NOTES ON SOME DATA-HANDLING DEVICES DEVELOPED
AND BEING DEVELOPED FOR NUCLEAR EXPERIMENTATION

by

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The purpose of these notes is to review what has been
done in this respect and, in particular, to stress the importance
of a general scheme for data handling in nucleonics.

We received requests from various sources to make dif-
ferent instruments, and we think that it is now time to try to ful-
fil many requirements with a system of flexible plug-in boxes.

We would be glad to receive comments (favourable or other-
wise!) on these notes.

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I. EXISTING EQUIPMENT

1. Pulse-height analysers

A large part of digital equipment is made by the different
pulse-height analysers. Since they now arrive as black boxes at
CERN, and since their use is well known, we need not give too much
time to this point.
Some circuitry has been developed for them (binary-decimal converters and print-out systems).

2. **Scaler print-out system**

Some years ago a scaler print-out system was developed (von Dardel and Iselin) working on a simple addition of 9 pulses to each decade and 10 to the last.

This simplified box was built with relays and selectors. It proved itself useful and worked perfectly, but its life is now finished.

3. **IEP electronics**

This was also developed some time ago. It uses reversible binary counters, complex logic, an IBM typewriter, and punched tape. These circuits were the first transistor circuits made at CERN. The difficulties with this first batch were the spurious pulses! Also interesting was the problem of reading out of the scaler’s content during ± or - counting. Existing IEP still uses this electronics with some modifications. The use of punched tape as a medium for storing information directly suitable for "Mercury" was here an absolute necessity. In the same way, for reasons of speed, facility, and later checks, physicists want more and more such means for improving the possibilities of counter experiments. (The electronics of IEP is now 100% in the hands of D.D. Division.)

4. **Trochotron scalers**

Some trochotron scalers were made (with print-out) but since some trouble occurred due to a high sensitivity of trochotrons (beam switching tubes), to magnetic influence, and also to change in characteristics, we stopped using this type of scaler. (Harwell also stopped using trochotrons.) They kept their basic advantages of relative circuit simplicity (no decoding matrix needed!) and they were "fast" at the time (10 Mc).
Now, with existing fast and cheap transistors, we think that beam switching tubes are obsolete, unless for special (?) use.

5. Automatic set-up for measurement of radioactive samples

This transistorized box was developed for the radio-chemistry department (only the electronics) and it organizes the drive, start, stop, timing, as well as measuring activity of samples (maximum 40 samples).

The print indicates the number of the sample, the time, the selected counting time for a sample measurement, the sample number, and the activity of this sample.

This instrument works satisfactorily.

II. EQUIPMENT UNDER DEVELOPMENT.

1. Digital Event Automatic Recorder (DEAR) (Note 61-1, Electronic Group

This very important box— not yet completed— has been designed for accepting many fast input signals during a short gate, recording them on ferrites, then on paper tape. This group of signals is called a Pattern or an Event. The instrument can "absorb" 16 patterns or events per PS burst. The number of inputs is 64 (for paper tape output).

When 16 events have been accepted they are punched out.

The input signals are gated by a 30 or .100 ns pulse common to all inputs (which can be delayed externally!). Inputs are divided into 16 plug-in units with 4 inputs each.

This version of paper tape output could be modified to a magnetic tape output if necessary (compactness of information!). Then 80 inputs could be provided. Instead of parallel (pattern) units, a scaling unit can be plugged in so that encoders can feed pulse height information of some event pulses.
The internal core memory (64 x 16 bits) can be used in different ways, for example:

64 inputs, 16 events (max.) or less;
32 " 32 " " " " ;
16 " 64 " " " .

Many test features are incorporated in the box (parity check, artificial injection of 111..., step by step in larger or small blocks, etc.).

Maximum resolution of the box is approximately 15 μs between events, but the internal dead-time can be adjusted manually to some ms, or then be given by an external signal.

2. Printing of 20 scalers

This arrangement -- nearing completion -- is, in fact, a modern version of what was described in Section I.2. It is fully transistorized and a new transistorized 10 Me is used within the system.

The read-out system is different from that in Section I.2. Each scaler is read out in parallel, and all information of this "information block" comes simultaneously to the printer.

Because printing was used, only one decoding box was made to transform binary-coded decimal scaler information in pure decimal (for the printer!).

The binary-coded decimal is still shown on the scalers (code 2421) to allow observation of counting speed, no count, etc. Decimal information is directly readable with some practice. Pushing on "look" button on a wanted scaler shows immediately decimal values in the decoding box (Mixies).

This system was so made because it avoids all decoding matrices in the scalers (240 diodes/scaler).
Since there is a strong tendency to use many scalers and print-out, we think this solution was the best. 20 scalers can be printed in ~ 5 seconds.

A test unit shall inject 111..., 222..., 333..., etc., for checking scalers (at 10 Mc) and printer.

3. General purpose print/punch box

    Looking at Sections II.1 and II.2 we see that some common points exist and that some sort of intermediate box could be made, fulfilling both conditions of recording a pattern (event) and recording scalers.

