

September 3, 2012 at 17:59

**1. Introduction.** The ur-game for computers — Adventure — was originally written by Will Crowther in 1975 or 1976 and significantly extended by Don Woods in 1977. I have taken Woods’s original FORTRAN program for Adventure Version 1.0 and recast it in the CWEB idiom.

I remember being fascinated by this game when John McCarthy showed it to me in 1977. I started with no clues about the purpose of the game or what I should do; just the computer’s comment that I was at the end of a forest road facing a small brick building. Little by little, the game revealed its secrets, just as its designers had cleverly plotted. What a thrill it was when I first got past the green snake! Clearly the game was potentially addictive, so I forced myself to stop playing — reasoning that it was great fun, sure, but traditional computer science research is great fun too, possibly even more so.

Now here I am, 21 years later, returning to the great Adventure after having indeed had many exciting adventures in Computer Science. I believe people who have played this game will be able to extend their fun by reading its once-secret program. Of course I urge everybody to *play the game first, at least ten times*, before reading on. But you cannot fully appreciate the astonishing brilliance of its design until you have seen all of the surprises that have been built in.

I believe this program is entirely faithful to the behavior of Adventure Version 1.0, except that I have slightly edited the computer messages (mostly so that they use both lowercase and uppercase letters). I have also omitted Woods’s elaborate machinery for closing the cave during the hours of prime-time computing; I believe John McCarthy insisted on this, when he saw the productivity of his AI Lab falling off dramatically—although it is rumored that he had a special version of the program that allowed him to play whenever he wanted. And I have not adopted the encryption scheme by which Woods made it difficult for users to find any important clues in the binary program file or core image; such modifications would best be done by making a special version of CTANGLE. All of the spelunking constraints and interactive behavior have been retained, although the structure of this CWEB program is naturally quite different from the FORTRAN version that I began with.

Many of the phrases in the following documentation have been lifted directly from comments in the FORTRAN code. Please regard me as merely a translator of the program, not as an author. I thank Don Woods for helping me check the validity of this translation.

By the way, if you don’t like **goto** statements, don’t read this. (And don’t read any other programs that simulate multistate systems.)

— Don Knuth, September 1998

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**2.** To run the program with, say, a UNIX shell, just type ‘**advent**’ and follow instructions. (Many UNIX systems come with an almost identical program called ‘**adventure**’ already built in; you might want to try it too, for comparison.)

```
#include <stdio.h>    /* basic input/output routines: fgets, printf */
#include <ctype.h>    /* isspace, tolower, and toupper routines */
#include <string.h>    /* strcmp and strcpy to compare and copy strings */
#include <time.h>      /* current time, used as random number seed */
#include <stdlib.h>    /* exit */
<Macros for subroutine prototypes 3>
typedef enum {
    false, true
} boolean;
<Type definitions 5>
<Global variables 7>
<Subroutines 6>
main()
{
    register int j, k;
    register char *p;
    <Additional local registers 22>;
    <Initialize all tables 200>;
    <Simulate an adventure, going to quit when finished 75>;
    <Deal with death and resurrection 188>;
    quit: <Print the score and say adieu 198>;
        exit(0);
}
```

**3.** The subroutines of this program are declared first with a prototype, as in ANSI C, then with an old-style C function definition. The following preprocessor commands make this work correctly with both new-style and old-style compilers.

```
<Macros for subroutine prototypes 3> ≡
#ifdef __STDC__
#define ARGS(list) list
#else
#define ARGS(list) ()
#endif
```

This code is used in section 2.

**4. The vocabulary.** Throughout the remainder of this documentation, “you” are the user and “we” are the game author and the computer. We don’t tell you what words to use, except indirectly; but we try to understand enough words of English so that you can play without undue frustration. The first part of the program specifies what we know about your language — about 300 words.

**5.** When you type a word, we first convert uppercase letters to lowercase; then we chop off all but the first five characters, if the word was longer than that, and we look for your word in a small hash table. Each hash table entry contains a string of length 5 or less, and two additional bytes for the word’s type and meaning. Four types of words are distinguished: *motion\_type*, *object\_type*, *action\_type*, and *message\_type*.

⟨Type definitions 5⟩ ≡

```
typedef enum {
    no_type, motion_type, object_type, action_type, message_type
} wordtype;
typedef struct {
    char text[6]; /* string of length at most 5 */
    char word_type; /* a wordtype */
    char meaning;
} hash_entry;
```

See also sections 9, 11, 13, 18, and 19.

This code is used in section 2.

**6.** Here is the subroutine that puts words into our vocabulary, when the program is getting ready to run.

```
#define hash_prime 1009 /* the size of the hash table */
```

⟨Subroutines 6⟩ ≡

```
void new_word ARGS((char *,int));
void new_word(w,m)
    char *w; /* a string of length 5 or less */
    int m; /* its meaning */
{
    register int h, k;
    register char *p;
    for (h = 0, p = w; *p; p++) h = *p + h + h;
    h %= hash_prime;
    while (hash_table[h].word_type) {
        h++; if (h ≡ hash_prime) h = 0;
    }
    strcpy(hash_table[h].text, w);
    hash_table[h].word_type = current_type;
    hash_table[h].meaning = m;
}
```

See also sections 8, 64, 65, 66, 71, 72, 154, 160, 194, and 197.

This code is used in section 2.

**7.** ⟨Global variables 7⟩ ≡

```
hash_entry hash_table[hash_prime]; /* the table of words we know */
wordtype current_type; /* the kind of word we are dealing with */
```

See also sections 15, 17, 20, 21, 63, 73, 74, 77, 81, 84, 87, 89, 96, 103, 137, 142, 155, 159, 165, 168, 171, 177, 185, 190, 193, 196, and 199.

This code is used in section 2.

8. While we're at it, let's write the program that will look up a word. It returns the location of the word in the hash table, or `-1` if you've given a word like `'tickle'` or `'terse'` that is unknown.

```
#define streq(a,b) (strcmp(a,b,5) == 0) /* strings agree up to five letters */
```

```
<Subroutines 6> +=
```

```
int lookup ARGS((char *));
int lookup(w)
    char *w; /* a string that you typed */
{
    register int h;
    register char *p;
    register char t;

    t = w[5];
    w[5] = '\0'; /* truncate the word */
    for (h = 0, p = w; *p; p++) h = *p + h + h;
    h %= hash_prime; /* compute starting address */
    w[5] = t; /* restore original word */
    if (h < 0) return -1; /* a negative character might screw us up */
    while (hash_table[h].word_type) {
        if (streq(w, hash_table[h].text)) return h;
        h++; if (h == hash_prime) h = 0;
    }
    return -1;
}
```

9. The **motion** words specify either a direction or a simple action or a place. Motion words take you from one location to another, when the motion is permitted. Here is a list of their possible meanings.

```
<Type definitions 5> +=
```

```
typedef enum {
    N, S, E, W, NE, SE, NW, SW, U, D, L, R, IN, OUT, FORWARD, BACK,
    OVER, ACROSS, UPSTREAM, DOWNSTREAM,
    ENTER, CRAWL, JUMP, CLIMB, LOOK, CROSS,
    ROAD, WOODS, VALLEY, HOUSE, GULLY, STREAM, DEPRESSION, ENTRANCE, CAVE,
    ROCK, SLAB, BED, PASSAGE, CAVERN, CANYON, AWKWARD, SECRET, BEDQUILT, RESERVOIR,
    GIANT, ORIENTAL, SHELL, BARREN, BROKEN, DEBRIS, VIEW, FORK,
    PIT, SLIT, CRACK, DOME, HOLE, WALL, HALL, ROOM, FLOOR,
    STAIRS, STEPS, COBBLES, SURFACE, DARK, LOW, OUTDOORS,
    Y2, XYZZY, PLUGH, PLOVER, OFFICE, NOWHERE
} motion;
```

10. And here is how they enter our vocabulary.

If I were writing this program, I would allow the word **woods**, but Don apparently didn't want to.

(Build the vocabulary 10)  $\equiv$

```

current_type = motion_type;
new_word("north", N); new_word("n", N);
new_word("south", S); new_word("s", S);
new_word("east", E); new_word("e", E);
new_word("west", W); new_word("w", W);
new_word("ne", NE);
new_word("se", SE);
new_word("nw", NW);
new_word("sw", SW);
new_word("upwar", U); new_word("up", U); new_word("u", U); new_word("above", U);
new_word("ascen", U);
new_word("downw", D); new_word("down", D); new_word("d", D); new_word("desce", D);
new_word("left", L);
new_word("right", R);
new_word("inwar", IN); new_word("insid", IN); new_word("in", IN);
new_word("out", OUT); new_word("outsi", OUT);
new_word("exit", OUT);
new_word("leave", OUT);
new_word("forwa", FORWARD); new_word("conti", FORWARD); new_word("onwar", FORWARD);
new_word("back", BACK); new_word("retur", BACK); new_word("retre", BACK);
new_word("over", OVER);
new_word("acros", ACROSS);
new_word("upstr", UPSTREAM);
new_word("downs", DOWNSTREAM);
new_word("enter", ENTER);
new_word("crawl", CRAWL);
new_word("jump", JUMP);
new_word("climb", CLIMB);
new_word("look", LOOK); new_word("exami", LOOK); new_word("touch", LOOK);
new_word("descr", LOOK);
new_word("cross", CROSS);
new_word("road", ROAD);
new_word("hill", ROAD);
new_word("fores", WOODS);
new_word("valle", VALLEY);
new_word("build", HOUSE); new_word("house", HOUSE);
new_word("gully", GULLY);
new_word("strea", STREAM);
new_word("depre", DEPRESSION);
new_word("entra", ENTRANCE);
new_word("cave", CAVE);
new_word("rock", ROCK);
new_word("slab", SLAB); new_word("slabr", SLAB);
new_word("bed", BED);
new_word("passa", PASSAGE); new_word("tunne", PASSAGE);
new_word("caver", CAVERN);
new_word("canyo", CANYON);
new_word("awkwa", AWKWARD);
new_word("secre", SECRET);

```

```
new_word("bedqu", BEDQUILT);
new_word("reser", RESERVOIR);
new_word("giant", GIANT);
new_word("orien", ORIENTAL);
new_word("shell", SHELL);
new_word("barre", BARREN);
new_word("broke", BROKEN);
new_word("debri", DEBRIS);
new_word("view", VIEW);
new_word("fork", FORK);
new_word("pit", PIT);
new_word("slit", SLIT);
new_word("crack", CRACK);
new_word("dome", DOME);
new_word("hole", HOLE);
new_word("wall", WALL);
new_word("hall", HALL);
new_word("room", ROOM);
new_word("floor", FLOOR);
new_word("stair", STAIRS);
new_word("steps", STEPS);
new_word("cobbl", COBBLES);
new_word("surfa", SURFACE);
new_word("dark", DARK);
new_word("low", LOW);
new_word("outdo", OUTDOORS);
new_word("y2", Y2);
new_word("xyzy", XYZZY);
new_word("plugh", PLUGH);
new_word("plove", PLOVER);
new_word("main", OFFICE); new_word("offic", OFFICE);
new_word("null", NOWHERE); new_word("nowhe", NOWHERE);
```

See also sections [12](#), [14](#), and [16](#).

This code is used in section [200](#).

**11.** The **object** words refer to things like a lamp, a bird, batteries, etc.; objects have properties that will be described later. Here is a list of the basic objects. Objects **GOLD** and higher are the “treasures.” Extremely large objects, which appear in more than one location, are listed more than once using ‘\_’.

```
#define min_treasure GOLD
```

```
#define is_treasure(t) (t ≥ min_treasure)
```

```
#define max_obj CHAIN
```

⟨Type definitions 5⟩ +≡

```
typedef enum {
    NOTHING, KEYS, LAMP, GRATE, GRATE_, CAGE, ROD, ROD2, TREADS, TREADS_,
    BIRD, DOOR, PILLOW, SNAKE, CRYSTAL, CRYSTAL_, TABLET, CLAM, OYSTER,
    MAG, DWARF, KNIFE, FOOD, BOTTLE, WATER, OIL,
    MIRROR, MIRROR_, PLANT, PLANT2, PLANT2_, STALACTITE, SHADOW, SHADOW_,
    AXE, ART, PIRATE, DRAGON, DRAGON_, BRIDGE, BRIDGE_, TROLL, TROLL_, TROLL2, TROLL2_,
    BEAR, MESSAGE, GEYSER, PONY, BATTERIES, MOSS,
    GOLD, DIAMONDS, SILVER, JEWELS, COINS, CHEST, EGGS, TRIDENT, VASE,
    EMERALD, PYRAMID, PEARL, RUG, RUG_, SPICES, CHAIN
} object;
```

**12.** Most of the objects correspond to words in our vocabulary.

⟨Build the vocabulary 10⟩ +≡

```

current_type = object_type;
new_word("key", KEYS); new_word("keys", KEYS);
new_word("lamp", LAMP); new_word("lante", LAMP); new_word("headl", LAMP);
new_word("grate", GRATE);
new_word("cage", CAGE);
new_word("rod", ROD);
new_word("bird", BIRD);
new_word("door", DOOR);
new_word("pillo", PILLOW);
new_word("snake", SNAKE);
new_word("fissu", CRYSTAL);
new_word("table", TABLET);
new_word("clam", CLAM);
new_word("oyste", OYSTER);
new_word("magaz", MAG); new_word("issue", MAG); new_word("spelu", MAG);
new_word("\spel", MAG);
new_word("dwarf", DWARF); new_word("dwarv", DWARF);
new_word("knife", KNIFE); new_word("knife", KNIFE);
new_word("food", FOOD); new_word("ratio", FOOD);
new_word("bottl", BOTTLE); new_word("jar", BOTTLE);
new_word("water", WATER); new_word("h2o", WATER);
new_word("oil", OIL);
new_word("mirro", MIRROR);
new_word("plant", PLANT); new_word("beans", PLANT);
new_word("stala", STALACTITE);
new_word("shado", SHADOW); new_word("figur", SHADOW);
new_word("axe", AXE);
new_word("drawi", ART);
new_word("pirat", PIRATE);
new_word("drago", DRAGON);
new_word("chasm", BRIDGE);
new_word("troll", TROLL);
new_word("bear", BEAR);
new_word("messa", MESSAGE);
new_word("volca", GEYSER); new_word("geyse", GEYSER);
new_word("vendi", PONY); new_word("machi", PONY);
new_word("batte", BATTERIES);
new_word("moss", MOSS); new_word("carpe", MOSS);
new_word("gold", GOLD); new_word("nugge", GOLD);
new_word("diamo", DIAMONDS);
new_word("silve", SILVER); new_word("bars", SILVER);
new_word("jewel", JEWELS);
new_word("coins", COINS);
new_word("chest", CHEST); new_word("box", CHEST); new_word("treas", CHEST);
new_word("eggs", EGGS); new_word("egg", EGGS); new_word("nest", EGGS);
new_word("tride", TRIDENT);
new_word("ming", VASE); new_word("vase", VASE); new_word("shard", VASE);
new_word("potte", VASE);
new_word("emera", EMERALD);
new_word("plati", PYRAMID); new_word("pyram", PYRAMID);

```



```
new_word("pearl", PEARL);  
new_word("persi", RUG); new_word("rug", RUG);  
new_word("spice", SPICES);  
new_word("chain", CHAIN);
```

**13.** The **action** words tell us to do something that's usually nontrivial.

⟨Type definitions 5⟩ +≡

```
typedef enum {  
    ABSTAIN, TAKE, DROP, OPEN, CLOSE, ON, OFF, WAVE, CALM, GO, RELAX,  
    POUR, EAT, DRINK, RUB, TOSS, WAKE, FEED, FILL, BREAK, BLAST, KILL,  
    SAY, READ, FEEFIE, BRIEF, FIND, INVENTORY, SCORE, QUIT  
} action;
```

14. Many of the action words have several synonyms. If an action does not meet special conditions, we will issue a default message.

```
#define ok default_msg[RELAX]
```

```
( Build the vocabulary 10 ) +=
```

```
current_type = action_type;
new_word("take", TAKE); new_word("carry", TAKE); new_word("keep", TAKE);
new_word("catch", TAKE); new_word("captu", TAKE); new_word("steal", TAKE);
new_word("get", TAKE); new_word("tote", TAKE);
default_msg[TAKE] = "You_are_already_carrying_it!";
new_word("drop", DROP); new_word("relea", DROP); new_word("free", DROP);
new_word("disca", DROP); new_word("dump", DROP);
default_msg[DROP] = "You_aren't_carrying_it!";
new_word("open", OPEN); new_word("unloc", OPEN);
default_msg[OPEN] = "I_don't_know_how_to_lock_or_unlock_such_a_thing.";
new_word("close", CLOSE); new_word("lock", CLOSE);
default_msg[CLOSE] = default_msg[OPEN];
new_word("light", ON); new_word("on", ON);
default_msg[ON] = "You_have_no_source_of_light.";
new_word("extin", OFF); new_word("off", OFF);
default_msg[OFF] = default_msg[ON];
new_word("wave", WAVE); new_word("shake", WAVE); new_word("swing", WAVE);
default_msg[WAVE] = "Nothing_happens.";
new_word("calm", CALM); new_word("placa", CALM); new_word("tame", CALM);
default_msg[CALM] = "I'm_game._Would_you_care_to_explain_how?";
new_word("walk", GO); new_word("run", GO); new_word("trave", GO); new_word("go", GO);
new_word("proce", GO); new_word("explo", GO); new_word("goto", GO); new_word("follo", GO);
new_word("turn", GO);
default_msg[GO] = "Where?";
new_word("nothi", RELAX);
default_msg[RELAX] = "OK.";
new_word("pour", POUR);
default_msg[POUR] = default_msg[DROP];
new_word("eat", EAT); new_word("devou", EAT);
default_msg[EAT] = "Don't_be_ridiculous!";
new_word("drink", DRINK);
default_msg[DRINK] =
    "You_have_taken_a_drink_from_the_stream._The_water_tastes_strongly_of\n\
    minerals,_but_is_not_unpleasant._It_is_extremely_cold.";
new_word("rub", RUB);
default_msg[RUB] = "Rubbing_the_electric_lamp_is_not_particularly_rewarding._Anyway,\n\
    nothing_exciting_happens.";
new_word("throw", TOSS); new_word("toss", TOSS);
default_msg[TOSS] = default_msg[DROP];
new_word("wake", WAKE); new_word("distu", WAKE);
default_msg[WAKE] = default_msg[EAT];
new_word("feed", FEED);
default_msg[FEED] = "There_is_nothing_here_to_eat.";
new_word("fill", FILL);
default_msg[FILL] = "You_can't_fill_that.";
new_word("break", BREAK); new_word("smash", BREAK); new_word("shatt", BREAK);
default_msg[BREAK] = "It_is_beyond_your_power_to_do_that.";
```

```

new_word("blast", BLAST); new_word("deton", BLAST); new_word("ignit", BLAST);
new_word("blowu", BLAST);
default_msg[BLAST] = "Blasting requires dynamite.";
new_word("attac", KILL); new_word("kill", KILL); new_word("fight", KILL);
new_word("hit", KILL); new_word("strik", KILL); new_word("slay", KILL);
default_msg[KILL] = default_msg[EAT];
new_word("say", SAY); new_word("chant", SAY); new_word("sing", SAY); new_word("utter", SAY);
new_word("mumbl", SAY);
new_word("read", READ); new_word("perus", READ);
default_msg[READ] = "I'm afraid I don't understand.";
new_word("fee", FEEFIE); new_word("fie", FEEFIE); new_word("foe", FEEFIE);
new_word("foo", FEEFIE); new_word("fum", FEEFIE);
default_msg[FEEFIE] = "I don't know how.";
new_word("brief", BRIEF);
default_msg[BRIEF] = "On what?";
new_word("find", FIND); new_word("where", FIND);
default_msg[FIND] = "I can only tell you what you see as you move about and manipulate\n\
things. I cannot tell you where remote things are.";
new_word("inven", INVENTORY);
default_msg[INVENTORY] = default_msg[FIND];
new_word("score", SCORE);
default_msg[SCORE] = "Eh?";
new_word("quit", QUIT);
default_msg[QUIT] = default_msg[SCORE];

```

#### 15. $\langle$ Global variables 7 $\rangle + \equiv$

```

char *default_msg[30]; /* messages for untoward actions, if nonzero */

```

16. Finally, our vocabulary is rounded out by words like `help`, which trigger the printing of fixed messages.

```
#define new_mess(x)  message[k++] = x
#define mess_wd(w)  new_word(w, k)

⟨ Build the vocabulary 10 ⟩ +=
    current_type = message_type;
    k = 0;
    mess_wd("abra"); mess_wd("abrac");
    mess_wd("opens"); mess_wd("sesam"); mess_wd("shaza");
    mess_wd("hocus"); mess_wd("pocus");
    new_mess("Good try, but that is an old worn-out magic word.");
    mess_wd("help"); mess_wd("?");
    new_mess("I know of places, actions, and things. Most of my vocabulary\n\
describes places and is used to move you there. To move, try words\n\
like forest, building, downstream, center, east, west, north, south,\n\
up, or down. I know about a few special objects, like a black rod\n\
hidden in the cave. These objects can be manipulated using some of\n\
the action words that I know. Usually you will need to give both the\n\
object and action words (in either order), but sometimes I can infer\n\
the object from the verb alone. Some objects also imply verbs; in\n\
particular, \"inventory\" implies \"take inventory\", which causes me to\n\
give you a list of what you're carrying. The objects have side\n\
effects; for instance, the rod scares the bird. Usually people having\n\
trouble moving just need to try a few more words. Usually people\n\
trying unsuccessfully to manipulate an object are attempting something\n\
beyond their (or my!) capabilities and should try a completely\n\
different tack. To speed the game you can sometimes move long\n\
distances with a single word. For example, \"building\" usually gets\n\
you to the building from anywhere above ground except when lost in the\n\
forest. Also, note that cave passages turn a lot, and that leaving a\n\
room to the north does not guarantee entering the next from the south.\nGood luck!");
    mess_wd("tree"); mess_wd("trees");
    new_mess("The trees of the forest are large hardwood oak and maple, with an\n\
occasional grove of pine or spruce. There is quite a bit of under-\n\
growth, largely birch and ash saplings plus nondescript bushes of\n\
various sorts. This time of year visibility is quite restricted by\n\
all the leaves, but travel is quite easy if you detour around the\n\
spruce and berry bushes.");
    mess_wd("dig"); mess_wd("excav");
    new_mess("Digging without a shovel is quite impractical. Even with a shovel\n\
progress is unlikely.");
    mess_wd("lost");
    new_mess("I'm as confused as you are.");
    new_mess("There is a loud explosion and you are suddenly splashed across the\n\
walls of the room.");
    new_mess("There is a loud explosion and a twenty-foot hole appears in the far\n\
wall, burying the snakes in the rubble. A river of molten lava pours\n\
in through the hole, destroying everything in its path, including you!");
    mess_wd("mist");
    new_mess("Mist is a white vapor, usually water, seen from time to time in\n\
caverns. It can be found anywhere but is frequently a sign of a deep\n\
pit leading down to water.");
    mess_wd("fuck");
```

```

new_mess("Watch_it!");
new_mess("There_is_a_loud_explosion,_and_a_twenty-foot_hole_appears_in_the_far\n\
wall,_burying_the_dwarves_in_the_rubble._You_march_through_the_hole\n\
and_find_yourself_in_the_main_office,_where_a_cheering_band_of\n\
friendly_elves_carry_the_conquering_adventurer_off_into_the_sunset.");
mess_wd("stop");
new_mess("I_don't_know_the_word_\\"stop\\"._Use_\\"quit\\"_if_you_want_to_give_up.");
mess_wd("info"); mess_wd("infor");
new_mess("If_you_want_to_end_your_adventure_early,_say_\\"quit\\"._To_get_full\n\
credit_for_a_treasure,_you_must_have_left_it_safely_in_the_building,\n\
though_you_get_partial_credit_just_for_locating_it._You_lose_points\n\
for_getting_killed,_or_for_quitting,_though_the_former_costs_you_more.\n\
There_are_also_points_based_on_how_much_(if_any)_of_the_cave_you've\n\
managed_to_explore;_in_particular,_there_is_a_large_bonus_just_for\n\
getting_in_(to_distinguish_the_beginners_from_the_rest_of_the_pack),\n\
and_there_are_other_ways_to_determine_whether_you've_been_through_some\n\
of_the_more_harrowing_sections._If_you_think_you've_found_all_the\n\
treasures,_just_keep_exploring_for_a_while._If_nothing_interesting\n\
happens,_you_haven't_found_them_all_yet._If_something_interesting\n\
DOES_happen,_it_means_you're_getting_a_bonus_and_have_an_opportunity\n\
to_garner_many_more_points_in_the_master's_section.\n\
I_may_occasionally_offer_hints_if_you_seem_to_be_having_trouble.\n\
If_I_do,_I'll_warn_you_in_advance_how_much_it_will_affect_your_score\n\
to_accept_the_hints._Finally,_to_save_paper,_you_may_specify_\\"brief\\",\n\
which_tells_me_never_to_repeat_the_full_description_of_a_place\n\
unless_you_explicitly_ask_me_to.");
mess_wd("swim");
new_mess("I_don't_know_how.");

```

### 17. <Global variables 7> +≡

```
char *message[13]; /* messages tied to certain vocabulary words */
```

**18. Cave data.** You might be in any of more than 100 places as you wander about in Colossal Cave. Let's enumerate them now, so that we can build the data structures that define the travel restrictions.

