Wordlock™, a combination lock using words instead of numbers, was created by Todd Basche, a Silicon Valley executive. Sold by Staples for $5.98 (in blue or black) or $3.90 (in orange), it consists of five independently-rotating rings, yielding one hundred thousand different positions, any one of which the user can select. Because words are more easily remembered than numbers, he inscribed four of the rings with ten different letters each, and the fifth with nine different letters and a blank, allowing the user to pick either a four-letter or a five-letter word (left column):

<table>
<thead>
<tr>
<th>MATCH</th>
<th>MASON</th>
</tr>
</thead>
<tbody>
<tr>
<td>JOCSS</td>
<td>JUNTA</td>
</tr>
<tr>
<td>LEIN</td>
<td>LOCI</td>
</tr>
<tr>
<td>SLEEK</td>
<td>STALE</td>
</tr>
<tr>
<td>AISYL</td>
<td>ALAY</td>
</tr>
<tr>
<td>CHDAD</td>
<td>CHINK</td>
</tr>
<tr>
<td>DULLY</td>
<td>DITCH</td>
</tr>
<tr>
<td>BRAIN</td>
<td>BERYL</td>
</tr>
<tr>
<td>ENRTA</td>
<td>ENDED</td>
</tr>
<tr>
<td>TTNOE</td>
<td>TRESS</td>
</tr>
</tbody>
</table>

With the default factory setting (left column), four of the ten combinations can be simultaneously read off as words. Three of these, MATCH, BRAIN, and SLEEK, must have been deliberately created to reside on the three raised sections of the rings, but DULLY was probably an afterthought. However, Basche could have rearranged the non-raised letters on the rings to spell THINE (or TENSE), ENROL, CODAS and LIST, for a total of seven out of ten words.

Rearranging all the letters on the rings, could Basche have created a full ten words? In other words, can ten mutually non-crashing words be found which use the specified letters on the various rings? (Two words are non-crashing if they have no common letters in the same position, such as sTraw and oTher or hoUse and brUnt.) The answer is yes—ten words from the Merriam-Webster Pocket Dictionary are given in the right column above. More generally, a set of seventeen mutually non-crashing Pocket Dictionary words can be found on page 211 of the author’s book Making the Alphabet Dance.

Basche apparently consulted letter-frequency tables to select the letters on the rings. The commonest ten first letters for four-letter words in the Pocket Dictionary are SBPTCLDMFR, and for five-letter ones, SCBAPTFGMD—so why did he select J and E for the first ring in preference to P and F? In the fourth ring, Y is rarely found in five-letter words and is less common than nine other letters (SETLDKNMR) ending four-letter ones; R would have been a better choice. The top ten Pocket Dictionary letters terminating five-letter words are EYTRDLNHKS, but he wisely included S in his set of nine because of noun plurals and verb present tenses. However, he should have substituted T for the relatively rare A, and (possibly) R for H or K.

The most interesting wordplay possibility for Wordlock™ is found in the word ladder—the successive transformation of one word into another by changing a single letter (i.e., by rotating a
single ring). The thousand-plus Pocket Dictionary words present on the rings of the lock can be sorted into various word networks, in which any word can be converted to any other word by successive single-letter changes. It is remarkable that more than 90 per cent of all possible words lie in a single network; in fact, the largest network not connected to the main network consists of only six words! The five-letter part of the main network is displayed in sections at the end of this article, with all connections to the four-letter part of the network (too tangled to diagram) shown.

In theory, any word in the main network can be transformed to a word with different letters in every position in a maximum of five steps (such as crane-crank-crack-crick-click-slick). The reality is that many more steps are usually needed. Consider, for example, CHILD to MIRTH. The shortest connection is apparently 25 steps:


Can it be done in 24 or fewer steps? More important, can one locate another pair of words for which the shortest possible connection is greater than 25? Each pair of words in the network has a shortest-possible-connection number; the largest such number for any pair of words in the network is called the span of the network.

