result values }
              elements := elements + 1;   new(NewValues);
              if RightValPtr = nil
                  { extend right argument if necessary }
              then RightValPtr := RightArg^.FirstValue;
              NewValues^.RealVal := RightValPtr^.RealVal;
              if switch
              then
                begin
                  switch := false;
                  NewValTabLink^.FirstValue := NewValues
                end
              else NewPtr^.NextValue := NewValues;
              NewPtr := NewValues;
              RightValPtr := RightValPtr^.NextValue
            end;
          NewValues^.NextValue := nil;
        end
    end {  reshape  };


  procedure InnerProduct(LeftArg, RightArg: TypeValTabPtr);

    var
      Inpro1Code, Inpro2Code, LeftSkip, RightSkip: integer;
      icount, jcount, kcount, lcount, mcount: integer;
      LastLeftDim, FirstRightDim, CommonLength: integer;
      lptr: ^values;
      hold: real;
      SFloat, value: real;

    begin { inner product is matrix multiplication }
      DimPtr := LeftArg^.FirstDimen;
      if LeftArg^.FirstDimen <> nil then
        while DimPtr^.NextDimen <> nil do
          DimPtr := DimPtr^.NextDimen
            { get last dimen of left arg(if any) };
      if (DimPtr <> nil) and (RightArg^.FirstDimen <> nil)
      then
        if DimPtr^.dimenlength <> RightArg^.FirstDimen^.dimenlength
        then
          error(52)
            { last dim of left arg not = to first dim of right arg }
        else
          begin
            Inpro1Code := code div 100 { separate operators };
            Inpro2Code := code - 100 * Inpro1Code;
            new(NewValTabLink);
            OldValTabLink^.NextValTabLink := NewValTabLink;
            NewValTabLink^.NextValTabLink := nil;
            NewValTabLink^.IntermedResult := true;
            if not LeftArg^.ForwardOrder
            then ReverseLinkList(LeftArg);
            if not RightArg^.ForwardOrder
            then ReverseLinkList(RightArg);
            NewValTabLink^.ForwardOrder := true;
            NewValTabLink^.dimensions := LeftArg^.dimensions +
               RightArg^.dimensions - 2;
            if NewValTabLink^.dimensions < 0
            then NewValTabLink^.dimensions := 0;
            switch := true;   LastLeftDim := 0;
          if LeftArg^.FirstDimen <> nil
          then
            begin { copy all but last of left arg dims into result }
              LeftSkip := 1;   DimPtr := LeftArg^.FirstDimen;
              while DimPtr^.NextDimen <> nil do
                begin { copy left arg dimensions }
                  new(NewDim);
                  NewDim^.dimenlength := DimPtr^.dimenlength;
                  LeftSkip := LeftSkip * DimPtr^.dimenlength;
                  if switch
                  then
                    begin
                      switch := false;
                      NewValTabLink^.FirstDimen := NewDim
                    end
                  else NewPtr^.NextDimen := NewDim;
                  NewPtr := NewDim;   DimPtr := DimPtr^.NextDimen
                end;
              LastLeftDim := DimPtr^.dimenlength
            end;
          if RightArg^.FirstDimen <> nil
          then
            begin
              { copy all but first of right arg dims into result }
              RightSkip := 1;
              DimPtr := RightArg^.FirstDimen^.NextDimen;
              while DimPtr <> nil do
                begin { copy right arg dimensions }
                  new(NewDim);
                  NewDim^.dimenlength := DimPtr^.dimenlength;
                  RightSkip := RightSkip * DimPtr^.dimenlength;
                  if switch
                  then
                    begin
                      switch := false;
                      NewValTabLink^.FirstDimen := NewDim
                    end
                  else NewPtr^.NextDimen := NewDim;
                  NewPtr := NewDim;   DimPtr := DimPtr^.NextDimen
                end
            end;
          if switch   then NewValTabLink^.FirstDimen := nil
          else NewDim^.NextDimen := nil;
          if LeftArg^.FirstValue = nil   then LeftSkip := 0;
          if RightArg^.FirstValue = nil   then RightSkip := 0;
          switch := true;
          if RightArg^.FirstDimen <> nil
          then FirstRightDim := RightArg^.FirstDimen^.dimenlength
          else FirstRightDim := 0;
          if FirstRightDim > LastLeftDim
          then CommonLength := FirstRightDim
          else CommonLength := LastLeftDim;
          icount := 0;   LeftValPtr := LeftArg^.FirstValue;
          while icount < LeftSkip do
            begin { loop for each row in left arg }
              lptr := LeftValPtr { hold start of row position };
              jcount := 0;
              while jcount < RightSkip do
                begin { loop for each column in right arg }
                  LeftValPtr := lptr;
                  RightValPtr := RightArg^.FirstValue;
                  lcount := 0;
                  while lcount < jcount do
                    begin { skip to starting value in right arg }
                      RightValPtr := RightValPtr^.NextValue;
                      if RightValPtr = nil then
                        RightValPtr := RightArg^.FirstValue
                            { extend arg };
                      lcount := lcount + 1
                    end;
                  kcount := 0;
                  while kcount < CommonLength do
                    begin { loop for each element in row/column }
                      SFloat := RightValPtr^.RealVal;
                      DyadComp(SFloat, LeftValPtr^.RealVal,
                         Inpro2Code);
                      value := SFloat;
                      if kcount = 0
                      then
                    { set identity value for first time through }
                        case Inpro1Code of
                          52, 53, 78: SFloat := 0.0;
                          54, 55, 56, 77: SFloat := 1.0;
                          71, 72, 73, 74, 75, 76: { null case }
                        end { case }
                      else SFloat := hold;
                      DyadComp(SFloat, value, Inpro1Code);
                      hold := SFloat { save summer result };
```

```
            LeftValPtr := LeftValPtr^.NextValue;
            if LeftValPtr = nil then
              LeftValPtr := LeftArg^.FirstValue
                  { extend arg };
            mcount := 0;
            while mcount < RightSkip do
              begin { skip to next value in right arg }
                mcount := mcount + 1;
                RightValPtr := RightValPtr^.NextValue;
                if RightValPtr = nil
                then RightValPtr := RightArg^.FirstValue;
              end;
            kcount := kcount + 1
          end;
        new(NewValues);   NewValues^.RealVal := SFloat;
        if switch
        then
          begin
            switch := false;
            NewValTabLink^.FirstValue := NewValues
          end
        else NewValPtr^.NextValue := NewValues;
                NewValPtr := NewValues;   jcount := jcount + 1;
              end;
            icount := icount + 1
          end;
        if switch   then NewValTabLink^.FirstValue := nil
        else NewValues^.NextValue := nil
      end
  end {  innerproduct  };

procedure OuterProduce(LeftArg, RightArg: TypeValTabPtr);

  var
    OutProCode: integer;
    SFloat: real;

  begin
    OutProCode := code div 10;   new(NewValTabLink);
    OldValTabLink^.NextValTabLink := NewValTabLink;
    NewValTabLink^.NextValTabLink := nil;
    NewValTabLink^.IntermedResult := true;
    if not LeftArg^.ForwardOrder
    then ReverseLinkList(LeftArg);
    if not RightArg^.ForwardOrder
    then ReverseLinkList(RightArg);
    NewValTabLink^.ForwardOrder := true;
    NewValTabLink^.dimensions := LeftArg^.dimensions + RightArg^.
       dimensions;
    switch := true;   DimPtr := LeftArg^.FirstDimen;
    while DimPtr <> nil do
      begin { copy left arg dimensions to result }
        new(NewDim);   NewDim^.dimenlength := DimPtr^.dimenlength;
        if switch
        then
          begin
            switch := false;   NewValTabLink^.FirstDimen := NewDim
          end
        else NewPtr^.NextDimen := NewDim;
        NewPtr := NewDim;   DimPtr := DimPtr^.NextDimen
      end;
    DimPtr := RightArg^.FirstDimen;
    while DimPtr <> nil do
      begin { copy dimensions of right arg to result }
        new(NewDim);   NewDim^.dimenlength := DimPtr^.dimenlength;
        if switch
        then
          begin
            switch := false;   NewValTabLink^.FirstDimen := NewDim
          end
        else NewPtr^.NextDimen := NewDim;
        NewPtr := NewDim;   DimPtr := DimPtr^.NextDimen
      end;
    if switch   then NewValTabLink^.FirstDimen := nil
    else NewDim^.NextDimen := nil;
    switch := true;   LeftValPtr := LeftArg^.FirstValue;
    while LeftValPtr <> nil do
      begin
        RightValPtr := RightArg^.FirstValue;
        while RightValPtr <> nil do
          begin
            SFloat := RightValPtr^.RealVal;
            DyadComp(SFloat, LeftValPtr^.RealVal, OutProCode);
            new(NewValues);
            if switch
            then
              begin
                switch := false;
                NewValTabLink^.FirstValue := NewValues
              end
            else NewValPtr^.NextValue := NewValues;
            NewValues^.RealVal := SFloat;   NewValPtr := NewValues;
            RightValPtr := RightValPtr^.NextValue
          end;
        LeftValPtr := LeftValPtr^.NextValue
      end;
    if switch   then NewValTabLink^.FirstValue := nil
    else NewValues^.NextValue := nil
  end {  outerproduct  };

procedure dyadic(LeftArg, RightArg: TypeValTabPtr);
{  operators with codes of 52 and higher  }

  var
    compatible: Boolean;
    arg: TypeValTabPtr;
    SFloat: real;

  begin
    if code > 1000   then InnerProduct(LeftArg, RightArg)
    else
      if code > 100   then OuterProduce(LeftArg, RightArg)
      else
        if code > 80
        then
          case code of
            87: IndexOf(LeftArg, RightArg);
            88: reshape(LeftArg, RightArg);
            89: catenate(LeftArg, RightArg)
          end { case }
        else
          begin { simple dyadics }
            compatible := true;
            if (LeftArg^.dimensions >= 1) and (RightArg^.
               dimensions >= 1)
            then
              if LeftArg^.dimensions <> RightArg^.dimensions
              then
                compatible := false
                    { different ranks/neither scalar }
              else
                begin { ranks match - check lengths }
                  LeftDimPtr := LeftArg^.FirstDimen;
                  RigthDimPtr := RightArg^.FirstDimen;
                  while LeftDimPtr <> nil do
                    begin
                      if LeftDimPtr^.dimenlength <> RigthDimPtr^.
                         dimenlength
                      then
                        compatible := false { different length(s) };
                      LeftDimPtr := LeftDimPtr^.NextDimen;
                      RigthDimPtr := RigthDimPtr^.NextDimen
                    end
                end;
            if compatible
              { arguments suitible for dyadic operation }
            then
              begin { build dimensions of result }
                if RightArg^.dimensions > LeftArg^.dimensions
                then arg := RightArg
                else
                  arg := LeftArg { result has shape of larger arg };
                new(NewValTabLink);
                OldValTabLink^.NextValTabLink := NewValTabLink;
                NewValTabLink^.NextValTabLink := nil;
                NewValTabLink^.IntermedResult := true;
                if LeftArg^.ForwardOrder <> RightArg^.ForwardOrder
                then ReverseLinkList(LeftArg);
                NewValTabLink^.ForwardOrder := arg^.ForwardOrder;
                NewValTabLink^.dimensions := arg^.dimensions;
                switch := true;   DimPtr := arg^.FirstDimen;
                while DimPtr <> nil do
                  begin { copy dimensions to result }
                    new(NewDim);
                    NewDim^.dimenlength := DimPtr^.dimenlength;
                    if switch
                    then
                      begin
                        switch := false;
                        NewValTabLink^.FirstDimen := NewDim
                      end
                    else NewPtr^.NextDimen := NewDim;
                    NewPtr := NewDim;
                    DimPtr := DimPtr^.NextDimen
                  end;
                if switch
                then
                  NewValTabLink^.FirstDimen := nil
                    { result is a scal }
                else NewDim^.NextDimen := nil;
                switch := true;
                RightValPtr := RightArg^.FirstValue;
                LeftValPtr := LeftArg^.FirstValue;
                ValPtr := arg^.FirstValue;
                while ValPtr <> nil do
                  begin { perform operation }
                    new(NewValues);
                    SFloat := RightValPtr^.RealVal;
                    DyadComp(SFloat, LeftValPtr^.RealVal, code);
                    NewValues^.RealVal := SFloat;
                    if switch
                    then
                      begin
                        switch := false;
                        NewValTabLink^.FirstValue := NewValues
                      end
                    else NewValPtr^.NextValue := NewValues;
                    NewValPtr := NewValues;
                    ValPtr := ValPtr^.NextValue;
                    LeftValPtr := LeftValPtr^.NextValue;
```

```
                    RightValPtr := RightValPtr^.NextValue;
                    if LeftValPtr = nil then
                      LeftValPtr := LeftArg^.FirstValue
                        { extend arg };
                    if RightValPtr = nil then
                      RightValPtr := RightArg^.FirstValue
                        { extend  }
                  end;
                if switch
                then
                  NewValTabLink^.FirstValue := nil
                    { vector of len 0 }
                else NewValues^.NextValue := nil
              end
            else
              error(55)
                { arguments imcompatible for dyadic operation }
          end
  end {  dyadic  };


procedure FunCall(var ValidFunk: Boolean);

  var
    ValidPm: Boolean;

  begin {  funcall  }
    ValidFunk := false;
    if FunctCall
    then
      begin
        if TokenTabPtr^.noun <> StatEnd
        then
          begin
            SubrTabPtr^.TokenCallingSubr := TokenTabPtr;
            primary(ValidPm);   if not ValidPm   then error(17);
          {  'leftarg of dyadic func call not a primary'  }
          end;
        CallSubr;   ValidFunk := true;
      end;
  end {  funcall  };


begin {  expression  }
  primary(ValidPri);
  if not ValidPri
  then
    begin
      if TokenTabPtr^.noun = StatEnd
      then begin ValidExp := true;   assign1 := true end
      else ValidExp := false
    end
  else
    begin
      DoneExp := false;
      while not DoneExp do
        begin
          FunCall(ValidFunc);
          if ValidFunc
          then begin expression(ValidExp);   DoneExp := true end
          else
            begin
              assignment(ValidAssn);
              if ValidAssn and (TokenTabPtr^.noun = StatEnd)
              then begin DoneExp := true;   ValidExp := true; end;
              if not ValidAssn
              then
                if mop
                then
                  begin
                    monadic(OperTabPtr^.OperPtr, hold);
                    OperTabPtr^.OperPtr := NewValTabLink
                  end
                else
                  if not dop
                  then begin ValidExp := true;   DoneExp := true end
                  else
                    begin
                      primary(ValidPri);
                      if not ValidPri
                      then
                        error(13)
                          {  dyad oper not preceded by a pri  }
                      else
                        begin
                          dyadic(OperTabPtr^.OperPtr, OperTabPtr^.
                            LastOper^.OperPtr);
                          AuxOperTabPtr := OperTabPtr;
                          OperTabPtr := OperTabPtr^.LastOper;
                          PtrLastOper := OperTabPtr;
                          dispose(AuxOperTabPtr);
                          OperTabPtr^.OperPtr := NewValTabLink;
                        end;
                    end;
            end;
        end;
    end;
  end {  expression  };


begin {  parser  }
  assign := false;   assign1 := false;   DoneParse := false;
  repeat
    expression(ValidExp) {  checks for valid expression  };
    if not ValidExp   then error(10) {  'invalid expression'  }
    else
      if SpecSymbol(XRightArrow)
      then
        if not ((OperTabPtr^.OperPtr^.FirstValue = nil) and (
          OperTabPtr^.OperPtr^.dimensions > 0))
        then {  branch  }
        {  result of expression is at opertabptr  }
          if OperTabPtr^.OperPtr^.FirstValue^.RealVal - 1.0 * trunc
            (OperTabPtr^.OperPtr^.FirstValue^.RealVal) <> 0.0
          then error(12) {  stmt.num.to branch to not an integer  }
          else
            if SubrTabPtr = nil
            then
              begin {  function mode  }
                TokenTabPtr := hold;   DoneParse := true
              end
            else
              if trunc(OperTabPtr^.OperPtr^.FirstValue^.RealVal) in
                [1 .. (SubrTabPtr^.CalledSubr ^.NumOfStatements)]
              then
                begin
                  VFuncHold := SubrTabPtr^.CalledSubr^.FirstStatement;
                  for cnt := 1 to trunc(OperTabPtr^.OperPtr^.
                      FirstValue^.RealVal) do
                    begin
                      VFuncPtr := VFuncHold;
                      TokenTabPtr := VFuncPtr^.NextStmnt;
                      VFuncHold := VFuncPtr^.NextVFunPrt
                    end;
                  AuxOperTabPtr := OperTabPtr;
                  OperTabPtr := OperTabPtr^.LastOper;
                  dispose(AuxOperTabPtr);   PtrLastOper := OperTabPtr;
                  TokenTabPtr := VFuncPtr^.NextStmnt
                end
              else ReturnToCallingSubr
        else {  successor  }
      else {  successor  }
        begin
          if not assign1   then OutPutVal;   assign1 := false;
          if SubrTabPtr = nil
          then
            begin {  interpretive  }
              hold := TokenTabPtr;
              TokenTabPtr := TokenTabPtr^.NextToken;
              DoneParse := true
            end
          else {  function  }
            begin
              VFuncPtr := VFuncPtr^.NextVFunPrt;
              DoneSuccessor := false;
              repeat
                if VFuncPtr <> nil
                then
                  begin
                    TokenTabPtr := VFuncPtr^.NextStmnt;
                    DoneSuccessor := true
                  end
                else
                  begin
                    ReturnToCallingSubr;
                    if TokenTabPtr^.noun = StatEnd
                    then DoneSuccessor := true;
                  end;
              until DoneSuccessor;
            end;
        end
    until DoneParse;
    release {  release memory  };
  end {  parser  };


begin {  scanner  }
  InitializeCharacterSet;   ReadInErrorMsgs;
  InitParser {  initialize tables etc.  };   FillUpTables;
  FunctionMode := false;   FirstFunction := true;
  OldValTabLink := nil;   OldFuncTabPtr := nil;   OldVarTabPtr := nil;
  OldTokenPtr := nil;   NewTokenPtr := nil;   NewFuncTabPtr := nil;
  NewVFuncPtr := nil;   HoldTokenPtr := nil;   TokenError := false;
  NewValTabLink := nil;   NewVarTabPtr := nil;   GetAPLstatement;
  while (APLstatement[1] <> character[ForwardSlash]) or (APLstatement[2]
    <> character[asterisk]) do {   /* ends program  }
    begin
      SkipSpaces;   TokenSwitch := true;
      while (position <= LineLength) and (not TokenError) and (not
        LineTooLong) do
        begin {  scanning  }
          if APLstatement[position] = character[del]
            {  function delimiter  }
          then {  del encountered  }
            if FunctionMode
            then
              begin {  end of current function  }
                if NewFuncTabPtr <> nil
                then NewFuncTabPtr^.NumOfStatements := FuncStatements;
                if FuncStatements > 0
```

