ATLAS: Collisions of gliders like phases of ether in rule 110

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(first version)

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Chapter 1

Introduction

In the last years the study of dynamical systems has had a lot of interest, mainly in complex systems and chaos theory. Cellular automata are discrete dynamical systems that evolve through time, these can evolve in several dimensions.

In general, cellular automata can be represented by a set K of states, a transition function φ, a neighborhood radius r and an initial configuration c_i. Rule 110 is a cellular automaton with two states in its alphabet and which evolves in one dimension.

A neighborhood is formed by a central cell and r cells to right and r cells to the left, that is, its neighbors. The transition function evaluates each one of the neighborhoods of the evolution rule, determining the state of cell for the following generation.

The initial configuration is a linear array of finite length, a single element or the set K is assigned to each one of the cells, this assignation can be made in a random way. The transition function evaluates each one of the neighborhoods defined by the evolution rule, forming a new configuration from a given generation to the next.

Using the notation defined by Stephen Wolfram [9], rule 110 is a cellular automaton of order $k = 2$ and $r = 1$, the set of states is $K = \{0, 1\}$, a neigborhood is formed by $2r + 1$ cells and the evolution rule has k^{2r+1} neighborhoods, this way rule 110 is represented like:

Transition function	
$\varphi(0,0,0) = 0$	$\varphi(1,0,0) = 0$
$\varphi(0,0,1) = 1$	$\varphi(1,0,1) = 1$
$\varphi(0,1,0) = 1$	$\varphi(1,1,0) = 1$
$\varphi(1,1,0) = 1$	$\varphi(1,1,1) = 0$

Table 1.1: Evolution rule 110

in decimal notation we have $2^0(0) + 2^1(1) \cdots + 2^7(0) = 110$.

Mathew Cook has made an extensive study of this cellular automaton, finding complex behaviors produced by the evolution rule in the evolution spaces. In [2] Cook presents a classification of the gliders[1] produced by rule 110. This one is the serious motivation to make a detailed analysis of the gliders and their collisions, taking the studies made by Harold V. McIntosh on [6] and [7] as basis.

Rule 110 shows behaviors similar to those observed in "The Game of Life", a cellular automaton of two dimensions proposed by John Horton Conway [1]. If the central cell is the state 0, then in the following generation it has the same value that its right neighbor. If the central cell is the state 1, in the following generation it conserves this same value; but if both neighbors are equal to the state 1, the cell changes to 0.

[1] Glider is a periodic structure that moves in the evolution space

One of the main differences between rule 110 and The Game of Life, is that rule 110 evolves in a periodic background and Life evolves in a stable one.

Rule 110 almost operates like the binary fuction OR operating on the two right cells of each neighborhood, except for the last one. Cook notices that in the case when the central cell is 0, in the following generation this one takes the value from its right neighbor and in any other case it follows the binary fuction NAND.

This cellular automaton can support complex behaviors through the interaction of gliders or decompositions of long transient structures. McIntosh in [6] presents an approach different from the one presented by Cook in [2], showing that rule 110 can be represented with mosaics.

This viewpoint is used in this analysis for dertermining with detail each one of the gliders, so that the amount of mosaics necessary to construct each one of them. The mosaics differ in size from T1 to T45 [7], these mosaics are rectangular triangles where the size of the triangle is defined by its interior, adding the amount of zeros which exist in any of its sides. Different combinations of Tn's can reproduce any structure generated by rule 110. Finally rule 110 can be see like a problem of covering the plane with triangles [3].

This initial study presents that rule 110 is defined in four fundamental phases, each one of these characterizes the different types of collisions which exist between gliders. These phases are determined by the periodic background or "ether" and all reproducible structure in the evolution space follows these phases.

It is important to see that the phases of ether can determine each one of the collisions between gliders and they restrict a distance among them as well. That distance is determined by the period 14 of the ether and it allows to give a space for the phases of each one of these structures, but this does not imply that it is the minimum distance that can exist.

First, the two types of triangles that can exist for a given Tn are presented, then each glider is characterized in full detall, in this part it is seen that each glider can cover the whole evolution space. Gliders are partitioned in phases, this allows to specify each one of the chains that produce given glider with a particular phase.

The contact points that a given glider has are determined, these contact points specify the type of collision that is desired to calculate. Finally all the collisions that can be produced of natural way in the evolution space are showed, finding very simple, very complex, symmetrical and some very pretty results.

In the list it is possible to see how a given glider can be obtained from others, besides some solitons, some symmetrical productions and united groups of gliders are presented.

Chapter 2

Two types of tilings

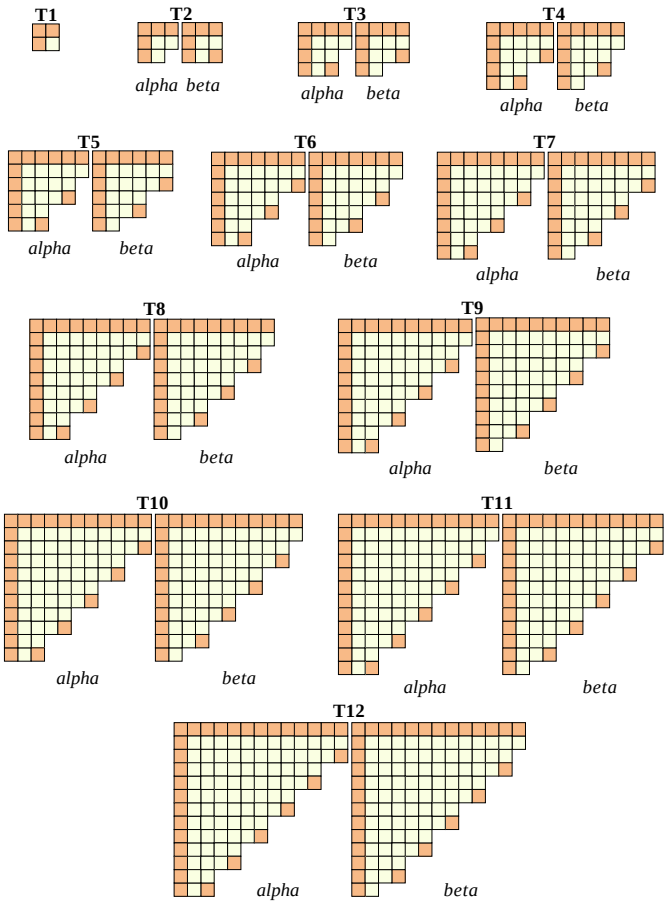


Figure 2.1: Tilings alpha and beta

2.1 Tilings covering the evolution space

2.1.1 Tiling T1

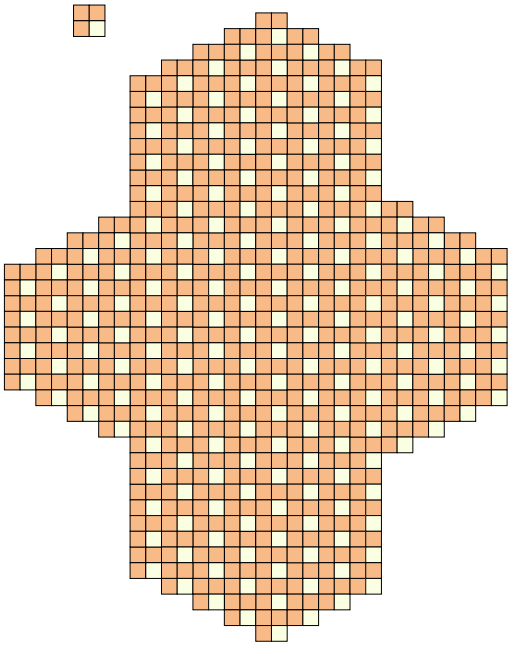


Figure 2.2: Tiling T1 covering the evolution space

2.1.2 Tiling T2

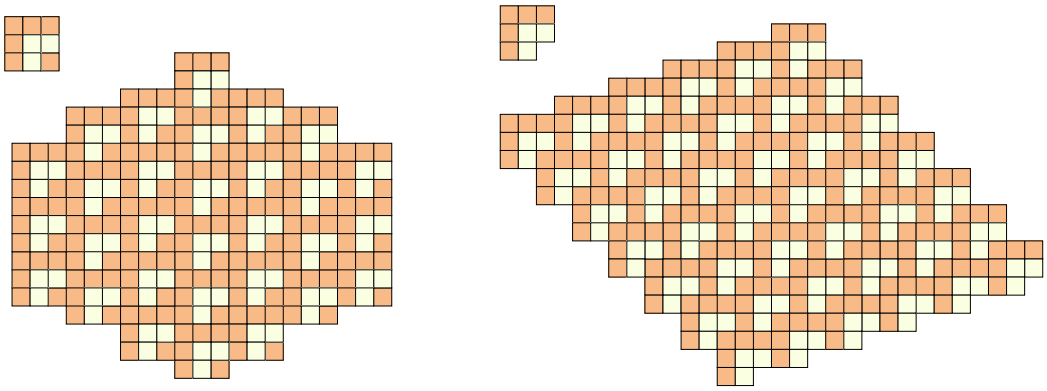


Figure 2.3: Tiling T2 covering the evolution space

2.1.3 Tiling T3

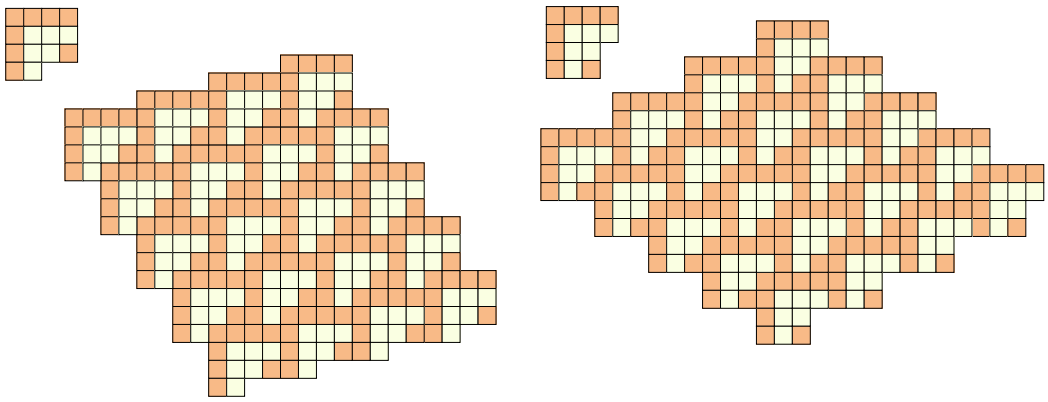


Figure 2.4: Tiling T3 covering the evolution space

2.1.4 Tiling T4

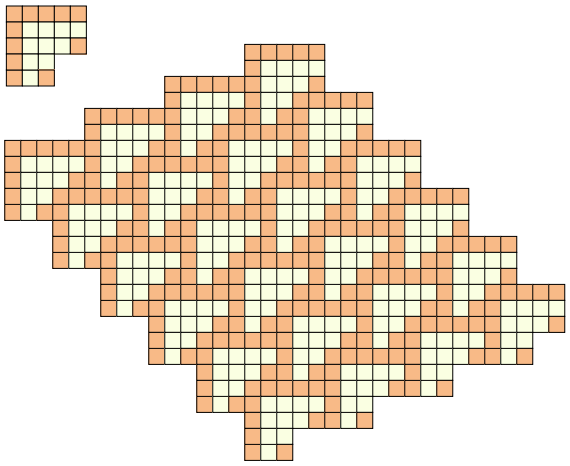


Figure 2.5: Tiling T4 covering the evolution space

2.1.5 More tilings

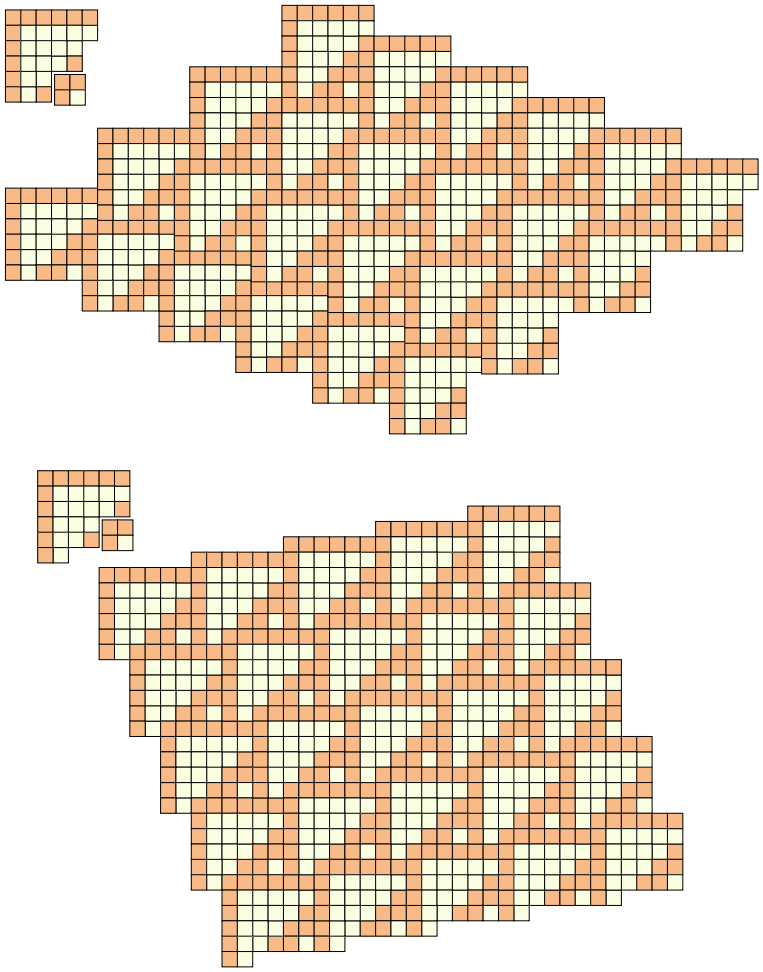


Figure 2.6: Tiling T5 covering the evolution space

Chapter 3

Tilings and phases of gliders

3.1 Tilings and phases of ether

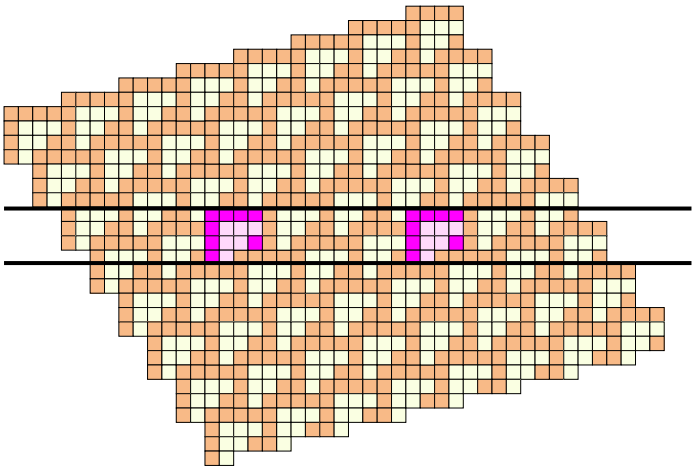


Figure 3.1: Phases of ether

line	cells	phase
11111000100110	14	1
10001001101111	14	2
10011011111000	14	3
10111110001001	14	4

Table 3.1: Lines to form ether

One tiling T3 phase beta to form ether.

Figure 3.2: Tiling of ether

3.2 Tilings and phases of glider A

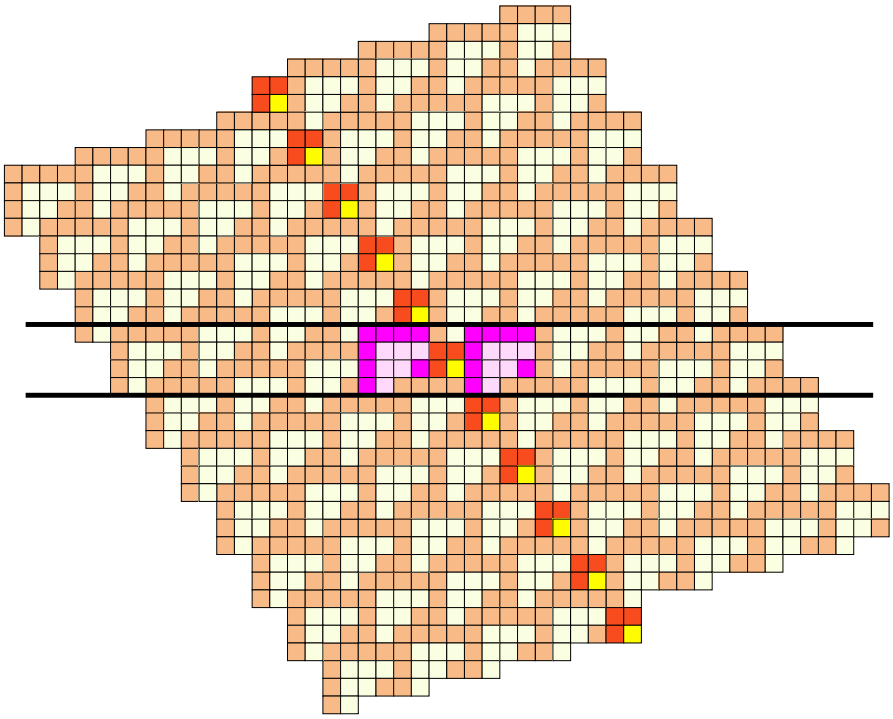


Figure 3.3: Phases of glider A

line	cells	phase
111110	6	1
100011	6	2
100110	6	3
101111	6	4

Table 3.2: Lines to form glider A

One tiling T1 to form glider A.

Figure 3.4: Tiling of glider A

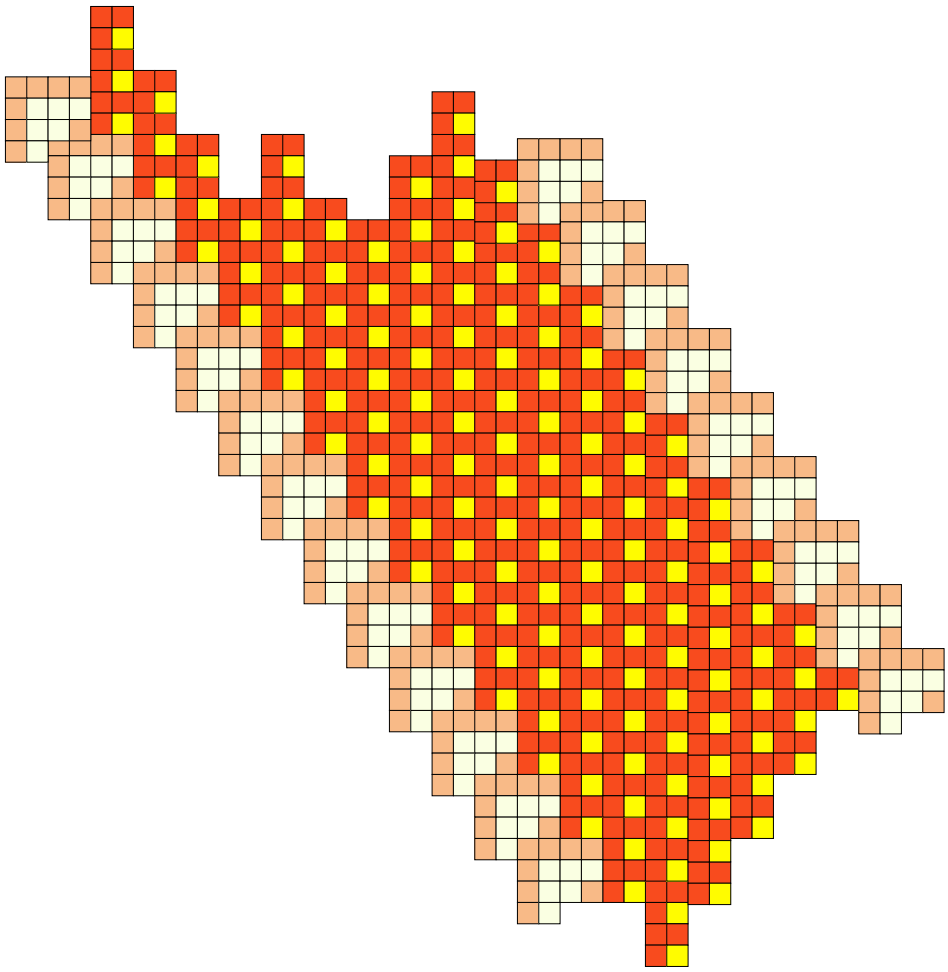


Figure 3.5: Glider A covering the evolution space

3.3 Tilings and phases of glider B

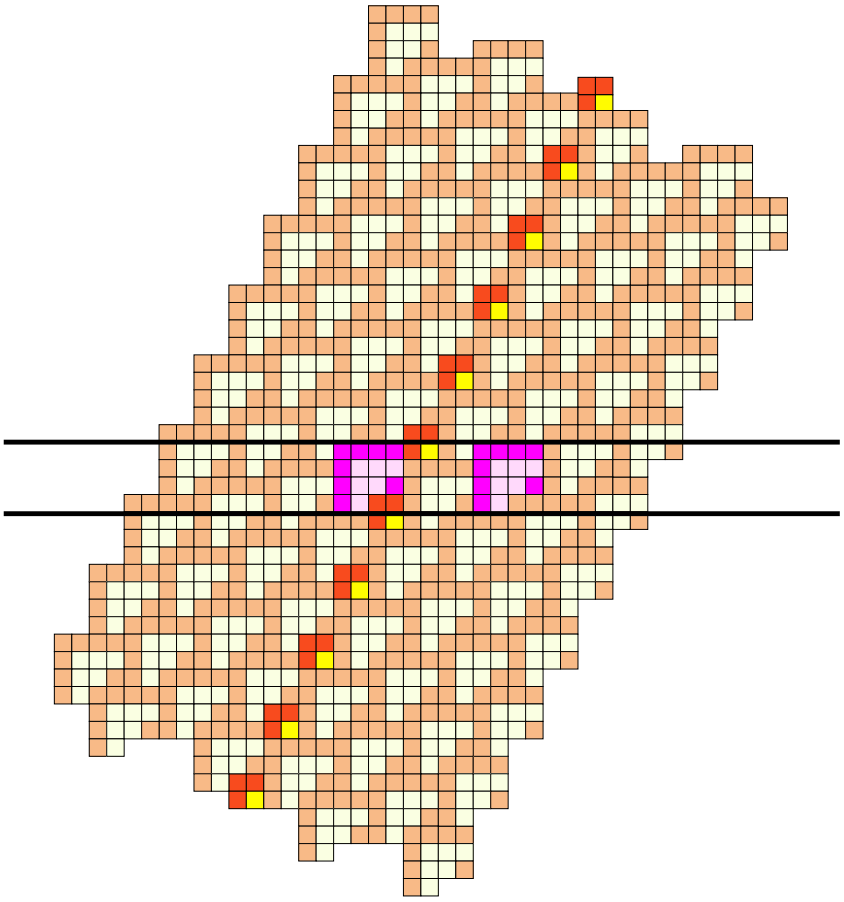


Figure 3.6: Phases of glider B

line	cells	phase
11111010	8	1
10001111	8	2
10011000	8	3
10111001	8	4

Table 3.3: Lines to form glider B

One tiling T1 to form glider B.

Figure 3.7: Tiling of glider B

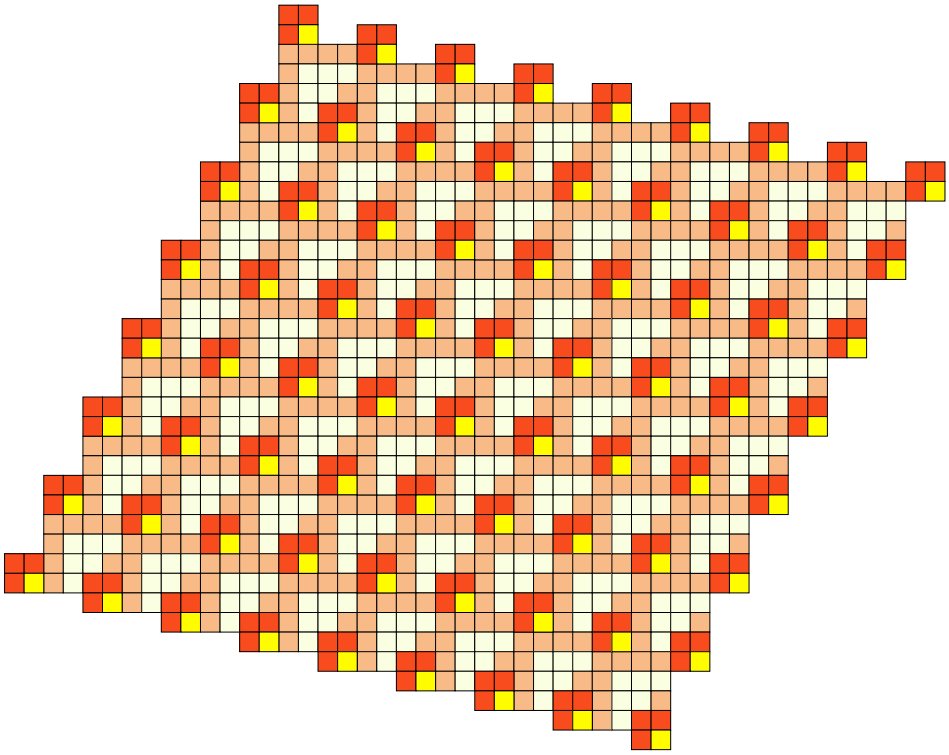


Figure 3.8: Glider B covering the evolution space

3.4 Tilings and phases of glider Bbar

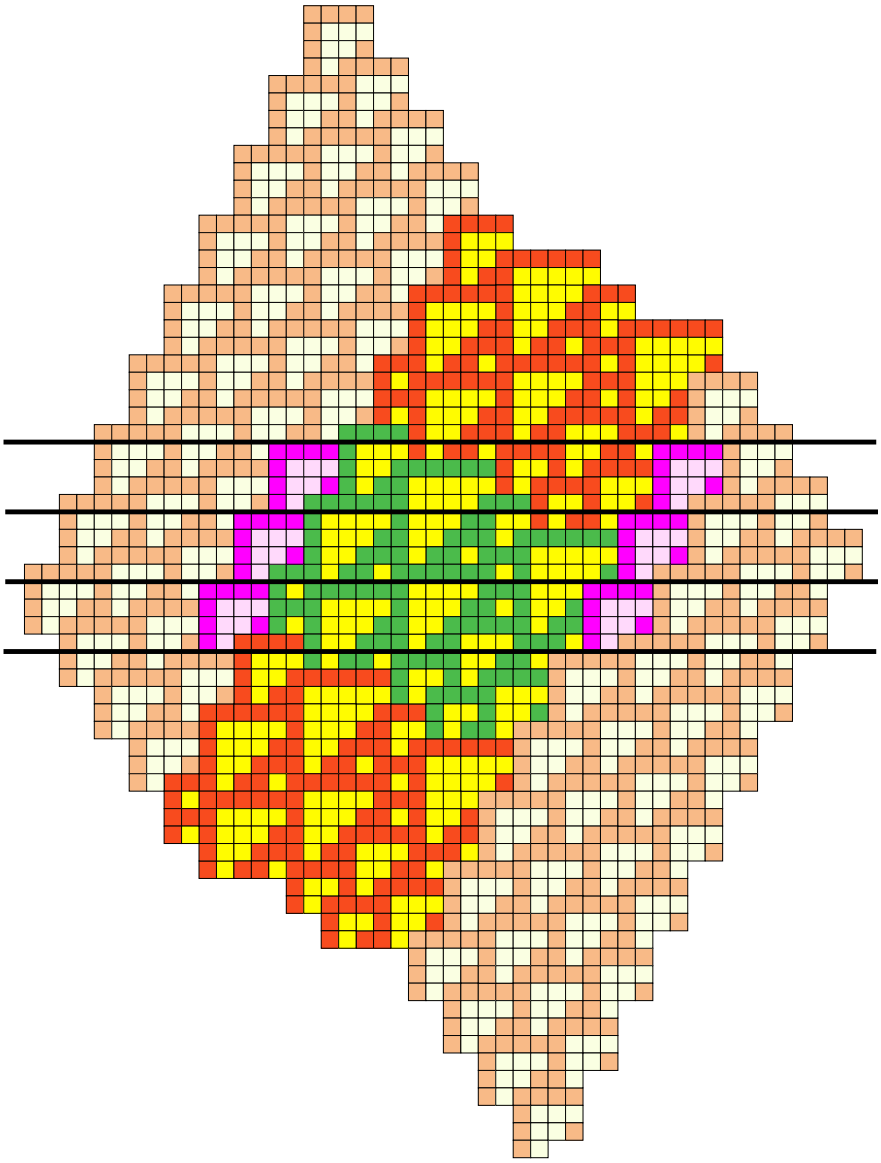


Figure 3.9: Phases of glider Bbar

line	cells	phase
1111100010110111100110	22	1
1000100111111100101111	22	2
1001101100000101111000	22	3
1011111100001111001001	22	4
1111100001000110010110	22	1
1000100011001110111111	22	2
1001100111011011100000	22	3
1011101101111110100001	22	4
1111101111110000111000	22	1
1000111000010001101001	22	2
1001101000110011111011	22	3
1011111001110110001110	22	4

Table 3.4: Lines to form glider Bbar

Twenty tilings to form glider Bbar.

no. tilings	tiling	phase
9	T1	-
3	T2	2 alpha, 1 beta
3	T3	1 alpha, 2 beta
3	T4	3 alpha
2	T5	1 alpha, 1 beta

Table 3.5: Tilings to form glider Bbar

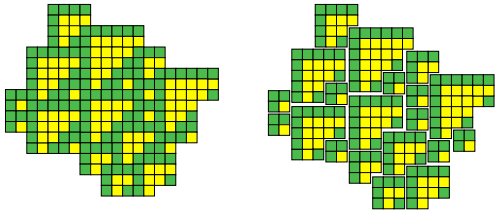


Figure 3.10: Tilings of glider Bbar

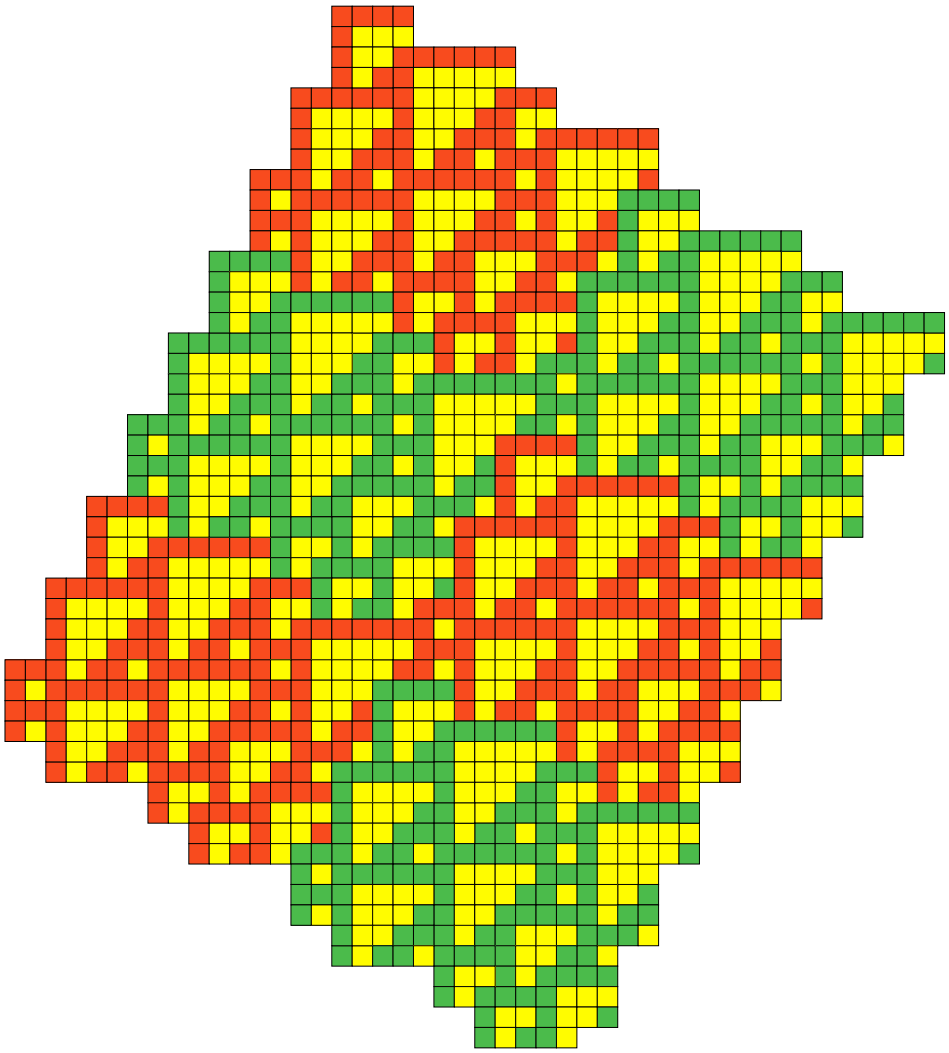


Figure 3.11: Glider Bbar covering the evolution space

3.5 Tilings and phases of glider Bbar8

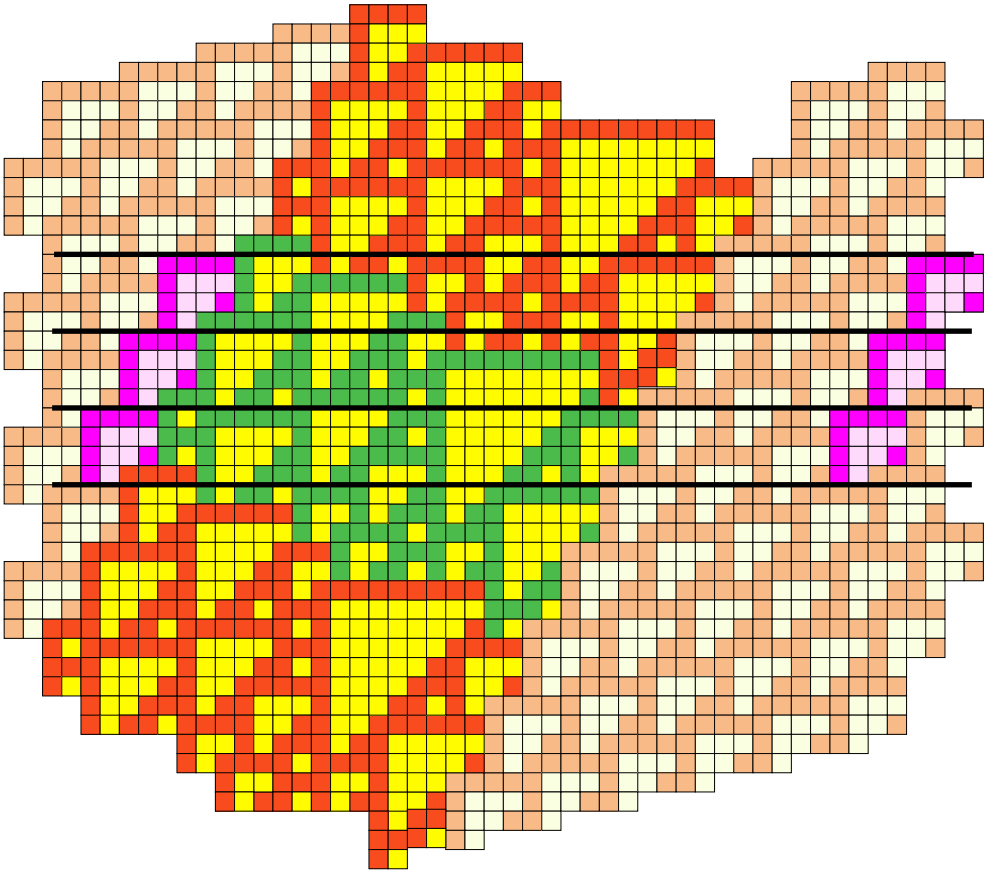


Figure 3.12: Phases of glider Bbar8

line	cells	phase
11111000101101111001100111111000100110	39	1
10001001111111001011101100000100110111	39	2
10011011000001011110111100001101111000	39	3
10111111000011110011100100011111000100	39	4
11111000010001100101101011001100010011	39	1
10001000110011101111111111101110011011	39	2
10011001110110111000000001110101111000	39	3
10111011011111101000000011011111000100	39	4
11111011111100001110000001111100010011	39	1
10001110000100011010000011000100110111	39	2
10011010001100111110000111001101111000	39	3
10111110011101100010001101011111000100	39	4

Table 3.6: Lines to form glider Bbar8

Twenty five tilings to form glider Bbar8.

no. tilings	tiling	phase
12	T1	-
4	T2	2 alpha, 2 beta
3	T3	1 alpha, 2 beta
3	T4	3 alpha
2	T5	1 alpha, 1 beta
1	T8	alpha

Table 3.7: Tilings to form glider Bbar8

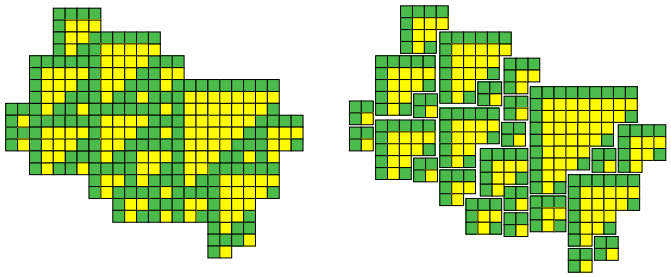


Figure 3.13: Tilings of glider Bbar8

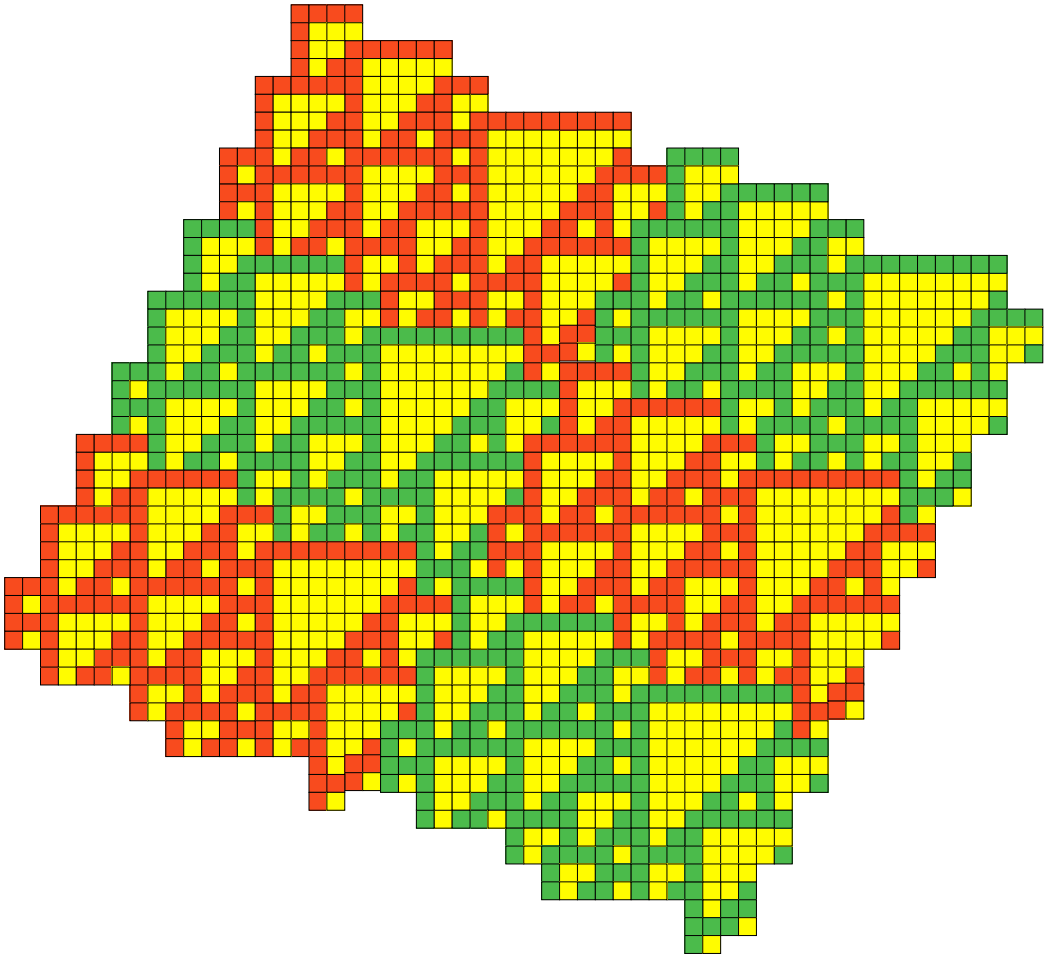


Figure 3.14: Glider Bbar8 covering the evolution space

3.6 Gliders C

3.6.1 Tilings and phases of glider C1

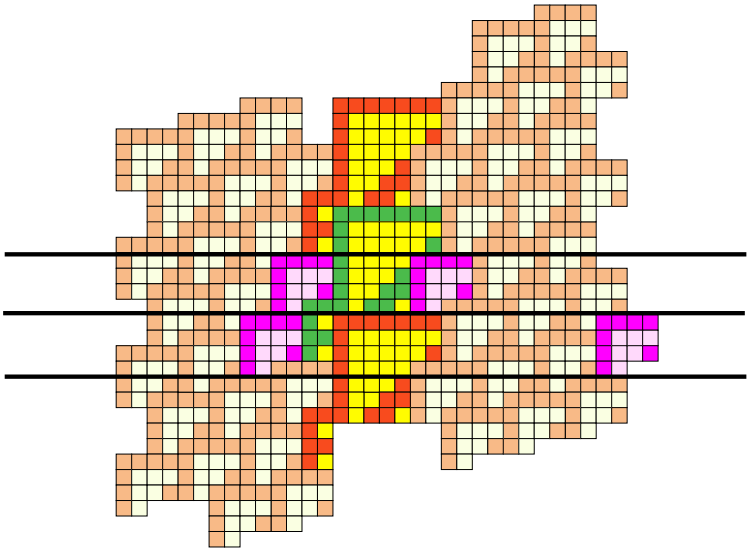


Figure 3.15: Phases of glider C1

line	cells	phase
111110000	9	1
100010001	9	2
100110011	9	3
101110110	9	4
11111011111111000100110	23	1
10001110000001001101111	23	2
10011010000011011111000	23	3
10111110000111110001001	23	4

Table 3.8: Lines to form glider C1

Four tiling to form glider C1.

no. tilings	tiling	phase
3	T1	-
1	T6	1 alpha

Table 3.9: Tilings to form glider C1

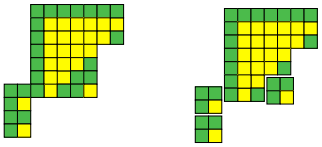


Figure 3.16: Tilings of glider C1

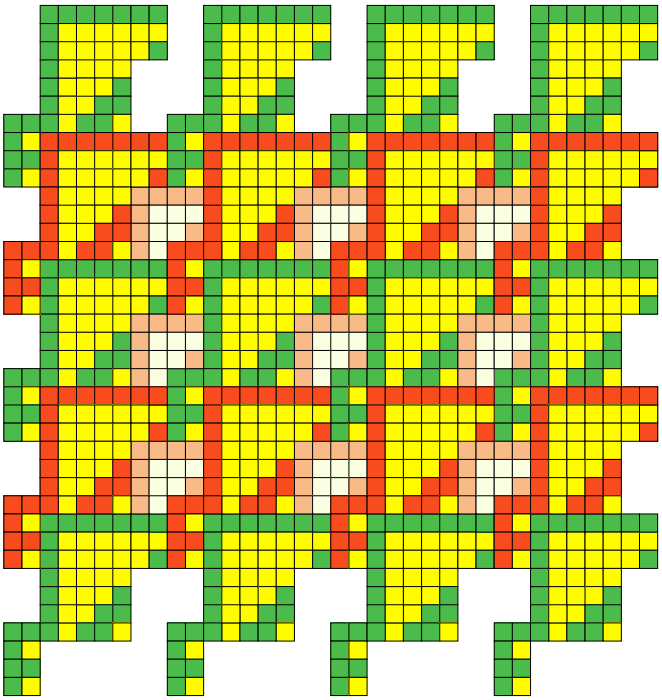


Figure 3.17: Glider C1 covering the evolution space

3.6.2 Tilings and phases of glider C2

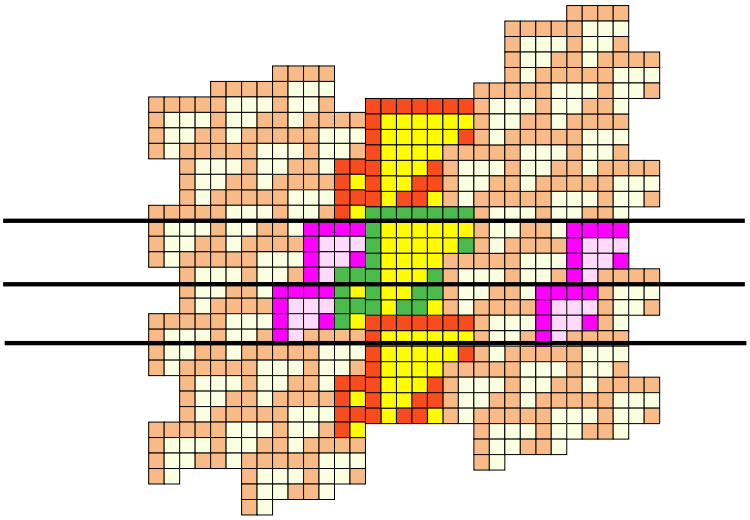


Figure 3.18: Phases of glider C2

line	cells	phase
11111000000100110	17	1
10001000001101111	17	2
10011000011111000	17	3
10111000110001001	17	4
11111010011100110	17	1
10001110110101111	17	2
10011011111111000	17	3
10111110000001001	17	4

Table 3.10: Lines to form glider C2

Four tilings to form glider C2.

no. tilings	tiling	phase
3	T1	-
1	T6	1 alpha

Table 3.11: Tilings to form glider C2

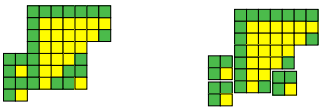


Figure 3.19: Tilings of glider C2

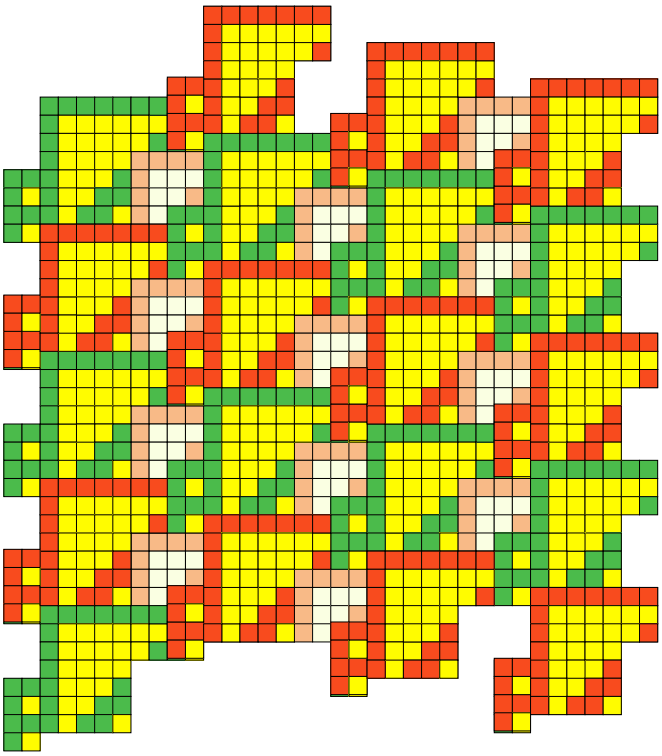


Figure 3.20: Glider C2 covering the evolution space

3.6.3 Tilings and phases of glider C3

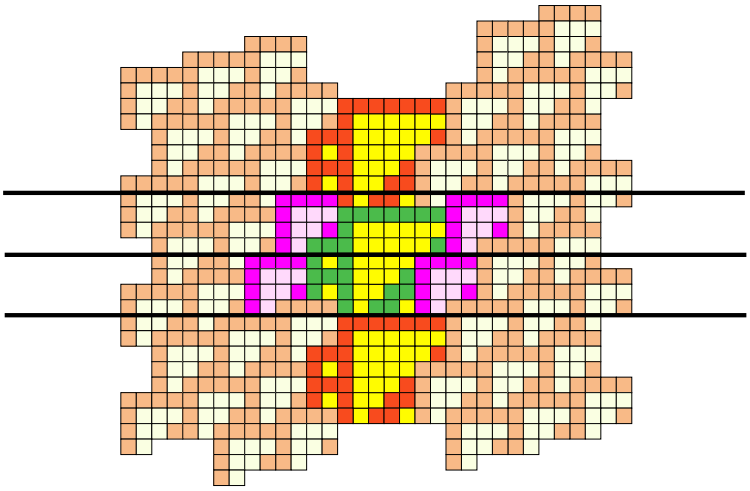


Figure 3.21: Phases of glider C3

line	cells	phase
11111011010	11	1
10001111111	11	2
10011000000	11	3
10111000001	11	4
11111010000	11	1
10001110001	11	2
10011010011	11	3
10111110110	11	4

Table 3.12: Lines to form glider C3

Four tilings to form glider C3.

no. tilings	tiling	phase
3	T1	-
1	T6	1 alpha

Table 3.13: Tilings to form glider C3

Figure 3.22: Tilings of glider C3

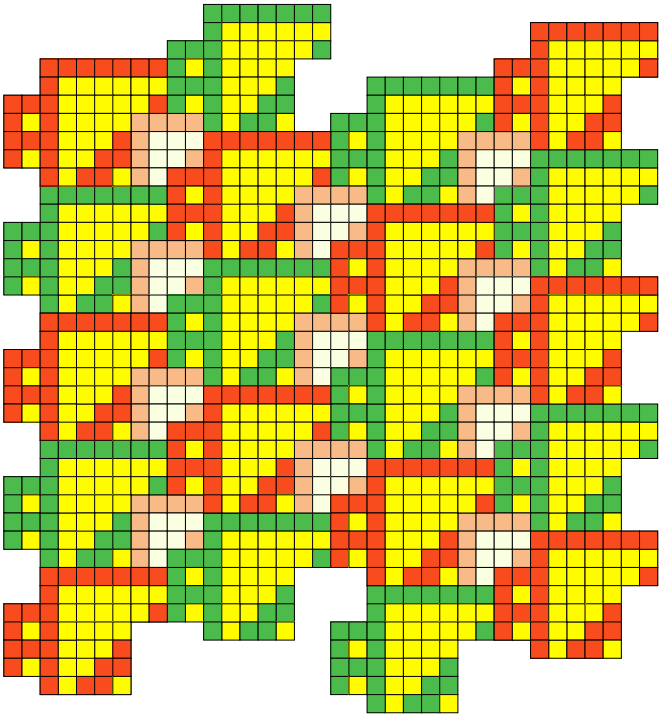


Figure 3.23: Glider C3 covering the evolution space

3.7 Gliders D

3.7.1 Tilings and phases of glider D1

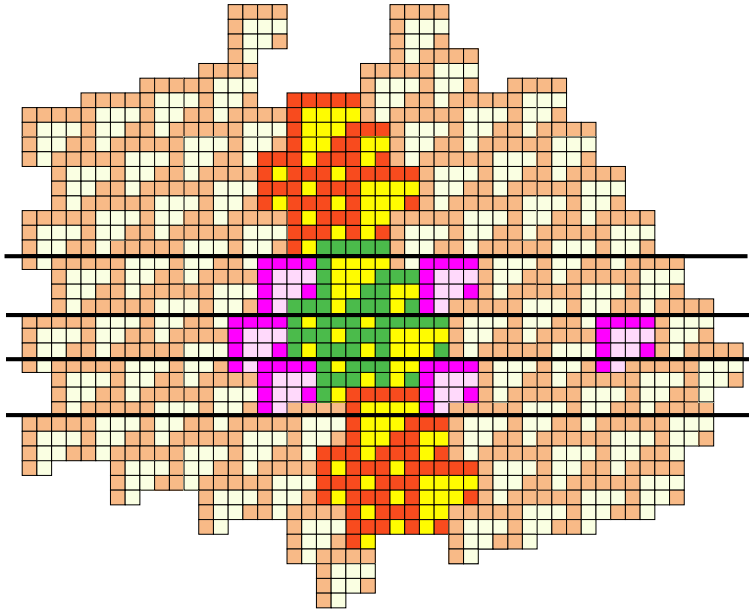


Figure 3.24: Phases of glider D1

line	cells	phase
11111000010	11	1
10001000111	11	2
10011001100	11	3
10111011101	11	4
111110111011111000100110	25	1
100011101110000100110111	25	2
100110111010001101111000	25	3
101111101110011111000100	25	4
11111011100	11	1
10001110101	11	2
10011011111	11	3
10111110000	11	4

Table 3.14: Lines to form glider D1

Eleven tilings to form glider D1.

no. tilings	tiling	phase
8	T1	-
1	T2	1 beta
2	T4	1 alpha, 1 beta

Table 3.15: Tilings to form glider D1

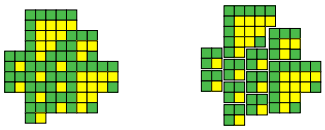


Figure 3.25: Tiles of glider D1

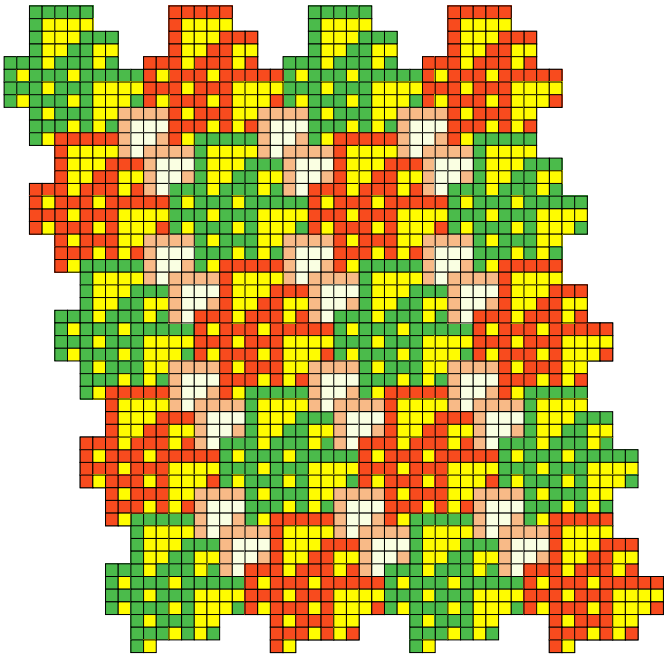


Figure 3.26: Glider D1 covering the evolution space, first case

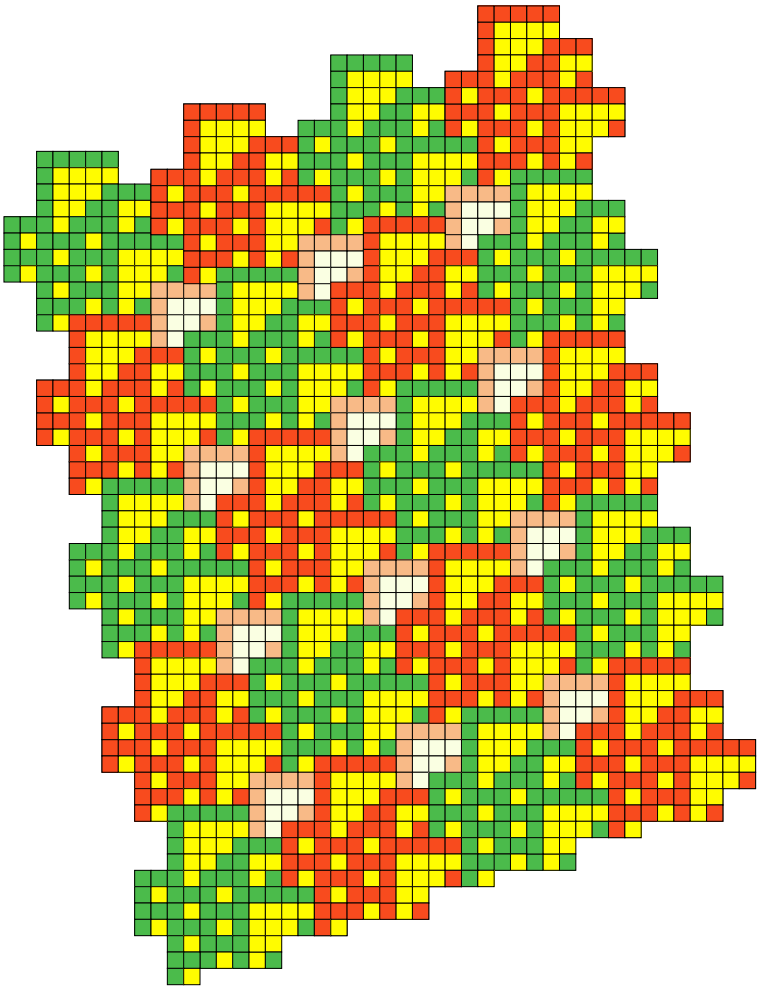


Figure 3.27: Glider D1 covering the evolution space, second case

3.7.2 Tilings and phases of glider D2

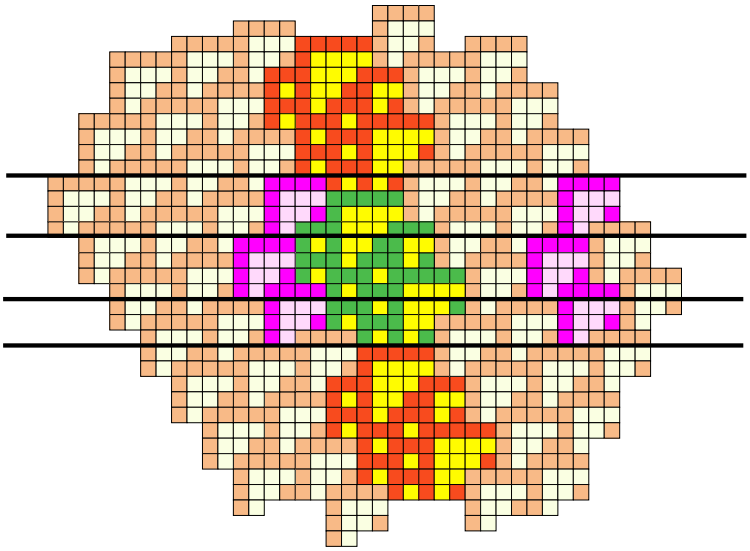


Figure 3.28: Phases of glider D2

line	cells	phase
1111101011000100110	19	1
1000111111001101111	19	2
1001100001011111000	19	3
1011100011110001001	19	4
1111101001100100110	19	1
1000111011101101111	19	2
1001101110111111000	19	3
1011111011100001001	19	4
1111101110000100110	19	1
1000111010001101111	19	2
1001101110011111000	19	3
1011111010110001001	19	4

Table 3.16: Lines to form glider D2

Ten tilings to form glider D2.