A special negative value called *inhand* is the location code for objects that you are carrying. But you yourself are always situated in a place that has a nonnegative location code.

Nonnegative places  $\leq$  *outside* are outside the cave, while places  $\geq$  *inside* are inside. The upper part of the cave, places  $<$  *emist*, is the easiest part to explore. (We will see later that dwarves do not venture this close to the surface; they stay  $\geq$  *emist*.)

Places between *inside* and *dead2*, inclusive, form the main cave; the next places, up to and including *barr*, form the hidden cave on the other side of the troll bridge; then *neend* and *swend* are a private cave.

The remaining places,  $\geq$  *crack*, are dummy locations, not really part of the maze. As soon as you arrive at a dummy location, the program immediately sends you somewhere else. In fact, the last three dummy locations aren't really even locations; they invoke special code. This device is a convenient way to provide a variety of features without making the program logic any more cluttered than it already is.

```
#define min_in_cave inside
#define min_lower_loc mist
#define min_forced_loc crack
#define max_loc didit
#define max_spec troll
(Type definitions 5) +=
typedef enum {
    inhand = -1, limbo,
    road, hill, house, valley, forest, woods, slit, outside,
    inside, cobbles, debris, awk, bird, spit,
    mist, nugget, efiss, wfiss, wmist,
    like1, like2, like3, like4, like5, like6, like7, like8, like9, like10, like11, like12, like13, like14,
    brink, elong, wlong,
    diff0, diff1, diff2, diff3, diff4, diff5, diff6, diff7, diff8, diff9, diff10,
    pony, cross, hmk, west, south, ns, y2, jumble, windoe,
    dirty, clean, wet, dusty, complex,
    shell, arch, ragged, sac, ante, witt,
    bedquilt, cheese, soft,
    e2pit, w2pit, epit, wpit,
    narrow, giant, block, immense, falls, steep,
    abovep, sjunc, tite, low, crawl, window,
    oriental, misty, alcove, proom, droom,
    slab, abover, mirror, res,
    scan1, scan2, scan3, secret,
    wide, tight, tall, boulders,
    scorr, swside,
    dead0, dead1, dead2, dead3, dead4, dead5, dead6, dead7, dead8, dead9, dead10, dead11,
    neside, corr, fork, warm, view, chamber, lime, fbarr, barr,
    neend, swend,
    crack, neck, lose, cant, climb, check, snaked, thru, duck, sewer, upnout, didit,
    ppass, pdrop, troll
} location;
```

19. Speaking of program logic, the complex cave dynamics are essentially kept in a table. The table tells us what to do when you ask for a particular motion in a particular location. Each entry of the table is called an instruction; and each instruction has three parts: a motion, a condition, and a destination.

The motion part of an instruction is one of the motion verbs enumerated earlier.

The condition part  $c$  is a small integer, interpreted as follows:

- if  $c = 0$ , the condition is always true;
- if  $0 < c < 100$ , the condition is true with probability  $c/100$ ;
- if  $c = 100$ , the condition is always true, except for dwarves;
- if  $100 < c \leq 200$ , you must have object  $c \bmod 100$ ;
- if  $200 < c \leq 300$ , object  $c \bmod 100$  must be in the current place;
- if  $300 < c \leq 400$ ,  $prop[c \bmod 100]$  must not be 0;
- if  $400 < c \leq 500$ ,  $prop[c \bmod 100]$  must not be 1;
- if  $500 < c \leq 600$ ,  $prop[c \bmod 100]$  must not be 2; etc.

(We will discuss properties of objects and the *prop* array later.)

The destination  $d$  is either a location or a number greater than  $max\_loc$ . In the latter case, if  $d \leq max\_spec$  we perform a special routine; otherwise we print  $remarks[d - max\_spec]$  and stay in the current place.

If the motion matches what you said but the condition is not satisfied, we move on to the next instruction that has a different destination and/or condition from this one. The next instruction might itself be conditional in the same way; but the motion is no longer checked after it has first been matched. (Numerous examples appear below; complete details of the table-driven logic can be found in section 146.)

⟨Type definitions 5⟩ +=

```
typedef struct {
    motion mot;      /* a motion you might have requested */
    int cond;        /* if you did, this condition must also hold */
    location dest;    /* and if so, this is where you'll go next */
} instruction;
```

20. Suppose you're at location  $l$ . Then  $start[l]$  is the first relevant instruction, and  $start[l + 1] - 1$  is the last. Also  $long\_desc[l]$  is a string that fully describes  $l$ ;  $short\_desc[l]$  is an optional abbreviated description; and  $visits[l]$  tells how many times you have been here. Special properties of this location, such as whether a lantern is necessary or a hint might be advisable, are encoded in the bits of *flags*[ $l$ ].

```
#define lighted 1      /* bit for a location that isn't dark */
#define oil 2         /* bit for presence of oil */
#define liquid 4       /* bit for presence of a liquid (oil or water) */
#define cave_hint 8    /* bit for hint about trying to get in the cave */
#define bird_hint 16   /* bit for hint about catching the bird */
#define snake_hint 32  /* bit for hint about dealing with the snake */
#define twist_hint 64  /* bit for hint about being lost in a maze */
#define dark_hint 128  /* bit for hint about the dark room */
#define witt_hint 256  /* bit for hint about Witt's End */
#define travel_size 740 /* at most this many instructions */
#define rem_size 15     /* at most this many remarks */
```

⟨Global variables 7⟩ +=

```
instruction travels[travel_size]; /* the table of instructions */
instruction *start[max_loc + 2]; /* references to starting instruction */
char *long_desc[max_loc + 1]; /* long-winded descriptions of locations */
char *short_desc[max_loc + 1]; /* short-winded descriptions, or 0 */
int flags[max_loc + 1]; /* bitmaps for special properties */
char *remarks[rem_size]; /* comments made when staying put */
int rem_count; /* we've made this many comments */
int visits[max_loc + 1]; /* how often have you been here? */
```

**21. Cave connections.** Now we are ready to build the fundamental table of location and transition data, by filling in the arrays just declared. We will fill them in strict order of their **location** codes.

It is convenient to define several macros and constants.

```
#define make_loc(x,l,s,f)
    { long_desc[x]=l; short_desc[x]=s; flags[x]=f; start[x]=q; }
#define make_inst(m,c,d)
    { q-mot = m; q-cond = c; q-dest = d; q++; }
#define ditto(m)
    { q-mot = m; q-cond = (q-1)-cond; q-dest = (q-1)-dest; q++; }
#define holds(o) (100+(o)) /* do instruction only if carrying object o */
#define sees(o) (200+(o)) /* do instruction only if object o is present */
#define not(o,k) (300+(o)+100*(k)) /* do instruction only if prop[o] ≠ k */
#define remark(m) remarks[++rem_count] = m
#define sayit (max_spec + rem_count)

⟨ Global variables 7 ⟩ +=
    char all_alike[] = "You_are_in_a_maze_of_twisty_little_passages,_all_alike.";
    char dead_end[] = "Dead_end.";
    int slit_rmk, grate_rmk, bridge_rmk, loop_rmk; /* messages used more than once */
```

**22.** ⟨ Additional local registers 22 ⟩ ≡

**register instruction** \*q, \*qq;

See also sections 68 and 144.

This code is used in section 2.

**23.** The *road* is where you start; its *long\_desc* is now famous, having been quoted by Steven Levy in his book *Hackers*.

The instructions here say that if you want to go west, or up, or on the road, we take you to *hill*; if you want to go east, or in, or to the house, or if you say ‘enter’, we take you to *house*; etc. Of course you won’t know about all the motions available at this point until you have played the game for awhile.

⟨ Build the travel table 23 ⟩ ≡

```
q = travels;
make_loc(road,
    "You_are_standing_at_the_end_of_a_road_before_a_small_brick_building.\n\
    Around_you_is_a_forest._A_small_stream_flows_out_of_the_building_and\n\
    down_a_gully.",
    "You're_at_end_of_road_again.", lighted + liquid);
make_inst(W,0,hill); ditto(U); ditto(ROAD);
make_inst(E,0,house); ditto(IN); ditto(HOUSE); ditto(ENTER);
make_inst(S,0,valley); ditto(D); ditto(GULLY); ditto(STREAM); ditto(DOWNSTREAM);
make_inst(N,0,forest); ditto(WOODS);
make_inst(DEPRESSION,0,outside);
```

See also sections 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, and 62.

This code is used in section 200.



24. There's nothing up the hill, but a good explorer has to try anyway.

⟨ Build the travel table 23 ⟩ +≡

```
make_loc(hill,
  "You_have_walked_up_a_hill,_still_in_the_forest._The_road_slopes_back\n\
    down_the_other_side_of_the_hill._There_is_a_building_in_the_distance.",
  "You're_at_hill_in_road.", lighted);
make_inst(ROAD, 0, road); ditto(HOUSE); ditto(FORWARD); ditto(E); ditto(D);
make_inst(WOODS, 0, forest); ditto(N); ditto(S);
```

25. The house initially contains several objects: keys, food, a bottle, and a lantern. We'll put them in there later.

Two magic words are understood in this house, to teleport spelunkers who have been there and done that. (Crowther is said to have pronounced the first one "zizzy"; the pronunciation of the other one is unknown.)

⟨ Build the travel table 23 ⟩ +≡

```
make_loc(house,
  "You_are_inside_a_building,_a_well_house_for_a_large_spring.",
  "You're_inside_building.", lighted + liquid);
make_inst(ENTER, 0, road); ditto(OUT); ditto(OUTDOORS); ditto(W);
make_inst(XYZZY, 0, debris);
make_inst(PLUGH, 0, y2);
make_inst(DOWNSTREAM, 0, sewer); ditto(STREAM);
```

26. A foolish consistency is the hobgoblin of little minds. (Emerson)

⟨ Build the travel table 23 ⟩ +≡

```
make_loc(valley,
  "You_are_in_a_valley_in_the_forest_beside_a_stream_tumbling_along_a\nrocky_bed.",
  "You're_in_valley.", lighted + liquid);
make_inst(UPSTREAM, 0, road); ditto(HOUSE); ditto(N);
make_inst(WOODS, 0, forest); ditto(E); ditto(W); ditto(U);
make_inst(DOWNSTREAM, 0, slit); ditto(S); ditto(D);
make_inst(DEPRESSION, 0, outside);
```

27. The instructions here keep you in the *forest* with probability 50%, otherwise they take you to the *woods*. This gives the illusion that we maintain more state information about you than we really do.

⟨ Build the travel table 23 ⟩ +≡

```
make_loc(forest,
  "You_are_in_open_forest,_with_a_deep_valley_to_one_side.",
  "You're_in_forest.", lighted);
make_inst(VALLEY, 0, valley); ditto(E); ditto(D);
make_inst(WOODS, 50, forest); ditto(FORWARD); ditto(N);
make_inst(WOODS, 0, woods);
make_inst(W, 0, forest); ditto(S);

make_loc(woods,
  "You_are_in_open_forest_near_both_a_valley_and_a_road.",
  short_desc[forest], lighted);
make_inst(ROAD, 0, road); ditto(N);
make_inst(VALLEY, 0, valley); ditto(E); ditto(W); ditto(D);
make_inst(WOODS, 0, forest); ditto(S);
```

**28.** You're getting closer. (But the program has forgotten that DEPRESSION leads *outside*; it knew this when you were at the *road* or the *valley*.)

(Build the travel table 23) +≡

```
make_loc(slit,
  "At your feet all the water of the stream splashes into a 2-inch slit\n\
   in the rock. Downstream the streambed is bare rock.",
  "You're at slit in streambed.", lighted + liquid);
make_inst(HOUSE, 0, road);
make_inst(UPSTREAM, 0, valley); ditto(N);
make_inst(WOODS, 0, forest); ditto(E); ditto(W);
make_inst(DOWNSTREAM, 0, outside); ditto(ROCK); ditto(BED); ditto(S);
remark("You don't fit through a two-inch slit!");
make_inst(SLIT, 0, sayit); ditto(STREAM); ditto(D);
slit_rmk = sayit;
```

**29.** We'll see later that the GRATE will change from state 0 to state 1 if you unlock it. So let's hope you have the KEYS.

(Build the travel table 23) +≡

```
make_loc(outside,
  "You are in a 20-foot depression floored with bare dirt. Set into the\n\
   dirt is a strong steel grate mounted in concrete. A dry streambed\n\
   leads into the depression.",
  "You're outside grate.", lighted + cave_hint);
make_inst(WOODS, 0, forest); ditto(E); ditto(W); ditto(S);
make_inst(HOUSE, 0, road);
make_inst(UPSTREAM, 0, slit); ditto(GULLY); ditto(N);
make_inst(ENTER, not(GRATE, 0), inside); ditto(IN); ditto(D);
remark("You can't go through a locked steel grate!");
grate_rmk = sayit;
make_inst(ENTER, 0, sayit);
```

**30.** If you've come this far, you're probably hooked, although your adventure has barely begun.

(Build the travel table 23) +≡

```
make_loc(inside,
  "You are in a small chamber beneath a 3x3 steel grate to the surface.\n\
   A low crawl over cobbles leads inwards to the west.",
  "You're below the grate.", lighted);
make_inst(OUT, not(GRATE, 0), outside); ditto(U);
make_inst(OUT, 0, grate_rmk);
make_inst(CRAWL, 0, cobbles); ditto(COBLES); ditto(IN); ditto(W);
make_inst(PIT, 0, spit);
make_inst(DEBRIS, 0, debris);
```

**31.** Go West, young man. (If you've got a lamp.)

⟨Build the travel table 23⟩ +≡

```

make_loc(cobbles,
  "You are crawling over cobbles in a low passage. There is a dim light\n\
   at the east end of the passage.",
  "You're in cobble crawl.", lighted);
make_inst(OUT, 0, inside); ditto(SURFACE); ditto(NOWHERE); ditto(E);
make_inst(IN, 0, debris); ditto(DARK); ditto(W); ditto(DEBRIS);
make_inst(PIT, 0, spit);
make_loc(debris,
  "You are in a debris room filled with stuff washed in from the surface.\n\
   A low wide passage with cobbles becomes plugged with mud and debris\n\
   here, but an awkward canyon leads upward and west. A note on the wall\n\
   says \"MAGIC WORD XYZZY\".",
  "You're in debris room.", 0);
make_inst(DEPRESSION, not(GRATE, 0), outside);
make_inst(ENTRANCE, 0, inside);
make_inst(CRAWL, 0, cobbles); ditto(COBBLES); ditto(PASSAGE); ditto(LOW); ditto(E);
make_inst(CANYON, 0, awk); ditto(IN); ditto(U); ditto(W);
make_inst(XYZZY, 0, house);
make_inst(PIT, 0, spit);
make_loc(awk,
  "You are in an awkward sloping east/west canyon.", 0, 0);
make_inst(DEPRESSION, not(GRATE, 0), outside);
make_inst(ENTRANCE, 0, inside);
make_inst(D, 0, debris); ditto(E); ditto(DEBRIS);
make_inst(IN, 0, bird); ditto(U); ditto(W);
make_inst(PIT, 0, spit);
make_loc(bird,
  "You are in a splendid chamber thirty feet high. The walls are frozen\n\
   rivers of orange stone. An awkward canyon and a good passage exit\n\
   from east and west sides of the chamber.",
  "You're in bird chamber.", bird_hint);
make_inst(DEPRESSION, not(GRATE, 0), outside);
make_inst(ENTRANCE, 0, inside);
make_inst(DEBRIS, 0, debris);
make_inst(CANYON, 0, awk); ditto(E);
make_inst(PASSAGE, 0, spit); ditto(PIT); ditto(W);
make_loc(spit,
  "At your feet is a small pit breathing traces of white mist. An east\n\
   passage ends here except for a small crack leading on.",
  "You're at top of small pit.", 0);
make_inst(DEPRESSION, not(GRATE, 0), outside);
make_inst(ENTRANCE, 0, inside);
make_inst(DEBRIS, 0, debris);
make_inst(PASSAGE, 0, bird); ditto(E);
make_inst(D, holds(GOLD), neck); ditto(PIT); ditto(STEPS);
make_inst(D, 0, emist); /* good thing you weren't loaded down with GOLD */
make_inst(CRACK, 0, crack); ditto(W);

```

**32.** Welcome to the main caverns and a deeper level of adventures.

(Build the travel table 23) +≡

```
make_loc(emist,
  "You are at one end of a vast hall stretching forward out of sight to\n\
   the west. There are openings to either side. Nearby, a wide stone\n\
   staircase leads downward. The hall is filled with wisps of white mist\n\
   swaying to and fro almost as if alive. A cold wind blows up the\n\
   staircase. There is a passage at the top of a dome behind you.",
  "You're in Hall of Mists.", 0);
make_inst(L, 0, nugget); ditto(S);
make_inst(FORWARD, 0, efiss); ditto(HALL); ditto(W);
make_inst(STAIRS, 0, hmk); ditto(D); ditto(N);
make_inst(U, holds(GOLD), cant); ditto(PIT); ditto(STEPS);
ditto(DOME); ditto(PASSAGE); ditto(E);
make_inst(U, 0, spit);
make_inst(Y2, 0, jumble);
```

**33.** To the left or south of the misty threshold, you might spot the first treasure.

(Build the travel table 23) +≡

```
make_loc(nugget,
  "This is a low room with a crude note on the wall. The note says,\n\
   \"You won't get it up the steps\".",
  "You're in nugget of gold room.", 0);
make_inst(HALL, 0, emit); ditto(OUT); ditto(N);
```

**34.** Unless you take a circuitous route to the other side of the Hall of Mists, via the Hall of the Mountain King, you should make the CRYSTAL bridge appear (by getting it into state 1).

(Build the travel table 23) +≡

```
make_loc(efiss,
  "You are on the east bank of a fissure slicing clear across the hall.\n\
   The mist is quite thick here, and the fissure is too wide to jump.",
  "You're on east bank of fissure.", 0);
make_inst(HALL, 0, emit); ditto(E);
remark("I respectfully suggest you go across the bridge instead of jumping.");
bridge_rmk = sayit;
make_inst(JUMP, not(CRYSTAL, 0), sayit);
make_inst(FORWARD, not(CRYSTAL, 1), lose);
remark("There is no way across the fissure.");
make_inst(OVER, not(CRYSTAL, 1), sayit); ditto(ACROSS); ditto(W); ditto(CROSS);
make_inst(OVER, 0, wfiss);

make_loc(wfiss,
  "You are on the west side of the fissure in the Hall of Mists.", 0, 0);
make_inst(JUMP, not(CRYSTAL, 0), bridge_rmk);
make_inst(FORWARD, not(CRYSTAL, 1), lose);
make_inst(OVER, not(CRYSTAL, 1), sayit); ditto(ACROSS); ditto(E); ditto(CROSS);
make_inst(OVER, 0, efiss);
make_inst(N, 0, thru);
make_inst(W, 0, wmist);
```

**35.** What you see here isn't exactly what you get; N takes you east and S sucks you in to an amazing maze.

⟨ Build the travel table 23 ⟩ +≡

```
make_loc(wmist,
  "You are at the west end of the Hall of Mists. A low wide crawl\n\
    continues west and another goes north. To the south is a little\n\
    passage 6 feet off the floor.",
  "You're at west end of Hall of Mists.", 0);
make_inst(S, 0, like1); ditto(U); ditto(PASSAGE); ditto(CLIMB);
make_inst(E, 0, wfiss);
make_inst(N, 0, duck);
make_inst(W, 0, elong); ditto(CRAWL);
```

**36.** The twisty little passages of this maze are said to be all alike, but they respond differently to different motions. For example, you can go north, east, south, or west from *like1*, but you can't go north from *like2*. In that way you can psych out the whole maze of 14 similar locations. (And eventually you will want to know every place where treasure might be hidden.) The only exits are to *wmist* and *brink*.

⟨ Build the travel table 23 ⟩ +≡

```

make_loc(like1, all_alike, 0, twist_hint);
make_inst(U, 0, wmist);
make_inst(N, 0, like1);
make_inst(E, 0, like2);
make_inst(S, 0, like4);
make_inst(W, 0, like11);

make_loc(like2, all_alike, 0, twist_hint);
make_inst(W, 0, like1);
make_inst(S, 0, like3);
make_inst(E, 0, like4);

make_loc(like3, all_alike, 0, twist_hint);
make_inst(E, 0, like2);
make_inst(D, 0, dead5);
make_inst(S, 0, like6);
make_inst(N, 0, dead9);

make_loc(like4, all_alike, 0, twist_hint);
make_inst(W, 0, like1);
make_inst(N, 0, like2);
make_inst(E, 0, dead3);
make_inst(S, 0, dead4);
make_inst(U, 0, like14); ditto(D);

make_loc(like5, all_alike, 0, twist_hint);
make_inst(E, 0, like6);
make_inst(W, 0, like7);

make_loc(like6, all_alike, 0, twist_hint);
make_inst(E, 0, like3);
make_inst(W, 0, like5);
make_inst(D, 0, like7);
make_inst(S, 0, like8);

make_loc(like7, all_alike, 0, twist_hint);
make_inst(W, 0, like5);
make_inst(U, 0, like6);
make_inst(E, 0, like8);
make_inst(S, 0, like9);

make_loc(like8, all_alike, 0, twist_hint);
make_inst(W, 0, like6);
make_inst(E, 0, like7);
make_inst(S, 0, like8);
make_inst(U, 0, like9);
make_inst(N, 0, like10);
make_inst(D, 0, dead11);

make_loc(like9, all_alike, 0, twist_hint);
make_inst(W, 0, like7);
make_inst(N, 0, like8);
make_inst(S, 0, dead6);

```

```

make_loc(like10, all_alike, 0, twist_hint);
make_inst(W, 0, like8);
make_inst(N, 0, like10);
make_inst(D, 0, dead7);
make_inst(E, 0, brink);

make_loc(like11, all_alike, 0, twist_hint);
make_inst(N, 0, like1);
make_inst(W, 0, like11); ditto(S);
make_inst(E, 0, dead1);

make_loc(like12, all_alike, 0, twist_hint);
make_inst(S, 0, brink);
make_inst(E, 0, like13);
make_inst(W, 0, dead10);

make_loc(like13, all_alike, 0, twist_hint);
make_inst(N, 0, brink);
make_inst(W, 0, like12);
make_inst(NW, 0, dead2); /* NW: a dirty trick! */

make_loc(like14, all_alike, 0, twist_hint);
make_inst(U, 0, like4); ditto(D);

```

**37.** 〈Build the travel table 23〉 +≡

```

make_loc(brink,
"You_are_on_the_brink_of_a_thirty-foot_pit_with_a_massive_orange_column\n\
down_one_wall. You could climb down here but you could not get back\n\
up. The maze continues at this level.",
"You're at brink of pit.", 0);
make_inst(D, 0, bird); ditto(CLIMB);
make_inst(W, 0, like10);
make_inst(S, 0, dead8);
make_inst(N, 0, like12);
make_inst(E, 0, like13);

```

**38.** Crawling west from *wmist* instead of south, you encounter this.

〈Build the travel table 23〉 +≡

```

make_loc(elong,
"You_are_at_the_east_end_of_a_very_long_hall_apparently_without_side\n\
chambers. To the east a low wide crawl slants up. To the north a\n\
round two-foot hole slants down.",
"You're at east end of long hall.", 0);
make_inst(E, 0, wmist); ditto(U); ditto(CRAWL);
make_inst(W, 0, wlong);
make_inst(N, 0, cross); ditto(D); ditto(HOLE);

make_loc(wlong,
"You_are_at_the_west_end_of_a_very_long_featureless_hall. The hall\n\
joins up with a narrow north/south passage.",
"You're at west end of long hall.", 0);
make_inst(E, 0, elong);
make_inst(N, 0, cross);
make_inst(S, 100, diff0);

```

**39.** Recall that the ‘100’ on the last instruction above means, “Dwarves not permitted.” It keeps them out of the following maze, which is based on an  $11 \times 11$  latin square. (Each of the eleven locations leads to each of the others under the ten motions N, S, E, W, NE, SE, NW, SW, U, D — except that *diff0* goes down to the entrance location *wlong* instead of to *diff10*, and *diff10* goes south to the dead-end location *pony* instead of to *diff0*. Furthermore, each location is accessible from all ten possible directions.)