```
          then
            begin
              NewFuncTabPtr^.NextFuncTabPtr := OldFuncTabPtr;
              OldFuncTabPtr := NewFuncTabPtr;
              NewVFuncPtr^.NextVFunPrt := nil
            end
          else
            SError(75) {  function defined with no statements };
          FunctionMode := false;   position := position + 1
        end
      else ProcessFuntionHeader {  start of a new function  }
    else {  not a del encountered  }
      begin
        if TokenSwitch
        then
          begin {  this is start of a new statement  }
            TokenSwitch := false;
            HoldTokenPtr := OldTokenPtr { save starting position }
              ;
            MakeTokenLink;   NewTokenPtr^.noun := StatEnd;
            NewTokenPtr^.EndAdj := 0;   HasLabel := false
          end;
        MakeTokenLink;   identifier(name, ItsAnIdentifier);
        if not ItsAnIdentifier   then TryToGetANumber
        else
          begin {  process identifier  }
            SkipSpaces;
            if (APLstatement[position] = character[colon]) and (
              NewTokenPtr^.NextToken^.noun = StatEnd)
            then
              begin {  process statement label  }
                SaveLabel := name;   HasLabel := true;
                position := position + 1
              end
            else
              begin {  process variable name  }
                if not FunctionMode
                then NewTokenPtr^.noun := GlobVar
                else
                  if NamesMatch(name, NewFuncTabPtr^.ResultName)
                  then NewTokenPtr^.noun := FormRes
                  else
                    if (NamesMatch(name, NewFuncTabPtr^.LeftArg))
                      or (NamesMatch(name, NewFuncTabPtr^.
                      RightArg))
                    then NewTokenPtr^.noun := FormArg
                    else NewTokenPtr^.noun := GlobVar;
                if NewTokenPtr^.noun <> GlobVar
                then TestFuncPtr := NewFuncTabPtr
                else TestFuncPtr := nil;
                if not NameInVarTable(name, VarPointer,
                  TestFuncPtr)
                then
                  begin
                    AddNameToVarTable(name);
                    NewTokenPtr^.VarTabPtr := NewVarTabPtr
                  end
                else NewTokenPtr^.VarTabPtr := VarPointer
              end
          end
      end;
    SkipSpaces;
  end;
if NewTokenPtr <> nil
then
  if (TokenError) or (NewTokenPtr^.noun = StatEnd)
  then DestroyStatement
  else
    if FunctionMode
    then
      begin
        FuncStatements := FuncStatements + 1;
        if FuncStatements > 0
        then
          begin {  catalog function statement  }
            new(NewVFuncPtr);
            if FuncStatements = 1

                then NewFuncTabPtr^.FirstStatement := NewVFuncPtr
                else OldVFuncPtr^.NextVFunPrt := NewVFuncPtr;
                OldVFuncPtr := NewVFuncPtr;
                if HasLabel
                then NewVFuncPtr^.StatLabel := SaveLabel;
                NewVFuncPtr^.NextStmnt := NewTokenPtr
              end
          end
        else
          if APLstatement[1] <> character[del] then
            begin
              parser(NewTokenPtr, NewValTabLink);
          100: DestroyStatement
            end;
    readln;   TokenError := false;   GetAPLstatement;
  end;
end { scanner }.
```

Contents of APLfile

```
ABCDEFGHIJKLMNOPQRSTUVWXYZ1234567890:→←∘.-][<;., +-×÷*ιρ,~(≠)≤=>∧∨|⌊○/
¨¯?ωε↑↓ι_∇Δ
'⊂⊃∩∪⊥⊤|\
INVALID CHARACTER FOLLOWS NEGATIVE SIGN
DIGIT MUST FOLLOW A DECIMAL POINT
EXTRANEOUS CHARS. FOLLOW FUNCTION HEADER
INVALID CHARACTER ENCOUNTERED
FUNCTION ALREADY DEFINED
ILLEGAL NAME TO RIGHT OF EXPLICIT RESULT
INVALID FUNCTION/ARGUMENT NAME
RESULT OF ASSIGNMENT NOT VALID VARIABLE
INVALID FUNCTION RIGHT ARGUMENT NAME
INVALID EXPRESSION
SYMBOL NOT FOUND
STATEMENT NO. TO BRANCH TO NOT INTEGER
DYADIC OPERATOR NOT PRECEDED BY PRIMARY
INVALID EXPRESSION WITHIN PARENTHESES
MISMATCHED PARENTHESES
NOT USED
LEFT ARG OF DYADIC FUNCT. NOT A PRIMARY
NOT USED
VALUE NOT BOOLEAN
ATTEMPTED DIVISION BY ZERO
ARGUMENT NOT A SCALAR
ARGUMENT IS NEGATIVE
ARGUMENT IS NOT AN INTEGER
ARGUMENT IS A SCALAR OR EMPTY VECTOR
NOT USED
INVALID OUTER PRODUCT EXPRESSION
INVALID INNER PRODUCT EXPRESSION
NOT USED
LEFT ARGUMENT IS NOT A VECTOR
NOT USED
NOT USED
ERROR IN FUNCTION ARGUMENT
ERROR IN FUNCTION ARGUMENT
INVALID INDEX EXPRESSION
NON-SCALAR INDICES
ASSIGNED EXPRESSION NOT A SCALAR
NON-INTEGER INDICES
INDEX OUT OF RANGE
INVALID INDEX EXPRESSION
NOT USED
NOT USED
NOT USED
NOT USED
NOT USED
NOT USED
NOT USED
NOT USED
NOT USED
NOT USED
NUMBER AND BASE OF DIFFERENT SIGN
ARGUMENT IS A VECTOR OF LENGTH ONE
ARGS. NOT COMPATIBLE FOR INNER PRODUCT
ARGUMENT-S] WITH RANK GREATER THAN ONE
ATTEMPTED INVERSE OF ZERO
ARGS. INCOMPATIBLE FOR DYADIC OPERATION
LEFT ARGUMENT NOT A VECTOR
NOT USED
NOT USED
NOT USED
GREATER THAN THREE DIMENSIONS
             NIL
RE-ENTER LAST LINE
INPUT
NOT USED
NOT USED
NOT USED
NOT USED
NOT USED
NOT USED
IDENTIFIER TOO LONG
INPUT LINE TOO LONG
INVALID REDUCTION OPERATOR
DYADIC REDUCTION REFERENCE
MONADIC REFERENCE TO DYADIC OPERATOR
FUNCTION DEFINED WITH NO STATEMENTS
NOT USED
NOT USED
NOT USED
NOT USED
NOT USED
NOT USED
NOT USED
NOT USED
NOT USED
NOT USED
NOT USED
NOT USED
NOT USED
NOT USED
NOT USED
NOT USED
NOT USED
NOT USED
NOT USED
NOT USED
NOT USED
NOT USED
NOT USED
VARIABLE NOT ASSIGNED A VALUE
```

"Don't Fail Me Now"

By Srully Blotnick

The government imposed a 55-mph speed limit on cars, not computers. Why, then, are computer owners going so slowly?

Are we in the early stages of a technology bust? Strange as this may sound at a time when the nation seems to have gone computer crazy, a good many scientists are starting to worry about just that.

Their concern stems from the massive switch in the computer business from a customer base consisting of a handful of large institutional buyers to millions of smaller ones. The computer finally has become a piece of mass-market electronics, much like video recorders. Why is that a problem? A basic rule of business is that risk accompanies opportunity. In this instance, the risk affects not only the companies in the field, but the entire country, thanks to the expanding economic importance of this industry. Its health will soon play a decisive role in determining the U.S.' international competitive position.

The risk in dealing with the mass market is always a simple one: The mob is fickle. What intrigues it today may leave it indifferent tomorrow. This time the fickleness could produce a national disaster. The U.S. has unwittingly invested a major portion of its capital — and even more important, its hopes — in this area. That's why some thoughtful workers in the field are beginning to pray quietly: "Don't fail me now."

How, specifically, do they see a failure occurring? The consensus view is as follows: "A Ferrari is exciting, but how exciting would it continue to be if the only place you could use it were your driveway? Well, that's exactly what is happening with way too many of the computers now being bought. Car or computer, people are eventually going to get tired of just looking at the thing and bragging about it to their friends. Then, the fad will pass. Computer manufacturing plants will close. Only a minuscule proportion of computer buyers are making good use of the machine's capabilities. They don't know enough about programming to make the machine *really* perform."

"Well, suppose everyone learned BASIC?" I asked.

The overwhelming majority had a better idea: "BASIC is a very easy language to learn, but it would be enormously better, a dream come true, if everyone learned Pascal, which is far superior and just as easy to master."

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Since last summer I, therefore, have been collecting the opinions of everyone, from teachers and hobbyists to investors and small business owners, who know Pascal to see which books they consider best. A tally of the nearly 1,600 replies shows the following:

For people who know nothing at all about computers or computer programming, the best place to begin is R. Pattis' *Karel the Robot: A Gentle Introduction to the Art of Programming* (John Wiley, $8.95). You don't need a computer to read this book (or the others about to be mentioned). By learning how to move a robot through the streets of a small town, you come to understand how programming instructs a computer to do what you want it to.

Pattis' book is *about* programming but doesn't actually teach the language. The elementary text that received the top rating in out survey was Arthur Keller's *A First Course in Computer Programming with Pascal* (McGraw-Hill, $14.95). The book received high praise ("Very clear and easy to read") from everyone from 17 to 70. It is suitable even as a high school text.

After Keller's book, the next step should be *A Primer on Pascal* by Conway, Gries and Zimmerman (Little, Brown, $20). The consensus view: "This book will help you *deepen* your understanding of the language once you've learned the elements." For those who already know BASIC, a good way to learn Pascal fast is *Quick Pascal* by D. Matuszek (John Wiley, $11.95).

One work that was highly rated by advanced students was the second edition of *Pascal — User's Manual and Report* (Springer-Verlag, $10.50) by K. Jensen and N. Wirth. That is hardly surprising since one of the coauthors, Nikolaus Wirth, invented the language.

To see what the language can really do, serious students will want to learn about data structures — that is, such things as lists, stacks, queues, trees, sets, records, recursion, sorting and searching. The three top-rated texts, all very well written, are: *Data Structures and Algorithms* by A. Aho, et al. (Addision-Wesley, $28.95); *Advanced Programming and Problem Solving with Pascal* by G. Schneider and S. Bruell (John Wiley, $26.95); and *Data Structures Using Pascal* by A. Tenenbaum and M. Augenstein (Prentis-Hall, $25.95). As the authors of the first work comment, "The only prerequisite we assume is familiarity with some high-level programming language such as Pascal."

Finally, people with a background in probability theory rated the second edition of R. Cooper's *Introduction to Queueing Theory* (North-Holland Publishing Co., $27) the best — clearest and most user-friendly — book on the subject.

Summing up: Buying a computer and not learning to program it properly not only wastes money, it also stands a good chance of eventually harming the nation's economy.

PUG

Computer Generated Population Pyramids Using Pascal

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Background

During the past twenty years the development of computer applications in geography has been extensive. Hundreds of programs have been written and many are available to users through various dispensing institutions, particularly the Geography Program Exchange located at Michigan State University.[1] Virtually all of the programs, however, are writen in FORTRAN and are suitable for easy installation primarily on large mainframe computers.[2]

A similar situation exists in cartographic computer program development. Although the number and variety of programs written is extensive, the FORTRAN language is used almost exclusively, and the software is designed for use on large systems. A recent textbook in computer-assisted cartography provides only passing mention of microcomputer graphics in the field of cartography.[3]

As a consequence of this situation, computer applications in geography and cartography are limited primarily to the larger colleges and universities that have mainframes and the faculty within the departments to teach the subjects. As a geographer in a small liberal arts college teaching not only introductory cartography but a course in micro-based computer mapping, I feel somewhat like a pioneer trying to make a clearing in the wood without the proper tools. The situation is further exacerbated because liberal arts colleges have not been as highly revered by the computer industry as have the high technology learning centers and are consequently not receiving anywhere near the number of equipment grants or the same degree of personnel support.

Yet, more than one writer has commented on the need for a closer association between the computer industry and the liberal arts college. In a recent editorial in *Datamation*, John L. Kirkely stated the following:

> We urge our industry to work with the liberal arts colleges to develop courses of study that combine the humanities and the sciences. A merging of these artificially separated disciplines could be a powerful tonic for both our colleges and our corporations.[4]

I believe that, in time, changes will be made which will result in the liberal arts colleges receiving their fair share of industry support. In the meantime, however, individuals in those colleges will continue to make contributions to the furtherance of computer applications in what would be considered today to be non-traditional disciplines. The set of programs included in this paper are suggestive of the kinds of things faculty can produce and which 1) are effective vehicles for developing the understanding of key concepts in a discipline (demography in this case); 2) are produced with a cost factor reflecting only the programmer's time; 3) can be easily implemented on any system, micro to mainframe; and 4) are written in the programming language of the day, Pascal.

The Population Pyramid (Age Structure) Diagram

It is abundantly clear that world population continues to grow at a less than acceptable rate, and that some regions, particularly those with countries exhibiting low levels of economic development, have exceptionally high rates of growth.[5] The population pyramid is a useful diagram to study the composition of the population of any country or region.

In the diagram, age groupings of five years each (0-4, 5-9, 10-14,..., up to 75+) are presented for both male and female segments of the population. The scale along the horizontal axis reports the percentage of the total population in each of the age groups. Generally a pyramid shape wide at the bottom (young age groups) is representative of a fast growing population while an age structure more evenly represented along the year's axis identifies a population that is stabilizing and that does not have a high rate of increase. The industrialized and urbanized countries in the developed world would fall into the later category; the less developed in the former.

The Programs

Three programs have been developed for student use in an introductory human geography course.[6] It is not necessary that the students know the Pascal language in order to run the programs. Introduction is given in class on login/logoff procedures and how to access the programs. The student need only find suitable information in the appropriate statistical source for each of the age groups for a particular region, round these values to a whole number, and enter the numbers in the sequence described in the program prompts.

The programs developed include:

1) pyramid_file — This program is used to create an external file of information including the region names, year of the data, and the percentages of male and female in each age group. Following the input, procedure echo-data publishes all the information entered for verification. If there were no input errors, the student selects the appropriate key and the program stores the information in an external file in the student's account. The listing of program pyramid_file follows:

```
program pyramid_file(input, output);

