THE SPRING RESEARCH ASSOCIATION

A SURVEY OF SOME PROGRAMMABLE

CALCULATORS WHICH CAN BE USED

TO AID SPRING DESIGN

by

A. H. Wilkinson, B.Sc.

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(May 1972)

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SUMMARY

Seven programmable calculators, which can be

used to aid spring design, are compared and the

advantages and disadvantages of the various

systems are discussed.   All the calculators are

considered to be good value, and choice would

depend largely upon individual preferences and

available funds.

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1. INTRODUCTION

In recent years a number of programmable calculators have come into existence. These are most useful labour-saving devices and are particularly suited to aiding spring design. Not only are they capable of performing fairly complex calculations automatically, but in general they are also capable of making logical decisions, such as repeating a design calculation on a trial and error basis until the desired result is achieved.

The calculators which have been selected for this survey do not by any means include all those which are presently available. A sample of seven has been chosen over a fairly wide price range, all of which are capable of being programmed to aid spring design, storing pro- grammes internally, storing programmes externally on cards or tape, producing a printed record of numerical solutions and making simple logical decisions. Also it is felt that they all represent good value.

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2. CALCULATORS

1. Muldivo Digiputer.   IME 86S, DG308 and printer

Available from:-   Muldivo Ltd.,
                                28-42 Banner Street,
                                London E.C.1
                                Tel: 01-253-7711/7

2.   Diehl Combitron S and Dilector

Available from:-   Northern Office System
                                Cardinal House,
                                163 Cardinal Road,
                                Leeds 6
                                Tel: 0532 59874

3.   Monroe 1265

Available from:-   Litton Business Systems Ltd.,
                                Litton House,
                                27 Goswell Road,
                                London E.C.1.
                                Tel: 01-253 3090

4.   Monroe 1665

Available as above

5.   Olivetti Programma 101

Available from:-   British Olivetti Ltd.,
                                Camden House,
                                The Parade,
                                Birmingham 1
                                Tel: 021-236 9012

6.   Hewlett Packard 9100A and 9120A

Available from:-   Hewlett Packard Ltd.,
                                224 Bath Road,
                                Slough,
                                Bucks.
                                Tel: Slough 33341

7.   Wang 700A and 701

Available from:-   Wang Electronics Ltd.,
                                Tavistock House,
                                Tavistock Square,
                                London W.C.1. H9LG
                                Tel: 01-387 0204/5

3. GENERAL CONSIDERATIONS

Each of the above calculators has its relative merits and faults and it is no easy matter to weigh one against another. In order to simplify the comparison a table has been drawn up which summarises the differences; this can be seen on page 10. A brief description of these differences follows.

3.1 Visual Display Units

The Muldivo, Hewlett Packard and Wang have visual display units. The Muldivo has a single register display, the Wang has a double register display and the Hewlett Packard a triple register display.

3.2 Print Units

All are equipped with some means of printing although in some cases there is a considerable reduction in price if it is excluded. All but the Wang have simple numerical line printers. The Hewlett Packard printer is based on an electric printing principle and requires special paper.

The Wang printer uses a wide roll of lined paper. It is possible to programme the unit to print words such as "Mean Coil Diameter = 1.000 inches" etc.

It is possible to obtain graph plotting units for both the Wang and Hewlett Packard. These could be used to plot load/deflection characteristics of non linear rate springs etc. This facility is, however, somewhat expensive. The Wang unit costs £965 extra and the Hewlett Packard unit costs approximately £1300 extra.

3.3   Internal Programme Stores

The amount of internal storage space is a very important consideration as this limits the length and, to some extent, complexity of programmes which the calculator can execute. The number of stores limits the number of programmes which can be stored at any one time as each programme must occupy one or more stores. For example; the Muldivo can store one programme of 512 steps or eight programmes of 64 steps each etc.

In order to give some indication of the relationship between programme size and number of steps required, a simple spring programme is shown on page 9 . This programme performs a function similar to that of the SRA Spring Calculator. The number of programme steps required would be about 120 and would vary between calculators as some have special features which reduce the number of steps required. However, this programme does border on the limits of the Diehl, Monroe and Olivetti calculators and, in some of these, extra manual operation may be necessary.

All the calculators can be programmed manually via the keyboard. This involves simply performing the particular calculation manually with the "programme key" engaged. The calculator will then perform the calculation automatically, pausing at the appropriate points for input of data.

In all but the Wang the internal memories are erased when the units are switched off.

3.4   External Programme Stores

All the calculators have facilities for storing programmes externally on magnetic or punched cards or tape.

The Diehl system seems good for the price as a large number of programmes can be stored on an endless belt of tape. Any one of these is available at the touch of a button. The system is, however, rather slow in operation.

Magnetic cards or tape have little advantage over punched cards or tape once the required programmes have been written and stored on them, but there is a considerable difference in the amount of effort required to store the programme. In order to store a programme on a magnetic card, the card is inserted into the calculator which has previously been programmed via the keyboard in the manner described in section 3.3. A button is pressed and the programme is stored in an instant. The method of storing a programme on a punched card (or tape) is somewhat more complex. The programme must be written out in terms of the order in which the buttons would be pressed if the calculator was to be operated manually. Each button has a three or four digit code (a list of these would be supplied with the instrument) and these must then be punched out in order on the card by means of a hand punch.

In the opinion of the writer the order of merit for the different systems is as follows:-

1. Magnetic tape
2. Magnetic card
3. Punched tape
4. Punched card

All the suppliers of calculators which use punched cards or tape provide a punching service to their customers although Monroe insist that punching is so easy that such a service is not really necessary.

