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ABSTRACT

This report contains instructions for the use of GENERAL, a tutorial type teaching logic developed for the PLATO system. The logic of GENERAL is first introduced and diagrammed for the user. Then lesson planning for program authors is discussed in terms of format rules, branching pages, challenge pages, and information retrieval pages. Control keys and procedures for student mode are provided followed by an explanation of author mode. Suggestions for the answer master and input of parameters for lessons are given followed by directions for authoring using GENAUTH, GENERAL, and CONSTNT. The appendix contains a list of special effects on GENERAL, a list of judgers, and an example of an INVSTAN subroutine. (CH)

CERL REPORT X-1 MAY, 1968

INSTRUCTIONS FOR USING THE PLATO LOGIC, GENERAL

(A REVISION OF COORDINATED SCIENCE LABORATORY REPORT I-130 BY D.L. BITZER, S. CHAN, R. JOHNSON & M. WALKER)

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Introduction

In 1965 a tutorial type teaching logic was developed for the PLATO system and programmed for the PLATO compiler by D. L. Bitzer and M. W. Walker.[3] The logic was designed initially for use in a course in circuit analysis for University of Illinois electrical engineering students (EE 322).[2] It provided sufficient flexibility for the presentation of material twice a week during the entire 1965 spring semester. The parameters to fit the lesson for the day could be changed by a simple operation from the PLATO keyset; the basic logic remained the same for all the lessons.

During the summer of 1965 the logic was revised by M. W. Walker, S. K. Chan and R. L. Johnson and additional flexibility added to it. During the next year it was used not only for the circuit analysis course, but also for a course in library science and one in computer programming.[1,7] An experiment in adapting the logic program to an inquiry type or information retrieval type logic using the circuit analysis material motivated further work on the program so that both tutorial and inquiry methods of teaching could be used in a lesson constructed from the basic program which is now called program GENERAL.[5]

During 1966-1967 a course in maternity nursing for students from the Mercy Hospital School of Nursing was written by M. Bitzer and M. Boudreaux and presented in the PLATO classroom to several groups of student nurses.[4] The logic of the tutorial program for the circuit analysis course served as the starting point for programming the course, but during the course development many features were added by D. L. Bitzer and E. R. Lyman to the original program, GENERAL. The net result is the latest version of the GENERAL logic which can be used to present both tutorial and inquiry

sequences in a lesson, with many options for branching being available to the lesson writer. Input and manipulation of the parameters of the program take place entirely from a PLATO temminal, although parameter input from flextape is also possible.* The basic logic is not so complex but that it can be modified for particular cases, so that adaptation of GENERAL to an extremely wide variety of uses is possible.[6] This report contains instructions for the use of GENERAL.

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*Flextape parameter input is not discussed in this report because on-line parameter input and off-line code checking has been more widely used.

Logic

Tutorial. A tutorial logic is designed to lead a student through a fixed sequence of topics with provisions for branching to specialized lesson elements at indicated places in the sequence (Figure 1). The logic presents basic information and examples and asks questions covering the material presented. The student composes answers to each question, and, when he is ready, he asks the system for a judgment which is provided immediately. In a tutorial logic, if the student finds that a question is too difficult, he may branch to a "help" sequence. Tutorial logic, also, may offer the students branching to more difficult work. Programmed evaluation of a student's response can also be used to prescribe involuntary branching to remedial or challenge sequences.

Inquiry. An inquiry teaching logic presents a student with a problem (or problems), requires him to specify what information he needs in order to solve the problem, and then provides computer responses to his questions (Figure 2). In this way, a student can solve a problem using a strategy of his own devising. Several types of tree-like branching are provided in an inquiry logic for information retrieval by the student. The logic usually provides judgment of the students' answers also.

The logic of Program GENERAL. For program GENERAL, as is customary in the PLATO system, the instructional material appears at each student station on the student's screen as an image from the "electronic book", (or slide selector), on which is superimposed an image from the "electronic blackboard", (or storage device) (Figure 3). The principal material presented is designated as the main sequence and the slides in this sequence are called "main pages". Problems for the student to solve appear on these

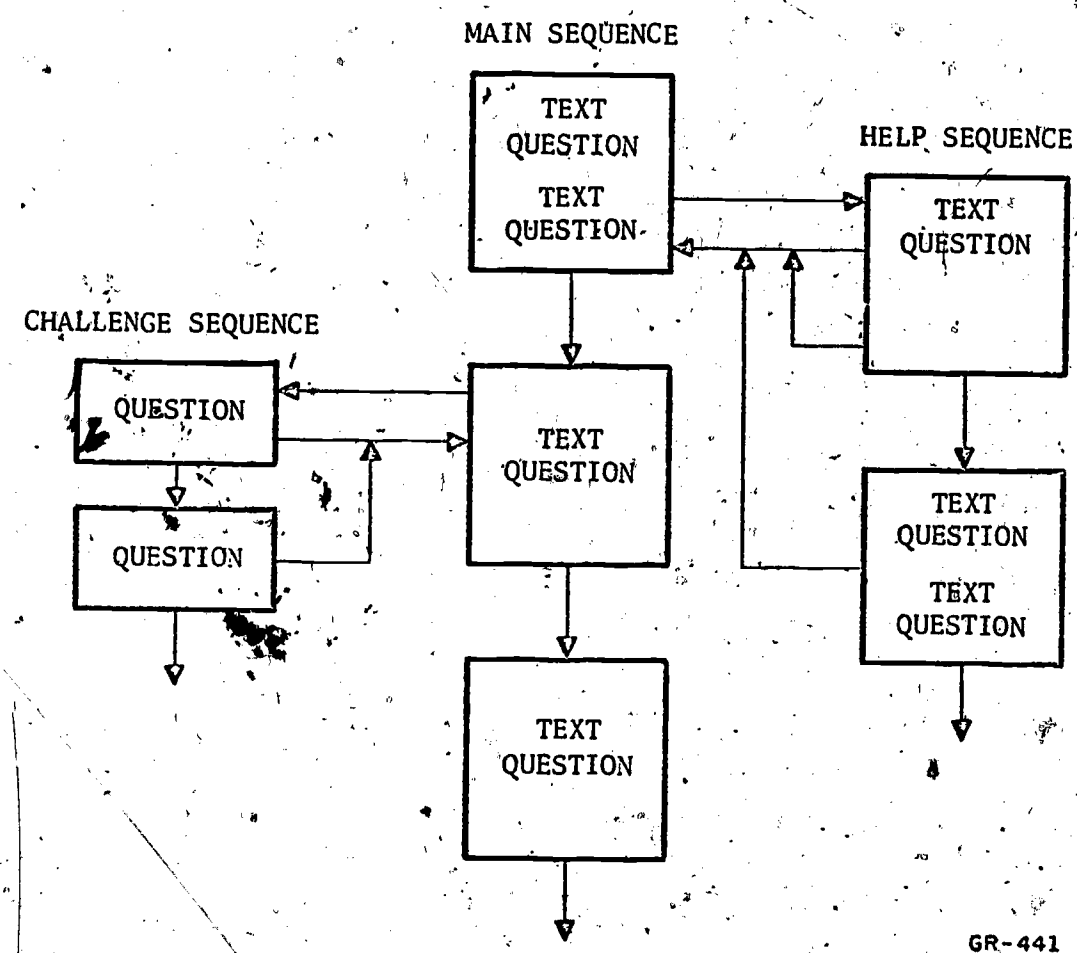


Figure 1. Basic tutorial logic

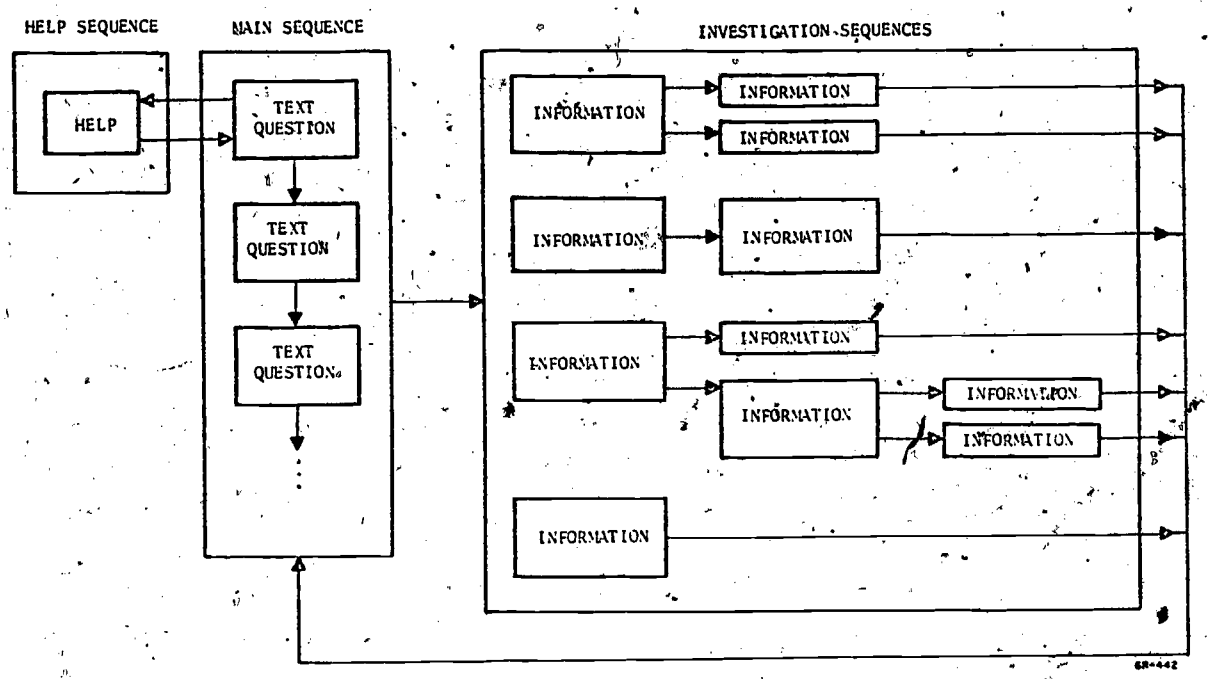


Figure 2. Basic inquiry logic

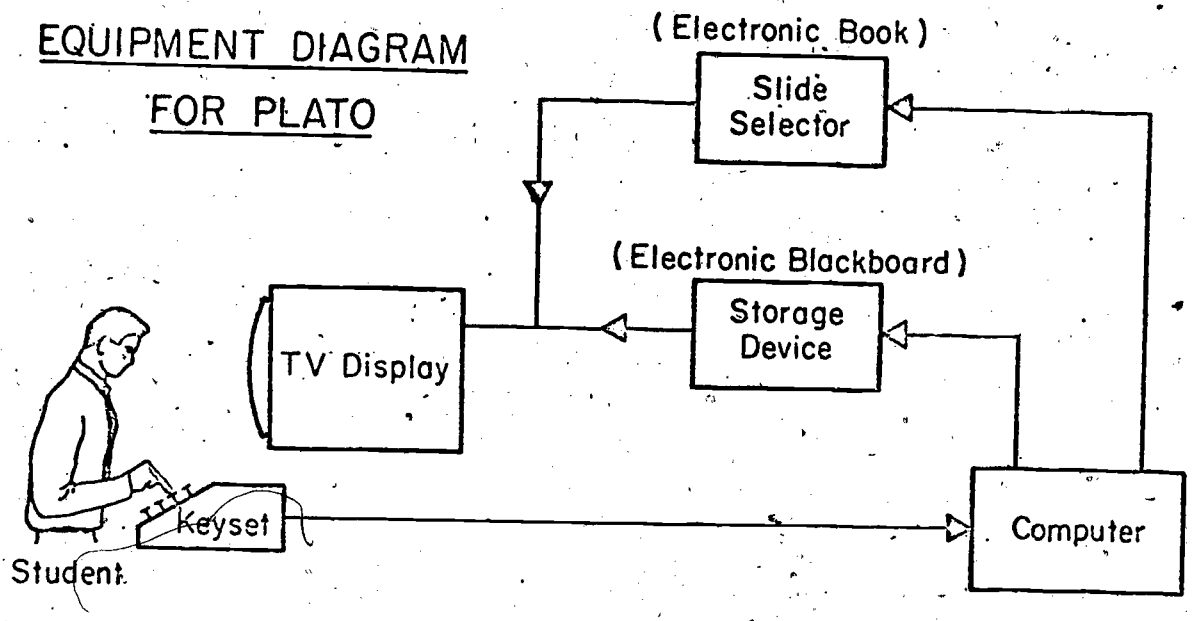


Figure 3. PLATO schematic, single student

pages. The student writes his answers to the problems on the screen by typing, using alphanumeric keys which are arranged in standard typewriter keyboard configuration. It is customary (but not mandatory) in most lessons to prevent the student from proceeding to the next page of the main sequence until all answers to the problems are filled in and are judged correct.

The student has control keys as well as alphanumeric keys available on his keyset. The control keys allow him to continue or reverse pages, take him to various branches for information retrieval or help, and allow him to obtain judgments. After he has composed his answer, the student pushes the JUDGE key. If his answer is correct, OK is plotted next to his answer. If his answer is incorrect, NO, NC, or SP is plotted next to his answer depending on whether the answer is judged incorrect, not complete, or just misspelled.

While studying the problem, before or after answering it, a student asks for help by pushing the HELP key. The HELP sequence is commonly a remedial sequence of pages of material to aid the student. The particular help page presented may depend on the kind of wrong answer which the student gives. An answer-dependent help page is called a "special help" page. Help pages need not be provided for every problem. Help pages may present problems of their own for the student to solve, just as the main pages offer problems; however, the student may leave the help sequence at any time, by pushing the AHA key, so that completion of help problems is not a requirement.

Occasionally the lesson author, or teacher, has provided an optional problem for the student to solve. For this type of branching a key marked

"CH" (for "challenge") is provided. The challenge key presents a sequence of pages with problems for the student which are usually more difficult than those in the main sequence. The choice of whether to try the challenge sequence or not is left up to the student. He returns to the main sequence at will by pushing the CONT or REV key. The design of a tutorial (or tutorial-inquiry) lesson aids the poorer student by means of the help sequences and caters to the better student by means of the challenge sequences.

