(See https://cs.stanford.edu/~knuth/programs.html for date.)

1. Intro. A simple program to find the vacillating tableau loop that corresponds to a given restricted growth string, given in the standard input file.

The program also computes the dual restricted growth string.

Apology: I wrote the following code in an awful hurry, so there was no time to apply spit and/or polish.

```
#define maxn 1000
#include <stdio.h>
  char buf[maxn];   /* the restricted growth string input */
  int last[maxn];   /* table for decoding the restricted growth string */
  int a[maxn], b[maxn];   /* rook positions */
  int p[maxn][maxn], q[maxn][maxn];   /* tableaux */
  int r[maxn];   /* row lengths */
  int dualins[maxn], dualdel[maxn];   /* row changes for the dual */
  int verbose = 1;

  main(int argc, char *argv[])
  {
    register int i, j, k, m, n, xi, xip;
    while (fgets(buf, maxn, stdin)) {
      ⟨Build the rook table 2⟩;
      ⟨Make the inverse rook table 3⟩;
      ⟨Compute and print the intermediate tableaux 4⟩;
      ⟨Compute the dual rook table 9⟩;
      ⟨Print the restricted growth string of the dual 12⟩;
    }
  }
```

2. ⟨Build the rook table 2⟩ ≡

```
  printf("Given: %s", buf);
  for (k = 0, m = −1; (buf[k] ≥ '0' ∧ buf[k] ≤ '9') ∨ (buf[k] ≥ 'a' ∧ buf[k] ≤ 'z'); k++) {
    j = (buf[k] ≥ 'a' ? buf[k] − 'a' + 10 : buf[k] − '0');
    if (j > m) {
      if (j ≠ m + 1) {
        buf[k] = 0;
        fprintf(stderr, "Bad form: %s%d should be %s%d!\n", buf, j, buf, m + 1);
        continue;
      }
      m = j, last[m] = 0;
    }
    a[k + 1] = last[j], last[j] = k + 1;
  }
  n = k;
```

This code is used in section 1.

3. ⟨Make the inverse rook table 3⟩ ≡

```
  for (k = 1; k ≤ n; k++) b[k] = 0;
  for (k = 1; k ≤ n; k++)
    if (a[k]) b[a[k]] = k;
```

This code is used in section 1.

4. **#define** *infty* 1000 /* infinity (approximately) */

⟨ Compute and print the intermediate tableaux 4 ⟩ ≡
```
  ⟨ Initialize the tableaux 5 ⟩;
  for (k = 1; k ≤ n; k++) {
    ⟨ Possibly delete k 7 ⟩;
    ⟨ Possibly insert k 6 ⟩;
  }
```
This code is used in section 1.

5. ⟨ Initialize the tableaux 5 ⟩ ≡
```
  for (k = 1; k ≤ n; k++) {
    r[k] = q[0][k] = q[k][0] = 0, p[0][k] = p[k][0] = infty;
    for (j = 1; j ≤ n; j++) q[k][j] = infty, p[k][j] = 0;
  }
```
This code is used in section 4.

6. Here's Algorithm 5.1.4I, but with order reversed in the p tableau. We insert $b[k]$ into p and k into q.

I wouldn't actually have to work with both p and q; either one would suffice to determine the vacillation. But I compute them both because I'm trying to get familiar with the whole picture.

⟨ Possibly insert k 6 ⟩ ≡
```
  if (b[k]) {
  i1: i = 1, xi = b[k], j = r[1] + 1;
    while (1) {
    i2: while (xi > p[i][j − 1]) j−−;
      xip = p[i][j];
    i3: p[i][j] = xi;
    i4: if (xip) i++, xi = xip;
      else break;
    }
    q[i][j] = k;
    r[i] = j;
    dualins[k] = j;
  } else dualins[k] = 0;
  ⟨ Print the tableau shape 8 ⟩;
```
This code is used in section 4.

7. And here's Algorithm 5.1.4D, applied to the q tableau. We delete k from p and $a[k]$ from q. The error messages here won't be needed unless I have made a mistake.

⟨ Possibly delete k 7 ⟩ ≡

```
if (a[k]) {
  for (i = 1, j = 0; r[i]; i++)
    if (p[i][r[i]] ≡ k) {
      j = r[i], r[i] = j − 1, p[i][j] = 0;
      dualdel[k] = j;
      break;
    }
  if (¬j) {
    fprintf(stderr, "I␣couldn't␣find␣%d␣in␣p!\n", k);
    exit(−1);
  }
d1: xip = infty;
  while (1) {
  d2: while (q[i][j + 1] < xip) j++;
    xi = q[i][j];
  d3: q[i][j] = xip;
  d4: if (i > 1) i−−, xip = xi;
    else break;
  }
  if (xi ≠ a[k]) {
    fprintf(stderr, "I␣removed␣%d,␣not␣%d,␣from␣q!\n", xi, a[k]);
    exit(−2);
  }
} else dualdel[k] = 0;
⟨ Print the tableau shape 8 ⟩;
```

This code is used in section 4.

8. If *verbose* is nonzero, we also print out the contents of p and q.

⟨ Print the tableau shape 8 ⟩ ≡

```
for (i = 1; r[i]; i++) printf("␣%d", r[i]);
if (verbose ∧ i > 1) {
  printf("␣(");
  for (i = 1; r[i]; i++) {
    if (i > 1) printf(";");
    for (j = 1; j ≤ r[i]; j++) printf("%s%d", j > 1 ? "," : "", p[i][j]);
  }
  printf("),(");
  for (i = 1; r[i]; i++) {
    if (i > 1) printf(";");
    for (j = 1; j ≤ r[i]; j++) printf("%s%d", j > 1 ? "," : "", q[i][j]);
  }
  printf(")");
}
if (i ≡ 1) printf("␣0\n"); else printf("\n");
```

This code is used in sections 6 and 7.

9. Now for the dual, I'll work only with q.

⟨ Compute the dual rook table 9 ⟩ ≡

```
for (k = 1; k ≤ n; k++) {
   if (dualdel[k]) ⟨ Dually delete k 11 ⟩;
   if (dualins[k]) ⟨ Dually insert k 10 ⟩;
}
```

This code is used in section 1.

10. ⟨ Dually insert k 10 ⟩ ≡

```
i = dualins[k], j = r[i] + 1, r[i] = j, q[i][j] = k;
```

This code is used in section 9.

11. ⟨ Dually delete k 11 ⟩ ≡

```
{
   i = dualdel[k], j = r[i], r[i] = j − 1, xip = infty;
   while (1) {
      while (q[i][j + 1] < xip) j++;
      xi = q[i][j];
      q[i][j] = xip;
      if (i > 1) i−−, xip = xi;
      else break;
   }
   a[k] = xi;
}
```

This code is used in section 9.

12. ⟨ Print the restricted growth string of the dual 12 ⟩ ≡

```
for (k = 1, m = −1; k ≤ n; k++)
   if (a[k]) buf[k − 1] = buf[a[k] − 1];
   else m++, buf[k − 1] = (m > 9 ? 'a' + m − 10 : '0' + m);
printf("Dual:␣%s", buf);
```

This code is used in section 1.

13. Index.

VACILLATE