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CONTRIBUTION TO THE AUTOMATION OF THE CALCULATIONS INVOLVING THE FOREST INVENTORY WITH THE AID OF AN OFFICE COMPUTER

by

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1. Problem

O.D.C. 58

Although the use of computers in sylvicultural research has become a reality, a general spread of these techniques will only be possible, when certain conditions are fulfilled. In many cases such means were used, either because a computer center was available, or because certain public or private institutions could be appealed to and were willing to work out each year a given number of problems. In case neither of these possibilities exist, the only solution is the buying or the hiring of a computer. In the former case sufficient and permanent computing work is required, whereas in the latter all calculations have to be effected within an as short as possible space of time. In both cases however considerable investments, adequate space and a specialised staff are required.

To a certain degree the problems described above may be solved by the use of smaller electronic calculators or office computers, which recently evolved considerably and the future development and applicability of which are scarcely be foreseen nowadays.

Of course we treat here of important aids which for the moment are not able to replace the existing and more extensive computers, especially not when more complicated and ample problems are dealt with.

The contribution below only aims at showing which are the possibilities of an office computer in forest inventory and which contingent simplifications have to be made. For this purpose an office computer OLIVETTI P 203 was used.

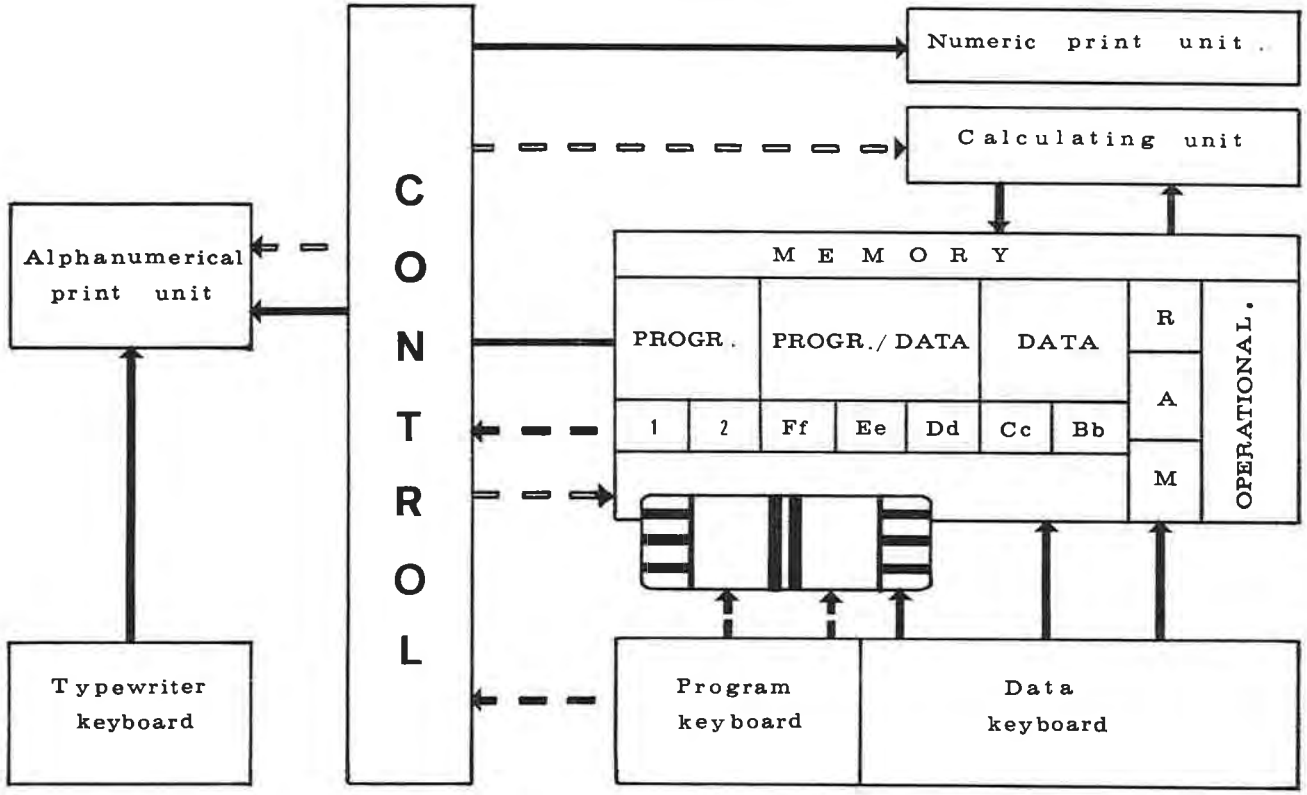


Fig. 1. Logical-operational diagram of the Olivetti P 203.
Data — — — Instructions ▭ ▭ ▭ Controls

2. **Hardware**

The OLIVETTI P 203 (*) is an electronic calculator, the program being transfered in the computer's memory by means of one or more magnetic cards. It consists of a modified office computer Programma 101 and a joined typewriter Tekne 3, both may operate together or separately.

In outline it may be reduced to the following fundamental units : memory, arithmetic-logical unit, print units and keyboards (see fig. 1).

The *memory* is subdivided into 10 registers : 3 operative ones, 2 for data only, 3 mixed ones (data, instructions or both) and 2 exclusively for the instructions which constitute the program.

The first three registers M, A and R each have a capacity of 30 digits, with decimal point and sign. The first register of the series receives the data from the keyboard of the calculator, whereas the other two preserve the results of the calculations.

The registers B, C, D, E and F each have a capacity of 30 digits and are used to preserve data (intermediary results or constants) or program instructions (in this case only the registers F, E and D).

It is also possible, and in most cases even desirable to split up each register into two parts of each 15 digits. Hence we get a maximum of 10 autonomous registers, indicated as follows : B, b, C, c, D, d, E, e, F and f.

The registers 1 and 2 (for instructions only) may store together 64 instructions. If a program exceeds this number, the registers F, f, E, e, D and d are succeedingly used, wholly or partly, for the instructions 65 till 160, according the length of the program. When a register contains only partly some instructions, it may contain also data of limited capacity.

The *arithmetic-logical unit* carries out the four basic arithmetic operations and extracts square root, taking acount of sign and aligning the decimal point automatically. It takes logical decisions (carries out jumps) in accordance with the value of specified results and conditions. All kinds of alternative subroutines can be provided in one program. Other calculations such as ln, sin, cos, and others have to be programmed separately.

The *print units* consist of a typewriter and a print unit connected with the calculator. The former unit prints automatically data with decimal point and minus sign, according to the instructions of the

(*) Manuel d'Information du Calculateur électronique P 203 — Olivetti 1969.

program and also determines automatically their position on a form inserted in the usual way in the carriage. The typewriter has a speed of 14 cps. The latter unit on the otherhand prints upon a tally roll at the rate of 30 cps.