Information retrieval (other than HELP sequences) is available in program GENERAL. The course in maternity nursing uses branching entitled "Investigate" in which a student can do simulated experiments or determine results of treatment, analyses or tests given under specified conditions; "Dictionary" in which definitions of terms can be found; and "Data" in which general information is stored for the students on a series of slides. Other names could be used to designate these branches or the control keys accessing these branches. Each inquiry branch is assigned a key for its access and the usual method of operation by the student is the typing of a choice of each condition (or term to be defined) until the desired situation is described. The ANS key is then pressed and the computer presents the desired result. Figure 4 gives a schematic picture of the logic of program GENERAL showing the possible branching, with titles indicating the manner in which it is used in the nursing course IMNURSE. The student can always return to the main page sequence at any time from any branch by pressing the AHA key.

A unique feature in program GENERAL is a "comment" mode. Students are at liberty in any part of the program to make a comment on the lesson by

pressing the "Comment" key and typing a remark. The teacher often gains insight into the success or failure of his teaching by studying the students' comments.

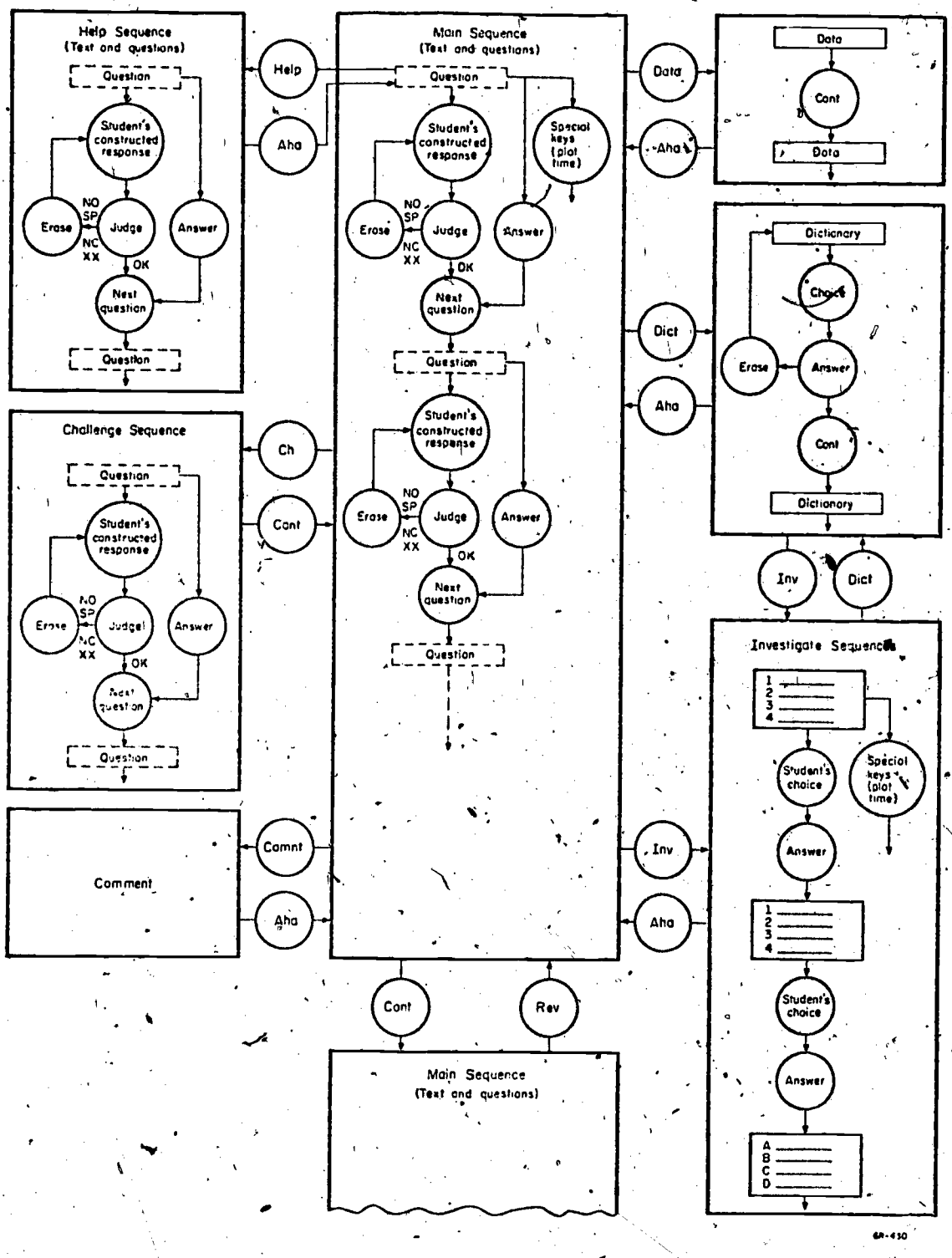


Figure 4. IMNURSE version of program GENERAL logic

Lesson Planning

Main text. An author of a lesson which will use the PLATO logic GENERAL first blocks out the material to appear on his main sequence of pages. No attempt is made here, it should be noted, to instruct the author in this procedure from the educational objective, psychological or pedagogical points of view. There are certain rules about format and certain limitations within the logic, however, which must be observed.* Those specifications affecting main page descriptions are listed below:

1. Each PLATO page may contain 18 PLATO typed lines or 18 typewriter-typed lines (Figure 5).
2. Each line may contain 40 PLATO typed characters or about 45 typewritten characters.
3. A maximum of 12 questions is allowed per page. A maximum of 126 questions is allowed in one unit or lesson.
4. The total number of pages (of any kind: main, help...) in a lesson is 150.
5. A maximum of 114 different slides is available for any one unit. Slide 0 is used for the title page of the unit. Slides 115 to 121 are used automatically by the program for the author mode pages, comment page and special instructions page.
6. Each main page can have one sequence of challenge pages associated with it. Several main pages can have the same challenge sequence.
7. Associated with every main page is an "overall lesson" or "global" page number and a "special effect". In a main sequence ordinarily all the control keys are legal (operable) on any page with the

*See Appendix V for summary of useful facts

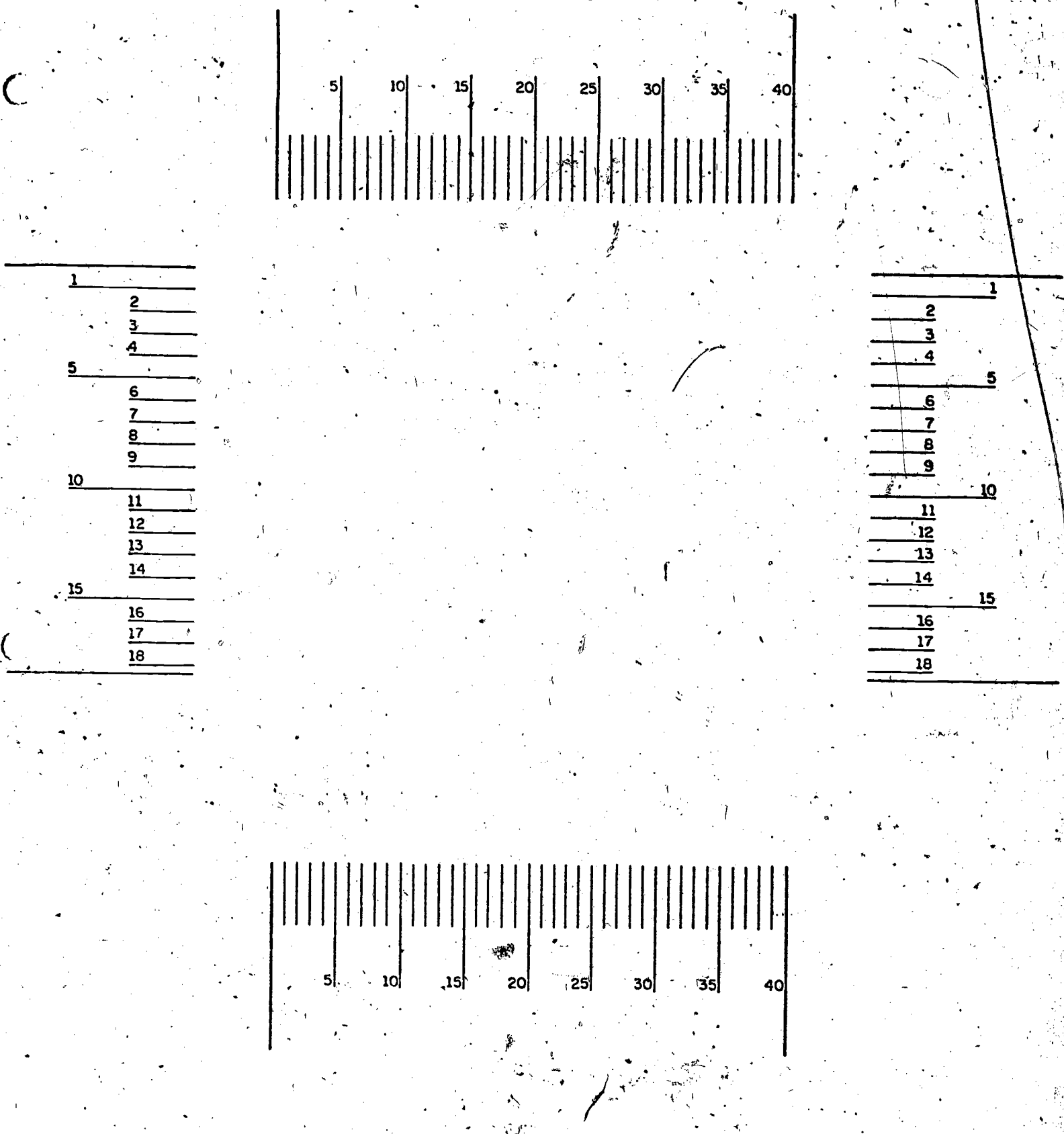


Figure 5. PLATO slide form with aligning scale

exception of the challenge key (which may be made legal by a "special effect"). At the option of the author a simple parameter change will allow a control key to perform a special function on that main page. The phenomenom is known as a "special effect". Each control key can have any one of eight special effects associated with it on any one main page in the lesson. There are sixteen control keys (known as channels) for which special effects can be specified. Appendix I gives the special effects available in the nursing program. The functions of the control keys are discussed in the section on Student Mode and the procedure for specification of special effects is described in the section on Parameter Input.

To summarize: the author designs his main text pages by assigning main page and page numbers to his pages, designating desired special effects, and indicating challenge sequences associated with the main pages.

Branches. The author next designs the branching pages which he wishes available to the student, indicating at which points in the main page sequence there should be access to these branches. As mentioned in the general discussion of the logic of program GENERAL, there are four types of branching available: help, challenge, information retrieval, and comment branches.

General rules for the branching are:

1. Help (or special help). Each question on a page in a main sequence can have up to six help pages assigned to it.

   Each specific wrong answer can have a special help page assigned to it with up to six special help pages assigned to six special wrong answers for any one question on a page.

   Help (or special help) pages may have questions on them; but there

are no help pages associated with questions on help pages.

2. Challenge pages. Each page of a challenge sequence behaves like a main page and can have answers, help and special help pages. The maximum number of challenge pages is six.

   The same challenge sequence can be assigned to several main pages.

3. Information retrieval pages.

   General reference material (Data pages). Information may be stored on slides which are available to the student from any page in the lesson, i.e., lists of standard data, normal criteria, etc. The pages are usually refereed to as "Data" pages. The student examines the data slides in sequence using the CONT key. A data sequence may contain as many pages in sequence as desired. The first data page must be numbered 147.

   Dictionary pages. Information such as definitions of terms may be presented on pages on which the name of the term desired may by typed by the student and the press of the answer key causes the computer to respond with the definition for the desired term. The first dictionary page must be number 148.

   Investigate pages. Many patterns of investigation sequences are possible. Some of the possible patterns are:

   Choice indicated by student ——→ slide change

   ——→ computer response

   ——→ slide change plus computer response

   A sequence of pages with such choices may be set up with the final computer response being dependent on previous choices. The general rules for investigation pages are:

1. The first page of the investigate sequence (the page seen when the INV key is pushed) is always page 149.
2. On page 149 there may be up to five choices made - i. e., five different types of investigation available to the student.
3. The ANS key always gives the computer's response to the student's request except in the case where the CONT key is to be used in the Investigate Mode to lead a student through a sequence of illustrative pages for his "investigation". (See Parameter Input section.)
4. The student can move between the DATA, DICTIONARY, and INVESTIGATE branches at will by pushing the appropriate keys (DATA, DICT, INVEST).

4. Comments. The comment slide is always slide 116.

The student can type up to five lines of comments, erase the five lines and type five more lines. (The erasures are stored and are retrieved by the teacher in the response analysis.)

The AHA key returns the student to the main page sequence.

Program GENERAL automatically assigns the comment and author slides.