{a program to create an external file of
 population pyramid data}

  const
    separator = '  ------------------------------------------------

  type
    data =
      record
        country: packed array [1..15] of char;
        year: packed array [1..4] of char;
        malepercent, femalepercent: array [1..16] of integer
      end;
    identifiers = file of data;

  var
    temp: data;
    info: identifiers;
    filename: packed array [1..10] of char;
    answer: char;


  procedure read_data;

    var
      i: integer;

    begin
      writeln;
      write(' enter file name:    ');
      readln(filename);
      writeln;
      writeln;
      write(' enter place name -- use 15 columns:      ');
      readln(temp.country);
      writeln;
      writeln;
      write(' enter the year of the data:      ');
      readln(temp.year);
      writeln;
      writeln(' now, enter male and female percentages for');
      writeln(' each age group; enter male percentages first');
      writeln(' from the highest age group to the lowest.');
      writeln(' you must have 16 entries for each group.');
      writeln('enter as integers all on the same line.');
      writeln;
      for i := 1 to 16 do
        read(temp.malepercent[i]);
      writeln(' next, enter the female percentages.');
      for i := 1 to 16 do
        read(temp.femalepercent[i]);
      readln;
    end {read_data} ;


  procedure echo_data;

    var
      i: integer;

    begin
      writeln;
      writeln(separator);
      writeln;
      writeln(' the following information was entered:');
      writeln;
      writeln(' ', temp.country);
      writeln;
      writeln(' ', temp.year);
      writeln;
      write(' male   : ');
      for i := 1 to 16 do
        write(temp.malepercent[i]: 3);
      writeln;
      writeln;
      write(' female : ');
      for i := 1 to 16 do
        write(temp.femalepercent[i]: 3);
      writeln;
      writeln;
      writeln(separator);
      writeln(' is the information correct?');
      writeln(' if yes, enter a ''y''; if not, enter');
      write(' ''n'':    ');
      readln(answer);
      writeln;
      writeln
    end {echo_data} ;


  procedure store_data;

    var
      i: integer;

    begin
      rewrite(info, filename);
      info^.country := temp.country;
      put(info);
      info^.year := temp.year;
      put(info);
      for i := 1 to 16 do
        begin
        info^.malepercent[i] := temp.malepercent[i];
        put(info)
        end;
      for i := 1 to 16 do
        begin
        info^.femalepercent[i] := temp.femalepercent[i];
        put(info)
        end;
      close(info)
    end {store_data} ;

begin
  read_data;
  echo_data;
  if (answer = 'y') or (answer = 'Y') then
    begin
    store_data;
    writeln(' ***** operation completed *****');
    writeln(' information stored in the file: ', filename)
    end
  else
    writeln(' invalid data; run the program again')
end.
```

2) get_pyr_file — An editing program which the student may use to access an external file, display the contents, and make any necessary changes. This program would come in handy if more recent data is received and the file is to be updated. The listing or program get_pyr_file and an example run of information contained in the external file, SWEDEN.PYR, follow:

```
program get_pyr_file(input, output);

{a program to examine the external data file
 created by the program, 'pyramid_file', and
 to make changes if necessary}

  type
    data =
      record
        country: packed array [1..15] of char;
        year: packed array [1..4] of char;
        mpct, fpct: array [1..16] of integer
      end;
    identifiers = file of data;

  var
    temp: data;
    info: identifiers;
    filename: packed array [1..10] of char;


  procedure skiplines;

    var
      i: integer;

    begin
      for i := 1 to 10 do
        writeln
    end {skiplines} ;


  procedure access_file_data;

    var
      i: integer;

    begin
      writeln;
      write(' enter file name:    ');
      readln(filename);
      reset(info, filename);
      temp.country := info^.country;
      get(info);
      temp.year := info^.year;
      get(info);
      for i := 1 to 16 do
        begin
        temp.mpct[i] := info^.mpct[i];
        get(info)
        end;
      for i := 1 to 16 do
        begin
        temp.fpct[i] := info^.fpct[i];
        get(info)
        end;
      close(info)
    end {access_file_data} ;

procedure publish_data;

  const
    separator = '  ------------------------------';
  var
    i: integer;

  begin
    skiplines;
    writeln(separator);
    writeln;
    writeln(' the following information is');
    writeln(' contained in ', filename, ':');
    writeln;
    writeln(' ', temp.country);
    writeln;
    writeln(' ', temp.year);
    writeln;
    write('   male percent:');
    for i := 1 to 16 do
      write(temp.mpct[i]: 3);
    writeln;
    write(' female percent:');
    for i := 1 to 16 do
      write(temp.fpct[i]: 3);
    writeln;
    writeln;
```

```
    writeln(separator)
  end {publish_data} ;

procedure make_file_changes;

  var
    i: integer;
    selector: char;

  begin
    writeln;
    writeln;
    writeln(' you may make any number of changes');
    writeln(' by selecting the appropriate symbol');
    writeln(' for the data to be changed.');
    writeln;
    writeln(' use the following set of selectors:');
    writeln;
    writeln(' area name -- ''a''');
    writeln(' year -- ''y''');
    writeln(' male percent -- ''m''');
    writeln(' female percent -- ''f''');
    writeln;
    writeln(' enter the selector, then <cr>, and');
    writeln(' you will be prompted to enter the');
    writeln(' new data.');
    writeln;
    writeln(' when you have completed the changes,');
    writeln(' enter an ''e'' to end the session.');
    writeln;
    write(' enter a selector:     ');
    readln(selector);
    repeat
      case selector of
        'A', 'a':
          begin
          writeln(' enter new area name.');
          writeln(' use 15 columns:     ');
          readln(temp.country)
          end;
        'Y', 'y':
          begin
          write(' enter the new year:     ');
          readln(temp.year)
          end;
        'M', 'm':
          begin
          writeln(' enter all sixteen male percent values --');
          writeln(' highest age groups to lowest:');
          for i := 1 to 16 do
            read(temp.mpct[i]);
          readln
          end;
        'F', 'f':
          begin
          writeln(' enter all sixteen female percent values --');
          writeln(' highest age groups to lowest:');
          for i := 1 to 16 do
            read(temp.fpct[i]);
          readln
          end;
      end {case} ;
      writeln(' make another selection:     ');
      readln(selector)
    until (selector = 'E') or (selector = 'e');
    rewrite(info, filename);
    info^.country := temp.country;
    put(info);
    info^.year := temp.year;
    put(info);
    for i := 1 to 16 do
      begin
      info^.mpct[i] := temp.mpct[i];
      put(info)
      end;
    for i := 1 to 16 do
      begin
      info^.fpct[i] := temp.fpct[i];
      put(info)
      end;
    close(info);
    writeln(' new data stored in ', filename);
    writeln;
    publish_data
  end {make_file_changes} ;

procedure modify_file_choice;

  var
    choice: char;

  begin
    writeln;
    writeln;
    writeln(' do you want to modify the data? --');
    writeln(' if so, enter a ''y''');
    write(' if not, enter an ''n'':     ');
    readln(choice);
    if (choice = 'Y') or (choice = 'y') then
      make_file_changes
    else
      writeln(' no changes to the file.')
  end {modify_file_choice} ;

begin
    access_file_data;
    publish_data;
    modify_file_choice
  end.
```

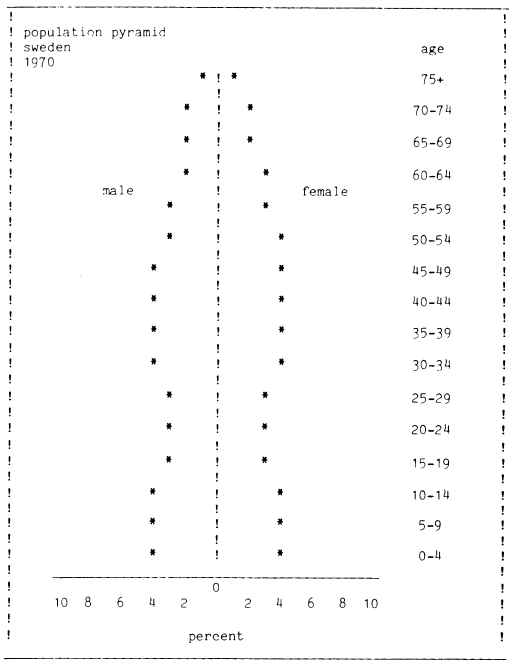
3) drawpyramid — The final program accesses the information stored in the external file and produces a pseudo-graphic on a line printer. The program can produce a single plot, as shown in the BERLIN example, or a double plot of either one region in two time periods or two different regions. The student selects single or double plot and enters the file names. The program takes over from there and produces the output. A double plot of SWEDEN and MEXICO illustrates the age structures of a country with a low rate of growth and one which is high.

```
run getpyr

 enter file name:   sweden.pyr




 -----------------------------------

 the following information is
 contained in sweden.pyr:

 sweden

 1970

   male percent:  1  2  2  2  3  3  4  4  4  4  3  3  3  4  4  4
 female percent:  1  2  2  3  3  4  4  4  4  4  3  3  3  4  4  4

 -----------------------------------


 do you want to modify the data? --
 if so, enter a 'y'
 if not, enter an 'n':    n

 no changes to the file.

Ready
```

```
program drawpyramid(input, output);

 {a program to produce a population pyramid graphic}

 const
   blank = ' ';

 type
   data =
     record
       country: packed array [1..15] of char;
       year: packed array [1..4] of char;
       male, female: array [1..16] of integer;
     end;
   identifiers = file of data;
   filename = packed array [1..10] of char;

 var
   choice: char;
   temp: data;
   matrix: array [1..42, 1..63] of char;
   pyramid: identifiers;
   file1, file2: filename;


 procedure initialize_array; {set all array elements to blank}

   var
     i, j: integer;

   begin
     for i := 1 to 42 do
       for j := 1 to 63 do
         matrix[i, j] := blank;
   end {initialize_array} ;


 procedure plot_choice; {single plot or superimposed plot}

   begin
     writeln;
     writeln(' enter a ''d'' if this is a double plot;');
     writeln(' enter an ''s'' for a single plot:     ');
     readln(choice);
     writeln
   end {plot_choice} ;


 procedure enter_file_name;

   begin
     if (choice = 'D') or (choice = 'd') then {double plot}
       begin
       writeln(' enter each file name on a separate line;');
       writeln(' use ten columns for each; note the marker,''^^^^;'');
       writeln(' if you are at the line printer,');
       writeln(' position the writing head to the');
       writeln(' last line of the paper before');
       writeln(' entering <cr> after the second file name.');
       writeln;
       writeln('^^', 10);
       readln(file1);
       readln(file2)
```

```
      end
    else (single plot)
      begin
      writeln(' enter the file name using ten columns;');
      writeln(' note the marker''^''');
      writeln(' if you are at the line printer,');
      writeln(' position the writing head to the');
      writeln(' last line of the paper before');
      writeln(' entering <cr>.');
      writeln;
      write('^'; 10);
      readln(file1)
      end
  end (enter_file_name) ;

procedure labels;

  var
    i, j, k: integer;
    shorttitle: packed array [1..18] of char;
    longtitle: packed array [1..35] of char;
    agegroups: packed array [1..65] of char;
    menwomen: packed array [1..10] of char;

  begin
    for i := 2 to 42 do
      begin
      matrix[i, 1] := '!';
      matrix[i, 63] := '!';
      end;
    for i := 1 to 63 do
      begin
      matrix[1, i] := '_';
      matrix[42, i] := '_';
      end;
    for i := 6 to 37 do
      matrix[i, 27] := '!';
    for i := 7 to 47 do
      matrix[37, i] := '_';
    if (choice = 'D') or (choice = 'd') then
      begin
      longtitle := 'population pyramids -- superimposed';
      for i := 3 to 37 do
        matrix[3, i] := longtitle[i - 2]
      end
    else
      begin
      shorttitle := 'population pyramid';
      for j := 3 to 20 do
        matrix[3, j] := shorttitle[j - 2]
      end;
    menwomen := 'maletemale';
    for j := 13 to 16 do
      matrix[13, j] := menwomen[i - 12];
    for j := 38 to 43 do
      matrix[13, j] := menwomen[j - 33];
    matrix[4, 53] := '0';
    matrix[4, 54] := '0';
    matrix[4, 55] := '0';
    matrix[6, 53] := '7';
    matrix[6, 54] := '5';
    matrix[6, 55] := '+';
    agegroups :=
          '70-7465-6960-6455-5950-5445-4940-4435-3930-3425
              -2920-2415-1910-14
                  ';
    i := 1;
    k := 8;
    while i <= 65 do
      begin
      for j := 52 to 56 do
        begin
        matrix[k, j] := agegroups[i];
        i := i + 1
        end;
      k := k + 2
      end;
    matrix[34, 53] := '5';
    matrix[34, 54] := '=';
    matrix[34, 55] := '9';
    matrix[36, 53] := '0';
    matrix[36, 54] := '=';
    matrix[36, 55] := '4';
    j := 7;
    while j <= 47 do
      begin
      matrix[38, j] := '^';
      j := j + 4
      end;
    matrix[38, 27] := '0';
    matrix[39, 7] := '1';
    matrix[39, 8] := '0';
    matrix[39, 11] := '8';
    matrix[39, 15] := '6';
    matrix[39, 19] := '4';
    matrix[39, 23] := '2';
    matrix[39, 31] := '2';
    matrix[39, 35] := '4';
    matrix[39, 39] := '6';
    matrix[39, 43] := '8';
    matrix[39, 46] := '1';
    matrix[39, 47] := '0';
    matrix[41, 24] := 'p';
    matrix[41, 25] := 'e';
    matrix[41, 26] := 'r';
    matrix[41, 27] := 'c';
    matrix[41, 28] := 'e';
    matrix[41, 29] := 'n';
    matrix[41, 30] := 't';
  end (labels) ;

procedure retrieve_and_assign_data;

  var
    i, j, k: integer;
    filearray: array [1..2] of filename;

  begin
    if (choice = 'D') or (choice = 'd') then (double plot)
      begin
      filearray[1] := file1;
      filearray[2] := file2;
      for i := 1 to 2 do
        begin
        if i = 1 then
          k := 43
        else
          k := 111;
        reset(pyramid, filearray[i]);
        temp.country := pyramid^.country;
        get(pyramid);
        if i = 2 then
        for j := 1 to 15 do
          matrix[4, j + 17] := temp.country[j]
        else
          for j := 1 to 15 do
            matrix[4, j + 2] := temp.country[j];
        temp.year := pyramid^.year;
        get(pyramid);
        if i = 2 then
          for j := 1 to 4 do
            matrix[5, j + 17] := temp.year[j]
        else
          for j := 1 to 4 do
            matrix[5, j + 2] := temp.year[i];
        for i := 1 to 16 do
          begin
          temp.male[i] := pyramid^.male[j];
          get(pyramid);
          if matrix[2 * j + 4, 27 - 2 * temp.male[i]] <> blank then
            matrix[2 * j + 4, 27 - 2 * temp.male[j]] := '='
          else
            matrix[2 * j + 4, 27 - 2 * temp.male[i]] := chr(k)
          end;
        for j := 1 to 16 do
          begin
          temp.female[j] := pyramid^.female[i];
          get(pyramid);
          if matrix[2 * j + 4, 27 + 2 * temp.female[i]] <> blank then
            matrix[2 * j + 4, 27 + 2 * temp.female[j]] := '='
          else
            matrix[2 * j + 4, 27 + 2 * temp.female[j]] := chr(k)
          end;
        close(pyramid)
        end
      end
    else (single plot)
      begin
      reset(pyramid, file1);
      temp.country := pyramid^.country;
      get(pyramid);
      for j := 1 to 15 do
        matrix[4, j + 2] := temp.country[j];
      temp.year := pyramid^.year;
      get(pyramid);
      for j := 1 to 4 do
        matrix[5, j + 2] := temp.year[i];
      for i := 1 to 16 do
        begin
        temp.male[i] := pyramid^.male[i];
        get(pyramid);
        matrix[2 * j + 4, 27 - 2 * temp.male[j]] := '*'
        end;
      for j := 1 to 16 do
        begin
        temp.female[i] := pyramid^.female[i];
        get(pyramid);
        matrix[2 * j + 4, 27 + 2 * temp.female[j]] := '*'
        end;
      close(pyramid)
      end
  end (retrieve_and_assign_data) ;

procedure symbol_explanation;

  var
    check1, check2: data;

    begin
      writeln;
      reset(pyramid, file1);
      check1.country := pyramid^.country;
      get(pyramid);
      check1.year := pyramid^.year;
      close(pyramid);
      reset(pyramid, file2);
      check2.country := pyramid^.country;
      get(pyramid);
      check2.year := pyramid^.year;
      close(pyramid);
      if check1.country = check2.country then (same area for both plots)
        begin
        writeln('  ', check1.year: 4, ' -- +');
        writeln('  ', check2.year: 4, ' -- o');
        writeln('  ''=''; same value for each year')
        end
      else (different areas)
        begin
        writeln('  ', check1.country, ' -- +');
        writeln('  ', check2.country, ' -- o');
        writeln('  ''=''; same value for both areas')
        end
    end (symbol_explanation) ;

  procedure skiplines; (for proper output formatting)

    var
      i: integer;
```

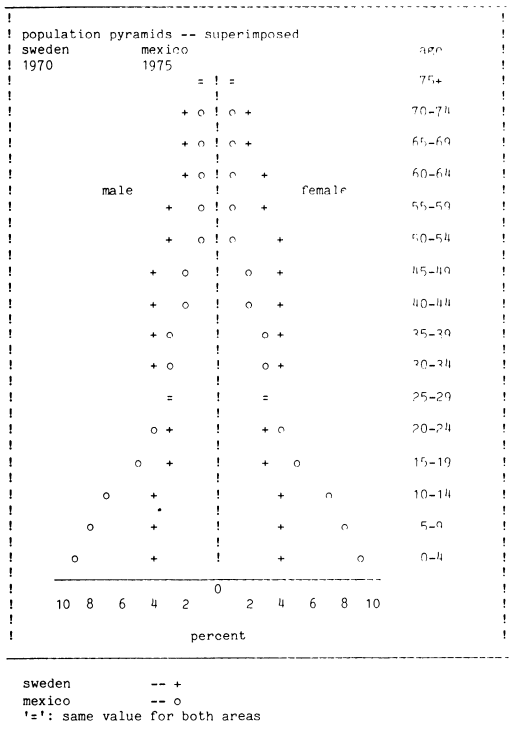
```
  begin
    for i := 1 to 12 do
      writeln
  end {skiplines} ;

procedure produce_pyramid;

  var
    i, j: integer;

  begin
    skiplines;
    for i := 1 to 42 do
      for j := 1 to 63 do
        begin
        write(matrix[i, j]);
        if j = 63 then
          writeln
        end;
    if (choice = 'D') or (choice = 'd') then
      symbol_explanation;
    skiplines
  end {produce_pyramid} ;

begin
  initialize_array;
  plot_choice;
  enter_file_name;
  labels;
  retrieve_and_assign_data;
  produce_pyramid
    end.
```



Conclusion

The inclusion of exercises such as this one in social science classes has proven to be valuable in a number of ways. It allows students with little or no programming background to get over their tentativeness about approaching a computer. In addition, I believe that such exposure to computers, however limited, contributes to the overall computer literacy of students. Finally, the experience may spur a student to want to take a course in computer programming or to learn other uses of the computer.

There is absolutely no reason why students in **all** divisions of the liberal arts setting should not benefit by




