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Forest Research Branch

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MACHINES AND PRINCIPLES IN UNIT RECORD DATA PROCESSING FOR FORESTRY PURPOSES

by

T. G. HONER

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CONTENTS

95283—2

ABSTRACT

The use of high speed data processing equipment in industry and government service is an accepted application of efficient management procedures.

This publication describes some of the basic machines of a unit record installation, sets down some of the principles involved and illustrates the use of these machines in processing two forestry problems.

RÉSUMÉ

L'usage d'ordinateurs ultra-rapides est aujourd'hui accepté dans tous les milieux industriels et gouvernementaux bien dirigés.

Le présent ouvrage décrit certaines des machines qui composent un ordinateur, analyse certains des principes qui interviennent dans l'ordination, et cite deux exemples de données forestières compilées et analysées à l'ordinateur.

Machines and Principles in Unit Record Data Processing for Forestry Purposes[1]

by

T. G. HONER[2]

INTRODUCTION

The use of high speed data processing equipment in industry and government service is an accepted application of efficient management procedures. The accountants and administrators were the first to organize their systems to take advantage of the great potential that automated services offer, with billing, payrolls and inventory control being widely accepted applications.

The application of business machines to forestry problems is relatively new both in Canada and the United States with perhaps one of the earliest applications being described by Hodgins (1940) when the forest resources inventory of British Columbia was prepared using the "Hollerith Punch Card System". More recently the continuous forest inventory has received a great deal of attention primarily because it combines systematic field sampling and recording techniques with systematic processing methods. By maintaining continuing records of individual trees on data cards, growth problems can be studied and up-to-date inventory reports maintained.

Much has been written on processing principles and the application of machines to various engineering, scientific and administrative problems, but generally this information is not readily available to the practising forester. Therefore it is the purpose of this publication to describe some of the basic machines of a unit record installation, set down some of the principles involved and illustrate the use of these machines in processing two forestry problems.

UNIT RECORD AND COMPUTING EQUIPMENT

Unit record equipment should not be confused with the more sophisticated electronic computers. There are several basic differences that should be noted.

A unit record installation is characterized by a variety of individual machines, each performing a distinct and limited function at moderate speed and under the overall control of a machine operator. The computer installation may have supporting unit record machines, but the core of the installation is the computing unit operating at high speed under the control of a stored program.

In using each system, a program (a sequence of operating steps) is prepared. This program, often depicted as a flow chart, shows the sequence of operations and the flow path which the data must follow to be summarized into the correct report forms.

To carry out a program in a unit record installation, the machine operators exert control over the system by manually transferring the cards to the required machines, setting them up and initiating the next specific operation in the program. We might say that the program is externally controlled by the machine operator.

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[1] Department of Forestry, Canada, Forest Research Branch Contribution No. 637.

[2] Research Officer, Forest Research Branch, Department of Forestry, Ottawa.

95283—2½

The computer operates on the stored program concept which permits the program to be stored in the memory of the computer and executed as the data is read by the computer's read unit. To do this, all operating instructions are reduced to a form which the computer understands; they are punched into program data cards and read into the computer's memory. In the execution of these instructions the computer is under the control of the internally stored program and except for special cases this control is not returned to the operator until the program is finished.

THE UNIT RECORD

In a unit record installation the data card is used as the means of storing basic information. Each card is a unit record of information collected from the sales of goods, purchases of materials, or the measurements taken on an individual tree. The data card below contains *80 vertical columns*, ten horizontal rows, and two horizontal zones (eleven and twelve). Each *column* then allows one digit punch and one zone punch; digits being used for coded or measured information, and zone and digit punches for alphabetic characteristics. (For alphabetic punching, row zero (0) is considered as a zone punch).

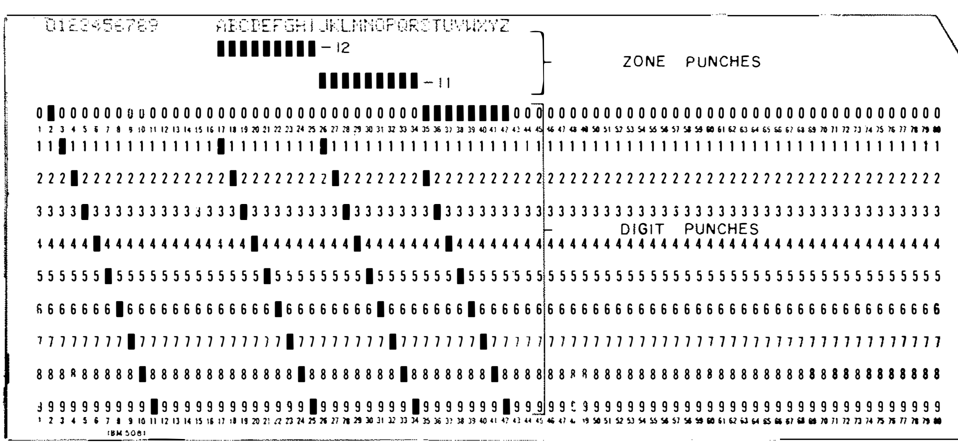

FIGURE 1. IBM punching codes.

Figure 1 shows the digit and zone punches used for alphabetic and numerical punches. Zone punches may also be used to identify special cards (generally called master cards), which may contain constants or information required for the calculation of subsequent products. The eleven and twelve zones may also be used to indicate the validity of a calculation; the twelve punch indicating a correct calculation, the eleven or x punch an error.

Data cards used for repetitive problems are usually face printed with the columns allocated for particular classifications being called "punching fields".

UNIT RECORD MACHINES*

A unit record data processing installation is characterized by a series of semi-automatic and automatic machines, each machine performing one or more simple functions. The semi-automatic machines require an operator to actively

* The machines described above are IBM machines currently in use in the Data Processing Unit, Department of Forestry.

participate in the processing at hand; the automatic machines which are controlled by a programmed panel will operate for short periods without attention.

The key punches, key verifiers and sorters are classified as semi-automatic machines.

FIGURE 2. Key punch and key verifier.

Semi-automatic Machines

Key Punch and Key Verifier

The basic data from a field tally form is transcribed to the data card at the punching station. The information is read from the tally form and punched into the data card as it moves through the key punch column by column, from right to left.

Figure 3 shows the card format used by the Department of Forestry to record individual tree measurements taken on permanent sample plots. There is one card per tree providing for four measurement periods. Before punching of the field measurements commences, the operator prepares a program card which is inserted into the program drum of the key punch to control the movement of data cards at the punching station. Figure 3 shows the program card which directs the machine to automatically duplicate common information from the previous card, stop the automatic movement to allow manual punching and skip columns which require no punching. The operator reads from the tally form and enters the data into a card by punching a key board which is similar to that of a typewriter. This operation activates the punching mechanism which punches the hole(s) corresponding to the appropriate key in the desired column.

In Figure 3, the zero punch in column one allows the information from the previous card (job and plot number) to duplicate automatically. Because there is no zone punch in column nine, the program stops the machine to allow the manual punching of tree number and species. The zero punch in column seventeen of the growth field permits this information to be duplicated from the previous card and manual punching continues from column twenty to column twenty-nine. The eleven zone punch of column thirty permits the machine to skip the height-curved field with the programming for the remainder of the card continuing in the same manner. Row two of the card, except for the fields which are skipped, is filled with punches. This permits the printing of the zeros on the tree cards should they be recorded in any of the columns.

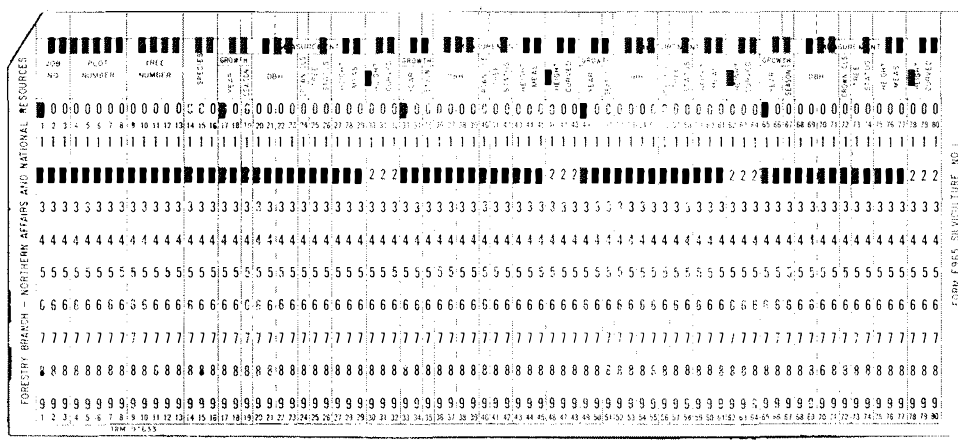

FIGURE 3. Individual tree measurement program card.

Following the key punch operation all cards are usually key verified. Verifying is simply a means of checking the accuracy of the original key punching. The key verifier looks basically the same as the key punch; however, the internal operation of the machine is different. As the operator punches the data onto the keyboard no punching mechanisms are activated, instead, a series of electrical circuits is completed from the machine through the punched hole(s) when the corresponding key is depressed. Should there be an error in punching, or in duplication, the circuit is not made and a red light flashes an error. When the card is verified as correct an "O.K." punch is scored on the right end of the card between the zero and one rows as in Figure 3. Key punches and key verifiers come in alphanumeric or in numeric mode only. The choice of model will depend on the particular processing application.

Sorter

Sorting arranges cards in the desired sequence and is done on a column-by-column basis. Sorters operate at set speeds; however, a great variety of models is available; the cost of rental or purchase rising in relation to the sorting speed of the model desired. When a column of figures is sorted into numerical order, the process involved is one of comparison; a given number is smaller than, equal to, or larger than each of the other numbers. One can scan the figures in Series A and readily arrange them in sequence to Series B.

