Let $N := (K, \Sigma, \Delta, s, F)$ be the finite automaton that recognizes L, i.e. $L(N) = L$. Let $E := \{q \in K \mid \exists f \in F, \text{s.t. } \exists \text{ path from } q \text{ to } f\}$, $F' := E \cup F$, $N' := (K, \Sigma, \Delta, s, F')$.

Claim: N' recognizes M, i.e. $L(N') = M$.

Proof:
We first show $L(N') \supseteq M$. Let $m \in M$ and $mm' = l \in L$. Since N recognizes L, $\exists p \in K, f \in F$ s.t. $(s, mm') \vdash_N^* (p, m') \vdash_N^* (f, \epsilon)$. By definition of F', $p \in F'$. Further, $(s, m) \vdash_N^* (p, \epsilon)$. Note that N and N' only differ by the final states, so $(s, m) \vdash_{N'}^* (p, \epsilon)$, which means $m \in L(N')$.
We then show $L(N') \subseteq M$. Let $m \in L(N')$ and $(s, m) \vdash_{N'}^* (p, \epsilon), p \in F'$. By definition of F', $\exists m', f \in F$ s.t. $(p, m') \vdash_{N'}^* (f, \epsilon)$. Therefore, $(s, mm') \vdash_{N'}^* (f, \epsilon)$, and since N and N' only differ by the final states, $(s, mm') \vdash_N^* (f, \epsilon)$, which means $mm' \in L(N) = L$, which means $m \in M$.

By Claim, M is regular.