```
sweden          -- +
mexico          -- o
'=': same value for both areas
```

the opportunities available in the field of computer science.

Notes

1. The Geography Program Exchange assists universities and other non-profit organizations with the interchange of computer software which relates to problems of a geographic nature. The address is:

   Geography Program Exchange
   Department of Geography
   Michigan State University
   East Lansing, Michigan 45824

2. One of only a few books written on the general topic of computer applications in geography is Paul M. Mather, *Computers in Geography: A Practical Approach* (Oxford: Basic Blackwell, 1976); it contains four chapters, one of which is an introduction to the FORTRAN language.

3. Mark S. Mormonier, *Computer-Assisted Cartography: Principles and Prospects* (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1982), p. 22.

4. John L. Kirkley, Editor, "Our Industry Could Lead a Liberal Arts Renaissance," *Datamation,* March, 1983, p. 29.

5. Brian J. L. Berry, et al, *The Geography of Economic Systems* (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1976), p.36.

6. The programs in this paper were prepared using Oregon Software Pascal, Version 2.0, and run on a DEC PDP 11/70.

PUG

Path Pascal
A Language for Concurrent Algorithms

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1. Introduction

This paper is intended to provide an overview of the Path Pascal programming language. Rather than introduce the language by studying its definition, the approach taken here is to explore a moderately complex example. While any detailed understanding of Path Pascal must be based upon the formal definition of the language, this paper will present the most important concepts embodied in the language.

After a brief history of the development of Path Pascal, the problem to be solved by the example program will be presented. Using this example, three major concepts of Path Pascal will be explored. With these major concepts, the operation of the program can be understood. Finally, a summary of the present status and anticipated future of Path Pascal are discussed.

2. Background

Path Pascal was originally developed at the University of Illinois in 1978 by Dr. Roy Campbell. Details of the original Path Pascal compiler project are available from the University of Illinois as a series of Research Reports. In addition, the definition of the language has appeared in SIGPLAN Notices [1].

The University of Illinois implementation of Path Pascal was for the LSI-11/23 processor. Path Pascal has now been implemented on a variety of machines including the M68000 (by NASA-LaRC), AMAC-80 (by Martin-Marietta) and VAX-11/780 (by NASA-Goddard). This report is based upon experience gained with Path Pascal as part of NASA Contract NAS1-16985 during 1982 using the M68000-based Path Pascal compiler developed by Dr. Ed Foudriat at NASA's Langley Research Center.

Path Pascal is based upon "Path Expressions" first described by Campbell and Habermann in 1974 [2]. The key concept is that coordination among a collection of concurrent processes should be expressed in a language designed especially for that purpose. "Path Expressions" conveniently and succinctly specify the central concepts of "mutual exclusion" (protecting "critical sections" of code) and of "synchronization" (waiting for information to be computed by other processes). In Path Pascal, the primary unit for mutual exclusion and synchronization is the subroutine, allowing the use symbolic names in the Path Expressions.

In Path Pascal, "counting semaphores" are used to implement both mutual exclusion and synchronization. By specifying the Path Expression prior to the subroutines that it controls, the compiler can generate appropriate initialization, P-operation and V-operation at the beginning and ending of each subroutine.

2.1 The Island

Before discussing the example Path Pascal program, it may be useful to understand that this program is a simple event-driven simulation. The simulation involves an island and its inhabitants.

The island of this program is a very special island. It consists of a 25 × 17 grid, each element of which can either be empty (displayed as a blank), contain a wolf (designated by a 'W'), or contain a rabbit (designated by a 'R'). Initially, there are 17 wolves (all in column 10) and 17 rabbits (all in column 16).

Each wolf begins with a user-specified "energy". This energy is used on an "annual" basis to remain alive, looking for rabbits to eat or other wolves with which to mate. Each "year" the wolf looks around his position on the grid, determining if there are any rabbits or wolves in his neighborhood. If there are any rabbits, the wolf's energy is increased by eating them. If, on the other hand, there are too many wolves in the neighborhood, the wolf loses excess energy due to overcrowding. Only if there are a reasonable number of neighbor wolves and this wolf is "fertile" does the wolf attempt to produce an offspring. If the wolf's energy is reduced to zero, it dies.

Each rabbit also begins with a user-specified "energy". This energy is affected in a manner similar to a wolf, except that a rabbit is considered to have been "eaten" if there are any wolves in its immediate neighborhood and that rabbits gain energy by overcrowding rather than losing it.

Finally, the user may wish to "repopulate" the island, assigning new energy and lifetime specifications. This is done by pressing any key on the keyboard.

3. Path Pascal Constructs

The example program, ISLAND, is primarily written in standard Pascal. It makes use of only three new constructs — OBJECTs, PROCESSes and Wait-for-Son processing.

3.1. OBJECTs

Of the several extensions to standard Pascal, the OBJECT construct is the most important to understanding Path Pascal. An OBJECT is a Path Pascal TYPE with several properties similar to a RECORD. As with a RECORD, each variable of an OBJECT TYPE allocates stack space and NEW of a pointer to an OBJECT TYPE allocates heap space. The space required for a OBJECT TYPE is that for the semaphores implied by the OBJECT's Path Expression and for any variables explicitly declared within the OBJECT. Unlike RECORDs, OBJECTs contain subroutines (PROCE-

DURESs, FUNCTIONs and PROCESSes). Those subroutines that are included in the Path Expression are termed "ENTRY" routines and may be accessed from outside of the OBJECT using the RECORD-like notation "object.entry(parameters)" (e.g., line 436 or line 444).

Lines 16-52, 71-95, 96-183 and 186-200 indicate four common kinds of OBJECTs. These examples will be discussed in the following sections.

3.1.1. OBJECT CRTOBJ (lines 16-52)

This OBJECT is an example of an "interprocess buffer" OBJECT. Since processes run concurrently (see Section 4), they must be synchronized in order to transfer information. Unlike ADA in which processes must "rendezvous", Path Pascal facilitates the concept of "interprocess buffers" that contain data to be transferred from one process to another. This allows the "sending" process to continue execution after generating the information for the other process.

The Path Expression on lines 19-21 has both mutual exclusion and synchronization expressions. the first two expressions simply state that the operations PUSH and POP are atomic (only one PUSH at a time and only one POP at a time). The last expression specifies the synchronization between PUSH and POP. It states that a call to POP may not proceed until a call to PUSH has completed and, furthermore, at most CRTSZ calls to PUSH can be honored before at least one call to POP occurs.

This last implication of the Path Expression, that at most CRTSZ calls to PUSH can proceed without at least one call to POP, is the key to understanding the data structures (lines 24-27) and code (lines 29-51) of CRTOBJ. Since at most CRTSZ calls to PUSH can occur without a call to POP, all that is required is space for CRTSZ "messages". Since the "interprocess message" in this case is just a character, BUF is simply an ARRAY of CRTSZ characters. INPTR specifies where PUSH is to put its character, and OUTPTR specifies where POP is to get its character. This code works because the Path Expression controls access to the routines PUSH and POP, and, therefore, controls access to the BUF ARRAY.

3.1.2. OBJECT CREATOR (lines 71-95)

This OBJECT is also an interprocess buffer; however, the buffer has only a single entry (the VARs XX, YY and EE). This form of the interprocess buffer is very similar to the ADA "rendezvous".

3.1.3. OBJECT SCREEN (lines 96-183)

This OBJECT is used to control access to the INFO ARRAY, the inmemory representation of the island. The Path Expression on line 99 simply states that one and only one of the allowed operations may be progress at any given instant.

The routines in this OBJECT include SETUP (for reinitialization), KILL (for termination), LOOK (for examining the "neighborhood" of a wolf or rabbit), ASSIGN (for direct control of INFO), CHANGE (a test-and-set operation) and DONE (a set-and-test operation). The routine WRITES (update terminal screen) is available only within this OBJECT.

3.1.4. OBJECT SHUTUP (lines 186-200)

This OBJECT is used to synchronize the termination of the simulation. Since Path Pascal does not allow "preemptive termination" of process (see Section 4), care must be taken when writing processes that must eventually terminate.

This OBJECT acts essentially as a binary semaphore. The call to SHUTUP.WAIT on line 376 will cause the calling process (SHUTDOWN) to suspend operation until the call to SHUTUP.SIGNAL is made on line 364.

3.2. PROCESSes

The second major addition of Path Pascal to standard Pascal is the PROCESS. Conceptually, a PROCESS is a PROCEDURE that, after it is called, executes in parallel with its caller. In Path Pascal, all processes that are not waiting due to a Path Expression, a DOIO (see below) or a DELAY are competing for the hardware processor(s). Also note that each call to a PROCESS creates a new process, as in lines 311-317.

PROCESSes in Path Pascal can either be normal or INTERRUPT PROCESSes. An INTERRUPT PROCESS has two special attributes not associated with normal PROCESSes. The PRIORITY and VECTOR information are used to control the interrupt hardware such that the DOIO statement (lines 213-237) acts as a "wait-for-interrupt". In addition, as shown on lines 211, 216, 234, 239, it is sometimes necessary to enter "supervisor state" in order to access device controllers.

3.2.1. INTERRUPT PROCESS DLVJIN (lines 201-221)

This process is an "infinite loop", waiting for an interrupt from the terminal input hardware. When such an input occurs, the character is forwarded to the appropriate interprocess buffer.

3.2.2. INTERRUPT PROCESS DLVJOUT (lines 224-241)

This process is also an "infinite loop". It waits for a character to be placed into the appropriate interprocess buffer, transfer the character to the terminal, and waits for the completion interrupt.

3.2.3. PROCESS WOLF (lines 242-270)

This process corresponds to a wolf in the simulation; it is called when a wolf is to be created. The process is a loop corresponding to the lifetime of the wolf. In the loop, the ENERGY of the wolf (a local variable) is constantly updated until it is reduced to zero and the wolf dies.

3.2.4. PROCESS RABBIT (lines 273-302)

This PROCESS is similar to PROCESS WOLF, except that it corresponds to a rabbit. As with the wolf, the ENERGY of the rabbit is constantly updated until it is reduced to zero and the rabbit dies.

3.2.5. PROCESS SHUTDOWN (lines 366-380)

This PROCESS is used to wait for input from the user (any input will do). When this input occurs, it is necessary to notify the screen monitor (line 374) and the main program (line 375). However, at thia point it is necessary to wait for the main program (actually, PROCEDURE PROCREATE) to complete its processing (line 376). Finally, SHUTDOWN "absorbs" any extra attempts to create rabbits or wolves. This is completed when the special message having an ENERGY of zero is encountered, and SHUTDOWN is terminated.

3.3. Wait-for-Sons Processing

When a PROGRAM, PROCEDURE, FUNCTION or PROCESS calls a PROCESS, it is necessary that this "son" process terminate before the "father" can terminate. This is logically necessary due to the scope rules of Path Pascal. Furthermore, this "wait-for-sons" processing is a useful tool for coordinating the termination of a system.

Except for "wait-for-sons" processing, there is no reason that the code in PROCEDURE PROCREATE could not be part of the main program. Note, however, that all of the WOLF and RABBIT processes are initiated by PROCREATE. Hence, PROCREATE cannot continue until all of these processes have terminated. This fact is critical to the coordination between PROCREATE and SHUTDOWN when the simulation is being terminated.

4. PROGRAM ISLAND

Having looked at the special features of Path Pascal that are used by this program, it is now possible to step through a typical execution of the program.

The main program begins (lines 430-433) by allocating heap-space for CRTIBUF and CRTOBUF, by initiating the input/output processes DLJVIN and DLVJOUT, and associating DLJVIN with CRTIBUF and DLJVOUT with CRTOBUF.

The driving loop of the program (lines 435-445) clears the terminal's screen (using DEC-VT52 protocol), prompts the user for parameters (PARAMS), reinitializes the simulation (SCREEN.SETUP), initiates a process to look for terminal input (SHUTDOWN), and calls PROCEDURE PROCREATE.

PROCEDURE PROCREATE (lines 303-365) begins by initiating 17 wolves and 17 rabbits. It then enters a loop waiting for requests for creation. When such a request occurs, it is first tested to see if it was generated by SHUTDOWN, indicating that termination should begin. If this is not a SHUTDOWN request, it is a request for the creation of a wolf (ENERGY>0) or a rabbit (ENERGY<0). Each direction (UP, DOWN, LEFT and RIGHT) is tested to see if it is available. If all directions are occupied, creation is not possible. If a free position on the island is found, the SCREEN.CHANGE call updates the simulation and the rabbit or wolf is created (lines 358-361). When the special SHUTDOWN request is encountered, PROCREATE signals SHUTDOWN that it has completed processing, and waits for all of the wolf and rabbit processes to terminate.

Once all of the wolf and rabbit processes terminate, PROCREATE returns to the main program (line 444). The main program now signals the SHUTDOWN process that no more requests for creation will be generated, and the master control loop iterates.

5. Summary and Conclusions

While a single example cannot cover all of the constructs and uses of those constructs, the ISLAND program is representative of the important capabilities that Path Pascal has that are not found in standard Pascal. These capabilities include multiple processes (PROCESS), interprocess coordination (OBJECT), and process termination coordination (Wait-for-Son).

Having programmed in Path Pascal for several months, it is clear that these new capabilities are useful. Many of the PROCESSes and OBJECTs that have been written have been found to be highly reuseable since they "encapsulate" and entire concept or function within the program. However, it is equally clear that these new capabilities do not "solve" the concurrent programming problem. Developing the Path Expressions is a tedious, error-prone undertaking. Nonetheless, once a Path Expression is finally "correct", it is usually clear to anyone reading the code exactly what will occur when the program is executed.

One of the goals of the current research with Path Pascal is to identify various "prototype" Path Expressions. The "interprocess buffer" is a good example. If a few such prototypes can be found to be sufficient for most situations, a "macro OBJECT" facility might be added to Path Pascal to make these prototypes readily available to the average programmer.

