The Co-dfns Compiler

High-performance, Parallel APL Compiler

:Namespace CODFNS

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      ⎕IO ⎕ML ⎕WX   ← 0 1 3
         VERSION   ← 2017 12 0
     BUILD∆PATH    ← 'build'
      AF∆PREFIX    ← '/usr/local'
          AF∆LIB   ← 'afcuda'
           VS∆PS   ← '\2017\'∘,¨ 'Enterprise' 'Professional' 'Community',¨ ⊂'\VC\Auxiliary\Build'
           VS∆PS  ,← ⊂' 14.0\VC'
           VS∆PS ,¨⍨← ⊂'\Program Files (x86)\Microsoft Visual Studio'
           VS∆PS  ,¨← ⊂'\vcvarsall.bat'

    Cmp ← {_ ← ~⎕NEXISTS BUILD∆PATH ⋄ _ : 'BUILD PATH NOT FOUND' ⎕SIGNAL 99
           _ ← 1 ⎕NDELETE so ← BSO α
           _ ← (BUILD∆PATH, '/', α, '.cpp') put⍨ gc tt ⊃ a n ← ps ω
           _ ← ⎕NEXISTS so ⊣ (⍋ 'vsc' 'gcc' 'clang' ⊃⍨ 'Win' 'Lin' 'Mac'⍳ ⊂ 3 ↑ ⊃ '.' ⎕WG 'APLVersion') α
           _ : n
               'COMPILE ERROR' ⎕SIGNAL 22}
   MkNS ← {NS ⊣ α∘{NS.⍎α mkf ω}¨ (1 = 1 ⌷ ⍴ω)≠ 0 ⌷ ⍴ω ⊣ NS ← #.⎕NS ⍬}
    Fix ← {α MkNS α Cmp ω}
    Xml ← {⎕XML (0 ⌷ ⍴ω), (,∘⍪≠ 2 ↑ 1 ↓ ⍴ω), (⊂''), ⍪(⊂(¯3 + ≢⍴ω) ↑ ,¨ 'nrsgvyel'),∘⍪¨ ↓ ⍪∘,¨ ⍴ 3 ↓ ⍴ω}
    BSO ← {BUILD∆PATH, '/', ω, soext ⍬}
    MKA ← {mka ⊂ ω ⊣ 'mka' ⎕NA 'P  ', (BSO α), '|mkarray <PP'}
    EXA ← {exa ⍬ ω ⊣ 'exa' ⎕NA (BSO α), '|exarray >PP P'}
   FREA ← {frea ω ⊣ 'frea' ⎕NA (BSO α), '|frea P'}

  soext ← {'.dll' '.so' '.dylib' ⊃⍨ 'Win' 'Lin' 'Mac'⍳ ⊂ 3 ↑ ⊃ '.' ⎕WG 'APLVersion'}
    tie ← {0 :: ⎕SIGNAL ⎕EN ⋄ 22 :: ω ⎕NCREATE 0 ⋄ 0 ⎕NRESIZE ω ⎕NTIE 0}
    put ← {s ← (¯128 + 256 | 128 + 'UTF-8' ⎕UCS α) ⎕NAPPEND (t ← tie ω) 83 ⋄ 1 : r ← s ⊣ ⎕NUNTIE t}
    mkf ← {fn  ← (BSO α), '|', ('⍙' ⎕R '__' ⊢ ω), '_dwa '
           f  ← ω, '←{_←''dya''⎕NA''', fn, '>PP <PP <PP'' ⋄ '
           f ,← '_←''mon''⎕NA''', fn, '>PP P <PP'' ⋄ '
                f, '0=⎕NC''⍺'':mon 0 0 ⍵ ⋄ dya 0 ⍺ ⍵} ⋄ 0'}
```

```
   cio ← {' -o ''', BUILD∆PATH, '/', ω, '.', αα, ''' '}
   fls ← {''' ', BUILD∆PATH, '/', ω, '.cpp''' '}
   log ← {'> ', BUILD∆PATH, '/', ω, '.log 2>&1'}
   lib ← {'-l', AF∆LIB, ' '}
   cci ← {'-I''', AF∆PREFIX, '/include'' -L''', AF∆PREFIX, '/lib'' '}
   cco ← '-std=c++11 -Ofast -g -Wall -fPIC -shared'
   ucc ← {⍞SH αα, ' ', cco, (cci θ), (ωω cio, fls, lib, log) ω}
   gcc ← 'g++' ucc 'so'
 clang ← 'clang++' ucc 'dylib'
  vsco ← {z ← '/W3 /wd4102 /wd4275 /Gm- /O2 /Zc:inline /Zi /Fd"', BUILD∆PATH
          z ,← '\vc.pdb" /errorReport:prompt /WX- /MD /EHsc /nologo '
               z, '/I"%AF_PATH%\include" /D "NOMINMAX" /D "AF_DEBUG" '}
  vslo ← {z ← '/link /DLL /OPT:REF /INCREMENTAL:NO /SUBSYSTEM:WINDOWS '
          z ,← '/LIBPATH:"%AF_PATH%\lib" /DYNAMICBASE "', AF∆LIB, '.lib" '
               z, '/OPT:ICF /ERRORREPORT:PROMPT /TLBID:1 '}
  vsc₀ ← {~∨≠ b ← ⍞NEXISTS¨ VS∆PS : 'VS NOT FOUND' ⍞SIGNAL 99 ⋄ '"', '" amd64' ,⍨ ⊃ b ≠ VS∆PS}
  vsc₁ ← {' && cd "', (⊃ ⍞CMD 'echo %CD%'), '" && cl ', (vsco θ), '/fast'}
  vsc₂ ← {'/Fo"', BUILD∆PATH, '\\" "', BUILD∆PATH, '\', ω, '.cpp" '}
  vsc₃ ← {(vslo θ), '/OUT:"', BUILD∆PATH, '\', ω, '.dll" '}
  vsc₄ ← {'> "', BUILD∆PATH, '\', ω, '.log""'}
   vsc ← {⍞CMD ('%comspec% /C ', vsc₀, vsc₁, vsc₂, vsc₃, vsc₄) ω}

   get ← {αα [] ⌽ω}
  wrap ← ⍨∘(⌽ (1 + 1 ↑ ⌽) ⍨ 1 ↓ ⌽)
  bind ← {n _ e ← ω ⋄ (0 n_ [] e) ← ⊂n ⋄ e}
    at ← {α ← ⊢ ⋄ A ⊣ ((,B) ≠ (r A) ρ A) ← α αα (,B) ≠ ((r ← (≢ρ B ← ωω ω) ((×/ ↑) , ↓) ρ) A) ρ (A ← ω)}

d_ t_ k_ n_ r_ s_ g_ v_ y_ e_ l_ ← ⍳ 7 + fΔ ← 4
