Strange hyperbolic attractors are hard to find in real physical systems. This paper provides the first example of a realistic system, a canonical three-dimensional (3D) model of bursting neurons, that is likely to have a strange hyperbolic attractor. Using a geometrical approach to the study of the neuron model, we derive a flow-defined Poincare map giving an accurate account of the system's dynamics. In a parameter region where the neuron system undergoes bifurcations causing transitions between tonic spiking and bursting, this two-dimensional map becomes a map of a disk with several periodic holes. A particular case is the map of a disk with three holes, matching the Plykin example of a planar hyperbolic attractor. The corresponding attractor of the 3D neuron model appears to be hyperbolic (this property is not verified in the present paper) and arises as a result of a two-loop (secondary) homoclinic bifurcation of a saddle. This type of bifurcation, and the complex behavior it can produce, have not been previously examined.