The four-letter part of the main network contains the densest cluster of words. This is evinced by the fact that the span of the four-letter network appears to be only 10, as given for example by

-duly-dull-doll-moll-molt-moat-coat-chat-chit-
JULY
-jury-bury-burn-turn-tern-teen-then-thin-chin-

Note that DUTY to CHIC has the same span.

Interestingly, only four of the ten non-crashing words presented earlier are in the main network. A typical connection (not necessarily the shortest) is


LOCO is connected only with LOCi, and ALLAY with ALLOY-ALLEY-ALLAH; the other four are isolanos (i.e., have no connecting words in the Pocket Dictionary).

THREE is the only cardinal, TENTH and NINTH the only ordinals, BORON the only element, MAINE the only state, and ARIES the only sign of the Zodiac. However, there exist three out of the twelve months, MARCH, JUNE and JULY, which are connectable. How about connecting CHINA, CHILE and MALTA (which have one-step connections to words in the network)? Or opposites such as THICK and THIN (an easy one-step via THINK), or EARLY and LATE? Alas, one cannot connect BLESS and CURSE, DIRTY and CLEAN, SATAN and ALLAH, or BIRTH and DEATH!
Partially-capitalized words connect with the four-letter network
Boldface words transfer five-letter words in the first network to five-letter words in the second
When three words are joined by equal signs, one can go directly from word 1 to word 3
When three vertical words are separated by underlines, one can go directly from word 1 to word 3

```
stein-stain-slain trail
staid blain brain=dRAIN=train
SHINy THINe-THANK braid
SHINe-THINe branD-BRANs-BRASs
seine briny | BRACTs
|              |     |  BRAyS
brace trine-trite brine blank-bland
|              |     |  BRAyS
trace-trice drink-brink-blank-blind
track-trick-----brick  |  crash-clash-slash
| brisk  | blend-bleed crass-class
| thick  | cress--------chess
|       | tress-dress
|       | CHICK
| break-bread-------breed  |  dries-dried
check creak tread=trend=treeD-TREEs=tries=tried
check------creek---|--------|---creed:cries-cried
| triad  | creel Aries
| trial  | ARIAs-alias
|       |    array-arras
| drill-trill |    
| drift   |    
| daily   |    
| daily-DAISy |    
| dally==|DULLY=|DOLLY
|       |  JELLY-jolly
|       | EARLy-MARLy-madly  |  BILLY=BULLy=BELLy
| badly     |  BELLy-belie
| sadly-sally=SILly=sully
| SALTy-SILTy-surly=CURly=burly
| Malay-MALTy

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crate-crane THINK
 crank-crack-crick---CHINK-CHINa
 CLANK-clack-click---cklink
| black  |    |  
| slack-slick---slink
| snack   |slice  |
| shank-shack |
stand-stank-stack-stick---stink
| scaly-scald |
| scale   |
| shale---|----shall-shell
| state-stale=stalk=stall |
| SLATe stile------still-shill
elate------elite  chill-child

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Transfers
black to blank
shank to thank
think to thank
think to thick
think to thine
chink to chick
click to chick
crick to click
crack to track
clink to blink
milch  
mulch  
lunch=bunch=munch  
lurch  |  beech-leech  
larch  bench=belch=beach=leach=teach  
MARSh-march  LEASh  
match=catch=batch  LEASe=cease=TEASe  
bitch-ditch  chase  
birch  
mirth-birth  
berth  
metal-medal-modal-MODEl-MOTEl  canal-banal-basal-basil  
|  basin  
coral-moral-mural  basis  
|  BASEs  
steed-steel  baste=CASTe=taste-tasty-TESTy  
stead  |  baste  
steak-steal  
sneak  CONEy-money  
mosey  
MASSy=MOSSy=MESSy=MUSSy  
sassy  BOSSy  MUSTy-MISTy-MINTy  
sissy  LUSTy  

Allah-allay=alley=alloy  moron-boron-baron=baton=bacon  
sense=dense=tense-terse  decal-decay-decoy  
delay  

Note that the steed network is the largest one not connected with the main network.