As in the case of the print unit the keyboards too belong to two separate units. The keyboard of the typewriter is a classical one. Hence it is alphanumerical and it can give only direct instructions to the print unit of this machine. On the other hand the keyboard of the calculator or the operational keyboard contains keys wich are able to enter numeric data, keys with symbols to perform manual operations or to write programs and about four keys (V, W, Y, Z) to make the program start or continue from a given position in this program.

The program received by the memory by means of the operational keyboard is recorded on a magnetic card so that it may be used unlimitedly. These magnetic cards have two registration tracks (A and B) each of which may contain maximum 160 instructions, stored into the registers 1, 2, D, d, E, e, F and f. Each instruction occupies only one position in the memory. It is coded by a number of symbols going from 1 to maximum 3. Finally it is also possible to make cards, the instructions (subroutine card) or numeric data (special card) only occupying the registers D, d, E and e. When a similar card (symbol SC) is inserted in a given way, only the content of these registers are modified without wiping out the basis program. This possibility is used for the so called « stand cards » (see below).

3. **Operating procedure**

The programmation has accounted for the desire to know for each stand or sample plot per tree species and for each tree species per diameter class, the value per ha of the number of trees, the basal area, the basal area increment, the volume increment, the volume, the money value of the standing trees, as well as the subtotals per tree species and the totals (for all the tree species) of these quantities.

Practically speaking the problem has been reduced to the elaboration of a main program « tree species », which is identical for each tree species, except for the value of the parameters, and which occupies the two tracks A and B of a single magnetic card. Moreover subroutine 1 enables us to preserve the subtotals per tree species temporarily on a « stand card », so that eventually after the last tree species, the totals per ha and certain average trees may be calculated (see flowchart 1).

31. *Program « Tree species ».*

Track A containing the program (see flowchart 1 and appendix 3) the following instructions and calculations are performed, after the magnetic card is inserted and key W is pressed.

311. Code for the tree species (k)

To distinguish afterwards the calculations per tree species, the typewriter prints automatically a code at the beginning of each program, which is to be found in the table below for each tree species.

These codes are situated on the document just above the first column of the diameter classes (see appendix 1).

10 Hardwoods	20 Conifers
11 Quercus robur/petraea	21 Pinus sylvestris
12 Quercus borealis	22 Pinus nigra var. calabrica
13 Fagus sylvatica	23 Pinus nigra var. austriaca
14 Fraxinus excelsior	24 Larix leptolepis
15 Acer pseudoplatanus	25 Picea abies
16 Populus sp.	26 Abies pectinata
17 Betula pubescens	27 Abies grandis
18 Prunus avium	28 Pseudotsuga taxifolia

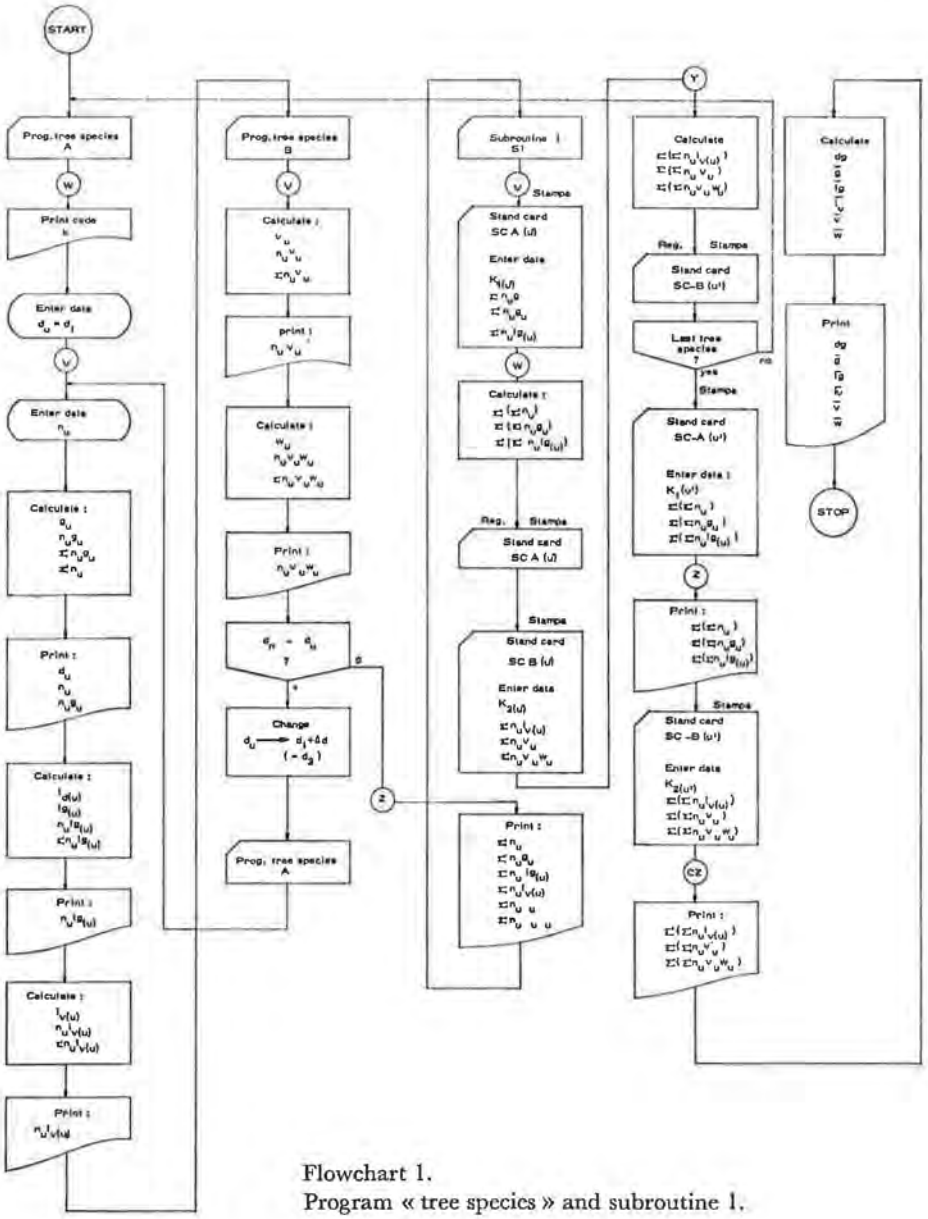
312. Diameter class (d_u)

At the beginning of each program the initial diameter (in m) has to be entered in the register M by means of the operational keyboard. When card A is inserted again for the next diameter class and the key V is pressed, these diameter class ($+ \Delta d = 4$ cm) is printed out automatically. The values of the diameter classes are printed in the first column of the form. If there is occasionally no tree in the next diameter class, then the calculations may be abridged by passing over this diameter class.

In this case the card is inserted, the value of the diameter class which does contain trees is formed on the keyboard and A is pressed. By pressing V again, the operation goes its normal way and this new diameter is stored in register F for further calculations.