```
PROGRAM ISLAND;  (* WOLF AND RABBIT SIMULATION PROGRAM *)
CONST
    BEL         7;      (* ASCII FOR TERMINAL BELL *)
    CR          13;     (* ASCII FOR TERMINAL END OF INPUT *)
    ESC         27;     (* ASCII FOR TERMINAL CREATOR *)

    CRTSZ       120;    (* SIZE OF TERMINAL BUFFER *)

    XMAX        26;     (* ISLAND SIZE: COLS+1 *)
    YMAX        18;     (* ISLAND SIZE: ROWS+1 *)

    XWOLF       10;     (* INITIAL COLUMN FOR WOLVES *)
    XRABBIT     16;     (* INITIAL COLUMN FOR RABBITS *)
TYPE
    CRTPTR      ^CRTOBJ;
    CRTOBJ      OBJECT  (* SYNCHRONIZE TERMINAL INPUT/OUTPUT *)

                  PATH
                          1:(PUSH),         (* ONE AT A TIME *)
                          1:(POP),          (* ONE AT A TIME *)
                      CRTSZ:(PUSH;POP)      (* PUSH THEN POP *)
                  END;

                  VAR
                      BUF     : ARRAY [1..CRTSZ] OF CHAR;
                      INPTR   : INTEGER;
                      OUTPTR  : INTEGER;

                  ENTRY PROCEDURE PUSH(CH:CHAR);
                  BEGIN
                      BUF[INPTR] := CH;
                      IF INPTR=CRTSZ THEN
                          INPTR := 1
                      ELSE
                          INPTR := INPTR+1;
                  END;  (* PROCEDURE PUSH *)

                  ENTRY PROCEDURE POP(VAR CH:CHAR);
                  BEGIN
                      CH := BUF[OUTPTR];
                      IF OUTPTR CRTSZ THEN
                          OUTPTR := 1
                      ELSE
                          OUTPTR := OUTPTR+1;
                  END;  (* PROCEDURE POP *)

                INIT;
                  BEGIN
                      INPTR := 1;
                      OUTPTR := 1;
                  END;
                END;  (* OBJECT CRTOBJ *)

VAR
    CRTIBUF : CRTPTR;   (* INPUT BUFFER *)
    CRTOBUF : CRTPTR;   (* OUTPUT BUFFER *)

    WINIT   : INTEGER;  (* WOLF: INITIAL ENERGY *)
```

```
    WYRS     : INTEGER;  (* WOLF: NORMAL LIFETIME *)
    WANNUAL  : INTEGER;  (* WOLF: ANNUAL ENERGY USAGE *)
    WFERTILE: INTEGER;  (* WOLF: ENERGY FOR FERTILITY *)
    WCROWD   : INTEGER;  (* WOLF: MAX ENERGY OF NEIGHBORS *)
    WMAX     : INTEGER;  (* WOLF: MAX ENERGY FOR AN INDIVIDUAL *)

    RINIT    : INTEGER;  (* RABBIT: INITIAL ENERGY *)
    RYRS     : INTEGER;  (* RABBIT: NORMAL LIFETIME *)
    RANNUAL  : INTEGER;  (* RABBIT: ANNUAL ENERGY USAGE *)
    RFERTILE: INTEGER;  (* RABBIT: ENERGY FOR FERTILITY *)
    RCROWD   : INTEGER;  (* RABBIT: MAX ENERGY OF NEIGHBORS *)
    RMAX     : INTEGER;  (* RABBIT: MAX ENERGY FOR AN INDIVIDUAL *

    CREATOR : OBJECT  (* SYNCHRONIZE WOLF/RABBIT CREATION *)
                PATH
                  1:(CREATE;STARTUP)
                END;

                VAR
                    XX  : INTEGER;
                    YY  : INTEGER;
                    EE  : INTEGER;

                ENTRY PROCEDURE CREATE(X,Y,E:INTEGER);
                BEGIN
                    XX := X;
                    YY := Y;
                    EE := E;
                END;  (* PROCEDURE CREATE *)

                ENTRY PROCEDURE STARTUP(VAR X,Y,E:INTEGER);
                BEGIN
                    X := XX;
                    Y := YY;
                    E := EE;
                END;  (* PROCEDURE STARTUP *)

            END;  (* OBJECT CREATOR *)

SCREEN  : OBJECT    (* COORDINATE SCREEN *)

          PATH
             1:(SETUP,KILL,LOOK,ASSIGN,CHANGE,DONE)
          END;

          VAR
              STOP  : BOOLEAN;
              INFO  : ARRAY [0..XMAX,0..YMAX] OF INTEGER;

          ENTRY PROCEDURE SETUP;  (* (RE)INITIALIZATION *)
          VAR
              X : INTEGER;
              Y : INTEGER;
          BEGIN
              STOP := FALSE;
              FOR X := 0 TO XMAX DO  (* RESET ENERGIES *)
                  FOR Y := 0 TO YMAX DO
                      INFO[X,Y] := 0;
          END;  (* PROCEDURE SETUP *)

          ENTRY PROCEDURE KILL;  (* BEGIN TERMINATION *)
          BEGIN
              STOP := TRUE;
          END;  (* PROCEDURE KILL *)

          ENTRY PROCEDURE LOOK(X,Y:INTEGER; VAR ER,EW:INTEGER);

            PROCEDURE TEST(ENERGY:INTEGER);
            BEGIN
                IF ENERGY<0 THEN
                    ER := ER+ENERGY
                ELSE
                    EW := EW+ENERGY;
            END;  (* PROCEDURE TEST *)

          BEGIN
              ER := 0;              (* SURROUNDING RABBIT ENERGIES *)
              EW := 0;              (* SURROUNDING WOLF ENERGIES *)
              TEST(INFO[X-1,Y]);
              TEST(INFO[X+1,Y]);
              TEST(INFO[X,Y-1]);
              TEST(INFO[X,Y+1]);
          END;  (* PROCEDURE LOOK *)

          PROCEDURE WRITES(X,Y,E:INTEGER);  (* WRITE TO SCREEN *)
          BEGIN
              CRTOBUF^.PUSH(CHR(ESC));      (* VT52 JUMP *)
              CRTOBUF^.PUSH('Y');
              CRTOBUF^.PUSH(CHR(Y+31));
              CRTOBUF^.PUSH(CHR(X+31));
              IF E=0 THEN                   (* EMPTY *)
                  CRTOBUF^.PUSH(' ')
              ELSE
                  IF E<0 THEN               (* RABBIT *)
                      CRTOBUF^.PUSH('R')
                  ELSE                      (* WOLF *)
                      CRTOBUF^.PUSH('W');
          END;  (* PROCEDURE WRITES *)

          ENTRY PROCEDURE ASSIGN(X,Y,E:INTEGER);
          BEGIN
              INFO[X,Y] := E;   (* UPDATE IN-MEMORY *)
              WRITES(X,Y,E);    (* UPDATE SCREEN *)
          END;  (* PROCEDURE ASSIGN *)

          ENTRY FUNCTION CHANGE(X,Y,E:INTEGER):BOOLEAN;
          BEGIN
              CHANGE := FALSE;
              IF (INFO[X,Y]=0) AND NOT STOP THEN  (* FREE *)
                BEGIN
                  INFO[X,Y] := E;  (* UPDATE IN-MEMORY *)
                  WRITES(X,Y,E);   (* UPDATE SCREEN *)
                  CHANGE := TRUE;
                END;
          END;  (* FUNCTION CHANGE *)

          ENTRY FUNCTION DONE(X,Y,E:INTEGER):BOOLEAN;
              BEGIN
                  INFO[X,Y] := E;         (* UPDATE IN-MEMORY *)
                  DONE := FALSE;
                  IF (E=0) OR STOP THEN  (* TERMINATE WOLF/RABBIT *)
                    BEGIN
                      WRITES(X,Y,0);      (* UPDATE SCREEN *)
                      DONE := TRUE;
                    END;
              END;  (* FUNCTION DONE *)

          END;  (* OBJECT SCREEN *)


SHUTUP  : OBJECT  (* SYNCHRONIZE TERMINATION *)

            PATH
              1:(SIGNAL;WAIT)
            END;

            ENTRY PROCEDURE SIGNAL;
            BEGIN
            END;  (* PROCEDURE SIGNAL *)

            ENTRY PROCEDURE WAIT;
            BEGIN
            END;  (* PROCEDURE WAIT *)

          END;  (* OBJECT SHUTUP *)

INTERRUPT PROCESS DLVJIN [PRIORITY=1,VECTOR=#300] (IBUF:CRTPTR);
   (* DEFAULT VECTOR  = #300 *)
   (* DEFAULT ADDRESS = #77777560 *)
VAR
    CSR[#77777560] : INTEGER;
    BUF[#77777562] : INTEGER;
    CHBUF          : INTEGER;
    CH             : CHAR;
BEGIN
    REPEAT
        SUPSET;
           CSR := 64;
           DOIO;
           CHBUF := BUF;
           CSR := CSR-64;
        SUPRTN;
        IF CHBUF<0 THEN
            IBUF^.PUSH(CHR(ESC));
        IBUF^.PUSH(CHR(CHBUF MOD 128));
    UNTIL FALSE;
END;  (* INTERRUPT PROCESS DLVJIN *)


INTERRUPT PROCESS DLVJOUT[PRIORITY=1,VECTOR #320] (OBUF:CRTPTR);
    (* DEFAULT VECTOR  = #320 *)
    (* DEFAULT ADDRESS = #77777564 *)
VAR
    CSR[#77777564] : INTEGER;
    BUF[#77777566] : INTEGER;
    CH             : CHAR;
BEGIN
    REPEAT
        OBUF^.POP(CH);
        SUPSET;
           CSR := 64;
           BUF := ORD(CH);
           DOIO;
           CSR := CSR-64;
        SUPRTN;
    UNTIL FALSE;
END;  (* INTERRUPT PROCESS DLVJOUT *)

PROCESS WOLF(X,Y,IENERGY:INTEGER);     (* ONE INSTANCE PER WOLF *)
VAR
    ENERGY : INTEGER;  (* CURRENT ENERGY LEVEL *)
    ER     : INTEGER;  (* ENERGY LEVEL OF NEIGHBORING RABBITS *)
    EW     : INTEGER;  (* ENERGY LEVEL OF NEIGHBORING WOLVES *)
    DLY    : INTEGER;  (* "REST" TIME BETWEEN ACTIVITIES *)
BEGIN
    ENERGY := IENERGY;                 (* ALWAYS >0 *)
    REPEAT
        ENERGY := ENERGY-WANNUAL;      (* ANNUAL ENERGY USAGE *)
        SCREEN.LOOK(X,Y,ER,EW);        (* CHECK NEIGHBORS *)
        IF ER<0 THEN                   (* RABBITS TO EAT *)
            ENERGY := ENERGY-4*ER
        ELSE
            IF EW>WCROWD THEN          (* TOO MANY WOLVES *)
                ENERGY := ENERGY-WANNUAL
            ELSE
                IF (EW>0) AND (ENERGY>WFERTILE) THEN  (* PROCREATE *)
                    CREATOR.CREATE(X,Y,ENERGY);
        IF ENERGY<0 THEN               (* AVOID BECOMING A RABBIT *)
            ENERGY := 0;
        IF ENERGY>WMAX THEN            (* CANNOT USE EXCESS ENERGY *)
            ENERGY := WMAX;
        DLY := WMAX-ENERGY;            (* REST BASED UPON ENERGY *)
        IF DLY>ENERGY THEN
            DLY := ENERGY;
        DELAY(DLY);                    (* REST *)
    UNTIL SCREEN.DONE(X,Y,ENERGY);     (* DECIDE WHETHER STILL "ALIVE" *)
END;  (* PROCESS WOLF *)


PROCESS RABBIT(X,Y,IENERGY:INTEGER);   (* ONE INSTANCE PER RABBIT *)
VAR
    ENERGY : INTEGER;  (* CURRENT ENERGY LEVEL *)
    ER     : INTEGER;  (* ENERGY LEVEL OF NEIGHBORING RABBITS *)
    EW     : INTEGER;  (* ENERGY LEVEL OF NEIGHBORING WOLVES *)
    DLY    : INTEGER;  (* "REST" TIME BETWEEN ACTIVITIES *)
BEGIN
    ENERGY := IENERGY;                 (* ALWAYS >0 *)
    REPEAT
        ENERGY := ENERGY-RANNUAL;      (* ANNUAL ENERGY USAGE *)
        SCREEN.LOOK(X,Y,ER,EW);        (* CHECK NEIGHBORS *)
        IF EW>WANNUAL THEN             (* EATEN BY WOLF *)
            ENERGY := 0
        ELSE
            IF (ER>0) AND (ENERGY>RFERTILE) THEN  (* PROCREATE *)
```

```
            BEGIN
              CREATOR.CREATE(X,Y,ENERGY);
              IF ER< RCROWD THEN     (* RABBITS LOVE A CROWD *)
                 ENERGY :  ENERGY+2*RANNUAL;
            END;
        IF ENERGY<0 THEN               (* AVOID BECOMING A WOLF *)
            ENERGY := 0;
        IF ENERGY<RMAX THEN            (* CANNOT USE EXCESS ENERGY *)
            ENERGY :  RMAX;
        DLY := ENERGY RMAX;            (* REST BASED UPON ENERGY *)
        IF DLY<= ENERGY THEN
            DLY := ENERGY;
        DELAY(DLY);                    (* REST *)
    UNTIL SCREEN.DONE(X,Y,ENERGY);     (* DECIDE WHETHER STILL "ALIVE" *)
END;  (* PROCESS RABBIT *)



PROCEDURE PROCREATE;  (* CREATE RABBITS AND WOLVES *)
VAR
    X      : INTEGER;                  (* CREATOR'S CURRENT POSITION *)
    Y      : INTEGER;
    ENERGY : INTEGER;                  (* CREATED'S INITIAL ENERGY *)
    DIR    : (UP,DOWN,LEFT,RIGHT);     (* CURRENT DIRECTION *)
    DIRS   : INTEGER;                  (* DIRECTION COUNTER *)
BEGIN
    FOR Y := 1 TO YMAX 1 DO  (* INITIALIZE SCREEN *)
      BEGIN
        SCREEN.ASSIGN(XWOLF,Y,WINIT);        (* A COLUMN OF WOLVES *)
        WOLF(XWOLF,Y,WINIT);
        SCREEN.ASSIGN(XRABBIT,Y,RINIT);      (* A COLUMN OF RABBITS *)
        RABBIT(XRABBIT,Y,RINIT);
      END;
    DIR := UP;  (* CREATION DIRECTION *)
    REPEAT  (* CREATE OFFSPRING AS REQUIRED *)
        CREATOR.STARTUP(X,Y,ENERGY);  (* OBTAIN OPERATION REQUEST *)
        IF ENERGY<>0 THEN             (* REQUEST FOR CREATION *)
          BEGIN
            DIRS :  4;                (* TRY ALL FOUR DIRECTIONS *)
            REPEAT
                IF DIR=RIGHT THEN     (* CONSIDER NEXT DIRECTION *)
                    DIR :  UP
                ELSE
                    DIR :  SUCC(DIR);
                CASE DIR OF
                UP :  IF Y>1 THEN
                        IF SCREEN.CHANGE(X,Y 1,ENERGY) THEN
                          BEGIN
                            DIRS :  0;    (* SET FLAG *)
                            Y :  Y 1;     (* UPDATE DIRECTION *)
                          END;
                DOWN :  IF Y+2<YMAX THEN
                        IF SCREEN.CHANGE(X,Y+1,ENERGY) THEN
                          BEGIN
                            DIRS :  0;    (* SET FLAG *)
                            Y := Y+1;     (* UPDATE DIRECTION *)
                          END;
                LEFT :  IF X>1 THEN
                        IF SCREEN.CHANGE(X 1,Y,ENERGY) THEN
                          BEGIN
                            DIRS :  0;    (* SET FLAG *)
                            X :  X 1;     (* UPDATE DIRECTION *)
                          END;
                RIGHT :  IF X+2<XMAX THEN
                        IF SCREEN.CHANGE(X+1,Y,ENERGY) THEN
                          BEGIN
                            DIRS :  0;    (* SET FLAG *)
                            X :  X+1;     (* UPDATE DIRECTION *)
                          END;
                END;
                DIRS :  DIRS 1;
            UNTIL DIRS< 0;
            IF DIRS<0 THEN                (* IF  0, CANNOT DO CREATION *)
                IF ENERGY<0 THEN          (* CREATE NEW RABBIT *)
                    RABBIT(X,Y,ENERGY)
                ELSE                      (* CREATE NEW WOLF *)
                    WOLF(X,Y,ENERGY);
          END;
    UNTIL ENERGY 0;  (* SHUTDOWN PROVIDES SPECIAL CODE FOR TERMINATION *)
    SHUTUP.SIGNAL;   (* SHUTDOWN HANDLES EXTRANEOUS CREATION REQUESTS *)
END;  (* PROCEDURE PROCREATE *)
```

```
PROCESS SHUTDOWN;  (* HANDLE TERMINATION *)
VAR
    CH       : CHAR;           (* INPUT CHARACTER *)
    X        : INTEGER;        (* ABSORB EXCESS ATTEMPTS TO PROCREATE *)
    Y        : INTEGER;
    ENERGY   : INTEGER;
BEGIN
    CRTIBUF^.POP(CH);          (* WAIT FOR TERMINAL INPUT *)
    SCREEN.KILL;               (* NOTIFY SCREEN MONITOR *)
    CREATOR.CREATE(0,0,0);     (* TERMINATE PROCEATION *)
    SHUTUP.WAIT;
    REPEAT  (* HANDLE ANY EXTRANEOUS ATTEMPTS AT CREATION *)
        CREATOR.STARTUP(X,Y,ENERGY);
    UNTIL ENERGY=0;
END;  (* PROCESS SHUTDOWN *)


PROCEDURE PARAMS;  (* PROMPT USER FOR INPUT *)
TYPE
    STRING6   PACKED ARRAY [1..6] OF CHAR;

  PROCEDURE PARAMIN(X,Y:INTEGER; MSG:STRING6; VAR VAL:INTEGER);
  VAR
      I   : INTEGER;
      CH  : CHAR;
  BEGIN
      CRTOBUF^.PUSH(CHR(ESC));         (* VT52 JUMP *)
      CRTOBUF^.PUSH('Y');
      CRTOBUF^.PUSH(CHR(Y+31));
      CRTOBUF^.PUSH(CHR(X+31));
      FOR I :  1 TO 6 DO               (* PROMPT MESSAGE *)
          CRTOBUF^.PUSH(MSG[I]);
      VAL :  0;
      REPEAT                           (* READ AND DECODE VALUE *)
          CRTIBUF^.POP(CH);
          IF (CH< '0') AND (CH< '9') THEN
            BEGIN
              VAL :  VAL*10+(ORD(CH) ORD('0'));
              CRTOBUF^.PUSH(CH);
            END
          ELSE
              IF CH<>CHR(CR) THEN    (* UNRECOGNIZED *)
                  CRTOBUF^.PUSH(CHR(BELL));
      UNTIL (VAL<0)4(0) OR (CH CHR(CR));
  END;  (* PROCEDURE PARAMIN *)

