The VFtoVP processor

(Version 1.4, January 2014)

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1* Introduction. The `VFtoVP` utility program converts a virtual font ("`VF`") file and its associated TEX font metric ("`TFM`") file into an equivalent virtual-property-list ("`VPL`") file. It also makes a thorough check of the given files, using algorithms that are essentially the same as those used by `DVI` device drivers and by TEX. Thus if TEX or a `DVI` driver complains that a `TFM` or `VF` file is "bad," this program will pinpoint the source or sources of badness. A `VPL` file output by this program can be edited with a normal text editor, and the result can be converted back to `VF` and `TFM` format using the companion program `VPtoVF`.

`VFtoVP` is an extended version of the program `TFtoPL`, which is part of the standard TEXware library. The idea of a virtual font was inspired by the work of David R. Fuchs who designed a similar set of conventions in 1984 while developing a device driver for ArborText, Inc. He wrote a somewhat similar program called `AMFtoXPL`.

The *banner* string defined here should be changed whenever `VFtoVP` gets modified.

define *my_name* ≡ `'vftovp'`
define *banner* ≡ `'This␣is␣VFtoVP,␣Version␣1.4'` { printed when the program starts }

2* This program is written entirely in standard Pascal, except that it occasionally has lower case letters in strings that are output. Such letters can be converted to upper case if necessary. The input is read from *vf_file* and *tfm_file*; the output is written on *vpl_file*. Error messages and other remarks are written on the *output* file, which the user may choose to assign to the terminal if the system permits it.

The term *print* is used instead of *write* when this program writes on the *output* file, so that all such output can be easily deflected.

define *print*(#) ≡ *write*(*stderr*, #)
define *print_ln*(#) ≡ *write_ln*(*stderr*, #)
define *print_real*(#) ≡ *fprint_real*(*stderr*, #)

{ Tangle doesn't recognize @ when it's right after the `=`. }
`@\␣@define␣var␣tfm;@\`
program *VFtoVP*(*vf_file*, *tfm_file*, *vpl_file*, *output*);
label ⟨ Labels in the outer block 3 ⟩
const ⟨ Constants in the outer block 4* ⟩
type ⟨ Types in the outer block 5 ⟩
var ⟨ Globals in the outer block 7 ⟩
⟨ Define *parse_arguments* 135* ⟩
procedure *initialize*; { this procedure gets things started properly }
var *k*: *integer*; { all-purpose index for initialization }
begin *kpse_set_program_name*(*argv*[0], *my_name*); *kpse_init_prog*(`'VFTOVP'`, 0, **nil**, **nil**);
{ We *xrealloc* when we know how big the file is. The 1000 comes from the negative lower bound. }
tfm_file_array ← *xmalloc_array*(*byte*, 1002); *parse_arguments*; ⟨ Set initial values 11* ⟩
end;

4* The following parameters can be changed at compile time to extend or reduce `VFtoVP`'s capacity.

define *class* ≡ *class_var*

⟨ Constants in the outer block 4* ⟩ ≡
vf_size = 100000; { maximum length of *vf* data, in bytes }
max_fonts = 300; { maximum number of local fonts in the *vf* file }
lig_size = 32510; { maximum length of *lig_kern* program, in words }
hash_size = 32579;
{ preferably a prime number, a bit larger than the number of character pairs in lig/kern steps }
max_stack = 100; { maximum depth of `DVI` stack in character packets }

See also section 143*.

This code is used in section 2*.

11.* We don't have to do anything special to read a packed file of bytes, but we do want to use environment variables to find the input files.

```
⟨ Set initial values 11* ⟩ ≡
    { See comments at kpse_find_vf in kpathsea/tex-file.h for why we don't use it. }
  vf_file ← kpse_open_file(vf_name, kpse_vf_format); tfm_file ← kpse_open_file(tfm_name, kpse_tfm_format);
  if verbose then
    begin print(banner); print_ln(version_string);
    end;
```

See also sections 21*, 50*, 55, 68, and 86.

This code is used in section 2*.