313. Number of trees (n_u)

By means of the operational keyboard, the number of trees per ha (n_u) belonging to the diameter class d_u is entered. This



Flowchart 1.
Program « tree species » and subroutine 1.

number is printed on the form in the second column, temporarily preserved in register f for further calculations and also added to the contents of register D to arrive at the subtotal $\Sigma\, n_u$.

314. Basal area (g_u)

The basal area g_u (m^2/ha) of the trees with diameter d_u is calculated as usual, then multiplied by n_u, which results in the total basal area $n_u g_u$ for the corresponding diameter class d_u.

This value is printed on the form in the third column and also added to the content of register b, wich contributes to the calculation of the subtotal $\Sigma\, n_u g_u$.

315. Current annual increment of the basal area ($ig_{(u)}$)

First the current annual growth (in m) of the diameter ($i_{d(u)}$) has to be known. To calculate this value, we start from the generally accepted rule, according to which there is a linear relation between the diameter classes and the current annual increment of the diameters in these classes (in even-aged stands and for a limited growth period), so that :

$$i_{d(u)} = a_o + a_1 d_u$$

having u = 1, 2, 3,... resp. d_u = .10, .14, .18, ... etc.

Having established this value, the current annual increment (in m) of the basal area $i_{g(u)}$ for the diameter class d_u may be calculated by means of the simplified formula below :

$$i_{g(u)} = \frac{\pi}{2}\, i_{d(u)}\, d_u$$

After the multiplication by n_u, the total current annual increment of the basal area $n_u i_{g(u)}$ is written in the fourth column and also added to the contents of register B ($\Sigma\, n_u i_{g(u)}$). The value of $i_{d(u)}$ has to be preserved temporarily in register e so as to calculate the current annual volume increment.

316. Volume (v_u)

To calculate the volume (m^3) for a tree of the diameter class d_u, we used a classical formula :

$$v_u = a'_0 + a'_2\, d_u^2$$

having u = 1, 2, 3,... resp. d_u = .10, .14, .18, ... etc.

The volume of all the trees of the diameter class d_u is arrived at by the multiplication of v_u by n_u. This result is written in the

sixth column and added to the contents of register d, to calculate $\Sigma\, n_u v_u$. This value is temporarily stored into register e for other calculations.

317. Current annual volume increment ($i_{v(u)}$)

For practical reasons $i_{v(u)}$ is calculated and printed before v_u. This is due to the fact that in the transfer to card B (see flowchart 1 and appendix 4) $i_{d(u)}$ can no longer be preserved in the memory and that on the other hand v_u is further needed for the calculation of the money value w_u.

Since in the paragraph above a given relation was assumed for v_u, this leads immediately to :

$$i_{v(u)} = 2\, a_2'\, d_u\, i_{d(u)}$$

having u = 1, 2, 3,... resp. d_u = .10; .14; .18; ... etc.

After multiplication of $i_{v(u)}$ by n_u, the current annual volume increment ($n_u i_{v(u)}$) of all the trees of diameter class d_u is printed in the fifth column (m^3/year/ha) and added to the content of register C ($\Sigma\, n_u i_{v(u)}$).

As v_u is calculated afterwards, the results $n_u v_u$ is to be found of course in the column before the last, exactly, after the current annual volume increment.

318. Money value of the standing trees (w_u)

Taking into account on the one hand the limited capacity and possibilities of the computer unit and on the other hand the fact that the trees are selled in the stand, the money value of a single tree depends in practice mainly on the tree species, the diameter at 1.3 m, the volume and the price per m^3.

If we search for a mathematical relation between the diameter class d_u of a given species and the price in Bfr/m^3, the following equation is very usefull :

$$w_u = a_0'' + a_1'' d_u + a_2'' d_u^2$$

having u = 1, 2, 3,... resp. d_u = .10; .14; .18; ... etc.

After multiplication of w_u by $n_u v_u$ preserved in register e (see above) the money value $n_u v_u w_u$ (Bfr/ha) of the number of trees n_u from diameter class d_u is arrived at and printed in the last column and added to the contents of register d ($\Sigma\, n_u v_u w_u$). After this last column is printed, the carriage of the typewriter automatically returns to the margin.

To get the next diameter class, only card A has to be inserted again and key V pressed. Afterwards the corresponding number of trees per ha of this new diameter class ($d_u + 1 = d_u + \Delta u$) is entered in register M by means of the keyboard and than it starts all over again. If d_u was the last diameter class of a given tree species of the stand or the sample plot, the card A is not inserted, but key Z is pressed. Consequently the values Σn_u, $\Sigma n_u g_u$, $\Sigma n_u i_{g(u)}$, $\Sigma n_u i_{v(u)}$, $\Sigma n_u v_u$ en $\Sigma n_u v_u w_u$ are printed under the corresponding columns.

As mostly stands or plots ore composed of several tree species, the values above have to be preserved temporarily on so-called special cards or stand cards (SC-A and SC-B) so as to be added to the subtotals of the other tree species and eventually to calculate the total of the whole and print it. These operations are carried out along the following subroutine (see also flowchart 1 and appendix 5).