Incidentally, if you ever get into a “little twisting maze of passages,” you’re really lost.

```
#define twist(l, n, s, e, w, ne, se, nw, sw, u, d, m)
    make_loc(l, m, 0, 0);
    make_inst(N, 0, n); make_inst(S, 0, s); make_inst(E, 0, e); make_inst(W, 0, w);
    make_inst(NE, 0, ne); make_inst(SE, 0, se); make_inst(NW, 0, nw); make_inst(SW, 0, sw);
    make_inst(U, 0, u); make_inst(D, 0, d);

⟨ Build the travel table 23 ⟩ +=
    twist(diff0, diff9, diff1, diff7, diff8, diff3, diff4, diff6, diff2, diff5, wlong,
    "You are in a maze of twisty little passages, all different.");
    twist(diff1, diff8, diff9, diff10, diff5, diff2, diff3, diff4, diff6, diff7,
    "You are in a maze of twisty little passages, all different.");
    twist(diff2, diff3, diff4, diff8, diff5, diff7, diff10, diff0, diff6, diff1, diff9,
    "You are in a maze of twisty passages, all different.");
    twist(diff3, diff7, diff10, diff6, diff2, diff4, diff9, diff8, diff5, diff0, diff1,
    "You are in a twisting maze of little passages, all different.");
    twist(diff4, diff1, diff7, diff5, diff9, diff0, diff3, diff2, diff10, diff8, diff6,
    "You are in a twisting little maze of passages, all different.");
    twist(diff5, diff10, diff3, diff4, diff6, diff8, diff1, diff9, diff7, diff10, diff2,
    "You are in a twisty little maze of passages, all different.");
    twist(diff6, diff10, diff5, diff0, diff1, diff9, diff8, diff7, diff3, diff2, diff4,
    "You are in a twisty maze of little passages, all different.");
    twist(diff7, diff6, diff2, diff9, diff10, diff1, diff0, diff5, diff8, diff4, diff3,
    "You are in a little twisty maze of passages, all different.");
    twist(diff8, diff5, diff6, diff1, diff4, diff2, diff7, diff10, diff9, diff3, diff0,
    "You are in a maze of little twisting passages, all different.");
    twist(diff9, diff4, diff8, diff2, diff3, diff10, diff6, diff1, diff0, diff7, diff5,
    "You are in a maze of little twisty passages, all different.");
    twist(diff10, diff2, pony, diff3, diff7, diff6, diff5, diff4, diff1, diff9, diff8,
    "You are in a little maze of twisting passages, all different.");

    make_loc(pony, dead_end, 0, 0);
    make_inst(N, 0, diff10); ditto(OUT);
```



40. Going north from the long hall, we come to the vicinity of another large room, with royal treasures nearby. (You probably first reached this part of the cavern from the east, via the Hall of Mists.) Unfortunately, a vicious snake is here too; the conditional instructions for getting past the snake are worthy of study.

⟨ Build the travel table 23 ⟩ +≡

```

make_loc(cross,
  "You_are_at_a_crossover_of_a_high_N/S_passage_and_a_low_E/W_one.", 0, 0);
make_inst(W, 0, elong);
make_inst(N, 0, dead0);
make_inst(E, 0, west);
make_inst(S, 0, wlong);

make_loc(hmk,
  "You_are_in_the_Hall_of_the_Mountain_King, with_passages_off_in_all\ndirections.",
  "You're_in_Hall_of_Mt_King.", snake_hint);
make_inst(STAIRS, 0, mist); ditto(U); ditto(E);
make_inst(N, not(SNAKE, 0), ns); ditto(L);
make_inst(S, not(SNAKE, 0), south); ditto(R);
make_inst(W, not(SNAKE, 0), west); ditto(FORWARD);
make_inst(N, 0, snaked);
make_inst(SW, 35, secret);
make_inst(SW, sees(SNAKE), snaked);
make_inst(SECRET, 0, secret);

make_loc(west,
  "You_are_in_the_west_side_chamber_of_the_Hall_of_the_Mountain_King.\n\
  A_passage_continues_west_and_up_here.",
  "You're_in_west_side_chamber.", 0);
make_inst(HALL, 0, hmk); ditto(OUT); ditto(E);
make_inst(W, 0, cross); ditto(U);

make_loc(south,
  "You_are_in_the_south_side_chamber.", 0, 0);
make_inst(HALL, 0, hmk); ditto(OUT); ditto(N);

```

41. North of the mountain king's domain is a curious shuttle station called Y2, with magic connections to two other places.

(Crowther led a team in 1974 that explored region "Y" of Colossal Cave; "Y2" was the second location to be named in this region.)

⟨Build the travel table 23⟩ +≡

```

make_loc(ns,
  "You_are_in_a_lowN/S_passage_at_a_hole_in_the_floor. The_hole_goes\n\
    down_to_anE/W_passage.",
  "You're_in_N/S_passage.", 0);
make_inst(HALL, 0, hmk); ditto(OUT); ditto(S);
make_inst(N, 0, y2); ditto(Y2);
make_inst(D, 0, dirty); ditto(HOLE);

make_loc(y2,
  "You_are_in_a_large_room, with_a_passage_to_the_south, a_passage_to_the\n\
    west, and_a_wall_of_broken_rock_to_the_east. There_is_a_large\n\
    a_rock_in_the_room's_center.",
  "You're_at_Y2.", 0);
make_inst(PLUGH, 0, house);
make_inst(S, 0, ns);
make_inst(E, 0, jumble); ditto(WALL); ditto(BROKEN);
make_inst(W, 0, windoe);
make_inst(PLOVER, holds(EMERALD), pdrop);
make_inst(PLOVER, 0, proom);

make_loc(jumble,
  "You_are_in_a_jumble_of_rock, with_cracks_everywhere.", 0, 0);
make_inst(D, 0, y2); ditto(Y2);
make_inst(U, 0, emist);

make_loc(windoe,
  "You're_at_a_low_window_overlooking_a_huge_pit, which_extends_up_out_of\n\
    sight. A_floor_is_indistinctly_visible_over_50_feet_below. Traces_of\n\
    white_mist_cover_the_floor_of_the_pit, becoming_thicker_to_the_right.\n\
    Marks_in_the_dust_around_the_window_would_seem_to_indicate_that\n\
    someone_has_been_here_recently. Directly_across_the_pit_from_you_and\n\
    25_feet_away_there_is_a_similar_window_looking_into_a_lighted_room.\n\
    A_shadowy_figure_can_be_seen_there_peering_back_at_you.",
  "You're_at_window_on_pit.", 0);
make_inst(E, 0, y2); ditto(Y2);
make_inst(JUMP, 0, neck);

```

42. Next let's consider the east/west passage below *ns*.

⟨ Build the travel table 23 ⟩ +≡

```

make_loc(dirty,
  "You_are_in_a_dirty_broken_passage. To the east is a crawl. To the\n\
    west is a large passage. Above you is a hole to another passage.",
  "You're_in_dirty_passage.", 0);
make_inst(E, 0, clean); ditto(CRAWL);
make_inst(U, 0, ns); ditto(HOLE);
make_inst(W, 0, dusty);
make_inst(BEDQUILT, 0, bedquilt);

make_loc(clean,
  "You_are_on_the_brink_of_a_small_clean_climbable_pit. A crawl leads\n\
    west.",
  "You're_by_a_clean_pit.", 0);
make_inst(W, 0, dirty); ditto(CRAWL);
make_inst(D, 0, wet); ditto(PIT); ditto(CLIMB);

make_loc(wet,
  "You_are_in_the_bottom_of_a_small_pit_with_a_little_stream, which\n\
    enters and exits through tiny slits.",
  "You're_in_pit_by_stream.", liquid);
make_inst(CLIMB, 0, clean); ditto(U); ditto(OUT);
make_inst(SLIT, 0, slit_rm); ditto(STREAM); ditto(D); ditto(UPSTREAM); ditto(DOWNSTREAM);

make_loc(dusty,
  "You_are_in_a_large_room_full_of_dusty_rock. There is a big hole in\n\
    the floor. There are cracks everywhere, and a passage leading east.",
  "You're_in_dusty_rock_room.", 0);
make_inst(E, 0, dirty); ditto(PASSAGE);
make_inst(D, 0, complex); ditto(HOLE); ditto(FLOOR);
make_inst(BEDQUILT, 0, bedquilt);

make_loc(complex,
  "You_are_at_a_complex_junction. A low hands-and-knees passage from the\n\
    north joins a higher crawl from the east to make a walking passage\n\
    going west. There is also a large room above. The air is damp here.",
  "You're_at_complex_junction.", 0);
make_inst(U, 0, dusty); ditto(CLIMB); ditto(ROOM);
make_inst(W, 0, bedquilt); ditto(BEDQUILT);
make_inst(N, 0, shell); ditto(SHELL);
make_inst(E, 0, ante);

```

**43.** A more-or-less self-contained cavelet can be found north of the complex passage. Its connections are more vertical than horizontal.

⟨ Build the travel table 23 ⟩ +≡

```

make_loc(shell,
  "You're in a large room carved out of sedimentary rock. The floor\n\
    and walls are littered with bits of shells embedded in the stone.\n\
    A shallow passage proceeds downward, and a somewhat steeper one\n\
    leads up. A low hands-and-knees passage enters from the south.",
  "You're in Shell Room.", 0);
make_inst(U, 0, arch); ditto(HALL);
make_inst(D, 0, ragged);
remark("You can't fit this five-foot clam through that little passage!");
make_inst(S, holds(CLAM), sayit);
remark("You can't fit this five-foot oyster through that little passage!");
make_inst(S, holds(OYSTER), sayit);
make_inst(S, 0, complex);
make_loc(arch,
  "You are in an arched hall. A coral passage once continued up and east\n\
    from here, but is now blocked by debris. The air smells of sea water.",
  "You're in arched hall.", 0);
make_inst(D, 0, shell); ditto(SHELL); ditto(OUT);
make_loc(ragged,
  "You are in a long sloping corridor with ragged sharp walls.", 0, 0);
make_inst(U, 0, shell); ditto(SHELL);
make_inst(D, 0, sac);
make_loc(sac,
  "You are in a cul-de-sac about eight feet across.", 0, 0);
make_inst(U, 0, ragged); ditto(OUT);
make_inst(SHELL, 0, shell);

```

44. A dangerous section lies east of the complex junction.

⟨ Build the travel table 23 ⟩ +≡

```

make_loc(ante,
  "You are in an anteroom leading to a large passage to the east. Small\n\
   passages go west and up. The remnants of recent digging are evident.\n\
   A sign in midair here says \"CAVE UNDER CONSTRUCTION BEYOND THIS POINT.\n\
   PROCEED AT OWN RISK. [WITT CONSTRUCTION COMPANY]\"",
  "You're in anteroom.", 0);
make_inst(U, 0, complex);
make_inst(W, 0, bedquilt);
make_inst(E, 0, witt);

make_loc(witt,
  "You are at Witt's End. Passages lead off in \"all\" directions.",
  "You're at Witt's End.", witt_hint);
remark("You have crawled around in some little holes and wound up back in the\n\
  main passage.");
loop_rmk = sayit;
make_inst(E, 95, sayit); ditto(N); ditto(S);
ditto(NE); ditto(SE); ditto(SW); ditto(NW); ditto(U); ditto(D);
make_inst(E, 0, ante); /* one chance in 20 */
remark("You have crawled around in some little holes and found your way\n\
  blocked by a recent cave-in. You are now back in the main passage.");
make_inst(W, 0, sayit);

```

**45.** Will Crowther, who actively explored and mapped many caves in Kentucky before inventing Adventure, named Bedquilt after the Bedquilt Entrance to Colossal Cave. (The real Colossal Cave was discovered near Mammoth Cave in 1895, and its Bedquilt Entrance was found in 1896; see *The Longest Cave* by Brucker and Watson (New York: Knopf, 1976) for further details.)

Random exploration is the name of the game here.

⟨Build the travel table 23⟩ +≡

```

make_loc (bedquilt,
  "You_are_in_Bedquilt,_a_long_east/west_passage_with_holes_everywhere.\n\
    To_explore_at_random_select_north,_south,_up,_or_down.",
  "You're_in_Bedquilt.", 0);
make_inst (E, 0, complex);
make_inst (W, 0, cheese);
make_inst (S, 80, loop_rmk);
make_inst (SLAB, 0, slab);
make_inst (U, 80, loop_rmk);
make_inst (U, 50, abovep);
make_inst (U, 0, dusty);
make_inst (N, 60, loop_rmk);
make_inst (N, 75, low);
make_inst (N, 0, sjunc);
make_inst (D, 80, loop_rmk);
make_inst (D, 0, ante);
make_loc (cheese,
  "You_are_in_a_room_whose_walls_resemble_Swiss_cheese._Obvious_passages\n\
    go_west,_east,_NE,_and_NW._Part_of_the_room_is_occupied_by_a_large\nbedrock_block.",
  "You're_in_Swiss_cheese_room.", 0);
make_inst (NE, 0, bedquilt);
make_inst (W, 0, e2pit);
make_inst (S, 80, loop_rmk);
make_inst (CANYON, 0, tall);
make_inst (E, 0, soft);
make_inst (NW, 50, loop_rmk);
make_inst (ORIENTAL, 0, oriental);
make_loc (soft,
  "You_are_in_the_Soft_Room._The_walls_are_covered_with_heavy_curtains,\n\
    the_floor_with_a_thick_pile_carpet._Moss_covers_the_ceiling.",
  "You're_in_Soft_Room.", 0);
make_inst (W, 0, cheese); ditto (OUT);

```

46. West of the quilt and the cheese is a room with two pits.

Why would you want to descend into the pits? Keep playing and you'll find out.

⟨Build the travel table 23⟩ +≡

```

make_loc(e2pit,
  "You are at the east end of the Twopit Room. The floor here is\n\
    littered with thin rock slabs, which make it easy to descend the pits.\n\
    There is a path here bypassing the pits to connect passages from east\n\
    and west. There are holes all over, but the only big one is on the\n\
    wall directly over the west pit where you can't get to it.",
  "You're at east end of Twopit Room.", 0);
make_inst(E, 0, cheese);
make_inst(W, 0, w2pit); ditto(ACROSS);
make_inst(D, 0, epit); ditto(PIT);
make_loc(w2pit,
  "You are at the west end of the Twopit Room. There is a large hole in\n\
    the wall above the pit at this end of the room.",
  "You're at west end of Twopit Room.", 0);
make_inst(E, 0, e2pit); ditto(ACROSS);
make_inst(W, 0, slab); ditto(SLAB);
make_inst(D, 0, wpit); ditto(PIT);
remark("It is too far up for you to reach.");
make_inst(HOLE, 0, sayit);
make_loc(epit,
  "You are at the bottom of the eastern pit in the Twopit Room. There is\n\
    a small pool of oil in one corner of the pit.",
  "You're in east pit.", liquid + oil);
make_inst(U, 0, e2pit); ditto(OUT);
make_loc(wpit,
  "You are at the bottom of the western pit in the Twopit Room. There is\n\
    a large hole in the wall about 25 feet above you.",
  "You're in west pit.", 0);
make_inst(U, 0, w2pit); ditto(OUT);
make_inst(CLIMB, not(PLANT, 4), check);
make_inst(CLIMB, 0, climb);

```

47. Oho, you climbed the plant in the west pit! Now you're in another scenic area with rare treasures—if you can get through the door.

⟨Build the travel table 23⟩ +≡

```

make_loc(narrow,
  "You are in a long, narrow corridor stretching out of sight to the\n\
   west. At the eastern end is a hole through which you can see a\n\
   profusion of leaves.",
  "You're in narrow corridor.", 0);
make_inst(D, 0, wpit); ditto(CLIMB); ditto(E);
make_inst(JUMP, 0, neck);
make_inst(W, 0, giant); ditto(GIANT);

make_loc(giant,
  "You are in the Giant Room. The ceiling here is too high up for your\n\
   lamp to show it. Cavernous passages lead east, north, and south. On\n\
   the west wall is scrawled the inscription, \"FEE FIE FOE FOO\" [sic].",
  "You're in Giant Room.", 0);
make_inst(S, 0, narrow);
make_inst(E, 0, block);
make_inst(N, 0, immense);

make_loc(block,
  "The passage here is blocked by a recent cave-in.", 0, 0);
make_inst(S, 0, giant); ditto(GIANT); ditto(OUT);

make_loc(immense,
  "You are at one end of an immense north/south passage.", 0, 0);
make_inst(S, 0, giant); ditto(GIANT); ditto(PASSAGE);
make_inst(N, not(DOOR, 0), falls); ditto(ENTER); ditto(CAVERN);
remark("The door is extremely rusty and refuses to open.");
make_inst(N, 0, sayit);

make_loc(falls,
  "You are in a magnificent cavern with a rushing stream, which cascades\n\
   over a sparkling waterfall into a roaring whirlpool that disappears\n\
   through a hole in the floor. Passages exit to the south and west.",
  "You're in cavern with waterfall.", liquid);
make_inst(S, 0, immense); ditto(OUT);
make_inst(GIANT, 0, giant);
make_inst(W, 0, steep);

make_loc(steep,
  "You are at the top of a steep incline above a large room. You could\n\
   climb down here, but you would not be able to climb up. There is a\n\
   passage leading back to the north.",
  "You're at steep incline above large room.", 0);
make_inst(N, 0, falls); ditto(CAVERN); ditto(PASSAGE);
make_inst(D, 0, low); ditto(CLIMB);

```



48. Meanwhile let's backtrack to another part of the cave possibly reachable from Bedquilt.

⟨Build the travel table 23⟩ +≡

```

make_loc(abovep,
  "You_are_in_a_secret_N/S_canyon_above_a_sizable_passage.", 0, 0);
make_inst(N, 0, sjunc);
make_inst(D, 0, bedquilt); ditto(PASSAGE);
make_inst(S, 0, tite);

make_loc(sjunc,
  "You_are_in_a_secret_canyon_at_a_junction_of_three_canyons,_bearing\n\
    north,_south,_and_SE. The_north_one_is_as_tall_as_the_other_two\ncombined.",
  "You're_at_junction_of_three_secret_canyons.", 0);
make_inst(SE, 0, bedquilt);
make_inst(S, 0, abovep);
make_inst(N, 0, window);

make_loc(tite,
  "A_large_stalactite_extends_from_the_roof_and_almost_reaches_the_floor\n\
    below. You_could_climb_down_it,_and_jump_from_it_to_the_floor,_but\n\
    having_done_so_you_would_be_unable_to_reach_it_to_climb_back_up.",
  "You're_on_top_of_stalactite.", 0);
make_inst(N, 0, abovep);
make_inst(D, 40, like6); ditto(JUMP); ditto(CLIMB);
make_inst(D, 50, like9);
make_inst(D, 0, like4); /* oh dear, you're in a random part of the maze */

make_loc(low,
  "You_are_in_a_large_low_room. Crawls_lead_north,_SE,_and_SW.", 0, 0);
make_inst(BEDQUILT, 0, bedquilt);
make_inst(SW, 0, scorr);
make_inst(N, 0, crawl);
make_inst(SE, 0, oriental); ditto(ORIENTAL);

make_loc(crawl,
  "Dead_end_crawl.", 0, 0);
make_inst(S, 0, low); ditto(CRAWL); ditto(OUT);

```

49. The described view from the west window, *window*, is identical to the view from the east window, *windowe*, except for one word. What on earth do you see from those windows? (Don Woods has confided that the shadowy figure is actually your own reflection, because *mirror* lies between the two window rooms. An intentional false clue.)

⟨Build the travel table 23⟩ +≡

```

make_loc(window,
  "You're_at_a_low_window_overlooking_a_huge_pit,_which_extends_up_out_of\n\
    sight. A_floor_is_indistinctly_visible_over_50_feet_below. Traces_of\n\
    white_mist_cover_the_floor_of_the_pit,_becoming_thicker_to_the_left.\n\
    Marks_in_the_dust_around_the_window_would_seem_to_indicate_that\n\
    someone_has_been_here_recently. Directly_across_the_pit_from_you_and\n\
    25_feet_away_there_is_a_similar_window_looking_into_a_lighted_room.\n\
    A_shadowy_figure_can_be_seen_there_peering_back_at_you.",
  short_desc[windowe], 0);
make_inst(W, 0, sjunc);
make_inst(JUMP, 0, neck);

```

50. More treasures await you via the *low* corridor.

(Build the travel table 23) +≡

```
make_loc(oriental,
  "This is the Oriental Room. Ancient oriental cave drawings cover the\n\
    walls. A gently sloping passage leads upward to the north, another\n\
    passage leads SE, and a hands-and-knees crawl leads west.",
  "You're in Oriental Room.", 0);
make_inst(SE, 0, cheese);
make_inst(W, 0, low); ditto(CRAWL);
make_inst(U, 0, misty); ditto(N); ditto(CAVERN);
make_loc(misty,
  "You are following a wide path around the outer edge of a large cavern.\n\
    Far below, through a heavy white mist, strange splashing noises can be\n\
    heard. The mist rises up through a fissure in the ceiling. The path\n\
    exits to the south and west.",
  "You're in misty cavern.", 0);
make_inst(S, 0, oriental); ditto(ORIENTAL);
make_inst(W, 0, alcove);
```

51. One of the darkest secrets is hidden here. You will discover that you must take the emerald from the Plover Room to the alcove. But you don't learn the name of the Plover Room until the second time you've been there, since your first visit will be lampless until you know the secret.

(Build the travel table 23) +≡

```
make_loc(alcove,
  "You are in an alcove. A small NW path seems to widen after a short\n\
    distance. An extremely tight tunnel leads east. It looks like a very\n\
    tight squeeze. An eerie light can be seen at the other end.",
  "You're in alcove.", dark_hint);
make_inst(NW, 0, misty); ditto(CAVERN);
make_inst(E, 0, ppass); ditto(PASSAGE);
make_inst(E, 0, proom); /* never performed, but seen by 'go back' */
make_loc(proom,
  "You're in a small chamber lit by an eerie green light. An extremely\n\
    narrow tunnel exits to the west. A dark corridor leads NE.",
  "You're in Plover Room.", lighted + dark_hint);
make_inst(W, 0, ppass); ditto(PASSAGE); ditto(OUT);
make_inst(W, 0, alcove); /* never performed, but seen by 'go back' */
make_inst(PLOVER, holds(EMERALD), pdrop);
make_inst(PLOVER, 0, y2);
make_inst(NE, 0, droom); ditto(DARK);
make_loc(droom,
  "You're in the Dark-Room. A corridor leading south is the only exit.",
  "You're in Dark-Room.", dark_hint);
make_inst(S, 0, proom); ditto(PLOVER); ditto(OUT);
```

**52.** We forgot to mention the circuitous passage leading west from the Twopit Room. It winds around and takes you to a somewhat more mundane area, yet not without interest.

⟨Build the travel table 23⟩ +≡

```

make_loc(slab,
  "You are in a large low circular chamber whose floor is an immense slab\n\
   fallen from the ceiling (SlabRoom). There once were large passages\n\
   to the east and west, but they are now filled with boulders. Low\n\
   small passages go north and south, and the south one quickly bends\n\
   east around the boulders.",
  /* Woods originally said 'west' */
  "You're in SlabRoom.", 0);
make_inst(S, 0, w2pit);
make_inst(U, 0, abover); ditto(CLIMB);
make_inst(N, 0, bedquilt);
make_loc(abover,
  "You are in a secret N/S canyon above a large room.", 0, 0);
make_inst(D, 0, slab); ditto(SLAB);
make_inst(S, not(DRAGON, 0), scan2);
make_inst(S, 0, scan1);
make_inst(N, 0, mirror);
make_inst(RESERVOIR, 0, res);
make_loc(mirror,
  "You are in a north/south canyon about 25 feet across. The floor is\n\
   covered by white mist seeping in from the north. The walls extend\n\
   upward for well over 100 feet. Suspended from some unseen point far\n\
   above you, an enormous two-sided mirror is hanging parallel to and\n\
   midway between the canyon walls. (The mirror is obviously provided\n\
   for the use of the dwarves, who as you know are extremely vain.)\n\
   A small window can be seen in either wall, some fifty feet up.",
  "You're in mirror canyon.", 0);
make_inst(S, 0, abover);
make_inst(N, 0, res); ditto(RESERVOIR);
make_loc(res,
  "You are at the edge of a large underground reservoir. An opaque cloud\n\
   of white mist fills the room and rises rapidly upward. The lake is\n\
   fed by a stream, which tumbles out of a hole in the wall about 10 feet\n\
   overhead and splashes noisily into the water somewhere within the\n\
   mist. The only passage goes back toward the south.",
  "You're at reservoir.", liquid);
make_inst(S, 0, mirror); ditto(OUT);

```

**53.** Four more secret canyons lead back to the Hall of the Mountain King. Three of them are actually the same, but the dragon blocks the connection between the northern passage (to *abover*) and the eastern passage (to *secret*). Once you've vanquished the dragon, *scan2* takes the place of *scan1* and *scan3*.

