The $v_1$-periodic homotopy groups can be roughly described as the portions of the actual homotopy groups localized at a prime $p$ that are detected by $K$-theory. In 1991 Bendersky and Davis published the paper 2-primary $v_1$-periodic homotopy groups of $SU(n)$. In the present work we make some significant refinements of that paper using a new $K$-theoretic approach. Namely, we determine the number of summands in the 2-primary groups $v_1^{-1}\pi_{2k-1}(SU(n))$. We also prove the existence of summands of certain sizes in such groups. Moreover, we determine explicit formulas for the existence of some differentials in the spectral sequence for $SU(n)$, which give us additional information about the actual homotopy groups. (Received September 23, 2004)