21.* If an explicit filename isn't given, we write to *stdout*.

```
⟨ Set initial values 11* ⟩ +≡
  if optind + 3 > argc then
    begin vpl_file ← stdout;
    end
  else begin vpl_name ← extend_filename(cmdline(optind + 2), 'vpl'); rewrite(vpl_file, vpl_name);
    end;
```

22:* Unpacking the TFM file. The first thing `VFtoVP` does is read the entire *tfm_file* into an array of bytes, *tfm*[0 .. (4 ∗ *lf* − 1)].

define *index* ≡ *index_type*

⟨ Types in the outer block 5 ⟩ +≡
index = *integer*; { address of a byte in *tfm* }

23:* ⟨ Globals in the outer block 7 ⟩ +≡
{ Kludge here to define *tfm* as a macro which takes care of the negative lower bound. We've defined *tfm* for the benefit of web2c above. }
`#define␣tfm␣(tfmfilearray␣+␣1001);` `@\`*tfm_file_array*: ↑*byte*; { the input data all goes here }
{ the negative addresses avoid range checks for invalid characters }

24:* The input may, of course, be all screwed up and not a `TFM` file at all. So we begin cautiously.

define *abort*(`#`) ≡
begin *print_ln*(`#`);
print_ln(`´Sorry,␣but␣I␣can´´t␣go␣on;␣are␣you␣sure␣this␣is␣a␣TFM?´`); *uexit*(1);
end

⟨ Read the whole `TFM` file 24* ⟩ ≡
read(*tfm_file*, *tfm*[0]);
if *tfm*[0] > 127 **then** *abort*(`´The␣first␣byte␣of␣the␣input␣file␣exceeds␣127!´`);
if *eof*(*tfm_file*) **then** *abort*(`´The␣input␣file␣is␣only␣one␣byte␣long!´`);
read(*tfm_file*, *tfm*[1]); *lf* ← *tfm*[0] ∗ *´400* + *tfm*[1];
if *lf* = 0 **then** *abort*(`´The␣file␣claims␣to␣have␣length␣zero,␣but␣that´´s␣impossible!´`);
tfm_file_array ← *xrealloc_array*(*tfm_file_array*, *byte*, 4 ∗ *lf* + 1000);
for *tfm_ptr* ← 2 **to** 4 ∗ *lf* − 1 **do**
begin if *eof*(*tfm_file*) **then** *abort*(`´The␣file␣has␣fewer␣bytes␣than␣it␣claims!´`);
read(*tfm_file*, *tfm*[*tfm_ptr*]);
end;
if ¬*eof*(*tfm_file*) **then**
begin *print_ln*(`´There´´s␣some␣extra␣junk␣at␣the␣end␣of␣the␣TFM␣file,´`);
print_ln(`´but␣I´´ll␣proceed␣as␣if␣it␣weren´´t␣there.´`);
end

This code is used in section 131*.

31.* Again we cautiously verify that we've been given decent data.

```
define read_vf(#) ≡ read(vf_file,#)
define vf_abort(#) ≡
        begin print_ln(#); print_ln('Sorry,␣but␣I␣can''t␣go␣on;␣are␣you␣sure␣this␣is␣a␣VF?');
        uexit(1);
        end
```

⟨ Read the whole VF file 31* ⟩ ≡

```
read_vf(temp_byte);
if temp_byte ≠ pre then vf_abort('The␣first␣byte␣isn''t␣`pre''!');
⟨ Read the preamble command 32* ⟩;
⟨ Read and store the font definitions and character packets 33 ⟩;
⟨ Read and verify the postamble 34 ⟩
```

This code is used in section 131*.

32.*

```
define vf_store(#) ≡
        if vf_ptr + # ≥ vf_size then vf_abort('The␣file␣is␣bigger␣than␣I␣can␣handle!');
        for k ← vf_ptr to vf_ptr + # − 1 do
          begin if eof(vf_file) then vf_abort('The␣file␣ended␣prematurely!');
          read_vf(vf[k]);
          end;
        vf_count ← vf_count + #; vf_ptr ← vf_ptr + #
```