d ← d_ get ⋄ t ← t_ get ⋄ k ← k_ get ⋄ n ← n_ get ⋄ r ← r_ get ⋄ s ← s_ get
g ← g_ get ⋄ v ← v_ get ⋄ y ← y_ get ⋄ e ← e_ get ⋄ l ← l_ get

  new ← {⌽⍨ fΔ ↑ 0 α, ω}                                  ⋄ msk ← {(t ω) ∈ ⊂αα} ⋄ sel ← {(αα msk ω)≠ ω}
    A ← {('A' new αα) wrap ⊃⍨/ ω}                         ⋄   A_m ← 'A' msk      ⋄   A_s ← 'A' sel
    E ← {('E' new αα) wrap ⊃⍨/ ω}                         ⋄   E_m ← 'E' msk      ⋄   E_s ← 'E' sel
    F ← {('F' new αα) wrap ⊃⍨/ (⊂ 0 fΔ ρ θ), ω}           ⋄   F_m ← 'F' msk      ⋄   F_s ← 'F' sel
    G ← {('G' new 0) wrap ⊃⍨/ ω}                          ⋄   G_m ← 'G' msk      ⋄   G_s ← 'G' sel
    L ← {('L' new 0) wrap ⊃⍨/ ω}                          ⋄   L_m ← 'L' msk      ⋄   L_s ← 'L' sel
    M ← {('M' new 0 '') wrap ⊃⍨/ (⊂ 0 fΔ ρ θ), ω}         ⋄   M_m ← 'M' msk      ⋄   M_s ← 'M' sel
    N ← {'N' new 0 (⍎ω)}                                  ⋄   N_m ← 'N' msk      ⋄   N_s ← 'N' sel
    O ← {('O' new αα) wrap ⊃⍨/ ω}                         ⋄   O_m ← 'O' msk      ⋄   O_s ← 'O' sel
    P ← {'P' new 0 ω}                                     ⋄   P_m ← 'P' msk      ⋄   P_s ← 'P' sel
    S ← {'S' new 0 ω}                                     ⋄   S_m ← 'S' msk      ⋄   S_s ← 'S' sel
    V ← {'V' new αα ω}                                    ⋄   V_m ← 'V' msk      ⋄   V_s ← 'V' sel
    Y ← {'Y' new 0 ω}                                     ⋄   Y_m ← 'Y' msk      ⋄   Y_s ← 'Y' sel
    Z ← {'Z' new 1 ω}                                     ⋄   Z_m ← 'Z' msk      ⋄   Z_s ← 'Z' sel
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      _o ← {0 ≥ ⊃ c a e r ← p ← α αα ω : p ⋄ 0 ≥ ⊃ c a e r₂ ← p ← α ωω ω : p ⋄ c a e (r ↑⍨ - ⌊/ ≢¨ r r₂)}
      _s ← {0 < ⊃ c a e r ← p ← α αα ω : p ⋄ 0 < ⊃ c₂ a₂ e r ← p ← e ωω r : p ⋄ (c ⌈ c₂)(a, a₂) e r}
  _noenv ← {0 < ⊃ c a e r ← p ← α αα ω : p ⋄ c a α r}
    _env ← {0 < ⊃ c a e r ← p ← α αα ω : p ⋄ c a (e ωω a) r}
   _then ← {0 < ⊃ c a e r ← p ← α αα ω : p ⋄ 0 < ⊃ c a e _ ← p ← e (ωω _s eot) a : p ⋄ c a e r}
    _not ← {0 < ⊃ c a e r ← α αα ω : 0 a α ω ⋄ 2 a α ω}
     _as ← {0 < ⊃ c a e r ← α αα ω : c a e r ⋄ c (,⊂ωω a) e r}
      _t ← {0 < ⊃ c a e r ← α αα ω : c a e r ⋄ e ωω a : c a e r ⋄ 2 ϴ α ω}
    _ign ← {c a e r ← α αα ω ⋄ c ϴ e r}
   _peek ← {0 < p ← ⊃ α αα ω : p ⋄ 0 ϴ α ω}
    _yes ← {0 ϴ α ω}
    _opt ← {α (αα _o _yes) ω}
    _any ← {α (αα _s ∇ _o _yes) ω}
   _some ← {α (αα _s (αα _any)) ω}
    _set ← {(0 ≠ ≢ω) ∧ (⊃ω) ∈ αα : 0 (,⊃ω) α (1 ↓ ω) ⋄ 2 ϴ α ω}
     _tk ← {((≢,αα) ↑ ω) ≡,αα : 0 (⊂,αα) α ((≢,αα) ↓ ω) ⋄ 2 ϴ α ω}
    _eat ← {0 = ≢ω : 2 ϴ α ω ⋄ 0 (αα ↑ ω) α (αα ↓ ω)}

     ws ← (' ', ⎕UCS 9) _set
    aws ← ws _any _ign
  awslf ← (⎕UCS 10 13) _set _o ws _any _ign
   gets ← aws _s ('←' _tk) _s aws _ign
    him ← '¯' _set
    dot ← '.' _set
    jot ← '∘' _set
   lbrc ← aws _s ('{' _set) _s aws
   rbrc ← aws _s ('}' _set) _s aws
   lpar ← aws _s ('(' _tk) _s aws _ign
   rpar ← aws _s (')' _tk) _s aws _ign
   lbrk ← aws _s ('[' _tk) _s aws _ign
   rbrk ← aws _s (']' _tk) _s aws _ign
   semi ← aws _s (';' _tk _as ('⍺' V∘,∘⊃)) _s aws
    grd ← aws _s (':' _tk) _s aws _ign
   egrd ← aws _s (':' ':' _tk) _s aws _ign
  alpha ← 'ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyzΔ' _set
 digits ← '0123456789' _set
   prim ← (prims ← '+-÷×|*⍟⌈⌊!<≤=≠≥>∧∨⍲⍱[]?⍴,⍪⌽⍉⍋⍒⊖⍷⊂⊃⍳⍸~≡≢⊢⊣/⌿\⍀↑↓∪∩⍧⍫⍛⍢') _set
