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NATIONAL RESEARCH COUNCIL OF CANADA

DIVISION OF BUILDING RESEARCH

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TECHNICAL NOTE

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FOR INTERNAL USE

PREPARED BY D. G. Stephenson

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DATE November 1961

PREPARED FOR Record Purposes

✓ [Signature]

SUBJECT D. B. R. DIGITAL RECORDING SYSTEM

There are a great many instances in testing and research work where it is desirable to use a digital computer for the analysis of experimental results. The processing may be as simple as applying calibration factors and computing averages, or it may involve extensive calculations such as finding harmonic components of periodic functions or calculating correlation functions. In either case the analysis can be done accurately and economically by a computer of modest accomplishments. The advantages of using a computer for data processing can only be fully realized, however, when the data are initially recorded in a form that can be read by the computer. The design of a recording system is, therefore, largely governed by the type of computer that will be used to process the records. This note describes an adaption of conventional strip-chart potentiometer recorders to produce 5-channel punched paper tape in a form suitable for input to the Bendix G-15 digital computer.

D. B. R. Recording System and Tape Format

In building research it is usually necessary to record several outputs from an experiment. While each output changes rather slowly, it is satisfactory to use one recorder for many signals by measuring them in sequence. The basic measuring instrument in the D. B. R. system is a 16-point self-balancing potentiometer type recorder (e. g. Leeds and Northrup or Honeywell) with a recording speed of 4 points per minute.

The standard recorder is fitted with the following extras:

1. A digital encoder with a resolution of 0.1 per cent of the recorder span (i. e. from 000 to 999 for full range of the recorder).
2. A readout switch that is closed momentarily as each reading is recorded.
3. A duplicate input selector switch used as part of the programmer.

The encoder and the readout switch are electrically connected to a tape-punching unit, while the duplicate selector switch controls a relay programmer that governs the recording format. The encoder, tape punch and associated control unit used by D. B. R. are manufactured by Datex Corporation. (This was thought to be the best equipment available when this system was designed in 1958.) The equipment will do the following operations:

1. Print and punch a 3-digit decimal number representing the value of the recorder input. This number is added to the contents of a mechanical adding register.
2. Print and punch the contents of the adding register. This clears the register.
3. Punch blank tape.
4. Punch control code 1.
5. Punch control code 2.

Each of these operations is initiated by making an appropriate connection between the control terminals on the control chassis. The relay programmer was designed and built at D. B. R. to make the appropriate connections for the special format required for input to the Bendix G-15 computer. The circuit diagram for this programmer is available upon request.

The Bendix computer requires a control code 1 to separate the data into blocks of 29 digits, and after not more than 27 blocks there must be a code 2 and a few inches of blank tape. In the D. B. R. format each 29-digit block (i. e. 4 words of computer memory) contains 8 readings (24 digits without any separation or point identification) followed

by their sum (5 digits including leading zeros). The sum is included to provide a check on the accuracy of the tape punching and reading operations since the 5-channel Bendix code does not use a parity bit. When this tape is read by the computer, the first 24 digits in each block are separated into eight 3-digit numbers and these are added and compared with the recorded sum. If they agree, then the punching and reading operations were performed correctly.

To compensate for not recording any sign, the recorder zero is recorded once in each block. The digital output corresponding to the recorder zero can, therefore, be subtracted from each of the other values to give numbers proportional to each input signal, including sign. This arrangement automatically corrects for any change in the recorder zero whether it is done intentionally or is the result of drift.

General Purpose Data Transcription Program

The paper tape punched in the format just described must be read by a basic machine language program. It is often preferable, however, to program the data processing computations in an interpretive program language that uses floating point numbers. A machine language program for the Bendix G-15 has been prepared that reads the close-packed paper tape and writes the data on magnetic tape as floating point binary numbers which can be used with an Intercom 500 program. This program for transcribing data may be considered as a part of the data recording system since it only gives a magnetic tape record of the experimental results. To produce a magnetic tape record in this way requires much less expensive hardware than would be needed to record floating point numbers directly on magnetic tape as the measurements are made.

A tape punch unit and its associated control chassis and relay programmer form a separate portable unit which can be used with any recorder that has an encoder and control switches. In most experiments, a large portion of the time is taken to establish the required conditions. During this stage the digital output is not required so that one punch unit can be shared between several experiments. In Canada the punch and its associated equipment costs about \$3000; the encoder and accessories that must be added to a standard recorder cost about \$500.

At the Division of Building Research, digital recording equipment is used in the following situations:

1. To record 3 periodic temperatures in a periodic heat flow apparatus for measuring the thermal conductivity and diffusivity of moist materials.
2. To record the weather data needed to define the environment for outside test work. This includes air temperature, humidity, wind speed and solar radiation on horizontal and vertical surfaces.
3. To record the output of a multipoint electronic manometer used to measure the pressure differences across the walls of a test house. This pressure measuring system will be described in a separate note.

The data that are recorded on punched paper tape can be edited or presented in tabular form without the use of a digital computer since it can be read and reproduced by a tape controlled electric typewriter (Friden Flexowriter). The flexowriter at D. B. R. automatically operates the tab key after a specified number of digits have been read and typed. The eight 3-digit numbers and the sum can, therefore, be reproduced as a table with 9 columns. The control code 1 is recognized as a carriage return by the flexowriter.