    We can still increase the generality of the box by saying that we want to print, or to punch, or to do both simultaneously (print and punch). We can also ask the box to handle "information blocks, or words" without specifying if scaler, event pattern, etc. We could thus fulfill requirements that are to be executed like the printing or punching, or both, of:

    i) 30 scalers (max.);
    ii) output of pulse-height analysers (1 scaler);
    iii) output of analogue to digital converters (ex: digital voltmeters) in different applications, for example a) trace follower (made by Richez for Fidecaro and others);
        b) magnetic measurements (Hedin and others);
        etc.;
    iv) one event/burst: one event could consist of many information blocks (max. 30). Each can be either a 10 Mc scaler or a pattern input (parallel independent inputs) with max. 18 bits/unit. Since 30 blocks could be used, a great number of bits could be accepted per event. Of course, this would be a simplified type of event recorder since only one event can be accepted per burst. There is still a strong interest in such a solution (Fidecaro et al.).
v) Fast pulse-height analyser. (Mustafa: Multichannel stacked discr. fast analyser)

This box is not yet realized but we were asked to study the problem. By doing a stacked discriminator system and using, say, 20 scalers (one for each channel) we come back to the print of 20 scalers. But we have here to decide if we are going to use window discriminators or "one side" discriminators. For this application we think that window discriminators are not necessary, because of their relative complication and comparatively slower speed. Half the circuit can do twice as fast for a "one side" discriminator provided a simple system of transformation from integral to differential type is feasible. It is not difficult to arrange the "test unit" to inject pulses to the scalers so that in the end the successive subtraction of one scaler to the others (beginning at the lowest count = highest level) leaves the result in a differential form. Simultaneously print/punch can be done.

Since the "test unit" already contains an oscillator which can be started, then stopped, only some modifications are needed to obtain this small computation. The time for computation + print/punch for 20 channels is approximately 10 seconds.

Of course, other systems for fast pulse-height analysis could be thought out but the main idea here is to use the existing 20 scalers print/punch as a logic part of the P.H.A. The "test/P.H.A." unit shall be made after the print/punch, this last unit being designed at present.

III. USE OF PRINT PUNCH - Examples

At the end of these notes we have indicated in a simplified manner some examples of use of the print/punch box (PP box) in correlation with the "test/P.H.A. box", the decoder, the printer, the puncher. The power supplies which are indicated are all the same.
They were originally made for II.2. (20 scalers print-out). We also intend to have a "32 addresses electronic selector", because existing ringscalers with 10 addresses are not compact enough.

IV. CONCLUSION

Other instrumentation with other requirements will, of course, be needed and there is a high probability that in the future faster and larger aggregates will be needed, combined with fast circuitry.

We would like to recall that such boxes are complicated and cannot be produced in a day (or even two). That is the reason why we have tried in these notes to indicate the direction in which we go, so that experimenters can prepare their experiments knowing what we have in mind, and vice versa.

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**Fig. 1**

<table>
<thead>
<tr>
<th>Basic elements</th>
<th>32 way selector</th>
<th>Print Punch</th>
<th>Test + P.H.A.</th>
<th>Power supply</th>
</tr>
</thead>
<tbody>
<tr>
<td>OUT at selected value</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1900/KF/keW
Fig. 2.
Print/Punch of one scaler.

<table>
<thead>
<tr>
<th>32 ways selector</th>
<th>PP logic</th>
<th>Test</th>
<th>Scaler 10 Me</th>
<th>Power supply</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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</tbody>
</table>

Decoder

Printer

Puncher

Fig. 3.
Punch of one scaler.
No test.

<table>
<thead>
<tr>
<th>32 ways selector</th>
<th>PP logic</th>
<th>Scaler 10 Me</th>
<th>Power supply</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

Puncher

Fig. 4.
Punch of one pattern unit (one event/burst, only 18 bits/event).
No test.

<table>
<thead>
<tr>
<th>32 ways selector</th>
<th>PP logic</th>
<th>Power supply</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

Gate

Inputs

Puncher

900/NP/kw
Fig. 5. Print/Punch of one event/burst.

Event: $3 \times 10$ Me scalers.

$4 \times 18$ bits patterns.

<table>
<thead>
<tr>
<th>Scalers, pattern or other units could be used</th>
<th>10 Me scaler</th>
<th>10 Me scaler</th>
<th>10 Me scaler</th>
<th>Power supply</th>
</tr>
</thead>
<tbody>
<tr>
<td>16 bits pattern unit</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$\ldots$</td>
<td>$\ldots$</td>
<td>$\ldots$</td>
<td></td>
</tr>
<tr>
<td>32 way selector logic</td>
<td>FF</td>
<td>Test</td>
<td>$18$ bits</td>
<td>Power supply</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$\ldots$</td>
<td></td>
</tr>
</tbody>
</table>

Decoder

Print

Punch
Fig. 6. General example.

Print/Punch of $2 \times 10 \text{ Mc scalers}$.

2 x Pattern units

3 x Digitized information.

<table>
<thead>
<tr>
<th>10 Mc scaler</th>
<th>10 Mc scaler</th>
<th>18 bits pattern unit</th>
<th>Power supply</th>
</tr>
</thead>
<tbody>
<tr>
<td>18 bits pattern unit</td>
<td>Converting unit</td>
<td>Converting unit</td>
<td>Power supply</td>
</tr>
<tr>
<td>32 way Selector</td>
<td>PP logic</td>
<td>Test</td>
<td>Converting unit</td>
</tr>
</tbody>
</table>

Decoding

Printer

Puncher

Fig. 7. The Print/Punch of the P.H.A.

This corresponds to PP of 20 - 30 scalers with adequate subtraction between Print/Punch, this being done by the Test/P.H.A. unit.