22. *Subroutine 1*

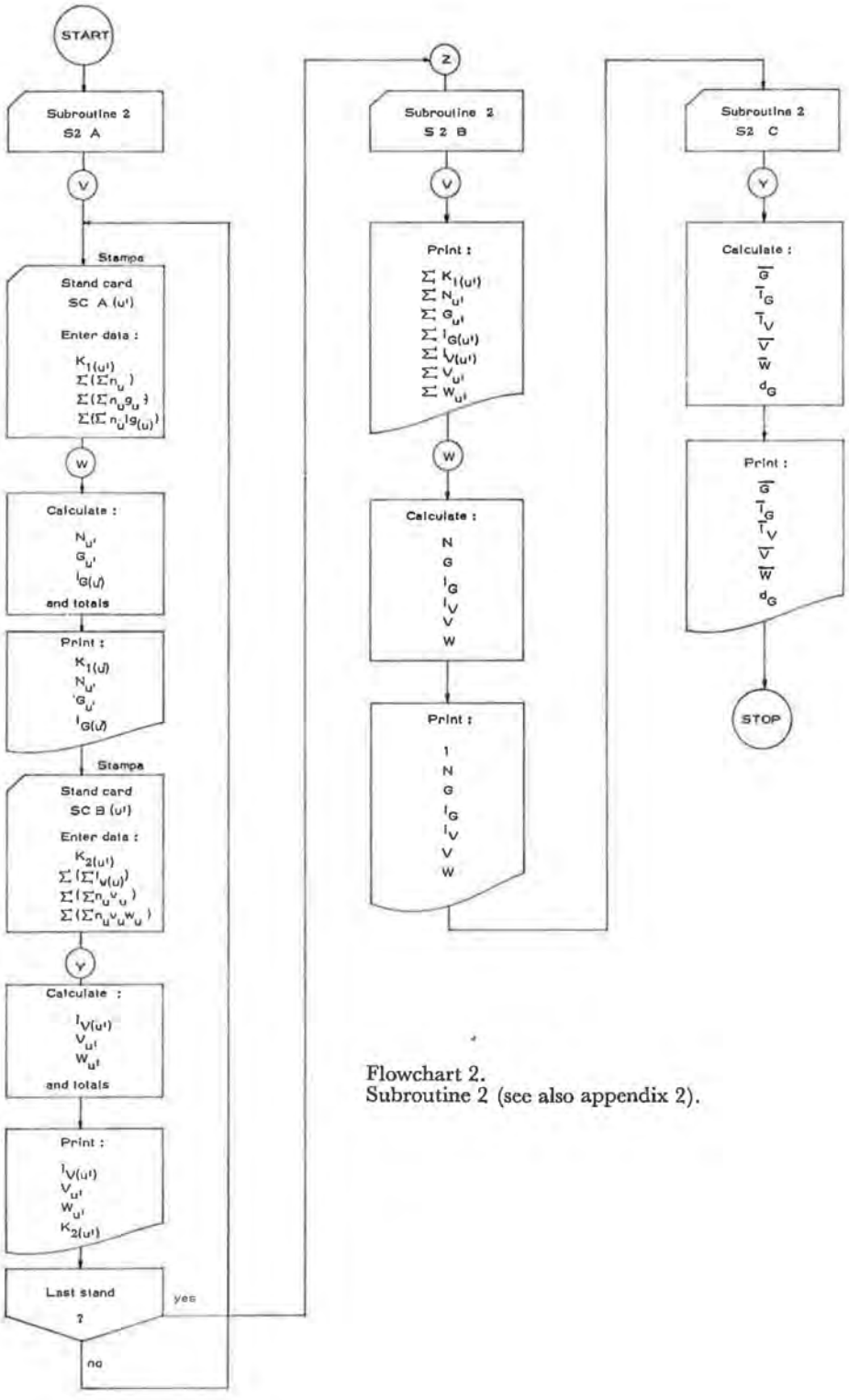
Card « subroutine 1 » being inserted and key V pressed, the stand card SC-A (u') is inserted in a special way (the index u' = 1, 2,3,... corresponding to series of stands or plots in a given order).

This card enters the respective area of the stand or plot K_1 (u'), Σn_u, $\Sigma n_u g_u$ and $\Sigma n_u i_{g(u)}$ in the registers d, D, e, and E wich results in the adding of the last values to the corresponding totals of the former tree species, after key W has been pressed. When card SC-A (u') is entered again the new subtotals are recorded on this card. Then track B of the same card is used to enter a code K_2 (u') for the stand or plot, $\Sigma n_u i_{v(u)}$, $\Sigma n_u v_u$ and $\Sigma n_u v_u w_u$ in the registers d, D, e and E. By pressing key Y exactly the same operations are performed as for SC-A (u') and in this case too the card SC-B (u') is entered again, so that it can preserve the new subtotals.

The constants K_1 (u') and K_2 (u') which were entered in the registers mentioned above in preparing the « stand cards », are not taken into account for these calculations.

When all the calculations for each tree species are carried out, the magnetic card SC-A (u') is inserted again and key Z pressed; hence the final totals Σ (Σn_u), Σ ($\Sigma n_u g_u$) and Σ ($\Sigma n_u i_{g(u)}$) are printed. Card SC-B (u') being treated in the same way and keys C and Z pressed the values Σ ($\Sigma n_u i_{v(u)}$), Σ ($\Sigma n_u v_u$) and Σ ($\Sigma n_u v_u w_u$) are printed too, while at the same time the « model tree » d_g and the mean values $\bar{g}$, $\overline{i_g}$, $\overline{i_v}$, $\bar{v}$ and $\bar{w}$ are calculated and printed in the same order under the corresponding columns.

Appendix 1 represents a similar form, resulting from calculations concerning a plot situated in an oak forest, locally mixed with Red oak, Japanese larch and Beech.



Flowchart 2.
Subroutine 2 (see also appendix 2).

The calculations and manipulations explained above are concentrated on one hand in a form (see appendix 1) and on the other hand in a stand card SC(u'). For each stand or plot, the form gives a very detailed survey per tree species and per diameter class of the number of trees, the basal area, the increment of the basal area, the volume increment and the money value of the standing trees. Besides the subtotals of these quantities per tree species and afterwards the totals for all the tree species belonging to the stand or plot together, a number of « average trees » is calculated at the same time.

The stand card SC (u'), at the beginning only a means to preserve subtotals temporarily, when passing from one tree species to another, becomes afterwards a kind of index card or memory card which contains the area (ha) of the stand or plot, under discussion and its code number, besides the quantities mentioned above such as total number of trees, basal area, increment of the basal area, volume, volume increment and money value of the standing trees per ha. Other calculations may be performed with a similar stand card combined with an appropriate subroutine, without the necessity to enter again the numeric data by means of the keyboard, which means eliminating one source of errors. By printing the code of stand or plot and the contents of the registers wanted, these values may be checked or tabulated at once.

The following subroutine describes one of the possible applications of such stand cards.

23. *Subroutine 2*

This subroutine is elaborated as an example (see also flowchart 2 and appendices 6, 7 and 8). Its aim is to convert the (relative) calculated results per ha of a series of stands into absolute values, the area of the stand taking into account as well as calculating the totals of the columns wich have to be printed; in other words asking for the results of the whole measured stands, plots or even a complete forest.

When the magnetic card « subroutine 2/A » is inserted and key V pressed, the first stand card SC-A (u') is entered and key W pressed. In this way the given area K_1 (u') of the stand under discussion, $\Sigma\,(\Sigma\, n_u g_u)$ and $\Sigma\,(\Sigma\, n_u i_{g(u)})$ are entered and the values $N_{u'}$ (number of trees), $G_{u'}$ (basal area) and $i_{G(u')}$ (current annual increment) calculated for this area. All these values are added to the registers meant for that purpose and printed in this order (see appendix 2). After inserting « stand card » SC-B(u') and pressing key Y, the values $\Sigma\,(\Sigma\, n_u i_{v(u)})$, $\Sigma\,(\Sigma\, n_u v_u)$, $\Sigma\,(\Sigma\, n_u v_u w_u)$ and the code K_2 (u') are entered into the memory. Than the values $i_{V(u')}$

(volume increment), $V_{(u')}$ (volume) and $W_{(u')}$ (money value) are calculated for the same area and added to the registers meant for that purpose. Next $i_{V(u')}$, $V_{)u'}$ $W_{(u')}$ and the code $K_2(u')$ are printed in this order on the same line and the carriage returns to the margin. Then the next stand card (track A) is inserted so that the operation starts again from the beginning.

