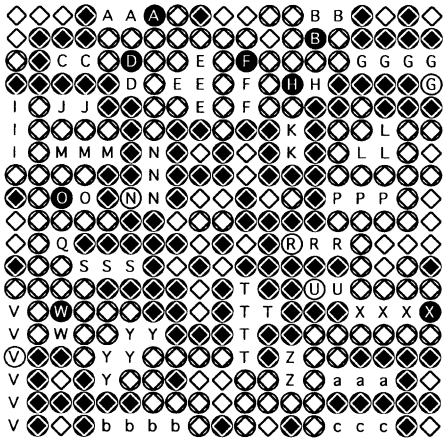

Fig. 6. C.11: an 89-point endgame problem.

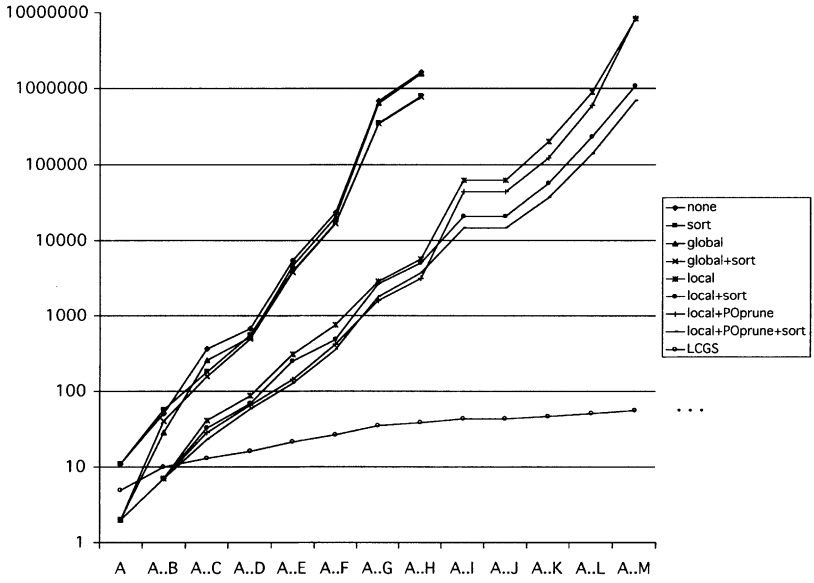

Fig. 7. Minimax search enhancements in Go endgames.

5.3. Evaluation of test results

The experiments show that global minimax search cannot compete with the local search method LCGS used in decomposition search, even with all global search enhancements in place. A solution of the full-board problem by global

search seems out of the question with current methods, whereas the same problem is easily solved by decomposition search. The fundamental disadvantage of global search relative to decomposition search is clearly demonstrated by the results: global search requires time that is exponential in the size of the *whole problem*, while LCGS' worst case time is exponential in the size of the *biggest subproblem*. If the local combinatorial game evaluations generated during LCGS can be computed and compared without too much overhead, as usually seems to be the case in these Go endgames, a dramatic speedup results.

In global minimax search, all four tested enhancements lead to substantial reductions in the number of nodes searched. The one outstanding improvement is the introduction of local move pruning, which greatly reduces both the branching factor and the depth of the search. Global and partial order move pruning are most effective in close-to-terminal positions. Earlier in the game they do not help much, since no pruning move can be found by global pruning, and almost all moves are contained in the catch-all *other* category of partial order move pruning. Move sorting works well in every combination.

5.4. Complete solution of C.11 by decomposition search

An optimal 62-move solution sequence to the full-board problem computed by decomposition search is shown in Fig. 8. On a Macintosh G3/250, the complete solution took 1.1 s, including 0.4 s for LCGS searching a total of 420 nodes in the 29 subgames. The remaining time was taken up mainly by proving the safety of territories and by operations on combinatorial games.

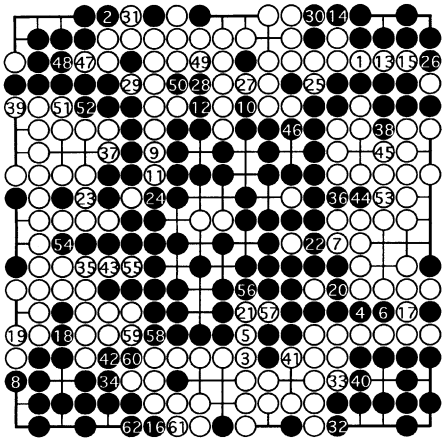

Fig. 8. An optimal solution to problem C.11.