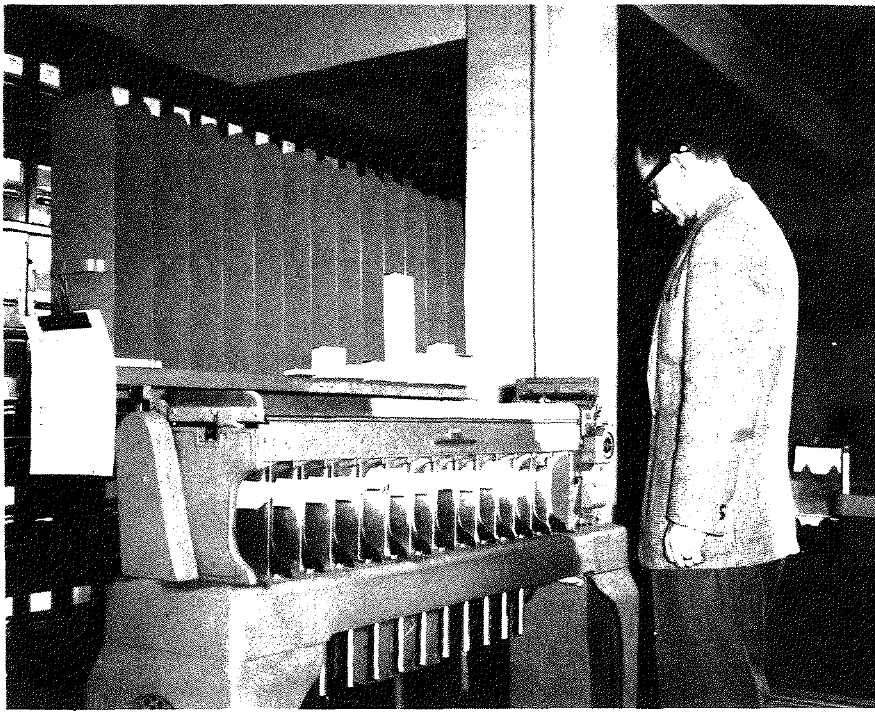

FIGURE 4. Sorter.

Series A	*Series B*
946	23
1001	365
365	749
23	946
749	1001

The machine operator in sorting the cards must proceed in logical sequence by sorting on the units, tens, hundreds, and thousands positions. This involves four sorts or passes through the sorter to achieve Series B as follows:

Sort 1 (*Units*)	*Sort 2* (*Tens*)	*Sort 3* (*Hundreds*)	*Sort 4* (*Thousands*)
1001	1001	1001	0023
0023	0023	0023	0365
0365	0946	0365	0749
0946	0749	0749	0946
0749	0365	0946	1001

Alphabetic sorting requires twice the normal sorting time because alphabetic letters (see Figure 1) are represented by two holes punched in each column. This requires two sorts on each column to arrange the letters in correct sequence; one sort to group the digits one to nine, and a second sort to group the twelve, eleven and zero zones. In sequence sorting operations, sorting begins with the units or first position and moves to the left on a column-by-column basis until all columns are sorted.

Automatic Machines

The collator, calculator, tabulator, and reproducer are classified as automatic machines. Their operation is directed by inserting an externally wired control panel into the panel receptacle of each machine. This control panel when installed completes a series of internal electrical circuits that control the machine to operate in the desired manner (Anon. 1956). Figure 5 illustrates this principle; data are read from the cards to the counters, totals accumulated and results printed by the type bars.

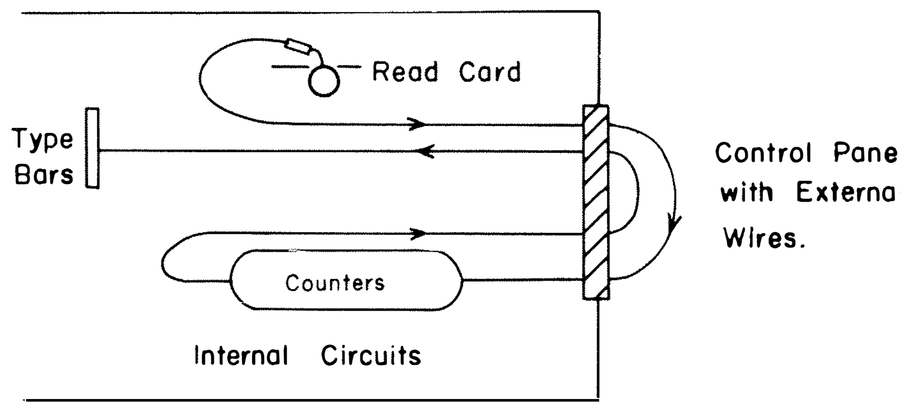

FIGURE 5. Directing machine operations using a programmed control panel.

Of the automatic machines, the collator and reproducer are controlled by small single-faced panels. The panels of the calculating punch and the tabulator are larger and divided into two parts: one part being wired to control the sequence of operations, the other part providing for the flow of data into memory, counters, printing or punching area.

Collator

Merging which is the primary function of the collator, combines two decks of cards into a single card deck and may be performed simultaneously with a sequence check and selection operation. The collator has two feeds: the primary feed for the card(s) which are to be fed first, and the secondary feed for the card(s) which will follow each primary card. As merging proceeds, the sequence check ensures that cards in both feeds are in proper order. Should an error be detected, the machine will stop. The selection feature ensures that each primary card has a matching secondary, and each secondary card a matching primary. Should neither of these conditions exist in the merging operation, the cards will be selected into the appropriate reject pockets. Merging is carried out at varying speeds depending on the problem at hand.

In compiling per acre volumes on a forest survey, cell detail cards showing the number of trees tallied for each plot cell (diameter class and species) are punched, verified, and sorted on diameter class and species. Unit volume master cards (local volume tables showing unit volumes by diameter class and species) are also punched, verified, and sorted in the same manner. The two decks of cards must now be merged so that the appropriate cell detail cards fall immediately behind the volume master card of the same diameter class and species. The volume master cards, identified by an x punch in column seventy-five, are placed in the primary feed and the detail cards (no x in column seventy-five) are placed in the secondary feed of the collator. The machine's control panel would be wired to perform the following operations:

1. Merge secondary cell detail cards behind the correct volume master card on the basis of diameter class and species.
2. Sequence check both decks of cards and stop if an out-of-sequence condition is detected.
3. Select out and stack separately all cell detail cards which do not have corresponding volume master cards.

Merging may also be accomplished on the sorter; however, it would not be possible to automatically perform the sequence check nor the selection operation.

When the merge operation is complete, the cards are ready for the calculator where the basic computations are performed.

Calculating Punch

The calculating punch performs four basic operations: addition, subtraction, multiplication and division. It reads information from the data card, stores the factors in memory, transfers from memory into the multiplier and the counters where the sums and products are developed, reads out to the punching area and punches the result into the same card or into designated cards that follow. Calculating punches also have the ability to prove each product developed. Proof calculations are generally performed on a separate run through the machine with a correct calculation being identified with a twelve zone punch, an error with an eleven zone punch.

Certain calculators operate at constant speeds while the models of the 602A series operate at varying speeds depending upon the complexity of the problem. The more complex the problem the slower the speed.

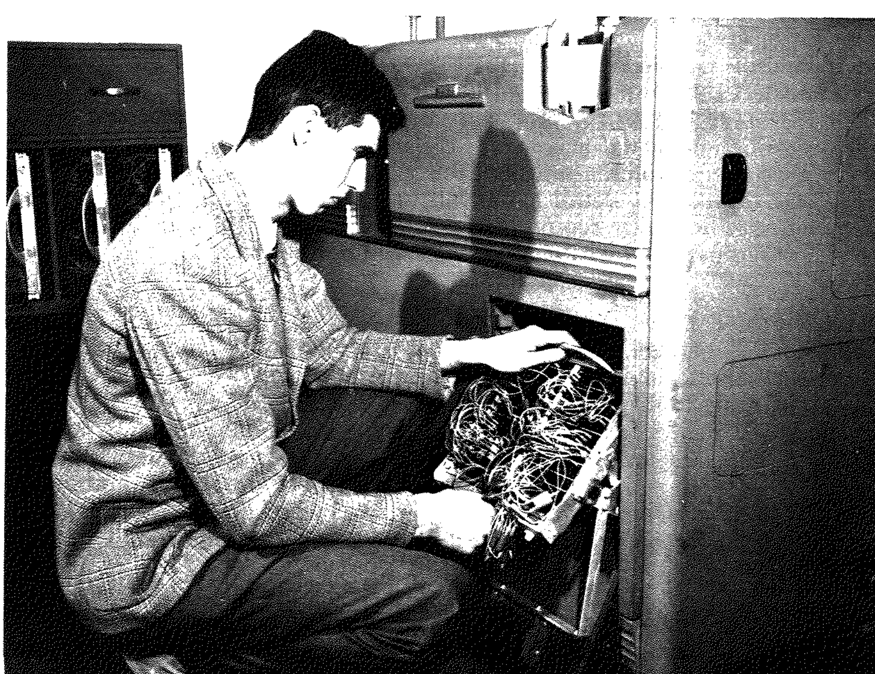

FIGURE 6. Calculating punch with control panel.

The 602A calculating punch is probably the most widely used of this series. The machine has a maximum storage (memory) of ninety-six digit positions, a maximum counter capacity of forty digit positions, and can perform up to thirty-five sequential operations. The machine is relatively slow but it has flexibility and can be used to perform most basic forestry calculations.

To compute the per acre cell volumes, the control panel is wired so that the calculator will:

(*a*) read the unit volumes from the x in column seventy-five volume master card, store them in memory, and skip out the volume master card,

(*b*) read from the cell detail cards the number of trees tallied and the plot size code, and store these values in memory.

Following the read operation the calculator is instructed to:

(1) calculate the number of trees per acre. (Number of trees tallied times plot size code),

(2) store this value in memory and punch onto the cell detail card the per acre number of trees,

(3) retrieve from memory and multiply the number of trees per acre times unit values,

  (*a*) Number of trees/acre × unit basal area

  (*b*) Number of trees/acre × unit volume total cubic feet

  (*c*) Number of trees/acre × unit volume merchantable cubic feet

  (*d*) Number of trees/acre × unit volume merchantable board feet

(4) punch per acre values on the cell detail card,

(5) skip out this cell detail card and read the next card.

The unit values read from the master volume card remain in the memory of the calculator until a new volume master card is read. When this condition occurs, the unit values stored in memory from the previous master card are erased and the values from the new master card are substituted.

The reasoning behind the previous collator operation is now apparent. Since the memory of the calculator is small, the unit values of the local volume table must be stored on a volume master deck which is then merged with the detail deck so that the correct detail cards fall behind the appropriate master cards. The calculator is now only required to retain in memory the unit values pertaining to the detail cards which follow each volume master card.

Tabulator

All reports, listings, or tabulations are produced by the tabulator. This machine is available in various models, each model having different speeds of operation, printing ability, counter and selector capacity.