no. tilings	tiling	phase
7	T1	-
1	T2	1 beta
2	T4	1 alpha, 1 beta

Table 3.17: Tilings to form glider D2

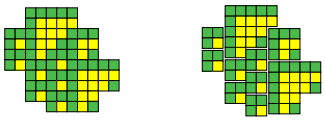


Figure 3.29: Tilings of glider D2

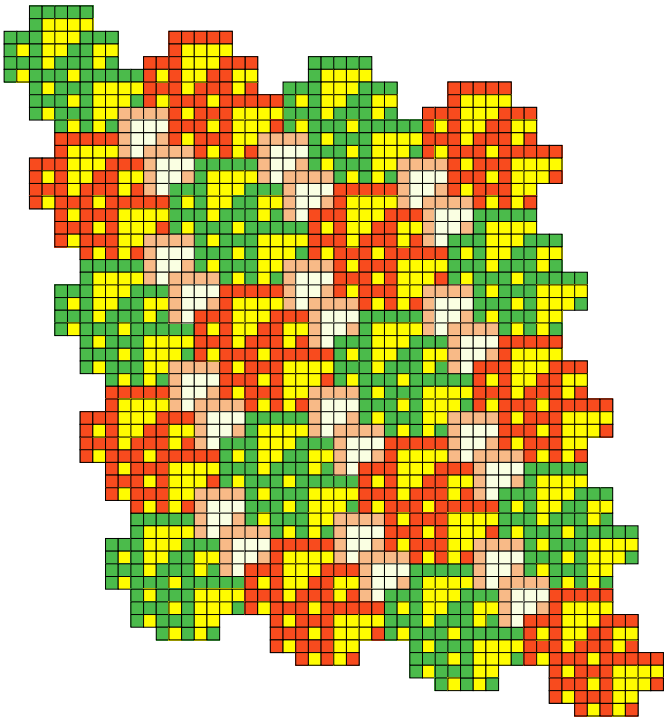


Figure 3.30: Glider D2 covering the evolution space, first case

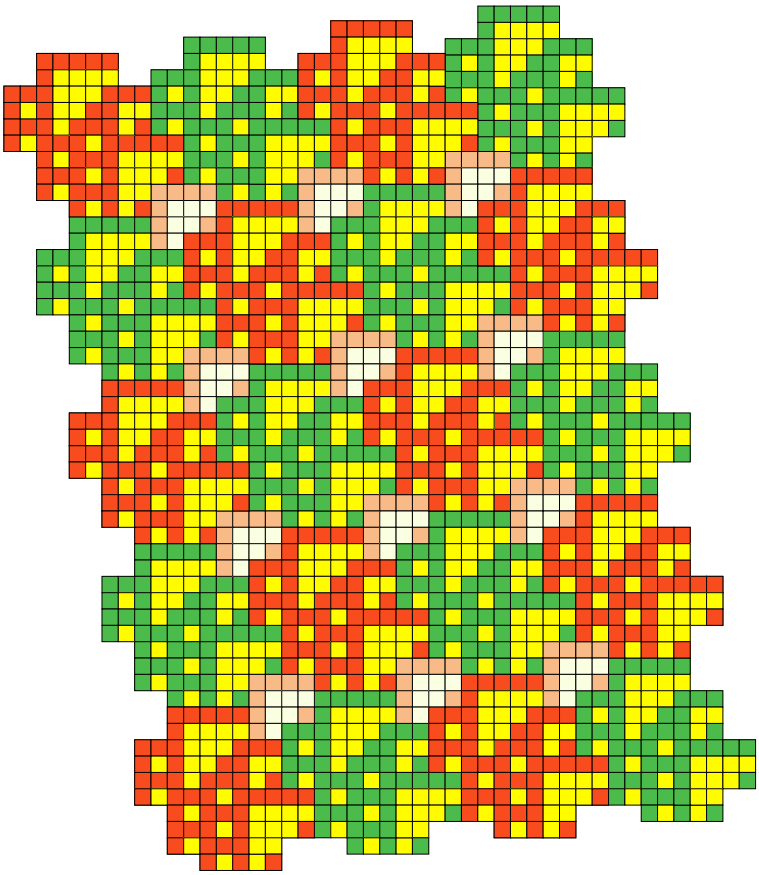


Figure 3.31: Glider D2 covering the evolution space, second case

3.8 Tilings and phases of glider E

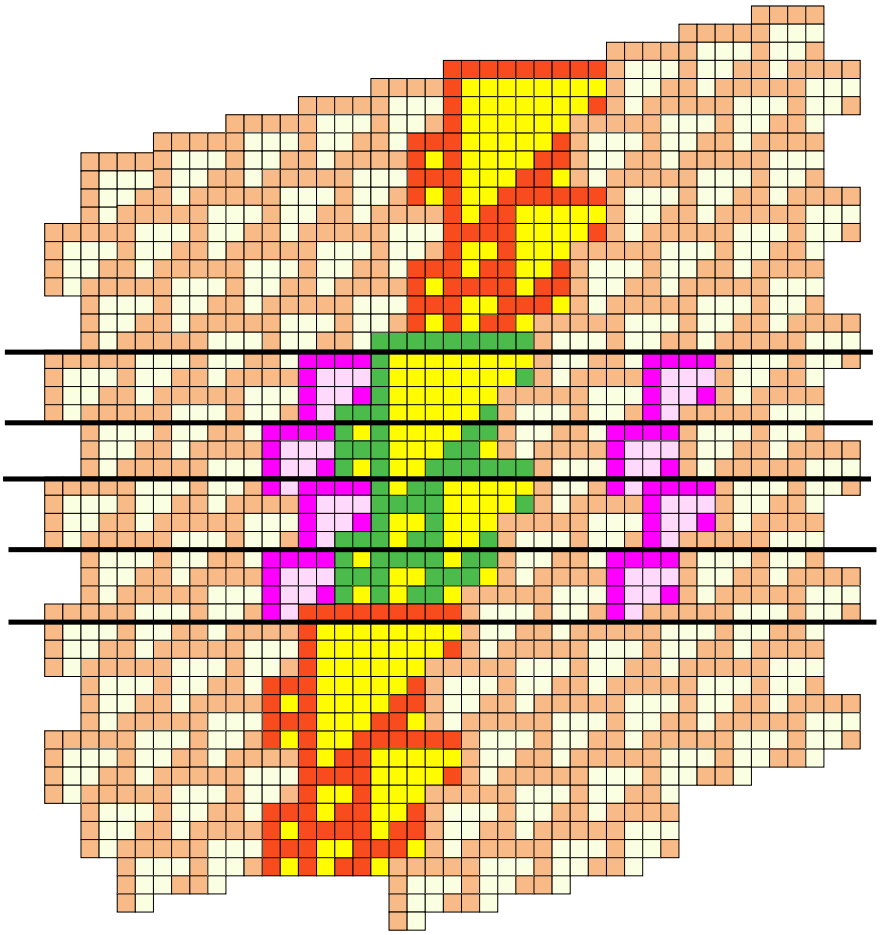


Figure 3.32: Phases of glider E

line	cells	phase
1111100000000100110	19	1
1000100000001101111	19	2
1001100000011111000	19	3
1011100000110001001	19	4
1111101000011100110	19	1
1000111000110101111	19	2
1001101001111111000	19	3
1011111011000001001	19	4
1111101100000100110	19	1
1000111100001101111	19	2
1001100100011111000	19	3
1011101100110001001	19	4
11111011111011100110	19	1
10001110011101101111	19	2
10011010111011111000	19	3
10111111111110001001	19	4

Table 3.18: Lines to form glider E

Eleven tilings to form glider E.

no. tilings	tiling	phase
7	T1	-
2	T2	2 beta
1	T5	1 beta
1	T8	1 alpha

Table 3.19: Tilings to form glider E

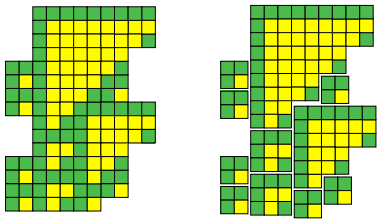


Figure 3.33: Tilings of glider E

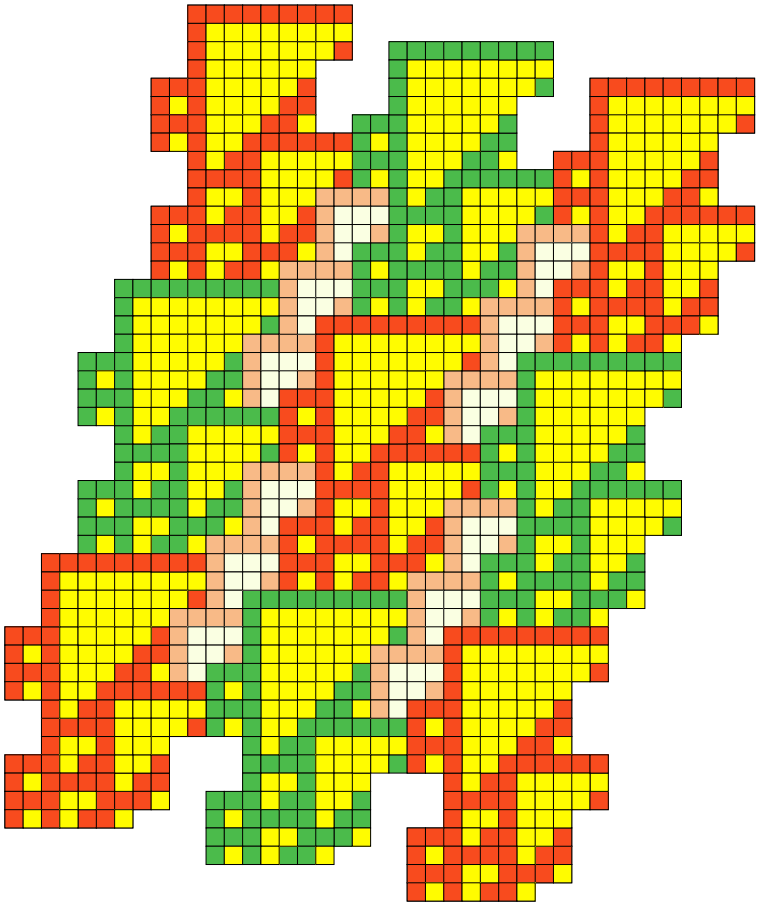


Figure 3.34: Glider E covering the evolution space

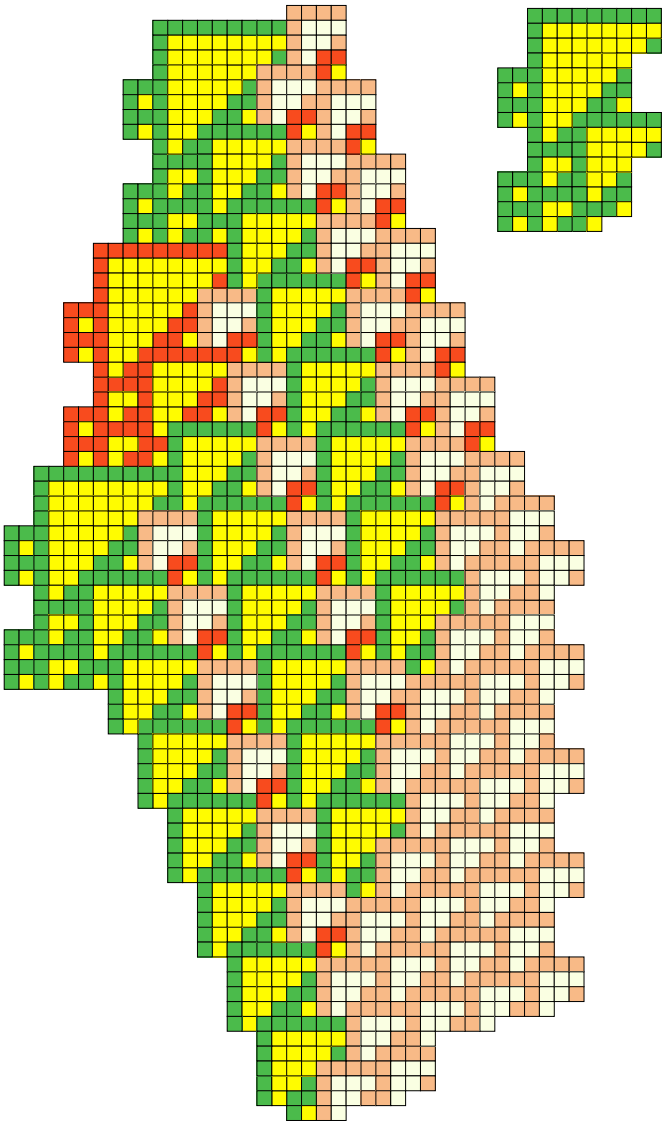


Figure 3.35: Extendible T5 by an T1 in glider E

3.9 Tilings and phases of glider Ebar

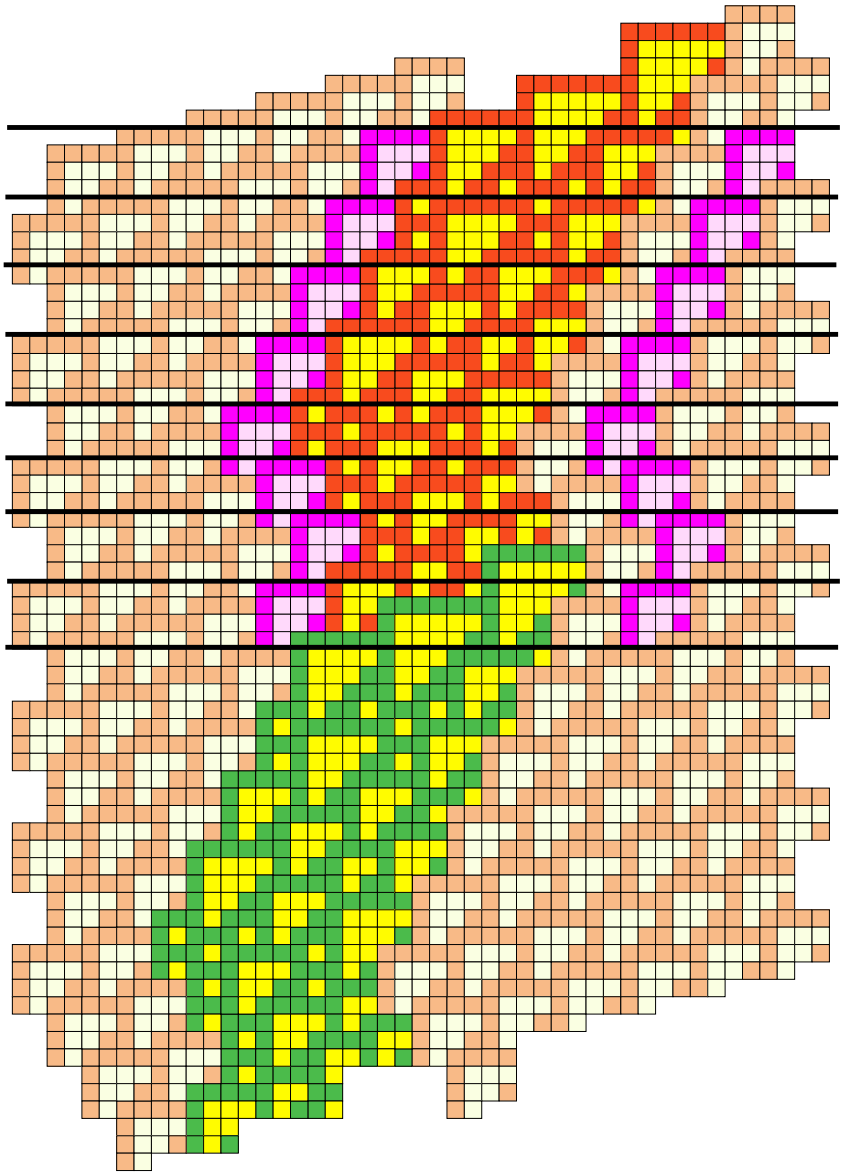


Figure 3.36: Phases of glider Ebar

line	cells	phase
111110000100011111010	21	1
100010001100110001111	21	2
100110011101110011000	21	3
101110110111010111001	21	4
111110111111011111010	21	1
100011100001110001111	21	2
100110100011010011000	21	3
101111100111110111001	21	4
111110001011000111010	21	1
100010011111001101111	21	2
100110110001011111000	21	3
101111110011110001001	21	4
111110000101100100110	21	1
100010001111101101111	21	2
100110011000111111000	21	3
101110111001100001001	21	4
111110111010111000110	21	1
100011101111101001111	21	2
100110111000111011000	21	3
101111101001101111001	21	4
111110100110111100110	21	1
100011101111100101111	21	2
100110111000101111000	21	3
101111101001111001001	21	4
111110100111100100110	21	1
100011101100101101111	21	2
100110111101111111000	21	3
101111100111000001001	21	4
111110001011010000110	21	1
100010011111110001111	21	2
100110110000010011000	21	3
101111110000110111001	21	4

Table 3.20: Lines to form glider Ebar

Fourty one tilings to form glider Ebar.

no. tilings	tiling	phase
21	T1	-
5	T2	2 alpha, 3 beta
10	T3	4 alpha, 6 beta
4	T4	3 alpha, 1 beta
2	T5	2 beta

Table 3.21: Tilings to form glider Ebar

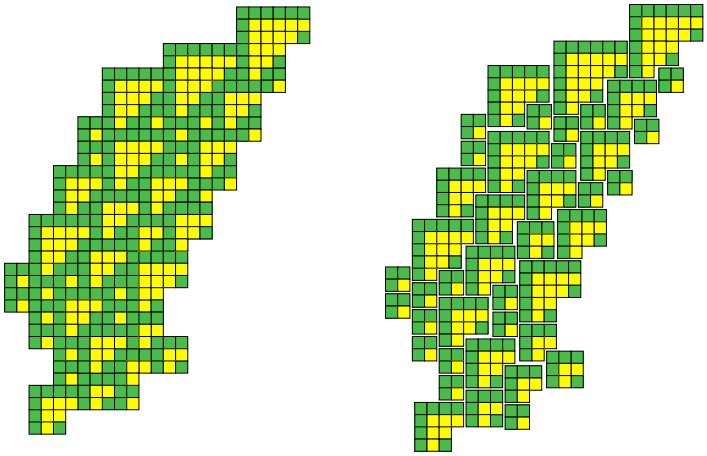


Figure 3.37: Tilings of glider Ebar

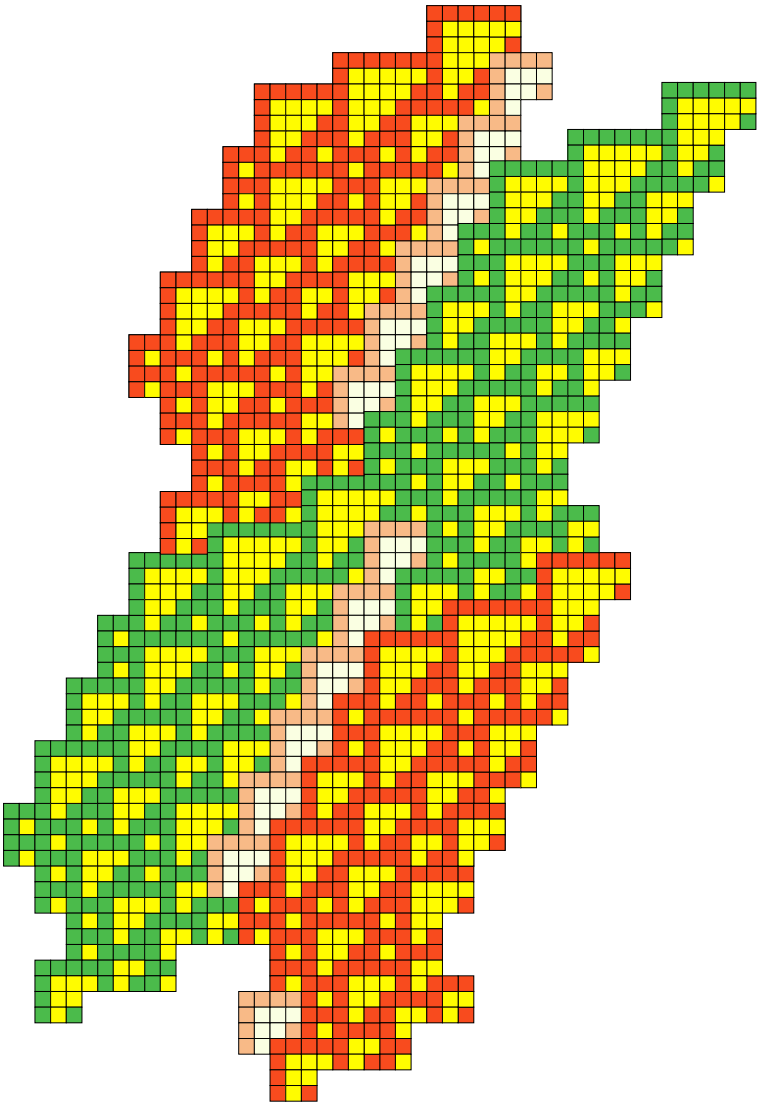


Figure 3.38: Glider Ebar covering the evolution space

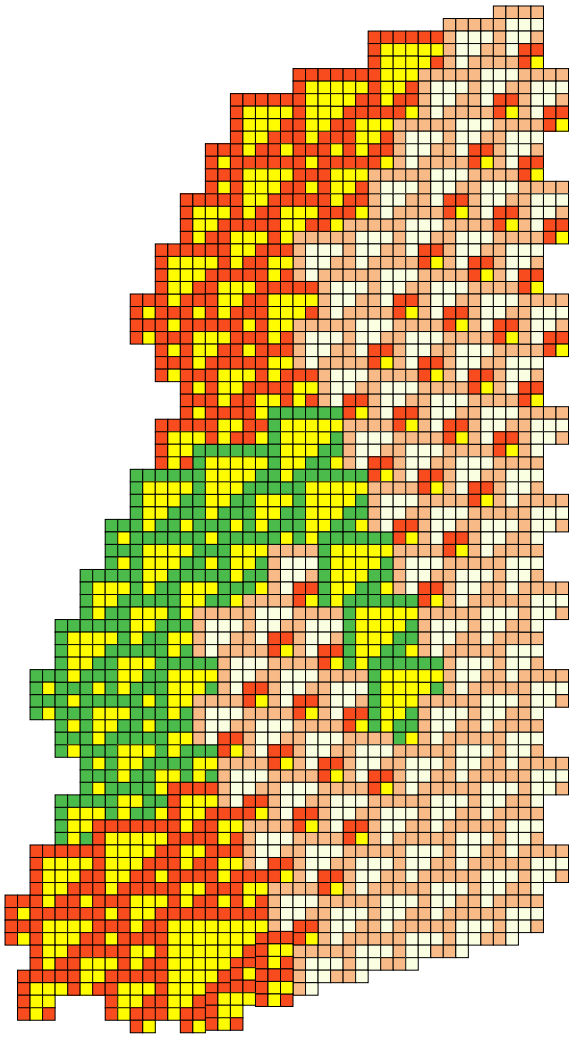


Figure 3.39: Extendible T5 by an T1 in glider Ebar

3.10 Tilings and phases of glider F

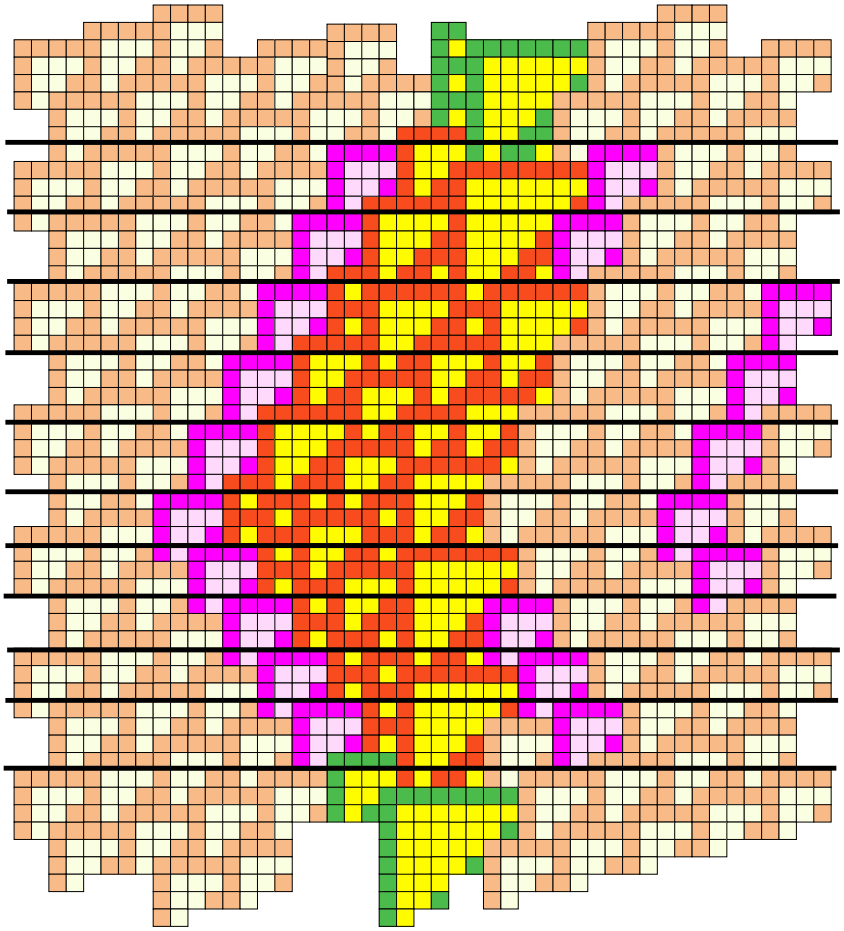


Figure 3.40: Phases of glider F

line	cells	phase
111110001011010	15	1
100010011111111	15	2
100110110000000	15	3
101111110000001	15	4
111110000100000	15	1
100010001100001	15	2
100110011100011	15	3
101110110100110	15	4
11111011111101111111000100110	29	1
10001110000111000001001101111	29	2
10011010001101000011011111000	29	3
10111110011111000111110001001	29	4
11111000101100010011000100110	29	1
10001001111100110111001101111	29	2
10011011000101111101011111000	29	3
10111111001111000111110001001	29	4
11111000010110010011000100110	29	1
10001000111110110111001101111	29	2
10011001100011111101011111000	29	3
10111011100110000111110001001	29	4
11111011101011100011000100110	29	1
10001110111110100111001101111	29	2
10011011100011101101011111000	29	3
10111110100110111111110001001	29	4
11111010011011111111000100110	29	1
10001110111110000001001101111	29	2
10011011100010000011011111000	29	3
10111110100110000111110001001	29	4
111110100110000	15	1
100011101110001	15	2
100110111010011	15	3
101111101110110	15	4
111110111011010	15	1
100011101111111	15	2
100110111000000	15	3
101111101000001	15	4
111110100000110	15	1
100011100001111	15	2
100110100011000	15	3
101111100111001	15	4

Table 3.22: Lines to form glider F

Fourty three tiles to form glider F.

no. tilings	tiling	phase
26	T1	-
1	T2	1 beta
8	T3	3 alpha, 5 beta
4	T4	3 alpha, 1 beta
1	T5	1 beta
2	T6	2 alpha
1	T7	1 beta

Table 3.23: Tilings to form glider F

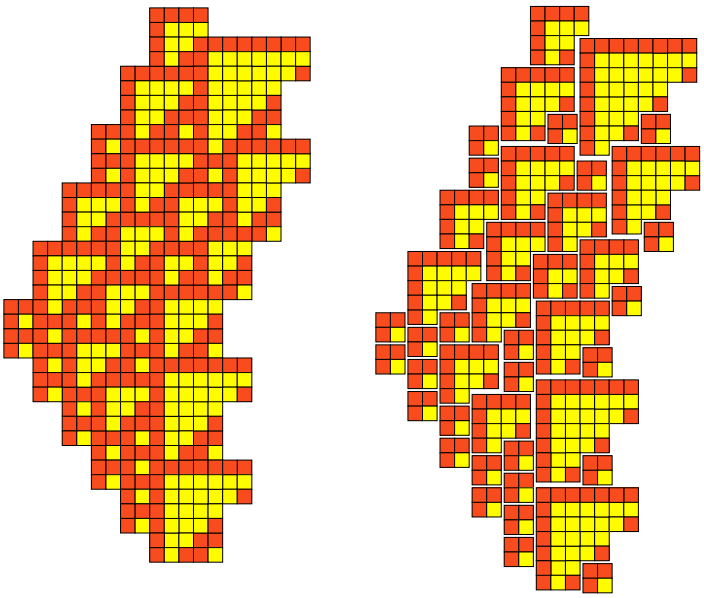


Figure 3.41: Tilings of glider F

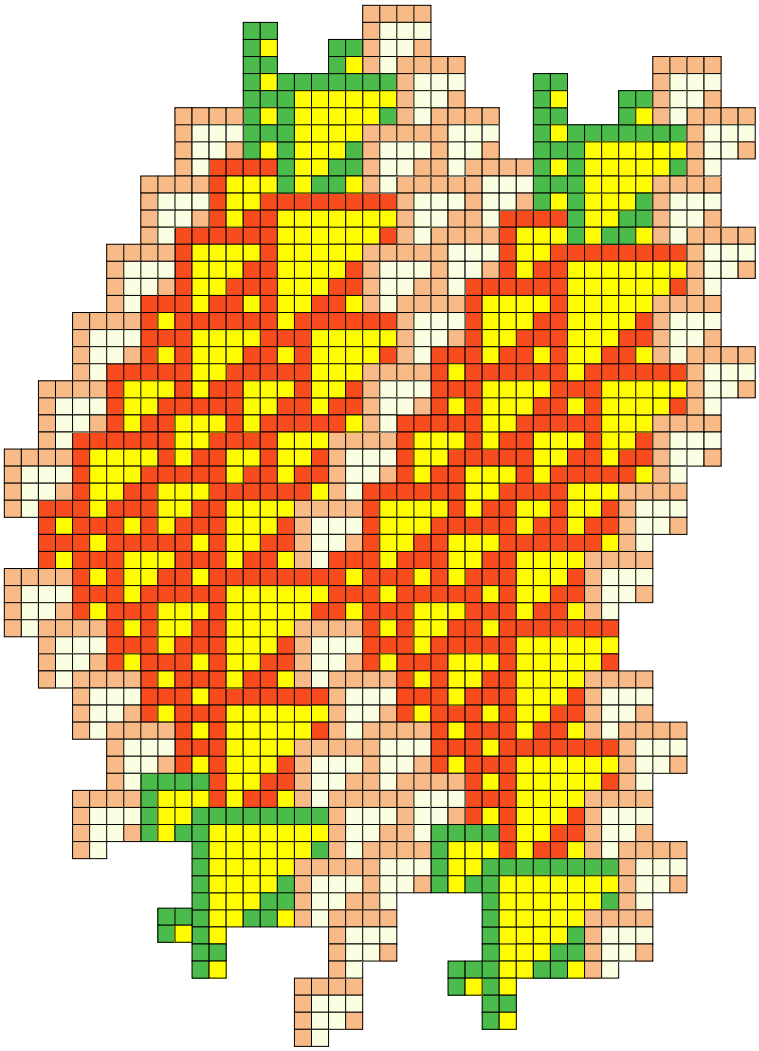


Figure 3.42: Glider F covering the evolution space

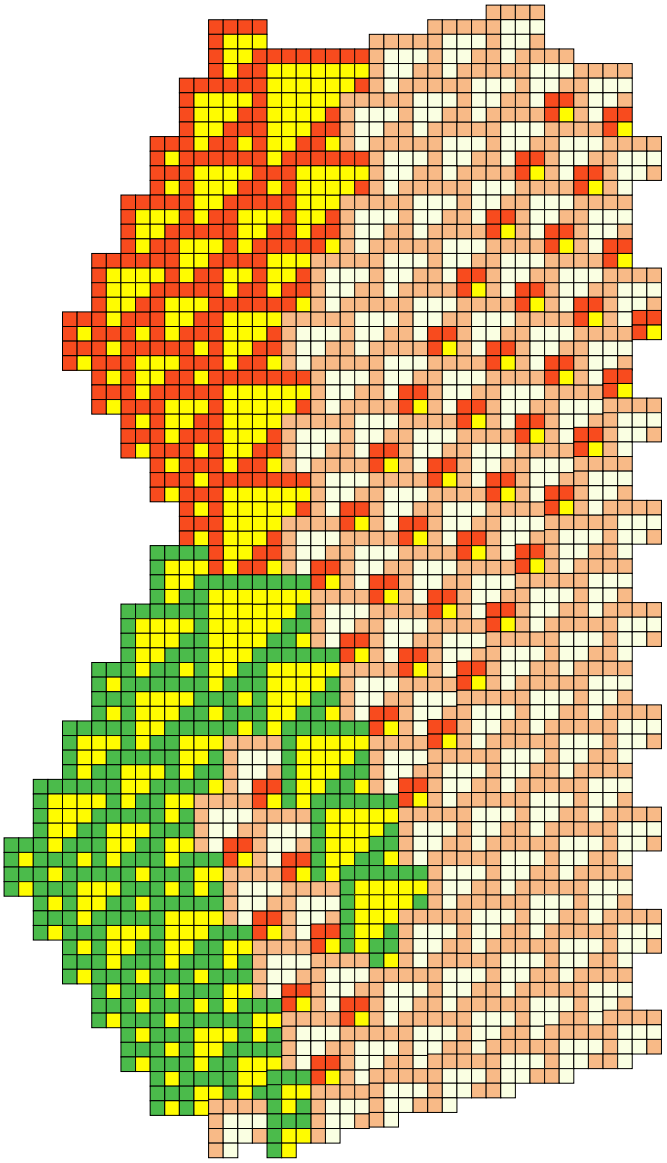


Figure 3.43: Extendible T5 by an T1 in glider F

3.11 Tilings and phases of glider G

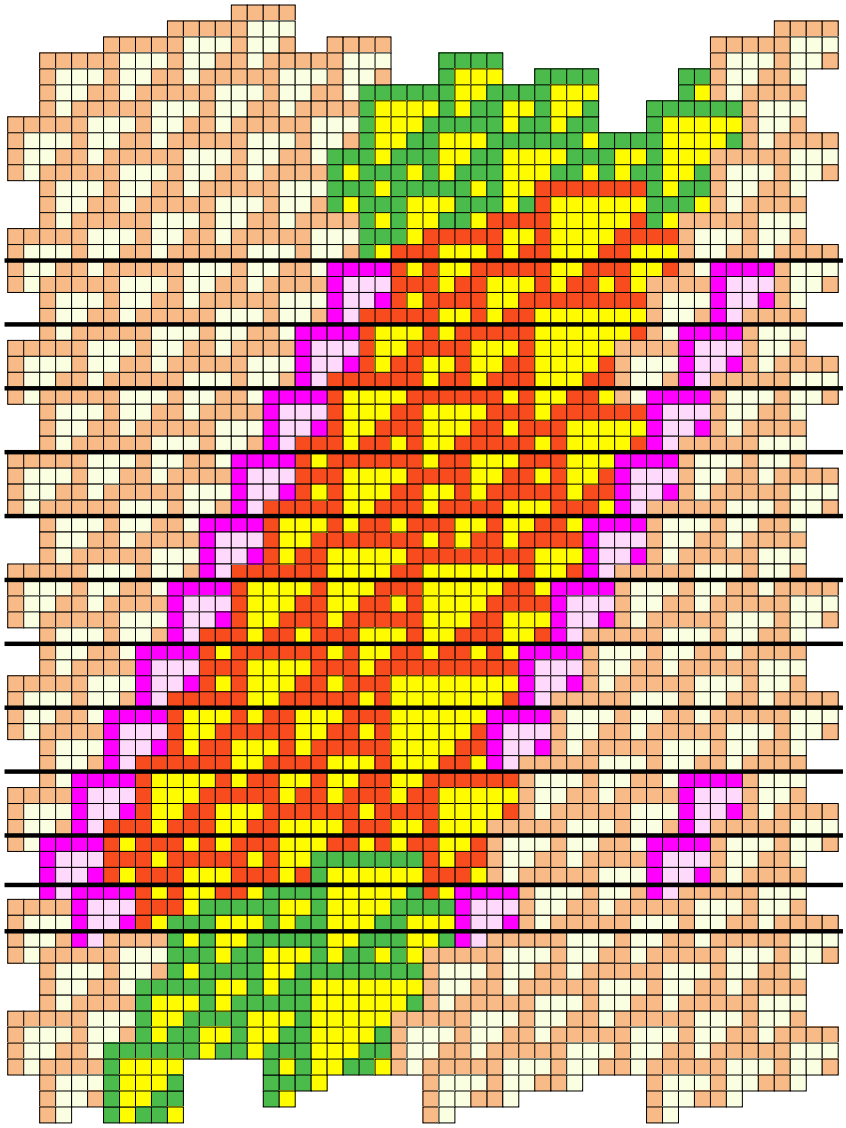


Figure 3.44: Phases of glider G

line	cells	phase
111110100111110011100110	24	1
100011101100010110101111	24	2
100110111100111111111000	24	3
101111100101100000001001	24	4
111110001011111000000110	24	1
100010011110001000001111	24	2
100110110010011000011000	24	3
101111110110111000111001	24	4
111110000111111010011010	24	1
100010001100001110111111	24	2
100110011100011011100000	24	3
101110110100111110100001	24	4
111110111111011000111000	24	1
100011100001111001101001	24	2
100110100011001011111011	24	3
101111100111011110001110	24	4
111110001011011100100110	24	1
100010011111110101101111	24	2
100110110000011111111000	24	3
101111110000110000001001	24	4
111110000100011100000110	24	1
100010001100110100001111	24	2
100110011101111100011000	24	3
101110110111000100111001	24	4
111110111111010011011010	24	1
100011100001110111111111	24	2
100110100011011100000000	24	3
101111100111110100000001	24	4
111110001011000111000000	24	1
100010011111001101000001	24	2
100110110001011111000011	24	3
101111110011110001000110	24	4
111110000101100100110011111111000100110	38	1
100010001111110111011011000001001101111	38	2
100110011000111111011110000110111111000	38	3
101110111001100001110010001111110001001	38	4
111110111010111000110101100110001001100110	38	1
100011101111101001111111101110011011111	38	2
100110111000111011000000111010111111000	38	3
101111101001101111000001101111110001001	38	4
111110100110111100000110	24	1
100011101111100100001111	24	2
100110111000101100011000	24	3
101111101001111100111001	24	4

Table 3.24: Lines to form glider G

Seventy four tilings to form glider G.

no. tilings	tiling	phase
37	T1	-
7	T2	2 alpha, 5 beta
17	T3	6 alpha, 11 beta
6	T4	5 alpha, 1 beta
3	T5	3 beta
2	T6	2 alpha
1	T7	1 beta
1	T8	1 alpha

Table 3.25: Tilings to form glider G

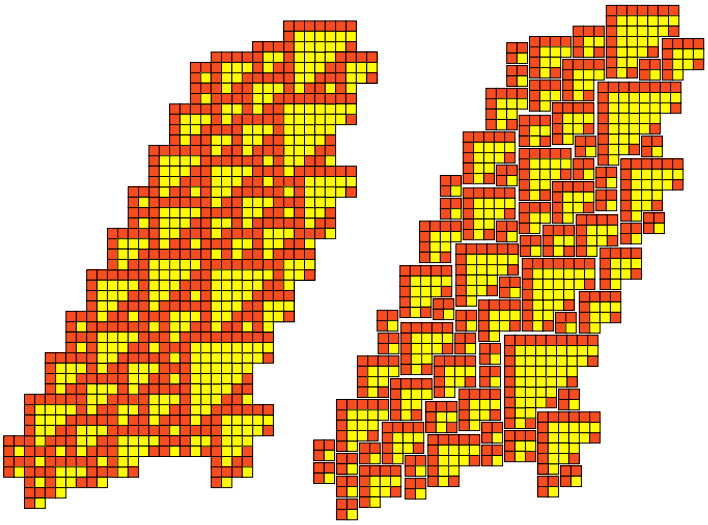


Figure 3.45: Tilings of glider G

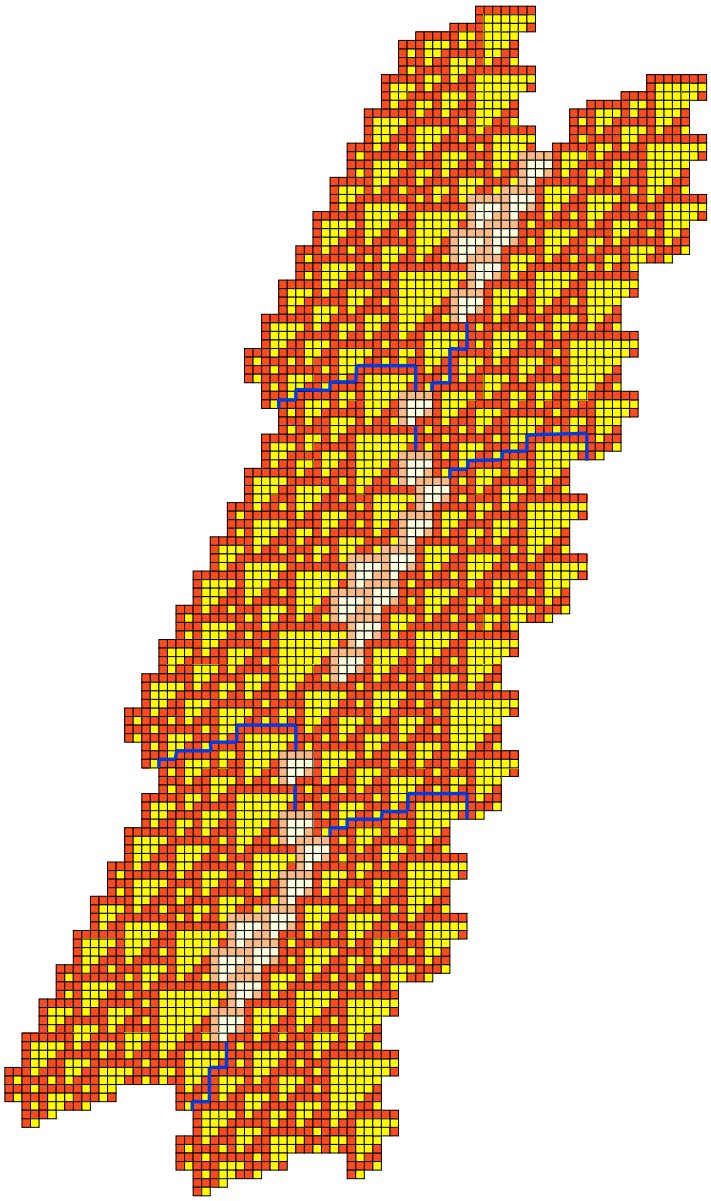


Figure 3.46: Glider G covering the evolution space, first case

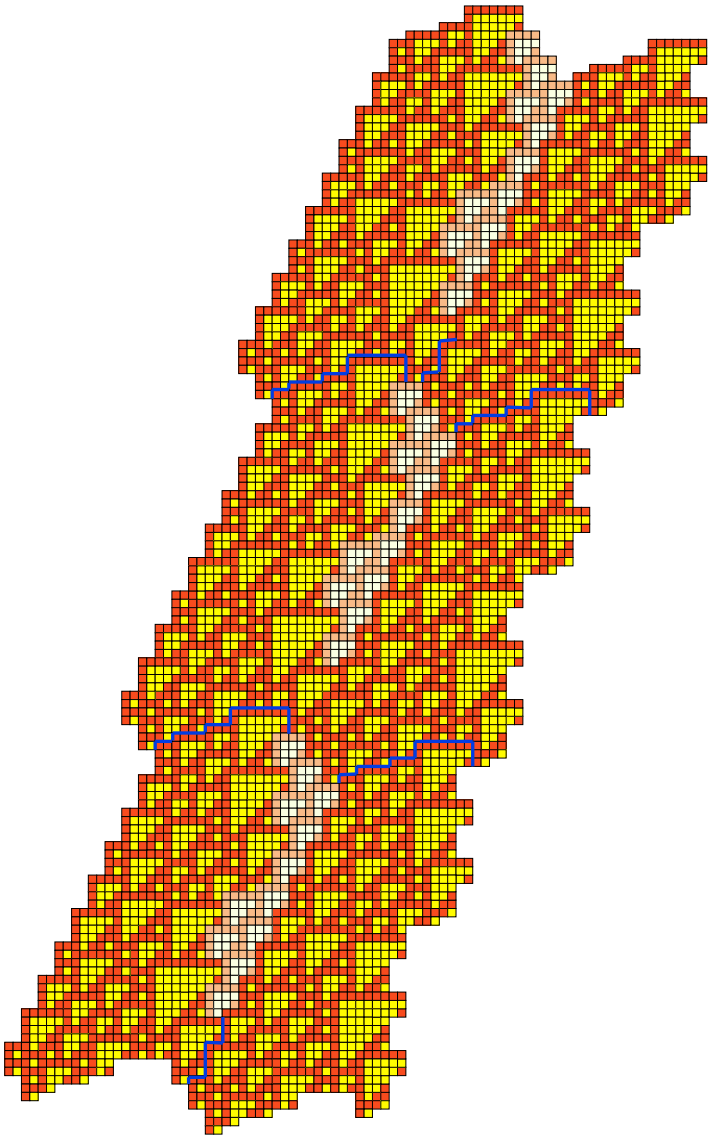


Figure 3.47: Glider G covering the evolution space, second case

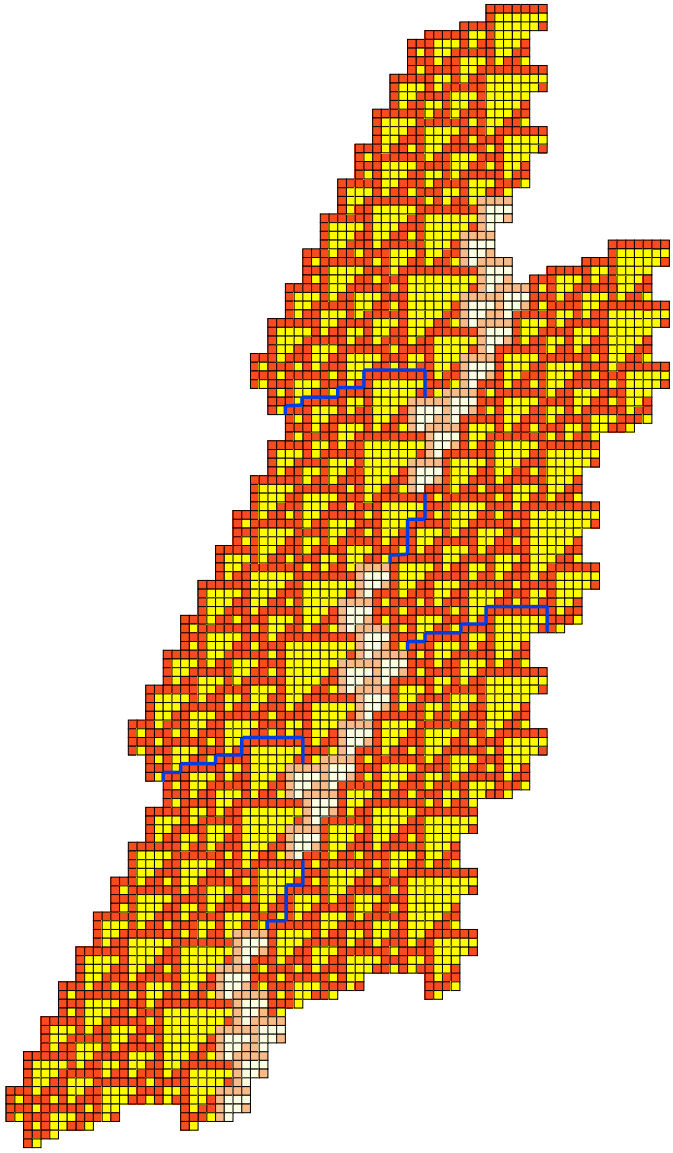


Figure 3.48: Glider G covering the evolution space, third case

3.12 Tilings and phases of glider H

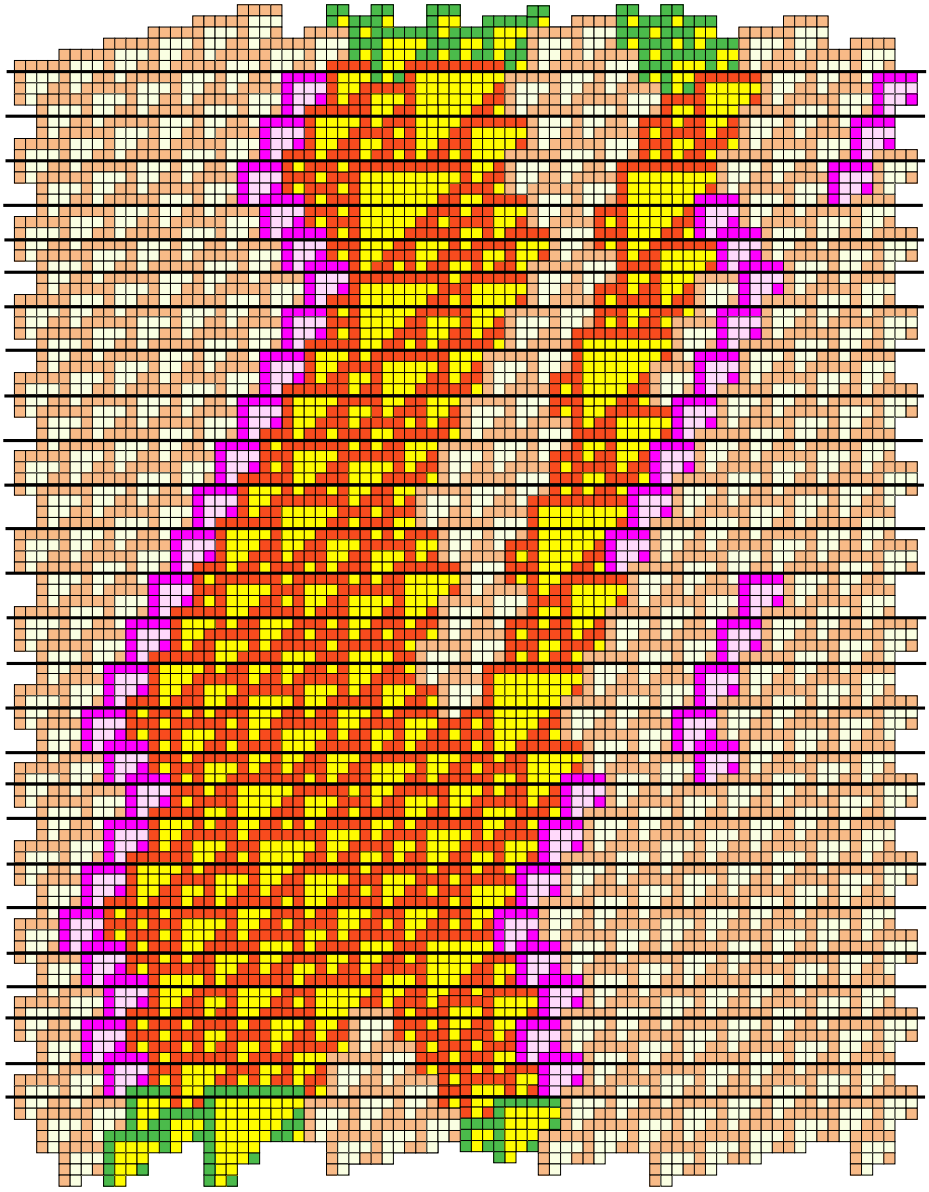


Figure 3.49: Phases of glider H

line	cells	phase
1111100010110000000001111100010011010011111111000100110	53	1
1000100111110000000011000100110111111011000001001101111	53	2
1001101100010000000111001101111100011110000110111110 00	53	3
1011111110011000000110101111100010011001000111110001001	53	4
1111100001011100001111111000100110111011001100010011 0	53	1
1000100011110100011000001001101111101111011100110111 1	53	2
1001100110011100111000011011111000111001110101111100 0	53	3
1011101110110101101000111110001001101011011111000100 1	53	4
1111101110111111111111001100010011011111111110001001 10	53	1
1000111011100000000001011100110111110000000001001101111	53	2
1001101110100000000011110101111100010000000011011111000	53	3
1011111011100000000110011111000100110000000111110001001	53	4
111110111000000001100111110001001100000 0	39	1
100011101000000011101100010011011100000 1	39	2
100110111000000110111100110111110100001 1	39	3
101111101000011111001011111000111000110	39	4
111110100001111100101111100011100011010	39	1
100011100011000101111000100110100111111	39	2
100110100111001111001001101111101100000	39	3
101111101101011001011011111000111100001	39	4
111110110101100101101111100011110000110	39	1
100011111111101111111000100110010001111	39	2
100110000000111000001001101110110011000	39	3
101110000000110100001101111101111011100 1	39	4
111110100000111110001111100011100111010	39	1
100011100000110001001100010011010110111 1	39	2
100110100011100110111001101111111111000	39	3
101111100110101111101011111000000001001	39	4
111110001011111110001111100010000000110	39	1
100010011110000001001100010011000000111 1	39	2
100110110010000110111001101110000011000	39	3
101111111011000111110101111101000011100 1	39	4
1111101001101111000111110110111110100111111110001001 10	53	1
1000111011111001001100011111100011101100000010011011 11	53	2
1001101110001011011100110000100110111100000110111110 00	53	3
1011111010011111110101110001101111100100011111000100 1	53	4
111110100111111101011100011011111001000	39	1
100011101100000011111010011111000101100 1	39	2
100110111100001100011101100010011111011	39	3
101111100100011100110111100110110001110	39	4
111110001011001101011111001011111100110	39	1
100010011111011111110001011110000101111	39	2
100110110001110000010011110010001111000	39	3
101111111001101000011011001011001100100 1	39	4
111110000101111100011111101111110111011 0	39	1
100010001111000100110000111000111011111	39	2
100110011001001101110001101001101110000	39	3
101110111011011111010011111011111101000 1	39	4
111110111011111110001110110001110001110 0	39	1
100011101110000100110111100110100110101	39	2
100110111010001101111100101111101111111	39	3
101111101110011111000101111000111000000	39	4
111110111001111100010111110001110000001 0	39	1
100011101011000100111100100110100000111	39	2
100110111111001101100101101111100001100	39	3
101111100001011111101111111000100011101	39	4
111110000101111110111111100010001110110	39	1
100010001111000011100000100110011011111	39	2
100110011001000110100001101110111110000	39	3
101110111011001111100011111011100010001	39	4
111110111011110110001001100011101001100	39	1
100011101110011110011011100110111011101	39	2
100110111010110010111110101111101110111	39	3
101111101111110111100011111000111011100	39	4
111110111111011110001111100011101110010	39	1
100011100000111001001100010011011101011 1	39	2
100110100011010110111001101111101111100	39	3
101111100111111111101011111000111000101	39	4

Table 3.26: Lines to form glider H

224 tilings to form glider H.

no. tilings	tiling	phase
136	T1	-
39	T2	10 alpha, 29 beta
46	T3	15 alpha, 31 beta
21	T4	14 alpha, 7 beta
13	T5	13 beta
1	T6	1 beta
1	T7	1 beta
5	T8	5 alpha
1	T9	1 alpha

