John Beasley, originally written January 2010, revised March 2015

This document desribes a file ZUG3456.PGN which is believed to contain all chess positions with not more than six men which are reciprocal zugzwang (Black to move loses, but White to move cannot win). These can be divided into full-point reciprocal zugzwangs (whoever is to move loses) and half-point reciprocal zugzwangs (Black to move loses) white to move cannot win but can hold the draw).

The file is being distributed as a zipped file ZUG3456.ZIP of size approximately 16MB. When unzipped, this should yield a file ZUG3456.PGN of size approximately 180MB plus the present file ZUG3456README.PDF. The file ZUG3456.PGN should contain 932,789 positions.

Presentation

The file has been designed for use and display by ChessBase and similar programs. As displayed in a ChessBase List, the White and Black men involved are shown under Players, the depths to win under Tournament, and the result with White to move in a column towards the right (so " $\frac{1}{2}-\frac{1}{2}$ " denotes a half-point reciprocal zugzwang and "0-1" a full-point). Thus the first position in the file displays as

Ka6 Pb7 - Kb8 DTM 9 with BTM, draw WTM 1/2-1/2

to indicate that the White king is on a6, there is a White pawn on b7, the Black king is on b8, and the depth to mate is 9 moves with Black to move. The first full-point reciprocal zugzwang in the file displays as

Ka7 Pb6 - Kc6 Pb7 DTM 13 with BTM, 14 WTM 0-1

to indicate that the depth to mate is 13 moves with Black to move and the depth to mate by Black is 14 moves with White to move, and the corresponding position with colours reversed appears as

later in the file. Each full-point reciprocal zugzwang appears twice in this way unless the White men reflect the Black either on the file (three cases typified by White Kb1, Pa6/c6 against Black Kb8, Pa3/c3) or diametrically (again three cases, this time typified by White Kg1, Pa6/c6 against Black Kb8, Pf3/h3). In these six cases, flipping or turning the board and reversing the colours gives a position which is identical to the original, and so does not appear separately. For a statistical summary, see the Appendix.

The depth to win normally gives the number of White moves needed to force mate (DTM), but in the case of the five-against-one zugzwangs it gives the number of White moves needed to force any of mate, winning capture by White, losing capture by Black, or promotion (DTC). There is no significance in this distinction, which merely reflects the data that were available. Note that while DTM is necessarily positive, DTC may be zero (signifying a position where Black's only available moves are captures and each of his possible captures gives a lost ending with fewer men).

When a position is displayed by ChessBase, a single pass move "1.--" appears in the "moves" window. When an engine offered within ChessBase is used to analyse the position, the presence of this move allows the user to flip between "White to move" and "Black to move" analyses by using the left and right arrow keys.

Sequencing and orientation

The positions are grouped by material, and are presented in a natural QRBNP sequence. Not every combination is represented, and the actual order is KP-K, KR-KB, KR-KN, KR-KP, KN-KP, KP-KB, KP-KN, KP-KP, KBP-K, KNP-K, KP-K, KQ-KRB, KQ-KRN, KQ-KRP, and so on.

Pawnless positions are reflected so that the White king is within the triangle a8-a5-d5. If this puts it on the long diagonal, the position is further reflected so that the Black king lies on or above this diagonal; if the Black king also lies on this diagonal, the position is reflected so that the White queen lies on or above it; if the White queen is absent or also lies on it, the position is reflected so that the Black queen lies on or above it; and so on.

For positions with pawns, the squares are assumed to be ordered in sequence a7-b7-c7-...-h7-a6-b6-...-h2, and the position is reflected so that the White pawns are as near as possible to a7. If there are no White pawns, or if the White pawns are disposed symmetrically, the same criterion is applied to the Black pawns; if these too are disposed symmetrically, or if they are non-existent, the White king is placed in the left-hand half of the board.

Within a group of positions with the same material, the locations of the White pawns take first priority, then the locations of the Black pawns, then the White king, and so on. This means that all the positions with the same material and with the pawns in the same locations are grouped together.

Searching for particular positions or sets of positions

Please note that this section relates to the versions of ChessBase and CQL installed on my own machine in January 2010. There may be more recent versions offering further facilities.

Some searches for particular positions can be done using either ChessBase or CQL, but searching for positions with the men in a particular relationship to each other can be conveniently done only using CQL, and searching for positions with a particular depth to the win can be done only using ChessBase.