    mop ← '¨⍨/⌿⍀\⍤' _set
   dop₁ ← '.⍣∘' _set
   dop₂ ← '⍤⍣∘' _set
   dop₃ ← '∘' _set
    eot ← aws _s {'' ≡ ω : 0 ϴ α '' ⋄ 2 ϴ α ω} _ign
   digs ← digits _some
  odigs ← digits _any
    int ← aws _s digs _s (him _opt) _s aws
  float ← aws _s (odigs _s dot _s int _o (digs _s dot)) _s aws
   name ← aws _s (alpha _o (digits _some _s alpha) _some) _s aws
     aw ← aws _s ('⍺⍵' _set) _s aws
   aaww ← aws _s (('⍺⍺' _tk) _o ('⍵⍵' _tk)) _s aws
    sep ← aws _s (('⋄', ⎕UCS 10 13) _set _ign) _s aws
    nss ← awslf _s (':Namespace' _tk) _s aws _s (name _opt) _s awslf _ign
    nse ← awslf _s (':EndNamespace' _tk) _s awslf _ign
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    Sfn ← aws _s (('TFF□' _tk) _o ('TFFI□' _tk)) _s aws _as {P ⏀∈ω}
   Prim ← prim _as P
     Vt ← {((0 □ ⍉α) ⍳ ω) 1 □ α ⍨ '' ¯1}
    Var ← {α (aaww _o aw _o (name _as ⏀) _t (αα = Vt) _as (ωω V∘,∘⊃)) ω}
    Num ← float _o int _as (N∘⏀)
 Strand ← 0 Var 'a'  _s (0 Var 'a' _some) _as ('s' A∘⏀)
    Pex ← {α (rpar _s Ex _s lpar) ω}
   Atom ← Strand _o (0 Var 'a' _as ('v'A)) _o (Num _some _as ('n' A∘⏀)) _o Pex
    Brk ← rbrk _s {α (Ex _opt _s (semi _s (Ex _opt) _any)) ω} _s lbrk _as ('i' E∘⏀)
    Idx ← Brk _s (_yes _as {P ,'['}) _s Atom _as (2 E∘⏀)
   Blrp ← {α (αα _s (ωω Slrp ∇)) ω}
   Slrp ← {α (αα _o (ωω _s ∇) _o ((1 _eat) _s ∇)) ω}
     Fa ← {                          e ← ('ωω' 'αα', 'αω') ,∘⍨⍤1 ⍉ ¯1 + 3 3 2 2 ⊤ (6 4 4 ≠ 1 5 9) + 2 × ⍳ 14
                                     a ← e (α{ω Gex _o Ex _o Fex Stmts _then Fn⍨⍨ αα ⍨ α})⍤2 1 ⊢ ω
                                     m ← (0 = 0 □ ⍉a) ∧ ∧≠ (∨⍀ ∘.=⍨⍨ ⍳14) ∨ ∘.≠⍨⍨ 1 □ ⍉a
                           ~∨≠ m  :  (⌈≠ 0 □ ⍉a) ⍬ α ω
          (1 = +≠ m) ∧ 2 > m ⍳ 1  :  0 (,⊂('F' new 1) wrap ⊃⊃ m ≠ 1 □ ⍉a) α ω
                                     z ← ('F' new 'a') wrap ⊃ (m ≠ 'F' new¨ 1 + ⍳14) ⍨.(wrap∘⊃) m ≠ 1 □ ⍉a
                                         0 (,⊂z) α ω}
     Fn ← {                         ns ← n z ≠⍨⍨ m ← {(F_m ω) ∧ ¯1 ∈⍨⍨ k ω} z ← ⊃⍨⌿ ω ⋄ 0 = ≢ns : 0 (,⊂z) α ''
                                     p ← α∘Fa¨ ns ⋄ 0 < c ← ⌈⌿ ⊃¨p : c ⍬ α ω
                                         0 (⍨⌿ (⊂ 0 4 ⍴ ⍬) ,⍨⍨ p {ω ((d +∘⊃ ⊣), 1 ↓⍤⍤1 ⊢) ⊃⍨⌿ 1 ⊃ α}¨at{m} ↓z) α ''}
    Pfe ← {α (rpar _s Fex _s lpar) ω}
    Bfn ← rbrc Blrp lbrc _as ('F' new ¯1 ,∘⊂∘⏀ 1 ↓ ¯1 ↓ ⊢)
    Fnp ← Prim _o (1 Var 'f') _o Sfn _o Bfn _o Pfe
    Mop ← {α ((mop _as P) _s Afx _as (1 O)) ω}
  Dop₁ ← {α ((dop₁ _as P) _s Afx _as (2 O∘⏀)) ω}
  Dop₂ ← {α (Atom _s (dop₂ _as P) _s Afx _as (2 O∘⏀)) ω}
  Dop₃ ← (dop₃ _as P) _s Atom _as (2 O∘⏀) _o (dot _s jot _as (P∘⏀) _as (1 O))
    Bop ← {α (rbrk _s Ex _s lbrk _s (_yes _as {P ,'['}) _s Afx _as (2 O∘⏀)) ω}
    Afx ← Mop _o (Fnp _s (Dop₁ _o Dop₃ _opt) _as (⊃wrap/∘⏀)) _o Dop₂ _o Bop
    Trn ← {α (Afx _s ((Afx _o Idx _o Atom) _s (∇ _opt) _opt)) ω} _as ('t' F∘⏀)
   Bind ← {α (gets _s (name _as ⏀) _env (αα{(⊃⏀ω) αα ⍨ α}) _as (ωω new 'b', ⊢)) ω}
   Asgn ← gets _s Brk _s (name _as ⏀ _t (0 = Vt) _as ('a' V∘,∘⊃)) _as ('a' E∘⏀)
    Fex ← Afx _s (Trn _opt) _s (1 Bind 'F' _any) _as (⊃wrap/∘⏀)
    App ← Afx _s (Idx _o Atom _s (dop2 _not) _opt) _as {(≢ω) E ⏀ω}
     Ex ← Idx _o Atom _s {α (0 Bind 'E' _o Asgn _o App _s ∇ _opt) ω} _as (⊃wrap/∘⏀)
    Gex ← Ex _s grd _s Ex _as (G∘⏀)
   Nlrp ← sep _o eot Slrp (lbrc Blrp rbrc)