Table 3.27: Tilings to form glider H

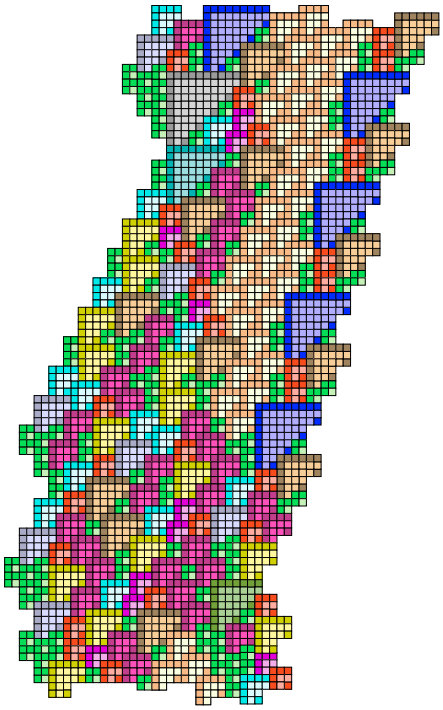


Figure 3.50: Tilings of glider H

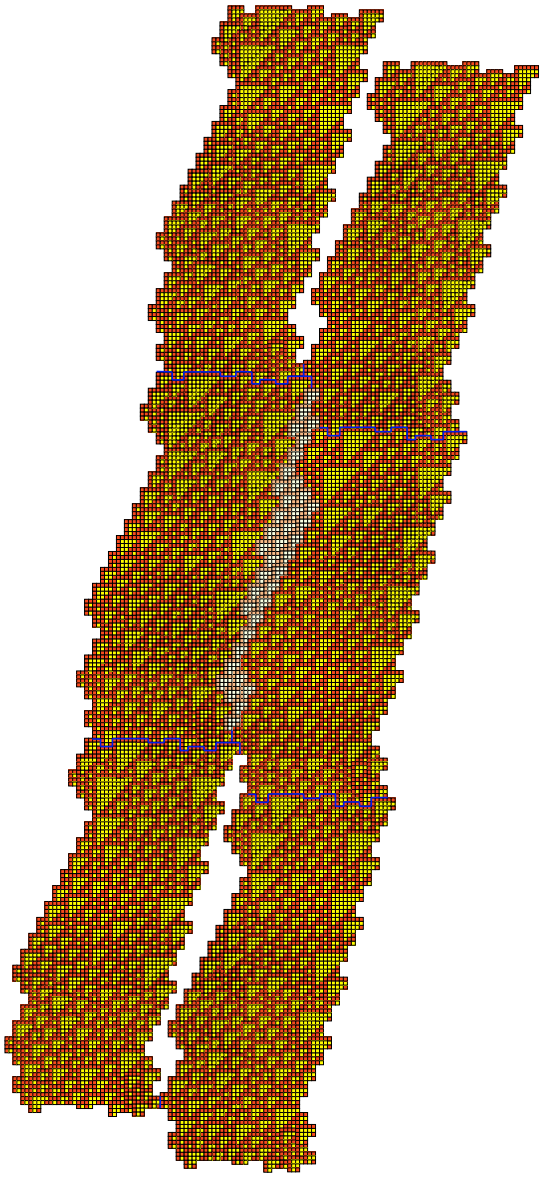


Figure 3.51: Glider H covering the evolution space

3.13 Glider gun

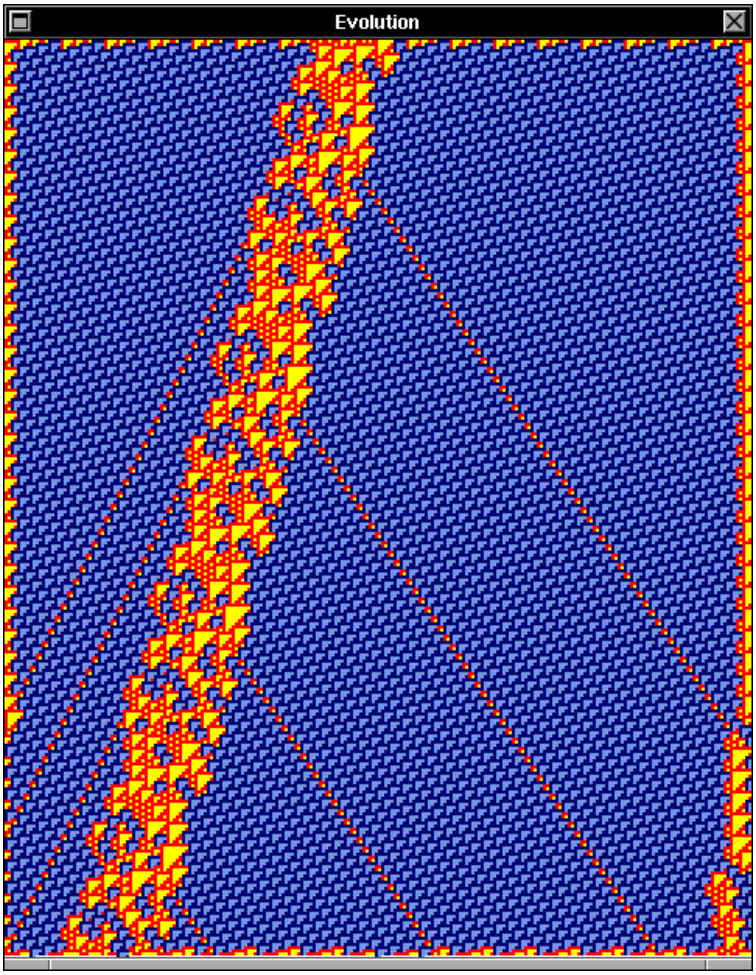


Figure 3.52: Glider gun

Chapter 4

Collisions of gliders

4.1 Contact points in gliders

4.1.1 Glider A

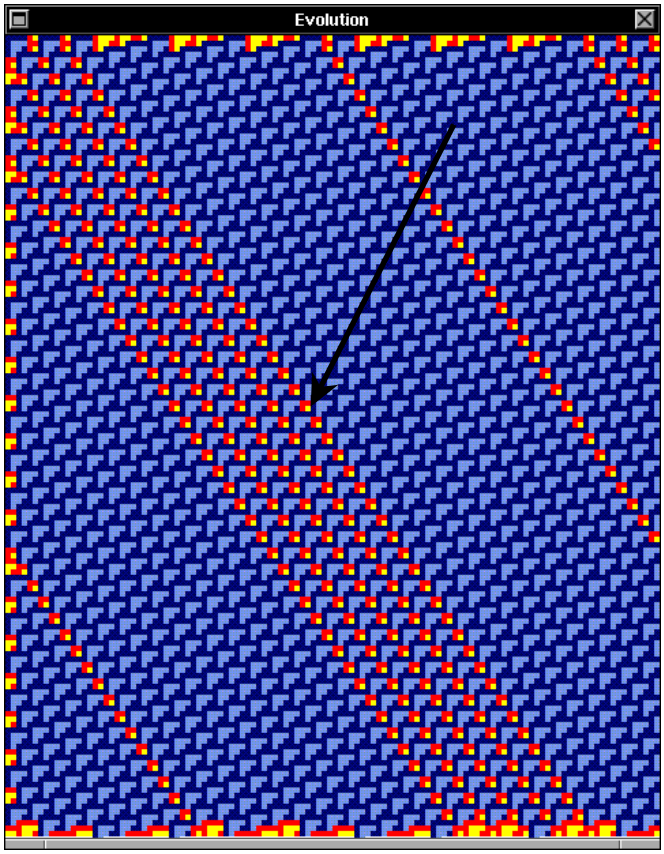


Figure 4.1: Contact points in glider A

4.1.2 Glider B

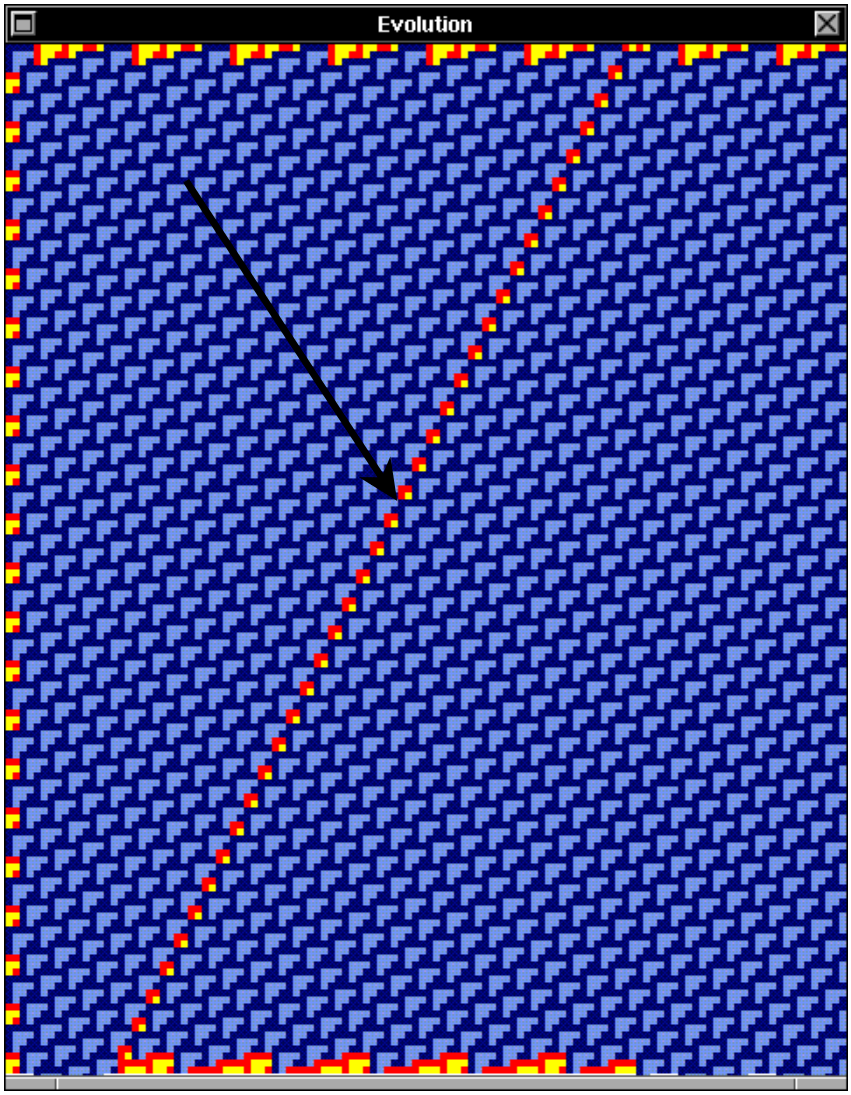


Figure 4.2: Contact points in glider B

4.1.3 Glider Bbar

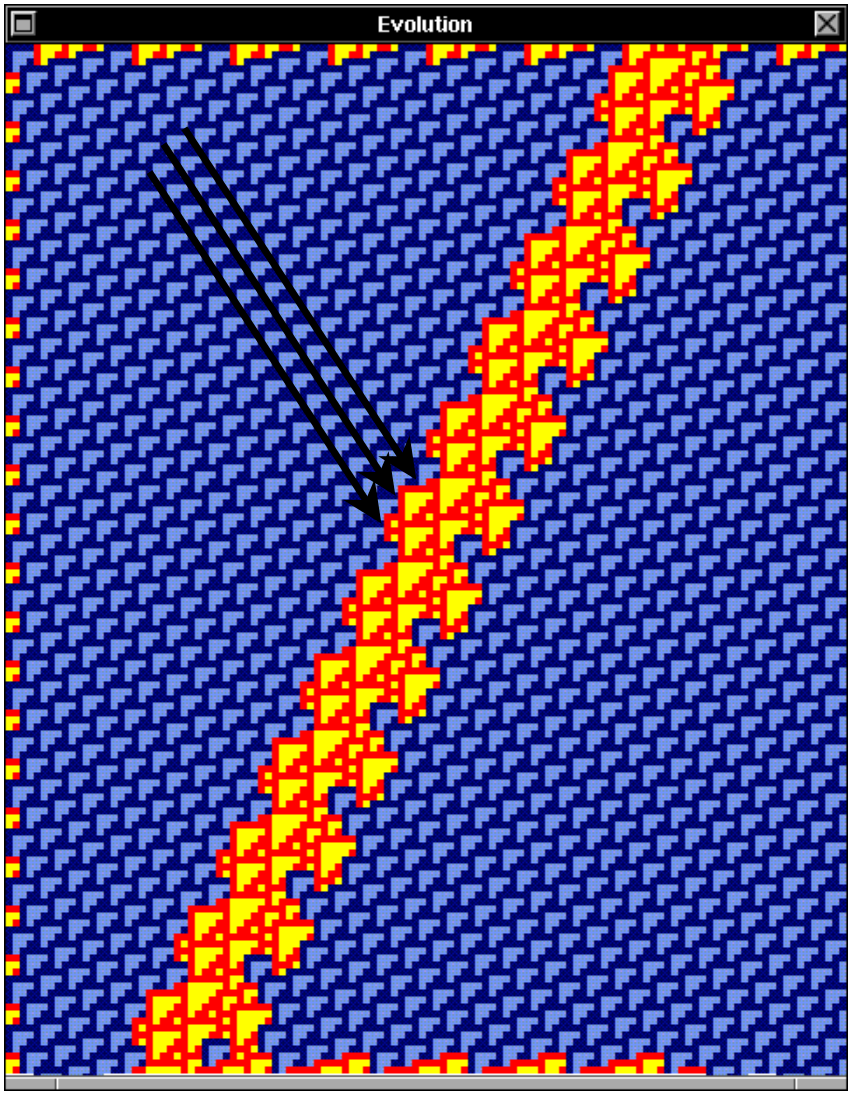


Figure 4.3: Contact points in glider Bbar

4.1.4 Glider Bbar8

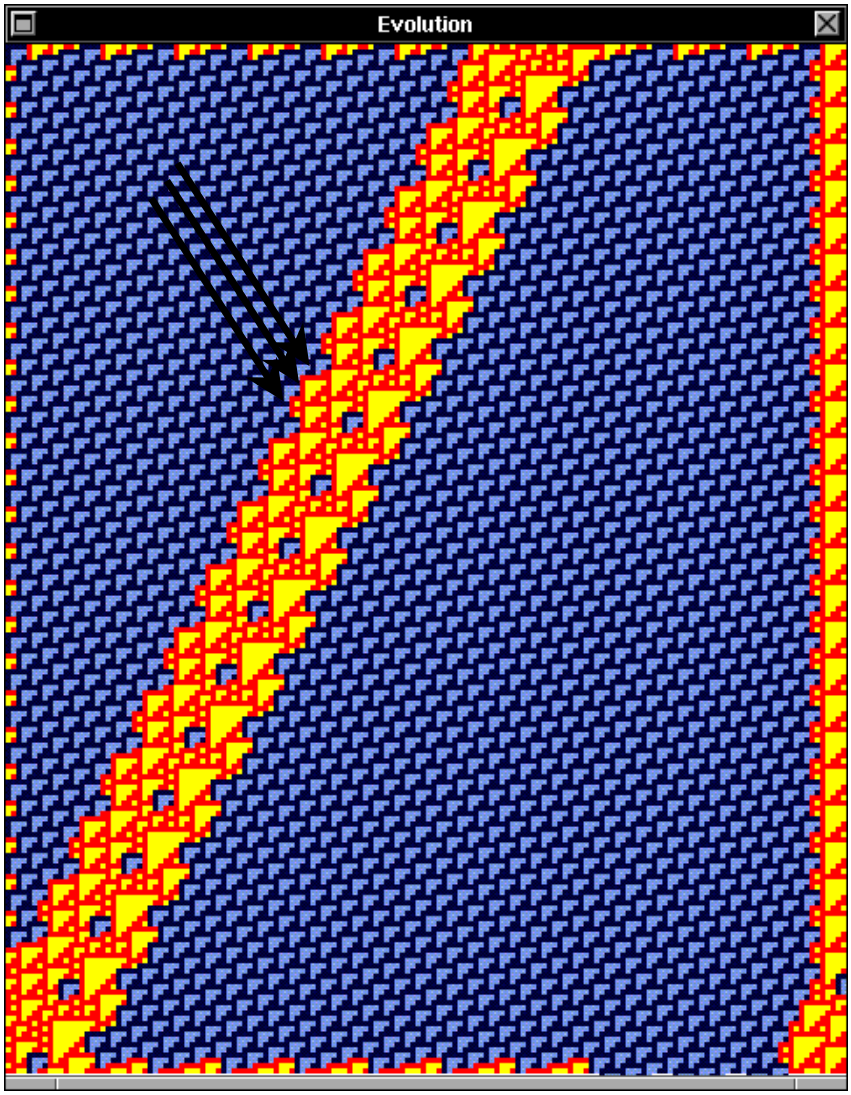


Figure 4.4: Contact points in glider Bbar8

4.1.5 Glider C1

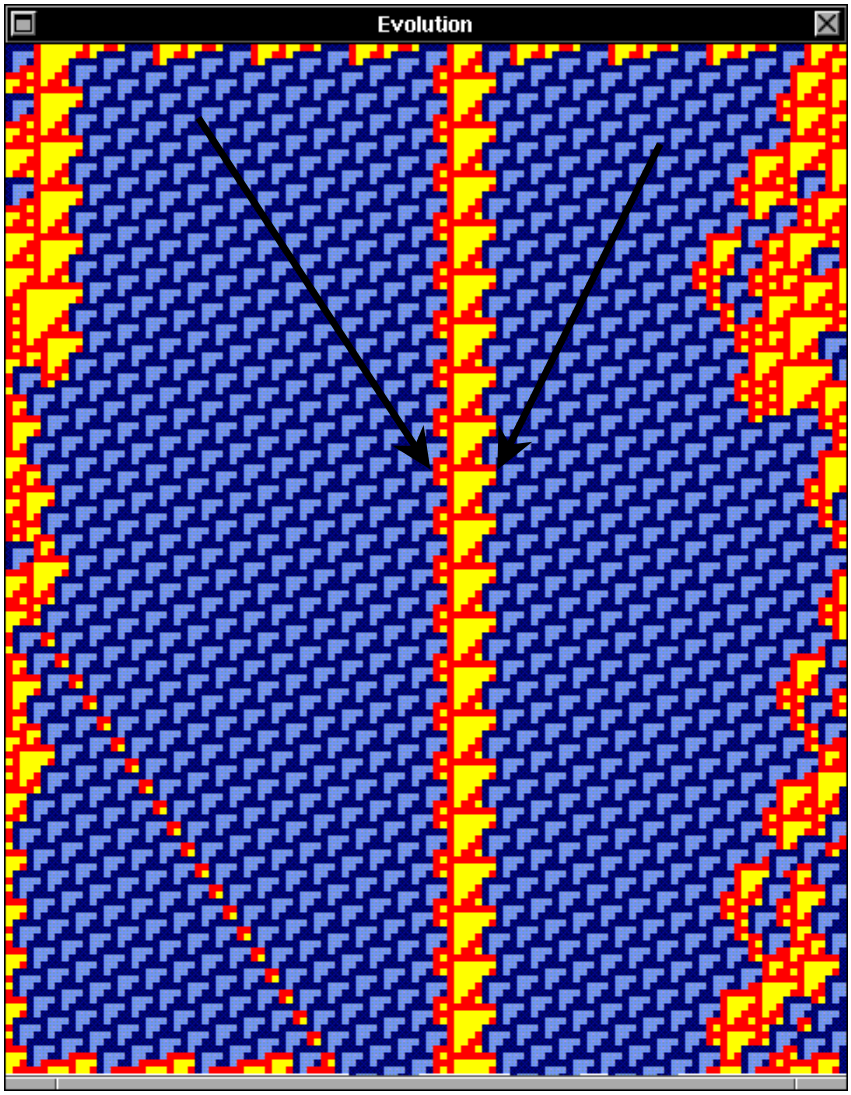


Figure 4.5: Contact points in glider C1

4.1.6 Glider C2

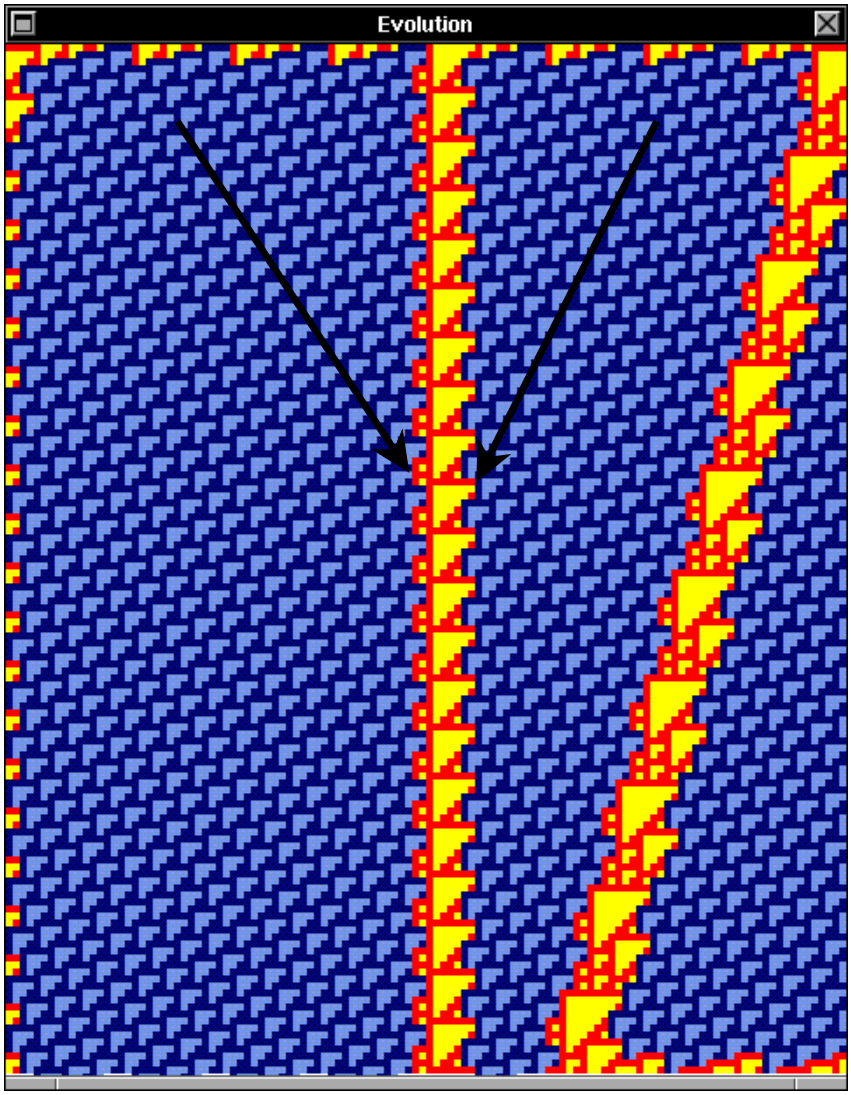


Figure 4.6: Contact points in glider C2

4.1.7 Glider C3

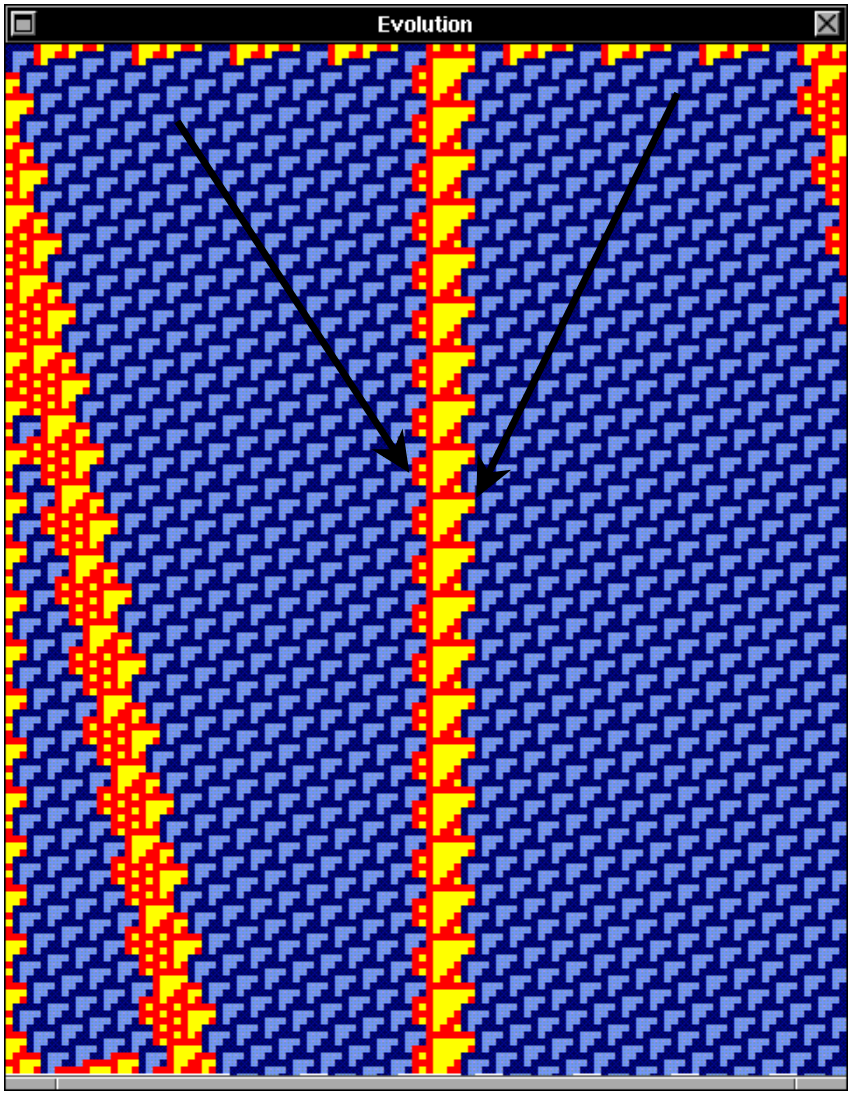


Figure 4.7: Contact points in glider C3

4.1.8 Glider D1

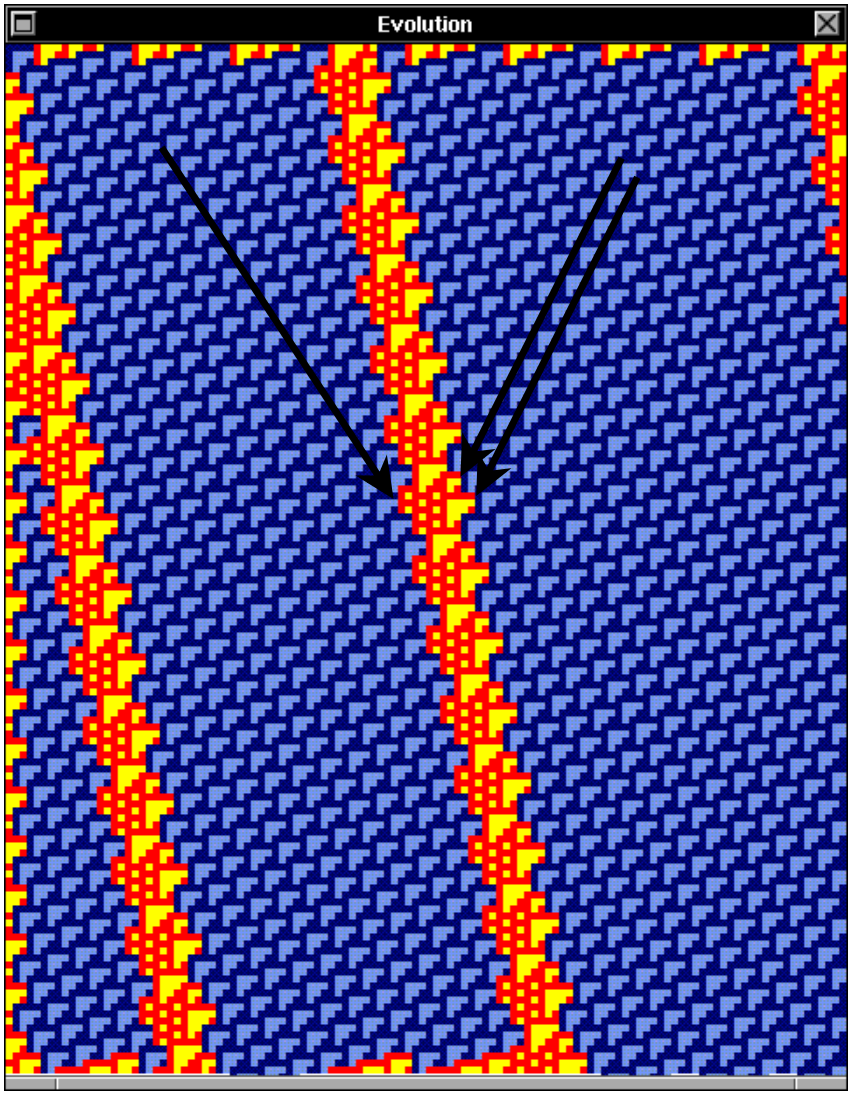


Figure 4.8: Contact points in glider D1

4.1.9 Glider D2

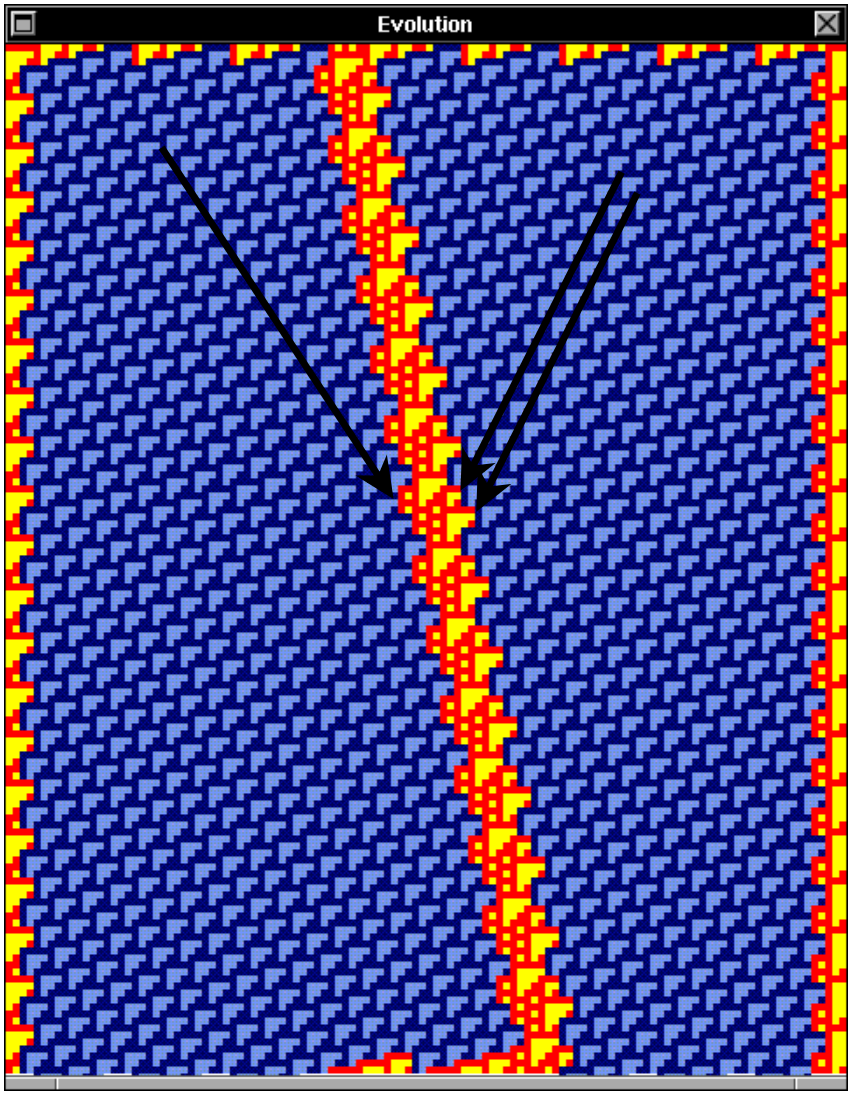


Figure 4.9: Contact points in glider D2

4.1.10 Glider E

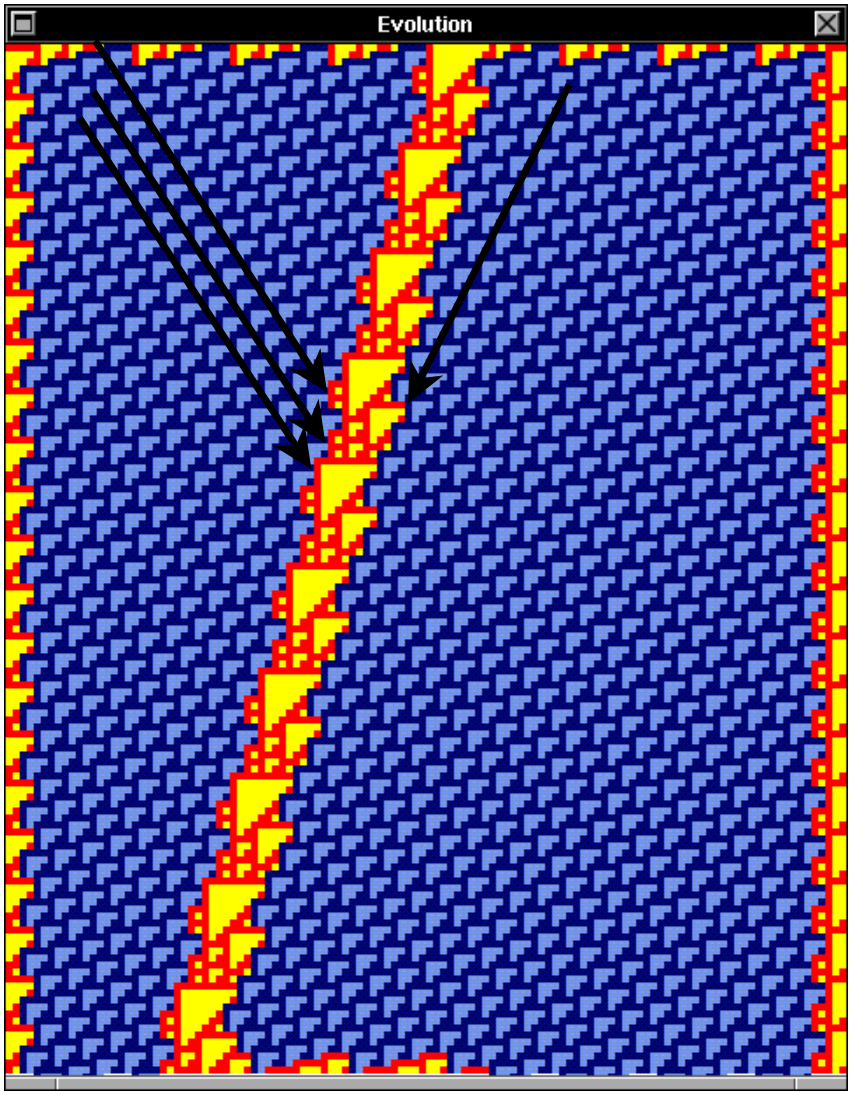


Figure 4.10: Contact points in glider E

4.1.11 Glider Ebar

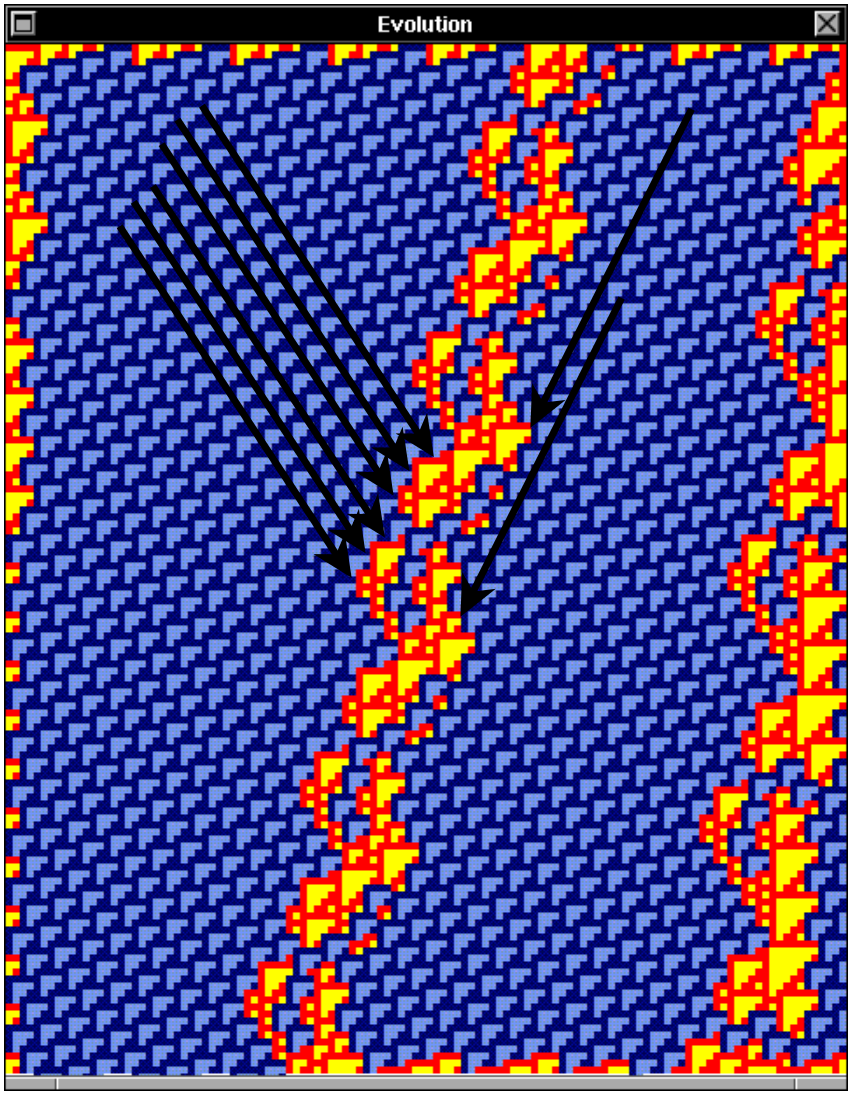


Figure 4.11: Contact points in Ebar

4.1.12 Glider F

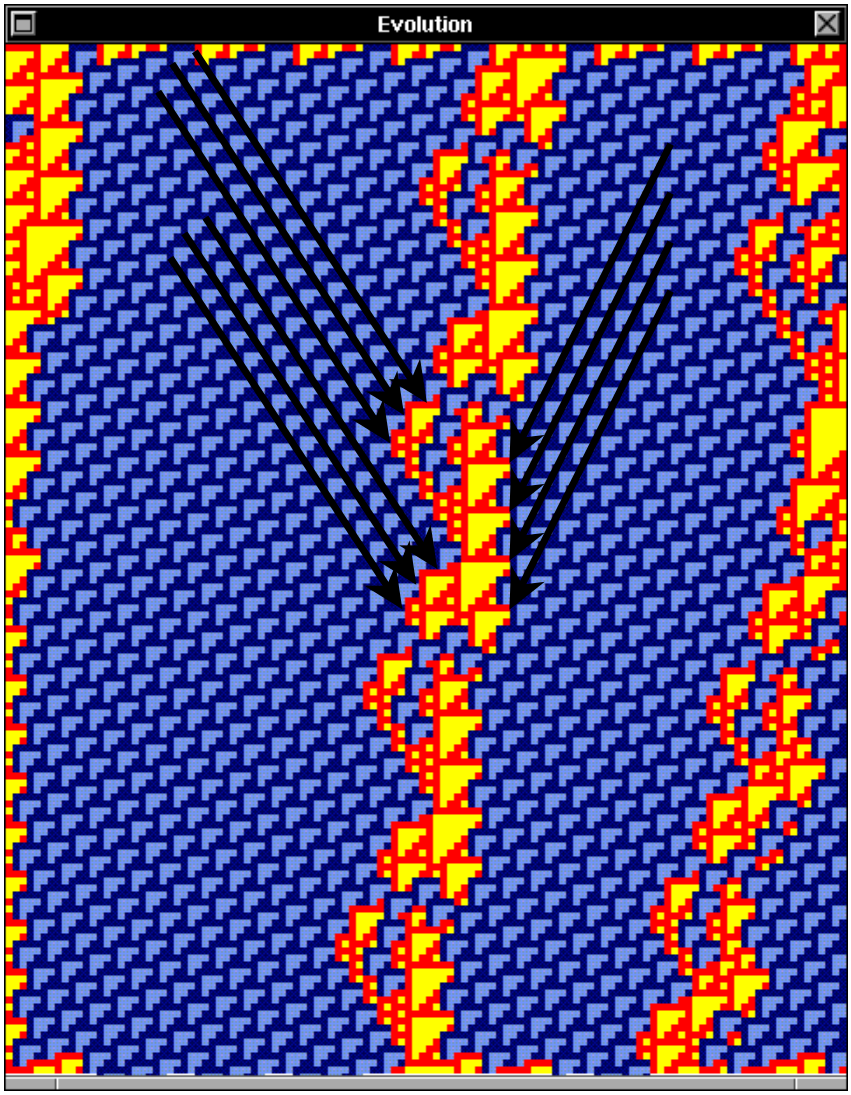


Figure 4.12: Contact points in glider F

4.1.13 Glider G

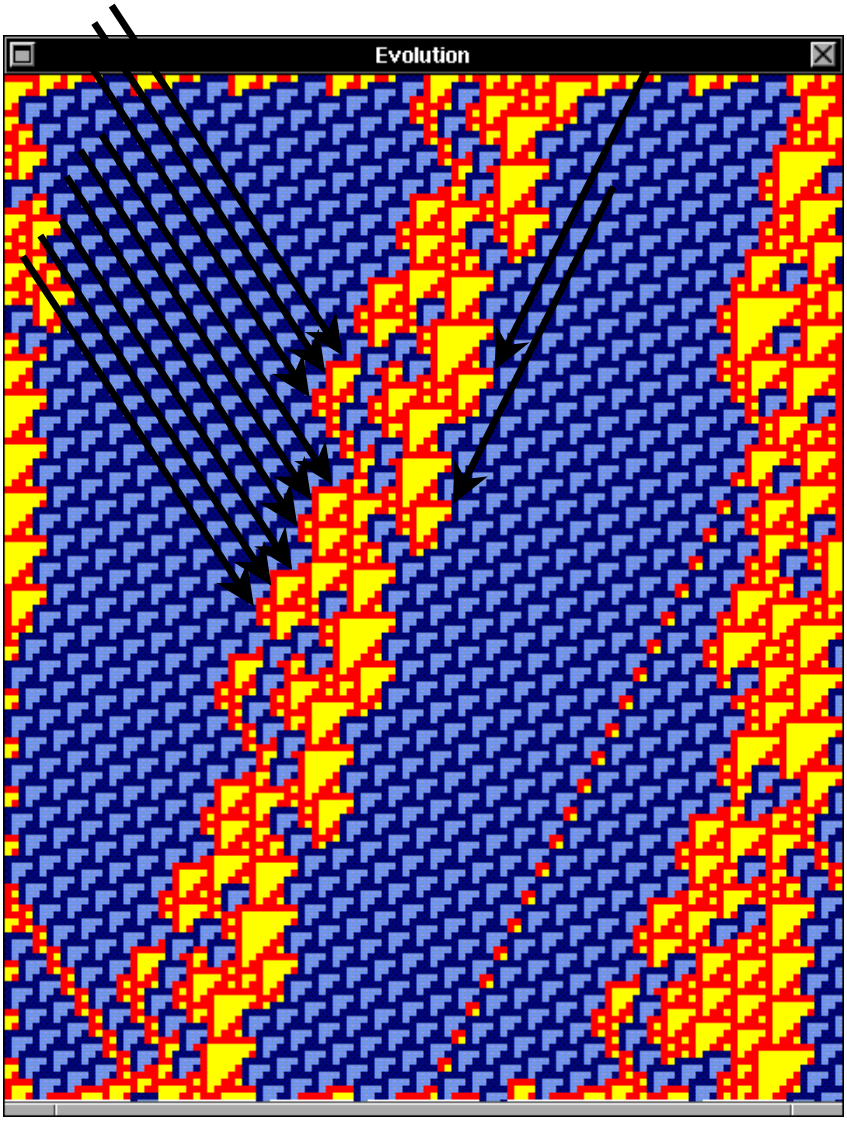


Figure 4.13: Contact points in glider G

4.1.14 Glider H

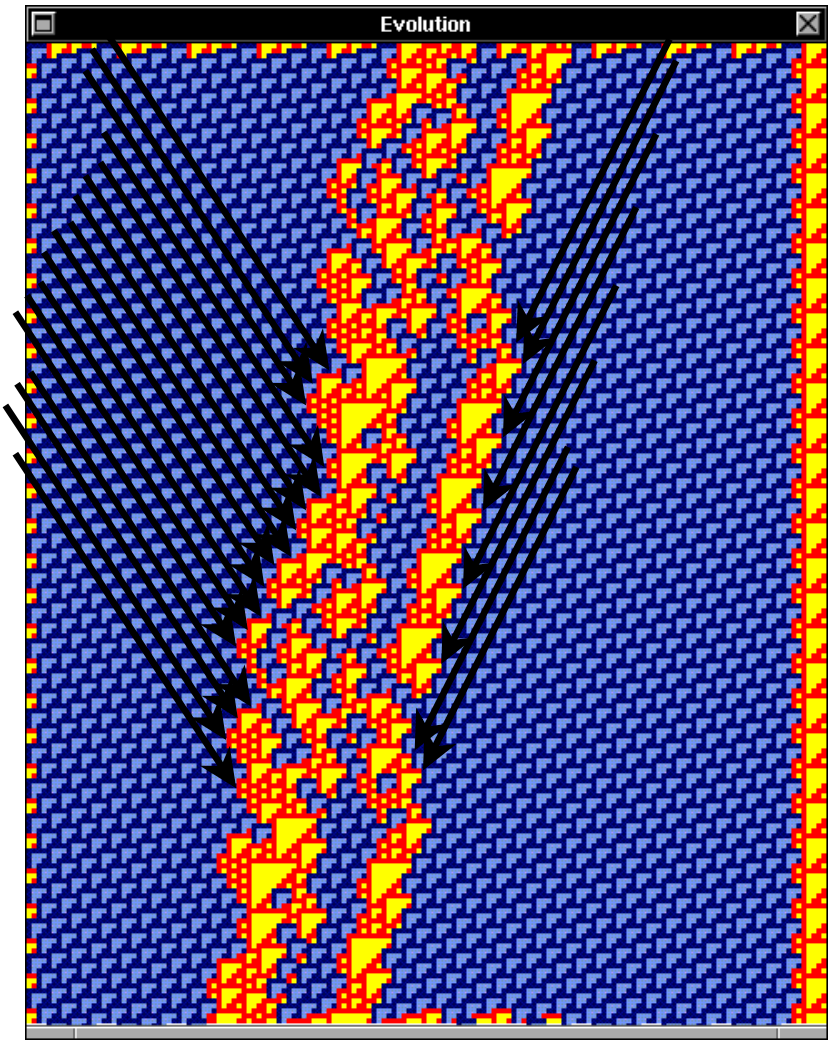


Figure 4.14: Contact points in glider H

4.2 Collisions of glider A

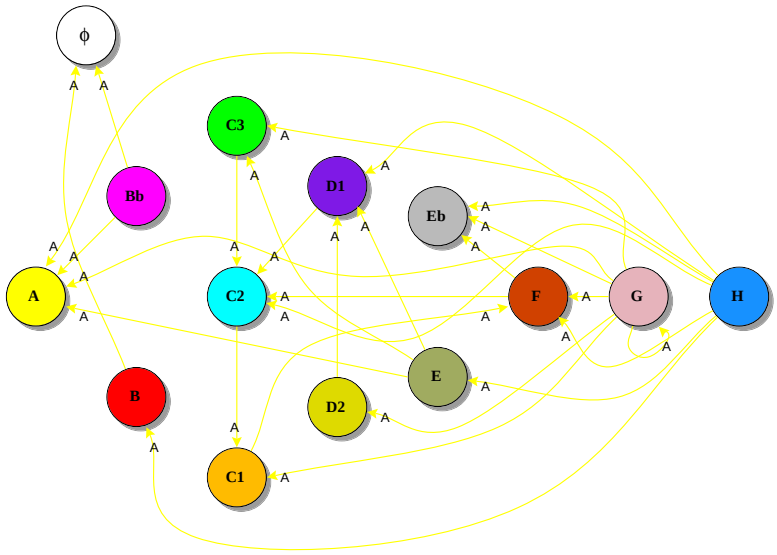


Figure 4.15: Collisions of glider A

	ϕ	A	B	$Bbar$	$C3$	$C2$	$C1$	$D2$	$D1$	E	$Ebar$	F	G	H
ϕ	.	.	1	1	.	.	.	.	.	.	.	.	.	.
A	.	.	.	1	.	.	.	.	.	1	.	.	1	1
B	.	.	.	.	.	.	.	.	.	.	.	.	.	1
$Bbar$	.	.	.	.	.	.	.	.	.	.	.	.	.	.
$C3$	.	.	.	.	.	.	.	.	.	1	.	.	.	1
$C2$	.	.	.	.	1	.	.	.	1	1	.	1	.	1
$C1$	.	.	.	.	.	1	.	.	.	.	.	.	1	.
$D2$	.	.	.	.	.	.	.	.	.	.	.	.	1	.
$D1$	.	.	.	.	.	.	.	1	.	1	.	.	.	1
E	.	.	.	.	.	.	.	.	.	.	.	.	.	1
$Ebar$	.	.	.	.	.	.	.	.	.	.	.	1	1	1
F	.	.	.	.	.	.	1	.	.	.	.	.	1	1
G	.	1	.	.	.	.	.	.	.	.	.	.	.	.
H	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Table 4.1: Matrix connection of collisions glider A

