

COMPUTER CONTROLLED PRINTING

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I. INTRODUCTION

This paper describes some of the characteristics and applications of programs that have been developed recently in the author's laboratory, for the production of coded paper tapes to control the Photon photocomposing machine. Conventional typesetting machines have been supplemented in the last two decades by a variety of photocomposing machines that produce the original copy for photolithographic reproduction by a photographic process. In this process, images of letters and characters are focused by an optical system at appropriate positions of a roll of sensitized paper. A photocomposing machine contains a matrix of transparent characters in an opaque background, with a mechanism for illuminating one selected character at a time. Several types of photocomposing machines have been designed and manufactured. The work that is reported here has used some Photon machines that are installed in Boston, and which are equipped with paper tape readers.

The present photocomposing programs enable Photon paper tapes to be punched off line from 709 output that is formed from input that was read from Hollerith cards or Flexowriter tape, or which was formed within the computer in binary-coded decimal form, by conversion from an internal number representation. This makes it possible to photocompose conventional computer results of a numerical nature, and to use the computer to organize verbal and other material in routine ways, for subsequent photocomposition. This organization may

be the mechanical imposition of format requirements that would require elaborate manual typesetting, on material that is punched on a simple keyboard device, such as a Flexowriter, with a separate description of output format, or interspersed parenthetical comments to specify format changes. The organization may entail selection, extraction and sorting of items of information, and more elaborate operations of verbal processing. The terms selection and extraction are used with specialized meanings—the selection of records which satisfy certain criteria (such as the occurrence of certain words) and the extraction of specified portions of successive records (for example the extraction of author names from abstracts of journal articles).

The features of the Photon machine that affect the programs are described in section II. The programs produce Photon code from the starting material by two or more successive string transformations. The so-called ω -strings that are punched on paper tape to drive the Photon machine contain codes that identify letters, and also codes that specify the spacing between letters, and codes that change the status of various units of the machine. This ω -code may be produced from any one of several sources—punched cards, Flexowriter tape, internal computer conversion and so forth. A large part of the construction of the ω -code is concerned with the calculation and accommodation of spacing requirements. It is convenient to produce ω -coded material from a representation of the material to be photocomposed that identifies characters by an enumeration which

takes account of case (i.e. capital or not) and which contains "operation" codes at points in the text where changes of format are to occur. Source material may represent characters in several different codes—the material on Hollerith cards is usually assumed to be in a single case, whilst Flexowriter tapes carry case shift indicators. It may be expedient to include format codes within the text when it is punched on an input medium. It may be prohibitively tedious, however, for a human agent to do this, but trivial for a computer using simple scanning rules. For these reasons, it is of some convenience to use a second code, called ρ -code, as an intermediate form in which material to be photocomposed is expressed within the computer. The programming problems of computer controlled photocomposition are thus divided into two quite separate parts that have been developed in parallel, with a simple and clearly defined interface. The evolution of the programs that effect the ρ -to- ω conversion has consisted largely of the provision for an ever increasing variety of format requirements. The programs that produce ρ -code from Flexowriter, punched card and other sources have been concerned with a variety of specialized problems—special input routines for binary card images of Flexowriter and other paper tapes, accommodation of different Flexowriter codes, translation of mnemonic format requirements, correction and modification of input texts, expansion of composite format requirements (macros), separation of case in Hollerith texts, and cyclic insertion of format changes in tabular and itemized material. These matters give rise to numerous scanning problems, some of which are quite difficult, particularly for the last two of the topics just mentioned. For this reason, the scanning systems developed in the author's laboratory⁽¹⁾ now are being combined with the photocomposing programs, to allow an even greater variety of scanning problems, associated with the preprocessing of input, to be handled easily.

An early photocomposing program separated the overall problem into the preparation and processing of ρ -strings, but dealt with the latter matter by a single, relatively long FAP coded subroutine. This formed the basis of the so-called PC1 and PC2 systems, reported previously, and which were used in some initial experimental studies.⁽²⁾ The programs to be re-

ported here are heavily subroutinized, in a way that allows many special details to be accommodated in specific applications. It has been our objective to develop a general purpose program which could deal with a considerable variety of photocomposing problems that were defined in a suitable input language. A language and the corresponding program have been developed that take care of features which are common to many typesetting situations. Application of this program to a variety of practical problems, however, has brought to light several special situations that were not anticipated when the input language was defined. The fact that such situations might occur was recognized when the programs were defined, and the subroutinized structure allows ready adaptation of the system to these special circumstances. It is our intention to seek generalizations and common characteristics of these novel situations and to define convenient ways of expressing individual cases for inclusion in later input languages and accommodation by later general programs. This classification and categorization of printing situations perhaps is the most intriguing part of the work. The variety of matters with which the input language and programs can deal has already evolved through several stages of increasing complexity. It seems that hazarding an approximation to a useful language, encoding it and trying it on real applications is the most effective way to proceed. In this regard the authors have been very fortunate in the willingness of other groups at MIT, particularly the Department of Libraries, the Publications Department, the Technology Press and the Registrar's Office to provide test material, critical comment and technical advice that has supplemented the photocomposing problems of our own laboratory, and compensated for our ignorance of printing technology.

After the description of the Photon machine and the ω -code in Section II, the idea of interspersed format control is developed in Section III and is illustrated by a few examples produced from Flexowriter and punched card input that use the simpler operation codes of the control language. The general structure of the present photocomposing program is described in Section IV. The processing of input material in accordance with an output format that is specified separately is introduced in Section V by reference to some simple examples of nu-

merical and verbal tables punched on cards in a fixed input format. Some more complicated constructions of the control language then are described in Section VI. Some examples of the processing of input by reference to an output format that is specified separately, and which require fairly complicated scanning of the input then are given in Section VII. Section VIII contains some examples of photocomposed results of actual computations. The photocomposition of built-up formulae, and problems of page composition are discussed in Section IX. Verbal processing, such as editing, index preparation and so forth, is considered briefly in Section X in relation to the photocomposing work and some examples are given of photocomposed output of verbal processing programs.

It should be mentioned that the methods described here are applicable in some degree to other forms of tape-controlled photocomposing, typesetting and electronic display equipment, and that other groups are working on similar problems.

II. THE PHOTON MACHINE AND THE ω -CODE

The "optical stencils" of the Photon machine are provided on a glass disc, etched in eight concentric annuli of 180 characters each. Several hundred such discs are in existence, and further discs, etched with new combinations of letters and symbols may be produced in a simple factory operation which involves photographing cards on which the relevant characters have been drawn. An extensive library of such cards exists. The replacement of one disc by another is a trivial manual operation, comparable with the replacement of a control panel on a punched-card machine. When the Photon machine is in operation, the disc rotates at high speed about a fixed axis. During each revolution of the disc, a light beam may be projected along a fixed path, through one of the annuli on the disc that is etched with characters. The illumination persists for a time interval that is very short compared with the period of rotation of the disc. An almost static image of any character on the disc thus can be produced for a very short time interval during each rotation. The timing of the burst of illumination, within the basic machine cycle, and the choice of annulus thus constitute two coordinates, or components of an

address, that determine which character is displayed during any rotation. The annulus is changed whenever necessary by a mechanical displacement of the axis of rotation. For many applications the switching between annuli is relatively infrequent.

The image of the character that is illuminated by the light beam is focused by a lens and prism system that determines the magnification of the character and also the position on the photosensitive material on which the image is focused.