⟨ Read the preamble command 32* ⟩ ≡

```
if eof(vf_file) then vf_abort('The␣input␣file␣is␣only␣one␣byte␣long!');
read_vf(temp_byte);
if temp_byte ≠ id_byte then vf_abort('Wrong␣VF␣version␣number␣in␣second␣byte!');
if eof(vf_file) then vf_abort('The␣input␣file␣is␣only␣two␣bytes␣long!');
read_vf(temp_byte); { read the length of introductory comment }
vf_count ← 11; vf_ptr ← 0; vf_store(temp_byte);
if verbose then
  begin for k ← 0 to vf_ptr − 1 do print(xchr[vf[k]]);
  print_ln('␣');
  end;
count ← 0;
for k ← 0 to 7 do
  begin if eof(vf_file) then vf_abort('The␣file␣ended␣prematurely!');
  read_vf(temp_byte);
  if temp_byte = tfm[check_sum + k] then incr(count);
  end;
real_dsize ← (((tfm[design_size] * 256 + tfm[design_size + 1]) * 256 + tfm[design_size + 2]) * 256 +
    tfm[design_size + 3])/'4000000;
if count ≠ 8 then
  begin print_ln('Check␣sum␣and/or␣design␣size␣mismatch.');
  print_ln('Data␣from␣TFM␣file␣will␣be␣assumed␣correct.');
  end
```

This code is used in section 31*.

35.* ⟨ Read and store a font definition 35* ⟩ ≡
```
begin if packet_found ∨ (temp_byte ≥ pre) then
  vf_abort('Illegal byte', temp_byte : 1, ' at beginning of character packet!');
font_number[font_ptr] ← vf_read(temp_byte − fnt_def1 + 1);
if font_ptr = max_fonts then vf_abort('I can''t handle that many fonts!');
vf_store(14);  { c[4] s[4] d[4] a[1] l[1] }
if vf[vf_ptr − 10] > 0 then  { s is negative or exceeds 2^24 − 1 }
  vf_abort('Mapped font size is too big!');
a ← vf[vf_ptr − 2]; l ← vf[vf_ptr − 1]; vf_store(a + l);  { n[a + l] }
if verbose then
  begin ⟨ Print the name of the local font 36* ⟩;
  end;
⟨ Read the local font's TFM file and record the characters it contains 39* ⟩;
incr(font_ptr); font_start[font_ptr] ← vf_ptr;
end
```
This code is used in section 33.

36.* The font area may need to be separated from the font name on some systems. Here we simply reproduce the font area and font name (with no space or punctuation between them).

⟨ Print the name of the local font 36* ⟩ ≡
```
print('MAPFONT ', font_ptr : 1, ' :');
for k ← font_start[font_ptr] + 14 to vf_ptr − 1 do print(xchr[vf[k]]);
k ← font_start[font_ptr] + 5; print(' at ');
print_real((((vf[k] * 256 + vf[k + 1]) * 256 + vf[k + 2])/'4000000) * real_dsize, 2, 2); print_ln('pt')
```
This code is used in section 35*.

37.* Now we must read in another TFM file. But this time we needn't be so careful, because we merely want to discover which characters are present. The next few sections of the program are copied pretty much verbatim from DVItype, so that system-dependent modifications can be copied from existing software.

It turns out to be convenient to read four bytes at a time, when we are inputting from the local TFM files. The input goes into global variables *b0*, *b1*, *b2*, and *b3*, with *b0* getting the first byte and *b3* the fourth.

⟨ Globals in the outer block 7 ⟩ +≡
```
a: integer;  { length of the area/directory spec }
l: integer;  { length of the font name proper }
cur_name: ↑char;  { external tfm name }
b0, b1, b2, b3: byte;  { four bytes input at once }
font_lh: 0 .. '77777;  { header length of current local font }
font_bc, font_ec: 0 .. '77777;  { character range of current local font }
```

39:* We use the *vf* array to store a list of all valid characters in the local font, beginning at location *font_chars*[*f*].

```
⟨ Read the local font's TFM file and record the characters it contains 39* ⟩ ≡
  font_chars[font_ptr] ← vf_ptr; ⟨ Move font name into the cur_name string 44* ⟩;
  tfm_name ← kpse_find_tfm(cur_name);
  if ¬tfm_name then
    print_ln('---not␣loaded,␣TFM␣file␣', stringcast(cur_name), '␣can''t␣be␣opened!')
  else begin resetbin(tfm_file, tfm_name); font_bc ← 0; font_ec ← 256;
        { will cause error if not modified soon }
    read_tfm_word;
    if b2 < 128 then
      begin font_lh ← b2 * 256 + b3; read_tfm_word;
      if (b0 < 128) ∧ (b2 < 128) then
        begin font_bc ← b0 * 256 + b1; font_ec ← b2 * 256 + b3;
        end;
      end;
    if font_bc ≤ font_ec then
      if font_ec > 255 then print_ln('---not␣loaded,␣bad␣TFM␣file␣', stringcast(tfm_name), '!')
      else begin for k ← 0 to 3 + font_lh do
          begin read_tfm_word;
          if k = 4 then ⟨ Check the check sum 40* ⟩;
          if k = 5 then ⟨ Check the design size 41 ⟩;
          end;
        for k ← font_bc to font_ec do
          begin read_tfm_word;
          if b0 > 0 then { character k exists in the font }
            begin vf[vf_ptr] ← k; incr(vf_ptr);
            if vf_ptr = vf_size then vf_abort('I'm␣out␣of␣VF␣memory!');
            end;
          end;
        end;
    if eof(tfm_file) then
      print_ln('---trouble␣is␣brewing,␣TFM␣file␣', stringcast(tfm_name), '␣ended␣too␣soon!');
    free(tfm_name);
    end;
  free(cur_name); incr(vf_ptr) { leave space for character search later }
```