4.2.1 Collisions of glider A with glider B

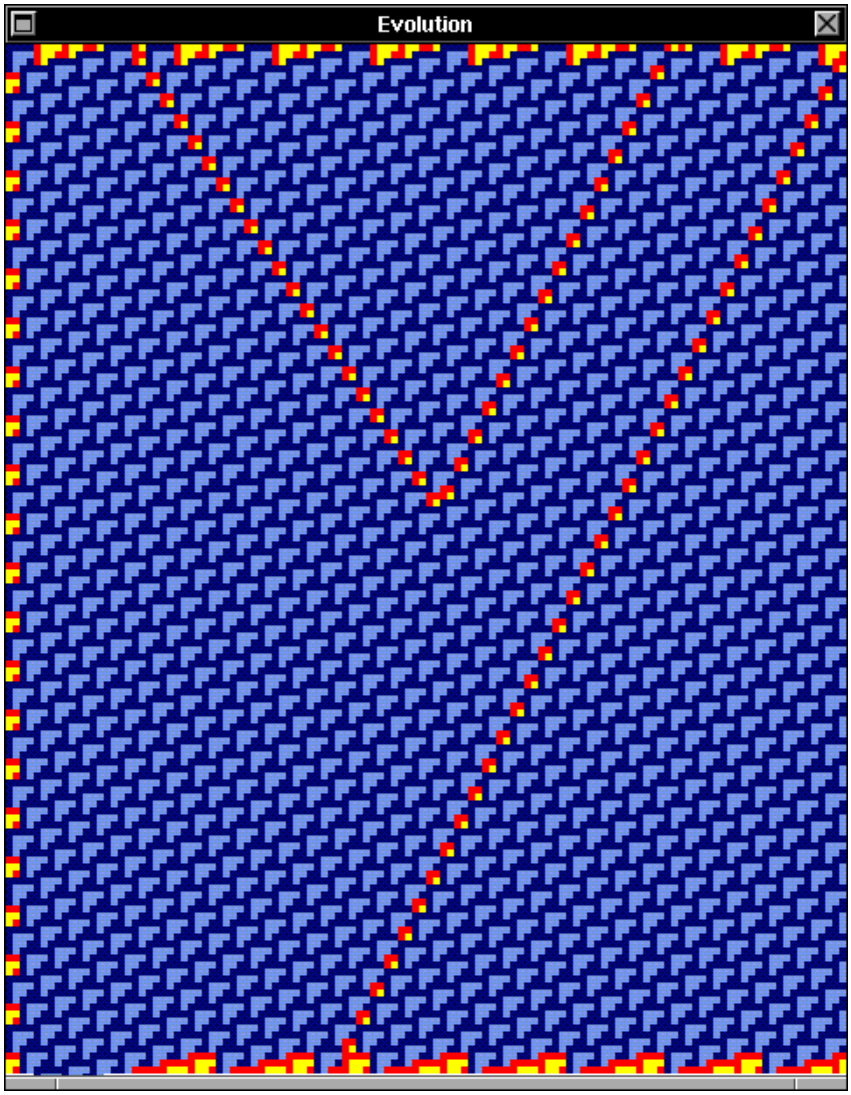


Figure 4.16: Collisions of glider A, A(p1)-e(p1)-B(p1)=ϕ

4.2.2 Collisions of glider A with glider Bbar

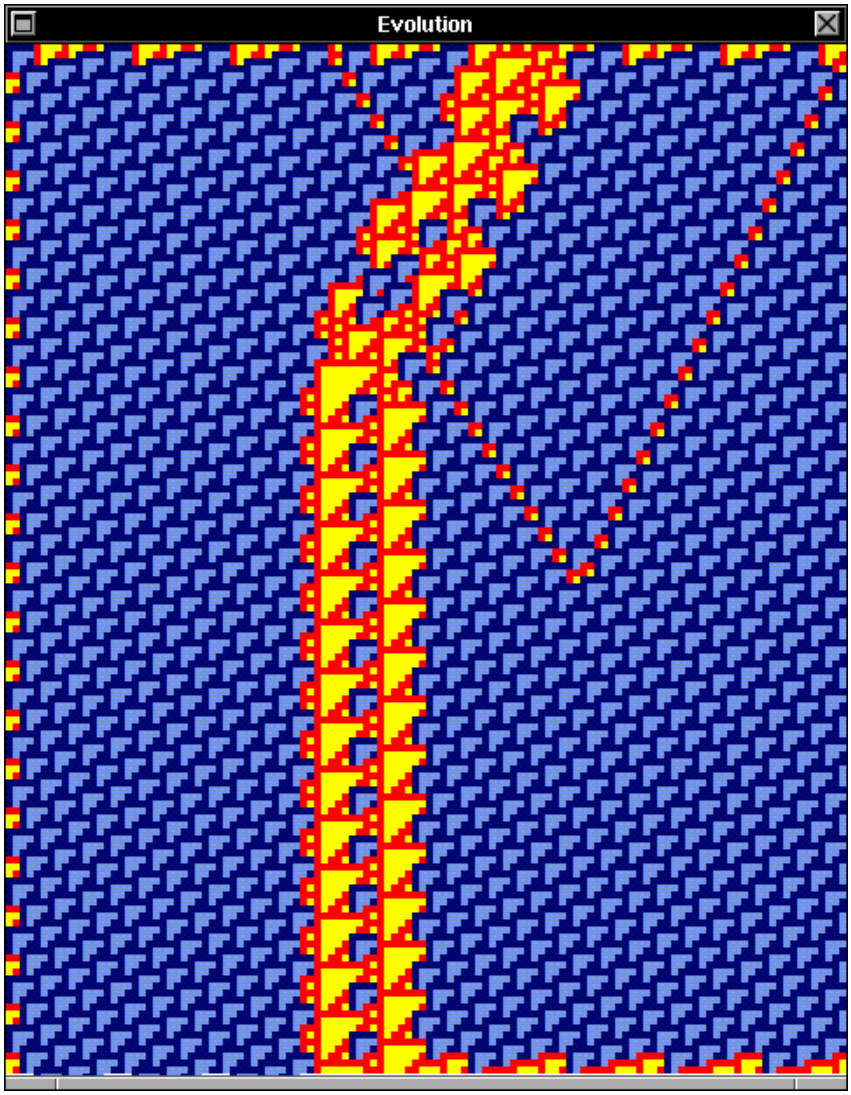


Figure 4.17: Collisions of glider A, A(p1)-e(p1)-Bbar(p1)(A)=2C3,A

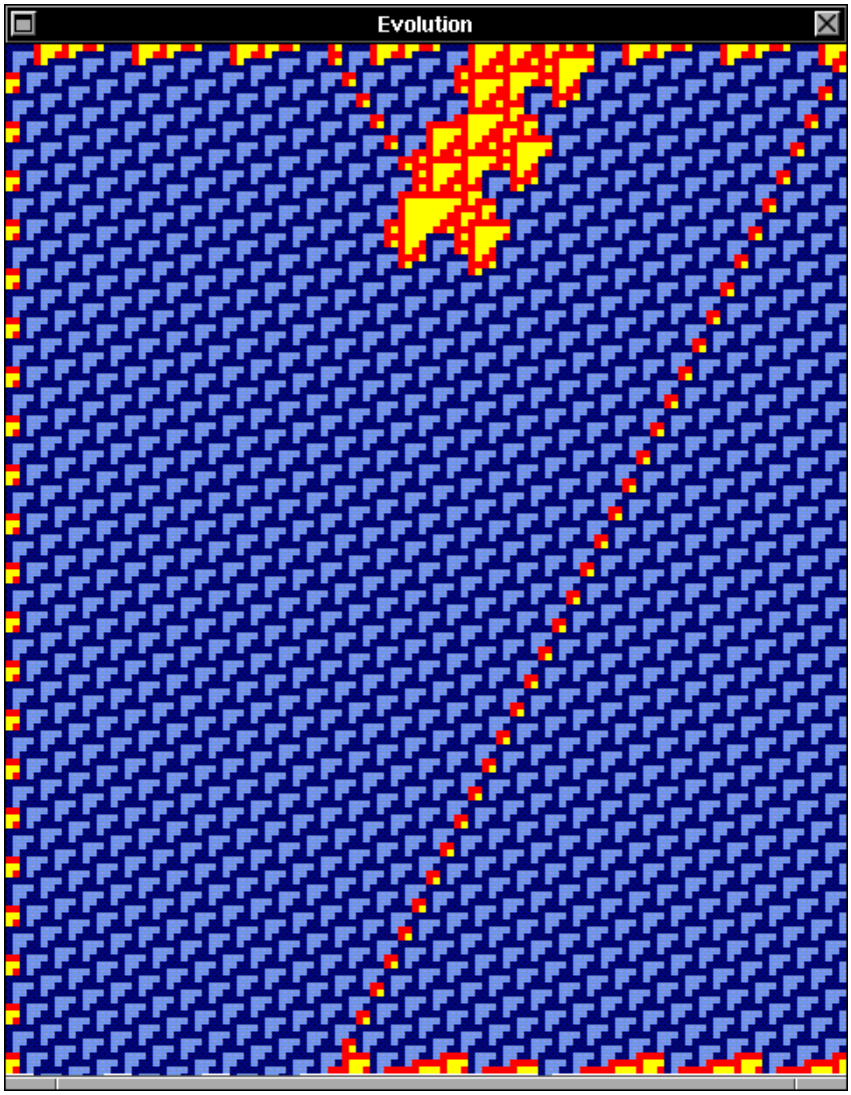


Figure 4.18: Collisions of glider A, A(p1)-e(p1)-Bbar(p1)(B)=ϕ

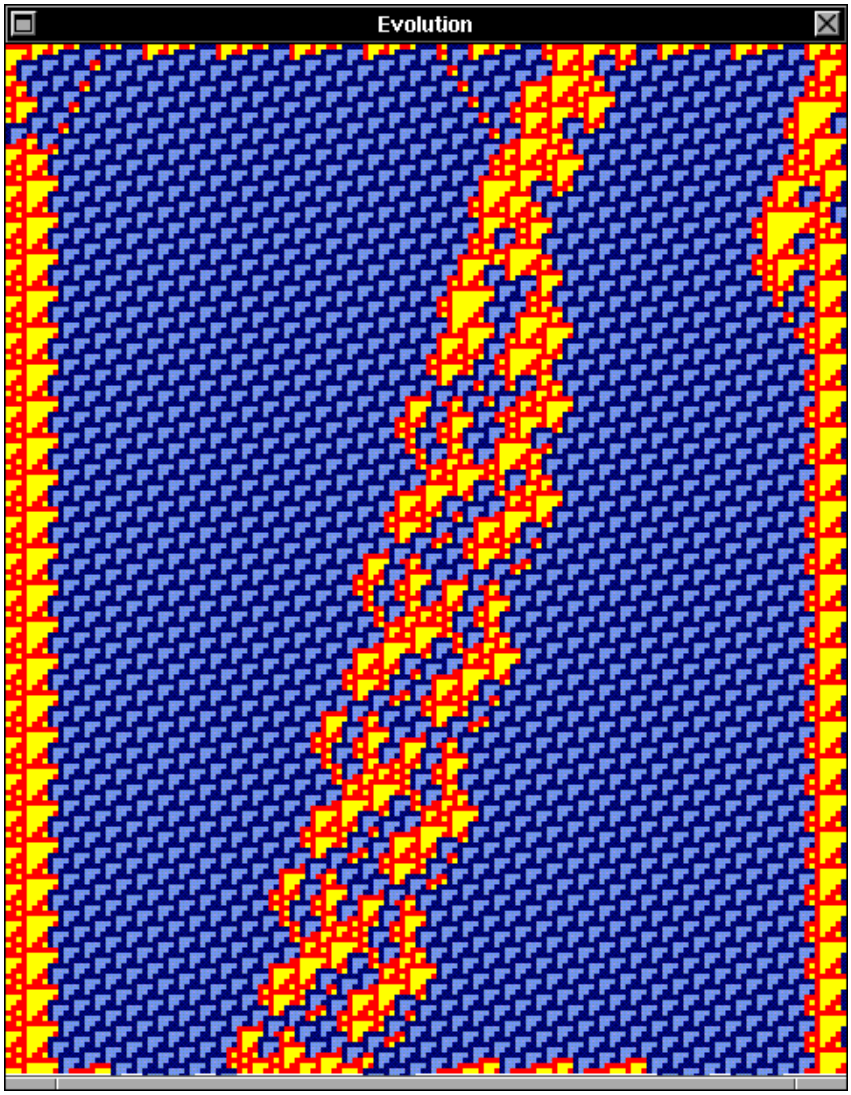


Figure 4.19: Collisions of glider A, A(p1)-e(p1)-Bbar(p1)(C)=2Bbar

4.2.3 Collisions of glider A with glider Bbar8

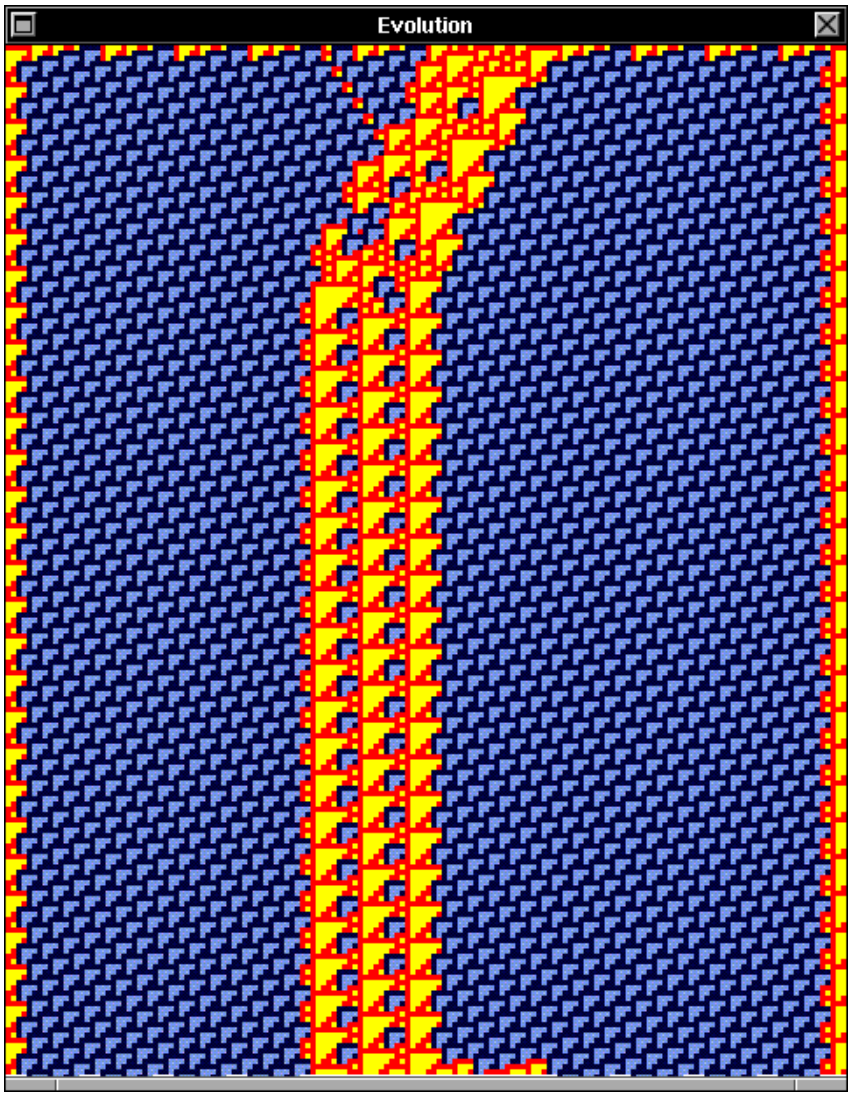


Figure 4.20: Collisions of glider A, A(p1)-e(p1)-Bbar8(p1)(A)=2C3,C1

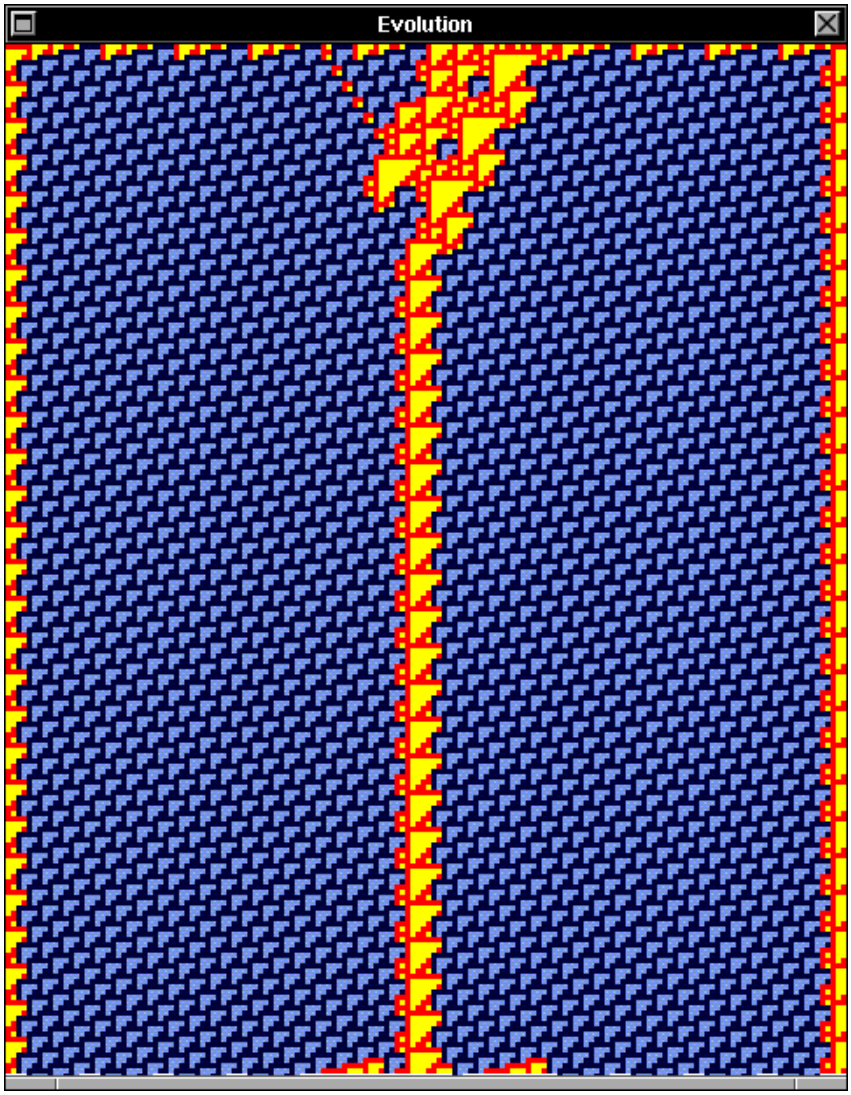


Figure 4.21: Collisions of glider A, A(p1)-e(p1)-Bbar8(p1)(B)=C2

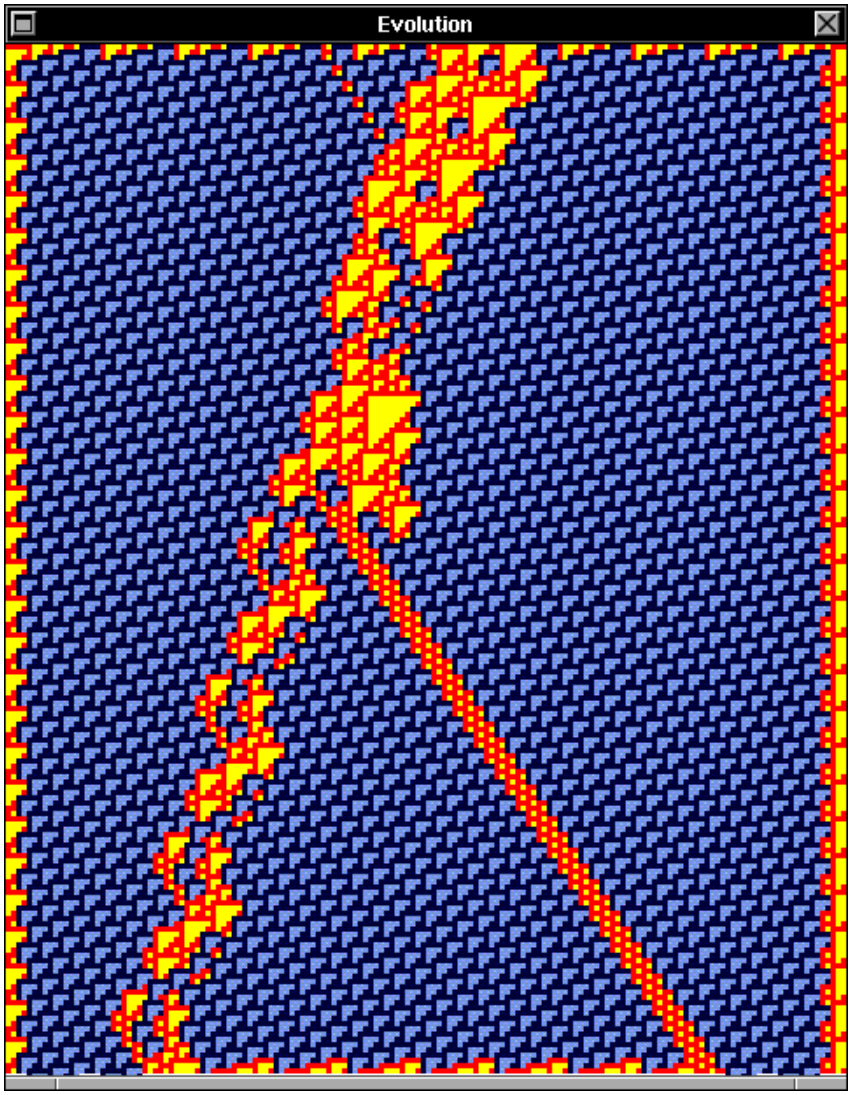


Figure 4.22: Collisions of glider A, A(p1)-e(p1)-Bbar8(p1)(C)=Ebar,4A

4.2.4 Collisions of glider A with glider C1

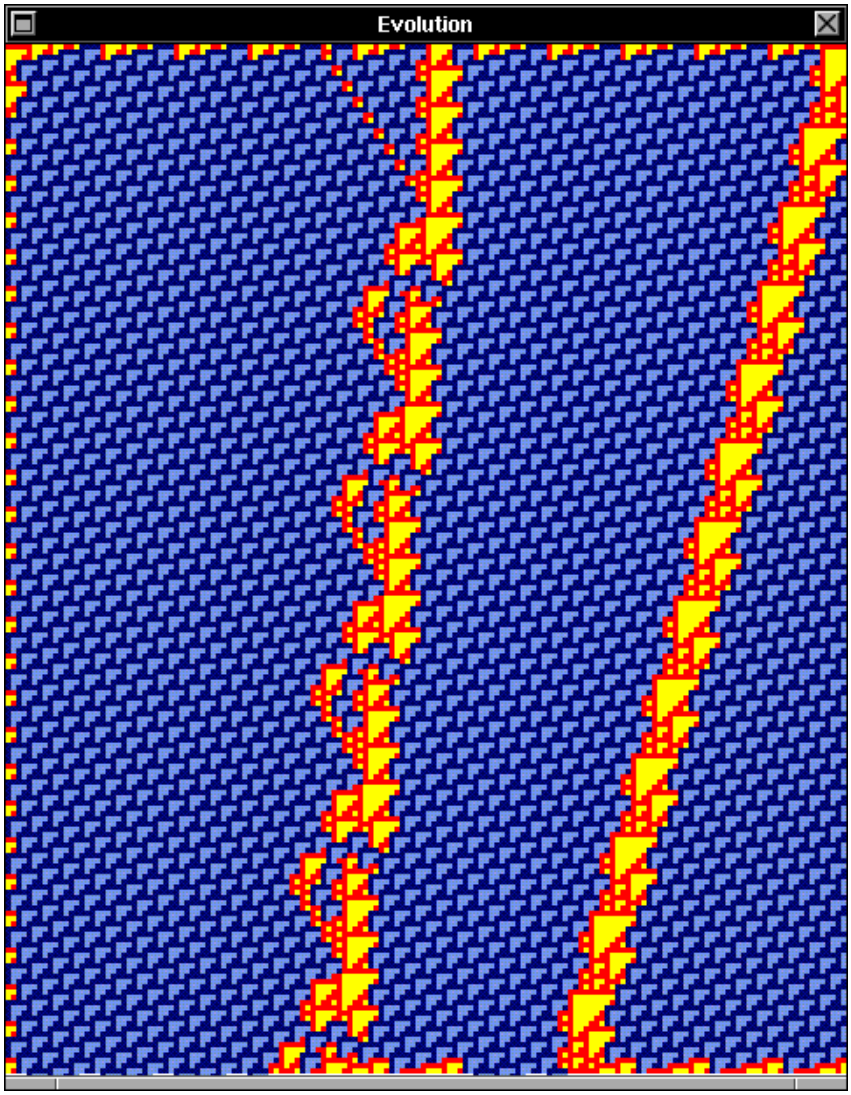


Figure 4.23: Collisions of glider A, A(p1)-e(p1)-C1(p1)(A)=F

4.2.5 Collisions of glider A with glider C2

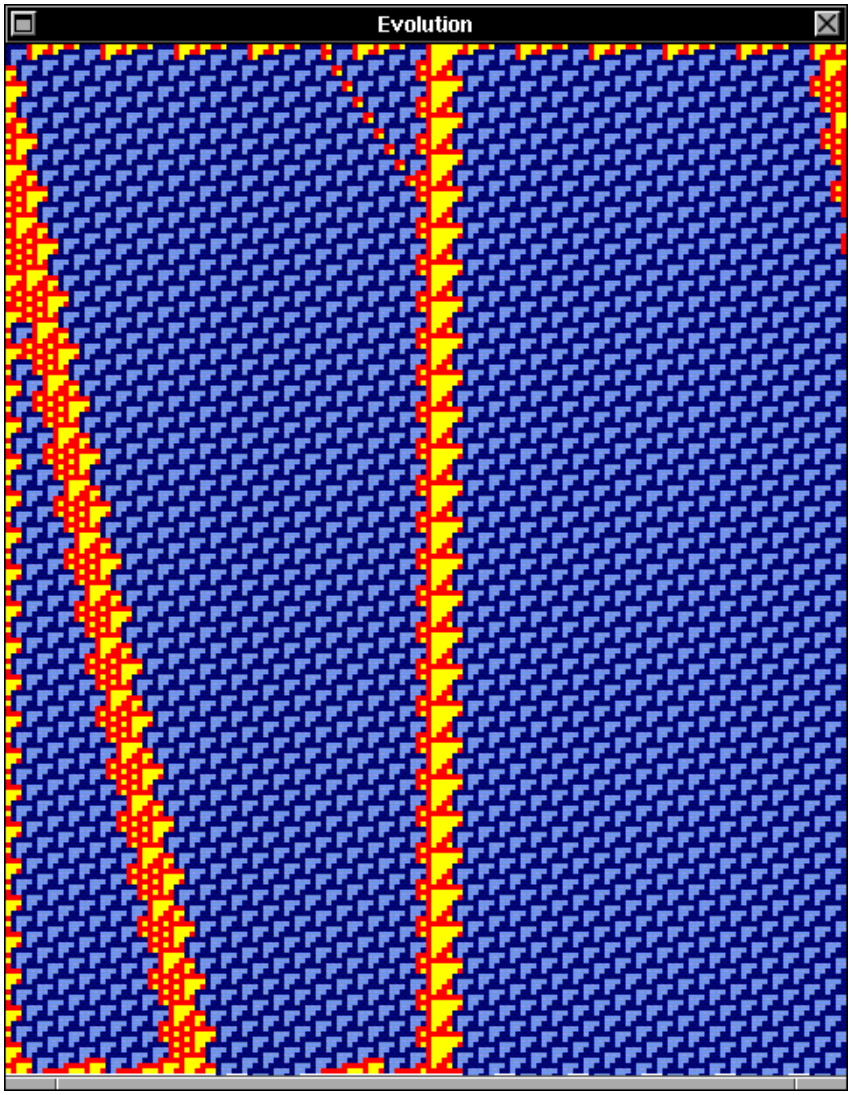


Figure 4.24: Collisions of glider A, A(p1)-e(p1)-C2(p1)(A)=C1

4.2.6 Collisions of glider A with glider C3

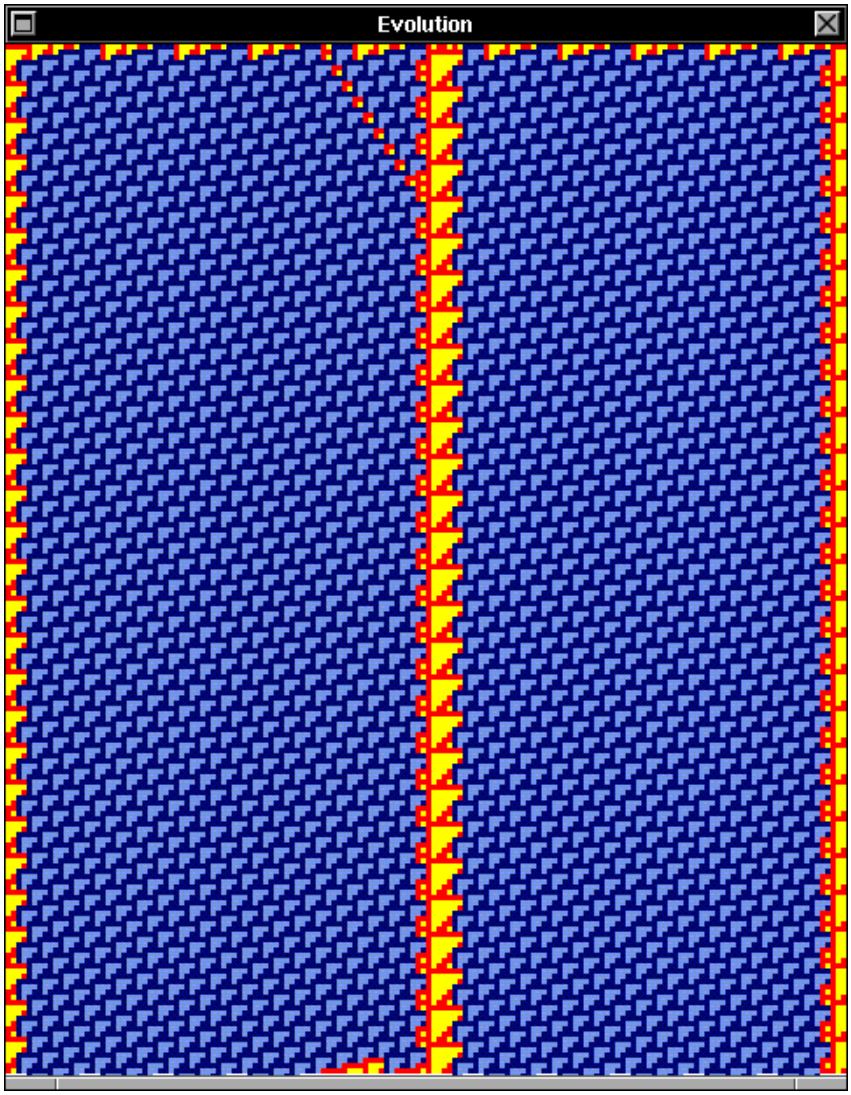


Figure 4.25: Collisions of glider A, A(p1)-e(p1)-C3(p1)(A)=C2

4.2.7 Collisions of glider A with glider D1

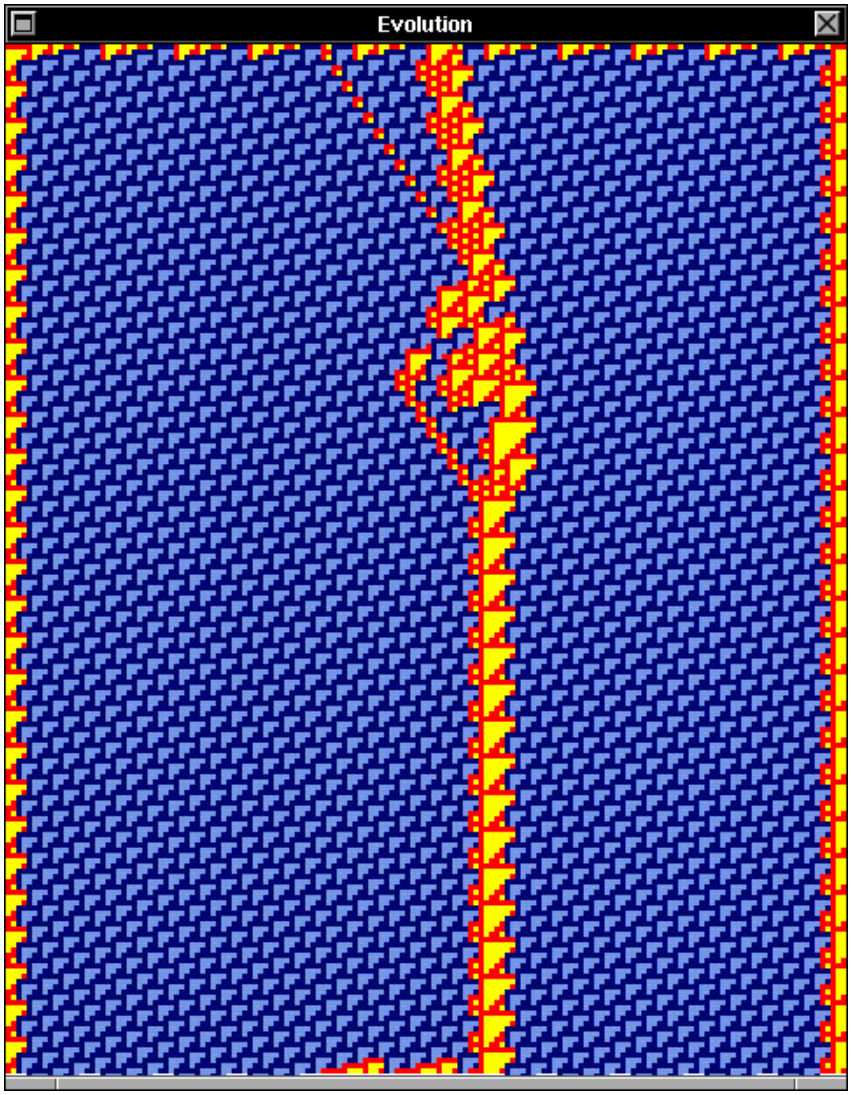


Figure 4.26: Collisions of glider A, A(p1)-e(p1)-D1(p1)(A)=C2

4.2.8 Collisions of glider A with glider D2

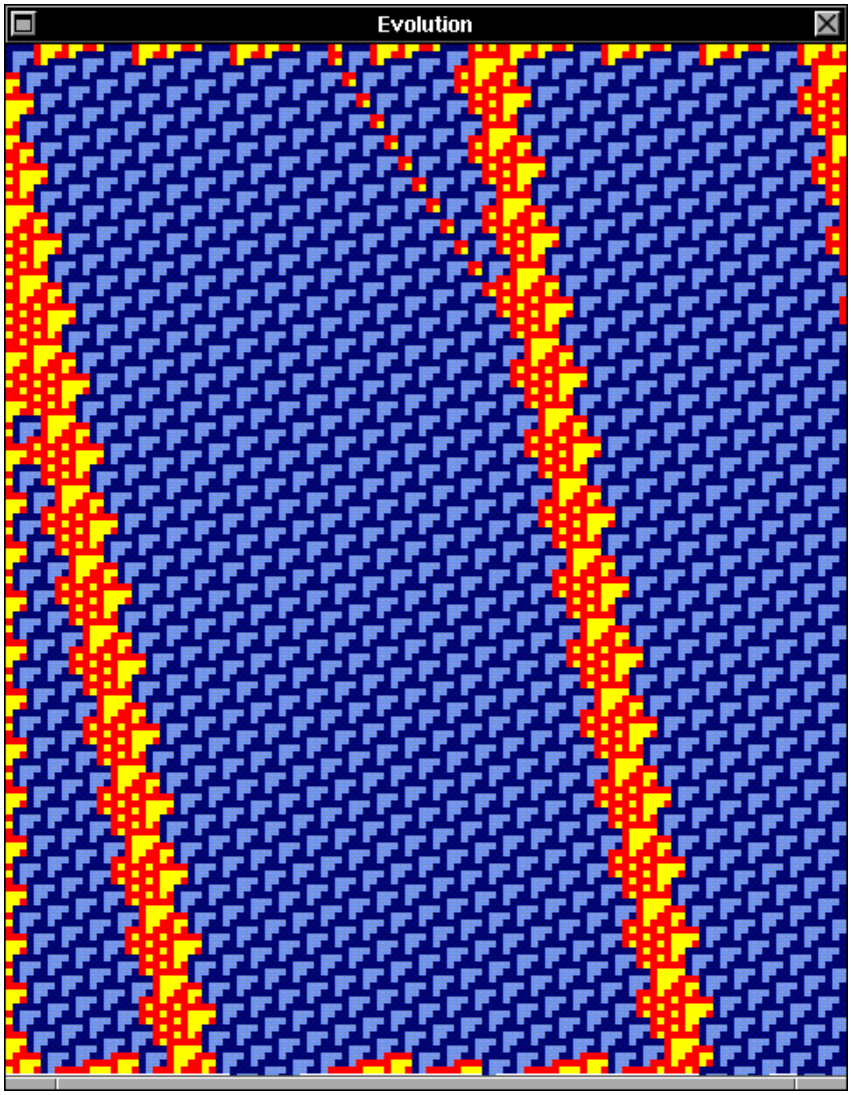


Figure 4.27: Collisions of glider A, A(p1)-e(p1)-D2(p1)(A)=D1

4.2.9 Collisions of glider A with glider E

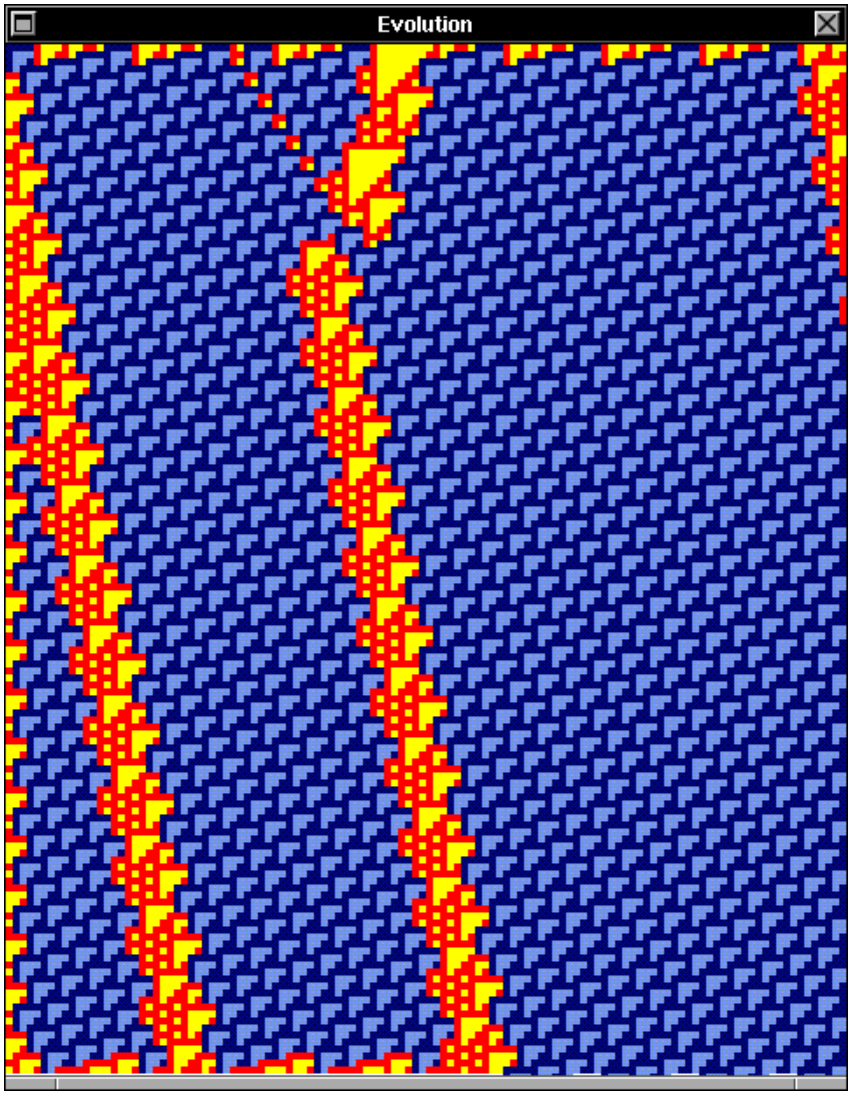


Figure 4.28: Collisions of glider A, A(p1)-e(p1)-E(p1)(A)=D1

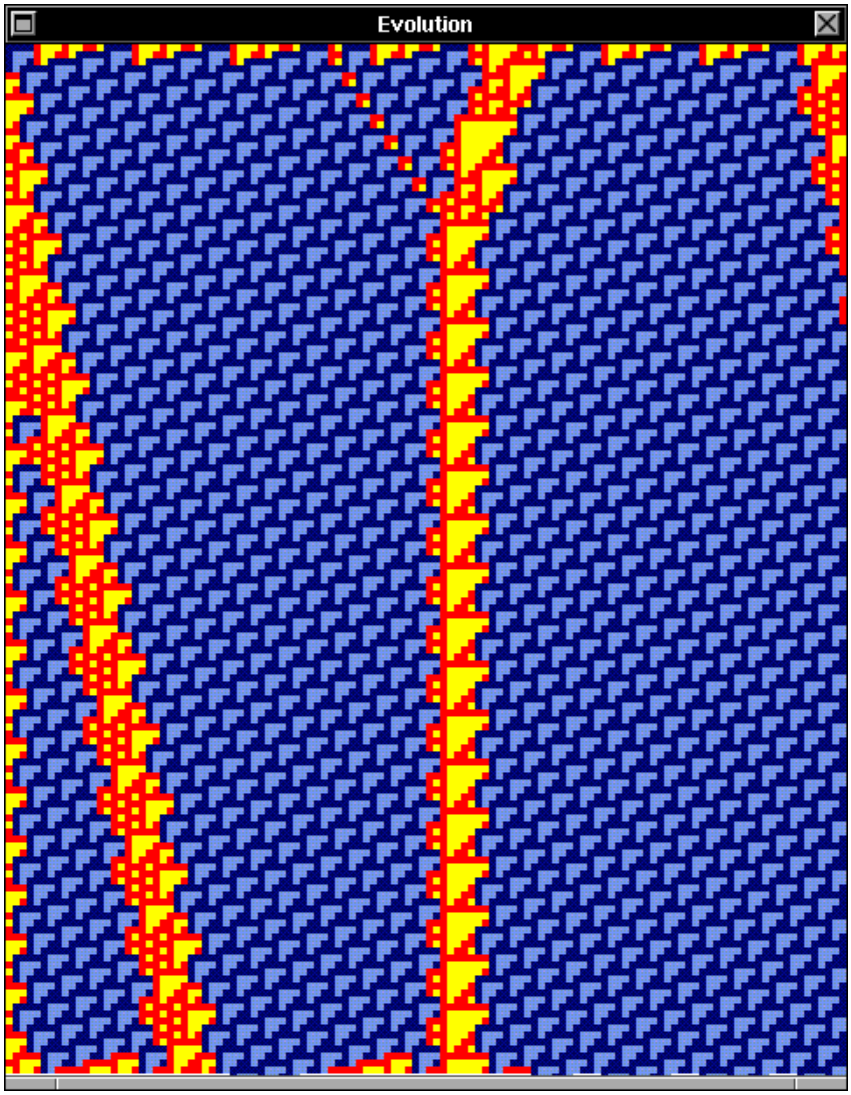


Figure 4.29: Collisions of glider A, A(p1)-e(p1)-E(p1)(B)=C3

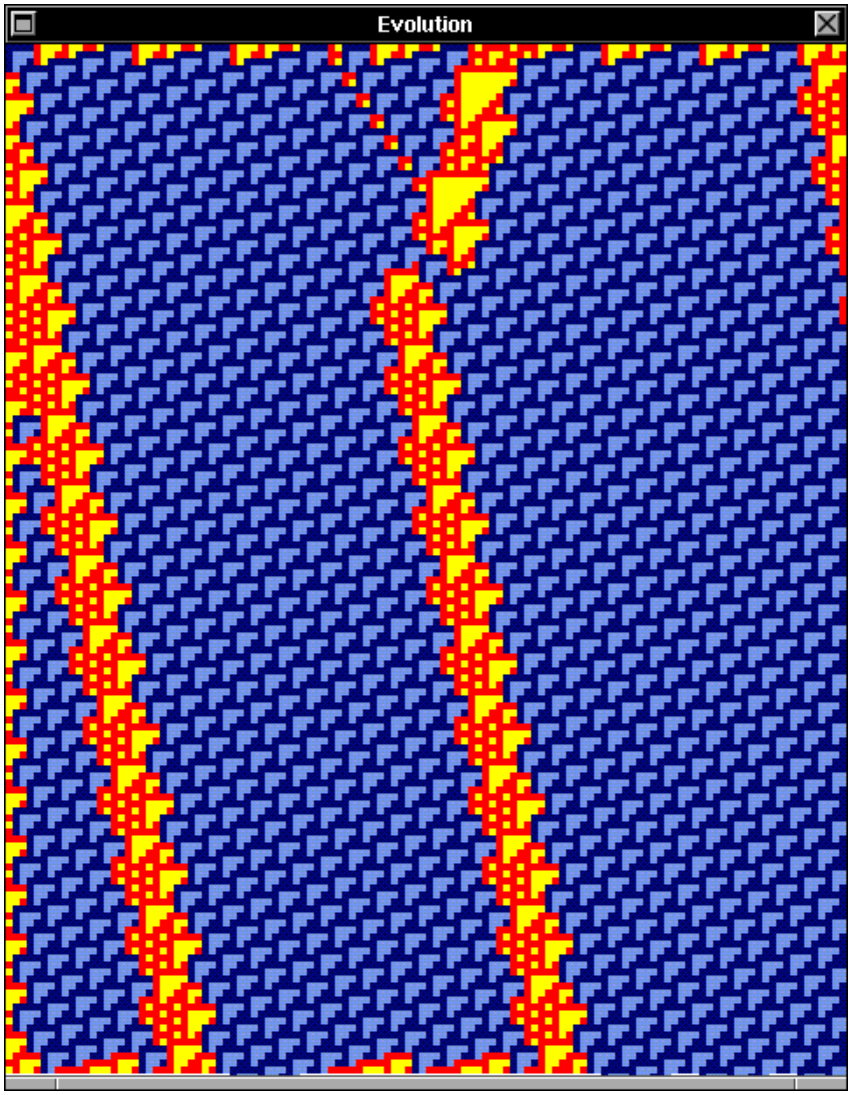


Figure 4.30: Collisions of glider A, A(p1)-e(p1)-E(p1)(D)=D1

4.2.10 Collisions of glider A with glider Ebar

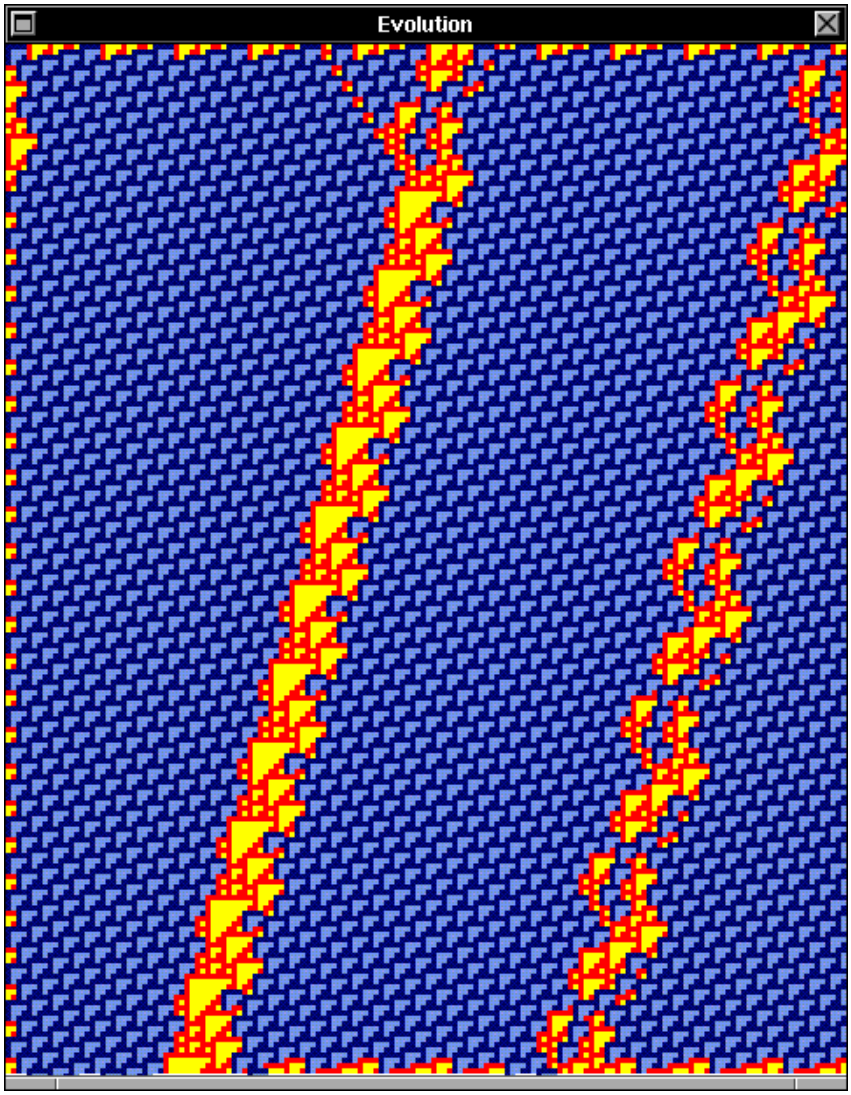


Figure 4.31: Collisions of glider A, A(p1)-e(p1)-Ebar(p1)(A)=E2

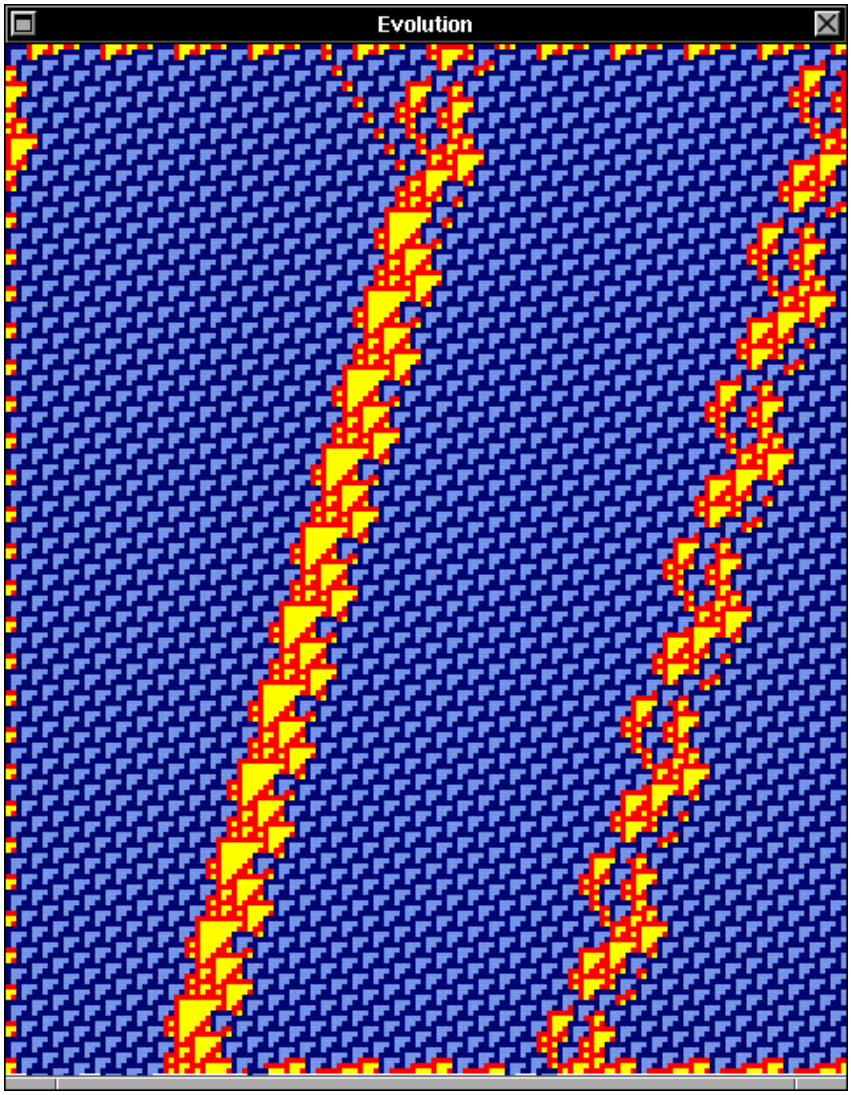


Figure 4.32: Collisions of glider A, A(p1)-e(p1)-Ebar(p1)(B)=E2

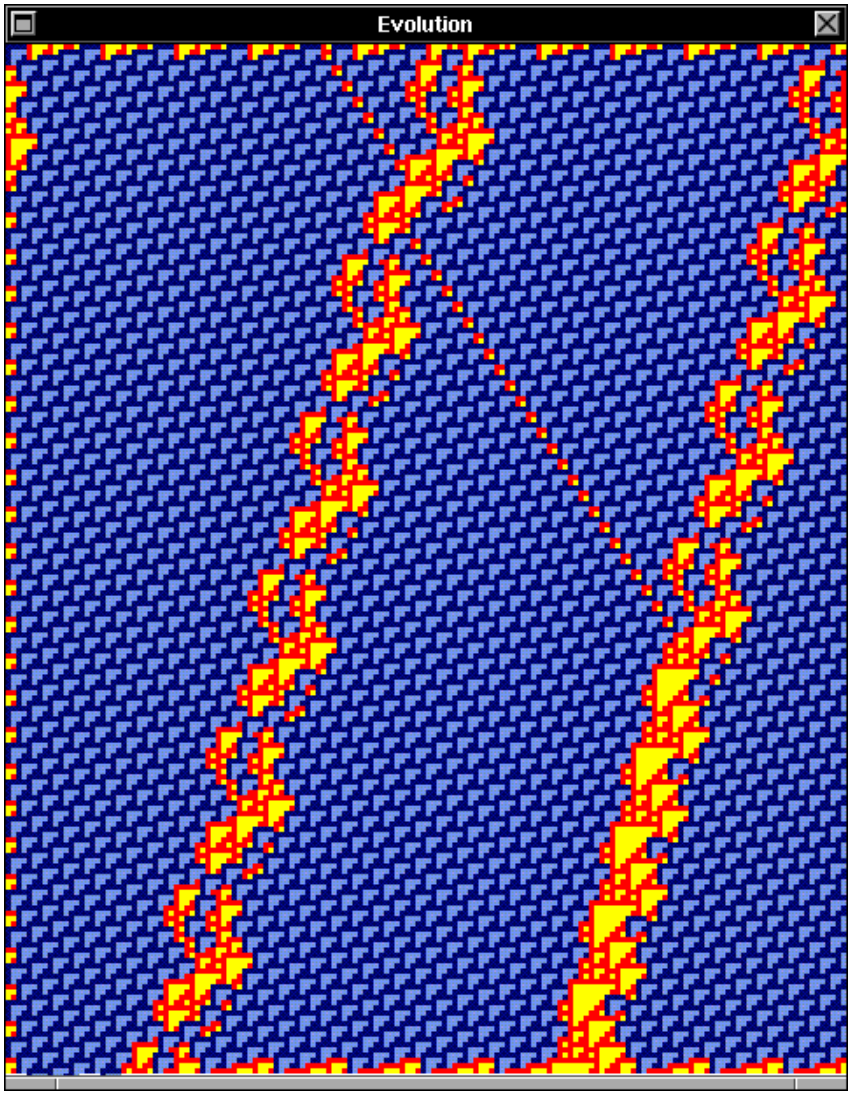