3.5 Library of Programmes

A comprehensive library of programmes is available
from all the suppliers including such subjects as statistics,
accounting, engineering etc. Some spring programmes were
available but those which were seen did not appear to be of
any great value.

3.6 Guarantee and Maintenance Costs

All calculators but the Monroes have a twelve month
comprehensive guarantee (excluding damage due to negligence).
The Monroe Calculators have only a three month guarantee.

Maintenance charges vary quite considerably, as shown
in the table on page 10. The representative from Wang said
that maintenance costs would be very small as this generally
involved the replacement of any one of a number of "plug in"
units. Only labour would be charged for, which would be a
matter of a few pounds per visit. This seems to be very
reasonable.

The estimated cost of maintaining the calculators over
a period of five years is given below:-

Muldivo	£224
Diehl	£260
Monroe 1265	£400
Monroe 1665	£627
Olivetti	£360
Hewlett Packard	£800
Wang	Probably less than £200

3.7 Speed of Operation

The calculating speed of the calculators does vary but no tests were actually carried out to compare them.

To give some indication of how long calculations took, the time taken to perform one complete calculation using the programme shown on page 9 and the Hewlett Packard calculator was about 45 seconds including inserting the magnetic card to programme the unit. About 30 seconds was taken up by manual operation such as programming the instrument via the card and feeding in data. In view of this, variation in calculating speeds is probably not very important for this type of calculation.

However, the Diehl calculator did seem to be somewhat slower than the others.

3.8 Some Miscellaneous Differences

The Monroe 1665 has micro-programme keys which are basically sub-routines such as raising a number to a power, sines, cosines, logarithms etc. These are useful and would save programming steps.

The Monroe 1665, the Hewlett Packard and Wang are capable of storing and using numbers in exponent form. In this way they can use numbers varying in size from 10^{+99} to 10^{-99}.

The durability and appearance of the calculators is in general very good but the Muldivo programming unit is rather delicate. The Hewlett Packard is very professional in appearance and a great deal of thought has gone into the design and layout of keys etc.

4. DISCUSSION

There are numerous differences between these calculators and only the major ones have been described in this report. The only satisfactory way to determine which calculator is most suited to any particular application is to arrange demonstrations of all of them. Having read this report it should then be possible to evaluate each one thoroughly.

New calculators are constantly appearing on the market and it seems likely that even better value will be obtained in future years than at present. Wang have very recently introduced a 500 series model which appears to have retained many of the good features of the 700 series, but is much cheaper. Japanese calculators are becoming very competitive; in particular Seiko Ltd. have very recently introduced a programmable machine.

It is suggested that the reader should, when asking for a demonstration of any machine, request that it be programmed to perform the spring calculation shown on page 9 . The operating time and number of programme steps required would be most useful information.

5. CONCLUSIONS

The Wang 700A is the most powerful of those examined and the others follow approximately in order of price. The cheapest calculator which is capable of aiding spring design is, therefore, the Diehl Combitron S with the Dilector (tape reading unit). However, as far as best value for money is concerned there is little to choose between them. The final selection would depend largely upon how much money was available.

6.   SAMPLE PROGRAMME

          Sample programme for programmable calculator
       to check the design of a helical compression spring

1.   Read from keyboard and print.

          Wire diameter   (d)

          Mean coil diameter (D)

          Active coils   (n)

          Free length   (FL)

2.   Calculate and print.

          Spring index C = D/d

          Rate   R = $\dfrac{11,500,000d}{8nC^3}$

          Solid length SL = $(n+1)d$

          Solid load   SP = $(FL-SL)R$

          Solid stress SS = $\dfrac{8.SP.C.(C+0.2)}{\pi d^2 (C-1)}$

3.   Read and print Load (P).

4.   Calculate and print.

          Length   =   FL-P/R

          Stress   = $SS.\dfrac{P}{SP}$

5.   Await instruction to jump back to either
       statements 1 or 3.

TABLE I SUMMARY OF FEATURES

CALCULATOR	PRICE (Approx)	EXTERNAL STORAGE	INTERNAL STORAGE	PUNCHING FACILITIES	MAINTENANCE COSTS
DIEHL Combitron S and Dilector	£1346	Punched Tape (Plastic) £5 per 100 yds	120 steps in 10 stores	Manual Punch £120 extra or service 50p per 100 steps	1st Year Free then £65 per year
MONROE 1265 and card reader	£1500	Punched Cards £1.25 per 100	128 steps in 8 stores	Hand Punch Supplied	3 Months Free then £84 per year
MULDIVO IME 86S DG 308 Printer	£1730 (£1300 without printer)	Punched Cards £1.25 per 100	512 steps in 8 stores	Hand Punch Supplied or Service £1.25 per programme	1st Year Free then £56 per year
OLIVETTI PROGRAMMA 101	£1900	Magnetic Cards £1.10 each	120 steps in 2 stores	N/A	1st Year Free then £90 per year (compulsory)
MONROE 1665 and Card Reader	£2250	Punched Cards £1.25 per 100	128 steps in 8 stores	Hand Punch Supplied	3 Months Free then £132 per year
HEWLETT PACKARD 9100 A and 9120 A	£2620 (£2060 without printer)	Magnetic Cards 26p each (200 lots)	196 steps in 16 stores	N/A	1st Year Free then £200 per year
WANG 700A and 701	£3620 (£2650 without printer)	Magnetic Tape Cassettes £6 each	960 steps in 120 stores	N/A	1st Year Free then Labour charges only at cost