This code is used in section 35*.

40:* ⟨ Check the check sum 40* ⟩ ≡

```
  if b0 + b1 + b2 + b3 > 0 then
    if (b0 ≠ vf[font_start[font_ptr]]) ∨ (b1 ≠ vf[font_start[font_ptr] + 1]) ∨
        (b2 ≠ vf[font_start[font_ptr] + 2]) ∨ (b3 ≠ vf[font_start[font_ptr] + 3]) then
      begin if verbose then print_ln('Check␣sum␣in␣VF␣file␣being␣replaced␣by␣TFM␣check␣sum');
      vf[font_start[font_ptr]] ← b0; vf[font_start[font_ptr] + 1] ← b1; vf[font_start[font_ptr] + 2] ← b2;
      vf[font_start[font_ptr] + 3] ← b3;
      end
```

This code is used in section 39*.

43:* (No initialization to be done. Keep this module to preserve numbering.)

44.* The string *cur_name* is supposed to be set to the external name of the `TFM` file for the current font. We do not impose an arbitrary limit on the filename length.

```
define name_start ≡ (font_start[font_ptr] + 14)
define name_end ≡ vf_ptr
⟨ Move font name into the cur_name string 44* ⟩ ≡
  r ← name_end − name_start; cur_name ← xmalloc_array(char, r);
      { strncpy might be faster, but it's probably a good idea to keep the xchr translation. }
  for k ← name_start to name_end do
    begin cur_name[k − name_start] ← xchr[vf[k]];
    end;
  cur_name[r] ← 0; { Append null byte since this is C. }
```

This code is used in section 39*.

49:* In order to stick to standard Pascal, we use an *xchr* array to do appropriate conversion of ASCII codes. Three other little strings are used to produce *face* codes like `MIE`.

```
⟨ Globals in the outer block 7 ⟩ +≡
ASCII_04, ASCII_10, ASCII_14: const_c_string;  { strings for output in the user's external character set }
xchr: packed array [0..255] of char;
MBL_string, RI_string, RCE_string: const_c_string;  { handy string constants for face codes }
```

50:* ⟨ Set initial values 11* ⟩ +≡

```
  ASCII_04 ← ' !"#$%&''()*+,-./0123456789:;<=>?';
  ASCII_10 ← '@ABCDEFGHIJKLMNOPQRSTUVWXYZ[\]^_';
  ASCII_14 ← '`abcdefghijklmnopqrstuvwxyz{|}~?';
  for k ← 0 to 255 do xchr[k] ← '?';
  for k ← 0 to '37 do
    begin xchr[k + '40] ← ASCII_04[k + 1]; xchr[k + '100] ← ASCII_10[k + 1];
    xchr[k + '140] ← ASCII_14[k + 1];
    end;
  MBL_string ← ' MBL'; RI_string ← ' RI '; RCE_string ← ' RCE';
```

60:* The property value may be a character, which is output in octal unless it is a letter or a digit.

```
procedure out_char(c: byte);  { outputs a character }
  begin if (font_type > vanilla) ∨ (charcode_format = charcode_octal) then
    begin tfm[0] ← c; out_octal(0, 1)
    end
  else if (charcode_format = charcode_ascii) ∧ (c > " ") ∧ (c ≤ "~") ∧ (c ≠ "(") ∧ (c ≠ ")") then
      out(' C ', xchr[c])  { default case, use C only for letters and digits }
    else if ((c ≥ "0") ∧ (c ≤ "9")) ∨ ((c ≥ "A") ∧ (c ≤ "Z")) ∨ ((c ≥ "a") ∧ (c ≤ "z")) then
        out(' C ', xchr[c])
      else begin tfm[0] ← c; out_octal(0, 1);
        end;
  end;
```