Tabulators operate automatically in both feeding of cards and printing of results. The information punched in the card can be read, added, subtracted, compared or selected according to the requirements of the report, and summary cards can also be punched simultaneously with the preparation of reports.

Report printing on the tabulator may be described as detail and group printing.

Detail printing is the printing of information from each card as the card passes through the machine. The function is used to prepare reports that show complete detail about each transaction. During this listing operation the tabulator may be controlled to add, subtract, cross-add, cross-subtract and print many combinations of totals (Anon. 1957).

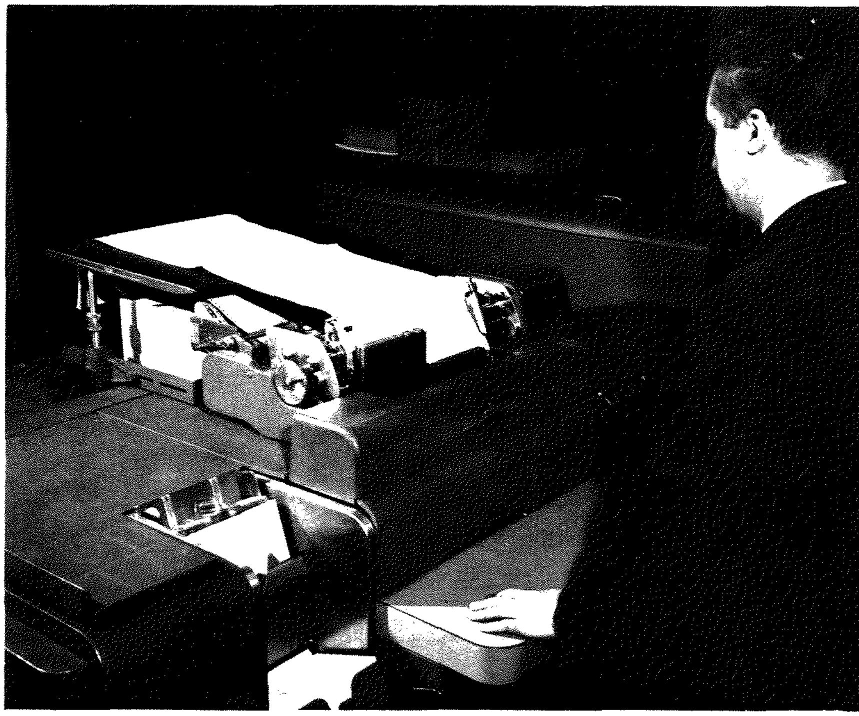

FIGURE 7. Tabulator.

Figure 8 illustrates a simple example of detail printing. This listing shows the raw map area (determined from a dot grid count), the adjusted area (as calculated by the 602A calculator) for each stand listed in numerical order. A count of the number of stands and the total raw and adjusted areas is given.

Group printing is a function that summarizes groups of cards and prints the totals on a report. Totals may involve adding, subtracting or cross-footing. Information read from punched cards is entered into counter units; at the end of each group of cards the totals are read out of the counters and printed on the report (Anon. 1957).

Each card group must have certain features that are common to all cards in that group. For example, if a plot summary is to be tabulated, all cards within the first group would have the same plot number, the cards in the second group would also have the same plot number but it would differ from that of the first group and so on. Figure 9 shows the plot listing, each plot being made up of individual cell cards (species-diameter class combinations) representing the tally on the plot.

To perform a group print operation, the tabulator must have the ability to detect any difference which separates one card group from the others. This is accomplished by means of the program control. Program control is comprised of a comparing unit (comparing entry and exit hubs) and a program start unit (minor, intermediate and major programs).

Activation of the comparing entry hub permits the tabulator to detect differences separating one group of cards from the others. If the corresponding comparing exit hubs are wired to a minor program start, the machine will print the totals (which have been accumulated in the counters) each time the difference between card groups is recognized. To print the plot listing, the data card columns

Job #	Stand Number	Cover	Cut Class	Sub Type	AREA IN ACRES Raw	AREA IN ACRES Adjusted
93	001	2	5	1100	2.0	2.0
93	002	2	3	0400	3.0	3.0
93	003	2	5	1100	2.6	2.5
93	004	2	3	1100	7.5	7.5
93	005	2	5	1100	17.2	17.0
93	006	8	3	6071	40.8	40.5
93	007	8	5	6000	2.5	2.5
93	008	2	5	0400	36.8	36.5
93	009	2	3	0400	26.2	26.0
93	010	2	5	1100	3.5	3.5
93	011	2	3	1100	26.7	26.5
93	012	2	4	1100	126.0	125.0
93	013	2	3	1100	4.0	4.0
93	014	2	3	0400	23.7	23.5
93	015	2	6	0400	4.0	4.0
93	016	2	4	0411	16.7	16.5
93	017	2	3	1100	11.6	11.5
93	018	2	4	1100	91.2	90.5
93	019	2	3	0400	11.1	11.0
93	020	2	3	0400	6.5	6.5
93	021	2	3	0400	7.1	7.0
93	022	2	3	1100	3.5	3.5
93	023	2	3	0400	49.9	49.5
93	024	5	4	0460	24.7	24.5
93	025	2	3	0400	19.1	19.0
93	026	2	5	1100	4.0	4.0
93	027	5	5	0460	203.1	201.5
93	028	2	3	1100	47.4	47.0
93	029	8	6	6071	60.0	59.5
93	030	8	6	6071	11.0	11.0
93	031	2	4	1100	3.1	3.0
93	032	2	3	0400	4.0	4.0
93	033	2	4	0411	150.2	149.0
93	034	2	4	1100	33.7	33.5
93	035	2	4	0411	14.6	14.5
93	036	8	4	6071	16.2	16.0
93	037	2	3	1100	65.0	64.5
93	038	2	3	1100	34.7	34.5
93	039	8	5	6000	26.2	26.0
93	040	2	3	0400	6.6	6.5
93	041	2	5	0400	49.9	49.5
93	042	8	5	6000	7.0	7.0
93	043	5	5	0460	8.1	8.0
93	044	2	4	0411	23.2	23.0
93	045	2	3	1100	16.1	16.0
93	046	2	4	0411	288.7	286.5
93	047	2	3	1100	4.6	4.5
93	048	2	4	1100	9.1	9.0
93	049	5	4	1171	47.8	47.5
93	050	2	5	1100	4.1	4.0
93	051	5	4	0460	5.0	5.0
93	052	2	4	1100	2.5	2.5
93	053	2	5	0400	9.6	9.5
	53				1723.4	1710.0 *

FIGURE 8. Detail printing.

Plot Number	Plot Type	Plot Size	Cover	Cut-Class	Sub Type	Site	Tree Status	Number	Basal Area	Vtcf	Vmcf	Vmbf	Job #	Year
								PER ACRE VALUES						
5001	0	10	2	4	1100	02	10	710 0	99 22	1730 7	1424		93	61
5002	0	10	2	4	1100	02	10	750 0	116 82	2209 9	1807	410	93	61
5003	0	10	2	4	1100	02	10	260 0	62 22	1262 1	1138	780	93	61
5004	0	10	0	1	0502	00	10						93	61
5005	0	10	0	1	0502	00	10						93	61
5006	0	10	0	1	0502	00	10	320 0	54 63	1069 4	929	820	93	61
5007	0	10	0	1	0502	00	10	820 0	108 40	1830 6	1486		93	61
5008	0	10	8	5	6071	02	10	220 0	47 78	1179 9	990	520	93	61
5009	0	10	8	5	6071	02	10	220 0	94 43	2633 7	2371	5220	93	61
5010	0	10	8	5	6071	02	10	400 0	84 48	2051 8	1728	1020	93	61
5011	0	10	2	5	1100	02	10	550 0	83 94	1486 2	1247		93	61
5012	0	10	2	5	1100	02	10	530 0	111 34	2097 7	1805		93	61
5013	0	10	2	5	1100	02	10	430 0	105 49	2136 3	1931	780	93	61
5014	0	10	8	5	6071	01	10	600 0	85 61	1914 7	1469		93	61
5015	0	10	8	5	6071	01	10	260 0	57 36	1547 7	1290	1960	93	61
5016	0	10	0	1	0502	00	10	220 0	55 57	1129 3	1027	1400	93	61
5017	0	10	5	5	0460	02	10	400 0	71 06	1686 7	1338		93	61
5018	0	10	5	5	0460	02	10	220 0	75 50	1683 9	1548	2330	93	61
5019	0	10	5	5	0460	02	10	170 0	38 79	922 0	776	410	93	61
5020	0	10	5	5	0460	02	10	360 0	75 93	1765 7	1468	500	93	61
5021	0	10	5	5	0460	02	10	410 0	83 66	1928 1	1587	410	93	61
5022	0	10	5	5	0460	02	10	390 0	94 03	2152 4	1862	1790	93	61
5023	0	10	5	5	0460	02	10	370 0	69 06	1646 1	1316		93	61
5024	0	10	5	5	0460	02	10	400 0	94 58	2291 9	1964	2430	93	61
5025	0	10	5	5	0460	02	10	300 0	86 37	1911 0	1725	3070	93	61
5026	0	10	2	5	1100	01	10	280 0	108 14	2366 5	2198	5340	93	61
5027	0	10	5	5	0460	02	10	550 0	114 35	2779 0	2283	2050	93	61
5028	0	10	5	5	0460	02	10	290 0	77 39	1663 3	1497	1450	93	61
5029	0	10	5	5	0460	02	10	550 0	107 37	2471 2	2006		93	61
5030	0	10	5	5	0460	02	10	630 0	113 32	2555 1	2030		93	61
5031	0	10	5	5	0460	02	10	410 0	108 78	2431 1	2153	800	93	61
5032	0	10	2	4	0400	02	10	590 0	94 50	1980 8	1513		93	61
5033	0	10	2	4	0400	02	10	510 0	127 29	2835 6	2477		93	61
5034	0	10	2	4	0400	02	10	520 0	134 34	3001 7	2632	410	93	61
5035	0	10	2	4	0400	02	10	240 0	64 58	1457 9	1289	410	93	61
5036	0	10	2	4	0400	02	10	330 0	121 97	2795 4	2579	2680	93	61
5037	0	10	5	4	0460	01	10	580 0	89 24	1953 3	1531		93	61
5038	0	10	2	4	0411	02	10	660 0	155 71	3361 2	2960	2870	93	61
5039	0	10	2	4	1100	02	10	720 0	117 21	2102 8	1780		93	61
5040	0	10	2	5	0400	02	10	300 0	134 03	3323 5	3084	7150	93	61
5041	0	10	2	5	0400	02	10	190 0	83 92	1938 3	1814	3090	93	61
5042	0	10	2	5	0400	02	10	290 0	129 46	3313 5	3057	7520	93	61
5043	0	10	5	5	0460	02	10	430 0	122 54	2904 9	2569		93	61
5044	0	10	2	4	0411	02	10	360 0	76 26	1493 4	1317	410	93	61
5045	0	10	2	4	0411	02	10	370 0	105 67	2262 5	2059	2520	93	61
5046	0	10	2	4	0411	02	10	380 0	80 84	1681 0	1453	930	93	61
5047	0	10	2	5	1100	01	10	290 0	82 46	1759 9	1620	1690	93	61
5048	0	10	2	4	1100	02	10	310 0	52 48	943 5	801		93	61
5049	0	10	2	4	1100	02	10	360 0	36 33	662 5	390		93	61
5050	0	10	2	4	1100	02	10	310 0	74 82	1500 8	1353		93	61
5051	0	10	2	4	1100	02	10	640 0	107 41	1942 7	1640		93	61
5052	0	10	2	4	0411	02	10	680 0	148 00	3109 3	2739	3150	93	61
5053	0	10	0	1	0501	00	10						93	61
53														

