INVERSION SQUARES

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It is now approaching two years since I began a computer search for a 10x10 word square. Since my last report in the November 1989 Word Ways, there has been a discouraging turn of events. I furnished statistics about the distribution of letter-frequencies in my wordstock to a researcher at the IBM Yorktown Research Center. He calculated, given these letter-frequencies, that a vocabulary of 289,000 words would be required to produce a symmetric 10x10 word square. I had already projected that when I finished transcribing the Levine list, there still would be fewer than 130,000 words -- less than half the required number.

Other than finding some massive new source of words, the only way around this dilemma would be to alter the letter-frequencies somehow. There were several possibilities. Some years ago, a 10x10 word square was published in Games magazine in which letters were grouped into two categories, vowels and consonants. The cells of the word square contained only V or C. This was an extreme way of increasing the letter-frequencies.

The vowel-consonant square had already been done, but I could think of several other ways to apply the same trick. One way would be to divide the alphabet into several ranges, such as A-D, E-H, etc. This would produce very artificial squares that I think would please nobody. A better way would be to leave all the consonants as is, but lump all the vowels into one category. This would produce squares far more satisfactory than a mere VC square, but it would still involve an artificial symbol that would represent all the vowels.

A different approach was to double the vocabulary by using each word and its reverse. This would have the advantage of using only valid words with the true alphabet. I could then choose those words with the highest frequency letters and enhance the letter-frequencies that way.

I began by merging the normal dictionary with the reversed dictionary that I had been maintaining in parallel. This produced a mixed list of about 207,700 words. I set the threshold of letter-frequencies quite high, accepting only 24,800 words from this stock.

I was very concerned about how long it would take to search this list, because the number of valid initial bigrams, trigrams, etc. in the mixed list would be much higher than either a normal or reversed list. This meant that the computer would accept far larger numbers of words for the top several lines of the partial

word square. That translates into a very long running time.

The search began on February 19, 1990 with this reduced vocabulary. It immediately started producing 6,10 partial squares. These had been very rare with the normal vocabulary, with only five known in the forward searches, and fourteen in the reverse searches. I present the first one found (at the left, below); altogether, 29 were produced in the limited search.

I did not have to wait long for a 10x10 square to appear. On February 21, 1990, the first mixed 10x10 square was generated (at the right, below). This has an intriguing symmetry: rows 6, 7, 8, 9, 10 are the reversals of rows 5, 4, 3, 2, 1, respectively. It has a sort of palindromic quality with its own esthetic appeal; I call it an Inversion Square.

A N I S A M I D E S	G O E S A S T E R N
N O N S I E N E S E	O L L E N R O T I R
I N T E R S H O O T	E L E O N O R I T E
S S E R D N E T T A	S E O R O T O R O T
A I R D N A R T E T	A N N O T A T O R S
M E S N A G I E R S	S R O T A T O N N A
I N H E R I T O R S	T O R O T O R O E S
D E O T T E L I T S	E T I R O N O E L E
E S O T E R I C A L	R I T O R N E L L O
S E T A T S A T A C	N R E T S A S E O G

This square is far more satisfying than the tautonymic squares produced by Dmitri Borgmann. Those squares had each element repeated four times, while this square has each element repeated just twice.

This search required only four days. It produced 15,116 5,10 squares, 29 6,10 squares, and one 7,9 square unrelated to the 10x10 square above. This compares to 12,735 5,10 squares produced in a forward search using 102,600 words. This encouraged me to undertake larger searches.

On February 28, 1990 I began a mixed search using 46,121 words from the combined wordstock. This search produced two more 10x10 Inversion Squares, given below. The FORTRESSES square actually results in six squares, because the words FORTRESSED and PORTRESSES can be substituted in various ways.

C O T R U S T E E S	F O R T R E S S E S
O C E A N T R A D E	O P E R E S E R I E
T E L L I N I D A E	R E V I S 1 T O R S
R A L I S A B I R T	T R I T U R A T E S
U N 1 S O N A N T S	R E S U R P R 1 S E
S T N A N O S I N U	E S I R P R U S E R
T R I B A S I L A R	S E T A R U T I R T
E A D I N I L L E T	S R O T I S I V E R
E D A R T N A E C O	E I R E S E R E P O
S E E T S U R T O C	S E S S E R T R O F

Could a 10x10 square with ten distinct words be found? The search

also produced a 7,10 partial square unrelated to the three Inversion Squares (at the left, below), the only known 7,10 square based on ten distinct words. Perhaps the most impressive result of this mixed search was a 9,9 partial square (at the right, below), which is also 6,10 if the term COAST SEALS or GREAT SEALS is inserted in reverse on the tenth line.

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P L E O N A S T E S
L A D I O N E H T E
E D I L S H T R A E
O I L H E A T E R S
N O S E B L E E D S
A N H A L O N I N E
S E T T E N G R O L
T H R E E I R O N S
E T A R D N O C E S
S E E S S E L B U S
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O I L T E M P E R S
1 D E A T I O N A L
L E N T I S S 1 M A
T A T T L E T A L E
E T I L O N E L E S
M 1 S E N T R E A T
P O S T E R E T T E
E N 1 A L E T A H C
R A M L E A T H E R
S L A E S T E C R
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The search ended on March 24, 1990, taking just 25 days. It produced 191,359 5,10 squares and 423 6,10 squares. These are dramatic increases from the previous search with 24,800 words. Unfortunately, these increases in yields are matched with similarly dramatic increases in running time, in this case from four days up to 25 days. It is this factor that will limit further searches.

OBoy! *Morice*