Student Mode

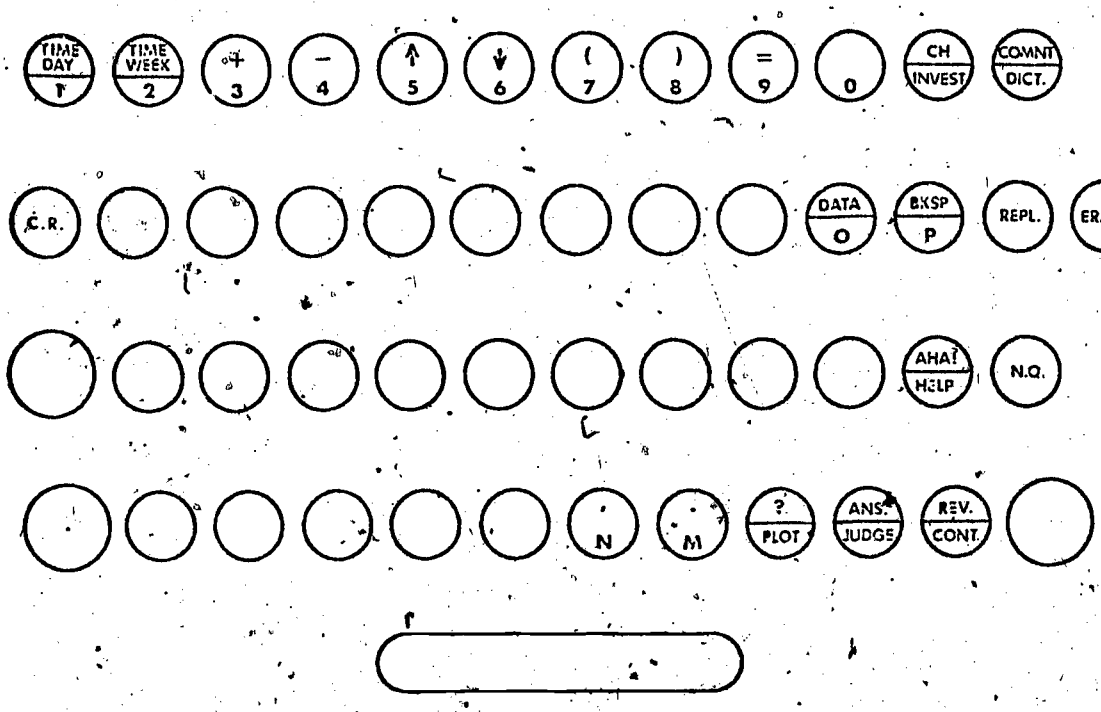
Control Keys. Figure 6 shows the PLATO keyset with both the alpha-numeric and control keys illustrated as they were labelled for the version of program GENERAL used for the maternity nursing course IMNURSE and for the electrical engineering course, EE 322. Labels appropriate for any lesson material being taught may, of course, be substituted. All alpha-numeric characters are in a standard typewriter keyboard arrangement. Usually upper case (capital letters) are used for the printing on the electronic blackboard. Other script could be available if desired by using an appropriate character list in the source program. Symbols such as punctuation symbols or special drawings are also available, usually appearing on the keyset as upper case symbols typed by holding down SHIFT and pushing the appropriate keys.

The use of the control keys, listed alphabetically, are explained below:

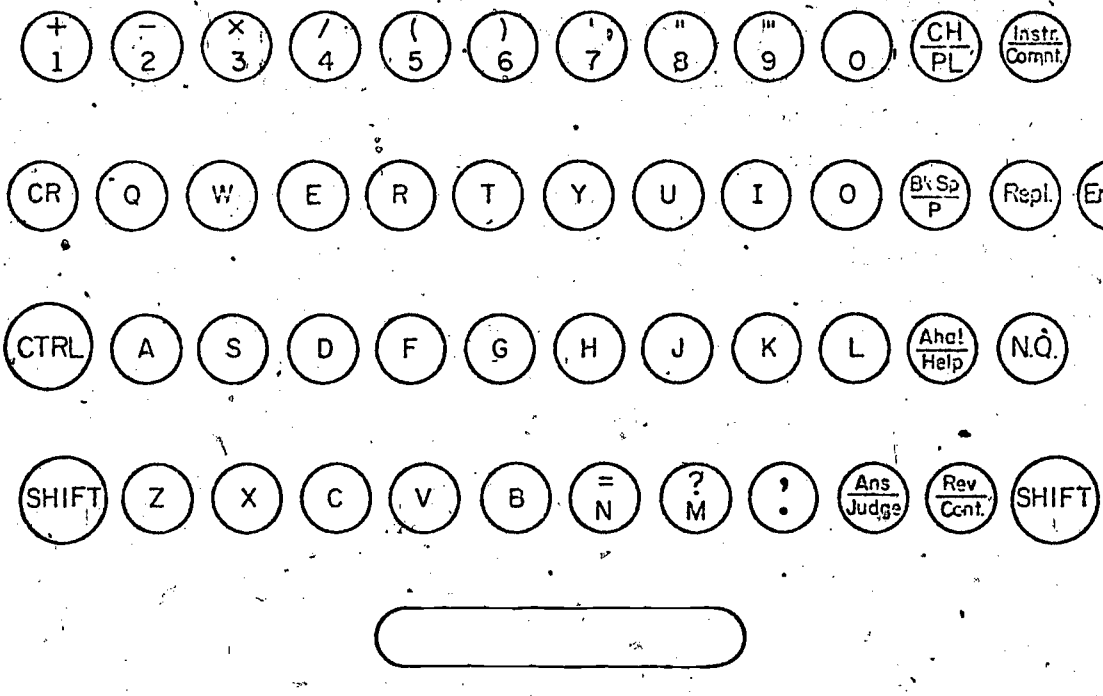
AHA! (AHA) + SHIFT. To return from any page in the help sequence, the comment page, data, dictionary, or investigate sequences, the student pushes AHA! . He then reenters the main sequence at the point from which he branched.

ANS (answer) + SHIFT. If the student cannot obtain the correct answer, he can ask for the right answer by holding down the SHIFT key while pushing ANS. The ANS key is also used in the Investigate and Dictionary sequences to provide the computer response to the student's inquiry.

BKSP (backspace) + SHIFT. The backspace erases the last character typed (including the 'space' and the 'carriage return' .



IMNURSE



Circuit Analysis

Figure 6. Keyset with appropriate keycaps for IMNURSE & Circuit Analysis

characters), and positions for writing a new character.

JUDGE — This key initiates judgment of the student's answer. The computer response depends on the judging routine indicated in the program for that question, and is OK for a correct answer, NO for an incorrect answer, SP for a spelling error, NC for an incomplete response, or presents a new slide.

COMNT — (comment) + SHIFT. At any time a student may make a comment or suggestion by entering the comment mode with this key.

CONT — (continue). This key moves the student to the next page of the main sequence after all questions, if there are any, have been answered on the current page. The CONT key also moves the student to the next page within the challenge, data, help, investigate (there are some exceptions) and dictionary sequences. While on the comment page or the last page of the help sequence, pushing CONT has the same effect as pushing the AHA key, whereas on the last data or dictionary page or the last page of a "continue" sequence in the investigate mode, pushing CONT takes the student to the first page of the sequence again.

CR — (carriage return). This key is similar to the carriage return on a typewriter. It shifts the blackboard writing position to the first left-hand character position of the next line on the page.

CTRL — (control). This key is of no use to the student. It is only used by the author or teacher.

DATA — (data) + SHIFT. The key takes the student to a page or sequence

of pages providing useful information.

DICT (dictionary). Pushing the DICT key presents a page or sequence of pages containing lists of terms whose definitions can be obtained from the computer. The term is typed by the student exactly as it appears in the list and the ANS key is pushed. The computer writes the definition on the student's screen.

ERASE This key erases any "blackboard" writing which the student or the computer has written on the student's screen. It is a "total erase" for the whole screen, but in the case of more than one answer on a page, the answers are all replotted except for the problem under consideration.

HELP If the student does not or cannot answer a question correctly, he can push the HELP key to ask for help (which is available for most questions). The help sequence gives hints or additional information to aid the student.

INVEST (investigation). By pushing INV the student is presented with a page describing the investigations available to him. He chooses which one he wishes by typing as indicated on his screen. He then pushes the ANS key to elicit the computer's response. If another choice is indicated, he types the choice and the ANS key will again give him the computer's reply. The AHA key takes him back to the main sequence; the INV key takes him back to the first page of the investigate sequence; the CONT key is only legal in the investigation sequence when a series of consecutive pages comprise the information to be

given to the student; the ERASE key erases the last choice made by the student, giving him the page on which he can make another choice at that level of the investigation; the DATA and DICT keys are legal anywhere in the investigation sequence.

JUDGE — This key judges the student's answer. The computer's response to the judgment depends on the judger chosen by the author or teacher. Usually a correct response elicits an OK plotted by the answer; an incorrect response gives a NO; an incomplete response plots an NC, and a misspelled response brings an SP. Some judgers force help or special help pages for wrong answers, or the next main page for a correct answer provided all the questions on the page have been correctly answered.

NQ — (next question). When there is more than one question on a page, the student may answer the questions in any order. The NQ key moves a small arrow which points to which question the student is answering.

PL — (plot). At points in a lesson where the plot key has been indicated as available, pushing PL will initiate special plot effects often dependent on parameter choices made by the student.

REPL — (replot). This key erases and replots any blackboard writing which has been on the TV screen. If a student reverses to previous pages, he can push REPL on any page to see what had been written on that page.

REV — (reverse) + SHIFT. This key moves the student back to the previous page. It is necessary to push REPL after REV to see the complete page with slide and blackboard writing.

TIME1 — Pushing this key adds one to a number input previously made by the student. This is a key used for "day" increments in special investigation sequences in IMNURSE.

TIME2 — Pushing this key adds seven to a number input previously made by the student. This key is a key used for "week" increments in special investigation sequences in IMNURSE.

Procedures. When a student seats himself at a terminal, he will see on his screen an introductory page such as "Welcome to PLATO" or an equivalent (Figure 7). If the lesson is a new unit, the student pushes the CONT key to start the lesson. He is usually required to type his name as his first move for purposes of easy identification of the student with the station. He then proceeds to follow directions through the lesson, answering questions in any order on a page, judging questions, studying text, branching to obtain necessary information for problem solving, and reversing to review his work. Whenever the student pushes a key which is not supposed to be available at that time in the lesson, an orange light at the upper right corner of the keyset will start flashing on and off, indicating that an illegal key has been pushed. The flashing will continue until a legal key is pushed. Students' answers are limited to 72 characters in length, although computer responses may be any length. Many teachers indicate for the student a half-way point in the lesson by a special "print-out" - "YOU ARE HALF-WAY THROUGH THE LESSON", or the end of the lesson by "END OF LESSON" which locks the student out of all further activity except review of previous

pages. If the student is starting in on a lesson on which he had been working the previous day, the first key he pushes at the start of the session is REPL and not CONT. At the end of a session, the day's work will either be saved or the lesson will be terminated by the instructor. The student need only rise and leave his station without making any special key input signifying "I am finished".

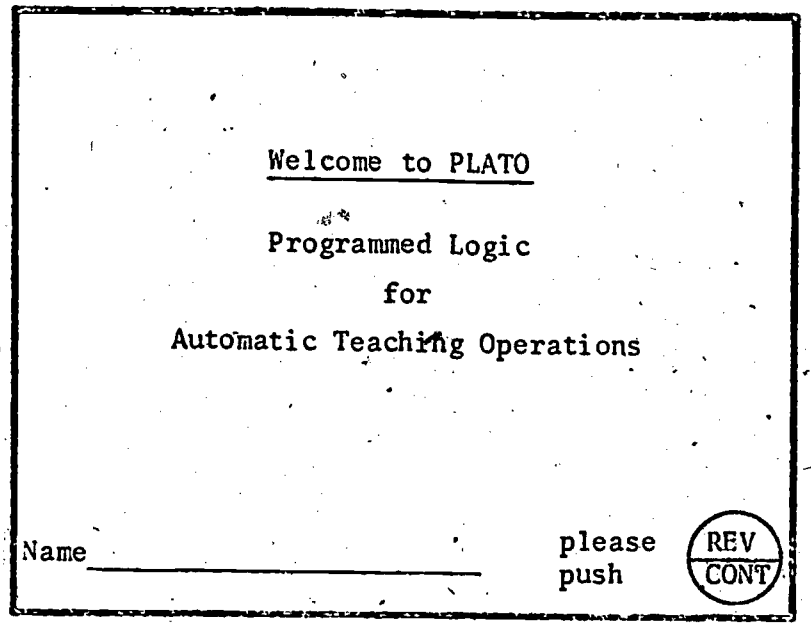


Figure 7 "Welcome to PLATO" page

Answer master. Before inserting the parameters pertinent to a given lesson using PLATO program GENERAL, it is recommended that a systematic collection be made of the necessary parameter information by preparing an answer master (Figure 8). The suggested answer master form provides 10 columns for entries. The appropriate entries for each column are described as follows:

USE — This column describes the principal use of the page, such as main, help, investigate, etc. Thus, for easy identification, a main page might be designated M1, a challenge page CH1, a help page H1, in the USE column.

PAGE # — The total lesson or unit may contain 150 pages. A unique lesson page number (or "global" page number) must be assigned every page of any type in the lesson. Thus, this column lists the unique page number (between 1 and 150) assigned to the page.

SLIDE # — Each page is assigned a slide position number. This column lists the slide number (between 1 and 114) assigned to this page. If a blank screen is desired as a page, a blank (or a fictitious) slide position (one containing no film) must be assigned to that page. If a slide is not assigned to the page, slide zero will be selected automatically.

EFFECTS — The special effect number and the channel into which it goes is written in this column (see Appendix I). The set of special effects is associated with the main page, not the individual question.

USER	PAGE #	SLIDE #	EFFECTS #	PROBLEM #	JUDGER #	ANSWERS	SPECIAL WRONG ANSWERS	HELP PAGE(S)	SPECIAL HELP PAGE(S)

Figure 8. Answer master form

PROBLEM The problems on a page are designated for convenience by sequential numbers, i.e., first problem on the page by 1, second problem by 2, etc. No problem on the page may be indicated by the letter "X" or by leaving the column blank.

JUDGER The judger number assigned to the respective problem is listed in this column. The judgers presently available are described in Appendix II.

ANSWERS The acceptable correct answers are listed in the "answer" column. There can be as many answers listed as desired. Judgers 11 and 12 have special formats which are discussed in conjunction with the judger listings.

SPECIAL WRONG ANSWERS The special wrong answers with which are associated special help pages are described in this space. The limit of special wrong answers for any one question is six. Any answer unlisted as either a correct or an incorrect answer is interpreted as a wrong answer unless "any" answer is acceptable under the provisions of the judger used (see Judger 1 or 9).

HELP PAGE(S) The help page or pages assigned to a problem are listed in this column. The number designating the page is the "global" page number.

SPECIAL HELP PAGE(S) The special help pages are assigned here in the order in which the special wrong answers are listed. If the same special help is used for two or more special wrong answers, the related global page number has to be written each time.

To illustrate the preparation of an answer master an example of the beginning of a lesson is given in Figures 9 and 10. Figure 9 shows nine slides of the fictitious lesson. Figure 10 shows the answer master for the slides in Figure 9.

