CONNECTION OF A SMALL COMPUTER TO A PHOTOPRODUCTION EXPERIMENT

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(presented by R. FESSEL)

We wish to describe the projected use of a small digital computer on-line with photoproduction experiments at the CEA. Since the function of this computer will be to service the experiment, a discussion of the entire system should begin with a description of the experimental apparatus.

The heart of the experiment is a large magnetic spectrometer system which rests on a 40 foot long pivoted table for angular distribution measurements (see Fig. 1). The magnetic system consists of a quadrupole doublet which images the particles leaving a hydrogen target into a nearly parallel beam. This parallel beam then goes through two deflecting magnets in tandem which serve to measure the momentum of the particles. The velocity of the particles may be measured in either one of two ways: Between the doublet and the deflecting magnets, a differential gas Cerenkov counter may be inserted, or time of flight of the particles may be measured between two of the triggering counters.

Distributed along the trajectory of the particles are scintillation counter hodoscopes which measure either the vertical or horizontal coordinate of the trajectory. In particular, the vertical hodoscope in the middle of the doublet is used to measure the azimuthal angle of the trajectory at the target. The horizontal hodoscope between the doublet and the deflecting magnets serves a twofold purpose: Firstly, it is used to measure the polar angle of the particle at the target; secondly, since the beam at this hodoscope is parallel, this hodoscope in conjunction with the 9 (redundant) double horizontal hodoscope behind the deflecting magnets, gives a rather direct measure of the momentum.

On the other side of the beam is another, smaller, pivoted table. On this rests a total absorption Cerenkov counter which is used for detecting deday gamma rays from π^0 and η^0. This Cerenkov counter is being replaced by a hodoscope of 48 lead glass blocks, each 3" x 3" x 27", arranged in a 6 x 8 array (see Fig. 2).

A photoproduction event is signalled by a triple coincidence of three trigger counters located on the large table. The general logic for processing an event is shown in Figure 3. A trigger opens the gates on the hodoscope discriminators and enables the digitizers for the total absorption counter pulse height, the time of flight pulse height, etc. The binary number of which counter in each hodoscope fired is encoded and all the bits of the event are stored in a 48 bit flip flop register (this temporary memory is currently being expanded to 96 bits).

The information in the buffer register is then sent to two places. All the bits in the buffer are punched on paper tape. Ten of the bits are used to select an address in a pulse height analyzer memory (Fig. 4). The information available during the collection of data is the contents of several scalers. The only information available to the experimenter immediately after the collection of data is the contents of the pulse height analyzer memory which is only a fraction of the total information. It is also in such a form that it can only be interpreted crudely on the spot. This method of collecting data has proven inadequate for monitoring the behaviour of the entire system during an experiment.

In view of the limitations of the present system as discussed above, it was felt that the best solution to the problem would be to connect a general purpose digital computer to the apparatus. The choice of which computer to use was governed both by price and availability. The computer chosen was a copy of the prototype of the LINC computer (see Fig. 5). This computer was originally designed by the Digital Computer group of the MIT Lincoln Laboratory and further developed by the same group as the MIT Center Development Office for Computer Technology in the Biomedical Sciences; it will be commercially available in the near future at a price of $35,000 to $40,000. It was originally designed for use in biological experiments; however, it is sufficiently flexible that it can be adapted to the present use. The prototype is a transistorized machine with a 1024 word magnetic core memory. The word length is 12 bits and the memory access time is 10 microseconds. It has a rather large set of order codes obtained by using two words for many of the instructions (Fig. 6). The only standard input-output hardware is a keyboard, two separately addressable oscilloscope displays, and the magnetic tape system. The only really novel feature of the machine is the use of small reels of magnetic tape driven by a simple mechanical arrangement with storage on the tape in fixed length, addressable blocks. The use of a fairly rapidly accessible mass storage medium makes this a much more powerful machine than it would otherwise seem, (see Figs. 7 and 8).