After the last « stand card », the magnetic card « subroutine 2/B » is inserted and key V pressed, by which the general totals $K_{1(u')}$, $\Sigma N_{u'}$, $\Sigma G(u')$, $\Sigma i_{G(u')}$, $\Sigma i_{V(u')}$ and $\Sigma W(u')$ are printed in this order in the corresponding columns. If there is an interest in mean values per ha of these quantities for the series of stands or the whole forest, key W should be pressed to calculate them and to have them printed in the order 1, N, i_G, i_v, V, W in the corresponding columns.

If, as in the case of subroutine 1, certain average trees are to be calculated, a third card « subroutine 2/C » has to be inserted. Key V being pressed the average values per tree, namely $\overline{G}$, $\overline{i_G}$, $\overline{i_V}$, $\overline{V}$, $\overline{W}$ and d_G are printed on the form under the mean values per ha calculated above. Since there is no column on this form for the diameters, the average tree d_G is printed at the bottom of the column of the stand codes.

Appendix 2 gives a survey of a similar operation.

3. Conclusions

In this contribution we esteem to have shown that in the field of forest inventory quite an amount of useful work can also be done with the aid of smaller computer units, limited in price such as the Olivetti P 203. Since we can dispose of a form for each stand or plot, with the required details as to structure, growth and compositions as well as a series of practical data such as total volume, increment and money value of the standing trees, a large amount of information, useful for research as well as for the practice, is at hand. Due to the « stand card » and later to several « stand cards » succeeding each other in time, it becomes possible to replace the classical index card system by magnetic cards (although these cards are to expensive at this moment). Thus the applications of the classical index cards are not only preserved, but it will also be possible to enter the cards directly in the office computer and to perform the necessary calculations and classifications by means of a subroutine elaborated for this purpose.

Finally we are conscient of the fact that similar operations are rather slow when compared with the larger computers. The drawbacks of the system are the facts that the data cannot get be entered

automatically and that for each tree species a « program card » is required.

It would be desirable also to introduce more parameters for certain calculations, especially concerning the volume and the money value. As the memory of the Olivetti P 203 is rather limited, it does not allow a similar extension without complicating the calculations and manipulations of the machine. Thus the advantages of similar machines would largely be lost. This would partly be remedied by supplying the office computer with a « punch read unit » wich will be realised in the near future, according to the constructors of this computer.

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APPENDIX 1

Forest : _____

Plot nr. _____
Section _____
Date _____

11							
	.10	60	.4710	.0015	.0186	1.6428	0
	.14	70	1.0770	.0067	.0784	8.0572	627
	.18	80	2.0347	.0159	.1857	18.5656	2899
	.22	50	1.8997	.0168	.1957	18.9139	4448
	.26	30	1.5919	.0151	.1769	16.6118	5230
	.38	10	1.1335	.0122	.1420	12.5552	7003
		300	8.2079	.0683	.7975	76.3468	20207
12							
	.34	10	.9074	.0341	.3969	9.9235	4725
	.38	10	1.1335	.0425	.4950	12.5552	7003
		20	2.0410	.0766	.8919	22.4787	11728
13							
	.14	20	.3077	.0211	.2456	2.3020	147
	.22	10	.3799	.0191	.2229	3.7827	648
	.30	30	2.1195	.0888	1.0342	22.7526	7081
	.34	20	1.8149	.0711	.8276	19.8470	7807
	.38	20	2.2670	.0839	.9766	25.1105	12143
		100	6.8891	.2841	3.3071	73.7950	27826
24							
	.18	10	.2543	.0063	.0735	2.3207	446
	.22	20	.7598	.0179	.2091	7.5655	1828
	.26	20	1.0613	.0242	.2817	11.0745	3219
	.30	70	4.9455	.1097	1.2776	53.0894	18022
	.34	10	.9074	.0197	.2294	9.9235	3850
	.38	10	1.1335	.0242	.2817	12.5552	5478
		140	9.0620	.2021	2.3533	96.5290	32843
		560	26.2001	.6313	7.3500	269.1497	92604
	.2440		.0467	.0011	.0131	.4806	165

Forest inventory
Name : _____
Section : _____
Date : _____

.5000	210	12.1486	.4227	4.9206	127.9796	50884	1000.1967
.5000	175	12.3260	.3835	4.4641	132.2848	54810	2000.1967
.5000	200	13.0121	.3034	3.5327	138.6713	61229	3000.1967
.5000	240	11.7059	.4900	5.7039	120.9057	65345	4000.1967
.5443	391	7.9438	.2175	2.5336	67.3916	15300	5000.1967
.4830	313	9.7564	.1705	1.9863	93.4791	22425	6000.1967
.4968	149	14.6604	.4641	5.4023	161.1199	88069	7000.1967
.3772	162	10.1136	.4018	4.6776	107.3500	64710	8000.1967
.2532	156	8.2414	.1434	1.6710	85.8899	32488	9000.1967
.5000	195	14.1535	.3545	4.1275	152.2780	75485	10000.1967
.5000	210	10.1516	.2721	3.1678	104.7325	38706	11000.1967
.5000	270	9.3414	.2706	3.1513	91.4621	50687	12000.1967
.4134	235	12.7743	.2689	3.1312	133.6224	143235	13000.1967
.4969	288	10.8749	.4454	5.1858	108.1488	45922	15000.1967
.5000	195	14.3042	.4181	4.8672	154.0325	92791	16000.1967
.5000	265	14.3764	.2925	3.4061	150.3932	63310	17000.1967
.3259	182	8.5386	.2057	2.3953	87.7158	30179	18000.1967
.1899	121	5.9533	.1839	2.1412	61.5228	25384	19000.1967
.5317	265	20.4251	.7390	8.6016	220.7496	100805	20000.1967
.5000	250	12.9901	.2958	3.4439	135.2155	64096	21000.1967
.4931	207	12.2659	.5513	6.4174	129.5298	72974	22000.1967
.5000	250	12.2993	.2365	2.7536	127.1740	47102	24000.1967
.5000	250	13.1283	.2668	3.1066	136.8238	48736	25000.1967
.5000	215	14.2980	.2016	2.3476	152.6794	62633	26000.1967
.6583	309	19.8582	.4109	4.7846	211.3635	89730	27000.1967
.6899	296	18.6712	.4180	4.8667	198.3610	88207	28000.1967
.4957	272	14.9905	.4932	5.7418	157.0536	64840	32000.1967
.5950	440	16.4896	.4740	5.5185	163.7723	62084	33000.1967
.5000	245	13.5161	.3213	3.7411	141.6580	72715	34000.1967
.5000	365	15.1112	.2867	3.3394	152.5463	61649	35000.1967
.7051	282	22.4943	.7537	8.7729	243.8011	137988	36000.1967
.5633	360	15.2821	.3919	4.5630	154.8224	63261	37000.1967
.5000	441	8.6189	.1541	1.7969	72.1074	27622	38000.1967
.5000	335	9.8391	.1520	1.7711	93.0955	28826	39000.1967
.5000	280	11.8692	.2501	2.9120	120.2464	39022	40000.1967
.3352	157	9.4295	.2372	2.7614	99.6848	41608	41000.1967
.3352	124	7.4234	.1941	2.2602	78.4773	35574	42000.1967
.5000	165	3.9202	.2148	2.5016	35.0750	8761	43000.1967
.4684	310	7.3124	.1954	2.2764	65.2767	28058	44999.1967
.2747	32	.6796	.0704	.8206	5.8024	814	45000.1967
.2500	65	2.3126	.2030	2.3628	22.7605	10589	46000.1967
.4600	354	6.4434	.5998	6.9824	52.3380	9850	52000.1967
19.9362	10226	490.0466	13.8216	160.9114	5049.3963	2288503	
1.0000	512	24.5807	.6932	8.0713	253.2777	11.4791	
		.0479	.0013	.0157	.4937	223	.2469