The Photon machine with which we work can be driven by a paper tape that contains codes of several types. These include track specifications (a track is half an annulus of characters, and is identified by an integer in the range 1-16 that is called the disc level) and lens specifications (in effect scaling factors—the machines contain twelve different lenses that give type sizes in the range 5 point to 28 point) that appear on the tape only when they are to be initialized or changed. The tape also contains, for each of the characters to be printed, the sequence number (i.e. position around the disc) of that character, and the escapement (i.e. distance to be allowed between the left edge of that character and the next, measured in units of 2^{-8} cms). Further codes cause prism return (which has the same effect as a carriage return on a typewriter) and vertical spacing of the film. The disc level, lens size, sequence number, escapement, carriage return and vertical space codes constitute the ω -code, that is produced by the photocomposing programs and is written on magnetic tape, from which punched paper tape is produced off line, using an improvised magnetic to paper tape converter. The further details of the ω -code are given elsewhere.⁽³⁾

It may be mentioned that Photon machines hitherto have been operated by a keyboard which restricts the overall speed to that of keyboard operation. The work reported here allows the production of photocomposed material in a much faster and more economical manner.

III. THE INPUT CONTROL CODES—SOME SIMPLE EXAMPLES

The input to the photocomposing system consists of data—the text to be photocomposed—and what is in effect a program, written in a special language. This is the control language

of the photocomposing system. It contains a mixture of procedural and implicit instructions, and it has several characteristics that are reminiscent of the more familiar programming languages which are in general use. The simplest way of using the photocomposing system, however, involves a mixing of data and "program" in a fashion that is not so common in high-speed computing. The word "program" is used here for the input instructions written by the user of the system and expressed in the photocomposing control language, just as a Fortran program is taken to mean a program written in the Fortran language rather than the Fortran compiler itself. Analogies can be sought for this mixing in other fields—stage instructions in a play, style comments and key changes in a musical score, control codes that set selectors in punched-card accounting—but very few in high-speed computing. Automatic machine tool control may provide some examples, and it may be that this "interspersed" programming, by parenthetic comment, will find wider use as computer control of other machines increases.

A Flexowriter may be used to prepare the source material for a photocomposing operation in the following manner. The text is typed on a standard Flexowriter, with the inclusion of control codes wherever necessary, contained within square brackets []. This precludes the use of square brackets as characters of the input text, but square brackets can be obtained in the photocomposed output by a simple device that is described later. In the simplest instance, it is necessary to include one collection of control codes, between square brackets, at the beginning of the text, and a single control code [EN], at the end of the text. The control codes at the beginning of the text specify type style (i.e. disc level—there being up to 16 different styles of type on a single disc), type size (i.e. lens size), page width (i.e. "measure"), page length and any extra spacing that should occur between lines ("added lead"). Even these codes can be omitted, and a single initialize code [IN] given if a certain standard format is acceptable (unjustified 5 point Scotch with a 36 pica measure, zero added lead and 108 lines per page).

To obtain justified 8-point Scotch italic on a page 4 inches wide and 8 inches high, however, the codes [JU, LS8, DL9, LN288, PD576]

would be given before the first word in the text. All dimensions in control codes are specified in points. A point is $\frac{1}{72}$ of an inch. A detailed explanation of these and other control codes is given elsewhere.⁽⁴⁾

Further codes may be included between square brackets anywhere in the text, to control the appearance of the material which follows. Most of these control individual aspects of the text's appearance which can be changed independently—for example type style can be changed without changing the size, and vice-versa.

In addition, macro-control codes may be defined at arbitrary points in the text. Each macro refers to an explicit set of control codes. Later reference to this group of control codes may be made by referring to the macro-code. The form of these macro-codes is described in Section VI.

Flexowriter input is treated as a continuous stream in which line breaks are imposed by the program, by reference to type size, page width, and justification considerations. Paragraph breaks in the input normally are preserved in the output, and indentations (but not trailing spaces at the end of a line) are preserved. All input spaces can be retained if necessary.

Material can be justified or kept unjustified by the use of appropriate control codes, and unjustified lines can be flushed left, centered or flushed right by the use of further codes. Justification is effected by expansion or compression of interword spaces, by reference to criteria that are specified by appropriate control codes.

New lines, new paragraphs and new pages can be started at points in a text that follow certain codes. Horizontal spaces and margin settings can be specified by further codes, as can different forms of vertical spacing.

Part of the Flexowriter input for a very simple application, and the corresponding photocomposed output of the earliest photocomposing program are included in Appendix I. This used a rather unwieldy convention for delimiting control codes (not the square brackets). The Flexowriter input and corresponding Photon output for another example of "straight matter" composed recently is included in Appendix II. An example of verbal

punched-card input, using a dollar sign as a case shift indicator, and corresponding Photon output is included in Appendix III. A more elaborate example of photocomposed text with corresponding Flexowriter input is provided in Appendix IV.

IV. PROGRAM STRUCTURE

A few aspects of the present photocomposing programs are now described. The programs were coded in Fortran II, with a few simple FAP coded input subroutines to read Flexowriter tape images from cards or magnetic tape. As mentioned in the Introduction, the various forms of input are processed by suitable programs that vary from problem to problem and which all produce material that is expressed in a so called ρ code, which is then converted to the ω code by a set of subroutines that has been used with only exceptional changes, for the applications that are reported here.

The conversion of the input described in the preceding Section into ρ -code is almost trivial. Each letter and symbol of the input text is represented in the ρ string by a positive integer in the range 1 to 90; different integers being used for the upper and lower case of the same character (when it can occur in two cases). An input space is represented by a zero in the ρ string, and operation codes are represented by negative Fortran integers. The input subroutines for Flexowriter material deal with backspacing and error correction codes in the tape, both in the representation of the text and within interspersed control information.

The conversion of ρ to ω code is effected by a hierarchy of subroutines that separate the several types of action that must follow, when control codes are encountered in the text, or when certain conditions are recognized by the various subroutines. Certain control codes set parameters for immediate, recurrent or delayed use as the "setting" proceeds. Such parameters include point size, disc level, page dimensions and so forth. Other control codes, and conditions detected by the program, require more extensive action: for example adjustments of interword spacing at the end of a line, and of interline spacings at the end of a page.

The programs that convert ρ code to ω code have a structure that may be called concentric.

A start text subroutine STTEXT is called first to initialize page count and various parameters. A " ρ to ω text" subroutine RTOT is called next, and this subroutine retains overall control of the conversion until an [EN] (i.e., "end") code is detected (by a lower level subroutine), at which juncture an ascent is made through several subsidiaries of RTOT, and then out of RTOT, to its calling program. This then calls an end text subroutine NDTEXT to deal with certain bookkeeping details. If the ρ string is exhausted during the operation of RTOT or its subsidiaries, control is returned to the program which called RTOT, to obtain further ρ material, and then to re-enter RTOT and descend through its subsidiaries to the appropriate subroutine level. The " ρ to ω text" subroutine RTOT first calls a "start page" subroutine STPAGE. This then calls a " ρ to ω page" subroutine RTOP which retains control until an end of page condition arises, due to an end of page or end of text control code in the input, or accumulation of sufficient ω code to set a page. The end page subroutine NDPAGE is then called, and control returned to STPAGE to start another page, unless NDPAGE had been called as a consequence of an [EN] control code, when an appropriate return to, and exit from, RTOT results. The " ρ to ω page" subroutine RTOP calls a "start line" subroutine STLINE. This calls a " ρ to ω line" subroutine RTOL, and an "end line" subroutine NDLIN in turn. The action that follows execution of the NDLIN subroutine depends on whether it was called to end a line in the body of a page, or at the end of a page, or at the end of a text. The " ρ to ω line" subroutine RTOL has a similar structure, calling a "start section" subroutine STSECT, which in turn calls a " ρ to ω section" subroutine RTOS and an end section subroutine NDSECT. A section is a portion of a line that has independent margin settings, within which material may be justified, flushed left or right, or centered. The RTOS subroutine tests the successive integers that form the ρ string, and takes appropriate action depending on whether they are positive, zero, or negative. A positive integer, in the range 1 to 90, specifies a character to be set, and an escapement is computed from the "relative width" that is given to that character in the style of type that is being used, and the

point size, (and sometimes certain other type-setting parameters that need not be considered here). A zero in the ρ string indicates an input space, that is converted into an escapement by reference to the point size and the relative width that is given to an input space. A negative entry corresponds to a control code, and a further subroutine that deals with control codes is then called by RTOS. This is switched by the control code to a subroutine that deals with the particular code which has been encountered. This segregation of the effects of individual control codes facilitates continued expansion of the set of codes with a minimum of recompilation.