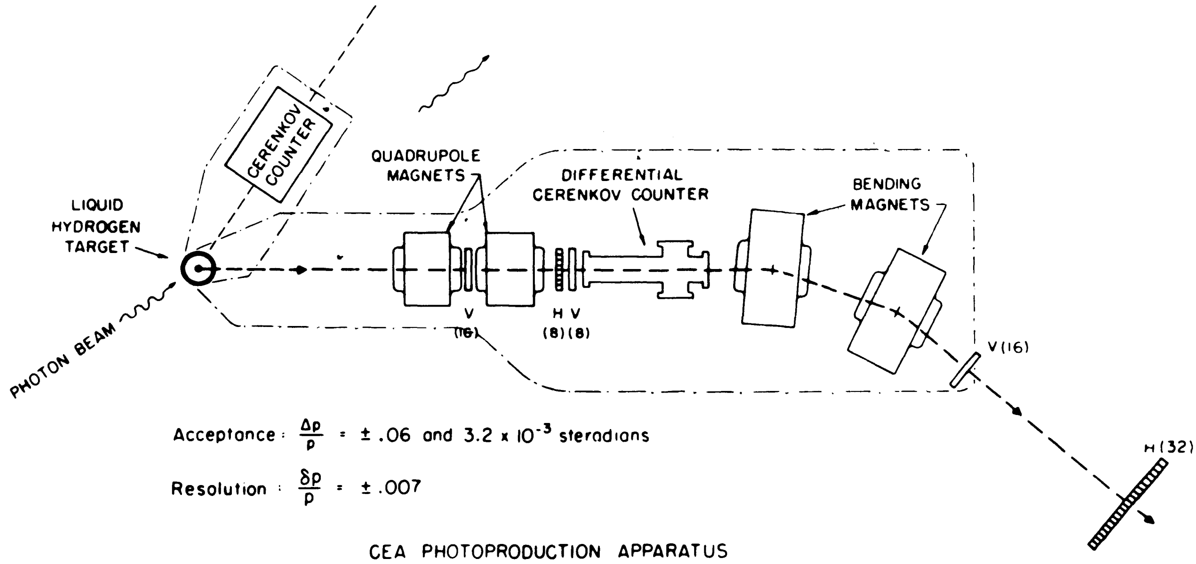

CERENKOV COUNTER
QUADRUPOLE MAGNETS
DIFFERENTIAL CERENKOV COUNTER
BENDING MAGNETS
LIQUID HYDROGEN TARGET
PHOTON BEAM
V (16)
H V (8) (8)
V (16)
H (32)
Acceptance: $\frac{\Delta p}{p}$ = ± .06 and 3.2 x 10^{-3} steradians
Resolution: $\frac{\delta p}{p}$ = ± .007
CEA PHOTOPRODUCTION APPARATUS