Lesson or "global" page 1 is the number assigned to main page 1. This is the page on which the student writes his name. Slide 0 is used for this. No slide assignment needs to be made for page 1, but a question must be indicated. Judger 1 is used - the "any answer" judger. The special effect, 7 in channel 1, allows the student to continue unconditionally.

Main page 2 is lesson page 2 and slide 1. No problems appear on this page. Main page 2 is lesson page 3 with slide 2 assigned to it and two problems appear on this page. The first problem has one correct answer, 5, and if help is desired it is found to be lesson page 5. The second problem lists two correct answers with regular help (page 5) and two special wrong answers: for the first one, 8 (special help page 6), for the second 2 (special help page 7). All other incorrect answers for problem 2 get help from page 5. On main page 4 (page 4, slide 3) there is no help for answer B, but there is the same special help for both possible incorrect answers on both problems on the page. In this example of a lesson there is also one dictionary page. The first dictionary page is always assigned lesson page 148 (see Branches, page 13).

Parameters. Having constructed answer master sheets, one is now ready to input the parameters for the lesson. The input is usually carried out on-line from a PLATO station as more than one person can author at once. Parameter input from flextape is also possible. A special program to print out the parameters which have been entered into the program is available for

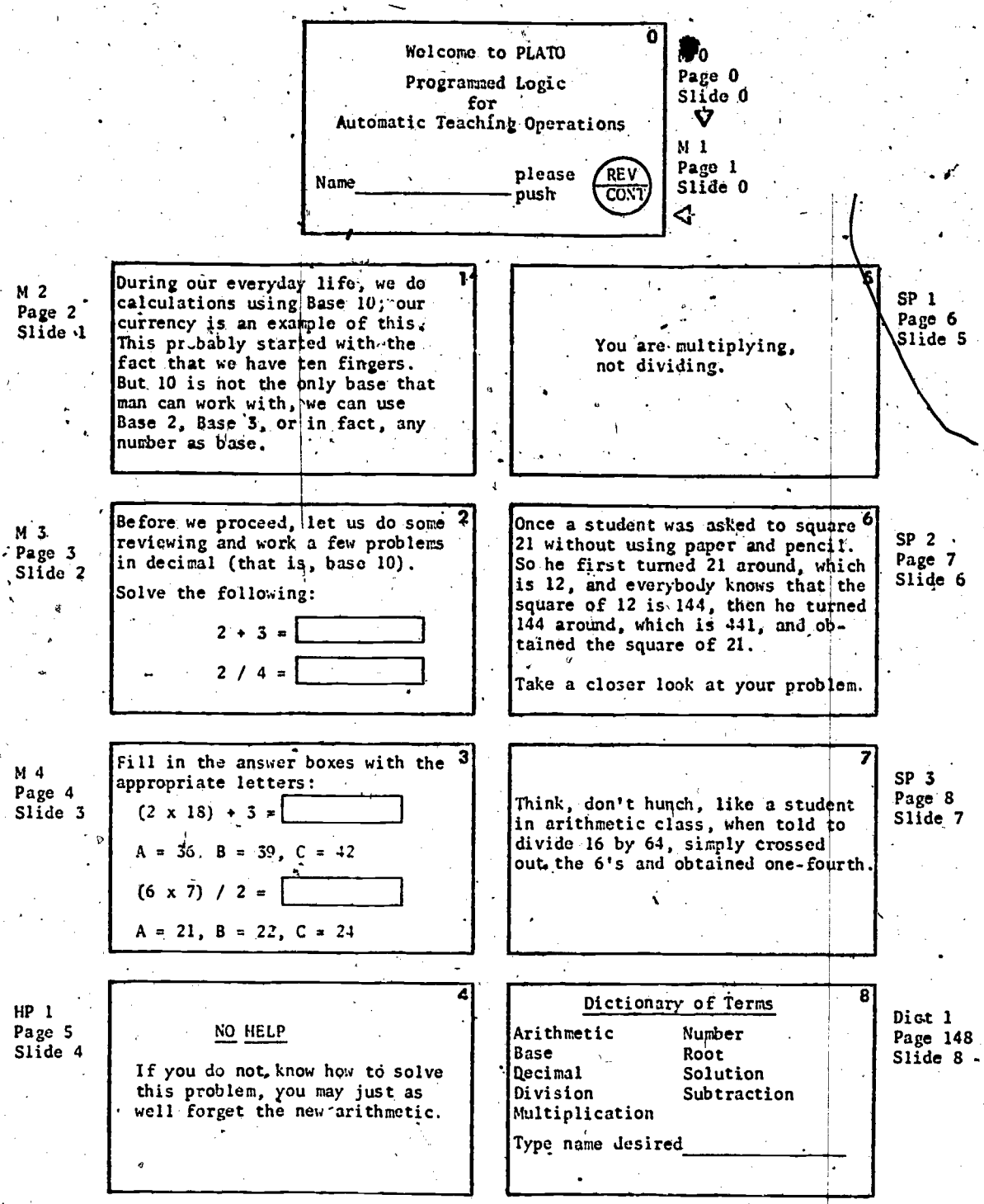


Figure 9. Slides of sample lesson

USE	PAGE #	SLIDE #	EFFECTS #	PROBLEM #	JUDGER #	ANSWERS	SPECIAL WRONG ANSWERS	HELP PAGE(S)	SPECIAL HELP PAGE(S)
M 0	0	0	x	x	x				
M 1	1	0	7 chl	1	1				
M 2	2	1	x	x	x				
M 3	3	2	x	1	4	5		5	
			x	2	4	1/2, .5	8, 2	5	6, 7
M 4	4	3	x	1	3	B	A, C		8, 8
			x	2	3	A	B, C		8, 8
HP 1	5	4	x	x	x				
SP 1	6	5	x	x	x				
SP 2	7	6	x	x	x				
SP 3	8	7	x	x	x				
Dict 1	148	8	x	1	1				

Figure 10. Answer master for sample lesson

checking the input parameters, since parameter input is so detailed. Because of the length of program GENERAL, the program was divided into three parts and the authoring procedures are carried out in three stages.

The program for authoring the parameters which include main page assignments, challenge assignments, special effects, lists of available dictionary words, names of investigation choices, and the strings of computer responses used in the dictionary and investigation sequences is called GENAUTH. This program is separate from the one for input of the description of each lesson page. The latter procedure takes place from an author mode available in the main lesson program, program GENERAL. A third program, program CONSTNT, is used to input the special arrays used in the investigate subroutines. It does not matter whether the GENAUTH or CONSTNT parameter input is done before the page descriptions or not. The three operations can be performed in any order. A diagram summarizing the three authoring procedures appears in Figure 11.

Authoring procedures using program GENAUTH.

1. Mount parameter tape on unit four, GENAUTH binary on unit two or three. Read in the program (catorun, genauth, i, 1), push door button, hit start.
2. Enter the author mode by pushing "L" while holding down CTRL and SHIFT at the same time. Figure 12 shows the slide which will appear. This page is the entry page of the author mode for both GENAUTH and GENERAL.
3. Read in previously written parameters from magnetic tape. (Remember, tapes are mounted on tape unit 4.) If one starts with parameters previously written on magnetic tape and one wishes to add to or change them,

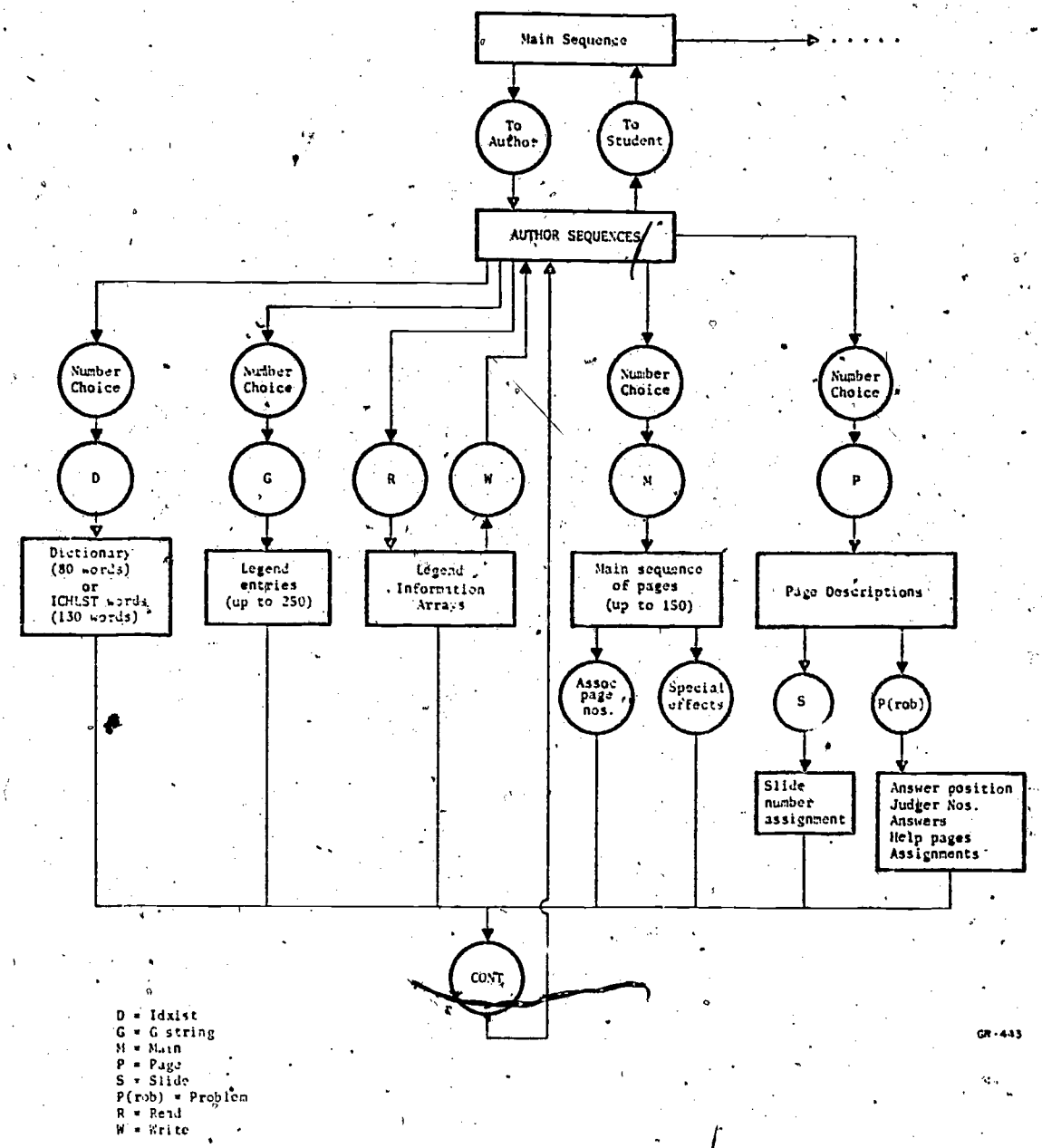


Figure 11. General flow diagram for "author" procedure.

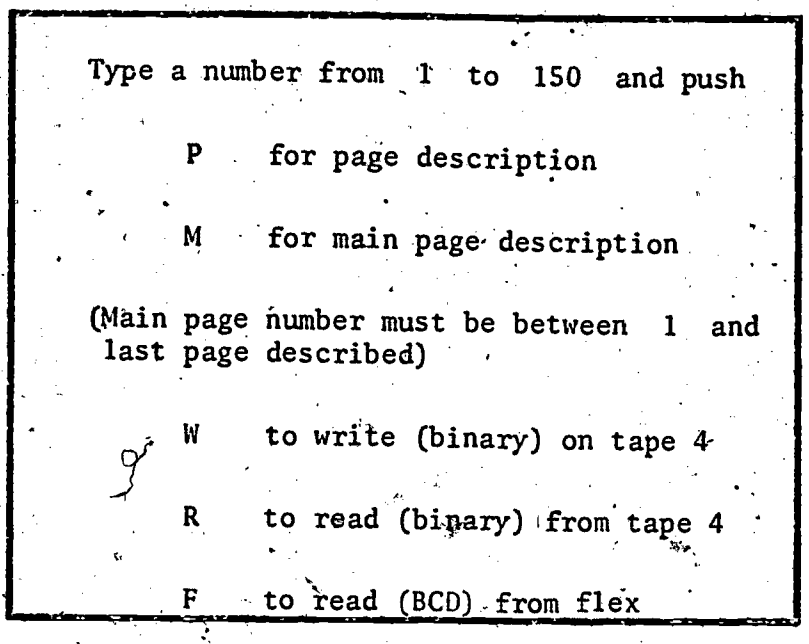


Figure 12. Author mode - entry slide

one first reads from tape four into the memory the previously written parameters by pushing "R". If parameters are stacked, see instructions on page 51.

4. Enter or change parameters.

Main pages (see Figures 13 and 14). Type the main page number and the letter "M". The following will appear on the screen: (supposing the number is a "1")

MAIN PAGE 001

PAGE 000 EFFECTS 000

a. To indicate correct lesson page number associated with the main page: type "C", then the number desired, and CONT. Suppose the number desired is "L", the screen will show:

MAIN PAGE 002

PAGE 001 EFFECTS 000

b. To advance a main page and page number by one: type "A". The legend in a. above would become:

MAIN PAGE 002

PAGE 002 EFFECTS 000

c. To delete present main page: type "D".

d. To insert main page number: type "I".

e. To reverse to previous main page assignment: press REV.

f. To see next main page (if already assigned): press NQ.

Special effects (see Appendix I).

Indicate main page needing special effect: type number and "M".

