① Repeat {C} until {B}

```
OK = 0;
while (!OK) {
    C;
    if (B) {
        OK = 1;
    }
    else {
        continue;
    }
}
```

É um laço que sempre irá ocorrer ao menos uma vez, então, é necessário o uso de if e while para construí-lo.

(2)

a) $\vdash_{par} (| \top |)\ P\ (| X \geq 0 \wedge ((Y = 2X) \to (Z = 4X)) |)$

$(| \top |)$

$(| 0 \geq 0 \wedge ((1 = 0) \to (Z = 0)) |)$ impl

$Y = 1;$

$(| 0 \geq 0 \wedge ((Y = 0) \to (Z = 0)) |)$ atrib

$X = 0;$

$(| X \geq 0 \wedge ((Y = 2X) \to (Z = 4X)) |)$ atrib

b) $\vdash_{par} (| \top |)\ P\ (| Y > 0 \wedge Z = 3X |)$

$(| \top |)$

$(| X = X |)$ impl

$(| 3X = 3X |)$ impl

$Z = 3X$

$(| Z = 3X |)$ atrib

$(| 1 > 0 \wedge Z = 3X |)$ impl

$Y = 1$

$(| Y > 0 \wedge Z = 3X |)$ atrib

③ $\vdash_{par} (\| x \geq 0 \|)\ Copy2\ (\| x = y \|)$

$(\| 0 \leq x \|)$

$y = 0;$

$(\| y \leq x \|)$ atrib

while (y != x)

$(\| y < x \rightarrow y + 1 \leq x \|)$

$(\| y \leq x \wedge y \mathrel{!=} x \rightarrow y + 1 \leq x \|)$ impl

$(\| y + 1 \leq x \|)$ impl

$y = y + 1;$

$(\| y \leq x \|)$ atrib

$(\| y \leq x \wedge y = x \|)$ while

$(\| x = y \|)$ impl

(4) $\vdash_{tot} (\| x > 0 \wedge y > 0 \|)\ \mathcal{E}xp\ (\| z = x^y \|)$

$E: y - c$

$\chi: z = x^c$

$(\| x > 0 \wedge y > 0 \|)$

$(\| y > 0 \|)$ impl

$(\| x = x \wedge 0 \leq y - 1 \|)$ impl

c = 1;

$(\| x = x^c \wedge 0 \leq y - c \|)$ atrib

z = x;

$(\| z = x^c \wedge 0 \leq y - c \|)$ atrib

while (c != y)

$(\| z = x^c \wedge c \,!= y \wedge 0 \leq y - c = E_0 \|)$

$(\| z * x = x^{c+1} \wedge 0 \leq y - c - 1 < E_0 \|)$ impl

z = z * x;

$(\| z = x^{c+1} \wedge 0 \leq y - c - 1 < E_0 \|)$ atrib

c = c + 1;

$(\| z = x^c \wedge 0 \leq y - c < E_0 \|)$ atrib

$(\| z = x^c \wedge c = y \|)$ while total

$(\| z = x^y \|)$ impl

5. $\vdash_{tot} (|y > 0|)\ Div\ (|(x = dy + r) \wedge (r < y)|)$

$(|y > 0|)$

$(|r > 0|)$ impl *

$(|x = x \wedge |r||)$ impl

r = x;

$(|x = r \wedge |r||)$ atrib

d = 0;

$(|x = dy + r \wedge |r||)$ atrib

while (r >= y)

$(|x = dy + r \wedge r \geq y \wedge 0 \leq |r - y| = E_0|)$

$(|x = dy + r \wedge 0 \leq |r - y| < E_0|)$ impl

$(|x = (d+1)y + (r - y) \wedge 0 \leq |r - y| < E_0|)$ impl

r = r - y;

$(|x = (d+1)y + r \wedge 0 \leq |r| < E_0|)$ atrib

d = d + 1;

$(|x = dy + r \wedge 0 \leq |r| < E_0|)$ atrib

$(|x = dy + r \wedge r < y|)$ while total

$(|x = dy + r \wedge r < y|)$

* pelo enunciado, se $y > 0$, então existe um único inteiro r, tal que $0 \leq r < y$.