Positions with particular material can be picked out in ChessBase by searching on Material and in CQL by using :piececount.

Searches for pawnless positions in which one or more men are on particular squares can be performed by CQL using :flip (and :flipcolor if appropriate). This will pick up the desired position irrespective of the orientation in which it is stored in the file. ChessBase is less flexible, and to find pawnless positions with (say) the White King on e1 it is necessary to put the king on e1, h4, h5, or e8 on the 'Or' board and to use V-Mirror, or to put it on all eight squares e1/h4/h5/e8/d8/a5/a4/d1.

Searches for positions with pawns in which one or more men are on particular squares can be performed by CQL using :flipvertical and by ChessBase using V-Mirror. Searches for positions with the key men in a particular relationship to each other (for example, the "trebuchet" position with White Ka5, Pb4 against Black Kc4, Pb5) can be performed by CQL using :flipvertical and :shift, but there is no convenient ChessBase equivalent.

Full-point zugzwangs can be found using either ChessBase or CQL by looking for positions with result 0-1.

Positions with a particular depth to mate or capture can be selected using ChessBase by specifying "n" under Tournament, bracketing it by spaces so that a search for say 1 does not also pick up 10, 11, 21, etc. There is no equivalent facility in CQL.

Note regarding legality and retro-analytical effects

The positions have been analysed ignoring legality, possible retro-analytical effects, and castling. Specifically,

- each position is presented as an object in its own right, no account being taken of whether it could have been produced by a sequence of legal moves from the normal initial array;
- no account is taken of the possibility that the side to move may have the option of an "en passant" capture;
- it is assumed that neither side can still castle, even if its king and one or both of its rooks are in their normal game array positions.

Additionally, no account is taken of the "fifty-move rule"; any eventual mate is treated as a win, even if more than fifty moves between successive captures or pawn moves necessarily occur on the way to it.

Sourcing and validation

My immediate source was a set of spreadsheets prepared by Guy Haworth and made available on the ICGA web site. These in turn, with the exception of that relating to five-against-one positions, were prepared from data extracted from the Nalimov depth-to-mate tablebases on Eiko Bleicher's web site www.k4it.de by programs written by Marc Bourzutschky and Eiko himself. The five-against-one spreadsheet was prepared from a depth-to-capture tablebase calculated by Marc. The spreadsheets include some "en passant" zugzwangs, where the player to move is assumed to have the option of a capture en passant, but these are not included in the present file.

The statistics for zugzwangs with up to five men were checked against the well-established figures presented in a note by Guy and others in the December 2001 issue of the *ICGA Journal* (pages 225-230), and appear to agree exactly. The statistics for zugzwangs with six men were checked against a further spreadsheet made available by Guy on the ICGA web site, and they appear to agree exactly except in some cases where both sides have pawns. Here, Guy's statistics include the "en passant" zugzwangs which I have excluded, and direct comparison is impossible. However, a paper "6-man Chess and Zugzwangs" by Eiko Bleicher and Guy, presented to a subsequent ICGA conference, included a table which enabled his statistics to be adjusted to exclude these, and if these adjustments are made our results again appear to agree exactly.

Additionally, spot checks were made to verify that some expected zugzwangs did indeed appear in the file, and it was confirmed that the zugzwangs in a small random sample from the file did indeed have the properties claimed for them.

Nearly all this work, including the verification of sample positions, depended on the validity of the Nalimov tablebases on Eiko Bleicher's web site. Some of these (for positions with up to five men, and for most pawnless positions with six men) repeated ground already covered by others, and various key parameters were verified against what was already known from other sources before they were posted. No previous data were available for six-man positions with pawns and for a time the Nalimov tablebases stood alone, but I am not aware of any respect in which they have been challenged and I think their validity is generally accepted.

Acknowledgements

My contribution to this exercise has been entirely cosmetic, and my immediate acknowledgements are to Guy Haworth for his spreadsheets. Guy in turn makes extensive acknowledgements, citing initials which I read as referring to Eiko Bleicher, Marc Bourzutschky, Peter Karrer, Eugene Nalimov, John Tamplin, Ken Thompson, and Christoph Wirth, and I am sure that tracing back down the literature would identify further workers whose contributions, though now duplicated or overtaken, were significant advances at the time.

Appendix : statistical summary

The figures that follow have been pasted in from a log file produced by the program which generated the PGN file.

Numbers of two-against-one half-point reciprocal zugzwangs

KP 80 ______ Total 80

Numbers of two-against-two half-point reciprocal zugzwangs (White men down, Black men across)

	KQ	KR	KB	KN	KP	Total
KQ	0	0	0	0	0	0
KR	0	0	5	18	12	35
KB	0	0	0	0	0	0
KN	0	0	0	0	22	22
KP	0	0	1	7	106	114
Total	0	0	6	25	140	171

Numbers of two-against-two full-point reciprocal zugzwangs

	KQ	KR	KB	KN	KP	Total
KQ KR KB KN	0	0 0	0 0 0	0 0 0	0 0 0 0	0 0 0
KP					15	15
Total	0	0	0	0	15	15

Numbers of three-against-one half-point reciprocal zugzwangs

	K
KBP	6
KNP KPP	75 43
Total	124

Numbers of three-against-two half-point and full-point reciprocal zugzwangs (White men down, Black men across)

	KQ	KR	KB	KN	KP	Total		KQ	KR	KB	KN	KP	Total
KQQ	0	0	0	0	0	0	KQQ	0	0	0	0	0	0
KQR	1	0	0	0	0	1	KQR	0	0	0	0	0	0
KQB	25	0	0	0	0	25	KQB	0	0	0	0	0	0
KQN	38	0	0	0	0	38	KQN	0	0	0	0	0	0
KQP	640	1	0	0	0	641	KQP	0	0	0	0	0	0
KRR	10	0	1	0	0	11	KRR	0	0	0	0	0	0
KRB	0	17	0	0	1	18	KRB	0	0	0	0	0	0
KRN	0	10	0	3	0	13	KRN	0	0	0	0	0	0
KRP	2	209	225	413	0	849	KRP	0	0	0	0	1	1
KBB	0	3	0	1	1	5	KBB	0	0	0	0	0	0
KBN	0	6	45	922	61	1034	KBN	0	0	0	0	0	0
KBP	0	4	160	2112	403	2679	KBP	0	0	0	0	1	1
KNN	0	0	0	362	3124	3486	KNN	0	0	0	0	0	0
KNP	0	23	640	4128	2281	7072	KNP	0	0	0	0	8	8
KPP	0	18	211	920	4179	5328	KPP	0	2	0	0	6	8
Total	716	291	1282	8861	10050	21200	Total	0	2	0	0	16	18

Numbers of two-against-three half-point reciprocal zugzwangs (White men down, Black men across)

	KQQ	KQR	KQB	KQN	KQP	KRR	KRB	KRN	KRP	KBB	KBN	KBP	KNN	KNP	KPP	Total
KQ	0	0	0	0	0	0	372	455	241	1	1	16	229	52	2	1369
KR	0	0	0	0	0	0	0	0	0	0	2	302	25	1158	99	1586
KB	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	3
KN	0	0	0	0	0	0	0	0	0	0	0	13	0	63	157	233
KP	0	0	0	0	0	0	0	0	2	0	1	2	19	14	52	90
Total	0	0	0	0	0	0	372	455	243	1	4	333	273	1289	311	3281

Numbers of four-against-one half-point reciprocal zugzwangs

	K
KBPP KNPP	6 93
KPPP	11

Total 110

Number	s of th	ree-aga	inst-th	nree hal	f-point	recipro	cal zu	gzwangs	(White	men do	wn, Bla	ack men	across)			
	KQQ	KQR	KQB	KQN	KQP	KRR	KRB	KRN	KRP	KBB	KBN	KBP	KNN	KNP	KPP	Total
KQQ	8	15	2	3	4	0	0	0	0	0	0	0	0	0	0	32
KQR	0	236	1359	1722	1019	5	1	3	0	1	0	0	0	0	0	4346
KQB	0	6	21	76	1450	161	16	15	16	0	0	0	0	1	0	1762
KQN	0	3 11	212	149	2540	905	0100 91	10552	187	10	12	10	1	202	0	4056
KQP	0	11	313	1516	316	1223	100	10555	905	12	42	90 73	946	202	9	1 1864
KRB	0	0	10	20	37	2	11	96	1059	376	1456	183	218	61.3	26	4086
KRN	Ō	Ō	0	Ō	22	0	7	69	669	801	7933	2113	8997	3316	171	24098
KRP	0	0	5	4	58	0	248	650	3794	1667	10807	12782	18954	20862	433	70264
KBB	0	0	0	0	0	2	2	5	171	0	16	79	817	1507	72	2671
KBN	0	0	0	0	0	0	11	/ 50	251	26	16 217	1850	402	30304	12222	34394
KNN	0	0	0	0	0	0	11	6	291	0	1	1562	32	12426	26532	40850
KNP	0	0	0	0	0	0	2	8	85	20	235	4819	739	28988	80091	114987
KPP	0	0	0	0	1	0	5	33	161	5	69	581	296	2482	32125	35758
Total	8	271	1749	3505	12107	2308	9384	12315	7821	2936	20950	26157	32811	117675	153253	403250
Number	s of th	ree-aga	inst-th	nree ful	l-point	recipro	cal zu	gzwangs								
	KQQ	KQR	KQB	KQN	KQP	KRR	KRB	KRN	KRP	KBB	KBN	KBP	KNN	KNP	KPP	Total
KQQ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1 0
KQR		U	0	0	0	0	0	0	0	0	0	0	0	0	0	1 0
KON			U	0	1	0	0	0	1	0	0	0	0	0	0	2
KQP				2	2	Ō	1	õ	3	Ő	Ő	Ő	Ő	Ő	Ő	6
KRR						0	0	0	0	0	0	0	0	0	0	0
KRB							0	0	0	0	0	0	0	0	0	0
KRN								0	0	0	0	0	0	1	2	1 30
KBB									0	0	0	0	0	0	20	1 0
KBN											0	0	0	0	0	0
KBP												0	0	18	222	240
KNN													0	0	0	0
KNP														1	2274	145
Total	0	0	0	0	3	0	1	0	4	0	0	3	0	21	2668	2700
Number	s of fo	ur-agai	nst-two	half-p	oint and	d full-p	oint r	eciproca	al zugz	wangs (White n	ien dowr	n, Black	c men ad	cross)	
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Numbers of two-against-four half-point reciprocal zugzwangs (White men across, Black men down)

	KQ	KR	КВ	KN	KP	Total
KQQQ	0	0	0	0	0	0
KQQR	0	0	0	0	0	0
KQQB	0	0	0	0	0	0
KQQN	0	0	0	0	0	0
KQQP	0	0	0	0	0	0
KQRR	0	0	0	0	0	0
KQRB	0	0	0	0	0	0
KQRN	0	0	0	0	0	0
KQRP	0	0	0	0	0	0
KQBB	0	0	0	0	0	0
KQBN	0	0	0	0	0	0
KQBP	6	0	0	0	0	6
KQNN	0	0	0	0	0	0
KQNP	2	0	0	0	0	2
KQPP	12	0	0	0	1	13
KRRR	0	0	0	0	0	0
KRRB	0	0	0	0	0	0
KRRN	1	0	0	0	0	1
KRRP	68	0	0	0	0	68
KRBB	22	0	0	0	0	22
KRBN	411	0	0	0	0	411
KRBP	14253	0	0	0	1	14254
KRNN	730	0	0	0	0	730
KRNP	22448	1	0	0	1	22450
KRPP	5519	13	0	2	1	5535
KBBB	463	0	0	0	0	463
KBBN	3290	0	0	0	8	3298
KBBP	5092	46	0	2	17	5143
KBNN	3779	70	0	0	1/	3/96
KBNP	15/55	/8	1	0	96	1 15930
KBPP	932	930	3	/1	8	1 1944
KINININ	2000	174	1 5	0	200	2093
KNNP	31143	1/4	15	200	209	1 31341
KNPP	2049	2029	40	299	33	1 2004
	129		14	600		2094
Total	109790	5283	79	1027	471	116650

Numbers of five-against-one half-point reciprocal zugzwangs

 K

 KQNPP
 58

 KRNPP
 58

 KRPPP
 2

 KBNPP
 58

 KBPPP
 11

 KNPPP
 89

 KPPPP
 17

 Total
 293

Total number of reciprocal zugzwangs: 929929 (927063 half-point, 2866 full-point)

Number of full-point reciprocal zugzwangs reflected into themselves on the file: 3 Number of full-point reciprocal zugzwangs reflected into themselves diametrically: 3 Number of positions written to output file: 932789 Full-point zugzwangs reflected neither on the file nor diametrically have been written twice