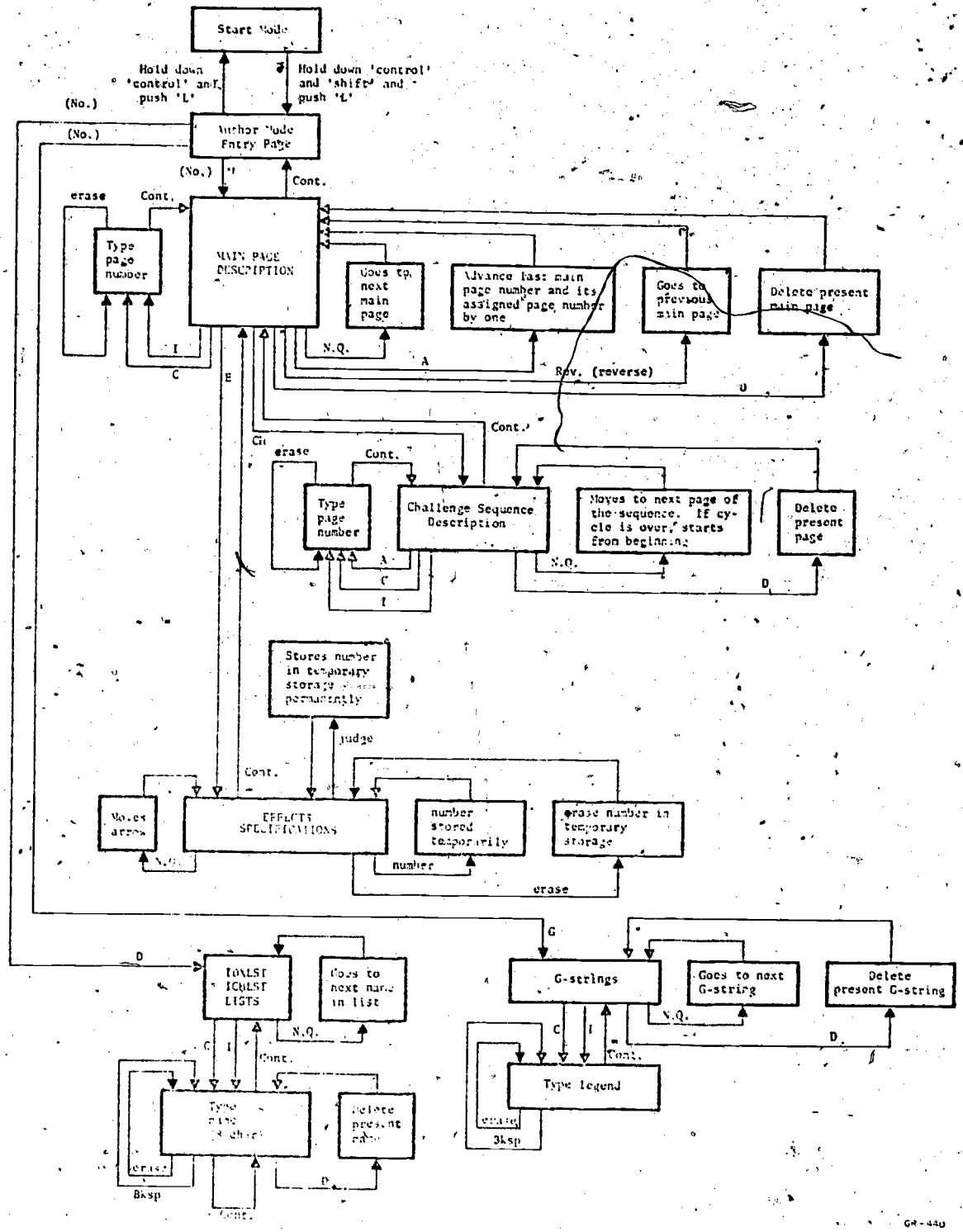


Figure 13. GENAUTH flow chart

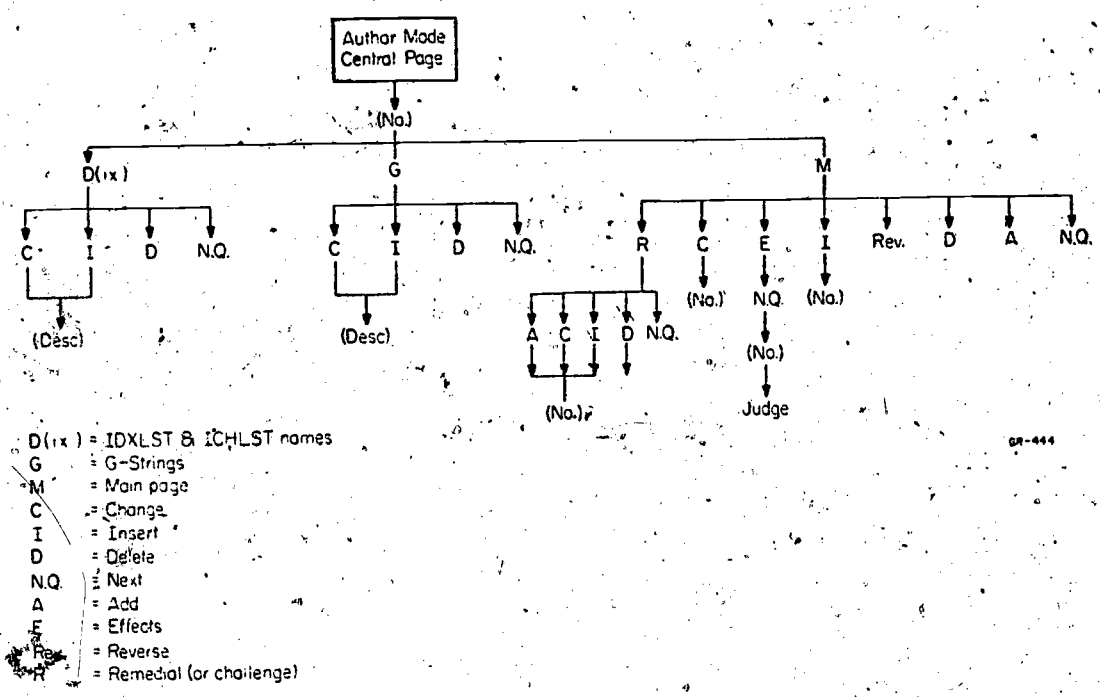


Figure 14. Simplified flow chart for authoring GENERAL

To enter special effect: type E. Screen will show 16 zeros.

0 →
0
0
0
0
0
0
0
0
0
0
0
0
0
0
0

Each zero represents a channel starting with channel 1 at the top of the column. To place a number in a channel, press NQ which will move the arrow vertically one channel at a time until it is opposite the desired channel. Type the number which will replace the zero, then press JUDGE. The zero will be replaced by the number. Proceed to replace any other zeros by numbers to designate desired special effects. Then push CONT. You will now see:

MPAGE (number)

PAGE (number) EFFECTS (number)

The number after "EFFECTS" is not significant except that one eventually learns to identify the number which appears for a specific special effect, such as "994" for "end of lesson" (a 6 in channel 1).

Challenge Sequences.

1. Indicate the main page needing the challenge sequence (type number, then "M").
2. Type "R", type "A", type the number of the first challenge page, press

CONT. To add a second page, type "A", type number of second challenge page, press CONT. Repeat to the maximum of six pages allowed in the challenge sequence, if desired.

3. Enter the special effect for making the challenge key leagl: a "1" in channel 13 (13th zero in the column of 16 zeros).

IDXLST and ICHLST Entries.

The list of names to be stored in the IDXLST and ICHSLT arrays may be authored from the keyset. In the IMNURSE program, the list of dictionary terms whose definitions can be requested is stored in the IDXLST array; the list of request names used by the student to indicate choices in the investigate sequence is stored in the ICHLST array. The rules and procedures are as follows:

1. The program stores the first eight characters of each name.
2. Eighty IDXLST items and 150 ICHLST items are allowed.
   a. IDXLST.
      1. Type a number between 1 and 80, followed by a "D". The number will appear on a blank screen.
      2. Type "C" and then the first 8 characters in the word. ERASE erases all the typed characters. BKSP erases one character at a time. CONT stores the word entered and replots the word for checking.
      3. To see next item in list: press NQ.
      4. To see previous entry: press REV.
      5. To insert a word after the word illustrated on the screen, type "I". The items above the insertion are all advanced one

position in the array. If there is an item at position 80, it is dropped from the list.

6. To delete the word on the screen: type "D". The items above the deletion are all decreased by one in position in the array.

7. To return to the entry page of the author mode: press CONT.

b. ICHLST

Type a number between 81 and 150 followed by "D". The number will appear on the screen. The rest of the procedures are like those for entering IDXLST items.

G-strings.

G-strings are strings of characters retrieved by the computer by reference in subroutines to the appropriate numbers at which the strings are stored. There may be 250 strings in all. The strings are principally used in "investigate" and "dictionary" branches. The procedures for storing G-strings are as follows:

1. Type a number between 1 and 25[illegible], followed by a "G". The number will appear on a blank screen.

2. Type "C", followed by the string as one wishes it to appear. ERASE erases all the characters. BKSP erases one character at at time. CONT stores the string and also replots the string for checking.

3. To see next string in the list: press NQ.

4. To see previous string: press REV.

5. To insert a string after the string appearing on the screen: type "I". Each string already in the list above the number being

inserted is advanced to the next position.

6. To delete the string on the screen: type "D". The items above the deletion are all moved backwards one position.

7. To return to the entry page of the author mode: press CONT.

Authoring procedures using the program GENERAL.

The authoring from the main program, GENERAL, involves describing each unique lesson page or "global" page, assigning to it slides, problems, and help pages (Figure 15). A more simplified tree-like flow chart of the same authoring appears in Figure 16 which may clarify the description of this part of the parameter input.

1. Mount parameter tape on unit four, GENERAL binary on unit two or three. Read in the program (catorun, GENERAL or program name, i, 1.), push door button, hit start.

2. Enter author mode by pushing "L" while holding down CTRL and SHIFT simultaneously. (Figure 12 will appear.)

3. Read in parameters from magnetic tape four by pushing "R". (Unnecessary procedure if no parameters yet entered.) (See also stacked parameter instructions.)

4. Enter or change the description of a page.

   a. Page number:

      Type the overall lesson (or global) page number, followed by a "P". If a slide has already been assigned to the page, the slide will appear with the legend written over it: "TYPE S OR P". If no slide has been assigned, slide 0 will appear with the legend "TYPE S OR P
      SELECT SLIDE".