The nested structure of the program can be extended to include further layers, and this will be done to deal with problems of page composition.

It should be noted that the subroutines which end sections, lines and pages may modify material that has been formed in the ω string at an earlier juncture. Thus the end section subroutine can alter interword spaces if justification is to be performed. The end line subroutine establishes the vertical spacing that is recorded in the ω string before the codes for the first character of the line just set. At present, ω code is retained only for a line. Expansion of the program to deal with larger units of text in a coordinated manner (e.g. providing page justification, arranging "run arounds" to leave space for diagrams that will be visible when the relevant portion of the text is read) will require increased provision in the program for retrospective modification of the ω string that has been formed.

The status of the setting process at any instant is recorded by some 70 parameters. These are stored in a "status" array (actually in common storage). Whenever a parameter is changed, a record is kept in a "backtrack" array of the position in the status array of the parameter that has been changed, and of the superseded value. If overset occurs before an interword space is encountered, the contents of the backtrack array may be used to restore the status of the setting process to that which was current when the previous word-end was encountered. The backtrack array is cleared whenever the end of a word is reached without overset occurring.

V. EXTERNAL FORMAT SPECIFICATION

The examples of photocomposed material that were given earlier were produced from input that contained interspersed control codes. Some simple examples now are given of photocomposed material which was produced from input which did not contain interspersed codes, but which was processed by the computer to form a ρ string in which these codes were inserted in accordance with appropriate specifications.

Appendix V contains photocomposed material that was produced from a card deck by a program which specified a particular point size, type style, and page length, started a new line flushed left from a fixed margin, did not justify, and treated each blank column on the card as a space of a certain width.

Appendix VI contains photocomposed material that was produced from a bcd tape by a similar program, each printer record being set on a new line.

Appendix VII contains tabular material, set from punched cards, by a program which read certain format tables from control cards that preceded the data cards. The format tables contained a set of entries for each section of the output (i.e., portion that was set by reference to a given pair of margins). These entries consisted of a specification of the card field that contained the data to be set in the section, and the margin positions, vertical alignment (flushed left or right, centered or justified) and style and size of type for that section. The data from each card was set on a new line, and page length was specified on a control card that preceded the format table.

VI. FURTHER CONTROL CODES

A few further types of control codes that are used in input to the photocomposing program may be mentioned here. These are "macros," special character codes, and delayed effect codes.

It can be seen that in some types of application, certain combinations of control codes would occur repeatedly in the input, if interspersed coding were employed. For this reason, it is convenient to define macros, for an individual job, by suitable statements that precede a text in the input medium, and then to use the

names of the macros, between square brackets in the text, whenever necessary. At present 25 macros may be defined for concurrent use. A macro definition consists of the macro identifier $Mn(n=1,25)$, followed by an = symbol and then the list of up to 12 individual control codes separated by commas that are to be incorporated. Each definition is enclosed in parentheses and the whole group of definitions is enclosed in square brackets.

The character set of input texts has been limited in the preceding discussion to the ordinary alphabet, numerals and punctuation marks. These normally occur on standard positions of the Photon disc. Special characters may be etched, however, on any one of the 1440 usable positions of a disc, and many discs contain a considerable number of mathematical and other symbols. Although these symbols are not represented on a Flexowriter or Hollerith keyboard, it is possible to assign arbitrary names to these characters and to define them in a similar manner to the macros. A character definition consists of a name of up to 6 lower case letters followed by an = symbol followed by the list of controls which give the requisite lens size and disc level change, if any, disc sequence number at that level and the disc level and lens size to which the text must return. A set of up to 12 characters may be defined in this manner, each definition being enclosed in parentheses and the set of definitions enclosed in square brackets.

When any special character is required in the text, it is obtained by giving the previously assigned name of the character, enclosed in square brackets. The control code sequence for that name will then be inserted in the rho-string automatically by the program.

A further type of control code, with which the programs will be able to deal shortly, will request some action to be taken after an appropriate delay. An example is a code which requests an inter-line spacing that is to take effect after the line in which it is encountered has been set. It would be convenient to allow mnemonic arguments for control codes that specify margin positions and other quantitative items of information, and to allow statements that specify progressions or cycles of values which these mnemonics should be given on the successive occasions that they are used.

At present, control codes mostly take effect at points in the text which can be anticipated before the setting process is accomplished. Delayed action codes will make it possible to specify elaborate formats in which changes in style and so forth occur at points, such as line endings, which cannot be anticipated until the spacing considerations have been determined by the ρ to ω conversion. The use of mnemonic arguments that are changed on use is reminiscent of conventional indexing operations. The use of mnemonic arguments that are to be given values by the program which are consistent with the realization of some preset criteria, present further interesting possibilities of program design. The complexity of the control code combinations that are encountered in applications of the present program has already created a need for a higher level of input language to be converted into existing control codes by a suitable processor.

VII. INPUT SCANNING FOR FORMAT CHANGES

A few examples will now be given of material that was photocomposed from input which did not contain interspersed codes, and which required a nontrivial scan to determine where suitable control codes should be inserted by the program.

Appendix VIII contains part of a Union Listing of Chinese Scientific Periodicals that is being prepared by the MIT Libraries. The source material has been punched on a Flexowriter, with special symbols representing diacritical marks in an arbitrary correspondence. Certain types of input item are delimited by carriage returns, tabulations, slashes, periods and combinations of these and a few other simple criteria. The relevant control codes are inserted for new lines, indentations, columnar alignments, changes of type and diacritical marks, by a program that is specific to this application. Corresponding portions of Flexowriter input and Photon output are included in the Appendix VIII. The photocomposing subroutines have been modified slightly, so that when information for a title continues from one page to the next, a comment to this effect is set at the foot of the page and the relevant title repeated at the top of the next page. This required a modification of just three or four of

the subroutines and is one of the few changes that has been made to date to subroutines that are concerned with ρ to ω conversion for an individual application of the program. Decimal classification codes are dropped, and entry numbers introduced, by some further trivial changes in the program.

Appendix IX contains a page of a Bibliography of North American Geology, that was set from Flexowriter input with interspersed control codes as a test, at an early stage in the development of this work. The corresponding Flexowriter material is included for comparison. It can be seen that inserting the codes manually is tedious, and that some simpler input is essential for production work.

Appendix X contains a page of a Current Serials and Journals catalogue of the MIT Libraries, that was set from punched cards that contained no case shift indicators or bold face indicators. These indicators were inserted by a program which uses the Shadow subroutine¹ and some rules of capitalization that were formulated by R. W. Snyder of the MIT Department of Libraries. A definition table corresponding to these rules was used by the Shadow subroutine to construct a list of pointers to capital letters in the input text and to positions at which control codes were to be inserted to produce bold facing and tabulation in the production of the Photon tape. Similar methods, using Shadow, can be used to process many other examples of itemized material, such as catalogues or bibliographies, in which successive items are to be treated in a cycle which involves calling Shadow, and using the output which it produces.