P 203

program: "tree species" (Oak)

code: 11 dec. indic.: 4 + (2)

card: A Nb. cards: 2

INSTRUCTIONS

regist. 1		regist. 2		regist. F		regist. E		regist. D	
1	A W	33	<	65	S	97	E V	129	
2	E/S	34	D ↕	66	S	98	↕	130	
3	A/↑	35	+	67	S	99	F ↓	131	
4	R/↓	36	R ↓	68	A Y	100	R S	132	
5	D ↓	37	D ↕	69	A <	101	S	133	
6	<	38	B/+	70	*	102		134	
7	R ↑	39	B/↕	71	B +	103		135	
8	E/S	40	F ↓	72	B ↕	104		136	
9	E/S	41	A/↑	73	A/↑	105		137	
10	S	42	R :	74	R :	106		138	
11	F ↑	43	R X	75	R ↑	107		139	
12	C V	44	R S	76	R/◇	108		140	
13	A V	45	R S	77	D ↓	109		141	
14	R S	46	D/S	78	R Y	110		142	
15	F ↕	47	X	79	S	111		143	
16	B V	48	A/↑	80	S	112		144	
17	F ↓	49	F -	81	S	113		145	
18	A <	50	F S	82	S	114		146	
19	R X	51	F S	83	S	115		147	
20	A/↑	52	F S	84	S	116		148	
21	R -	53	E/S	85	F Y	117		149	
22	R ◇	54	+	86	F ↓	118		150	
23	R :	55	E/↕	87	X	119		151	
24	D/S	56	E/↓	88	F/X	120		152	
25	X	57	A/↑	89	E/X	121		153	
26	F X	58	R :	90	A <	122		154	
27	S	59	R -	91	<	123		155	
28	F/↑	60	D/↓	92	C +	124		156	
29	X	61	X	93	C ↕	125		157	
30	<	62	F X	94	F/↓	126		158	
31	R ◇	63	F/X	95	D Y	127		159	
32	A <	64	Y	96	S	128		160	

content of register	
M	operational
A	operational
R	operational
b	$\Sigma n_u g_u$
B	$\Sigma n_u i_u g(u)$
c	$\Sigma n_u v_u$
C	$\Sigma n_u i_u v(u)$
d	$\Sigma n_u v_u w_u$
D	Σn_u
e	subtotals
E	instruct.
f	n_u/instruct.
F	d_u/instruct.

input data	digits
n_u	4

constants on card		constants on card	
	↑		↑
	↑		↑
	↑		↑

REMARKS:

START : First diameter class ⟶ W
Next diameter classes ⟶ V

APPENDIX 3

P 203

program: " tree species " (Oak)

code: 11 dec. indic.: 4 + (2)

card: B Nb. cards: 2

INSTRUCTIONS

regist. 1		regist. 2		regist. F		regist. E		regist. D	
1	A V	33	X	65	S	97		129	
2	R S	34	A/↑	66	S	98		130	
3	F/↑	35	F ↓	67	S	99		131	
4	F ↕	36	F/↓	68	S	100		132	
5	F ↓	37	F *	69	A W	101		133	
6	A X	38	E ↓	70	R S	102		134	
7	A/↑	39	+	71	S	103		135	
8	R ◇	40	E ↕	72	A Z	104		136	
9	R ↕	41	F ↓	73	R S	105		137	
10	R ↓	42	A/↑	74	E/S	106		138	
11	D/*	43	R/↑	75	D <	107		139	
12	X	44	R *	76	R Z	108		140	
13	A/↑	45	R ◇	77	B/<	109		141	
14	F +	46	D ↓	78	<	110		142	
15	F X	47	X	79	Y	111		143	
16	F S	48	E +	80	S	112		144	
17	E/S	49	E/X	81	S	113		145	
18	+	50	/↑	82	S	114		146	
19	F/X	51	A <	83	S	115		147	
20	A <	52	R <	84	S	116		148	
21	√	53	D/+	85	A Y	117		149	
22	E/↕	54	D ↓	86	B <	118		150	
23	C/↓	55	D/↕	87	*	119		151	
24	E/+	56	F ↓	88	C <	120		152	
25	C/↕	57	A/↑	89	<	121		153	
26	F ↓	58	R +	90	C/<	122		154	
27	A X	59	R S	91	√	123		155	
28	A/↑	60	D/S	92	D/<	124		156	
29	R X	61	+	93	R <	125		157	
30	R/:	62	R ↓	94	E/S	126		158	
31	R S	63	E/S	95	R S	127		159	
32	D ↑	64	W	96	S	128		160	

content of register	
M	operational
A	operational
R	operational
b	$\Sigma n_u g_u$
B	$\Sigma n_u i_u g(u)$
c	$\Sigma n_u v_u$
C	$\Sigma n_u i_u v(u)$
d	$\Sigma n_u v_u w_u$
D	Σn_u
e	subtotals
E	subtotals
f	n_u/instruct.
F	d_u/instruct.

input data	digits

constants on card		constants on card	
	↑		↑
	↑		↑
	↑		↑

REMARKS:

START ⟶ V
After last diameter class ⟶ Z
(printing subtotals)

