a "dynamic" keyboard. It is perfectly suited to interactive
programs and games that require keyboard responses. This is
a very simple design to implement on the ELF=II, and full de-
tails are included in this article.

Before you start thinking about using the original ELF-II key
board, you must be aware of the fact that it latches up 8
bits on the data bus when INPUT is pressed. In addition, the
low (or first) digit pressed is shifted when you enter a sub-
sequent digit. Even if you write another routine to read the
ELF-II keyboard, you will be pressing three keys to do the
function of one on a dynamic-type keyboard. This situation
won't allow you to take full advantage of the CHIP-8 games.

Before I discuss the actual conversion, refer to figure 1
for a summary of ELF-II and VIP I/O instructions. The 64
instruction is really doing the same function on both machines,
but with the ELF-II, you have the additional feature of dis-
playing the contents of memory on the 7-segment displays. The
other mahor difference between the I/O instructions is the hex
keypad enables. The ELF-II uses the 6C, which is an input
instruction, and the VIP uses a 62, which is an output in-
struction. This should give you a clue as to why a different
keyboard is needed to run CHIP-8.

ELF-II	VIP	
61 video off	61 video off	
62 available	62 output to keyboard	
63 available	63 output port	
64 display LEDs·	64 Mx-bus, Rx 1	
65 available	65 available	FIGURE 1
66 available	66 available	
67 output port	67 available	I/O INSTRUC-
68 illegal	68 illegal	TION SUMMARY
69 video on	69 video on	
6A available	6A available	
6B available	6B input port	
6C input from keyboard	6C available	
6D available	6D available	
6E available	6E available	
6F input port	6F available	

The operating system in the VIP actually outputs the low 4
bits of the data bus to a (4 to 16 line decoder) attached to
one side of the hex keypad, allowing EF3 to be enabled cor-
responding to the key being pressed. So actually, the VIP
keypad only inputs EF3, not data. The ELF-II, on the other