BEGIN
    PARAMIN(XMAX+8,1,'WINIT:',WINIT);  (* INITIAL ENERGY FOR WOLVES *)
    PARAMIN(XMAX+8,2,'RINIT:',RINIT);  (* INITIAL ENERGY FOR RABBITS *)
    PARAMIN(XMAX+8,5,' WYRS:',WYRS);   (* NORMAL LIFETIME FOR WOLVES *)
    PARAMIN(XMAX+8,6,' RYRS:',RYRS);   (* NORMAL LIFETIME FOR RABBITS *)

    WANNUAL :  WINIT DIV WYRS;         (* WOLF VALUES ARE POSITIVE *)
    WFERTILE :  4*WANNUAL;
    WCROWD :  4*WINIT;
    WMAX :  2*WINIT

    RINIT :  RINIT;                    (* RABBIT VALUES ARE NEGATIVE *)
    RANNUAL :  RINIT DIV RYRS;
    RFERTILE :  2*RANNUAL;
    RCROWD :  4*RINIT;
    RMAX :  2*RINIT;
END;  (* PROCEDURE PARAMS *)

BEGIN  (* PROGRAM ISLAND *)
    NEW(CRTIBUF);                      (* CREATE INPUT BUFFER *)
    DLV.JOIN(CRTIBUF);                 (* STARTUP INPUT PROCESS *)
    NEW(CRTOBUF);                      (* CREATE OUTPUT BUFFER *)
    DLV.JOUT(CRTOBUF);                 (* STARTUP OUTPUT PROCESS *)

    REPEAT
        CRTOBUF^.PUSH(CHR(ESC));       (* VT52 HOME OPERATION *)
        CRTOBUF^.PUSH('H');
        CRTOBUF^.PUSH(CHR(ESC));       (* VT52 CLEAR_SCREEN OPERATION *)
        CRTOBUF^.PUSH('J');
        PARAMS;                        (* ASK USER FOR PARAMETERS *)
        SCREEN.SETUP;                  (* INITIALIZE INTERNAL SCREEN *)
        SHUTDOWN;                      (* SETUP FOR EVENTUAL TERMINATION *)
        PROCREATE;                     (* RETURNS WHEN ALL TASKS COMPLETED *)
        CREATOR.CREATE(0,0,0);         (* TERMINATE SHUTDOWN *)
    UNTIL FALSE;
END.  (* PROGRAM ISLAND *)
```

PUG

An Introduction to Modula-2 for Pascal Programmers

By Lee Jacobson and Bebo White
Jacobson, White, & Associates
San Francisco, CA

THE BACKGROUND AND HISTORY OF MODULA-2

Modula-2 (like Pascal) was developed at the ETH-Zurich under the direction of Niklaus Wirth (Institut fur Informatik). Its development grew largely from a practical need for a general purpose, efficiently implementable systems programming language. The first production use of Modula-2 occurred in 1981. Dr. Wirth's book, *'Programming in Modula-2'* was published by Springer-Verlag in 1982.

It is virtually impossible to examine Modula-2 without recognizing its roots in Pascal. In its original design, Pascal was intended to be a language suitable for teaching programming as a systematic discipline based on certain fundamental concepts clearly and naturally reflected within it. These concepts were largely centered around stepwise refinement of problem solutions and structured programming.

Inasmuch as Pascal is basically an academic language, its widespread use for a variety of applications has clearly exceeded its design intention. Hence, many extensions to the original Pascal definition have been designed. Likewise, it has attracted as many critics as it has disciples.

Modula-2 has assumed all of the positive features of Pascal, and has attempted to address its commonly recognized shortcomings. The result is a structured, modular, portable, readable, efficient, machine independent, flexible language.

This paper will address the primary differences between Modula-2 and Pascal with particular emphasis on some of those features which the authors consider quite significant. Programming examples will be given in both Modula-2 and Pascal.

MODULA-2'S DIFFERENCES FROM PASCAL

The Role of Modules in Modula-2

Modules are the most important feature distinguishing Modula-2 from Pascal. Relying heavily upon the concepts of scope and block, modules address the problem, usually found in large programs, of separating visibility from existence. In block-structured languages, the range in which an object (e.g. a variable or procedure) is known is called the object's scope, and therefore, defines its visibility. However, an object's visibility also binds its existence, in that objects are created when the block in which they reside is entered and destroyed when the block is exited. It should be possible to declare variables that maintain their values, but are visible only in a few parts of a program. Concurrently, there is also a need for closer control of visibility. A procedure should not be able to access every object declared outside of it when it only needs to access a few of them.

Syntactically, modules closely resemble procedures, but they have different rules about visibility and the existence of their locally declared objects. Consider the following declarations:

```
PROCEDURE Outside;
  VAR x,y,z: INTEGER;

  MODULE Mod;
    IMPORT x;
    EXPORT a,P1;
    VAR a,b,c: INTEGER;

    PROCEDURE P1;
    BEGIN
      a := a + 1;
      x := a;
    END P1;

  END Mod;

  . . . .

END Outside;
```

```
PROCEDURE Outside;
  VAR x,y,z: INTEGER;

    (* no module here *)

    a,b,c: INTEGER;

  PROCEDURE P1;
  BEGIN
    a := a + 1;
    x := a;
  END; (* P1 *)

  . . . .

END; (* Outside *)
```

The only syntactic difference between the module Mod and a normal Pascal procedure declaration are the reserved word beginning the declaration (MODULE instead of PROCEDURE) and the presence of IMPORT and EXPORT declarations following the module heading.

The semantic differences are more interesting. The objects declared within Mod (a, b, c) exist at the same time as the variables x, y, and z, and remain so as long as Outside is active. The objects named in Mod's IMPORT list are the only externally declared objects visible within Mod (x but not y or z). The objects declared in Mod's EXPORT list are the only locally declared objects visible outside Mod. Thus, a and P1 are accessible from Outside, but b and c remain hidden inside Mod.

Specifically, a module can be thought of as a syntactically opaque wall protecting its enclosed objects, be they variables or procedures. The export list names identifiers defined inside the module that are also to be visible outside. The import list names the identifier defined outside the module that is visible inside. Generally, the rules for modules are:

1. Locally declared objects exist as long as the enclosing procedure remains activated;
2. Locally declared objects are visible inside the module and if they appear in the module's export list, they are also visible outside;
3. Objects declared outside of the module are visible inside only if they appear in the module's import list;

The following example demonstrates the essence of modularity:

```
MODULE MainProgram;

    . . . .

  MODULE RandomNumbers;
    IMPORT TimeOfDay;
    EXPORT Random;
    CONST Modulus = 2345;
          Increment = 7227;
    VAR Seed : INTEGER;

    PROCEDURE Random() : INTEGER;
    BEGIN
     Seed := (Seed+Increment)
             MOD Modulus;
     RETURN Seed;
    END Random;

  BEGIN (* RandomNumber *)
    Seed := TimeOfDay;
  END RandomNumber;
      . . . .

BEGIN (* MainProgram *)

    . . . . .
  WriteInt(Random(), 7);

    . . . .
END MainProgram.
```

```
PROGRAM MainProgram;
  VAR Seed : INTEGER;

      . . . .

FUNCTION Random : INTEGER;
  CONST Modulus = 2345;
        Increment = 7227;
BEGIN
  Seed := (Seed+Increment)
          MOD Modulus;
  Random := Seed;
END; (* Random *)

      . . . .

BEGIN (* MainProgram *)
  Seed := TimeOfDay;
   . . . .
  WriteLn(Random, 7);

   . . . .
END. (* MainProgram *)
```

The random number generator in these examples uses a seed variable to generate the next random number. Thus, the seed must maintain its value across function calls. The program on the right shows the classical Pascal solution. Notice that Seed's declaration is at the top of the program, while its initialization is forced to the bottom. Two obvious disadvantages arise from the scattering of Seed across the face of the program:

1. Its occurences become hard to find, especially in a large program;
2. It becomes accessible to every other procedure in the program even though it is used only by Random;

The example on the left demonstrates the usefulness of the module structure. The only object visible to the ouside world is the procedure Random, while all objects pertaining to the random number generator are contained in one place. Note that the module RandomNumber contains both declarations and a statement part. Module bodies are the (optional) outermost statement parts of module declarations and serve to initialize a module's variables. Although subject to the module's restrictive visibility rules, module bodies conceptually belong to the enclosing procedure rather than the modules themselves. Therefore, module bodies are automatically executed when the enclosing procedure is called.

Relaxed Declaration Order

New Pascal users are often frustrated and confused by the enforced declaration and definition block structure required within the program skeleton. Despite the emphasis on modules, blocks still play an important part in Modula-2: implementation modules, program modules, internal modules, and procedures are all declared as blocks. Differences from Pascal include relaxed order of declarations, termination of all blocks by a procedure or module identifier, and the optional nature of block bodies.

Pascal imposes a strict order on the declaration of objects; within any given block, labels must be declared before constants, constants before types, and so on. Modula-2 eliminates this restriction — declarations can appear in any order. Programs containing a large number of declarations are easier to read and understand when related declarations are grouped together (regardless of their kind).

The following is an example of relaxed declaration order:

```
MODULE Xlator;
  CONST MaxsSym = 1024;

  TYPE SymBuffer = ARRAY[1..MaxSym] OF CHAR;
  VAR SymBuff1, SymBuff2: SymBuffer;
  . . . .
  CONST MaxCode = 512;
  TYPE CodeBuffer = ARRAY[1..MaxCode] OF BYTE;
  VAR CodeBuff: CodeBuffer;
  . . . .
END Xlator.
```

This example easily demonstrates how various related declarations may be placed together in a Modula-2 program, whereas in a Pascal program they may be scattered due to strict block ordering. Relaxed declaration order not only improves readability but enables a logical ordering which may be very important in large programs.

GOTO-less Programming In Modula-2

Inasmuch as structured programming is often equated with elimination of the use of unconditional transfers, Pascal was designed to de-emphasize use of the GOTO statement. Still the GOTO statement and the LABEL 'type' were supported to allow programming cases where the Pascal logical structures were insufficient. This meant that a GOTO statement was available for use in a situation which would otherwise have forced restructuring of the program logic.

For example, consider the following two program segments:

```
Remainder := Alpha MOD Beta;
WHILE Remainder <> 0 DO
  BEGIN
    Alpha := Beta;
    Beta := Remainder;
    Remainder := Alpha MOD Beta
  END;
```

```
10: Remainder := Alpha MOD Beta;
    IF Remainder = 0 THEN
                   GOTO :20;
    Alpha := Beta;
    Beta := Remainder;
    GOTO 10;
20: . . . .
```

The example on the left avoids use of a GOTO by duplicating an operation. The example on the right, while using GOTOs is actually more explicit.

Modula-2 does not support Pascal GOTO and LABEL. Instead it provides transfer mechanisms for uses under particular controlled circumstances. One of these mechanisms is the EXIT statement which permits premature exiting of a loop. The following is a program segment in Modula-2 performing the same operation:

