access to cause another bus fault. Thus, if the problem that first caused the fault is not corrected, and the fault handler signals to the processor that the machine is to complete the access, a continuous fault-loop effect occurs. During this loop, the stack frame occupies the same location; thus, such a loop does not cause the stack to grow.

**MC68010 facilities**

**Virtual machine operation.** The MC68010 provides the mechanisms needed to implement a virtual machine environment in which any degree of emulation is supported. This is achieved in large part by the virtual memory mechanisms described above. Virtual I/O, for instance, is readily achieved by defining a memory area as an I/O device which is not physically resident. When an access is made to that address, an access fault occurs. The fault address can then be evaluated by the operating system to determine the activity that should take place. After the appropriate action has been taken, a software rerun can be signalled and the RTE executed. Indicating to the processor that the access has been completed makes it possible to provide virtual I/O transfers. This technique can of course be generalized to any other type of virtual activity that the processor requests the operating system to execute.

**Performance enhancements.** Since some new internal resources had to be added to the processor to support virtual operations, we wanted to apply these resources, whenever possible, to other instructions to improve their performance. The result of these efforts is a small performance improvement, which we have estimated to be about 15 percent for a typical instruction mix. A common criticism of the MC68000 is that it is not optimized for fast block operations. Instructions dedicated to handling block operations, however, carry with them some rather unattractive architectural consequences, as they tend not to fit well into the instruction map and do not have the full range of available address modes. The MC68010 provides perhaps the best solution to the performance/regularity problem by recognizing code sequences in which the block operations are defined and by executing these loops very quickly, with no superfluous instruction accesses.

Several new microprocessors which support virtual memory have been introduced recently, with each providing different degrees of such support. The MC68010, utilizing the instruction continuation method, cleanly and elegantly supports the fault detection/fault correction/program resumption process. The options available as a consequence of the use of continuation method—hardware and software rerun—provide powerful support for various implementations of virtual memory. The continuation method also provides the ability to make any access virtual via the software rerun method of return.