VIII. COMPUTED OUTPUT

Two examples of results obtained by the computer, which were converted to Photon code without intermediate recording on conventional output media, are given in appendices XI and XII. Both were produced by the PC1 system, which includes a modified Fortran compiler which can deal with COMPOSE statements. These are output statements, comparable with PRINT and PUNCH, which contain the statement number of a FORMAT statement, and a list of variable names. The FORMAT statement may contain any conventional field specifications. It also may contain K fields each of

which consists of a count of the symbols in that K field, then a letter K, and then a sequence of photocomposing control codes.

The output in Appendix XI was produced from the short Fortran program which is also listed in the Appendix together with the input data which the program used for the test.

The output in Appendix XII was produced by a program that constructs a numerical representation of a table of algebraic formulae, that is discussed elsewhere.⁵

IX. BUILT UP FORMULAE

With the exception of the example of Appendix XII, relatively little has been done to date by the authors on the setting of built up mathematical and chemical formulae. The construction of a convenient and intelligible linear representation of such formulae, that could be punched on a keyboard machine such as a Flexowriter, with a limited character set, is not trivial. The problem of linearizing formulae is really a special case of the more general problem of linearizing two dimensional topologies. A scheme is being developed by the authors, that gives names to objects, and then compounds these names in expressions in which connective symbols and operators are used to indicate topological association, scaling and alignment. Names are given to composite objects that are represented by these expressions, and these names are then used to form further expressions. Page composition provides a descriptive problem that is less serious, as the subdivision of pages into rectangles of material that can be set as units usually is simpler than the corresponding subdivision of formulae. A simple notation can be used to describe a page by an expression which uses names for items of text, and a nested algebraic notation for the distribution of these, in adjacent rectangles of different sizes.

X. VERBAL PROCESSING

Verbal processing by digital computer is of potential importance in many fields. Although mechanical translation and automatic abstracting have attracted considerable attention, the usefulness of the results is still being assessed. There are numerous processes of a more routine nature, however, that are certainly within

the scope of existing computer techniques. Updating verbal texts by reference to editorial commands of a relatively simple type has been discussed elsewhere.⁶ More elaborate editing systems provide an interesting programming challenge. The production of indexes by the extraction of items from records of a reasonably standard format, and alphabetic sorting, is another problem of widespread interest. The definition of convenient languages for the specifications of such problems to general purpose programs that could be used for mechanized documentation requires further consideration.

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APPENDIX IA

Flexowriter Input

LL36D1L 18CEN

Computer Controlled Printing Devices

L 12RLJEI4

A set of programs has been developed with the cooperation of the Machine Composition Company, and Photon Incorporated, that enable a digital computer to produce, as output, a punched paper tape to control the operation of the Photon photocomposing machine.

This machine is used extensively in the printing of books and periodicals which contain verbal texts and mathematical, chemical and other symbolic material. The paper tape is punched with codes that determine the choice, size and spacing of the successive symbols that are to appear on the printed page. During any one continuous operation of the photocomposing machine, a total of 1440 different letters, digits and symbols can be selected in any sequence and in any two dimensional arrangement that is necessary. ELO

EL4 The computer can produce output to control the Photon machine in three ways. The first is by converting the numerical results of calculations, which the computer has effected, into Photon code. The second is by converting, to the Photon code, information that has been read into the computer, in some other code, on punched cards, paper tape, or other input media. The third is by reading into the computer information expressed in Photon code and punched on paper tape that has been produced by the computer in earlier operations of these three types. ELO

APPENDIX IB

Photocomposition

Computer Controlled Printing Devices

A set of programs has been developed with the cooperation of the Machine Composition Company, and Photon Incorporated, that enable a digital computer to produce, as output, a punched paper tape to control the operation of the Photon photocomposing machine. This machine is used extensively in the printing of books and periodicals which contain verbal texts and mathematical, chemical and other symbolic material. The paper tape is punched with codes that determine the choice, size and spacing of the successive symbols that are to appear on the printed page. During any one continuous operation of the photocomposing machine, a total of 1440 different letters, digits and symbols can be selected in any sequence and in any two dimensional arrangement that is necessary.

The computer can produce output to control the Photon machine in three ways. The first is by converting the numerical results of calculations, which the computer has effected, into Photon code. The second is by converting, to the Photon code, information that has been read into the computer, in some other code, on punched cards, paper tape, or other input media. The third is by reading into the computer information expressed in Photon code and punched on paper tape that has been produced by the computer in earlier operations of these three types.

The first of these methods enables the Photon to be used essentially as a powerful output device for a computer. Attention has been directed during the past quarter to the second of these methods using the computer to organize the information needed to control the Photon in the printing of verbal text, mathematical and chemical equations, and so forth from a less readable representation of such material prepared on a flexowriter. At present the flexowriter tape must be converted to punched cards in a trivial preliminary operation, and the computer output on punched cards converted to paper tape in another comparable operation. These stages will be bypassed later, using paper tape input-output attachments on the 709.

Completely verbal material can be typed on a flexowriter that produces a typescript similar to that of a conventional typewriter (fixed letter-width, single letter style, no justification) and a paper tape punched with a representation of this text. This can be converted by the computer to the tape that controls the Photon in an operation which prints the requisite text in any selected letter style and with justification if necessary. Comments may be interspersed in the text or appended to it that relate to changes of letter style or size, format control and so forth and these used by the computer to produce a tape which causes the Photon to print the text in the manner that the comments specify (the comments, of course, are not printed).

APPENDIX IIA

Flexowriter Input

[IN][DL2][LS10][LN500]I. Introduction[NP]This paper describes some of the characteristics and applications of programs that have been developed recently in the author's laboratory, for the production of coded paper tapes to control the Photon photocomposing machine. Conventional typesetting machines have been supplemented in the last two decades by a variety of photocomposing machines that produce the original copy for photolithographic reproduction by a photographic process. In this process, images of letters and characters are focused by an optical system at appropriate positions of a roll of sensitized paper. A photocomposing machine contains a matrix of transparent characters in an opaque background, with a mechanism for illuminating one selected character at a time. Several types of photocomposing machines have been designed and manufactured. The work that is reported here has used some Photon machines that are installed in Boston, and which are equipped with paper tape readers.[NP]The present photocomposing programs enable Photon paper tapes to be punched from 709 output that is formed from input that was read from Hollerith cards or Flexowriter tape, or which was formed within the computer in binary coded decimal form by conversion from an internal number representation. This makes it possible to photocompose conventional computer results of a numerical nature, and to use the computer to organize verbal and other material in routine ways, for subsequent photocomposition. This organization may be the mechanical imposition of format requirements that would require elaborate manual typesetting, on material that is punched on a simple keyboard device, such as Flexowriter, with a separate description of output format, or interspersed parenthetical comments to specify format changes. The organization may entail selection, extraction and sorting of items of information, and more elaborate operations of verbal processing. The terms selection and extraction are used with specialized meanings--the selection of records which satisfy certain criteria (such as the occurrence of certain words) and the extraction of specified portions of successive records, (for example the extraction of author names from abstracts of journal articles).[EN]

APPENDIX IIb

Photocomposition

I. Introduction

This paper describes some of the characteristics and applications of programs that have been developed recently in the author's laboratory, for the production of coded paper tapes to control the Photon photocomposing machine. Conventional typesetting machines have been supplemented in the last two decades by a variety of photocomposing machines that produce the original copy for photolithographic reproduction by a photographic process. In this process, images of letters and characters are focused by an optical system at appropriate positions of a roll of sensitized paper. A photocomposing machine contains a matrix of transparent characters in an opaque background, with a mechanism for illuminating one selected character at a time. Several types of photocomposing machines have been designed and manufactured. The work that is reported here has used some Photon machines that are installed in Boston, and which are equipped with paper tape readers.