FIGURE 9. Plot listing

representing the plot number field were wired into the comparing entry hubs permitting the machine to detect differences in plot number. The corresponding comparing exit hubs were then wired to a minor program. This sequence permits the machine to compare plot numbers and to print out the plot per acre values as a minor total each time the plot number changes.

The standard IBM 402 tabulator has three program levels: minor, intermediate and major. By wiring the control panel, the tabulator can be controlled to print out totals corresponding to each level. Figure 10 shows a plot tabulation which was printed during the processing of a forest inventory survey. The totals representing the program levels are indicated as follows:

1. A minor program is detected by a change in diameter group. In this example three diameter groups are possible:
   (*a*) Code 2 representing diameter classes one to three inches (1″—3″),
   (*b*) Code 4 representing diameter classes four to nine inches (4″—9″),
   (*c*) Code 6 representing diameter classes ten inches and up (10″ +).
2. An intermediate program is detected by a change in species.
3. A major program is detected by a change in plot number.

Before such a report is tabulated the data cards would have been sorted in the following order:

(*a*) diameter group—minor program
(*b*) species —intermediate program
(*c*) plot number —major program

An examination of Figure 10 reveals that the minor totals are the sums of individual cards within each diameter group, species and plot; the intermediate totals are the sums of diameter groups within each species and plot; the major totals are the sums of species within each plot.

A basic knowledge of tabulator functions is extremely helpful in specifying how reports should be printed. The specification for the reports discussed above would read as follows:

Figure 8 Area Listing—list stands in numerical order, show all identifying features and the raw and adjusted areas of each stand. Show the total raw and adjusted areas of all stands.

Figure 9 Plot Listing—list plots in numerical order, show all identifying features and plot per acre values for number of trees, basal area, volume total cubic feet, merchantable cubic feet and merchantable board feet.

Figure 10 Plot, Species, DBH Group Tabulation—list plots in numerical order, show all identifying features and per acre values for number of trees, basal area, volume total cubic feet, merchantable cubic feet, merchantable board feet and totals by dbh groups (1″—3″, 4″—9″, 10″ +), species, and plot number.
(*a*) dbh group —minor totals
(*b*) species —intermediate totals
(*c*) plot number—major totals

One feature that has many applications is the card count. When this hub is wired to a counter, a count of cards is recorded and may be printed out for each program level. In general, this feature will only be used when each data card represents one item. A major application of the card count is to determine the number of items within a given class which contribute to the class total. Once the totals and card counts are obtained, it is then possible to compute the class means through division on the calculating punch.

Plot Number	Plot Size	Cover	Cut-Class	Sub Type	Site		Species	Status	DBH Group		Number	Basal Area	Vtcf	Vmcf	Vmbf	Job	Year
5001	10	2	4	1100	02		110	10	4		680 0	90 28	1527 3	1242		93	61
											680 0	90 28	1527 3	1242			
5001	10	2	4	1100	02		310	10	4		20 0	6 98	150 6	140		93	61
											20 0	6 98	150 6	140			
5001	10	2	4	1100	02		610	10	4		10 0	1 96	52 8	42		93	61
											10 0	1 96	52 8	42			
										*	710 0	99 22	1730 7	1424			
5002	10	2	4	1100	02	Minor program	040	10	4		190 0	33 49	711 6	562		93	61
5002	10	2	4	1100	02	Intermediate program	040	10	6		10 0	5 45	127 5	121	410	93	61
											200 0	38 94	839 1	683	410		
5002	10	2	4	1100	02		110	10	4		520 0	72 49	1240 9	1018		93	61
											520 0	72 49	1240 9	1018			
5002	10	2	4	1100	02		130	10	4		10 0	1 36	20 5	18		93	61
											10 0	1 36	20 5	18			
5002	10	2	4	1100	02		610	10	4		20 0	4 03	109 4	88		93	61
											20 0	4 03	109 4	88			
						Major program				*	750 0	116 82	2209 9	1807	410		
5003	10	2	4	1100	02		110	10	4		240 0	51 32	1000 9	888		93	61
5003	10	2	4	1100	02		110	10	6		20 0	10 90	261 2	250	780	93	61
											260 0	62 22	1262 1	1138	780		
										*	260 0	62 22	1262 1	1138	780		
5004	10	0	1	0502	00			10	0							93	61
										*							
5005	10	0	1	0502	00			10	0							93	61
										*							
5006	10	0	1	0502	00		40	10	4		50 0	19 42	444 8	413		93	61
5006	10	0	1	0502	00		40	10	6		20 0	10 90	255 0	242	820	93	61
											70 0	30 32	699 8	655	820		
5006	10	0	1	0502	00		110	10	4		250 0	24 31	369 6	274		93	61
											250 0	24 31	369 6	274			
										*	320 0	54 63	1069 4	929	820		
5007	10	0	1	0502	00		110	10	4		820 0	108 40	1830 6	1486		93	61
											820 0	108 40	1830 6	1486			
										*	820 0	108 40	1830 6	1486			
7										*							

FIGURE 10. Plot, species, d.b.h. group tabulation.

Species	ΣHt.		ΣDBHib		ΣVtcf		ΣNo.	$\overline{\text{Ht.}}$		$\overline{\text{DBHib}}$		$\overline{\text{Vtcf}}$	
14	193	0	24	8	24	810	4	48	25	6	20	6	202
14	91	0	14	2	12	846	2	45	50	7	10	6	423
14	333	0	34	4	34	794	6	55	50	5	73	5	799
14	223	0	26	0	25	986	4	55	75	6	50	6	496
14	111	0	14	2	17	000	2	55	50	7	10	8	500
14	219	0	32	2	42	021	4	54	75	8	05	10	505
14	121	0	13	8	15	806	2	60	50	6	90	7	903
14	404	0	45	8	62	686	6	67	33	7	63	10	448
14	473	5	58	3	88	893	7	67	64	8	33	12	699
14	129	0	19	8	36	286	2	64	50	9	90	18	143
14	141	0	15	2	22	468	2	70	50	7	60	11	234
14	749	0	87	4	149	102	10	74	90	8	74	14	910
14	587	0	74	6	146	340	8	73	38	9	32	18	292
14	628	0	84	8	184	534	8	78	50	10	60	23	067
14	745	0	114	8	246	186	10	74	50	11	48	24	619
14	150	0	24	2	54	656	2	75	00	12	10	27	328
14	325	0	38	6	83	020	4	81	25	9	65	20	755
14	676	0	84	4	204	308	8	84	50	10	55	25	538
14	338	0	46	0	115	978	4	84	50	11	50	28	994
14	174	0	25	0	74	102	2	87	00	12	50	37	051
14	356	0	53	4	160	418	4	89	00	13	35	40	104
14	168	0	30	6	97	558	2	84	00	15	30	48	779
14	171	0	34	4	133	174	2	85	50	17	20	66	587
14	182	0	19	6	47	564	2	91	00	9	80	23	782
14	186	0	21	2	59	192	2	93	00	10	60	29	596
14	561	0	74	6	245	859	6	93	50	12	43	40	976
14	954	0	134	6	443	150	10	95	40	13	46	44	315

FIGURE 11. Mean heights, diameters and volumes.

The data card showing the card count and totals would be produced through a summary punch operation. The tabulator would be connected by cable to the reproducing summary punch, and as the tabulator printed a total for each class, the reproducer would punch one card containing the information printed on the corresponding line of the report form. Following a calculator division operation, the cards are listed by the tabulator. Figure 11 illustrates the type of listing the tabulator would produce to show mean heights, diameters and volumes for ten-foot and one-inch classes of height and diameter.

Reproducing Summary Punch

Reproducing punches perform several functions: reproducing card decks column-for-column or to other selected columns, gang punching common information into a single deck of cards, and when connected to the tabulator the production of summary cards. For example, individual tree cards may be summarized down to a plot card showing total number of trees and total plot volume.

The reproducer has two feeds: a reading feed and a punching feed. Information is read from the card deck in the read feed and punched into the deck in the punch feed. The read feed is to the left, the punch feed to the right.

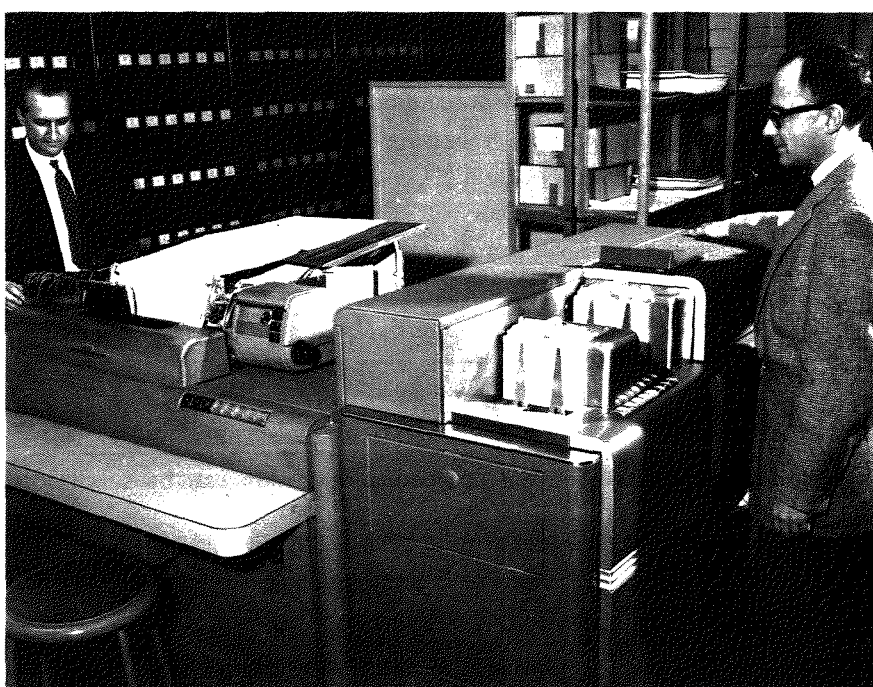

FIGURE 12. Tabulator and reproducer.