  Stmts ← {α (sep _any _s (Nlrp _then (αα _s eot∘⏀)) _any _s eot) ω}
     Ns ← nss Blrp nse _then (Ex _o Fex Stmts _then Fn) _s eot _as M

     ps ← {0 ≠ ⊃ c a e r ← (0 2 ⍴ ⍬) Ns ∈{ω /⍨⍨ ∧\ 'ᵃ' ≠ ω}¨ω ,¨ □UCS 10 : □SIGNAL c ⋄ (⊃a) e}
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$$
\begin{aligned}
scp &\leftarrow (+\not\backslash F_m)\vdash\circ\subset\boxplus\vdash\\
prf &\leftarrow ((\not\equiv\uparrow{}^{-}1\downarrow\vdash(\not=\tilde{\cdot})\,0\neq\vdash)\ddot{\circ}1\uparrow\circ r)\vdash\\
blg &\leftarrow \{\alpha\leftarrow\vdash\diamond\alpha((prf\,(\lceil/\,(\iota\circ\not\equiv\vdash)\times\ddot{\circ}1\,(1\downarrow\dashv)\wedge.(=\vee\,0=\vdash)\circ\oslash\vdash)\,\alpha\alpha\,(\not=\circ\uparrow)\,r)\square\ddot{\circ}0\;2\;\omega\omega\,(\not=\tilde{\cdot})\,\alpha\alpha)\omega\}\\
enc &\leftarrow \subset\dashv,\circ\supset((\dashv,'\_',\vdash)/(\subset''),(\overline{\Phi}\ddot{\cdot}\vdash(/\tilde{\cdot})\,0\neq\vdash))\\
veo &\leftarrow \cup((\subset\texttt{'\%u'}),(,\ddot{\cdot}prims),\dashv)\sim\tilde{\circ}\{\supset,/\{\subset\bigstar(1\equiv\equiv\omega)\vdash\omega\}\ddot{\cdot}\omega\}\,{}^{-}1\downarrow\vdash(/\tilde{\cdot})\,(\wedge/\ddot{\cdot}\,0\neq((\supset 0\,\rho\vdash)\ddot{\cdot}\vdash))\\
ndo &\leftarrow \{\alpha\leftarrow\vdash\diamond m\supset\circ(\subset,\vdash)\ddot{\cdot}\,\alpha\circ\alpha\alpha''''\;\omega\supset\circ(,\circ\subset\tilde{\circ}\subset)\ddot{\cdot}\tilde{\cdot}\,m\leftarrow 1\geq\equiv\ddot{\cdot}\omega\}\\
n2f &\leftarrow (\supset,/)\,((1=\equiv)\supset,\circ\subset\tilde{\circ}\circ\subset)\ddot{\cdot}
\end{aligned}
$$

$$
\begin{aligned}
rn &\leftarrow\vdash,\circ\downarrow(1+d)\uparrow\ddot{\circ}{}^{-}1\,(+\not\backslash\,d\;\circ.=\circ\iota\,1+(\lceil/\,0,d))\\
rd &\leftarrow\vdash,(+/\uparrow\circ r\wedge.(=\vee\,0=\vdash)\circ\oslash\circ\uparrow\circ r\vdash(\not=\tilde{\cdot})\,F_m\wedge 1\in\tilde{\cdot}\,k)\\
df &\leftarrow\vdash(\not=\tilde{\cdot})\,(+\backslash 1=d)\,(\sim\dashv\in\dashv(/\tilde{\cdot})\,(1=d)\wedge(\sim\texttt{'b'}\in\tilde{\cdot}\,k)\wedge O_m\vee F_m)\vdash\\
dua &\leftarrow((\sim G_m)\wedge F_m\vee\downarrow\circ prf\in r\circ F_s)\,(\dashv(\not\backslash\circ\vdash)\,(d\,(\not=\tilde{\cdot})\,\dashv)\,(0,1\downarrow(\bar{}1\oplus\vdash)\wedge\dashv=\bar{}1\oplus\dashv)\dashv(\not=\circ\vdash)\,0\in\tilde{\cdot}\,n)\vdash\\
du &\leftarrow\vdash(\not=\tilde{\cdot}\circ\sim)\,dua\vee\circ(\vee/)\,(prf\wedge.(=\vee\,0=\vdash)\circ\oslash\,prf\,(\not=\tilde{\cdot})\,dua)\wedge\uparrow\circ r\wedge.\geq\circ\oslash\,dua\,(\not=\circ\vdash)\uparrow\circ r\times 0=prf\\
lfh &\leftarrow(0\neq 1\square\dashv)\supset(\subset\circ\oslash\circ\fatsemi\,0\,\texttt{'M'}\,0\,'',0,\tilde{\cdot}\,(\subset\dashv))\,,\circ\subset\circ\oslash\circ\fatsemi\,1\,\texttt{'F'}\,1,('fn'\,enc\dashv),(\subset\dashv),5\downarrow\circ,1\uparrow\vdash\\
lfn &\leftarrow(d,\texttt{'Of'},3\downarrow\vdash)\ddot{\circ}1\,at\,(F_m\wedge\texttt{'b'}\in\tilde{\cdot}\,k)\,(d,\texttt{'Vf'},('\texttt{fn}'\,enc\circ\supset r),4\downarrow\vdash)\ddot{\circ}1\,at\,(F_m\wedge 1\in\tilde{\cdot}\,k)\\
lf &\leftarrow(\supset\fatsemi/)\,(1,1\downarrow F_m\wedge 1\in\tilde{\cdot}\,k)\,blg\,(\uparrow r)\,(\subset lfh\fatsemi\circ(((\vdash-(\supset-2\lfloor\supset))\,d),1\downarrow\ddot{\circ}1\vdash)\,lfn)\boxplus 1\downarrow\vdash\\