Fig. 1

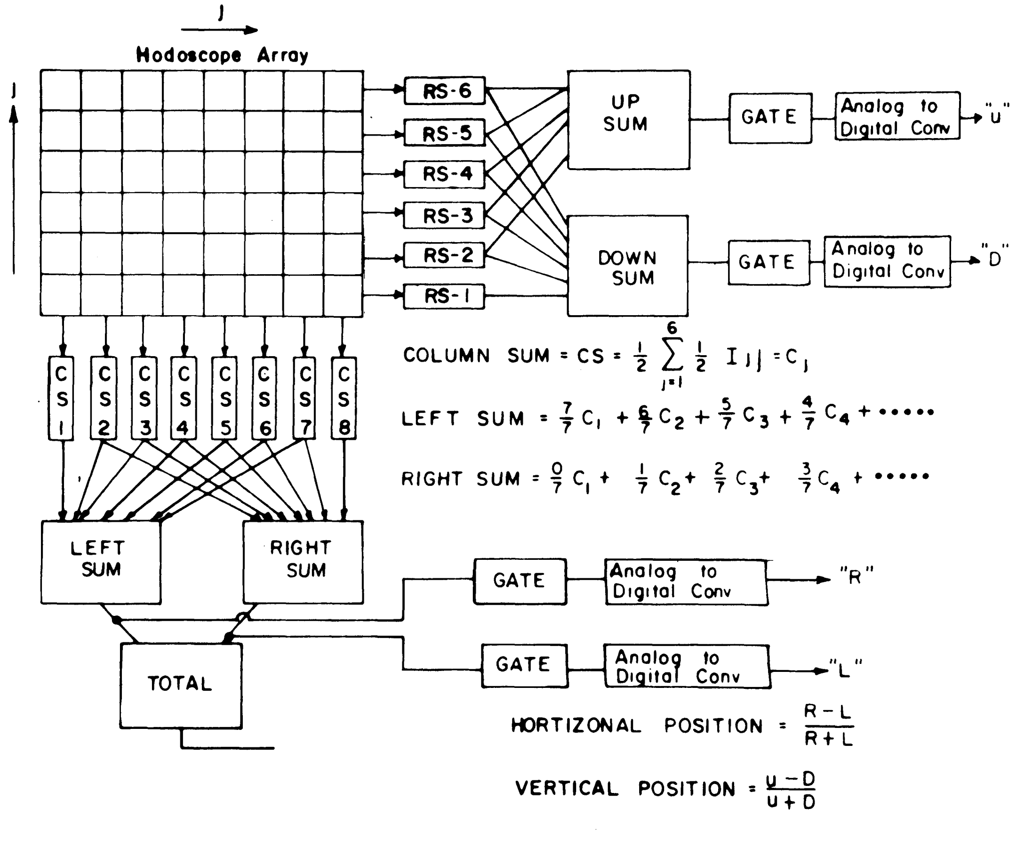
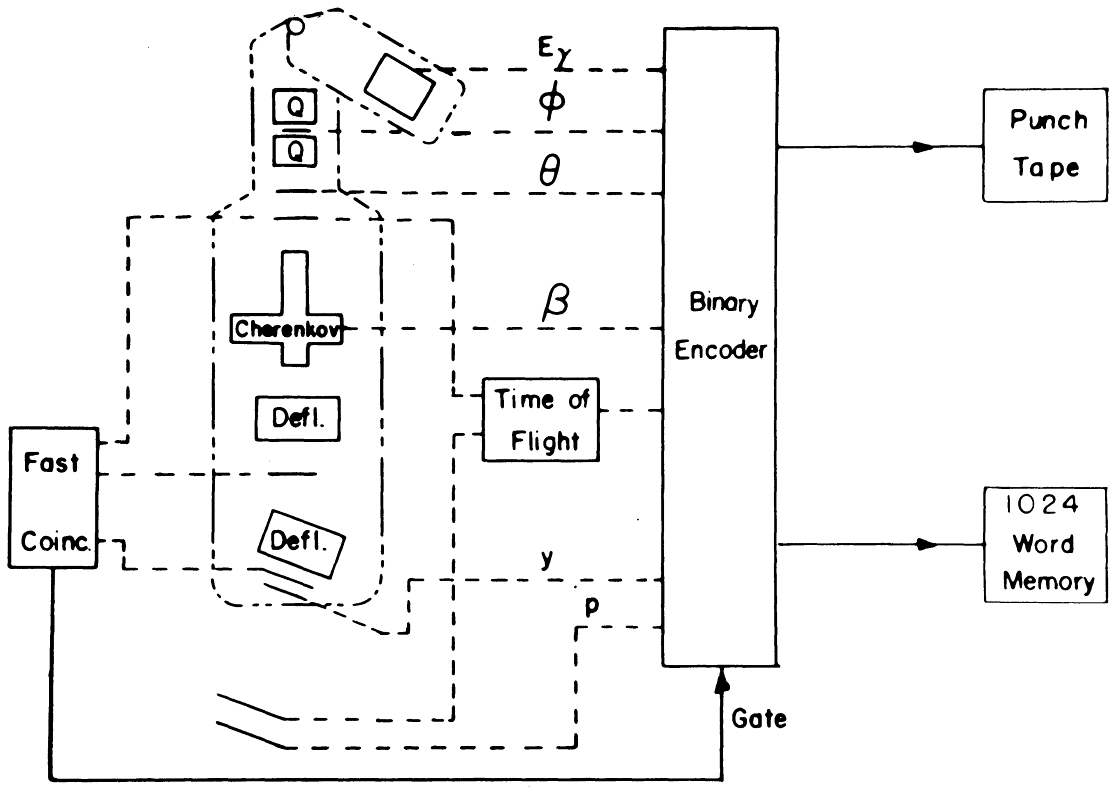