```
LOOP
 Remainder := Alpha MOD Beta;
 IF Remainder := 0 THEN EXIT;
 Alpha := Beta;
 Beta := Remainder
END;
```

This example also illustrates the Modula-2 LOOP construct which operates as a Loop-Forever structure. When the EXIT statement is executed, program control

will transfer to the statement following the END statement which terminates the range of the LOOP.

Additional examples of unconditional transfers supported by Modula-2 include the RETURN statement which is used to prematurely exit a procedure, and the HALT standard procedure which terminates the current program.

Dynamic Array Parameters

Another important distinction between Modula-2 and Pascal involves the capability to declare dynamic array parameters. Modula-2 allows formal parameter types of the form:

ARRAY OF T

where T is an arbitrary base type. Note that the array bounds are omitted defining a dynamic array type which is compatible with all (one dimensional) arrays having the same base type T.

The ramifications of this feature are widespread. through it, procedures are able to pass to other procedures (functions, etc.) arrays of unspecified size. (Index checking is accomplished by means of a new standard procedure HIGH).

Perhaps the most important way in which dynamic array perameters may be used is in the area of string processing. This feature lifts the rigid Pascal restriction concerning the value assignment and comparison of string variables. No longer is it necessary that operations may only be performed on strings which have the same length.

Separate Compilation

Separate compilation is allowed by the Modula-2 compiler through the use of the compilation unit. Modula-2 programs are constructed from two kinds of compilation units: program modules and library modules. Program modules are single compilation units and their compiled forms constitute executable programs. They are analogous to standard Pascal programs.

Library modules are a different animal and form the basis for the Modula-2 library. They are divided into a definition module and an implementation module. Definition modules contain declarations of the objects which are exported to other compilation units. Implementation modules contain the code implementing the library module. Both always exist as a pair and are related by being declared with the same module identifier.

To understand the rationale behind dividing a library module into separate definition and implementation modules, consider the design and development of a large software system, such as an operating system. The first step in designing such a system is to identify major subsystems and design interfaces through which the subsystems communicate. Once this is done, actual development of the subsystems can proceed, with each programmer responsible for developing one (or more) of the subsystems.

Now consider the project requirements in terms of Modula-2's separate compilation facilities. Subsystems will most likely be composed of one or more compilation units. Defining and maintaining consistent interfaces is of critical importance in ensuring error-free communication between subsystems. During the design stage, however, the subsystems themselves do not yet exist. They are known only by their interfaces.

The concept of a subsystem interface corresponds to the definition module construct. Thus, interfaces can be defined as a set of definition modules before subsystem development (i.e., design and coding of the implementation modules) begins. These modules are distributed to all members of the programming group, and it is through these modules that inter-subsystem is defined. Interface consistency is automatically enforced by the compiler.

Modula-2 Libraries

The library is a collection of separately compiled modules that forms an essential part of most Modula-2 implementations. It typically contains the following kinds of modules:

1. Low-level system modules which provide access to local system resources;
2. Standard utility modules which provide a consistent system environment across all Modula-2 implementations;
3. General-purpose modules which provide useful operations to many programs;
4. Special-purpose modules which form part of a single program;

The library is stored on one or more disk files containing compiled forms of the library module's compilation units. The library is accessed by both the compiler and the program loader — the former reads the compiled definition modules while compiling and the latter loads the compiled implementation modules when executing the program that imports library modules.

A dependency arises between library modules and the modules that import them. Consider the example of a single library module. The compiler must reference the module's symbol file (a compiled definition module) in order to compile the implementation module. Therefore, the definition module must be compiled first. Once an implementation module has been compiled, its object file is tied to the current symbol file, as the object code is based on procedure and data offsets obtained from the symbol file. Similarly, when a program imports a library module, it is assumed that the symbol file offsets are accurate reflections of the corresponding object file.

The Modula-2 language contains no standard procedures for I/O, memory allocation, or process scheduling. Instead, these facilities are provided by standard utility modules stored in the library. Standard utility modules are expected to be available in every Modula-2 implementation. Thus, by using only standard modules, Modula-2 programs become portable across all implementations.

The advantages of expressing commonly-used routines as library modules (rather than part of the language) include a smaller compiler, smaller run-time system, and the ability to define alternative facilities when the standard facilities prove insufficient. Disadvantages include the need to explicitly import and bind

library modules, and *occasionally* a less flexible syntax imposed by expressing standard routines as library modules (as opposed to their being handled specially by the compiler).

CONCLUSION

The examples cited above can only provide a clue as to the power and flexibility of the Modula-2 language. It is the hope of the authors that they can pique significant curiosity and interest into this amazing new programming tool.

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PUG

Data Structures Using Pascal
by A.M. Tenenbaum and M.J. Augenstein
Prentice-Hall, 1981

This book is intended as a text for a first course in data structures that is also a second course in programming. It presents all of the major data structures including stacks, queues, lists, trees, and graphs and describes recursion, list processing, sorting, and searching. An appendix provides a brief tutorial on Pascal. The emphasis is on practical techniques as opposed to theoretical concepts. All algorithms and examples are presented in Pascal.

This book is excellent both for students and for practicing programmers who want to learn how to apply algorithms and data structures, whether or not they use Pascal. However it would not be appropriate, nor was it intended to be, for those merely wishing to learn Pascal.

The authors employ several pedagogical techniques which others would do well to emulate. First numerous examples and sample programs are presented; the authors do not merely rely on textual explanations. In spite of this, there are very few typographical or algorithmic errors as so often is the case with multiple figures. Second, the same basic figure is repeated several times with each version successively updated to show the intermediate results of an algorithm. For example, an array is listed after each pass of a sorting algorithm so the reader can follow how the sort progresses. Third, algorithms are often presented as a combination of Pascal and pseudocode, thus highlighting the key points and not confusing the reader with such irrelevancies as initialization or I/O. Fourth, algorithms are presented several times with each new version a refinement of the previous one.

My only criticisms would be that some of the algorithms could be simplified, frequently by more appropriate tests in "while" statements; and more use should be made of enumeration types — certain algorithms had a Fortran ring to them. However these are nitpicks: the book is excellent and is highly recommended to all PUG'ers.

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SOFTWARE BUILDING BLOCKS, INC. ANNOUNCES PASCAL COMPILER FOR THE IBM PERSONAL COMPUTER®

ITHACA, NY — A new company, Software Building Blocks, Incorporated, has been formed in Ithaca, New York. The founders of the company are Jeff Moskow, author of the popular, highly acclaimed Pascal/Z™ compiler marketed by Ithaca InterSystems, Inc.; Laurie Hanselman Moskow, formerly Software Products Manager at InterSystems; and William Kellner, a software engineer who has worked extensively with Moskow on the Pascal/Z compiler.

The first product to be released by Software Building Blocks, Inc. is a two-pass, locally optimizing Pascal compiler for the IBM Personal Computer. The initial release will run under PC-DOS™; and a CP/M-86™ version is planned for the near future. Based on the Pascal/Z compiler, the Software Building Blocks implementation, SBB Pascal™, closely follows the Jensen & Wirth definition of the language, with extensions designed to aid the professional programmer in serious software development. Extensions will include: variable length strings, direct file access, arbitrary precision BCD numbers for business arithmetic, functions returning structured values, separate compilation, exterenal routines, include files, symbolic I/O of enumeration types, an ELSE clause for the CASE statement, overlays and chaining.

The compiler package includes a sophisticated interactive Pascal debugger, written in SBB Pascal, designed to aid in isolating and correcting faults in Pascal programs. Features of the debugger include the abilities to set and display both absolute and conditional breakpoints; set watches on variables, procedures or functions; display and modify both global and local variables; display the procedure/function stack, current statement and module numbers, current run-time requirements, and the last ten statements executed; trace through a program by statement number and procedure/function entry/exit; and more.

Also included in the package is a screen editor, provided in SBB Pascal source. The editor's capabilities include: insertion and deletion of lines and characters, finding and/or replacing of strings, copying lines of text, autoindent for entering structured programs, and many other features. The editor makes use of the function keys on the IBM PC to make editting as easy and efficient as possible. The editor is provided in source as an example of the advantages of programming in SBB Pascal. The library routines are also provided in 8086 assembly language source, and many other example programs are included as well.

Software Building Blocks, Inc. intends to release the PC-DOS version of the compiler in June. For more information, contact Laurie Moskow, Software Building Blocks, Inc., P.O. Box 119, Ithaca, New York, 14851-0119, (607) 272-2807.

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SAGE OPENS BOSTON DIVISION

Sage Computer Technology, headquartered in Reno, Nevada, has announced the opening of its Boston division.

The purpose of the new facility is to provide regional support for dealers and users of the Sage line of 16-bit microcomputers, and to expedite delivery of new units throughout the Eastern United States.

A complete inventory of Sage II's, Sage IV's, parts and literature is stocked, and a fully-equipped and staffed service department is maintained on the premises.

According to Rod Coleman, Sage president, plans call for a total of nine such offices to augment the company's domestic sales and support activities. "Regional support for our dealers and OEMS is a critical part of our marketing plan."

Sage's Boston office is now open to dealers & OEMS, and is located at 15 New England Executive Park, Suite 120, Burlington, MA 01803. The telephone number is (617) 229-6868.

More information about Sage micros is available from either Boston office or corporate office at 4905 Energy Way, Reno, Nevada 89502. Telephone (702) 322-6868.

If agency contact is required, phone or write The Schraff Group, 18226 W. McDurmott, Suite E, Irvine, CA 92714. Telephone (714) 540-8977.

NEW, 16-BIT SAGE IV HAS WINCHESTER PLUS MULTI-USER CAPABILITY

RENO, NEVADA — Sage Computer Technology has announced availability of the Sage IV, 16-bit (68000) supermicro.

The new multi-user computer, which accommodates up to 6 simultaneous users, surpasses the considerable capabilities of the Sage II introduced in March, 1982.

Both machines are based on the 8 MHz 68000 processor, and both are capable of performing 2-million operations per second. According to Rod Coleman, Sage president, they offer performance comparable to that of high-end mini-computers at a mid-range to high-end business micro price.

The Sage IV comes standard with 128K of main

memory which is expandable, optionally to a megabyte. This represents an enormous jump from the 128K to 512K expandability of the Sage II, which in turn offers far greater capacity than the typical 64K, 8-bit computer.

In addition, a 5 to 30Mb Winchester disk, either fixed or removable, is built into the Sage IV next to a 5¼ inch floppy backup. Since there are no wait states, a 20K program loads from the floppy in 1 second, and from the hard disk in $^1/_{10}$ second.

The cabinet, though about 1½ inches taller than that of the Sage II, is still deceptively small, measuring only 6½″ high, 12½″ wide and 16¾″ deep.

"There aren't any tradeoffs with either of these machines, said Coleman, "the user doesn't have to give up software support to get high performance, because the Sages' p-System standard operating system is able to run hundreds of popular programs developed for 8-bit micros."

More information may be had by contacting Sage Computer Technology, 35 North Edison Way, Suite 4, Reno, Nevada 89502. Telephone (702) 322-6868.

If agency contact is required, phone or write The Schraff Group, 1325 Airmotive Way, Suite 175, Reno, Nevada 89502. Telephone (702) 348-7339.

NEW MODULA-2 MANUAL FEATURES TUTORIALS, STANDARD LIBRARY

DEL MAR, CA, Jan. 21 — A 264-page Modula-2 user's manual, featuring a language tutorial and standard library definitions, is now available from Volition Systems here.

Modula-2 is a new programming language designed by Niklaus Wirth to replace his earlier language, Pascal, in a wide range of real-world applications. Together with Wirth's own specifications of the language, this manual provides a complete description of Volition's implementation of Modula-2, according to its author Richard Gleaves of Volition Systems.

The manual is designed to be used with Wirth's 48-page monograph which defines Modula-2 in a concise but informal style. The monograph is included with the manual. Wirth's newly published book *Programming in Modula-2* is also available from Volition.

The manual contains a tutorial for Pascal programmers that can make them comfortable with the language within a few hours and proficient within a week, Gleaves said.

The name Modula-2 comes from MODUlar LAnguage. It uses modules to facilitate the development and maintenance of large, complex systems. The language is especially useful in large industrial and commercial applications where it can save software developers both time and money.

Modula-2 is designed to utilize standard software modules, which are defined in the new manual. These modules provide access to the facilities normally provided by an operating system, such as program and process control; console and file I/O, including random access files and disk directory operations; and storage management. The standard software modules also include utility routines for format conversion, strings, 19 digit BCD arithmetic, and other facilities.

The manual is divided into six sections. The Modula-2 tutorial for Pascal programmers comprises about one-third of the book.

In addition, there is an introductory section and sections defining the standard library modules, the utility library, a system document that describes the implementation of Modula-2 for UCSD Pascal™ and a machine-specific implementation guide which includes information on machine specific library modules, interrupt handling, and machine-level data representation.

The Modula-2 User's Manual, including Wirth's Modula-2 report, is immediately available from Volition Systems, P.O. Box 1236, Del Mar, CA 92014 for $35 per copy. Wirth's book, *Programming in Modula-2*, published in 1982 by Springer-Verlag, can be ordered for $16. Further information about the programming language is also available from Volition Systems.

Volition Systems concentrates on systems software development and on research and development in hardware and sotware. Since the company was founded in 1980, it has been a leader in the implementation and dissemination of the Modula-2 language and other high level languages and in the design and development of advanced computer architectures.

For further information, contact:

Volition Systems
P.O. Box 1236, Del Mar, CA 92014
(619) 481-2286

™ UCSD Pascal is a trademark of the Regents of the University of California.

MODULA-2 USER'S MANUAL from Volition Systems (Del Mar, CA) describes Niklaus Wirth's new programming language in a 264-page loose-leaf format. document contains a complete tutorial for Pascal programmers, sections defining the standard library modules and the utility library, and an implementation guide. The manual comes with a copy of Wirth's 48-page technical report on Modula-2.

Modula-2 is particularly useful in large industrial and commercial applications where using standard modules facilitates development of large, complex systems, according to Volition, which has pioneered in commercial implementations of the new language. The *Modula-2 User's Manual* is immediately available from Volition Systems, P.O. Box 1236, Del Mar, CA 92014 for $35.

For further information, contact:

A. Winsor Brown
(714) 891-6043

USUS FALL MEETING SET FOR WASHINGTON,D.C.

WASHINGTON, D.C., June 3 — USUS, Inc., the UCSD Pascal User's Society, will hold its semi-annual national meeting at the Crystal City Hyatt Hotel here October 14-16, according to Robert Peterson, USUS president.

In conjunction with the meeting, USUS will sponsor two free tutorials — an introduction to the p-System and an introduction to UCSD Pascal, including Apple Pascal.*

The meeting will feature technical presentations, hardware and software demonstrations, language tutorials, special interest group meetings and software library exchange. Also planned are expert user and major vendor panels. Election of officers will be held.

"Non-USUS members are welcome to register and attend any or all of the meeting programs," Peterson noted.

USUS (pronounced use-us) represents users of the UCSD Pascal System and its derivatives including the UCSD p-System and Apple Pascal. It is the most widely-used, machine-independent software system. The society is non-profit and vendor independent.

The UCSD Pascal System has more than 100,000 users and is capable of running on nearly any computer. It was developed at the University of California San Diego to facilitate software portability.

Among the special interest group meetings scheduled for the Washington meeting are those for users of IBM Personal Computers, Apple, DEC, Texas Instruments, NEC Advanced Personal Computer, the IBM display writer and Sage Computer Technology computers.

Also meeting will be those interested in application development, graphics, communications, file access, Modula-2, UCSD Pascal compatibility and the Advanced System Editor.

The software library, with significant recent acquisitions, will be available for reproduction on various diskette formats. Members at the meeting will be able to copy the library onto their own disks for $1.00 each.

Those registering for the meeting before September 23 will qualify for the pre-registration price of $25. Checks should be made payable to USUS and mailed to USUS Meeting Committee, P.O. Box 1148, La Jolla, CA 92038. Registration at the door will be $35 and will begin at 10 a.m. Friday, October 14.

Hotel reservations should be made directly with the Crystal City Hyatt hotel (adjacent to Washington National Airport), 2799 Jefferson Davis Highway, Arlington, VA 22202, (703) 486-1234. Additional meeting information is available from Thomas Woteki, Information Systems Inc., 3865 Wilson Blvd., Suite 202, Arlington, VA 22203, (703) 522-8898.

USUS was created to promote and influence the development of the UCSD Pascal System and to provide users and vendors with a forum for education and information exchange about it. Annual membership in the society is $25 for individuals and $500 for institutions.

* Apple Pascal is a trademark of Apple Computer, Inc.

UCSD PASCAL USERS FORM TEXT EDITOR INTEREST GROUP

SAN FRANCISCO, CA, June 15, 1983 — A special interest group (SIG) for users of the Advanced System Editor (ASE) for the UCSD Pascal System has been formed by USUS, the UCSD Pascal System User's Society, according to Robert W. Peterson, president of the society.

The new SIG will be chaired by Sam Bassett, of San Francisco, CA. "The ASE SIG will be open to any USUS member who is using or thinking about getting the Advanced System Editor." Peterson said.

The new ASE SIG allows members to share common problems and solutions and will serve as a clearing house for information relating to implementation, optimization and use of ASE on a variety of systems which have the UCSD p-System installed.

The SIG has established a liaison with Volition Systems of Del Mar, CA, the creators of ASE. It will coordinate relevant contributions to the USUS Software Exchange Library and to USUS News, the society's quarterly newsletter, Bassett said. Furthermore, SIG members may communicate via electronic mail under USUS sponsorship.

The next ASE SIG meeting will take place at the USUS semi-annual national meeting in Washington, D.C., October 14-16. In addition to the ASE and other SIG sessions, the USUS meeting will feature tutorials on UCSD Pascal and the UCSD p-System. Also on the agenda are technical presentations, software exchange, hardware and software demonstrations and an expert user panel.

Membership in the ASE SIG is free of charge to any member of USUS, the vendor-independent, non-profit user's group for the UCSD Pascal System. Annual membership in the society is $25 for individuals and $500 for institutions.

USUS (pronounced use-us) was founded in 1980 to promote and influence the development of the UCSD Pascal System and to provide a forum for education and information exchange about it. Further information on USUS is available from the Secretary, USUS, P.O. Box 1148, La Jolla, CA 92038.

PASCAL USER'S SOCIETY FORMS MODULA-2 GROUP

SAN DIEGO, CA, May 26 — USUS, the UCSD Pascal System User's Society, has formed a special interest group (SIG) for users of the new Modula-2 programming language, according to Robert W. Peterson, USUS president.

The new SIG will be chaired by David Ramsey of Corvus Systems, Inc. (San Jose, CA). The group was formed when USUS held its semi-annual national meeting here last month. Modula-2 runs on Version II based UCSD Pascal Systems.