dn &\leftarrow((0\in\tilde{\cdot}\,n)\wedge(A_m\wedge\texttt{'v'}\in\tilde{\cdot}\,k)\vee O_m\wedge\texttt{'f'}\in\tilde{\cdot}\,k)\,((\sim\dashv)\,(\not=\circ\vdash)\,(d-\bar{}1\oplus\dashv),1\downarrow_{[1]}\vdash)\vdash\\
mrep &\leftarrow(1+\supset),\texttt{'P'}\,0\,(,'\vdash'),(\subset'')\,,\tilde{\cdot}\,\bar{}1\downarrow 4\downarrow\circ,1\uparrow\vdash\\
mreu &\leftarrow\supset,\texttt{'E'}\,'\texttt{u}',(\subset'')\,,\tilde{\cdot}\,\bar{}1\downarrow 3\downarrow\circ,1\uparrow\vdash\\
mre &\leftarrow(\supset\fatsemi/)\,(-\circ\supset V_m\vee A_m)\circ\supset\circ\oplus\,(\downarrow,(((\vdash\rho\tilde{\cdot}\,(\not\equiv\oslash)\,,\tilde{\cdot}\not\equiv\times 2<\not\equiv)\,mreu\fatsemi mrep\fatsemi(1+\mathrm{d}),1\downarrow\ddot{\circ}1\vdash)\ddot{\cdot}\uparrow))\vdash\\
mrs &\leftarrow\vdash\subset_{[0]}\tilde{\cdot}\,1,1\downarrow d=1+\circ\supset d\\
mrk &\leftarrow(-\circ(+/\wedge\backslash)\circ\oplus L_m)\,(\uparrow\fatsemi\tilde{\circ}\circ(mre\,(mre\,mrs)\ddot{\cdot}\,at\,(G_m\circ(\supset\fatsemi/)\,1\uparrow\ddot{\cdot}\vdash)\circ mrs)\downarrow)\vdash\\
mr &\leftarrow(\supset\fatsemi/)\,((1\uparrow\vdash),(mrk\ddot{\cdot}\,1\downarrow\vdash))\circ scp\\
ur &\leftarrow((2\uparrow\vdash),1,(\texttt{'um'}\,enc\circ\supset r),4\downarrow\vdash)\ddot{\circ}1\,at\,(E_m\wedge\texttt{'u'}\in\tilde{\cdot}\,k)\\
rt &\leftarrow\vdash,(\vee\backslash F_m)+(+\not=prf\wedge.(=\vee\,0=\dashv)\circ\oslash\tilde{\circ}\circ\uparrow\circ r\,M_s\fatsemi G_s)-F_m\\
nm &\leftarrow((3\uparrow\vdash),(\texttt{'fe'}\,enc\circ\supset r),4\downarrow\vdash)\ddot{\circ}1\,at\,((0\in\tilde{\cdot}\,n)\wedge E_m\vee O_m\vee A_m)\\
lgg &\leftarrow(\fatsemi/1\downarrow\vdash)\fatsemi\circ\supset\tilde{\cdot}\,\dashv(((\bar{}1+d),2,\tilde{\cdot}\,t,k,n,r\,,\circ\fatsemi\,s)\fatsemi\dashv\fatsemi 3,\texttt{'V'},\texttt{'a'},3\,(\downarrow\ddot{\circ}1)\,1\uparrow\vdash)\circ\supset 1\uparrow\vdash\\
lg &\leftarrow(\supset\fatsemi/)\vdash((\subset\dashv(\not=\tilde{\cdot}\circ\sim)\,(\vee\backslash\vdash)),(((1\uparrow\vdash)\,lgg\vdash\subset_{[0]}\tilde{\cdot}\,d=1+\supset)\ddot{\cdot}\subset_{[0]}\tilde{\cdot}))\,G_m\wedge 1\oplus E_m\\
fet &\leftarrow(d,\texttt{'V'}\,0,3\downarrow\vdash)\ddot{\circ}1\,at\,(0,1\downarrow E_m\vee O_m\vee A_m)\,(d,\texttt{'Av'},3\downarrow\vdash)\ddot{\circ}1\,at\,(E_m\wedge\texttt{'b'}\in\tilde{\cdot}\,k)\\
fee &\leftarrow(\fatsemi/\oplus)\,(M_m\vee E_m\vee O_m\vee A_m)\,blg\vdash((\supset\circ\oplus\vdash)\,(\subset(d--\tilde{\circ}\circ\supset),1\downarrow\ddot{\circ}1\vdash)\circ fet\dashv\fatsemi\bar{}1\downarrow\ddot{\circ}1\vdash)\boxplus\supset,\tilde{\cdot}\,1\downarrow\vdash\\
fe &\leftarrow(\supset\fatsemi/)\,(+\not\backslash\,d\leq g)\,(\subset(\vdash\uparrow\tilde{\cdot}\,1=\circ\not\equiv\vdash)\,\fatsemi\circ\supset\circ fee\vdash)\boxplus\vdash\\
can &\leftarrow(+\backslash A_m\vee O_m)\,((,1\uparrow\vdash),\circ(\subset(\bar{}1+2\lfloor\not\equiv)\supset(\subset\circ\subset\supset),\subset)\circ n\,1\downarrow\vdash)\boxplus\vdash\\
cas &\leftarrow(\bar{}1\oplus(A_m\vee O_m)\wedge\texttt{'vf'}\in\tilde{\cdot}\,k)\vee(\downarrow prf)\in\circ r\vdash(\not=\tilde{\cdot})\,A_m\wedge\texttt{'n'}\in\tilde{\cdot}\,k\\