The information read from the read feed is compared with the information being punched. If no differences are observed, the machine keeps reading and punching. If a difference is observed the machine will stop, the compare lights flash on, and the column(s) in error show on the comparing indicator. In this way the machine checks its operation. Reproducers generally run at a fixed speed of 100 cards per minute.

A reproducing operation usually transcribes data from a record deck so that additional computations may be undertaken. As shown in Figure 13, the recorded measurements taken in 1960 have been reproduced onto a work card for the computation of per acre basal area and volume.

These then are the basic machines* which comprise a unit record installation, each machine performing one or more individual functions in the overall processing operation. Individually their scope is limited but when each machine's particular forte is integrated into the processing scheme, the unit record installation becomes a very versatile processing tool.

PRELIMINARY ANALYSIS OF THE PROBLEM

Machine processing requires planning, and in approaching this problem, most potential users seem primarily concerned with the minimum quantity of data necessary to justify machine processing rather than being concerned with the amount and type of processing required to produce the desired results. Generally the following points should receive thorough scrutiny in relation to the specific problem:

(*a*) frequency of occurrence

(*b*) type and amount of computation involved

(*c*) number and variety of reports required

(*d*) nature and volume of the source data

(*e*) time required for manual processing

(*f*) availability of clerical personnel

(*g*) clerical versus machine costs

The points mentioned above will not be expanded as they are only presented to aid the prospective user to orientate his thoughts on the subject.

Should this preliminary analysis result in the decision to initiate machine processing, it is advisable to count on extensive planning, for this is the essential ingredient of the processing operation.

PLANNING

The planning required for the processing operation can be subdivided as follows:

(*a*) the organization and preparation prior to processing,

(*b*) the development of efficient processing techniques to produce the desired results.

Preparing the data for processing may take considerable time and thought. However, comprehensive planning at this stage will produce many dividends in subsequent operations. Initially the project manager may be concerned with codes.

Codes

Data processing codes are numerical values used to identify logical classifications of qualitative and quantitative measures. Events or measurements which affect a given project must be classified so that their full significance may be assessed.

* Manufacturers are constantly bringing out new equipment that often combines the features of some of the machines described here. So that each of the basic processes (punching, verification, sorting, collating, reproducing, calculation, tabulation) may be readily understood, they have been described in terms of single machine units.

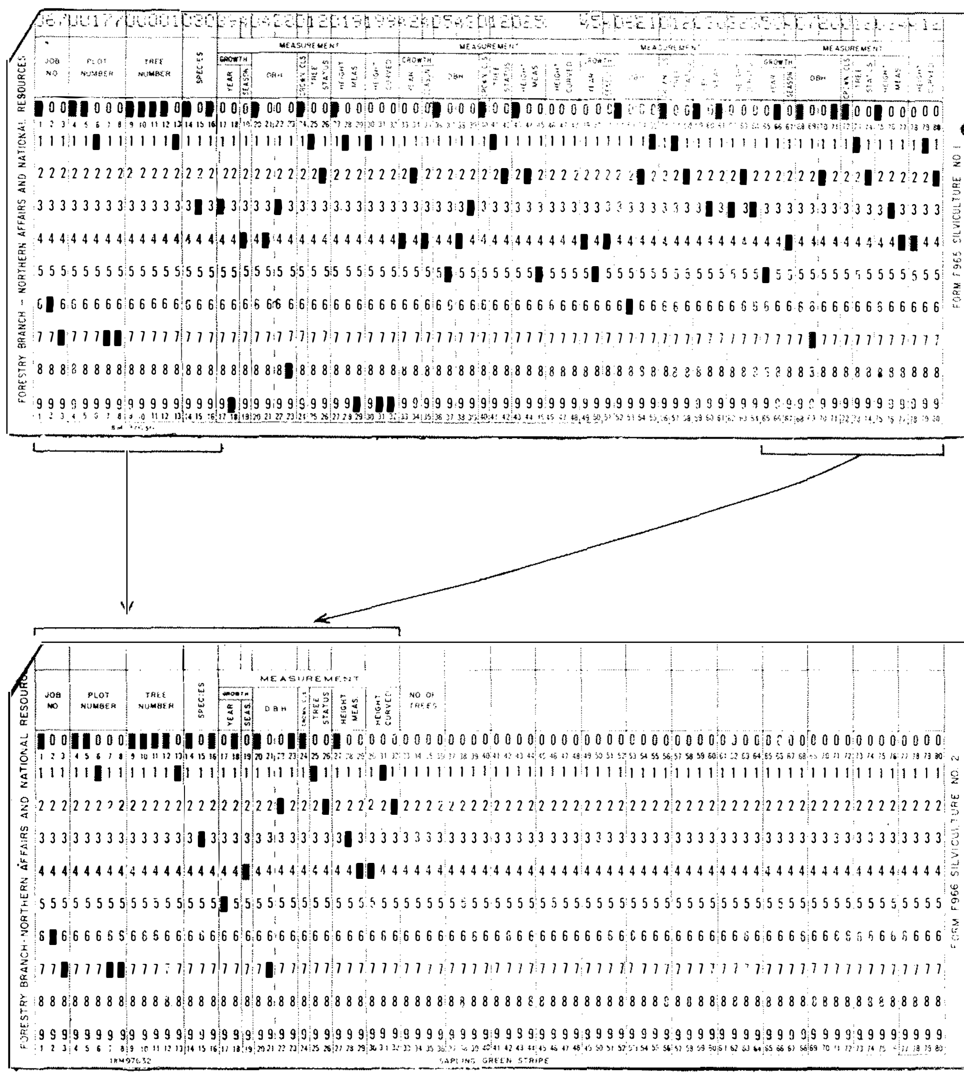

FIGURE 13. Data reproduced from record card to work card.

Because proper coding is vital to the success of any processing operation, it is essential to develop the right code for the right situation. This inevitably will involve a thorough appraisal of the job to be done and consideration of all the possible methods of accomplishment.

Initially the code must be operational; it must allow for all machine segregations necessary to provide the required reports. It must also be flexible to provide for additional entries and additional categories if necessary. The code should be easy to assign, and if possible facilitate visual identification.

A brief description of several common code types and examples follows (Anon. (c) and Honer 1960):

1. Sequence Codes. The sequence code is perhaps the coding method most commonly thought of when one is confronted with a coding problem. The method is simple and involves assigning numbers starting with one,

to a list of items arranged in any order. This method has one major disadvantage; it does not provide for any subsequent groupings of the initial classes and should not be used where such requirements exist.

2. Block Codes. This system utilizes groups or blocks of numbers in sequence to represent various classifications. These blocks may be arranged according to any desired number of units.

Species

0. Pine 1. Spruce 2. Fir 3. Larch 4. Cedar 5. Hemlock	Softwoods
6. Poplar 7. Birch 8. Maple 9. Other Hardwoods	Hardwoods

Block coding provides a method of coding by classes where the number of digits must be limited.

3. Group Classification Codes. Group classification codes have major and minor classifications represented by the succeeding digits of the number. In general this is the most efficient system for ordinary coding problems.

100. Spruce	—Generic name
110. Black spruce	—Species name
120. Red spruce	—Species name
130. White spruce	—Species name
131. Porsild spruce	—Species variety
132. Western white spruce	—Species variety
200. Fir	
210. Balsam fir	
211. Bracted balsam fir	

In the above code the primary classification identifies the generic name, the secondary identifies the species and the tertiary identifies varieties within species. When constructing a group code, it is well to start each subdivision with a numeral rather than "0", leaving the latter open to indicate the groups.

4. Significant Digit Codes. This term has been applied to codes wherein all or some of the digits represent weight, dimension, distance, time interval, or any other factor which has been transferred bodily into the code. In one sense this is not actual coding as these factors determine the numbers without coding.
The object of significant codes is to eliminate or reduce the work of decoding by providing a code number that is directly readable.

Code Number	*Plot Number*
16044	Line 16 Sample 44
22085	Line 22 Sample 85

The primary and secondary numbers represent line number, while the remaining numbers represent the sample.

Source Documents

Information gathered in the field must be recorded on some type of form or source document. A revision of documents in use may be necessary to prepare such forms for the key punch operation, for the tally sheet should provide adequate space to record various classifications (cover type, site type, age class) and field measurements, for maximum ease of transcription to the data card. Ideally, each item will be in read-punch sequence, and each line on the form will represent one data card. Most foresters are familiar with the basic inventory forms, however some thought should also be given to the possibility of using the data card as the source document. To do this the field tally is either "mark sensed" onto the card or a specially perforated card is used with an IBM "Port-A-Punch" (Anon. (d)) and the field records punched directly into the card. This system will generally be used where each item tallied represents one card.

The "mark sense" card (Figure 14) contains a maximum of twenty-seven marking positions, each position encompassing approximately three regular card columns. The item classified is marked onto the card with a pen or pencil which has a high graphite content. The correct method of marking must be used since the function of mark-sensing is dependent upon the fact that a pen or pencil mark can be electrically conductive.