The present photocomposing programs enable Photon paper tapes to be punched from 709 output that is formed from input that was read from Hollerith cards or Flexowriter tape, or which was formed within the computer in binary coded decimal form by conversion from an internal number representation. This makes it possible to photocompose conventional computer results of a numerical nature, and to use the computer to organize verbal and other material in routine ways, for subsequent photocomposition. This organization may be the mechanical imposition of format requirements that would require elaborate manual typesetting, on material that is punched on a simple keyboard device, such as Flexowriter, with a separate description of output format, or interspersed parenthetical comments to specify format changes. The organization may entail selection, extraction and sorting of items of information, and more elaborate operations of verbal processing. The terms selection and extraction are used with specialized meanings--the selection of records which satisfy certain criteria (such as the occurrence of certain words) and the extraction of specified portions of successive records, (for example the extraction of author names from abstracts of journal articles).

APPENDIX III

Hollerith Input

*IN,LS10,DL2,JU,**\$CHEMISTRY *NL,VL2*\$HE \$D\$DEPARTMENT OF \$C\$HEMISTRY OFFERS A SINGLE UNDERGRADUATE \$C\$OURSE, SUFFICIENTLY FLEXIBLE IN ITS ELECTIVES SO THAT IT PROVIDES EXCELLENT PREPARATION FOR CAREERS IN MANY DIFFERENT AREAS OF CHEMISTRY, AND GRADUATE PROGRAMS FOR THREE ADVANCED DEGREES . \$T\$HERE ARE EXCELLENT OPPORTUNITIES FOR STUDY AND RESEARCH IN PHYSICAL, ORGANIC, NUCLEAR, AND ANALYTICAL CHEMISTRY. \$I\$N ADDITION, THE \$D\$EPARTMENT IS RESPONSIBLE FOR UNDERGRADUATE AND GRADUATE INSTRUCTION IN CHEMISTRY FOR STUDENTS IN MANY OTHER \$I\$NSTITUTE \$C\$OURSES. *VL5,EN*

Photocomposition

CHEMISTRY

The Department of Chemistry offers a single undergraduate Course, sufficiently flexible in its electives so that it provides excellent preparation for careers in many different areas of chemistry, and graduate programs for three advanced degrees. There are excellent opportunities for study and research in physical, organic, nuclear, and analytical chemistry. In addition, the Department is responsible for undergraduate and graduate instruction in chemistry for students in many other Institute Courses.

APPENDIX IV

Flexowriter Input

```

[indn77d121s24st1,.36cnxs1]
EXCERPT FROM ALICE IN WONDERLAND
[n11s18]
December 6, 1961
[sp4st2,10,36st3,11,36st4,12,36st5,13,36st6,14,36st7,15,36
st8,16,36st9,17,36st10,18,36sl14d11xs2r1]
[scl9scl9]Fury said to
[xs3]a mouse, That
[nlxs6]he met
[xs7]in the
[xs8]house,
[xs9][scl9]Let us
[xs7]both go
[xs6sls12]to law:
[xs5d19]I[d11] will
[xs3]prosecute
[xs2d19]you.
[nlxs3d11] Come, I'll
[nlxs4]take no
[nlxs5]denial:
[nlxs7]We must
[nlxs6sls11]have a
[nlxs9]trial[sc47]
[nlxs10] For
[xs7]really
[xs6]this
[n1] morning
[nlxs6sls10] I've
[xs6]nothing
[xs5]to do.'
[xs4]Said the
[xs2]mouse to
[xs1] the cur,
[nlxs3][scl9]Such a
[nlxs4ls9]trial,
[xs3]dear sir,
[xs2] With no
[xs2]jury or
[xs1ls8]judge,
[nlxs2]would be
[xs2] wasting
[xs2] our breath.'
[xs3ls7][scl9]I'll be
[xs2] judge,
[xs2] I'll be
[xs2] jury, '
[xs1] Said
[xs1ls6] cunning
[xs1] old Fury:
[xs2][scl9]I'll try
[xs2]the whole
[nlxs3ls5] cause,
[nlxs4]and
[xs3] condemn
[xs3]you
[xs3]to
[xs3] death.'''
[en]

```

Photocomposition

```

"Fury said to
a mouse, That
he met
in the
house,
'Let us
both go
to law:
I will
prosecute
you.
Come, I'll
take no
denial:
We must
have a
trial;
For
really
this
morning
I've
nothing
to do.'
Said the
mouse to
the cur,
'Such a
trial,
dear sir,
With no
jury or
judge,
would be
wasting
our breath.
'I'll be
judge,
I'll be
jury.'
Said
cunning
old Fury:
'I'll try
the whole
cause,
and
condemn
you
to
death.'"

```

APPENDIX V

Photocomposition

u	v	w	m	n	a coefficient
0	0	0	0	0	1/1
0	0	1	1	0	1/1
0	0	2	0	0	1/3
			2	0	2/3
0	0	3	1	0	3/5
			3	0	2/5
0	0	4	0	0	1/5
			2	0	4/7
			4	0	8/35
0	1	0	1	1	-1/1
			4	0	8/35
0	1	1	2	1	-1/3
			3	0	-2/15
			3	2	-1/45
			5	0	1/21
			5	2	1/315
			5	4	1/7,560
			7	1	4/1,001
			7	3	2/45,045
0	4	2	0	0	1/35
			2	2	-1/63
			4	0	-3/55
			4	2	-1/231
			4	4	1/9,240
			6	0	2/77
			6	2	4/3,465
			6	4	1/41,580
0	4	3	1	0	1/35
			3	0	-4/165
			3	2	-1/165
			5	0	-5/273
			5	2	-1/1,365
			5	4	1/32,760
			7	0	2/143
			7	2	4/9,009
			7	4	1/180,180
0	4	4	0	0	1/105
			2	0	2/231
			2	2	-1/231
			4	0	-111/5,005
			4	2	-1/455
			4	4	1/40,040
			6	0	-4/1,155
			6	4	1/103,950
			8	0	16/2,145
			8	2	8/45,045
			8	4	1/675,675
1	0	0	1	1	-1/1
			3	1	-4/45
			5	1	-8/315

APPENDIX VI

BCD Input

- II
- 0 AT THE ANNUAL CASC (COUNCIL FOR THE ADVANCEMENT OF SMALL COLLEGES) CONFERENCE IN AUGUST, THE THEME WAS FACILITIES. A REPORT ON THE GASP PROJECT WAS MADE AT THAT TIME. THE IDEA THAT COMPUTER SIMULATION TECHNIQUES COULD BE USED IN STUDYING FACILITIES WAS INTRODUCED AND OUR SPACE UTILIZATION STUDY REPORT (ISSUED 16 JULY WITH THE SECOND GASP PROGRESS REPORT) WAS DISCUSSED.
- III
- 0 A LABORATORY COURSE IN OPERATIONS RESEARCH METHODS IS GIVEN AT M.I.T. IN WHICH PROBLEMS WITHIN THE INSTITUTE AMENABLE TO SOLUTION BY SUCH TECHNIQUES ARE CONSIDERED. THIS TERM A PART OF THAT CLASS IS STUDYING SOME ASPECTS OF THE SCHEDULING PROBLEM UNDER THE DIRECTION OF DR. H. P. GALLIHER. THERE HAS BEEN, AND WILL CONTINUE TO BE, MUCH CONTACT BETWEEN THIS GROUP AND THE GASP PROJECT.

Photocomposition

II

AT THE ANNUAL CASC (COUNCIL FOR THE ADVANCEMENT OF SMALL COLLEGES) CONFERENCE IN AUGUST, THE THEME WAS FACILITIES. A REPORT ON THE GASP PROJECT WAS MADE AT THAT TIME. THE IDEA THAT COMPUTER SIMULATION TECHNIQUES COULD BE USED IN STUDYING FACILITIES WAS INTRODUCED AND OUR SPACE UTILIZATION STUDY REPORT (ISSUED 16 JULY WITH THE SECOND GASP PROGRESS REPORT) WAS DISCUSSED.