(Build the travel table 23) +≡

```
make_loc(scan1,
  "You are in a secret canyon that exits to the north and east.", 0, 0);
make_inst(N, 0, abover); ditto(OUT);
remark("The dragon looks rather nasty. You'd best not try to get by.");
make_inst(E, 0, sayit); ditto(FORWARD);
make_loc(scan2, long_desc[scan1], 0, 0);
make_inst(N, 0, abover);
make_inst(E, 0, secret);

make_loc(scan3, long_desc[scan1], 0, 0);
make_inst(E, 0, secret); ditto(OUT);
make_inst(N, 0, sayit); ditto(FORWARD);

make_loc(secret,
  "You are in a secret canyon, which here runs E/W. It crosses over a\n\
  very tight canyon 15 feet below. If you go down you may not be able\n\
  to get back up.",
  "You're in secret E/W canyon above tight canyon.", 0);
make_inst(E, 0, hmk);
make_inst(W, not(DRAGON, 0), scan2);
make_inst(W, 0, scan3);
make_inst(D, 0, wide);
```

**54.** Below *secret* there's another way to reach the cheese.

(Build the travel table 23) +≡

```
make_loc(wide,
  "You are at a wide place in a very tight N/S canyon.", 0, 0);
make_inst(S, 0, tight);
make_inst(N, 0, tall);

make_loc(tight,
  "The canyon here becomes too tight to go further south.", 0, 0);
make_inst(N, 0, wide);

make_loc(tall,
  "You are in a tall E/W canyon. A low tight crawl goes 3 feet north and\n\
  seems to open up.",
  "You're in tall E/W canyon.", 0);
make_inst(E, 0, wide);
make_inst(W, 0, boulders);
make_inst(N, 0, cheese); ditto(CRAWL);

make_loc(boulders,
  "The canyon runs into a mass of boulders --- dead end.", 0, 0);
make_inst(S, 0, tall);
```

**55.** If you aren't having fun yet, wait till you meet the troll. The only way to get here is to crawl southwest from the *low* room. And then you have a new problem to solve; we'll see later that the **TROLL** and the **BRIDGE** are here.

(Don Woods got the idea for the mist-covered bridge after an early morning visit to Mount Diablo; see Steven Levy, *Hackers* (New York: Delta, 1994), Chapter 7.)

⟨ Build the travel table 23 ⟩ +≡

```

make_loc(scorr,
  "You are in a long winding corridor sloping out of sight in both directions.",
  "You're in sloping corridor.", 0);
make_inst(D, 0, low);
make_inst(U, 0, swside);
make_loc(swside,
  "You are on one side of a large, deep chasm. A heavy white mist rising\n\
  up from below obscures all view of the far side. A SW path leads away\n\
  from the chasm into a winding corridor.",
  "You're on SW side of chasm.", 0);
make_inst(SW, 0, scorr);
remark("The troll refuses to let you cross.");
make_inst(OVER, sees(TROLL), sayit); ditto(ACROSS); ditto(CROSS); ditto(NE);
remark("There is no longer any way across the chasm.");
make_inst(OVER, not(BRIDGE, 0), sayit);
make_inst(OVER, 0, troll);
make_inst(JUMP, not(BRIDGE, 0), lose);
make_inst(JUMP, 0, bridge_rmk);

```

**56.** The only things not yet explored on this side of the troll bridge are a dozen dead ends. They appear at this place in the ordering of all locations because of the pirate logic explained later: The pirate will never go to locations  $\geq dead3$ .

**#define** *max\_pirate\_loc* *dead2*

$\langle$  Build the travel table 23  $\rangle + \equiv$

```

    make_loc(dead0, dead_end, 0, 0);
    make_inst(S, 0, cross); ditto(OUT);

    make_loc(dead1, dead_end, 0, twist_hint);
    make_inst(W, 0, like11); ditto(OUT);

    make_loc(dead2, dead_end, 0, 0);
    make_inst(SE, 0, like13);

    make_loc(dead3, dead_end, 0, twist_hint);
    make_inst(W, 0, like4); ditto(OUT);

    make_loc(dead4, dead_end, 0, twist_hint);
    make_inst(E, 0, like4); ditto(OUT);

    make_loc(dead5, dead_end, 0, twist_hint);
    make_inst(U, 0, like3); ditto(OUT);

    make_loc(dead6, dead_end, 0, twist_hint);
    make_inst(W, 0, like9); ditto(OUT);

    make_loc(dead7, dead_end, 0, twist_hint);
    make_inst(U, 0, like10); ditto(OUT);

    make_loc(dead8, dead_end, 0, 0);
    make_inst(E, 0, brink); ditto(OUT);

    make_loc(dead9, dead_end, 0, twist_hint);
    make_inst(S, 0, like3); ditto(OUT);

    make_loc(dead10, dead_end, 0, twist_hint);
    make_inst(E, 0, like12); ditto(OUT);

    make_loc(dead11, dead_end, 0, twist_hint);
    make_inst(U, 0, like8); ditto(OUT);

```

**57.** A whole nuther cave with nine sites and additional treasures is on tuther side of the troll bridge! This cave was inspired in part by J. R. R. Tolkien's stories.

⟨Build the travel table 23⟩ +≡

```

make_loc(neside,
  "You_are_on_the_far_side_of_the_chasm.  A_NE_path_leads_away_from_the\n\
    chasm_on_this_side.",
  "You're_on_NE_side_of_chasm.", 0);
make_inst(NE, 0, corr);
make_inst(OVER, sees(TROLL), sayit - 1); ditto(ACROSS); ditto(CROSS); ditto(SW);
make_inst(OVER, 0, troll);
make_inst(JUMP, 0, bridge_rmk);
make_inst(FORK, 0, fork);
make_inst(VIEW, 0, view);
make_inst(BARREN, 0, fbarr);

make_loc(corr,
  "You're_in_a_long_east/west_corridor.  A_faint_rumbling_noise_can_be\n\
    heard_in_the_distance.",
  "You're_in_corridor.", 0);
make_inst(W, 0, neside);
make_inst(E, 0, fork); ditto(FORK);
make_inst(VIEW, 0, view);
make_inst(BARREN, 0, fbarr);

make_loc(fork,
  "The_path_forks_here.  The_left_fork_leads_northeast.  A_dull_rumbling\n\
    seems_to_get_louder_in_that_direction.  The_right_fork_leads_southeast\n\
    down_a_gentle_slope.  The_main_corridor_enters_from_the_west.",
  "You're_at_fork_in_path.", 0);
make_inst(W, 0, corr);
make_inst(NE, 0, warm); ditto(L);
make_inst(SE, 0, lime); ditto(R); ditto(D);
make_inst(VIEW, 0, view);
make_inst(BARREN, 0, fbarr);

make_loc(warm,
  "The_walls_are_quite_warm_here.  From_the_north_can_be_heard_a_steady\n\
    roar, _so_loud_that_the_entire_cave_seems_to_be_trembling.  Another\n\
    passage_leads_south, _and_a_low_crawl_goes_east.",
  "You're_at_junction_with_warm_walls.", 0);
make_inst(S, 0, fork); ditto(FORK);
make_inst(N, 0, view); ditto(VIEW);
make_inst(E, 0, chamber); ditto(CRAWL);

make_loc(view,
  "You_are_on_the_edge_of_a_breath-taking_view.  Far_below_you_is_an\n\
    active_volcano, _from_which_great_gouts_of_molten_lava_come_surgin\n\
    out, _cascading_back_down_into_the_depths.  The_glowing_rock_fills_the\n\
    farthest_reaches_of_the_cavern_with_a_blood-red_glare, _giving_every\n\
    thing_an_eerie, _macabre_appearance.  The_air_is_filled_with_flickering\n\
    sparks_of_ash_and_a_heavy_smell_of_brimstone.  The_walls_are_hot_to\n\
    the_touch, _and_the_thundering_of_the_volcano_drowns_out_all_other\n\
    sounds.  Embedded_in_the_jagged_roof_far_overhead_are_myriad_twisted\n\
    formations, _composed_of_pure_white_alabaster, _which_scatter_the_murky\n\
    light_into_sinister_apparitions_upon_the_walls.  To_one_side_is_a_deep\n\

```

```

gorge, filled with a bizarre chaos of tortured rock that seems to have\n
been crafted by the Devil himself. An immense river of fire crashes\n
out from the depths of the volcano, burns its way through the gorge,\n
and plummets into a bottomless pit far off to your left. To the\n
right, an immense geyser of blistering steam erupts continuously\n
from a barren island in the center of a sulfurous lake, which bubbles\n
ominously. The far right wall is aflame with an incandescence of its\n
own, which lends an additional infernal splendor to the already\n
hellish scene. A dark, foreboding passage exits to the south.",
"You're at a breath-taking view.", lighted);
make_inst(S, 0, warm); ditto(PASSAGE); ditto(OUT);
make_inst(FORK, 0, fork);
remark(default_msg[EAT]);
make_inst(D, 0, sayit); ditto(JUMP);
make_loc(chamber,
"You are in a small chamber filled with large boulders. The walls are\n
very warm, causing the air in the room to be almost stifling from the\n
heat. The only exit is a crawl heading west, through which a low\n
rumbling noise is coming.",
"You're in chamber of boulders.", 0);
make_inst(W, 0, warm); ditto(OUT); ditto(CRAWL);
make_inst(FORK, 0, fork);
make_inst(VIEW, 0, view);
make_loc(lime,
"You are walking along a gently sloping north/south passage lined with\n
oddly shaped limestone formations.",
"You're in limestone passage.", 0);
make_inst(N, 0, fork); ditto(U); ditto(FORK);
make_inst(S, 0, fbarr); ditto(D); ditto(BARREN);
make_inst(VIEW, 0, view);
make_loc(fbarr,
"You are standing at the entrance to a large, barren room. A sign\n
posted above the entrance reads: \"CAUTION! BEAR IN ROOM!\"",
"You're in front of barren room.", 0); /* don't laugh too loud */
make_inst(W, 0, lime); ditto(U);
make_inst(FORK, 0, fork);
make_inst(E, 0, barr); ditto(IN); ditto(BARREN); ditto(ENTER);
make_inst(VIEW, 0, view);
make_loc(barr,
"You are inside a barren room. The center of the room is completely\n
empty except for some dust. Marks in the dust lead away toward the\n
far end of the room. The only exit is the way you came in.",
"You're in barren room.", 0);
make_inst(W, 0, fbarr); ditto(OUT);
make_inst(FORK, 0, fork);
make_inst(VIEW, 0, view);

```



58. The two storage locations are accessible only from each other, and they lead only to each other.

(Build the travel table 23) +≡

```
make_loc(neend,
"You are at the northeast end of an immense room, even larger than the\n\
Giant Room. It appears to be a repository for the \"Adventure\"\n\
program. Massive torches far overhead bathe the room with smoky\n\
yellow light. Scattered about you can be seen a pile of bottles (all\n\
of them empty), a nursery of young beanstalks murmuring quietly, a bed\n\
of oysters, a bundle of black rods with rusty stars on their ends, and\n\
a collection of brass lanterns. Off to one side a great many dwarves\n\
are sleeping on the floor, snoring loudly. A sign nearby reads: \"DO\n\
NOT DISTURB THE DWARVES!\" An immense mirror is hanging against one\n\
wall, and stretches to the other end of the room, where various other\n\
sundry objects can be glimpsed dimly in the distance.",
"You're at NE end.", lighted);
make_inst(SW, 0, swend);
make_loc(swend,
"You are at the southwest end of the repository. To one side is a pit\n\
full of fierce green snakes. On the other side is a row of small\n\
wicker cages, each of which contains a little sulking bird. In one\n\
corner is a bundle of black rods with rusty marks on their ends.\n\
A large number of velvet pillows are scattered about on the floor.\n\
A vast mirror stretches off to the northeast. At your feet is a\n\
large steel grate, next to which is a sign that reads, \"TREASURE\n\
VAULT. KEYS IN MAIN OFFICE.\" ",
"You're at SW end.", lighted);
make_inst(NE, 0, neend);
make_inst(D, 0, grate_rmk);
```

59. When the current location is *crack* or higher, it's a pseudo-location. In such cases we don't ask you for input; we assume that you have told us to force another instruction through. For example, if you try to go through the crack by the small pit in the upper cave (location *spit*), the instruction there sends you to *crack*, which immediately sends you back to *spit*.

```
#define forced_move(loc) (loc ≥ min_forced_loc)
#define FORCE 0 /* actually any value will do here */
```

(Build the travel table 23) +≡

```
make_loc(crack,
"The crack is far too small for you to follow.", 0, 0);
make_inst(FORCE, 0, spit);
```

60. Here are some forced actions that are less pleasant.

(Build the travel table 23) +≡

```
make_loc(neck,
"You are at the bottom of the pit with a broken neck.", 0, 0);
make_inst(FORCE, 0, limbo);
make_loc(lose, "You didn't make it.", 0, 0);
make_inst(FORCE, 0, limbo);
```

**61.** The rest are more-or-less routine, except for *check*—which executes a *conditional* forced command.

```

⟨ Build the travel table 23 ⟩ +≡
    make_loc(cant,
        "The_dome_is_unclimbable.", 0, 0);
    make_inst(FORCE, 0, emist);
    make_loc(climb,
        "You_clamber_up_the_plant_and_scurry_through_the_hole_at_the_top.", 0, 0);
    make_inst(FORCE, 0, narrow);
    make_loc(check, 0, 0, 0);
    make_inst(FORCE, not(PLANT, 2), upnout);
    make_inst(FORCE, 0, didit);
    make_loc(snaked,
        "You_can't_get_by_the_snake.", 0, 0);
    make_inst(FORCE, 0, hmk);
    make_loc(thru,
        "You_have_crawled_through_a_very_low_wide_passage_parallel_to_and_north\n\
         of_the_Hall_of_Mists.", 0, 0);
    make_inst(FORCE, 0, wmist);
    make_loc(duck, long_desc[thru], 0, 0);
    make_inst(FORCE, 0, wfiss);
    make_loc(sewer,
        "The_stream_flows_out_through_a_pair_of_1-foot-diameter_sewer_pipes.\n\
         It_would_be_advisable_to_use_the_exit.", 0, 0);
    make_inst(FORCE, 0, house);
    make_loc(upnout,
        "There_is_nothing_here_to_climb._Use_\\"up\\"or_\\"out\\"_to_leave_the_pit.", 0, 0);
    make_inst(FORCE, 0, wpit);
    make_loc(didit,
        "You_have_climbed_up_the_plant_and_out_of_the_pit.", 0, 0);
    make_inst(FORCE, 0, w2pit);

```

**62.** The table of instructions ends here; the remaining “locations” *ppass*, *pdrop*, and *troll* are special.

```

⟨ Build the travel table 23 ⟩ +≡
    start[ppass] = q;
    if (q > &travels[travel_size] ∨ rem_count > rem_size) {
        printf("Oops, I'm broken!\n"); exit(-1);
    }

```

**63. Data structures for objects.** A fixed universe of objects was enumerated in the vocabulary section. Most of the objects can move or be moved from place to place; so we maintain linked lists of the objects at each location. The first object at location  $l$  is  $first[l]$ , then comes  $link[first[l]]$ , then  $link[link[first[l]]]$ , etc., ending with 0 (which is the “object” called **NOTHING**).

Some of the objects are placed in *groups* of one or more objects. In such cases  $base[t]$  is the smallest object in the group containing object  $t$ . Objects that belong to groups are immovable; they always stay in the same location. Other objects have  $base[t] = \text{NOTHING}$  and they are free to leave one list and join another. For example, it turns out that the **KEYS** are movable, but the **SNAKE** is always in the Hall of the Mountain King; we set  $base[\text{KEYS}] = \text{NOTHING}$  and  $base[\text{SNAKE}] = \text{SNAKE}$ . Several groups, such as the **GRATE** and **GRATE\_**, consist of two objects. This program supports operations on groups of more than two objects, but no such objects actually occur.

Each movable or base object  $t$  has a current property  $prop[t]$ , which is initially  $-1$  for treasures, otherwise initially 0. We change  $prop[t]$  to 0 when you first see treasure  $t$ ; and property values often change further as the game progresses. For example, the **PLANT** can grow. When you see an object, we usually print a message that corresponds to its current property value. That message is the string  $note[prop[t] + offset[t]]$ .

(Exception: When you first see the **RUG** or the **CHAIN**, its property value is set to 1, not 0. The reason for this hack is that you get maximum score only if the property values of all treasures are zero when you finish.)

Each object is in at most one list,  $place[t]$ . If you are carrying object  $t$ , the value of  $place[t]$  is *inhand*, which is negative. The special location *limbo* has value 0; we don’t maintain a list  $first[limbo]$  for objects that have  $place[t] = limbo$ . Thus object  $t$  is in a list if and only if  $place[t] > 0$ . The global variable *holding* counts how many objects you are carrying.

One more array completes our set of data structures: Objects that appear in inventory reports have a name,  $name[t]$ .

**#define** *toting*( $t$ ) ( $place[t] < 0$ )

⟨ Global variables 7 ⟩ +=

```

object first[max_loc + 1];    /* the first object present at a location */
object link[max_obj + 1];    /* the next object present in the same location */
object base[max_obj + 2];    /* the smallest object in each object’s group, if any */
int prop[max_obj + 1];      /* each object’s current property value */
location place[max_obj + 1]; /* each object’s current location */
char *name[max_obj + 1];    /* name of object for inventory listing */
char *note[100];           /* descriptions of object properties */
int offset[max_obj + 1];    /* where notes for each object start */
int holding;                /* how many objects have place[ $t$ ] < 0? */
int note_ptr = 0;           /* how many notes have we stored? */

```

64. Here then is a simple subroutine to place an object at a given location, when the object isn't presently in a list.

```

⟨Subroutines 6⟩ +≡
  void drop ARGS((object, location));
  void drop(t, l)
    object t;
    location l;
  {
    if (toting(t)) holding--;
    place[t] = l;
    if (l < 0) holding++;
    else if (l > 0) {
      link[t] = first[l];
      first[l] = t;
    }
  }

```

65. Similarly, we need a subroutine to pick up an object.

```

#define move(t, l) { carry(t); drop(t, l); }
#define destroy(t) move(t, limbo)
⟨Subroutines 6⟩ +≡
  void carry ARGS((object));
  void carry(t)
    object t;
  { register location l = place[t];
    if (l ≥ limbo) {
      place[t] = inhand;
      holding++;
      if (l > limbo) {
        register object r, s;
        for (r = 0, s = first[l]; s ≠ t; r = s, s = link[s]) ;
        if (r ≡ 0) first[l] = link[s];
        else link[r] = link[s]; /* remove t from list */
      }
    }
  }

```

**66.** The *is\_at\_loc* subroutine tests if a possibly multipart object is at a particular place, represented by the global variable *loc*. It uses the fact that multipart objects have consecutive values, and *base*[*max\_obj* + 1]  $\equiv$  NOTHING.

```

⟨ Subroutines 6 ⟩ +≡
  boolean is_at_loc ARGS((object));
  boolean is_at_loc(t)
    object tt;
  {
    register object tt;
    if (base[t]  $\equiv$  NOTHING) return place[t]  $\equiv$  loc;
    for (tt = t; base[tt]  $\equiv$  t; tt++)
      if (place[tt]  $\equiv$  loc) return true;
    return false;
  }

```

**67.** A few macros make it easy to get each object started.

```

#define new_obj(t, n, b, l)
  { /* object t named n with base b starts at l */
    name[t] = n;
    base[t] = b;
    offset[t] = note_ptr;
    prop[t] = (is_treasure(t) ? -1 : 0);
    drop(t, l);
  }
#define new_note(n)  note[note_ptr++] = n

```

**68.** ⟨ Additional local registers 22 ⟩ +≡  
**register object** *t*;

**69. Object data.** Now it's time to build the object structures just defined.

We put the objects into their initial locations backwards, that is, highest first; moreover, we place all two-part objects before placing the others. Then low-numbered objects will appear first in the list, and two-part objects will appear last.

Here are the two-part objects, which are mostly unnamed because you won't be picking them up.

```
(Build the object tables 69) ≡
  new_obj (RUG_, 0, RUG, scan3);
  new_obj (RUG, "Persian_rug", RUG, scan1);
  new_note ("There is a Persian rug spread out on the floor!");
  new_note ("The dragon is sprawled out on a Persian rug!!");
  new_obj (TROLL2_, 0, TROLL2, limbo);
  new_obj (TROLL2, 0, TROLL2, limbo);
  new_note ("The troll is nowhere to be seen.");
  new_obj (TROLL_, 0, TROLL, neside);
  new_obj (TROLL, 0, TROLL, swside);
  new_note ("A burly troll stands by the bridge and insists you throw him a\n\
    treasure before you may cross.");
  new_note ("The troll steps out from beneath the bridge and blocks your way.");
  new_note (0);
  new_obj (BRIDGE_, 0, BRIDGE, neside);
  new_obj (BRIDGE, 0, BRIDGE, swside);
  new_note ("A rickety wooden bridge extends across the chasm, vanishing into the\n\
    mist. A sign posted on the bridge reads, \"STOP! PAY TROLL!\"");
  new_note ("The wreckage of a bridge (and a dead bear) can be seen at the bottom\n\
    of the chasm.");
  new_obj (DRAGON_, 0, DRAGON, scan3);
  new_obj (DRAGON, 0, DRAGON, scan1);
  new_note ("A huge green fierce dragon bars the way!");
  new_note ("Congratulations! You have just vanquished a dragon with your bare\n\
    hands! (Unbelievable, isn't it?)");
  new_note ("The body of a huge green dead dragon is lying off to one side.");
  new_obj (SHADOW_, 0, SHADOW, window);
  new_obj (SHADOW, 0, SHADOW, windoe);
  new_note ("The shadowy figure seems to be trying to attract your attention.");
  new_obj (PLANT2_, 0, PLANT2, e2pit);
  new_obj (PLANT2, 0, PLANT2, w2pit);
  new_note (0);
  new_note ("The top of a 12-foot-tall beanstalk is poking out of the west pit.");
  new_note ("There is a huge beanstalk growing out of the west pit up to the hole.");
  new_obj (CRYSTAL_, 0, CRYSTAL, wfiss);
  new_obj (CRYSTAL, 0, CRYSTAL, efiss);
  new_note (0);
  new_note ("A crystal bridge now spans the fissure.");
  new_note ("The crystal bridge has vanished!");
  new_obj (TREADS_, 0, TREADS, emist);
  new_obj (TREADS, 0, TREADS, spit);
  new_note ("Rough stone steps lead down the pit.");
  new_note ("Rough stone steps lead up the dome.");
  new_obj (GRATE_, 0, GRATE, inside);
  new_obj (GRATE, 0, GRATE, outside);
  new_note ("The grate is locked.");
  new_note ("The grate is open.");
```

```
new_obj(MIRROR_, 0, MIRROR, limbo);    /* joins up with MIRROR later */
```

See also section [70](#).

This code is used in section [200](#).

