



XVIII. On the magic square of the knight's march

William Beverley

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the integral of which is $V = \psi(s - a_1 t)$. In the same way it may be shown that the density (ρ) must be a function of $s - a_1 t$ in the case of a constant rate of propagation.

Now these criteria of uniform propagation are not satisfied by the hypothesis of plane waves, because on that hypothesis we have

$$V = a \text{ Nap. log } \rho = f(s - (a + V)t).$$

Still less are they satisfied by the hypothesis of spherical waves.

But they are fully satisfied on the hypothesis of non-divergent waves, because the above value of ϕ shows that in this case $\frac{d\phi}{dz}$ is a function of $z - a't$; and from the known general equation

$$a^2 \text{ Nap. log } \rho + \frac{d\phi}{dt} + \frac{V^2}{2} = 0,$$

it follows that ρ is also a function of $z - a't$.

I have thus shown, by reasoning with exact equations, the entire compatibility of the hypothesis of non-divergent waves with the hydrodynamical equations. Having at the same time demonstrated the incompatibility of plane-waves and spherical waves, I consider that the theorems of capital importance, to which the reasoning in this and the two former communications has been directed, are established; viz. that non-divergence is the normal character of aërial waves, and that the velocity of propagation is 'greater than a '. I propose in a future communication to draw some inferences from the equations (B.) and (C.)

Cambridge Observatory,
July 20, 1848.

XVIII. *On the Magic Square of the Knight's March.*

By WILLIAM BEVERLEY.

To the Editors of the Philosophical Magazine and Journal.

GENTLEMEN,

I INCLOSE for insertion in the *Philosophical Magazine* a very interesting MAGIC SQUARE, formed by numbering consecutively the *moves of the KNIGHT in the grand tour* of the chess-board. The *knight's march* has engaged the ingenuity of many eminent philosophers and mathematicians; but I believe that Mr. W. Beverley is the first who has solved the difficult problem of converting it into a *magic square*. The principle upon which he has effected it, seems to be somewhat akin to that invented by Dr. Roget, S.R.S., as explained in his paper on the *Knight's Move* in vol. xvi. of the *Philosophical Magazine*.

Yours very faithfully,

5 Smith Street, Chelsea,
March 29, 1848.

H. PERIGAL, Jun.

Fig. 1.

Columns.	9	10	11	12	13	14	15	16	
		<i>e</i>		<i>a</i>		<i>g</i>			
1	1	30	47	52	5	28	43	54	=260
2	48	51	2	29	44	53	6	27	=260
		A				B			
3	31	46	49	4	25	8	55	42	=260
4	50	3	32	45	56	41	26	7	=260
	<i>c</i>							<i>d</i>	
5	33	62	15	20	9	24	39	58	=260
6	16	19	34	61	40	57	10	23	=260
	<i>k</i>		C			D		<i>l</i>	
7	63	14	17	36	21	12	59	38	=260
8	18	35	64	13	60	37	22	11	=260
		<i>f</i>		<i>b</i>		<i>h</i>			
	260	260	260	260	260	260	260	260	

Fig. 2.—The reverse.

64	35	18	13	60	37	22	11	= 260
17	14	63	36	21	12	59	38	= 260
34	19	16	61	40	57	10	23	= 260
15	62	33	20	9	24	39	58	= 260
32	3	50	45	56	41	26	7	= 260
49	46	31	4	25	8	55	42	= 260
2	51	48	29	44	53	6	27	= 260
47	30	1	52	5	28	43	54	= 260
260	260	260	260	260	260	260	260	

These figures show the successive moves of the knight over the chess-board, every square being numbered in the order of the knight's march; so that the numbers in each vertical and horizontal column, added together, shall be equal; the sum of the eight numbers in each column being = 260.

These figures also present many other peculiarities.

1. The chess-board (see fig. 1) is divided into four equal parts by the lines *ab* and *cd*. These parts are marked A, B, C and D, and consist each of sixteen squares,—four squares in height and four in width; and if the columns of any of these parts be added up, both vertically and horizontally, each column will give the same addition, 130.

e. g. the part marked C.

33	62	15	20	130
16	19	34	61	130
63	14	17	36	130
18	35	64	13	130
130	130	130	130	

2. The figure is divided into sixteen equal parts by the lines *ab*, *ef*, *gh*, *cd*, *ij*, *kl*: each of these parts consists of four squares; and if the four numbers in the four squares which compose any one of these parts be added together, they will make 130.