Figure 4.33: Collisions of glider A, A(p1)-e(p1)-Ebar(p1)(C)=A,Ebar; across

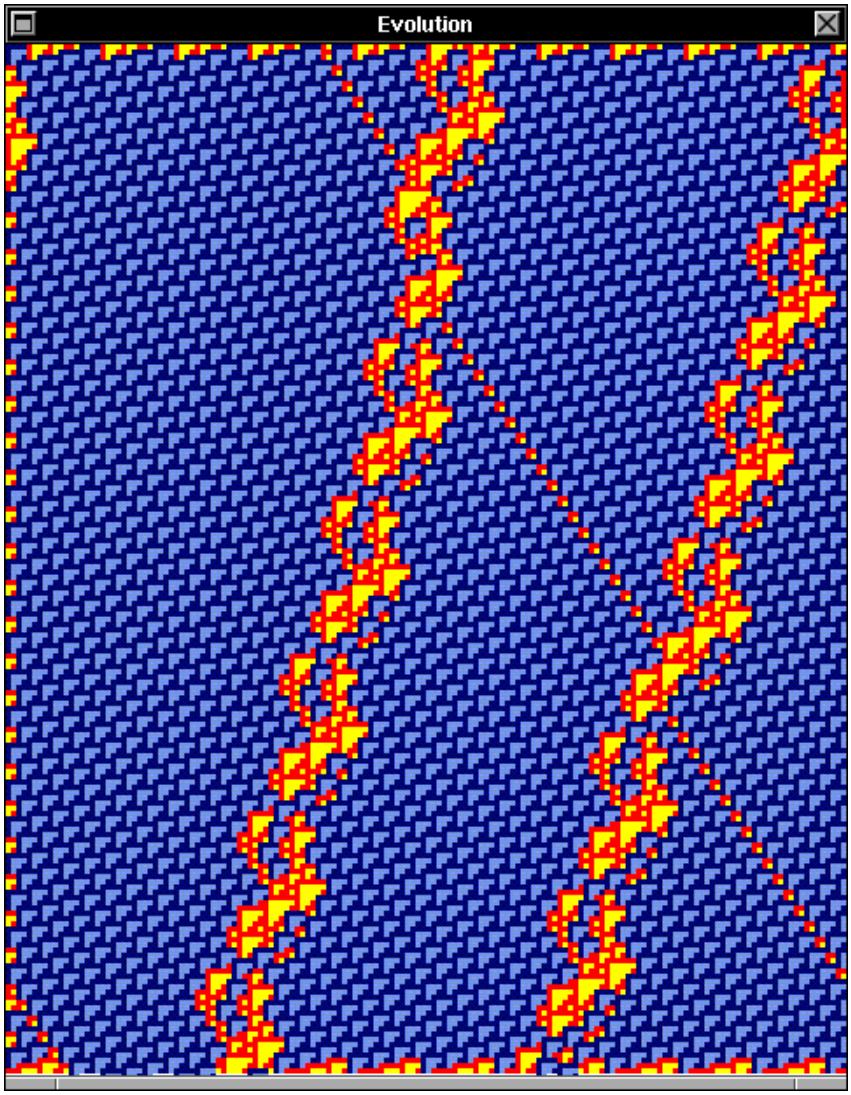


Figure 4.34: Collisions of glider A, A(p1)-e(p1)-Ebar(p1)(D)=A,Ebar; across

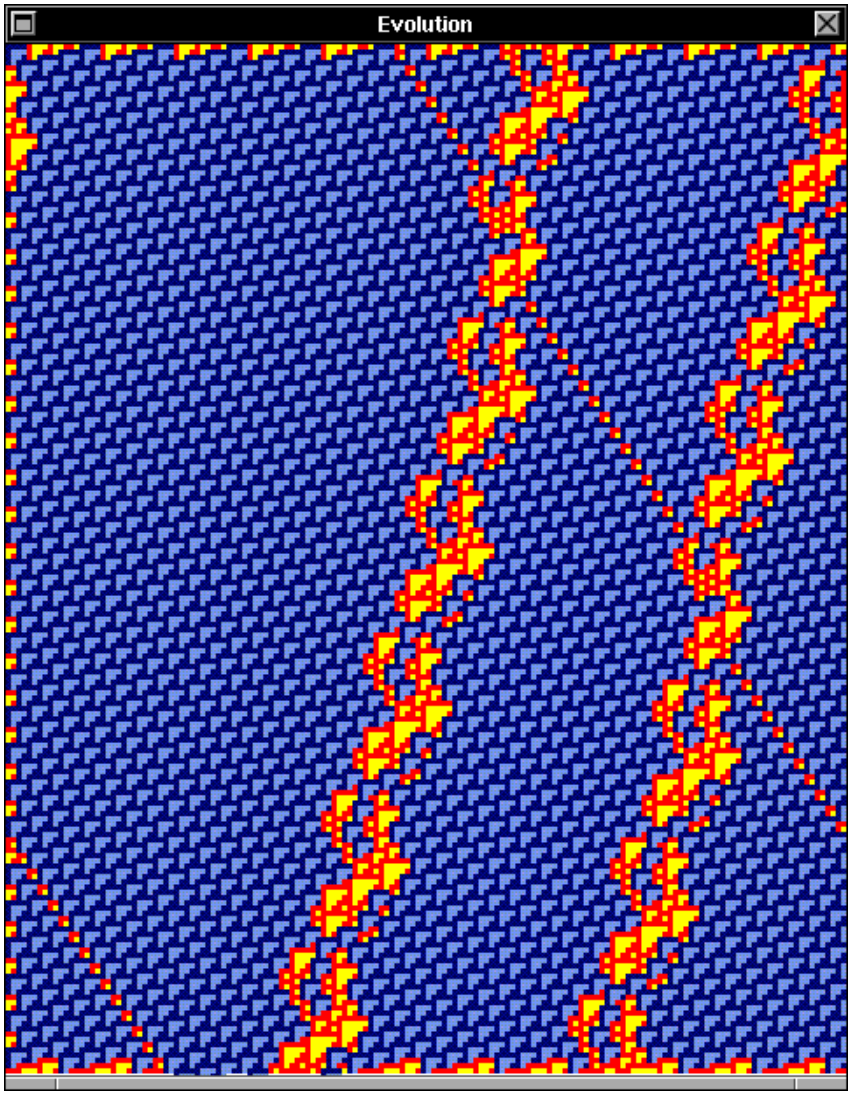


Figure 4.35: Collisions of glider A, A(p1)-e(p1)-Ebar(p1)(E)=A,Ebar; across

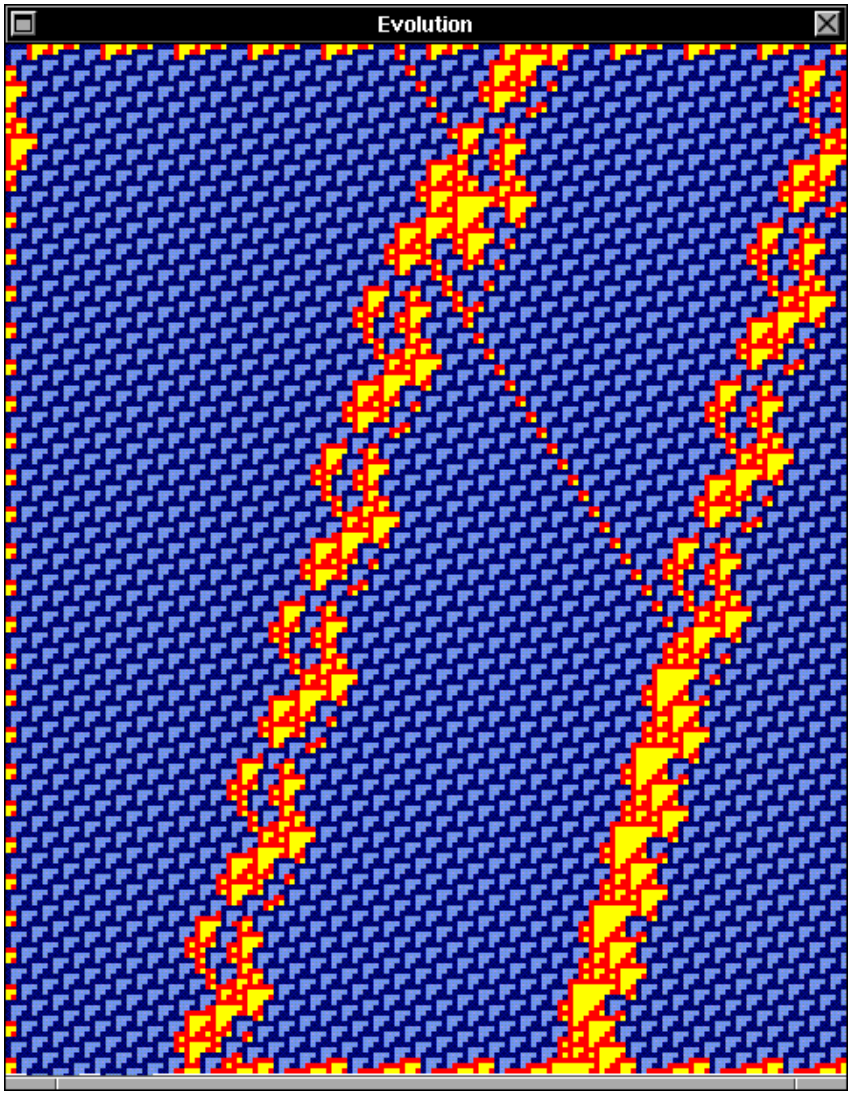


Figure 4.36: Collisions of glider A, A(p1)-e(p1)-Ebar(p1)(H)=A,Ebar; across

4.2.11 Collisions of glider A with glider F

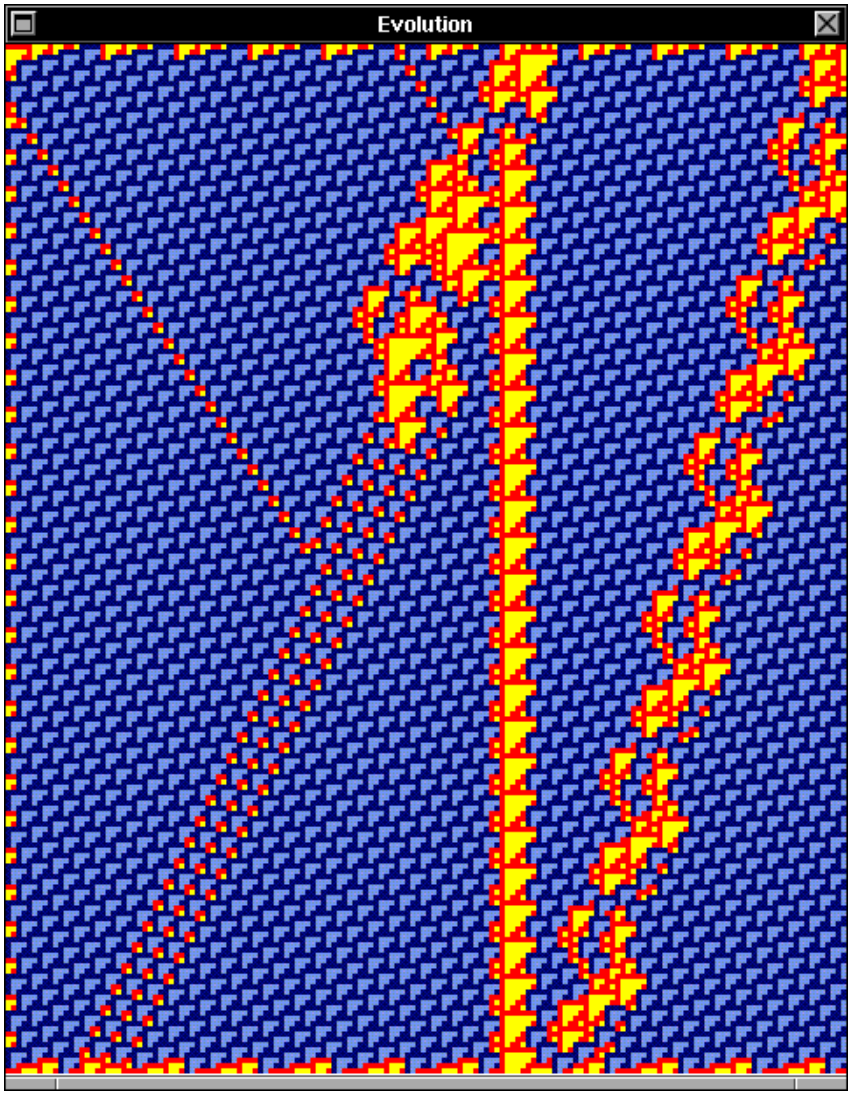


Figure 4.37: Collisions of glider A, A(p1)-e(p1)-F(p1)(A)=4B,C2

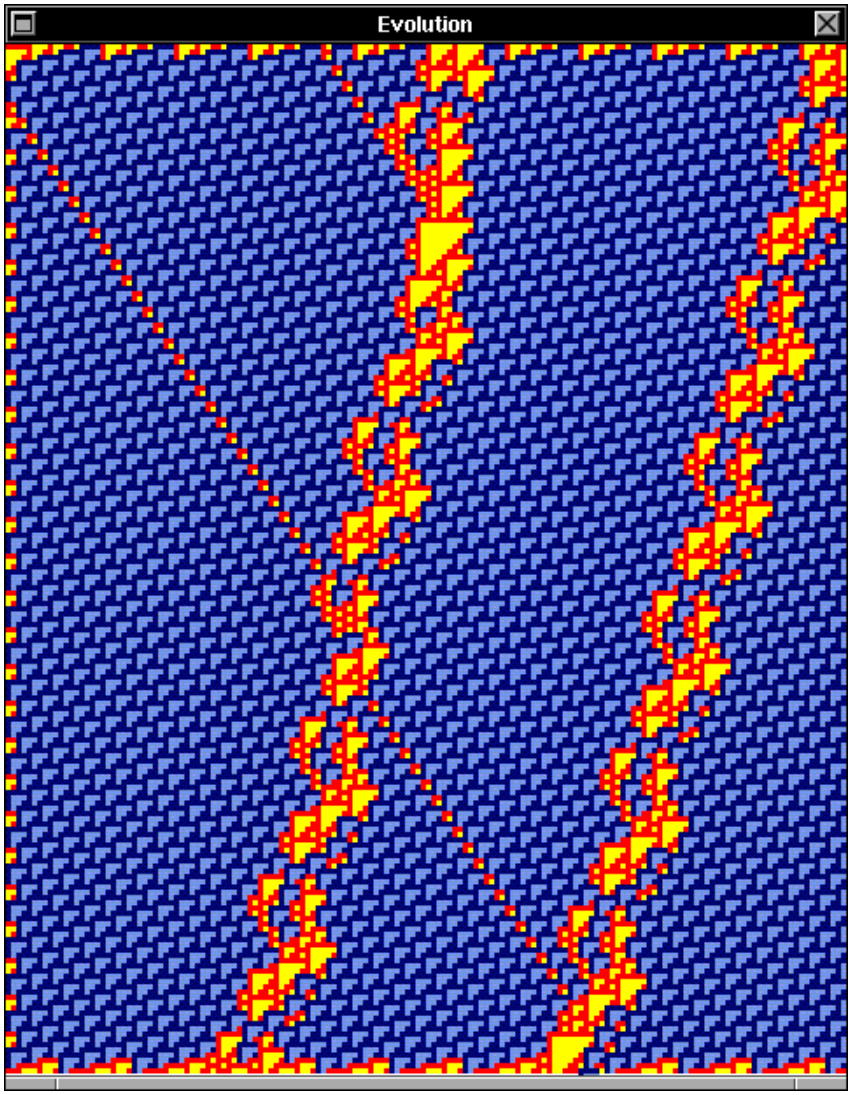


Figure 4.38: Collisions of glider A, A(p1)-e(p1)-F(p1)(B)=Ebar

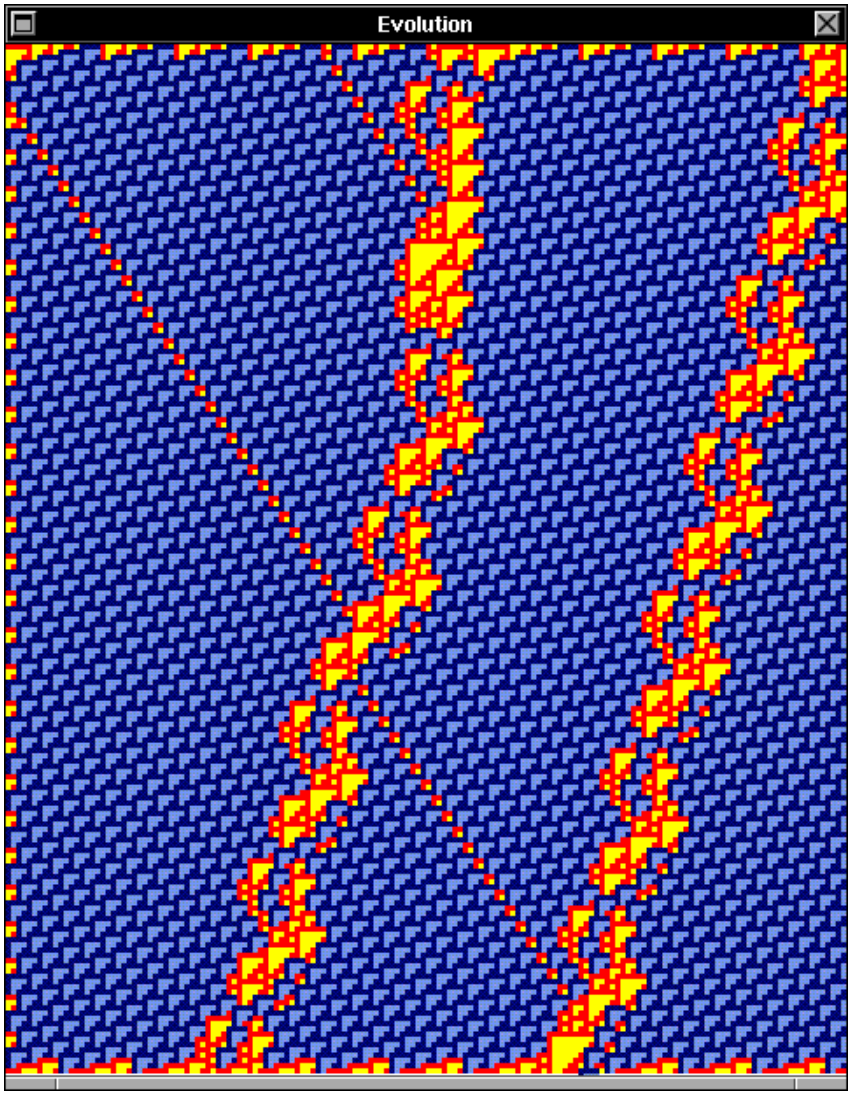


Figure 4.39: Collisions of glider A, A(p1)-e(p1)-F(p1)(C)=Ebar

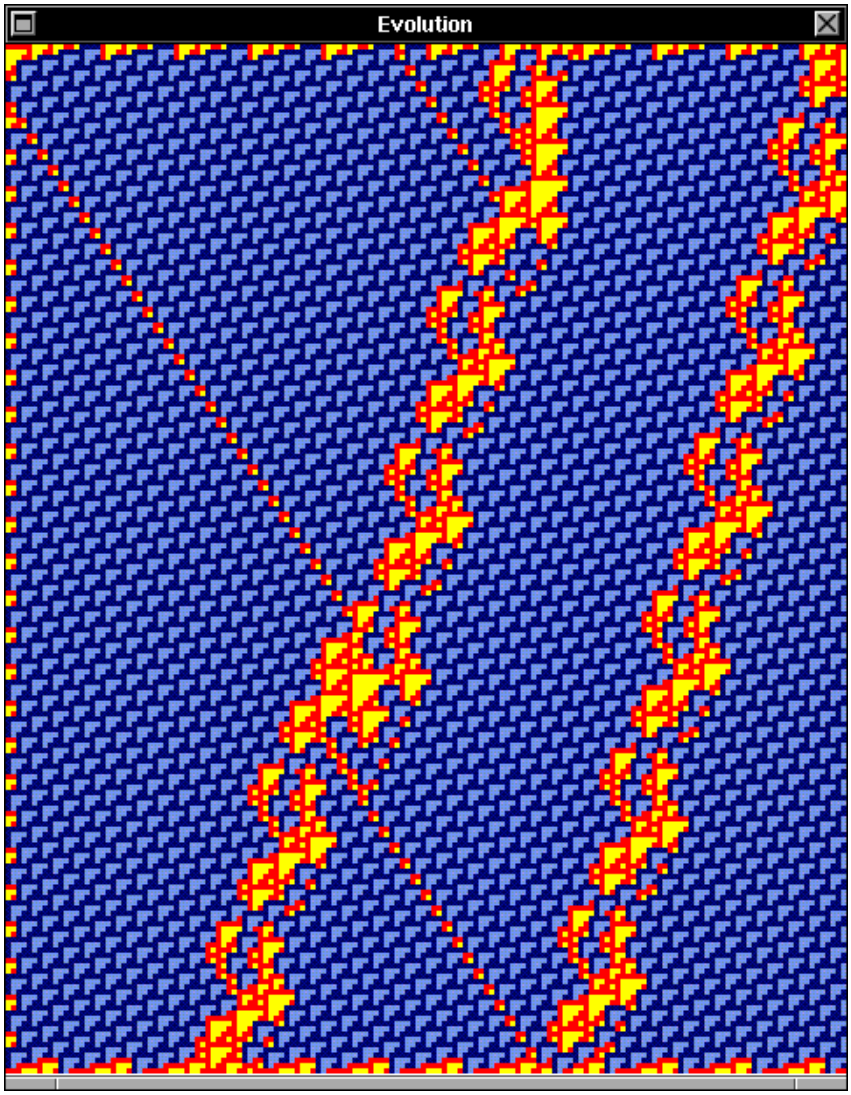


Figure 4.40: Collisions of glider A, A(p1)-e(p1)-F(p1)(D)=Ebar

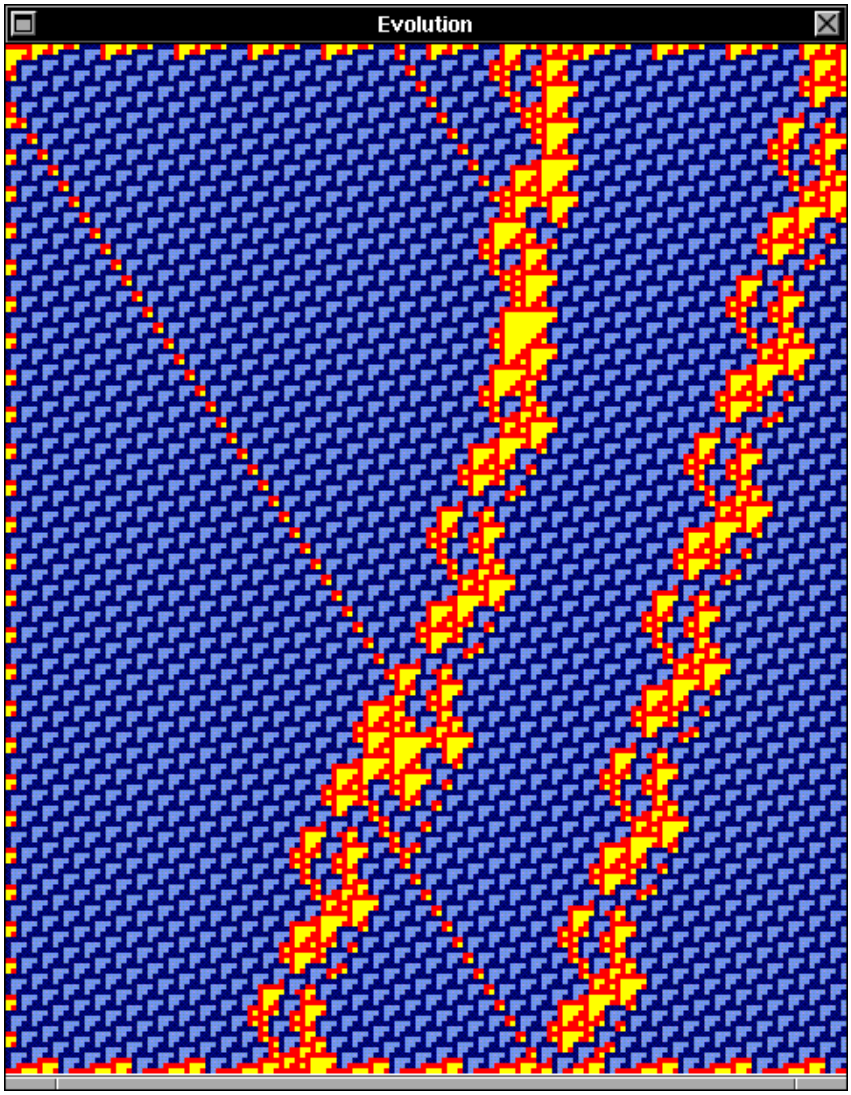


Figure 4.41: Collisions of glider A, A(p1)-e(p1)-F(p1)(E)=Ebar

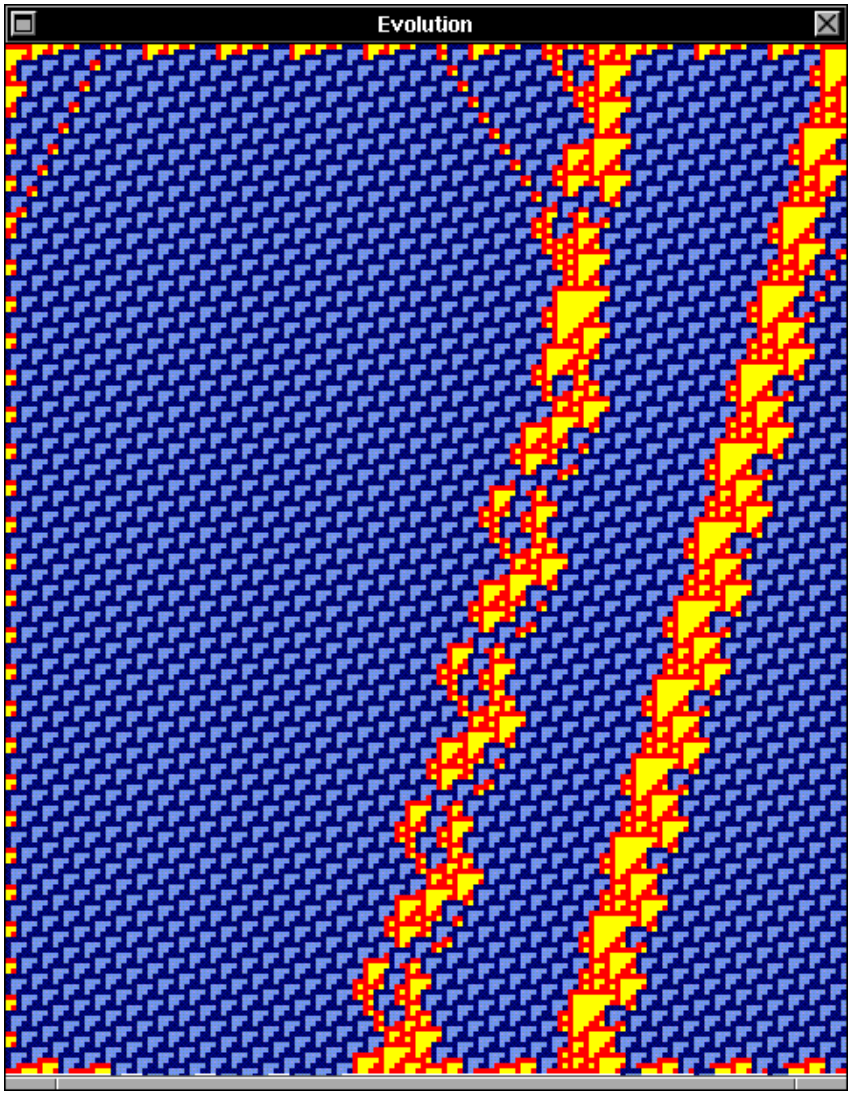


Figure 4.42: Collisions of glider A, A(p1)-e(p1)-F(p1)(F)=Ebar

4.2.12 Collisions of glider A with glider G

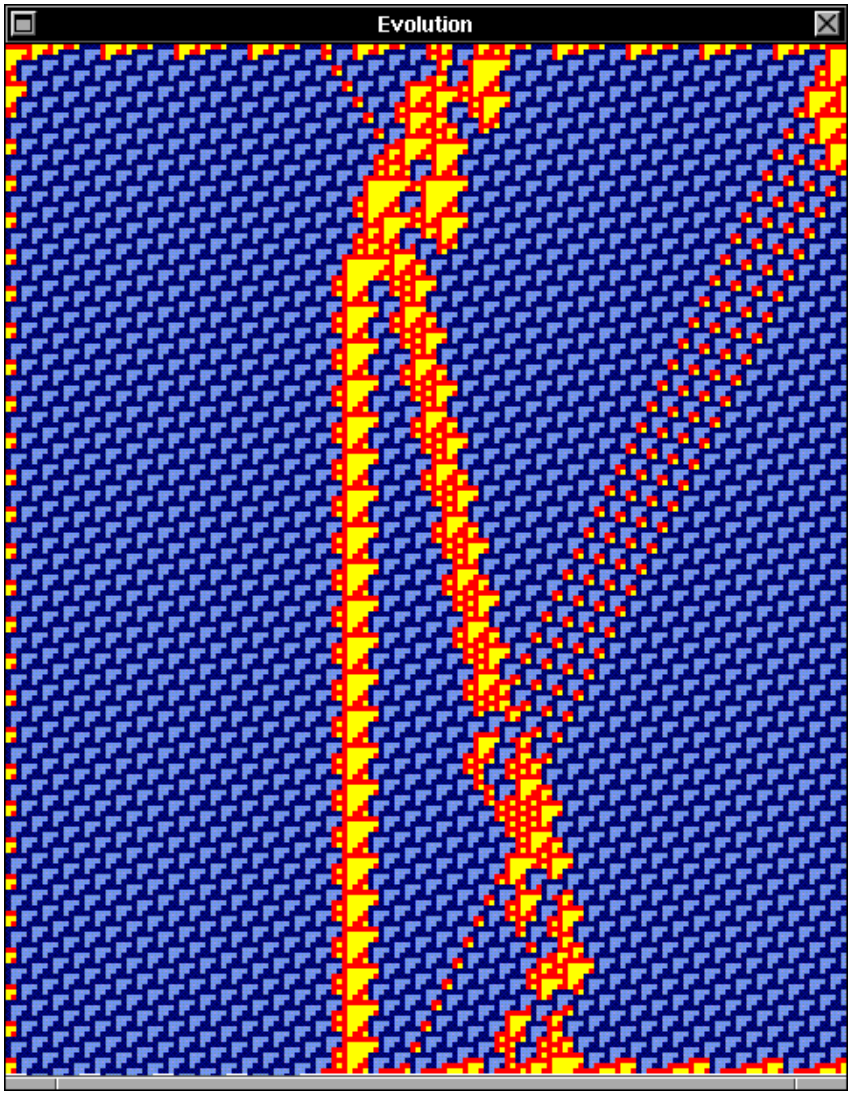


Figure 4.43: Collisions of glider A, A(p1)-e(p1)-G(p1)(A)=D2,C3

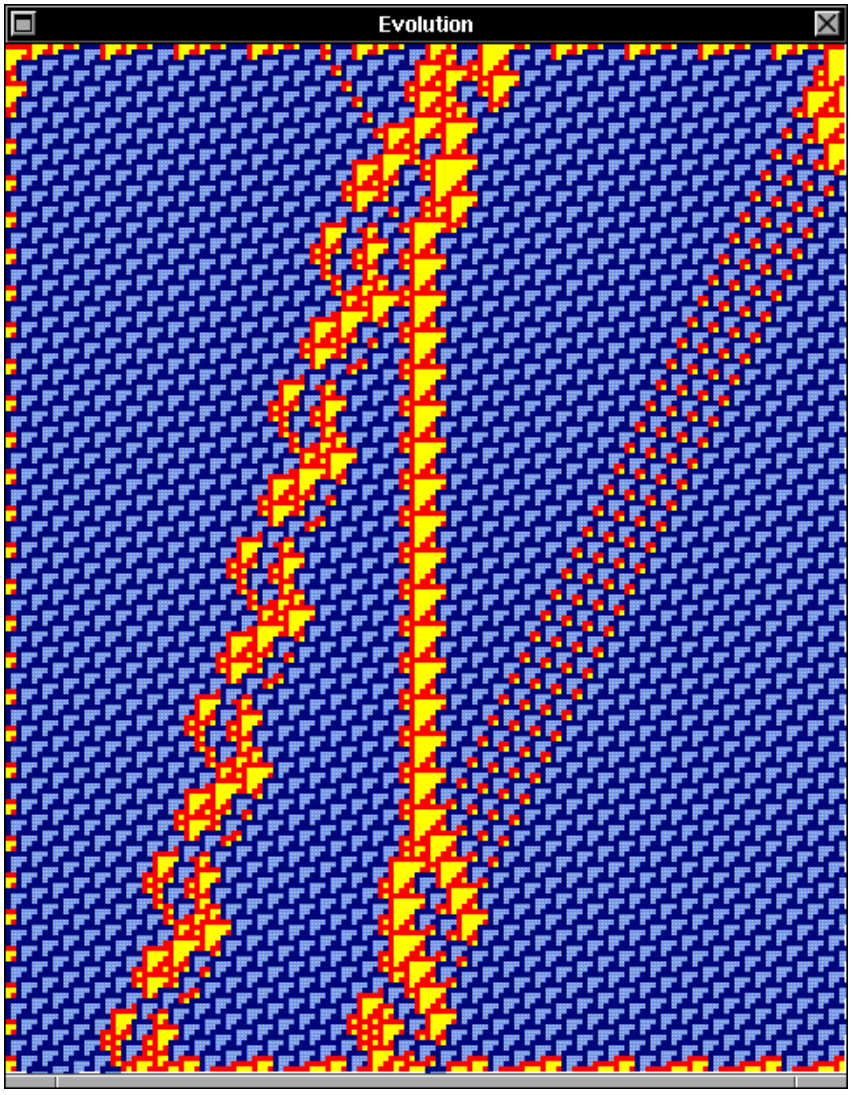


Figure 4.44: Collisions of glider A, A(p1)-e(p1)-G(p1)(B)=C1,Ebar

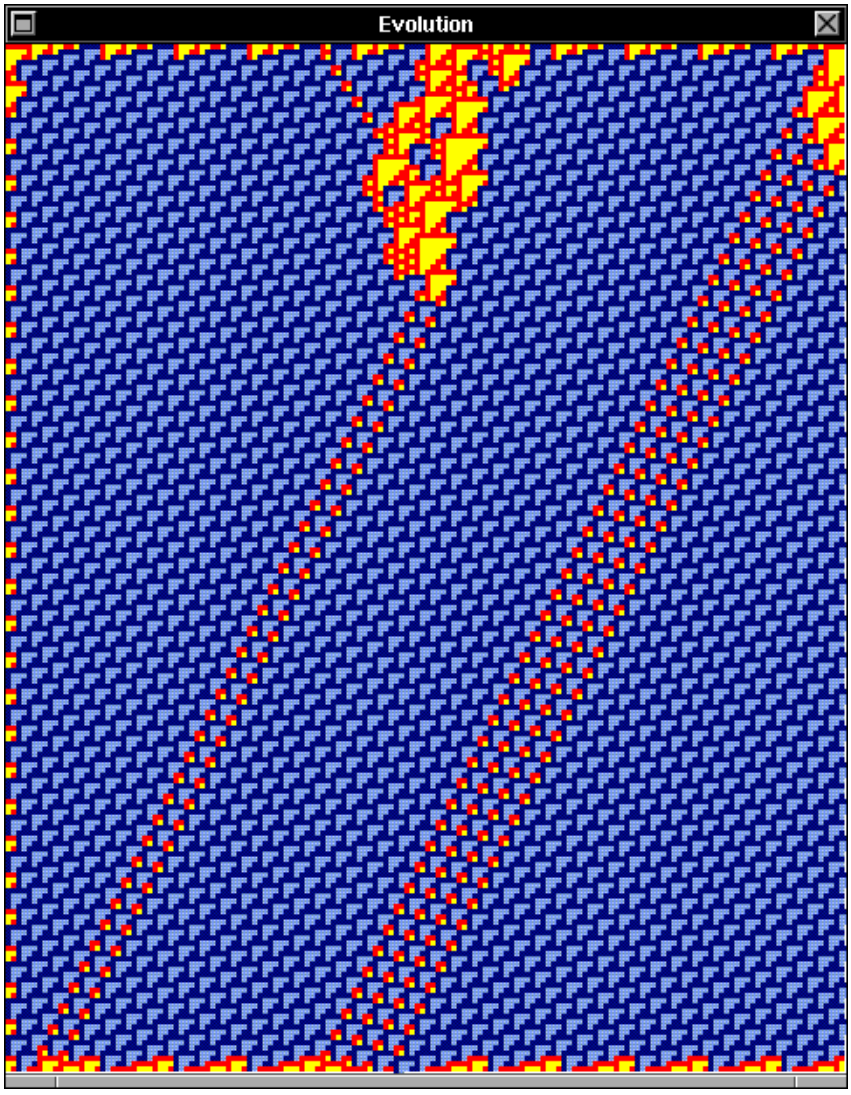


Figure 4.45: Collisions of glider A, A(p1)-e(p1)-G(p1)(C)=2B

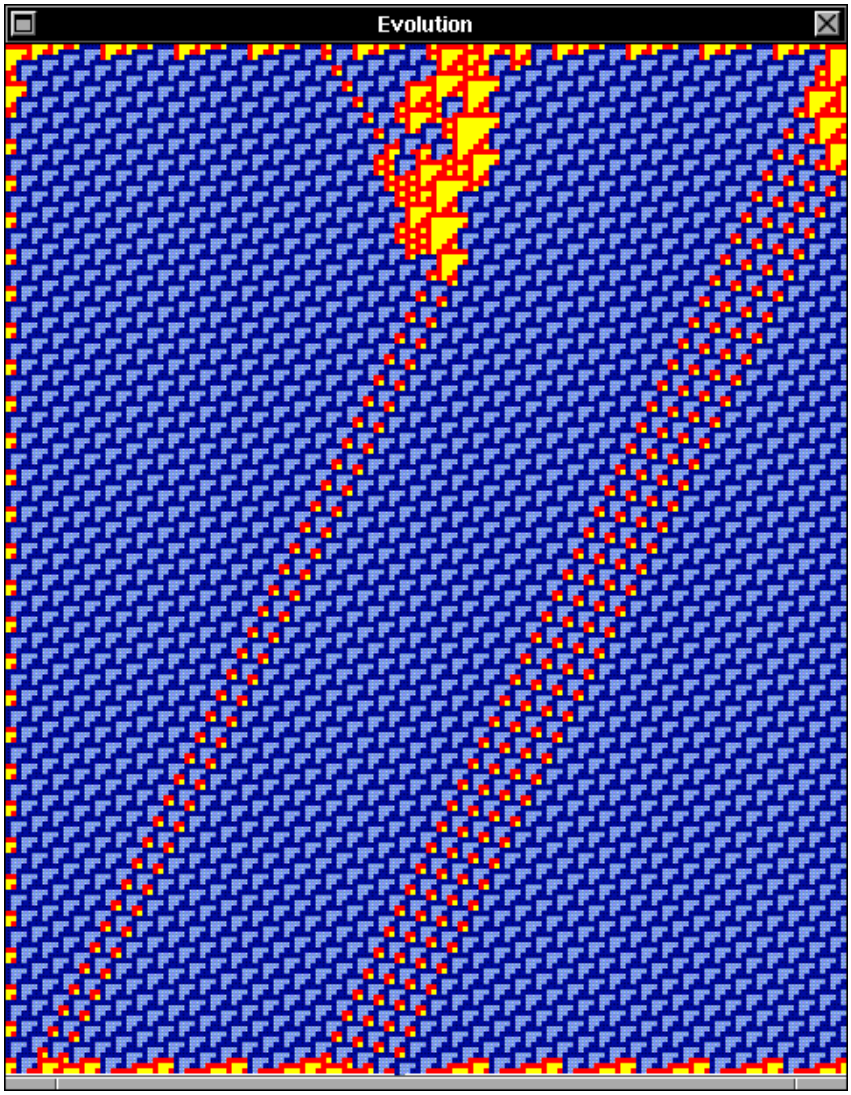


Figure 4.46: Collisions of glider A, A(p1)-e(p1)-G(p1)(D)=2B

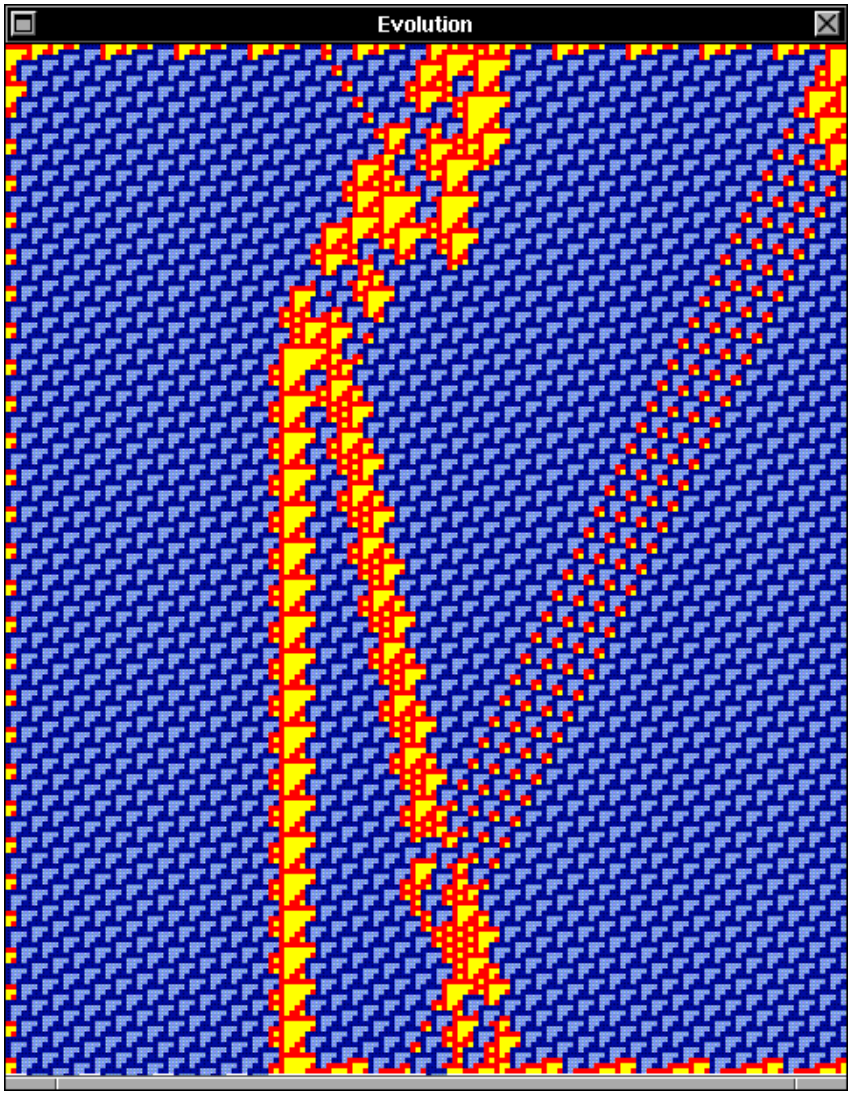


Figure 4.47: Collisions of glider A, A(p1)-e(p1)-G(p1)(E)=C3,D2

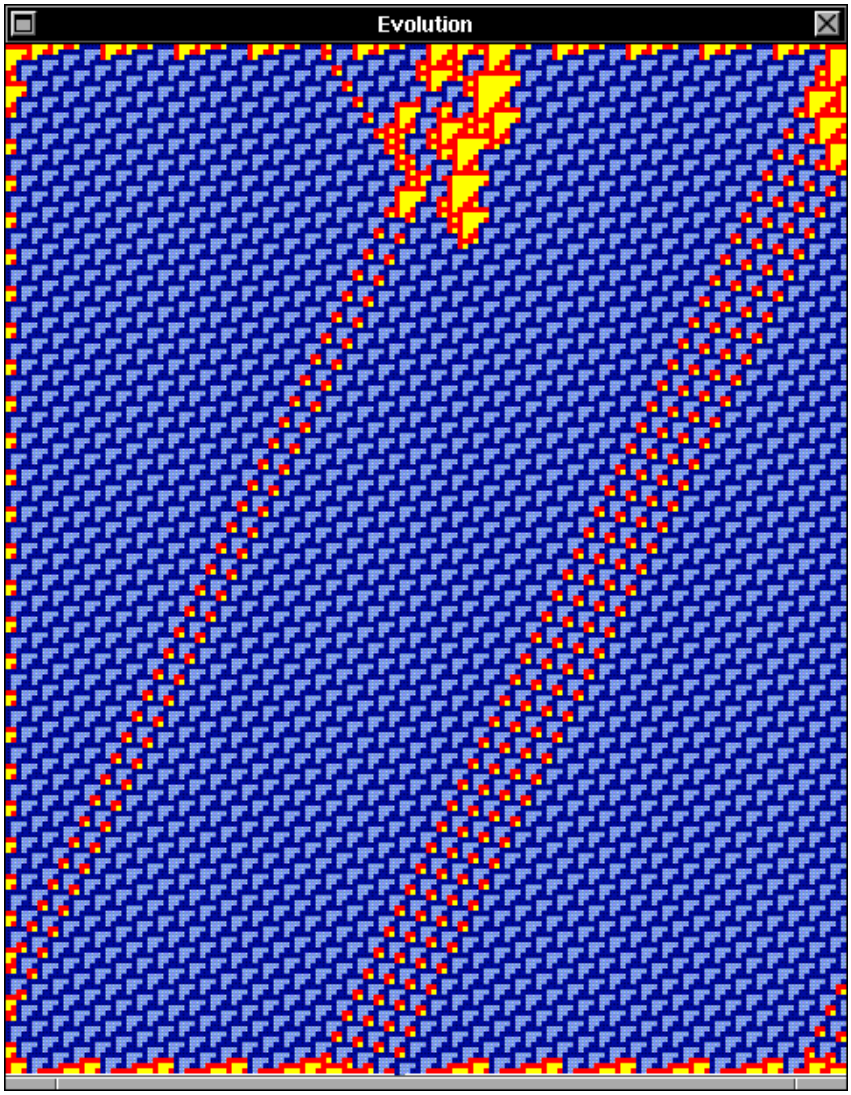


Figure 4.48: Collisions of glider A, A(p1)-e(p1)-G(p1)(F)=2B

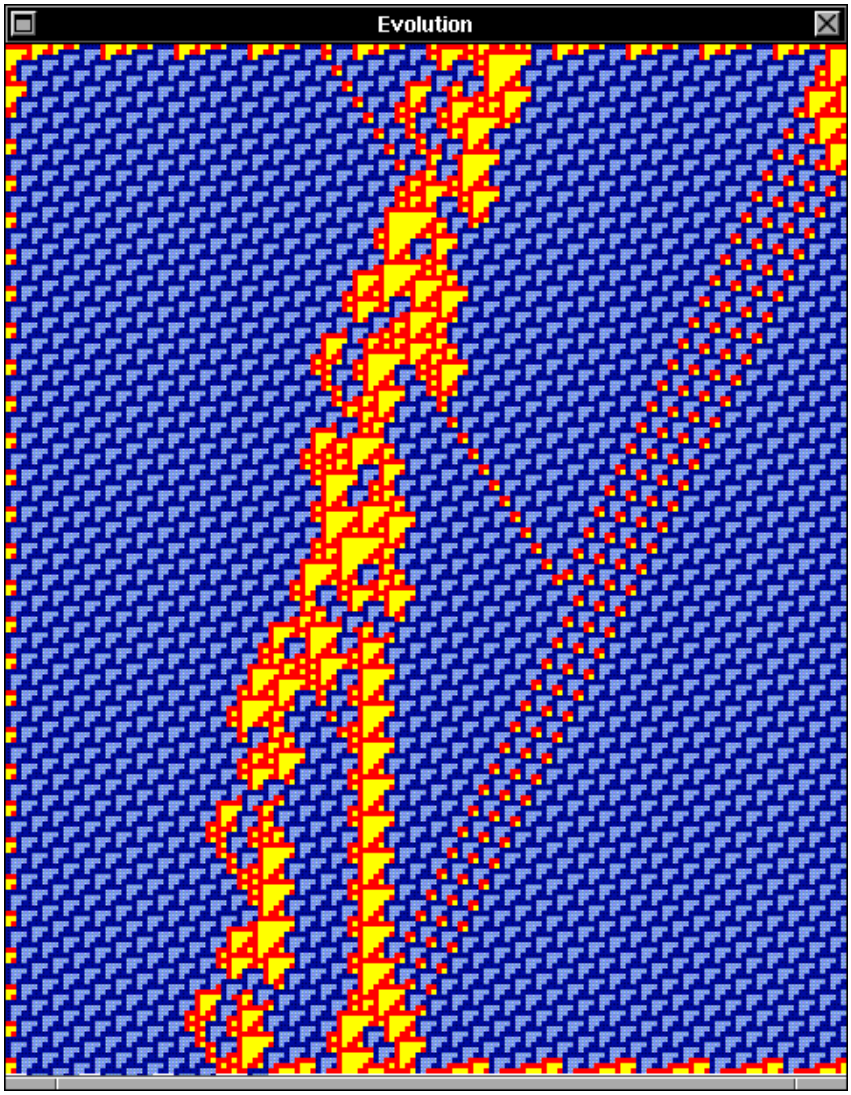


Figure 4.49: Collisions of glider A, A(p1)-e(p1)-G(p1)(G)=A,C1,F

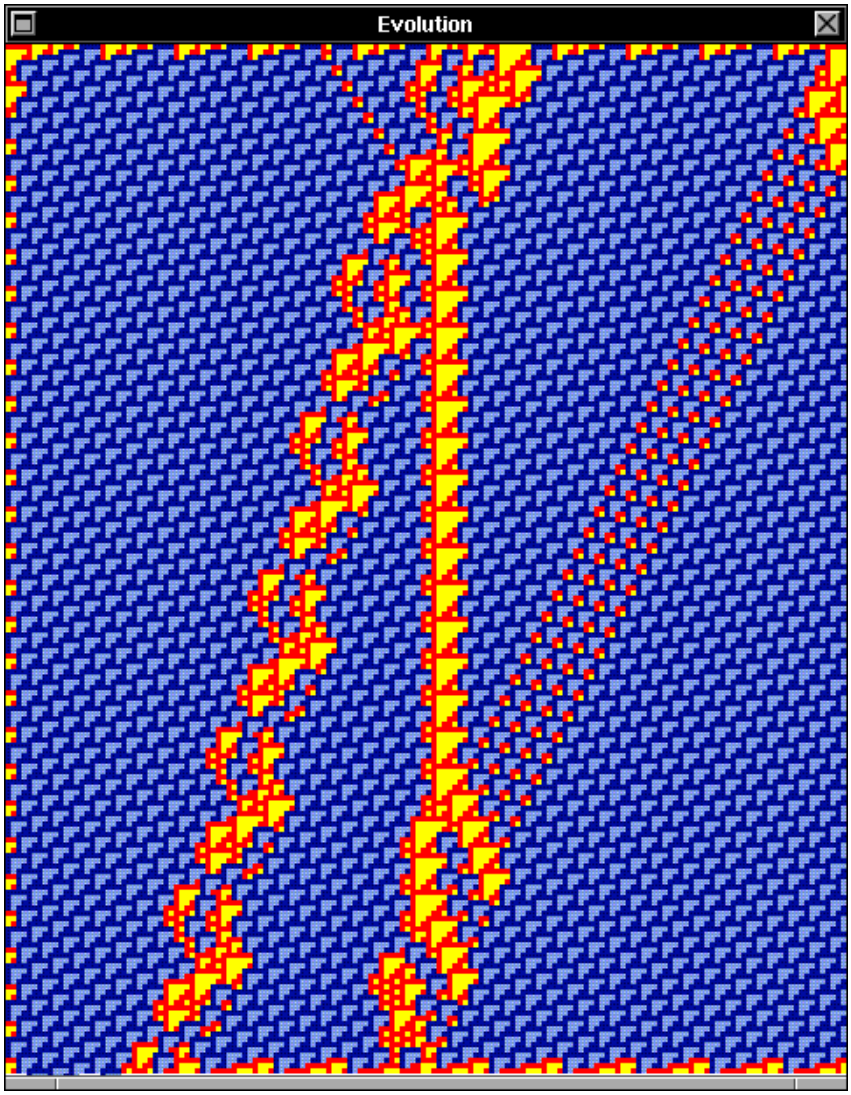


Figure 4.50: Collisions of glider A, A(p1)-e(p1)-G(p1)(H)=Ebar,C1

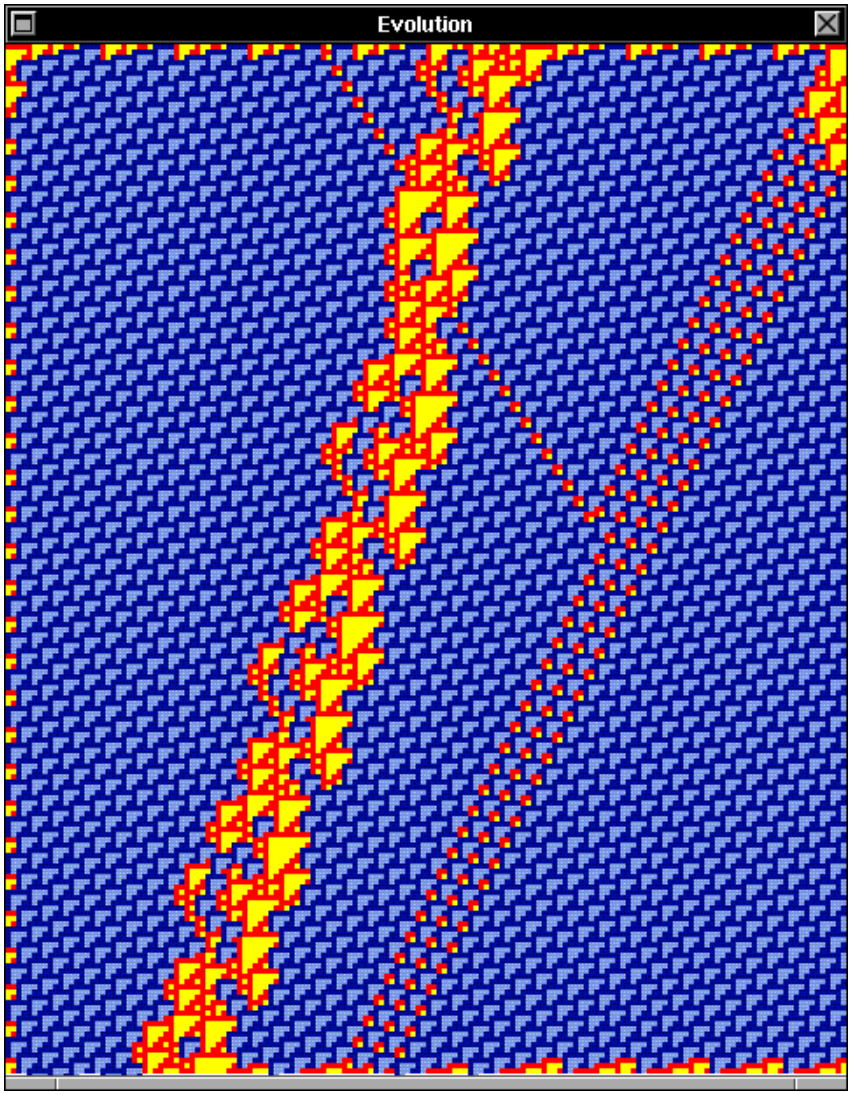


Figure 4.51: Collisions of glider A, A(p1)-e(p1)-G(p1)(A2)=A,G; across

4.2.13 Collisions of glider A with glider H

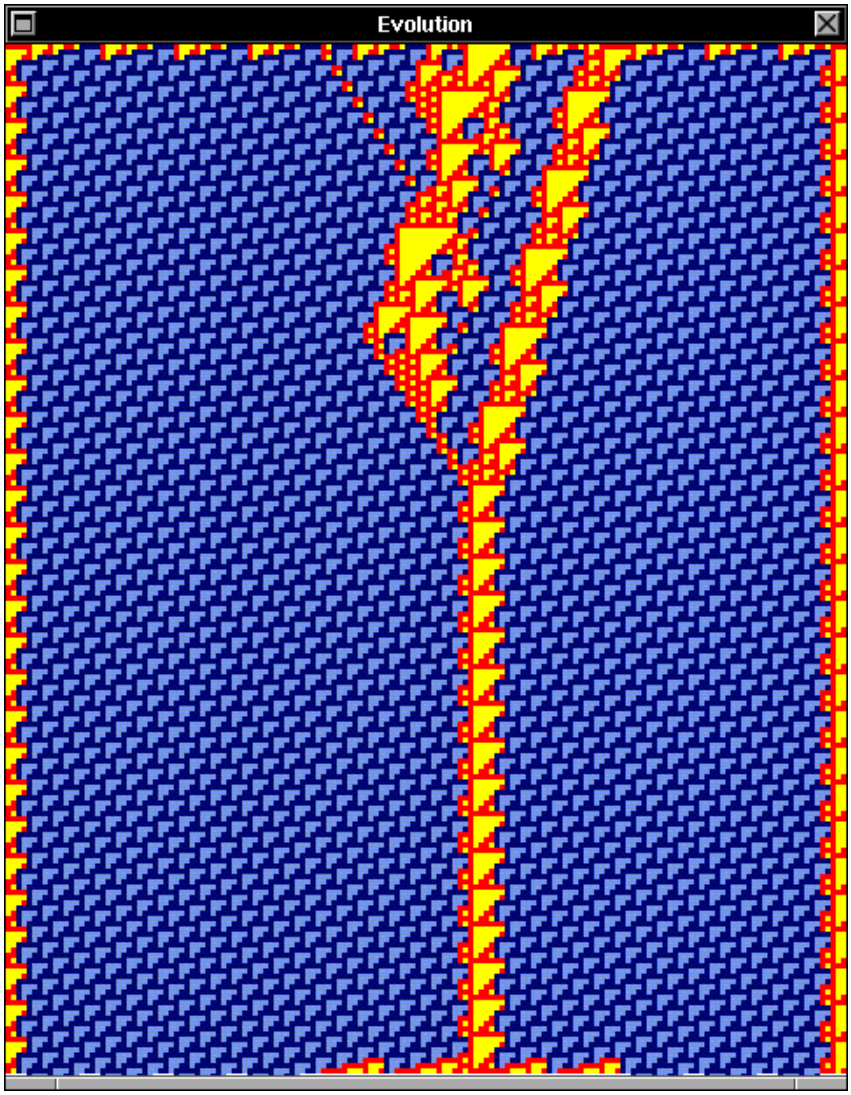


Figure 4.52: Collisions of glider A, A(p1)-e(p1)-H(p1)(A)=C2

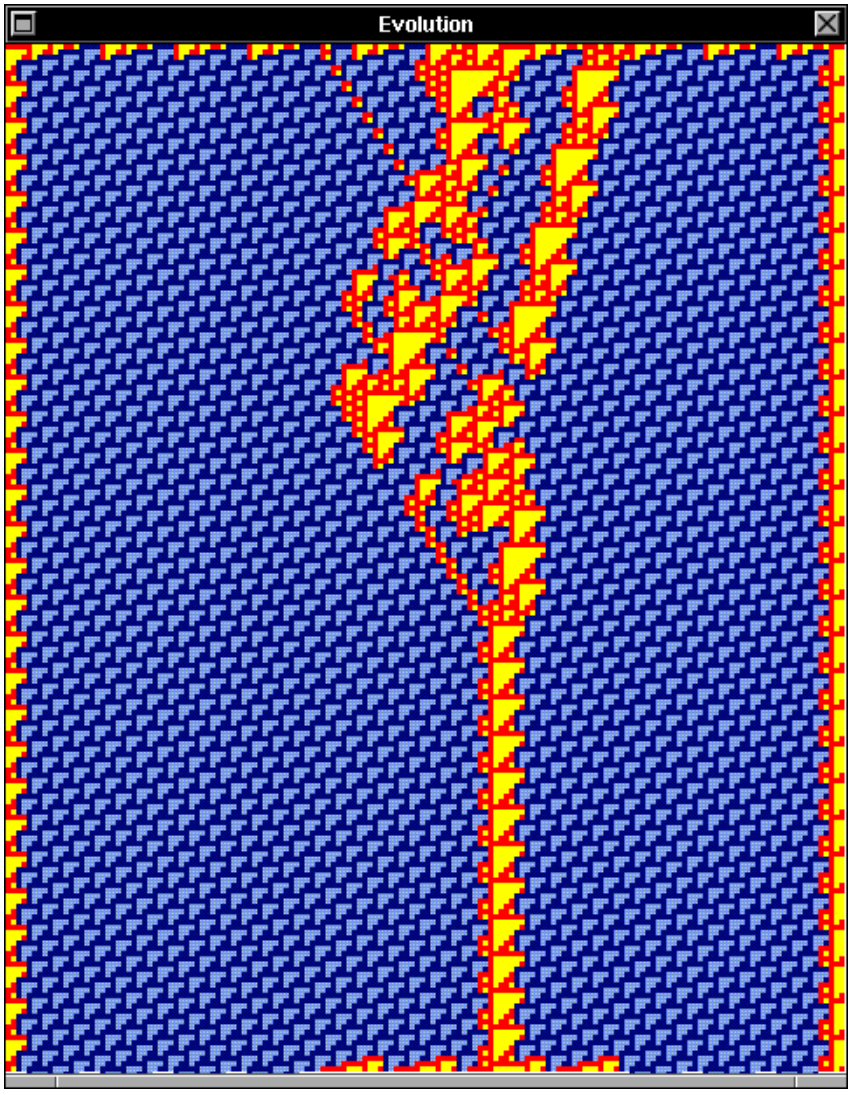


Figure 4.53: Collisions of glider A, A(p1)-e(p1)-H(p1)(B)=C2