III

A LABORATORY COURSE IN OPERATIONS RESEARCH METHODS IS GIVEN AT M.I.T. IN WHICH PROBLEMS WITHIN THE INSTITUTE AMENABLE TO SOLUTION BY SUCH TECHNIQUES ARE CONSIDERED. THIS TERM A PART OF THAT CLASS IS STUDYING SOME ASPECTS OF THE SCHEDULING PROBLEM UNDER THE DIRECTION OF DR. H. P. GALLIHER. THERE HAS BEEN, AND WILL CONTINUE TO BE, MUCH CONTACT BETWEEN THIS GROUP AND THE GASP PROJECT.

APPENDIX VII

Photocomposition

11	Astrojet	Dallas, Texas	DAL
12	Boeing	Danville, Ill.	DNV
13	Convair	Danville, Va.	DAN
14	Douglas	Dauphin, Manitoba	YDN
15	Electra	Dawson City, Y.T.	YDA
16	Fairchild	Dawson Creek, Br.Col.	YDQ
17	Golden Falcon	Dayton, Ohio	DAY
18	Helio	Daytona Beach, Fla.	DAB
19	Jetaway Vacations	Decatur, Ala.	DCU
20	Jet-Powered	Decatur, Ill.	DEC
21	Lockheed	Deering, Alaska	DRG
22	Mainliner	Del Monte, Calif.	MRY
23	Non-Stop	Delta, Colo.	MTJ
24	On-Time	Denison, Texas	SWI
25	Prop-Jet	Denver, Colo.	DEN
26	Qantas	De Ridder, Louisiana	DRI
27	Red Carpet	Des Moines, Iowa	DSM
28	Sunliner	Destin, Fla.	VPS
29	Tourist	Detroit, Mich.	DTW
30	Vickers	Devils Lake, N.D.	DVL

11	Astrojet	Dallas, Texas	DAL
12	Boeing	Danville, Ill.	DNV
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15	Electra	Dawson City, Y.T.	YDA
16	Fairchild	Dawson Creek, Br.Col.	YDQ
17	Golden Falcon	Dayton, Ohio	DAY
18	Helio	Daytona Beach, Fla.	DAB
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22	Mainliner	Del Monte, Calif.	MRY
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24	On-Time	Denison, Texas	SWI
25	Prop-Jet	Denver, Colo.	DEN
26	Qantas	De Ridder, Louisiana	DRI
27	Red Carpet	Des Moines, Iowa	DSM
28	Sunliner	Destin, Fla.	VPS
29	Tourist	Detroit, Mich.	DTW
30	Vickers	Devils Lake, N.D.	DVL

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12	Boeing	Danville, Ill.	DNV
13	Convair	Danville, Va.	DAN
14	Douglas	Dauphin, Manitoba	YDN
15	Electra	Dawson City, Y.T.	YDA
16	Fairchild	Dawson Creek, Br.Col.	YDQ
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19	Jetaway Vacations	Decatur, Ala.	DCU
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21	Lockheed	Deering, Alaska	DRG
22	Mainliner	Del Monte, Calif.	MRY
23	Non-Stop	Delta, Colo.	MTJ
24	On-Time	Denison, Texas	SWI
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26	Qantas	De Ridder, Louisiana	DRI
27	Red Carpet	Des Moines, Iowa	DSM
28	Sunliner	Destin, Fla.	VPS
29	Tourist	Detroit, Mich.	DTW
30	Vickers	Devils Lake, N.D.	DVL

APPENDIX VIII

Flexowriter Input

616.21

Chu-hua erh pi yen hou k'o tsa chih (Zhonghua erbiyanhouke zazhi)

[Chinese Journal of Otorhinolaryngology]

Peking, People's Medical Publishers, [Aug. 1953], varies, bimonthly

DNLM	v.2, 4, 1954	v.3-7, 1955-59	
	v.8, 1-3, 1960		
MCM		v.3-7, 1955-59	v.8, 1-3, 1960
MH-HY	v.2, 4, 1954	v.3-7, 1955-59	
GbBM	v.4, 4, 1956		

615.84

Chung-hua fang she hsuZeh tsa chih (Zhonghua fangshexue zazhi)

[Chinese Journal of Radiology]

Peking, People's Health Press, [Sept. 1953], varies, bimonthly

DNLM	v.2, 2, 4, 1954	v.3-7, 1955-59	
	v.8, 1, 2, 1960		
MCM		v.3, 1-3, 1955	v.4-7, 1956-59
	v.8, 1, 2, 1960		
MH-HY	v.2, 4, 1954	v.4, 1956	
	v.5, 1957		
GbDSIR	v.7, 4-6, 1959		
HkURI	v.4, 1956	v.5, 1-3, 1957	

618

Chung-hua fu ch'an k'o tsa chih (Zhonghua fuchanke zazhi)

[Chinese Journal of Obstetrics and Gynecology]

Peking, People's Medical Publishers, [Apr. 1953], varies, bimonthly

DNLM	v.2, 3, 4, 1954	v.3-5, 1955-57	
	v.6, 1-5, 1958	v.7, 1959	
	v.8, 1, 2, 1960		
MCM		v.3, 2-4, 1955	v.4, 1956
	v.5, 1957	v.6, 1-5, 1958	
	v.7, 1959	v.8, 1, 2, 1960	
MH-HY	v.2, 4, 1954	v.4, 1956	
	v.5, 1957	v.6, 1-5, 1958	
	v.7, 1959		
JpNDL	v.6, 1958		

APPENDIX VIII

Photocomposition

004

Chung-hua erh pi yen hou k'o tsa chih (Zhonghua erbiyanhouke zazhi)
 [Chinese Journal of Otorhinolaryngology]
 Peking, People's Medical Publishers, [Aug. 1953], varies, bimonthly

DNLM	v.2, 4, 1954	v.3-7, 1955-59
	v.8, 1-3, 1960	
MCM	v.3-7, 1955-59	v.8, 1-3, 1960
MH-HY	v.2, 4, 1954	v.3-7, 1955-59
GbBM	v.4, 4, 1956	

005

Chung-hua fang she hsueh tsa chih (Zhonghua fangshexue zazhi)
 [Chinese Journal of Radiology]
 Peking, People's Health Press, [Sept. 1953], varies, bimonthly

DNLM	v.2, 2,4, 1954	v.3-7, 1955-59
	v.8, 1,2, 1960	
MCM	v.3, 1-3, 1955	v.4-7, 1956-59
	v.8, 1,2, 1960	
MH-HY	v.2, 4, 1954	v.4, 1956
	v.5, 1957	
GbDSIR	v.7, 4-6, 1959	
HkURI	v.4, 1956	v.5, 1-3, 1957

006

Chung-hua fu ch'an k'o tsa chih (Zhonghua fuchanke zazhi)
 [Chinese Journal of Obstetrics and Gynecology]
 Peking, People's Medical Publishers, [Apr. 1953], varies, bimonthly

DNLM	v.2, 3,4, 1954	v.3-5, 1955-57
	v.6, 1-5, 1958	v.7, 1959
	v.8, 1,2, 1960	
MCM	v.3, 2-4, 1955	v.4, 1956
	v.5, 1957	v.6, 1-5, 1958
	v.7, 1959	v.8, 1,2, 1960
MH-HY	v.2, 4, 1954	v.4, 1956
	v.5, 1957	v.6, 1-5, 1958
	v.7, 1959	
JpNDL	v.6, 1958	

007

Chung-hua i hsueh tsa chih (Zhonghua yixue zazhi)
 [National Medical Journal of China]
 Peking, People's Health Press, [1914], monthly