**70.** And here are the one-place objects, some of which are immovable (because they are in a group of size one).

(Build the object tables 69) +≡

```

new_obj(CHAIN, "Golden_chain", CHAIN, barr);
new_note("There is a golden chain lying in a heap on the floor!");
new_note("The bear is locked to the wall with a golden chain!");
new_note("There is a golden chain locked to the wall!");
new_obj(SPICES, "Rare spices", 0, chamber);
new_note("There are rare spices here!");
new_obj(PEARL, "Glistening pearl", 0, limbo);
new_note("Off to one side lies a glistening pearl!");
new_obj(PYRAMID, "Platinum pyramid", 0, droom);
new_note("There is a platinum pyramid here, 8 inches on a side!");
new_obj(EMERALD, "Egg-sized emerald", 0, proom);
new_note("There is an emerald here the size of a plover's egg!");
new_obj(VASE, "Ming vase", 0, oriental);
new_note("There is a delicate, precious, Ming vase here!");
new_note("The vase is now resting, delicately, on a velvet pillow.");
new_note("The floor is littered with worthless shards of pottery.");
new_note("The Ming vase drops with a delicate crash.");
new_obj(TRIDENT, "Jeweled trident", 0, falls);
new_note("There is a jewel-encrusted trident here!");
new_obj(EGGS, "Golden eggs", 0, giant);
new_note("There is a large nest here, full of golden eggs!");
new_note("The nest of golden eggs has vanished!");
new_note("Done!");
new_obj(CHEST, "Treasure chest", 0, limbo);
new_note("The pirate's treasure chest is here!");
new_obj(COINS, "Rare coins", 0, west);
new_note("There are many coins here!");
new_obj(JEWELS, "Precious jewelry", 0, south);
new_note("There is precious jewelry here!");
new_obj(SILVER, "Bars of silver", 0, ns);
new_note("There are bars of silver here!");
new_obj(DIAMONDS, "Several diamonds", 0, wfiss);
new_note("There are diamonds here!");
new_obj(GOLD, "Large gold nugget", 0, nugget);
new_note("There is a large sparkling nugget of gold here!");
new_obj(MOSS, 0, MOSS, soft);
new_note(0);
new_obj(BATTERIES, "Batteries", 0, limbo);
new_note("There are fresh batteries here.");
new_note("Some worn-out batteries have been discarded nearby.");
new_obj(PONY, 0, PONY, pony);
new_note("There is a massive vending machine here. The instructions on it read:\n\
    \"Drop coins here to receive fresh batteries.\\\"");
new_obj(GEYSER, 0, GEYSER, view);
new_note(0);
new_obj(MESSAGE, 0, MESSAGE, limbo);
new_note("There is a message scrawled in the dust in a flowery script, reading:\n\
    \"This is not the maze where the pirate leaves his treasure chest.\\\"");
new_obj(BEAR, 0, BEAR, barr);

```



```

new_note("There is a ferocious cave bear eyeing you from the far end of the room!");
new_note("There is a gentle cave bear sitting placidly in one corner.");
new_note("There is a contented-looking bear wandering about nearby.");
new_note(0);
new_obj(PIRATE, 0, PIRATE, limbo);
new_note(0);
new_obj(ART, 0, ART, oriental);
new_note(0);
new_obj(AXE, "Dwarf's axe", 0, limbo);
new_note("There is a little axe here.");
new_note("There is a little axe lying beside the bear.");
new_obj(STALACTITE, 0, STALACTITE, tite);
new_note(0);
new_obj(PLANT, 0, PLANT, wpit);
new_note("There is a tiny little plant in the pit, murmuring \"Water, water, ...\"");
new_note("The plant spurts into furious growth for a few seconds.");
new_note("There is a 12-foot-tall beanstalk stretching up out of the pit, \n\
    bellowing \"Water!! Water!!\"");
new_note("The plant grows explosively, almost filling the bottom of the pit.");
new_note("There is a gigantic beanstalk stretching all the way up to the hole.");
new_note("You've over-watered the plant! It's shriveling up! It's, it's...");
new_obj(MIRROR, 0, MIRROR, mirror);
new_note(0);
new_obj(OIL, "Oil in the bottle", 0, limbo);
new_obj(WATER, "Water in the bottle", 0, limbo);
new_obj(BOTTLE, "Small bottle", 0, house);
new_note("There is a bottle of water here.");
new_note("There is an empty bottle here.");
new_note("There is a bottle of oil here.");
new_obj(FOOD, "Tasty food", 0, house);
new_note("There is food here.");
new_obj(KNIFE, 0, 0, limbo);
new_obj(DWARF, 0, DWARF, limbo);
new_obj(MAG, "\"Spelunker Today\"", 0, ante);
new_note("There are a few recent issues of \"Spelunker Today\" magazine here.");
new_obj(OYSTER, "Giant oyster>GROAN!<", 0, limbo);
new_note("There is an enormous oyster here with its shell tightly closed.");
new_note("Interesting. There seems to be something written on the underside of\n\
    the oyster.");
new_obj(CLAM, "Giant clam>GRUNT!<", 0, shell);
new_note("There is an enormous clam here with its shell tightly closed.");
new_obj(TABLET, 0, TABLET, droom);
new_note("A massive stone tablet embedded in the wall reads:\n\
    \"CONGRATULATIONS ON BRINGING LIGHT INTO THE DARK-ROOM!\"");
new_obj(SNAKE, 0, SNAKE, hmk);
new_note("A huge green fierce snake bars the way!");
new_note(0);
new_obj(PILLOW, "Velvet pillow", 0, soft);
new_note("A small velvet pillow lies on the floor.");
new_obj(DOOR, 0, DOOR, immense);
new_note("The way north is barred by a massive, rusty, iron door.");
new_note("The way north leads through a massive, rusty, iron door.");

```

```
new_obj(BIRD, "Little_bird_in_cage", 0, bird);
new_note("A_cheerful_little_bird_is_sitting_here_singing.");
new_note("There_is_a_little_bird_in_the_cage.");
new_obj(ROD2, "Black_rod", 0, limbo);
new_note("A_three-foot_black_rod_with_a_rusty_mark_on_an_end_lies_nearby.");
new_obj(ROD, "Black_rod", 0, debris);
new_note("A_three-foot_black_rod_with_a_rusty_star_on_an_end_lies_nearby.");
new_obj(CAGE, "Wicker_cage", 0, cobbles);
new_note("There_is_a_small_wicker_cage_discarded_nearby.");
new_obj(LAMP, "Brass_lantern", 0, house);
new_note("There_is_a_shiny_brass_lamp_nearby.");
new_note("There_is_a_lamp_shining_nearby.");
new_obj(KEYS, "Set_of_keys", 0, house);
new_note("There_are_some_keys_on_the_ground_here.");
```

**71. Low-level input.** Sometimes we need to ask you a question, for which the answer is either yes or no. The subroutine *yes*(*q*, *y*, *n*) prints *q*, waits for you to answer, and then prints *y* or *n* depending on your answer. It returns a nonzero value if your answer was affirmative.

⟨Subroutines 6⟩ +=

```

boolean yes ARGS((char *,char *,char *));
boolean yes(q, y, n)
    char *q, *y, *n;
{
    while (1) {
        printf("s\n**_", q); fflush(stdout);
        fgets(buffer, buf_size, stdin);
        if (tolower(*buffer) ≡ 'y') {
            if (y) printf("s\n", y); return true;
        }
        else if (tolower(*buffer) ≡ 'n') {
            if (n) printf("s\n", n); return false;
        }
        else printf("_Please_answer_Yes_or_No.\n");
    }
}

```

**72.** The only other kind of input is almost as simple. You are supposed to tell us what to do next in your adventure, by typing one- or two-word commands. We put the first word in *word1* and the (possibly null) second word in *word2*. Words are separated by white space; otherwise white space is ignored.

⟨Subroutines 6⟩ +=

```
void listen ARGS((void));
void listen() {
    register char *p, *q;
    while (1) {
        printf("*_"); fflush(stdout);
        fgets(buffer, buf_size, stdin);
        for (p = buffer; isspace(*p); p++) ;
        if (*p == 0) {
            printf("_Tell_me_to_do_something.\n"); continue;
        }
        for (q = word1; *p; p++, q++) {
            if (isspace(*p)) break;
            *q = tolower(*p);
        }
        *q = '\0'; /* end of word1 */
        for (p++; isspace(*p); p++) ;
        if (*p == 0) {
            *word2 = '\0'; return;
        }
        for (q = word2; *p; p++, q++) {
            if (isspace(*p)) break;
            *q = tolower(*p);
        }
        *q = '\0'; /* end of word2 */
        for (p++; isspace(*p); p++) ;
        if (*p == 0) return;
        printf("_Please_stick_to_1-_and_2-word_commands.\n");
    }
}
```

**73.** A 20-character buffer would probably be big enough, but what the heck.

**#define** *buf\_size* 72

⟨Global variables 7⟩ +=

```
char buffer[buf_size]; /* your input goes here */
char word1[buf_size], word2[buf_size]; /* and then we snarf it to here */
```

**74. The main control loop.** Now we’ve got enough low-level mechanisms in place to start thinking of the program from the top down, and to specify the high-level control.

A global variable *loc* represents where you currently live in the simulated cave. Another variable *newloc* represents where you will go next, unless something like a dwarf blocks you. We also keep track of *oldloc* (the previous value of *loc*) and *oldoldloc* (the previous previous value), for use when you ask to ‘go back’.

```
#define here(t) (toting(t) ∨ place[t] ≡ loc)    /* is object t present? */
#define water_here ((flags[loc] & (liquid + oil)) ≡ liquid)
#define oil_here ((flags[loc] & (liquid + oil)) ≡ liquid + oil)
#define no_liquid_here ((flags[loc] & liquid) ≡ 0)

⟨Global variables 7⟩ +=
  location oldoldloc, oldloc, loc, newloc;    /* recent and future locations */
```

**75.** Here is our overall strategy for administering the game. It is understood that the program might **goto** *quit* from within any of the subsections named here, even though the section names don’t mention this explicitly. For example, while checking for interference we might find out that time has run out, or that a dwarf has killed you and no more reincarnations are possible.

The execution consists of two nested loops: There are “minor cycles” inside of “major cycles.” Actions define minor cycles in which you stay in the same place and we tell you the result of your action. Motions define major cycles in which you move and we tell you what you can see at the new place.

```
⟨Simulate an adventure, going to quit when finished 75⟩ ≡
  while (1) {
    ⟨Check for interference with the proposed move to newloc 153⟩;
    loc = newloc;    /* hey, we actually moved you */
    ⟨Possibly move dwarves and the pirate 161⟩;
    commence: ⟨Report the current state 86⟩;
    while (1) {
      ⟨Get user input; goto try_move if motion is requested 76⟩;
      ⟨Perform an action in the current place 79⟩;
    }
    try_move: ⟨Handle special motion words 140⟩;
    oldoldloc = oldloc;
    oldloc = loc;
    go_for_it: ⟨Determine the next location, newloc 146⟩;
  }
```

This code is used in section 2.

**76.** Our main task in the simulation loop is to parse your input. Depending on the kind of command you give, the following section of the program will exit in one of four ways:

- **goto** *try\_move* with *mot* set to a desired motion.
- **goto** *transitive* with *verb* set to a desired action and *obj* set to the object of that action.
- **goto** *intransitive* with *verb* set to a desired action and *obj* = **NOTHING**; no object has been specified.
- **goto** *speakit* with *hash\_table[k].meaning* the index of a message for a vocabulary word of *message\_type*.

Sometimes we have to ask you to complete an ambiguous command before we know both a verb and its object. In most cases the words can be in either order; for example, **take rod** is equivalent to **rod take**. A motion word overrides a previously given action or object.

Lots of special cases make the program a bit messy. For example, if the verb is **say**, we don't want to look up the object in our vocabulary; we simply want to "say" it.

```

⟨ Get user input; goto try_move if motion is requested 76 ⟩ ≡
    verb = oldverb = ABSTAIN;
    oldobj = obj;
    obj = NOTHING;
cycle: ⟨ Check if a hint applies, and give it if requested 195 ⟩;
    ⟨ Make special adjustments before looking at new input 85 ⟩;
    listen();
pre_parse: turns++;
    ⟨ Handle special cases of input 82 ⟩;
    ⟨ Check the clocks and the lamp 178 ⟩;
    ⟨ Handle additional special cases of input 83 ⟩;
parse: ⟨ Give advice about going WEST 80 ⟩;
    ⟨ Look at word1 and exit to the right place if it completes a command 78 ⟩;
shift: strcpy(word1, word2); *word2 = '\0'; goto parse;
This code is used in section 75.
```

**77.** ⟨ Global variables 7 ⟩ +≡

```

motion mot;      /* currently specified motion, if any */
action verb;     /* currently specified action, if any */
action oldverb;  /* verb before it was changed */
object obj;      /* currently specified object, if any */
object oldobj;   /* former value of obj */
wordtype command_type; /* type of word found in hash table */
int turns;      /* how many times we've read your commands */
```

**78.** The *try\_motion* macro is often used to end a major cycle.

```
#define try_motion(m) { mot = m; goto try_move; }
#define stay_put try_motion(NOWHERE)

⟨ Look at word1 and exit to the right place if it completes a command 78 ⟩ ≡
    k = lookup(word1);
    if (k < 0) { /* Gee, I don't understand */
        printf("Sorry, I don't know the word \"%s\".\n", word1); goto cycle;
    }
    branch: command_type = hash_table[k].word_type;
    switch (command_type) {
    case motion_type: try_motion(hash_table[k].meaning);
    case object_type: obj = hash_table[k].meaning;
        ⟨ Make sure obj is meaningful at the current location 90 ⟩;
        if (*word2) break; /* fall through to shift */
        if (verb) goto transitive;
        printf("What do you want to do with the %s?\n", word1); goto cycle;
    case action_type: verb = hash_table[k].meaning;
        if (verb ≡ SAY) obj = *word2;
        else if (*word2) break; /* fall through to shift */
        if (obj) goto transitive; else goto intransitive;
    case message_type: goto speakit;
    }
}
```

This code is used in section 76.

**79.** Here is the multiway branch where many kinds of actions can be launched.

If a verb can only be transitive, but no object has been given, we must go back and ask for an object.

If a verb can only be intransitive, but an object has been given, we issue the default message for that verb and start over.

The variable *k*, initially zero, is used to count various things in several of the action routines.

The *report* macro is often used to end a minor cycle.

```
#define report(m) { printf("%s\n",m); continue; }
#define default.to(v) report(default_msg[v])
#define change.to(v) { oldverb = verb; verb = v; goto transitive; }

⟨ Perform an action in the current place 79 ⟩ ≡
intransitive: k = 0;
    switch (verb) {
        case GO: case RELAX: goto report_default;
        case ON: case OFF: case POUR: case FILL: case DRINK: case BLAST: case KILL: goto transitive;
        ⟨ Handle cases of intransitive verbs and continue 92 ⟩;
        default: goto get_object;
    }
transitive: k = 0;
    switch (verb) {
        ⟨ Handle cases of transitive verbs and continue 97 ⟩;
        default: goto report_default;
    }
speakit: report(message[hash_table[k].meaning]);
report_default: if (default_msg[verb]) report(default_msg[verb]) else continue;
get_object: word1[0] = toupper(word1[0]); printf("%s_what?\n", word1);
    goto cycle;
cant_see_it: if ((verb ≡ FIND ∨ verb ≡ INVENTORY) ∧ *word2 ≡ '\0') goto transitive;
    printf("I_see_no_s_here.\n", word1); continue;
```

This code is used in section 75.

**80.** Here's a freely offered hint that may save you typing.

```
⟨ Give advice about going WEST 80 ⟩ ≡
    if (streq(word1, "west")) {
        if (++west_count ≡ 10) printf("_If_you_prefer,_simply_type_W_rather_than_WEST.\n");
    }
```

This code is used in section 76.

**81.** ⟨ Global variables 7 ⟩ +=

```
int west_count; /* how many times have we parsed the word 'west'? */
```

**82.** Maybe you said 'say' and we said 'Say what?' and you replied with two things to say. Then we assume you don't really want us to say anything.

```
⟨ Handle special cases of input 82 ⟩ ≡
    if (verb ≡ SAY) {
        if (*word2) verb = ABSTAIN; else goto transitive;
    }
```

See also section 138.

This code is used in section 76.



**83.** The verb ‘enter’ is listed in our vocabulary as a motion rather than an action. Here we deal with cases where you try to use it as an action. Notice that ‘H20’ is not a synonym for ‘water’ in this context.

```

⟨Handle additional special cases of input 83⟩ ≡
  if (streq(word1, "enter")) {
    if (streq(word2, "water") ∨ streq(word2, "strea")) {
      if (water_here) report("Your feet are now wet.");
      default_to(G0);
    }
    else if (*word2) goto shift;
  }

```

See also section 105.

This code is used in section 76.

**84.** Cavers can become cadavers if they don’t have light. We keep a variable *was\_dark* to remember how dark things were when you gave your last command.

```

#define dark ((flags[loc] & lighted) ≡ 0 ∧ (prop[LAMP] ≡ 0 ∨ ¬here(LAMP)))

```

```

⟨Global variables 7⟩ +=
  boolean was_dark; /* you’ve recently been in the dark */

```

**85.** ⟨Make special adjustments before looking at new input 85⟩ ≡  
*was\_dark* = *dark*;

See also sections 158, 169, and 182.

This code is used in section 76.

**86.** After moving to *newloc*, we act as your eyes. We print the long description of *newloc* if you haven’t been there before; but when you return to a previously seen place, we often use a short form. The long form is used every 5th time, unless you say ‘BRIEF’, in which case we use the shortest form we know. You can always ask for the long form by saying ‘LOOK’.

```

⟨Report the current state 86⟩ ≡
  if (loc ≡ limbo) goto death;
  if (dark ∧ ¬forced_move(loc)) {
    if (was_dark ∧ pct(35)) goto pitch_dark;
    p = pitch_dark_msg;
  }
  else if (short_desc[loc] ≡ 0 ∨ visits[loc] % interval ≡ 0) p = long_desc[loc];
  else p = short_desc[loc];
  if (toting(BEAR)) printf("You are being followed by a very large, tame bear.\n");
  if (p) printf("\n%s\n", p);
  if (forced_move(loc)) goto try_move;
  ⟨Give optional plugh hint 157⟩;
  if (¬dark) ⟨Describe the objects at this location 88⟩;

```

This code is used in section 75.

**87.** ⟨Global variables 7⟩ +=  
 int interval = 5; /\* will change to 10000 if you want us to be BRIEF \*/  
 char pitch\_dark\_msg[] =  
 "It is now pitch dark. If you proceed you will most likely fall into a pit.";

**88.** If TREADS are present but you have a heavy load, we don't describe them. The treads never actually get property value 1; we use the *note* for property 1 only when they are seen from above.

The global variable *tally* counts the number of treasures you haven't seen. Another variable, *lost\_treasures*, counts those you never will see.

```

⟨Describe the objects at this location 88⟩ ≡
{
  register object tt;
  visits[loc]++;
  for (t = first[loc]; t; t = link[t]) {
    tt = (base[t] ? base[t] : t);
    if (prop[tt] < 0) { /* you've spotted a treasure */
      if (closed) continue; /* no automatic prop change after hours */
      prop[tt] = (tt ≡ RUG ∨ tt ≡ CHAIN); /* initialize the property value */
      tally--;
      ⟨Zap the lamp if the remaining treasures are too elusive 183⟩;
    }
    if (tt ≡ TREADS ∧ toting(GOLD)) continue;
    p = note[prop[tt] + offset[tt] + (tt ≡ TREADS ∧ loc ≡ emist)];
    if (p) printf("%s\n", p);
  }
}

```

This code is used in section 86.

**89.** ⟨Global variables 7⟩ +=

```

int tally = 15; /* treasures awaiting you */
int lost_treasures; /* treasures that you won't find */

```

**90.** When you specify an object, it must be at the current location, unless the verb is already known to be FIND or INVENTORY. A few other special cases also are permitted; for example, water and oil are funny, since they are never actually dropped at any location, but they might be present inside the bottle or as a feature of the location.

```

#define object_in_bottle ((obj ≡ WATER ∧ prop[BOTTLE] ≡ 0) ∨ (obj ≡ OIL ∧ prop[BOTTLE] ≡ 2))

```

⟨Make sure *obj* is meaningful at the current location 90⟩ ≡

```

if (¬toting(obj) ∧ ¬is_at_loc(obj))
  switch (obj) {
    case GRATE: ⟨If GRATE is actually a motion word, move to it 91⟩;
      goto cant_see_it;
    case DWARF: if (dflag ≥ 2 ∧ dwarf()) break; else goto cant_see_it;
    case PLANT: if (is_at_loc(PLANT2) ∧ prop[PLANT2]) {
      obj = PLANT2; break;
    }
    else goto cant_see_it;
    case KNIFE: if (loc ≠ knife_loc) goto cant_see_it;
      knife_loc = -1;
      report("The dwarves' knives vanish as they strike the walls of the cave.");
    case ROD: if (¬here(ROD2)) goto cant_see_it;
      obj = ROD2; break;
    case WATER: case OIL: if (here(BOTTLE) ∧ object_in_bottle) break;
      if ((obj ≡ WATER ∧ water_here) ∨ (obj ≡ OIL ∧ oil_here)) break;
    default: goto cant_see_it;
  }
}

```

This code is used in section 78.

**91.** Henning Makholm has pointed out that the logic here makes **GRATE** a motion word regardless of the verb. For example, you can get to the grate by saying ‘**wave grate**’ from the *road* or the *valley* (but curiously not from the *slit*).

⟨ If **GRATE** is actually a motion word, move to it 91 ⟩ ≡

```
if (loc < min_lower_loc)
  switch (loc) {
    case road: case valley: case slit: try_motion(DEPRESSION);
    case cobbles: case debris: case awk: case bird: case spit: try_motion(ENTRANCE);
    default: break;
  }
```

This code is used in section 90.

**92. Simple verbs.** Let's get experience implementing the actions by dispensing with the easy cases first.

First there are several "intransitive" verbs that reduce to transitive when we identify an appropriate object. For example, 'take' makes sense by itself if there's only one possible thing to take.

```
< Handle cases of intransitive verbs and continue 92 > +=
case TAKE: if (first[loc]  $\equiv$  0  $\vee$  link[first[loc]]  $\vee$  dwarf() ) goto get_object;
    obj = first[loc]; goto transitive;
case EAT: if ( $\neg$ here(FOOD)) goto get_object;
    obj = FOOD; goto transitive;
```

See also sections 93, 94, 95, and 136.

This code is used in section 79.

**93.** Only the objects GRATE, DOOR, CLAM/OYSTER, and CHAIN can be opened or closed. And only a few objects can be read.

```
< Handle cases of intransitive verbs and continue 92 > +=
case OPEN: case CLOSE: if (place[GRATE]  $\equiv$  loc  $\vee$  place[GRATE_]  $\equiv$  loc) obj = GRATE;
    else if (place[DOOR]  $\equiv$  loc) obj = DOOR;
    else if (here(CLAM)) obj = CLAM;
    else if (here(OYSTER)) obj = OYSTER;
    if (here(CHAIN)) {
        if (obj) goto get_object; else obj = CHAIN;
    }
    if (obj) goto transitive;
    report("There_is_nothing_here_with_a_lock!");
case READ: if (dark) goto get_object; /* can't read in the dark */
    if (here(MAG)) obj = MAG;
    if (here(TABLET)) {
        if (obj) goto get_object; else obj = TABLET;
    }
    if (here(MESSAGE)) {
        if (obj) goto get_object; else obj = MESSAGE;
    }
    if (closed  $\wedge$  toting(OYSTER)) obj = OYSTER;
    if (obj) goto transitive; else goto get_object;
```

**94.** A request for an inventory is pretty simple too.

```
< Handle cases of intransitive verbs and continue 92 > +=
case INVENTORY: for (t = 1; t  $\leq$  max_obj; t++)
    if (toting(t)  $\wedge$  (base[t]  $\equiv$  NOTHING  $\vee$  base[t]  $\equiv$  t)  $\wedge$  t  $\neq$  BEAR) {
        if (k  $\equiv$  0) k = 1, printf("You_are_currently_holding_the_following:\n");
        printf("_%s\n", name[t]);
    }
    if (toting(BEAR)) report("You_are_being_followed_by_a_very_large,_tame_bear.");
    if (k  $\equiv$  0) report("You're_not_carrying_anything.");
continue;
```

95. Here are other requests about the mechanics of the game.

⟨Handle cases of intransitive verbs and **continue** 92⟩ +≡

```
case BRIEF: interval = 10000;
    look_count = 3;
    report("Okay, from now on I'll only describe a place in full the first time\n\
        you come to it. To get the full description, say \"LOOK\".");
case SCORE: printf("If you were to quit now, you would score %d\nout of a possible %d.\n",
    score() - 4, max_score);
    if (!yes("Do you indeed wish to quit now?", ok, ok)) continue;
    goto give_up;
case QUIT: if (!yes("Do you really want to quit now?", ok, ok)) continue;
give_up: gave_up = true; goto quit;
```

96. ⟨Global variables 7⟩ +≡

```
boolean gave_up; /* did you quit while you were alive? */
```

97. The SAY routine is just an echo unless you say a magic word.

⟨Handle cases of transitive verbs and **continue** 97⟩ ≡

```
case SAY: if (*word2) strcpy(word1, word2);
    k = lookup(word1);
    switch (hash_table[k].meaning) {
    case FEEFIE:
        if (hash_table[k].word_type != action_type) break;
    case XYZZY: case PLUGH: case PLOVER: *word2 = '\0'; obj = NOTHING; goto branch;
    default: break;
    }
    printf("Okay, \"%s\".\n", word1); continue;
```

See also sections 98, 99, 100, 101, 102, 106, 107, 110, 112, 117, 122, 125, 129, 130, and 135.

This code is used in section 79.