61:* The property value might be a "face" byte, which is output in the curious code mentioned earlier, provided that it is less than 18.

```
procedure out_face(k: index);  { outputs a face }
  var s: 0..1;  { the slope }
    b: 0..8;  { the weight and expansion }
  begin if tfm[k] ≥ 18 then out_octal(k, 1)
  else begin out(' F ');  { specify face-code format }
    s ← tfm[k] mod 2; b ← tfm[k] div 2; put_byte(MBL_string[1 + (b mod 3)], vpl_file);
    put_byte(RI_string[1 + s], vpl_file); put_byte(RCE_string[1 + (b div 3)], vpl_file);
    end;
  end;
```

100:* The last thing on VFtoVP's agenda is to go through the list of *char_info* and spew out the information about each individual character.

```
⟨ Do the characters 100* ⟩ ≡
  sort_ptr ← 0;  { this will suppress 'STOP' lines in ligature comments }
  for c ← bc to ec do
    if width_index(c) > 0 then
      begin if chars_on_line = 8 then
        begin print_ln('␣'); chars_on_line ← 1;
        end
      else begin if chars_on_line > 0 then print('␣');
        if verbose then incr(chars_on_line);  { keep chars_on_line = 0 }
        end;
      if verbose then print_octal(c);  { progress report }
      left; out('CHARACTER'); out_char(c); out_ln; ⟨ Output the character's width 101 ⟩;
      if height_index(c) > 0 then ⟨ Output the character's height 102 ⟩;
      if depth_index(c) > 0 then ⟨ Output the character's depth 103 ⟩;
      if italic_index(c) > 0 then ⟨ Output the italic correction 104 ⟩;
      case tag(c) of
      no_tag: do_nothing;
      lig_tag: ⟨ Output the applicable part of the ligature/kern program as a comment 105 ⟩;
      list_tag: ⟨ Output the character link unless there is a problem 106 ⟩;
      ext_tag: ⟨ Output an extensible character recipe 107 ⟩;
      end;
      if ¬do_map(c) then goto final_end;
      right;
      end
```

This code is used in section 133*.

112:* ⟨ Check for ligature cycles 112* ⟩ ≡

```
hash_ptr ← 0; y_lig_cycle ← 256;
for hh ← 0 to hash_size do hash[hh] ← 0;  { clear the hash table }
for c ← bc to ec do
  if tag(c) = lig_tag then
    begin i ← remainder(c);
    if tfm[lig_step(i)] > stop_flag then i ← 256 * tfm[lig_step(i) + 2] + tfm[lig_step(i) + 3];
    ⟨ Enter data for character c starting at location i in the hash table 113 ⟩;
    end;
if bchar_label < nl then
  begin c ← 256; i ← bchar_label;
  ⟨ Enter data for character c starting at location i in the hash table 113 ⟩;
  end;
if hash_ptr = hash_size then
  begin print_ln('Sorry, I haven''t room for so many ligature/kern pairs!'); uexit(1);
  end;
for hh ← 1 to hash_ptr do
  begin r ← hash_list[hh];
  if class[r] > simple then  { make sure f is defined }
    r ← lig_f(r, (hash[r] − 1) div 256, (hash[r] − 1) mod 256);
  end;
if y_lig_cycle < 256 then
  begin print('Infinite ligature loop starting with '');
  if x_lig_cycle = 256 then print('boundary') else print_octal(x_lig_cycle);
  print(' and '); print_octal(y_lig_cycle); print_ln('!');
  out('(INFINITE LIGATURE LOOP MUST BE BROKEN!)'); uexit(1);
  end
```

This code is used in section 88.