CSt-H	v.39, 6-12, 1953	v.40-44, 1954-58
DLC	v.37, 6-8, 1951	v.38, 7-12, 1952
	v.39-44, 1953-58	
DNLM	v.35, 1-8,10-12, 1949	v.37, 8,11,12, 1951
	v.38,1-3,7,8,10,12, 1952	v.39, 2,4-6,8-12, 1953
	v.44, 1958	v.46, 1, 1960
MCM	v.35, 1949	v.36, 1950

APPENDIX IXa

Flexowriter Input

[1,4025]DAVID MOSS MITCCL 1962[4]GEOLOGICAL LISTING[19,4720,5]280[16]BIBLIOGRAPHY OF NORTH AMERICAN GEOLOGY, 1959[20,5]Summerson, Charles Henry.[29][30]1. Evidence of weathering at the Silurian-Devonian contact in central Ohio: Jour. Sed. Petrology, v. 29, no. 3, p. 425-429, illus, Sept. 1959.[17]2. Pre-glacial residual soil in central Ohio: Jour. Sed. Petrology, v. 29, no. 3, p. 430-435, illus., Sept. 1959.[18]Sun, Ming-Shan.[28][30]1. (and Weege, Randall J.). Native selenium from Grants, New Mexico: Am. Mineralogist, v. 44, nos. 11-12, p. 1309-1311, illus., Nov.-Dec. 1959.[17]2. Determination of selenium by X-ray spectroscopic method [23]abs.[24], [21]in[22] N. Mex. Geol. Soc., Guidebook, 10th Field Conf., Oct. 1959, p. 157, 1959.[18]Sun, Shiou Chuan. [21]See[2] Spokes, E. M. [31]Sund, J. Olaf.[28][30]Origin of the New Brunswick gypsum deposits: Canadian Min. Metall. Bull ., no. 571, p. 707-712, illus., Nov. 1959: Canadian Inst. Mining and Metallurgy Trans., v. 62, p. 395-400, illus., 1959.[18]Sundelius, Harold Wesley.[28][30]Occurrence and origin of the Peg Claims spodumene pegmatites, Knox County, Maine [23]abs.[24]: Dissert. Abs., v. 20, no. 2, p. 642, Aug. 1959.[18]Sundius, Nils. [21]See[22] Vogt, T.[31]Susuki, Takeo. [21]See[22] Crowell, J. C., 1; Valentine, J. W., 2.[31]Suter, Max.[28][30](and others). Preliminary report on ground-water resources of the Chicago region, Illinois: Ill. State Water Survey Cooperative Ground-Water Rept. 1, 89 p., illus. incl. geol. maps, 1959, summary, Rept. 1-S, 18 p., illus., 1959.[18]

APPENDIX IXB

Photocomposition

280

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Summerson, Charles Henry.

1. Evidence of weathering at the Silurian-Devonian contact in central Ohio: Jour. Sed. Petrology, v. 29, no. 3, p. 425-429, illus., Sept. 1959.
2. Pre-glacial residual soil in central Ohio: Jour. Sed. Petrology, v. 29, no. 3, p. 430-435, illus., Sept. 1959.

Sun, Ming-Shan.

1. (and Weege, Randall J.). Native selenium from Grants, New Mexico: Am. Mineralogist, v. 44, nos. 11-12, p. 1309-1311, illus., Nov.-Dec. 1959.
2. Determination of selenium by X-ray spectroscopic method [abs.], in N. Mex. Geol. Soc., Guidebook, 10th Field Conf., Oct. 1959, p. 157, 1959.

Sun, Shiou Chuan. See Spokes, E. M.**Sund, J. Olaf.**

- Origin of the New Brunswick gypsum deposits: Canadian Min. Metall. Bull., no. 571, p. 707-712, illus., Nov. 1959, Canadian Inst. Mining and Metallurgy Trans., v. 62, p. 395-400, illus., 1959.

Sundelius, Harold Wesley.

- Occurrence and origin of the Peg Claims spodumene pegmatites, Knox County, Maine [abs.]: Dissert. Abs., v. 20, no. 2, p. 642, Aug. 1959.

Sundius, Nils. See Vogt, T.**Susuki, Takeo.** See Crowell, J. C., 1, Valentine, J. W., 2.**Suter, Max.**

- (and others). Preliminary report on ground-water resources of the Chicago region, Illinois: Ill. State Water Survey Cooperative Ground-Water Rept. 1, 89 p., illus. incl. geol. maps, 1959, summary, Rept. 1-S, 18 p., illus., 1959.

Sutherland, Patrick Kennedy.

1. (and Amsden, Thomas William). A re-illustration of the trilobite *Lonchodomas mcgeheeii* Decker from the Bromide formation (Ordovician) of southern Oklahoma: Okla. Geology Notes, v. 19, no. 10, p. 212-219, illus. incl. geol. sketch map, Oct. 1959.
2. (and Land, Cooper B., Jr.). Mississippian limestone boulder conglomerates in the southernmost Sangre de Cristo mountains, New Mexico [abs.]: Geol. Soc. America Bull., v. 70, no. 12, pt. 2, p. 1683, Dec. 1959.

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- New England's new desert [Maine]: Desert Mag., v. 22, no. 2, p. 10-11, illus., Feb. 1959.

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- A stratigraphic analysis of the Winterburn and Wabamun groups in southern Alberta, in Am. Assoc. Petroleum Geologists Rocky Mtn. Sec., Geological record, Feb. 1959, p. 17-23, illus. [1959].

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1. Use of flute casts in stratigraphic correlation [N.Y.]: Am. Assoc. Petroleum Geologists Bull., v. 43, no. 1, p. 230-237, illus., Jan. 1959.
2. Structural geology of the Dryden and Harford quadrangles, New York. 15 p., illus., Albany, Univ. State N. Y., July 1959.

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1. (and Blumentals, A., and Millers, R.). Stratigraphic distribution of amino acids in peats from Cedar Creek Bog, Minnesota, and Dismal Swamp, Virginia: Limnology and Oceanography, v. 4, no. 2, p. 119-127, illus., Apr. 1959.
2. Amino acid distribution in lake deposits [abs.]: Minn. Univ. Center Continuation Study Inst. Lake Superior Geology, 5th Ann. Mtg., Apr. 13-14, 1959, p. 13(1) [1959]

APPENDIX Xa

Hollerith Input

A.E.G. PROGRESS		41611	7
(ALLGEMEINE ELEKTRICITATSGESELLSCHAFT, BERLIN)		0041621	7
NO.1, APRIL 1925-1934	ENG G VAIL	004163B	7
1956, NO.1+		41642	7
A.E.I. ENGINEERING		42011	7
(ASSOCIATED ELECTRICAL INDUSTRIES, LTD.)		0042021	7
V.1, 1961+	ENG G VAIL	004203B	7
A.I.B.S. BULLETIN		43211	2
(AMERICAN INSTITUTE OF BIOLOGICAL SCIENCES)		0043221	2
V.1, 1951+	SCIENCE BIOL P 570.51 A51	004323B	2
A.I.C.H.E. JOURNAL		44811	2
(AMERICAN INSTITUTE OF CHEMICAL ENGINEERS)		0044821	2
V.1, NO.1, MAR 1955+	SCIENCE 660.51 A11	004483B	2
A.I.P. DOCUMENTATION NEWSLETTER		45611	3
(AMERICAN INSTITUTE OF PHYSICS)		0 45621	3
V.1, NO.1, JULY 1959+	*HAYDEN P 530.51 A11	004563B	3
A.O.P.A. PILOT		51211	1
(AIRCRAFT OWNERS AND PILOTS ASSOCIATION)		0051221	1
V.2, NO.8, AUG 1959+	AERO	0 5123B	1
A.P.C.A. ABSTRACTS		52811	7
(AIR POLLUTION CONTROL ASSOCIATION)		0052821	7
V.2, NO.4, SEPT,	ENG G	0 5283B	7
NO.6, NOV 1956+		52842	7
A.S.E.A.		57611	
(ALLMANNA SVENSKA ELEKTRISKA AKTIEBOLAGET)		0057621	
SEE ASEA		57631	
A.S.H.R.A.E. JOURNAL		59211	7
(AMERICAN SOCIETY OF HEATING, REFRIGERATING		0059221	7
AND AIR-CONDITIONING ENGINEERS)		0 59231	7
EARLIER SEE REFRIGERATING ENGINEERING		0059241	7
V.1, NO.3, MAR 1959-NO.12,	HAYDEN P 628.8051 A11	005925B	3
DEC 1959		59262	3
V.1, NO.3, MAR 1959+	ENG G	0 5927K	7
A.T.E. JOURNAL		60811	7
(AUTOMATIC TELEPHONE AND ELECTRIC COMPANY)		0060821	7
V.8, 1951+	ENG G VAIL	006083B	7