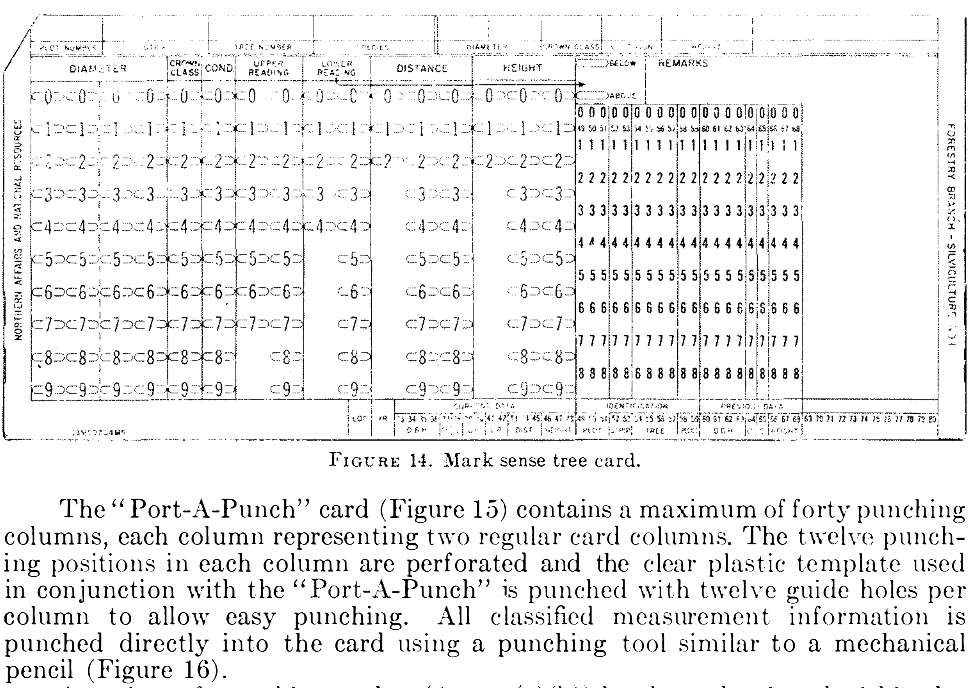

FIGURE 14. Mark sense tree card.

The "Port-A-Punch" card (Figure 15) contains a maximum of forty punching columns, each column representing two regular card columns. The twelve punching positions in each column are perforated and the clear plastic template used in conjunction with the "Port-A-Punch" is punched with twelve guide holes per column to allow easy punching. All classified measurement information is punched directly into the card using a punching tool similar to a mechanical pencil (Figure 16).

A variety of portable punches (Anon. (a)(b)) has been developed within the last few years, and by using these punches in the field, information can be entered into the regular data card as the measurements are being taken.

Control Checks

When the operations of a job are set down, consideration must be given to developing controls so that at each stage of development the previous operations can be checked to ensure the validity of the results. The ideal control system incorporates field, clerical, and machine processing checks into the overall operation. In this way errors are eliminated before extensive machine processing is undertaken.

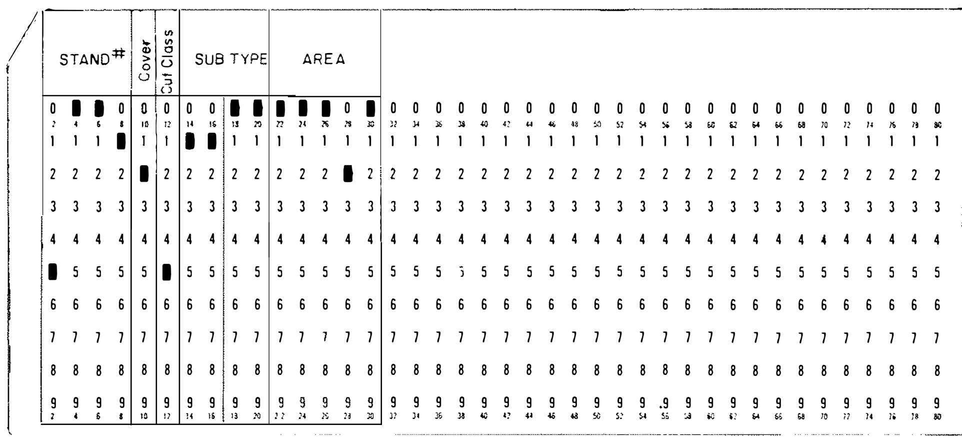

FIGURE 15. Port-A-Punch card for area records.

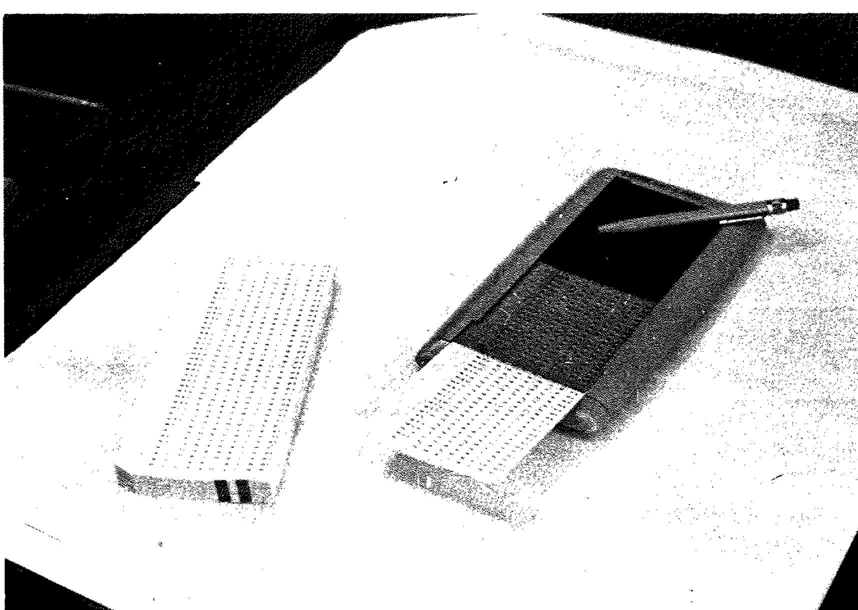

FIGURE 16. Port-A-Punch and mechanical pencil.

One form of control that is generally incorporated into the system is a simple count of items being processed. The basic input is listed and a total provided by the tabulator is compared with a control count which has been provided from a previous clerical operation. If the totals do not balance, the data must be checked to determine the source of error. Such controls may involve additional clerical and machine operations, but ensure accurate report summaries.

The machine output is only as good as the input.

Reports

The development of codes and the design of source documents go hand-in-hand with what the forest manager expects to get out of the survey in the form of machine listings and tabulations. Therefore it is necessary to set down in clear and concise terms the calculations needed and the report forms required. In many cases it means giving a very detailed breakdown of each computation and describing in simple terms each proposed report form. This point cannot be overemphasized, for if there is disappointment in the results produced from a data processing application, it can generally be attributed to a lack of communication between the user and the processor.

The stand and stock table is a common report required in forestry. However, to many processors and some foresters this has little meaning, so the report description is set down as follows:

> Report 1: Plot stand and stock tables showing per acre values for number of trees, basal area, volume total cubic feet, merchantable cubic feet, merchantable board feet, totals by one inch diameter classes, diameter groups (1″-3″, 4″-9″, 10″+), species and plot number.

Specifications

Per Acre:

	Number of trees	—two decimal places
	Basal area	—three decimal places

Volume:

	Total cubic feet	—two decimal places
	Merchantable cubic feet (4″+)	—one decimal place
	Merchantable board feet (10″+)	—no decimal place

Per Acre:

Number of trees—number of trees recorded by species in each diameter class multiplied by the reciprocal of the plot area.

Basal area—number of trees per acre times the unit basal area provided for that diameter class.

Volume—number of trees per acre times the unit volumes (volume total cubic feet, volume merchantable cubic feet, volume merchantable board feet) provided for that diameter class and species.

In such a case the local volume tables would be attached to the request.

A great variety of reports previously unattainable by manual procedures can be produced when a particular problem is compiled using machine techniques. However the potential user is well advised to initially request only the essential reports required for immediate action. Miscellaneous reports may be of interest but the user should ensure that he has the time and staff available to analyze the mountains of forms that may be tabulated. Machine processing is designed to eliminate dull clerical operations and the application should not result in time-consuming analysis of non-essential reports.

Systems

Processing systems should be developed for all problems, for although individual machine operations are usually quite simple, the processing scheme for a detailed problem can be very complex. Development of a good program ensures that the basic data will be processed and summarized in a correct and efficient manner, and depends upon the ability of the forester to state his requirements clearly and the ability of the programmer to translate them into a series of sequential machine operations.

In developing the processing sequence, the programmer generally breaks the problem into several general parts, each part representing a series of operations peculiar to the derivation of that part. For example, to obtain the per acre stand and stock tables indicated above the problem is separated into three parts, each part being further subdivided to show the sequence of operations required.

STAND AND STOCK TABLE PROGRAM

1. Preliminary processing and checks:
   (*a*) key punch—key verify tree cards and local volume tables,
   (*b*) collator—sequence check tree cards on plot number,
   (*c*) tabulator—list each tree card and show total count of number of trees,
   (*d*) check machine and clerical totals. If correct proceed to part 2, if in error submit reports for a clerical check, correct any errors.
2. Computation of per acre values:
   (*a*) calculator—calculate unit basal area on local volume table master cards,
   (*b*) sorter—sort tree cards on diameter and species,
   (*c*) collator—merge with local volume tables,
   (*d*) calculator—calculate and prove per acre values,
   (*e*) sorter—separate and file local volume tables,
   (*f*) tabulator—list per acre values for spot check. If no errors are detected go to part 3, if errors are present take corrective action.
3. Tabulate per acre stand and stock tables:
   (*a*) sorter—sort tree cards on plot number,
   (*b*) collator—sequence check tree cards on diameter, species, and plot number,
   (*c*) tabulator—print plot per acre stand and stock tables.

Where it is necessary the programmer will also prepare the wiring diagrams for the automatic machines (collator, calculator, reproducer, tabulator). When complex programs are being prepared it is common practice to show the overall processing scheme as a flow chart for they are useful in the processing operation and in planning for any revisions that may be required.

Therefore systems work involves an appraisal of the problem, separating it into several general components with each component being further subdivided into basic machine operations. Each operation is described and where applicable wiring diagrams prepared. Appendices I and II illustrate to some extent the points outlined previously.

Appendix I, a study of natural regeneration, describes the planning and processing operations used in this problem. Although only a small part of the processing chart is shown it illustrates how the punch, sorter, and tabulator are used to prepare a number of frequency tables. Brief descriptions of the codes, field sheets, report forms, and processing instructions are given.

Appendix II illustrates the use of the collator, reproducer and calculator in deriving total cubic foot volumes. Each operation shown on the flow chart is briefly explained.