98. Hungry?

⟨Handle cases of transitive verbs and **continue** 97⟩ +≡

```
case EAT: switch (obj) {
    case FOOD: destroy(FOOD);
        report("Thank you, it was delicious!");
    case BIRD: case SNAKE: case CLAM: case OYSTER: case DWARF: case DRAGON: case TROLL: case BEAR:
        report("I think I just lost my appetite.");
    default: goto report_default;
}
```

99. Waving to the shadowy figure has no effect; but you might wave a rod at the fissure. Blasting has no effect unless you've got dynamite, which is a neat trick! Rubbing yields only snide remarks.

```

< Handle cases of transitive verbs and continue 97 > +=
case WAVE: if (obj ≠ ROD ∨ (loc ≠ efiss ∧ loc ≠ wfiss) ∨
    ¬toting(obj) ∨ closing) {
    if (toting(obj) ∨ (obj ≡ ROD ∧ totting(ROD2))) goto report_default;
    default_to(DROP);
}
prop[CRYSTAL] = 1 - prop[CRYSTAL];
report(note[offset[CRYSTAL] + 2 - prop[CRYSTAL]]);
case BLAST: if (closed ∧ prop[ROD2] ≥ 0) {
    bonus = (here(ROD2) ? 25 : loc ≡ neend ? 30 : 45);
    printf("%s\n", message[bonus/5]); goto quit;
}
else goto report_default;
case RUB: if (obj ≡ LAMP) goto report_default;
report("Peculiar. Nothing unexpected happens.");

```

100. If asked to find an object that isn't visible, we give a caveat.

```

< Handle cases of transitive verbs and continue 97 > +=
case FIND: case INVENTORY: if (toting(obj)) default_to(TAKE);
if (closed) report("I daresay whatever you want is around here somewhere.");
if (is_at_loc(obj) ∨ (object_in_bottle ∧ place[BOTTLE] ≡ loc) ∨
    (obj ≡ WATER ∧ water_here) ∨ (obj ≡ OIL ∧ oil_here) ∨
    (obj ≡ DWARF ∧ dwarf())) report("I believe what you want is right here with you.");
goto report_default;

```

101. Breaking and/or waking have no effect until the cave is closed, except of course that you might break the vase. The dwarves like mirrors and hate being awakened.

```

< Handle cases of transitive verbs and continue 97 > +=
case BREAK: if (obj ≡ VASE ∧ prop[VASE] ≡ 0) {
    if (toting(VASE)) drop(VASE, loc); /* crash */
    printf("You have taken the vase and hurled it delicately to the ground.\n");
    smash: prop[VASE] = 2; base[VASE] = VASE; /* it's no longer movable */
    continue;
}
else if (obj ≠ MIRROR) goto report_default;
if (closed) {
    printf("You strike the mirror a resounding blow, whereupon it shatters into a\n\
        myriad tiny fragments.");
    goto dwarves_upset;
}
report("It is too far up for you to reach.");
case WAKE: if (closed ∧ obj ≡ DWARF) {
    printf("You prod the nearest dwarf, who wakes up grumpily, takes one look at\n\
        you, curses, and grabs for his axe.\n");
    goto dwarves_upset;
}
else goto report_default;

```

**102.** Here we deal with lighting or extinguishing the lamp. The variable *limit* tells how much juice you've got left.

```

⟨ Handle cases of transitive verbs and continue 97 ⟩ +≡
case ON: if ( $\neg$ here(LAMP)) goto report_default;
    if (limit < 0) report("Your_lamp_has_run_out_of_power.");
    prop[LAMP] = 1;
    printf("Your_lamp_is_now_on.\n");
    if (was_dark) goto commence;
    continue;
case OFF: if ( $\neg$ here(LAMP)) goto report_default;
    prop[LAMP] = 0;
    printf("Your_lamp_is_now_off.\n");
    if (dark) printf("%s\n", pitch_dark_msg);
    continue;

```

**103.** ⟨ Global variables 7 ⟩ +≡  
**int** *limit*; /\* countdown till darkness \*/

**104. Liquid assets.** Readers of this program will already have noticed that the BOTTLE is a rather complicated object, since it can be empty or filled with either water or oil. Let's consider now the main actions that involve liquids.

When you are carrying a bottle full of water, *place*[WATER] will be *inhand*; hence both *toting*(WATER) and *toting*(BOTTLE) are true. A similar remark applies to a bottle full of oil.

The value of *prop*[BOTTLE] is 0 if it holds water, 2 if it holds oil, otherwise either 1 or -2. (The value -2 is used after closing the cave.)

```
#define bottle_empty (prop[BOTTLE] == 1 ∨ prop[BOTTLE] < 0)
```

**105.** Sometimes 'water' and 'oil' are used as verbs.

```
< Handle additional special cases of input 83 > +=
  if ((streq(word1, "water") ∨ streq(word1, "oil")) ∧
      (streq(word2, "plant") ∨ streq(word2, "door"))) ∧
      (loc == place[hash_table[lookup(word2)].meaning])) strcpy(word2, "pour");
```

**106.** If you ask simply to drink, we assume that you want water. If there's water in the bottle, you drink that; otherwise you must be at a water location.

```
< Handle cases of transitive verbs and continue 97 > +=
case DRINK: if (obj == NOTHING) {
  if (¬water_here ∧ ¬(here(BOTTLE) ∧ prop[BOTTLE] == 0)) goto get_object;
}
else if (obj ≠ WATER) default_to(EAT);
if (¬(here(BOTTLE) ∧ prop[BOTTLE] == 0)) goto report_default;
prop[BOTTLE] = 1; place[WATER] = limbo;
report("The_bottle_of_water_is_now_empty.");
```

**107.** Pouring involves liquid from the bottle.

```
< Handle cases of transitive verbs and continue 97 > +=
case POUR: if (obj == NOTHING ∨ obj == BOTTLE) {
  obj = (prop[BOTTLE] == 0 ? WATER : prop[BOTTLE] == 2 ? OIL : 0);
  if (obj == NOTHING) goto get_object;
}
if (¬toting(obj)) goto report_default;
if (obj ≠ WATER ∧ obj ≠ OIL) report("You_can't_pour_that.");
prop[BOTTLE] = 1; place[obj] = limbo;
if (loc == place[PLANT]) < Try to water the plant 108 >;
if (loc == place[DOOR]) < Pour water or oil on the door 109 >;
report("Your_bottle_is_empty_and_the_ground_is_wet.");
```

**108.** < Try to water the plant 108 > ≡

```
{
  if (obj ≠ WATER)
    report("The_plant_indignantly_shakes_the_oil_off_its_leaves_and_asks,\"Water?\"");
  printf("%s\n", note[prop[PLANT] + 1 + offset[PLANT]]);
  prop[PLANT] += 2; if (prop[PLANT] > 4) prop[PLANT] = 0;
  prop[PLANT2] = prop[PLANT] >> 1;
  stay_put;
}
```

This code is used in section 107.



109.  $\langle \text{Pour water or oil on the door } 109 \rangle \equiv$   
`switch (obj) {`  
`case WATER: prop[DOOR] = 0;`  
`report("The_hinges_are_quite_thoroughly_rusted_now_and_won't_budge.");`  
`case OIL: prop[DOOR] = 1;`  
`report("The_oil_has_freed_up_the_hinges_so_that_the_door_will_now_open.");`  
`}`

This code is used in section 107.

110. You can fill the bottle only when it's empty and liquid is available. You can't fill the lamp with oil.

$\langle \text{Handle cases of transitive verbs and } \textbf{continue } 97 \rangle + \equiv$   
`case FILL: if (obj  $\equiv$  VASE)  $\langle \text{Try to fill the vase } 111 \rangle$ ;`  
`if ( $\neg$ here(BOTTLE)) {`  
`if (obj  $\equiv$  NOTHING) goto get_object; else goto report_default;`  
`}`  
`else if (obj  $\neq$  NOTHING  $\wedge$  obj  $\neq$  BOTTLE) goto report_default;`  
`if ( $\neg$ bottle_empty) report("Your_bottle_is_already_full.");`  
`if (no_liquid_here) report("There_is_nothing_here_with_which_to_fill_the_bottle.");`  
`prop[BOTTLE] = flags[loc] & oil;`  
`if (toting(BOTTLE)) place[prop[BOTTLE] ? OIL : WATER] = inhand;`  
`printf("Your_bottle_is_now_full_of_%s.\n", prop[BOTTLE] ? "oil" : "water");`  
`continue;`

111. Filling the vase is a nasty business.

$\langle \text{Try to fill the vase } 111 \rangle \equiv$   
`{`  
`if (no_liquid_here) report("There_is_nothing_here_with_which_to_fill_the_vase.\n");`  
`if ( $\neg$ toting(VASE)) report(default_msg[DROP]);`  
`printf("The_sudden_change_in_temperature_has_delicately_shattered_the_vase.\n");`  
`goto smash;`  
`}`

This code is used in section 110.

**112.** Picking up a liquid depends, of course, on the status of the bottle. Other objects need special handling, too, because of various side effects and the fact that we can't take bird and cage separately when the bird is in the cage.

```

⟨Handle cases of transitive verbs and continue 97⟩ +≡
case TAKE: if (toting(obj)) goto report_default; /* already carrying it */
  if (base[obj]) { /* it is immovable */
    if (obj ≡ CHAIN ∧ prop[BEAR]) report("The_chain_is_still_locked.");
    if (obj ≡ BEAR ∧ prop[BEAR] ≡ 1) report("The_bear_is_still_chained_to_the_wall.");
    if (obj ≡ PLANT ∧ prop[PLANT] ≤ 0)
      report("The_plant_has_exceptionally_deep_roots_and_cannot_be_pulled_free.");
    report("You_can't_be_serious!");
  }
  if (obj ≡ WATER ∨ obj ≡ OIL) ⟨Check special cases for taking a liquid 113⟩;
  if (holding ≥ 7)
    report("You_can't_carry_anything_more. You'll_have_to_drop_something_first.");
  if (obj ≡ BIRD ∧ prop[BIRD] ≡ 0) ⟨Check special cases for taking a bird 114⟩;
  if (obj ≡ BIRD ∨ (obj ≡ CAGE ∧ prop[BIRD])) carry(BIRD + CAGE - obj);
  carry(obj);
  if (obj ≡ BOTTLE ∧ ¬bottle_empty) place[prop[BOTTLE] ? OIL : WATER] = inhand;
  default_to(RELAX); /* OK, we've taken it */

```

**113.** ⟨Check special cases for taking a liquid 113⟩ ≡

```

if (here(BOTTLE) ∧ object_in_bottle) obj = BOTTLE;
else {
  obj = BOTTLE;
  if (toting(BOTTLE)) change_to(FILL);
  report("You_have_nothing_in_which_to_carry_it.");
}

```

This code is used in section 112.

**114.** ⟨Check special cases for taking a bird 114⟩ ≡

```

{
  if (toting(ROD))
    report("The_bird_was_unafraid_when_you_entered, but_as_you_approach_it_becomes\n\
    disturbed_and_you_cannot_catch_it.");
  if (toting(CAGE)) prop[BIRD] = 1;
  else report("You_can_catch_the_bird, but_you_cannot_carry_it.");
}

```

This code is used in section 112.

**115.** Similarly, when dropping the bottle we must drop also its liquid contents, if any.

```

⟨Check special cases for dropping a liquid 115⟩ ≡
  if (object_in_bottle) obj = BOTTLE;
  if (obj ≡ BOTTLE ∧ ¬bottle_empty) place[prop[BOTTLE] ? OIL : WATER] = limbo;

```

This code is used in section 117.

**116. The other actions.** Now that we understand how to write action routines, we're ready to complete the set.

**117.** Dropping an object has special cases for the bird (which might attack the snake or the dragon), the cage, the vase, etc. The verb **THROW** also reduces to **DROP** for most objects.

(The term **PONY** is a nod to the vending machine once installed in a room called The Prancing Pony, part of Stanford's historic AI Laboratory.)

```

⟨Handle cases of transitive verbs and continue 97⟩ +≡
case DROP: if (obj ≡ ROD ∧ toting(ROD2) ∧ ¬toting(ROD)) obj = ROD2;
  if (¬toting(obj)) goto report_default;
  if (obj ≡ COINS ∧ here(PONY)) ⟨Put coins in the vending machine 118⟩;
  if (obj ≡ BIRD) ⟨Check special cases for dropping the bird 120⟩;
  if (obj ≡ VASE ∧ loc ≠ soft) ⟨Check special cases for dropping the vase 121⟩;
  if (obj ≡ BEAR ∧ is_at_loc(TROLL)) ⟨Chase the troll away 119⟩;
  ⟨Check special cases for dropping a liquid 115⟩;
  if (obj ≡ BIRD) prop[BIRD] = 0;
  else if (obj ≡ CAGE ∧ prop[BIRD]) drop(BIRD, loc);
  drop(obj, loc);
  if (k) continue; else default_to(RELAX);

```

```

118. ⟨Put coins in the vending machine 118⟩ ≡
{
  destroy(COINS);
  drop(BATTERIES, loc);
  prop[BATTERIES] = 0;
  report(note[offset[BATTERIES]]);
}

```

This code is used in section 117.

**119.** **TROLL2** is the absent troll. We move the troll bridge up to first in the list of things at its location.

```

⟨Chase the troll away 119⟩ ≡
{
  printf("The_bear_lumbers_toward_the_troll,_who_lets_out_a_startled_shriek_and\n\
    scurries_away._The_bear_soon_gives_up_the_pursuit_and_wanders_back.\n");
  k = 1; /* suppress the "OK" message */
  destroy(TROLL); destroy(TROLL_);
  drop(TROLL2, swside); drop(TROLL2_, neside);
  prop[TROLL] = 2;
  move(BRIDGE, swside); move(BRIDGE_, neside); /* put first in their lists */
}

```

This code is used in section 117.

120.  $\langle \text{Check special cases for dropping the bird } 120 \rangle \equiv$

```

{
  if (here(SNAKE)) {
    printf("The little bird attacks the green snake, and in an astounding flurry\n\
          drives the snake away.\n");
    k = 1;
    if (closed) goto dwarves_upset;
    destroy(SNAKE);
    prop[SNAKE] = 1; /* used in conditional instructions */
  }
  else if (is_at_loc(DRAGON) ∧ prop[DRAGON] ≡ 0) {
    destroy(BIRD); prop[BIRD] = 0;
    if (place[SNAKE] ≡ hmk) lost_treasures++;
    report("The little bird attacks the green dragon, and in an astounding flurry\n\
          gets burnt to a cinder. The ashes blow away.");
  }
}

```

This code is used in section 117.

121.  $\langle \text{Check special cases for dropping the vase } 121 \rangle \equiv$

```

{
  prop[VASE] = (place[PILLOW] ≡ loc ? 0 : 2);
  printf("%s\n", note[offset[VASE] + 1 + prop[VASE]]); k = 1;
  if (prop[VASE]) base[VASE] = VASE;
}

```

This code is used in section 117.

122. Throwing is like dropping, except that it covers a few more cases.

$\langle \text{Handle cases of transitive verbs and } \mathbf{continue} \ 97 \rangle + \equiv$

case TOSS: if ( $obj \equiv ROD \wedge \text{toting}(ROD2) \wedge \neg \text{toting}(ROD)$ )  $obj = ROD2$ ;

```

  if ( $\neg \text{toting}(obj)$ ) goto report_default;
  if ( $\text{is_treasure}(obj) \wedge \text{is_at_loc}(TROLL)$ )  $\langle \text{Snarf a treasure for the troll } 124 \rangle$ ;
  if ( $obj \equiv \text{FOOD} \wedge \text{here}(\text{BEAR})$ ) {
     $obj = \text{BEAR}$ ;  $\text{change\_to}(\text{FEED})$ ;
  }
  if ( $obj \neq \text{AXE}$ )  $\text{change\_to}(\text{DROP})$ ;
  if ( $\text{dwarf}()$ )  $\langle \text{Throw the axe at a dwarf } 163 \rangle$ ;
  if ( $\text{is_at_loc}(\text{DRAGON}) \wedge \text{prop}[\text{DRAGON}] \equiv 0$ )
    printf("The axe bounces harmlessly off the dragon's thick scales.\n");
  else if ( $\text{is_at_loc}(\text{TROLL})$ )
    printf("The troll deftly catches the axe, examines it carefully, and tosses it\n\
          back, declaring, \"Good workmanship, but it's not valuable enough.\"\n");
  else if ( $\text{here}(\text{BEAR}) \wedge \text{prop}[\text{BEAR}] \equiv 0$ )  $\langle \text{Throw the axe at the bear } 123 \rangle$ 
  else {
     $obj = \text{NOTHING}$ ;
     $\text{change\_to}(\text{KILL})$ ;
  }
  drop(AXE, loc); stay_put;

```

**123.** This'll teach you a lesson.

⟨Throw the axe at the bear 123⟩ ≡

```
{
  drop(AXE, loc);
  prop[AXE] = 1; base[AXE] = AXE; /* it becomes immovable */
  if (place[BEAR] ≡ loc) move(BEAR, loc); /* put bear first in its list */
  report("The_axe_misses_and_lands_near_the_bear_where_you_can't_get_at_it.");
}
```

This code is used in section 122.

**124.** If you toss the vase, the skillful troll will catch it before it breaks.

⟨Snarf a treasure for the troll 124⟩ ≡

```
{
  drop(obj, limbo);
  destroy(TROLL); destroy(TROLL_);
  drop(TROLL2, swside); drop(TROLL2_, neside);
  move(BRIDGE, swside); move(BRIDGE_, neside);
  report("The_troll_catches_your_treasure_and_scurries_away_out_of_sight.");
}
```

This code is used in section 122.

**125.** When you try to attack, the action becomes violent.

⟨Handle cases of transitive verbs and **continue** 97⟩ +≡

**case KILL:** if (*obj* ≡ NOTHING) ⟨See if there's a unique object to attack 126⟩;

```
switch (obj) {
  case 0: report("There_is_nothing_here_to_attack.");
  case BIRD: ⟨Dispatch the poor bird 127⟩;
  case DRAGON: if (prop[DRAGON] ≡ 0) ⟨Fun stuff for dragon 128⟩;
  cry: report("For_crying_out_loud,_the_poor_thing_is_already_dead!");
  case CLAM: case OYSTER: report("The_shell_is_very_strong_and_impervious_to_attack.");
  case SNAKE: report("Attacking_the_snake_both_doesn't_work_and_is_very_dangerous.");
  case DWARF: if (closed) goto dwarves_upset;
  report("With_what?_Your_bare_hands?");
  case TROLL: report("Trolls_are_close_relatives_with_the_rocks_and_have_skin_as_tough_as\n\
    a_rhinoceros_hide._The_troll_fends_off_your_blows_effortlessly.");
  case BEAR: switch (prop[BEAR]) {
    case 0: report("With_what?_Your_bare_hands?_Against_HIS_bear_hands?");
    case 3: goto cry;
    default: report("The_bear_is_confused;_he_only_wants_to_be_your_friend.");
  }
  default: goto report_default;
}
```

**126.** Attackable objects fall into two categories: enemies (snake, dwarf, etc.) and others (bird, clam).

We might get here when you threw an axe; you can't attack the bird with an axe.

⟨ See if there's a unique object to attack 126 ⟩ ≡

```
{
  if (dwarf()) k++, obj = DWARF;
  if (here(SNAKE)) k++, obj = SNAKE;
  if (is_at_loc(DRAGON) ∧ prop[DRAGON] ≡ 0) k++, obj = DRAGON;
  if (is_at_loc(TROLL)) k++, obj = TROLL;
  if (here(BEAR) ∧ prop[BEAR] ≡ 0) k++, obj = BEAR;
  if (k ≡ 0) { /* no enemies present */
    if (here(BIRD) ∧ oldverb ≠ TOSS) k++, obj = BIRD;
    if (here(CLAM) ∨ here(OYSTER)) k++, obj = CLAM;
    /* no harm done to call the oyster a clam in this case */
  }
  if (k > 1) goto get_object;
}
```

This code is used in section 125.

**127.** ⟨ Dispatch the poor bird 127 ⟩ ≡

```
{
  if (closed) report("Oh, leave the poor unhappy bird alone.");
  destroy(BIRD); prop[BIRD] = 0;
  if (place[SNAKE] ≡ hmk) lost_treasures++;
  report("The little bird is now dead. Its body disappears.");
}
```

This code is used in section 125.

**128.** Here we impersonate the main dialog loop. If you insist on attacking the dragon, you win! He dies, the Persian rug becomes free, and *scan2* takes the place of *scan1* and *scan3*.

⟨ Fun stuff for dragon 128 ⟩ ≡

```
{
  printf("With what? Your bare hands?\n");
  verb = ABSTAIN; obj = NOTHING;
  listen();
  if (¬(streq(word1, "yes") ∨ streq(word1, "y"))) goto pre_parse;
  printf("%s\n", note[offset[DRAGON] + 1]);
  prop[DRAGON] = 2; /* dead */
  prop[RUG] = 0; base[RUG] = NOTHING; /* now it's a usable treasure */
  base[DRAGON_] = DRAGON_;
  destroy(DRAGON_); /* inaccessible */
  base[RUG_] = RUG_;
  destroy(RUG_); /* inaccessible */
  for (t = 1; t ≤ max_obj; t++)
    if (place[t] ≡ scan1 ∨ place[t] ≡ scan3) move(t, scan2);
  loc = scan2; stay_put;
}
```

This code is used in section 125.

**129.** Feeding various animals leads to various quips. Feeding a dwarf is a bad idea. The bear is special.

⟨Handle cases of transitive verbs and **continue** 97⟩ +≡

```
case FEED: switch (obj) {
  case BIRD: report("It's not hungry (it's merely pinin' for the fjords). Besides, you\n\
    have no bird seed.");
  case TROLL: report("Gluttony is not one of the troll's vices. Avarice, however, is.");
  case DRAGON: if (prop[DRAGON]) report(default_msg[EAT]);
    break;
  case SNAKE: if (closed ∨ ¬here(BIRD)) break;
    destroy(BIRD); prop[BIRD] = 0; lost_treasures++;
    report("The snake has now devoured your bird.");
  case BEAR: if (¬here(FOOD)) {
    if (prop[BEAR] ≡ 0) break;
    if (prop[BEAR] ≡ 3) verb = EAT;
    goto report_default;
  }
  destroy(FOOD); prop[BEAR] = 1;
  prop[AXE] = 0; base[AXE] = NOTHING; /* axe is movable again */
  report("The bear eagerly wolfs down your food, after which he seems to calm\n\
    down considerably and even becomes rather friendly.");
  case DWARF: if (¬here(FOOD)) goto report_default;
    dflag++;
    report("You fool, dwarves eat only coal! Now you've made him REALLY mad!");
  default: report(default_msg[CALM]);
}
report("There's nothing here it wants to eat (except perhaps you).");
```

**130.** Locking and unlocking involves several interesting special cases.

⟨Handle cases of transitive verbs and **continue** 97⟩ +≡

```
case OPEN: case CLOSE: switch (obj) {
  case OYSTER: case CLAM: ⟨Open/close clam/oyster 134⟩;
  case GRATE: case CHAIN: if (¬here(KEYS)) report("You have no keys!");
    ⟨Open/close grate/chain 131⟩;
  case KEYS: report("You can't lock or unlock the keys.");
  case CAGE: report("It has no lock.");
  case DOOR: if (prop[DOOR]) default_to(RELAX);
    report("The door is extremely rusty and refuses to open.");
  default: goto report_default;
}
```

**131.**  $\langle \text{Open/close grate/chain 131} \rangle \equiv$   
 if (*obj*  $\equiv$  CHAIN)  $\langle \text{Open/close chain 132} \rangle$ ;  
 if (*closing*) {  
    $\langle \text{Panic at closing time 180} \rangle$ ; **continue**;  
 }  
*k* = *prop*[GRATE];  
*prop*[GRATE] = (*verb*  $\equiv$  OPEN);  
**switch** (*k* + 2 \* *prop*[GRATE]) {  
 case 0: *report*("It was already locked.");  
 case 1: *report*("The grate is now locked.");  
 case 2: *report*("The grate is now unlocked.");  
 case 3: *report*("It was already unlocked.");  
 }

This code is used in section 130.

**132.**  $\langle \text{Open/close chain 132} \rangle \equiv$   
 {  
   if (*verb*  $\equiv$  OPEN)  $\langle \text{Open chain 133} \rangle$ ;  
   if (*loc*  $\neq$  *barr*) *report*("There is nothing here to which the chain can be locked.");  
   if (*prop*[CHAIN]) *report*("It was already locked.");  
   *prop*[CHAIN] = 2, *base*[CHAIN] = CHAIN;  
   if (*toting*(CHAIN)) *drop*(CHAIN, *loc*);  
   *report*("The chain is now locked.");  
 }

This code is used in section 131.

**133.**  $\langle \text{Open chain 133} \rangle \equiv$   
 {  
   if (*prop*[CHAIN]  $\equiv$  0) *report*("It was already unlocked.");  
   if (*prop*[BEAR]  $\equiv$  0)  
     *report*("There is no way to get past the bear to unlock the chain, which is\n\ probably just as well.");  
   *prop*[CHAIN] = 0, *base*[CHAIN] = NOTHING;   /\* chain is free \*/  
   if (*prop*[BEAR]  $\equiv$  3) *base*[BEAR] = BEAR;  
   else *prop*[BEAR] = 2, *base*[BEAR] = NOTHING;  
   *report*("The chain is now unlocked.");  
 }

This code is used in section 132.