J
Hodoscope Array
I
RS-6
RS-5
RS-4
RS-3
RS-2
RS-1
UP SUM
DOWN SUM
GATE
Analog to Digital Conv
"U"
"D"
CS 1
CS 2
CS 3
CS 4
CS 5
CS 6
CS 7
CS 8
COLUMN SUM = CS = $\frac{1}{2}\sum_{J=1}^{6}\frac{1}{2}\ I_{IJ} = C_I$
LEFT SUM = $\frac{7}{7}C_1 + \frac{6}{7}C_2 + \frac{5}{7}C_3 + \frac{4}{7}C_4 + \cdots$
RIGHT SUM = $\frac{0}{7}C_1 + \frac{1}{7}C_2 + \frac{2}{7}C_3 + \frac{3}{7}C_4 + \cdots$
LEFT SUM
RIGHT SUM
TOTAL
"R"
"L"
HORTIZONAL POSITION = $\frac{R-L}{R+L}$
VERTICAL POSITION = $\frac{U-D}{U+D}$

Fig. 2



Logic for Data Acquisition

Fig. 3

LOGIC FOR CEA PHOTOPRODUCTION EXPERIMENT

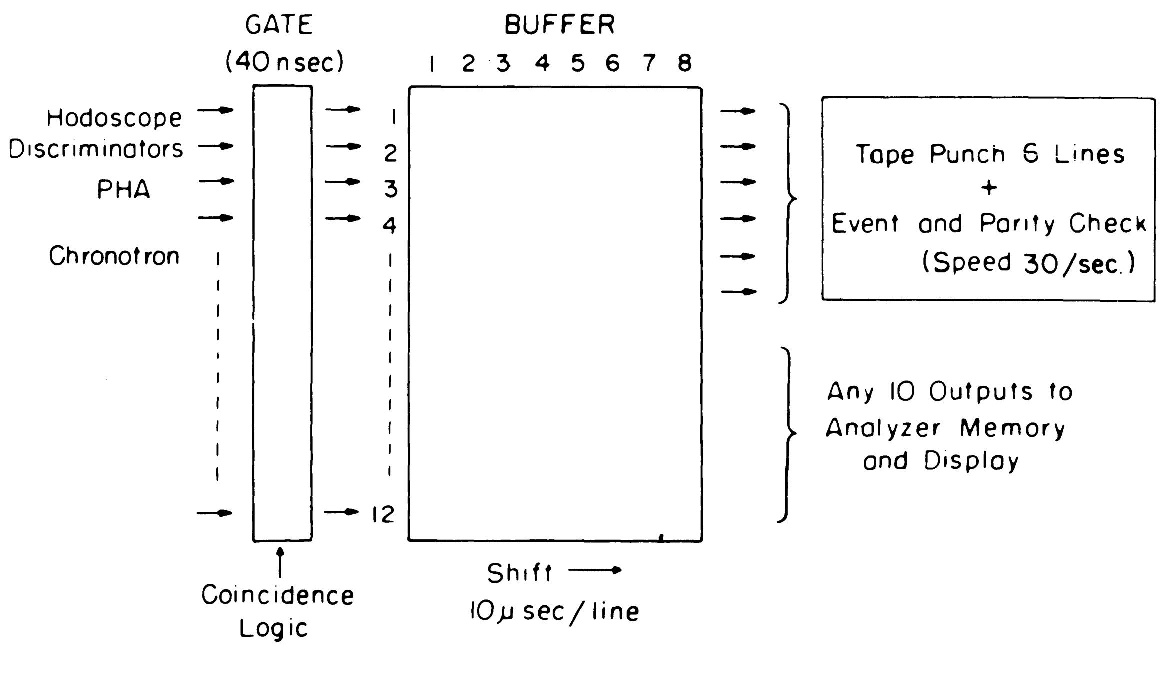


Fig. 4

CENTRAL MACHINE

12-BIT BINARY, PARALLEL
1024 WORDS OF CORE STORAGE
10 μsec. CYCLE

INPUT OUTPUT

KEYBOARD
2 CRT DISPLAYS
8 MULTIPLEXED ANALOG INPUT CHANNELS
MISCELLANEOUS DIGITAL INPUTS AND OUTPUTS

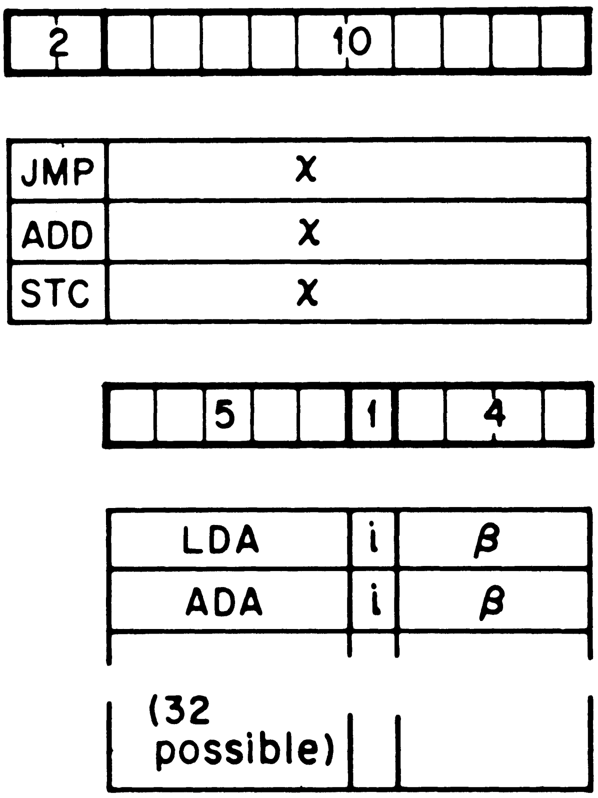
INSTRUCTIONS

35 INSTRUCTIONS
SINGLE ADDRESS
16 INDEX REGISTERS
HALF WORD OPERATIONS
MULTIPLE-LENGTH PROVISIONS

MAGNETIC TAPE

2 UNITS
1024 BLOCKS PER UNIT
256 WORDS PER BLOCK
AUTOMATIC SEARCHING & BLOCK TRANSFER
20 BLOCKS PER SECOND