SUMMARY

The use of data processing techniques is relatively new in forestry work, however interest in its application is increasing. To assist the practising forester in understanding the fundamentals of unit record processing, the basic machines and planning principles have been briefly described. Two appendices are presented to illustrate the part each machine plays in the processing scheme and how the various planning principles were put into effect.

APPENDIX I

THE ABUNDANCE AND GROWTH OF SEEDLINGS RELATIVE TO ENVIRONMENTAL FACTORS*

This study of natural regeneration illustrates the use of the punch, sorter and tabulator in preparing a number of frequency tables, and briefly describes the codes, field sheets and report forms.

The purpose of the study was to determine what environmental characteristics play a major role in the survival of spruce and fir regeneration in the Crowsnest Forest of Alberta. Seedlings of both species were classified according to the environmental conditions in which they were found; certain measurements were taken and recorded.

The first objective was to assess the qualitative classes and prepare suitable codes. The basic coding system employed for the project was the sequence code. Sequence codes are used for items which are distinct from the others and where there is absolute assurance that no subsequent grouping will be needed. Since the number of items within each qualitative class was limited, sequence codes 0 to 9 covered all situations.

TABLE I EXAMPLES OF SEQUENCE CODES

Site Type (*Column 6*)	*Seedbed Class* (*Column 11*)
1. Bottomland Alluvium	1. Mineral Soil
2. Moderately exposed and poorly drained slopes	2. Mineral soil with incorporated humus
3. Moderately exposed and well drained slopes	3. Humus "F" and "H" horizons
4. Moderately protected and poorly drained slopes	4. Decayed wood
5. Moderately protected and well drained slopes	5. Moss (Sphagnum or Pleurozium)
6. Steep, exposed slopes	6. Humus, L. horizon
7. Steep, protected slopes	7. Black muck

Field Sheets

The design of the field form was governed by two factors:

(*a*) the characteristics of the information being collected and classified

(*b*) the order in which information is recorded

In this study, each seedling was identified for qualitative and quantitative classes, qualitative classes being recorded to the left of the form, quantitative measures to the right. As seen in Figure 17, the tally sheet provides maximum ease of transcription to the data card; each item is in read-punch sequence and each line on the field sheet represents one seedling data card. The location of each digit on the data card is shown by the column indicator at the top of the form. Therefore the field sheets and data cards have the same column allocation.

* Day, R. J. 1960. Project A-57. Seedling Growth and Environment Study. Forest Research Branch, Department of Forestry, Canada.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
Seedling Number				Drainage	Site type	Residual Std.	Species	Canker	Dir. of Canker	Seedbed	Compaction	Local Slope Dir.	Local Slope Int.	Shade Cast by	Shape Int.	Shade Duration	Unshaded Dir.	Depth to Min. Soil	Root Moist. Status	Length of Shoot		Number of Branches		Lenght of Tap Root		Lenght of Lateral		Age by Node Count		Age by Sectioning		Mean Annual Increment		M. A. I. Code	Length of Shoot 2				Length of Tap Root 2				Length of Lateral Root 2				Age Class
0	0	4	6	3	4	2	2	0	0	3	5	1	2	2	2	4	5	4	3	0	5	0	2	1	7	0	2	0	4	0	4	1	3	3	0	0	2	5	0	2	8	9	0	0	0	4	2
0	0	4	7	3	4	2	2	0	0	3	5	1	2	2	2	4	5	4	3	0	6	0	0	1	1	0	2	0	5	0	5	1	2	3	0	0	3	6	0	1	2	1	0	0	0	4	2
0	0	5	1	3	4	3	1	0	0	2	3	7	2	6	3	4	0	1	2	0	2	0	1	1	0	0	2	0	3	0	3	0	7	2	0	0	0	4	0	1	0	0	0	0	0	4	1

FIGURE 17. Field tally form.

Report Forms

Machine report forms are determined by the nature of the problem and the ability of the machines to print in the desired manner. In many instances, the form must be a compromise, with machine capabilities being the governing factor. The design was originally requested in the form of Figure 18, but after some consideration the machine form Figure 19 was used. The change resulted in moving site type to the vertical axis because in this and subsequent reports, site was the controlling factor. The horizontal axis is used to record the number of seedlings falling into each class of the microsite factor. The fir data are printed beneath rather than adjacent to the spruce data as the number of counter positions available in the tabulator was the limiting factor. Control totals were also provided by site, species, and all species combined.

This report is simple and provides a maximum of information for control and further analysis.

Submission Instructions

An excerpt from the submission instructions reads as follows: *Analysis No. 11—The relation between site type and various microsite factors.*

This analysis is designed to show what variation occurs in the proportion of microsites available in each macrosite condition.

Method—(1) Sort into species classes 1 and 2, column 8.

(2) Sort into site classes 1 to 7, column 6.

	SPRUCE								FIR						
(B) Seedbed	Site							(B) Seedbed	Site						
	1	2	3	4	5	6	7		1	2	3	4	5	6	7
0															
1															
2		(3 figs. max. in totals)								(3 figs. max. in totals)					
3															
4															

FIGURE 18. Proposed report form. Analysis No. 11.

Species	Site	NUMBER OF SEEDLINGS BY SEEDBED										
		0	1	2	3	4	5	6	7	8	9	Total
Spruce	0											
	1											
	2											
	3											
	4											
	5											
	6											
	7											
Totals												
Fir	0											
	1											
	etc.											
Totals												
Grand totals												

FIGURE 19. Final machine report form. Analysis No. 11.

(3) Sort each species site group into the various classes of each of the following factors:—

	Col.	*Factor*	*Code*
A.	7	Residual Stand	0–4
B.	11	Seedbed	1–7
C.	13	Local Slope (Direction)	1–9

These instructions describe briefly the purpose of the reports, and explain in a clear and concise manner the sorts required to produce the desired reports.

1. Field tally.

2. Key punch verify

3. One card per seedling.

4. Sequence check.

5. Control listing for final check.

6. Correct errors.

7. Sort.

8. Tabulate.

9. Report forms.

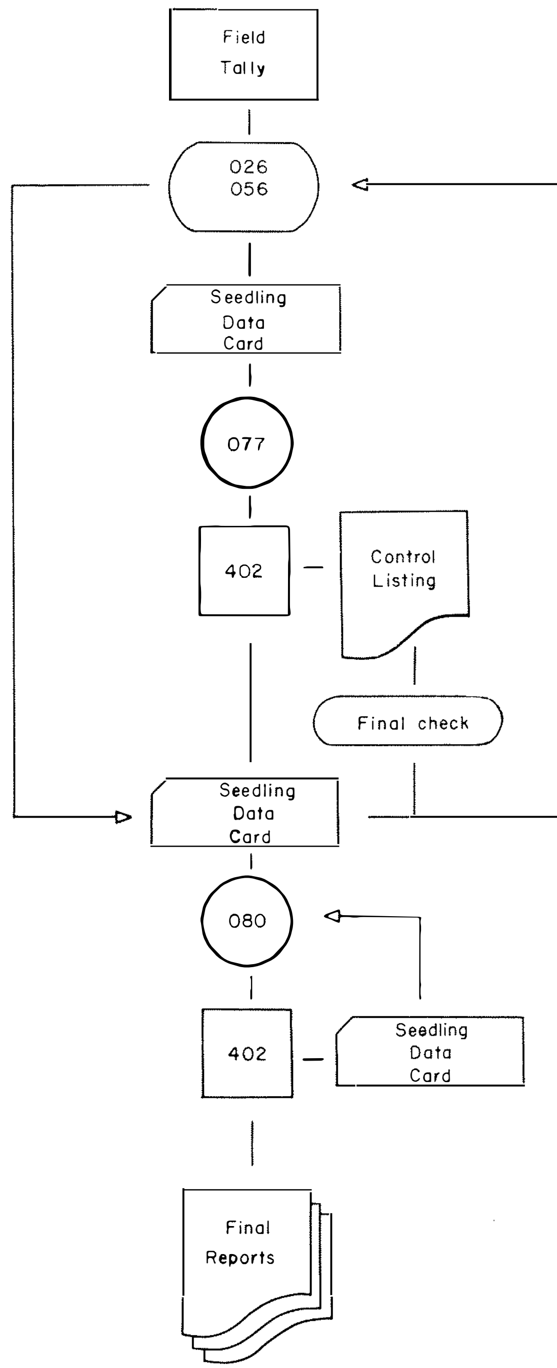

FIGURE 20. Seedling flow chart.

Systems Planning

The operations involved in processing this problem cover three main areas:

1. Key punching, key verification, and checks
2. Sorting
3. Tabulating

From this basic analysis a flow chart showing the sequence of operations is developed (Figure 20). Following the preparation of the flow chart, machine operator instructions were prepared as follows:

Report 11B:

(*a*) Sort: (1) Seedbed class, column 11
(2) Site class, column 6
(3) Species, column 8

(*b*) Print (Figure 19) selecting on seedbed class (Column 11) and showing a minor total on species and site (Columns 8 and 6). Tabulate each species separately and run automatic totals for each species and all species combined.

Therefore the preliminary planning involved designing the field form, setting up the codes and determining the type of report forms required. At the processing end, flow charts were developed and concise operator instructions set down.

APPENDIX II

TREE SECTION VOLUME*

This problem involved measurements taken on one hundred and sixty-eight sectioned trees and illustrates the use of the reproducer, collator and calculator. At each section the inside bark radius measurements were recorded for each ten-year period. The work order, Figure 21, specifies the source data and clearly indicates the computations and reports required. The planning and machine operations, which are briefly described below, pertain to those operations required in section 2A(i) of the work order.

The basic measurements were punched on card form 1, Figure 22; one card for each section containing measurements for eleven age periods. Since these basic measurements take up all the columns of the card, the volume computations have to be punched onto another card form. Card form 2, Figure 23, was designed to accommodate the volume computations. Note that columns 1 to 11 are common to each form to permit merging of the radius and volume cards. In Figure 25 we can see the sequence of operations to reproduce, assemble and compute the required volumes.

Card form 2, columns 1 to 11 are reproduced from form 1. The reproducer reads column 1 to 11 and punches the same information into card form 2 in the same columns. On this operation the comparing feature of the machine is utilized. The information read from card 1 is compared on a column-for-column basis, with the information punched into card 2. If no differences are observed, the machine keeps reading and punching; if a difference is observed, the machine will stop, the compare lights flash on, and the column in error is shown on the comparing indicator.