**134.** The clam/oyster is extremely heavy to carry, although not as heavy as the gold.

```
#define clam_oyster (obj ≡ CLAM ? "clam" : "oyster")
⟨ Open/close clam/oyster 134 ⟩ ≡
  if (verb ≡ CLOSE) report("What?");
  if (¬toting(TRIDENT)) {
    printf("You don't have anything strong enough to open the %s", clam_oyster);
    report(".");
  }
  if (toting(obj)) {
    printf("I advise you to put down the %s before opening it.", clam_oyster);
    report(obj ≡ CLAM ? ">STRAIN!<" : ">WRENCH!<");
  }
  if (obj ≡ CLAM) {
    destroy(CLAM); drop(OYSTER, loc); drop(PEARL, sac);
    report("A glistering pearl falls out of the clam and rolls away. Goodness, \n\
      this must really be an oyster. (I never was very good at identifying \n\
      bivalves.) Whatever it is, it has now snapped shut again.");
  } else report("The oyster creaks open, revealing nothing but oyster inside. \n\
    It promptly snaps shut again.");
```

This code is used in section 130.

**135.** You get little satisfaction from asking us to read, unless you hold the oyster—*after* the cave is closed.

```
⟨ Handle cases of transitive verbs and continue 97 ⟩ +≡
case READ: if (dark) goto cant_see_it;
  switch (obj) {
  case MAG: report("I'm afraid the magazine is written in dwarvish.");
  case TABLET: report("\nCONGRATULATIONS ON BRINGING LIGHT INTO THE DARK-ROOM!\n");
  case MESSAGE:
    report("\nThis is not the maze where the pirate hides his treasure chest.\n");
  case OYSTER: if (hinted[1]) {
    if (toting(OYSTER)) report("It says the same thing it did before.");
  }
  else if (closed ∧ toting(OYSTER)) {
    offer(1); continue;
  }
  default: goto report_default;
}
```

**136.** OK, that just about does it. We're left with only one more “action verb” to handle, and it is intransitive. In order to penetrate this puzzle, you must pronounce the magic incantation in its correct order, as it appears on the wall of the Giant Room. A global variable *foobar* records your progress.

```
⟨ Handle cases of intransitive verbs and continue 92 ⟩ +≡
case FEEFIE: while (¬streq(word1, incantation[k])) k++;
  if (foobar ≡ -k) ⟨ Proceed foobarically 139 ⟩;
  if (foobar ≡ 0) goto nada_sucede;
  report("What's the matter, can't you read? Now you'd best start over.");
```

**137.** ⟨ Global variables 7 ⟩ +≡  
 char \*incantation[] = {"fee", "fie", "foe", "foo", "fum"};  
 int foobar; /\* current incantation progress \*/

**138.** Just after every command you give, we make the *foobar* counter negative if you're on track, otherwise we zero it.

```

⟨ Handle special cases of input 82 ⟩ +≡
  if (foobar > 0) foobar = -foobar;
  else foobar = 0;

```

**139.** If you get all the way through, we zip the eggs back to the Giant Room, unless they're already there. The troll returns if you've stolen the eggs back from him.

```

⟨ Proceed foobarically 139 ⟩ ≡
{
  foobar = k + 1;
  if (foobar ≠ 4) default_to(RELAX);
  foobar = 0;
  if (place[EGGS] ≡ giant ∨ (toting(EGGS) ∧ loc ≡ giant))
    nada_sucede: report(default_msg[WAVE]);
  if (place[EGGS] ≡ limbo ∧ place[TROLL] ≡ limbo ∧ prop[TROLL] ≡ 0) prop[TROLL] = 1;
  k = (loc ≡ giant ? 0 : here(EGGS) ? 1 : 2);
  move(EGGS, giant);
  report(note[offset[EGGS] + k]);
}

```

This code is used in section 136.

**140. Motions.** A major cycle comes to an end when a motion verb *mot* has been given and we have computed the appropriate *newloc* accordingly.

First, we deal with motions that don't refer directly to the travel table.

```

⟨Handle special motion words 140⟩ ≡
    newloc = loc;    /* by default we will stay put */
    if (mot ≡ NOWHERE) continue;
    if (mot ≡ BACK) ⟨Try to go back 143⟩;
    if (mot ≡ LOOK) ⟨Repeat the long description and continue 141⟩;
    if (mot ≡ CAVE) {
        if (loc < min_in_cave)
            printf("I can't see where the cave is, but hereabouts no stream can run on\n\
                the surface for long. I would try the stream.\n");
        else printf("I need more detailed instructions to do that.\n");
        continue;
    }

```

This code is used in section 75.

**141.** When looking around, we pretend that it wasn't dark (though it may *now* be dark), so you won't fall into a pit while staring into the gloom.

```

⟨Repeat the long description and continue 141⟩ ≡
{
    if (++look_count ≤ 3)
        printf("Sorry, but I am not allowed to give more detail. I will repeat the\n\
            long description of your location.\n");
    was_dark = false;
    visits[loc] = 0;
    continue;
}

```

This code is used in section 140.

**142.** ⟨Global variables 7⟩ +≡

```

int look_count;    /* how many times you've asked us to look */

```

**143.** If you ask us to go back, we look for a motion that goes from *loc* to *oldloc*, or to *oldoldloc* if *oldloc* has forced motion. Otherwise we can't take you back.

```

⟨ Try to go back 143 ⟩ ≡
{
  l = (forced_move(oldloc) ? oldoldloc : oldloc);
  oldoldloc = oldloc;
  oldloc = loc;
  if (l ≡ loc) ⟨ Apologize for inability to backtrack 145 ⟩;
  for (q = start[loc], qq = Λ; q < start[loc + 1]; q++) {
    ll = q→dest;
    if (ll ≡ l) goto found;
    if (ll ≤ max_loc ∧ forced_move(ll) ∧ start[ll]→dest ≡ l) qq = q;
  }
  if (qq ≡ Λ) {
    printf("You can't get there from here.\n"); continue;
  }
  else q = qq;
found: mot = q→mot;
  goto go_for_it;
}

```

This code is used in section 140.

**144.** ⟨ Additional local registers 22 ⟩ +≡  
**register location** *l*, *ll*;

```

145. ⟨ Apologize for inability to backtrack 145 ⟩ ≡
{
  printf("Sorry, but I no longer seem to remember how you got here.\n");
  continue;
}

```

This code is used in section 143.

**146.** Now we are ready to interpret the instructions in the travel table. The following code implements the conventions of section 19.

```

⟨Determine the next location, newloc 146⟩ ≡
  for (q = start[loc]; q < start[loc + 1]; q++) {
    if (forced_move(loc) ∨ q-mot ≡ mot) break;
  }
  if (q ≡ start[loc + 1]) ⟨Report on inapplicable motion and continue 148⟩;
  ⟨If the condition of instruction q isn't satisfied, advance q 147⟩;
  newloc = q-dest;
  if (newloc ≤ max_loc) continue;
  if (newloc > max_spec) {
    printf("%s\n", remarks[newloc - max_spec]);
    stay: newloc = loc; continue;
  }
  switch (newloc) {
  case ppass: ⟨Choose newloc via plover-alcove passage 149⟩;
  case pdrop: ⟨Drop the emerald during plover transportation 150⟩; goto no_good;
  case troll: ⟨Cross troll bridge if possible 151⟩;
  }

```

This code is cited in section 19.

This code is used in section 75.

**147.** ⟨If the condition of instruction *q* isn't satisfied, advance *q* 147⟩ ≡

```

while (1) {
  j = q-cond;
  if (j > 300) {
    if (prop[j % 100] ≠ (int)((j - 300)/100)) break;
  } else if (j ≤ 100) {
    if (j ≡ 0 ∨ pct(j)) break;
  } else if (toting(j % 100) ∨ (j ≥ 200 ∧ is_at_loc(j % 100))) break;
  no_good:
  for (qq = q++;
    q-dest ≡ qq-dest ∧ q-cond ≡ qq-cond;
    q++) ;
}

```

This code is used in section 146.

**148.** Here we look at *verb* just in case you asked us to ‘find gully’ or something like that.

⟨Report on inapplicable motion and **continue** 148⟩ ≡

```
{
  if (mot ≡ CRAWL) printf("Which_way?");
  else if (mot ≡ XYZZY ∨ mot ≡ PLUGH) printf(default_msg[WAVE]);
  else if (verb ≡ FIND ∨ verb ≡ INVENTORY) printf(default_msg[FIND]);
  else if (mot ≤ FORWARD)
    switch (mot) {
      case IN: case OUT:
        printf("I_don't_know_in_from_out_here._._Use_compass_points_or_name_something\n\
              in_the_general_direction_you_want_to_go.");
        break;
      case FORWARD: case L: case R:
        printf("I_am_unsure_how_you_are_facing._._Use_compass_points_or_nearby_objects.");
        break;
      default: printf("There_is_no_way_to_go_in_that_direction.");
    } else printf("I_don't_know_how_to_apply_that_word_here.");
  printf("\n"); continue; /* newloc = loc */
}
```

This code is used in section 146.

**149.** Only the emerald can be toted through the plover-alcove passage — not even the lamp.

⟨Choose *newloc* via plover-alcove passage 149⟩ ≡

```
if (holding ≡ 0 ∨ (toting(EMERALD) ∧ holding ≡ 1)) {
  newloc = alcove + proom - loc; continue; /* move through the passage */
} else {
  printf("Something_you're_carrying_won't_fit_through_the_tunnel_with_you.\n\
        You'd_best_take_inventory_and_drop_something.\n");
  goto stay;
}
```

This code is used in section 146.

**150.** The *pdrop* command applies only when you're carrying the emerald. We make you drop it, thereby forcing you to use the plover-alcove passage if you want to get it out. We don't actually tell you that it was dropped; we just pretend you weren't carrying it after all.

⟨Drop the emerald during plover transportation 150⟩ ≡

```
drop(EMERALD, loc);
```

This code is used in section 146.

**151.** Troll bridge crossing is treated as a special motion so that dwarves won't wander across and encounter the bear.

You can get here only if `TROLL` is in limbo but `TROLL2` has taken its place. Moreover, if you're on the southwest side, `prop[TROLL]` will be nonzero. If `prop[TROLL]` is 1, you've crossed since paying, or you've stolen away the payment. Special stuff involves the bear.

```

⟨ Cross troll bridge if possible 151 ⟩ ≡
  if (prop[TROLL] ≡ 1) ⟨ Block the troll bridge and stay put 152 ⟩;
  newloc = neside + swside - loc;    /* cross it */
  if (prop[TROLL] ≡ 0) prop[TROLL] = 1;
  if (¬toting(BEAR)) continue;
  printf("Just as you reach the other side, the bridge buckles beneath the\n\
        weight of the bear, who was still following you around. You\n\
        scramble desperately for support, but as the bridge collapses you\n\
        stumble back and fall into the chasm.\n");
  prop[BRIDGE] = 1; prop[TROLL] = 2;
  drop(BEAR, newloc); base[BEAR] = BEAR; prop[BEAR] = 3;    /* the bear is dead */
  if (prop[SPICES] < 0 ∧ place[SPICES] ≥ neside) lost_treasures++;
  if (prop[CHAIN] < 0 ∧ place[CHAIN] ≥ neside) lost_treasures++;
  oldoldloc = newloc;    /* if you are revived, you got across */
  goto death;

```

This code is used in section 146.

```

152.   ⟨ Block the troll bridge and stay put 152 ⟩ ≡
  {
    move(TROLL, swside); move(TROLL_, neside); prop[TROLL] = 0;
    destroy(TROLL2); destroy(TROLL2_);
    move(BRIDGE, swside); move(BRIDGE_, neside);
    printf("%s\n", note[offset[TROLL] + 1]);
    goto stay;
  }

```

This code is used in section 151.

**153.** Obstacles might still arise after the choice of `newloc` has been made. The following program is executed at the beginning of each major cycle.

```

⟨ Check for interference with the proposed move to newloc 153 ⟩ ≡
  if (closing ∧ newloc < min_in_cave ∧ newloc ≠ limbo) {
    ⟨ Panic at closing time 180 ⟩; newloc = loc;
  } else if (newloc ≠ loc) ⟨ Stay in loc if a dwarf is blocking the way to newloc 176 ⟩;

```

This code is used in section 75.

**154. Random numbers.** You won't realize it until you have played the game for awhile, but adventures in Colossal Cave are not deterministic. Lots of things can happen differently when you give the same input, because caves are continually changing, and the dwarves don't have consistent aim, etc.

A simple linear congruential method is used to provide numbers that are random enough for our purposes.

⟨Subroutines 6⟩ +≡

```
int ran ARGS((int));
int ran(range)
    int range;    /* for uniform integers between 0 and range - 1 */
{
    rx = (1021 * rx) & #ffff;    /* multiply by 1021, modulo 220 */
    return (range * rx) >> 20;
}
```

**155.** ⟨Global variables 7⟩ +≡

```
int rx;    /* the last random value generated */
```

**156.** Each run is different.

⟨Initialize the random number generator 156⟩ ≡

```
rx = (((int) time(Λ)) & #ffff) | 1;
```

This code is used in section 200.

**157.** The *pct* macro returns true a given percentage of the time.

```
#define pct(r) (ran(100) < r)
```

⟨Give optional *plugh* hint 157⟩ ≡

```
if (loc ≡ y2 ∧ pct(25) ∧ ¬closing) printf("A_hollow_voice_says_PLUGH\n");
```

This code is used in section 86.

**158.** We kick the random number generator often, just to add variety to the chase.

⟨Make special adjustments before looking at new input 85⟩ +≡

```
k = ran(0);
```



**159. Dwarf stuff.** We've said a lot of vague stuff about dwarves; now is the time to be explicit. Five dwarves roam about the cave. Initially they are dormant but eventually they each walk about at random. A global variable called *dflag* governs their level of activity:

```

0  no dwarf stuff yet (we wait until you reach the Hall of Mists)
1  you've reached that hall, but haven't met the first dwarf
2  you've met one; the others start moving, but no knives thrown yet
3  a knife has been thrown, but it misses
4  knives will hit you with probability .095
5  knives will hit you with probability .190
6  knives will hit you with probability .285

```

and so on. Dwarves get madder and madder as *dflag* increases; this increases their accuracy.

A pirate stalks the cave too. He acts a lot like a dwarf with respect to random walks, so we call him *dwarf*[0], but actually he is quite different. He starts at the location of his treasure chest; you won't see that chest until after you've spotted him.

The present location of *dwarf*[*i*] is *dloc*[*i*]; initially no two dwarves are adjacent. The value of *dseen*[*i*] records whether or not dwarf *i* is following you.

```

#define nd 5      /* this many dwarves */
#define chest_loc dead2
#define message_loc pony
⟨Global variables 7⟩ +=
  int dflag;      /* how angry are the dwarves? */
  int dkill;      /* how many of them have you killed? */
  location dloc[nd + 1] = {chest_loc, hmk, wfiss, y2, like3, complex}; /* dwarf locations */
  location odloc[nd + 1]; /* prior locations */
  boolean dseen[nd + 1]; /* have you been spotted? */

```

**160.** The following subroutine is often useful.

```

⟨Subroutines 6⟩ +=
  boolean dwarf ARGS((void));
  boolean dwarf() /* is a dwarf present? */
  {
    register int j;
    if (dflag < 2) return false;
    for (j = 1; j ≤ nd; j++)
      if (dloc[j] ≡ loc) return true;
    return false;
  }

```

**161.** Just after you've moved to a new *loc*, we move the other guys. But we bypass all dwarf motion if you are in a place forbidden to the pirate, or if your next motion is forced. In particular, this means that the pirate can't steal the return toll, and dwarves can't meet the bear. It also means that dwarves won't follow you into a dead end of the maze, but c'est la vie; they'll wait for you outside the dead end.

```

⟨ Possibly move dwarves and the pirate 161 ⟩ ≡
  if (loc ≤ max.pirate_loc ∧ loc ≠ limbo) {
    if (dflag ≡ 0) {
      if (loc ≥ min.lower_loc) dflag = 1;
    }
    else if (dflag ≡ 1) {
      if (loc ≥ min.lower_loc ∧ pct(5)) ⟨ Advance dflag to 2 162 ⟩;
    }
    else ⟨ Move dwarves and the pirate 164 ⟩;
  }

```

This code is used in section 75.

**162.** When level 2 is reached, we silently kill 0, 1, or 2 of the dwarves. Then if any of the survivors is in the current location, we move him to *nugget*; thus no dwarf is presently tracking you. Another dwarf does, however, toss an axe and grumpily leave the scene.

(The grumpy dwarf might throw the axe while you're in the maze of all-different twists, even though other dwarves never go in there!)

```

⟨ Advance dflag to 2 162 ⟩ ≡
{
  dflag = 2;
  for (j = 0; j < 2; j++)
    if (pct(50)) dloc[1 + ran(nd)] = limbo;
  for (j = 1; j ≤ nd; j++) {
    if (dloc[j] ≡ loc) dloc[j] = nugget;
    odloc[j] = dloc[j];
  }
  printf("A little dwarf just walked around a corner, saw you, threw a little\n\
    axe at you, cursed, and ran away. (The axe missed.)\n");
  drop(AXE, loc);
}

```

This code is used in section 161.

**163.** It turns out that the only way you can get rid of a dwarf is to attack him with the axe. You'll hit him 2/3 of the time; in either case, the axe will be available for reuse.

```

⟨ Throw the axe at a dwarf 163 ⟩ ≡
{
  for (j = 1; j ≤ nd; j++)
    if (dloc[j] ≡ loc) break;
  if (ran(3) < 2) {
    dloc[j] = limbo; dseen[j] = 0; dkill++;
    if (dkill ≡ 1)
      printf("You_killed_a_little_dwarf._.The_body_vanishes_in_a_cloud_of_greasy\n\
black_smoke.\n");
    else printf("You_killed_a_little_dwarf.\n");
  } else printf("You_attack_a_little_dwarf,_but_he_dodges_out_of_the_way.\n");
  drop(AXE, loc); stay_put;
}

```

This code is used in section 122.

**164.** Now things are in full swing. Dead dwarves don't do much of anything, but each live dwarf tends to stay with you if he's seen you. Otherwise he moves at random, never backing up unless there's no alternative.

```

⟨ Move dwarves and the pirate 164 ⟩ ≡
{
  dtotal = attack = stick = 0; /* initialize totals for possible battles */
  for (j = 0; j ≤ nd; j++)
    if (dloc[j] ≠ limbo) {
      register int i;
      ⟨ Make a table of all potential exits, ploc[0] through ploc[i - 1] 166 ⟩;
      if (i ≡ 0) i = 1, ploc[0] = odloc[j];
      odloc[j] = dloc[j];
      dloc[j] = ploc[ran(i)]; /* this is the random walk */
      dseen[j] = (dloc[j] ≡ loc ∨ odloc[j] ≡ loc ∨ (dseen[j] ∧ loc ≥ min_lower_loc));
      if (dseen[j]) ⟨ Make dwarf j follow 167 ⟩;
    }
  if (dtotal) ⟨ Make the threatening dwarves attack 170 ⟩;
}

```

This code is used in section 161.

**165.** ⟨ Global variables 7 ⟩ +≡

```

int dtotal; /* this many dwarves are in the room with you */
int attack; /* this many have had time to draw their knives */
int stick; /* this many have hurled their knives accurately */
location ploc[19]; /* potential locations for the next random step */

```

**166.** Random-moving dwarves think *scan1*, *scan2*, and *scan3* are three different locations, although you will never have that perception.

```

⟨ Make a table of all potential exits, ploc[0] through ploc[i - 1] 166 ⟩ ≡
  for (i = 0, q = start[dloc[j]]; q < start[dloc[j] + 1]; q++) {
    newloc = q-dest;
    if (newloc ≥ min_lower_loc ∧ newloc ≠ odloc[j] ∧ newloc ≠ dloc[j] ∧
        (i ≡ 0 ∨ newloc ≠ ploc[i - 1]) ∧ i < 19 ∧ q-cond ≠ 100 ∧
        newloc ≤ (j ≡ 0 ? max_pirate_loc : min_forced_loc - 1)) ploc[i++] = newloc;
  }

```

This code is used in section 164.

**167.** A global variable *knife\_loc* is used to remember where dwarves have most recently thrown knives at you. But as soon as you try to refer to the knife, we tell you it's pointless to do so; *knife\_loc* is -1 thereafter.

```

⟨ Make dwarf j follow 167 ⟩ ≡
{
  dloc[j] = loc;
  if (j ≡ 0) ⟨ Make the pirate track you 172 ⟩
  else {
    dtotal++;
    if (odloc[j] ≡ dloc[j]) {
      attack++;
      if (knife_loc ≥ 0) knife_loc = loc;
      if (ran(1000) < 95 * (dflag - 2)) stick++;
    }
  }
}

```

This code is used in section 164.

**168.** ⟨ Global variables 7 ⟩ +≡  
**int** *knife\_loc*; /\* place where knife was mentioned, or -1 \*/

**169.** ⟨ Make special adjustments before looking at new input 85 ⟩ +≡  
**if** (*knife\_loc* > *limbo* ∧ *knife\_loc* ≠ *loc*) *knife\_loc* = *limbo*;

**170.** We actually know the results of the attack already; this is where we inform you of the outcome, pretending that the battle is now taking place.

⟨ Make the threatening dwarves attack 170 ⟩ ≡

```
{
  if (dtotal ≡ 1) printf("There is a threatening little dwarf");
  else printf("There are %d threatening little dwarves", dtotal);
  printf(" in the room with you!\n");
  if (attack) {
    if (dflag ≡ 2) dflag = 3;
    if (attack ≡ 1) k = 0, printf("One sharp nasty knife is thrown");
    else k = 2, printf("%d of them throw knives", attack);
    printf(" at you ---");
    if (stick ≤ 1) printf("%s!\n", attack_msg[k + stick]);
    else printf("%d of them get you!\n", stick);
    if (stick) {
      oldoldloc = loc; goto death;
    }
  }
}
```

This code is used in section 164.

**171.** ⟨ Global variables 7 ⟩ +≡

```
char *attack_msg[] = {"it misses", "it gets you",
  "none of them hit you", "one of them gets you"};
```

**172.** The pirate leaves you alone once you have found the chest. Otherwise he steals all of the treasures you're carrying, although he ignores a treasure that's too easy. (The pyramid is too easy, if you're in the Plover Room or the Dark-Room.)

You spot the pirate if he robs you, or when you have seen all of the possible treasures (except, of course, the chest) and the current location has no treasures. Before you've spotted him, we may give you a vague indication of his movements.

We use the value of *place*[MESSAGE] to determine whether the pirate has been seen; the condition of *place*[CHEST] is not a reliable indicator, since the chest might be in limbo if you've thrown it to the troll.

```
#define pirate_not_spotted (place[MESSAGE] == limbo)
#define too_easy(i) (i == PYRAMID ∧ (loc == proom ∨ loc == droom))

⟨ Make the pirate track you 172 ⟩ ≡
{
  if (loc ≠ max_pirate_loc ∧ prop[CHEST] < 0) {
    for (i = min_treasure, k = 0; i ≤ max_obj; i++) {
      if (¬too_easy(i) & toting(i)) {
        k = -1; break;
      }
      if (here(i)) k = 1;
    }
    if (k < 0) ⟨ Take booty and hide it in the chest 173 ⟩
    else if (tally == lost_treasures + 1 ∧ k == 0 ∧ pirate_not_spotted ∧ prop[LAMP] ∧ here(LAMP))
      ⟨ Let the pirate be spotted 175 ⟩
    else if (odloc[0] ≠ dloc[0] ∧ pct(20))
      printf("There are faint rustling noises from the darkness behind you.\n");
  }
}
```

This code is used in section 167.

**173.** The pirate isn't secretive about the fact that his chest is somewhere in a maze. However, he doesn't say which maze he means. Nor does he explain why he is interested in treasures only when you are carrying them; evidently he just likes to see you squirm.

```
⟨ Take booty and hide it in the chest 173 ⟩ ≡
{
  printf("Out from the shadows behind you pounces a bearded pirate! \"Har, har, \"\n\
    he chortles, \"I'll just take all this booty and hide it away with me\n\
    chest deep in the maze! \" He snatches your treasure and vanishes into\n\
    the gloom.\n");
  ⟨ Snatch all treasures that are snatchable here 174 ⟩;
  if (pirate_not_spotted) {
    move_chest: move(CHEST, chest_loc); move(MESSAGE, message_loc);
  }
  dloc[0] = odloc[0] = chest_loc; dseen[0] = false;
}
```

This code is used in section 172.

**174.**  $\langle \text{Snatch all treasures that are snatchable here } 174 \rangle \equiv$   

```

for ( $i = \text{min\_treasure}; i \leq \text{max\_obj}; i++$ )
  if ( $\neg \text{too\_easy}(i)$ ) {
    if ( $\text{base}[i] \equiv \text{NOTHING} \wedge \text{place}[i] \equiv \text{loc}$ )  $\text{carry}(i)$ ;
    if ( $\text{toting}(i)$ )  $\text{drop}(i, \text{chest\_loc})$ ;
  }

```

This code is used in section 173.