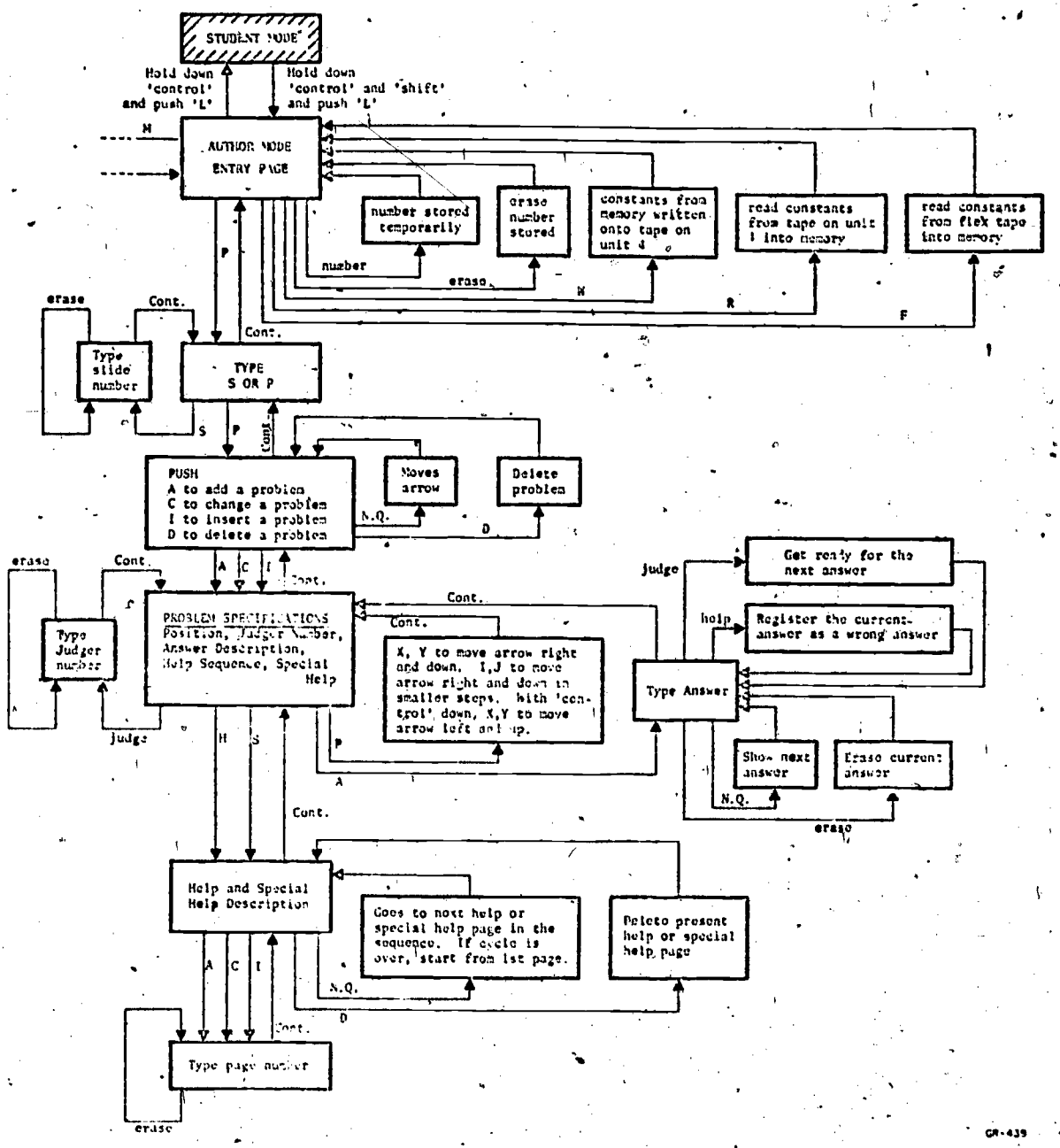


Figure 15. Flow chart for "authoring" GENERAL

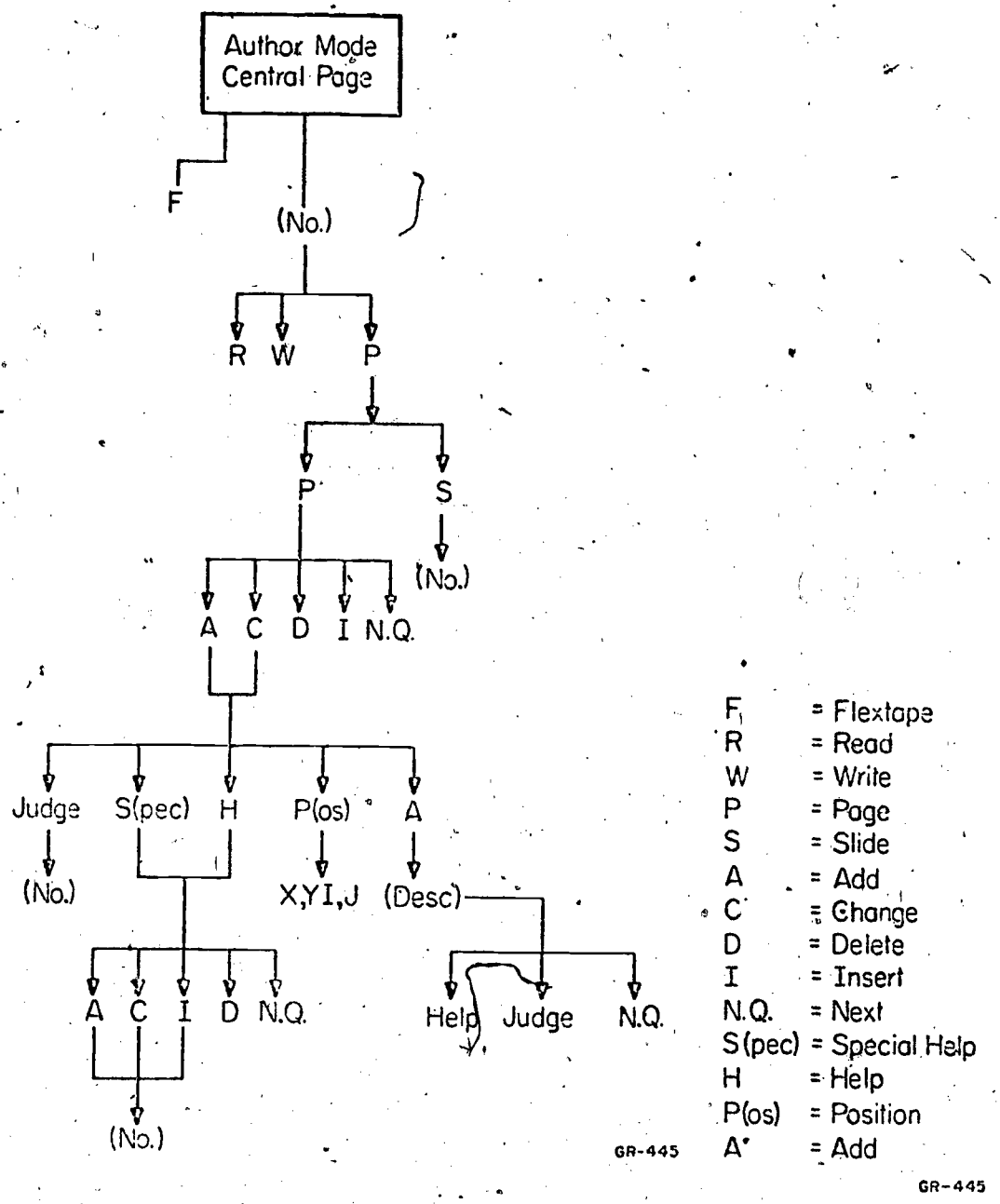


Figure 16. Simplified flow chart for authoring GENERAL

b. Slide assignments:

Type "S". Figure 17 appears.

1. To assign slide to page: Type the slide number (position on slide sheet) and CONT.

2. To change slide to another position assignment: type the new slide position number and CONT.

c. Problem (or question) descriptions:

Type "P". The slide appears on which the problem is located.

1. To assign or add a problem to a page: type "A". Figure 18 appears. The problem is now further described as follows:

   a. Position.

      To position the problem on the page, type "P". This allows one to move a small arrow around on the screen to position where the first character should appear when an answer is input for that problem. The arrow appears originally in the upper left-hand corner of the screen. When the arrow has been properly positioned by using the keys listed below, press CONT to record the position in the computer memory.

      "X" moves arrow to right

      "Y" moves arrow down

      "X" plus CTRL moves arrow to left

      "Y" plus CTRL moves arrow up

      "I" moves arrow to right (small increments)

      "J" moves arrow down (small increments)

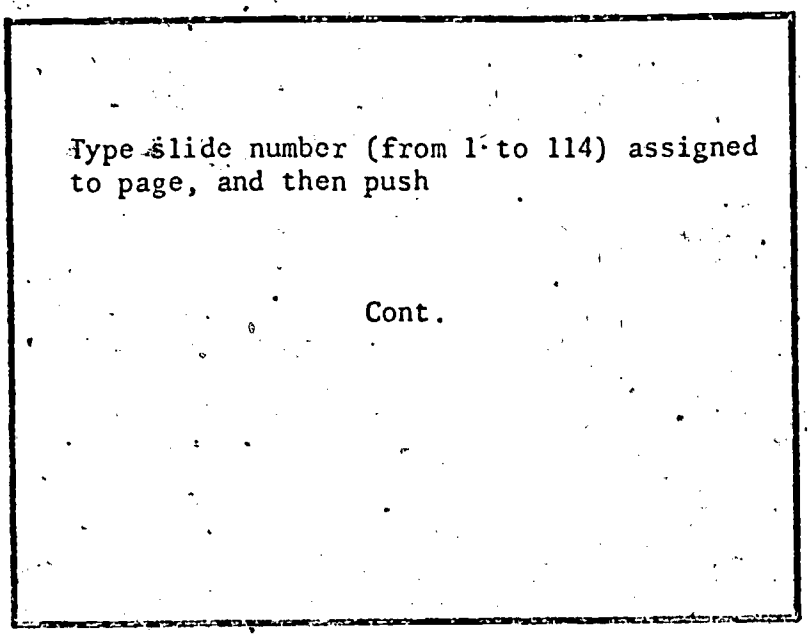


Figure 17. Slide instruction page in author mode

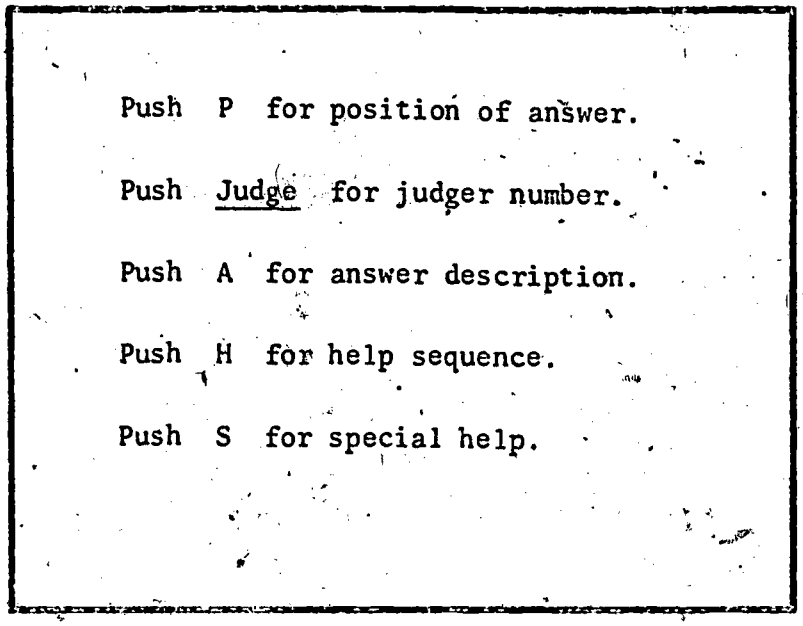


Figure 18. Problem description slide in author mode

Note: do not be alarmed at the position of the arrow when "P" is first pressed. The position is not necessarily that of the correct previous position. Just position the arrow where you want it to be for this particular problem.

b. Judger.

To record judger number for the problem: press JUDGE, type the number, and then press CONT. The judger number for the problem is thus recorded. The list of possible judgers is in Appendix II. If the judger number has not been assigned, the legend "JUDGE=0" will appear on the screen when return to the entry author page is attempted. The legend is a reminder that there must be a judger number assigned to every problem. When "JUDGE=0" appears, push JUDGE, the appropriate judger number and CONT to correct the omission.

c. Answers.

1. To enter answers: type "A", then type the answer. Press JUDGE to add a second answer. (Repeat procedure for more.) NOTE: "backspace erase" does not operate in this author mode as yet. It will be added in the future.
2. To enter special wrong answers: type the answer in a set of correct answers, but press HELP instead of JUDGE.
3. To end the answer set: press CONT.

d. Help pages.

1. To assign help pages to the question being described: type "H". Slide 0 and the legend PUSH A" will appear on the screen. Push "A", the number of the help page and CONT. The desired page will appear with the legend HPAGE1 overwriting it.

2. To add more help pages to the series (maximum limit: 6 pages) press "NQ" and repeat the operation of pushing "A", a number and CONT. Each successive page will be designated HPAGE 2, HPAGE 3, etc.

3. To end the help page sequence: press CONT.

e. Special help pages.

To assign special help pages to special wrong answers: type "S". Slide 0 and the legend "PUSH A" will appear. Push "A" the number of the help page associated with the first special wrong answer and CONT. The desired slide will appear overwritten with the legend SPHEP1. Adding a second special help page (see procedure in the previous section on adding help pages) assigns the page to the second special wrong answer described for the problem. There may be six special help pages assigned to six special wrong answer.

f. Termination of problem description: press CONT.

The slide on which the problem was being described appears with the arrow in the proper position for that problem. One can now add another problem (page 42)

inspect, change, delete, or insert a problem or return to the initial author page (see below).

2. To change or examine any part of the problem description: position the arrow to the problem to be examined by pressing "NQ". Press "C". Figure 18 will appear. The changing or inspecting procedures are:

a. Position.

Pressing "P" allows the arrow to be moved by the keys indicated previously (i.e., "X", "Y", "I", "J").

b. Judger.

Change the judger by proceeding as if a judger had not been entered at all. The new judger number overwrites the old one.

c. Answers.

Press "A". The first answer in the list appears. Press "NQ" sequentially to examine the answers one by one. An anticipated correct answer appears with an "OK" beside it; a special wrong answer will be followed by "NO". Answers are deleted or corrected by erasing them. A replaced answer appears at the end of the list of answers. Asking for the answer in the student mode produces the answer on the screen which is the first one in the recorded list of answers. The order of appearance of the answers may be checked on-line by seeing in what order answers appear after pressing "C" and then "A" in the "examination of problem" procedure.

d. Help or special help pages.

1. To change help pages: press "H" (or "S"), "C", the new number, and finally CONT.

2. To examine the help sequence: press "H" (or "S") and then "NQ" as many times as is necessary to take one through the sequence.

3. To delete a problem: position the arrow to the problem to be deleted by pressing "NQ". Press "D".

4. To insert a problem: press "NQ" to position the arrow to the problem after which the insertion is to occur. Press "I". Then describe the problem.

5. To return to initial page of author mode: press CONT twice.

5. Describe special pages.

a. Help pages:

Help pages are described in the same manner as regular pages on which problems appear. There can be no help pages, however, assigned to problems on help pages.

b. Data pages:

1. Assign page 147 to the first page in a data sequence: from initial author page, type 147 and "P". Press "P"again.

2. Add a problem to page 147: press "A". Leave the position of the arrow in the upper left-hand corner of the screen.

3. Enter the first page in the data sequence (after page 147) as help page 1 for the problem on page 147; and the last page in the data sequence as help page 2: type "H", "A", the number of first page in sequence, CONT, "A", number of last page in

sequence, CONT. Use Judger 1. Return to initial author page by pressing CONT twice.

4. Assign slides to the rest of the data pages being sure that the data pages (after data page 1) have consecutive "overall lesson" numbers. Example: data pages: page 147, 87-90, slides 25, 63, 67, 69, 70.

HPAGE1 = 87, HPAGE2 = 90

c. Dictionary pages:

1. Assign page 148 to the first dictionary page: from initial author page, type 148, and "P".
2. Assign the correct slide to the first dictionary page (p. 148).
3. Press "P" again.
4. Add a problem to page 148: press "A".

   Position the arrow to the place where the dictionary word is to be typed. Use judger "1".
5. Enter the first page number in the dictionary sequence (after 148) as help page 1 for the problem on page 148, and the last page in the dictionary sequence as help page 2: type "H", "A", number of first page in sequence, CONT, "A", number of last page in sequence, CONT.
6. Return to the initial author page by pushing CONT twice.
7. Assign slides to the rest of the dictionary pages being sure that the pages after dictionary page 1 have consecutive page numbers (see data section).
8. Place a problem on each dictionary page positioned where the dictionary word is to be typed. Use Judger 1.

d. Investigate pages: (see Appendix III for details of the Investigate subroutine.)

1. Assign page 149 to the first investigate slide.
2. Place a problem on the page if the student is to type a choice, positioning the arrow where the choice is to be typed. Use judger 1. Place a "1" in HPAGE 1. If there is a second choice on the page, place a second problem on the page and a "1" in HPAGE 1 and a "1" in HPAGE 2 for the second problem. If the student is only to "continue" through a series of consecutive slides, place a "99" in HPAGE 1, the initial page number of the sequence after 149 in HPAGE 2, and the final page number in HPAGE 3. Leave the position arrow in the upper left-hand corner in this case. Return to initial author page by pushing CONT twice.
3. Assign slides to the other investigate pages. If the student is to indicate a choice on a page, position the arrow accordingly. Enter numbers in the help pages which are the appropriate "flags" for the investigate subroutines (see Appendix III).

Authoring procedures using program CONSTNT.

Program CONSTNT writes on the parameter tape the special arrays used in the investigate subroutines (Appendix III). The source program contains the array for the "always acceptable" list of words used by Judger 11, the keyword judger. One then inserts in the program any other arrays needed. The program is next compiled in the usual PLATO manner and read into the

computer. The parameter tape is then placed on unit 4, and key "R" then reads any already written parameters into the program. Pushing key "W" writes them out again on the magnetic tape with the arrays properly filled.

