Definition 4.7 *Checkpoints. Primary inputs and fanout branches of a combinational circuit consisting only of Boolean gates are called the* checkpoints.

Theorem 4.2 *Checkpoint theorem. A test set that detects all single stuck-at faults of the checkpoints of a combinational circuit detects all single stuck-at faults in that circuit.*

Proofs of these theorems can be constructed from the notions of fault equivalence and dominance. Checkpoints provide a starting set for dominance fault collapsing in which further reduction is possible with the three rules specified above. When tests are specially generated for detecting multiple faults using a procedure given by Bossen and Hong [85], the number of checkpoints can be reduced by eliminating primary input stems that fanout. This will eliminate the second and third primary inputs in the circuit of Figure 4.11(b).

Abramovici *et al.* [7] point out that the dominance relations in a combinational circuit may not remain valid when that circuit is embedded in a sequential circuit. This is because a fault can dominate several faults. For example, the fault $F2$ in Figure 4.10 dominates all input s-a-1 faults. Hence, in the collapsed set $F2$ is represented by three faults, which are not equivalent to each other. In a sequential circuit, considering multiple time-frames (see Chapter 8) $F2$ can have many more activations than each dominated fault, thus providing a greater chance of fault effect cancellation.

A "dominated" fault can become redundant due to the circuit structure. If the fault set used for test generation is obtained by dominance fault collapsing, then no test may be obtained for the dominating fault even when it is detectable. In fact, the checkpoint theorem (Theorem 4.2) gives no guarantees if the test set has a less than 100% coverage of the checkpoint faults, some of which may be redundant [11].

In spite of the greater reduction of the fault list (smaller collapse ratio) that dominance fault collapsing provides, the two reasons cited above limit its use. In practice, therefore, equivalence fault collapsing is more popular and is often recommended.

4.5.5 Summary

Many workers believe that Eldred's 1959 paper [215] laid the foundation for the stuck-at fault model. Eldred's main contribution was to break away from functional testing and demonstrate the practicality of testing at the hardware level. His paper did not mention the stuck-at fault. The term "stuck-at fault" appeared in the 1961 paper by Galey, Norby, and Roth [237]. It is possible that other researchers of that time may have used it as well. Many people think that the "stuck-open" fault model was first mentioned in Wadsack's 1978 paper [701]. Actually, it was proposed by Case in 1976 [115], a fact brought to our notice by Don Ross.

It is essential to grasp the ideas behind the stuck-at fault model, which is most fundamental to digital testing. Chapters 5 through 8 develop algorithms based on these. In addition, one must gain working knowledge of models used in testing of