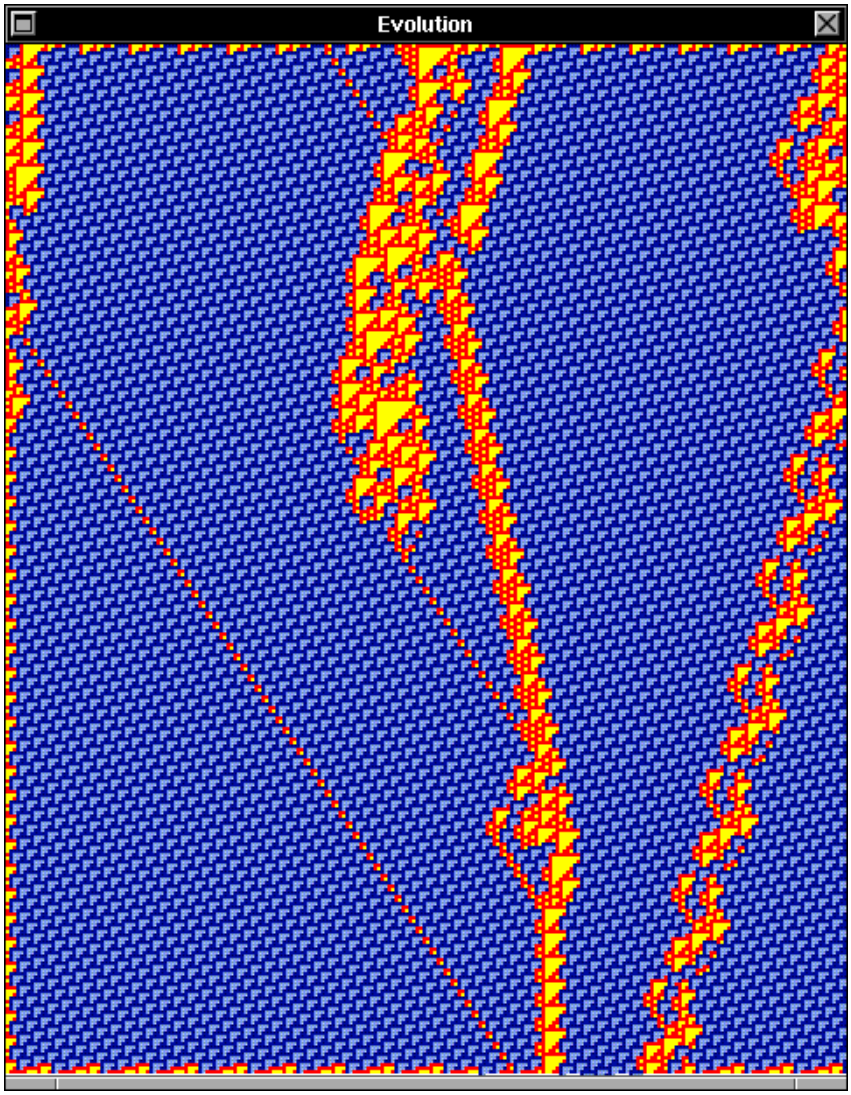


Figure 4.54: Collisions of glider A, A(p1)-e(p1)-H(p1)(C)=C2

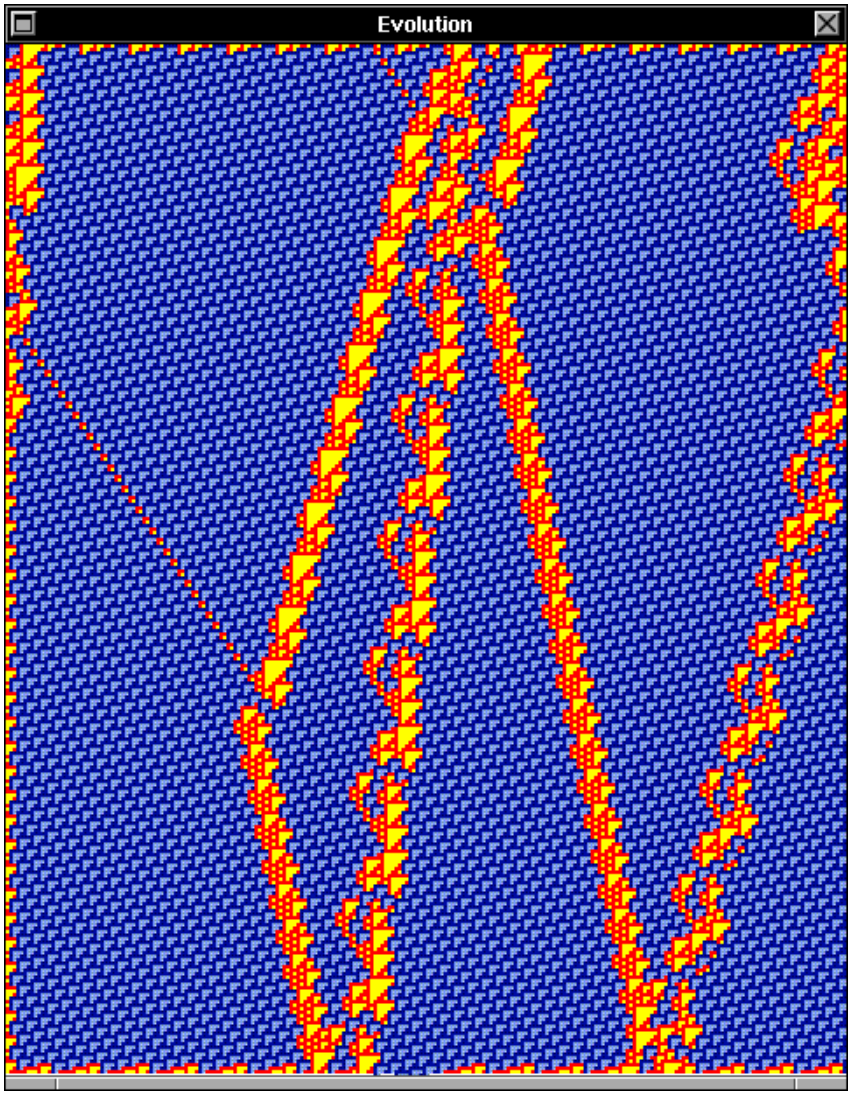


Figure 4.55: Collisions of glider A, A(p1)-e(p1)-H(p1)(G)=E,F,D1

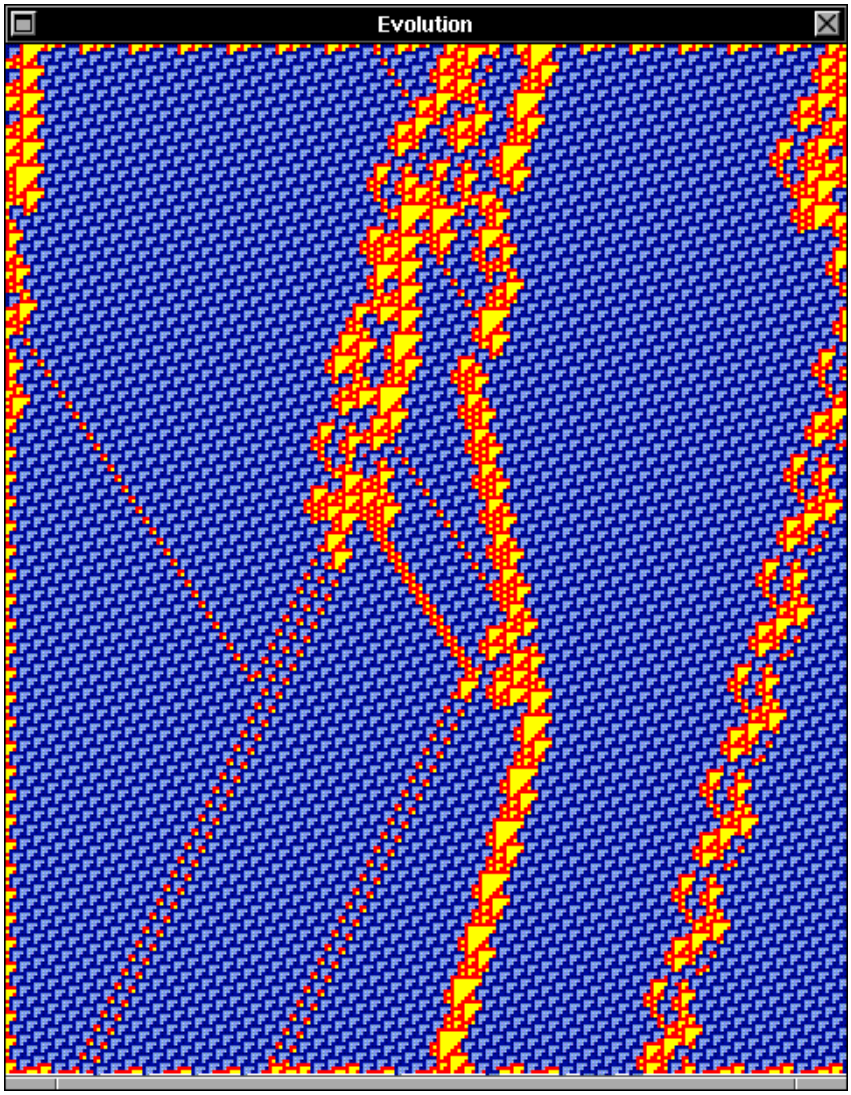


Figure 4.56: Collisions of glider A, A(p1)-e(p1)-H(p1)(H)=3B,2B,E

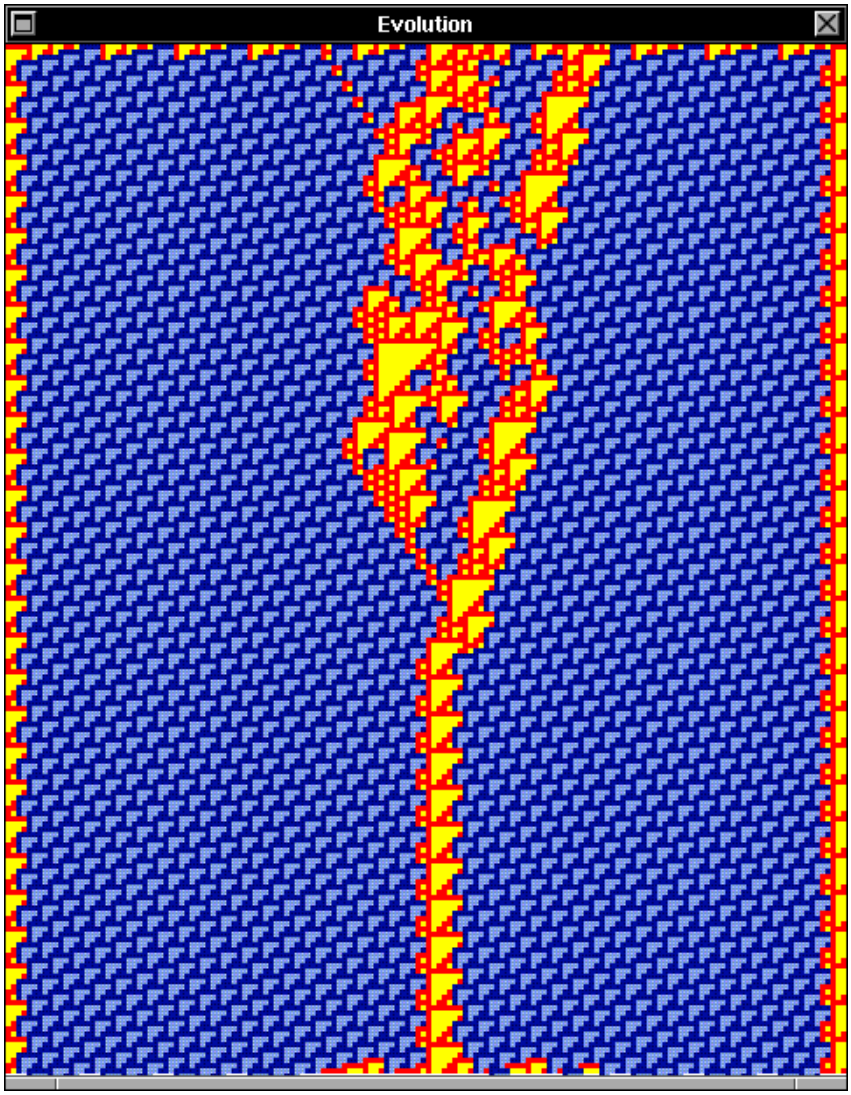


Figure 4.57: Collisions of glider A, A(p1)-e(p1)-H(p1)(A2)=C2

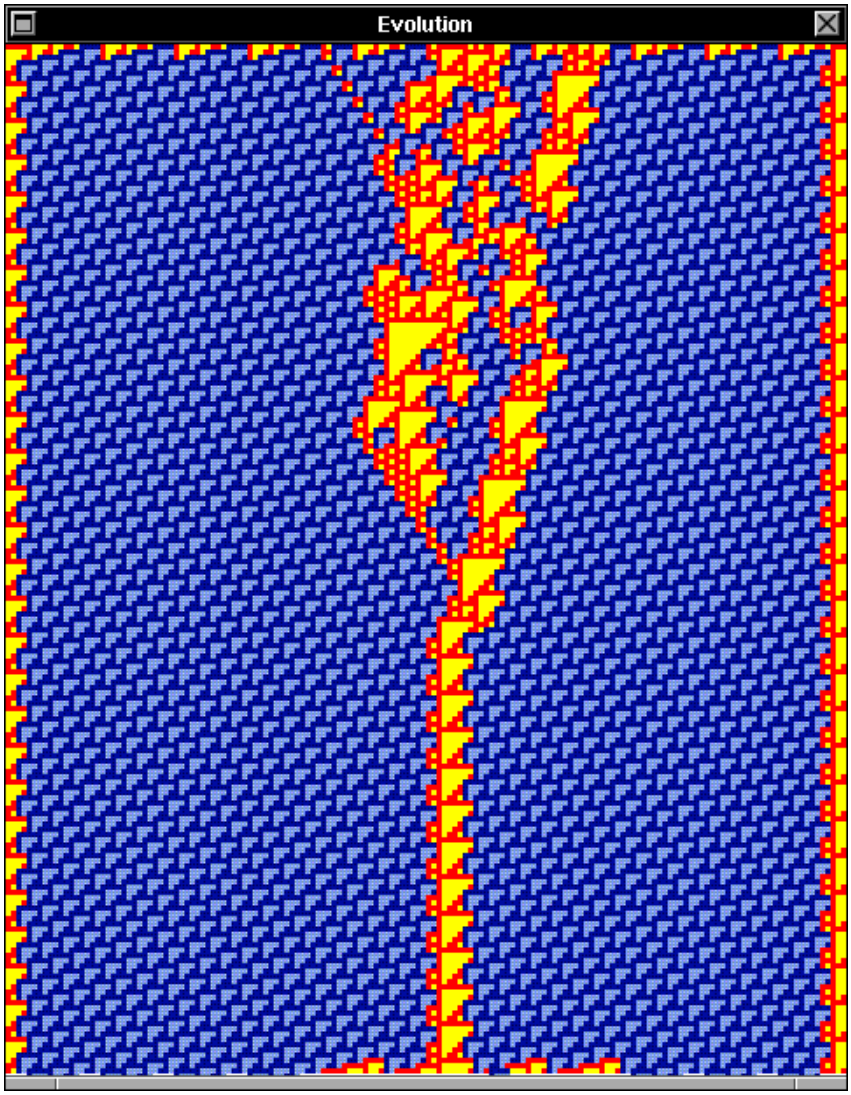


Figure 4.58: Collisions of glider A, A(p1)-e(p1)-H(p1)(B2)=C2

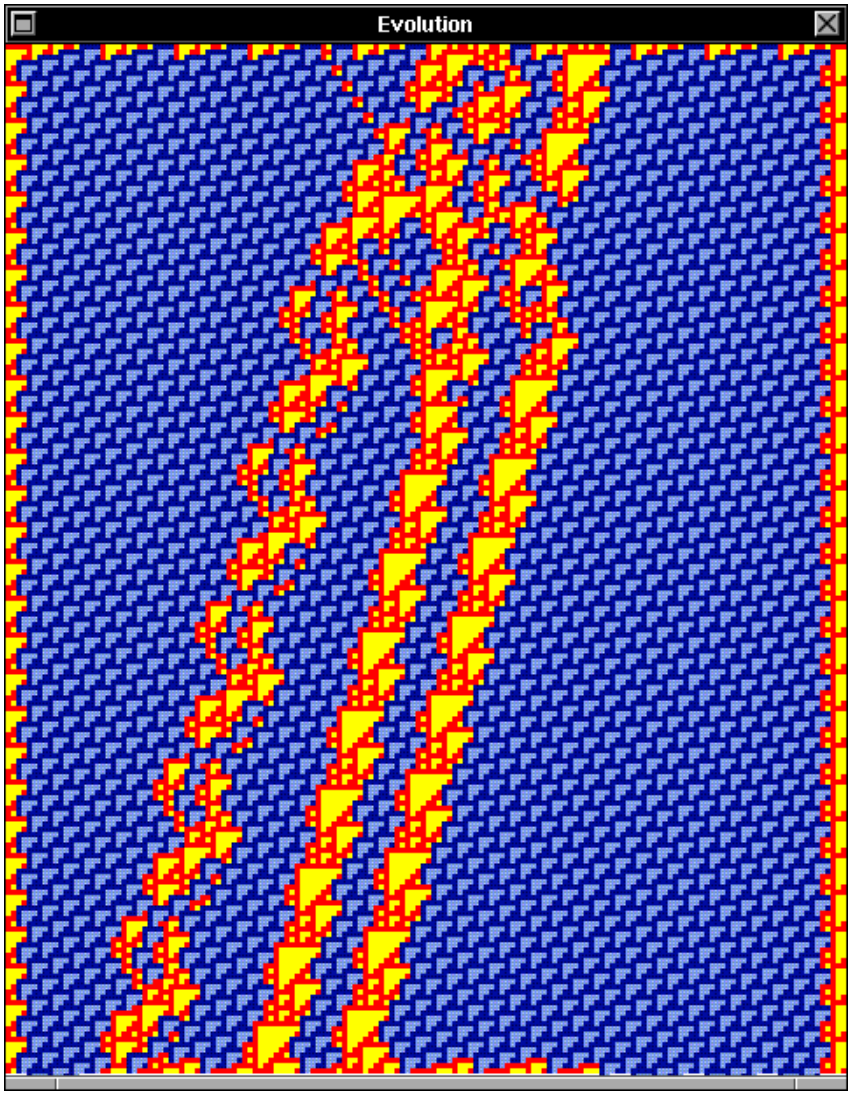


Figure 4.59: Collisions of glider A, A(p1)-e(p1)-H(p1)(C2)=Ebar,E,E

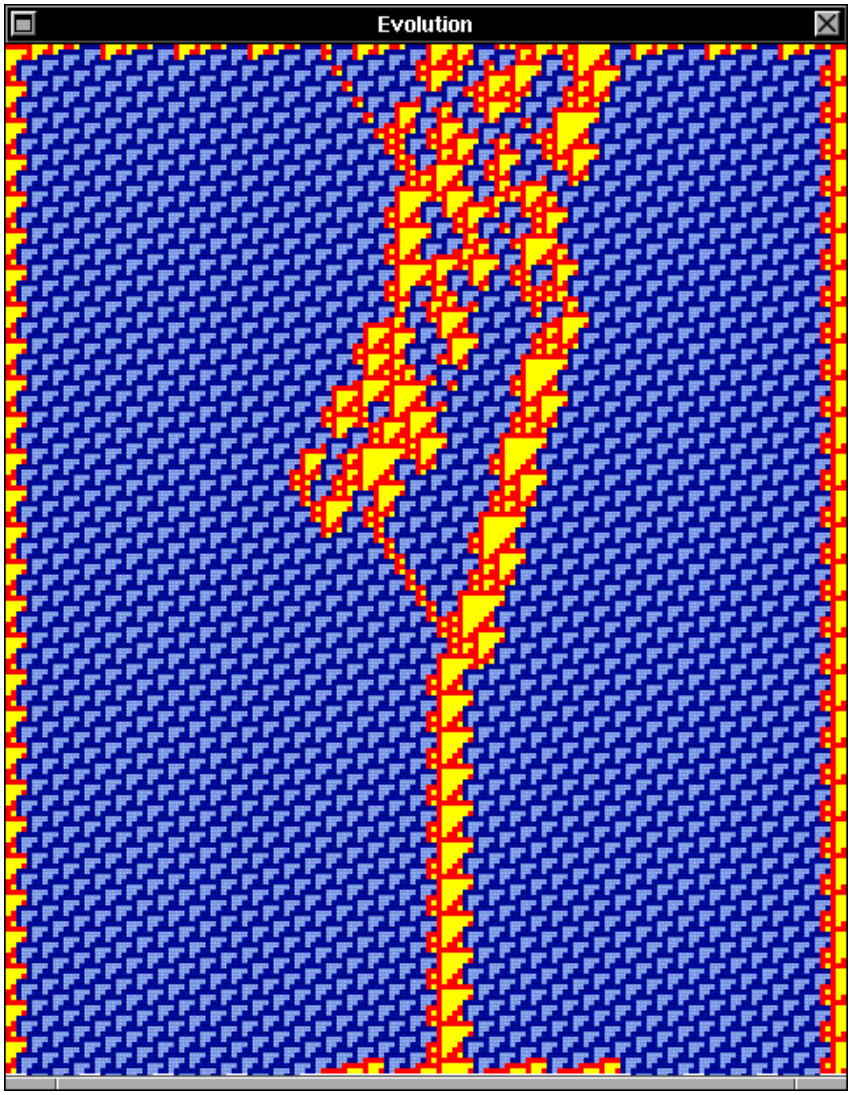


Figure 4.60: Collisions of glider A, A(p1)-e(p1)-H(p1)(D2)=C2

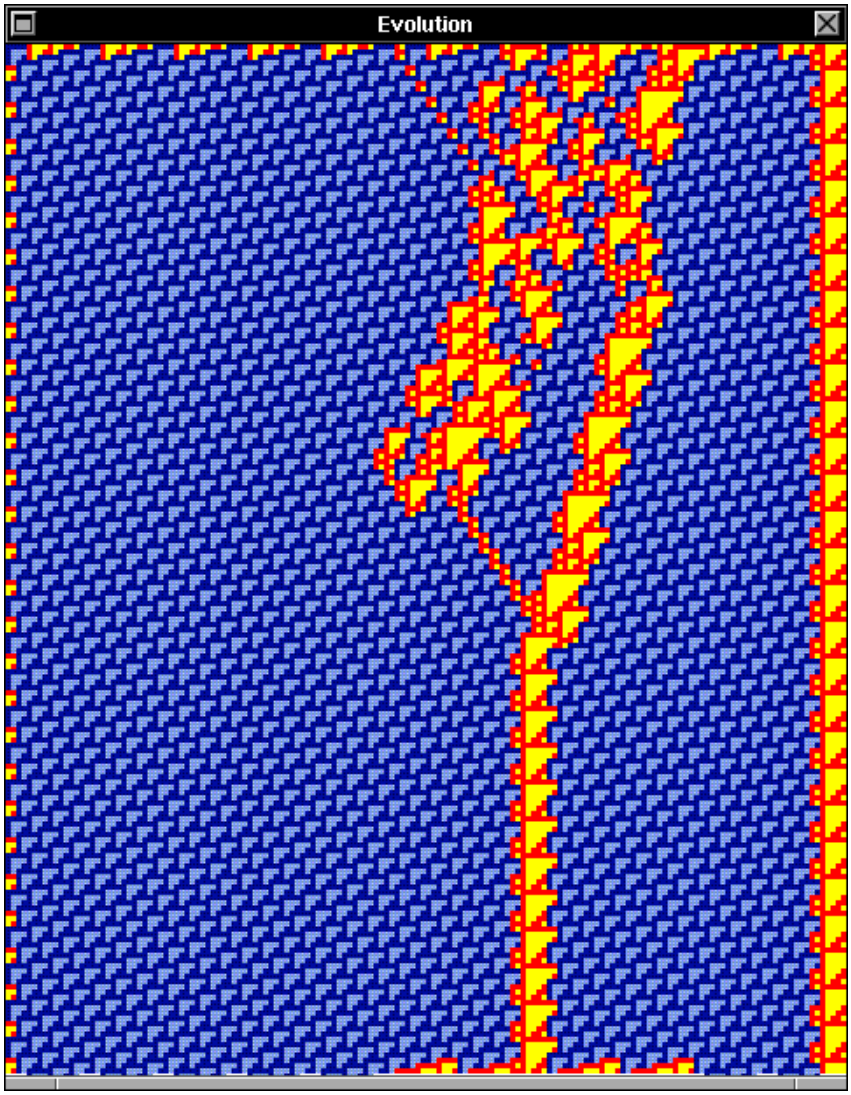


Figure 4.61: Collisions of glider A, A(p1)-e(p1)-H(p1)(E2)=C2

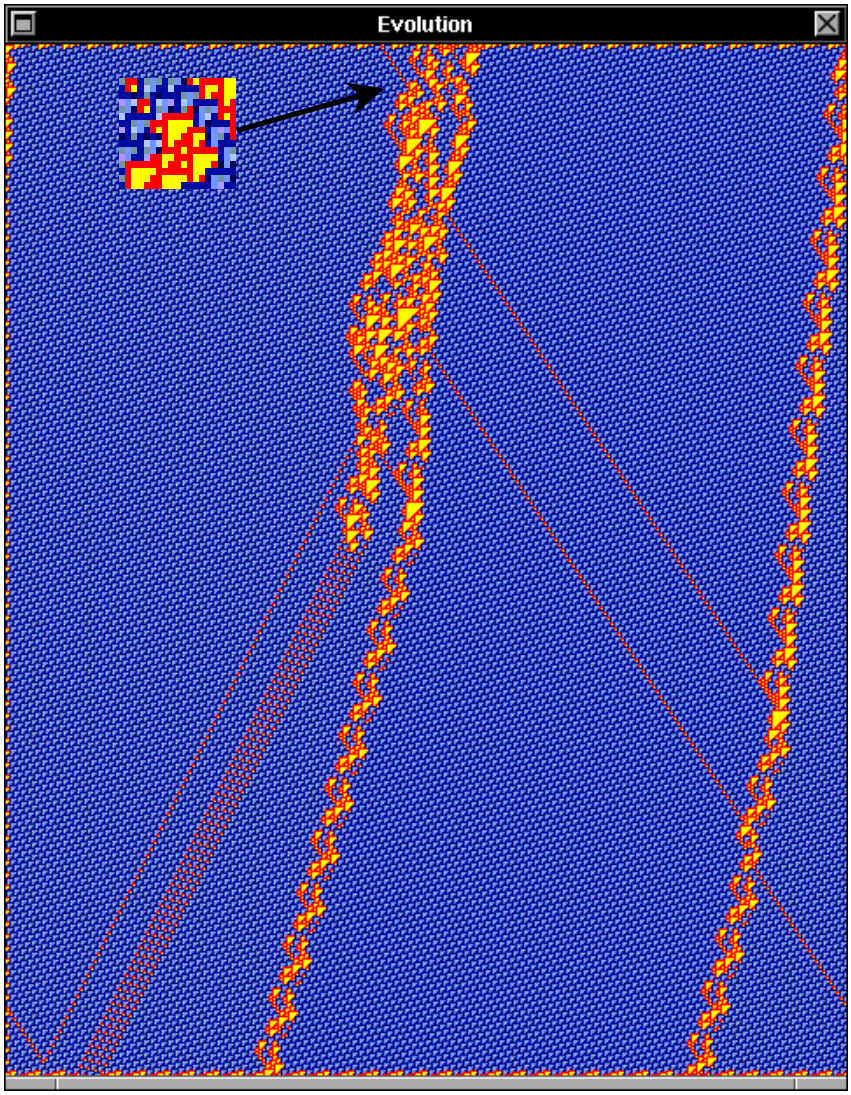


Figure 4.62: Collisions of glider A, A(p1)-e(p1)-H(p1)(F2)=B,4B,Ebar

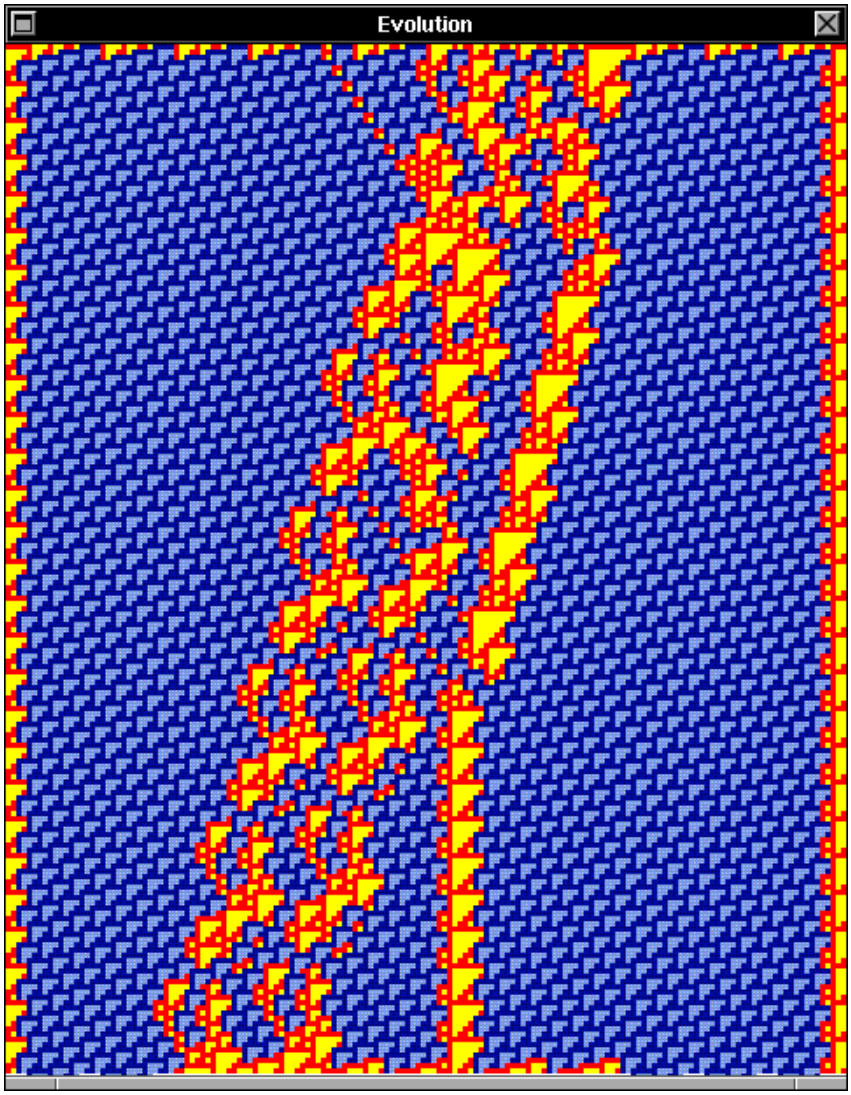


Figure 4.63: Collisions of glider A, A(p1)-e(p1)-H(p1)(G2)=Ebar,Ebar,C2

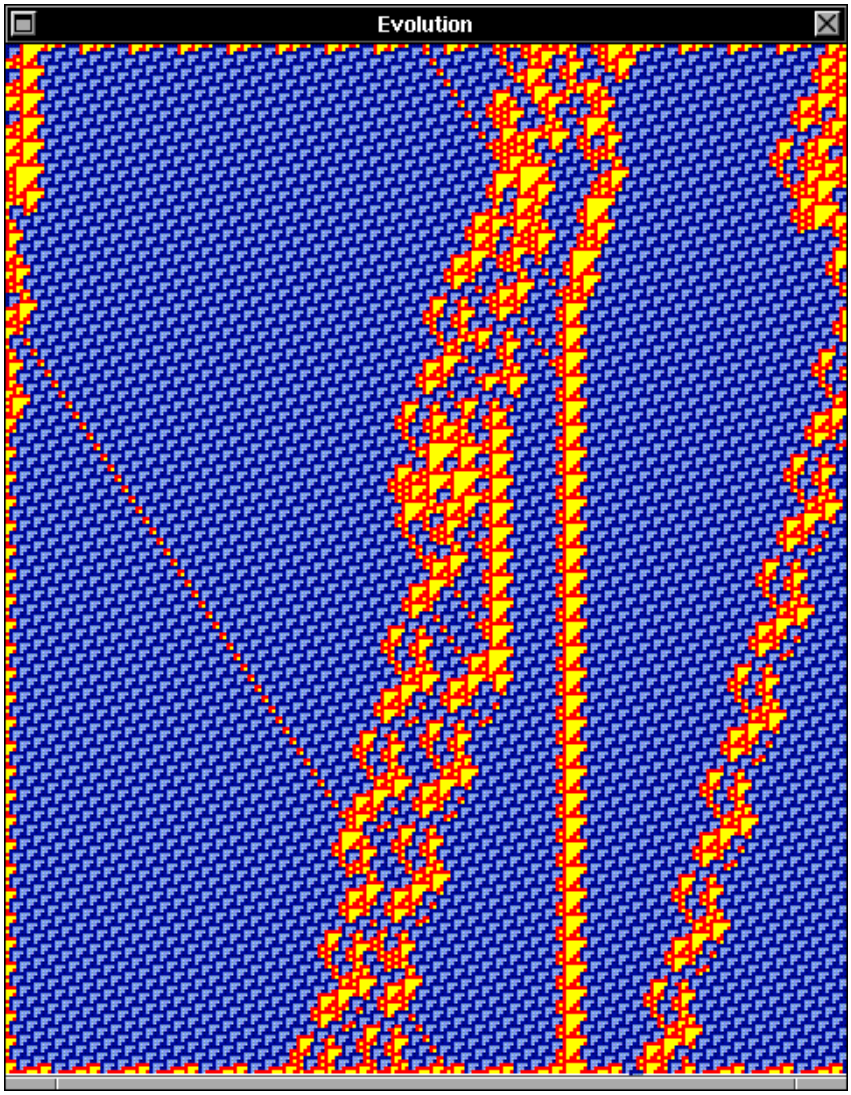


Figure 4.64: Collisions of glider A, A(p1)-e(p1)-H(p1)(H2)=Ebar,Ebar,C2

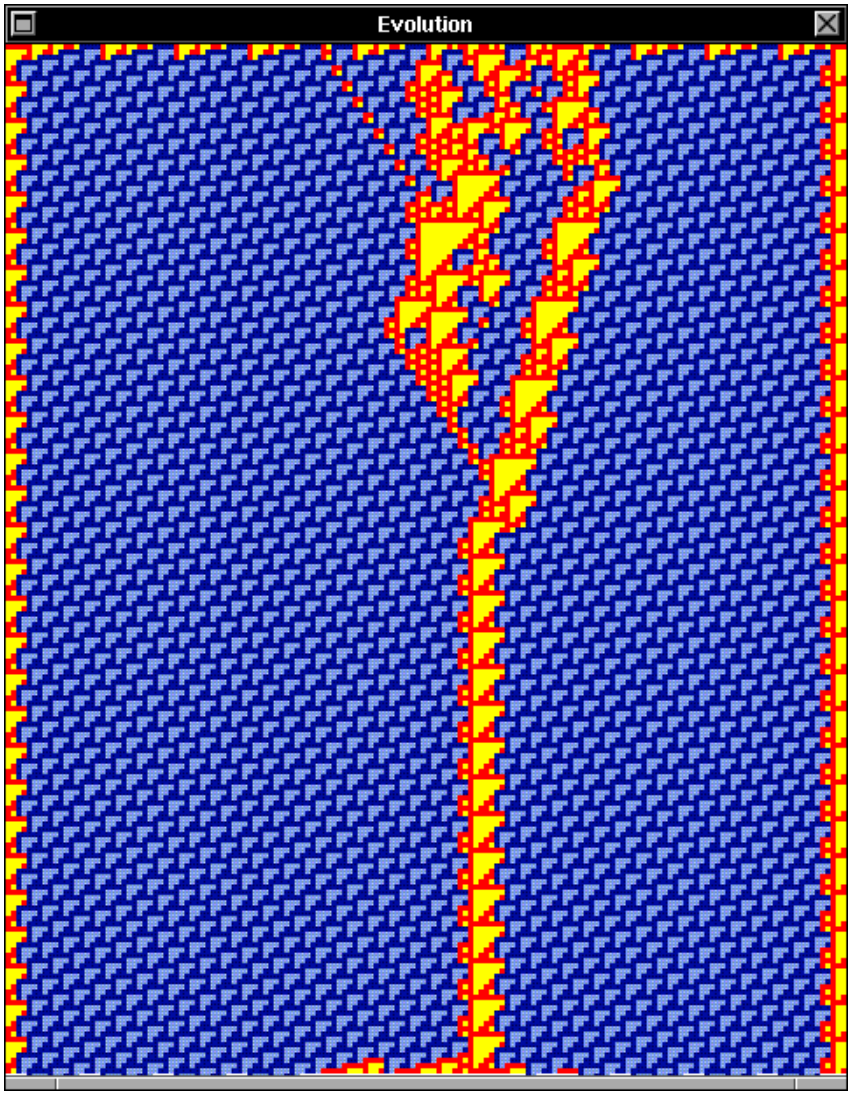


Figure 4.65: Collisions of glider A, A(p1)-e(p1)-H(p1)(C3)=C2

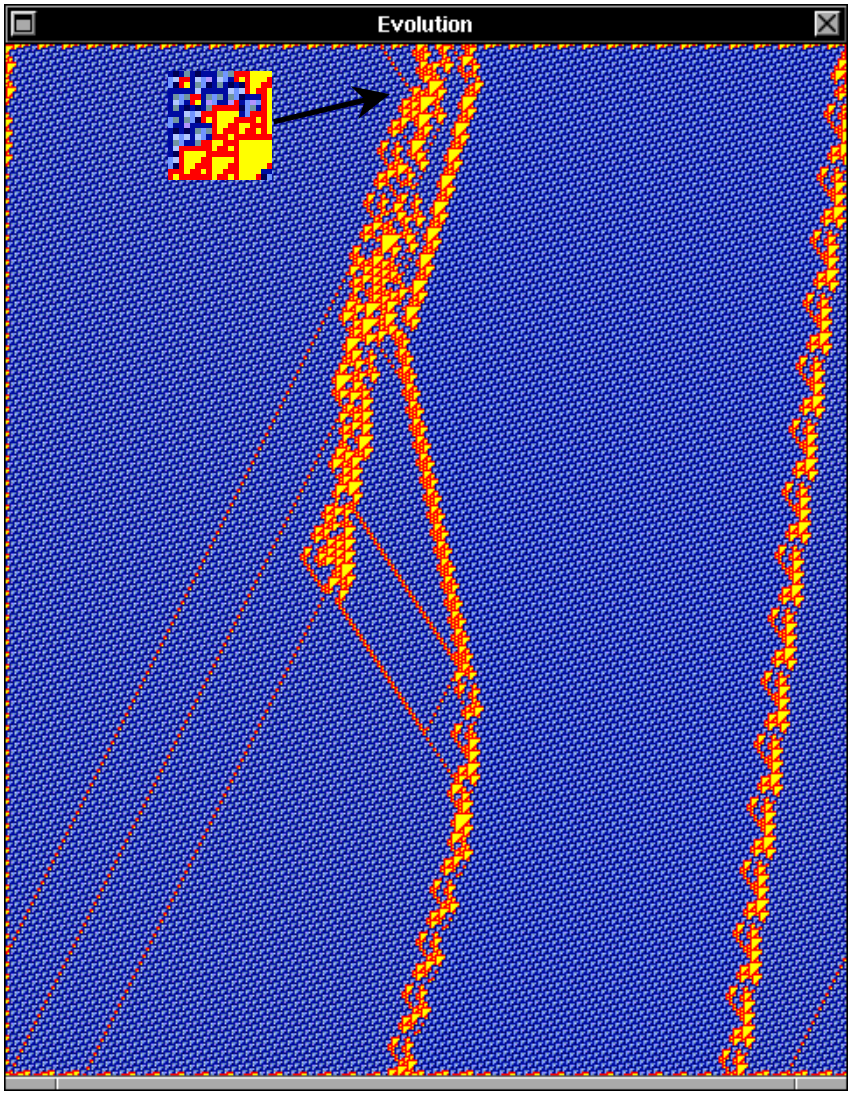


Figure 4.66: Collisions of glider A, A(p1)-e(p1)-H(p1)(D3)=B,B,B,Ebar

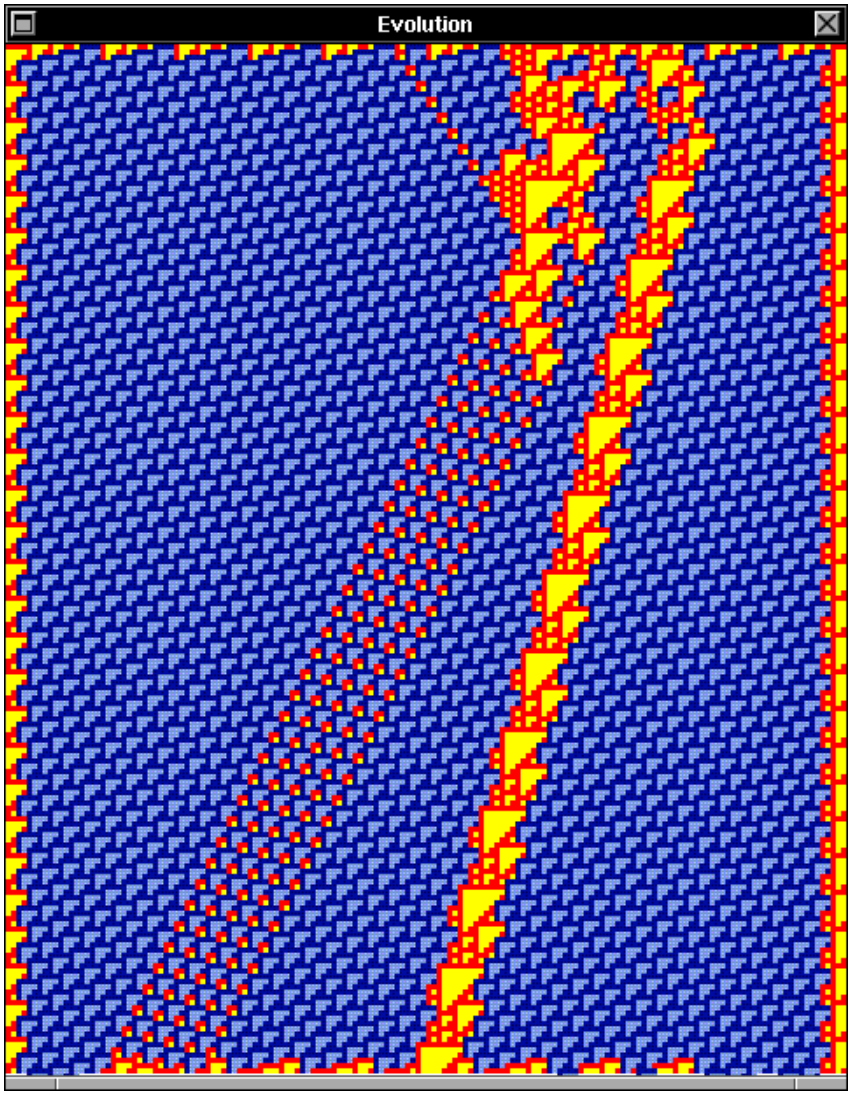


Figure 4.67: Collisions of glider A, A(p1)-e(p1)-H(p1)(E3)=5B,E

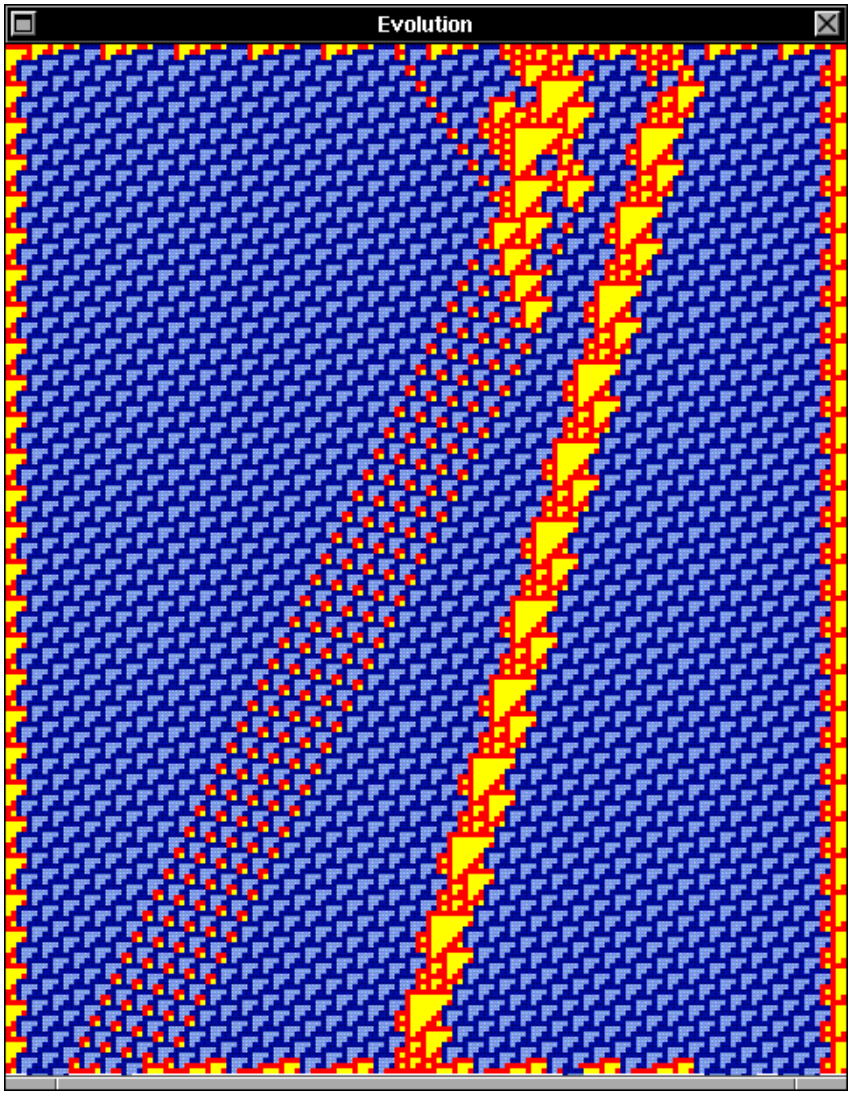


Figure 4.68: Collisions of glider A, A(p1)-e(p1)-H(p1)(H3)=5B,E

4.3 Collisions of glider B

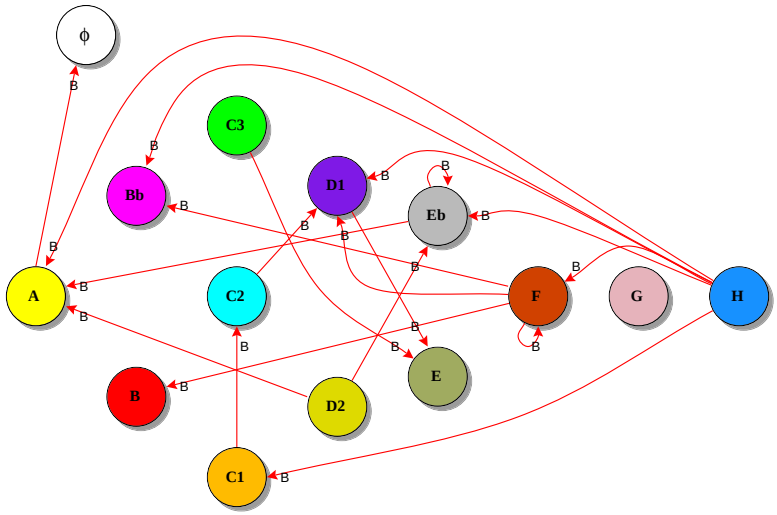


Figure 4.69: Collisions of glider B

	ϕ	A	B	$Bbar$	$C3$	$C2$	$C1$	$D2$	$D1$	E	$Ebar$	F	G	H
ϕ	.	1	.	.	.	.	.	.	.	.	.	.	.	.
A	.	.	.	.	.	.	.	1	.	.	1	.	.	1
B	.	.	.	.	.	.	.	.	.	.	.	1	.	.
$Bbar$	.	.	.	.	.	.	.	.	.	.	.	1	.	1
$C3$	.	.	.	.	.	.	.	.	.	.	.	.	.	.
$C2$	.	.	.	.	.	.	1	.	.	.	.	.	.	.
$C1$	.	.	.	.	.	.	.	.	.	.	.	.	.	1
$D2$	.	.	.	.	.	.	.	.	.	.	.	.	.	.
$D1$	.	.	.	.	.	1	.	.	.	.	.	1	.	1
E	.	.	.	.	1	.	.	.	1	.	.	.	.	.
$Ebar$	.	.	.	.	.	.	.	.	1	.	1	.	.	1
F	.	.	.	.	.	.	.	.	.	.	.	1	.	1
G	.	.	.	.	.	.	.	.	.	.	.	.	.	.
H	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Table 4.2: Matrix connection of collisions glider B