Parameter code checking.

The most reliable checking of parameter errors is done by checking a listing of the parameters made on the computer line-printer using Program PRINT. Follow the procedure:

1. Mount parameter tape on unit 4.
2. CATORUN,PRINT,i,1.
3. Push door button, hit start.
4. Press "R". This reads the parameters into the computer memory.
5. Press "P". The parameters are immediately printed on the line-printer.

Parameter stacking.

The parameters for several lessons may be stacked on one magnetic tape for efficient storage. Since they are in binary form, they can, of course, be transferred to paper tapes also, albeit the paper tapes will be long because of the size of parameter arrays contained in the program.*

The procedures for parameter stacking are as follows:

1. Mount binary of program GENERAL on unit 2. Mount parameter tape on unit 4. Mount scratch tape on unit 3.
2. Read in program:

   CATORUN,GENERAL,2,1.
3. Enter the author mode: CONTROL, SHIFT, "L".
4. Read in parameters by pushing "R".

*See footnote, page 2.

5. Replace tape on unit 4 with tape on which parameters are to be stacked.

6a. For first set in stack: press 1 and "W". Parameters will write on tape on unit 4.

b. For any except first set in stack: press the number for the position in the stack, i.e., "2"...and "W". The parameters are automatically written on tape 3, the tape on 4 positions itself to write the next set of parameters at the end of those already on the tape; and the parameters on 3 are then copied onto tape 4.

The procedures for using a set of parameters on the stacked tape is as follows:

1. Mount the binary of program GENERAL on unit 2 or 3. Mount the stacked tape on unit 4.
2. Read in the program: CATORUN,GENERAL,i,1.
3. Enter the author mode: CONTROL, SHIFT, "L".
4. Select and read in desired parameter set by pressing the set number and "R". The computer searches the parameter tape for the desired set number and reads in that set of parameters.

Data Obtained for Program Evaluation (DOPE)

Doping

The usual method of recording student responses records in binary format the student number, key number, mode number and time (in 1/60's of a second), plus an identification tag for the session. In addition, program GENERAL stores extra dope information: namely, the page number, problem number, and time spent in various special modes, the judging result, and the fact that there was a coded computer response or not.

Dope Analysis

Several programs are available for sorting and analyzing the student responses. The most simple lists all the key pushes sequentially by key name for each student. Other programs allow the instructor a choice of items to be listed such as comments only, time taken on the lesson, etc. The Evaluation group (formerly the SIRA group) of the Computer-based Education Research Laboratory has developed a variety of analysis techniques. Special acknowledgment should go to James Kraatz for his work on programs applicable to program GENERAL.

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APPENDIX I

SPECIAL EFFECTS

Channel	Effect	Result
1	0	CONT key legal
1	1	CONT key illegal
1	2	CONT key executes EVAL 1 subroutine
1	3	CONT key illegal if judger 11 spots duplicate answer. Must be used with a 2 in channel 9.
1	4	CONT key executes EVAL 3 subroutine
1	5	CONT key plots YOU ARE HALFWAY THROUGH THE LESSON
1	6	CONT key plots END OF LESSON
1	7	Unconditional continuing legal
2	0	REV key legal
2	1	REV key illegal
3	0	ERASE key legal
3	1	ERASE key illegal
4	0	JUDGE key legal
4	1	JUDGE key illegal
5	0	REPLOT key legal
5	1	REPLOT key illegal

Channel	Effect	Result
6	0	NQ key legal
6	1	NQ key illegal
7	0	HELP key legal
7	1	HELP key illegal
7	2	Allows change in help page assignment for a particular problem. A 3 in channel 12 must be used with this effect. The new help pages are stored in the array JPDV2, one page number per array word.
8	0	Constructed responses legal
8	1	Constructed responses illegal
9	0	ANS key legal
9	1	ANS key illegal
9	2	Judger 11 spots duplicate answer if there is a 3 in channel 1 as well as this special effect.
10	0	COMMENT key legal
10	1	COMMENT key illegal
11	0	DATA key legal
11	1	DATA key illegal
12	0	PLOT key illegal
12	1	PLOT key legal for subroutine PLOTSRL used in EE322 to plot $\frac{1}{R}(1-e^{R/L\ t})$ when L and R are specified.

Channel	Effect	Result
12	2	PLOT key legal for plotting a circle centered at (x,y) with radius R. x, y, and R are specified.
12	3	PLOT key legal for subroutine PLOTWAN used in IMNURSE to plot arrows whose positions are stored in the array JPDV1.
13	0	CH key illegal
13	1	CH key legal
14	0	BKSP key legal (selective erase of 1 character)
14	1	BKSP key illegal
15	0	DICT key legal
15	1	DICT key illegal
16	0	INV key legal
16	1	INV key illegal

APPENDIX II

JUDGERS

Judger Number	Description	Judgment Response
1.	Does nothing.	No plot.
2.	All answers are judged correct.	Plots OK for all responses.
3.	Number judger. Check signs (equivalent signs are accepted, no sign, a "plus" sign, or four "minus" signs in a row are all equivalent).	Correct answers - plots OK. Incorrect answers - plots NO.
4.	Letter judger. Represses spaces.	Correct answers - plots OK. Incorrect answers - plots NO.
5.	Tests for valid fix-point (integer) number.	Correct answers - plots OK. Incorrect answers - plots NO.
6.	Tests for valid floating-point number.	Correct answers - plots OK. Incorrect answers - plots NO.
7.	Tests for valid fix-point (integer) variable name. (six characters or less)	Correct answers - plots OK. Incorrect answers - plots NO.
8.	Tests for valid floating-point variable name (six characters or less).	Correct answers - plots OK. Incorrect answers - plots NO.

Judger Number	Description	Judgment Response
9.	Allows student to compare his response with a response written on a slide.	Calls another slide, but does not erase student's constructed answer. Student's answer receives "OK" response no matter what it is.
10.	Spelling judger.	Correct answer - plots OK. Misspelled answer - plots SP. Wrong answer - plots NO.
11.	Key word judger.	Correct answers - plots OK. Incorrect answers - plots NO and crosses out unacceptable words. Incomplete answers - plots NC. Duplicate answers - plots DUPLICATE ANSWER.
12.	Tolerance judger. Tests numerical answer for values within set limits.	Correct answer - plots OK. Incorrect answers - plots NO.
13.	Spelling judger (Judger 10) plus automatic presentation of help slide for wrong answer.	Correct answers - plots OK. Presents help slide for wrong answer. Upon return to question page: Misspelled answer - plots SP. Wrong answer - plots NO.

Appendix II (cont)

Judger Number	Description	Judgment Response
14.	Judger 11 plus automatic presentation of help slide for a wrong answer.	Correct answers - plots OK. Presents help slide for wrong answer. Upon return to question page: Incorrect answers - plots NO and crosses out unacceptable words. Incomplete answers - plots NC. Duplicate answers - plots DUPLICATE ANSWER.
15.	Judger 4 plus automatic presentation of help slide for a wrong answer.	Correct answers - plots OK. Presents help slide for wrong answers. Upon return to question page: Incorrect answers - plots NO.
16.	Presents another slide instead of a written judgment.	Calls another slide. Erases student's answer. Student's answer is acceptable no matter what it is.
17. for	Judger 4 plus automatic presentation of help slide for a wrong answer and next main page for a correct answer.	Presents help slide for wrong answer, next main page for correct answer. Upon return to question page: Correct answers - plots OK. Incorrect answers - plots NO.

Judger Number	Description	Judgment Response
18.	Judger 10 plus automatic presentation of help slide for a wrong answer and next main page for a correct answer.	Presents help slide for wrong answer, next main page for correct answer. Upon return to question page: Correct answers - plots OK. Misspelled answers - plots SP. Wrong answer - plots NO.
19.	Judger 11 plus automatic presentation of help slide for a wrong answer and next main page for a correct answer.	Presents help slide for wrong answer, next main page for correct answer. Upon return to question page: Correct answers - plots OK Incorrect answers - plots NO and crosses out un-acceptable words. Incomplete answers - plots NC. Duplicate answers - plots DUPLICATE ANSWER.
20.	Judger 4 plus automatic change to next main page on correct answer.	Correct answer automatically changes to next main page if all answers are correct. Incorrect answer - plots NO.
21.	Judger 10 (spelling judger) plus automatic change to next main page on correct answer.	Correct answer automatically changes to next main page if all answers on page are correct. Misspelled answers - plots SP. Wrong answers - plots NO.

Appendix II (cont)

Judger Number	Description	Judgment Response
22.	Judger 11 plus automatic change to next main page on correct answer.	Correct answer automatically changes to next main page if all answers on page are correct. Incorrect answers - plots NO and crosses out unacceptable words. Incomplete answers - plots NC. Duplicate answers - plots DUPLICATE ANSWER.

Further Explanation of Judgers

Judger 1 — Judger 1 is a "do nothing" judger. Since each problem must have a judger assigned to it, judger 1 is the assignment for a constructed response requiring no judgment. If judger 1 is used, one must remember to put in the special effect for that page which allows one to continue to the next page regardless of the response, a 7 in channel 1. The special effect need not, however, be entered on investigate, data or dictionary pages which use judger 1.

Judger 2 — Judger 2 judges all answers correct. An "OK" is plotted next to the response when the JUDGE key is pressed.

Judger 3 — Judger 3 is a number judger. It checks signs and accepts equivalent signs such as no sign, a "plus" sign or four "minus" signs. A correct response produces an "OK" written next to the answer; an incorrect answer is marked "NO".

Judger 4 — Judger 4 is an alphanumeric character judger. It ignores spaces. "OK" is written next to a correct answer, "NO" next to an incorrect answer.

Judger 5-8 — Judgers 5-8 are judgers written for the course in FORTRAN programming. Each correct answer is judged "OK", incorrect answer is judged "NO". Judger 5 tests for a valid fixed point (integer) number; Judger 6 for a valid floating point number; Judger 7 for a valid fixed-point (integer) variable name of six

characters or less; and Judger 8 for a valid floating-point variable name of six characters or less.

Judger 9 — Judger 9 allows the student to compare his response with one already prepared on a slide. On pressing JUDGE, the new slide appears, but the student's answer remains plotted on the screen. The new slide must be assigned (and mounted accordingly) the next consecutive slide number to the slide number of the page on which the question appeared. The "overall" page number of the new slide is immaterial. The new slide is not assigned a main page number.

Judger 10 — Judger 10 is the spelling judger. It indicates "OK" for a correct answer, "SP" for a misspelled answer and "NO" for a wrong answer. The judger counts as one mistake each omission, insertion, substitution or inversion. The number of mistakes allowed for an answer is one-fifth the number of characters in the answer $(\frac{N}{5})$ if the number is evenly divisible by 5. If $\frac{N}{5}$ has a remainder, an additional mistake is allowed.

Judger 11 — Judger 11 is the "key word" judger which allows a wide variety of answers with varying syntax. The judger not only marks responses correct with an "OK", incorrect with a "NO", but also indicates partially correct answers by giving a response "NC" for "not complete" as well as crossing out the words in the answer which are unacceptable. In addition, if there are several questions on a page whose answers are interchangeable,

the judger will check the answers for duplication. Although each answer may in itself be correct, and, therefore, judged "OK", "DUPLICATE ANSWER" will be printed at the bottom of the page in case of duplication, and the student will not be able to proceed to the next page by pressing CONT.

Parameter entry of the answers using Judger 11 require a special format. A special effect must also be used on the page on which the questions appear if Judger 11 is to search for duplicate answers. In the latter case, no questions may be asked on the page unless they use Judger 11 and are ones where the duplication of answers may appear, as the judger examines all the answers on the page which the student has given, if the special effect for duplication is in effect.

The Judger 11 format is as follows:

1. Enter as the first answer in the list of answers for the problem, the answer as the computer would print it.
2. Enter as alternate answers up to six answers in the following format:
   a. Required words - words which must be present in the answer appear in parentheses with as many as eight words separated by commas in any one parentheses. The eight words are synonyms or alternatives for each other. There may be eight required or key words, i.e., eight parenthetical groups, for one answer.

b. Also acceptable words - words which may occur in the answer, but are not required are added as a list following the parentheses. Type a special hyphen ("K" plus SHIFT) and then the list of up to twenty "also acceptable" words.

Example: - fat, soluble, vitamins, vit, vitamin, mean, indicat==, pass, slowly, slower, slowest, more, weight, weigh, fatty, acids, slowly.

c. Word-form abbreviations - any words longer than eight characters which are acceptable as long as the first eight characters are correct may be used as required or acceptable words by typing the first eight characters followed by two "equal" signs. Example: Contrast== could be used is contrasts, contrast, contrasted, contrasting were all acceptable.

Two typical questions and the answers from one of the IMNURSE lessons are shown below as an example of straightforward answers using Judger 11.

1a. Fat soluble vitamins indicate large molecules.

b. (large, larger, big, great, greater) (molecule, molecules, molecular) - fat, soluble, vitamins, vit, vitamin, mean, indicate==, pass, slowly, slower, slowest, more, weight, weigh, fatty, acids, slowly

2a. Bacilla rarely passes placenta. Drugs also protect fetus.

b. (rare, rarely, seldom) - bacillus, tubercul==, TB, germ, organism, passes, crosses, placenta, placental, barrier,

bacteria, infection, baby, infant, fetus

c. (drugs, medication, medications, med, meds, drug) (protect, protected, protection, protects, prevents) - fetus, infant, child, baby, also, disease, tuberculosis, TB, mothers, mother, infection, maternal

d. Duplicate answer abbreviations. If the questions on a page have interchangeable answers, it is not necessary to enter the alternate answers in the answer list of each answer. The answers to the first question are entered completely. For the other questions, the first answer in the answer list is that which the computer would give on pressing the ANS key. As a second answer in the list, a "plus" sign is typed. This signifies to the judger that the alternative answers listed under question one are also applicable here. There may be as many as four questions whose answers are interchangeable. Example:

1a. poliomyelitis

b. (poliomyelitis, polio)

c. (smallpox)

d. (tetanus)

e. (diptheria)

2a. Smallpox

b. +

3a. Tetanus

b. +

4a. Diptheria

b. +

e. Special effect for duplicate answer checking. A "3" in channel 1 and a "2" in channel 9 need to be entered as special parameters for duplicate answer checking by Judger 11.