"The Modula-2 SIG will be open to any USUS member using or wanting to investigate this language," Ramsey said. "It is, to my knowledge, the first user's group devoted to communication about Modula-2."

The new language was created by Niklaus Wirth to answer difficulties encountered with his earlier language, Pascal. "As people discover the benefits of working in this new language, we expect this SIG to expand repidly," Ramsey said.

Implementations of the Modula-2 programming language are available for the Apple II, //e and /// computers, the IBM Personal Computer, the 68000-based Sage 2 and 4, the Texas Instruments 9900, the Scenic One and Z80/8080-based systems, according to Joel J. McCormack of Volition Systems (Del Mar, CA).

Volition is the only current supplier of the language for use on microcomputers and supplies systems as well as the Modula-2 language to run on them.

"Because the language is modular, users spend less time writing and maintaining code," McCormack said. "Standard library modules provide Modula-2 with a standard operating environment, and programs created within it are portable across all Modula-2 systems."

The new Modula-2 SIG will enable users to share experiences with others using the language or developing applications in it, Ramsey said. "We expect to serve as a clearing house for user information in this fast-changing area."

One of the first goals of the SIG is creation of a user's library of Modula-2 programs that will be included in the USUS library, Ramsey noted. It will be compiled by Curt Snyder of Allergan Pharmaceuticals (Irvine, CA).

Membership in the Modula-2 SIG is free of charge to any member of USUS, which is the vendor-independent, non-profit user's group for the UCSD Pascal System. Annual membership in the society is $25 for individuals and $500 for institutions. Further information on USUS is available from the Secretary, USUS, P.O. Box 1148, La Jolla, CA 92038.

For those wanting to know more about the Modula-2 SIG, Ramsey can be reached at Corvus Systems, 2029 O'Toole Avenue, San Jose, CA 95131, (408) 946-7700, extension 267.

Volition Systems has pioneered in the implementation and dissemination of the Modula-2 language. Further information about Modula-2 and available implementations may be obtained from Tracy Barrett, Volition Systems, P.O. Box 1236, Del Mar, CA 92014, (619) 481-2286.

PASCAL USERS, VENDORS GATHER FOR USUS SAN DIEGO MEETING

SAN DIEGO, CA, May 2 — USUS, the UCSD Pascal System User's Society, formed five new special interest groups (SIG's) and made plans for a first regional chapter at its well-attended, semi-annual national meeting here last week, according to Robert W. Peterson, USUS president.

In addition, two vendors of UCSD Pascal products — Apple Computer, Inc. and Volition Systems — chose the occasion to reveal new offerings.

"Record meeting attendance reflects the users' commitment to increased knowledge about use of the UCSD Pascal System," Peterson said. "More than 240 attended and actively participated in special interest group and committee meetings, panel discussions and the four tutorials."

Keynote speaker for the event was Andrew Greenberg, designer and co-author of the popular Wizardry games. He told how he had solved the challenge of putting a very large program like Wizardry on a microcomputer with limited disk and main memory storage.

"Greenberg offered members valuable insights into program design, structure and implementation," Peterson noted.

The new special interest groups are for application developers and for users of the NEC Advanced Personal Computer, the IBM Display Writer, the Advanced System Editor from Volition Systems, and the Modula-2 programming language. In addition, plans for the national organization's first local group in Southern California were discussed.

USUS already has SIG's for users of Apple, DEC, Texas Instruments and Sage computers, the IBM Personal Computer and for those interested in communications, word processing and UCSD Pascal compatibility.

Of particular interest to those attending the meeting was the demonstration area, where the latest advances in UCSD Pascal hardware, software and applications were demonstrated on 20 different machines, Peterson said.

At the meeting, Apple Computer, Inc., which has an installed base of some 82,000 Pascal development systems on its Apple II and Apple /// computers, announced that updates of Apple II Pascal and Apple /// Pascal will be available this year.

Apple revealed that Version 1.2 of Apple II Pascal will be available in the fourth quarter of 1983 and will provide support for all features of the Apple IIe including extended memory support for the 128K IIe. Version 1.2 also makes available facilities for integrating into the UCSD Pascal environment in a natural way additional mass storage devices such as hard disks.

Apple also confirmed that Version 1.1 of Apple /// Pascal will be available at the end of June 1983. Its most notable feature is the Standard Apple Numeric Environment that fully implements the IEEE standard for floating point arithmetic.

Volition Systems demonstrated the new Modula-2 programming language running for the first time on an IBM Personal Computer. USUS members formed a Modula-2 SIG at the meeting to exchange information about the language. It will be chaired by Dave Ramsey, Corvus Systems (San Jose, CA).

The chairman of the newly formed application developer's SIG is Dennis Gallinat, Apple Computer (Cupertino, CA), and Samuel Bassett, Bassett Information Processing (San Francisco, CA) is chairing the Advanced System Editor SIG.

Lane Sharman, Resource Systems Group (Del Mar, CA) will head the Special Interest Group for the IBM Display Writer, and the NEC Advanced Personal Computer SIG will be chaired by George Symons, TICOM Systems, Inc. (Marina del Ray, CA).

The fall USUS meeting will be held in Washington, D.C., at the Hyatt Regency Crystal City, October 14-16, 1983. Further information is available from the Sec-

retary, USUS, P.O. Box 1148, La Jolla, CA 92038.

USUS (pronounced use-us) is a vendor-independent, non-profit user's group for the most widely used, machine-independent software system — the UCSD Pascal System, and its successors such as the Apple Pascal System and the UCSD p-System.

USUS was created to promote and influence the development of the UCSD Pascal System and to provide a forum for education and information exchange about it. USUS has institutional as well as individual members in more than 20 countries. Annual membership in the society is $25 for individuals and $500 for institutions.

VOLITION DEMONSTRATES MODULA-2 FOR IBM PC

DEL MAR, CA, May 3 — Volition Systems here has demonstrated Niklaus Wirth's new Modula-2 programming language running for the first time on the IBM Personal Computer.

The new implementation was demonstrated for members of USUS, the UCSD Pascal[1] System User's Society, at its semi-annual national meeting in San Diego last week. Modula-2 will be included as part of Volition's complete software development system.

"Modula-2 is proving especially valuable in large industrial and commercial applications where standard software modules can save time and money in program development and maintenance," according to Joel J. McCormack of Volition Systems.

"Now our new implementation will make these savings possible on the IBM PC. Our software development system will even run efficiently on 64K PC's," he continued. "And the availability of Modula-2 on the IBM PC should make the language even more attractive to application developers."

The IBM PC implementation will significantly expand the availability of Modula-2. Current Volition versions are based on the 6502 (including Apple II[2] and Apple /// computers), the 8080/Z80, TI 9900, and the 68000.

Niklaus Wirth developed Modula-2 (from MODular LAnguage) to replace his earlier language, Pascal. Whereas Pascal was intended as a teaching language, Modula-2 is expressly designed for use in a wide range of real-world applications, and it offers great flexibility in the development of large, complex systems.

The implementation for the IBM PC is expected to be available in the third quarter of 1983, McCormack said. The system will include Modula-2 and Pascal compilers, the modula library, the powerful ASE text editor, V-NIX™ command shell (that provides a UNIX[3]-like programming environment), and a complete set of utility programs for file manipulation and electronic mail communication.

Volition Systems concentrates on systems software development and on research and development in hardware and software. Since the company was founded in 1980, it has led in the implementation and dissemination of the Modula-2 language and other high-level languages and in the design and development of advanced computer architectures.

For further information, contact:

Volition Systems
P.O. Box 1236, Del Mar, CA 92014
(619) 481-2286

[1] UCSD Pascal is a trademark of the Regents of the University of California.

[2] Apple II and Apple /// are trademarks of Apple Computer, Inc.

[3] UNIX is a trademark of Bell Laboratories.

PUG

0. **DATE** Apr. 28,1983

1. **IMPLEMENTOR/MAINTAINER/DISTRIBUTOR** *(* Give a person, address and phone number. *)*

Robert Reimiller
OmegaSoft
P.O. Box 842
Camarillo, CA 93010
(805) 987-6426

2. **MACHINE/SYSTEM CONFIGURATION** *(* Any known limits on the configuration or support software required, e.g. operating system. *)*

MC 6809 Processor
Running Moos, 05-9, or Flex OS
Requires 48K to 56K (Recommended)

3. **DISTRIBUTION** *(* Who to ask, how it comes, in what options, and at what price. *)*

North America: From Omega Soft
International: From OmegaSoft or distributors in Germany, Switzerland, Great Britain, Australia, Sweden, and the Netherlands. Price is $425 to $475 for Compiler, Debugger, and Runtime.
Relocatable Assembler/Linker available for $125 to $150.

4. **DOCUMENTATION** *(* What is available and where. *)*

220 pg. Pascal manual with complete syntax and installation instructions.

5. **MAINTENANCE** *(* Is it unmaintained, fully maintained, etc? *)*

Yearly maintenance is $100 to $125

6. **STANDARD** *(* How does it measure up to standard Pascal? Is it a subset? Extended? How. *)*

Complete ISO standard except packed variables and procedural parameters. Scored 92% on conformance section of validation suite. ISO report in manual. Extended for real time and industrial control applications.

7. **MEASUREMENTS** *(* Of its speed or space. *)*

Warshalls Algorithm: procedure size=270 bytes,
Execution time=9.7 seconds

8. **RELIABILITY** *(* Any information about field use or sites installed *)*

Over 400 sites installed.
Over 4000 sites installed.

9. **DEVELOPMENT METHOD** *(* How was it developed and what was it written in? *)*

From scratch in assemble language.

10 **LIBRARY SUPPORT** *(* Any other support for compiler in the form of linkages to other languages, source libraries, etc *)*

Optional libraries to handle AMD9511 APU CHIP, and Multi-Tasking Primatives.

OmegaSoft Pascal Version 2

Pascal Processor Identification

Host Computer: Smoke Signal Broadcasting Chieftain 9522812W10 running the OS-9 operating system.
Host Computer Requirements: MC6809 processor, minimum of 48K bytes of memory, 2 or more disk drives, running the OS-9, MDOS, XDOS, DOS69, or FLEX operating system.
Processor: OmegaSoft pascal version 2.10

Test Conditions

Tester: R.D. Reimiller
Date: June 1982
Validation Suite Version: 3.0

General Introduction to the OmegaSoft Implementation

The OmegaSoft Pascal compiler was developed to provide the users of the 6809 processor with a fast and efficient way to develop code capable of running on the host development system or installed into a target system. The compiler is aimed primarily at industrial applications such as process control and instrumentation. Due to the nature of these applications many extensions were added such as byte arithmetic, long integers, dynamic length strings, modular compilation, and versatile variable addressing. As a secondary requirement it was desired that the compiler be able to accept a Pascal program written in ISO standard Pascal wherever possible.

CONFORMANCE TESTS

Number of tests passed = 144
Number of tests failed = 12 (9 reasons)

Details of Failed Tests

Test 6.4.2.3-3: If an enumerated type is defined in the index declaration part of an array its values cannot be referenced until the array declaration is complete.
Test 6.4.2.3-4: If an enumerated type is defined in a record its values cannot be referenced until the record declaration is complete.
Tests 6.6.3.1-4, 6.6.3.4-1, 6.6.3.4-2, and 6.6.3.5-1: Procedures and functions cannot be passed as parameters.
Test 6.6.5.4-1: Pack and Unpack procedures are not supported.
Test 6.7.2.2-3: Failed on MOD using a negative dividend. The Jenson/Wirth "remainder after division" method is used rather than the method specified in the ISO standard.
Test 6.8.2.4-1: Non-local GOTO's are not allowed.
Test 6.8.3.9-1: Assignment to the control variable of a FOR loop occurs after the evaluation of the first expression.
Test 6.9.3-1: Standard I/O devices may not be redefined if declared.
Test 6.9.3.5.1-1: Real numbers written out in floating point format always have six digits to the right of the decimal point.

DEVIANCE TESTS

Number of deviations correctly detected = 83
Number of tests showing true extensions = 45 (22 reasons)
Number of tests not detecting erroneous deviations = 9 (6 reasons)

Details of Extensions

Test 6.1.5-4: No digits are needed after the decimal point in a real number.
Tests 6.1.6-4 and 6.1.6-5: Labels may be a positive integer constant.
Tests 6.1.7-5, 6.4.3.1-3, 6.4.3.1-4, 6.6.3.3-5, 6.9.3.2-2: All variables are packed at the byte level, the reserved word "Packed" is ignored in any type declaration.
Tests 6.1.7-6, 6.1.7-7, 6.1.7-8, 6.4.3.2-5: Strings, characters, and arrays of less than 127 elements are all compatible.
Tests 6.1.7-11 and 6.4.5-12: Strings are dynamic length, allowable length is from 0 (null string) to 126.
Tests 6.2.1-8 and 6.2.1-10: Label, const, type, and var declaration sections can be in any order and repeated multiple times until a procedure/function declaration or "begin" is encountered.
Test 6.3-9: In any context where a constant is acceptable an expression with a constant value may be used.
Test 6.4.2.3-5: All enumerated type values are compatible.
Test 6.4.3.3-8: The values of the case constants in a record variant declaration are not used, access is provided to all variants at all times.
Test 6.4.5-7: All subranges of the same type are compatible.
Tests 6.4.5-8 and 6.4.5-13: Arrays of the same size are compatible.
Tests 6.4.5-9 and 6.4.6-7: Records of the same size are compatible.
Test 6.4.5-10: All pointers are compatible with other pointers or the type "Hex".
Test 6.6.2-5: Any type with a size of less than 128 bytes can be used as a function return type.
Test 6.6.6.3-2: Trunc and round can have integer or longinteger parameters.
Test 6.7.2.3-2: Logical operators are valid for character and integer expressions.
Test 6.7.2.5-6: Arrays of the same size can be compared. Records of the same size can be compared.

Test 6.8.2.4-2: Goto between branches of an If statement are allowed.

Test 6.8.2.4-3: Goto between branches of a Case statement are allowed.

Tests 6.8.3.5-7 and 6.8.3.5-8: Subrange Case statement constants are allowed.

Tests 6.8.3.9-5, 6.8.3.9-6, 6.8.3.9-7, 6.8.3.9-10, 6.8.3.9-12, 6.8.3.9-13, 6.8.3.9-14, 6.8.3.9-15, 6.8.3.9-16, and 6.8.3.9-17: No restrictions are placed on For statement control variable.

Tests 6.8.3.9-8 and 6.8.3.9-9: If a For statement is entered and exited normally the control variable will be valid and contain the final value. If a For statement is not entered then the control variable will be valid and contain the initial value.

Details of Deviations

Test 6.1.8-5: A number can be terminated by a letter.

Tests 6.2.1-5 and 6.2.1-6: Multiple siting for labels is not checked, nor are labels required to be sited at all.

Tests 6.2.2-8, 6.3-6, and 6.4.1-3: Error in scope rules.

Test 6.6.1-7: Unresolved forward function or procedure declaration is not detected.

Test 6.6.3.3-4: Use of a field selector as a parameter is not detected.

Test 6.10-4: No check is made for duplication of program parameters.

ERROR-HANDLING

Number of errors correctly detected = 19
Number of errors not detected = 31 (13 reasons)

Details of Errors Not Detected

Tests 6.2.1-11, 6.4.3.3-11, 6.4.3.3-12, 6.4.3.3-11, 6.5.4-2, and 6.6.2-9: No checking is made to verify whether or not a variable is accessed that has an undefined value. Instead the variables are guaranteed to contain garbage unless initialized.

Tests 6.4.3.3-1, 6.6.5.3-8, 6.6.5.3-9, and 6.6.5.3-10: Any tagfields or selector variables in a record variant are irrelevant to which variants can be accessed.

Test 6.4.6-10: No subrange checking on parameter passing.

Tests 6.4.6-12, 6.4.6-13, and 6.7.2.4-4: Overflow checking is done on sets based on byte count — not per element.

Tests 6.5.4-1, 6.6.5.3-4, 6.6.5.3-5, and 6.6.5.3-11: Pointer value is not checked before use.

Tests 6.5.5-2, 6.5.5-3, 6.6.5.3-6, and 6.6.5.3-7: There are no restrictions on the use of pointers or file buffer variables which are currently parameters or elements of a with statement.

Test 6.6.5.2-5: To support random files a "get" is not executed until called as a procedure or when accessing the file buffer without a valid element — not at the time of "reset".

Test 6.6.6.4-7: Char and Hex variables "roll over" from maximum value to zero — it is not considered an error.

Test 6.6.6.5-7: If eof is true — so is eoln — it is not considered an error to check eoln if eof is true.

Tests 6.8.3.5-10 and 6.8.3.5-11: If no match in case statement, falls through with no error.

Test 6.8.3.9-18: No restrictions on the control variable of a For loop.

Test 6.8.3.9-1: At the completion of a For loop the control variable is valid and has the final value.

Tests 6.9.3.2-5 and 6.9.3.2-5: Writing of real numbers with no digits past the decimal point is permissible.

QUALITY MEASUREMENT

Number of tests run = 52
Number of tests incorrectly handled = 5

Results of Tests

"Synthetic Benchmark" — execution time 1 minute, 10 seconds.

"GAMM measure" — execution time 1 minute, 40 seconds for N = 1000

procedure calls — execution time 40 seconds

identifiers are significant up to 120 characters.

source lines may be up to 120 characters.

no reasonable limit on number of real literals allowed.

no reasonable limit on number of strings allowed.

if a line of code is incorrectly part of an unclosed comment the compiler will signal that no code was generated for the line.

at least 50 types may be declared in a program.

no reasonable limit on number of labels, but there can be a maximum of 8 forward referenced goto's in a block.

at least 128 constant definitions are allowed per constant declaration part.

at least 128 procedures are permitted in a program.

maximum size for an array or record or for any variable section is 32750 bytes.

at least 8 index types can appear in an array type.

at least 128 case-constant values are permitted in a variant record.

at least 50 record-sections can appear in the fixed part of a record.

at least 30 distinct variants are permitted in a record.

"Warshall's algorithm" procedure size = 270 bytes, execution time = 9.7 seconds.

considerably less than 300 indentifiers are allowed in a declaration list (actual number depends on length of identifier).

at least 8 dimensional array is allowed.

procedures may be nested to at least 15 levels.

at least 30 formal parameter sections can appear in one parameter list.

the dispose in the standard heap manager is a dummy, a more complex heap manager is available.

deeply nested function calls are allowed (at least 6).

deeply nested compound statements are allowed (at least 25).

a procedure may have at least 300 statements.

deeply nested if statements are allowed (at least 25).

at least 256 case constants are allowed.

at least 300 constants are allowed in a case-constant list.

case statements can be nested to at least 15 deep.

repeat loops can be nested to at least 15 deep.

while loops can be nested to at least 15 deep.

for loops can be nested to at least 15 deep.

with statements can be nested to at least 15 deep.

recursive I/O can be used with the same file for the second I/O action.

at least 30 variable-accesses can appear in a read or readln parameter list.

at least 30 write-parameters can appear in a write or writeln parameter list.

data written on the output field appears regardless of the omission of a line marker.

IMPLEMENTATION-DEFINED

Number of tests run = 12

Number of tests incorrectly handled = 1

Details of Implementation-Defined Features

Tests 6.1.9-5 and 6.1.9-6: alternate symbols are available for comments, array indices, and pointers.

Test 6.4.2.2-10: Maxint is 32767

Test 6.4.3.4-5: maximum range of set elements is 0..1007

Test 6.6.6.2-11: Base = 2, Bits of mantissa = 24, not rounding, minimum value = 2.710506E-20, maximum value = 9.223372E+18

Tests 6.7.2.3-3 and 6.7.2.3-4: Boolean expressions are fully evaluated.

Tests 6.8.2.2-1 and 6.8.2.2-2: In an assignment statement evaluation of the expression is done before the selection of the variable.

Test 6.8.2.3-2: When a procedure is called the parameters are evaluated in forward order.

Test 6.9.3.2-6: Default field widths are: Integers = 10, Boolean = 6, Real = 16, Longinteger = 16, Hex = 6.

Test 6.9.3.5.1-2: Real values written in floating point format have 2 exponent digits.

Test 6.9.3.6-1: Boolean values written in the default fieldwidth have the format as shown (between quotes) " TRUE" and " FALSE".

Details of Tests Incorrectly Handled

Tests 6.6.6.1-1: Functions are not allowed to be passed as parameters to a procedure.

Level 1 Tests — Not applicable

EXTENSIONS

Extension present = 1

Result of Extension

Test 6.8.3.5-16: An otherwise clause is allowed on a case statement.

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( ) Single Density

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On Behalf of A. H. J. Sale and B. S. I.

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Pascal is a small, practical, and general-purpose (but *not all-purpose*) programming language possessing algorithmic and data structures to aid systematic programming. Pascal was intended to be easy to learn and read by humans, and efficient to translate by computers.

Pascal has met these goals and is being used successfully for:

- teaching programming concepts
- developing reliable "production" software
- implementing software efficiently on today's machines
- writing portable software

Pascal implementations exist for more than 105 different computer systems, and this number increases every month. The "Implementation Notes" section of *Pascal News* describes how to obtain them.

The standard reference ISO 7185 tutorial manual for Pascal is:

Pascal — User Manual and Report (Second, study edition)
by Kathleen Jensen and Niklaus Wirth.
Springer-Verlag Publishers: New York, Heidelberg, Berlin
1978 (corrected printing), 167 pages, paperback, $7.90.

Introductory textbooks about Pascal are described in the "Here and There" section of *Pascal News*.

The programming language, Pascal, was named after the mathematician and religious fanatic Blaise Pascal (1623-1662). Pascal is not an acronym.

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