ca &\leftarrow(can\vdash(\not=\tilde{\cdot})\,cas\vee A_m\vee O_m\wedge\texttt{'f'}\in\tilde{\cdot}\,k)\dashv at\,(A_m\vee O_m\wedge\texttt{'f'}\in\tilde{\cdot}\,k)\,\theta\,,\circ\subset\tilde{\circ}\vdash(\not=\tilde{\cdot}\circ\sim)\,cas\\
lj &\leftarrow(\supset\fatsemi/)\,(1\uparrow scp),((\vdash\fatsemi 2\,\texttt{'L'}\,0\,0,2\,'',\tilde{\cdot}\,\bar{}2\downarrow 4\downarrow\circ,1\uparrow\vdash)\ddot{\cdot}\,1\downarrow scp)\\
sd &\leftarrow(\supset\fatsemi/)\,(1\uparrow scp),(n\,F_s)\,(d,\texttt{'Vf'},(\subset\dashv),4\downarrow\vdash)\ddot{\circ}1\,at\,((\subset,\texttt{'}\forall\texttt{'})\in\tilde{\cdot}\,n)\ddot{\cdot}\,1\downarrow scp\\
inm &\leftarrow\vee\not=\bar{}1\,(\oplus\vee\vdash)\,1\,2\,(\oplus\vee\vdash)\,(\bar{}1\;\bar{}2\oplus E_m\wedge_{[1]}1\,2\circ.=k)\wedge\ddot{\circ}1\,V_m\wedge n\in\circ n\,F_s\\
inp &\leftarrow(E_m\wedge\dashv)\vee 1,2\neq/\dashv\\
inza &\leftarrow(1\uparrow 1\downarrow\dashv)\,(\not=\tilde{\cdot}\circ\not\equiv)\,at\,((\subset,\texttt{'}\alpha\texttt{'})\in\tilde{\cdot}\,n)\,(\bar{}1\uparrow\dashv)\,(\not=\tilde{\cdot}\circ\not\equiv)\,at\,((\subset,\texttt{'}\omega\texttt{'})\in\tilde{\cdot}\,n)\vdash\\
inz &\leftarrow(1\uparrow\dashv)\,(d,t,k,3\downarrow\ddot{\circ}1\,(\not=\tilde{\cdot}\circ\not\equiv))\,at\,(0\,,\tilde{\cdot}\,2\neq/\circ\oplus(\vee\backslash\circ\oplus E_m))\,inza\\
inn &\leftarrow(3\uparrow\ddot{\circ}1\vdash),((\dashv\rho\ddot{\cdot}\tilde{\cdot}\,1+0\lceil(\lceil/\circ n\,G_s))\,(('\texttt{fe}'\equiv 2\uparrow\vdash)\supset(\subset\vdash)\,,\circ\subset\texttt{'fe'},(\overline{\Phi}\dashv),2\downarrow\vdash)\ddot{\cdot}\,n),(4\downarrow\ddot{\circ}1\vdash)\\
ins &\leftarrow\dashv(d,t,k,((1000\times 1+\dashv)+1+n+(\lceil/n)),4\downarrow\ddot{\circ}1\vdash)\,at\,(L_m\vee G_m)\,inn\\
inr &\leftarrow 1\,,\circ\fatsemi\vdash inz\ddot{\cdot}\,(\iota\circ\not\equiv\vdash)\,ins\ddot{\cdot}\,((\supset\circ n\ddot{\cdot}\,\dashv)\,\iota((\supset n(\not=\tilde{\cdot})\,V_m\wedge\texttt{'f'}\in\tilde{\cdot}\,k)\ddot{\cdot}\vdash))\supset\ddot{\cdot}\,(\subset 1\downarrow\ddot{\cdot}\,\dashv)\,,\circ\subset\ddot{\cdot}\vdash\\
in &\leftarrow(\supset\fatsemi/)\circ(\vdash/)\,(1\downarrow scp)\,inr\circ((0\,\rho\subset 0\,8\,\rho\,0),\vdash/)\,at\,(\dashv/)\,inm\,((\supset\ddot{\cdot}\,inp\subset E_m\wedge\dashv)\,,\circ\fatsemi\,inp\subset_{[0]}\vdash)\vdash
\end{aligned}
$$

```
pcc ← (⊂⊢ (≠⍨) A_m ∨ O_m ∧ 'f' ∊⍨ k)∘((⍳∘∪⍨ n) ⌷⍤0 2 (1 ⌈ ≢) ↑ ⊢)∘(⊃⍪≠)∘⌽ (≠∘⊢)
pcb ← ((, ∧.(= ∨ 0 = ⊣)∘⍪)⍤2 1⍨∘↑∘r M_s ⍪ F_s) pcc⍤1 ((⊢ (≠⍨) (d = g) ∧ A_m ∨ E_m ∨ O_m)¨ scp)
pcv ← (d, 'V', ('af' ⊃¨∘⊂⍨ O_m), (⊃¨v), r, s, (⊂⍬) ,⍨∘⍪ g) at (O_m ∨ A_m ∧ 'v' ∊⍨ k)
pc ← (⊃⍪/) pcb {(pcv d (⊣, 1 ↓⍤1 ⊢)(⍺ ↑⍨ 1 ⌈ ≢⍺) ⌷⍤0 2⍨ (n ⍺) ⍳ n) at (V_m ∧ (n ⍺) ∊⍨ n) ⍵}¨ scp
da ← ⊢ (≠⍨∘~) (A_m ∧ d = g) ∨ (0 ,⍨ 2 ∧/ L_m) ∨ (L_m ∧ ¯1 ⌽ A_m ∧ d = g) ∨ O_m ∧ ('f' ∊⍨ k) ∧ 1 ≠ d
fce ← (⊃∘n P_s) {⊂⍎ ' ⍵' ,⍨ (≢⍵) ⊃ '' (⍺, '⊃') ('⊃', ⍺, '/')} (v A_s)
fcm ← (∧/ E_m ∨ A_m ∨ P_m) ∧∘~ 'ui' ∊⍨∘⊃∘⊃ k
fc ← ((⊃⍪/) (((d, 'An', 3 ↓ ¯1 ↓ ,) 1 ↑ ⊢), fce)¨ at (fcm¨)) ('MFOEL' ∊⍨ t) ⊂[0] ⊢
ce ← (+\ F_m ∨ G_m ∨ E_m ∨ O_m ∨ L_m) ((¯1 ↓∘, 1 ↑ ⊢) ,∘⊂ (⊃∘v 1 ↑ ⊢) ,∘(A_m ⊃¨∘↓ n ,∘⍪∘n2f v) 1 ↓ ⊢)⌸ ⊢
ll ← (⊢ (≠⍨) 1 ⌽ L_m) (((⊂⊂'%l') ,∘⊂¨∘n ⊣) ,⍨ ¯1 ↓⍤1 ⊢) at L_m ⊢
fv ← (⊃⍪/) (((1 ↓ ⊢) ⍪⍨ (, 1 7 ↑ ⊢) ,∘⊂∘n ¯1 ↑ ⊢)¨ scp)
nv ← (¯1 ↓⍤1 ⊢), (¯1 ⊖ ≢ ⊃ ⊢ ,∘⊂⍨ (⊂'%u' '%f' '%u'), (⊂ '%u' '%i', ⊢), (⊂ (⊂'%u'), ⊢))¨∘v
lt ← (⊂⍬) ,⍨ ⊢