4.3.1 Collisions of glider B with glider C1

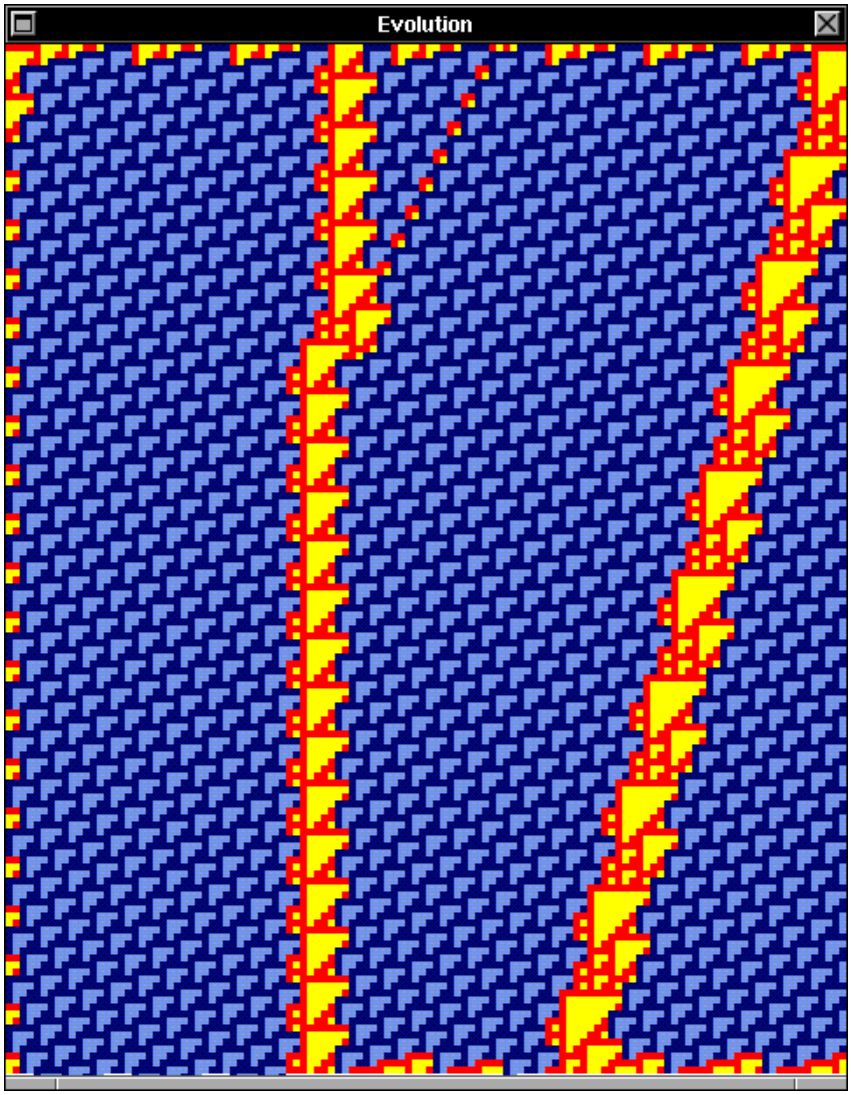


Figure 4.70: Collisions of glider B, C1(p1)(A)-e(p1)-B(p1)=C2

4.3.2 Collisions of glider B with glider C2

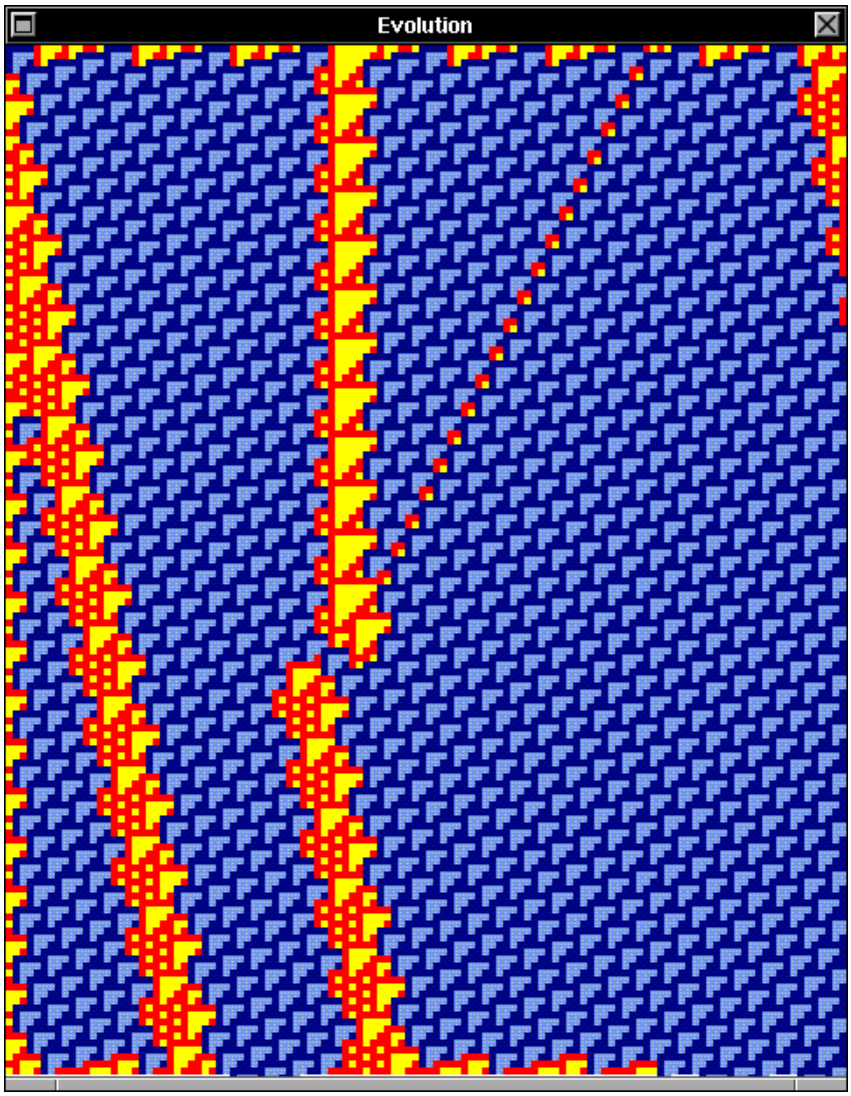


Figure 4.71: Collisions of glider B, C2(p1)(A)-e(p1)-B(p1)=D1

4.3.3 Collisions of glider B with glider C3

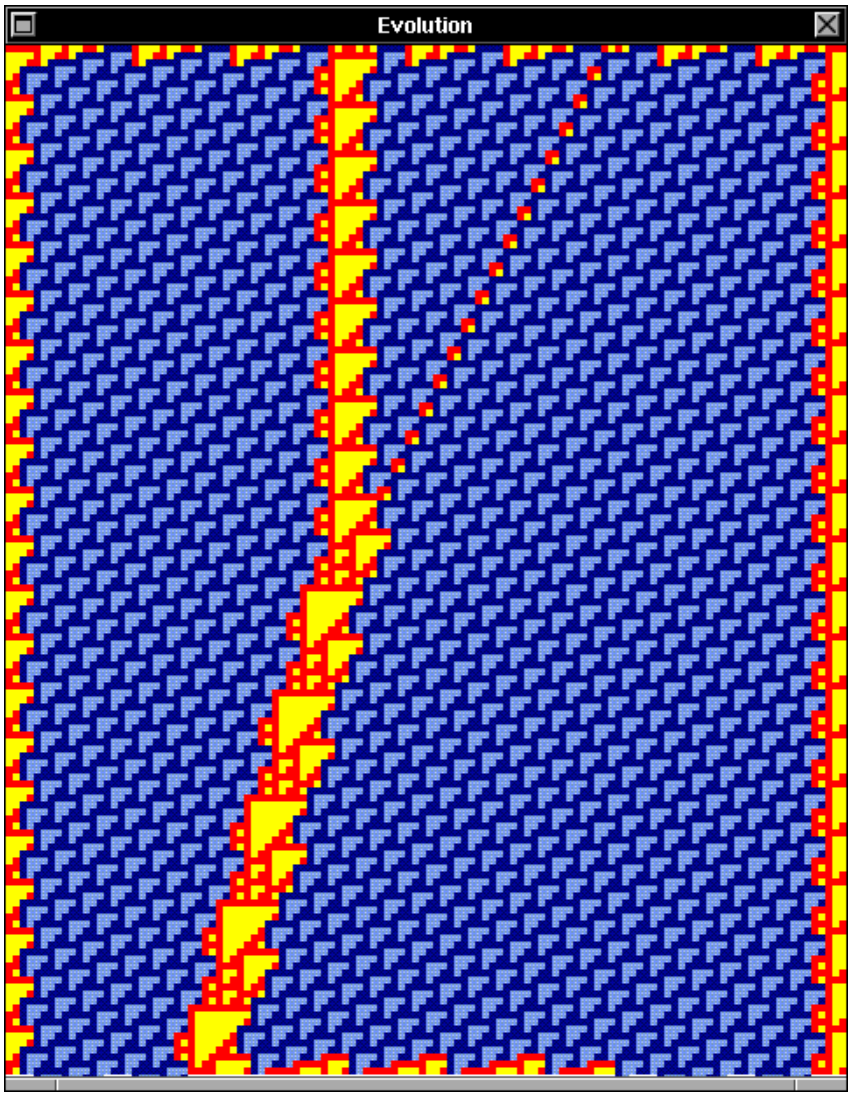


Figure 4.72: Collisions of glider B, C3(p1)(A)-e(p1)-B(p1)=E

4.3.4 Collisions of glider B with glider D1

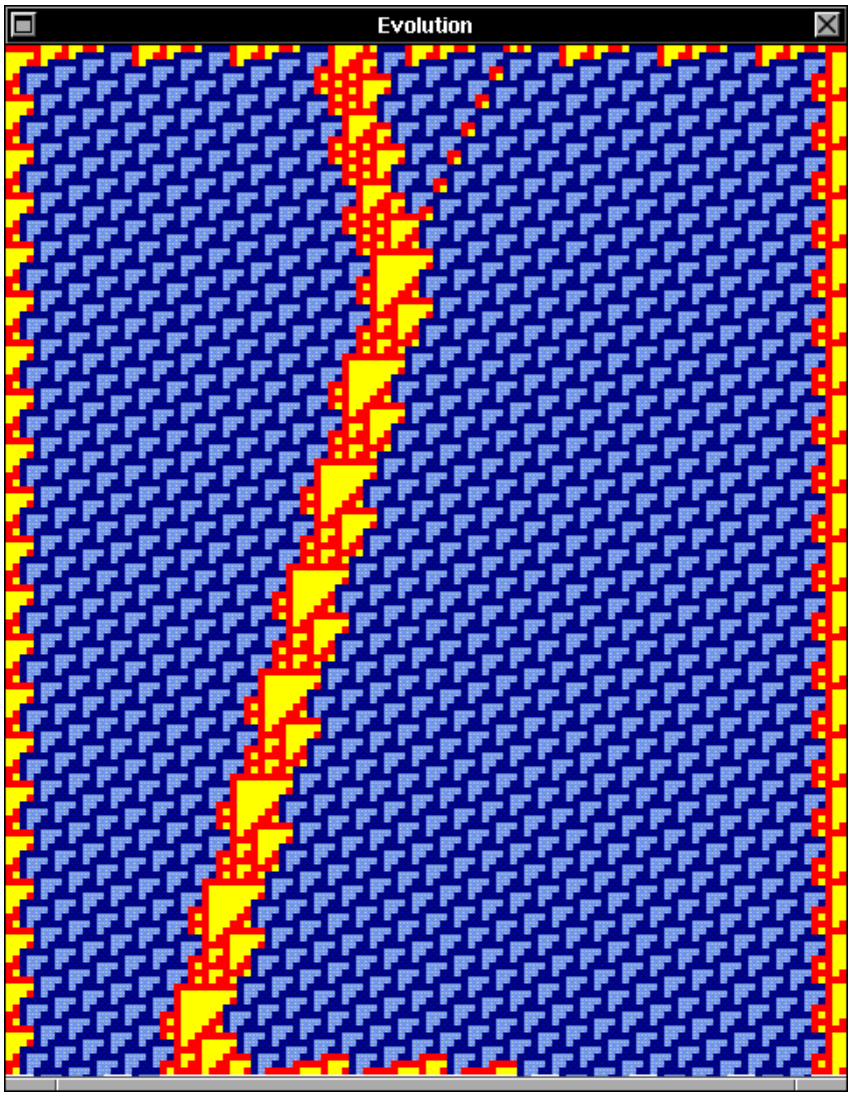


Figure 4.73: Collisions of glider B, D1(p1)(A)-e(p1)-B(p1)=E

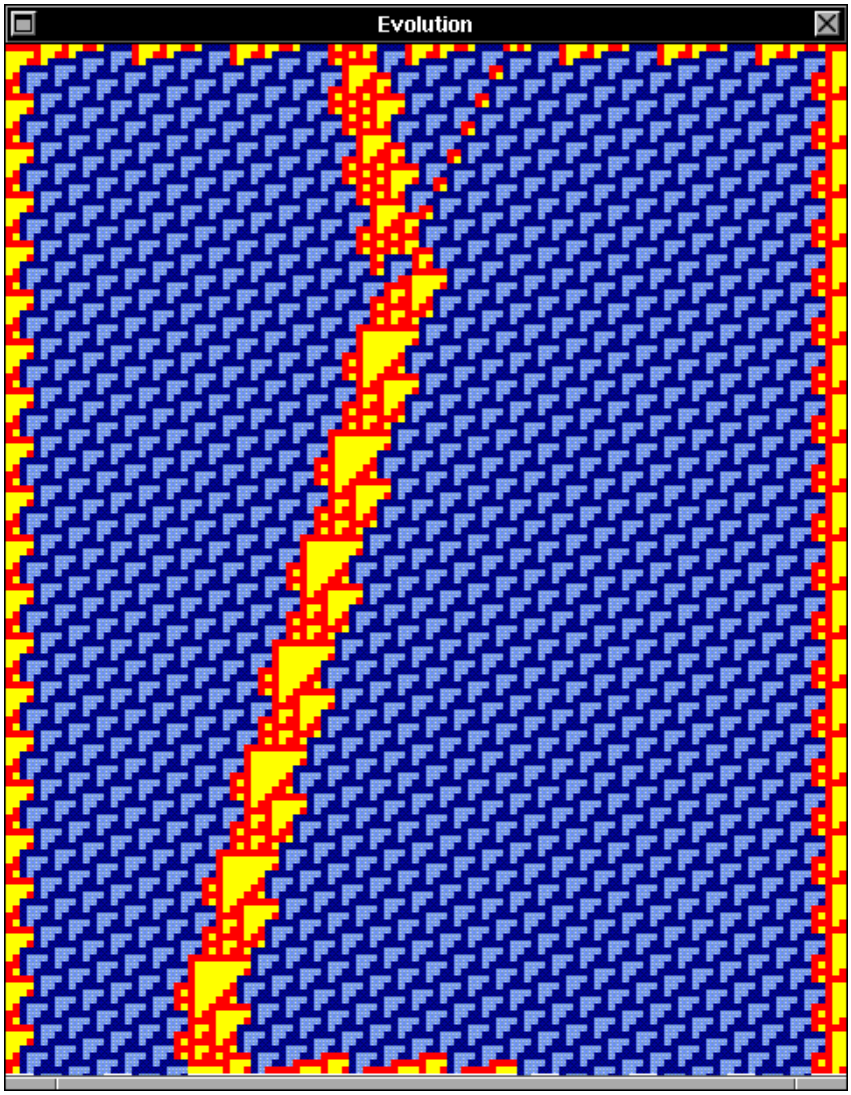


Figure 4.74: Collisions of glider B, D1(p1)(C)-e(p1)-B(p1)=E

4.3.5 Collisions of glider B with glider D2

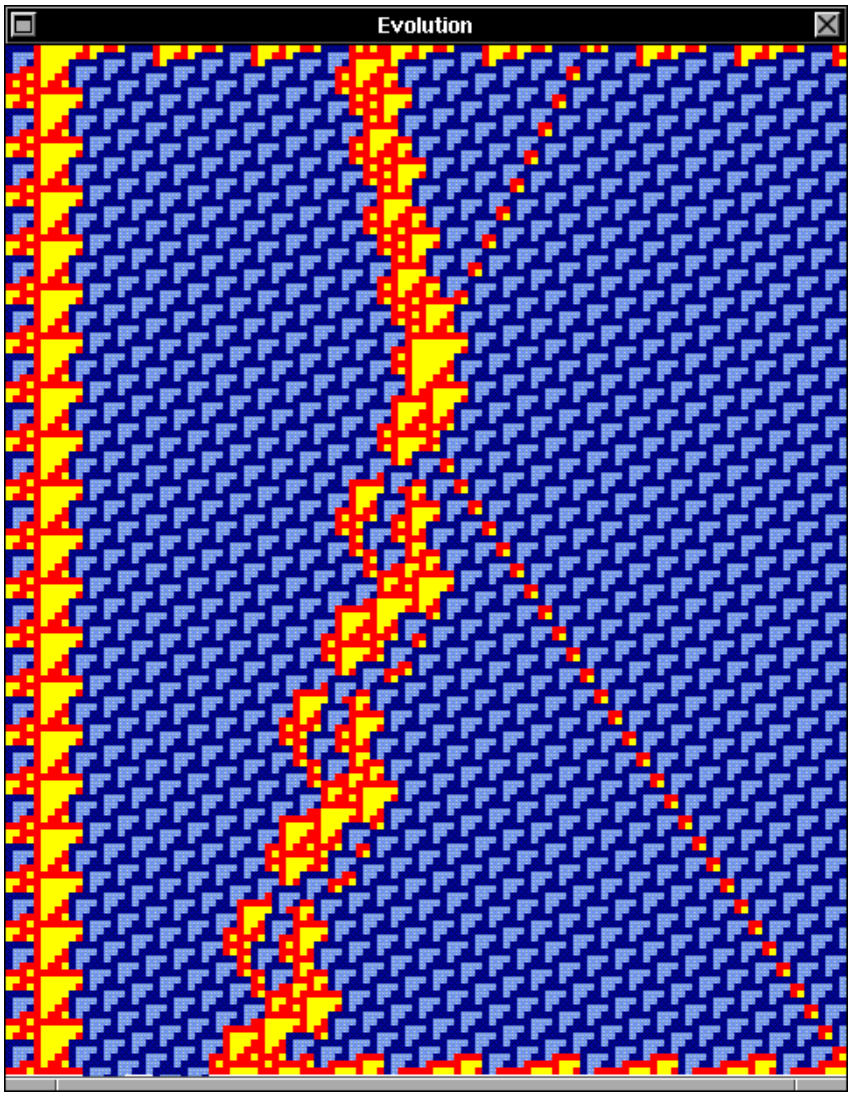


Figure 4.75: Collisions of glider B, D2(p1)(A)-e(p1)-B(p1)=A,Ebar

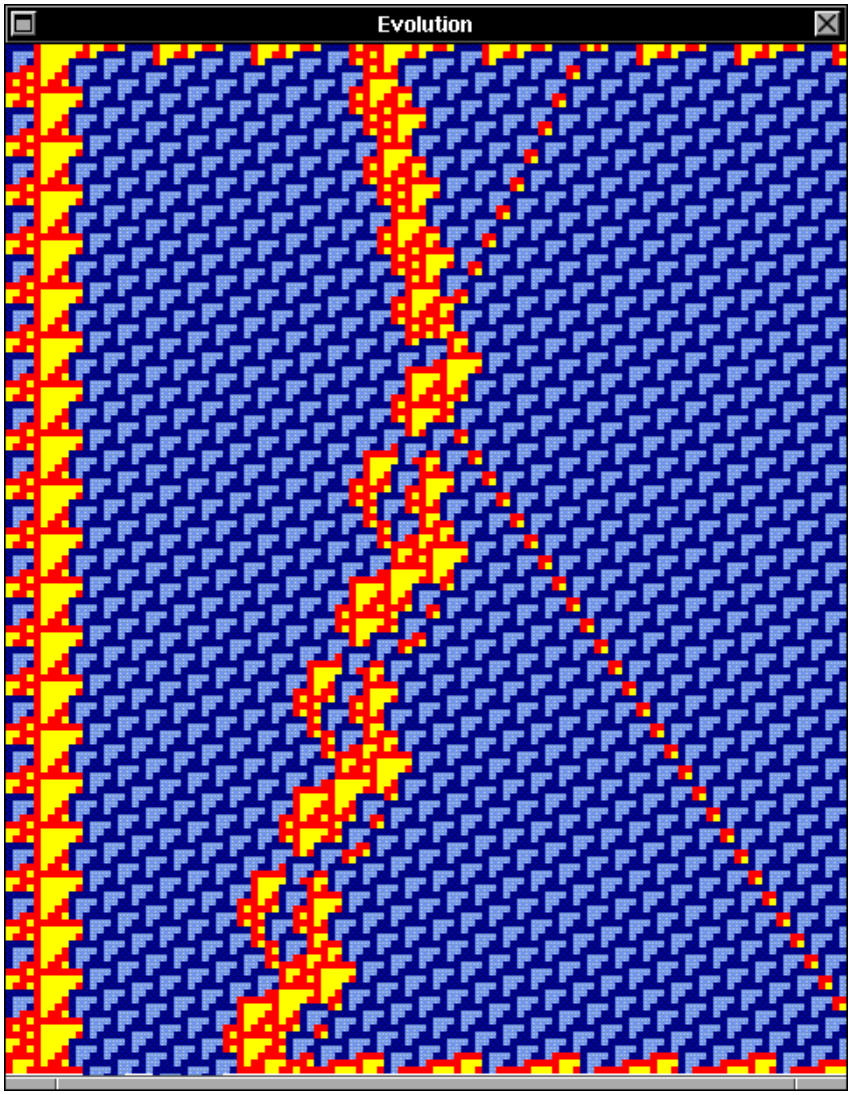


Figure 4.76: Collisions of glider B, D2(p1)(C)-e(p1)-B(p1)=A,Ebar

4.3.6 Collisions of glider B with glider E

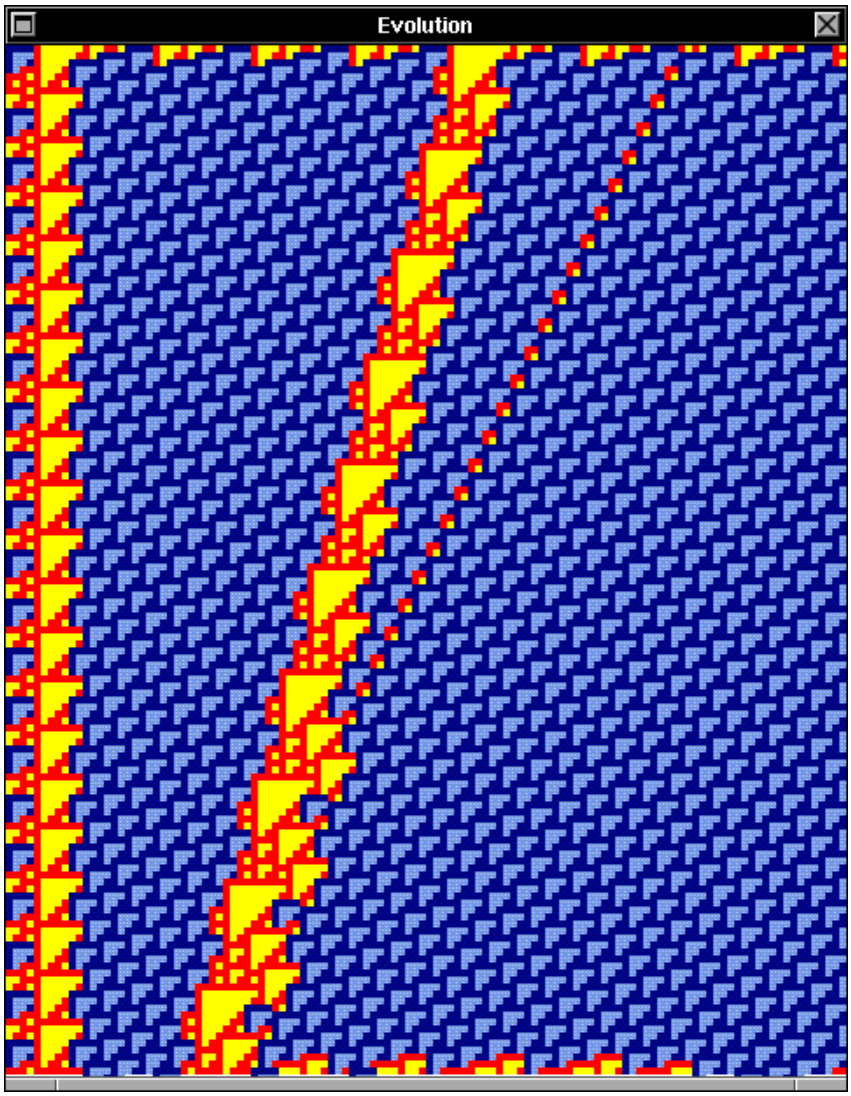


Figure 4.77: Collisions of glider B, E(p1)(A)-e(p1)-B(p1)=E2

4.3.7 Collisions of glider B with glider Ebar

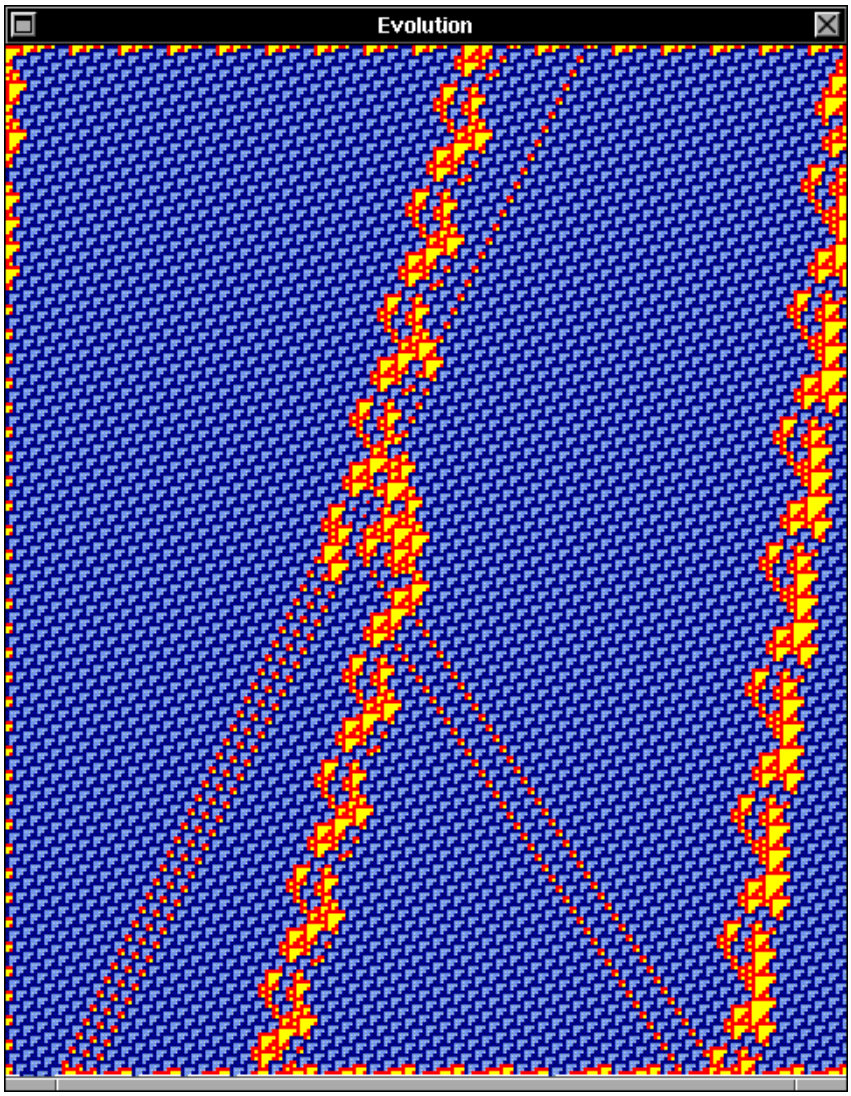


Figure 4.78: Collisions of glider B, Ebar(p1)(A)-e(p1)-B(p1)=3B,A,A,Ebar

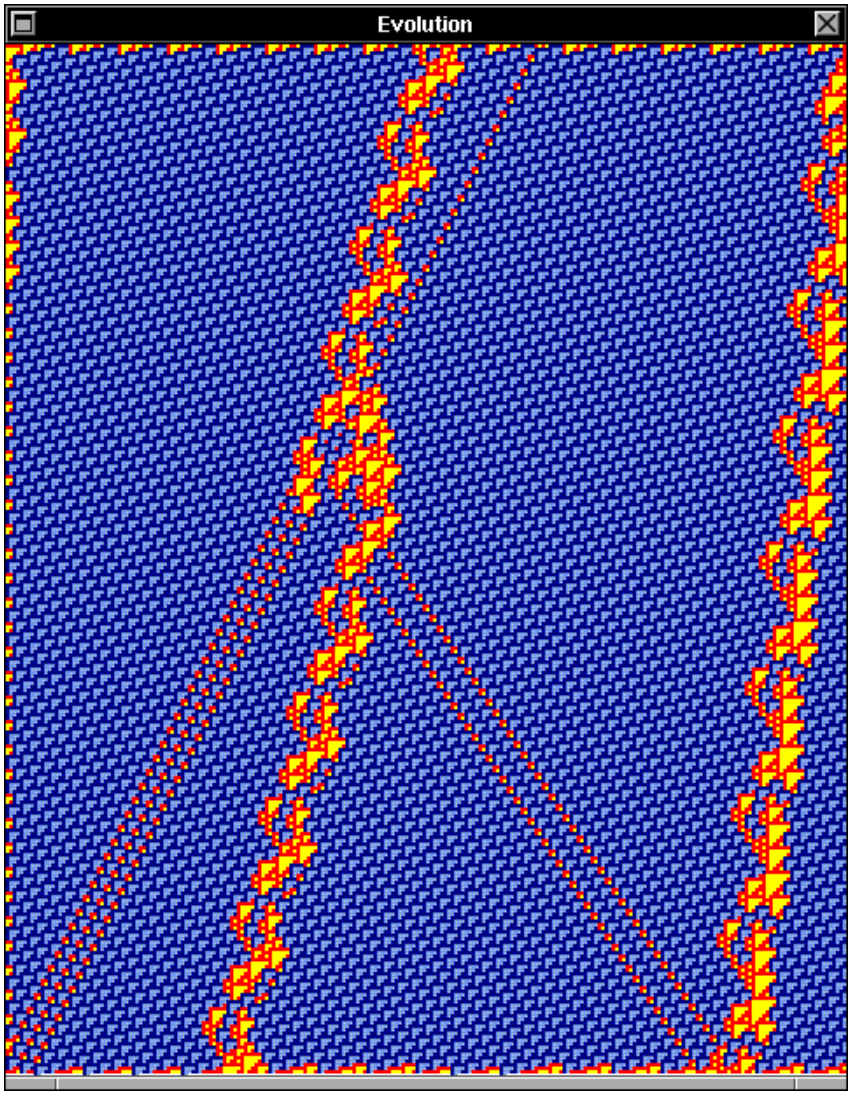


Figure 4.79: Collisions of glider B, Ebar(p1)(F)-e(p1)-B(p1)=3B,A,A,Ebar

4.3.8 Collisions of glider B with glider F

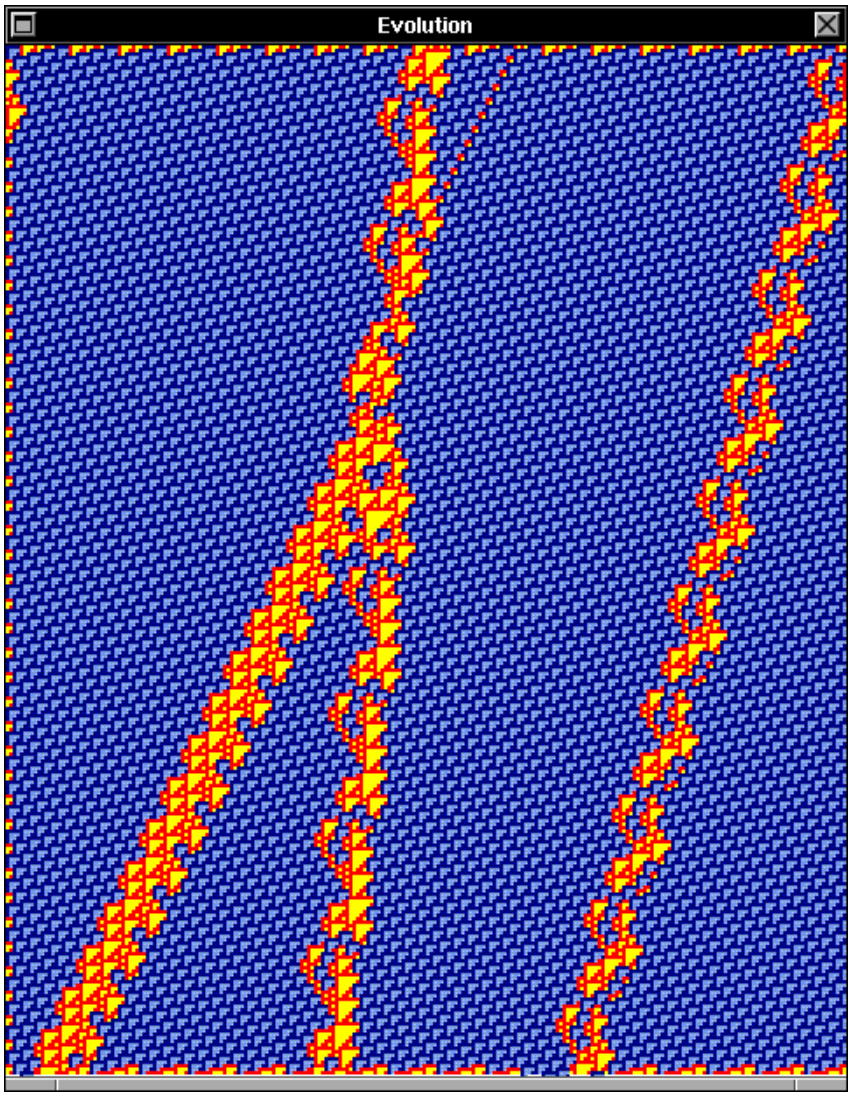


Figure 4.80: Collisions of glider B, F(p1)(A)-e(p1)-B(p1)=Bbar,F

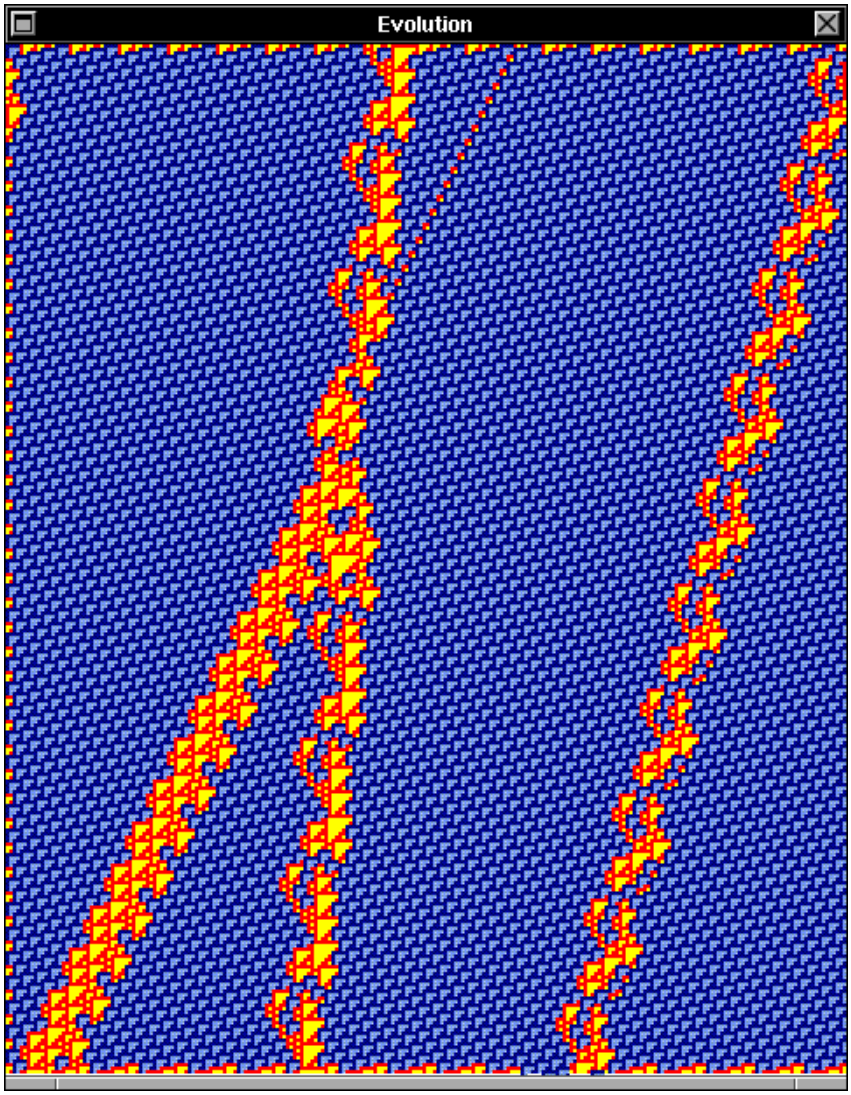


Figure 4.81: Collisions of glider B, F(p1)(G)-e(p1)-B(p1)=Bbar,F

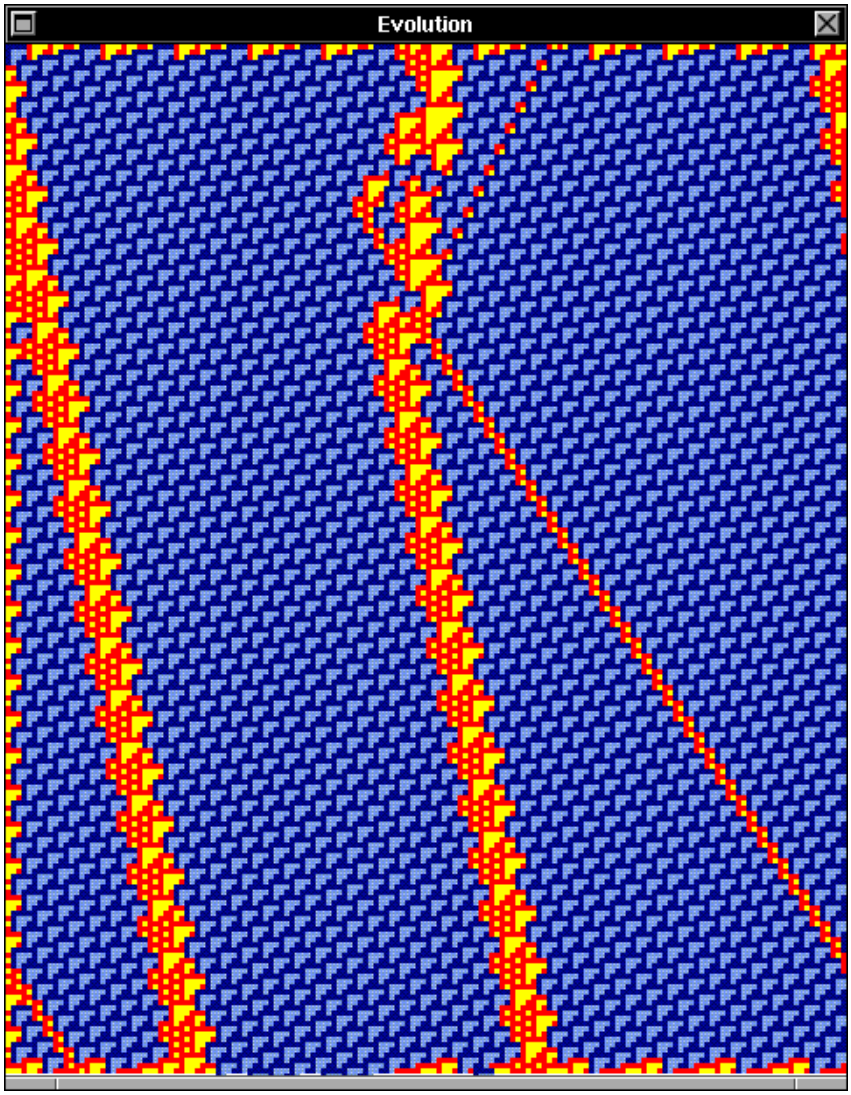


Figure 4.82: Collisions of glider B, F(p1)(H)-e(p1)-B(p1)=D2,2A

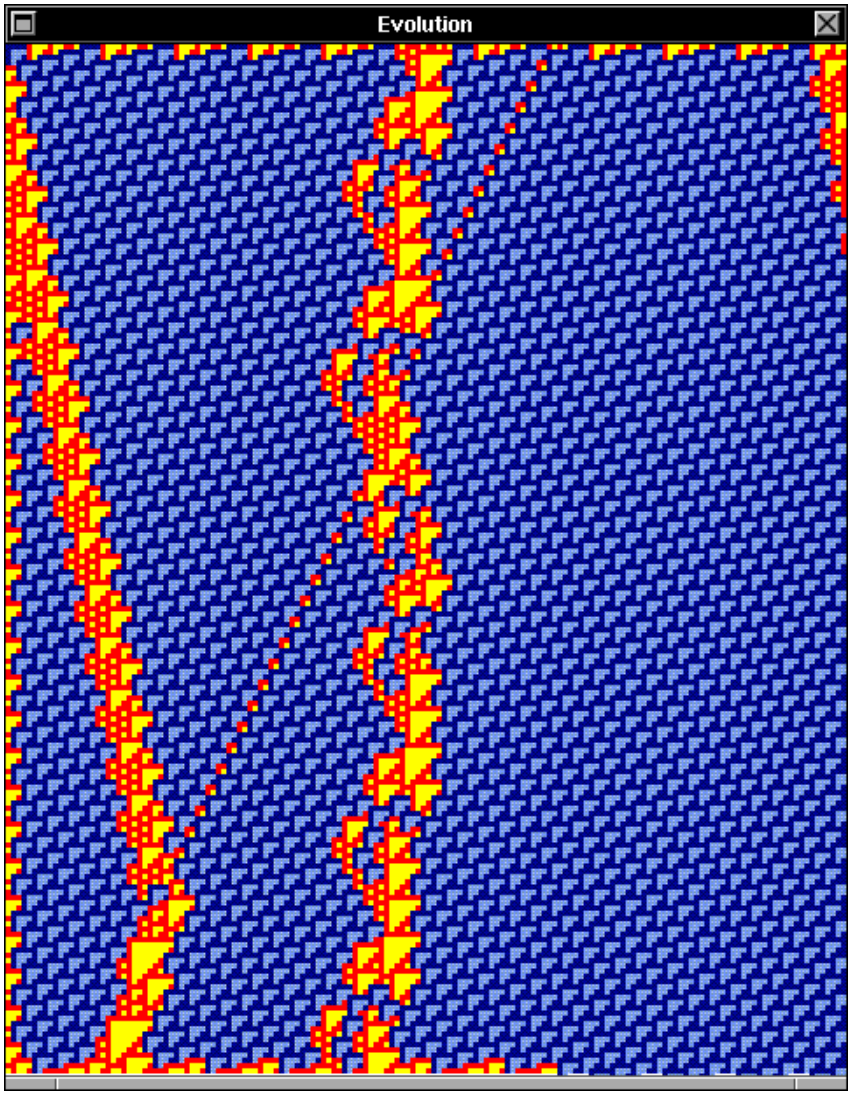


Figure 4.83: Collisions of glider B, F(p1)(A2)-e(p1)-B(p1)=B,F; across

4.3.9 Collisions of glider B with glider G

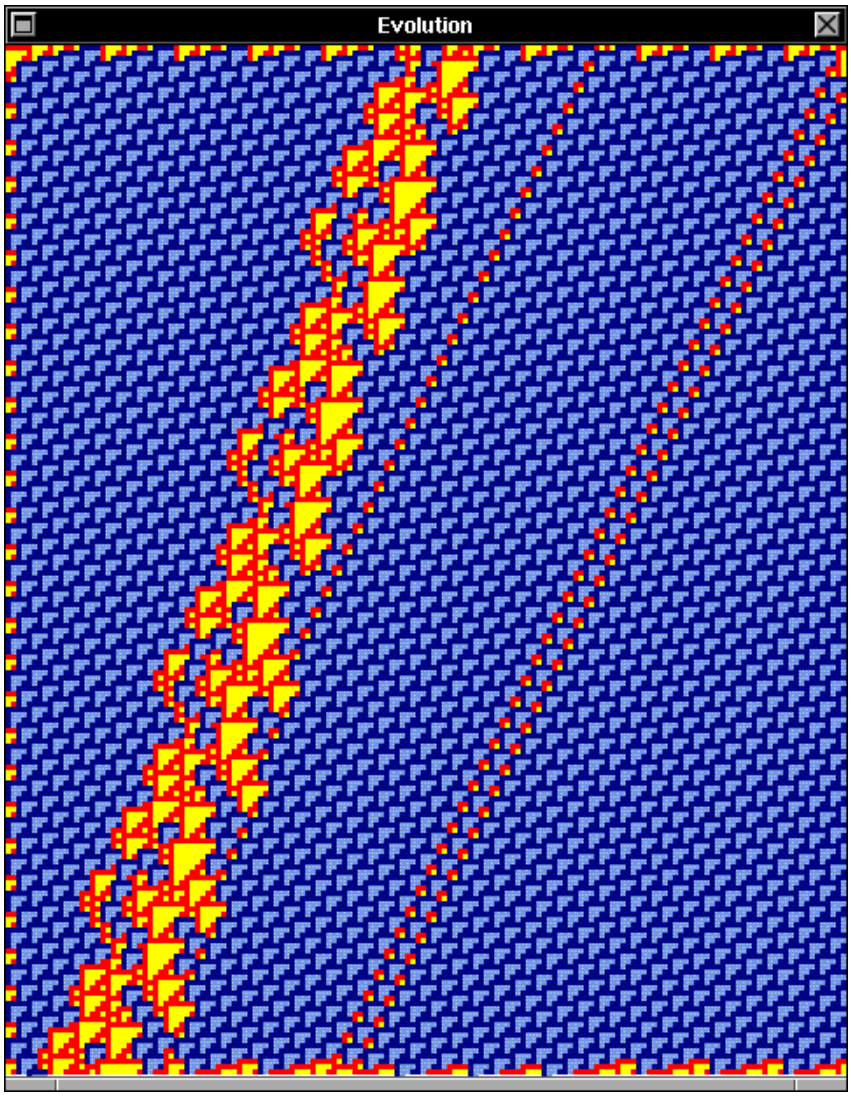


Figure 4.84: Collisions of glider B, G(p1)(A)-e(p1)-B(p1)=G2

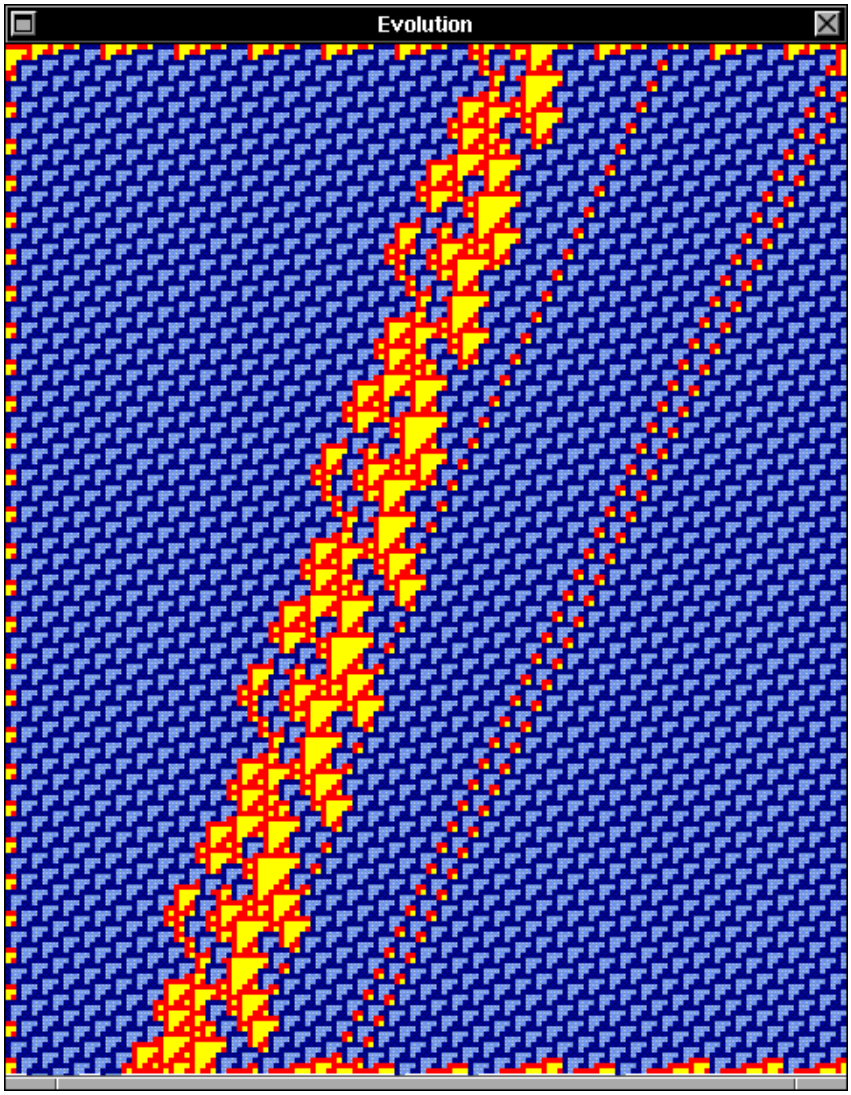


Figure 4.85: Collisions of glider B, G(p1)(C2)-e(p1)-B(p1)=G2

4.3.10 Collisions of glider B with glider H

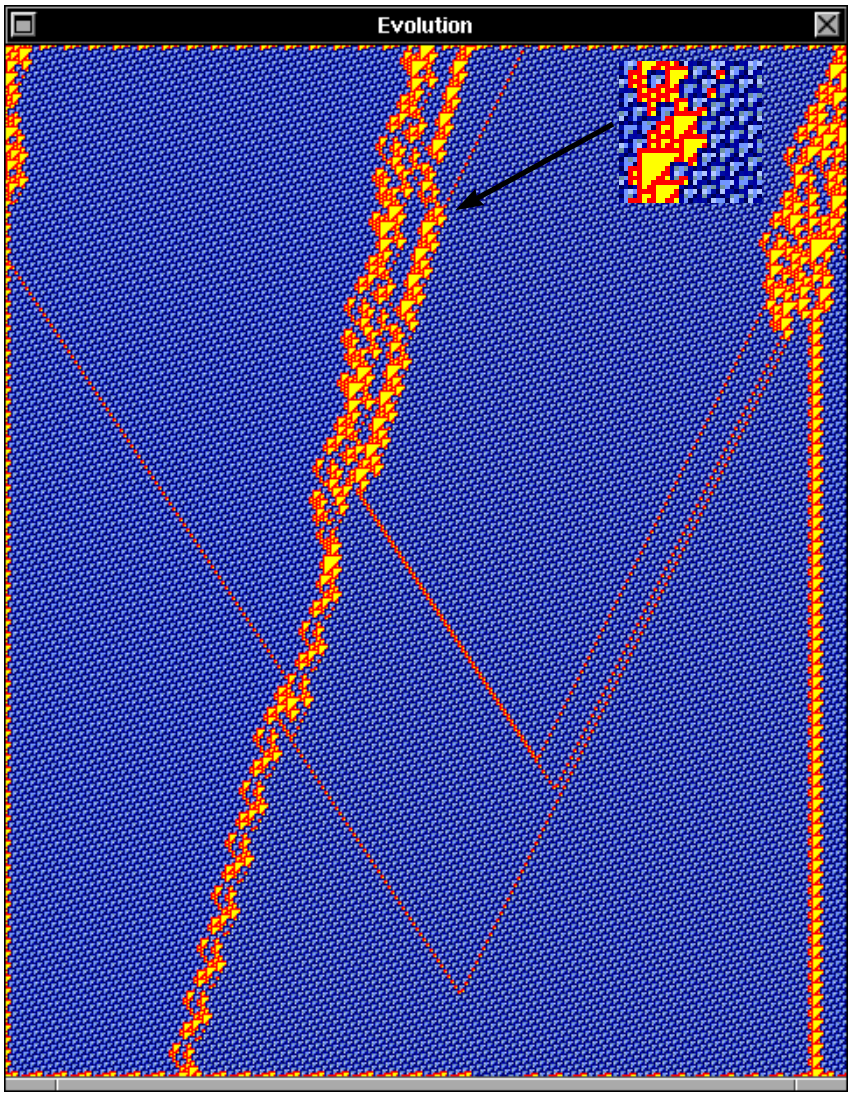


Figure 4.86: Collisions of glider B, H(p1)(A)-e(p1)-B(p1)=2A,Ebar

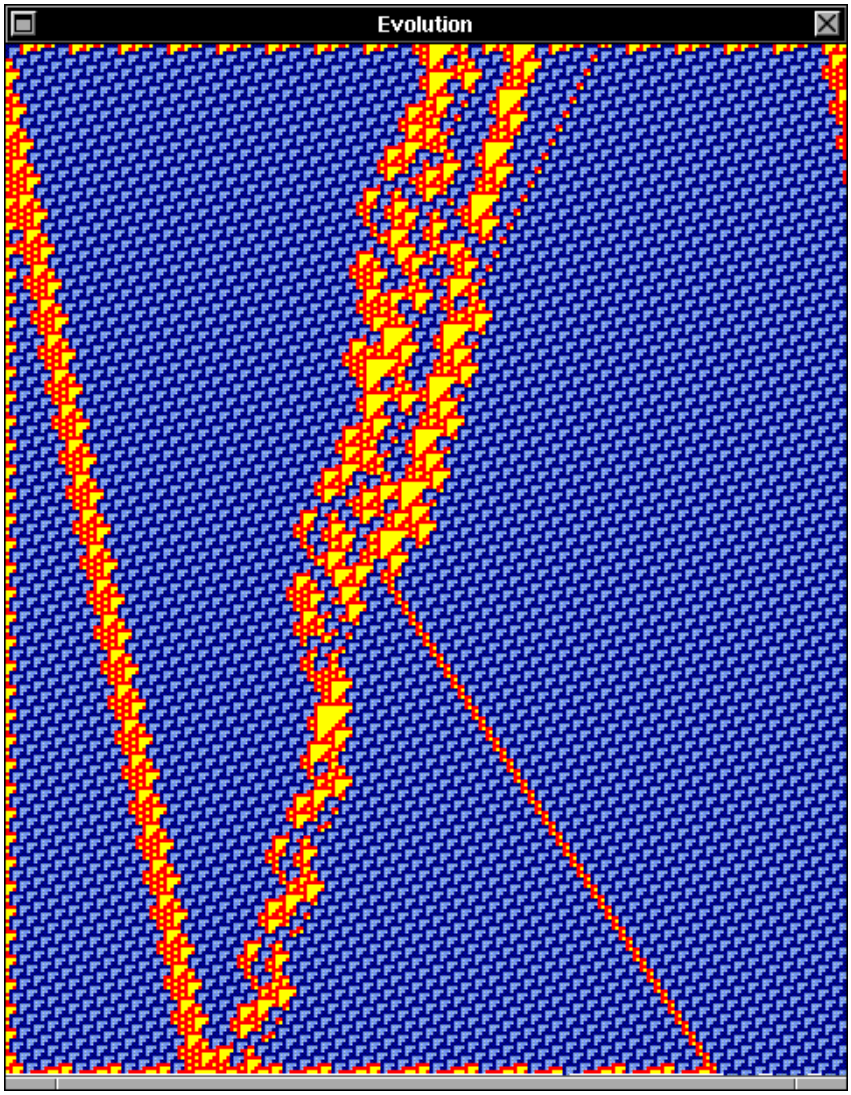


Figure 4.87: Collisions of glider B, H(p1)(D)-e(p1)-B(p1)=2A,Ebar

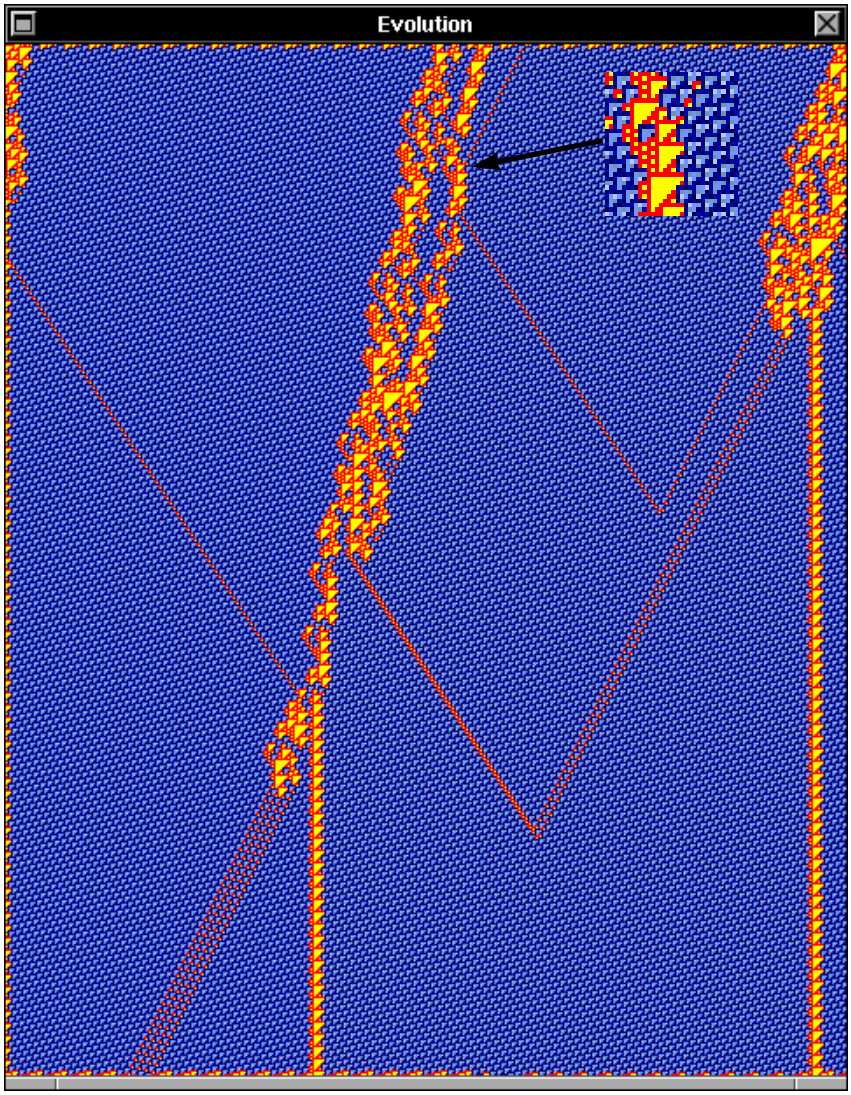


Figure 4.88: Collisions of glider B, H(p1)(E)-e(p1)-B(p1)=A,2A,F

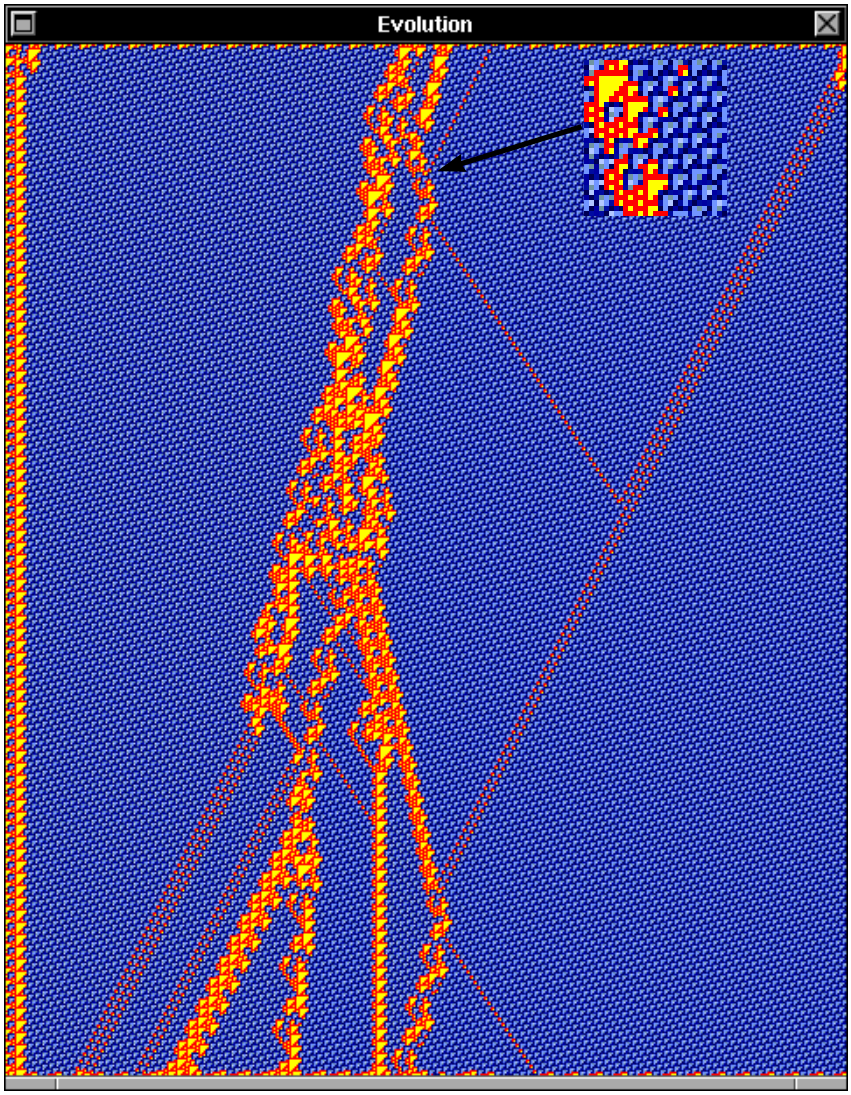


Figure 4.89: Collisions of glider B, H(p1)(F)-e(p1)-B(p1)=A,D1,3B,2B,Bbar,C1,F

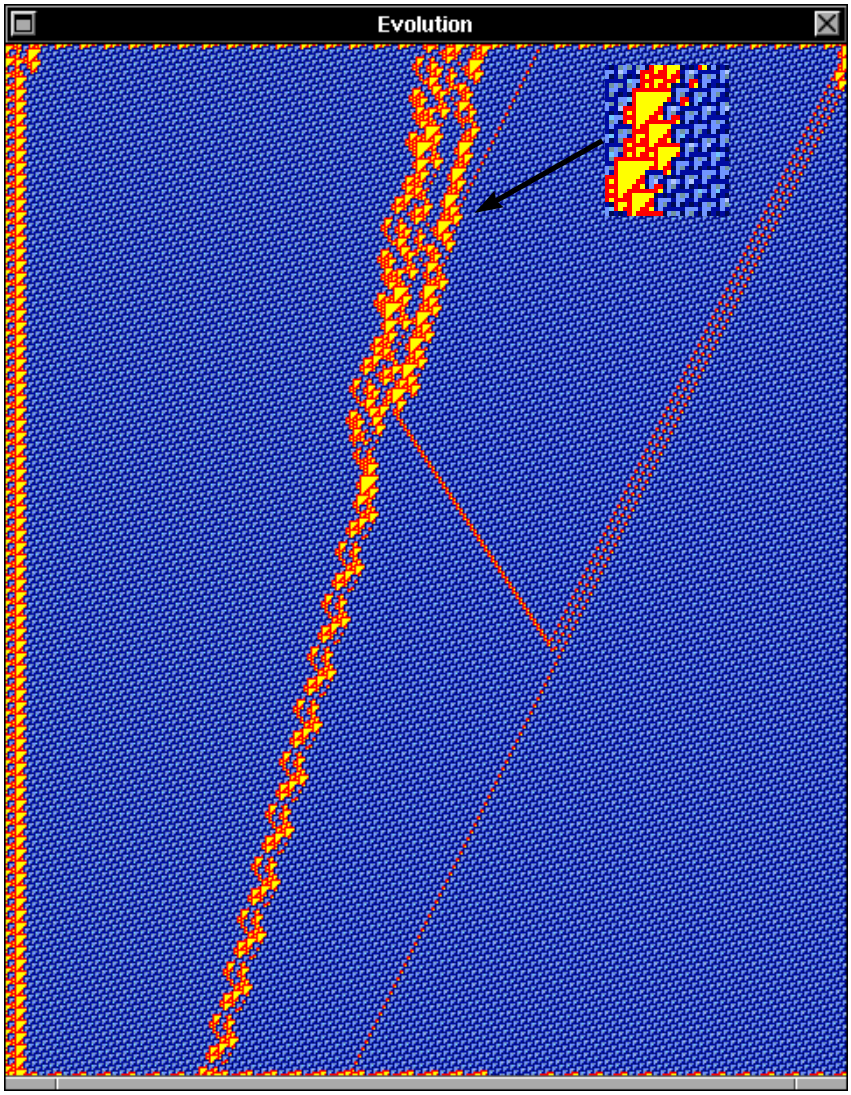


Figure 4.90: Collisions of glider B, H(p1)(E2)-e(p1)-B(p1)=2A,Ebar

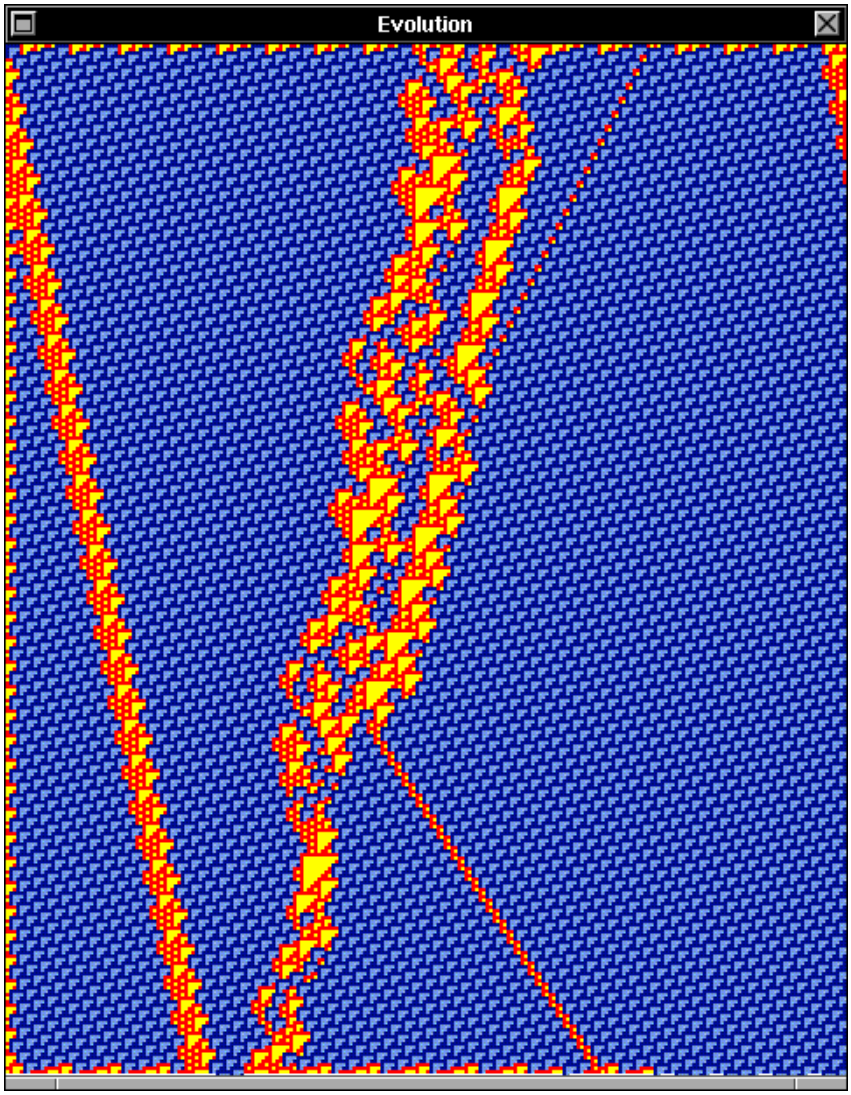


Figure 4.91: Collisions of glider B, H(p1)(A3)-e(p1)-B(p1)=2A,Ebar

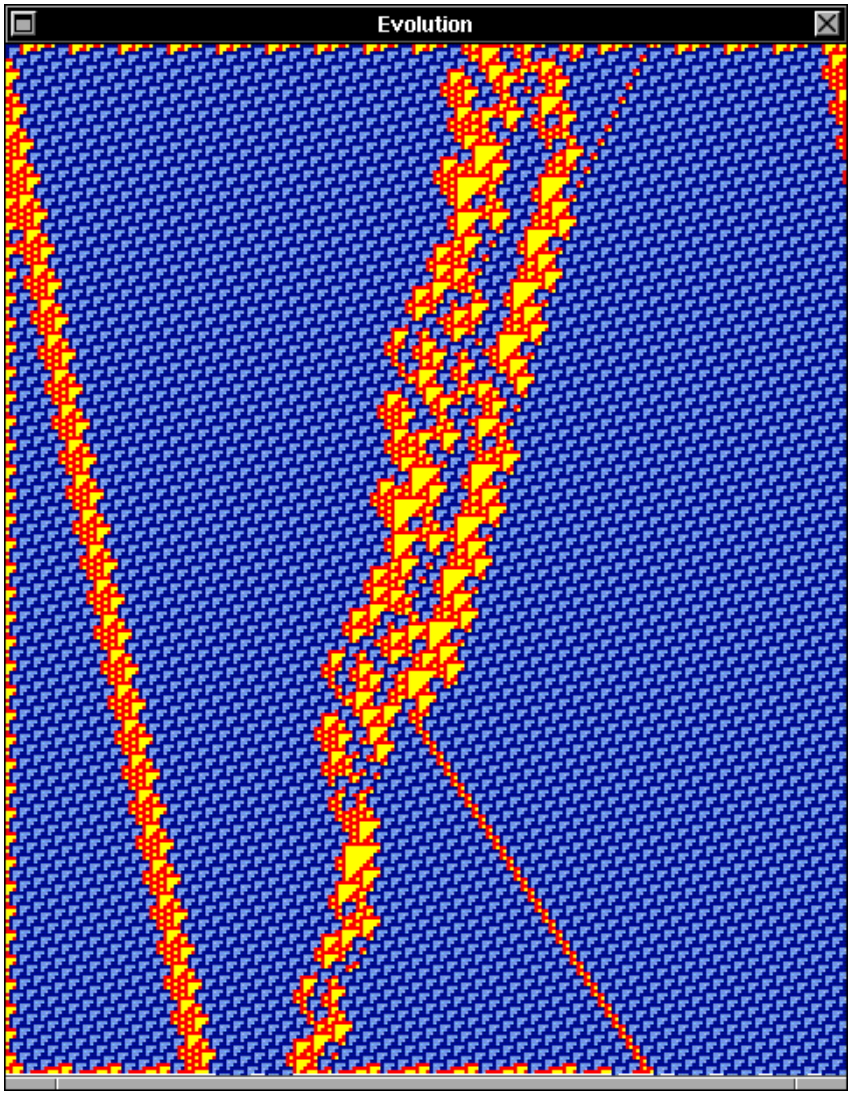


Figure 4.92: Collisions of glider B, H(p1)(B3)-e(p1)-B(p1)=2A,Ebar

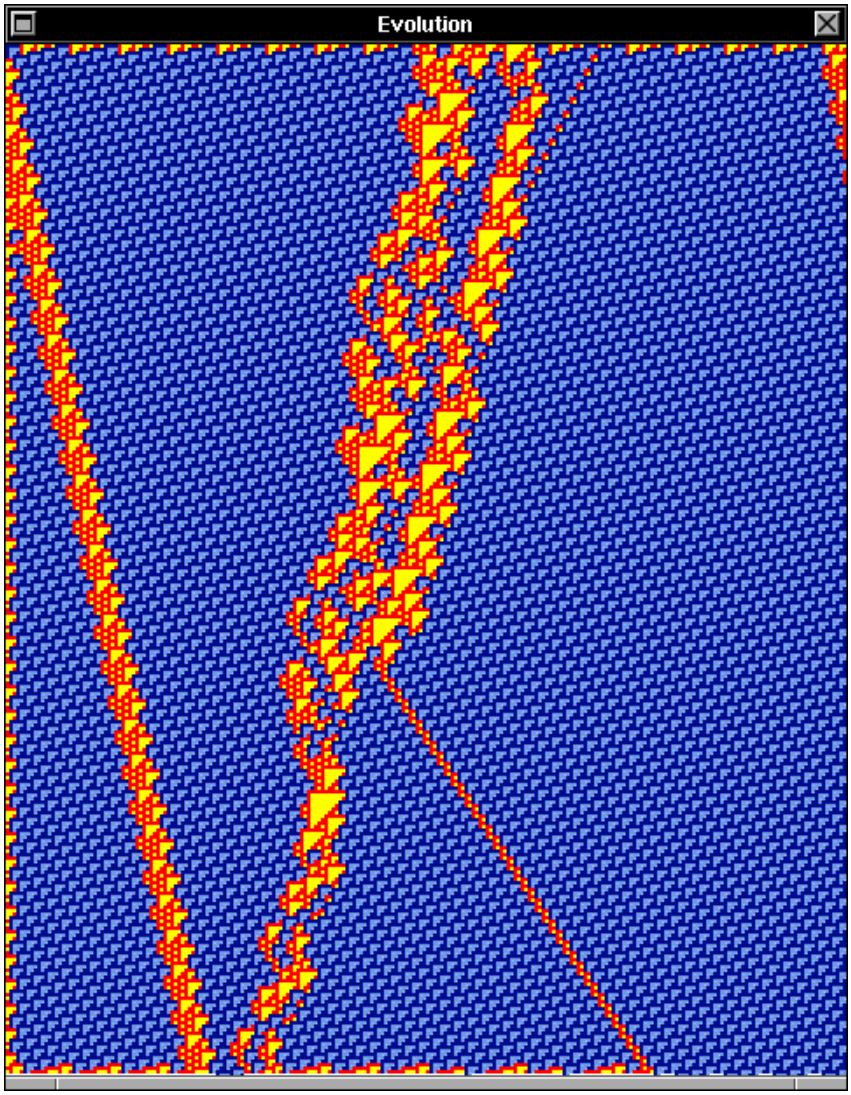


Figure 4.93: Collisions of glider B, H(p1)(F3)-e(p1)-B(p1)=2A,Ebar

4.4 Collisions of glider Bbar

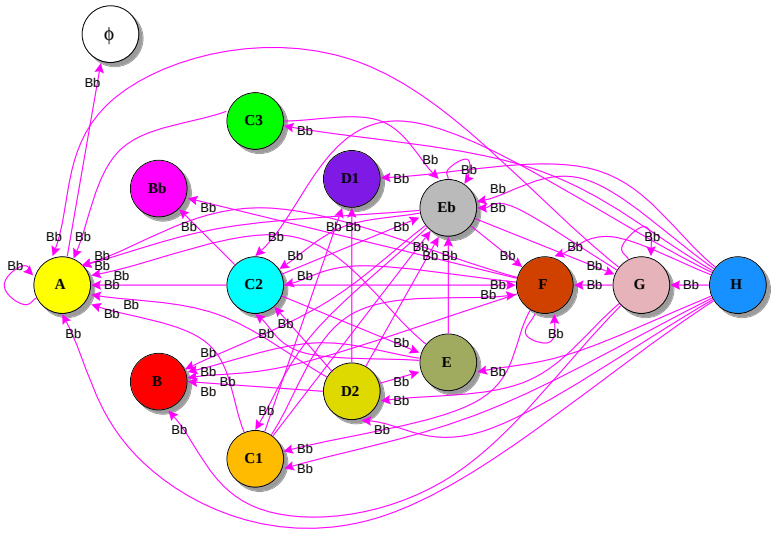


Figure 4.94: Collisions of glider Bbar

	ϕ	A	B	$Bbar$	$C3$	$C2$	$C1$	$D2$	$D1$	E	$Ebar$	F	G	H
ϕ	.	1	.	.	.	.	.	.	.	.	.	.	.	.
A	.	1	.	.	1	1	1	1	.	1	1	1	1	1
B	.	.	.	.	.	.	.	1	.	1	1	1	1	.
$Bbar$	.	.	.	.	.	1	.	.	.	.	.	1	.	.
$C3$	.	.	.	.	.	.	.	.	.	.	.	.	.	1
$C2$	.	.	.	.	.	.	.	1	.	1	1	1	.	1
$C1$	.	.	.	.	.	.	.	.	.	.	1	1	.	1
$D2$	.	.	.	.	.	.	.	.	.	.	.	.	1	1
$D1$	.	.	.	.	.	.	1	1	.	.	.	.	.	1
E	.	.	.	.	.	1	.	1	.	.	.	.	.	1
$Ebar$	.	.	.	.	1	1	1	1	.	1	1	.	1	1
F	.	.	.	.	.	.	1	1	.	.	1	1	1	1
G	.	.	.	.	.	.	.	.	.	.	1	.	1	1
H	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Table 4.3: Matrix connection of collisions glider Bar