Fig. 5



LINC INSTRUCTION FORMATS

Fig. 6

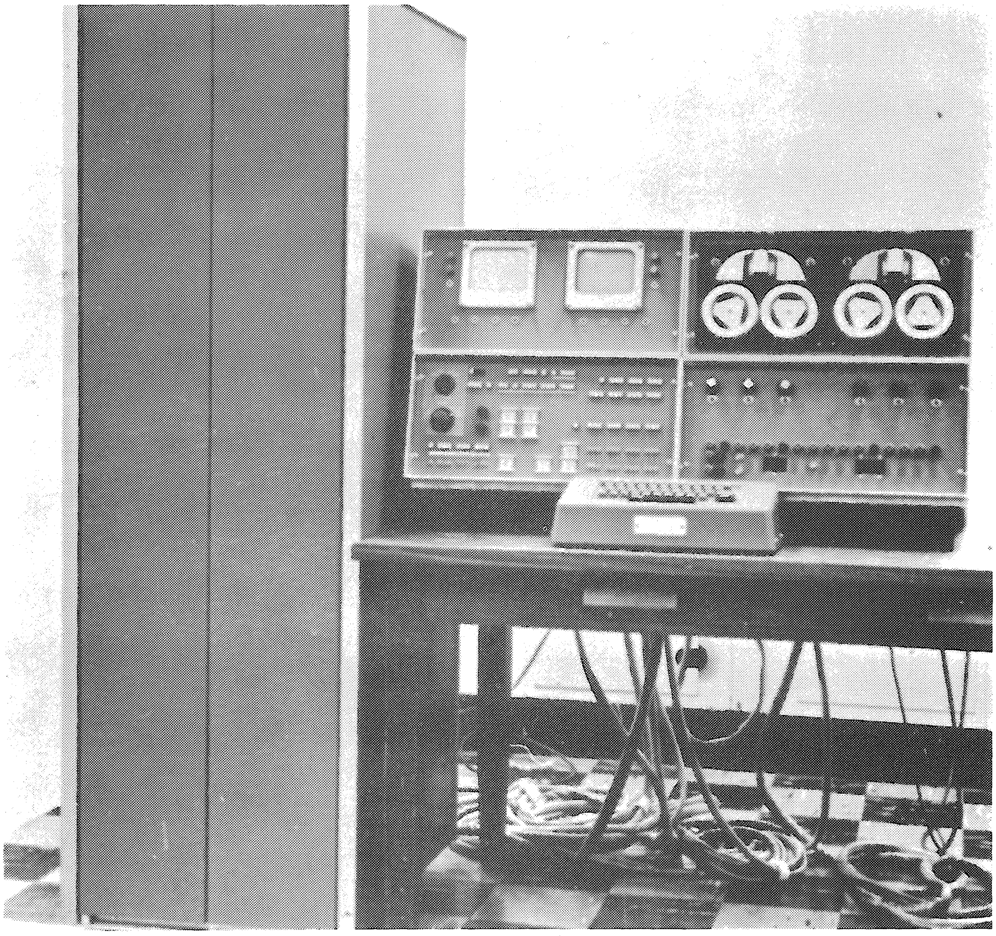


Fig. 7

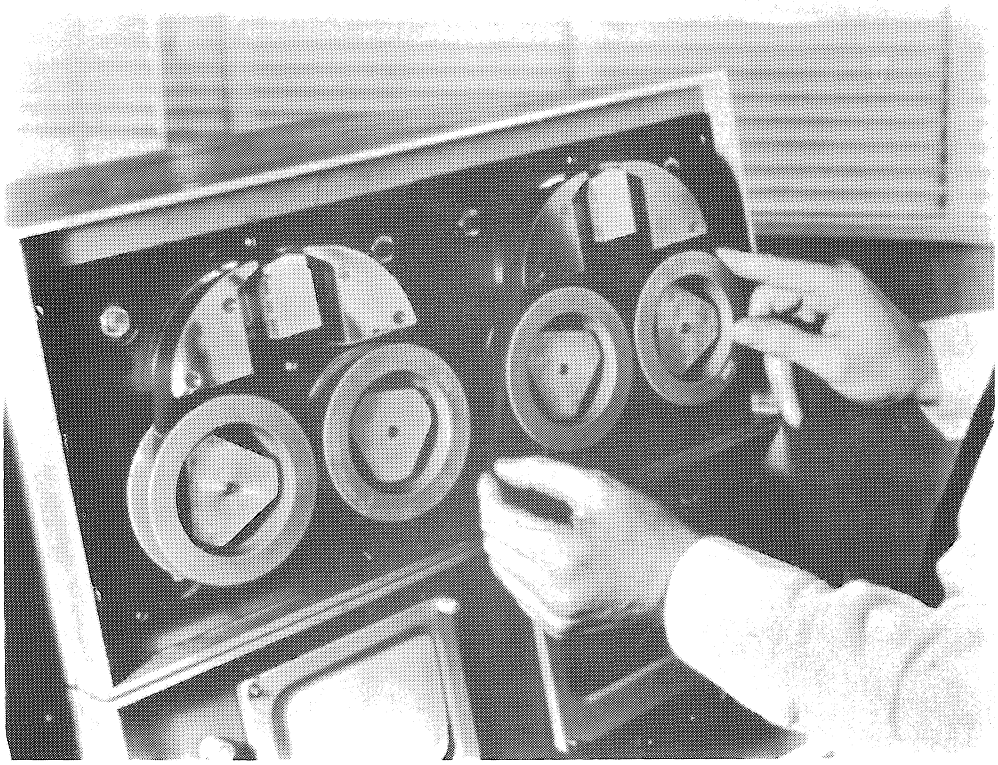


Fig. 8

DISCUSSION

BLUM: Do you control the beam elements with the computer ?

FESSEL: No, we do not. We might at some future date, but it is not a completely straightforward addition. We run the system at momenta from about 0.7 GeV/c up to about 3.5 GeV/c and to get that wide a range with our system, you have to go and manually change taps, transformers etc. Consequently we have not really thought about it too hard.