The set of production rules we have initially is:

$S \rightarrow aTa$
$T \rightarrow bTb \mid aCa$
$C \rightarrow C+C \mid C-C \mid C*C \mid C/C \mid (C) \mid H$
$H \rightarrow Y.Y \mid Y. \mid .Y$
$Y \rightarrow NY \mid N$
$N \rightarrow 0 \mid 1 \mid 2 \mid 3 \mid 4 \mid 5 \mid 6 \mid 7 \mid 8 \mid 9$

Remove unit production $C \rightarrow H$ and $Y \rightarrow N$, we have:

$S \rightarrow aTa$
$T \rightarrow bTb \mid aCa$
$C \rightarrow C+C \mid C-C \mid C*C \mid C/C \mid (C) \mid Y.Y \mid Y. \mid .Y$
$H \rightarrow Y.Y \mid Y. \mid .Y$
$Y \rightarrow NY \mid 0 \mid 1 \mid 2 \mid 3 \mid 4 \mid 5 \mid 6 \mid 7 \mid 8 \mid 9$
$N \rightarrow 0 \mid 1 \mid 2 \mid 3 \mid 4 \mid 5 \mid 6 \mid 7 \mid 8 \mid 9$

Before going into the formal definition of this grammar, let's denote:

- Σ_N = {0, 1, 2, 3, 4, 5, 6, 7, 8, 9} because these digit terminal symbols are created equally by variable N.
- $\Sigma_{OPERATOR}$ = {+, -, *, /} because operators have the same purpose.

The **formal definition of Pushdown Automata** (7-tuples) to this grammar is:

- **Finite set of states Q** = $\{q_0, q_1, q_2, q_3, q_4, q_5, q_6, q_7, q_8, q_9, q_{10}\}$
- **Finite set of input alphabet Σ** = {., 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, +, -, *, /, (,), a, b}
- **Finite stack alphabet Γ** = $\{Z_0$, a, b, (}
- **Start state q_0** = q_0
- **Initial stack top symbol Z_0** = Z_0
- **Set of accepted states F** = $\{q_{10}\}$
- **Transition function δ**:

  $\delta(q_0, \varepsilon, \varepsilon) \vdash (q_1, Z_0)$
  $\delta(q_1, a, \varepsilon) \vdash (q_2, a)$
  $\delta(q_2, a, \varepsilon) \vdash (q_3, a)$
  $\delta(q_2, b, \varepsilon) \vdash (q_2, b)$
  $\delta(q_3, (, \varepsilon) \vdash (q_3, ()$
  $\delta(q_3, \Sigma_N, \varepsilon) \vdash (q_4, \varepsilon)$

δ(q_3, ., ε) ⊢ (q_5, ε)
δ(q_4, Σ_N, ε) ⊢ (q_4, ε)
δ(q_4, ., ε) ⊢ (q_6, ε)
δ(q_5, Σ_N, ε) ⊢ (q_6, ε)
δ(q_6, Σ_N, ε) ⊢ (q_6, ε)
δ(q_6,), () ⊢ (q_7, ε)
δ(q_6, a, a) ⊢ (q_8, ε)
δ(q_6, $\Sigma_{OPERATOR}$, ε) ⊢ (q_3, ε)
δ(q_7, $\Sigma_{OPERATOR}$, ε) ⊢ (q_3, ε)
δ(q_7,), ( ) ⊢ (q_7, ε)
δ(q_7, a, a) ⊢ (q_8, ε)
δ(q_8, b, b) ⊢ (q_8, ε)
δ(q_8, a, a) ⊢ (q_9, ε)
δ(q_9, ε, Z_0) ⊢ (q_{10}, ε)

State diagram: