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Stott

(54) **COMBINATORIAL TWISTING CUBE PUZZLES**

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(51) **Int. Cl.**
A63F 9/08 (2006.01)

(52) **U.S. Cl.** ..... **273/153 S**

(57) **ABSTRACT**

The present invention relates to n×n×n combinatorial twisting cube puzzles of the kind known as Rubik's Cube, wherein a total of $6[1]\times(n-2)+8$ cube-like blocks have $6n^2$ exposed faces [**4**], which are labelled with 6n identical or equivalent copies each of n different colours, marks, symbols, words, letters, numbers, pictures or other features. The objective of the puzzles is to rearrange the blocks so that one copy of each feature appears on every row and every column of blocks on each face of the puzzle, and no two copies of the same feature appear on any one row or column of blocks on any face of the puzzle. The absence of a more clearly defined solution provides a greater and more stimulating intellectual challenge.

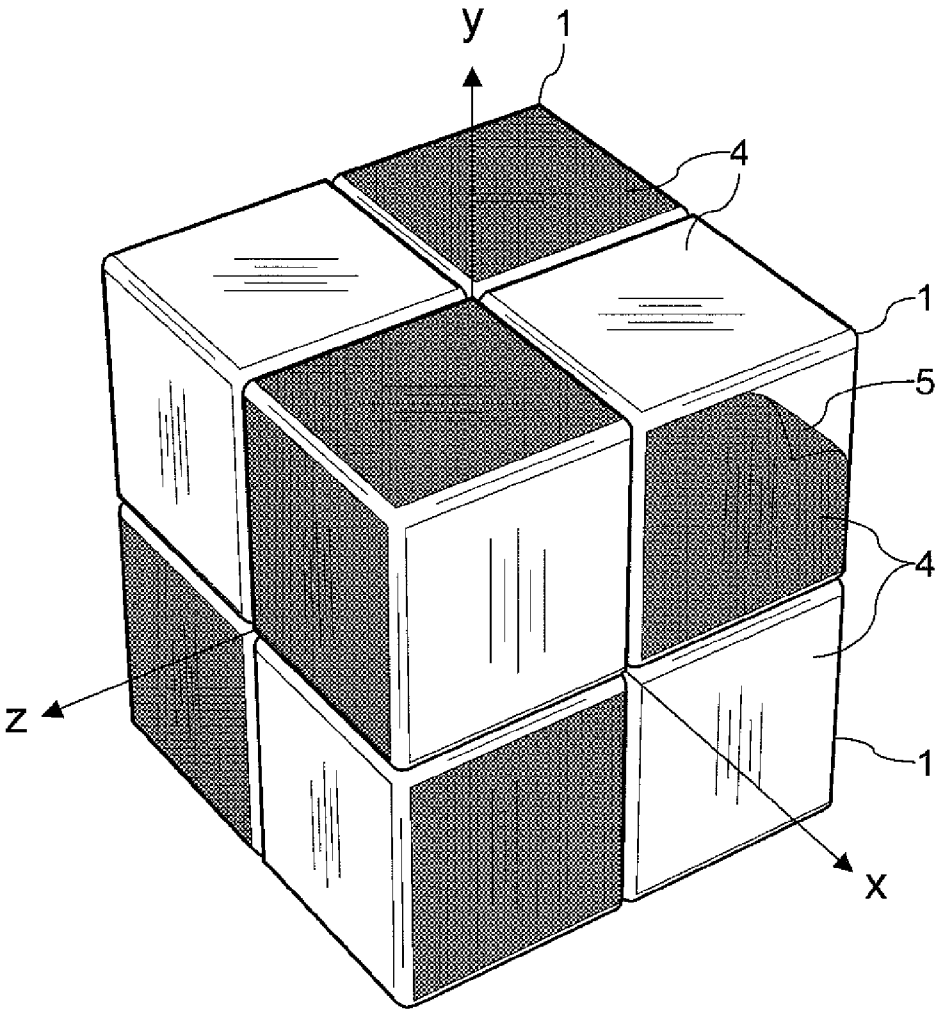
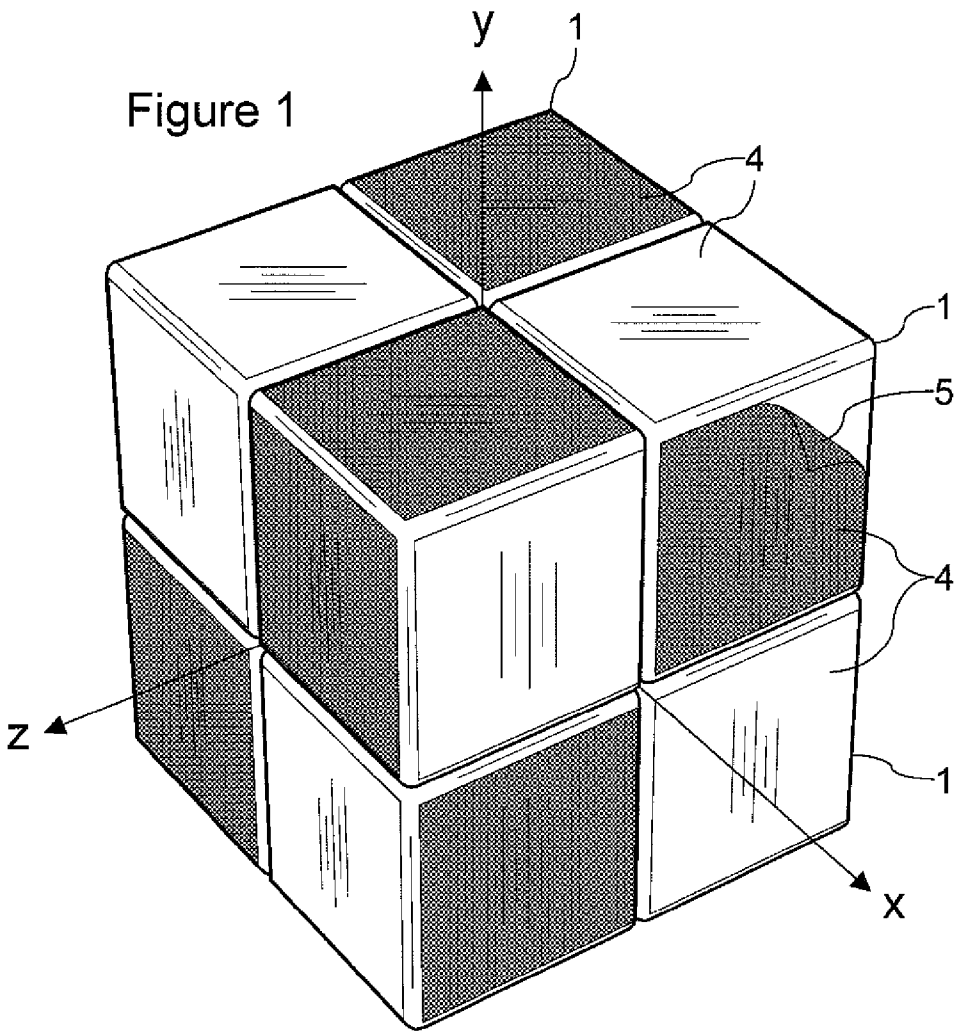


Figure 1



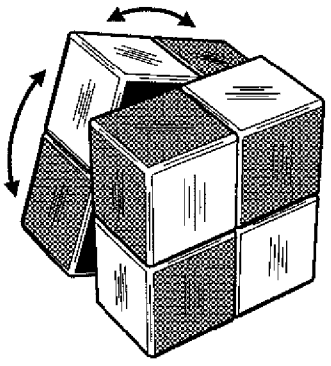


Fig 1a

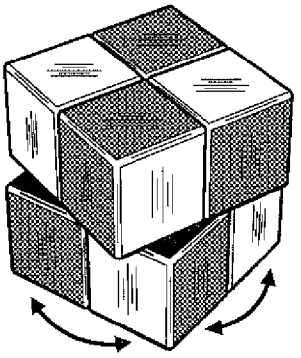


Fig 1b

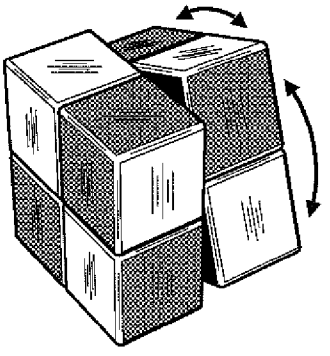


Fig 1c

Figure 2

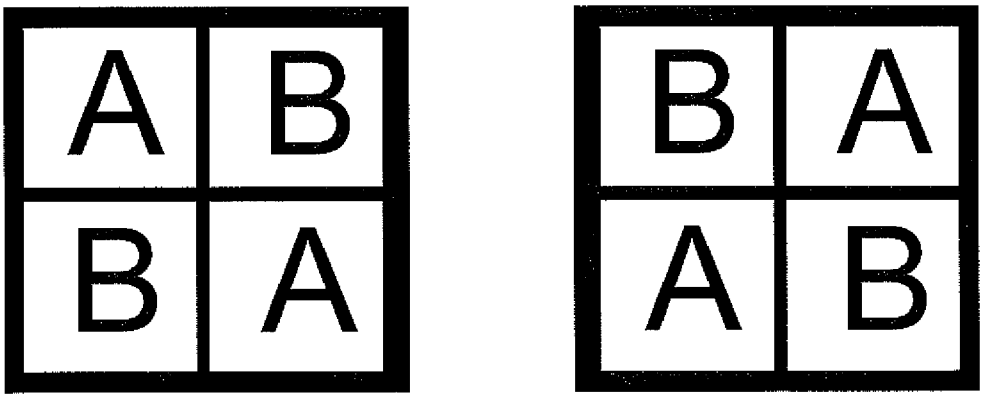


Figure 3

Config. No.	No. of corner blocks [1]				Sym.	Red.	S.D.	Sol.
	AAA	AAB	ABB	BBB				
1	2	2	2	2	8	4	0.00	12
2	1	3	3	1	8	4	1.15	24
3	0	4	4	0	8	6	2.31	18
4	4	0	0	4	8	6	2.31	2
5	0	6	0	2	0	6	2.83	4
6	2	0	6	0	0	6	2.83	4

64

Figure 4

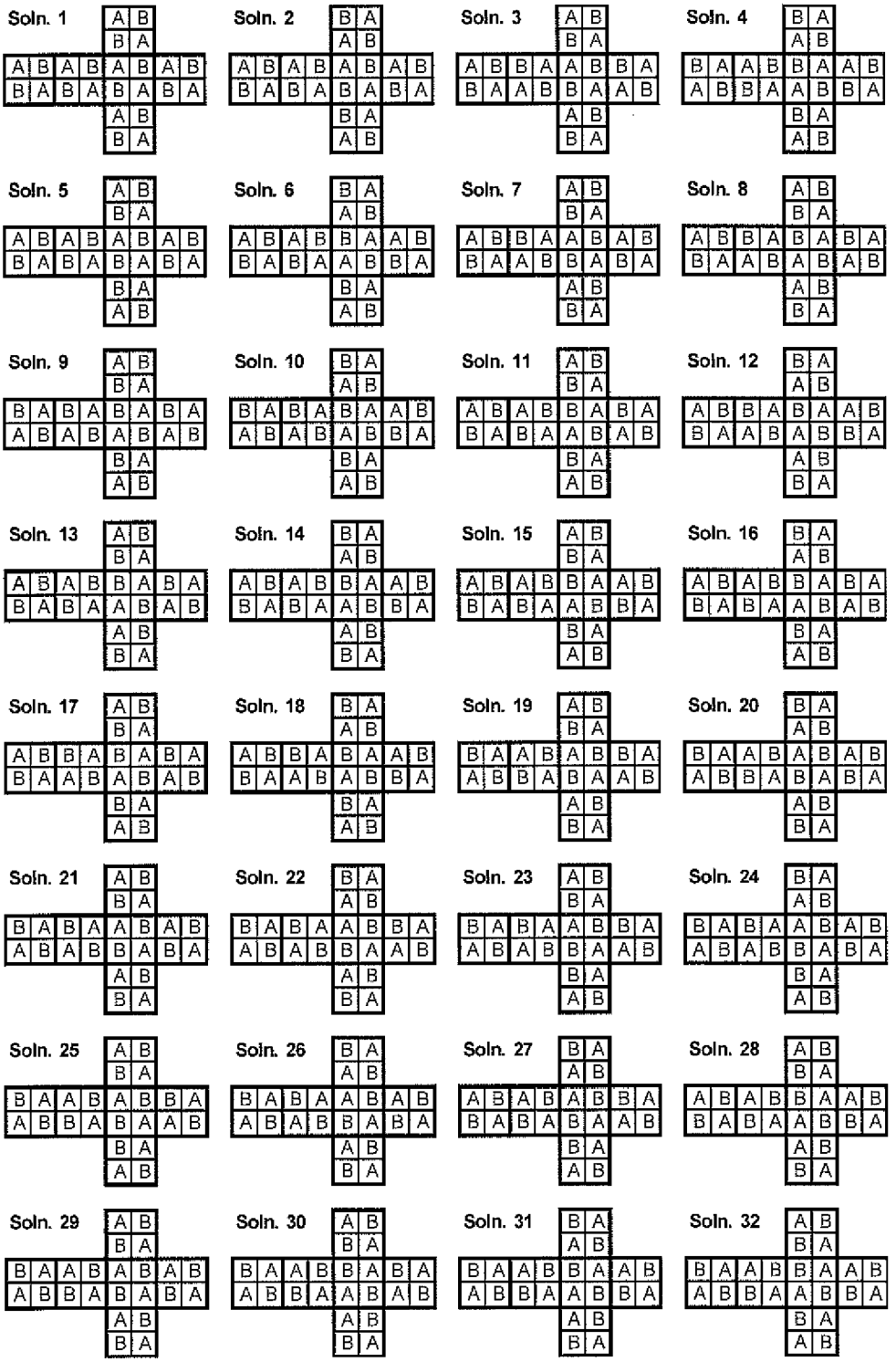

Soln. 1
Soln. 2
Soln. 3
Soln. 4
Soln. 5
Soln. 6
Soln. 7
Soln. 8
Soln. 9
Soln. 10
Soln. 11
Soln. 12
Soln. 13
Soln. 14
Soln. 15
Soln. 16
Soln. 17
Soln. 18
Soln. 19
Soln. 20
Soln. 21
Soln. 22
Soln. 23
Soln. 24
Soln. 25
Soln. 26
Soln. 27
Soln. 28
Soln. 29
Soln. 30
Soln. 31
Soln. 32

Figure 4 (continued)

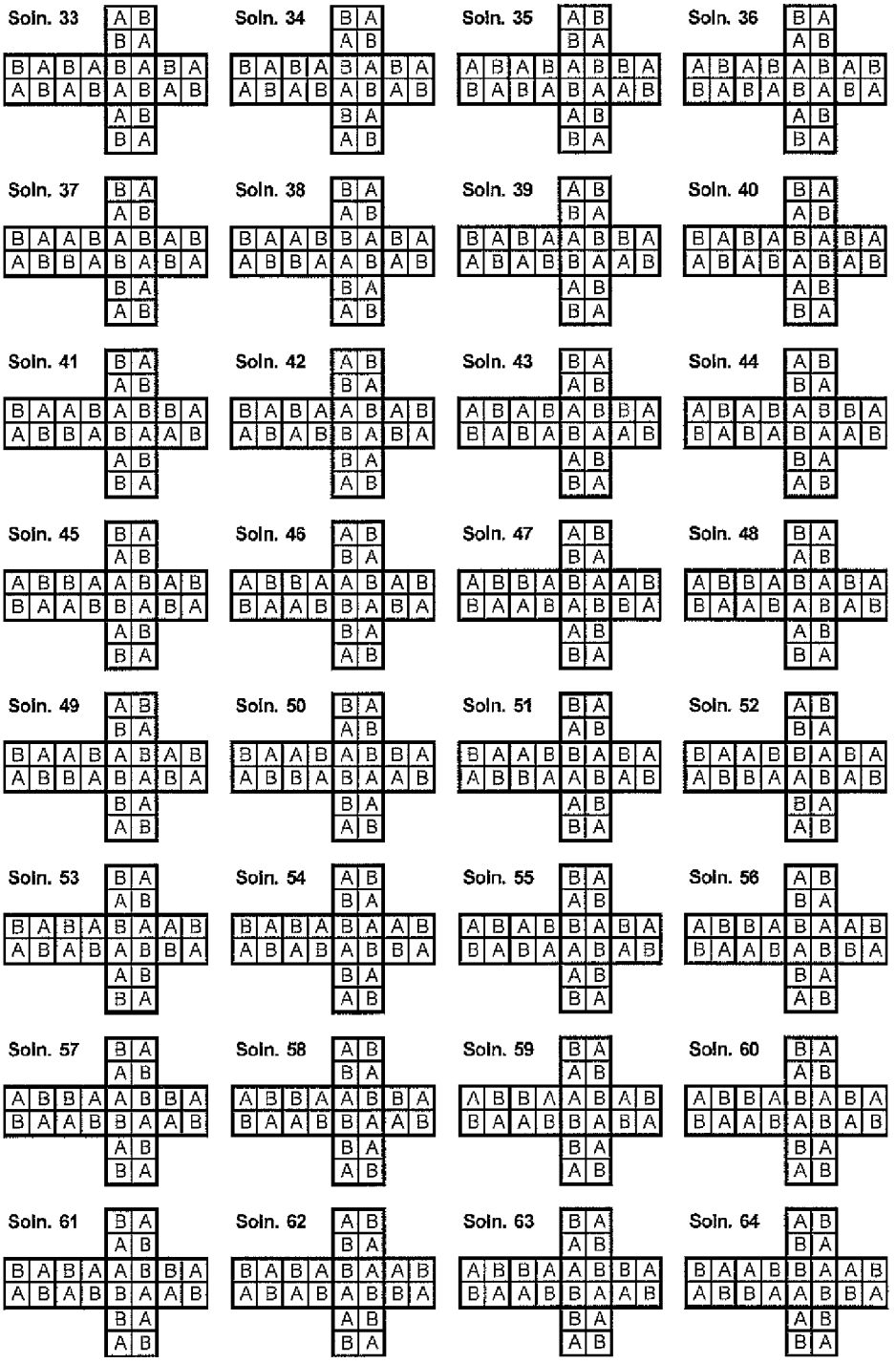


Figure 5a

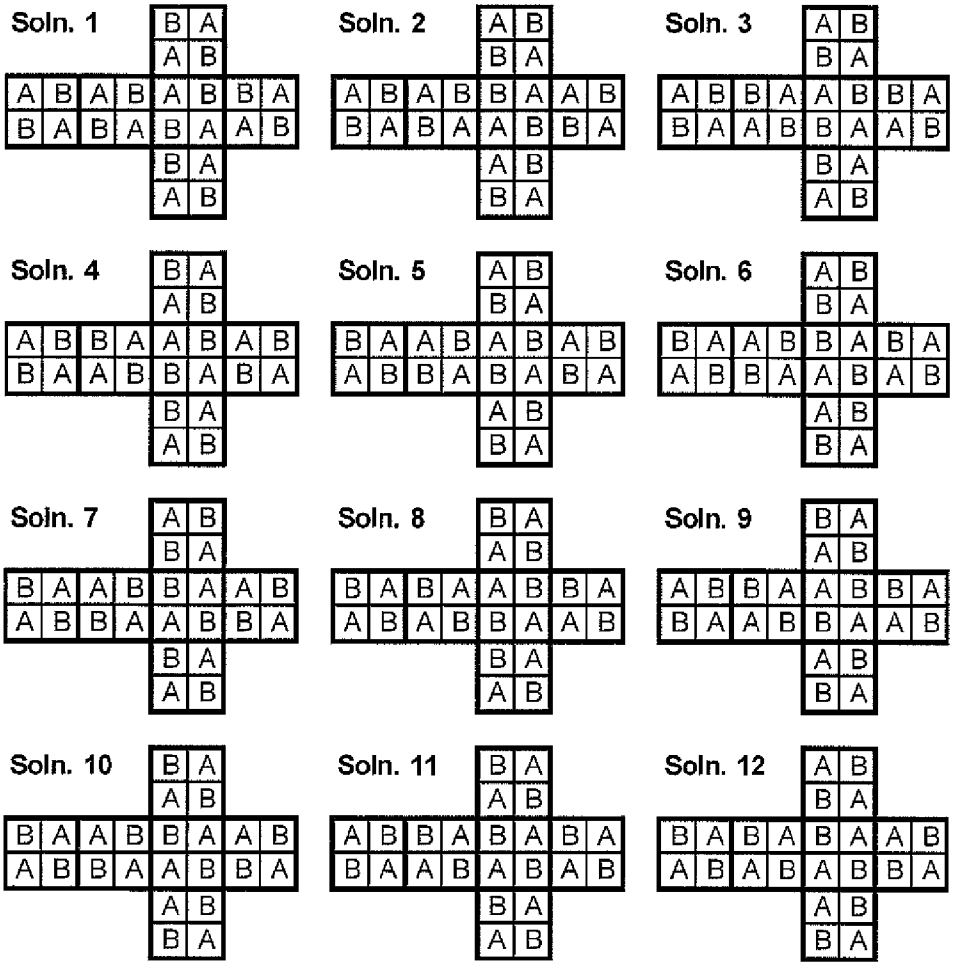


Figure 5b

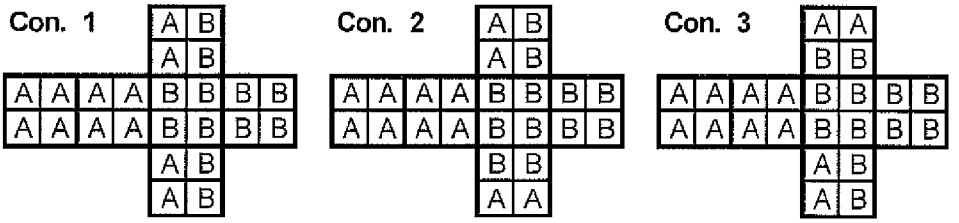


Figure 6a

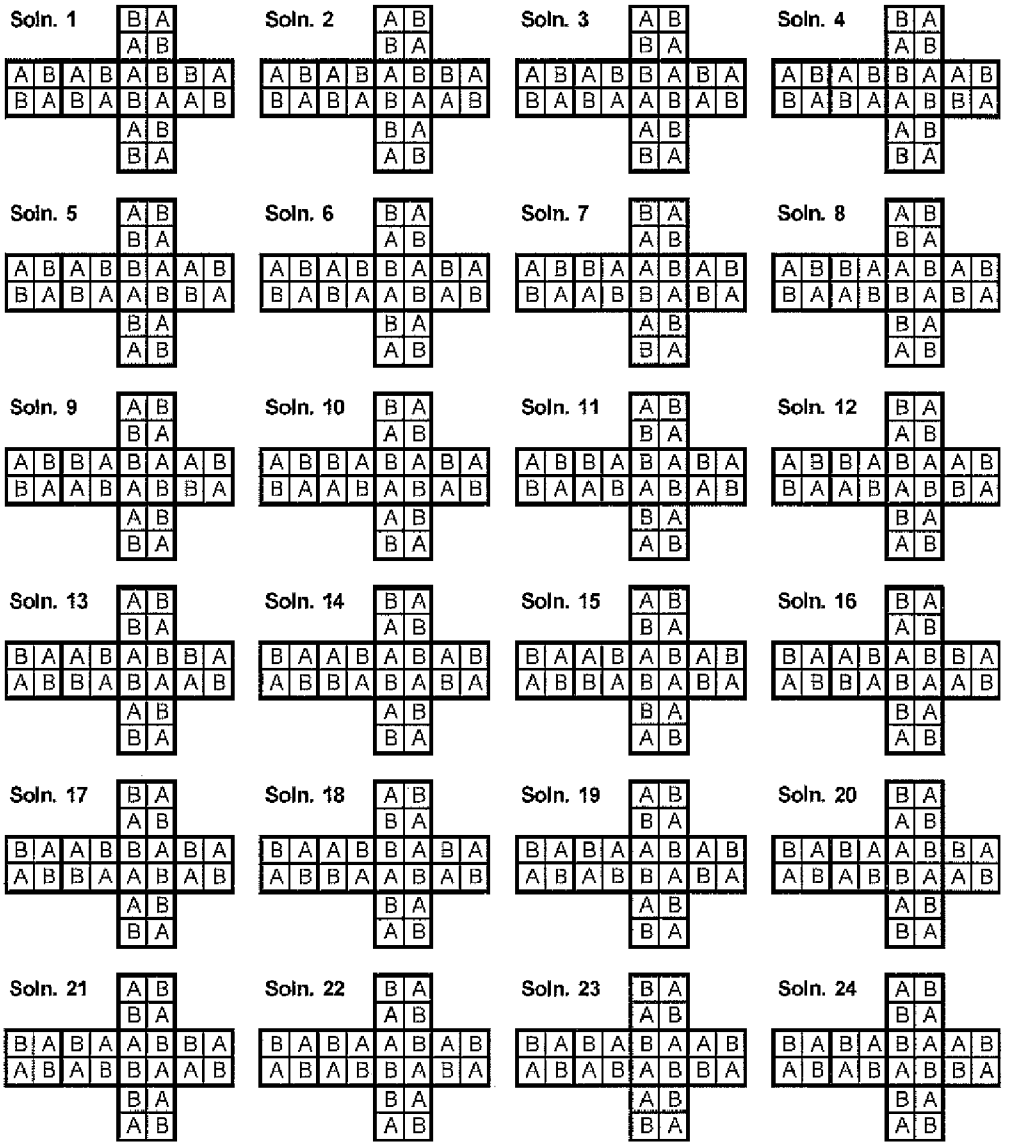


Figure 6b

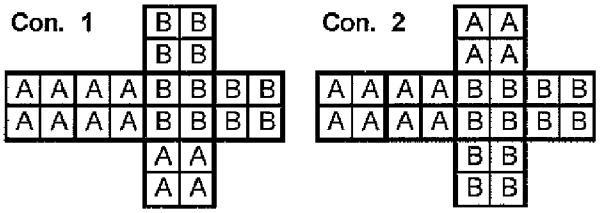


Figure 7a

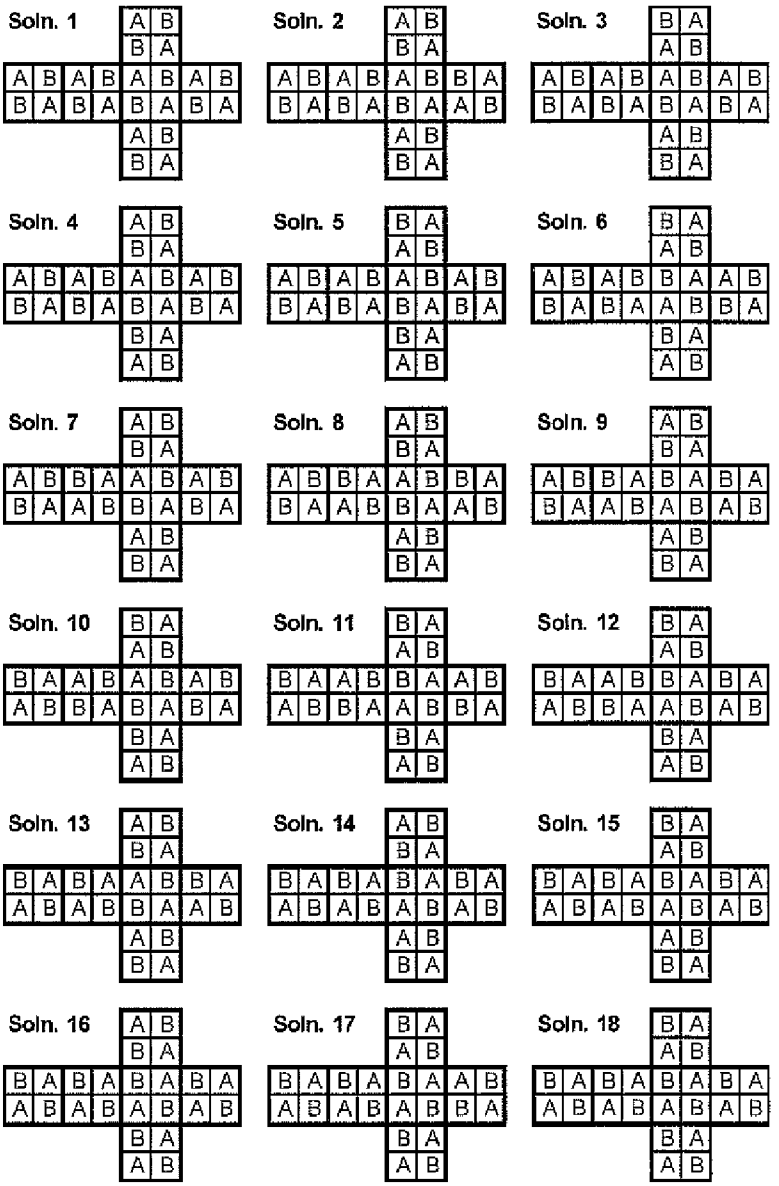


Figure 7b

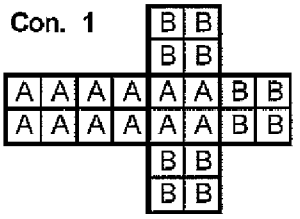


Figure 8a

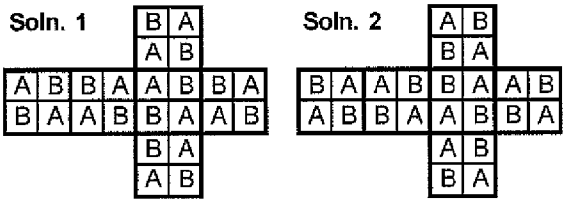


Figure 8b

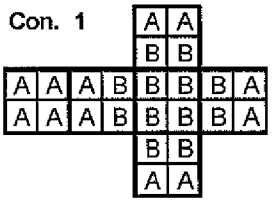


Figure 9a

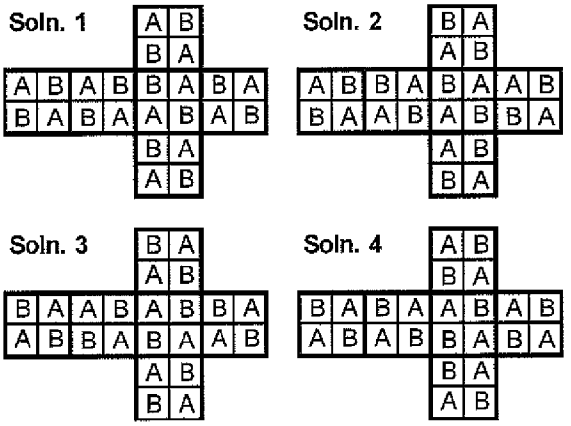


Figure 9b

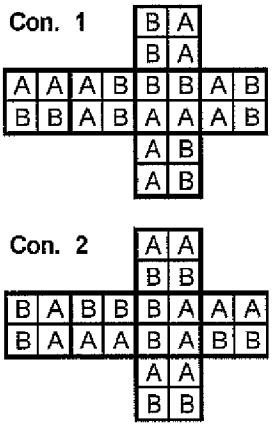


Figure 10a

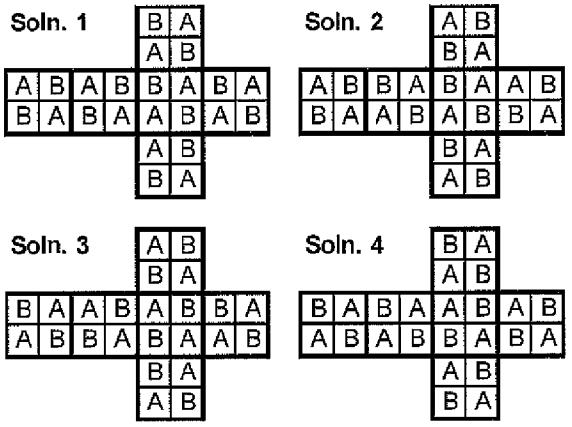


Figure 10b

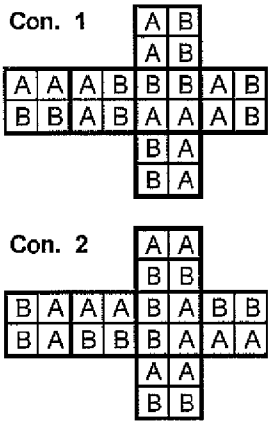


Figure 11a

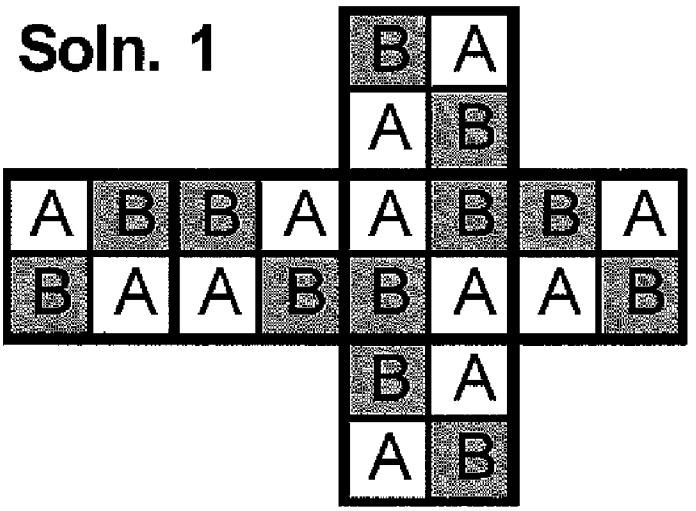


Figure 11b

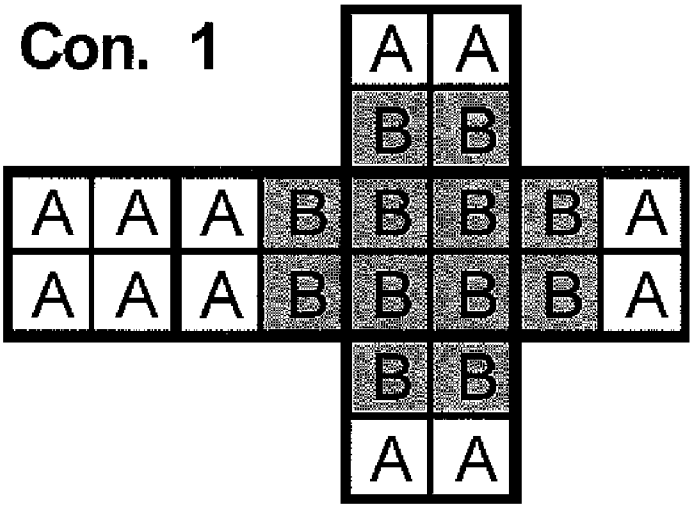


Figure 12

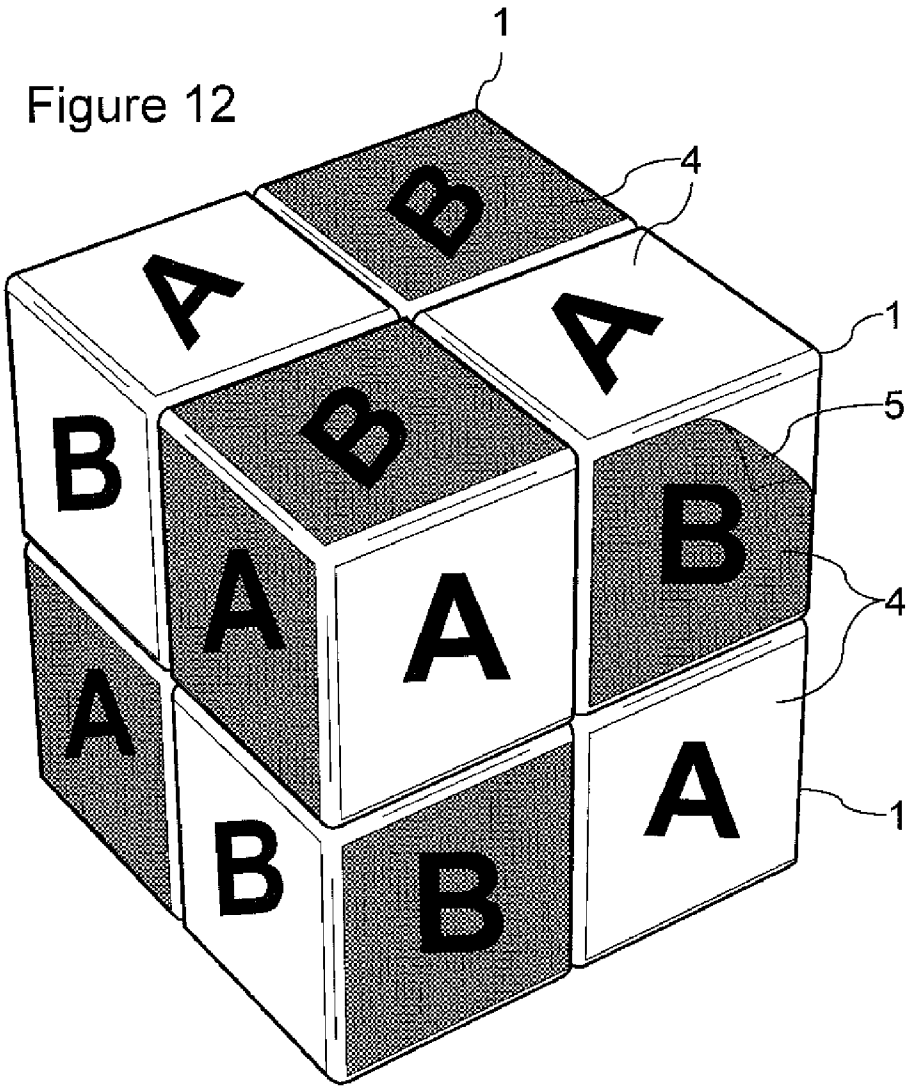
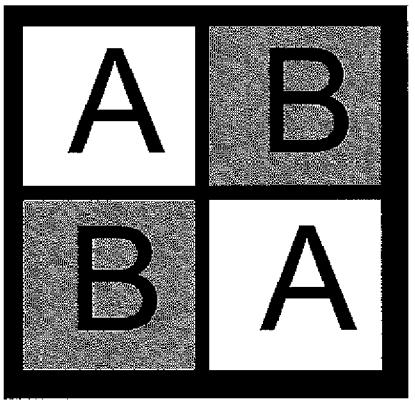
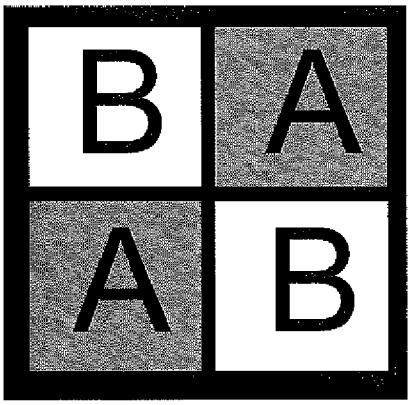
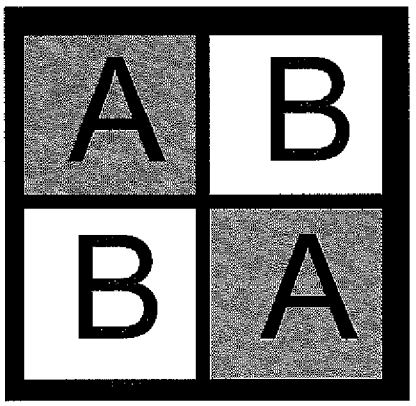


Figure 13







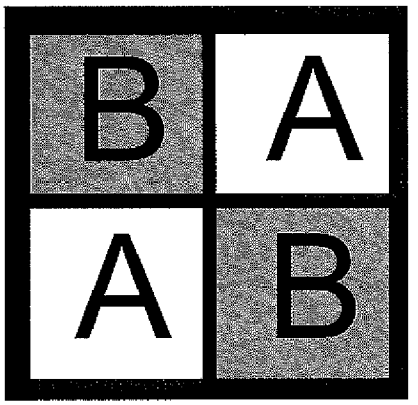


Figure 14

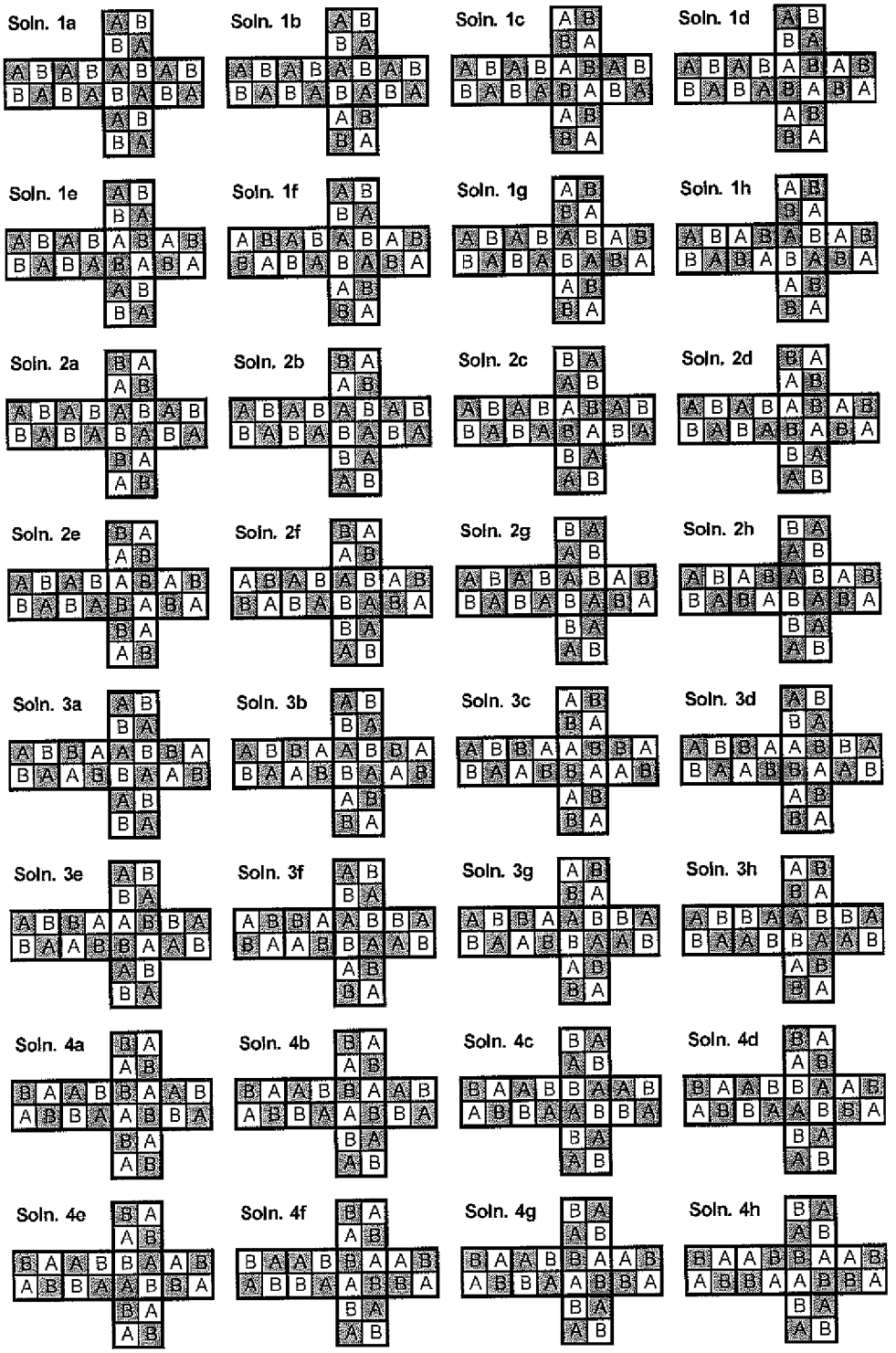

Soln. 1a
Soln. 1b
Soln. 1c
Soln. 1d
Soln. 1e
Soln. 1f
Soln. 1g
Soln. 1h
Soln. 2a
Soln. 2b
Soln. 2c
Soln. 2d
Soln. 2e
Soln. 2f
Soln. 2g
Soln. 2h
Soln. 3a
Soln. 3b
Soln. 3c
Soln. 3d
Soln. 3e
Soln. 3f
Soln. 3g
Soln. 3h
Soln. 4a
Soln. 4b
Soln. 4c
Soln. 4d
Soln. 4e
Soln. 4f
Soln. 4g
Soln. 4h

Figure 14 (continued)

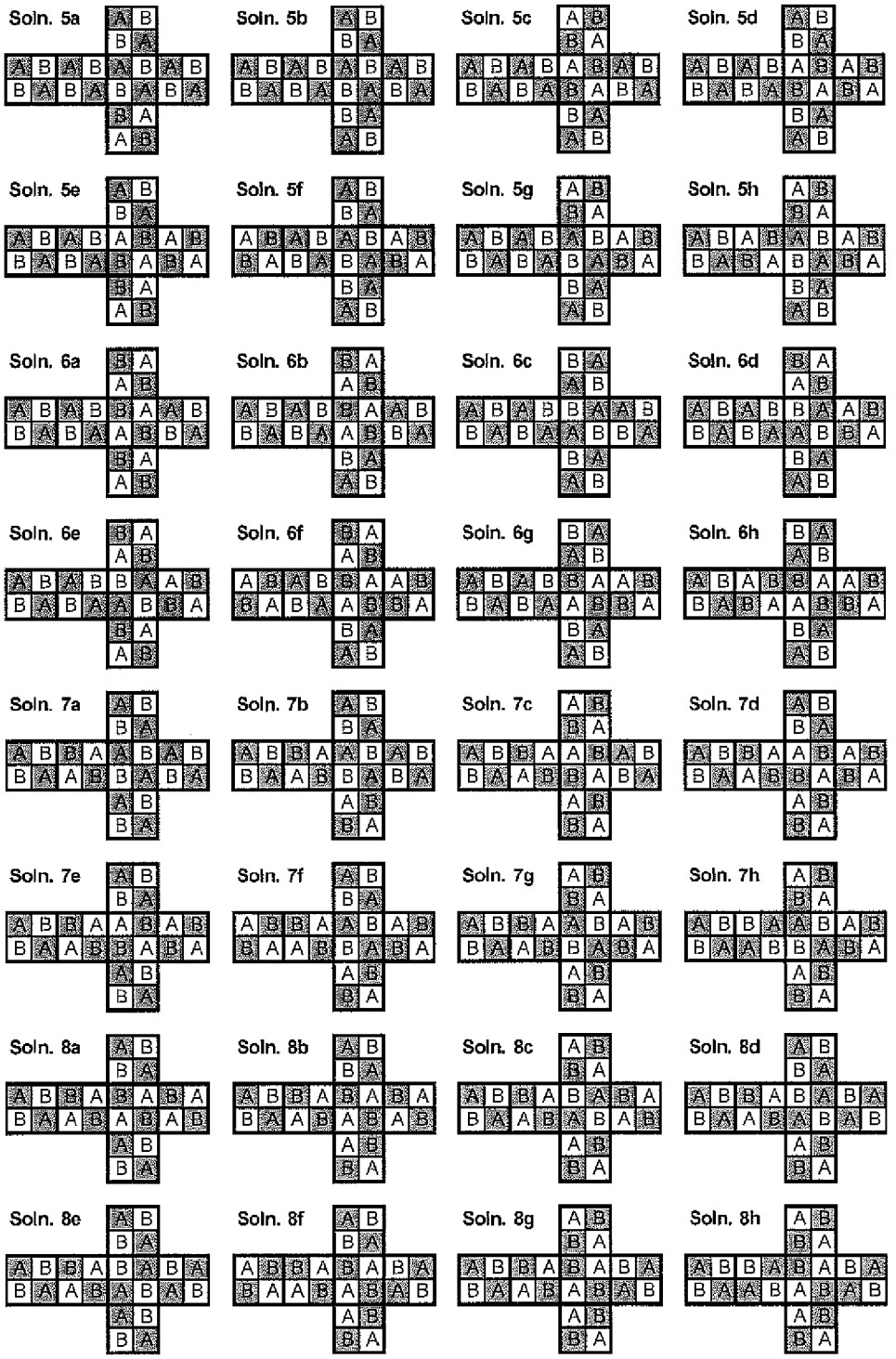
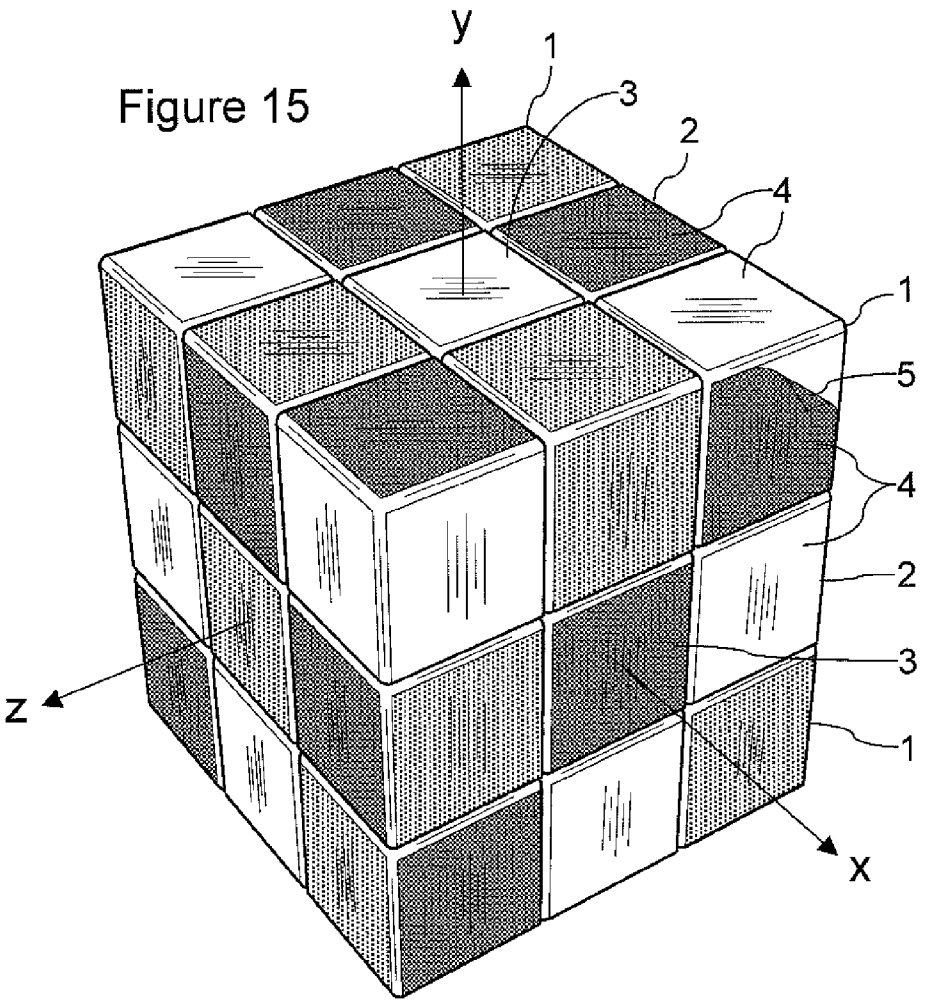


Figure 15



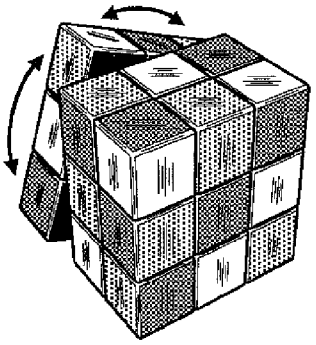


Fig 15a

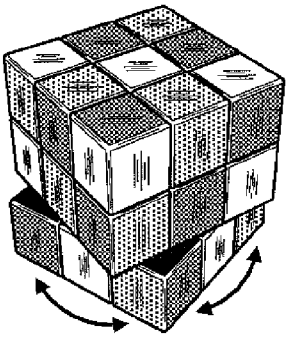


Fig 15b

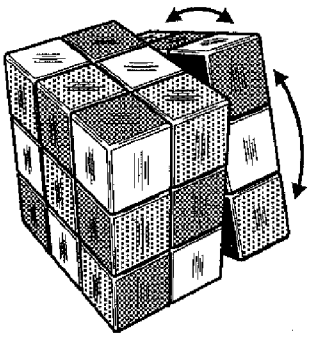


Fig 15c

Figure 16

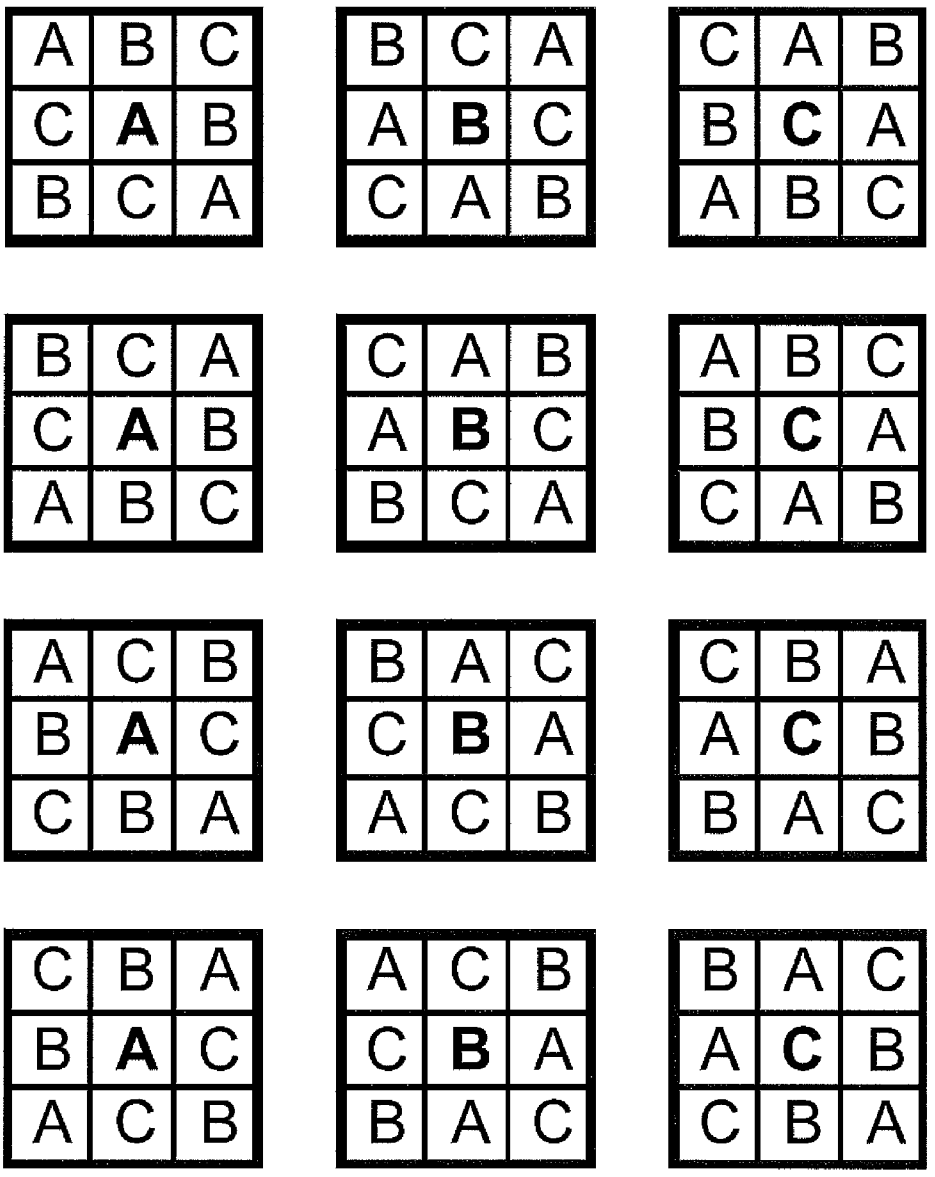

A B C
C A B
B C A
B C A
A B C
C A B
C A B
A B C
B C A
B C A
C A B
A B C
A B C
B C A
C A B
A C B
B A C
C B A
A C B
C B A
B A C
A C B
C B A
B A C
A C B
C B A
B A C
A C B
C B A
B A C
A C B

Figure 17a

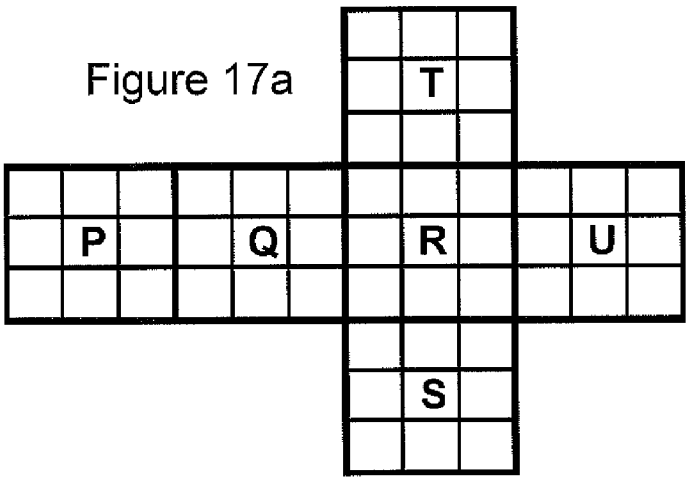


Figure 17b

Config. No.	Feature on facial block						No. blocks			Sym.	Red.	S.D.
	P	Q	R	S	T	U	A	B	C			
1	A	A	B	B	C	C	2	2	2	6	3	0.00
2	A	A	B	C	B	C	2	2	2	6	3	0.00
3	A	A	B	C	C	B	2	2	2	6	3	0.00
4	A	A	C	B	B	C	2	2	2	6	3	0.00
5	A	B	A	B	C	C	2	2	2	6	3	0.00
6	A	B	A	C	C	B	2	2	2	6	3	0.00
7	A	A	A	B	B	C	3	2	1	3	3	1.00
8	A	A	A	B	C	B	3	2	1	3	3	1.00
9	A	A	B	A	C	B	3	2	1	3	3	1.00
10	A	A	A	B	C	C	3	1	2	3	3	1.00
11	A	A	A	C	C	B	3	1	2	3	3	1.00
12	A	A	B	A	C	C	3	1	2	3	3	1.00
13	A	A	B	B	B	C	2	3	1	3	3	1.00
14	A	A	B	B	C	B	2	3	1	3	3	1.00
15	A	B	A	B	C	B	2	3	1	3	3	1.00
16	A	A	B	C	C	C	2	1	3	3	3	1.00
17	A	A	C	B	C	C	2	1	3	3	3	1.00
18	A	B	A	C	C	C	2	1	3	3	3	1.00
19	A	B	B	B	C	C	1	3	2	3	3	1.00
20	A	B	B	C	C	B	1	3	2	3	3	1.00
21	A	B	C	B	C	B	1	3	2	3	3	1.00
22	A	B	B	C	C	C	1	2	3	3	3	1.00
23	A	B	C	B	C	C	1	2	3	3	3	1.00
24	A	B	C	C	C	B	1	2	3	3	3	1.00
25	A	A	A	A	C	B	4	1	1	3	3	1.73
26	A	A	A	B	C	A	4	1	1	3	3	1.73
27	A	B	B	B	C	B	1	4	1	3	3	1.73
28	A	B	C	B	B	B	1	4	1	3	3	1.73
29	A	B	C	C	C	C	1	1	4	3	3	1.73
30	A	C	B	C	C	C	1	1	4	3	3	1.73

Config. No.	Feature on facial block						No. blocks			Sym.	Red.	S.D.
	P	Q	R	S	T	U	A	B	C			
31	A	A	A	B	B	B	3	3	0	0	4	1.73
32	A	A	B	A	B	B	3	3	0	0	4	1.73
33	A	A	A	C	C	C	3	0	3	0	4	1.73
34	A	A	C	A	C	C	3	0	3	0	4	1.73
35	B	B	B	C	C	C	0	3	3	0	4	1.73
36	B	B	C	B	C	C	0	3	3	0	4	1.73
37	A	A	A	A	B	B	4	2	0	0	4	2.00
38	A	A	A	B	B	A	4	2	0	0	4	2.00
39	A	A	A	A	C	C	4	0	2	0	4	2.00
40	A	A	A	C	C	A	4	0	2	0	4	2.00
41	A	A	B	B	B	B	2	4	0	0	4	2.00
42	A	B	A	B	B	B	2	4	0	0	4	2.00
43	A	A	C	C	C	C	2	0	4	0	4	2.00
44	A	C	A	C	C	C	2	0	4	0	4	2.00
45	B	B	B	B	C	C	0	4	2	0	4	2.00
46	B	B	B	C	C	B	0	4	2	0	4	2.00
47	B	B	C	C	C	C	0	2	4	0	4	2.00
48	B	C	B	C	C	C	0	2	4	0	4	2.00
49	A	A	A	A	B	A	5	1	0	0	4	2.65
50	A	A	A	A	C	A	5	0	1	0	4	2.65
51	A	B	B	B	B	B	1	5	0	0	4	2.65
52	A	C	C	C	C	C	1	0	5	0	4	2.65
53	B	B	B	B	C	B	0	5	1	0	4	2.65
54	B	C	C	C	C	C	0	1	5	0	4	2.65
55	A	A	A	A	A	A	6	0	0	0	5	3.46
56	B	B	B	B	B	B	0	6	0	0	5	3.46
57	C	C	C	C	C	C	0	0	6	0	5	3.46

Figure 18

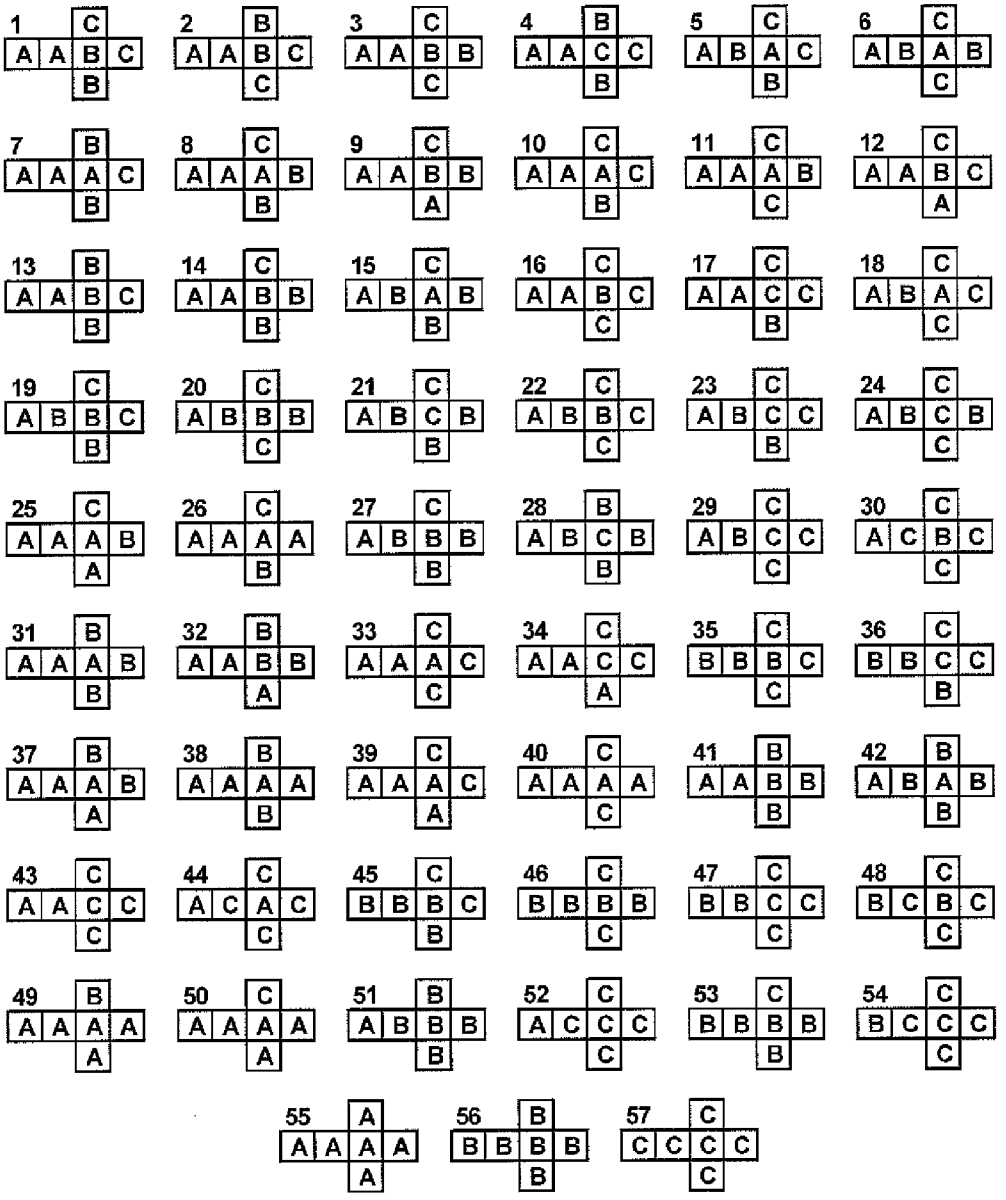

1 C A A B C B
2 B A A B C C
3 C A A B B C
4 B A A C C B
5 C A B A C B
6 C A B A B C
7 B A A A C B
8 C A A A B B
9 C A A B B A
10 C A A A C B
11 C A A A B C
12 C A A B C A
13 B A A B C B
14 C A A B B B
15 C A B A B B
16 C A A B C C
17 C A A C C B
18 C A B A C C
19 C A B B C B
20 C A B B B C
21 C A B C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

Figure 19

Config.	Number of corner blocks [1]											Number of edge blocks [2]						Facial blocks			Sym.	Red.	S.D.	Sol.
No.	ABCc	ABCa	AAB	AAC	BBA	BBC	CCA	CCB	AAA	BBB	CCC	AB	BC	CA	AA	BB	CC	A	B	C				
1	1	1	1	1	1	1	1	1	0	0	0	2	2	2	2	2	2	2	2	2	26	9	0.73	5
2	1	1	1	1	1	1	1	1	0	0	0	3	3	3	1	1	1	2	2	2	26	9	0.92	19
3	1	1	0	1	1	0	0	1	1	1	1	3	3	3	1	1	1	2	2	2	26	9	0.92	1
4	1	1	1	0	0	1	1	0	1	1	1	3	3	3	1	1	1	2	2	2	26	9	0.92	1
5	1	1	1	1	1	1	1	1	0	0	0	1	1	1	3	3	3	2	2	2	26	9	0.92	1
6	1	1	0	2	2	0	0	2	0	0	0	1	1	1	3	3	3	2	2	2	26	12	1.08	1
7	1	1	2	0	0	2	2	0	0	0	0	1	1	1	3	3	3	2	2	2	26	12	1.08	1
8	1	1	1	1	1	1	1	1	0	0	0	4	4	4	0	0	0	2	2	2	26	12	1.34	10
9	1	1	0	2	2	0	0	2	0	0	0	4	4	4	0	0	0	2	2	2	26	15	1.45	4
10	1	1	2	0	0	2	2	0	0	0	0	4	4	4	0	0	0	2	2	2	26	15	1.45	4
11	4	4	0	0	0	0	0	0	0	0	0	4	4	4	0	0	0	2	2	2	26	18	1.75	1
12	0	2	1	1	1	1	1	1	0	0	0	3	3	3	1	1	1	2	2	2	24	10	0.98	3
13	2	0	1	1	1	1	1	1	0	0	0	3	3	3	1	1	1	2	2	2	24	10	0.98	3
14	0	0	1	1	2	1	2	1	0	0	0	2	2	2	2	2	2	2	2	2	24	11	0.86	2
15	0	0	1	2	1	2	1	1	0	0	0	2	2	2	2	2	2	2	2	2	24	11	0.86	2
16	0	0	2	1	1	1	1	2	0	0	0	2	2	2	2	2	2	2	2	2	24	11	0.86	2
17	0	0	1	1	2	1	2	1	0	0	0	3	3	3	1	1	1	2	2	2	24	11	1.03	4
18	0	0	1	2	1	2	1	1	0	0	0	3	3	3	1	1	1	2	2	2	24	11	1.03	4
19	0	0	2	1	1	1	1	2	0	0	0	3	3	3	1	1	1	2	2	2	24	11	1.03	4
20	0	2	0	2	2	0	0	2	0	0	0	2	2	2	2	2	2	2	2	2	24	13	0.98	3
21	2	0	2	0	0	2	2	0	0	0	0	2	2	2	2	2	2	2	2	2	24	13	0.98	3
22	2	0	0	2	2	0	0	2	0	0	0	3	3	3	1	1	1	2	2	2	24	13	1.13	3
23	0	2	2	0	0	2	2	0	0	0	0	3	3	3	1	1	1	2	2	2	24	13	1.13	3
24	0	0	1	1	2	1	2	1	0	0	0	4	4	4	0	0	0	2	2	2	24	14	1.42	2
25	0	0	1	2	1	2	1	1	0	0	0	4	4	4	0	0	0	2	2	2	24	14	1.42	2
26	0	0	2	1	1	1	1	2	0	0	0	4	4	4	0	0	0	2	2	2	24	14	1.42	2
27	1	1	1	1	1	1	1	1	0	0	0	1	1	3	2	3	2	2	2	2	23	9	0.86	2
28	1	1	1	1	1	1	1	1	0	0	0	3	1	1	2	2	3	2	2	2	23	9	0.86	2
29	1	1	1	1	1	1	1	1	0	0	0	1	3	1	3	2	2	2	2	2	23	9	0.86	2
30	1	1	1	1	1	1	1	1	0	0	0	2	2	4	1	2	1	2	2	2	23	9	0.92	6
31	1	1	1	1	1	1	1	1	0	0	0	4	2	2	1	1	2	2	2	2	23	9	0.92	6
32	1	1	1	1	1	1	1	1	0	0	0	2	4	2	2	1	1	2	2	2	23	9	0.92	6
33	1	1	0	2	1	0	1	1	0	1	0	2	2	2	2	2	2	2	2	2	23	10	0.80	1
34	1	1	1	1	0	1	2	0	0	1	0	2	2	2	2	2	2	2	2	2	23	10	0.80	1
35	1	1	1	1	2	0	0	1	0	0	1	2	2	2	2	2	2	2	2	2	23	10	0.80	1
36	1	1	2	0	1	1	1	0	0	0	1	2	2	2	2	2	2	2	2	2	23	10	0.80	1
37	1	1	0	1	1	1	0	2	1	0	0	2	2	2	2	2	2	2	2	2	23	10	0.80	1
38	1	1	1	0	0	2	1	1	1	0	0	2	2	2	2	2	2	2	2	2	23	10	0.80	1
39	1	1	0	2	1	0	1	1	0	1	0	3	3	3	1	1	1	2	2	2	23	10	0.98	1
40	1	1	1	1	0	1	2	0	0	1	0	3	3	3	1	1	1	2	2	2	23	10	0.98	1
41	1	1	1	1	2	0	0	1	0	0	1	3	3	3	1	1	1	2	2	2	23	10	0.98	1
42	1	1	2	0	1	1	1	0	0	0	1	3	3	3	1	1	1	2	2	2	23	10	0.98	1
43	1	1	0	1	1	1	0	2	1	0	0	3	3	3	1	1	1	2	2	2	23	10	0.98	1
44	1	1	1	0	0	2	1	1	1	0	0	3	3	3	1	1	1	2	2	2	23	10	0.98	1
45	1	2	0	1	2	0	1	1	0	0	0	2	2	2	2	2	2	2	2	2	23	11	0.86	2
46	1	2	0	2	1	1	0	1	0	0	0	2	2	2	2	2	2	2	2	2	23	11	0.86	2
47	2	1	1	0	1	1	2	0	0	0	0	2	2	2	2	2	2	2	2	2	23	11	0.86	2
48	2	1	1	1	0	2	1	0	0	0	0	2	2	2	2	2	2	2	2	2	23	11	0.86	2
49	1	2	1	1	1	0	0	2	0	0	0	2	2	2	2	2	2	2	2	2	23	11	0.86	2
50	2	1	2	0	0	1	1	1	0	0	0	2	2	2	2	2	2	2	2	2	23	11	0.86	2
51	2	1	0	1	2	0	1	1	0	0	0	3	3	3	1	1	1	2	2	2	23	11	1.03	2
52	2	1	0	2	1	1	0	1	0	0	0	3	3	3	1	1	1	2	2	2	23	11	1.03	2
53	1	2	1	0	1	1	2	0	0	0	0	3	3	3	1	1	1	2	2	2	23	11	1.03	2
54	1	2	1	1	0	2	1	0	0	0	0	3	3	3	1	1	1	2	2	2	23	11	1.03	2
55	2	1	1	1	1	0	0	2	0	0	0	3	3	3	1	1	1	2	2	2	23	11	1.03	2
56	1	2	2	0	0	1	1	1	0	0	0	3	3	3	1	1	1	2	2	2	23	11	1.03	2
57	1	2	0	1	2	0	1	1	0	0	0	3	3	3	1	1	1	2	2	2	23	11	1.03	1
58	1	2	0	2	1	1	0	1	0	0	0	3	3	3	1	1	1	2	2	2	23	11	1.03	1
59	2	1	1	0	1	1	2	0	0	0	0	3	3	3	1	1	1	2	2	2	23	11	1.03	1
60	2	1	1	1	0	2	1	0	0	0	0	3	3	3	1	1	1	2	2	2	23	11	1.03	1
61	1	2	1	1	1	0	0	2	0	0	0	3	3	3	1	1	1	2	2	2	23	11	1.03	1
62	2	1	2	0	0	1	1	1	0	0	0	3	3	3	1	1	1	2	2	2	23	11	1.03	1
63	1	1	1	1	1	1	1	1	0	0	0	3	3	5	0	1	0	2	2	2	23	11	1.26	8
64	1	1	1	1	1	1	1	1	0	0	0	5	3	3	0	0	1	2	2	2	23	11	1.26	8
65	1	1	1	1	1	1	1	1	0	0	0	3	5	3	1	0	0	2	2	2	23	11	1.26	8

Figure 19 (continued)

Config.	Number of corner blocks [1]								Number of edge blocks [2]							Facial blocks			Sym.	Red.	S.D.	Sol.
No.	ABCc	ABCa	AAB	AAC	BBA	BBC	CCA	CCB	AAA	BBB	CCC	AB	BC	CA	AA	BB	CC	A	B	C				
66	1	1	0	0	0	0	0	0	2	2	2	1	1	3	2	3	2	2	2	2	23	12	1.03	1
67	1	1	0	0	0	0	0	0	2	2	2	3	1	1	2	2	3	2	2	2	23	12	1.03	1
68	1	1	0	0	0	0	0	0	2	2	2	1	3	1	3	2	2	2	2	2	23	12	1.03	1
69	4	1	0	1	1	0	0	1	0	0	0	3	3	3	1	1	1	2	2	2	23	12	1.22	5
70	1	4	1	0	0	1	1	0	0	0	0	3	3	3	1	1	1	2	2	2	23	12	1.22	5
71	1	1	0	2	2	0	0	2	0	0	0	3	3	5	0	1	0	2	2	2	23	14	1.38	2
72	1	1	2	0	0	2	2	0	0	0	0	3	3	5	0	1	0	2	2	2	23	14	1.38	2
73	1	1	0	2	2	0	0	2	0	0	0	5	3	3	0	0	1	2	2	2	23	14	1.38	2
74	1	1	2	0	0	2	2	0	0	0	0	5	3	3	0	0	1	2	2	2	23	14	1.38	2
75	1	1	0	2	2	0	0	2	0	0	0	3	5	3	1	0	0	2	2	2	23	14	1.38	2
76	1	1	2	0	0	2	2	0	0	0	0	3	5	3	1	0	0	2	2	2	23	14	1.38	2
77	4	4	0	0	0	0	0	0	0	0	0	2	2	4	1	2	1	2	2	2	23	15	1.45	1
78	4	4	0	0	0	0	0	0	0	0	0	4	2	2	1	1	2	2	2	2	23	15	1.45	1
79	4	4	0	0	0	0	0	0	0	0	0	2	4	2	2	1	1	2	2	2	23	15	1.45	1
80	2	2	0	1	1	1	1	0	0	0	0	2	2	2	2	2	2	2	2	2	22	11	0.86	2
81	2	2	1	0	1	0	1	1	0	0	0	2	2	2	2	2	2	2	2	2	22	11	0.86	2
82	2	2	1	1	0	1	0	1	0	0	0	2	2	2	2	2	2	2	2	2	22	11	0.86	2
83	2	2	0	1	1	1	1	0	0	0	0	3	3	3	1	1	1	2	2	2	22	11	1.03	2
84	2	2	1	0	1	0	1	1	0	0	0	3	3	3	1	1	1	2	2	2	22	11	1.03	2
85	2	2	1	1	0	1	0	1	0	0	0	3	3	3	1	1	1	2	2	2	22	11	1.03	2
86	2	2	1	1	0	0	0	0	0	1	1	3	3	3	1	1	1	2	2	2	22	11	1.03	2
87	2	2	0	0	0	0	1	1	1	1	0	3	3	3	1	1	1	2	2	2	22	11	1.03	2
88	2	2	0	0	1	1	0	0	1	0	1	3	3	3	1	1	1	2	2	2	22	11	1.03	2
89	2	3	0	1	0	0	1	0	0	1	0	3	3	3	1	1	1	2	2	2	22	12	1.13	1
90	3	2	0	1	0	0	1	0	0	1	0	3	3	3	1	1	1	2	2	2	22	12	1.13	1
91	2	3	1	0	1	0	0	0	0	0	1	3	3	3	1	1	1	2	2	2	22	12	1.13	1
92	3	2	1	0	1	0	0	0	0	0	1	3	3	3	1	1	1	2	2	2	22	12	1.13	1
93	2	3	0	0	0	1	0	1	1	0	0	3	3	3	1	1	1	2	2	2	22	12	1.13	1
94	3	2	0	0	0	1	0	1	1	0	0	3	3	3	1	1	1	2	2	2	22	12	1.13	1
95	2	2	0	0	2	0	2	0	0	0	0	2	2	2	2	2	2	2	2	2	22	13	0.98	1
96	2	2	0	2	0	2	0	0	0	0	0	2	2	2	2	2	2	2	2	2	22	13	0.98	1
97	2	2	2	0	0	0	0	2	0	0	0	2	2	2	2	2	2	2	2	2	22	13	0.98	1
98	2	2	0	0	2	0	2	0	0	0	0	3	3	3	1	1	1	2	2	2	22	13	1.13	1
99	2	2	0	2	0	2	0	0	0	0	0	3	3	3	1	1	1	2	2	2	22	13	1.13	1
100	2	2	2	0	0	0	0	2	0	0	0	3	3	3	1	1	1	2	2	2	22	13	1.13	1
101	2	4	0	0	1	0	1	0	0	0	0	2	2	2	2	2	2	2	2	2	22	13	1.13	1
102	4	2	0	0	1	0	1	0	0	0	0	2	2	2	2	2	2	2	2	2	22	13	1.13	1
103	2	4	0	1	0	1	0	0	0	0	0	2	2	2	2	2	2	2	2	2	22	13	1.13	1
104	4	2	0	1	0	1	0	0	0	0	0	2	2	2	2	2	2	2	2	2	22	13	1.13	1
105	2	4	1	0	0	0	0	1	0	0	0	2	2	2	2	2	2	2	2	2	22	13	1.13	1
106	4	2	1	0	0	0	0	1	0	0	0	2	2	2	2	2	2	2	2	2	22	13	1.13	1
107	2	2	0	1	1	1	1	0	0	0	0	4	4	4	0	0	0	2	2	2	22	14	1.42	5
108	2	2	1	0	1	0	1	1	0	0	0	4	4	4	0	0	0	2	2	2	22	14	1.42	5
109	2	2	1	1	0	1	0	1	0	0	0	4	4	4	0	0	0	2	2	2	22	14	1.42	5
110	0	1	0	1	1	1	1	0	1	1	1	2	2	2	2	2	2	2	2	2	21	9	0.73	1
111	1	0	0	1	1	1	1	0	1	1	1	2	2	2	2	2	2	2	2	2	21	9	0.73	1
112	0	1	1	0	1	0	1	1	1	1	1	2	2	2	2	2	2	2	2	2	21	9	0.73	1
113	1	0	1	0	1	0	1	1	1	1	1	2	2	2	2	2	2	2	2	2	21	9	0.73	1
114	0	1	1	1	0	1	0	1	1	1	1	2	2	2	2	2	2	2	2	2	21	9	0.73	1
115	1	0	1	1	0	1	0	1	1	1	1	2	2	2	2	2	2	2	2	2	21	9	0.73	1
116	1	0	1	1	1	0	2	1	0	1	0	2	2	2	2	2	2	2	2	2	21	10	0.80	3
117	0	1	1	1	2	1	1	0	0	0	1	2	2	2	2	2	2	2	2	2	21	10	0.80	3
118	0	1	1	2	0	1	1	1	0	1	0	2	2	2	2	2	2	2	2	2	21	10	0.80	3
119	1	0	2	1	1	1	0	1	0	0	1	2	2	2	2	2	2	2	2	2	21	10	0.80	3
120	1	0	0	1	1	2	1	1	1	0	0	2	2	2	2	2	2	2	2	2	21	10	0.80	3
121	0	1	1	0	1	1	1	2	1	0	0	2	2	2	2	2	2	2	2	2	21	10	0.80	3
122	0	1	1	1	1	0	2	1	0	1	0	2	2	2	2	2	2	2	2	2	21	10	0.80	2
123	1	0	1	1	2	1	1	0	0	0	1	2	2	2	2	2	2	2	2	2	21	10	0.80	2
124	1	0	1	2	0	1	1	1	0	1	0	2	2	2	2	2	2	2	2	2	21	10	0.80	2
125	0	1	2	1	1	1	0	1	0	0	1	2	2	2	2	2	2	2	2	2	21	10	0.80	2
126	0	1	0	1	1	2	1	1	1	0	0	2	2	2	2	2	2	2	2	2	21	10	0.80	2
127	1	0	1	0	1	1	1	2	1	0	0	2	2	2	2	2	2	2	2	2	21	10	0.80	2
128	1	0	1	2	1	0	0	1	0	1	1	2	2	2	2	2	2	2	2	2	21	10	0.80	1
129	0	1	2	1	0	1	1	0	0	1	1	2	2	2	2	2	2	2	2	2	21	10	0.80	1
130	1	0	0	1	1	0	1	2	1	1	0	2	2	2	2	2	2	2	2	2	21	10	0.80	1

Figure 20a

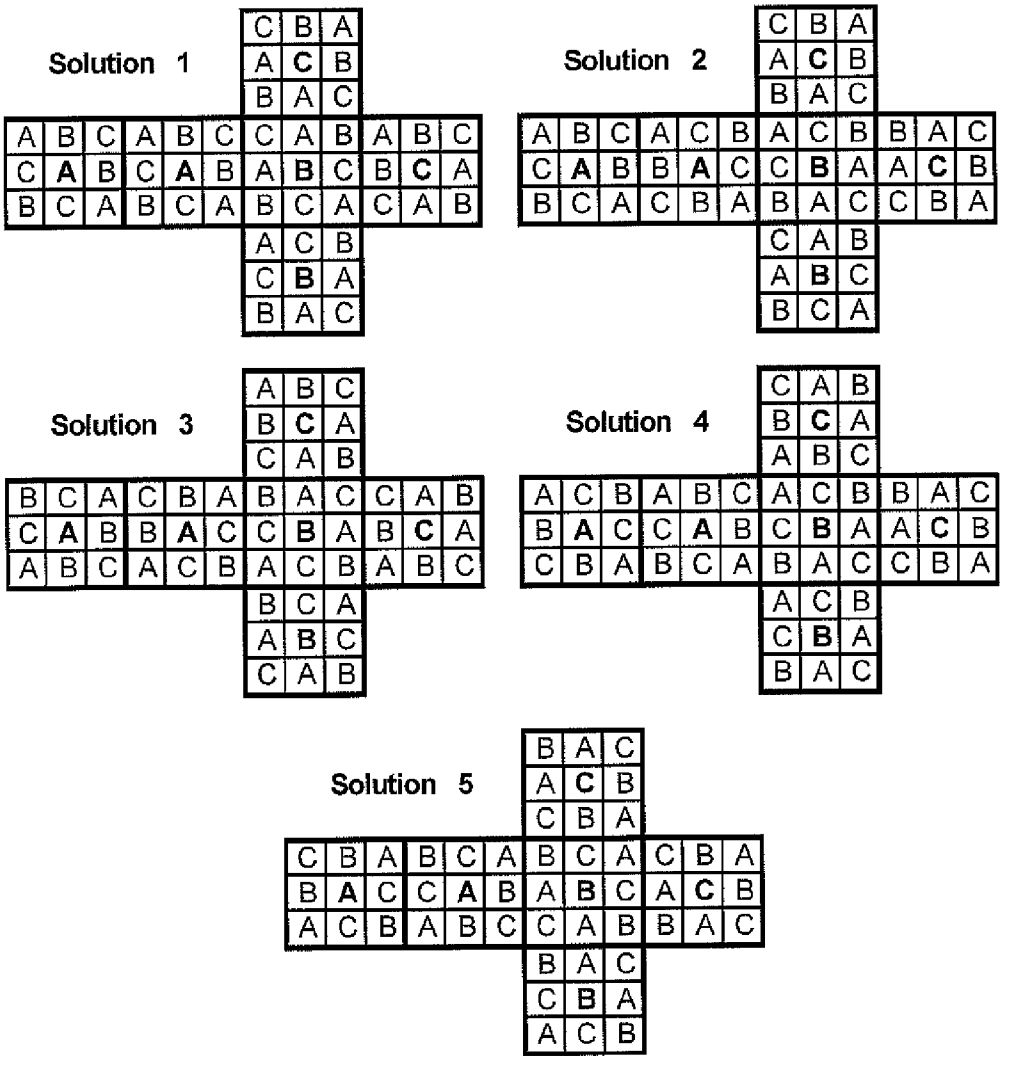


Figure 20b

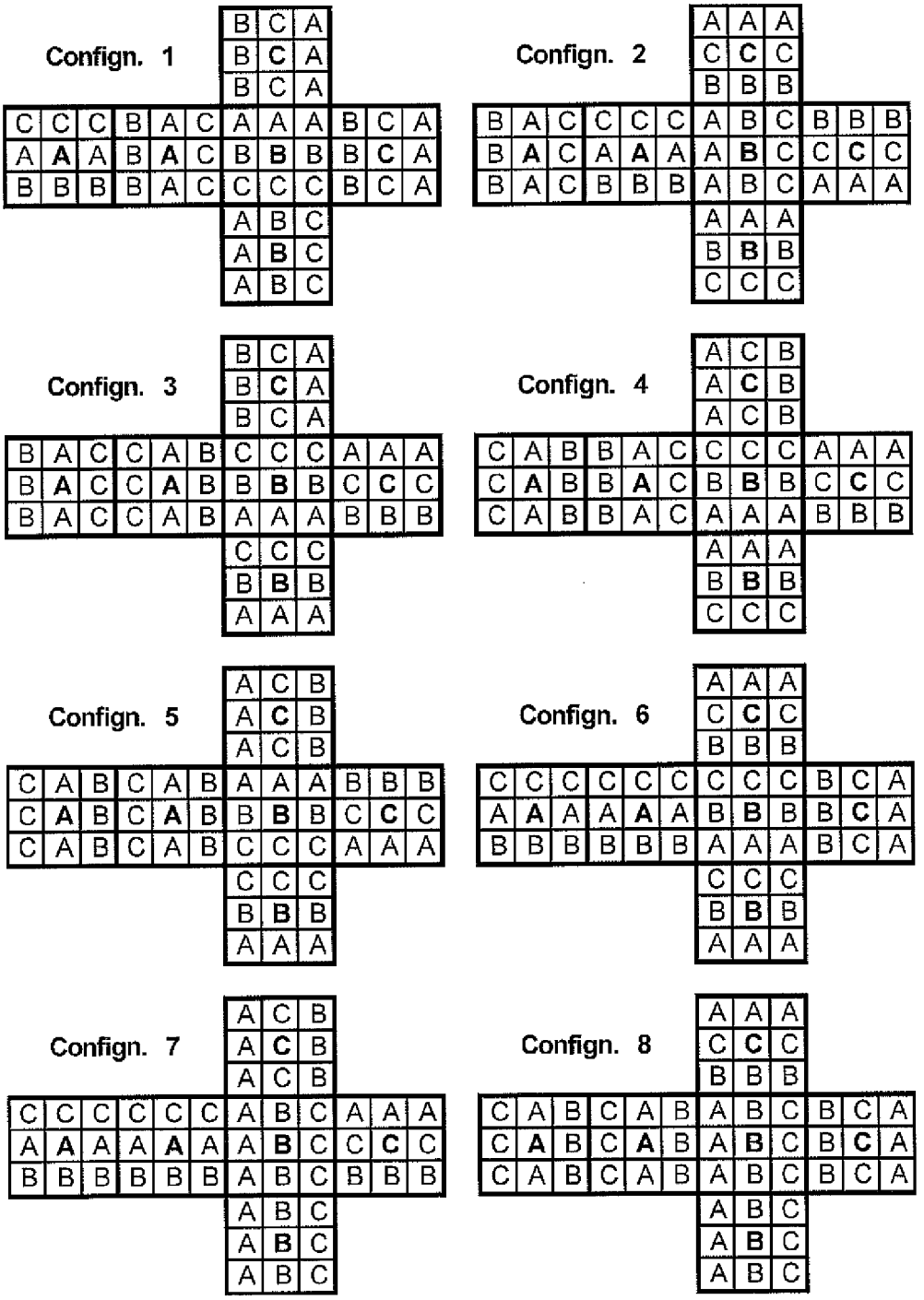

Confign. 1
Confign. 2
Confign. 3
Confign. 4
Confign. 5
Confign. 6
Confign. 7
Confign. 8

Figure 20b (continued)

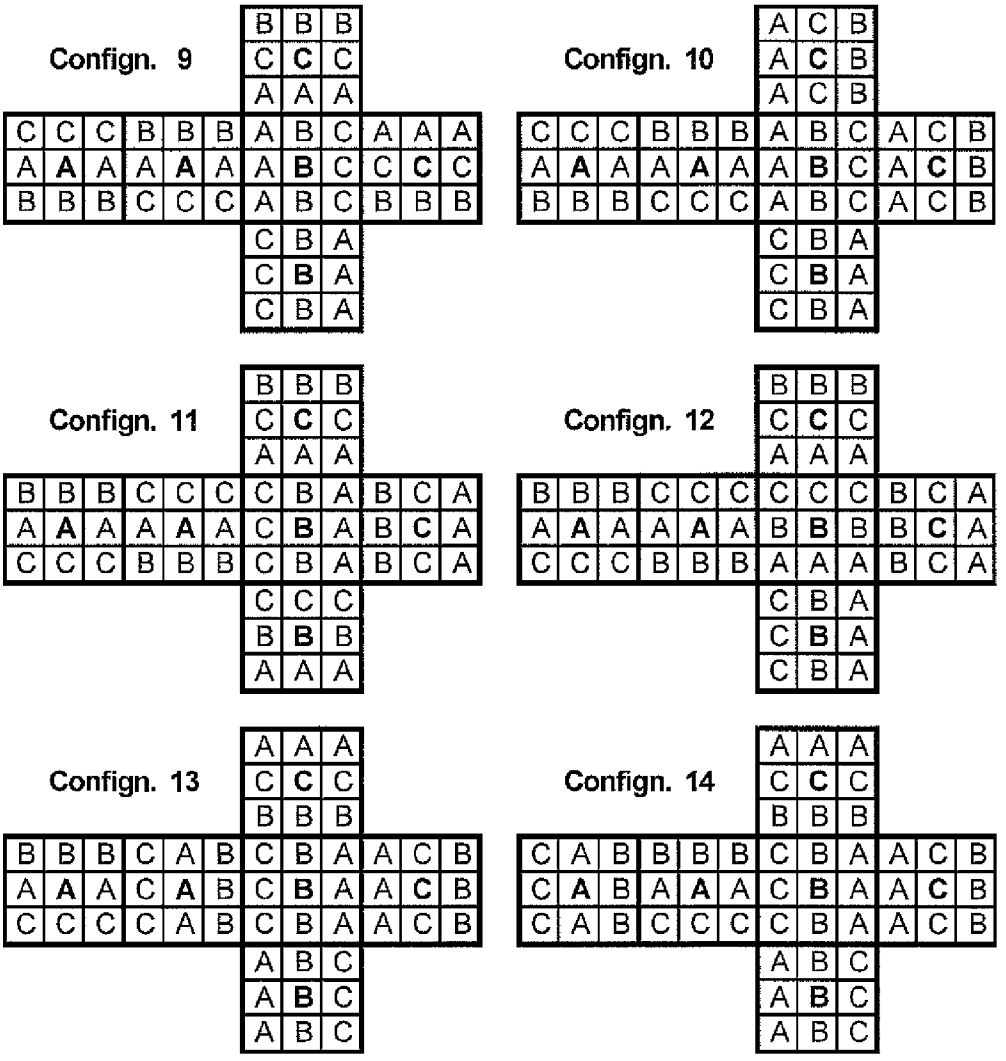


Figure 21a

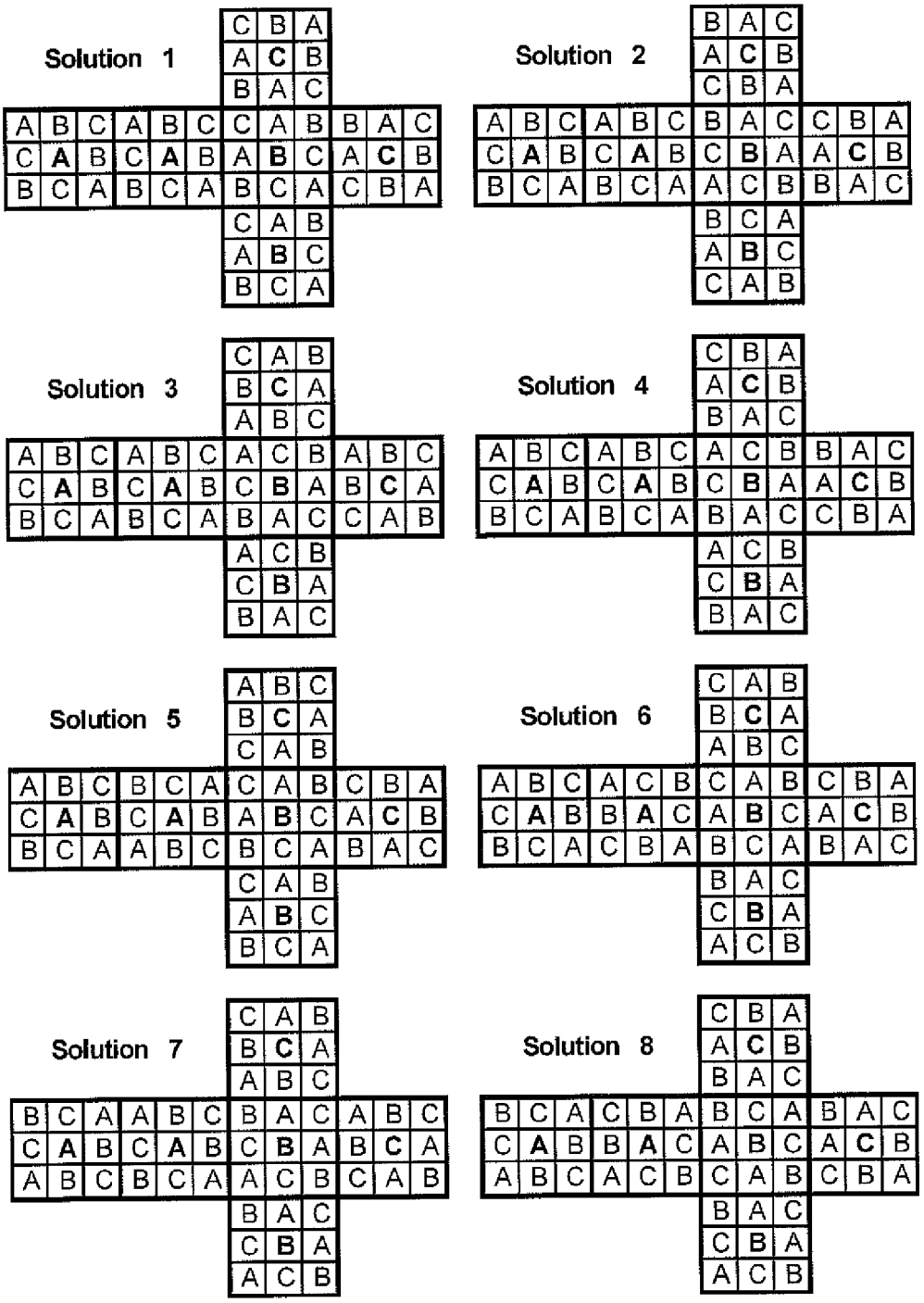

Solution 1
Solution 2
Solution 3
Solution 4
Solution 5
Solution 6
Solution 7
Solution 8

Figure 21a (continued)

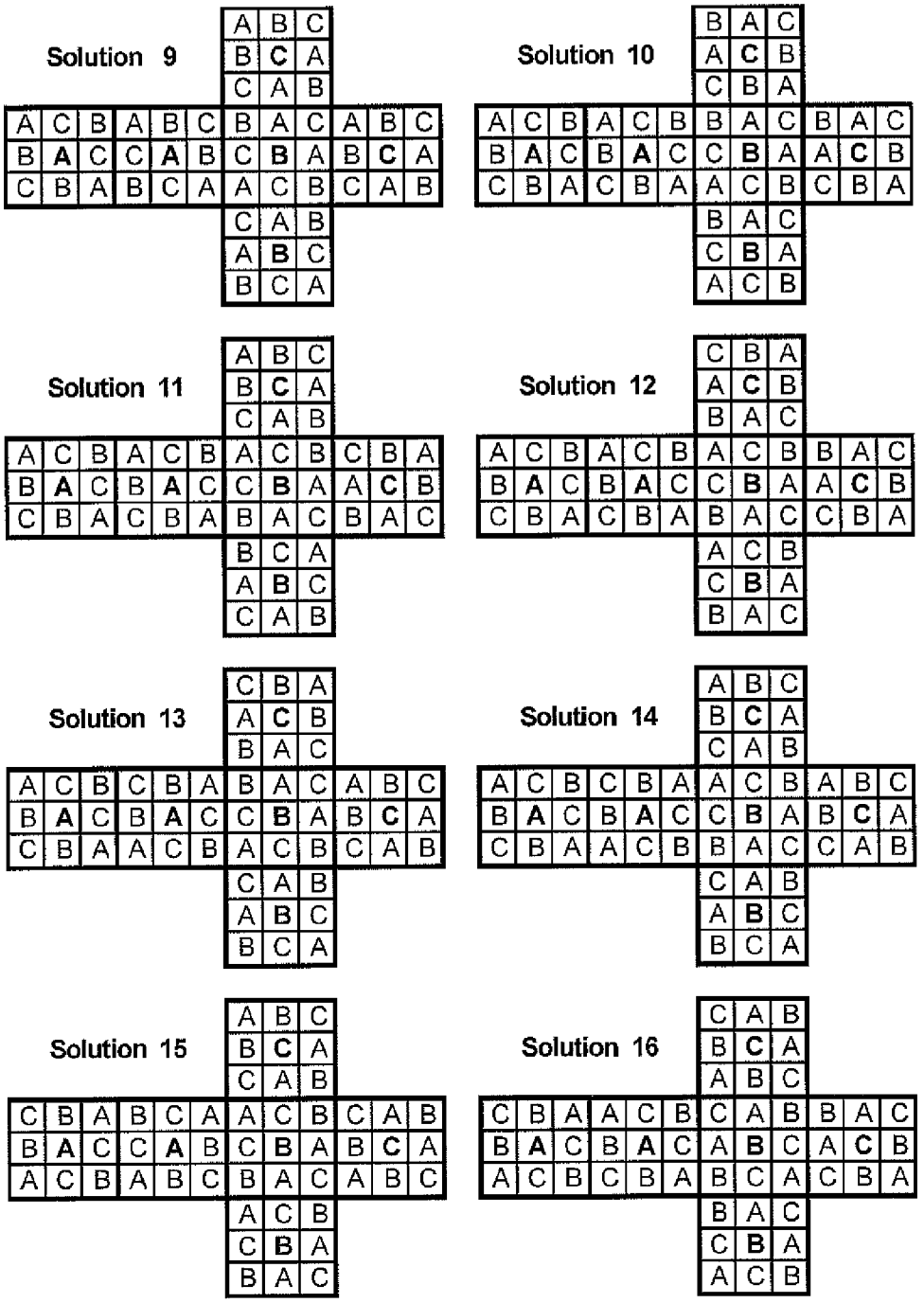


Figure 21a (continued)

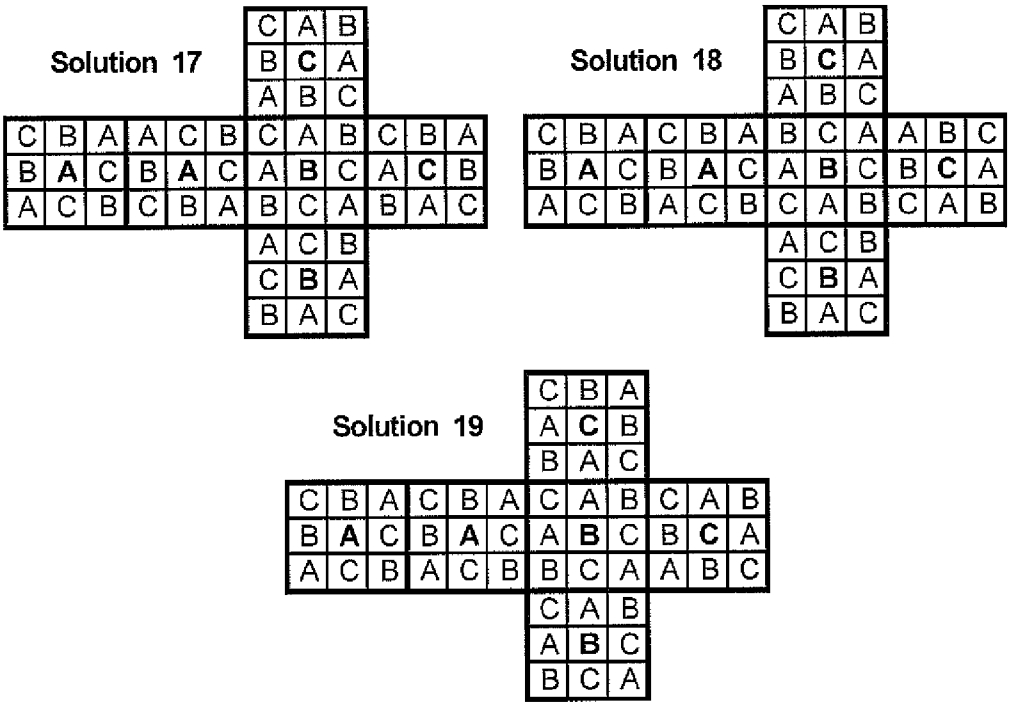


Figure 21b

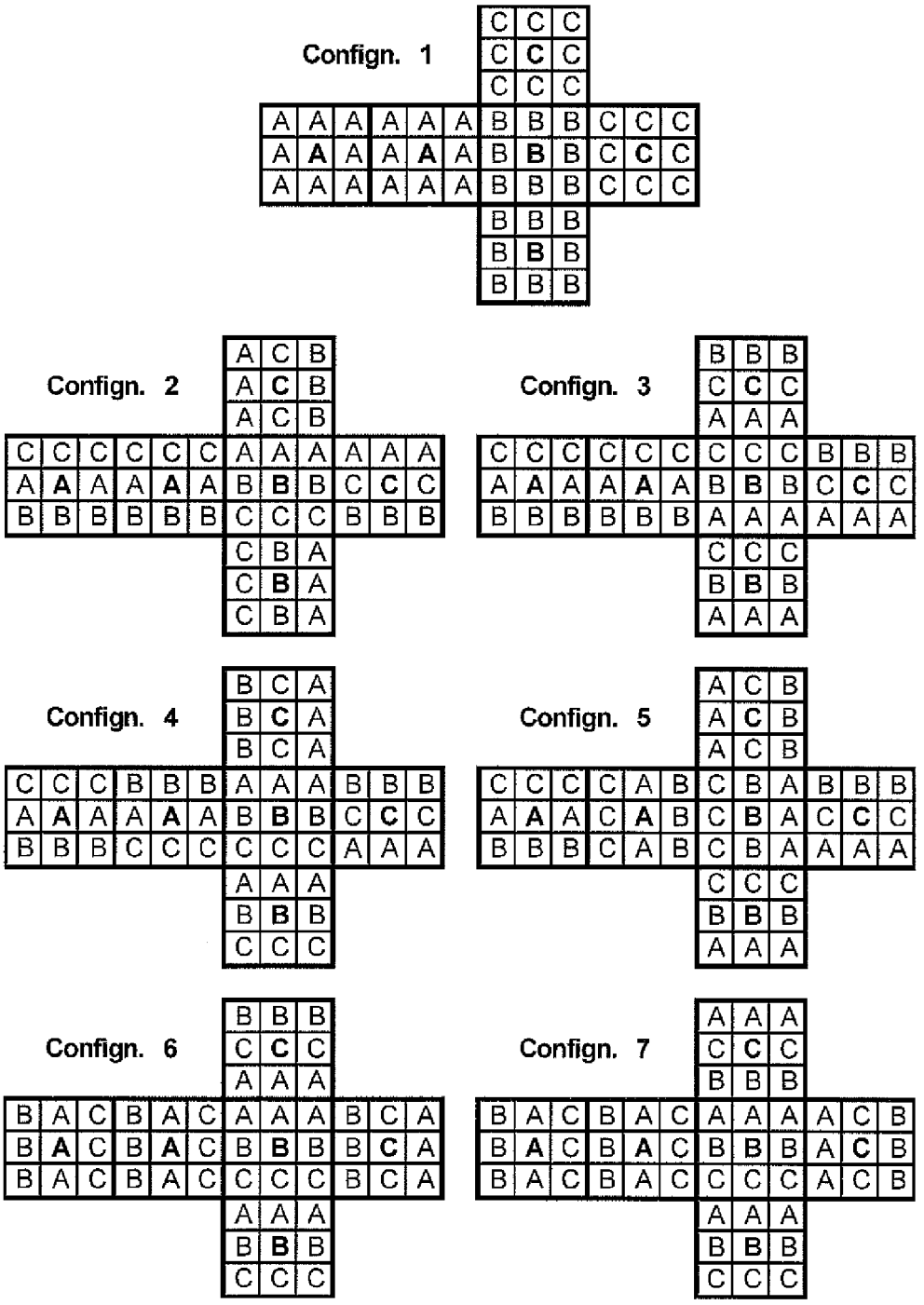

Confign. 1
Confign. 2
Confign. 3
Confign. 4
Confign. 5
Confign. 6
Confign. 7

Figure 22

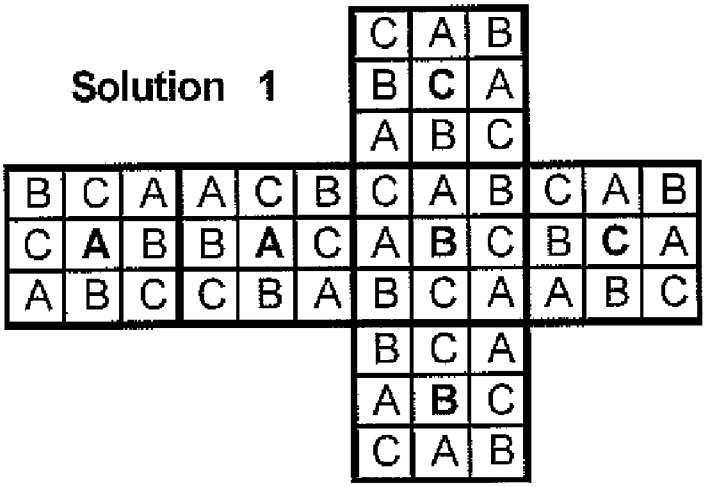


Figure 23

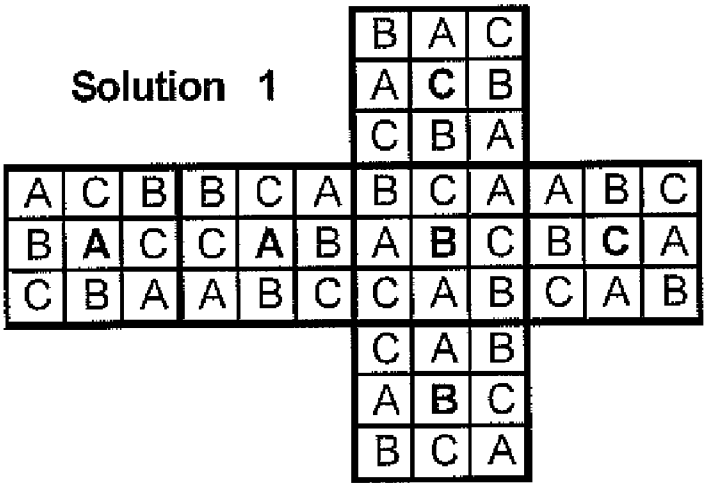


Figure 24a

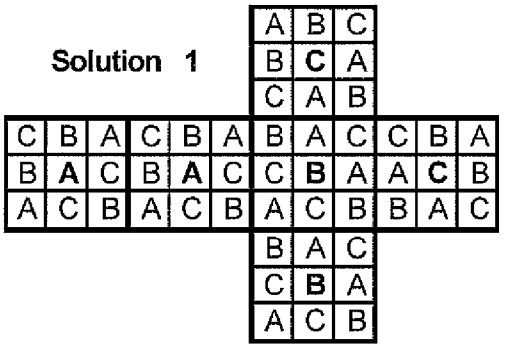


Figure 24b

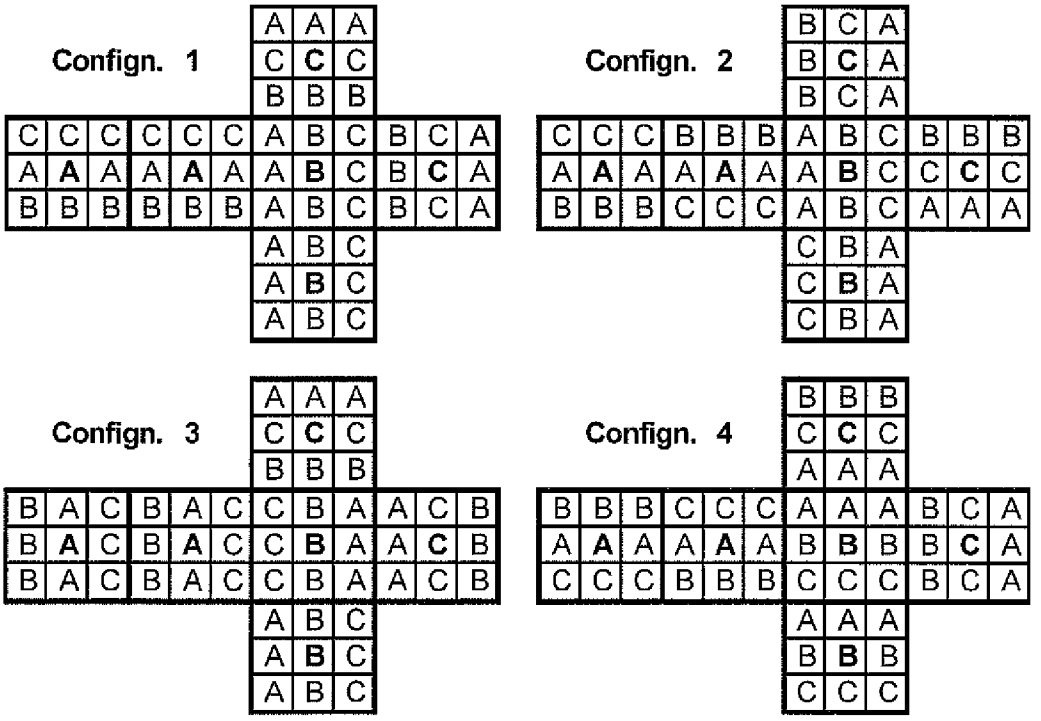


Figure 25

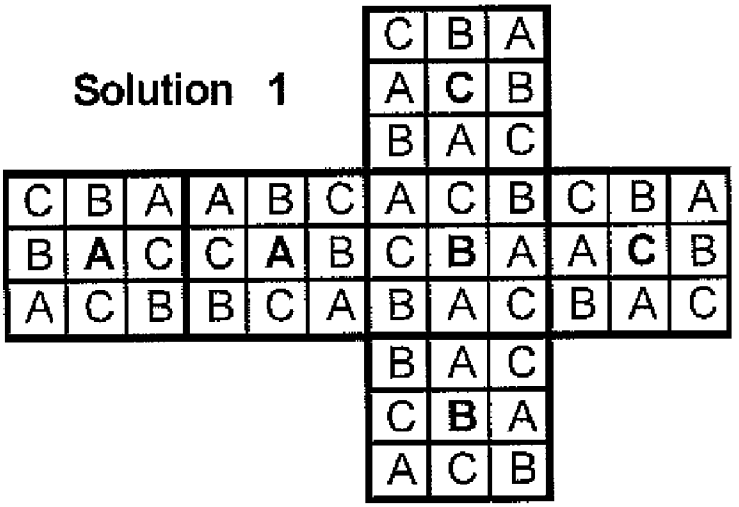


Figure 26

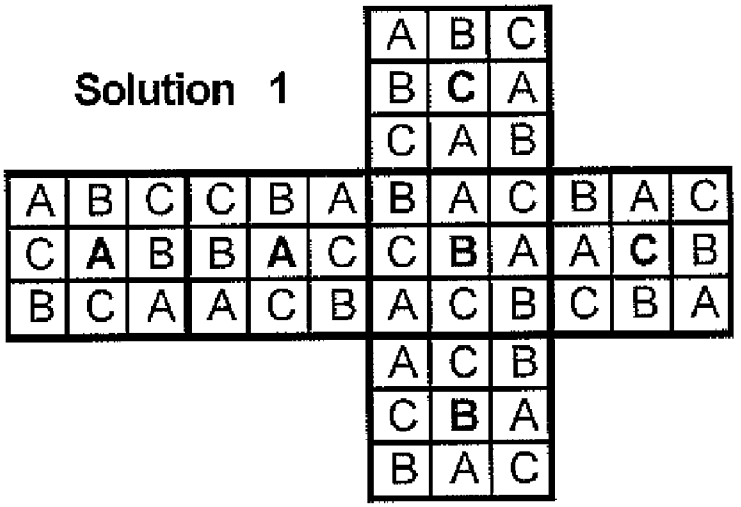


Figure 27a

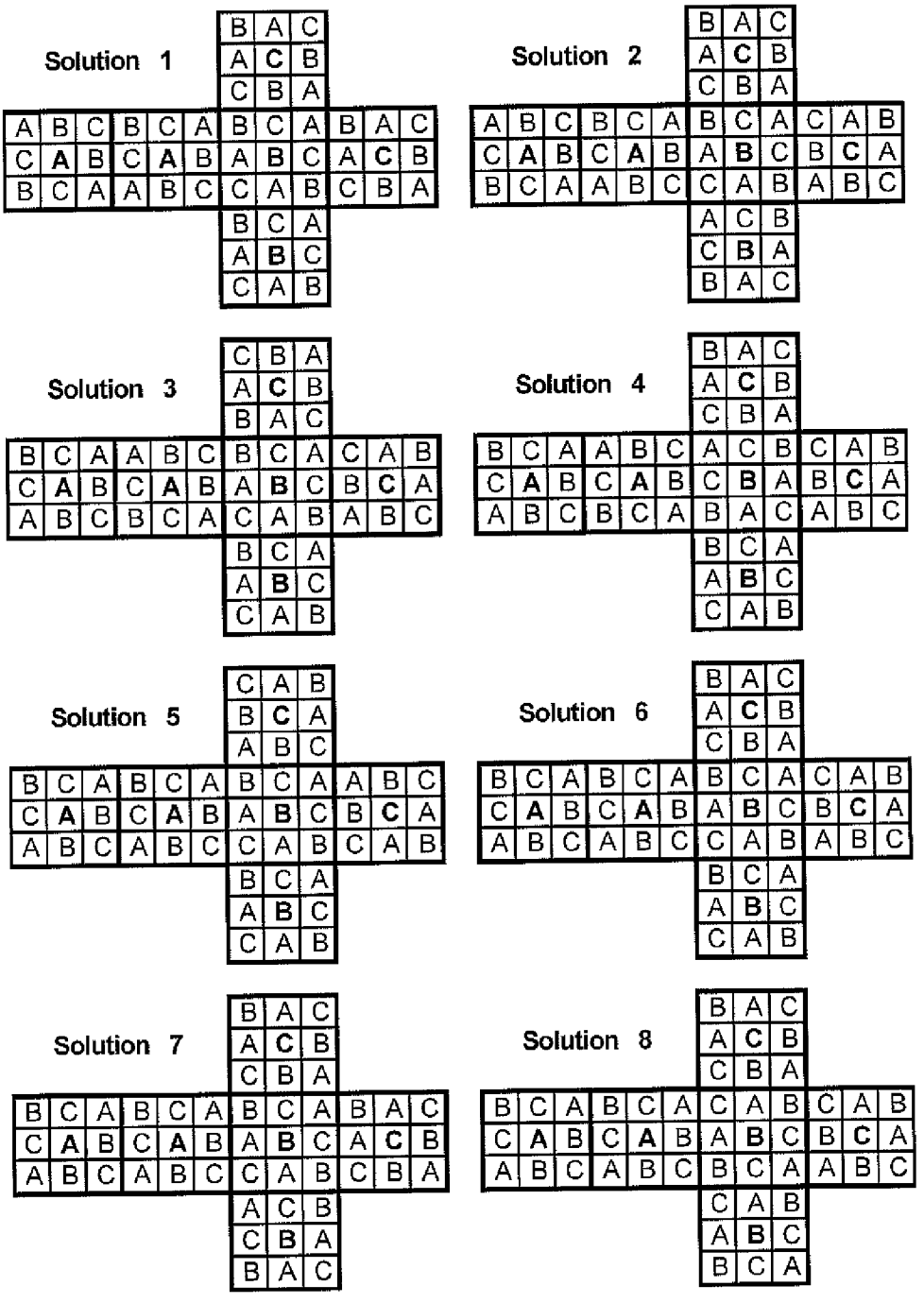

Solution 1
Solution 2
Solution 3
Solution 4
Solution 5
Solution 6
Solution 7
Solution 8

Figure 27a (continued)

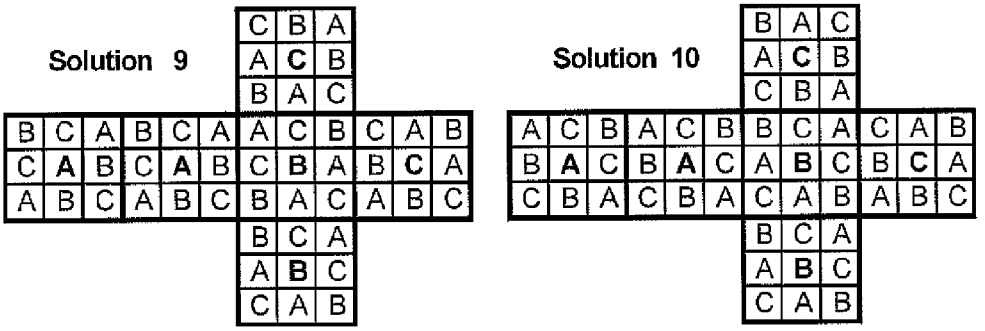


Figure 27b

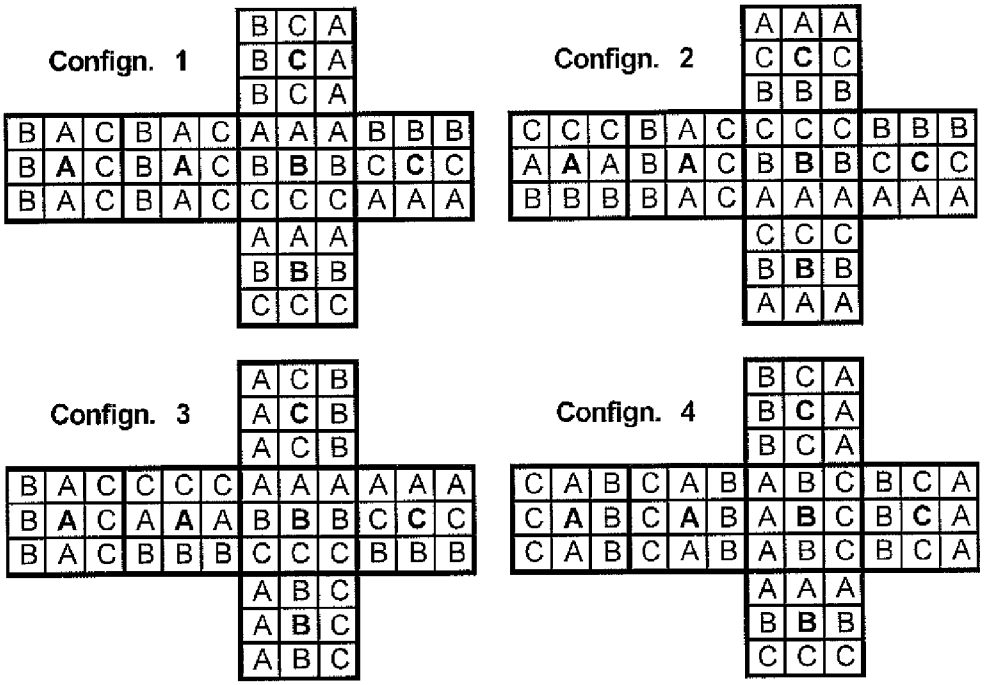


Figure 28

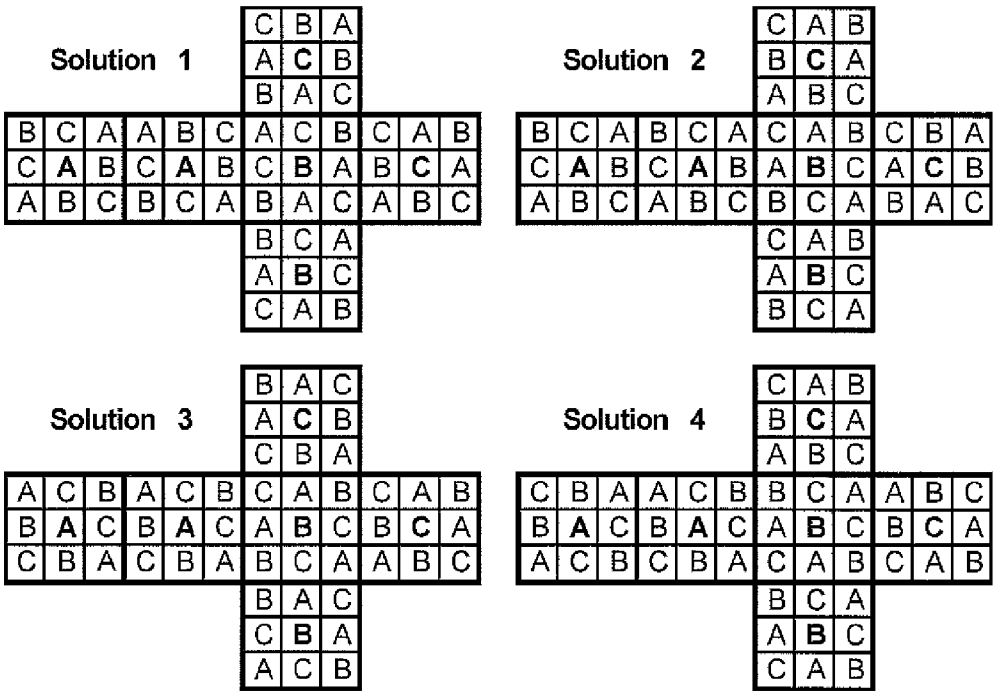


Figure 29

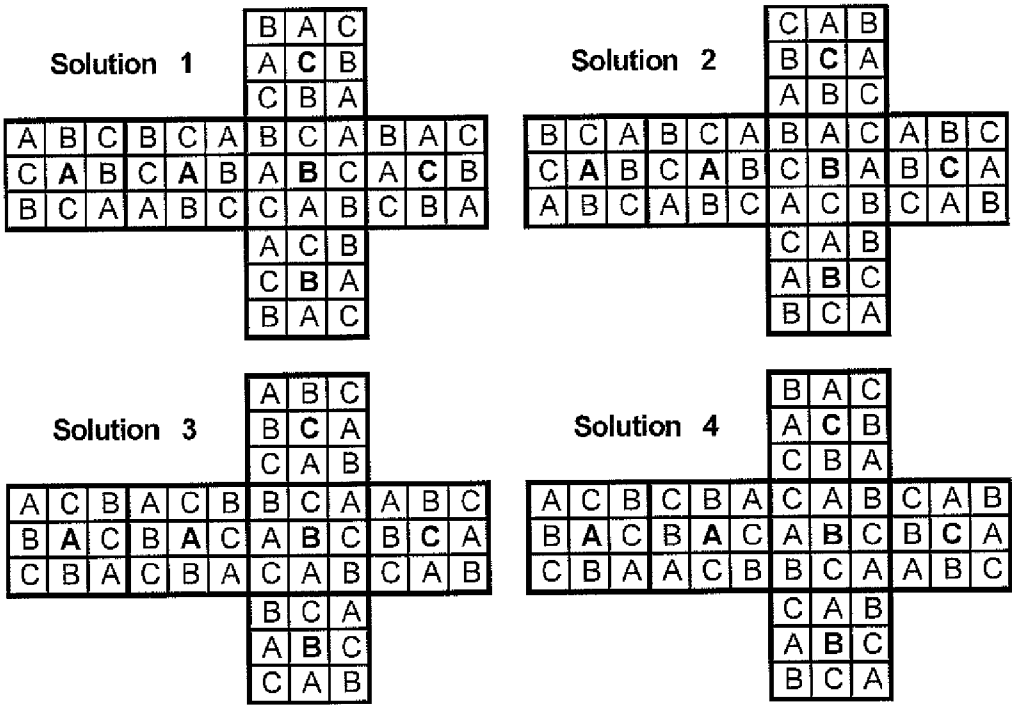


Figure 30

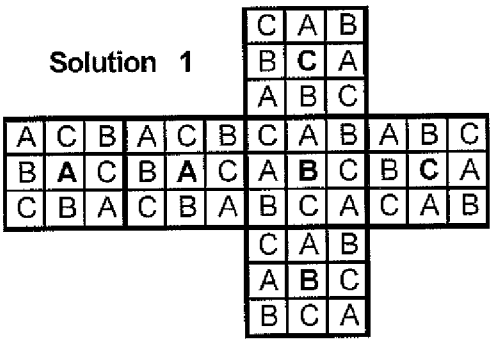


Figure 31

Config.	Number of corner blocks [1]											Number of edge blocks [2]						Facial blocks			Sym.	Red.	S.D.	Sol.
No.	ABCc	ABCa	AAB	AAC	BBA	BBC	CCA	CCB	AAA	BBB	CCC	AB	BC	CA	AA	BB	CC	A	B	C				
1	1	1	0	0	0	0	0	0	2	2	2	2	2	2	2	2	2	2	2	2	26	12	0.92	2
2	1	1	0	2	2	0	0	2	0	0	0	3	3	3	1	1	1	2	2	2	26	12	1.08	12
3	1	1	2	0	0	2	2	0	0	0	0	3	3	3	1	1	1	2	2	2	26	12	1.08	12
4	1	1	1	1	1	1	1	1	0	0	0	4	4	4	0	0	0	2	2	2	26	12	1.34	16
5	4	4	0	0	0	0	0	0	0	0	0	2	2	2	2	2	2	2	2	2	26	15	1.34	2
6	1	1	0	2	2	0	0	2	0	0	0	4	4	4	0	0	0	2	2	2	26	15	1.45	4
7	1	1	2	0	0	2	2	0	0	0	0	4	4	4	0	0	0	2	2	2	26	15	1.45	4
8	0	2	1	1	1	1	1	1	0	0	0	3	3	3	1	1	1	2	2	2	24	10	0.98	8
9	2	0	1	1	1	1	1	1	0	0	0	3	3	3	1	1	1	2	2	2	24	10	0.98	8
10	0	0	1	2	1	2	1	1	0	0	0	2	2	2	2	2	2	2	2	2	24	11	0.86	4
11	0	0	1	2	1	2	1	1	0	0	0	3	3	3	1	1	1	2	2	2	24	11	1.03	8
12	0	0	1	1	2	1	2	1	0	0	0	3	3	3	1	1	1	2	2	2	24	11	1.03	4
13	0	0	2	1	1	1	1	2	0	0	0	3	3	3	1	1	1	2	2	2	24	11	1.03	4
14	0	2	0	2	2	0	0	2	0	0	0	3	3	3	1	1	1	2	2	2	24	13	1.13	2
15	2	0	0	2	2	0	0	2	0	0	0	3	3	3	1	1	1	2	2	2	24	13	1.13	2
16	0	2	2	0	0	2	2	0	0	0	0	3	3	3	1	1	1	2	2	2	24	13	1.13	2
17	2	0	2	0	0	2	2	0	0	0	0	3	3	3	1	1	1	2	2	2	24	13	1.13	2
18	0	0	1	2	1	2	1	1	0	0	0	4	4	4	0	0	0	2	2	2	24	14	1.42	4
19	1	1	1	1	1	1	1	1	0	0	0	4	2	2	1	1	2	2	2	2	23	9	0.92	16
20	1	1	0	1	1	0	0	1	1	1	1	2	2	4	1	2	1	2	2	2	23	9	0.92	4
21	1	1	1	0	0	1	1	0	1	1	1	2	4	2	2	1	1	2	2	2	23	9	0.92	4
22	1	1	1	0	1	0	0	0	1	1	2	2	2	2	2	2	2	2	2	2	23	10	0.80	6
23	1	1	1	1	0	1	2	0	0	1	0	3	3	3	1	1	1	2	2	2	23	10	0.98	4
24	1	1	1	1	2	0	0	1	0	0	1	3	3	3	1	1	1	2	2	2	23	10	0.98	4
25	1	1	2	0	1	1	1	0	0	0	1	3	3	3	1	1	1	2	2	2	23	10	0.98	4
26	1	1	0	1	1	1	0	2	1	0	0	3	3	3	1	1	1	2	2	2	23	10	0.98	4
27	1	2	0	1	0	1	0	0	1	1	1	3	3	3	1	1	1	2	2	2	23	10	0.98	2
28	2	1	0	1	0	1	0	0	1	1	1	3	3	3	1	1	1	2	2	2	23	10	0.98	2
29	1	2	0	2	1	1	0	1	0	0	0	3	3	3	1	1	1	2	2	2	23	11	1.03	8
30	2	1	0	2	1	1	0	1	0	0	0	3	3	3	1	1	1	2	2	2	23	11	1.03	8
31	1	2	1	1	0	2	1	0	0	0	0	3	3	3	1	1	1	2	2	2	23	11	1.03	8
32	2	1	1	1	0	2	1	0	0	0	0	3	3	3	1	1	1	2	2	2	23	11	1.03	8
33	1	2	1	0	1	1	2	0	0	0	0	3	3	3	1	1	1	2	2	2	23	11	1.03	2
34	2	1	1	0	1	1	2	0	0	0	0	3	3	3	1	1	1	2	2	2	23	11	1.03	2
35	1	2	1	1	1	0	0	2	0	0	0	3	3	3	1	1	1	2	2	2	23	11	1.03	2
36	2	1	1	1	1	0	0	2	0	0	0	3	3	3	1	1	1	2	2	2	23	11	1.03	2
37	1	1	1	1	1	1	1	1	0	0	0	5	3	3	0	0	1	2	2	2	23	11	1.26	4
38	1	1	0	2	2	0	0	2	0	0	0	2	2	4	1	2	1	2	2	2	23	12	1.08	4
39	1	1	0	2	2	0	0	2	0	0	0	4	2	2	1	1	2	2	2	2	23	12	1.08	4
40	1	1	2	0	0	2	2	0	0	0	0	4	2	2	1	1	2	2	2	2	23	12	1.08	4
41	1	1	2	0	0	2	2	0	0	0	0	2	4	2	2	1	1	2	2	2	23	12	1.08	4
42	4	4	0	0	0	0	0	0	0	0	0	4	2	2	1	1	2	2	2	2	23	15	1.45	2
43	2	2	1	0	1	0	1	1	0	0	0	2	2	2	2	2	2	2	2	2	22	11	0.86	4
44	2	2	1	0	1	0	1	1	0	0	0	3	3	3	1	1	1	2	2	2	22	11	1.03	12
45	2	2	0	1	1	1	1	0	0	0	0	3	3	3	1	1	1	2	2	2	22	11	1.03	8
46	2	2	1	1	0	1	0	1	0	0	0	3	3	3	1	1	1	2	2	2	22	11	1.03	8
47	2	3	0	1	0	0	1	0	0	1	0	3	3	3	1	1	1	2	2	2	22	12	1.13	2
48	3	2	0	1	0	0	1	0	0	1	0	3	3	3	1	1	1	2	2	2	22	12	1.13	2
49	2	3	0	0	0	1	0	1	1	0	0	3	3	3	1	1	1	2	2	2	22	12	1.13	2
50	3	2	0	0	0	1	0	1	1	0	0	3	3	3	1	1	1	2	2	2	22	12	1.13	2
51	2	4	0	1	0	1	0	0	0	0	0	2	2	2	2	2	2	2	2	2	22	13	1.13	2
52	4	2	0	1	0	1	0	0	0	0	0	2	2	2	2	2	2	2	2	2	22	13	1.13	2
53	2	2	1	0	1	0	1	1	0	0	0	4	4	4	0	0	0	2	2	2	22	14	1.42	8
54	2	2	0	1	1	1	1	0	0	0	0	4	4	4	0	0	0	2	2	2	22	14	1.42	4
55	2	2	1	1	0	1	0	1	0	0	0	4	4	4	0	0	0	2	2	2	22	14	1.42	4
56	2	2	0	0	0	0	1	1	1	1	0	4	4	4	0	0	0	2	2	2	22	14	1.42	4
57	2	2	0	2	0	2	0	0	0	0	0	4	4	4	0	0	0	2	2	2	22	16	1.49	4
58	0	0	1	1	1	1	0	0	1	1	2	2	2	2	2	2	2	2	2	2	21	10	0.80	12
59	0	0	1	0	1	1	2	0	1	1	1	1	1	3	2	3	2	2	2	2	21	10	0.92	4
60	0	0	1	1	1	0	0	2	1	1	1	1	3	1	3	2	2	2	2	2	21	10	0.92	4
61	0	2	1	1	1	1	1	1	0	0	0	1	1	3	2	3	2	2	2	2	21	10	0.92	2
62	2	0	1	1	1	1	1	1	0	0	0	1	1	3	2	3	2	2	2	2	21	10	0.92	2
63	0	2	1	1	1	1	1	1	0	0	0	1	3	1	3	2	2	2	2	2	21	10	0.92	2
64	2	0	1	1	1	1	1	1	0	0	0	1	3	1	3	2	2	2	2	2	21	10	0.92	2
65	0	1	1	2	0	1	1	1	0	1	0	3	3	3	1	1	1	2	2	2	21	10	0.98	12

Figure 32

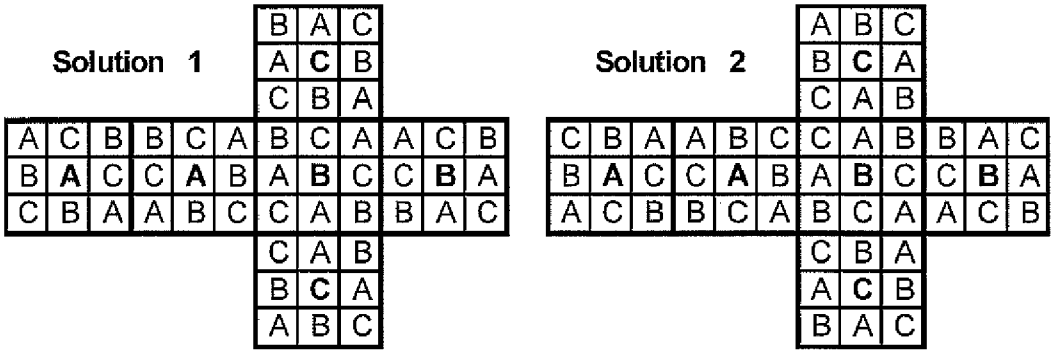


Figure 33

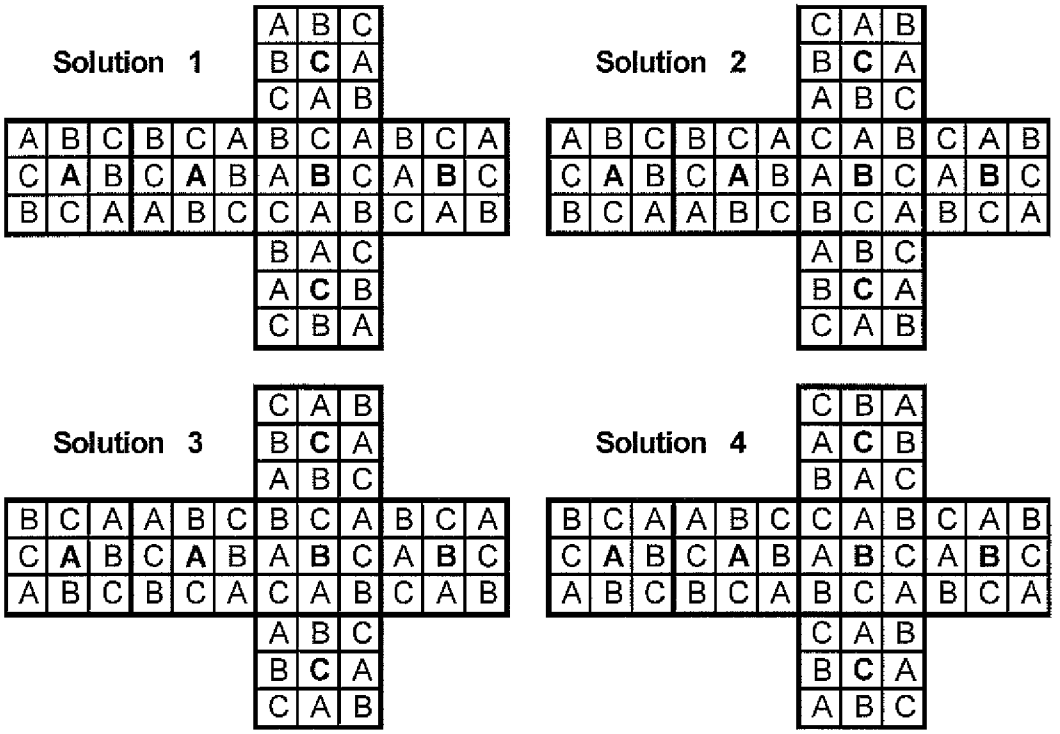


Figure 33 (continued)

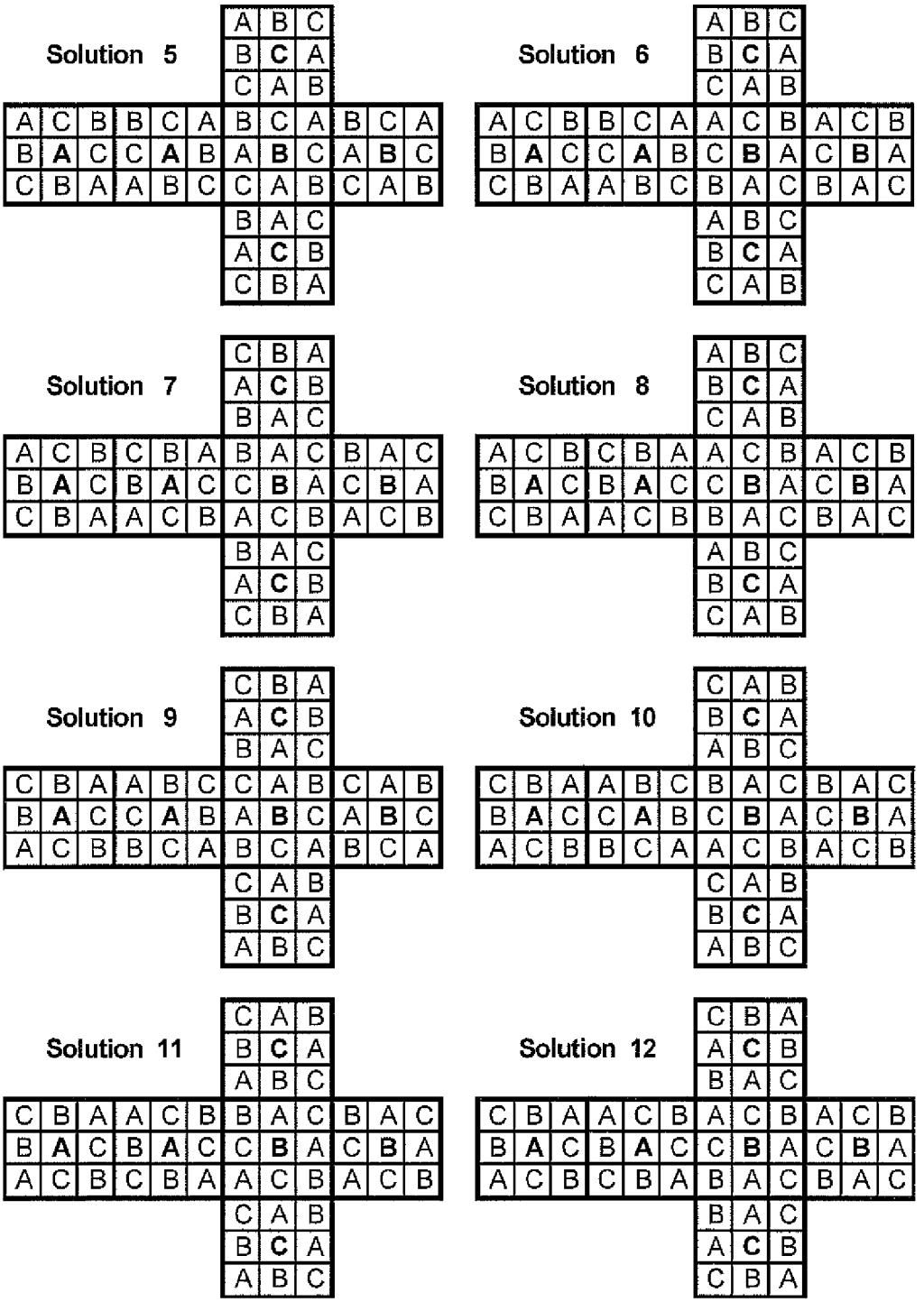


Figure 34

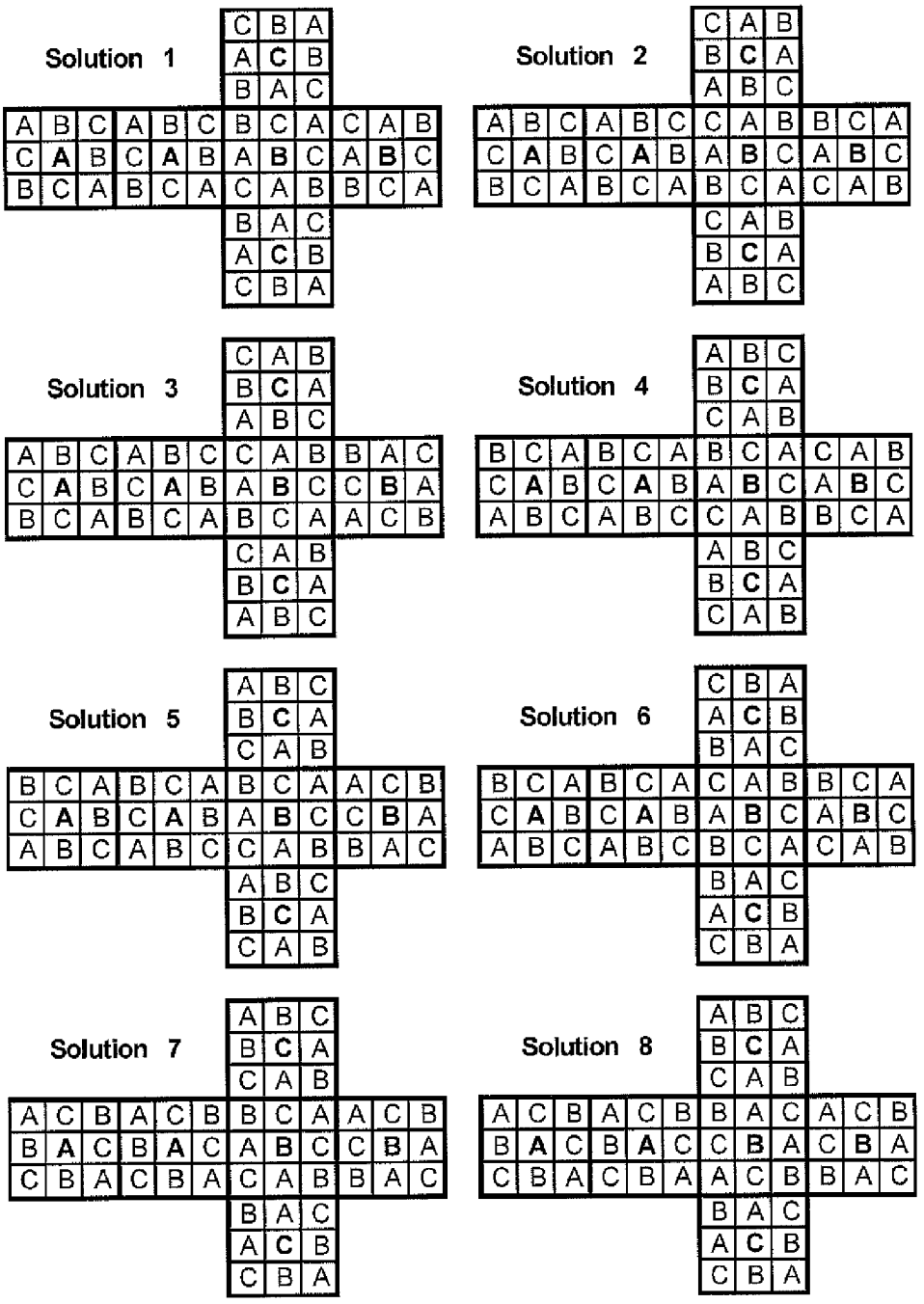

Solution 1
Solution 2
Solution 3
Solution 4
Solution 5
Solution 6
Solution 7
Solution 8

Figure 34 (continued)

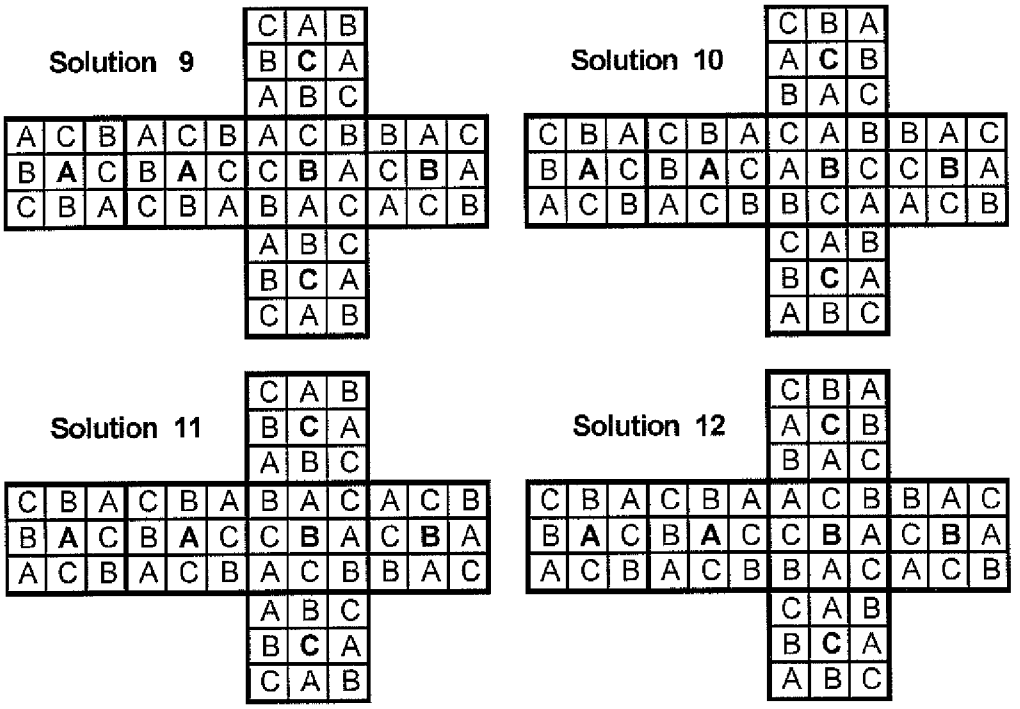


Figure 35a

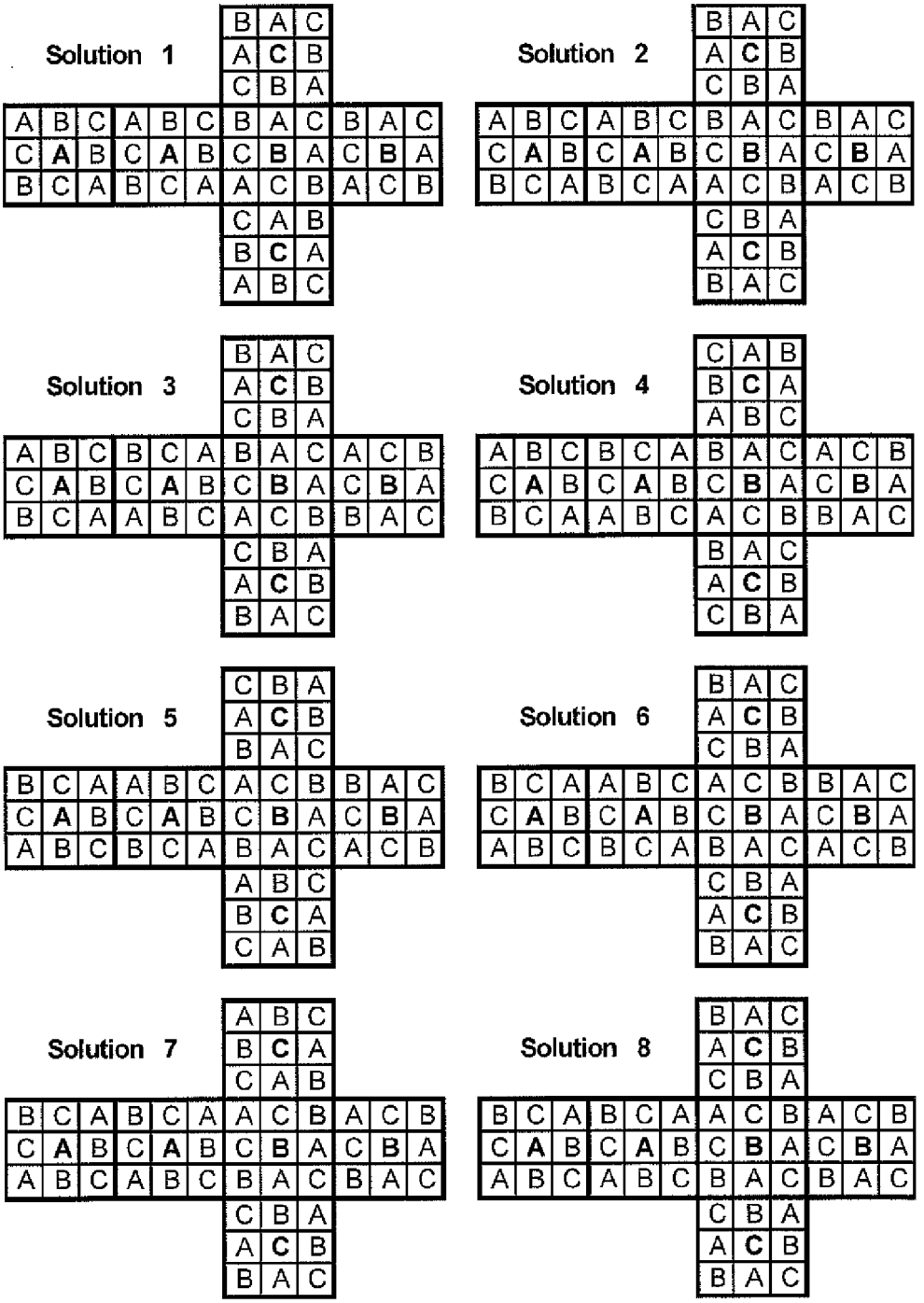

Solution 1
Solution 2
Solution 3
Solution 4
Solution 5
Solution 6
Solution 7
Solution 8

Figure 35a (continued)

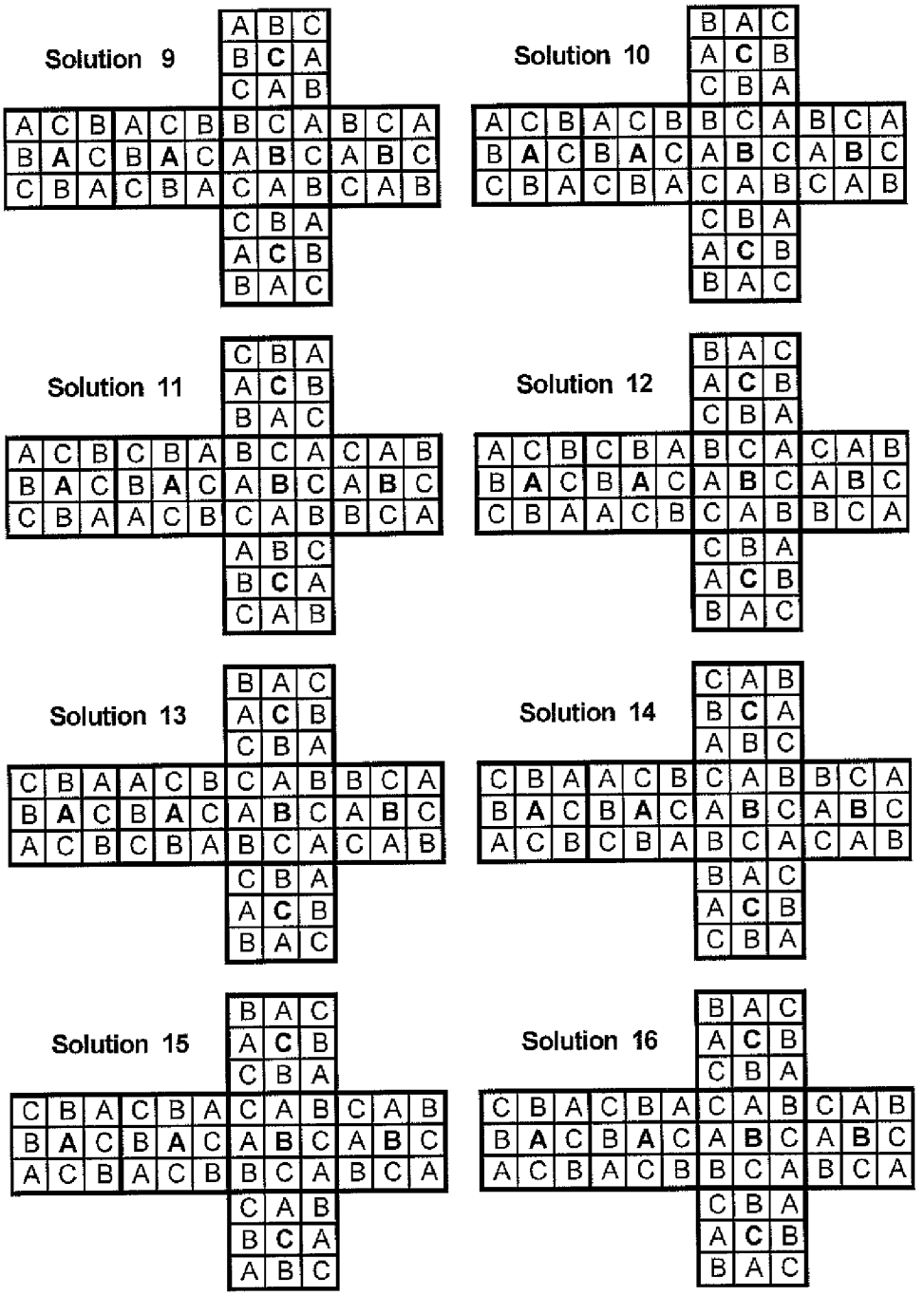


Figure 35b

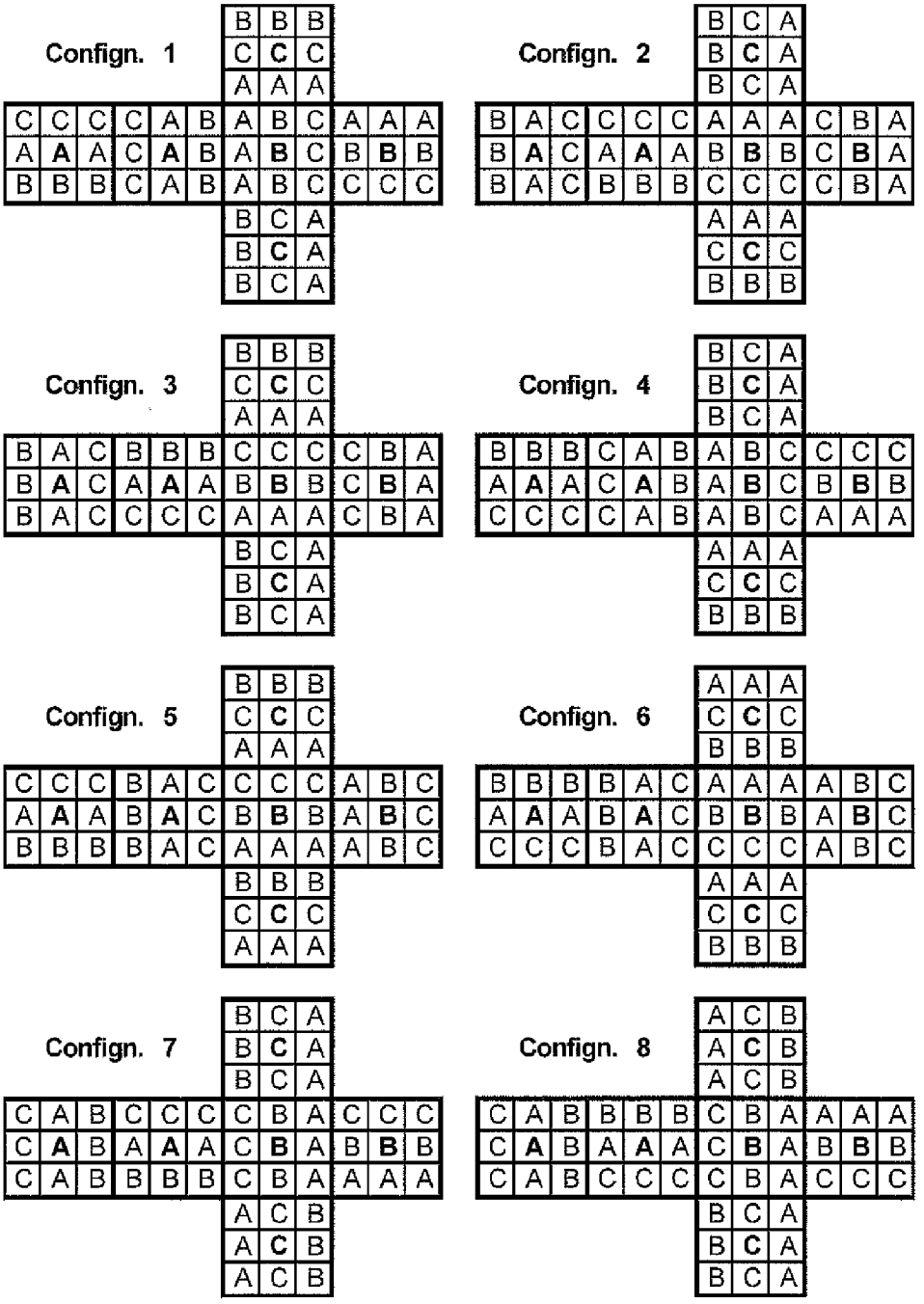

Confign. 1
Confign. 2
Confign. 3
Confign. 4
Confign. 5
Confign. 6
Confign. 7
Confign. 8

Figure 36

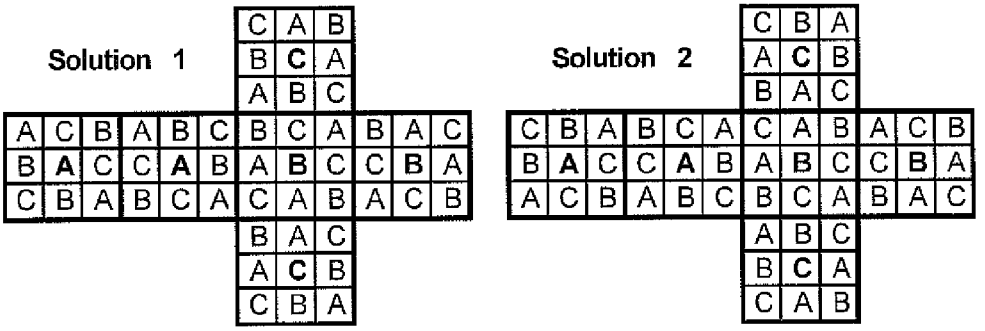


Figure 37

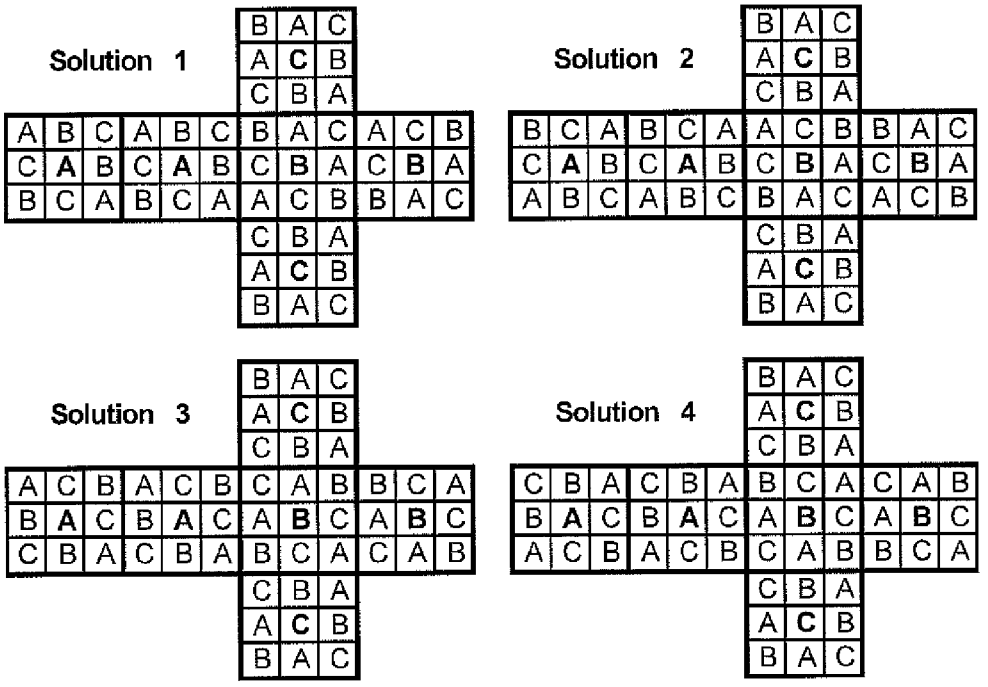


Figure 38

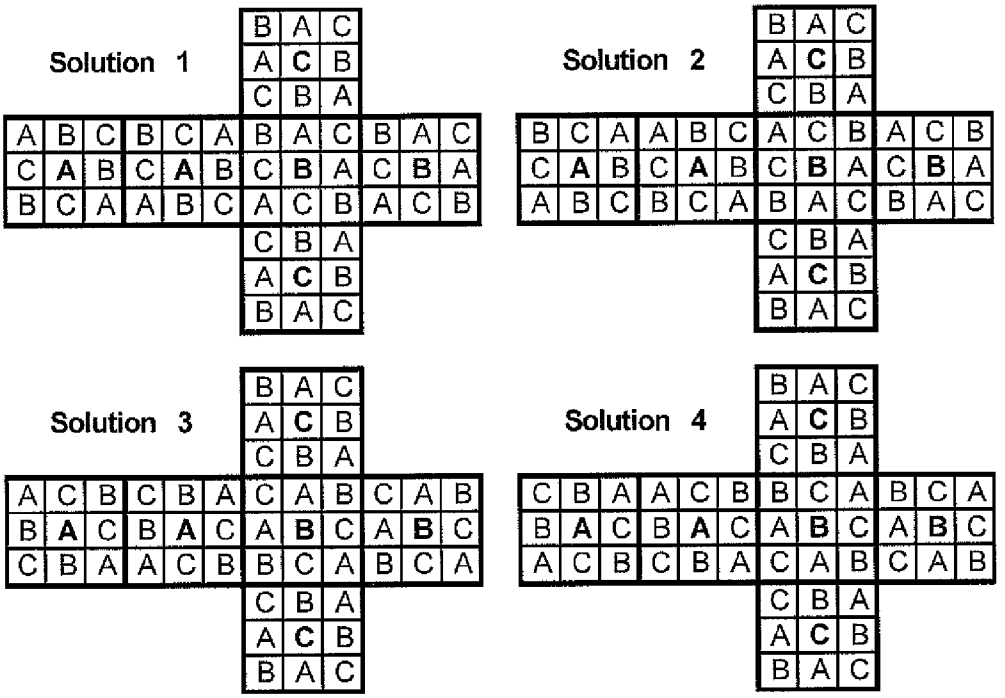


Figure 39

Config.	Number of corner blocks [1]											Number of edge blocks [2]						Facial blocks			Sym.	Red.	S.D.	Sol.
No.	ABCc	ABCa	AAB	AAC	BBA	BBC	CCA	CCB	AAA	BBB	CCC	AB	BC	CA	AA	BB	CC	A	B	C				
1	1	1	1	1	1	1	1	1	0	0	0	3	3	3	1	1	1	2	2	2	26	9	0.92	8
2	1	1	0	0	0	0	0	0	2	2	2	2	2	2	2	2	2	2	2	2	26	12	0.92	4
3	4	4	0	0	0	0	0	0	0	0	0	2	2	2	2	2	2	2	2	2	26	15	1.34	4
4	1	1	0	2	2	0	0	2	0	0	0	4	4	4	0	0	0	2	2	2	26	15	1.45	4
5	1	1	2	0	0	2	2	0	0	0	0	4	4	4	0	0	0	2	2	2	26	15	1.45	4
6	0	0	2	1	1	1	1	2	0	0	0	3	3	3	1	1	1	2	2	2	24	11	1.03	32
7	0	0	1	2	1	2	1	1	0	0	0	3	3	3	1	1	1	2	2	2	24	11	1.03	32
8	0	0	1	1	2	1	2	1	0	0	0	3	3	3	1	1	1	2	2	2	24	11	1.03	32
9	2	0	0	2	2	0	0	2	0	0	0	3	3	3	1	1	1	2	2	2	24	13	1.13	12
10	2	0	2	0	0	2	2	0	0	0	0	3	3	3	1	1	1	2	2	2	24	13	1.13	12
11	0	2	0	2	2	0	0	2	0	0	0	3	3	3	1	1	1	2	2	2	24	13	1.13	12
12	0	2	2	0	0	2	2	0	0	0	0	3	3	3	1	1	1	2	2	2	24	13	1.13	12
13	1	1	1	0	0	2	1	1	1	0	0	3	3	3	1	1	1	2	2	2	23	10	0.98	8
14	1	1	0	2	1	0	1	1	0	1	0	3	3	3	1	1	1	2	2	2	23	10	0.98	8
15	1	1	1	1	2	0	0	1	0	0	1	3	3	3	1	1	1	2	2	2	23	10	0.98	8
16	1	1	0	1	1	1	0	2	1	0	0	3	3	3	1	1	1	2	2	2	23	10	0.98	8
17	1	1	1	1	0	1	2	0	0	1	0	3	3	3	1	1	1	2	2	2	23	10	0.98	8
18	1	1	2	0	1	1	1	0	0	0	1	3	3	3	1	1	1	2	2	2	23	10	0.98	8
19	1	2	0	0	1	0	1	0	1	1	1	3	3	3	1	1	1	2	2	2	23	10	0.98	4
20	1	2	1	0	0	0	0	1	1	1	1	3	3	3	1	1	1	2	2	2	23	10	0.98	4
21	1	2	0	1	0	1	0	0	1	1	1	3	3	3	1	1	1	2	2	2	23	10	0.98	4
22	2	1	1	0	0	0	0	1	1	1	1	3	3	3	1	1	1	2	2	2	23	10	0.98	4
23	2	1	0	1	0	1	0	0	1	1	1	3	3	3	1	1	1	2	2	2	23	10	0.98	4
24	2	1	0	0	1	0	1	0	1	1	1	3	3	3	1	1	1	2	2	2	23	10	0.98	4
25	2	1	0	2	1	1	0	1	0	0	0	3	3	3	1	1	1	2	2	2	23	11	1.03	4
26	2	1	2	0	0	1	1	1	0	0	0	3	3	3	1	1	1	2	2	2	23	11	1.03	4
27	1	2	1	1	1	0	0	2	0	0	0	3	3	3	1	1	1	2	2	2	23	11	1.03	4
28	1	2	1	1	0	2	1	0	0	0	0	3	3	3	1	1	1	2	2	2	23	11	1.03	4
29	2	1	1	0	1	1	2	0	0	0	0	3	3	3	1	1	1	2	2	2	23	11	1.03	4
30	1	2	0	1	2	0	1	1	0	0	0	3	3	3	1	1	1	2	2	2	23	11	1.03	4
31	1	2	1	0	1	1	2	0	0	0	0	3	3	3	1	1	1	2	2	2	23	11	1.03	4
32	2	1	0	1	2	0	1	1	0	0	0	3	3	3	1	1	1	2	2	2	23	11	1.03	4
33	2	1	1	1	0	2	1	0	0	0	0	3	3	3	1	1	1	2	2	2	23	11	1.03	4
34	2	1	1	1	1	0	0	2	0	0	0	3	3	3	1	1	1	2	2	2	23	11	1.03	4
35	1	2	0	2	1	1	0	1	0	0	0	3	3	3	1	1	1	2	2	2	23	11	1.03	4
36	1	2	2	0	0	1	1	1	0	0	0	3	3	3	1	1	1	2	2	2	23	11	1.03	4
37	4	1	1	0	0	1	1	0	0	0	0	3	3	3	1	1	1	2	2	2	23	12	1.22	8
38	4	1	0	1	1	0	0	1	0	0	0	3	3	3	1	1	1	2	2	2	23	12	1.22	8
39	1	4	1	0	0	1	1	0	0	0	0	3	3	3	1	1	1	2	2	2	23	12	1.22	8
40	1	4	0	1	1	0	0	1	0	0	0	3	3	3	1	1	1	2	2	2	23	12	1.22	8
41	1	4	0	0	0	0	0	0	1	1	1	3	3	3	1	1	1	2	2	2	23	12	1.22	4
42	4	1	0	0	0	0	0	0	1	1	1	3	3	3	1	1	1	2	2	2	23	12	1.22	4
43	2	2	1	1	0	1	0	1	0	0	0	3	3	3	1	1	1	2	2	2	22	11	1.03	24
44	2	2	0	1	1	1	1	0	0	0	0	3	3	3	1	1	1	2	2	2	22	11	1.03	24
45	2	2	1	0	1	0	1	1	0	0	0	3	3	3	1	1	1	2	2	2	22	11	1.03	24
46	3	2	0	1	0	0	1	0	0	1	0	3	3	3	1	1	1	2	2	2	22	12	1.13	4
47	2	3	0	0	0	1	0	1	1	0	0	3	3	3	1	1	1	2	2	2	22	12	1.13	4
48	3	2	1	0	1	0	0	0	0	0	1	3	3	3	1	1	1	2	2	2	22	12	1.13	4
49	3	2	0	0	0	1	0	1	1	0	0	3	3	3	1	1	1	2	2	2	22	12	1.13	4
50	2	3	1	0	1	0	0	0	0	0	1	3	3	3	1	1	1	2	2	2	22	12	1.13	4
51	2	3	0	1	0	0	1	0	0	1	0	3	3	3	1	1	1	2	2	2	22	12	1.13	4
52	0	1	0	1	1	0	1	2	1	1	0	3	3	3	1	1	1	2	2	2	21	10	0.98	8
53	1	0	1	0	0	1	2	1	1	1	0	3	3	3	1	1	1	2	2	2	21	10	0.98	8
54	1	0	1	2	1	0	0	1	0	1	1	3	3	3	1	1	1	2	2	2	21	10	0.98	8
55	1	0	0	1	2	1	0	1	1	0	1	3	3	3	1	1	1	2	2	2	21	10	0.98	8
56	1	0	2	1	0	1	1	0	0	1	1	3	3	3	1	1	1	2	2	2	21	10	0.98	8
57	0	1	1	0	1	2	1	0	1	0	1	3	3	3	1	1	1	2	2	2	21	10	0.98	8
58	0	1	1	2	1	0	0	1	0	1	1	3	3	3	1	1	1	2	2	2	21	10	0.98	8
59	1	0	0	1	1	0	1	2	1	1	0	3	3	3	1	1	1	2	2	2	21	10	0.98	8
60	1	0	1	0	1	2	1	0	1	0	1	3	3	3	1	1	1	2	2	2	21	10	0.98	8
61	0	1	0	1	2	1	0	1	1	0	1	3	3	3	1	1	1	2	2	2	21	10	0.98	8
62	0	1	2	1	0	1	1	0	0	1	1	3	3	3	1	1	1	2	2	2	21	10	0.98	8
63	0	1	1	0	0	1	2	1	1	1	0	3	3	3	1	1	1	2	2	2	21	10	0.98	8
64	0	1	1	0	1	1	1	2	1	0	0	3	3	3	1	1	1	2	2	2	21	10	0.98	4
65	1	0	1	2	0	1	1	1	0	1	0	3	3	3	1	1	1	2	2	2	21	10	0.98	4

Figure 40

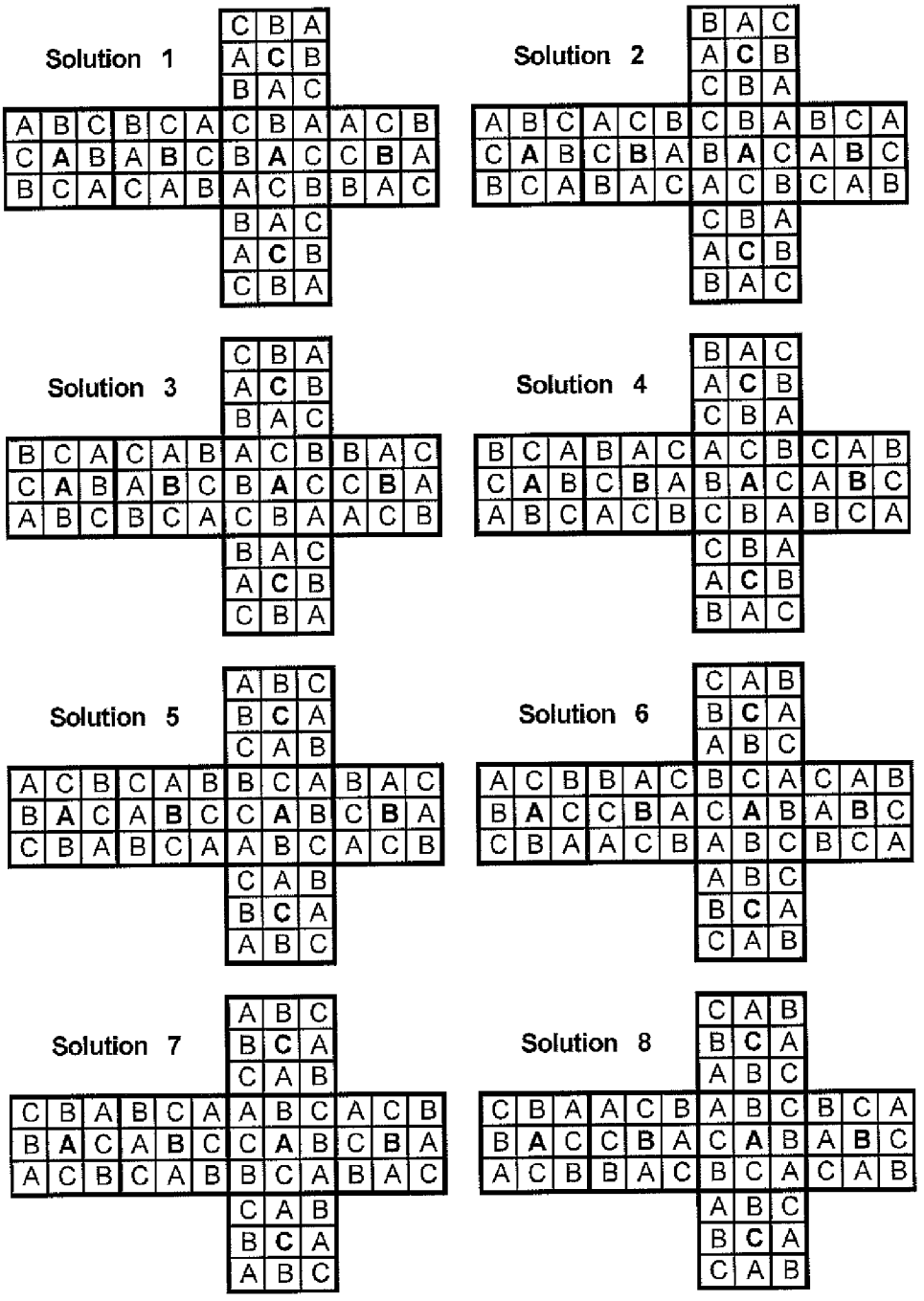

Solution 1
Solution 2
Solution 3
Solution 4
Solution 5
Solution 6
Solution 7
Solution 8

Figure 41

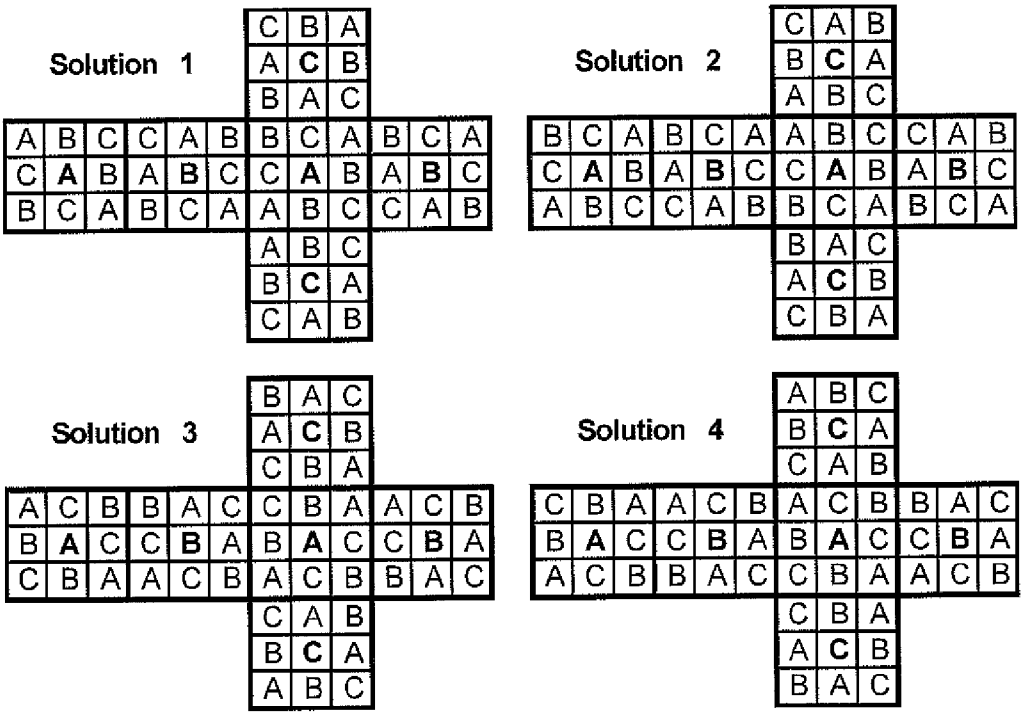


Figure 42

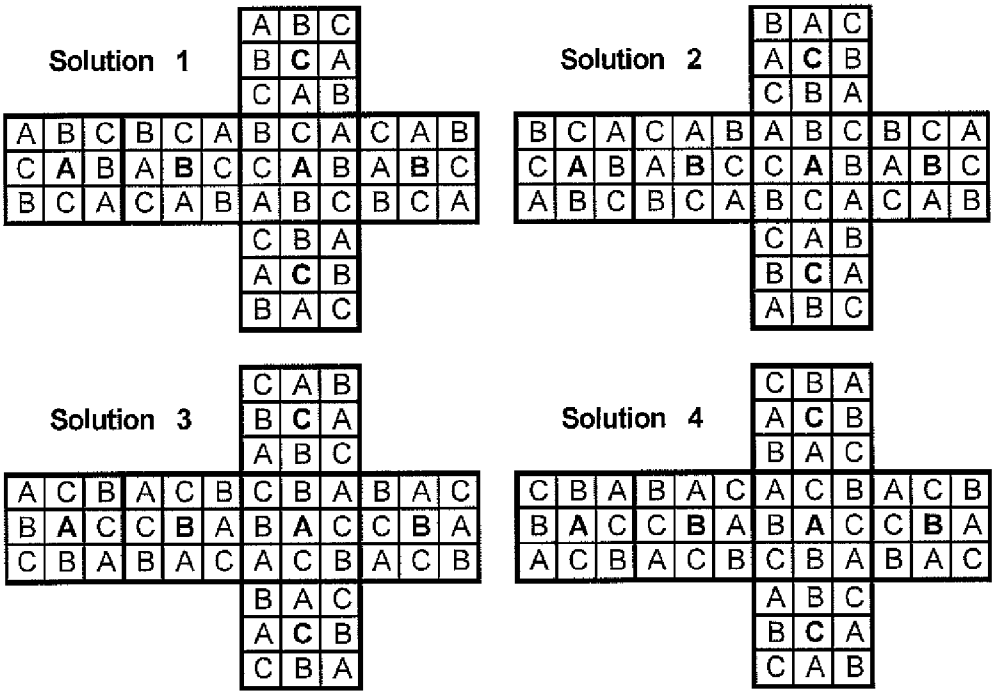


Figure 43

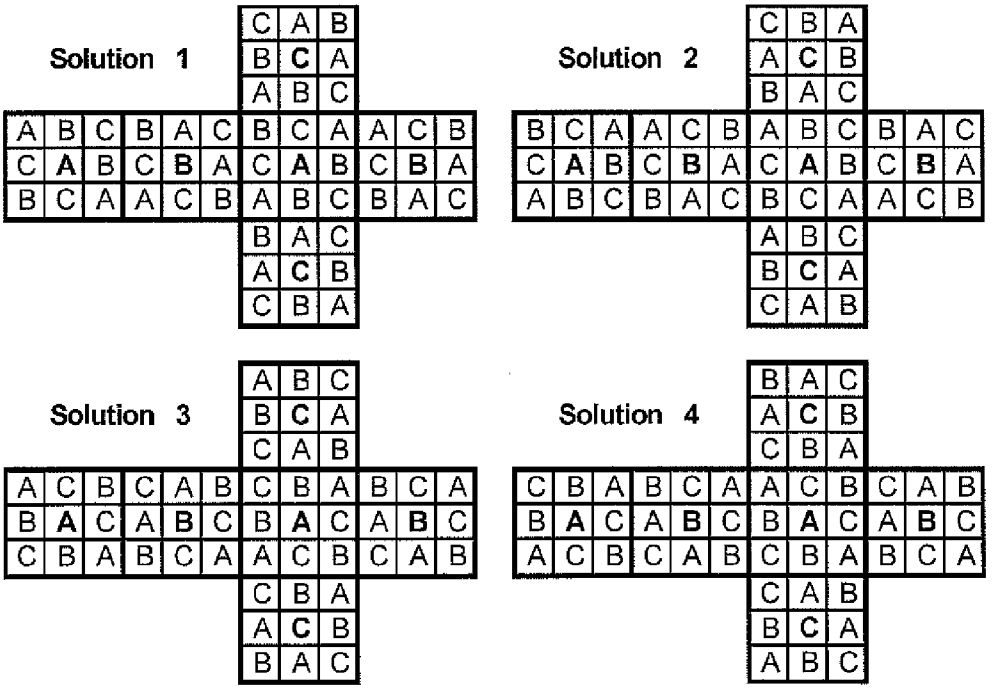


Figure 44

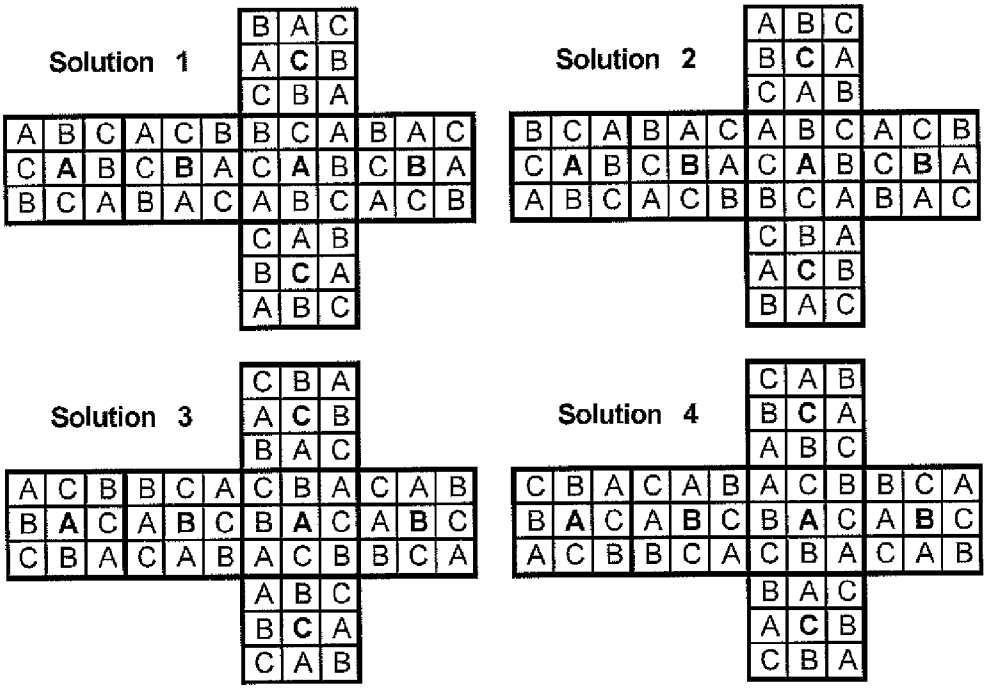


Figure 45a

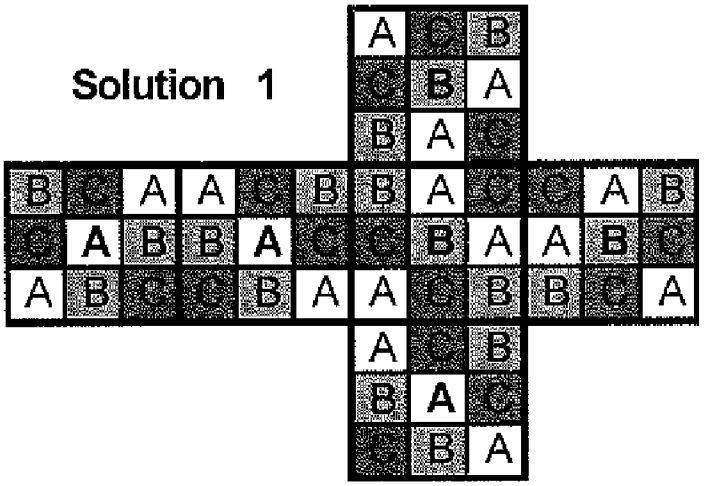


Figure 45b

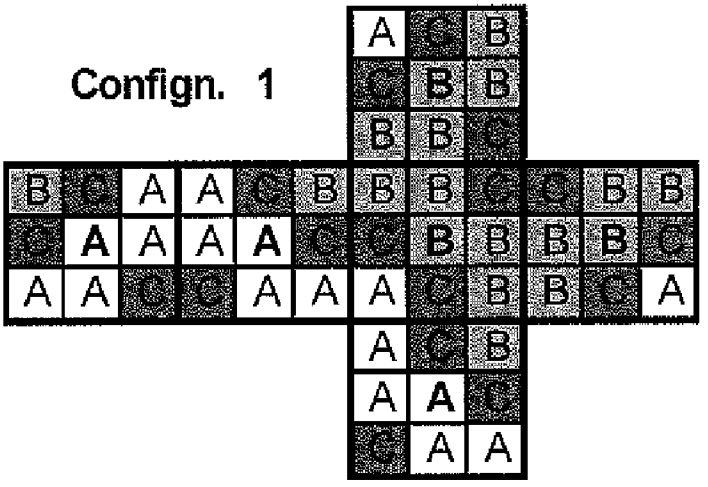


Figure 46

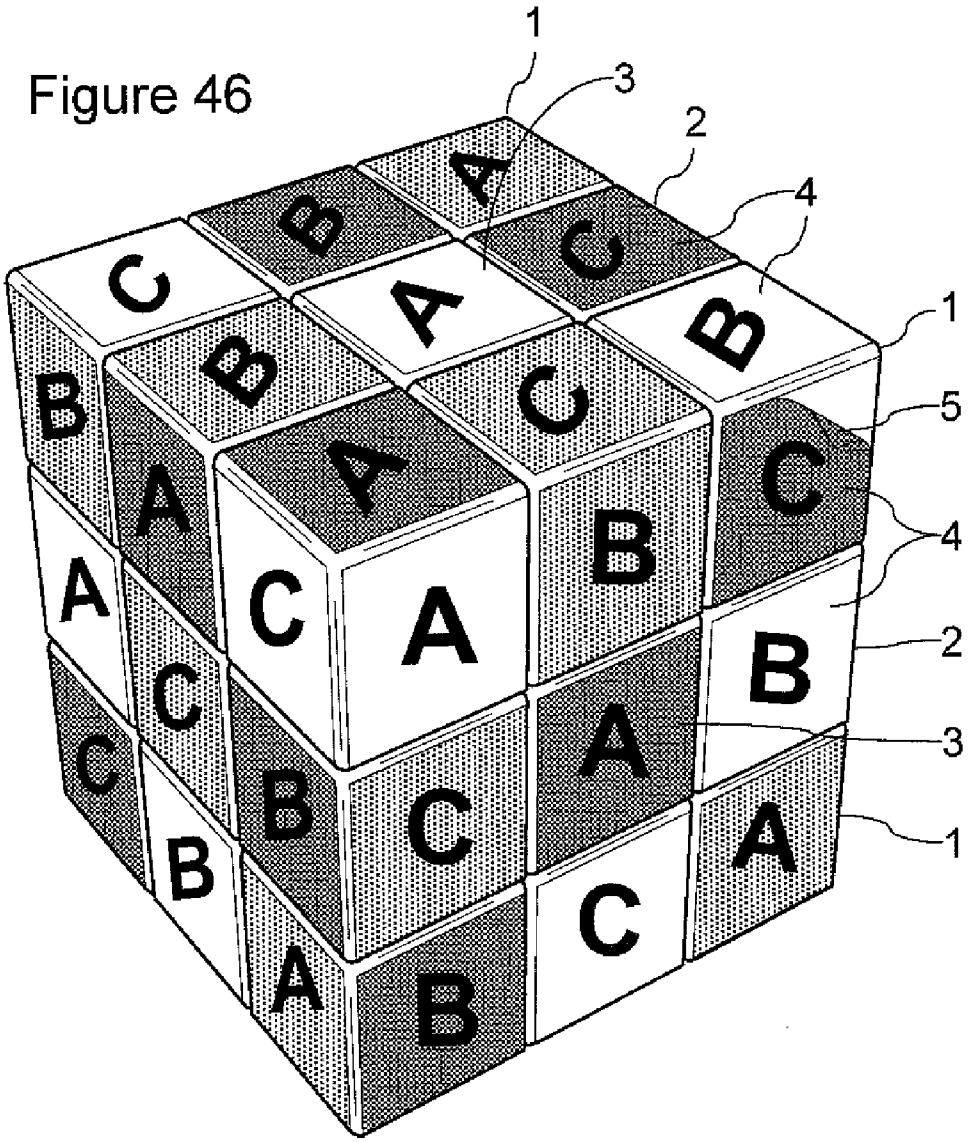


Figure 47

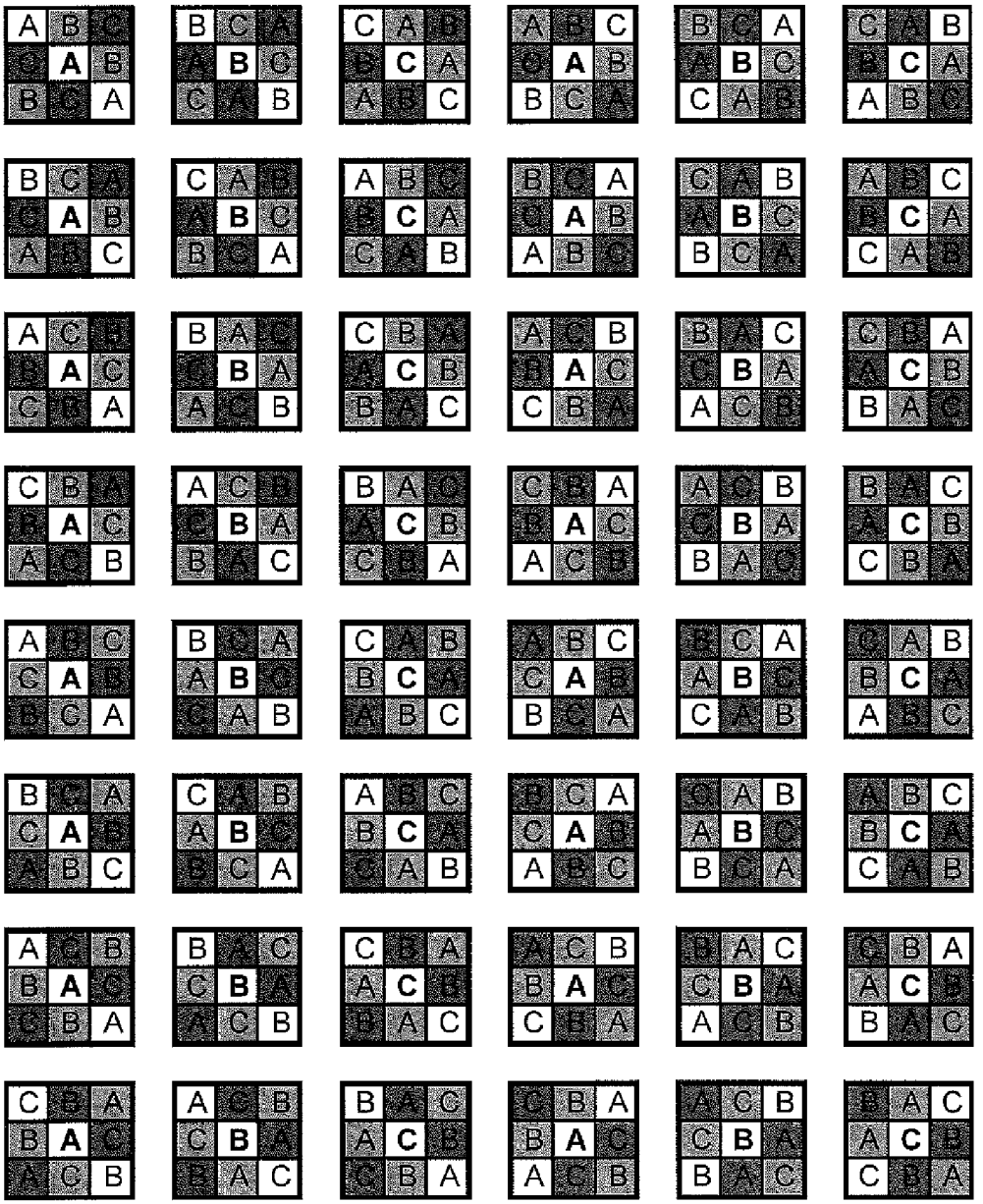


Figure 47 (continued)

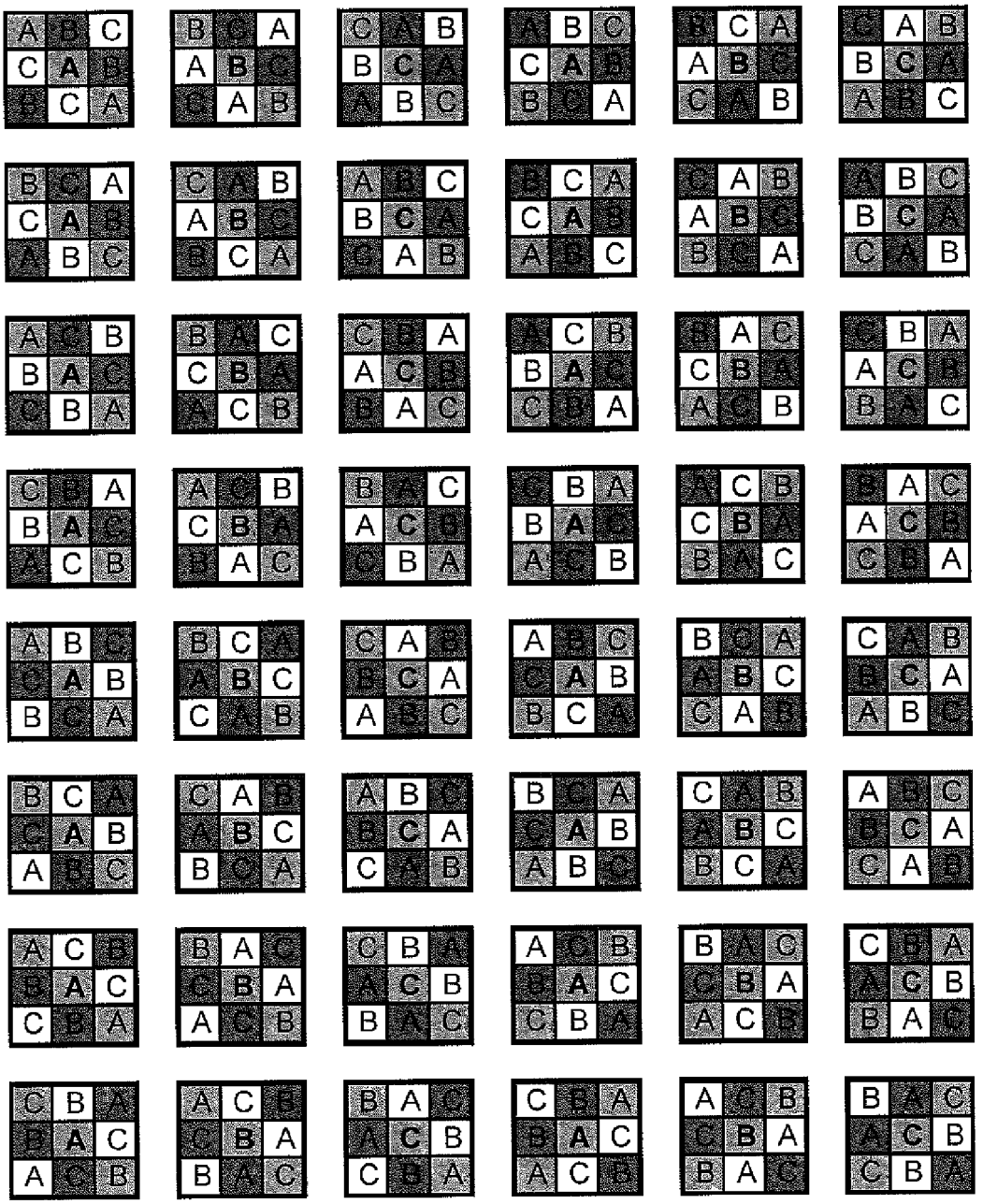


Figure 47 (continued)

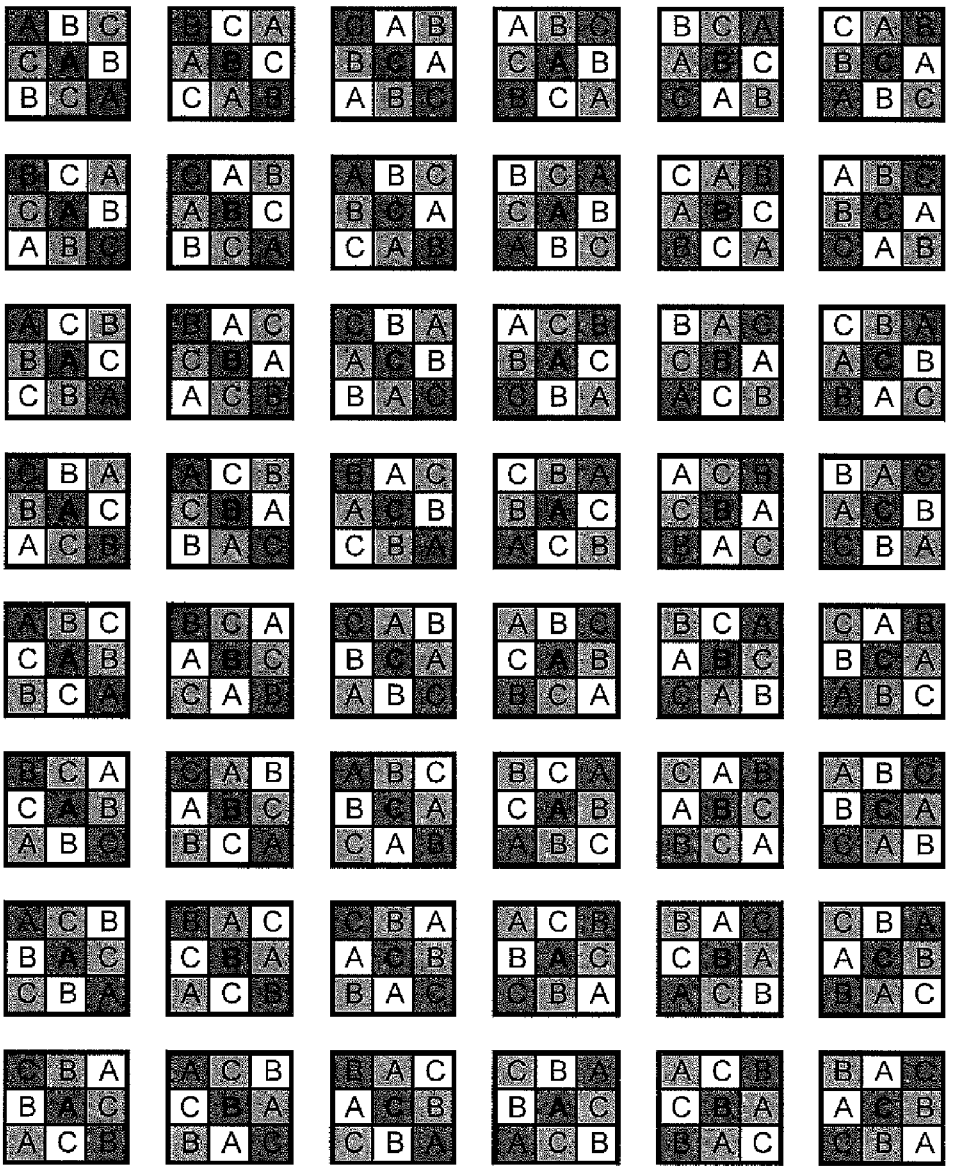


Figure 48

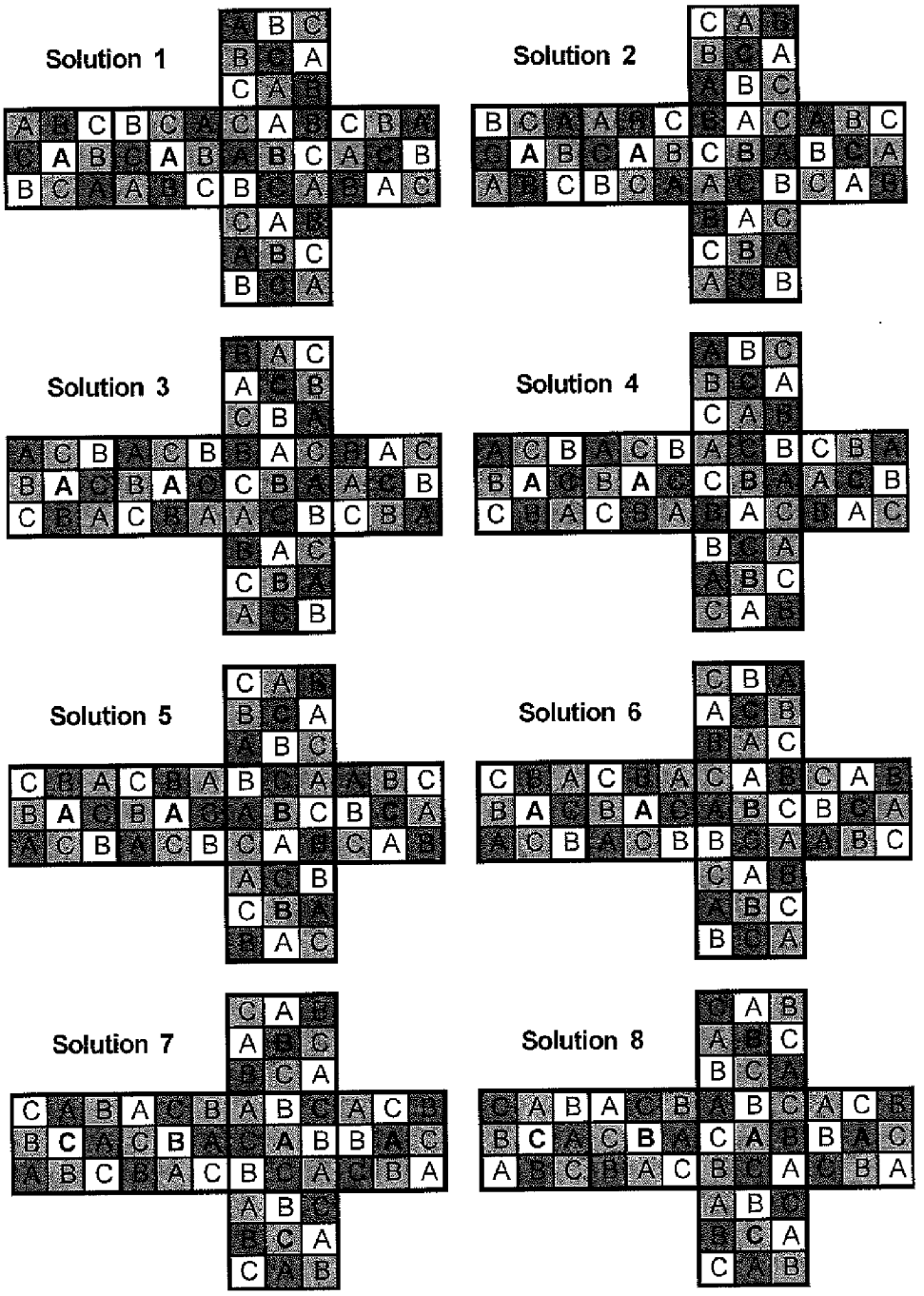

Solution 1
Solution 2
Solution 3
Solution 4
Solution 5
Solution 6
Solution 7
Solution 8

Figure 48 (continued)

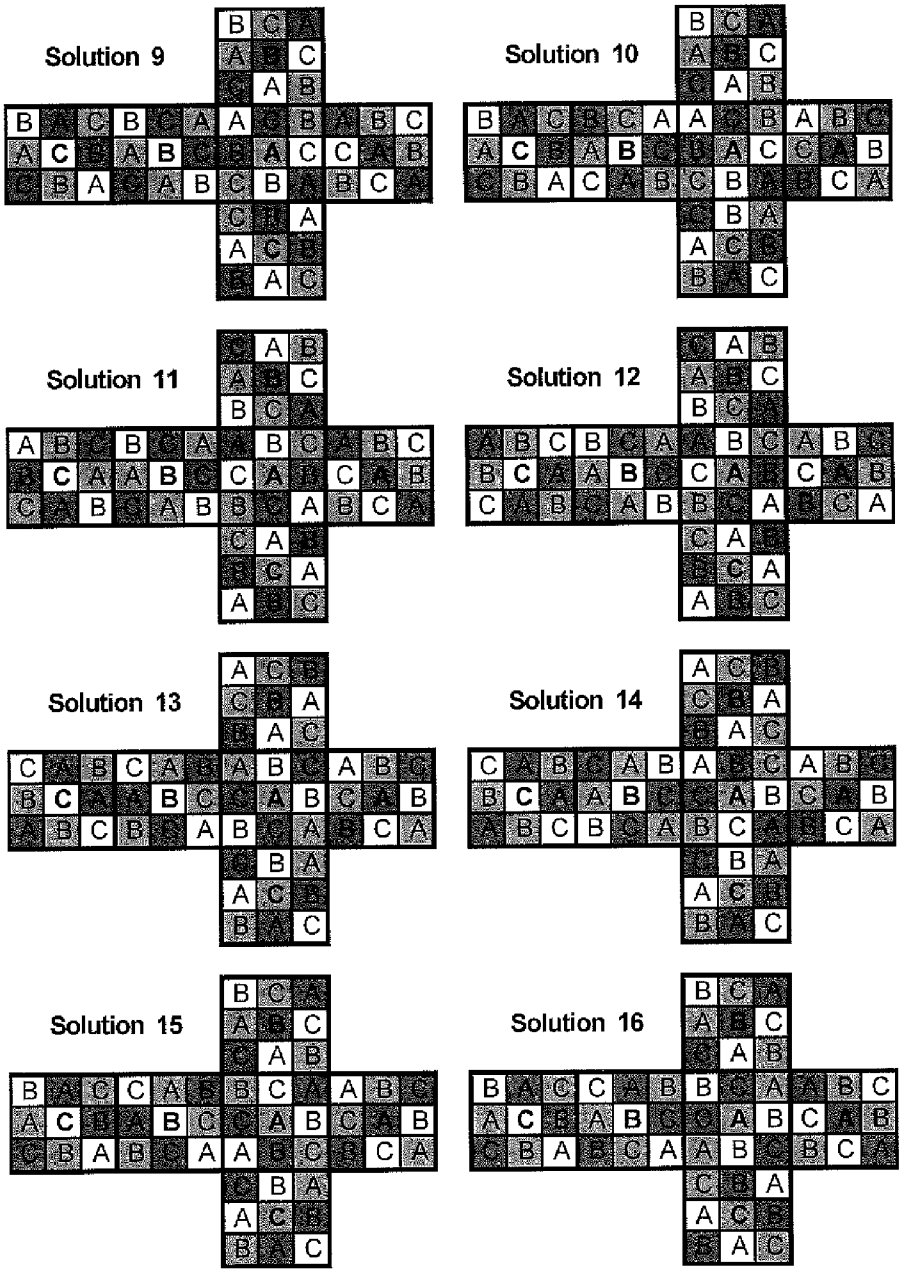


Figure 48 (continued)

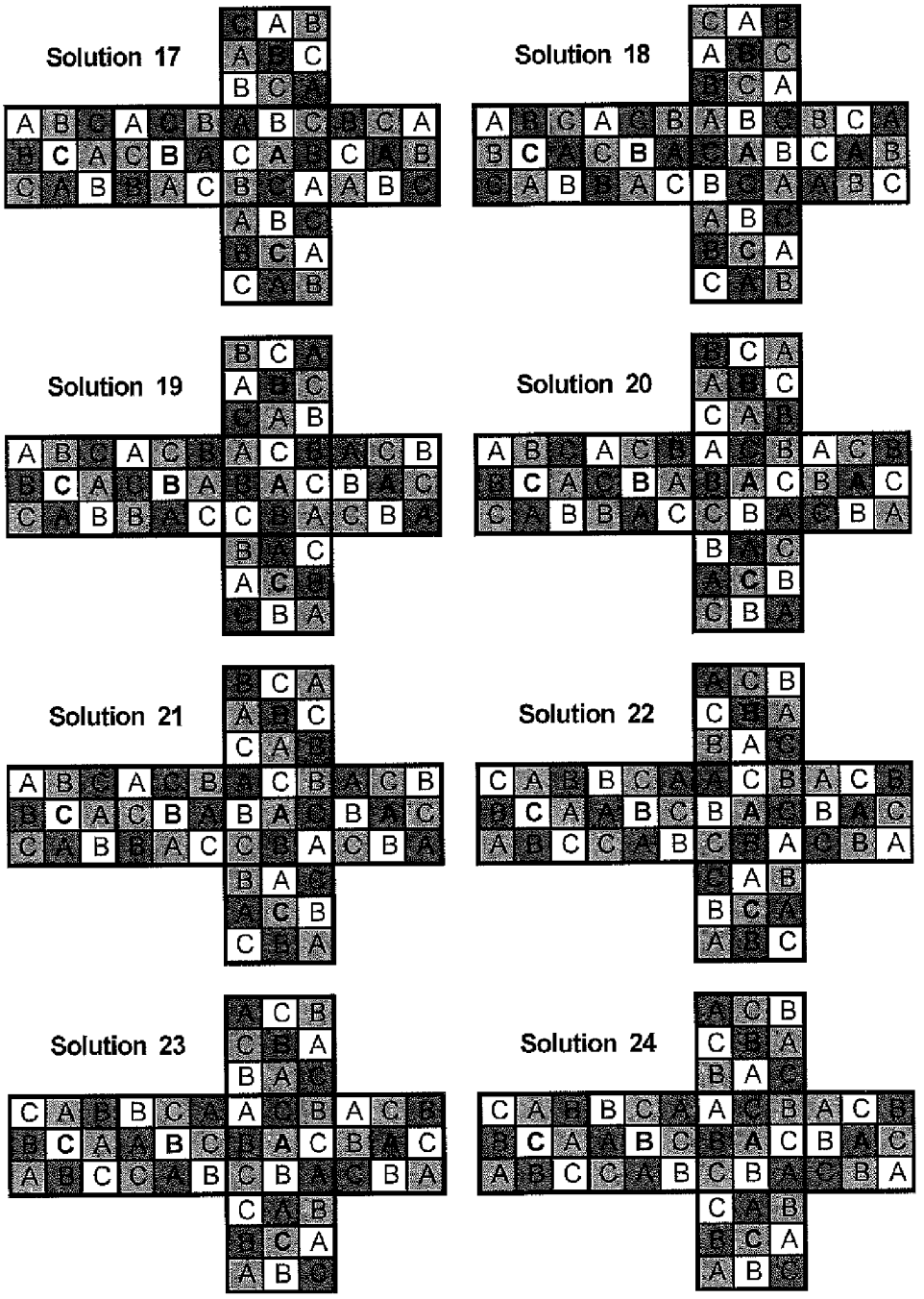


Figure 49

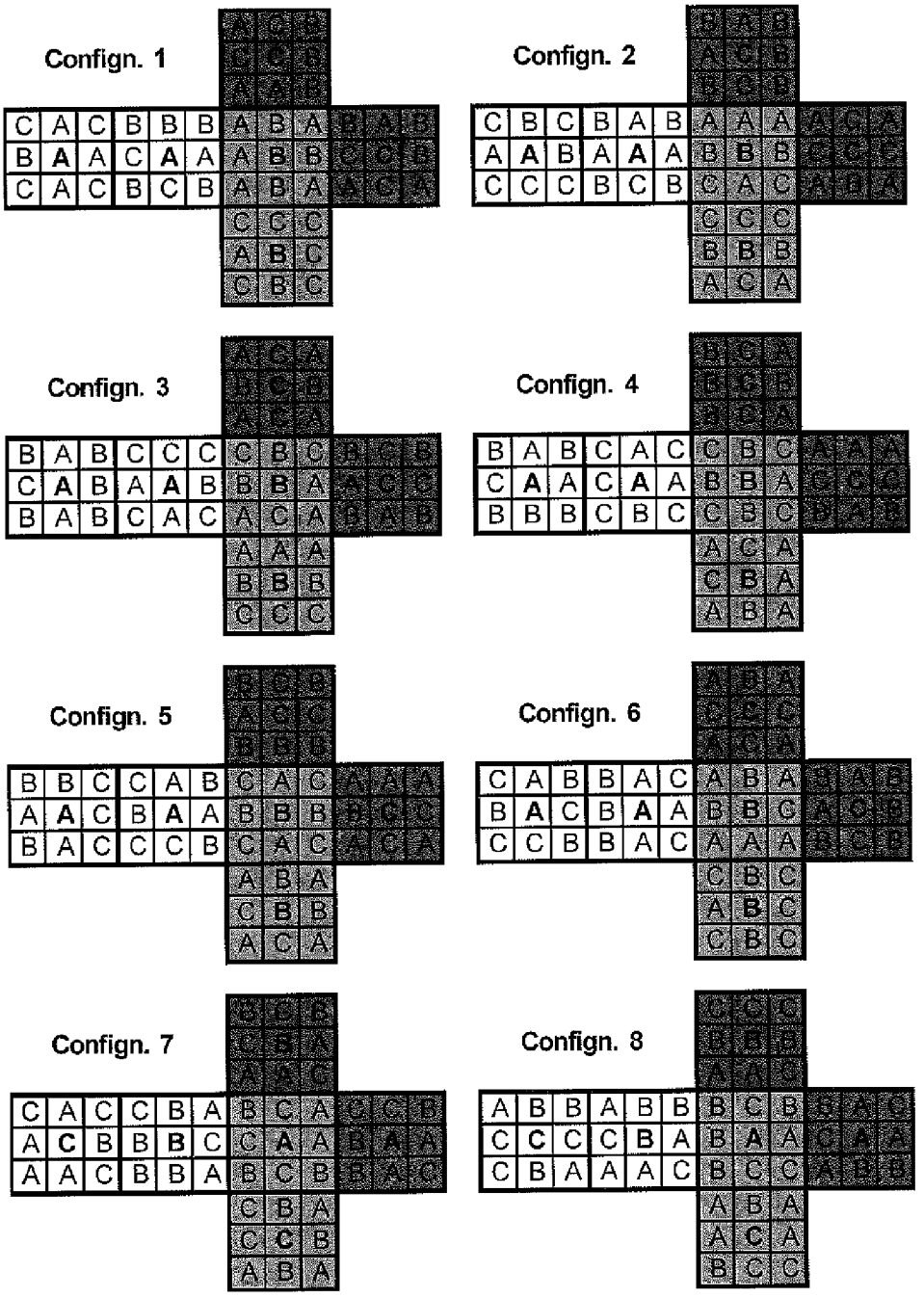

Confign. 1
Confign. 2
Confign. 3
Confign. 4
Confign. 5
Confign. 6
Confign. 7
Confign. 8

Figure 49 (continued)

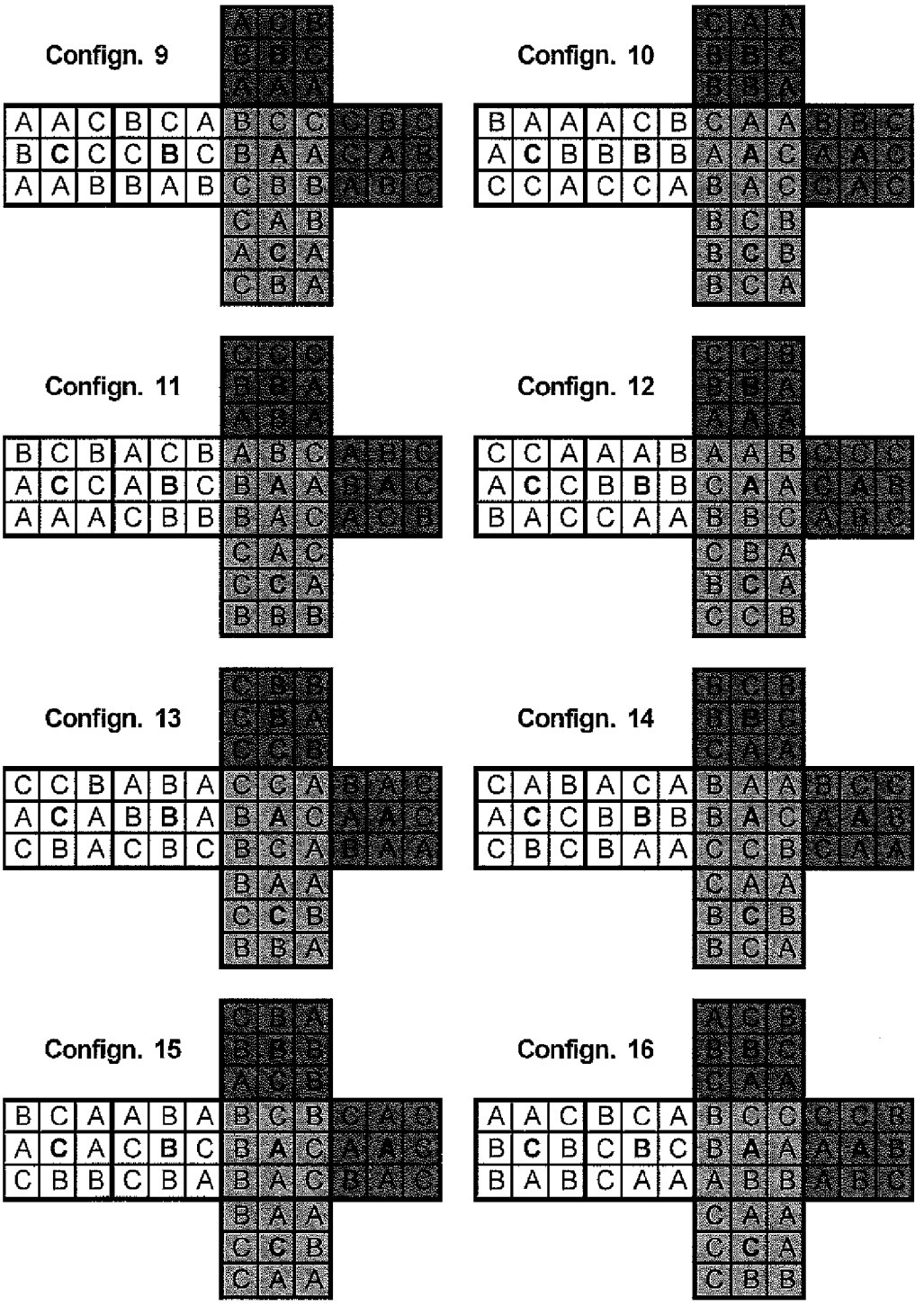


Figure 49 (continued)

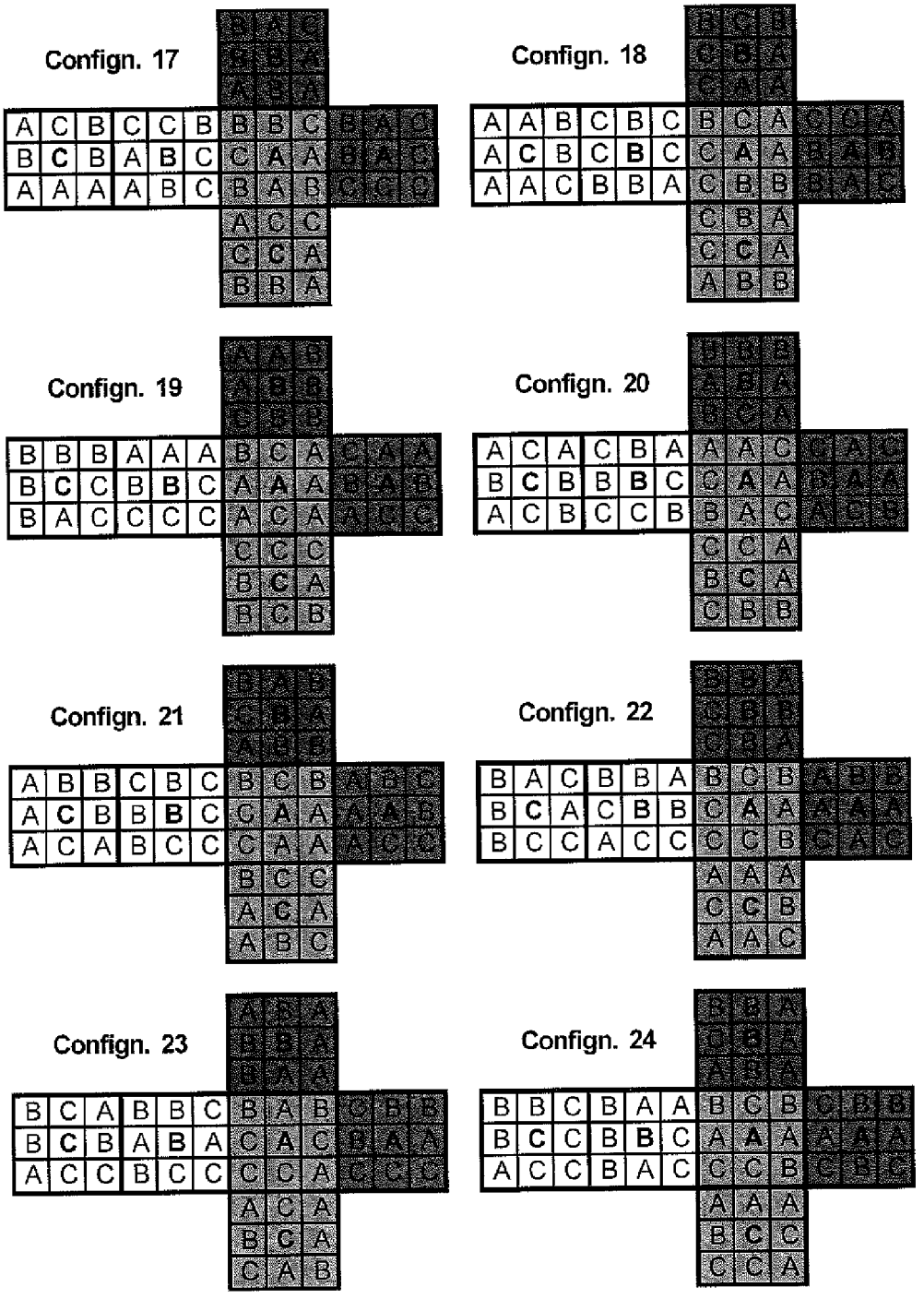
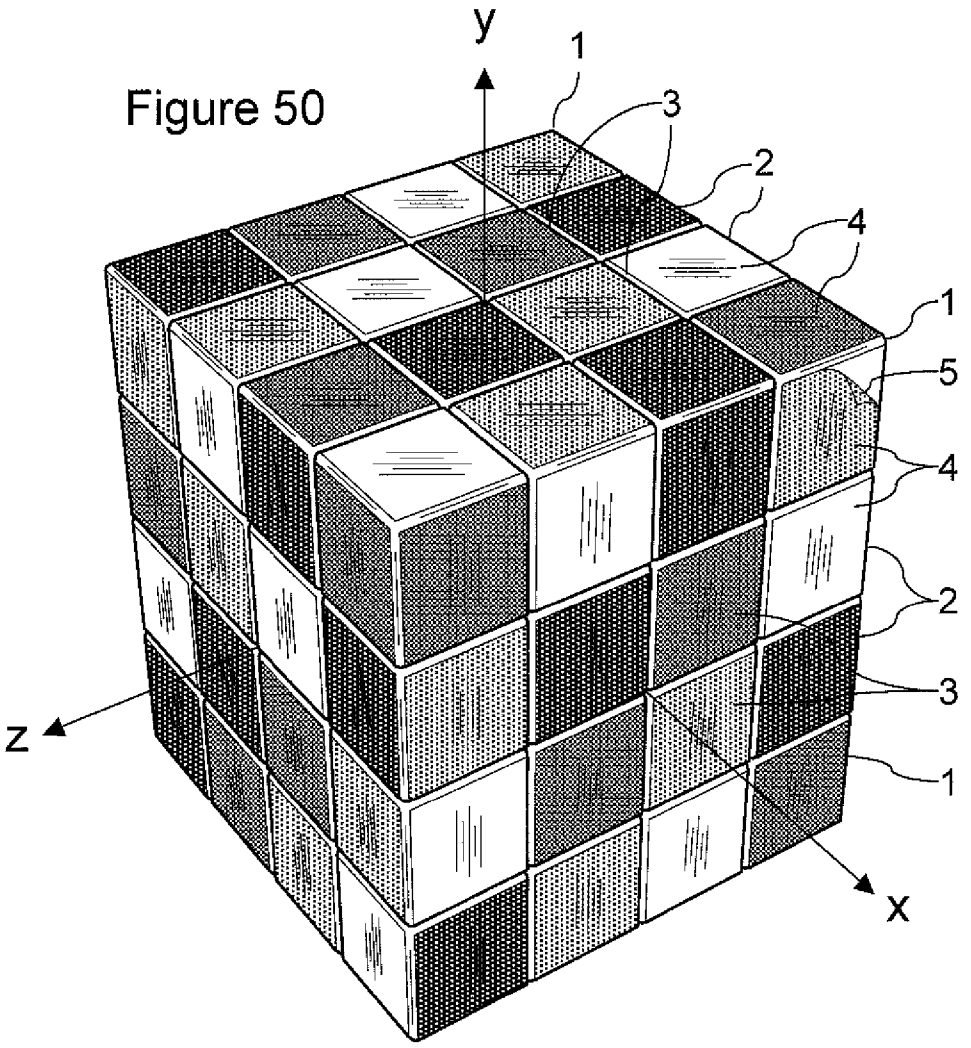


Figure 50



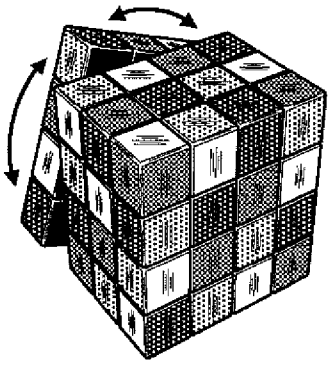


Fig 50a

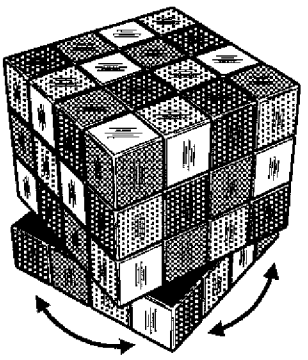


Fig 50b

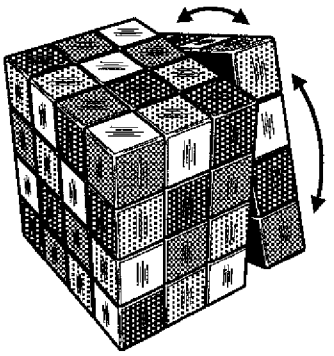


Fig 50c

Figure 51

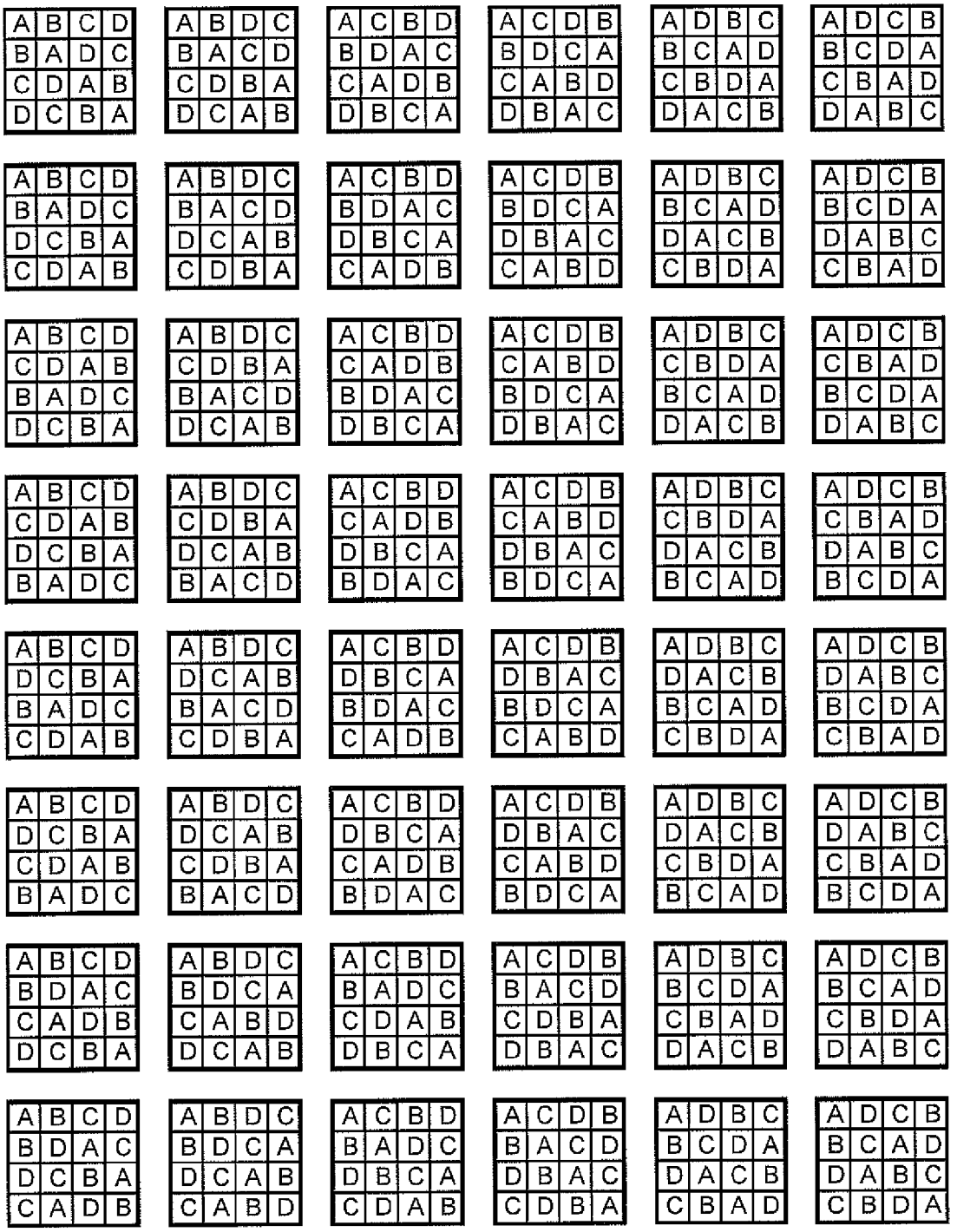

A B C D
B A D C
C D A B
D C B A
A B D C
B A C D
C D B A
D C A B
A C B D
B D A C
C A D B
D B C A
A C D B
B D C A
C A B D
D B A C
A D B C
B C A D
C B D A
D A C B
A D C B
B C D A
C B A D
D A B C

Figure 51 (continued)

A	B	C	D
C	A	D	B
B	D	A	C
D	C	B	A

A	B	D	C
C	A	B	D
B	D	C	A
D	C	A	B

A	C	B	D
C	D	A	B
B	A	D	C
D	B	C	A

A	C	D	B
C	D	B	A
B	A	C	D
D	B	A	C

A	D	B	C
C	B	A	D
B	C	D	A
D	A	C	B

A	D	C	B
C	B	D	A
B	C	A	D
D	A	B	C

A	B	C	D
C	A	D	B
D	C	B	A
B	D	A	C

A	B	D	C
C	A	B	D
D	C	A	B
B	D	C	A

A	C	B	D
C	D	A	B
D	B	C	A
B	A	D	C

A	C	D	B
C	D	B	A
D	B	A	C
B	A	C	D

A	D	B	C
C	B	A	D
D	A	C	B
B	C	D	A

A	D	C	B
C	B	D	A
D	A	B	C
B	C	A	D

A	B	C	D
D	C	B	A
B	D	A	C
C	A	D	B

A	B	D	C
D	C	A	B
B	D	C	A
C	A	B	D

A	C	B	D
D	B	C	A
B	A	D	C
C	D	A	B

A	C	D	B
D	B	A	C
B	A	C	D
C	D	B	A

A	D	B	C
D	A	C	B
B	C	D	A
C	B	A	D

A	D	C	B
D	A	B	C
B	C	A	D
C	B	D	A

A	B	C	D
D	C	B	A
C	A	D	B
B	D	A	C

A	B	D	C
D	C	A	B
C	A	B	D
B	D	C	A

A	C	B	D
D	B	C	A
C	D	A	B
B	A	D	C

A	C	D	B
D	B	A	C
C	D	B	A
B	A	C	D

A	D	B	C
D	A	C	B
C	B	A	D
B	C	D	A

A	D	C	B
D	A	B	C
C	B	D	A
B	C	A	D

B	A	D	C
A	B	C	D
C	D	A	B
D	C	B	A

B	A	C	D
A	B	D	C
C	D	B	A
D	C	A	B

B	D	A	C
A	C	B	D
C	A	D	B
D	B	C	A

B	D	C	A
A	C	D	B
C	A	B	D
D	B	A	C

B	C	A	D
A	D	B	C
C	B	D	A
D	A	C	B

B	C	D	A
A	D	C	B
C	B	A	D
D	A	B	C

B	A	D	C
A	B	C	D
D	C	B	A
C	D	A	B

B	A	C	D
A	B	D	C
D	C	A	B
C	D	B	A

B	D	A	C
A	C	B	D
D	B	C	A
C	A	D	B

B	D	C	A
A	C	D	B
D	B	A	C
C	A	B	D

B	C	A	D
A	D	B	C
D	A	C	B
C	B	D	A

B	C	D	A
A	D	C	B
D	A	B	C
C	B	A	D

B	A	D	C
C	D	A	B
A	B	C	D
D	C	B	A

B	A	C	D
C	D	B	A
A	B	D	C
D	C	A	B

B	D	A	C
C	A	D	B
A	C	B	D
D	B	C	A

B	D	C	A
C	A	B	D
A	C	D	B
D	B	A	C

B	C	A	D
C	B	D	A
A	D	B	C
D	A	C	B

B	C	D	A
C	B	A	D
A	D	C	B
D	A	B	C

B	A	D	C
C	D	A	B
D	C	B	A
A	B	C	D

B	A	C	D
C	D	B	A
D	C	A	B
A	B	D	C

B	D	A	C
C	A	D	B
D	B	C	A
A	C	B	D

B	D	C	A
C	A	B	D
D	B	A	C
A	C	D	B

B	C	A	D
C	B	D	A
D	A	C	B
A	D	B	C

B	C	D	A
C	B	A	D
D	A	B	C
A	D	C	B

Figure 51 (continued)

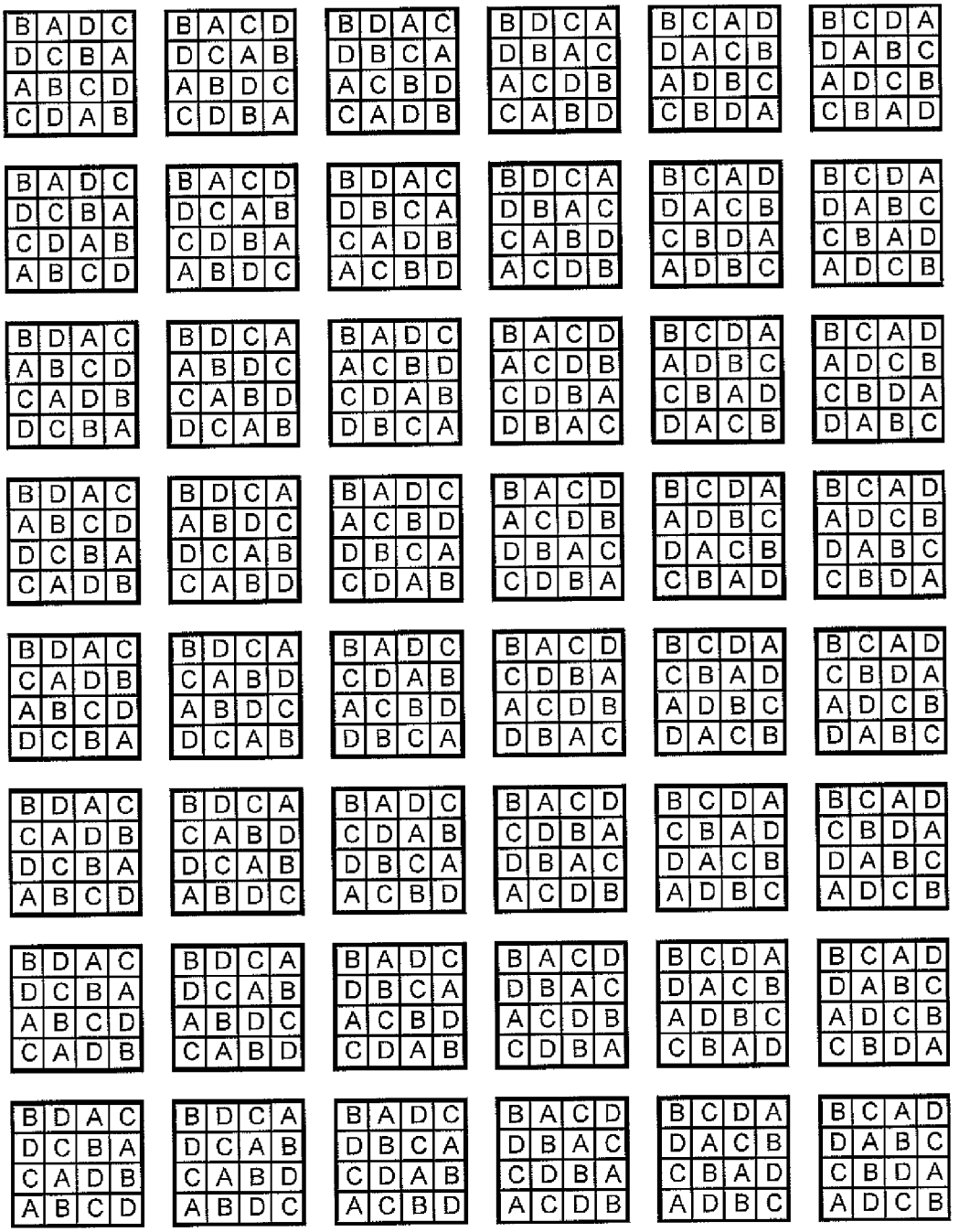


Figure 51 (continued)

C	D	A	B		C	D	B	A		C	A	D	B		C	A	B	D		C	B	D	A		C	B	A	D
A	B	C	D		A	B	D	C		A	C	B	D		A	C	D	B		A	D	B	C		A	D	C	B
B	A	D	C		B	A	C	D		B	D	A	C		B	D	C	A		B	C	A	D		B	C	D	A
D	C	B	A		D	C	A	B		D	B	C	A		D	B	A	C		D	A	C	B		D	A	B	C

C	D	A	B		C	D	B	A		C	A	D	B		C	A	B	D		C	B	D	A		C	B	A	D
A	B	C	D		A	B	D	C		A	C	B	D		A	C	D	B		A	D	B	C		A	D	C	B
D	C	B	A		D	C	A	B		D	B	C	A		D	B	A	C		D	A	C	B		D	A	B	C
B	A	D	C		B	A	C	D		B	D	A	C		B	D	C	A		B	C	A	D		B	C	D	A

C	D	A	B		C	D	B	A		C	A	D	B		C	A	B	D		C	B	D	A		C	B	A	D
B	A	D	C		B	A	C	D		B	D	A	C		B	D	C	A		B	C	A	D		B	C	D	A
A	B	C	D		A	B	D	C		A	C	B	D		A	C	D	B		A	D	B	C		A	D	C	B
D	C	B	A		D	C	A	B		D	B	C	A		D	B	A	C		D	A	C	B		D	A	B	C

C	D	A	B		C	D	B	A		C	A	D	B		C	A	B	D		C	B	D	A		C	B	A	D
B	A	D	C		B	A	C	D		B	D	A	C		B	D	C	A		B	C	A	D		B	C	D	A
D	C	B	A		D	C	A	B		D	B	C	A		D	B	A	C		D	A	C	B		D	A	B	C
A	B	C	D		A	B	D	C		A	C	B	D		A	C	D	B		A	D	B	C		A	D	C	B

C	D	A	B		C	D	B	A		C	A	D	B		C	A	B	D		C	B	D	A		C	B	A	D
D	C	B	A		D	C	A	B		D	B	C	A		D	B	A	C		D	A	C	B		D	A	B	C
A	B	C	D		A	B	D	C		A	C	B	D		A	C	D	B		A	D	B	C		A	D	C	B
B	A	D	C		B	A	C	D		B	D	A	C		B	D	C	A		B	C	A	D		B	C	D	A

C	D	A	B		C	D	B	A		C	A	D	B		C	A	B	D		C	B	D	A		C	B	A	D
D	C	B	A		D	C	A	B		D	B	C	A		D	B	A	C		D	A	C	B		D	A	B	C
B	A	D	C		B	A	C	D		B	D	A	C		B	D	C	A		B	C	A	D		B	C	D	A
A	B	C	D		A	B	D	C		A	C	B	D		A	C	D	B		A	D	B	C		A	D	C	B

C	A	D	B		C	A	B	D		C	D	A	B		C	D	B	A		C	B	A	D		C	B	D	A
A	B	C	D		A	B	D	C		A	C	B	D		A	C	D	B		A	D	B	C		A	D	C	B
B	D	A	C		B	D	C	A		B	A	D	C		B	A	C	D		B	C	D	A		B	C	A	D
D	C	B	A		D	C	A	B		D	B	C	A		D	B	A	C		D	A	C	B		D	A	B	C

C	A	D	B		C	A	B	D		C	D	A	B		C	D	B	A		C	B	A	D		C	B	D	A
A	B	C	D		A	B	D	C		A	C	B	D		A	C	D	B		A	D	B	C		A	D	C	B
D	C	B	A		D	C	A	B		D	B	C	A		D	B	A	C		D	A	C	B		D	A	B	C
B	D	A	C		B	D	C	A		B	A	D	C		B	A	C	D		B	C	D	A		B	C	A	D

Figure 51 (continued)

C	A	D	B
B	D	A	C
A	B	C	D
D	C	B	A

C	A	B	D
B	D	C	A
A	B	D	C
D	C	A	B

C	D	A	B
B	A	D	C
A	C	B	D
D	B	C	A

C	D	B	A
B	A	C	D
A	C	D	B
D	B	A	C

C	B	A	D
B	C	D	A
A	D	B	C
D	A	C	B

C	B	D	A
B	C	A	D
A	D	C	B
D	A	B	C

C	A	D	B
B	D	A	C
D	C	B	A
A	B	C	D

C	A	B	D
B	D	C	A
D	C	A	B
A	B	D	C

C	D	A	B
B	A	D	C
D	B	C	A
A	C	B	D

C	D	B	A
B	A	C	D
D	B	A	C
A	C	D	B

C	B	A	D
B	C	D	A
D	A	C	B
A	D	B	C

C	B	D	A
B	C	A	D
D	A	B	C
A	D	C	B

C	A	D	B
D	C	B	A
A	B	C	D
B	D	A	C

C	A	B	D
D	C	A	B
A	B	D	C
B	D	C	A

C	D	A	B
D	B	C	A
A	C	B	D
B	A	D	C

C	D	B	A
D	B	A	C
A	C	D	B
B	A	C	D

C	B	A	D
D	A	C	B
A	D	B	C
B	C	D	A

C	B	D	A
D	A	B	C
A	D	C	B
B	C	A	D

C	A	D	B
D	C	B	A
B	D	A	C
A	B	C	D

C	A	B	D
D	C	A	B
B	D	C	A
A	B	D	C

C	D	A	B
D	B	C	A
B	A	D	C
A	C	B	D

C	D	B	A
D	B	A	C
B	A	C	D
A	C	D	B

C	B	A	D
D	A	C	B
B	C	D	A
A	D	B	C

C	B	D	A
D	A	B	C
B	C	A	D
A	D	C	B

D	C	B	A
A	B	C	D
B	A	D	C
C	D	A	B

D	C	A	B
A	B	D	C
B	A	C	D
C	D	B	A

D	B	C	A
A	C	B	D
B	D	A	C
C	A	D	B

D	B	A	C
A	C	D	B
B	D	C	A
C	A	B	D

D	A	C	B
A	D	B	C
B	C	A	D
C	B	D	A

D	A	B	C
A	D	C	B
B	C	D	A
C	B	A	D

D	C	B	A
A	B	C	D
C	D	A	B
B	A	D	C

D	C	A	B
A	B	D	C
C	D	B	A
B	A	C	D

D	B	C	A
A	C	B	D
C	A	D	B
B	D	A	C

D	B	A	C
A	C	D	B
C	A	B	D
B	D	C	A

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C	B	D	A
B	C	A	D

D	A	B	C
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C	B	A	D
B	C	D	A

D	C	B	A
B	A	D	C
A	B	C	D
C	D	A	B

D	C	A	B
B	A	C	D
A	B	D	C
C	D	B	A

D	B	C	A
B	D	A	C
A	C	B	D
C	A	D	B

D	B	A	C
B	D	C	A
A	C	D	B
C	A	B	D

D	A	C	B
B	C	A	D
A	D	B	C
C	B	D	A

D	A	B	C
B	C	D	A
A	D	C	B
C	B	A	D

D	C	B	A
B	A	D	C
C	D	A	B
A	B	C	D

D	C	A	B
B	A	C	D
C	D	B	A
A	B	D	C

D	B	C	A
B	D	A	C
C	A	D	B
A	C	B	D

D	B	A	C
B	D	C	A
C	A	B	D
A	C	D	B

D	A	C	B
B	C	A	D
C	B	D	A
A	D	B	C

D	A	B	C
B	C	D	A
C	B	A	D
A	D	C	B

Figure 51 (continued)

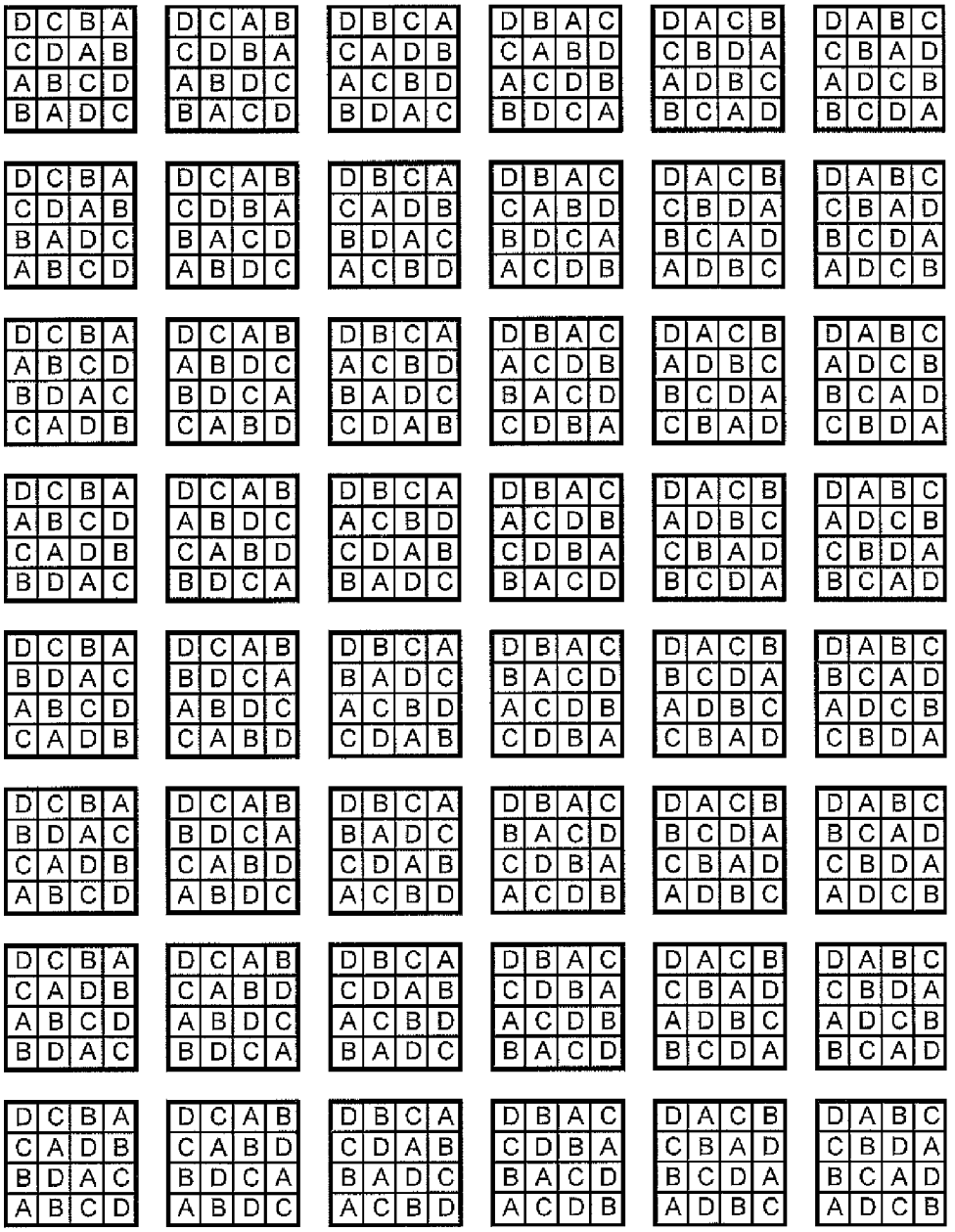

Figure 52

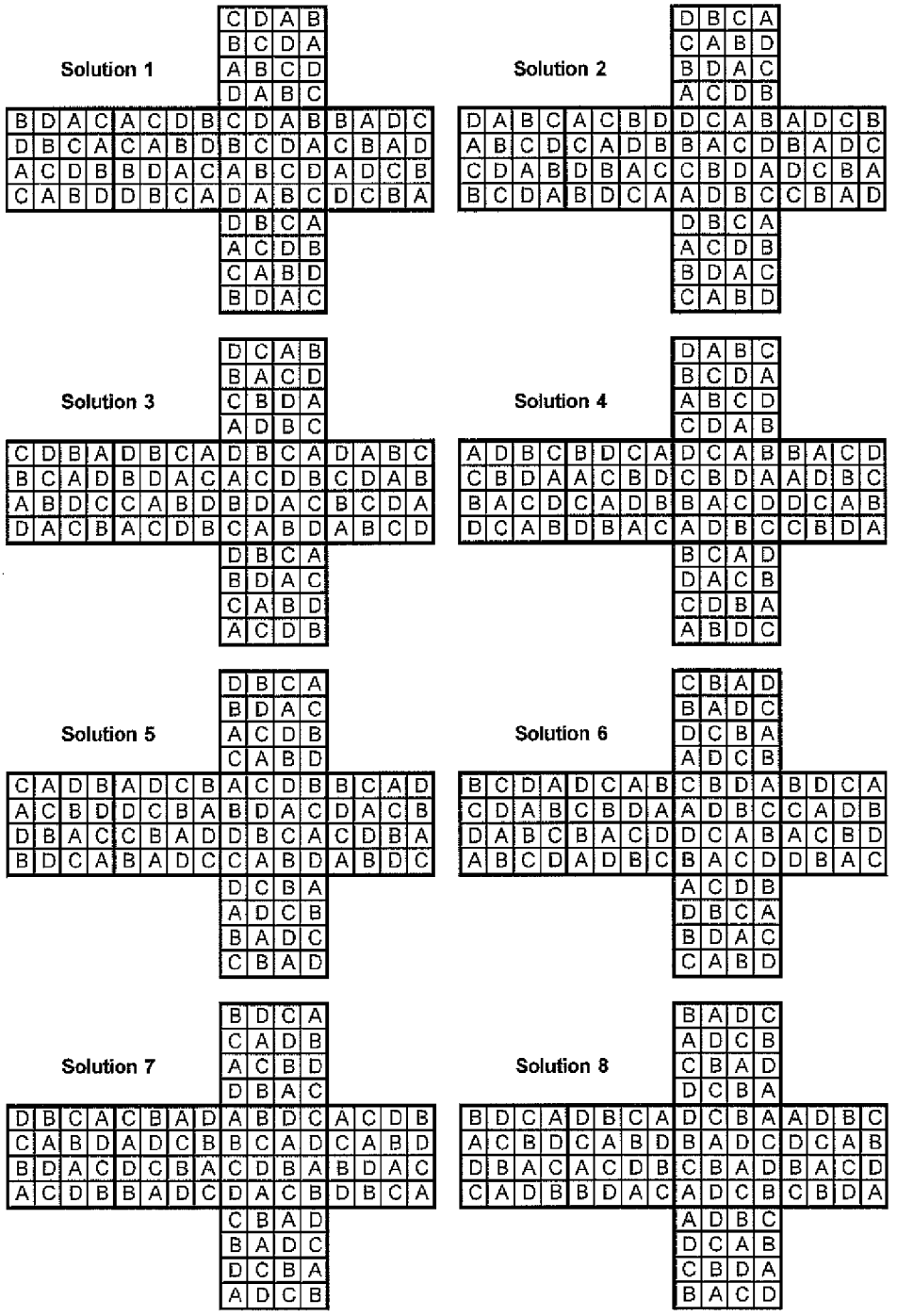
Solution 1
Solution 2
Solution 3
Solution 4
Solution 5
Solution 6
Solution 7
Solution 8

Figure 53

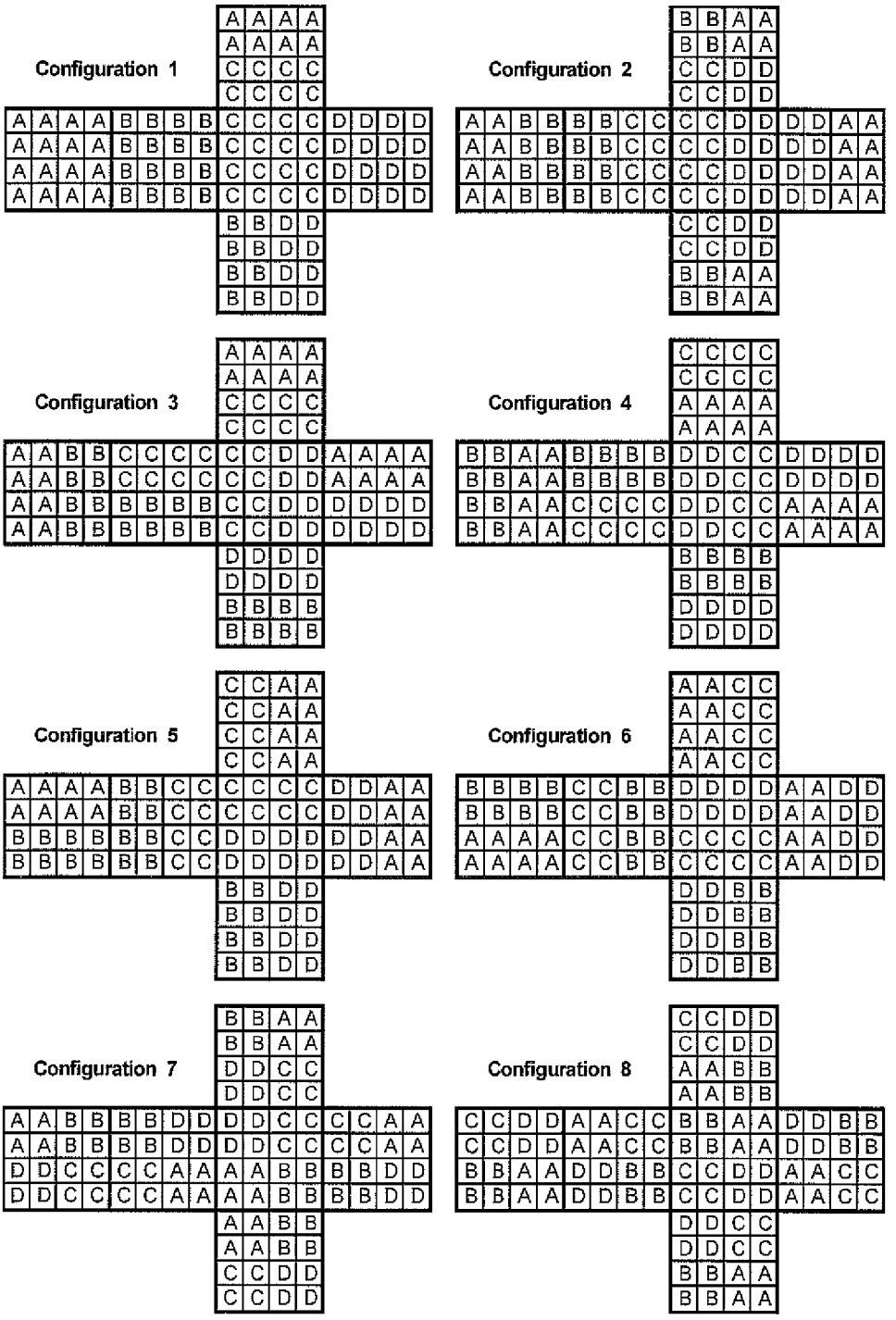
Configuration 1
Configuration 2
Configuration 3
Configuration 4
Configuration 5
Configuration 6
Configuration 7
Configuration 8

Figure 54

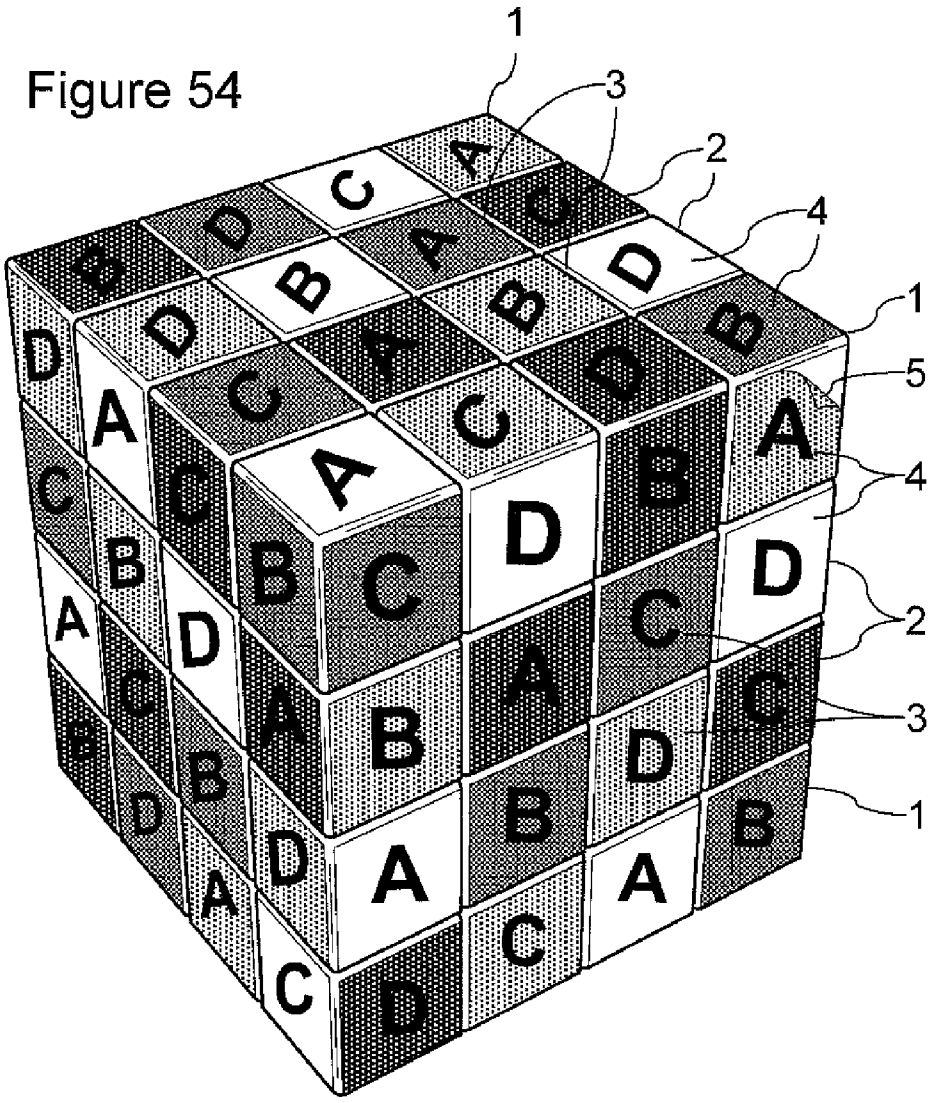

Figure 55

Figure 55 (continued)

COMBINATORIAL TWISTING CUBE PUZZLES

BACKGROUND

[0001] The present invention relates to n×n×n combinatorial twisting cube puzzles of the kind invented by Erno Rubik (HU170062), whose classic 3×3×3 puzzle was sold under the trade mark "Rubik's Cube" and achieved worldwide popularity in the early 1980s. In particular, this invention relates to novel and distinctive combinations and configurations of colours, marks, symbols, words, letters, numbers, pictures or other identifiable features on the faces of these puzzles, which directly enhance or improve their intellectual complexity rather than any aspect of their mechanical design.

[0002] Rubik's original 3×3×3 combinatorial twisting cube puzzle, "Rubik's Cube", has the overall form of a regular three-dimensional cube, with 6 square faces, 8 corners and 12 edges. The puzzle comprises 26 smaller cube-like blocks, including: 8 "corner" blocks, each of which has three exposed faces and resides at one of the puzzle's 8 corners; 12 "edge" blocks, each of which has two exposed faces and lies along one of the puzzle's 12 edges; and 6 "facial" blocks, each of which has just one exposed face and resides at the centre of one of the puzzle's 6 faces. Thus, each of the puzzle's 6 faces are formed by the corresponding faces of 4 corner blocks (one at each corner), 4 edge blocks (one along each edge) and one facial block (at the centre). All 6 facial blocks are connected directly to an orthogonal spindle mechanism which is concealed within the body of the puzzle. The other 20 blocks (8 corner blocks and 12 edge blocks) are held in place by appendages that extend into body of the puzzle between the six facial blocks, such that any 3×3 layer of blocks can be independently rotated by any angle in either direction about the perpendicular x, y or z axis. Each block is characterised by a different set of colours on its exposed faces and the intellectual challenge of the puzzle is to determine and apply the correct sequence of rotations to restore all of the blocks to their original positions and orientations such that they display the same colour on any one face of the puzzle and a different colour on each of the puzzle's six faces.

[0003] One major problem with the Rubik's Cube, which may not have been fully appreciated until now, stems from the fact that the desired position and orientation of each block in the puzzle's known solution is immediately apparent from the distinctive set of colours indicated on its exposed faces. For example: each corner block clearly belongs to that corner of the puzzle which bears the same three colours as the corner block itself; each edge block clearly belongs to that edge of the puzzle which bears the same two colours as the edge block itself; and each facial block clearly belongs to that face of the puzzle which bears the same single colour as the facial block itself. This means that the only intellectual challenge of the puzzle is to determine the correct sequence of rotations to move each block to its desired position and orientation, rather than to determine where each block should go in the first place. However, a method for solving the puzzle has been published, so that anybody who knows this method could easily solve the puzzle within minutes, without any real intellectual input. Consequently, the puzzle began to lose intellectual appeal and popularity as people became aware that they could solve it very easily if they just took the time to learn and practice the published solution.

[0004] Since the solution to the Rubik's Cube was published and its popularity began to fade, Rubik himself and many others have attempted to modify and revive the puzzle in a number of ways. For example, a wide variety of non-cubic polyhedral combinatorial twisting puzzles have been designed based around similar internal rotary mechanisms, including simple spheres, cylinders, prisms, pyramids, tetrahedrons, octahedrons and dodecahedrons, as well as irregular polyhedrons and more complex forms such as the heads of well-known characters like Darth Vader and Homer Simpson.

[0005] Even within the original class of cubic puzzles, various alternative rotary mechanisms have been designed for the classic 3×3×3 cube as well as for n×n×n combinatorial twisting cube puzzles of lower order (where n=2) or higher order (n=4, 5, 6, 7, etc.). Some of these so-called "n×n×n combinatorial twisting cube puzzles" (including the original 3×3×3 Rubik's Cube) are described in the following patent documents:

[0006] HU170062; JP53113642; JP53120946; U.S. Pat. No. 4,344,623; U.S. Pat. No. 4,378,117; U.S. Pat. No. 4,421,311; GB2092454; FR2501516; DE3111381; DE3125817; NL8103469; DE8109568U; DE3133235; U.S. Pat. No. 4,415,158; U.S. Pat. No. 4,405,131; BE890547; U.S. Pat. No. 4,600,199; WO8301203; DE3143716; U.S. Pat. No. 4,427,197; GB2113104; NL8105604; FR2.521865; U.S. Pat. No. 4,540,177; U.S. Pat. No. 4,593,908; U.S. Pat. No. 4,593,907; BE894943; GB2111840; BE896950; SU1247028; SU1258457; FR2593075; U.S. Pat. No. 4,781,380; SU1733028; U.S. Pat. No. 5,271,688; U.S. Pat. No. 5,826,871; U.S. Pat. No. 5,992,850; U.S. Pat. No. 6,129,356; FR2787033; GB2356150; WO2004103497

[0007] In addition, numerous variations of these n×n×n combinatorial twisting cube puzzles have been designed in which the colours indicated on the faces of the puzzle have been replaced with various pictures (e.g., U.S. Pat. No. 4,407,502), symbols (e.g., DE3143716), numbers (e.g., U.S. Pat. No. 6,626,431), words or letters (e.g., U.S. Pat. No. 4,437,667), or any combination of these features (e.g., U.S. Pat. No. 4,409,750).

[0008] In all these rather simple variations of the original Rubik's Cube, however, the desired position and orientation of each block in the puzzle's solution are still immediately apparent from the distinctive set of colours, marks, symbols, numbers, letters, pictures or other features indicated on its exposed faces. Moreover, the intellectual challenge of the puzzles remains to determine the correct sequence of rotations to move each block to its desired position and orientation, rather than to determine where each block should go in the first place. Consequently, all of these puzzles can easily be solved using the same methods that have been published to solve the original Rubik's Cube, without any real intellectual input, so the intellectual appeal of these puzzles is still rather limited, regardless of whether the six faces of the puzzle are characterised by different colours, marks, symbols, words, letters, numbers, pictures, or otherwise.

[0009] A key objective of the present invention, therefore, is to provide novel and distinctive combinations and configurations of colours, marks, symbols, words, letters, numbers, pictures or other identifiable features on the faces of n×n×n combinatorial twisting cube puzzles, wherein the desired position and orientation of each block in the puzzle's final solution are not immediately apparent from the distinctive set of colours, marks, symbols or other features indicated on the exposed faces of each block. The absence of a clearly defined solution provides a greater and more stimulating intellectual

challenge. It is important to note, however, that the invention does not focus on the mechanical design of these puzzles, which has been adequately addressed in the patent documents cited above.

SUMMARY OF THE INVENTION

[0010] Accordingly, the present invention provides a n×n×n combinatorial twisting cube puzzle which has the overall form of a regular cube, with 8 corners, 12 edges and 6 faces, and which comprises:

[0011] i) 8 cube-like corner blocks [**1**], each of which has three exposed faces [**4**] and resides at one of the puzzle's 8 corners;

[0012] ii) 12×(n−2) cube-like edge blocks [**2**], each of which has two exposed faces [**4**] and resides along one of the puzzle's 12 edges;

[0013] iii) $6\times(n-2)^2$ cube-like facial blocks [**3**], each of which has one exposed face [**4**] and resides in one of the puzzle's 6 faces; and

[0014] iv) a rotary mechanism which holds all the blocks in the puzzle together while allowing free and independent rotation of any n×n layer of blocks in either direction about an axis that is perpendicular to the rotating layer of blocks;

WHEREIN:

[0015] a) a total of 6n×(n−2)+8 cube-like blocks have $6n^2$ exposed faces [**4**] which are labelled with 6n identical or equivalent copies each of n different colours, marks, symbols, words, letters, numbers, pictures or other features; and

[0016] b) the puzzle has at least one solution wherein one copy of each different colour, mark, symbol, word, letter, number, picture or other feature appears on every row and every column of blocks on each face of the puzzle, such that no two identical or equivalent copies of any one colour, mark, symbol, word, letter, number, picture or other feature appear on the same row or column of blocks on any face of the puzzle.

[0017] IN PARTICULAR, the present invention provides a n×n×n combinatorial twisting cube puzzle comprising a total of 6n×(n−2)+8 cube-like blocks with $6n^2$ exposed faces [**4**], which are labelled with 6n identical or equivalent copies each of n different colours, marks, symbols, words, letters, numbers, pictures or other features.

[0018] In a first embodiment of the present invention (Example 1), n is 2, corresponding to a 2×2×2 combinatorial twisting cube puzzle wherein 8 cube-like corner blocks have 24 exposed faces [**4**], which are labelled with 12 identical or equivalent copies each of 2 different colours, marks, symbols, words, letters, numbers, pictures or other features.

[0019] In a second embodiment of the present invention (Example 2), n is 3, corresponding to a 3×3×3 combinatorial twisting cube puzzle wherein a total of 26 cube-like blocks have 54 exposed faces [**4**], which are labelled with 18 identical or equivalent copies each of 3 different colours, marks, symbols, words, letters, numbers, pictures or other features.

[0020] In a third embodiment of the present invention (Example 3), n is 4, corresponding to a 4×4×4 combinatorial twisting cube puzzle wherein a total of 56 cube-like blocks have 96 exposed faces [**4**], which are labelled with 24 identical or equivalent copies each of 4 different colours, marks, symbols, words, letters, numbers, pictures or other features.

[0021] In a fourth embodiment of the present invention (Example 4), n is 5, corresponding to a 5×5×5 combinatorial twisting cube puzzle wherein a total of 98 cube-like blocks have 150 exposed faces [**4**], which are labelled with 30 identical or equivalent copies each of 5 different colours, marks, symbols, words, letters, numbers, pictures or other features.

[0022] The overall objective of the puzzles of the present invention is essentially to determine and apply the correct sequence of rotations to "scramble" or "mix up" (rearrange) the blocks such that one copy of each different colour, mark, symbol, word, letter, number, picture or other feature appears on every row and every column of blocks on each face of the puzzle, and no two copies of any one colour, mark, symbol, word, letter, number, picture or other feature appear on the same row or column of blocks on any face of the puzzle. However, since the desired position and orientation of each individual block in the puzzle's solution are not immediately apparent, this has to be determined either by logical deduction or by trial and error in order to solve the puzzle, thereby providing a greater and more stimulating intellectual challenge.

[0023] Accordingly, the puzzles of the present invention preferably have at least one solution wherein one copy of each different colour, mark, symbol, word, letter, number, picture or other feature appears on every row and every column of blocks on each face of the puzzle, and no two identical or equivalent copies of any colour, mark, symbol, word, letter, number, picture or other feature appear on any one row or column of blocks on any face of the puzzle.

INTRODUCTION TO THE DRAWINGS

[0024] The invention will now be described in more detail by referring to the accompanying drawings:

[0025] FIG. **1** shows a three-dimensional (perspective) drawing of a 2×2×2 combinatorial twisting cube puzzle according to the present invention, wherein n=2 and all 8 corner blocks [**1**] have a total of 24 exposed faces [**4**], which are labelled with 12 copies each of 2 different colours (white and grey) using adhesive labels or stickers [**5**] so that one copy of each colour appears on every row and every column of blocks on each face of the puzzle, and no two copies of any colour appear on any row or column of blocks on any face of the puzzle, in accordance with a possible solution of the puzzle as defined herein.

[0026] FIGS. **1***a*, **1***b* and **1***c* show how alternative layers of blocks within the same 2×2×2 combinatorial twisting cube puzzle may be rotated freely and independently in either direction about an axis that is perpendicular to the rotating layer of blocks.

[0027] FIG. **2** shows two alternative configurations of two different colours, marks, symbols, words, letters, numbers, pictures or other features (indicated by A and B) on each face of a 2×2×2 combinatorial twisting cube puzzle, corresponding to $2^6=64$ alternative solutions of the puzzle as defined herein (shown in FIG. **4**).

[0028] FIG. **3** shows the numbers of identical or equivalent blocks bearing various different sets or combinations of 2 different colours, marks, symbols, words, letters, numbers, pictures or other features (indicated by A and B) in 6 different possible configurations of a 2×2×2 combinatorial twisting cube puzzle according to the present invention. For each configuration (Config. Nos. **1** to **6**), FIG. **3** also shows: the total number of blocks which form part of a complete set of analogous blocks bearing complementary sets of features

(Sym., reflecting the overall degree of symmetry between the blocks); the number of redundant blocks that are identical or equivalent copies of other block(s) in the puzzle (Red.); the standard deviation in the numbers of blocks bearing different sets or combinations of features (S.D.); and the number of possible solutions (Sol.).

[0029] FIG. **4** shows 64 alternative configurations of two different colours, marks, symbols, words, letters, numbers, pictures or other features (indicated by A and B) on all six faces of a 2×2×2 combinatorial twisting cube puzzle, representing various possible solutions of the puzzle (Solns. **1** to **64**) as defined herein.

[0030] FIGS. **5***a* and **5***b* show 12 possible solutions plus 3 possible starting configurations (Solns. **1** to **12** and Cons. **1** to **3**, respectively) for a 2×2×2 combinatorial twisting cube puzzle corresponding to Config. No. **1** of FIG. **3**.

[0031] FIGS. **6***a* and **6***b* show 24 possible solutions plus 2 possible starting configurations (Solns. **1** to **24** and Cons. **1** and **2**, respectively) for a 2×2×2 combinatorial twisting cube puzzle corresponding to Config. No. **2** of FIG. **3**.

[0032] FIGS. **7***a* and **7***b* show 18 possible solutions and one possible starting configuration (Solns. **1** to **18** and Con. **1**, respectively) for a 2×2×2 combinatorial twisting cube puzzle corresponding to Config. No. **3** of FIG. **3**.

[0033] FIGS. **8***a* and **8***b* show 2 possible solutions and one possible starting configuration (Solns. **1** and **2** and Con. **1**, respectively) for a 2×2×2 combinatorial twisting cube puzzle corresponding to Config. No. **4** of FIG. **3**.

[0034] FIGS. **9***a* and **9***b* show 4 possible solutions plus 2 possible starting configurations (Solns. **1** to **4** and Cons. **1** and **2**, respectively) for a 2×2×2 combinatorial twisting cube puzzle corresponding to Config. No. **5** of FIG. **3**.

[0035] FIGS. **10***a* and **10***b* show 4 possible solutions plus 2 possible starting configurations (Solns. **1** to **4** and Cons. **1** and **2**, respectively) for a 2×2×2 combinatorial twisting cube puzzle corresponding to Config. No. **6** of FIG. **3**.

[0036] FIGS. **11***a* and **11***b* show one possible solution and one possible starting configuration (Soln. **1** and Con. **1**, respectively) for a 2×2×2 combinatorial twisting cube puzzle wherein all the exposed faces of each block bear the same colour (indicated by A on a white block or B on a grey block), such that the particular colour associated with each block may be incorporated directly into the substance or material of the block itself.

[0037] FIG. **12** shows a three-dimensional perspective drawing of a 2×2×2 combinatorial twisting cube puzzle according to the present invention, wherein n=2 and all 8 corner blocks [**1**] have a total of 54 exposed faces [**4**], which are labelled with 12 copies each of 2 different colours (white and grey) and 12 copies each of 2 different letters (A and B), such that one copy of each colour and one copy of each letter appear on every row and every column of blocks on each face of the puzzle and no two copies of the same colour or letter appear on the same row or column of blocks on any face of the puzzle, in accordance with a possible solution of the puzzle as defined herein.

[0038] FIG. **13** shows 4 alternative configurations of two different colours, marks, symbols, words, letters, numbers, pictures or other features (represented by A and B) combined with another set of two different features (indicated by white and grey blocks) on each face of a 2×2×2 combinatorial twisting cube puzzle, representing 4^6=4,096 possible solutions of the puzzle as defined herein.

[0039] FIG. **14** shows 64 different configurations of two different colours, marks, symbols, words, letters, numbers, pictures or other features (represented by A and B) combined with a different set of two different features (indicated by white and grey blocks) on all six faces of a 2×2×2 combinatorial twisting cube puzzle, representing 64 out of 512 possible solutions of the puzzle as defined herein.

[0040] FIG. **15** shows a three-dimensional perspective drawing of a 3×3×3 combinatorial twisting cube puzzle according to the present invention, wherein n=3 and all 26 cube-like blocks (8 corner blocks [**1**], 12 edge blocks [**2**] and 6 facial blocks [**3**]) have a total of 54 exposed faces [**4**], which are labelled with 18 copies each of 3 different colours (white and two shades of grey) using adhesive labels or stickers [**5**] such that one copy of each colour appears on every row and every column of blocks on each face of the puzzle and no two copies of the same colour appear on any row or column of blocks on any face of the puzzle, in accordance with a possible solution of the puzzle as defined herein.

[0041] FIGS. **15***a*, **15***b* and **15***c* show how alternative layers of blocks within the same 3×3×3 combinatorial twisting cube puzzle may be rotated freely and independently in either direction about an axis that is perpendicular to the rotating layer of blocks.

[0042] FIG. **16** shows 12 alternative configurations of 3 different colours, marks, symbols, words, letters, numbers, pictures or other features (indicated by A, B and C) on each face of a 3×3×3 combinatorial twisting cube puzzle, representing 12^6=3.0×10^6 possible solutions of the puzzle as defined herein.

[0043] FIG. **17***a* indicates the respective positions of all six facial blocks (indicated by P, Q, R, S, T and U, respectively) on the six faces of a 3×3×3 combinatorial twisting cube puzzle, corresponding to the six facial blocks indicated in FIG. **17***b*.

[0044] FIG. **17***b* shows 57 alternative configurations of 3 different colours, marks, symbols, words, letters, numbers, pictures or other features (indicated by A, B and C) on all six facial blocks of a 3×3×3 combinatorial twisting cube puzzle in accordance with the present invention. For each configuration (Config. Nos. **1** to **57**, respectively), FIG. **17***b* shows: the particular feature (A, B or C) which is indicated on each facial block (P, Q, R, S, T and U, in accordance with FIG. **17***a*); the number of facial blocks that bear each feature; the number of facial blocks that form part of a complete set of analogous facial blocks bearing complementary features (Sym., reflecting the degree of symmetry between the facial blocks); the number of redundant facial blocks that bear the same feature as another facial block in the puzzle (Red.); and the standard deviation in the numbers of facial blocks bearing different features (S.D.).

[0045] FIG. **18** shows 57 alternative configurations of 3 different colours, marks, symbols, words, letters, numbers, pictures or other features (indicated by A, B and C) on all six facial blocks (P, Q, R, S, T and U) of a 3×3×3 combinatorial twisting cube puzzle, corresponding to Config. Nos. **1** to **57** of FIG. **17***b*, respectively.

[0046] FIG. **19** shows the numbers of identical or equivalent corner, edge and facial blocks bearing various different sets or combinations of 3 different colours, marks, symbols, words, letters, numbers, pictures or other features (indicated by A, B and C) in 130 different configurations of a 3×3×3 combinatorial twisting cube puzzle according to Config. No. **1** of FIGS. **17***b* and **18**, wherein any 2 facial blocks which bear

the same feature reside on adjacent faces of the puzzle. ABCc indicates that A, B and C appear on the exposed faces of a corner block in clockwise order, while ABCa indicates that these 3 features appear on the exposed faces of a corner block in anticlockwise order. For each configuration (Config. Nos. **1** to **130**), FIG. **19** also shows: the number of blocks which form part of a complete set of analogous blocks bearing complementary sets of features (Sym., reflecting the overall degree of symmetry between the blocks); the number of redundant blocks that are identical or equivalent copies of another block in the puzzle (Red.); the standard deviation in the numbers of blocks bearing different sets or combinations of features (S.D.); and the number of possible solutions (Sol.).

[0047] FIGS. **20***a* and **20***b* show 5 possible solutions and 14 possible starting configurations (Solutions **1** to **5** and Configs. **1** to **14**, respectively) for a 3×3×3 combinatorial twisting cube puzzle corresponding to Config. No. **1** of FIG. **19** (in accordance with Config. No. **1** of FIGS. **17***b* and **18**).

[0048] FIGS. **21***a* and **21***b* show 19 possible solutions and 7 possible starting configurations (Solutions **1** to **19** and Configs. **1** to **7**, respectively) for a 3×3×3 combinatorial twisting cube puzzle corresponding to Config. No. **2** of FIG. **19** (in accordance with Config. No. **1** of FIGS. **17***b* and **18**).

[0049] FIG. **22** shows just one possible solution (Solution **1**) for a 3×3×3 combinatorial twisting cube puzzle corresponding to Config. No. **3** of FIG. **19** (in accordance with Config. No. **1** of FIGS. **17***b* and **18**).

[0050] FIG. **23** shows just one possible solution (Solution **1**) for a 3×3×3 combinatorial twisting cube puzzle corresponding to Config. No. **4** of FIG. **19** (in accordance with Config. No. **1** of FIGS. **17***b* and **18**).

[0051] FIGS. **24***a* and **24***b* show one possible solution and 4 possible starting configurations (Solution **1** and Configs. **1** to **4**, respectively) for a 3×3×3 combinatorial twisting cube puzzle corresponding to Config. No. **5** of FIG. **19** (in accordance with Config. No. **1** of FIGS. **17***b* and **18**).

[0052] FIG. **25** shows just one possible solution (Solution **1**) for a 3×3×3 combinatorial twisting cube puzzle corresponding to Config. No. **6** of FIG. **19** (in accordance with Config. No. **1** of FIGS. **17***b* and **18**).

[0053] FIG. **26** shows just one possible solution (Solution **1**) for a 3×3×3 combinatorial twisting cube puzzle corresponding to Config. No. **7** of FIG. **19** (in accordance with Config. No. **1** of FIGS. **17***b* and **18**).

[0054] FIGS. **27***a* and **27***b* show 10 possible solutions and 4 possible starting configurations (Solutions **1** to **10** and Configs. **1** to **4**, respectively) for a 3×3×3 combinatorial twisting cube puzzle corresponding to Config. No. **8** of FIG. **19** (in accordance with Config. No. **1** of FIGS. **17***b* and **18**).

[0055] FIG. **28** shows 4 possible solutions (Solutions **1** to **4**) for a 3×3×3 combinatorial twisting cube puzzle corresponding to Config. No. **9** of FIG. **19** (in accordance with Config. No. **1** of FIGS. **17***b* and **18**).

[0056] FIG. **29** shows 4 possible solutions (Solutions **1** to **4**) for a 3×3×3 combinatorial twisting cube puzzle corresponding to Config. No. **10** of FIG. **19** (in accordance with Config. No. **1** of FIGS. **17***b* and **18**).

[0057] FIG. **30** shows just one possible solution (Solution **1**) for a 3×3×3 combinatorial twisting cube puzzle corresponding to Config. No. **11** of FIG. **19** (in accordance with Config. No. **1** of FIGS. **17***b* and **18**).

[0058] FIG. **31** shows the numbers of identical or equivalent corner, edge and facial blocks bearing various different sets or combinations of 3 different colours, marks, symbols, words, letters, numbers, pictures or other features (indicated by A, B and C) in 65 different configurations of a 3×3×3 combinatorial twisting cube puzzle according to Config. No. **3** of FIGS. **17***b* and **18**, wherein two facial blocks which bear feature C reside on opposite faces of the puzzle, while any two facial blocks which bear identical or equivalent copies of any other feature (A or B) lie on adjacent faces of the puzzle. ABCc indicates that features A, B and C appear on the exposed faces of a corner block in clockwise order, while ABCa indicates that these 3 features appear on the exposed faces of a corner block in anticlockwise order. For each configuration (Config. Nos. **1** to **65**), FIG. **31** also shows: the total number of blocks that form part of a complete set of analogous blocks bearing complementary sets of features (Sym., reflecting the overall degree of symmetry between the blocks); the number of redundant blocks that are identical or equivalent copies of another block in the puzzle (Red.); the standard deviation in the numbers of blocks bearing different sets or combinations of features (S.D.); and the number of possible solutions (Sol.).

[0059] FIG. **32** shows 2 possible solutions (Solutions **1** and **2**) for a 3×3×3 combinatorial twisting cube puzzle corresponding to Config. No. **1** of FIG. **31** (in accordance with Config. No. **3** of FIGS. **17***b* and **18**).

[0060] FIG. **33** shows 12 possible solutions (Solutions **1** to **12**) for a 3×3×3 combinatorial twisting cube puzzle corresponding to Config. No. **2** of FIG. **31** (in accordance with Config. No. **3** of FIGS. **17***b* and **18**).

[0061] FIG. **34** shows 12 possible solutions (Solutions **1** to **12**) for a 3×3×3 combinatorial twisting cube puzzle corresponding to Config. No. **3** of FIG. **31** (in accordance with Config. No. **3** of FIGS. **17***b* and **18**).

[0062] FIGS. **35***a* and **35***b* show 16 possible solutions and 8 possible starting configurations (Solutions **1** to **16** and Configs. **1** to **8**, respectively) for a 3×3×3 combinatorial twisting cube puzzle corresponding to Config. No. **4** of FIG. **31** (in accordance with Config. No. **3** of FIGS. **17***b* and **18**).

[0063] FIG. **36** shows 2 possible solutions (Solutions **1** and **2**) for a 3×3×3 combinatorial twisting cube puzzle corresponding to Config. No. **5** of FIG. **31** (in accordance with Config. No. **3** of FIGS. **17***b* and **18**).

[0064] FIG. **37** shows 4 possible solutions (Solutions **1** to **4**) for a 3×3×3 combinatorial twisting cube puzzle corresponding to Config. No. **6** of FIG. **31** (in accordance with Config. No. **3** of FIGS. **17***b* and **18**).

[0065] FIG. **38** shows 4 possible solutions (Solutions **1** to **4**) for a 3×3×3 combinatorial twisting cube puzzle corresponding to Config. No. **7** of FIG. **31** (in accordance with Config. No. **3** of FIGS. **17***b* and **18**).

[0066] FIG. **39** shows the numbers of identical or equivalent corner, edge and facial blocks bearing various different sets or combinations of 3 different colours, marks, symbols, words, letters, numbers, pictures or other features (indicated by A, B and C) in 65 different configurations of a 3×3×3 combinatorial twisting cube puzzle according to Config. No. **6** of FIGS. **17***b* and **18**, wherein any 2 facial blocks which bear the same feature reside on opposite faces of the puzzle. ABCc indicates that A, B and C appear on the exposed faces of a corner block in clockwise order, while ABCa indicates that these 3 features appear on the exposed faces of a corner block in anticlockwise order. For each configuration (Config. Nos. **1** to **65**), FIG. **39** also shows: the number of blocks which form part of a complete set of analogous blocks bearing comple-

mentary sets of features (Sym., reflecting the overall degree of symmetry between the blocks); the number of redundant blocks that are identical or equivalent copies of another block in the puzzle (Red.); the standard deviation in the numbers of blocks bearing different sets or combinations of features (S.D.); and the number of possible solutions (Sol.).

[0067] FIG. **40** shows 8 possible solutions (Solutions **1** to **8**) for a 3×3×3 combinatorial twisting cube puzzle corresponding to Config. No. **1** of FIG. **39** (in accordance with Config. No. **6** of FIGS. **17***b* and **18**).

[0068] FIG. **41** shows 4 possible solutions (Solutions **1** to **4**) for a 3×3×3 combinatorial twisting cube puzzle corresponding to Config. No. **2** of FIG. **39** (in accordance with Config. No. **6** of FIGS. **17***b* and **18**).

[0069] FIG. **42** shows 4 possible solutions (Solutions **1** to **4**) for a 3×3×3 combinatorial twisting cube puzzle corresponding to Config. No. **3** of FIG. **39** (in accordance with Config. No. **6** of FIGS. **17***b* and **18**).

[0070] FIG. **43** shows 4 possible solutions (Solutions **1** to **4**) for a 3×3×3 combinatorial twisting cube puzzle corresponding to Config. No. **4** of FIG. **39** (in accordance with Config. No. **6** of FIGS. **17***b* and **18**).

[0071] FIG. **44** shows 4 possible solutions (Solutions **1** to **4**) for a 3×3×3 combinatorial twisting cube puzzle corresponding to Config. No. **5** of FIG. **39** (in accordance with Config. No. **6** of FIGS. **17***b* and **18**).

[0072] FIGS. **45***a* and **45***b* show one possible solution and one possible starting configuration (Solution **1** and Confign. **1**) for a 3×3×3 combinatorial twisting cube puzzle wherein all the exposed faces of each block bear the same colour (represented by A on a white block, B on a light grey block, or C on a dark grey block), such that the particular colour associated with each block may be incorporated directly into the substance or material of the block itself.

[0073] FIG. **46** shows a three-dimensional perspective drawing of a 3×3×3 combinatorial twisting cube puzzle according to the present invention, wherein n=3 and all 26 cube-like blocks (8 corner blocks [**1**], 12 edge blocks [**2**] and 6 facial blocks [**3**]) have a total of 54 exposed faces [**4**], which are labelled with 18 copies each of 3 different colours (white and two shades of grey) and 18 copies each of 3 different letters (A, B and C), such that one copy of each colour and one copy of each letter appear on every row and every column of blocks on each face of the puzzle and no two copies of any colour or letter appear on any row or column of blocks on any face of the puzzle, in accordance with a possible solution of the puzzle as defined herein.

[0074] FIG. **47** shows 144 alternative configurations of 3 different colours, marks, symbols, words, letters, numbers, pictures or other features (indicated by A, B and C) combined with another set of 3 different features (indicated by white and two shades of grey) on each face of a 3×3×3 combinatorial twisting cube puzzle, representing $144^6=8.92\times10^{12}$ potential solutions of the puzzle as defined herein.

[0075] FIG. **48** shows 24 alternative configurations of 3 different colours, marks, symbols, words, letters, numbers, pictures or other features (indicated by A, B and C) combined with another set of 3 different features (indicated by white and two shades of grey) on all 6 faces of a 3×3×3 combinatorial twisting cube puzzle, representing 24 possible solutions of the puzzle (solutions **1** to **24**, respectively) as defined herein.

[0076] FIG. **49** shows 24 possible starting configurations (Configns. **1** to **24**) for a 3×3×3 combinatorial twisting cube puzzle corresponding to the first 24 solutions (Solutions **1** to **24**, respectively) of FIG. **48**.

[0077] FIG. **50** shows a three-dimensional perspective drawing of a 4×4×4 combinatorial twisting cube puzzle according to the present invention, where n=4 and all 56 blocks (including 8 corner blocks [**1**], 24 edge blocks [**2**] and 24 facial blocks [**3**]) have a total of 96 exposed faces [**4**], which are labelled with 24 copies each of 4 different colours (white and three shades of grey) using adhesive labels or stickers [**5**], so that one copy of each colour appears on every row and every column of blocks on each face of the puzzle and no two copies of the same colour appear on any row or column of blocks on any face of the puzzle, in accordance with a possible solution of the puzzle as defined herein.

[0078] FIGS. **50***a*, **50***b* and **50***c* show how alternative layers of blocks within the same 4×4×4 combinatorial twisting cube puzzle may be rotated freely and independently in either direction about an axis that is perpendicular to the rotating layer of blocks.

[0079] FIG. **51** shows 288 alternative configurations of 4 different colours, marks, symbols, words, letters, numbers, pictures or other features (indicated by A, B, C and D) on each face of a 4×4×4 combinatorial twisting cube puzzle, representing $288^6=5.71\times10^{14}$ potential solutions of the puzzle as defined herein.

[0080] FIG. **52** shows 8 alternative configurations of four different colours, marks, symbols, words, letters, numbers, pictures or other features (indicated by A, B, C and D) on all 6 faces of a 4×4×4 combinatorial twisting cube puzzle, representing various potential solutions of the puzzle as defined herein.

[0081] FIG. **53** shows eight possible starting configurations of four different colours, marks, symbols, words, letters, numbers, pictures or other features (indicated by A, B, C and D) on all six faces of a 4×4×4 combinatorial twisting cube puzzle, each of which has at least one possible solution as defined herein (not shown).

[0082] FIG. **54** shows a three-dimensional perspective drawing of a 4×4×4 combinatorial twisting cube puzzle according to the present invention, where n=4 and all 56 blocks (including 8 corner blocks [**1**], 24 edge blocks [**2**] and 24 facial blocks [**3**]) have a total of 96 exposed faces [**4**], which are labelled with 24 copies each of 4 different colours (white and three shades of grey) and 24 copies each of 4 different letters (A, B, C and D), such that one copy of each colour and one copy of each letter appear on every row and every column of blocks on each face of the puzzle and no two copies of any colour or letter appear on any row or column of blocks on any face of the puzzle, representing a possible solution of the puzzle as defined herein.

[0083] FIG. **55** shows 96 of 432 alternative configurations of 4 different colours, marks, symbols, words, letters, numbers, pictures or other features (indicated by letters A, B, C and D) combined with another set of 4 different features (indicated by white and three shades of grey) on each face of a 4×4×4 combinatorial twisting cube puzzle, corresponding to $432^6=6.50\times10^{15}$ potential solutions of the puzzle as defined herein.

[0084] In each of the three-dimensional perspective drawings (FIGS. **1**, **12**, **15**, **46**, **50** and **54**), only a limited selection of the corner blocks [**1**], edge blocks [**2**], facial hocks [**3**] and their exposed faces [**4**] are indicated by reference numbers, in

order to maintain clarity. In all other figures, A, B, C and D represent different colours, marks, symbols, words, letters, numbers, pictures or other features on one or more faces of the puzzle. Where A, B, C and D represent different letters, these letters can be any letters and are not necessarily "A", "B", "C" and "D" as such.

[0085] In FIGS. **12**, **13**, **14**, **46**, **47**, **48**, **49**, **54** and **55**, the shading of the exposed faces (white or different shades of grey) represents a second set of different colours, marks, symbols, words, letters, numbers, pictures or other features, which is superimposed or otherwise combined with the first set of features represented by A, B, C and D. In this case, each set of features can be considered independently (by ignoring the other set of features) or in combination with the other set of features (by considering both sets of features at the same time), as explained below.

DETAILED DESCRIPTION OF THE INVENTION

Context of the Invention—Form and Construction of the Puzzles

[0086] According to the present invention, the term "n×n×n combinatorial twisting cube puzzle" refers to the general class of puzzles described in the patent documents cited above. Such puzzles have the overall form of a regular cube, with 8 corners, 12 edges and 6 faces. However, one or more corners, edges and/or faces of the puzzle may be rounded, moulded, shaped, truncated, bevelled, chamfered, or otherwise modified to some degree without extending the overall nature and essence of the puzzle beyond the scope of the present invention. For example, the puzzle's corners, edges and/or faces may be rounded to produce a more spherical form wherein the underlying cubic form and octahedral symmetry of the puzzle are still apparent, as shown in WO2004103497. Alternatively, the corners and/or edges of the puzzle may be truncated, chamfered or bevelled at a 45° angle to each face, thus forming a truncated cube, truncated rhombic dodecahedron, or a small or great rhombicuboctahedron, for example. In such cases, the "corners", "edges" and "faces" of the puzzle refer to the 8 corners, 12 edges and 6 faces of the puzzle's underlying cubic form, ignoring any modifications.

[0087] The variable n refers to the number of cube-like blocks that reside along each edge of the puzzle, including two corner blocks [**1**] which reside at either end of each edge (at two adjacent corners of the puzzle), as well as the edge blocks [**2**] that reside between these two corner blocks [**1**], along each edge of the puzzle. According to the present invention, the variable n may be 2, 3, 4, 5, 6, 7, or any larger integer, corresponding to 2, 3, 4, 5, 6, 7 or more cube-like blocks along each edge of the puzzle. Preferably, n is 2, 3, 4 or 5, corresponding to 2, 3, 4 or 5 cube-like blocks along each edge of a 2×2×2, 3×3×3, 4×4×4, or 5×5×5 combinatorial twisting cube puzzle, respectively. Ideally, n is 3, corresponding to three cube-like blocks along each edge of a 3×3×3 combinatorial twisting cube puzzle.

[0088] The term "cube-like" refers to the fact that the individual blocks have the overall form and appearance of a regular cube on the external surface of the puzzle. Like the puzzle itself, however, the faces, corners and/or edges of the blocks can be rounded, moulded, shaped, truncated, bevelled, chamfered, or otherwise modified to some degree without extending the overall scope of the present invention. Moreover, they may have knobs, appendages or other features which form part of a rotary mechanism concealed within the body of the puzzle, as described in the patent documents cited above. Accordingly, the term "block" refers to the indefinite and potentially irregular form of the individual elements which make up the puzzle.

[0089] A "corner block" [**1**] is a block which resides at one of the puzzle's 8 corners, so there are 8 such corner blocks in any n×n×n combinatorial twisting cube puzzle, regardless of n. Each corner block has 3 exposed faces [**4**] (one on each corresponding face of the puzzle itself), so the 8 corner blocks have 3×8=24 exposed faces in total, with 4 of these exposed faces on each of the puzzle's own six faces.

[0090] An "edge block" [**2**] is a block that resides on one of the puzzle's 12 edges, excluding two corner blocks which lie at either end of each edge, therefore there are 12×(n−2) such edge blocks in a n×n×n combinatorial twisting cube puzzle. Each edge block has 2 exposed faces [**4**] (one on each adjacent face of the puzzle), so the 12×(n−2) edge blocks have 24×(n−2) exposed faces in total, with 4×(n−2) of these exposed faces on each of the puzzle's own six faces.

[0091] A "facial block" [**3**] is a block which resides in one of the puzzle's 6 faces, excluding any corner and edge blocks which lie at the corners and edges of each face, so there are $6\times(n-2)^2$ such facial edge blocks in a n×n×n combinatorial twisting cube puzzle. Each facial block has one exposed face [**4**], on the corresponding face of the puzzle, so the $6\times(n-2)^2$ facial blocks have $6\times(n-2)^2$ exposed faces in total, with $1\times(n-2)^2$ of these exposed faces on each of the puzzle's own six faces.

[0092] In general, a n×n×n combinatorial twisting cube puzzle comprises 6n×(n−2)+8 cube-like blocks in total, with a total of $6n^2$ exposed faces [**4**], or n^2 exposed faces on each of the puzzle's own six faces.

[0093] For example, a 2×2×2 combinatorial twisting cube puzzle (wherein n=2, as shown in FIG. **1**) comprises a total of 8 cube-like blocks, all of which are corner blocks [**1**], with 24 exposed faces [**4**] in total, or 4 exposed faces on each of the puzzle's six faces. Meanwhile, a 3×3×3 combinatorial twisting cube puzzle (wherein n=3, as shown in FIG. **15**) comprises 26 cube-like blocks (8 corner blocks [**1**], 12 edge blocks [**2**] and 6 facial blocks [**3**]), with 54 exposed faces [**4**] in total, or 9 exposed faces on each of the puzzle's six faces. A 4×4×4 combinatorial twisting cube puzzle (wherein n=4, as shown in FIG. **50**) comprises 56 cube-like blocks (8 corner blocks [**1**], 24 edge blocks [**2**] and 24 facial blocks [**3**]), with 96 exposed faces [4] in total, or 16 exposed faces on each of the puzzle's six faces. And a 5×5×5 combinatorial twisting cube puzzle (n 5) comprises a total of 98 cube-like blocks (8 corner blocks [**1**], 36 edge blocks [**2**] and 54 facial blocks [**3**]), which have 150 exposed faces [**4**] in total, or 25 exposed faces on each of the puzzle's six faces.

[0094] As used herein the term "comprise(s)" (or "comprising") means include(s) or contain(s) (or including or containing), as appropriate. Thus, the n×n×n combinatorial twisting cube puzzles of the present invention may comprise (include or contain) other elements, components or features in addition to the cube-like blocks. In particular, the puzzles of the present invention also comprise some form of rotary mechanism, which holds all of the blocks in the puzzle together, while allowing any n×n layer of blocks to be rotated freely and independently in either direction about an axis which is perpendicular to the rotating layer of blocks. The rotary mechanism is ideally concealed within the body of the puzzle such that the puzzle's overall form and appearance are not

compromised. A variety of such rotary mechanisms have been designed, some of which are described in the patent documents cited above, while others may be developed in the future. Any of these alternative mechanisms may be employed in the puzzles of the present invention, since the inventive step of the present invention does not relate to any particular rotary mechanism.

Inventive Step—Labelling of the Puzzles

[0095] The inventive step of the present invention relates specifically to novel and distinctive combinations and configurations of colours, marks, symbols, words, letters, numbers, pictures and/or other identifiable features on the faces of such n×n×n combinatorial twisting cube puzzles, wherein the desired position and orientation of each individual block in the puzzle's solution are not immediately apparent from the distinctive set of colours, marks, symbols or other features indicated on the exposed faces of each block, thus providing a greater and more stimulating intellectual challenge. In particular, an essential feature of the present invention is that the $6n^2$ exposed faces of all 6n×(n−2)+8 cube-like blocks in the puzzle are labelled with 6n identical or equivalent copies each of n different colours, marks, symbols, words, letters, numbers, pictures or other features.

[0096] In a 2×2×2 combinatorial twisting cube puzzle (n=2), for example, the 24 exposed faces [**4**] of all 8 cube-like blocks are labelled with 12 identical or equivalent copies each of 2 different colours, marks, symbols, words, letters, numbers, pictures or other features. In a 3×3×3 combinatorial twisting cube puzzle (n=3), the 54 exposed faces [**4**] of all 26 cube-like blocks are labelled with 18 identical or equivalent copies each of 3 different colours, marks, symbols, words, letters, numbers, pictures or other features. In a 4×4×4 combinatorial twisting cube puzzle (n=4), the 96 exposed faces [**4**] of all 56 cube-like blocks are labelled with 24 identical or equivalent copies each of 4 different colours, marks, symbols, words, letters, numbers, pictures or other features. In a 5×5×5 combinatorial twisting cube puzzle (11=5), the 150 exposed faces [**4**] of all 98 cube-like blocks are labelled with 30 identical or equivalent copies each of 5 different colours, marks, symbols, words, letters, numbers, pictures or other features.

Selection of Features

[0097] Preferably, the n different colours, marks, symbols, words, letters, numbers, pictures or other features are sufficiently different and distinguishable from each other so that they are (or may be) regarded as non-equivalent, while the 6n identical or equivalent copies of each different colour, mark, symbol, word, letter, number, picture or other feature are identical, indistinguishable from each other, or sufficiently similar or otherwise related to each other so that they are (or may be) regarded as equivalent and/or interchangeable. Accordingly, any two exposed faces which are labelled with "different" colours, marks, symbols, words, letters, numbers, pictures or other features may be easily distinguished from each other, whereas any two exposed faces labelled with "identical or equivalent copies" of the same colour, mark, symbol, word, letter, number, picture or other feature may be regarded as equivalent and/or interchangeable. Ideally, the n different colours, marks, symbols, words, letters, numbers, pictures or other features are clearly different and distinguishable from each other, while the 6n copies of each different colour, mark, symbol, word, letter, number, picture or other feature are identical to each other.

[0098] In general, the term "feature" relates to any colour, mark, symbol, word, letter, number, picture or any other element or characteristic which can be distinguished from another. Moreover, any n different colours, marks, symbols, words, letters, numbers, pictures or other features may be indicated on the faces of the puzzle, provided that they can easily be distinguished from each other. For example, different colours include black, white, grey, red, orange, yellow, green, cyan, blue, pink, magenta, purple, indigo, violet, gold, silver and bronze. Examples of different marks or symbols include simple geometric shapes (e.g., circle, oval, triangle, square, rectangle, diamond, pentagon, hexagon, star, cross, dot), simple signs, symbols or characters (e.g., +, −, x, *, £, $, €, ¥, @, &, #, ?, !, spade, heart, diamond, club) or logos. Different words or letters may be selected from any language (e.g., English, Greek, Japanese). Different numbers may have any value and may be represented in any manner (e.g., as digits, numerals, groups of dots, lines or other symbols, or coins). Different pictures may show any image at any level of detail or complexity, from simple symbols to high quality photographs. The examples given above illustrate the wide variety of features which may be indicated on the faces of the puzzles, but are not intended to limit the scope of the invention in any way.

[0099] Where two or more different sets of features are superimposed or combined with each other, as described below, each set of features may be considered independently when determining whether any two features within each set are identical or equivalent. For example, where one particular set of features consisting of different numbers, letters or symbols is superimposed or otherwise combined with another set of features consisting of different colours as described below, any two copies of the same number, letter or symbol may be considered as identical or equivalent even if they are associated with different colours. Similarly, any two copies of the same colour may be considered as identical or equivalent to each other even if they are associated with different numbers, letters or symbols. Accordingly, the term "identical or equivalent copies" refers to the degree of similarity between any two or more copies of a particular feature in isolation, ignoring any effect which their combination with another set of features may have on their appearance.

Combination of Features

[0100] In one embodiment of the present invention, two or more different sets of features are independently superimposed or combined with each other on the exposed faces of the blocks, such that the features can be considered either independently or in combination with each other, in accordance with the present invention. For example, one particular set of features consisting of different numbers, letters or symbols can be independently superimposed or combined with another set of features consisting of different colours, so that equivalent copies of each number, letter or symbol may have different colours, while equivalent copies of each colour may have different numbers, letters or symbols on different blocks, as illustrated in FIGS. **12**, **13**, **14**, **46**, **47**, **48**, **49**, **54** and **55**, for example.

[0101] Where two or more different sets of features are superimposed or combined with each other, either one or both sets of features may be considered in solving the puzzle. For example, where one particular set of features consisting of

different numbers, letters or symbols is superimposed or otherwise combined with another set of features consisting of different colours as described above, either the numbers, letters or symbols alone, or the colours alone, or both the numbers, letters or symbols and colours together, may be considered when solving the puzzle. Where only one set of features is considered, the other set of features may be ignored. For example, where only colours are considered, the numbers, letters or symbols may be ignored; and where only the numbers, letters or symbols are considered, the colours may be ignored. Alternatively, the colours may be considered in combination with the numbers, letters or symbols.

Application of Features

[0102] The blocks can be labelled with a particular set of features (or combination of features) by any means. For example, they may be labelled using adhesive labels or stickers [5], or by printing the colours, marks, symbols, words, letters, numbers, pictures or other features directly onto the exposed faces of each block. Alternatively, the features may be embossed or otherwise incorporated into the fabric of the blocks themselves, either during or after their manufacture or assembly. Where the exposed faces are labelled using adhesive labels or stickers, appropriate sets of labels or stickers can be supplied separately from the puzzle itself and applied to the puzzle at a later stage. The present invention therefore includes sets of adhesive labels or stickers bearing 6n identical or equivalent copies each of n different colours, marks, symbols, words, letters, numbers, pictures or other features, for use on a n×n×n combinatorial twisting cube puzzle in accordance with the present invention.

[0103] Furthermore, the colours, marks, symbols, words, letters, numbers, pictures or other features may be applied to the exposed faces of each block in any orientation. Ideally, however, they are applied to the exposed faces of the blocks so that their orientations are all aligned with each other on each face of the puzzle when the puzzle is solved in accordance with the present invention. For example, where the exposed faces of the blocks are labelled with 6n copies each of n different numbers (e.g., 1, 2 and 3) all of the numbers and their copies preferably have the same orientation on each face of the puzzle when the puzzle is solved.

[0104] Alternatively, the colours, marks, symbols, words, letters, numbers, pictures or other features have four-fold symmetry, so that they may be applied to the exposed faces of each block in any orientation and yet still appear to be aligned with each other. For example, symbols which have four-fold symmetry include circles (● or ○), squares (■ or □), diamonds (◆ or ◇), octagons, crosses (+ or x), dots (•), 4- or 8-pointed flowers, stars or other patterns, or any combination thereof (e.g., ◘, ¤, ¤).

[0105] In one special embodiment of the invention, each individual block in the puzzle bears the same colour on all of its exposed faces. For example, according to FIGS. **8***a* and **8***b*, each corner block in a 2×2×2 combinatorial twisting cube puzzle may bear the same colour on all 3 of its exposed faces, as shown in FIGS. **11***a* and **11***b*. Similarly, each individual block in a 3×3×3 combinatorial twisting cube puzzle may bear the same colour on all of its exposed faces, as shown in FIGS. **45***a* and **45***b*, for example. In such cases, where each block in the puzzle bears the same colour on all its exposed faces, the particular colour which is associated with each block may be incorporated directly into the fabric or material of the block itself. For example, all of the blocks in the puzzle may be effectively labelled as required by manufacturing each block using the appropriate coloured plastic or other material.

Primary Objective

[0106] The primary objective of the puzzles of the present invention is essentially to determine and apply the correct sequence of rotations to rearrange the blocks and thus achieve a solution wherein one copy of each different colour, mark, symbol, word, letter, number, picture or other feature appears on every row and every column of blocks on each face of the puzzle, and no two copies of any one colour, mark, symbol, word, letter, number, picture or other feature appear on the same row or column of blocks on any face of the puzzle. However, since the desired position and orientation of each individual block in the puzzle's solution are not immediately apparent from the distinctive set of colours, marks, symbols or other features indicated on the exposed faces of each block, this has to be determined, either by logical deduction or by trial and error, in order to solve the puzzle, thus providing a greater and more stimulating intellectual challenge.

[0107] Accordingly, the puzzles of the present invention preferably have at least one solution wherein one copy of each different colour, mark, symbol, word, letter, number, picture or other feature appears on every row and every column of blocks on each face of the puzzle, so that no two identical or equivalent copies of any colour, mark, symbol, word, letter, number, picture or other feature appear on any one row or column of blocks on any face of the puzzle.

[0108] A "solution" of the puzzle is accordingly defined as a configuration of blocks wherein one copy of each different colour, mark, symbol, word, letter, number, picture or other feature appears on every row and every column of blocks on each face of the puzzle, while no two identical or equivalent copies of any colour, mark, symbol, word, letter, number, picture or other feature appear on any row or column of blocks on any face of the puzzle. For example, where the exposed faces of the blocks are labelled with 6n copies each of n different numbers (e.g., 1, 2, 3, etc.), a solution of the puzzle consists of any configuration of blocks wherein one copy of each different number appears on every row and every column of blocks on each face of the puzzle, while no 2 identical or equivalent copies of any number appear on any one row or column of blocks on any face of the puzzle.

[0109] Where two or more different sets of features are superimposed or otherwise combined with each other as described above, the solution of the puzzle (as defined herein) may apply to any particular set of features alone (ignoring the other set(s) of features), or to any two or more sets of features simultaneously, in combination with each other. For example, where one particular set of features consisting of different numbers, letters or symbols is superimposed or otherwise combined with another set of features consisting of different colours, the solution of the puzzle may apply either to the numbers, letters or symbols alone (while ignoring the colours), to the colours alone (while ignoring the numbers, letters or symbols), or to the numbers, letters or symbols in combination with the colours, by considering both sets of features together. In this case, the puzzle may have one or more different solutions which apply to one particular set of features alone, or one or more common solutions which apply to both sets of features simultaneously, in combination with each other.

[0110] The possibility of at least one solution can be ensured by applying the colours, marks, symbols or other features directly to the exposed faces of the puzzle such that one copy of each different colour, mark, symbol, word, letter, number, picture or other feature appears on every row and every column of blocks on each face of the puzzle, while no two identical or equivalent copies of any colour, mark, symbol, word, letter, number, picture or other feature appear on any row or column of blocks on any face of the puzzle (i.e., by labelling the puzzle in the form of its solution). The blocks of the puzzle can then be scrambled or mixed up by applying a random sequence of rotations, so that the puzzle can then be solved from a random configuration.

[0111] Where two or more sets of features are superimposed or otherwise combined with each other as described above, the possibility of at least one common solution for both or all sets of can be ensured by labelling the puzzle in the form of its solution for both (or all) sets of features at the same time. For example, where one set of features consisting of different numbers, letters or symbols is superimposed or combined with another set of features consisting of different colours, the possibility of at least one common solution for both sets of features can be ensured by labelling the puzzle in the form of a solution with respect to the numbers, letters or symbols, then applying a different configuration of colours which also has the form of a solution, as indicated in FIGS. **12**, **13**, **14**, **46**, **47**, **48**, **49**, **54** and **55**, for example.

[0112] Possibility of Multiple Solutions

[0113] According to one possible embodiment of the present invention, the puzzle has at least 2, 3, 4, 5, 6, 8, 10, 12 or 16 solutions. Preferably, the puzzle has at least 8, 10, 12 or 16 solutions. In FIG. **3**, for example, Config. Nos. **1**, **2** and **3** have 12, 24 and 18 solutions, respectively. In FIG. **19**: Config. Nos. **2** and **8** have 19 and 10 solutions, respectively; and Config. Nos. **63** to **65** each have 8 solutions. In FIG. **31**: Config. Nos. **4** and **19** each have 16 solutions; Config. Nos. **2**, **3**, **44**, **58** and **65** each have 12 solutions. And in FIG. **39**: Config. Nos. **6**, **7** and **8** each have 32 solutions; Config. Nos. **43**, **44** and **45** each have 24 solutions; and Config. Nos. **9** to **12** each have 12 solutions.

[0114] Alternatively, where a more challenging puzzle is required, the puzzle preferably has no more than 8, 6, 5, 4, 3, 2 or 1 solution(s). Ideally, the puzzle has only one solution. In FIG. **3**, for example, Config. No. **4** has just 2 solutions, and Config. Nos. **5** and **6** each have 4 solutions. Meanwhile, many of the configurations shown in FIG. **19** each have just one solution (as indicated).

Symmetry

[0115] In another possible embodiment of the present invention, the colours, marks, symbols, words, letters, numbers, pictures or other features are applied to the faces of the blocks such that a large number and/or proportion of the blocks in the puzzle have analogous counterparts bearing complementary sets of features, or form part of a complete set of analogous blocks with complementary sets or combinations of features, corresponding to a high degree of symmetry between the blocks.

[0116] In a 2×2×2 combinatorial twisting cube puzzle, for example, one complete set of analogous corner blocks which bear complementary sets of features may consist of:

[0117] a) one corner block that bears 3 copies of a first feature A (AAA) and a second corner block that bears 3 copies of a second feature B (BBB); or

[0118] b) one corner block that bears 2 copies of feature A and one copy of feature B (AAB) and a second corner block that bears 2 copies of feature B and one copy of feature A (BBA).

[0119] Similarly, in a 3×3×3 combinatorial twisting cube puzzle, a set of analogous corner blocks which bear complementary sets of features may consist of:

[0120] a) one corner block with 3 copies of feature A (AAA), a second corner block with 3 copies of feature B (BBB) and a third corner block with 3 copies of feature C (CCC); or

[0121] b) one corner block with 2 copies of feature A and one copy of feature B (AAB), a second corner block with 2 copies of feature B and one copy of feature C (BBC) and a third corner block with 2 copies of feature C and one copy of feature A (CCA); or

[0122] c) one corner block with 2 copies of feature A and one copy of feature C (AAC), a second corner block with 2 copies of feature B and one copy of feature A (BBA) and a third corner block with 2 copies of feature C and one copy of feature B (CCB); or

[0123] d) two corner blocks which each bear one copy of all 3 features (A, B and C), in clockwise order on one block (ABCc) and in anticlockwise order on the other block (ABCa).

[0124] Meanwhile, a complete set of analogous edge blocks which bear complementary sets of features in a 3×3×3 combinatorial twisting cube puzzle may consist of:

[0125] a) one edge block with 2 copies of feature A (AA), a second edge block with 2 copies of feature B (BB) and a third edge block with 2 copies of feature C (CC); or

[0126] b) one edge block with one copy of feature A and one copy of feature B (AB), a second edge block with one copy of feature B and one copy of feature C (BC) and a third edge block with one copy of feature C and one copy of feature A (CA).

[0127] Finally, a complete set of analogous facial blocks which bear complementary sets of features in a 3×3×3 combinatorial twisting cube puzzle consists of 3 facial blocks which bear 3 different features (A, B and C, respectively).

[0128] Thus, the analogous blocks that form a complete set are identical or equivalent in form and may occupy equivalent positions in the puzzle, however they bear different sets or combinations of features which are complementary to each other, so that the complete set of blocks has a symmetrical pattern of complementary features. Accordingly, the total number of analogous blocks that form part of a complete set indicates the overall degree of symmetry between the blocks in the puzzle.

[0129] The total number of blocks that form part of a complete set of analogous blocks with complementary sets or combinations of features is indicated in the "Sym." column for each configuration in FIGS. **3**, **19**, **31** and **39**.

[0130] Preferably, at least 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90% or 100% of the blocks in the puzzle fatal part of a complete set of analogous blocks that bear complementary sets of features. Ideally, all (100%) of the blocks in the puzzle form part of a complete set of analogous blocks bearing complementary sets or combinations of features so that none of the blocks in the puzzle lack a complementary counterpart, corresponding to a high degree of symmetry between all the blocks in the puzzle.

[0131] In Config. Nos. **1** to **4** of FIG. **3**, for example, all 8 blocks of a 2×2×2 combinatorial twisting cube puzzle form

part of a complete set of analogous counterparts which bear complementary sets or combinations of features, reflecting perfect symmetry between the blocks in those four configurations.

[0132] Meanwhile, in Config. Nos. **1** to **11** of FIG. **19**, Config. Nos. **1** to **7** of FIG. **31** and Config. Nos. **1** to **5** of FIG. **39**, all 26 blocks of a 3×3×3 combinatorial twisting cube puzzle form part of a complete set of analogous blocks that bear complementary sets or combinations of features, reflecting the perfect symmetry between the blocks in those configurations. In all the other configurations of FIGS. **19**, **31** and **39**, however, at least 2 of the 26 blocks do not form part of a complete set of analogous blocks bearing complementary sets or combinations of features, reflecting a lower degree of symmetry between the blocks in those configurations.

[0133] Alternatively, where a lower degree of symmetry is preferred, no more than 60%, 50%, 40%, 30%, 20%, 10% or 0% of the blocks in the puzzle form part of a complete set of analogous blocks that bear complementary sets or combinations of features. Ideally, no more than 20%, 10% or 0% of the blocks in the puzzle form part of a complete set of analogous blocks that bear complementary sets or combinations of features.

[0134] In Config. Nos. **5** and **6** of FIG. **3**, for example, none (0%) of the 8 blocks of a 2×2×2 combinatorial twisting cube puzzle form part of a complete set of analogous blocks which bear complementary sets or combinations of features, reflecting a complete lack of symmetry between the blocks in those two configurations.

[0135] Meanwhile, in some configurations, only 6 (23%) of the 26 blocks in a 3×3×3 combinatorial twisting cube puzzle form part of a complete set of analogous blocks that bear complementary sets of features, reflecting a low degree of symmetry between the blocks in those configurations.

Duplication of Blocks

[0136] In another possible embodiment of the present invention, the colours, marks, symbols, words, letters, numbers, pictures or other features are applied to the faces of the blocks such that no more than 6, 5, 4, 3 or 2 blocks in the puzzle bear any one particular set or combination of features. Preferably, no more than 3 and ideally no more than 2 blocks in the puzzle bear the same set or combination of features on their exposed faces.

[0137] In Config. No. **1** of FIG. **3**, for example, no more than 2 blocks in the puzzle bear the same set or combination of features, while in Config. No. **2** of FIG. **3**, no more than 3 blocks bear the same set or combination of features. Similarly, no more than 2 blocks bear the same set or combination of features in Config. Nos. **1**, **14**, **15**, **16**, **20**, **21**, **33** to **38** and **45** to **50** of FIG. **19**, and many other configurations in FIGS. **19**, **31** and **39**.

[0138] Alternatively, where a more biased distribution of blocks with different sets of features is preferred, at least 3, 4, 5, 6 or 7 blocks in the puzzle bear any one particular set or combination of features. Preferably, at least 5 or 6 and ideally 7 blocks in the puzzle bear the same set or combination of features on their exposed faces.

[0139] In Config. Nos. **3** and **4** of FIG. **3**, for example, as many as 4 blocks bear the same set or combination of features, while in Config. Nos. **5** and **6** of FIG. **3**, 6 blocks bear the same set or combination of features. Similarly, in other configurations, as many as 7 blocks bear the same set or combination of features.

Redundant Blocks

[0140] In another possible embodiment of the present invention, the colours, marks, symbols, words, letters, numbers, pictures or other features are applied to the faces of the blocks such that the puzzle comprises a low number or proportion of redundant blocks which bear the same set or combination of features as one or more other blocks in the puzzle which are otherwise unique, reflecting a high degree of complexity in the puzzle.

[0141] The total number of redundant blocks is indicated in the "Red." column for each of the configurations shown in FIGS. **3**, **19**, **31** and **39**.

[0142] A "redundant" block is essentially an identical or equivalent copy of another block in the puzzle which is otherwise unique, in the absence of its copies. Preferably, no more than 90%, 80%, 70%, 60%, 50%, or 40% of the blocks are redundant copies of one or more other blocks in the puzzle. Ideally, no more than 60%, 50% or 40% of the blocks are redundant copies of other blocks in the puzzle which are otherwise unique, so that the puzzle comprises a wide variety of blocks bearing different sets or combinations of features.

[0143] In Config. Nos. **1** and **2** of FIG. **3**, for example, only 4 (50%) of the 8 blocks in a 2×2×2 combinatorial twisting cube puzzle are redundant copies of other blocks in the puzzle which bear the same set or combination of features, because the puzzle includes all four possible sets of features on its 8 blocks: AAA, AAB, BBA and BBB, respectively.

[0144] Meanwhile, in Config. Nos. **1** to **5**, **27** to **32** and **110** to **115** of FIG. **19**, for example, only 9 (35%) of the 26 blocks of a 3×3×3 combinatorial twisting cube puzzle are redundant copies of other blocks in the puzzle which bear the same set or combination of features, because the puzzle includes 17 of the 20 possible sets of features on all of its corner, edge and facial blocks. Further configurations of a 3×3×3 combinatorial twisting cube puzzle which comprise 9 redundant copies of other blocks in the puzzle include: Config. Nos. **19** to **21** of FIG. **31**; and Config. No. **1** of FIG. **39**.

[0145] Alternatively, where a low degree of complexity is preferred, at least 40%, 50%, 60%, or 70% of the blocks are redundant copies of one or more other blocks in the puzzle. Ideally, at least 60% or 70% of the blocks are redundant copies of one or more other blocks in the puzzle which are otherwise unique (in the absence of their copies).

[0146] In Config. Nos. **3** to **6** of FIG. **3**, for example, as many as 6 (75%) of the 8 blocks in a 2×2×2 combinatorial twisting cube puzzle are redundant copies of other blocks in the puzzle that bear the same set of features, because the puzzle includes only 2 of the four possible sets of features on its 8 corner blocks: AAB and ABB, AAA and BBB, AAB and BBB, or AAA and ABB, respectively. Meanwhile, in Config. No. **11** of FIG. **19**, as many as 18 (69%) of the 26 blocks in a 3×3×3 combinatorial twisting cube puzzle are redundant copies of other blocks in the puzzle that bear the same set or combination of features, because the puzzle includes only 8 of the 20 possible sets of features on all of its corner, edge and facial blocks: ABCc (×4) and ABCa (×4) on its 8 corner

blocks; AB (×4), BC (×4) and CA (×4) on its 12 edge blocks; and A (×2), B (×2) and C (×2) on its 6 facial blocks.

Diversity of Blocks

[0147] In a further possible embodiment of the present invention, the colours, marks, symbols, words, letters, numbers, pictures or other features are applied to the faces of the blocks such that the standard deviation (S.D.) in the numbers of identical or equivalent blocks that bear various different sets or combinations of features is no more than 2.5, 2.0, 1.8, 1.7, 1.6, 1.5, 1.4, 1.3, 1.2, 1.1, 1.0, 0.9 or 0.8, indicating a progressively more uniform distribution of blocks which bear different sets or combinations of features. Ideally, the standard deviation in the numbers of identical or equivalent blocks which bear various different sets of features is no more than 1.1, 1.0, 0.9 or 0.8. The standard deviation in the numbers of blocks which bear different sets or combinations of features is indicated in the "S.D." column for each configuration in FIGS. **3**, **19**, **31** and **39**.

[0148] In Config. No. **1** of FIG. **3**, for example, the standard deviation (S.D.) in the numbers of identical or equivalent blocks that bear different sets of features is 0.00, because the puzzle comprises 2 copies of all 4 possible sets of features in a 2×2×2 combinatorial twisting cube puzzle (AAA, AAB, BBA and BBB, respectively), reflecting a uniform distribution of blocks bearing different sets of features.

[0149] Similarly, in Config. Nos. **1** and **110** to **115** of FIG. **19**, for example, the standard deviation (S.D.) in the numbers of identical or equivalent blocks bearing different sets of features is 0.73. Meanwhile, in Config. Nos. **33** to **38** and **116** to **130** of FIG. **19** and Config. Nos. **22** and **58** of FIG. **31**, the standard deviation in the numbers of blocks bearing different sets of features is 0.80. The low standard deviations of these configurations indicate that the puzzles comprise a relatively uniform distribution of blocks bearing different sets of features. This is confirmed by the fact that no more than 2 blocks in any of these configurations bear the same set of features on their exposed faces.

[0150] Alternatively, where a more biased distribution of blocks with different sets of features is preferred, the standard deviation in the numbers of identical or equivalent blocks that bear various different sets or combinations of features is at least 0.8, 0.9, 1.0, 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.8 or 2.0. Ideally, the standard deviation in the numbers of identical or equivalent blocks which bear different sets of features is at least 1.6, 1.8 or 2.0.

[0151] In Config. Nos. **3** and **4** of FIG. **3**, for example, the standard deviation in the numbers of blocks bearing different sets of features is 2.31, while in Config. Nos. **5** and **6** of FIG. **3**, the standard deviation in the numbers of blocks bearing different sets of features is as high as 2.83. Meanwhile, in Config. No. **11** of FIG. **19**, the standard deviation in the numbers of blocks with different sets of features is 1.75. The high standard deviations of these configurations indicate that the puzzles have a relatively biased distribution of blocks bearing different sets or combinations of features. This is confirmed by the fact that as many as 4 or even 6 blocks in these configurations bear the same set of features on their exposed faces.

Alternative Starting Configurations

[0152] While the puzzles may be produced and/or supplied in the form of a solution, they may also be produced or supplied in some alternative "starting" configuration, provided that the blocks can be rearranged into at least one possible solution in accordance with the present invention. For example, they may be produced and/or supplied in a scrambled configuration, or in some alternative configuration which is highly ordered, but which does not fulfil the requirements of a solution. In this case, the possibility of a solution can easily be verified using a simple computer program to check that the blocks can be rearranged to form at least one configuration wherein one copy of each different colour, mark, symbol, word, letter, number, picture or other feature appears on every row and every column of blocks on each face of the puzzle, while no two identical or equivalent copies of any colour, mark, symbol, word, letter, number, picture or feature appear on the same row or column of blocks on any face of the puzzle. Such a computer program was used to calculate the solutions to all the configurations shown in the accompanying drawings, to verify that each configuration has at least one solution in accordance with the present invention.

[0153] In one embodiment of the present invention, the puzzle is produced and/or supplied in some highly ordered starting configuration, wherein identical or equivalent copies of each different colour, mark, symbol, word, letter, number, picture or other feature are grouped together in a symmetrical pattern, arrangement or configuration.

[0154] For example, a 2×2×2 combinatorial twisting cube puzzle may be produced and/or supplied in any one of the starting configurations shown in FIGS. **5***b*, **6***b*, **7***b*, **8***b*, **9***b*, **10***b* and **11***b*, which have the alternative solutions shown in FIGS. **5***a*, **6***a*, **7***a*, **8***a*, **9***a*, **10***a* and **11***a*, respectively.

[0155] Meanwhile, a 3×3×3 combinatorial twisting cube puzzle may be produced and/or supplied in any one of the starting configurations shown in FIGS. **20***b*, **21***b*, **24***b*, **27***b*, **35***b*, and Configns. **1** to **24** of FIG. **49**, which have the alternative solutions shown in FIGS. **20***a*, **21***a*, **24***a*, **27***a*, **35***a*, and Configns. **1** to **24** of FIG. **48**, respectively.

[0156] Moreover, any n×n×n combinatorial twisting cube puzzle may be produced and/or supplied in one or more similar ordered or symmetrical starting configurations.

EXAMPLES

[0157] Various embodiments of the present invention will now be illustrated in the following examples:

Example 1

2×2×2 Combinatorial Twisting Cube Puzzles (n=2)

[0158] According to one embodiment of the invention, where n is 2, a 2×2×2 combinatorial twisting cube puzzle comprises a total of 8 cube-like corner blocks [**1**], which have 24 exposed faces [**4**] in total (4 exposed faces on each of the puzzle's six faces), as shown in FIG. **1**. In this embodiment, any 2×2 layer of blocks may be rotated freely and independently in either direction about an axis that is perpendicular to the rotating layer of blocks, as shown in FIGS. **1***a*, **1***b* and **1***c*. Thus, the blocks can be rearranged into more than 10^8 different configurations by applying a particular sequence of rotations to alternative 2×2 layers of blocks in a successive and combinatorial manner.

[0159] The 24 exposed faces of all 8 corner blocks in a 2×2×2 combinatorial twisting cube puzzle are essentially labelled with 12 identical or equivalent copies each of 2 different colours, marks, symbols, words, letters, numbers, pictures or other features. Moreover, according to a solution

of the puzzle, one copy of each different colour, mark, symbol, word, letter, number, picture or other feature appears on every row, and every column of blocks on each face of the puzzle, while no two identical or equivalent copies of any colour, mark, symbol, word, letter, number, picture or other feature appear on any row or column of blocks on any face of the puzzle. Accordingly, the puzzle preferably has (or is able to adopt) at least one configuration or "solution" wherein the arrangement of colours, marks, symbols, words, letters, numbers, pictures or other features on each of the puzzle's six faces is independently selected from the two alternative configurations shown in FIG. **2**, wherein A and B represent copies of the 2 different colours, marks, symbols, words, letters, numbers, pictures or other features.

[0160] Preferably, the blocks in a 2×2×2 combinatorial twisting cube puzzle are labelled in accordance with one of the six configurations (Config. Nos. **1** to **6**) shown in FIG. **3**, each of which has at least one possible solution, according to the definition above. In particular, the blocks may be labelled in accordance with Config. No. **1**, **2**, **3**, **4**, **5** or **6** of FIG. **3**, to ensure the possibility of at least one solution as defined above.

[0161] In a further embodiment of a 2×2×2 combinatorial twisting cube puzzle, the puzzle has or is otherwise able to adopt at least one possible solution or configuration wherein the arrangement of colours, marks, symbols, words, letters, numbers, pictures or other features on all six faces of the puzzle (in any orientation) is selected from the group of 64 alternative configurations (Solns. **1** to **64**, respectively) shown in FIG. **4**, where A and B represent copies of 2 different colours, marks, symbols, words, letters, numbers, pictures or other features. Furthermore, the puzzle preferably has or is able to adopt at least one possible solution or configuration wherein the arrangement of colours, marks, symbols, words, letters, numbers, pictures or other features on all 6 faces of the puzzle is selected from any group of alternative configurations shown in FIG. **5***a*, **5***b*, **6***a*, **6***b*, **7***a*, **7***b*, **8***a*, **8***b*, **9***b*, **10***a* or **10***b* (wherein A and B represent copies of 2 different colours, marks, symbols, words, letters, numbers, pictures or other features).

[0162] In a special embodiment of a 2×2×2 combinatorial twisting cube puzzle, the puzzle has or is otherwise able to adopt at least one solution or configuration shown in FIG. **11***a* or **11***b*, wherein each block bears the same colour on all of its exposed faces.

[0163] In another embodiment of a 2×2×2 combinatorial twisting cube puzzle, two or more different sets of features are superimposed or otherwise combined with each other, as shown in FIG. **12**, for example. In this case, the puzzle preferably has or is otherwise able to adopt at least one possible solution or configuration wherein the arrangement of colours, marks, symbols, words, letters, numbers, pictures or other features on each of the puzzle's six faces is independently selected from the four alternative configurations shown in FIG. **13**, wherein A and B represent one set of two different colours, marks, symbols, words, letters, numbers, pictures or other features, while the white and grey shades represent a different set of two different colours, marks, symbols, words, letters, numbers, pictures or other features, which is superimposed or otherwise combined with the first set of features.

[0164] In particular, the puzzle preferably has or is able to adopt at least one possible solution or configuration wherein the arrangement of colours, marks, symbols, words, letters, numbers, pictures or other features on all six faces of the puzzle (in any orientation) is selected from the group of 64 alternative configurations shown in FIG. **14**, wherein A and B represent one set of two different colours, marks, symbols, words, letters, numbers, pictures or other features, while the white and grey shades represent another set of two different colours, marks, symbols, words, letters, numbers, pictures or other features, which is superimposed or otherwise combined with the first set of features.

Example 2

3×3×3 Combinatorial Twisting Cube Puzzles (n=3)

[0165] According to one embodiment of the invention, where n is 3, a 3×3×3 combinatorial twisting cube puzzle comprises a total of 26 cube-like blocks (8 corner blocks [**1**], 12 edge blocks [**2**] and 6 facial blocks [**3**]), which have 54 exposed faces [**4**] in total (with 9 exposed faces on each of the puzzle's six faces), as shown in FIG. **15**. In this case, any 3×3 layer of blocks may be rotated freely and independently in either direction about an axis that is perpendicular to the rotating layer of blocks, as shown in FIGS. **15***a*, **15***b* and **15***c*, for example. Thus, the blocks can be rearranged into more than 10^{20} different configurations by applying a particular sequence of rotations to alternative 3×3 layers of blocks in a successive and combinatorial manner.

[0166] According to one essential feature of the present invention, the 54 exposed faces of all 26 cube-like blocks in a 3×3×3 combinatorial twisting cube puzzle are labelled with 18 identical or equivalent copies each of 3 different colours, marks, symbols, words, letters, numbers, pictures or other features. Furthermore, according to a solution of the puzzle, one copy of each different colour, mark, symbol, word, letter, number, picture or other feature appears on every row and every column of blocks on each face of the puzzle, while no two identical or equivalent copies of any colour, mark, symbol, word, letter, number, picture or other feature appear on any one row or column of blocks on any face of the puzzle. Accordingly, the puzzle preferably has or is otherwise able to adopt at least one solution or configuration wherein the arrangement of colours, marks, symbols, words, letters, numbers, pictures or other features on each of the puzzle's six faces is independently selected from the 3!×2!=12 alternative configurations shown in FIG. **16**, wherein A, B and C represent copies of the three different colours, marks, symbols, words, letters, numbers, pictures or other features.

[0167] Preferably, the six facial blocks of such a 3×3×3 combinatorial twisting cube puzzle are labelled in accordance with one of the 57 alternative configurations (Config. Nos. **1** to **57**) shown in FIG. **17***b*, wherein A, B and C represent copies of the three different colours, marks, symbols, words, letters, numbers, pictures or other features, while P, Q, R, S, T and U represent the respective positions of the 6 facial blocks in the puzzle, as indicated in FIG. **17***a*. Accordingly, the six facial blocks of a 3×3×3 combinatorial twisting cube puzzle are preferably labelled according to one of the 57 configurations shown in FIG. **18**, which correspond to those 57 configurations shown in FIG. **17***b* (Config. Nos. **1** to **57**, respectively). For example, the six facial blocks may be labelled in accordance with Config. No. **1**, **2**, **3**, **4**, **5** or **6** of FIG. **17***b* or FIG. **18**, such that 2 copies each of the 3 different colours, marks, symbols, words, letters, numbers, pictures or other features appear on the six facial blocks of the puzzle.

[0168] Where the six facial blocks of such a 3×3×3 combinatorial twisting cube puzzle are labelled in accordance with Config. No. **1** or **2** of FIGS. **17***b* and **18** (wherein any two

facial blocks which bear the same feature lie on adjacent faces of the puzzle), the other blocks in the puzzle are preferably labelled according to one of the 130 alternative configurations (Config. Nos. **1** to **130**) shown in FIG. **19**. For example, the blocks may be labelled according to Config. No. **1**, **2**, **3**, **4**, **5**, **6**, **7**, **8**, **9**, **10** or **11** of FIG. **19**, wherein all 26 blocks form a complete set of analogous blocks bearing complementary sets or combinations of features, corresponding to a high degree of symmetry between the blocks. In particular, a 3×3×3 combinatorial twisting cube puzzle preferably has or is otherwise able to adopt at least one possible solution or configuration wherein the arrangement of colours, marks, symbols, words, letters, numbers, pictures or other features on all six faces of the puzzle (in any orientation) is selected from any group of alternative configurations shown in FIG. **20***a*, **20***b*, **21***a*, **21***b*, **22**, **23**, **24***a*, **24***b*, **25**, **26**, **27***a*, **27***b*, **28**, **29** or **30** (wherein A, B and C represent copies of the 3 different colours, marks, symbols, words, letters, numbers, pictures or other features).

[0169] Alternatively, where the facial blocks of a 3×3×3 combinatorial twisting cube puzzle are labelled in accordance with Config. No. **3**, **4** or **5** of FIGS. **17***b* and **18** (wherein 2 facial blocks which bear identical or equivalent copies of one feature reside on opposite faces of the puzzle, while any 2 facial blocks which bear identical or equivalent copies of any other feature reside on adjacent faces of the puzzle), the remaining blocks in the puzzle are preferably labelled according to one of the 65 alternative configurations (Config. Nos. **1** to **65**) shown in FIG. **31**. For example, the blocks may be labelled in accordance with Config. No. **1**, **2**, **3**, **4**, **5**, **6** or **7** of FIG. **31**, wherein all 26 blocks faun a complete set of analogous blocks that bear complementary sets or combinations of features, corresponding to a high degree of symmetry between analogous blocks. In particular, a 3×3×3 combinatorial twisting cube puzzle preferably has or is otherwise able to adopt at least one solution or configuration wherein the arrangement of colours, marks, symbols, words, letters, numbers, pictures or other features on all 6 faces of the puzzle (in any orientation) is selected from any group of alternative configurations in FIG. **32**, **33**, **34**, **35***a*, **35***b*, **36**, **37** or **38** (wherein A, B and C represent copies of the 3 different colours, marks, symbols, words, letters, numbers, pictures or other features).

[0170] Furthermore, where the facial blocks of a 3×3×3 combinatorial twisting cube puzzle are labelled in accordance with Config. No. **6** of FIGS. **17***b* and **18** (wherein any two facial blocks which bear the same feature lie on opposite faces of the puzzle), the other blocks in the puzzle are preferably labelled according to one of the 65 configurations (Config. Nos. **1** to **65**) shown in FIG. **39**. For example, the blocks may be labelled according to Config. No. **1**, **2**, **3**, **4** or **5** of FIG. **39**, wherein all 26 blocks form part of a complete set of analogous blocks which bear complementary sets or combinations of features, corresponding to a high degree of symmetry between the blocks. Preferably, the puzzle has or is able to adopt at least one possible solution or configuration wherein the arrangement of colours, marks, symbols, words, letters, numbers, pictures or other features on all six faces of the puzzle (in any orientation) is selected from any group of alternative configurations in FIG. **40**, **41**, **42**, **43** or **44** (wherein A, B and C represent copies of 3 different colours, marks, symbols, words, letters, numbers, pictures or other features).

[0171] In a special embodiment of a 3×3×3 combinatorial twisting cube puzzle, the puzzle has or is otherwise able to adopt at least one solution or configuration shown in FIG. **45***a* or **45***b*, wherein each block bears the same colour on all of its exposed faces.

[0172] In another embodiment of a 3×3×3 combinatorial twisting cube puzzle, two or more different sets of features are superimposed or otherwise combined with each other, as shown in FIG. **46**, for example. In this case, the puzzle preferably has or is otherwise able to adopt at least one possible solution or configuration wherein the arrangement of colours, marks, symbols, words, letters, numbers, pictures or other features on each of the puzzle's six faces is independently selected from the 144 alternative configurations in FIG. **47**, wherein A, B and C represent one set of 3 different colours, marks, symbols, words, letters, numbers, pictures or other features, while the white and 2 shades of grey represent a different set of 3 different colours, marks, symbols, words, letters, numbers, pictures or other features, which is superimposed or otherwise combined with the first set of features.

[0173] In particular, the puzzle preferably has or is able to adopt at least one possible solution or configuration wherein the arrangement of colours, marks, symbols, words, letters, numbers, pictures or other features on all six faces of the puzzle (in any orientation) is selected from the 24 alternative configurations shown in FIG. **48**, or from the 24 alternative starting configurations in FIG. **49**, wherein A, B and C represent one set of 3 different colours, marks, symbols, words, letters, numbers, pictures or other features, while the white and 2 shades of grey represent another set of 3 different colours, marks, symbols, words, letters, numbers, pictures or other features, which is superimposed or otherwise combined with the first set of features.

Example 3

4×4×4 Combinatorial Twisting Cube Puzzles (n=4)

[0174] According to one embodiment of the invention, where n is 4, a 4×4×4 combinatorial twisting cube puzzle comprises a total of 56 cube-like blocks (8 corner blocks [**1**], 24 edge blocks [**2**], 24 facial blocks [**3**]), which have 96 exposed faces [**4**] in total (with 16 exposed faces on each of the puzzle's 6 faces), as shown in FIG. **50**. In this case, any 4×4 layer of blocks may be rotated freely and independently in either direction about an axis that is perpendicular to the rotating layer of blocks, as shown in FIGS. **50***a*, **50***b* and **50***c*, for example. Thus, the blocks can be rearranged into more than 10^{55} different configurations by applying a particular sequence of rotations to alternative 4×4 layers of blocks in a successive and combinatorial manner

[0175] According to one essential feature of the present invention, the 96 exposed faces of all 56 cube-like blocks in a 4×4×4 combinatorial twisting cube puzzle are labelled with 24 identical or equivalent copies each of 4 different colours, marks, symbols, words, letters, numbers, pictures or other features. Furthermore, according to a solution of the puzzle, one copy of each different colour, mark, symbol, word, letter, number, picture or other feature appears on every row and every column of blocks on each face of the puzzle, while no two identical or equivalent copies of any colour, mark, symbol, word, letter, number, picture or other feature appear on any one row or column of blocks on any face of the puzzle. Accordingly, the puzzle preferably has or is otherwise able to adopt at least one solution or configuration wherein the

arrangement of colours, marks, symbols, words, letters, numbers, pictures or other features on each of the puzzle's six faces is independently selected from the 4!×3!×2!=288 alternative configurations shown in FIG. **51**, wherein A, B, C and D represent copies of the 4 different colours, marks, symbols, words, letters, numbers, pictures or other features.

[0176] For example, the blocks may be labelled such that the puzzle has or is otherwise able to adopt at least one possible solution or configuration wherein the arrangement of colours, marks, symbols, words, letters, numbers, pictures or other features on all 6 faces of the puzzle (in any orientation) is selected from the 8 alternative configurations (Solutions **1** to **8**, respectively) shown in FIG. **52**, or from the 8 alternative starting configurations (Configurations 11 to 8) shown in FIG. **53**, wherein A, B, C and D represent copies of 4 different colours, marks, symbols, words, letters, numbers, pictures or other features. It should be noted, however, that these examples represent only a very limited selection of the possible configurations which may be adopted by such a 4×4×4 combinatorial twisting cube puzzle in accordance with the present invention. In particular, there are $288^6=5.7\times10^{14}$ possible solutions for a 4×4×4 combinatorial twisting cube puzzle according to the present invention (not shown), although many of these configurations are equivalent by rotation of the entire puzzle into 6×4=24 possible orientations.

[0177] In another embodiment of a 4×4×4 combinatorial twisting cube puzzle, two or more different sets of features are superimposed or otherwise combined with each other, as shown in FIG. **54**, for example. In this case, the puzzle preferably has or is otherwise able to adopt at least one possible solution or configuration wherein the arrangement of colours, marks, symbols, words, letters, numbers, pictures or other features on each of the puzzle's six faces is independently selected from the 96 alternative configurations shown in FIG. **55**, wherein A, B, C and D represent one set of four different colours, marks, symbols, words, letters, numbers, pictures or other features, while the white and 3 shades of grey represent another set of four different colours, marks, symbols, words, letters, numbers, pictures or other features, that is superimposed or otherwise combined with the first set of features. Again, however, it should be noted that these examples represent only a limited selection of the possible configurations which may be adopted by a 4×4×4 combinatorial twisting cube puzzle according to this embodiment of the present invention, wherein two different sets of features are superimposed or otherwise combined with each other. In particular, there are $(288\times288)^6=3.3\times10^{29}$ possible solutions for a 4×4×4 combinatorial twisting cube puzzle in this embodiment of the invention, though many of these configurations are equivalent by rotation of the entire puzzle into 6×4=24 possible orientations.

Example 4

5×5×5 Combinatorial Twisting Cube Puzzles (n=5)

[0178] According to one embodiment of the invention, where n is 5, a 5×5×5 combinatorial twisting cube puzzle comprises a total of 98 cube-like blocks (8 corner blocks [**1**], 36 edge blocks [**2**] and 54 facial blocks [**3**]), which have 150 exposed faces [**4**] in total (25 exposed faces on each of the puzzle's 6 faces). In this case, any 5×5 layer of blocks may be rotated freely and independently in either direction about an axis perpendicular to the rotating layer of blocks. Thus, the blocks can be rearranged into more than 10^{90} different configurations by applying a particular sequence of rotations to alternative 5×5 layers of blocks in a successive and combinatorial manner.

[0179] According to an essential feature of the present invention, the 150 exposed faces of all 98 cube-like blocks in a 5×5×5 combinatorial twisting cube puzzle are labelled with 30 identical or equivalent copies each of 5 different colours, marks, symbols, words, letters, numbers, pictures or other features. Furthermore, according to a solution of the puzzle, one copy of each different colour, mark, symbol, word, letter, number, picture or other feature appears on every row and every column of blocks on each face of the puzzle, while no two identical or equivalent copies of any colour, mark, symbol, word, letter, number, picture or other feature appear on any one row or column of blocks on any face of the puzzle. Accordingly, the puzzle preferably has or is otherwise able to adopt at least one solution or configuration wherein the arrangement of colours, marks, symbols, words, letters, numbers, pictures or other features on each of the puzzle's six faces is independently selected from 5!×4!×3!×2!=34,560 possible configurations wherein one copy of each different colour, mark, symbol, word, letter, number, picture or other feature appears on every row and every column of blocks on each face of the puzzle, while no two identical or equivalent copies of any colour, mark, symbol, word, letter, number, picture or other feature appear on any one row or column of blocks on any face of the puzzle (not shown). Further, the puzzle preferably has or is otherwise able to adopt at least one solution or configuration wherein the arrangement of colours, marks, symbols, words, letters, numbers, pictures or other features on all 6 faces of the puzzle is selected from $34{,}560^6=1.7\times10^{27}$ possible configurations wherein one copy of each different colour, mark, symbol, word, letter, number, picture or other feature appears on every row and every column of blocks on each face of the puzzle, while no two identical or equivalent copies of any colour, mark, symbol, word, letter, number, picture or other feature appear on any one row or column of blocks on any face of the puzzle (not shown).

[0180] In another embodiment of a 5×5×5 combinatorial twisting cube puzzle, two or more different sets of features are superimposed or otherwise combined with each other. In this embodiment, the puzzle preferably has or is otherwise able to adopt at least one possible solution or configuration wherein the arrangement of colours, marks, symbols, words, letters, numbers, pictures or other features on each of the puzzle's six faces is independently selected from 34,560×34,560=1.2×10^9 alternative configurations wherein one copy of each different colour, mark, symbol, word, letter, number, picture or other feature appears on every row and every column of blocks on each face of the puzzle, while no two identical or equivalent copies of any colour, mark, symbol, word, letter, number, picture or other feature appear on any one row or column of blocks on any face of the puzzle (not shown). Further, the puzzle preferably has or is otherwise able to adopt at least one solution or configuration wherein the arrangement of colours, marks, symbols, words, letters, numbers, pictures or other features on all 6 faces of the puzzle is selected from $(34{,}560\times34{,}560)^6=2.9\times10^{54}$ possible configurations where one copy of each different colour, mark, symbol, word, letter, number, picture or other feature appears on every row and every column of blocks on each face of the puzzle, while no two identical or equivalent copies of any

colour, mark, symbol, word, letter, number, picture or other feature appear on any row or column of blocks on any face of the puzzle (not shown).

Generality of the Invention

[0181] Due to the combinatorial nature of the invention, the skilled person will appreciate that an astronomical number of different combinations, permutations or other embodiments of a n×n×n combinatorial twisting cube puzzle may be envisaged within the overall spirit and scope of the invention as described herein. Moreover, the skilled person will appreciate that the limited selection of examples described above represent only a very small portion of those combinations, permutations or other embodiments of the present invention which may be envisaged. Accordingly, the present invention is intended to include any n×n×n combinatorial twisting cube puzzle that reflects or embodies the overall essence or spirit of the invention as described herein.

[0182] Furthermore, the present invention provides a set of adhesive labels or stickers bearing 6n identical or equivalent copies each of n different colours, marks, symbols, words, letters, numbers, pictures or other features, which are intended for use with a n×n×n combinatorial twisting cube puzzle in accordance with the invention. Conversely, the invention provides a n×n×n combinatorial twisting cube puzzle which is intended to be labelled or otherwise modified in accordance with the present invention.

[0183] Finally, the present invention provides a computer program or algorithm which models or simulates any aspect of the invention as described above. In particular, the present invention provides a computer program or algorithm which models or simulates a n×n×n combinatorial twisting cube puzzle comprising a total of 6n×(n−2)+8 cube-like blocks having $6n^2$ exposed faces [**4**], which are labelled with 6n identical or equivalent copies each of n different colours, marks, symbols, words, letters, numbers, pictures or other features. Such a computer program or algorithm may be developed by adapting any one of the existing computer programs or algorithms which model or simulate the classic Rubik's Cube, or any of its ×n×n variants, a wide variety of which have been published on the interne. For example, the variables in such a program or algorithm which define the colours on the individual blocks of a n×n×n combinatorial twisting cube puzzle may easily be redefined so that the $6n^2$ exposed faces [4] of the blocks in the puzzle are labelled with 6n identical or equivalent copies each of n different colours, marks, symbols, words, letters, numbers, pictures or other features, in accordance with the present invention.

[0184] The present invention relates to n×n×n combinatorial twisting cube puzzles of the kind known as Rubik's Cube, wherein a total of 6n×(n−2)+8 cube-like blocks have $6n^2$ exposed faces [**4**], which are labelled with 6n identical or equivalent copies each of n different colours, marks, symbols, words, letters, numbers, pictures or other features. The objective of the puzzles is to rearrange the blocks so that one copy of each feature appears on every row and every column of blocks on each face of the puzzle, and no two copies of the same feature appear on any one row or column of blocks on any face of the puzzle. The absence of a more clearly defined solution provides a greater and more stimulating intellectual challenge

1-48. (canceled)

49. A n×n×n combinatorial twisting cube puzzle wherein a total of 6n×(n−2)+8 cube-like blocks have $6n^2$ exposed faces, which are labelled with 6n identical or equivalent copies each of n different colours, marks, symbols, words, letters, numbers, pictures or other features.

50. A n×n×n combinatorial twisting cube puzzle according to claim **49**, which has at least one configuration ("solution") wherein one copy of each different colour, mark, symbol, word, letter, number, picture or other feature appears on every row and every column of blocks on each face of the puzzle, and no two copies of any one colour, mark, symbol, word, letter, number, picture or other feature appear on the same row or column of blocks on any face of the puzzle.

51. A n×n×n combinatorial twisting cube puzzle according to claim **50**, which has no more than 8 alternative solutions.

52. A n×n×n combinatorial twisting cube puzzle according to claim **49**, wherein two or more different sets of features are superimposed or combined with each other.

53. A n×n×n combinatorial twisting cube puzzle according to claim **49**, wherein the blocks are labelled with a particular set of features using adhesive labels or stickers, or by printing the features directly onto the exposed faces of each block, or by incorporating the features into the blocks during or after their manufacture or assembly, or by any other means.

54. n×n×n combinatorial twisting cube puzzle according to claim **49**, wherein the colours, marks, symbols, words, letters, numbers, pictures or other features have four-fold symmetry, or have the same orientation on each face of the puzzle in any configuration.

55. A n×n×n combinatorial twisting cube puzzle according to claim **49**, wherein no more than 6 blocks in the puzzle bear any one particular set or combination of features.

56. A n×n×n combinatorial twisting cube puzzle according to claim **49** where n is 2, corresponding to a 2×2×2 combinatorial twisting cube puzzle wherein a total of 8 cube-like blocks have 24 exposed faces, which are labelled with 12 identical or equivalent copies each of 2 different features.

57. A 2×2×2 combinatorial twisting cube puzzle according to claim **56**, which has at least one configuration wherein the arrangement of features on each of the puzzle's six faces is independently selected from the two alternative configurations shown in FIG. **2**.

58. A 2×2×2 combinatorial twisting cube puzzle according to claim **56**, wherein two different sets of features are superimposed or otherwise combined with each other, and the puzzle has at least one configuration wherein the arrangement of features on each of the puzzle's six faces is independently selected from the four alternative configurations shown in FIG. **13**.

59. A n×n×n combinatorial twisting cube puzzle according to claim **49** where n is 3, corresponding to a 3×3×3 combinatorial twisting cube puzzle wherein a total of 26 cube-like blocks have 54 exposed faces, which are labelled with 18 identical or equivalent copies each of 3 different features.

60. A 3×3×3 combinatorial twisting cube puzzle according to claim **59**, which has at least one configuration wherein the arrangement of features on each of the puzzle's six faces is independently selected from the 12 alternative configurations shown in FIG. **16**.

61. A 3×3×3 combinatorial twisting cube puzzle according to claim **59**, wherein two different sets of features are superimposed or otherwise combined with each other, and the puzzle has at least one configuration wherein the arrangement

of features on each of the puzzle's six faces is independently selected from the 144 alternative configurations shown in FIG. **47**.

62. A n×n×n combinatorial twisting cube puzzle according to claim **49** where n is 4, corresponding to a 4×4×4 combinatorial twisting cube puzzle wherein a total of 56 cube-like blocks have 96 exposed faces, which are labelled with 24 identical or equivalent copies each of 4 different features.

63. A 4×4×4 combinatorial twisting cube puzzle according to claim **62**, which has at least one configuration wherein the arrangement of features on each of the puzzle's six faces is independently selected from the 288 alternative configurations shown in FIG. **51**.

64. A 4×4×4 combinatorial twisting cube puzzle according to claim **62**, wherein two different sets of features are superimposed or otherwise combined with each other, and the puzzle has at least one configuration wherein the arrangement of features on each of the puzzle's six faces is independently selected from the 96 alternative configurations shown in FIG. **55**.

65. A n×n×n combinatorial twisting cube puzzle according to claim **49** where n is 5, corresponding to a 5×5×5 combinatorial twisting cube puzzle wherein a total of 98 cube-like blocks have 150 exposed faces, which are labelled with 30 identical or equivalent copies each of 5 different features.

66. A n×n×n combinatorial twisting cube puzzle according to claim **53**, wherein a set of adhesive labels or stickers bearing 6n identical or equivalent copies each of n different colours, marks, symbols, words, letters, numbers, pictures or other features is supplied separately from the body of the puzzle.

67. A computer program or algorithm which simulates or otherwise models a n×n×n combinatorial twisting cube puzzle in accordance with claim **49**.

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