116:* Evaluation of $f(x, y)$ is handled by two mutually recursive procedures. Kind of a neat algorithm, generalizing a depth-first search.

```
ifdef('notdef')
function lig_f(h, x, y : index): index;
  begin end;
  { compute f for arguments known to be in hash[h] }
endif('notdef')
function eval(x, y : index): index;  { compute f(x, y) with hashtable lookup }
  var key: integer;  { value sought in hash table }
  begin key ← 256 * x + y + 1; h ← (1009 * key) mod hash_size;
  while hash[h] > key do
    if h > 0 then decr(h) else h ← hash_size;
  if hash[h] < key then eval ← y  { not in ordered hash table }
  else eval ← lig_f(h, x, y);
  end;
```

117:* Pascal's beastly convention for *forward* declarations prevents us from saying **function** $f(h,x,y:index)$: *index* here.

```
function lig_f(h,x,y:index): index;
  begin case class[h] of
  simple: do_nothing;
  left_z: begin class[h]←pending; lig_z[h]←eval(lig_z[h],y); class[h]←simple;
    end;
  right_z: begin class[h]←pending; lig_z[h]←eval(x,lig_z[h]); class[h]←simple;
    end;
  both_z: begin class[h]←pending; lig_z[h]←eval(eval(x,lig_z[h]),y); class[h]←simple;
    end;
  pending: begin x_lig_cycle←x; y_lig_cycle←y; lig_z[h]←257; class[h]←simple;
    end; { the value 257 will break all cycles, since it's not in hash }
  end; { there are no other cases }
  lig_f←lig_z[h];
  end;
```

124.* ⟨ Do the packet for character c 124* ⟩ ≡

```
if packet_start[c] = vf_size then bad_vf('Missing␣packet␣for␣character␣', c : 1)
else begin left; out('MAP'); out_ln; top ← 0; wstack[0] ← 0; xstack[0] ← 0; ystack[0] ← 0;
  zstack[0] ← 0; vf_ptr ← packet_start[c]; vf_limit ← packet_end[c] + 1; f ← 0;
  while vf_ptr < vf_limit do
    begin o ← vf[vf_ptr]; incr(vf_ptr);
    if (o ≤ set1 + 3) ∨ ((o ≥ put1) ∧ (o ≤ put1 + 3)) then
      ⟨ Special cases of DVI instructions to typeset characters 129* ⟩
    else case o of
        ⟨ Cases of DVI instructions that can appear in character packets 126* ⟩
      improper_DVI_for_VF: bad_vf('Illegal␣DVI␣code␣', o : 1, '␣will␣be␣ignored');
      end; { there are no other cases }
    end;
  if top > 0 then
    begin bad_vf('More␣pushes␣than␣pops!');
    repeat out('(POP)'); decr(top); until top = 0;
    end;
  right;
  end
```

This code is used in section 133*.

125.* A procedure called *get_bytes* helps fetch the parameters of DVI commands.

```
define signed ≡ is_signed { signed is a reserved word in ANSI C }
function get_bytes(k : integer; signed : boolean): integer;
  var a: integer; { accumulator }
  begin if vf_ptr + k > vf_limit then
    begin bad_vf('Packet␣ended␣prematurely'); k ← vf_limit − vf_ptr;
    end;
  a ← vf[vf_ptr];
  if (k = 4) ∨ signed then
    if a ≥ 128 then a ← a − 256;
  incr(vf_ptr);
  while k > 1 do
    begin a ← a ∗ 256 + vf[vf_ptr]; incr(vf_ptr); decr(k);
    end;
  get_bytes ← a;
  end;
```

126.* Let's look at the simplest cases first, in order to get some experience.

```
define four_cases(#) ≡ #, # + 1, # + 2, # + 3
define eight_cases(#) ≡ four_cases(#), four_cases(# + 4)
define sixteen_cases(#) ≡ eight_cases(#), eight_cases(# + 8)
define thirty_two_cases(#) ≡ sixteen_cases(#), sixteen_cases(# + 16)
define sixty_four_cases(#) ≡ thirty_two_cases(#), thirty_two_cases(# + 32)
```

⟨ Cases of DVI instructions that can appear in character packets 126* ⟩ ≡

```
nop: do_nothing;
push: begin if top = max_stack then
    begin print_ln('Stack␣overflow!'); uexit(1);
    end;
  incr(top); wstack[top] ← wstack[top − 1]; xstack[top] ← xstack[top − 1]; ystack[top] ← ystack[top − 1];
  zstack[top] ← zstack[top − 1]; out('(PUSH)'); out_ln;
  end;
pop: if top = 0 then bad_vf('More␣pops␣than␣pushes!')
  else begin decr(top); out('(POP)'); out_ln;
    end;
set_rule, put_rule: begin if o = put_rule then out('(PUSH)');
  left; out('SETRULE'); out_as_fix(get_bytes(4, true)); out_as_fix(get_bytes(4, true));
  if o = put_rule then out(')(POP');
  right;
  end;
```

See also sections 127, 128, and 130.

This code is used in section 124*.

129.* Before we typeset a character we make sure that it exists.

⟨ Special cases of DVI instructions to typeset characters 129* ⟩ ≡

```
begin if o ≥ set1 then
  if o ≥ put1 then k ← get_bytes(o − put1 + 1, false)
  else k ← get_bytes(o − set1 + 1, false)
else k ← o;
c ← k;
if (k < 0) ∨ (k > 255) then bad_vf('Character␣', k : 1, '␣is␣out␣of␣range␣and␣will␣be␣ignored')
else if f = font_ptr then bad_vf('Character␣', c : 1, '␣in␣undeclared␣font␣will␣be␣ignored')
  else begin vf[font_start[f + 1] − 1] ← c;   { store c in the "hole" we left }
    k ← font_chars[f]; while vf[k] ≠ c do incr(k);
    if k = font_start[f + 1] − 1 then
      bad_vf('Character␣', c : 1, '␣in␣font␣', f : 1, '␣will␣be␣ignored')
    else begin if o ≥ put1 then out('(PUSH)');
      left; out('SETCHAR'); out_char(c);
      if o ≥ put1 then out(')(POP');
      right;
      end;
    end;
end
```

This code is used in section 124*.

131.* The main program. The routines sketched out so far need to be packaged into separate procedures, on some systems, since some Pascal compilers place a strict limit on the size of a routine. The packaging is done here in an attempt to avoid some system-dependent changes.

First come the *vf_input* and *organize* procedures, which read the input data and get ready for subsequent events. If something goes wrong, the routines return *false*.

```
function vf_input: boolean;
  var vf_ptr: 0 .. vf_size;  { an index into vf }
    k: integer;  { all-purpose index }
    c: integer;  { character code }
  begin ⟨ Read the whole VF file 31* ⟩;
  vf_input ← true;
  end;
function organize: boolean;
  var tfm_ptr: index;  { an index into tfm }
  begin ⟨ Read the whole TFM file 24* ⟩;
  ⟨ Set subfile sizes lh, bc, ..., np 25 ⟩;
  ⟨ Compute the base addresses 27 ⟩;
  organize ← vf_input;
  end;
```

133.* And then there's a routine for individual characters.

```
function do_map(c : byte): boolean;
  var k: integer; f: 0 .. vf_size;  { current font number }
  begin ⟨ Do the packet for character c 124* ⟩;
  do_map ← true;
  end;
function do_characters: boolean;
  label final_end, exit;
  var c: byte;  { character being done }
    k: index;  { a random index }
    ai: 0 .. lig_size;  { index into activity }
  begin ⟨ Do the characters 100* ⟩;
  do_characters ← true; return;
final_end: do_characters ← false;
exit: end;
```

134.* Here is where `VFtoVP` begins and ends.

```
  begin initialize;
  if ¬organize then goto final_end;
  do_simple_things;
  ⟨ Do the ligatures and kerns 88 ⟩;
  ⟨ Check the extensible recipes 109 ⟩;
  if ¬do_characters then goto final_end;
  if verbose then print_ln('.');
  if level ≠ 0 then print_ln('This␣program␣isn''t␣working!');
  if ¬perfect then
    begin out('(COMMENT␣THE␣TFM␣AND/OR␣VF␣FILE␣WAS␣BAD,␣');
    out('SO␣THE␣DATA␣HAS␣BEEN␣CHANGED!)'); write_ln(vpl_file);
    end;
final_end: end.
```

135* System-dependent changes. Parse a Unix-style command line.