APPENDIX 4

P 203

program: Subroutine 1

code: S 1 dec. indic.: 4 + (2)

card: - Nb. cards: 1

INSTRUCTIONS

regist. 1		regist. 2		regist. F		regist. E		regist. D	
1	A V	33	E/S	65	A <	97		129	
2	R S	34	E/S	66	◇	98		130	
3	D ↓	35	D/<	67	B/↓	99		131	
4	↕	36	R Z	68	B :	100		132	
5	D/↓	37	D <	69	A <	101		133	
6	S	38	<	70	/S	102		134	
7	A W	39	E/<	71	C/↓	103		135	
8	D/↕	40	*	72	:	104		136	
9	+	41	D ↓	73	A <	105		137	
10	R ↓	42	B/↕	74	*	106		138	
11	D/↕	43	D/↓	75	D/↓	107		139	
12	D ↕	44	B ↕	76	:	108		140	
13	B/+	45	E/↓	77	A <	109		141	
14	D ↕	46	C/↕	78	<	110		142	
15	E/↕	47	S	79	D ↓	111		143	
16	B +	48	B Z	80	:	112		144	
17	E/↕	49	D/<	81	A <	113		145	
18	S	50	<	82	√	114		146	
19	A Y	51	√	83	E/↓	115		147	
20	E/+	52	E/<	84	:	116		148	
21	R ↓	53	R <	85	/↑	117		149	
22	E/↕	54	E/S	86	A <	118		150	
23	C/↓	55	E/S	87	R <	119		151	
24	D +	56	A/↑	88	E/S	120		152	
25	D ↕	57	R ↕	89	E/S	121		153	
26	C ↓	58	R :	90	B/*	122		154	
27	D/+	59	R ↑	91	B *	123		155	
28	D/↕	60	D/↓	92	C/*	124		156	
29	S	61	B/↓	93	C *	125		157	
30	A Z	62	X	94	A *	126		158	
31	E/S	63	B :	95	S	127		159	
32	E/S	64	A √	96		128		160	

constants on card		constants on card	
	↑		↑
	↑		↑
	↑		↑

REMARKS:

START ⟶ V
W after inserting SC A(u') STAMPA
Y after inserting SC A(u')-STAMPA/REG.,
SC B(u')-STAMPA, SC B(u')-STAMPA/REG.
After last tree species ⟶ Z and CZ

content of register	
M	operational
A	operational
R	operational
b	subtotals
B	subtotals
c	subtotals
C	subtotals
d	subtotals
D	subtotals
e	subtotals
E	subtotals
f	instructions
F	instructions

input data	digits

APPENDIX 5

P 203

program: Subroutine 2

code: S 2 dec. indic.: 4 + (2)

card: A Nb. cards: 3

INSTRUCTIONS

regist. 1		regist. 2		regist. F		regist. E		regist. D	
1	A V	33	A <	65		97		129	
2	S	34	/S	66		98		130	
3	A W	35	↕	67		99		131	
4	E <	36	C ↕	68		100		132	
5	<	37	+	69		101		133	
6	E +	38	C ↕	70		102		134	
7	D/↕	39	D ↕	71		103		135	
8	X	40	D X	72		104		136	
9	/↑	41	A <	73		105		137	
10	A <	42	/S	74		106		138	
11	R V	43	F/+	75		107		139	
12	B/+	44	F/↕	76		108		140	
13	B/↕	45	E/↓	77		109		141	
14	D ↓	46	D X	78		110		142	
15	E X	47	/↑	79		111		143	
16	A <	48	A <	80		112		144	
17	Z	49	R Y	81		113		145	
18	B +	50	F +	82		114		146	
19	B ↕	51	F ↕	83		115		147	
20	E/↓	52	E <	84		116		148	
21	E X	53	/↓	85		117		149	
22	A <	54	E/S	86		118		150	
23	Y	55	D/↕	87		119		151	
24	C/+	56	V	88		120		152	
25	C/↕	57	A Z	89		121		153	
26	E ↓	58	E/S	90		122		154	
27	↕	59	D/↕	91		123		155	
28	D/↓	60	F/↓	92		124		156	
29	S	61	↕	93		125		157	
30	A Y	62	F ↓	94		126		158	
31	D/↕	63	R S	95		127		159	
32	X	64	S	96		128		160	

content of register	
M	operational
A	operational
R	operational
b	$\Sigma N_{u'}$
B	$\Sigma G_{u'}$
c	$\Sigma i_{G(u')}$
C	$\Sigma i_{V(u')}$
d	$\Sigma K_{1(u')}$
D	subtotals
e	subtotals
E	subtotals
f	$\Sigma V_{u'}$
F	$\Sigma W_{u'}$

input data	digits

constants on card	↕	constants on card	↕
	↕		↕
	↕		↕
	↕		↕

REMARKS:

START ⟶ V
W after inserting SC A(u')-STAMPA
Y after inserting SC B(u')-STAMPA
Z after last stand card

APPENDIX 6

P 203

program: Subroutine 2

code: S 2 dec. indic.: 4 + (2)

card: B Nb. cards: 3

INSTRUCTIONS

regist. 1		regist. 2		regist. F	regist. E	regist. D
1	A V	33	:	65	97	129
2	R S	34	/↑	66	98	130
3	F/↑	35	A <	67	99	131
4	F ↕	36	R V	68	100	132
5	E/S	37	B ↓	69	101	133
6	E/S	38	:	70	102	134
7	E/S	39	A <	71	103	135
8	D/<	40	Z	72	104	136
9	<	41	C/↓	73	105	137
10	B/↓	42	:	74	106	138
11	/↑	43	A <	75	107	139
12	A <	44	Y	76	108	140
13	R V	45	C ↓	77	109	141
14	B <	46	:	78	110	142
15	Z	47	A <	79	111	143
16	C/<	48	/S	80	112	144
17	Y	49	F/↓	81	113	145
18	C <	50	:	82	114	146
19	/S	51	A <	83	115	147
20	F ↓	52	/S	84	116	148
21	/↑	53	F ↓	85	117	149
22	A <	54	:	86	118	150
23	R Y	55	/↑	87	119	151
24	E/S	56	A <	88	120	152
25	E/S	57	R Y	89	121	153
26	S	58	F/↓	90	122	154
27	A W	59	↕	91	123	155
28	D/↓	60	F ↓	92	124	156
29	D/:	61	R S	93	125	157
30	A <	62	S	94	126	158
31	<	63		95	127	159
32	B/↓	64		96	128	160

constants on card		constants on card	
	↑		↑
	↑		↑
	↑		↑

REMARKS:

START ⟶ V
Mean values per ha ⟶ W

content of register	
M	operational
A	operational
R	operational
b	$\Sigma_i N_u$
B	$\Sigma_i G_{u'}$
c	$\Sigma_i i_{G(u')}$
C	$\Sigma_i i_{V(u')}$
d	$\Sigma_i K_{1(u')}$
D	—
e	—
E	—
f	$\Sigma_i V_{u'}$
F	$\Sigma_i W_{u'}$

input data	digits

APPENDIX 7

P 203

program: Subroutine 2

code: S 2 dec. indic.: 4 + (2)