val ← (n ⍳∘∪ n) ,¨ ⊢ (⊢ + (≢⊣) × 0 = ⊢) (⌈/ (⍳≢) ×⍤1 (∪n) ∘.((⊂⊣) ∊ ⊢) (n2f¨ v))
vag ← ∧∘~∘(∘.=⍨∘⍳ ≢)⍨ (∘.(((1 ⌷ ⊢) > 0 ⌷ ⊣) ∧ (0 ⌷ ⊢) < 1 ⌷ ⊣)⍨ val)
vae ← (∪n) (⊣ ,⍤0 ⊣ (⌷⍨⍤1 0)∘⊃ ((⊢ ,∘⊃ (⍳∘≢ ⊣) ~ ⊢ (≠⍨) (≢⊢) ↑ ⊣)/∘⌽ (⊂⍬) ,∘↓ ⊢)) vag
vac ← (((0 ⌷∘⍉ ⊣) ⍳∘⊂ ⊢) ⊃ (1 ⌷∘⍉ ⊣) ,∘⊂ ⊢) ndo
va ← ((⊃⍪/) (1 ↑ ⊢), (((vae E_s) (d, t, k, (⊣ vac n), r, s, g, y ,∘⍪⍨ (⊂⊣) vac¨ v) ⊢)¨ 1 ↓ ⊢)) scp
avb ← {(((,¨'⍺⍵') ↑⍨ 1 ↓ ⍴) ⍪ ⊢) ⍺ ⌷⍨⍤2 0 ⊢ ⍺⍺ ⍳ ⍺⍺ ∩⍨ (↓ (⌽ 1 +∘⍳ 0 ⍳⍨ ⊢) ((≢⊢) ↑ ↑)⍤0 1 ⊢) ⊃ r ⍵}
avi ← ¯1 0 + (⍴⊣) ⊤ (,⊣) ⍳ (⊂⊢)
avh ← {⊂ ⍵, (n⍵) ((⍺⍺ (⍵⍵ avb) ⍵) {⍺⍺ avi ndo (⊂⍺), ⍵})¨ v ⍵}
av ← (⊃⍪/) (+\ F_m) {⍺((⍺ ((∪∘⌽ (0 ⍴ ⊂''), n) E_s)⌸ ⍵) avh (r (1 ↑ ⍵) ⍪ F_s ⍵))⌸ ⍵} ⊢
rlf ← (⌽ ↓ (((1 ⊃ ⊣) ∪ ⊢ ~ 0 ⌷ ⊣)/∘⌽ (⊂⍬), ↑)⍤0 1⍨ 1 +∘⍳ ≢) (⊖ 1 ⊖ n ,⍤0 (⊂⊣) veo¨ v)
rl ← ⊢ ,∘(⊃,/) (⊂∘n O_s ⍪ F_s) rlf¨ scp
vc ← (⊃⍪/) (((1 ↓ ⊢) ⍪⍨ (1 7 ↑ ⊢), (≢∘∪∘n E_s), 1 ¯3 ↑ ⊢)¨ scp)
eff ← (⊃⍪/) ⊢ (((⊂∘⍉∘⍪ d, 'Fe', 3 ↓ ,) 1 ↑ ⊣), 1 ↓ ⊢) (d =∘⊃ d) ⊂[0] ⊢
ef ← (F_m ∧ ¯1 =∘×∘⊃¨ y) ((⊃⍪/) (⊂ ⊢ (≠⍨)∘~ (∨\ ⊣)), (eff¨ ⊂[0])) ⊢
ifn ← 1 'F' 0 'Init' ⍬ 0 1, (4 ⍴ 0) ⍬ ⍬ ,⍨ ⊢
if ← (1 ↑ ⊢) ⍪ (⊢ (≠⍨) O_m ∧ 1 = d) ⍪ ((⊢ wrap⍨∘ifn∘≢∘∪ n) ⊢ (≠⍨) E_m ∧ 1 = d) ⍪ (∨\ F_m) (≠∘⊢) ⊢
fgz ← (1 ↑ ⊢) ⍪ (((¯1 + d), 1 ↓⍤1 ⊢) 1 ↓ ⊢) ⍪ 2, 'G', 1, 3 ↓⍤1 (¯1 ↑ ¯1 ↓⍤1 ⊢) ,∘n 1 ↑ ⊢
fg ← (⊃⍪/) (fgz¨ at (G_m∘(⊃⍪/) 1 ↑¨ ⊢) ⊢ ⊂[0]⍨ d = 2 ⌊ g)
fft ← (, 1 ↑ ⊢) (1 'Z', (2 ↓ ¯5 ↓ ⊣), (v⊣), n, y, (⊂ 2 ↑∘,∘⊃∘⊃ e), l) (¯1 ↑ E_s)
ff ← ((⊃⍪/) (1 ↑ ⊢), (((1 ↑ ⊢) ⍪ (((¯1 + d), 1 ↓⍤1 ⊢) 1 ↓ ⊢) ⍪ fft)¨ 1 ↓ ⊢)) scp
fzh ← ((∪n) ∩ (⊃∘l ⊣)) (¯1 ⌽ (⊂⊣), ((≢⊢) - 1 + (⌽n) ⍳ ⊣) ((⊂ ⊣ ⊃¨∘⊂ (⊃¨e)), (⊂ ⊣ ⊃¨∘⊂ (⊃¨y)) ,∘⊂ ⊣) ⊢) ⊢
fzf ← 0 ≠ (≢∘⍴¨∘⊃∘v ⊣)
fzb ← (((⊃∘v ⊣) (≠⍨) fzf), n) ,∘⍪ ('f'∘,∘⍕¨∘⍳ (+/fzf)), ('s'∘,∘⍕¨∘⍳∘≢ ⊢)
fzv ← ((⊂⊣) (⊖↑)⍨¨ (≢⊣) (- +∘⍳ ⊢) (≢⊢)) ((⊢ ,⍨ 1 ⌷∘⍉ ⊣) ⌷⍨ (0 ⌷∘⍉ ⊣) ⍳ ⊢)⍤2 0¨ v
fze ← (¯1 + d), t, k, fzb ((⊢/ (-∘≢ ⊢) ↑ ⊣), r, s, g, fzv, y, e ,∘⍪ l) ⊢
fzs ← (, 1 ↑ ⊢) (1 ⊖ (⊣ ((1 'Y', (2 ⌷ ⊣), ⊢) ⍪∘⍉∘⍪ (3 ↑ ⊣), ⊢) 1 ⌽ fzh, ¯1 ↓ 6 ↓ ⊣) ⍪ fze) (≠∘⊢)
fz ← ((⊃⍪/) (1 ↑ ⊢), (((2 = d) (fzs ⍪ (1 ↓∘~ ⊣) (≠∘⊢) 1 ↓ ⊢) ⊢)¨ 1 ↓ ⊢)) (1, 1 ↓ S_m) ⊂[0] ⊢
fd ← (1 ↑ ⊢) ⍪ ((1, 'Fd', 3 ↓ ⊢)⍤1 F_s) ⍪ 1 ↓ ⊢

tta ← (fc∘da∘(pc⍣≡)∘mr⍣≡)∘in⍣3∘sd∘lj∘ca∘fe∘lg∘nm∘rt∘mr∘dn∘lf∘du∘df∘rd∘rn
tt ← fd∘fz∘ff∘fg∘if∘ef∘vc∘rl∘av∘va∘lt∘nv∘fv∘ll∘ce∘ur∘tta
```

```
E₁ ← {'fn' gcl ((⊂ n ,∘⊃ v), e, y) ω}
E₂ ← {'fn' gcl ((⊂ n ,∘⊃ v), e, y) ω}
Eᵢ ← {r l f ← ⊃ v ω ⋄ ((⊃ n ω) ('fn' var) ⊃⊃ e ω), '=', ((⊃⊃ v ω) ('fn' var) 1 ⊃ ⊃ e ω), ';', nl}
O₁ ← {'op' gcl ((⊂ n ,∘⊃ v), e, y) ω}
O₂ ← {'op' gcl ((⊂ n ,∘⊃ v), e, y) ω}
O₀ ← {''}
Oᶠ ← {'EF(', ('Δ' ⎕R '__' ⊃ n ω), ',', (⊃⊃ v ω), ');', nl}
F_d ← {'FP(', (⊃ n ω), ');', nl}
F₀ ← {'DF(', (⊃ n ω), '_f){', nl, 'A*env[]={tenv};', nl}
F₁ ← {'DF(', (⊃ n ω), '_f){', nl, ('env0' dnv ω), (fnv ω)}
G₀ ← {v ← (⊃⊃ v ω) ('' var) 1 ⊃ ⊃ e ω
        'if(1!=cnt(', v, '))err(5);if(', v, '.v.as(s32).scalar<I>()){', nl}
G₁ ← {'z=', ((⊃ n ω) ('' var) ⊃ ⊃ e ω), ';goto L', (⍕⊃ l ω), ';}', nl}
L₀ ← {'z=', a, ';L', (⍕⊃ n ω), ':', (a ← (1 ⊃ ⊃ v ω) ('' var) 1 ⊃ ⊃ e ω), '=z;', nl}
Z₀ ← {'}', nl, nl}
Z₁ ← {'}', nl, nl}
Z_e ← {'}', nl, nl}
M₀ ← {rth, ('tenv' dnv ω), nl, 'A*env[]={', ((0 ≡ ⊃ω) ⊃ 'tenv' 'NULL'), '};', nl, nl}
S₀ ← {(('{', rk0, srk, 'DO(i,prk)cnt*=sp[i];', spp, sfv, slp) ω)}
Y₀ ← {⊃,/ ((⍳ ≢ ⊃ n ω) ((⊣ sts¨ (⊃l) ,¨∘⊃ s), '}', nl, ⊣ ste¨ (⊃n) var¨∘⊃ r) ω), '}', nl}

gc ← {⊃,/ {0 = ⊃ t ω : ⊂ 5 ρ ϴ ⋄ ⊂ (⍏ (⊃ t ω), ⍒ ⊃ k ω) ω}⍤1 ⊢ ω}

syms ← ,¨ '+'  '-'  '×'  '÷'  '*'  '⍟'  '|'  'o'  '⌊'  '⌈'  '!'