Following the reproduction operation, card forms 1 and 2 are merged for calculation. Merging is performed on the collator, and in this case the speed will approximate 250 cards per minute, feeding from both feeds simultaneously. The collator has a primary and secondary feed; the primary for the cards to be fed first and the secondary feed for the cards which will follow immediately behind. In this operation, one secondary card (for the volume records) will follow the

* Bajzak, D. 1961. Project NF-55. Study of Mensurational Characteristics of the Forest Types of Central Newfoundland. Forest Research Branch, Department of Forestry, Canada.

WORK ORDER

Job No.	Job Name
74	NF-55

Issuing Officer	Unit	Due In	Due Out
D. Bajzak	Newfoundland District		Sept. 1961

1. Source data: (Quantity, type, coding, etc.)

2. Summary of results required: (append suggested report forms)

1. Source of data: 168 trees (Numbered 201-379). Each tree sectioned into twelve sections: 1 foot stump section; 3.5 feet breast height section, and ten equal sections between breast height and tree top. The following information is recorded and coded:

   a). Tree number; species; location (Lat.-Long.): site (site type): DBHob; DBHib; total height; age at stump; and point age at breast height.

   b). Each section numbered in sequence with the following recorded at smaller end for each:

   Disc. Age; Section Length; Diameter ob. now; Av. Radius now; and Av. Radius 10 years ago, 20 years ago, 30 years ago, etc. to the last decade.

2. Result required:

   A. Volume computation:

   (i) Compute the volume for each section of the tree using Smalian's formula: $V = K (D^2 + d^2)L$, where $K = 0.002727$, D = Large end diameter, d = small end diameter, L = section length. Volume to three places of decimal.

   (ii) Volume computation by decades for each section as follows:

   Volume now using Dib. now
   Volume 10 years ago using Dib 10
   Volume 20 years ago using Dib 20
   Volume etc. to the last decade.

   (iii) Volume increment for each section

   Volume now - Volume 10
   Volume 10 - Volume 20
   Etc. to the last decade.

.../2

Division Chief	Head - D.P.U.	Completion Date
A. Bickerstaff	Honer	Sept. 61

F969

FIGURE 21. Work order.

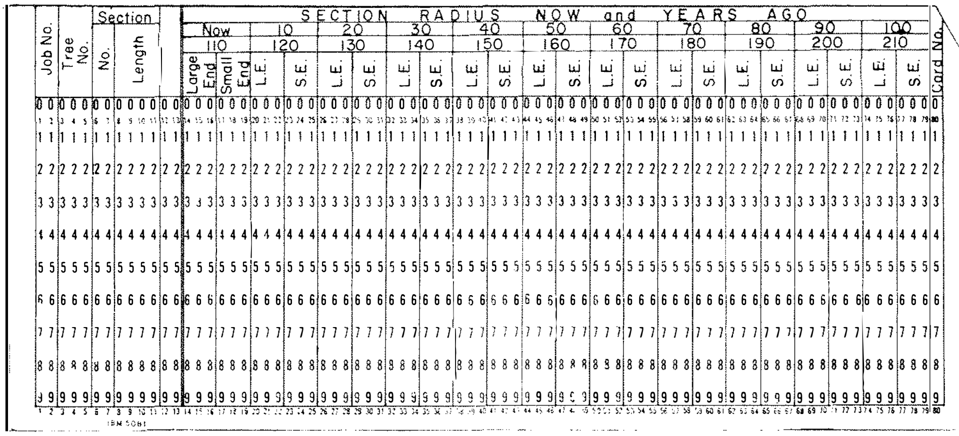

FIGURE 22. Card Form 1. (Radius=x.xx)

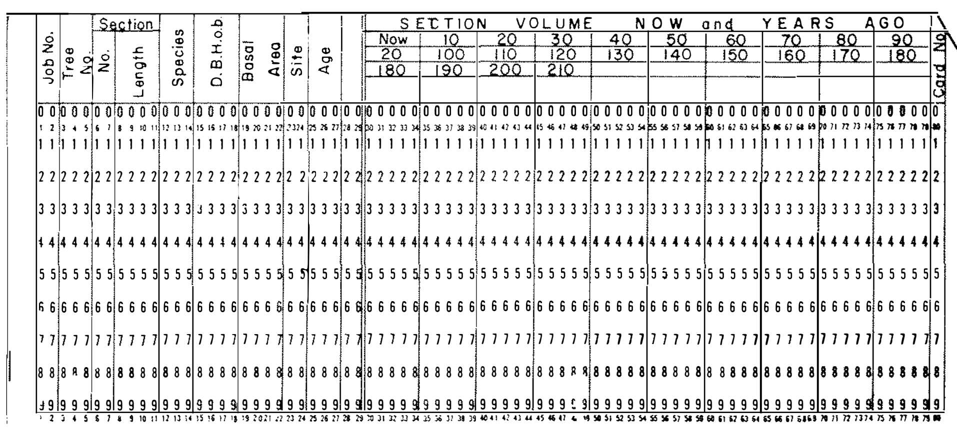

FIGURE 23. Card Form 2. (Volume=xx.xxx)

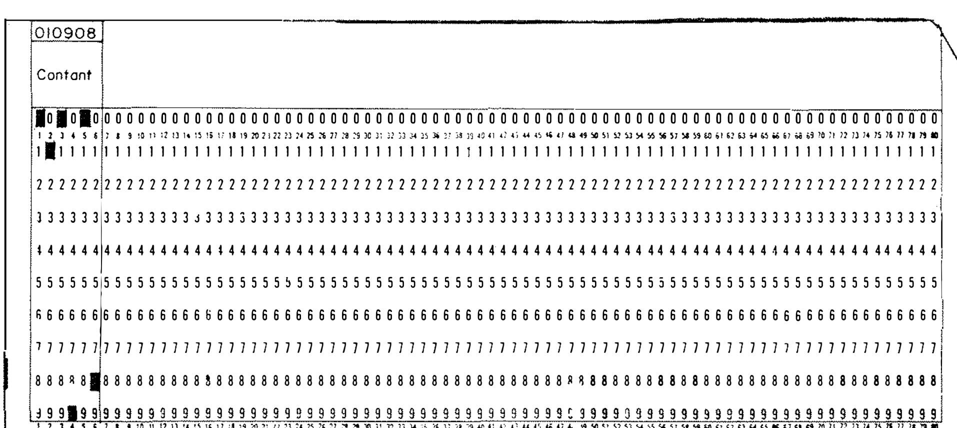

FIGURE 24. Card Form 3.

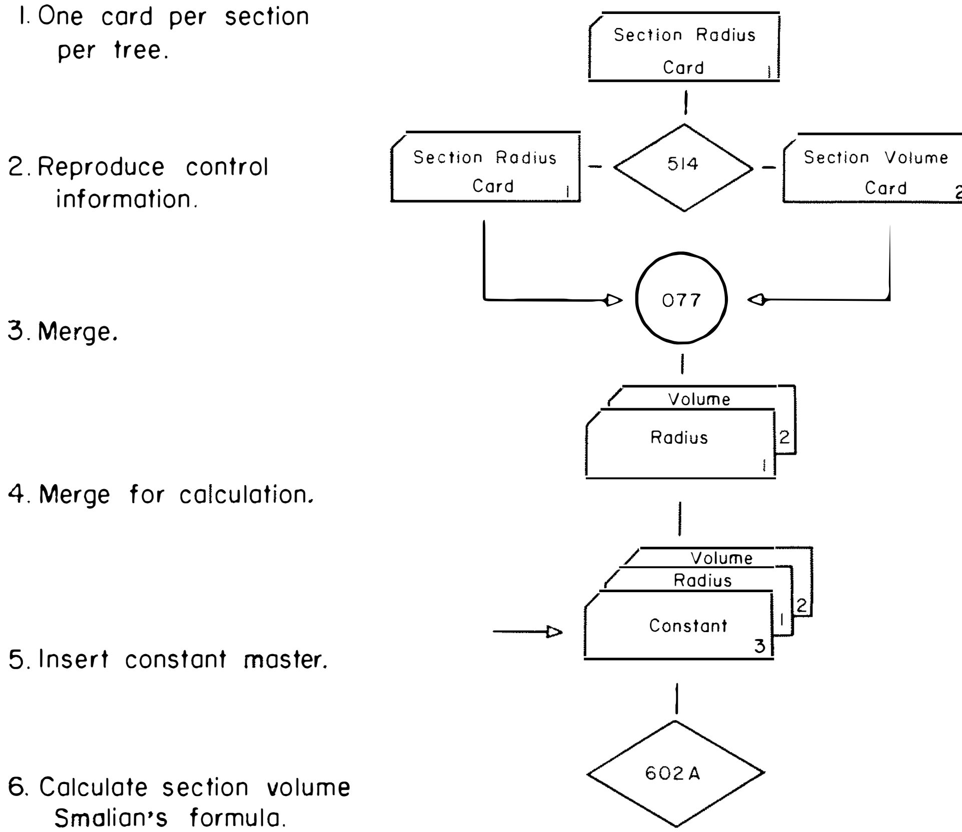

FIGURE 25. Volume flow chart.

appropriate primary card. Two important features are utilized; the sequence check and the selection feature. The sequence check ensures that cards in both feeds are in the proper order as merging proceeds, the selection feature ensures that each primary has a matching secondary and each secondary a matching primary. Should neither of these conditions exist in the merging operation, the cards will be selected into the appropriate reject pockets.

The two card forms are now assembled and in sequence for the cubic foot volume calculation, using Smalian's formula:

$$Vtcf = K\ (R^2 + r^2)\ L$$

Where $K = .010908$

R = Section radius of the large end in inches

r = Section radius of the small end in inches

L = Section length in feet

Since the constant K is not recorded on either form 1 or 2, it is necessary to put it on a third card (Figure 24) and place it at the front of the merged deck. The problem for the calculator is as follows: it must read the K constant from form 3, read the R, r, and L values from form 1, retain this information in memory, retrieve it as it is required, compute the sum of the squares, multiply by the length, adjust the value by multiplication with the constant K, and punch the computed volume in card form 2.

Calculating punches of the 602A series operate at various speeds depending upon the complexity of the problem. In this case approximately 460 volume calculations per hour would be made.

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——— (c) Modern Coding Methods. International Business Machine Corporation, 590 Madison Avenue, New York 22, N.Y.

——— (d) IBM Port-A-Punch. International Business Machine Corporation, 590 Madison Avenue, New York 22, N.Y.

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