<i>e. g.</i>		} = 130	or		} = 130
15	20		55	42	
34	61		26	7	

3. The figure is divided, by the vertical line *ab*, and the horizontal column 1 is also divided by the same line, into two equal parts. Each part consists of four squares, in two of which the numbers are even, and in the others odd. Take the even numbers in the left division of the column, and the odd numbers in the right division, and add them together, thus:

in column 1, $30 + 52 = 82$

in column 1, $5 + 43 = 48$

and they will make $\overline{130}$

Or take the odd numbers in the left division, $1 + 47 = 48$

and the even numbers in the right division, $28 + 54 = 82$

and they will make $\overline{130}$

This will be found the case with all the horizontal columns 1 to 8.

The figure is divided, by the horizontal line cd , and the vertical column 16 is also divided by the same line, into two equal parts. Each part consists of four squares, two of whose numbers are even and the others odd. Take the even numbers above the line cd , and add them to the odd numbers below the line, thus:

in column 16, $54 + 42 = 96$

in column 16, $23 + 11 = 34$

and they will produce $\overline{130}$

Or take the odd numbers above the line, $27 + 7 = 34$

and the even numbers below the line, $58 + 38 = 96$

and they will also produce $\overline{130}$

This will be found the case with the columns 10, 12, 13, 14, 15, 16; that is to say, all the vertical columns except Nos. 9 and 11, which are different in consequence of a peculiar movement of the knight in these columns.

Take the odd numbers in the upper half } $1 + 31 = 32$
of column 9, }
and the even numbers in the lower half } $34 + 64 = 98$
of column 11, }

and they will make $\overline{130}$

Or the even numbers in the upper half } $48 + 50 = 98$
of column 9, }
and the odd numbers in the lower half } $15 + 17 = 32$
of column 11, }

and they will make $\overline{130}$

Or the even numbers in the lower half of column 9 }
and the odd numbers in the upper half of column 11 }
Or the odd numbers in the lower half of column 9 }
and the even numbers in the upper half of column 11 }
will, added together, produce the same amount, $\overline{130}$

4. The top and bottom numbers of the same vertical column
the 2nd and 7th do. do.
the 3rd and 6th do. do.
the 4th and 5th do. do.
added together, will produce the same amount, 65.

Thus in column 16, the top No. 54 and the bottom No. 11 make 65
... 13, ... 2nd ... 44 ... 7th ... 21 ... 65
... 15, ... 3rd ... 55 ... 6th ... 10 ... 65
... 10, ... 4th ... 3 ... 5th ... 62 ... 65

But the columns 9 and 11 are different from the others in this respect, which arises from the peculiar movement of the knight in these columns already alluded to.

In these columns—

The top No. of the col. 9 and the bottom No. of the col. 11, 1 + 64 make 65
... 2nd ... 9 ... 7th ... 11, 48 + 17 ... 65
... 3rd ... 9 ... 6th ... 11, 31 + 34 ... 65
... 4th ... 9 ... 5th ... 11, 50 + 15 ... 65
or the top ... 11 ... bottom ... 9, 47 + 18 ... 65
and so with the rest.

5. It will be observed that every number in the figure is in apposition in six different ways. For example, No. 54 is
1st, in apposition in the same vertical column with } 65
No. 11, making
2nd, in conjunction with No. 28 it is in apposition } 130
with Nos. 1 and 47, making
3rd, in conjunction with No. 42 it is in apposition } 130
with Nos. 23 and 11, making
4th, in apposition with the numbers in the same sub- } 130
division 43, 6 and 27, making
5th, in apposition with Nos. 5, 28 and 43, forming a } 130
horizontal column in division B, making
6th, in apposition with Nos. 27, 42 and 7, forming a } 130
vertical column in the same division, making

6. The knight's march may be commenced at the square marked 64, in fig. 1, and so backwards, until the 64th move terminates on the square marked 1. This will produce fig. 2, which answers to the first figure in all its peculiarities.

It will be easily observed that the march can be commenced from any of the corner or rooks' squares of the board; from any of the bishops' squares, or bishops' eighths; or from either of the rooks' thirds, or rooks' sixths.

WILLIAM BEVERLEY.

9 Upper Terrace, Islington,
June 5, 1847.