define *argument_is*(#) ≡ (*strcmp*(*long_options*[*option_index*].*name*, #) = 0)

```
⟨ Define parse_arguments 135* ⟩ ≡
procedure parse_arguments;
  const n_options = 4;  { Pascal won't count array lengths for us. }
  var long_options: array [0 .. n_options] of getopt_struct;
    getopt_return_val: integer; option_index: c_int_type; current_option: 0 .. n_options;
  begin ⟨ Initialize the option variables 140* ⟩;
  ⟨ Define the option table 136* ⟩;
  repeat getopt_return_val ← getopt_long_only(argc, argv, ´´, long_options, address_of(option_index));
    if getopt_return_val = −1 then
      begin do_nothing;  { End of arguments; we exit the loop below. }
      end
    else if getopt_return_val = "?" then
        begin usage(my_name);
        end
      else if argument_is(´help´) then
          begin usage_help(VFTOVP_HELP, nil);
          end
        else if argument_is(´version´) then
            begin print_version_and_exit(banner, nil, ´D.E.␣Knuth´, nil);
            end
          else if argument_is(´charcode-format´) then
              begin if strcmp(optarg, ´ascii´) = 0 then charcode_format ← charcode_ascii
              else if strcmp(optarg, ´octal´) = 0 then charcode_format ← charcode_octal
                else print_ln(´Bad␣character␣code␣format␣´, stringcast(optarg), ´.´);
              end;  { Else it was a flag; getopt has already done the assignment. }
  until getopt_return_val = −1;  { Now optind is the index of first non-option on the command line. We
        must have one two three remaining arguments. }
  if (optind + 1 ≠ argc) ∧ (optind + 2 ≠ argc) ∧ (optind + 3 ≠ argc) then
    begin print_ln(my_name, ´:␣Need␣one␣to␣three␣file␣arguments.´); usage(my_name);
    end;
  vf_name ← cmdline(optind);
  if optind + 2 ≤ argc then
    begin tfm_name ← cmdline(optind + 1);  { The user specified the TFM name. }
    end
  else begin  { User did not specify TFM name; default it from the VF name. }
    tfm_name ← basename_change_suffix(vf_name, ´.vf´, ´.tfm´);
    end;
  end;
```

This code is used in section 2*.

136* Here are the options we allow. The first is one of the standard GNU options.

```
⟨ Define the option table 136* ⟩ ≡
  current_option ← 0; long_options[current_option].name ← ´help´;
  long_options[current_option].has_arg ← 0; long_options[current_option].flag ← 0;
  long_options[current_option].val ← 0; incr(current_option);
```

See also sections 137*, 138*, 141*, and 146*.

This code is used in section 135*.

137.* Another of the standard options.

⟨ Define the option table 136* ⟩ +≡
long_options[*current_option*].*name* ← ´**version**´; *long_options*[*current_option*].*has_arg* ← 0;
long_options[*current_option*].*flag* ← 0; *long_options*[*current_option*].*val* ← 0; *incr*(*current_option*);

138.* Print progress information?

⟨ Define the option table 136* ⟩ +≡
long_options[*current_option*].*name* ← ´**verbose**´; *long_options*[*current_option*].*has_arg* ← 0;
long_options[*current_option*].*flag* ← *address_of*(*verbose*); *long_options*[*current_option*].*val* ← 1;
incr(*current_option*);

139.* The global variable *verbose* determines whether or not we print progress information.

⟨ Globals in the outer block 7 ⟩ +≡
verbose: *c_int_type*;

140.* It starts off *false*.

⟨ Initialize the option variables 140* ⟩ ≡
verbose ← *false*;

See also section 145*.

This code is used in section 135*.

141.* Here is an option to change how we output character codes.

⟨ Define the option table 136* ⟩ +≡
long_options[*current_option*].*name* ← ´**charcode-format**´; *long_options*[*current_option*].*has_arg* ← 1;
long_options[*current_option*].*flag* ← 0; *long_options*[*current_option*].*val* ← 0; *incr*(*current_option*);

142.* We use an "enumerated" type to store the information.

⟨ Types in the outer block 5 ⟩ +≡
charcode_format_type = *charcode_ascii* .. *charcode_default*;

143.* ⟨ Constants in the outer block 4* ⟩ +≡
charcode_ascii = 0; *charcode_octal* = 1; *charcode_default* = 2;

144.* ⟨ Globals in the outer block 7 ⟩ +≡
charcode_format: *charcode_format_type*;

145.* It starts off as the default, that is, we output letters and digits as ASCII characters, everything else in octal.

⟨ Initialize the option variables 140* ⟩ +≡
charcode_format ← *charcode_default*;

146.* An element with all zeros always ends the list.

⟨ Define the option table 136* ⟩ +≡
long_options[*current_option*].*name* ← 0; *long_options*[*current_option*].*has_arg* ← 0;
long_options[*current_option*].*flag* ← 0; *long_options*[*current_option*].*val* ← 0;

147.* Global filenames.

⟨ Globals in the outer block 7 ⟩ +≡
tfm_name: *c_string*;
vf_name, *vpl_name*: *const_c_string*;

148* Index. Pointers to error messages appear here together with the section numbers where each identifier is used.

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