APPENDIX Xb

Photocomposition

TITLE	HOLDINGS	LIBRARY	CALL NUMBER
A.E.G. Progress (Allgemeine Elektrizitätsgesellschaft, Berlin)	no.1, April 1925-1934 1956, no.1 +	ENG G	Vail
A.E.I. Engineering (Associated Electrical Industries, Ltd.)	v.1, 1961 +	ENG G	Vail
A.I.B.S. Bulletin (American Institute of Biological Sciences)	v.1, 1951 +	SCIENCE	Biol P 570.51 A51
A.I.Ch.E. Journal (American Institute of Chemical Engineers)	v.1, no.1, Mar 1955 +	SCIENCE	660.51 A11
A.I.P. Documentation Newsletter (American Institute of Physics)	v.1, no.1, July 1959 +	*HAYDEN	P 530.51 A11
A.O.P.A. Pilot (Aircraft Owners and Pilots Association)	v.2, no.8, Aug 1959 +	AERO	
A.P.C.A. Abstracts (Air Pollution Control Association)	v.2, n. 4, Sept. no.6, Nov 1956 +	ENG G	
A.S.E.A. (Allmänna Svenska Elektriska Aktiebolaget) See Asea			
A.S.H.R.A.E. Journal (American Society of Heating, Refrigerating and Air-Conditioning Engineers) Earlier See Refrigerating Engineering	v.1, no.3, Mar 1959-no.12, Dec 1959 v.1, no.3, Mar 1959 +	HAYDEN ENG G	P 628.8051 A11
A.T.E. Journal (Automatic Telephone and Electric Company)	v.8, 1951 +	ENG G	Vail
A.W.A. Technical Review (Amalgamated Wireless, Ltd.)	v.3, 1937 +	ENG G	Vail
Abhandlungen in Addition to the following Title See Abhandlungen Under Names of Societies and Institutions			
Abhandlungen aus der Sowjetischen Physik	v.1, 1951 +	SCIENCE	
Abo (Finland). Akademi. Acta. Mathematica et Physica	v.4, 1927, v.12, 1940 +	SCIENCE	510.6945 A15 Aa
Abstracts Journal of Metallurgy	1957, no.1 +	SCIENCE	Lindgren 016.669 A16
Abstracts of English Studies	v.1, 1958 +	GEN + HUM	016.8 A16

APPENDIX XIa

Source Program and Data

```

*      XEQ
*      LIST
C      MAIN PROGRAM
      DIMENSION FORM(24),FORMA(12)
      READ INPUT TAPE 4,9,(FORM(K),K=1,24),(FORMA(K),K=1,12)
      COMPOSE FORM
5     READ INPUT TAPE 4, 2, N1, N2
      IF (N1) 6, 7, 7
7     N3 = N1 + N2
      COMPOSE 3, N1, N2, N3
      GO TO 5
2     FORMAT (2I5)
3     FORMAT (2KRJ I3, 3H + I3, 5KXS3RL 3H = I4, 3KXS2)
6     COMPOSE FORMA
      CALL EXIT
9     FORMAT (12A6)
      END
*      DATA
(21KINDL2LS18ST1,,36XS1CN 50H$SIMPLE ARITHMETIC TO DEMONSTRATE PHOTOCOMP
OSITION 7KXS1AU15 15H$D$ECEMBER 1961 29KSP3DL1LS12ST2,,18ST3,18,36XS2)
(5KXS1CN 4H$END 4KNLEN)
      1      1
      1      2
      27     54
      57     82
      7      2
      0      0
      100    1000
      26     14
      -1

```

APPENDIX XIb

Photocomposition

**SIMPLE ARITHMETIC TO DEMONSTRATE
PHOTOCOMPOSITION****December 1961**

$$1 + 1 = 2$$

$$1 + 2 = 3$$

$$27 + 54 = 81$$

$$57 + 82 = 139$$

$$7 + 2 = 9$$

$$0 + 0 = 0$$

$$100 + 1000 = 1100$$

$$26 + 14 = 40$$

END

APPENDIX XII

Photocomposition

TABLE OF e COEFFICIENTS

$u+v$	w	j	i	$e_{u+v,w}^{k,j,i}$
1	2	1	3	$2(k+2)(k+3)/(2k+1)(2k+3)(2k+5)$
2	1	0	-3	$-2k(k-1)(k-2)/(2k-1)(2k+1)(2k-3)$
2	1	0	-1	$2k(k^2-3)/(2k+1)(2k-3)(2k+3)$
2	1	0	1	$2(k^2+2k-2)(k+1)/(2k+1)(2k-1)(2k+5)$
2	1	0	3	$-2(k+1)(k+2)(k+3)/(2k+1)(2k+3)(2k+5)$
2	1	2	-3	$2(k-2)/(2k-1)(2k+1)(2k-3)$
2	1	2	-1	$-2(k-3)/(2k+1)(2k-3)(2k+3)$
2	1	2	1	$-2(k+4)/(2k+1)(2k-1)(2k+5)$
2	1	2	3	$2(k+3)/(2k+1)(2k+3)(2k+5)$
3	0	1	-3	$2(k-1)(k-2)/(2k-1)(2k+1)(2k-3)$
3	0	1	-1	$-2(3k^2-k-6)/(2k+1)(2k-3)(2k+3)$
3	0	1	1	$2(3k^2+7k-2)/(2k+1)(2k-1)(2k+5)$
3	0	1	3	$-2(k+2)(k+3)/(2k+1)(2k+3)(2k+5)$
3	0	3	-3	$-2/(2k-1)(2k+1)(2k-3)$
3	0	3	-1	$6/(2k+1)(2k-3)(2k+3)$
3	0	3	1	$-6/(2k+1)(2k-1)(2k+5)$
3	0	3	3	$2/(2k+1)(2k+3)(2k+5)$
0	4	0	-4	$2k(k-1)(k-2)(k-3)/(2k+1)(2k-1)(2k-3)(2k-5)$
0	4	0	-2	$4k(2k^2-2k-7)(k-1)/(2k-1)(2k+1)(2k+3)(2k-5)$
0	4	0	0	$6(2k^4+4k^3-6k^2-8k+3)/(2k-1)(2k-3)(2k+3)(2k+5)$
0	4	0	2	$4(2k^2+6k-3)(k+1)(k+2)/(2k+1)(2k-1)(2k+3)(2k+7)$
0	4	0	4	$2(k+1)(k+2)(k+4)(k+3)/(2k+1)(2k+3)(2k+5)(2k+7)$
1	3	1	-4	$-2(k-1)(k-2)(k-3)/(2k+1)(2k-1)(2k-3)(2k-5)$