COMPANY CONFIDENTIAL

PROJECT STRETCH

FILE MEMORANDUM #6

SUBJECT: Basic Accumulator Logic
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This memorandum describes the basic logic of a binary adder for the Stretch machine. The same adder would be used in all positions of all accumulators in the machine. The adder described is based upon the assumptions developed in earlier Memorandums #2 and #3. Its logic is presented at this time to assist in evaluation of components and packaging, and to guide the program for automation of design.

It was the writer's original intention to describe the adder diagrammatically as interconnected matrices. As successive diagrams were drawn, it became apparent that they were a related series of executions of a single set of Boolian statements. Once these statements were set down, it was clear that all of the possible executions could be derived directly from them. By treating the subject in this way, it becomes possible to take a first step in our preparations for automation of logical design.

Base Points

For a first examination of the subject, we will assume that carry is propagated through only one stage each adding cycle, and will momentarily ignore shifting.

Within this context there are four pairs of base or reference points included in the adder. These base points provide momentary memory. Addition and subtraction are performed by passing impulses from these base points through a switching network to set up other base points in the set. The base points can be triggers, blocking oscillators, or any other type of memory devices.

One pair of base points (M0 and M1) represent 0 and 1 for a binary digit of the augend. The second pair (A0 and A1) represent a digit of the addend, the third pair (NCO and CO) represent a digit of carry and the fourth pair are the overall add-subtract control for the adding cycle. Of each pair, it is required that one be on and one be off at all times. For both to be on or both to be off is an immediate indication of an error.

Setup of the Base Points

As already noted, the new setup for a base point is obtained from the previous setup of the same and other base points by logical switching.

The setup table for the augend base points M0 and M1 is as follows:

M0' = Add . M0 . A0 . No Carry In
= Add . M0 . A1 . Carry In
= Add . M1 . A1 . No Carry In
= Add . M1 . A0 . Carry In
= Subt. M0 . A1 . No Carry In
= Subt . M0 . A0 . Carry In
= Subt . M1 . A0 . No Carry In
= Subt . M1 . A1 . Carry In

M1' = Add . M1 . A0 . No Carry In
= Add . M0 . A1 . No Carry In
= Add . M0 . A0 . Carry In
= Add . M1 . A1 . Carry In
= Subt . M1 . A1 . No Carry In
= Subt . M0 . A0 . No Carry In
= Subt . M0 . A1 . Carry In
= Subt . M1 . A0 . Carry In

M0 and M1 can be set up by any one of 8 4-way AND circuits connected through a single 8-way OR circuit. They also can be set up equally well by any equivalent combination of AND and OR circuits.

The setup table for the carry base points depends upon the augend, addend, and carry base points of the position at the right and upon the add-subtract control. The table is imperfect in that three of the four conditions are sufficient to determine the result.

No Carry Out = Add . M0 . A0 . (No Carry In + Carry In)
= Add . M1 . A0 . No Carry In
= Add . M0 . A1 . No Carry In
= Subt . M0 . A1 . (No Carry In + Carry In)
= Subt . M1 . A1 . No Carry In
= Subt . M0 . A0 . No Carry In

Carry Out = Add . M0 . A1 . Carry In
= Add . M1 . A0 . Carry In
= Add . M1 . A1 . (No Carry In + Carry In)
= Subt . M0 . A0 . Carry In
= Subt . M1 . A1 . Carry In
= Subt . M1 . A0 . (No Carry In + Carry In)

The addend base points are set for the entire accumulator when the addend is read in, and do not change from cycle to cycle. The add-subtract control base points are modified each cycle under control of the multiply-divide and related arithmetic controls.

Shifting

Shifting requires a 4 by 6 matrix switch in the following form, or its equivalent.

	M0'	M1'	NCO'	CO'
Shift 1 right				
No Shift				
Shift 1 left				
Shift 2 left				
Shift 3 left				
Shift 4 left				

The purpose of the switch is to shift the augend and carry impulses to right or left. It is injected between the logical switching which sets up the new augend and carry and the base points for them.

Carry

If it is desired to have carry pass through more than one adder stage each cycle, it is only necessary to modify our notation to the extent of omitting certain of the carry base points and interpreting the output of each omitted base point as equal to its input. When this is done, the timing of the circuit must be modified to allow time for the DC carry wave to travel through the additional logical elements between one base point and the next.

Later memoranda will provide a statement of the control logic of the arithmetic unit, and will consider the means by which logical statements like those in this memorandum can be reduced to practice by automatic means.

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