Judger 12 Judger 12 accepts all numerical answers between upper and lower integer values. The answer is entered as "A" - "B", i.e., lower limit, special hyphen, upper limit.

Example: If an answer between 15 and 30 were acceptable, the answer in the answer list would be : 15 - 30 where the "hyphen" was the special one - "K" plus SHIFT. The judger would mark "OK" for 15, any value between 15 and 30, and 30. It would mark "NO" for all other numbers.

Judger 13 Judger 13 (like Judgers 14 and 15) automatically changes the student's slide to a help slide if the student's answer is wrong. The judger used is the spelling judger. When the student returns to the main page from the automatically presented help page, either the SP or NO judgment appears by the incorrect answer.

Judger 14 Judger 14 (like Judgers 13 and 15) automatically changes the student's slide to a help slide if the student's answer is wrong. The judger used is Judger 11. When the student returns to the main page from the automatically presented page, either the "OK" or the "NO" judgment appears by the incorrect answer.

Judger 15 — Judger 15 (like Judgers 13 and 14) automatically changes the student's slide to a help slide if the student's answer is wrong. The judger used is Judger 4. When the student returns to the main page from the automatically presented help page, the "NO" judgment appears by the incorrect answer.

Judger 16 — Judger 16 is similar to Judger 9 except that the student's response is erased when the new slide is presented.

Judger 17 — Judger 17 is similar to Judger 15, but adds an additional feature, that of automatic presentation of the next main page if the student's response is correct, provided all other answers on the page are correct.

Judger 18 — Judger 18 is similar to Judger 13, but adds an additional feature, that of automatic presentation of the next main page if the student's response is correct, provided all other answers on the page are correct.

Judger 19 — Judger 18 is similar to Judger 14, but adds an additional feature, that of automatic presentation of the next main page if the student's response is correct, provided all other answers on the page are correct.

Judger 20 — Judger 20 is similar to Judger 4, but adds an additional feature, that of automatic presentation of the next main page if the student's response is correct, provided all other answers on the page are correct.

Judger 21 Judger 21 is similar to Judger 10, but adds an additional feature, that of automatic presentation of the next main page if the student's response is correct, provided all other answers on the page are correct.

Judger 22 Judger 22 is similar to Judger 11, but adds an additional feature, that of automatic presentation of the next main page if the student's response is correct, provided all other answers on the page are correct.

APPENDIX III

The INVSTAN Subroutine

"Pattern" for the Investigate Subroutines. The INVESTIGATE section of a lesson produces a computer response (a legend, a graphic display, a slide change, or some combination thereof) to an input or series of inputs from the student. The student's inputs are choices which he makes setting up the conditions of the experiment, test, or situation which he wishes to investigate.

Page 149 is always the first page in the investigate sequence and on page 149 there will usually be a choice or choices for the student to make. The case of a single choice will be considered first. The single choice on page 149 is usually a choice of the possible investigations. At the present time a special subroutine, INVSTAN, is written for the investigation for each individual lesson. The subroutine first compares the student's input with the list of possible responses (ICHLST) which have already been inserted in the program from the author mode. Each word in ICHLST consists of up to eight characters, the characters being the first eight of the characters the student would type as a choice.

If there is a match between student's input and a word in ICHLST, the computer looks for a directive to indicate which part of the INVSTAN subroutine to execute to provide the information desired by the student. The number which has been stored as help page 1 for the answer on that investigate page is the directive to the computer. The computer response from the portion of the subroutine used depends on the ICHLST number of the student's choice or choices. The response, as stored above, may be a slide change, the results of a numerical calculation, or the plotting of a

picture or legend. The appropriate parameters for each section of the INVSTAN subroutine are input, by program CONSTNT, in array format. The parameters may be G-string legend numbers, special characters to be plotted, coordinate information for positions of unique plots, or the like.

If the information to be given to the student depends on two choices, the flag or directive number for the computer is stored as the number for help page 2 for the second answer (or choice entry) on the page. It does not matter what number is stored as help page 1 in the second answer.

Although this report does not explain the programming details of GENERAL, an example of an INVSTAN subroutine appears in Appendix IV. The general annotations may help clarify the pattern of an "investigate" sequence.

Directions for using INVSTAN. In program GENERAL the subroutine INVSTAN exists as a "do-nothing" subroutine. The INVSTAN subroutine especially designed for a specific lesson is substituted for the "dummy" subroutine in the GENERAL source. The appropriate flags (discussed above) are inserted during parameter input, the flags being "help page" numbers for the answers on the investigate pages. The array information used in the subroutine is added to the parameters for the lesson by program CONSTNT. The names in ICHLST are input using the GENAUTH program (see page 38).

It is hoped eventually to generalize the INVSTAN subroutine so that a subroutine need not be custom-made for each lesson. A general subroutine could then handle all investigation possibilities, with the arrays being input as parameters from the PLATO keyset also.

APPENDIX IV

An Example of an INVSTAN Subroutine

```
555     PROGRAM INVSTAN
        DIMENSION JSLL(150,3),JKLL(150,3),JPP(126,5),JAANS(2047),
       1IAANS(70),IANS(70),JSBNK(31),KPTFM1(1000),KPTFM2(1000)
        DIMENSION JWL1(80),IWL1(20),IWL2(20),IKW(8),ISW1(8,8)
        DIMENSION ISW2(8,8),IDXLST(80),ICHLST(150),JIVD(2,3,25)
        DIMENSION JJVD(2,3,25),JPDV1(3,20),JPDV2(3,20)
        DIMENSION JWAN(10,4),JWAN1(4)
        COMMON JJWAN1,JJWAN2,JWAN,JWAN1
        COMMON JSLL,JKLL,JPP,JAANS,IAANS,IANS,JSBNK,KPTFM1,KPTFM2
        COMMON JWL1,IWL1,IWL2,IKW,ISW1,ISW2,IDXLST,ICHLST,JIVD
        COMMON JJVD,JPDV1,JPDV2
        COMMON JT1,JT2,JT3,JT4,JT5,KSP,KR,KPD,KPL,KM
C
C
C
C
2       DO 10 KT1=1,MI5                         .UNPACKS STUDENT ANSWER
        JI1=KT1
        CALL GLOBAL
        CALL STAD
        CALL STUNPAK
        IF(JI6)20,20,3
20      JI2=JPP(JI1,3)
        JI1,.JPP(JI1,2)+(JI6+2)*XINCRMT
        KK=2
        JPLT=-1
        CALL PLOT(JI1,JI2,JPLT,KK,NO)
        RETURN
3       JT1=0
        KT3=0
4       DO 6 KT2=1,JI6
        IF(IANS(KT2)-KSP)5,6,5                  .IGNORES SPACES,CARRIAGE RETURNS
5       IF(IANS(KT2)-KR)7,6,7
7       LDA(JT1)ENQ(0)LLS(6)STA(JT1)            .COMPARES 1ST 8 CHARACTERS IN
        JT1=JT1+IANS(KT2)                       .STUDENT RESPONSE WITH ITEMS IN
        KT3=KT3+1                               .ICHLST
        IF(KT3-8)6,8,8
6       CONTINUE
        KT3=6*(8-KT3)
        LDA(JT1)ALS7(KT3)STA(JT1).
8       ENI3(150)LDA(JT1)
        +EQS3(ICHLST)SLJ(20).
        ENA3(0)STA(JT1)
10      JPPP(KT1)=JT1                           .STORES ICHLST ITEM NUMBER
        IF(JXXSW)9857,9858,9857                 .STUDENT BANK
9858    CALL DOPE (MI2,MI6,-0,-0,JT1)           .X DOPE FOR INVESTIGATE
        JXXSW=1
        GO TO 9856
9857    CALL DOPE(MI2,MI6,-0,-0,-0,JT1)
        JXXSW=0
9856    CONTINUE
        JI1=1
        CALL GLOBAL
        JT1=JPP(JI1,4)                          .UNPACKS NUMBER DESIGNATED AS FIRST
```

```
      LDQ(JT1ENA(0)LLS(8)STA(JT1)          .HELP PAGE
      IF(JT1)15,15,16
15    CALL INSTRUT
      RETURN
16    IF(JT1-6)  17,17,15                  .DIRECTS TO PROPER PORTION OF SUB
17    GO TO(101,102,103,104,105,106),JT1   .ROUTINE ACCORDING TO NUMBER FOR
101   JT1=JPPP(1)                          .HELP PAGE 1
      IF(JT1) 20,20,11
11    IF(JT1-2) 12,13,14
12    MI9=120
      GO TO 19
13    MI9=131
      GO TO 19                             .DEPENDENT ON STUDENTS CHOICE ON
14    IF(JT1-4) 18,9,333                   .THIS PAGE,SLIDE IS CHANGED TO SLIDE
18    MI9=132                              .120,131,132,133,134
      GO TO 19
333   IF (JT1-5) 14,334,25
334   MI9=134
      GO TO 19
9     MI9=133
19    MSTM=0
      RETURN
102   JT1=JPPP(1)                          .IF THE INVESTIGATE CHOICE IS THE
      IF(JT1) 20,20,23                     . FIRST ONE,THERE IS NOW ANOTHER CHOICE
23    IF(JT1-10) 24,24,25                  .FOR THE STUDENT ON THE SECOND SLIDE
24    JI1=5+JT1                            .IN THE INVESTIGATE SEQUENCE.IF THE
      CALL ERASE                           .CHOICE IS A NUMBER LESS THAN 10,THE
      CALL SLIDE(JI1)                      .SLIDE IS CHANGED AGAIN.
      RETURN
25    JI1=1
      CALL GLOBAL
      GO TO 20
103   JT1=JPPP(1)                          .THE SECOND INVESTIGATION SEQUENCE
      IF(JT1) 20,20,30                     .RESULTS IN A LEGEND WRITTEN ON THE
30    IF(JT1-10) 31,31,25                  .SCREEN.THE LEGEND NUMBER IS STORED
31    JT2=JPPP(2)-10                       .IN THE ARRAY JIVD(I,J,K)WITH THE
      IF(JT2) 20,20,33                     .PROPER WORD BEING REFERNCED DEPENDING
32    JI1=2                                .ON THE STUDENTS CHOICE ON THIS PAGE.
      CALL GLOBAL
      GO TO 20
33    IF(JT2-24) 34,34,32
34    IF(JT1-5) 35,35,36
35    JT3=9*(JT1-1)
      JT1=JIVD(1,1,JT2)
37    ENA(0)LDQ(JT1)LLS7(JT3)ENA(0)LLS(9)STA6(JI2).
      JI3=0                                .THE LEGENDS ARE PRINTED OUT BY SUB
      JI4=150                              .ROUTINE SBPT WITH THE VARIABLE JI2=
      CALL SBPT                            .THE G STRING NUMBER,JI3=X AND JI4=Y
      RETURN                               .SBPT UNPACKS THE G STRING AND PLOTS
36    JT3=9*(JT1-6)                        .IT ON THE SCREEN.
      JT1=JIVD(2,1,JT2)
      GO TO 37
104   JT1=JPPP(1)                          .THIS INVESTIGATE DEPENDS ON 2 CHOICES
      IF(JT1) 20,20,40                     .OF THE STUDENT WITH THE LEGENDS BEING
```

```
40      IF (JT1-2) 41,41,25
41      JT2=JPPP(2)-10
        IF(JT2) 20,20,43
42      JI1=3
        CALL GLOBAL
        GO TO 20
43      IF(JT2-11) 44,44,42
44      JT3=9*(JT1-1)
        JT1=JIVD(1,2,JT2)
        GO TO 37
105     JT1=JPPP(1)-10
        IF(JT1)20,20,50
50      IF(JT1-8) 51,51,25
51      JT2=JPPP(2)
        IF(JT2) 20,20,53
52      JI1=4
        CALL GLOBAL
        GO TO 20
53      IF(JT2-3) 54,54,52
54      IF(JT1-5) 55,55,56
55      JT3=9*(JT1-1)
        JT1=JIVD(1,3,JT2)
        GO TO 37
56      JT3=9*(JT1-6)
        JT1=JIVD(2,3,JT2)
        GO TO 37
106     JT1=JPPP(1)
        IF(JT1) 20,20,60
60      IF(JT1-3) 61,61,25
61      JT2=JPPHM(2)-10
        IF(JT2) 20,20,63
62      JI1=5
        CALL GLOBAL
        GO TO 20
63      IF(JT2-5) 64,64,62
64      JT3=9*(JT1-1)
        JT1=JIVD(2,2,JT2)
        GO TO 37
        END
        X
```

```
.STORED IN JIVD(I,J,K) WHERE K DEPENDS
.ON THE STUDENTS SECOND CHOICE AND I
.AND J DEPEND ON THE FIRST CHOICE

.THIS INVESTIGATE DEPENDS ON THE SAME
.TYPE OF CIRCUMSTANCES AS IN 104. THE
.PROPER G STRING NUMBER IS CHOSEN FROM
.THE ARRAY JIVD(I,J,K) DEPENDENT ON
.THE VALUES AND CONDITIONS DESIGNATED
.BY STUDENTS CHOICES.

.THIS INVESTIGATE FOLLOWS THE SAME
.PATTERN AS THE PREVIOUS ONES,104 AND 105.
```

Appendix V

Useful Facts for Program GENERAL

Challenge Pages

Up to 6 pages in sequence

Effects

16 channels per main page

8 effects per channel

Global Pages

150 pages per lesson

12 questions per page

18 lines per page

Page 147 is first data page

Page 148 is first dictionary page

Page 149 is first investigate page

Lesson

150 pages maximum

126 questions maximum

Line

40 characters per line

18 lines per page

Main Page

16 special effects/main page

1 challenge sequence/main page

Question

Not more than 69 characters allowed in answer which has to be judged.

Slides

114 slides available for lesson material

Slide 0 is title page

Slide 116 is comment page

Slide 121 is main authoring page

Slide 120 is slide assignment page

Slide 119 is page description authoring page