card: C Nb. cards: 3

INSTRUCTIONS

regist. 1		regist. 2		regist. F		regist. E		regist. D	
1	A V	33	D/:	65		97		129	
2	E/S	34	B/:	66		98		130	
3	E/S	35	/↑	67		99		131	
4	R S	36	A <	68		100		132	
5	F ↕	37	R Y	69		101		133	
6	F/↑	38	B ↓	70		102		134	
7	B/↓	39	D/:	71		103		135	
8	D/:	40	B/:	72		104		136	
9	B/↕	41	A/↑	73		105		137	
10	B ↓	42	R ↕	74		106		138	
11	D/:	43	R :	75		107		139	
12	B/:	44	R ↑	76		108		140	
13	/<	45	D/↓	77		109		141	
14	/:	46	X	78		110		142	
15	A <	47	A √	79		111		143	
16	Y	48	A <	80		112		144	
17	C/↓	49	/↓	81		113		145	
18	D/:	50	E/S	82		114		146	
19	B/:	51	E/S	83		115		147	
20	A <	52	S	84		116		148	
21	Y	53		85		117		149	
22	C ↓	54		86		118		150	
23	D/:	55		87		119		151	
24	B/:	56		88		120		152	
25	A <	57		89		121		153	
26	/S	58		90		122		154	
27	F/↓	59		91		123		155	
28	D/:	60		92		124		156	
29	B/:	61		93		125		157	
30	A <	62		94		126		158	
31	/S	63		95		127		159	
32	F ↓	64		96		128		160	

content of register	
M	operational
A	operational
R	operational
b	$\Sigma N_{u'} / \Sigma K_{\uparrow(u')}$
B	$\Sigma G_{u'}$
c	$\Sigma i_{G(u')}$
C	$\Sigma i_{V(u')}$
d	$\Sigma K_{\uparrow(u')}$
D	—
e	—
E	—
f	$\Sigma V_{u'}$
F	$\Sigma W_{u'}$

input data	digits

constants on card	↑	constants on card	↑
	↑		↑
	↑		↑
	↑		↑

REMARKS:

START ⟶ V (printing model trees)

APPENDIX 8

SUMMARY

Contribution to the Automation of the Calculations Involving the Forest Inventory with the Aid of an Office Computer

In this contribution an attempt was made to perform the calculations involving the forest inventory by means of an office computer Olivetti P203.

The general program (flowchart 1), identical for all tree species except for the values of the different parameters, occupies the tracks A and B of a magnetic card used with this computer. For each tree species one magnetic card is required, while some supplementary cards are used for the subroutines. The first subroutine (flowchart 1) enables us to preserve temporarily the subtotals between two tree species (mixed stands) an so called special or stand cards (SC). After the last tree species the totals per ha are calculated and printed on the former, the average trees occuring on the line below. Appendix 1 gives an example of a similar form resulting from calculations involving a sampling in a mixed stand consisting of Oak (code 11), Red oak (code 12), Japanese larch (code 24) and Beech (code 13). On this form we find from the left to the right: the diameter class (m), the number of trees per ha, the basal area (m2/ha), the current annual increment of the basal area (m2/year/ha), current annual volume increment (m3/year/ha), the volume (m3/ha) and the money value of the standing trees (Bfr/ha). On the line before the last, the totals of the quantities mentioned above and of all the tree species together are to be found. The last line gives a survey of the average values dg, $\bar{g}$, $\bar{i}_g$, $\bar{i}_g$, $\bar{v}$ and $\bar{w}$.

Besides this form each stand or plot has a so-called « stand card SC (u') » on wich the totals cited above as well as the area of the stand or the plot and its code are stored. Similar « stand cards » may replace in many cases completely the classical index cards; moreover they have the advantage that the data can be entered directly into the computer so that further calculations, classifications or tabling can be carried out by means of an appropriate program or subroutine. The subroutine 2 (flowchart 2) illustrates the use of similar cards for a series of stands or eventually a complete forest, the real values of the different quantities above are calculated and tabled (taking into account the area). At the same time the general totals and the general mean values per ha, as well as the average trees are calculated and printed. Appendix 2 represents a form resulting from such calculations by means of subroutine 2.

SAMENVATTING

Bijdrage tot de automatisering van de berekeningen bij de inventarisatie van bossen met behulp van een bureelcomputer.

In dit artikel werd een poging gedaan om met behulp van een bureelcomputer Olivetti P203, het rekenwerk te automatiseren dat bij de inventarisatie van bossen noodwendig is.

Het algemeen programma (blokschema 1) dat op de waarde van de diverse parameters na, voor alle boomsoorten hetzelfde is, neemt de beide sporen A en B in van een klassieke magneetkaart, welke bij deze machine wordt gebruikt. Per boomsoort is bijgevolg één enkele magneetkaart nodig, terwijl een paar supplementaire kaarten voor de subroutines worden aangewend. Een eerste subroutine (blokschema 1) maakt het mogelijk om tijdelijk de subtotalen tussen twee boomsoorten in (gemengde bestanden) te bewaren op zgn. speciale- of bestandskaarten (SC). Na de laatste boomsoort kunnen de totalen per ha worden berekend en op het formulier uitgeschreven, terwijl op een volgende lijn de gemiddelde bomen of modelbomen voorkomen. Bijlage 1 geeft een voorbeeld van een dergelijk formulier dat het resultaat weergeeft van berekeningen afkomstig van opnamen in een gemengd loofhoutbestand van inlandse Eik (code 11), Amerikaanse Eik (code 12), Japanse Lork (code 24) en Beuk (code 13). Op dit dokument bevinden zich van links naar rechts: de diameterklasse (in m), het stamtal per ha, het grondvlak (in m2/ha), de lopende jaarlijkse aanwas van het grondvlak (in m2/ha) de lopende jaarlijkse volume-aanwas (in m3/ha/j) het volume (in m3/ha) en de geldwaarde (in Bfr/ha) van de bomen op stam.

Op de voorlaatste lijn worden de totalen uitgedrukt van alle hoger vernoemde grootheden en voor alle boomsoorten samen. De laatste lijn geeft een overzicht van de waarden van de modelboom d_g en $\bar{g}$, $\bar{i}_g$, $\bar{i}_g$, $\bar{v}$ en $\bar{w}$. Buiten dit dokument bezit elke opname nog een zgn. « bestandskaart SC (u') » waarop naast de hoger vernoemde totalen, ook nog de oppervlakte van het perceel of bestand en een codenummer of volgnummer zijn gestockeerd. Dergelijke « bestandskaarten » kunnen in vele gevallen de klassieke steekkaarten volledig vervangen en hebben daarenboven het grote voordeel de gegevens rechtstreeks in de computer in te lezen, waardoor met behulp van een aangepast programma verdere berekeningen, klassifikaties of tabellaties kunnen doorgevoerd worden.

De subroutine 2 (blokschema 2) is een voorbeeld van het gebruik van dergelijke kaarten, waarin voor een reeks van bestanden of eventueel een gans bos, de werkelijke waarden van de diverse vernoemde grootheden (rekening houdend met de oppervlakten) worden berekend en getabelleerd. Hierbij worden tevens de algemene totalen, het algemeen gemiddelde per ha alsook de modelbomen berekend en uitgedrukt. Bijlage 2 geeft een voorbeeld van een dergelijk dokument dat het resultaat is van hoger genoemde berekeningen met behulp van de subroutine 2.