**175.** The window rooms are slightly lighted, but you don't spot the pirate there unless your lamp is on. (And you do spot him even if the lighted lamp is on the ground.)

$\langle \text{Let the pirate be spotted } 175 \rangle \equiv$   

```

{
   $\text{printf}(\text{"There are faint rustling noises from the darkness behind you. As you\n\}$ 

```

This code is used in section 172.

**176.** One more loose end related to dwarfs needs to be addressed here. If you're coming from a place forbidden to the pirate, so that the dwarves are rooted in place, we let you get out (and be attacked). Otherwise, if a dwarf has seen you and has come from where you want to go, he blocks you.

We use the fact that  $\text{loc} \leq \text{max\_pirate\_loc}$  implies  $\neg \text{forced\_move}(\text{loc})$ .

$\langle \text{Stay in } \text{loc} \text{ if a dwarf is blocking the way to } \text{newloc } 176 \rangle \equiv$   

```

if ( $\text{loc} \leq \text{max\_pirate\_loc}$ ) {
  for ( $j = 1; j \leq \text{nd}; j++$ )
    if ( $\text{odloc}[j] \equiv \text{newloc} \wedge \text{dseen}[j]$ ) {
       $\text{printf}(\text{"A little dwarf with a big knife blocks your way.\n"})$ ;
       $\text{newloc} = \text{loc}$ ; break;
    }
  }
}

```

This code is used in section 153.

**177. Closing the cave.** You get to wander around until you've located all fifteen treasures, although you need not have taken them yet. After that, you enter a new level of complexity: A global variable called *clock1* starts ticking downwards, every time you take a turn inside the cave. When it hits zero, we start closing the cave; then we sit back and wait for you to try to get out, letting *clock2* do the ticking. The initial value of *clock1* is large enough for you to get outside.

```
#define closing (clock1 < 0)
⟨Global variables 7⟩ +=
    int clock1 = 15, clock2 = 30;    /* clocks that govern closing time */
    boolean panic, closed;          /* various stages of closedness */
```

**178.** Location Y2 is virtually outside the cave, so *clock1* doesn't tick there. If you stay outside the cave with all your treasures, and with the lamp switched off, the game might go on forever; but you wouldn't be having any fun.

There's an interesting hack by which you can keep *tally* positive until you've taken all the treasures out of the cave. Namely, if your first moves are

```
in, take lamp, plugh, on, drop lamp, s, take silver,
back, take lamp, plugh, out, drop silver, in,
```

the silver bars will be at *road*; but *prop*[SILVER] will still be  $-1$  and *tally* will still be 15. You can bring the other 14 treasures to the *house* at your leisure; then the *tally* will drop to zero when you step outside and actually see the silver for the first time.

```
⟨Check the clocks and the lamp 178⟩ ≡
    if (tally ≡ 0 ∧ loc ≥ min_lower_loc ∧ loc ≠ y2) clock1 --;
    if (clock1 ≡ 0) ⟨Warn that the cave is closing 179⟩
    else {
        if (clock1 < 0) clock2 --;
        if (clock2 ≡ 0) ⟨Close the cave 181⟩
        else ⟨Check the lamp 184⟩;
    }
```

This code is used in section 76.

**179.** At the time of first warning, we lock the grate, destroy the crystal bridge, kill all the dwarves (and the pirate), remove the troll and the bear (unless dead), and set *closing* to true. It's too much trouble to move the dragon, so we leave it. From now on until *clock2* runs out, you cannot unlock the grate, move to any location outside the cave, or create the bridge. Nor can you be resurrected if you die.

```
⟨Warn that the cave is closing 179⟩ ≡
{
    printf("A sepulchral voice, reverberating through the cave, says, \"Cave\n\
        closing soon. All adventurers exit immediately through main office.\"\n");
    clock1 = -1;
    prop[GRATE] = 0;
    prop[CRYSTAL] = 0;
    for (j = 0; j ≤ nd; j++) dseen[j] = 0, dloc[j] = limbo;
    destroy(TROLL); destroy(TROLL_);
    move(TROLL2, swside); move(TROLL2_, neside);
    move(BRIDGE, swside); move(BRIDGE_, neside);
    if (prop[BEAR] ≠ 3) destroy(BEAR);
    prop[CHAIN] = 0; base[CHAIN] = NOTHING;
    prop[AXE] = 0; base[AXE] = NOTHING;
}
```

This code is used in section 178.



**180.** If you try to get out while the cave is closing, we assume that you panic; we give you a few additional turns to get frantic before we close.

$\langle$  Panic at closing time 180  $\rangle \equiv$

```
{
  if ( $\neg$ panic) clock2 = 15, panic = true;
  printf("A_mysterious_recorded_voice_groans_into_life_and_announces:\n\
        \"This_exit_is_closed._Please_leave_via_main_office.\n\n");
}
```

This code is used in sections 131 and 153.

**181.** Finally, after *clock2* hits zero, we transport you to the final puzzle, which takes place in the previously inaccessible storage room. We have to set everything up anew, in order to use the existing machinery instead of writing a special program. We are careful not to include keys in the room, since we don't want to allow you to unlock the grate that separates you from your treasures. There is no water; otherwise we would need special code for watering the beanstalks.

The storage room has two locations, *neend* and *swend*. At the northeast end, we place empty bottles, a nursery of plants, a bed of oysters, a pile of lamps, rods with stars, sleeping dwarves, and you. At the southwest end we place a grate, a snake pit, a covey of caged birds, more rods, and pillows. A mirror stretches across one wall. But we destroy all objects you might be carrying, lest you have some that could cause trouble, such as the keys. We describe the flash of light and trundle back.

From the fact that you've seen all the treasures, we can infer that the snake is already gone, since the jewels are accessible only from the Hall of the Mountain King. We also know that you've been in the Giant Room (to get eggs); you've discovered that the clam is an oyster (because of the pearl); the dwarves have been activated, since you've found the chest. Therefore the long descriptions of *neend* and *swend* will make sense to you when you see them.

Dear reader, all the clues to this final puzzle are presented in the program itself, so you should have no trouble finding the solution.

⟨ Close the cave 181 ⟩ ≡

```
{
    printf("The sepulchral voice intones, \"The cave is now closed.\" As the echoes\n\
        fade, there is a blinding flash of light (and a small puff of orange\n\
        smoke). . . . Then your eyes refocus; you look around and find... \n");
    move(BOTTLE, neend); prop[BOTTLE] = -2;
    move(PLANT, neend); prop[PLANT] = -1;
    move(OYSTER, neend); prop[OYSTER] = -1;
    move(LAMP, neend); prop[LAMP] = -1;
    move(ROD, neend); prop[ROD] = -1;
    move(DWARF, neend); prop[DWARF] = -1;
    move(MIRROR, neend); prop[MIRROR] = -1;
    loc = oldloc = neend;
    move(GRATE, swend); /* prop[GRATE] still zero */
    move(SNAKE, swend); prop[SNAKE] = -2;
    move(BIRD, swend); prop[BIRD] = -2;
    move(CAGE, swend); prop[CAGE] = -1;
    move(ROD2, swend); prop[ROD2] = -1;
    move(PILLOW, swend); prop[PILLOW] = -1;
    move(MIRROR_, swend);
    for (j = 1; j ≤ max_obj; j++)
        if (toting(j)) destroy(j);
    closed = true;
    bonus = 10;
    stay_put;
}
```

This code is used in section 178.

**182.** Once the cave has closed, we look for objects being toted with  $prop < 0$ ; their property value is changed to  $-1 - prop$ . This means they won't be described until they've been picked up and put down, separate from their respective piles.

⟨ Make special adjustments before looking at new input 85 ⟩ +≡

```

if (closed) {
  if ( $prop[OYSTER] < 0 \wedge toting(OYSTER)$ ) printf("%s\n", note[offset[OYSTER] + 1]);
  for ( $j = 1; j \leq max\_obj; j++$ )
    if ( $toting(j) \wedge prop[j] < 0$ )  $prop[j] = -1 - prop[j]$ ;
}
```

**183. Death and resurrection.** Only the most persistent adventurers get to see the closing of the cave, because their lamp gives out first. For example, if you have lost the ability to find any treasures, *tally* will never go to zero.

⟨Zap the lamp if the remaining treasures are too elusive 183⟩ ≡  
 if (*tally* ≡ *lost\_treasures* ∧ *tally* > 0 ∧ *limit* > 35) *limit* = 35;

This code is used in section 88.

**184.** On every turn, we check to see if you are in trouble lampwise.

⟨Check the lamp 184⟩ ≡  
 {  
   if (*prop*[LAMP] ≡ 1) *limit* --;  
   if (*limit* ≤ 30 ∧ *here*(BATTERIES) ∧ *prop*[BATTERIES] ≡ 0 ∧ *here*(LAMP)) ⟨Replace the batteries 186⟩  
   else if (*limit* ≡ 0) ⟨Extinguish the lamp 187⟩  
   else if (*limit* < 0 ∧ *loc* < *min\_in\_cave*) {  
     printf("There's not much point in wandering around out here, and you can't\n\  
       explore the cave without a lamp. So let's just call it a day.\n");  
     goto *give\_up*;  
   } else if (*limit* ≤ 30 ∧ ¬*warned* ∧ *here*(LAMP)) {  
     printf("Your lamp is getting dim");  
     if (*prop*[BATTERIES] ≡ 1) printf(", and you're out of spare batteries. You'd\n\  
       best start wrapping this up.\n");  
     else if (*place*[BATTERIES] ≡ *limbo*) printf(". You'd best start wrapping this up, unless\n\  
       you can find some fresh batteries. I seem to recall that there's\n\  
       a vending machine in the maze. Bring some coins with you.\n");  
     else printf(". You'd best go back for those batteries.\n");  
     *warned* = true;  
   }  
 }

This code is used in section 178.

**185.** ⟨Global variables 7⟩ +≡  
 boolean *warned*; /\* have you been warned about the low power supply? \*/

**186.** The batteries hold a pretty hefty charge.

⟨Replace the batteries 186⟩ ≡  
 {  
   printf("Your lamp is getting dim. I'm taking the liberty of replacing\n\  
     the batteries.\n");  
   *prop*[BATTERIES] = 1;  
   if (*toting*(BATTERIES)) *drop*(BATTERIES, *loc*);  
   *limit* = 2500;  
 }

This code is used in section 184.

**187.** ⟨Extinguish the lamp 187⟩ ≡  
 {  
   *limit* = -1; *prop*[LAMP] = 0;  
   if (*here*(LAMP)) printf("Your lamp has run out of power.");  
 }

This code is used in section 184.

**188.** The easiest way to get killed is to fall into a pit in pitch darkness.

```
⟨Deal with death and resurrection 188⟩ ≡
pitch_dark: printf("You_fell_into_a_pit_and_broke_every_bone_in_your_body!\n");
    oldoldloc = loc;
```

See also sections 189, 191, and 192.

This code is used in section 2.

189. "You're dead, Jim."

When you die, *newloc* is undefined (often *limbo*) and *oldloc* is what killed you. So we look at *oldoldloc*, the last place you were safe.

We generously allow you to die up to three times: *death\_count* is the number of deaths you have had so far.

```
#define max_deaths 3
```

$$\langle \text{Deal with death and resurrection } 188 \rangle + \equiv$$

```

death: death_count++;
if (closing) {
    printf("It looks as though you're dead. Well, seeing as how it's so close\n\
        to closing time anyway, let's just call it a day.\n");
    goto quit;
}
if ( $\neg$ yes(death_wishes[2*death_count-2], death_wishes[2*death_count-1], ok)  $\vee$  death_count  $\equiv$  max_deaths)
    goto quit;

```

**190.**  $\langle \text{Global variables } 7 \rangle + \equiv$

```
int death_count;      /* how often have you kicked the bucket? */
char *death_wishes[2 * max_deaths] = {
    "Oh, dear, you seem to have gotten yourself killed.  I might be able to\n\
        help you out, but I've never really done this before.  Do you want me\n\
        to try to reincarnate you?",
    "All right.  But don't blame me if something goes wr.....\n\
        PPOOF!!\n\
        You are engulfed in a cloud of orange smoke.  Coughing and gasping,\n\
        you emerge from the smoke and find...",
    "You clumsy oaf, you've done it again!  I don't know how long I can\n\
        keep this up.  Do you want me to try reincarnating you again?",
    "Okay, now where did I put my resurrection kit?... >PPOOF!<\n\
        Everything disappears in a dense cloud of orange smoke.",
    "Now you've really done it!  I'm out of orange smoke!  You don't expect\n\
        me to do a decent reincarnation without any orange smoke, do you?",
    "Okay, if you're so smart, do it yourself!  I'm leaving!"
};
```

**191.** At this point you are reborn. All objects you were carrying are dropped at *oldoldloc* (presumably your last place prior to being killed), with their properties unchanged. The loop runs backwards, so that the bird is dropped before the cage. The lamp is a special case, because we wouldn't want to leave it underground; we turn it off and leave it outside the building—only if you were carrying it, of course. You yourself are left *inside* the building. (Heaven help you if you try to xyzzzy back into the cave without the lamp.) We zap *oldloc* so that you can't just go back.

⟨ Deal with death and resurrection 188 ⟩ +≡

```

if (toting(LAMP)) prop[LAMP] = 0;
place[WATER] = limbo; place[OIL] = limbo;    /* must not drop them */
for (j = max_obj; j > 0; j-- )
    if (toting(j)) drop(j, j ≡ LAMP ? road : oldoldloc);
loc = oldloc = house;
goto commence;

```

**192.** Oh dear, you've disturbed the dwarves.

⟨ Deal with death and resurrection 188 ⟩ +≡

*dwarves\_upset*:

```

printf("The resulting ruckus has awakened the dwarves.  There are now several\n\
    threatening little dwarves in the room with you!  Most of them throw\n\
    knives at you!  All of them get you!\n");

```

**193. Scoring.** Here is the scoring algorithm we use:

<i>Objective</i>	<i>Points</i>	<i>Total possible</i>
Getting well into cave	25	25
Each treasure < chest	12	60
Treasure chest itself	14	14
Each treasure > chest	16	144
Each unused death	10	30
Not quitting	4	4
Reaching Witt's End	1	1
Getting to <i>closing</i>	25	25
Various additional bonuses		45
Round out the total	2	2
	Total:	350

Points can also be deducted for using hints. One consequence of these rules is that you get 32 points just for quitting on your first turn. And there's a way to get 57 points in just three turns.

Full points for treasures are awarded only if they aren't broken and you have deposited them in the building. But we give you 2 points just for seeing a treasure.

```
#define max_score 350
```

```
<Global variables 7> +=
```

```
    int bonus;    /* extra points awarded for exceptional adventuring skills */
```

**194.** The hints are table driven, using several arrays:

- *hint\_count[j]* is the number of recent turns whose location is relevant to hint *j*;
- *hint\_thresh[j]* is the number of such turns before we consider offering that hint;
- *hint\_cost[j]* is the number of points you pay for it;
- *hint\_prompt[j]* is the way we offer it;
- *hint[j]* is the hint;
- *hinted[j]* is true after we've given it.

Hint 0 is for instructions at the beginning; it costs you 5 points, but you get extra power in the lamp. The other hints also usually extend the lamp's power. Hint 1 is for reading the oyster. And hints 2 through 7 are for the *cave\_hint*, *bird\_hint*, *snake\_hint*, *twist\_hint*, *dark\_hint*, and *witt\_hint*, respectively.

Here's the subroutine that handles all eight kinds of hints.

```
<Subroutines 6> +=
```

```
void offer ARGS((int));
```

```
void offer(j)
```

```
    int j;
```

```
{
```

```
    if (j > 1) {
```

```
        if (!yes(hint_prompt[j], "I am prepared to give you a hint, ", ok)) return;
```

```
        printf("but it will cost you %d points.\n", hint_cost[j]);
```

```
        hinted[j] = yes("Do you want the hint?", hint[j], ok);
```

```
    } else hinted[j] = yes(hint_prompt[j], hint[j], ok);
```

```
    if (hinted[j] ^ limit > 30) limit += 30 * hint_cost[j];
```

```
}
```

```

195.  ⟨ Check if a hint applies, and give it if requested 195 ⟩ ≡
  for ( $j = 2, k = \text{cave\_hint}; j \leq 7; j++, k += k$ )
    if ( $\neg \text{hinted}[j]$ ) {
      if ( $(\text{flags}[\text{loc}] \& k) \equiv 0$ )  $\text{hint\_count}[j] = 0$ ;
      else if ( $++\text{hint\_count}[j] \geq \text{hint\_thresh}[j]$ ) {
        switch ( $j$ ) {
          case 2: if ( $\text{prop}[\text{GRATE}] \equiv 0 \wedge \neg \text{here}(\text{KEYS})$ ) break; else goto bypass;
          case 3: if ( $\text{here}(\text{BIRD}) \wedge \text{oldobj} \equiv \text{BIRD} \wedge \text{toting}(\text{ROD})$ ) break;
                   else continue;
          case 4: if ( $\text{here}(\text{SNAKE}) \wedge \neg \text{here}(\text{BIRD})$ ) break; else goto bypass;
          case 5: if ( $\text{first}[\text{loc}] \equiv 0 \wedge \text{first}[\text{oldloc}] \equiv 0 \wedge \text{first}[\text{oldoldloc}] \equiv 0 \wedge \text{holding} > 1$ ) break;
                   else goto bypass;
          case 6: if ( $\text{prop}[\text{EMERALD}] \neq -1 \wedge \text{prop}[\text{PYRAMID}] \equiv -1$ ) break;
                   else goto bypass;
          case 7: break;
        }
        offer( $j$ );
        bypass:  $\text{hint\_count}[j] = 0$ ;
      }
    }
  }

```

This code is used in section 76.



196. `#define n_hints 8`

(Global variables 7) +=

```

int hint_count[n_hints];    /* how long you have needed this hint */
int hint_thresh[n_hints] = {0,0,4,5,8,75,25,20};    /* how long we will wait */
int hint_cost[n_hints] = {5,10,2,2,2,4,5,3};    /* how much we will charge */
char *hint_prompt[n_hints] = {
    "Welcome to Adventure!! Would you like instructions?",
    "Hmmm, this looks like a clue, which means it'll cost you 10 points to\n\
    read it. Should I go ahead and read it anyway?",
    "Are you trying to get into the cave?",
    "Are you trying to catch the bird?",
    "Are you trying to deal somehow with the snake?",
    "Do you need help getting out of the maze?",
    "Are you trying to explore beyond the Plover Room?",
    "Do you need help getting out of here?";
char *hint[n_hints] = {
    "Somewhere nearby is Colossal Cave, where others have found fortunes in\n\
    treasure and gold, though it is rumored that some who enter are never\n\
    seen again. Magic is said to work in the cave. I will be your eyes\n\
    and hands. Direct me with commands of one or two words. I should\n\
    warn you that I look at only the first five letters of each word, so\n\
    you'll have to enter \"NORTHEAST\" as \"NE\" to distinguish it from\n\
    \"NORTH\". Should you get stuck, type \"HELP\" for some general hints.\n\
    For information on how to end your adventure, etc., type \"INFO\".\n\
    ~~~~~~\n\
    The first adventure program was developed by Willie Crowther.\n\
    Most of the features of the current program were added by Don Woods;\n\
    all of its bugs were added by Don Knuth.",
    "It says, \"There is something strange about this place, such that one\n\
    of the words I've always known now has a new effect.\" ",
    "The grate is very solid and has a hardened steel lock. You cannot\n\
    enter without a key, and there are no keys in sight. I would recommend\n\
    looking elsewhere for the keys.",
    "Something seems to be frightening the bird just now and you cannot\n\
    catch it no matter what you try. Perhaps you might try later.",
    "You can't kill the snake, or drive it away, or avoid it, or anything\n\
    like that. There is a way to get by, but you don't have the necessary\n\
    resources right now.",
    "You can make the passages look less alike by dropping things.",
    "There is a way to explore that region without having to worry about\n\
    falling into a pit. None of the objects available is immediately\n\
    useful for discovering the secret.",
    "Don't go west."};
boolean hinted[n_hints];    /* have you seen the hint? */

```

197. Here's a subroutine that computes the current score.

```

⟨Subroutines 6⟩ +=
  int score ARGS((void));
  int score()
  {
    register int j, s = 2;
    register object k;
    if (dflag) s += 25; /* you've gotten well inside */
    for (k = min_treasure; k ≤ max_obj; k++) {
      if (prop[k] ≥ 0) {
        s += 2;
        if (place[k] ≡ house ∧ prop[k] ≡ 0) s += (k < CHEST ? 10 : k ≡ CHEST ? 12 : 14);
      }
    }
    s += 10 * (max_deaths - death_count);
    if (¬gave_up) s += 4;
    if (place[MAG] ≡ witt) s++; /* proof of your visit */
    if (closing) s += 25;
    s += bonus;
    for (j = 0; j < n_hints; j++)
      if (hinted[j]) s -= hint_cost[j];
    return s;
  }

```

198. The worst possible score is  $-3$ . It is possible (but unusual) to earn exactly 1 point.

```

#define highest_class 8
⟨Print the score and say adieu 198⟩ ≡
  k = score();
  printf("You scored %d point%s out of a possible %d, using %d turn%s.\n", k, k ≡ 1 ? "" : "s",
    max_score, turns, turns ≡ 1 ? "" : "s");
  for (j = 0; class_score[j] ≤ k; j++) ;
  printf("%s\nTo achieve the next higher rating", class_message[j]);
  if (j < highest_class)
    printf(", you need %d more point%s.\n", class_score[j] - k, class_score[j] ≡ k + 1 ? "" : "s");
  else printf("would be a neat trick!\nCongratulations!!\n");

```

This code is used in section 2.

```

199. ⟨Global variables 7⟩ +=
  int class_score[] = {35, 100, 130, 200, 250, 300, 330, 349, 9999};
  char *class_message[] = {
    "You are obviously a rank amateur. Better luck next time.",
    "Your score qualifies you as a novice class adventurer.",
    "You have achieved the rating \"Experienced Adventurer\".",
    "You may now consider yourself a \"Seasoned Adventurer\".",
    "You have reached \"Junior Master\" status.",
    "Your score puts you in Master Adventurer Class C.",
    "Your score puts you in Master Adventurer Class B.",
    "Your score puts you in Master Adventurer Class A.",
    "All of Adventuredom gives tribute to you, Adventure Grandmaster!"
  };

```

**200. Launching the program.** The program is now complete; all we must do is put a few of the pieces together.

Most of the initialization takes place while you are reading the opening message.

```
⟨Initialize all tables 200⟩ ≡  
  ⟨Initialize the random number generator 156⟩;  
  offer(0); /* Give the welcome message and possible instructions */  
  limit = (hinted[0] ? 1000 : 330); /* set lifetime of lamp */  
  ⟨Build the vocabulary 10⟩;  
  ⟨Build the travel table 23⟩;  
  ⟨Build the object tables 69⟩;  
  oldoldloc = oldloc = loc = newloc = road;
```

This code is used in section 2.

**201. Index.** A large cloud of green smoke appears in front of you. It clears away to reveal a tall wizard, clothed in grey. He fixes you with a steely glare and declares, “This adventure has lasted too long.” With that he makes a single pass over you with his hands, and everything around you fades away into a grey nothingness.

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*word2*: [72](#), [73](#), [76](#), [78](#), [79](#), [82](#), [83](#), [97](#), [105](#).  
*wpit*: [18](#), [46](#), [47](#), [61](#), [70](#).  
*w2pit*: [18](#), [46](#), [52](#), [61](#), [69](#).  
XYZZY: [9](#), [10](#), [25](#), [31](#), [97](#), [148](#).  
*y*: [71](#).  
*yes*: [71](#), [95](#), [189](#), [194](#).  
*y2*: [18](#), [25](#), [41](#), [51](#), [157](#), [159](#), [178](#).  
Y2: [9](#), [10](#), [32](#), [41](#).

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- ⟨ Apologize for inability to backtrack 145 ⟩ Used in section 143.
- ⟨ Block the troll bridge and stay put 152 ⟩ Used in section 151.
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- ⟨ Chase the troll away 119 ⟩ Used in section 117.
- ⟨ Check for interference with the proposed move to *newloc* 153 ⟩ Used in section 75.
- ⟨ Check if a hint applies, and give it if requested 195 ⟩ Used in section 76.
- ⟨ Check special cases for dropping a liquid 115 ⟩ Used in section 117.
- ⟨ Check special cases for dropping the bird 120 ⟩ Used in section 117.
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- ⟨ Close the cave 181 ⟩ Used in section 178.
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- ⟨ Describe the objects at this location 88 ⟩ Used in section 86.
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- ⟨ If the condition of instruction *q* isn't satisfied, advance *q* 147 ⟩ Used in section 146.
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- ⟨ Initialize the random number generator 156 ⟩ Used in section 200.
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〈Move dwarves and the pirate 164〉 Used in section 161.  
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 〈Open/close chain 132〉 Used in section 131.  
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