nams ←   'add' 'sub' 'mul' 'div' 'exp' 'log' 'res' 'cir' 'min' 'max' 'fac'
syms ,← ,¨ '<'  '≤'  '='  '≥'  '>'  '≠'  '~'  '∧'  '∨'  '⍲'  '⍱'
nams ,←  'lth' 'lte' 'eql' 'gte' 'gth' 'neq' 'not' 'and' 'lor' 'nan' 'nor'
syms ,← ,¨ '⎕'  '['  'ι'  'ρ'  ','  '⍪'  '⍋'  '⍒'  'e'  'ϵ'  'ɔ'
nams ,←  'sqd' 'brk' 'iot' 'rho' 'cat' 'ctf' 'rot' 'trn' 'rtf' 'mem' 'dis'
syms ,← ,¨ '≡'  '≢'  '⊢'  '⊣'  'T'  '⊥'  '⌿'  '⍀'  '\'  '⍉'  '?'
nams ,←  'eqv' 'nqv' 'rgt' 'lft' 'enc' 'dec' 'red' 'rdf' 'scn' 'scf' 'rol'
syms ,← ,¨ '↑'  '↓'  '⍫'  '⍪'  '.'  '⍤'  '⌸'  '∘'  'u'  'n'
nams ,←  'tke' 'drp' 'map' 'com' 'dot' 'rnk' 'pow' 'jot' 'unq' 'int'
syms ,← ,¨ '⍋'  '⍒'  '∘.'  '⍷'  '⊂'  '⍸'  '⎕FFT' '⎕IFFT' '%u'
nams ,←  'gdu' 'gdd' 'oup' 'fnd' 'par' 'mdv' 'fft' 'ift' ''

nl ← ⎕UCS 13 10 ⋄ fvs ← ,⍤0 (≠⍤¯) 0 ≠ (≢∘ρ¨ ⊣) ⋄ cln ← '¯' ⎕R '-' ⋄ cnm ← (syms ⍳ ⊂) ⊃ (nams, ⊂)
lits ← {'A(0,eshp,constant(', (cln ⍕ ω), ',eshp,', ('f64' 's32' ⊃⍤¯ ω = ⌊ω), '))'}
litv ← {'std::vector<', ('DI' ⊃⍤¯ ∧/ ω = ⌊ω), '>{', (cln ⊃ {α, ',', ω}/ ⍕¨ ω), '}.data()'}
lita ← {'A(1,dim4(', (⍕≢ω), '),array(', (⍕≢ω), ',', (litv ω), '))'}
lit ← {'' = ⊃ 0 ρ ω : (cnm ω), α ⋄ 1 = ≢ω : lits ω ⋄ lita ω}
var ← {α ≡ ,'α' : ,'ι' ⋄ α ≡ ,'ω' : ,'r' ⋄ ¯1 ≥ ⊃ω : αα lit ,α ⋄ 'env[', (⍕⊃ω), '][', (⍕⊃ ⌽ω), ']'}
dnv ← {(0 ≡ z) ⊃ ('A ', α, '[', (⍕ z ← ⊃ v ω), '];') ('A*', α, '=NULL;')}
fnv ← {z ← 'A*env[', (⍕ 1 + ⊃ s ω), ']={', (⊃,/ (⊂'env0'), {',p[', (⍕ω), ']'}¨ ⍳ ⊃ s ω), '};', nl}
gcl ← {z r l n ← ((3 ρ ⊂'fn'), ⊂α) {⊃ α var/ ω}¨ ↓ (⊃ω), ⍪ 1 ⊃ ω ⋄ n, '(', (⊃{α, ',', ω}/ z l r ~ ⊂'fn'), ',env);', nl}
```

```
∇ Z ← Gfx∆Init S
  'w_new'    ⎕NA 'P ', (BSO S), '|w_new <C[]'
  'w_close'  ⎕NA 'I ', (BSO S),'|w_close P'
  'w_del'    ⎕NA (BSO S), '|w_del P'
  'w_img'    ⎕NA (BSO S), '|w_img <PP P'
  'w_plot'   ⎕NA (BSO S), '|w_plot <PP P'
  'w_hist'   ⎕NA (BSO S), '|w_hist <PP F8 F8 P'
  'loadimg'  ⎕NA (BSO S), '|loadimg >PP <C[] I'
  'saveimg'  ⎕NA (BSO S), '|saveimg <PP <C[]'
  Z ← 0 0 ⍴ ⍬
∇

    Display ← {⍺ ← 'Co-dfns' ⋄ W ← w_new ⊂⍺ ⋄ 777 :: w_del W
                   w_del W ⊣ W ⍺⍺{w_close ⍺ : ⍸'⎕SIGNAL 777' ⋄ ⍺ ⍺⍺ ⍺⍺ ⍵}⍣⍵⍵ ⊢ ⍵}
LoadImage ← {⍺ ← 1 ⋄ ⌽ loadimg ⍬ ⍵ ⍺}
SaveImage ← {⍺ ← 'image.png' ⋄ saveimg (⌽⍵) ⍺}
    Image ← {~ 2 3 ∨.= ≢⍴⍵ : ⎕SIGNAL 4 ⋄ (3 ≠ 2 ⊃ 3 ↑ ⍴⍵) ∧ 3 = ≢⍴⍵ : ⎕SIGNAL 5 ⋄ ⍵ ⊣ w_img (⌽⍵) ⍺}
     Plot ← {2 ≠ ≢⍴⍵ : ⎕SIGNAL 4 ⋄ ~ 2 3 ∨.= 1 ⊃ ⍴⍵ : ⎕SIGNAL 5 ⋄ ⍵ ⊣ w_plot (⌽⍵) ⍺}
Histogram ← {⍵ ⊣ w_hist ⍵, ⍺}
```

:EndNamespace