4.4.1 Collisions of glider Bbar with glider C1

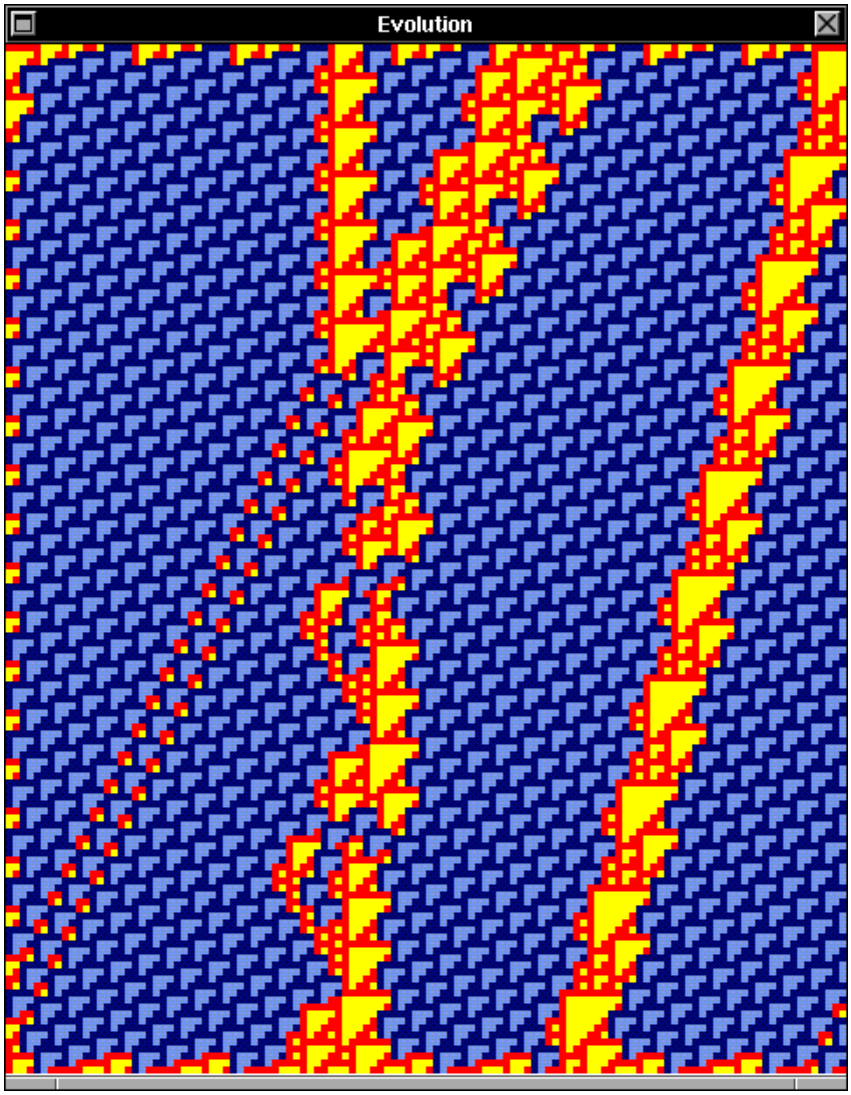


Figure 4.95: Collisions of glider Bbar, C1(p1)(A)-e(p1)-Bbar(p1)(A)=2B,F

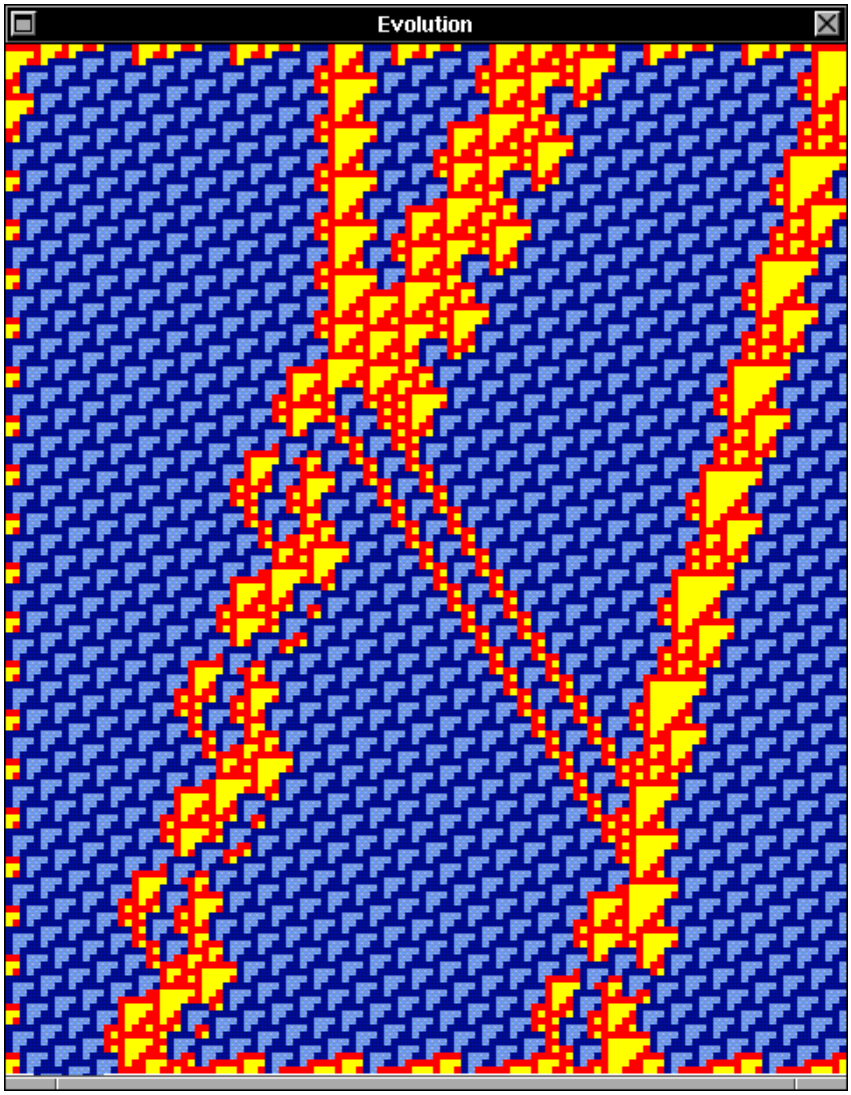


Figure 4.96: Collisions of glider Bbar, C1(p1)(A)-e(p1)-Bbar(p1)(B)=2A,2A,Ebar

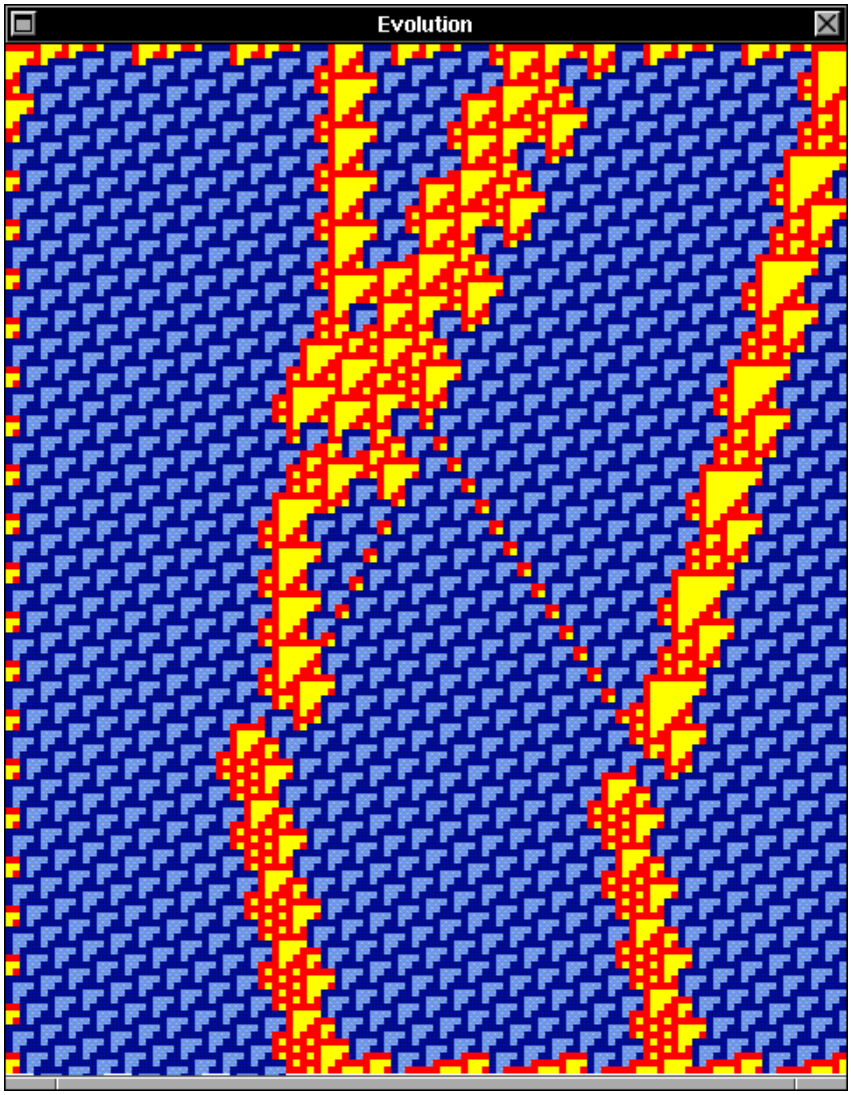


Figure 4.97: Collisions of glider Bbar, C1(p1)(A)-e(p1)-Bbar(p1)(C)=A,D2

4.4.2 Collisions of glider Bbar with glider C2

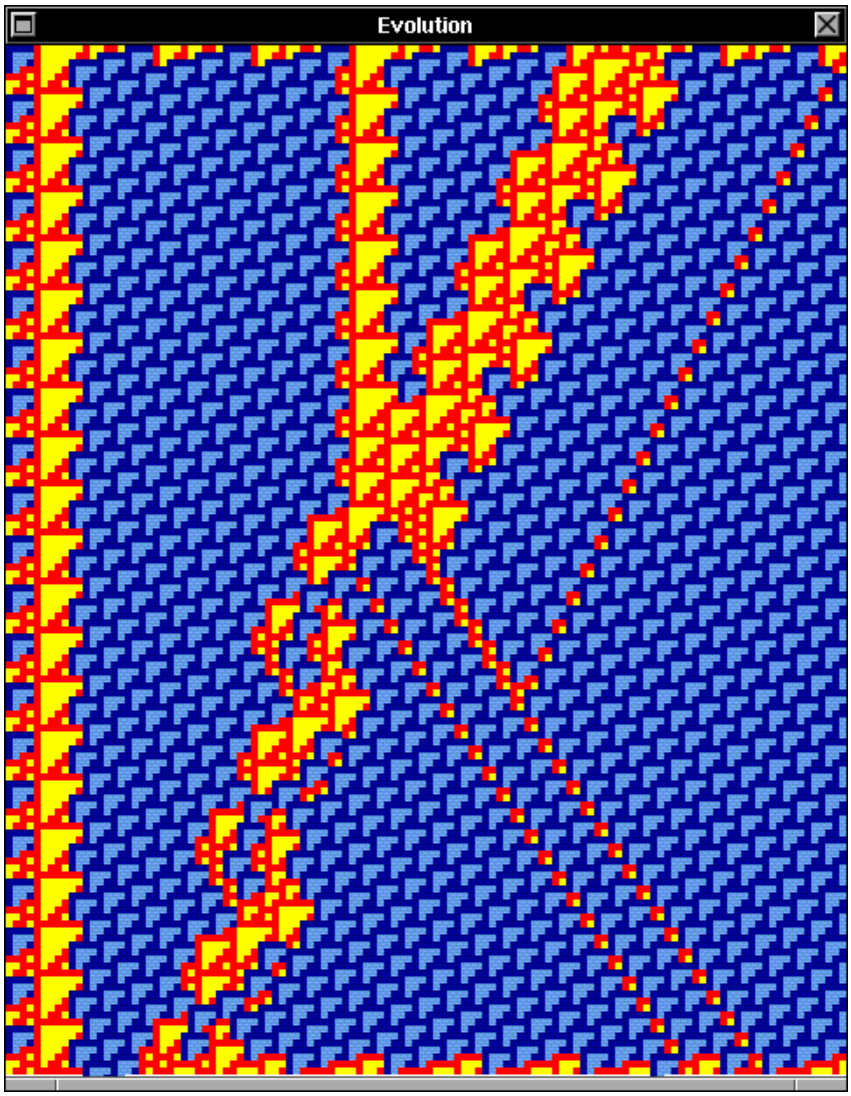


Figure 4.98: Collisions of glider Bbar, C2(p1)(A)-e(p1)-Bbar(p1)(A)=2A,A,Ebar

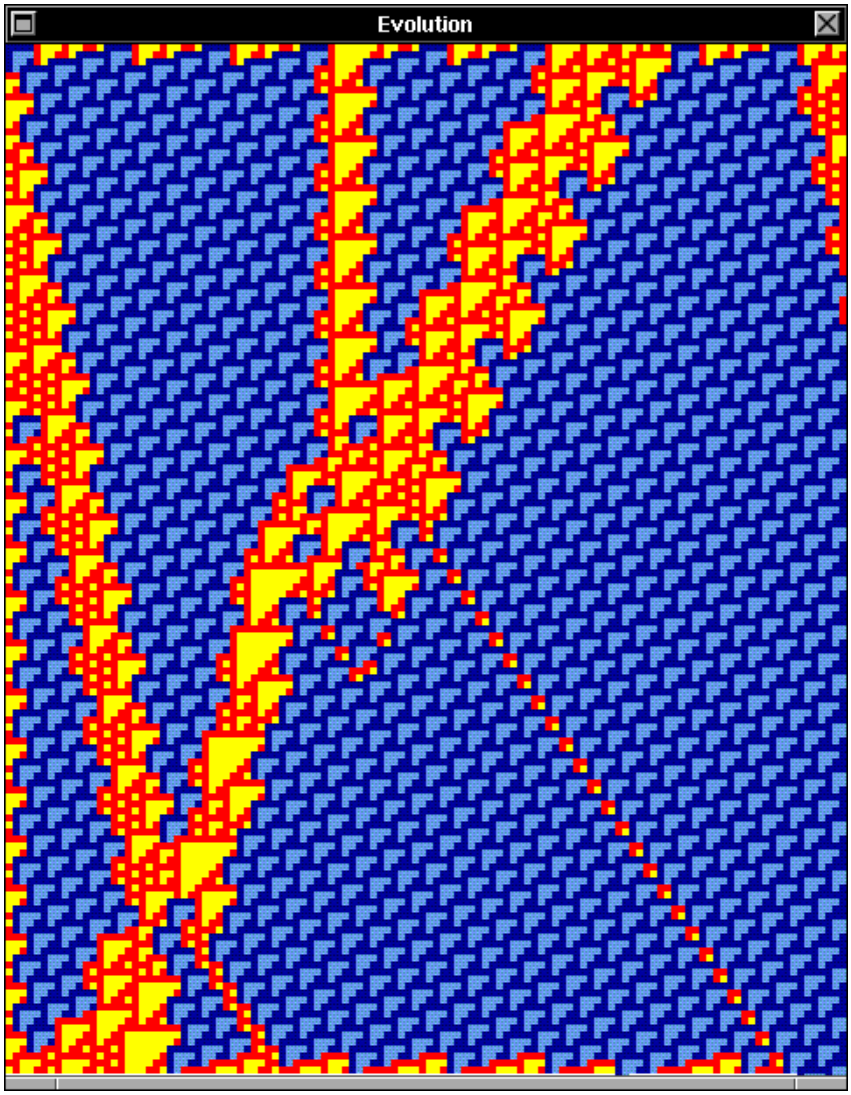


Figure 4.99: Collisions of glider Bbar, C2(p1)(A)-e(p1)-Bbar(p1)(B)=A,E

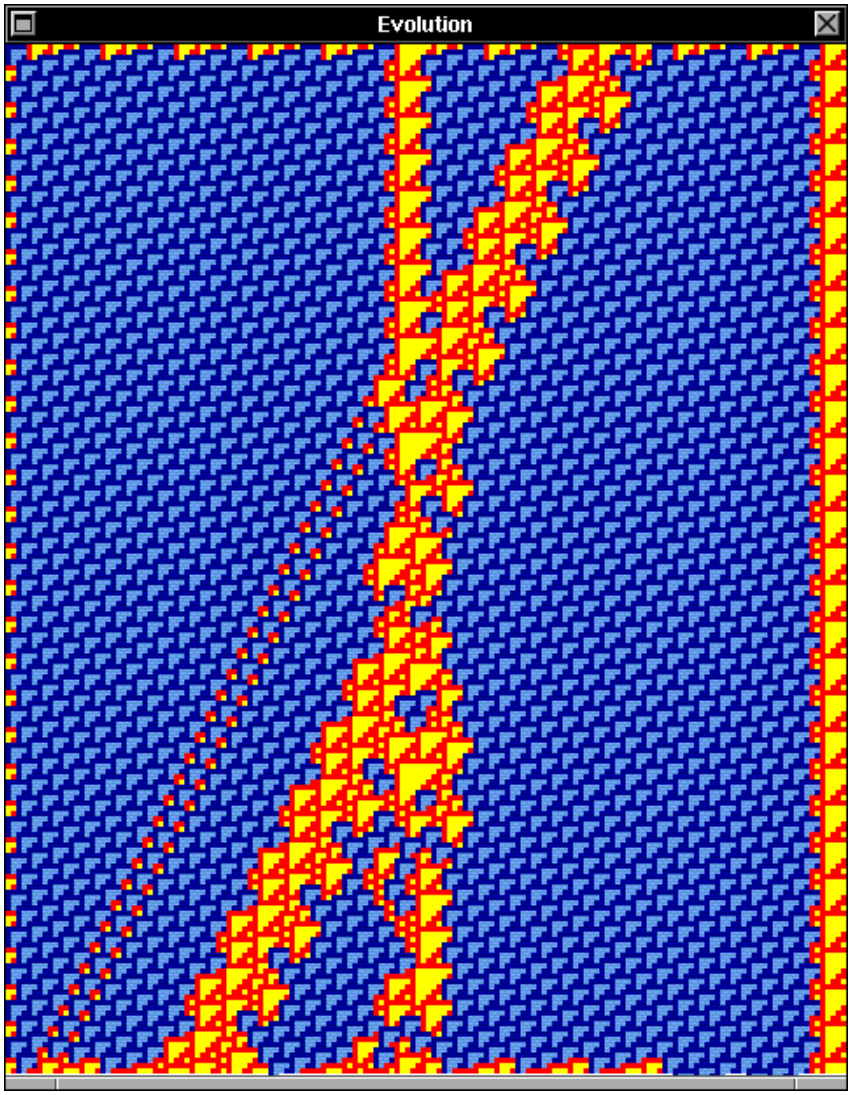


Figure 4.100: Collisions of glider Bbar, C2(p1)(A)-e(p1)-Bbar(p1)(C)=2B,Ebar,F

4.4.3 Collisions of glider Bbar with glider C3

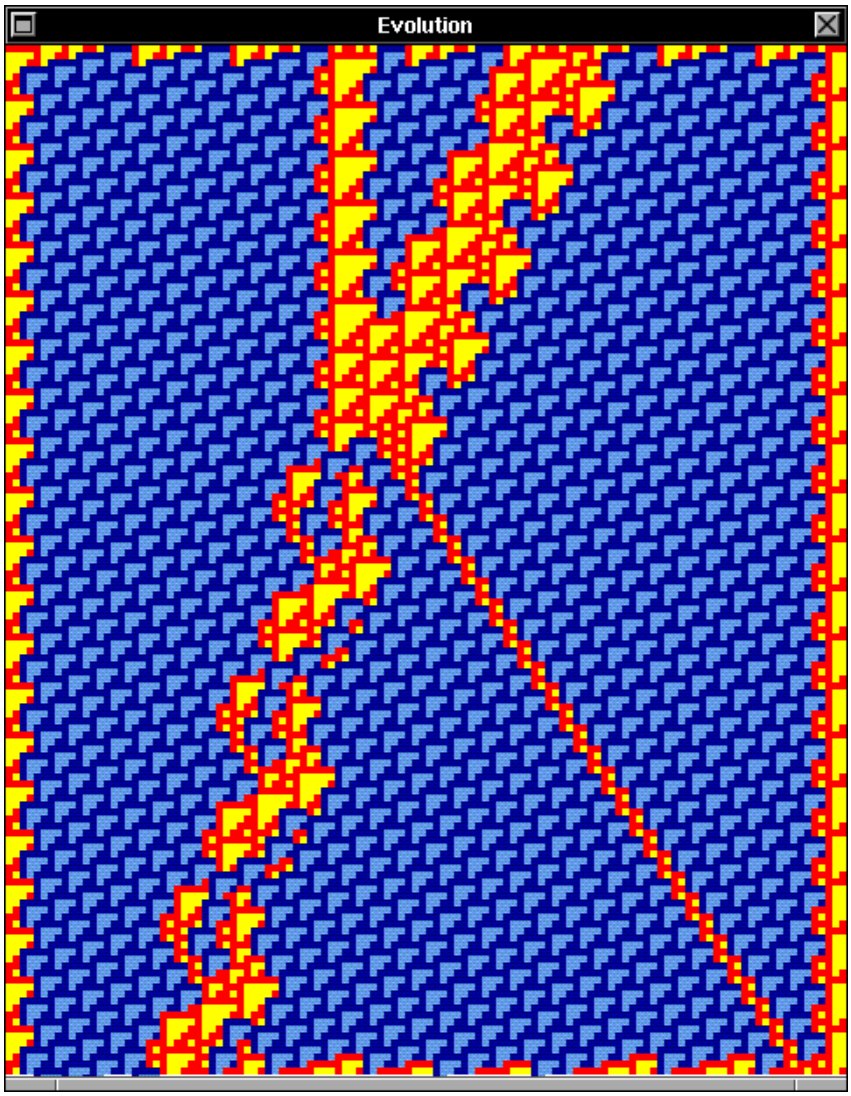


Figure 4.101: Collisions of glider Bbar, C3(p1)(A)-e(p1)-Bbar(p1)(A)=2A,Ebar

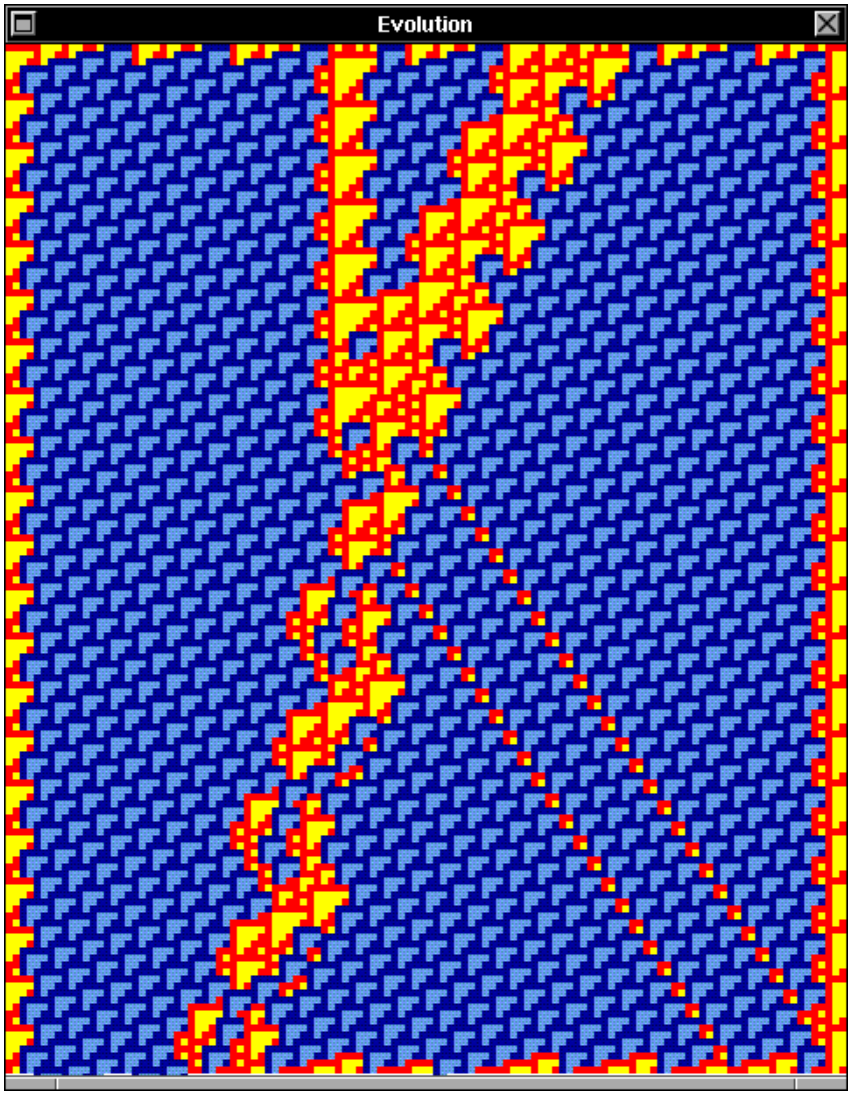


Figure 4.102: Collisions of glider Bbar, C3(p1)(A)-e(p1)-Bbar(p1)(B)=A,A,Ebar

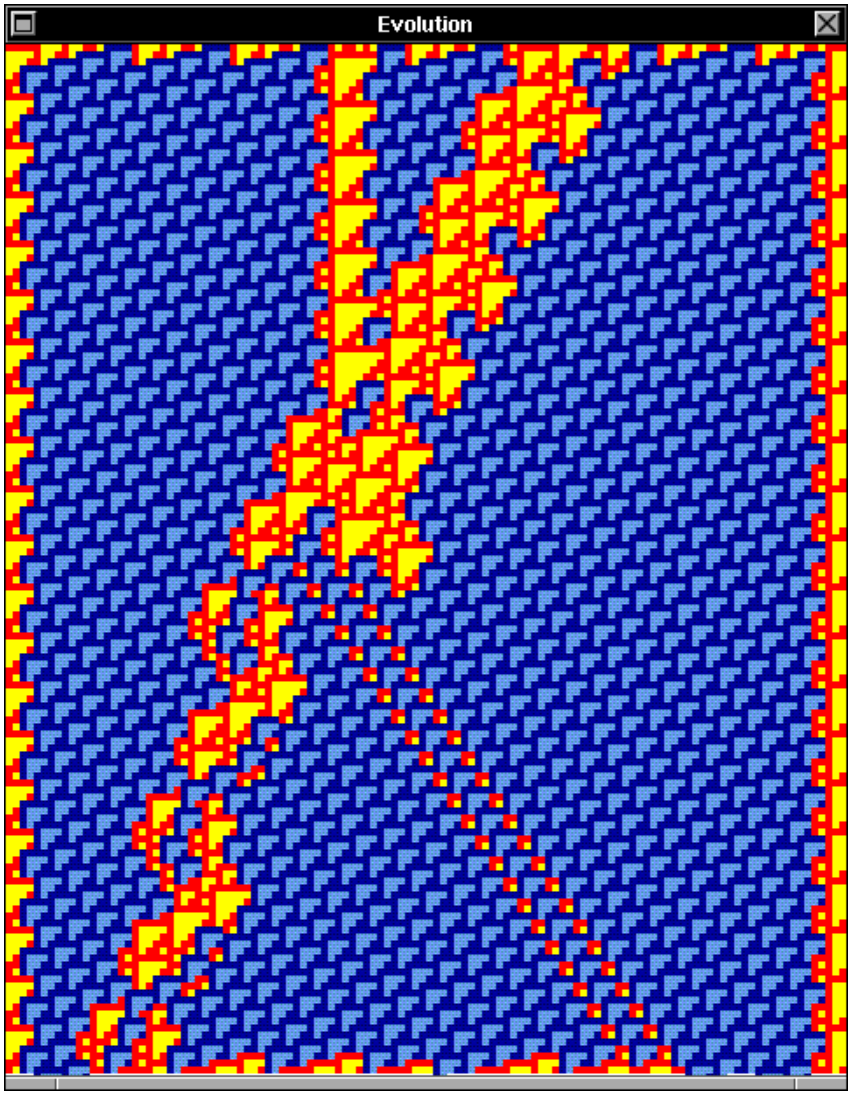


Figure 4.103: Collisions of glider Bbar, C3(p1)(A)-e(p1)-Bbar(p1)(C)=A,A,Ebar

4.4.4 Collisions of glider Bbar with glider D1

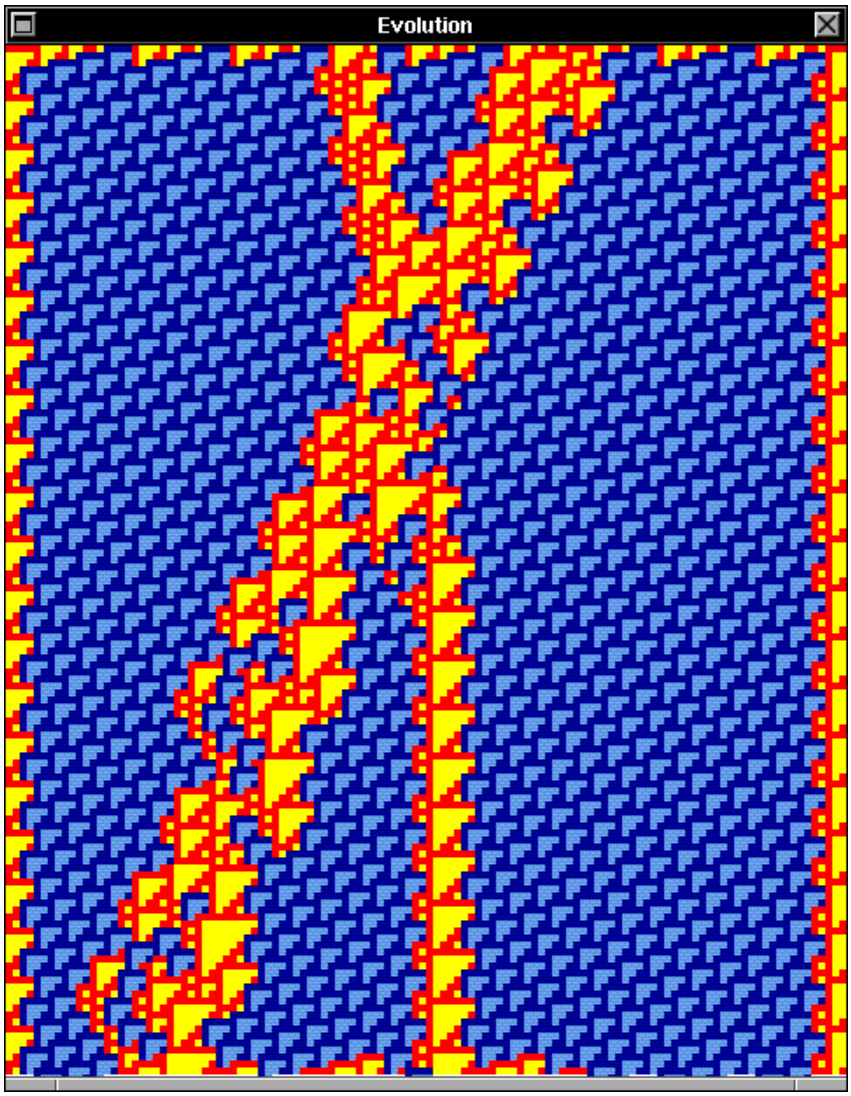


Figure 4.104: Collisions of glider Bbar, D1(p1)(A)-e(p1)-Bbar(p1)(A)=G,C1

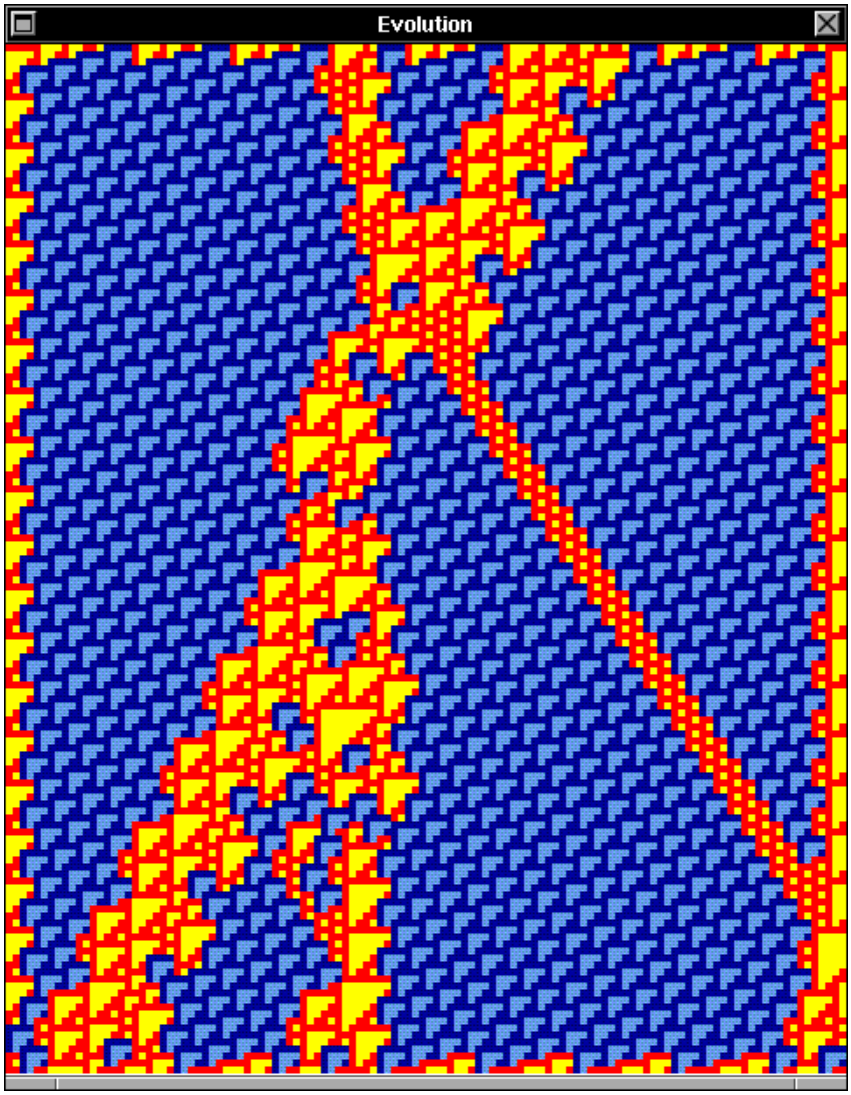


Figure 4.105: Collisions of glider Bbar, D1(p1)(A)-e(p1)-Bbar(p1)(B)=4A,Ebar,F

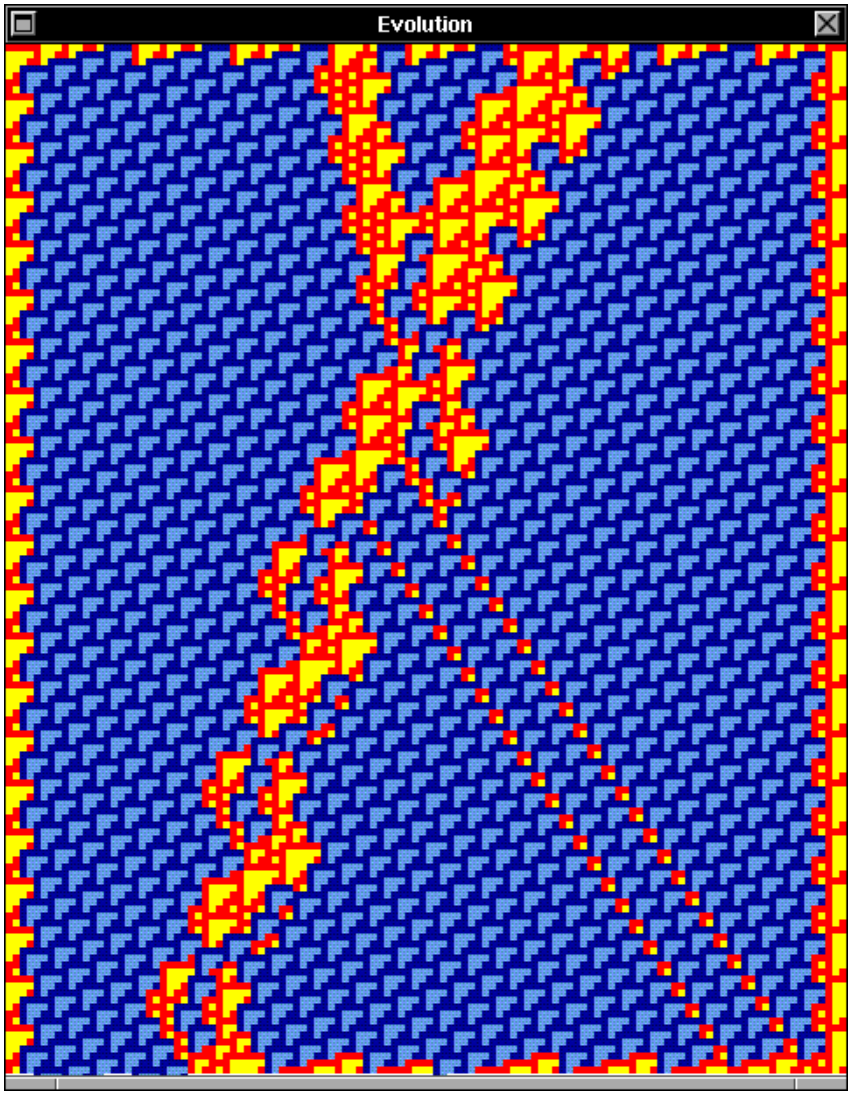


Figure 4.106: Collisions of glider Bbar, D1(p1)(A)-e(p1)-Bbar(p1)(C)=A,A,Ebar

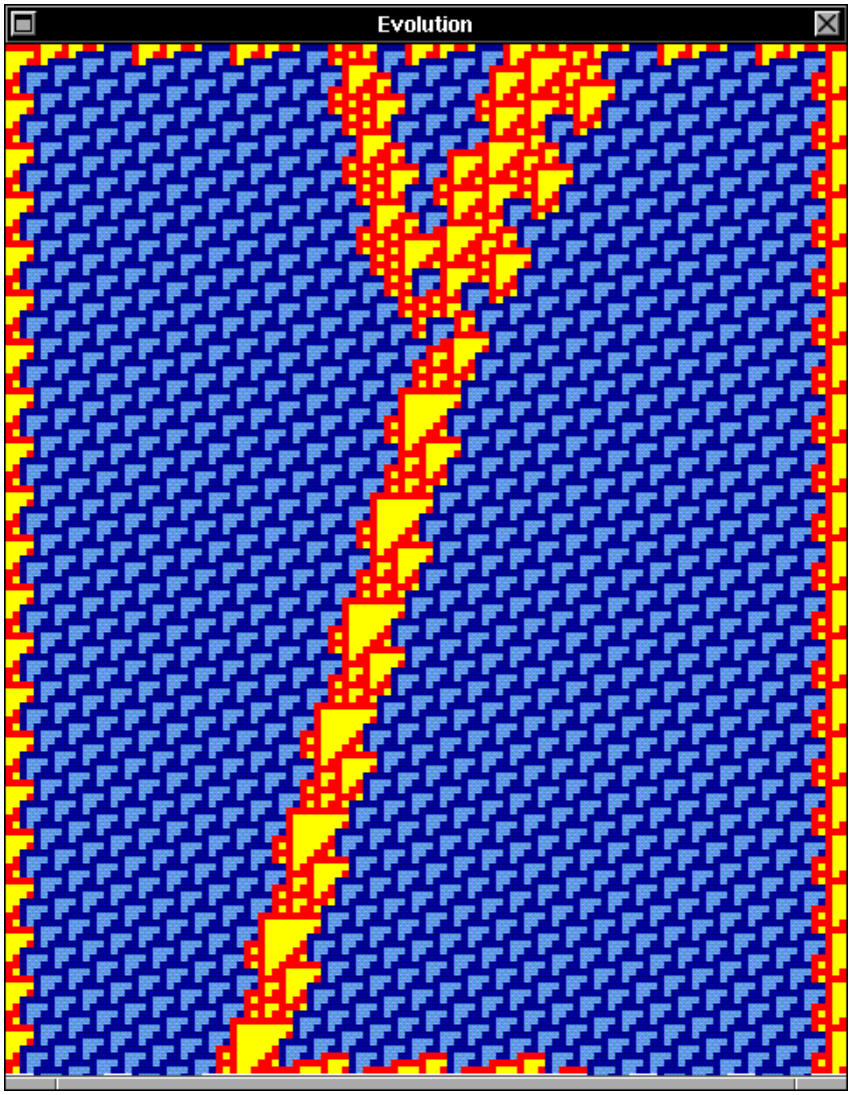


Figure 4.107: Collisions of glider Bbar, D1(p1)(C)-e(p1)-Bbar(p1)(A)=E

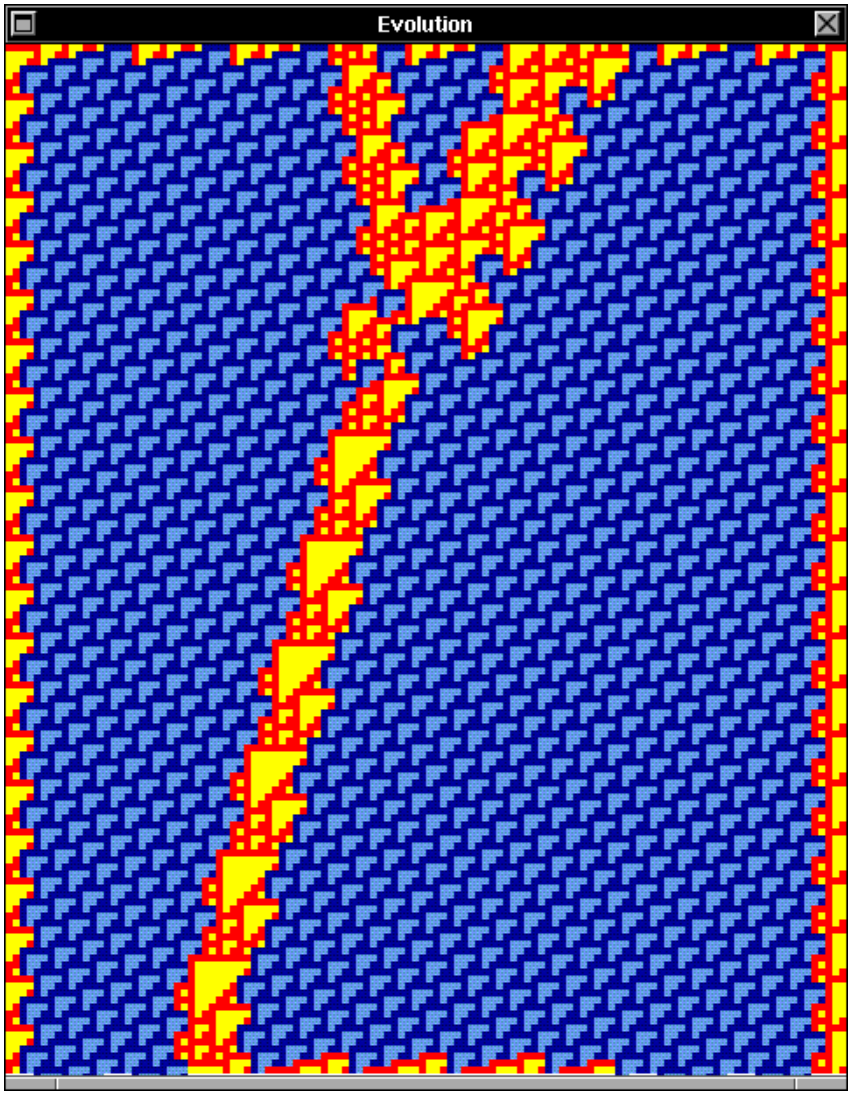
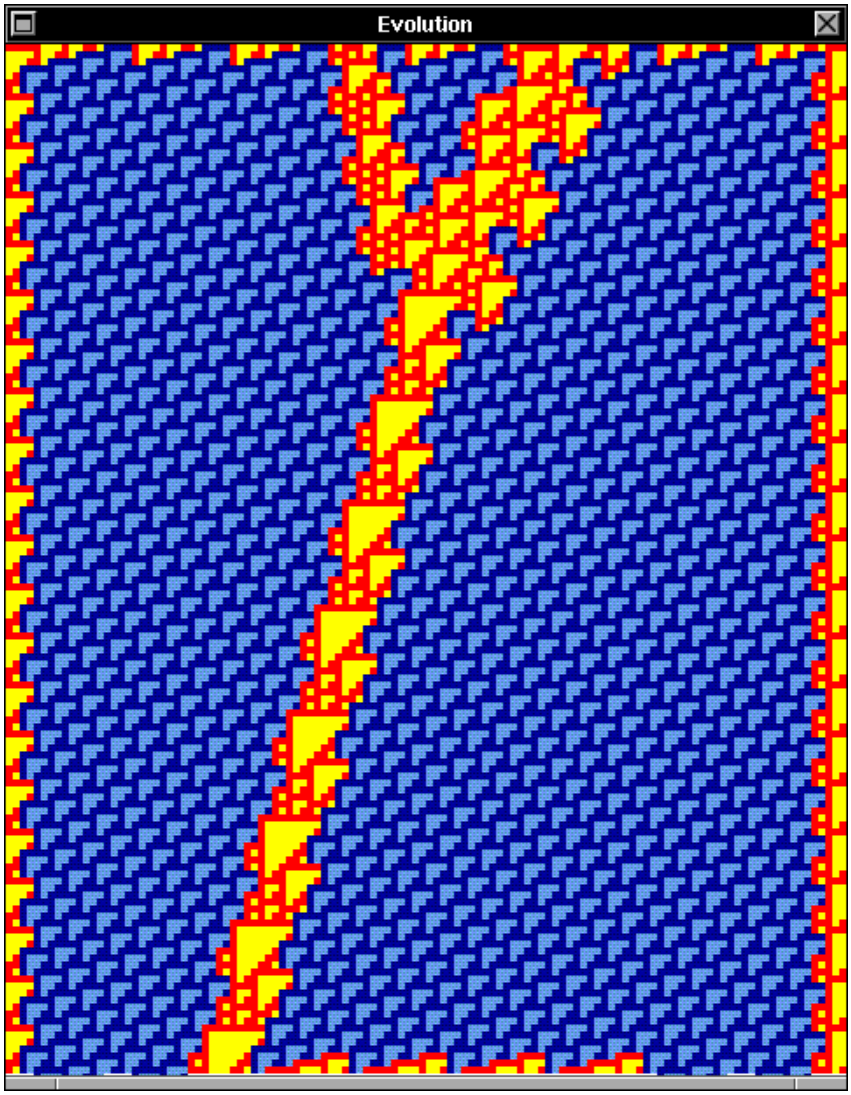


Figure 4.108: Collisions of glider Bbar, D1(p1)(C)-e(p1)-Bbar(p1)(B)=E



vifig

Figure 4.109: Collisions of glider Bbar, D1(p1)(C)-e(p1)-Bbar(p1)(C)=E

4.4.5 Collisions of glider Bbar with glider D2

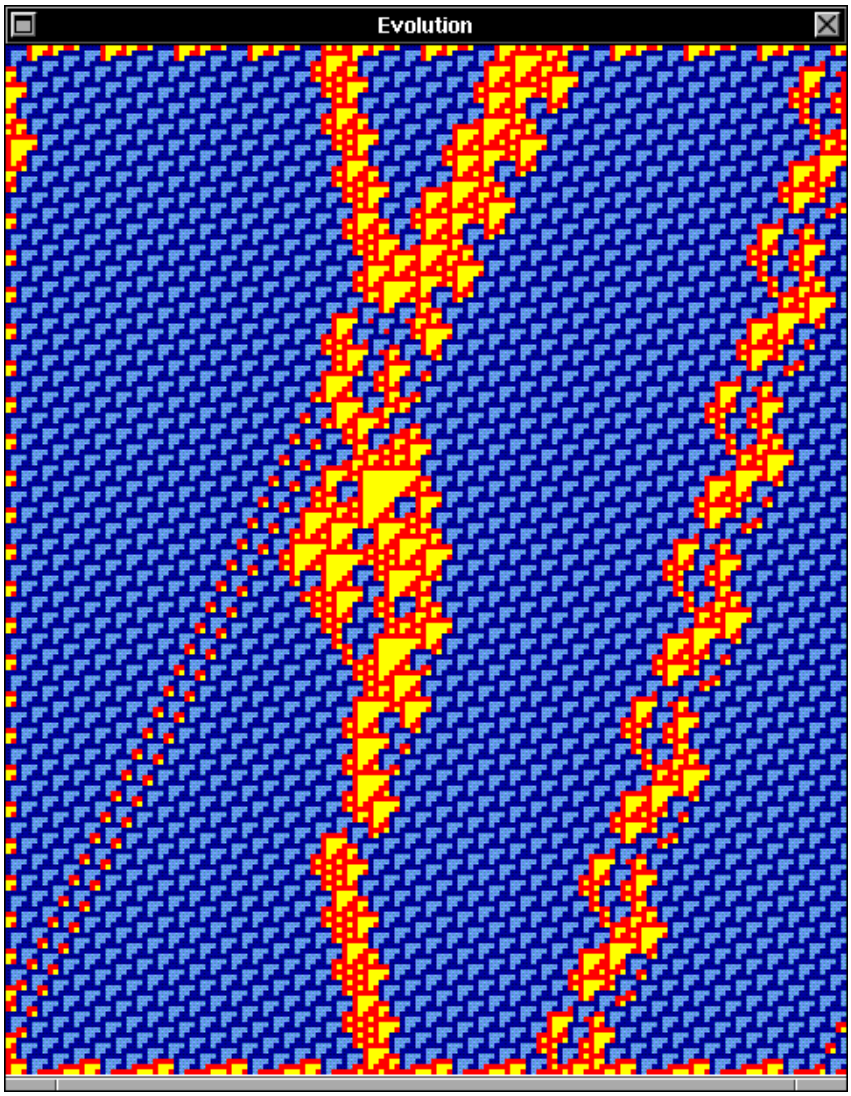


Figure 4.110: Collisions of glider Bbar, D2(p1)(A)-e(p1)-Bbar(p1)(A)=2B,D1

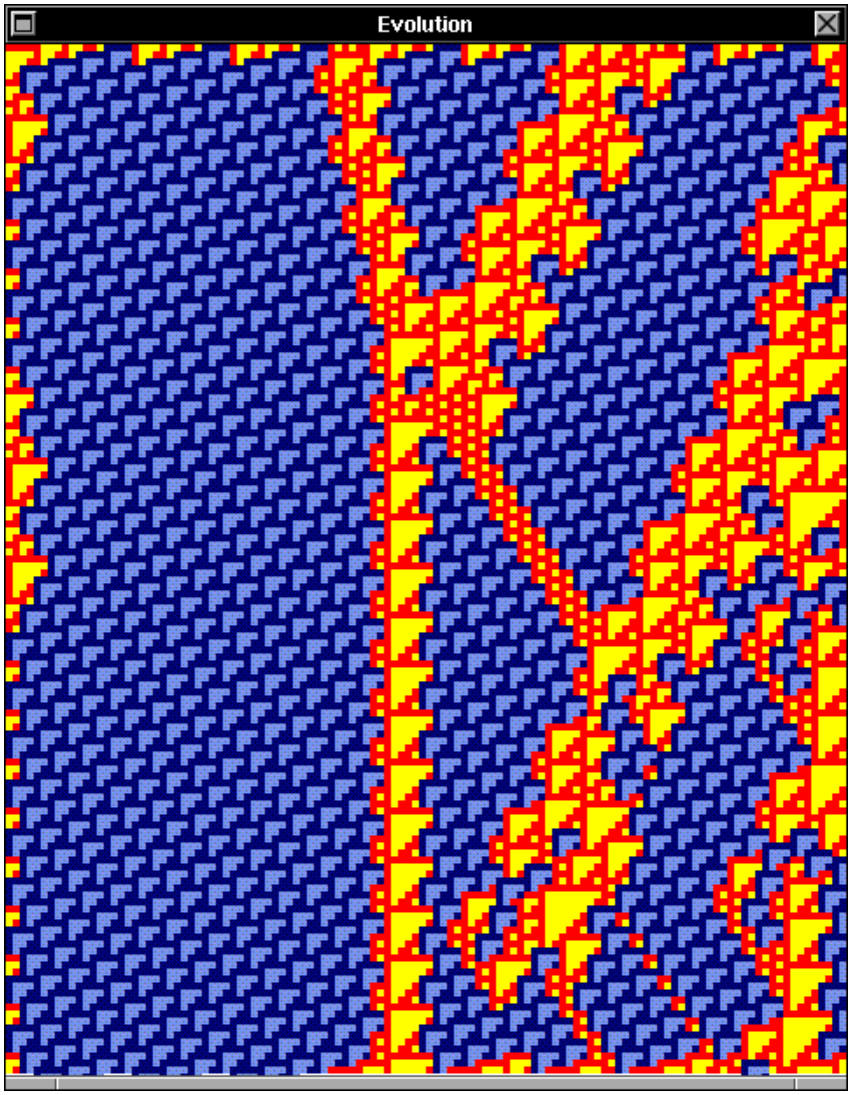


Figure 4.111: Collisions of glider Bbar, D2(p1)(A)-e(p1)-Bbar(p1)(B)=C2,4A

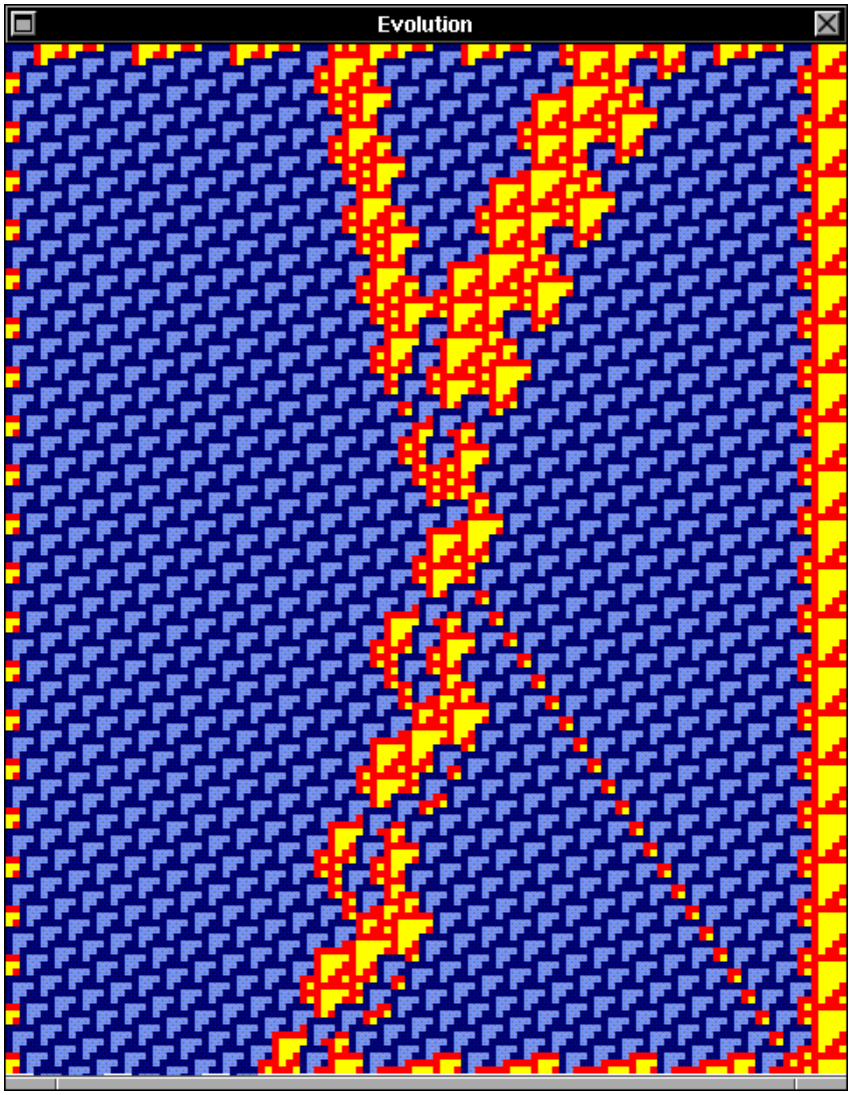


Figure 4.112: Collisions of glider Bbar, D2(p1)(A)-e(p1)-Bbar(p1)(C)=A,Ebar

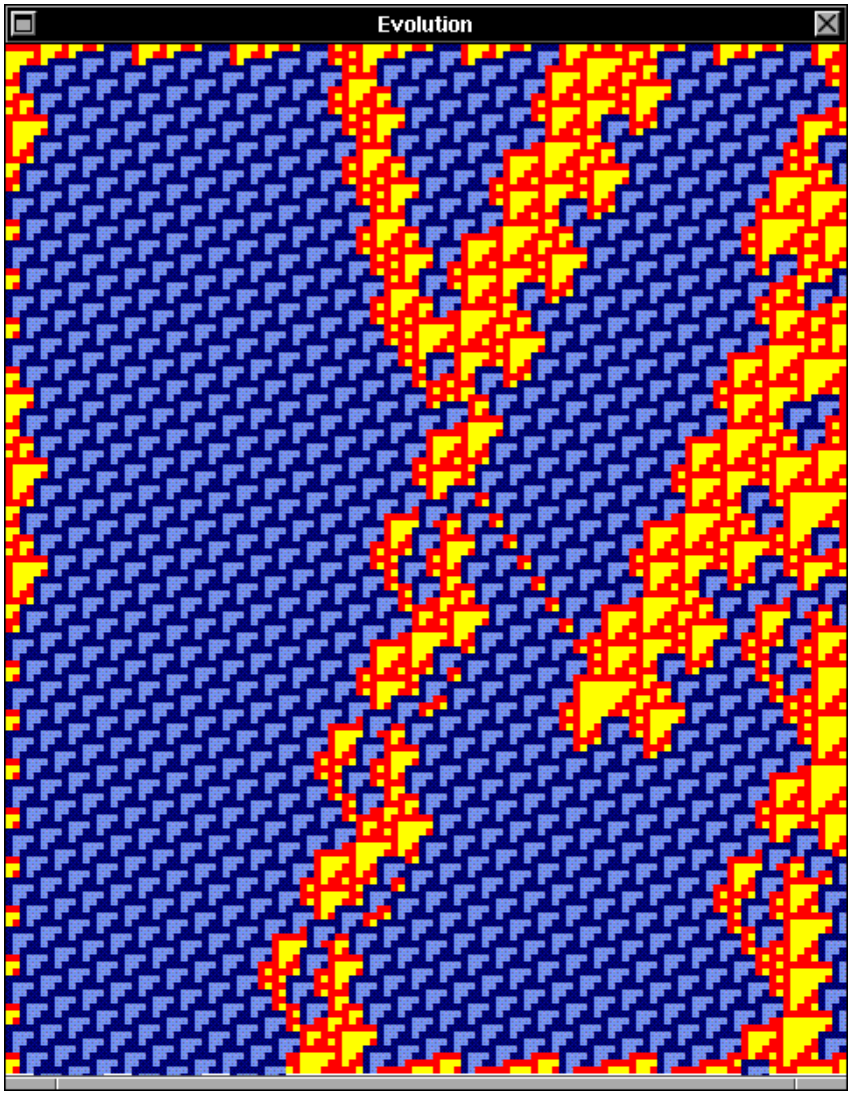


Figure 4.113: Collisions of glider Bbar, D2(p1)(C)-e(p1)-Bbar(p1)(A)=A,Ebar

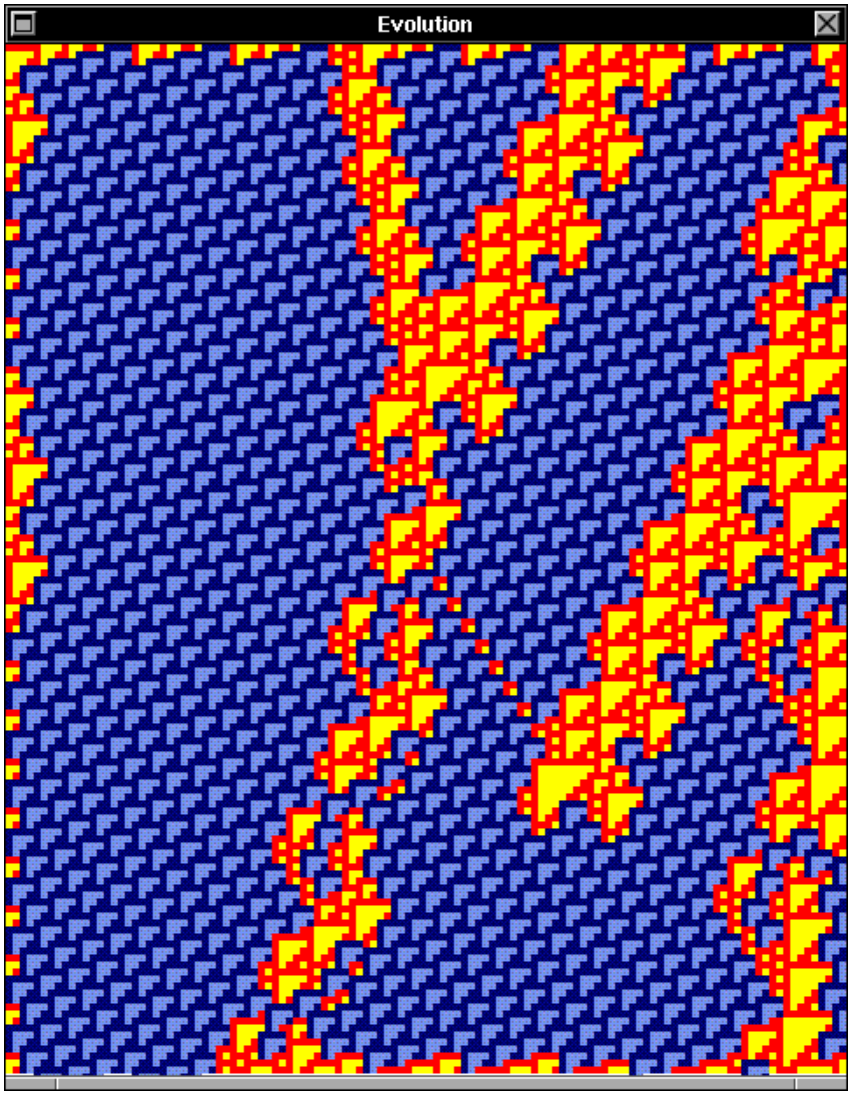


Figure 4.114: Collisions of glider Bbar, D2(p1)(C)-e(p1)-Bbar(p1)(B)=A,Ebar

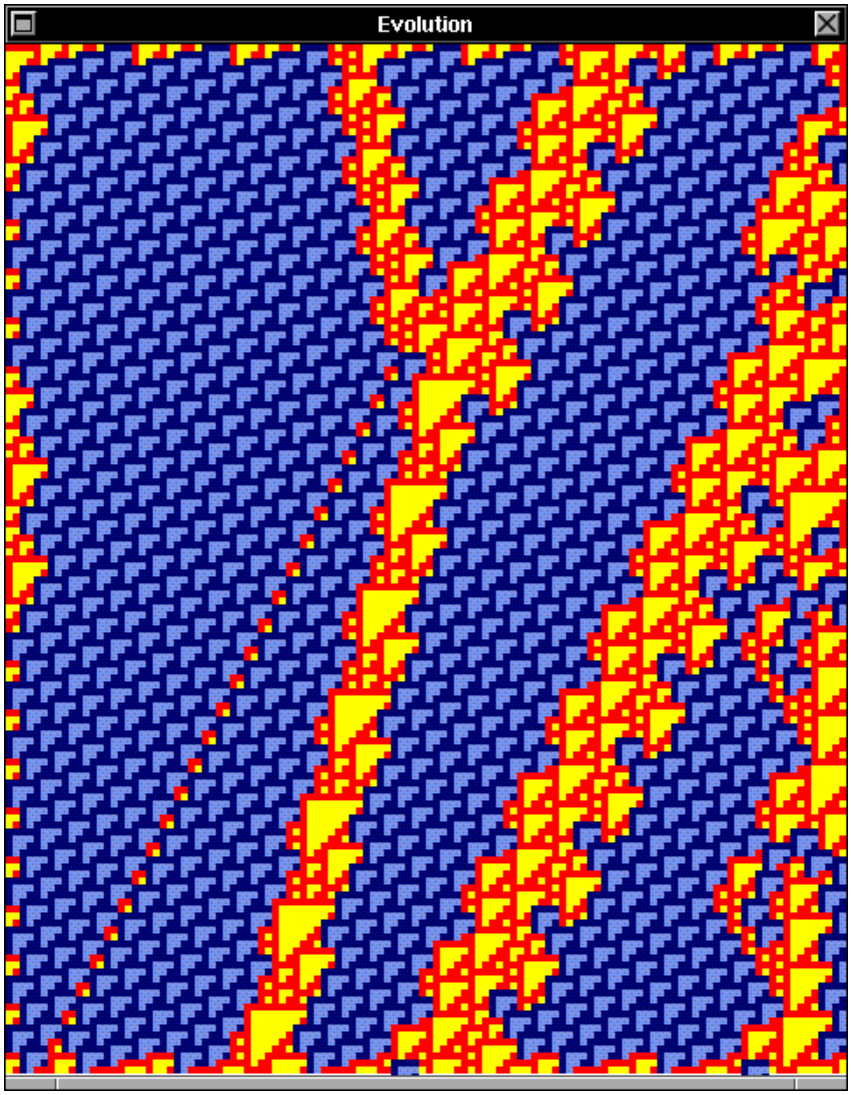


Figure 4.115: Collisions of glider Bbar, D2(p1)(C)-e(p1)-Bbar(p1)(C)=B,E

4.4.6 Collisions of glider Bbar with glider E

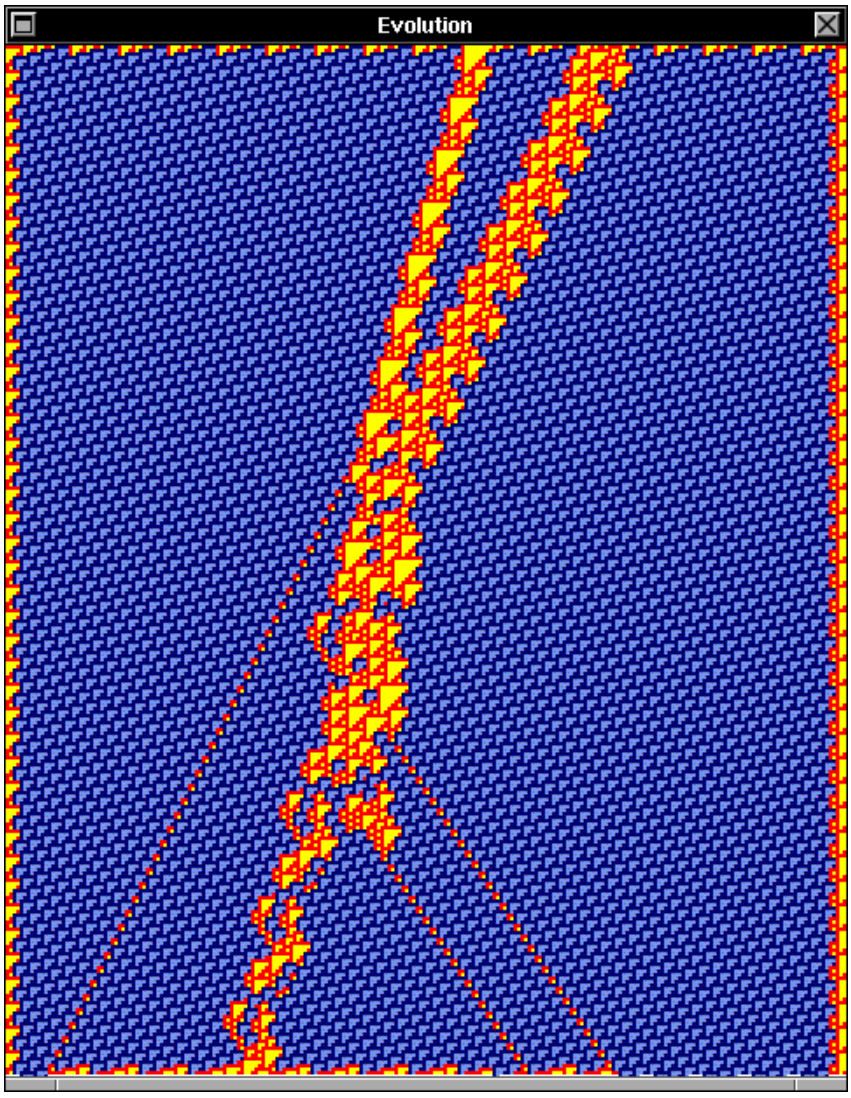


Figure 4.116: Collisions of glider Bbar, E(p1)(A)-e(p1)-Bbar(p1)(A)=B,A,A,Ebar

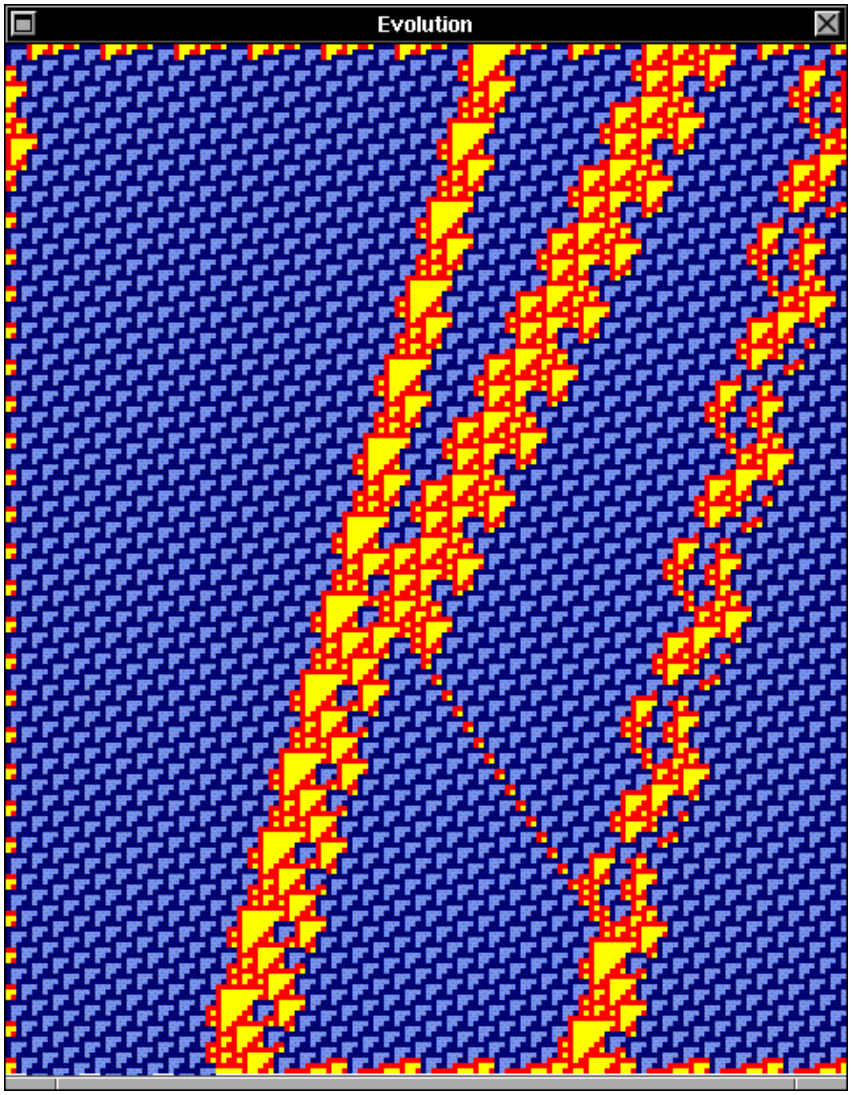


Figure 4.117: Collisions of glider Bbar, E(p1)(A)-e(p1)-Bbar(p1)(B)=E3,A

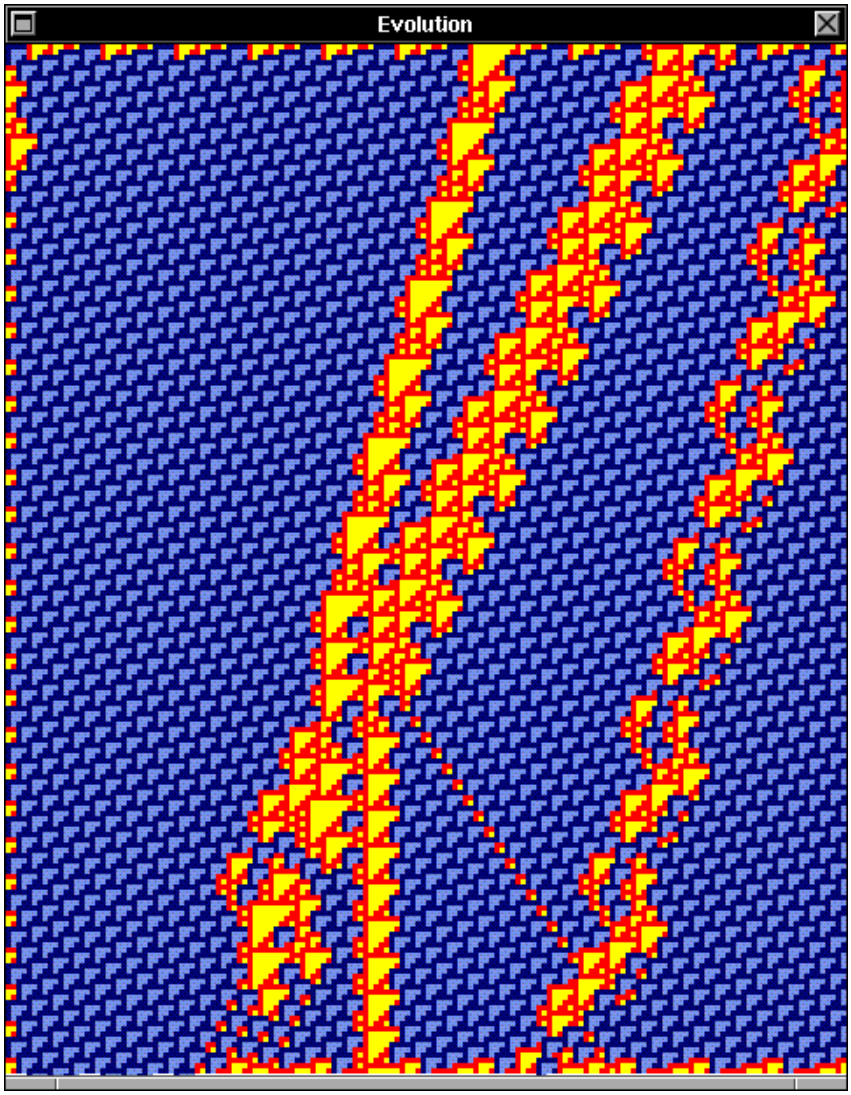


Figure 4.118: Collisions of glider Bbar, E(p1)(A)-e(p1)-Bbar(p1)(C)=A,C2,4B

4.4.7 Collisions of glider Bbar with glider Ebar

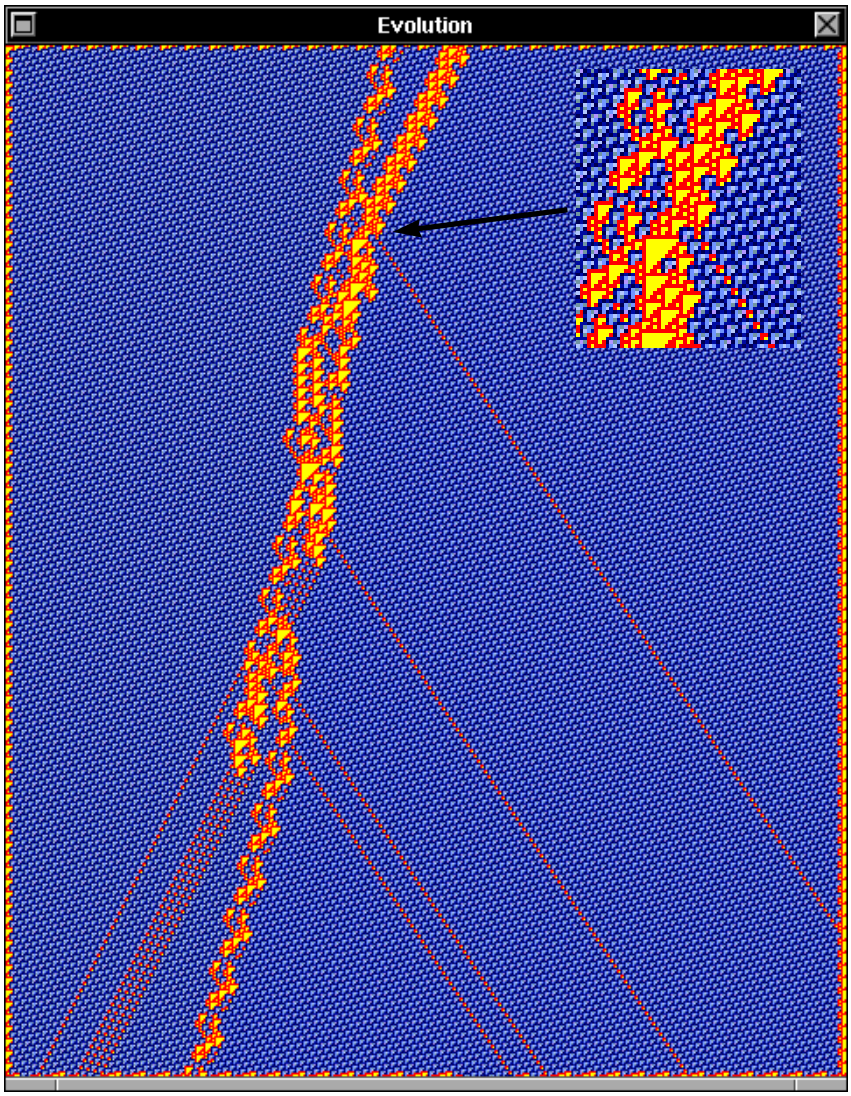


Figure 4.119: Collisions of glider Bbar, Ebar(p1)(A)-e(p1)-Bbar(p1)(A)=A,A,B,A,A,Ebar,4B

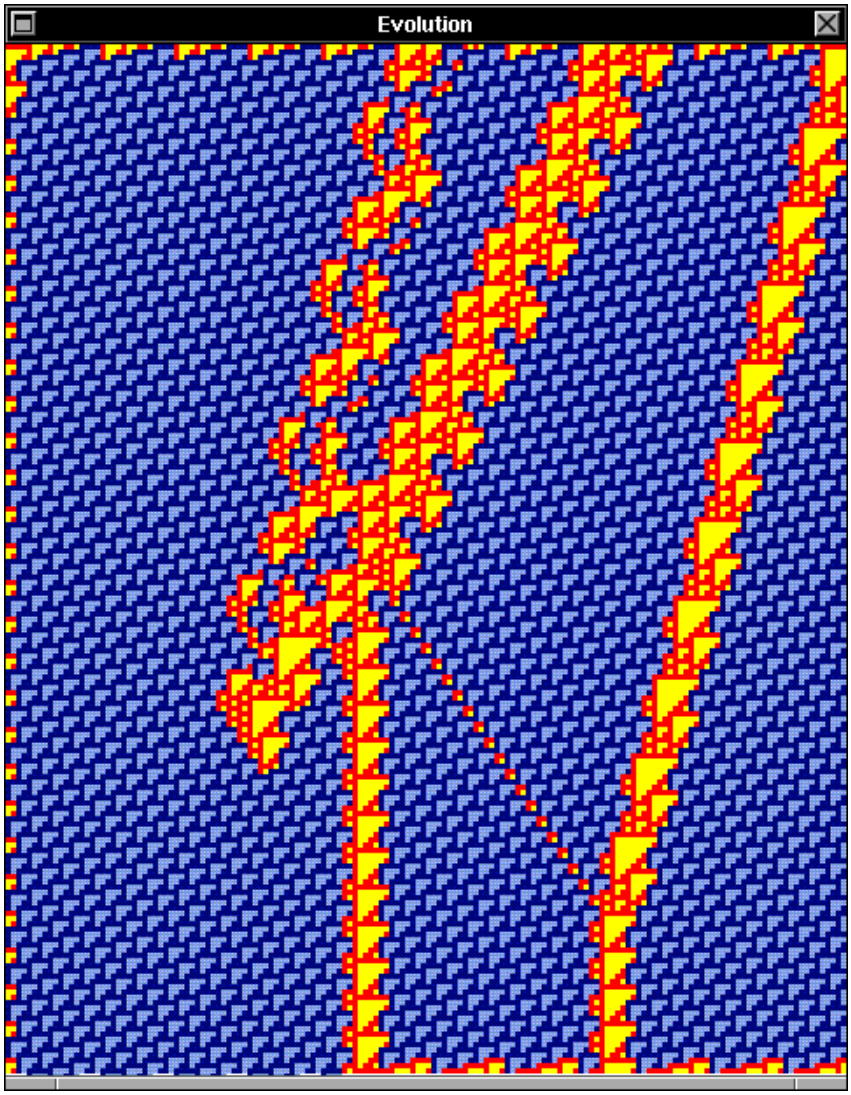


Figure 4.120: Collisions of glider Bbar, Ebar(p1)(A)-e(p1)-Bbar(p1)(B)=A,C1

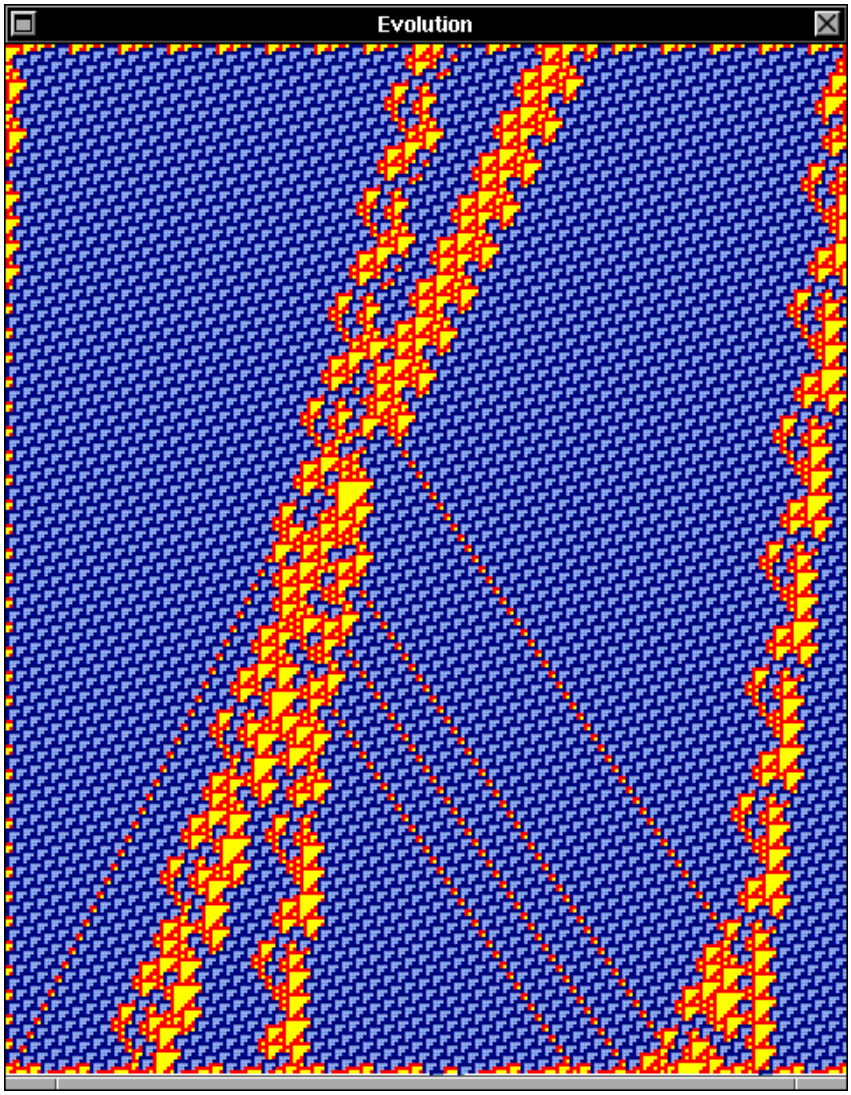


Figure 4.121: Collisions of glider Bbar, Ebar(p1)(A)-e(p1)-Bbar(p1)(C)=A,B,A,A,A,G,F

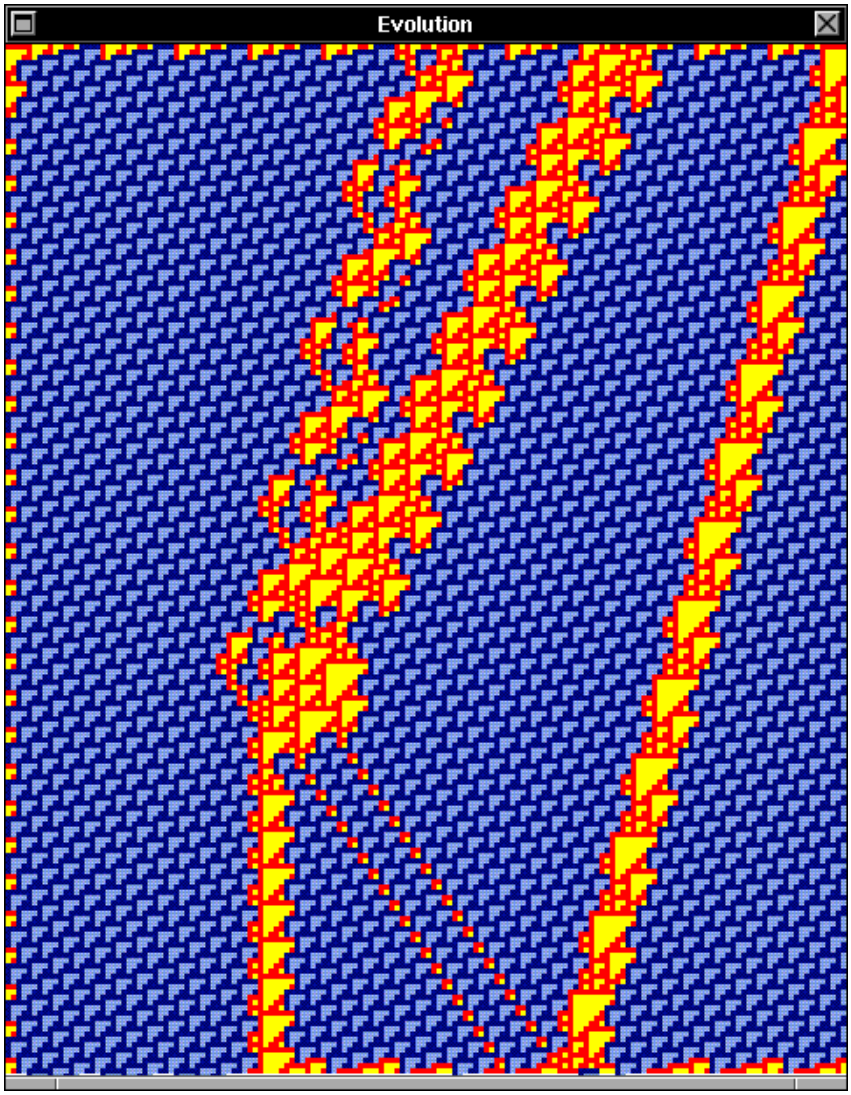


Figure 4.122: Collisions of glider Bbar, Ebar(p1)(F)-e(p1)-Bbar(p1)(A)=A,A,C2

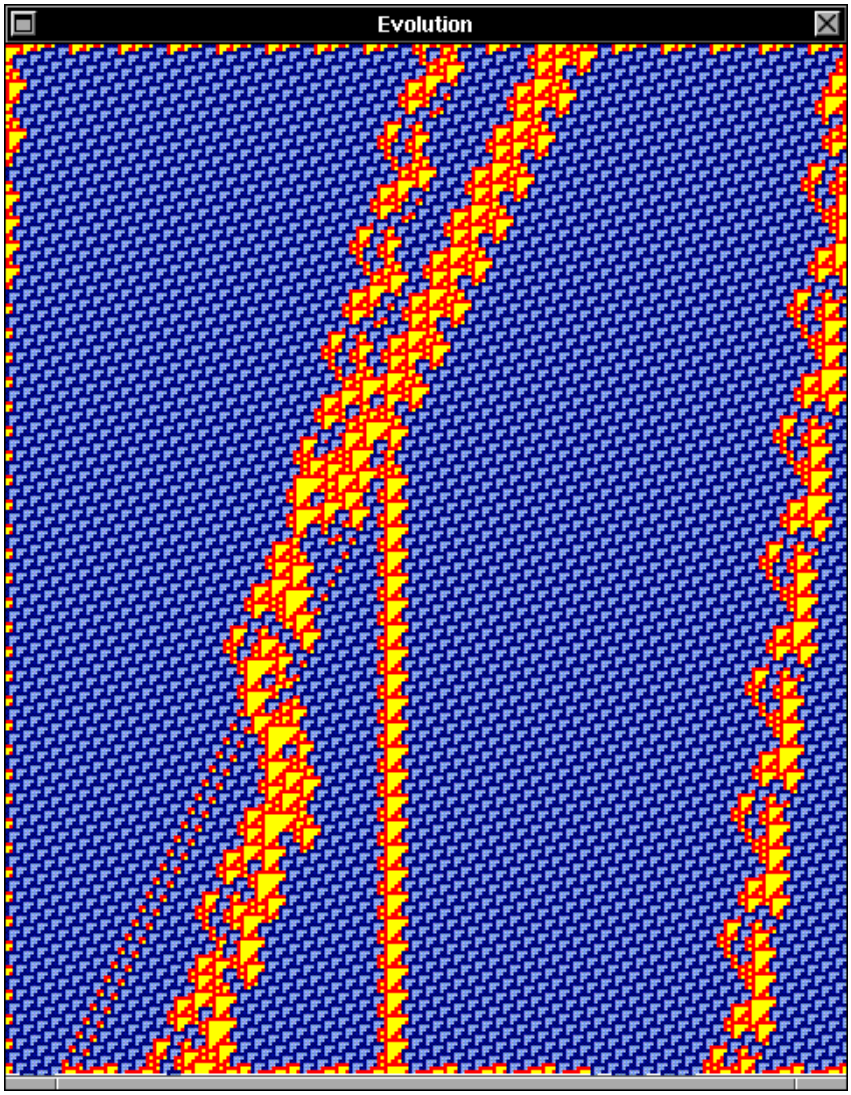


Figure 4.123: Collisions of glider Bbar, Ebar(p1)(F)-e(p1)-Bbar(p1)(B)=C2,2B,G

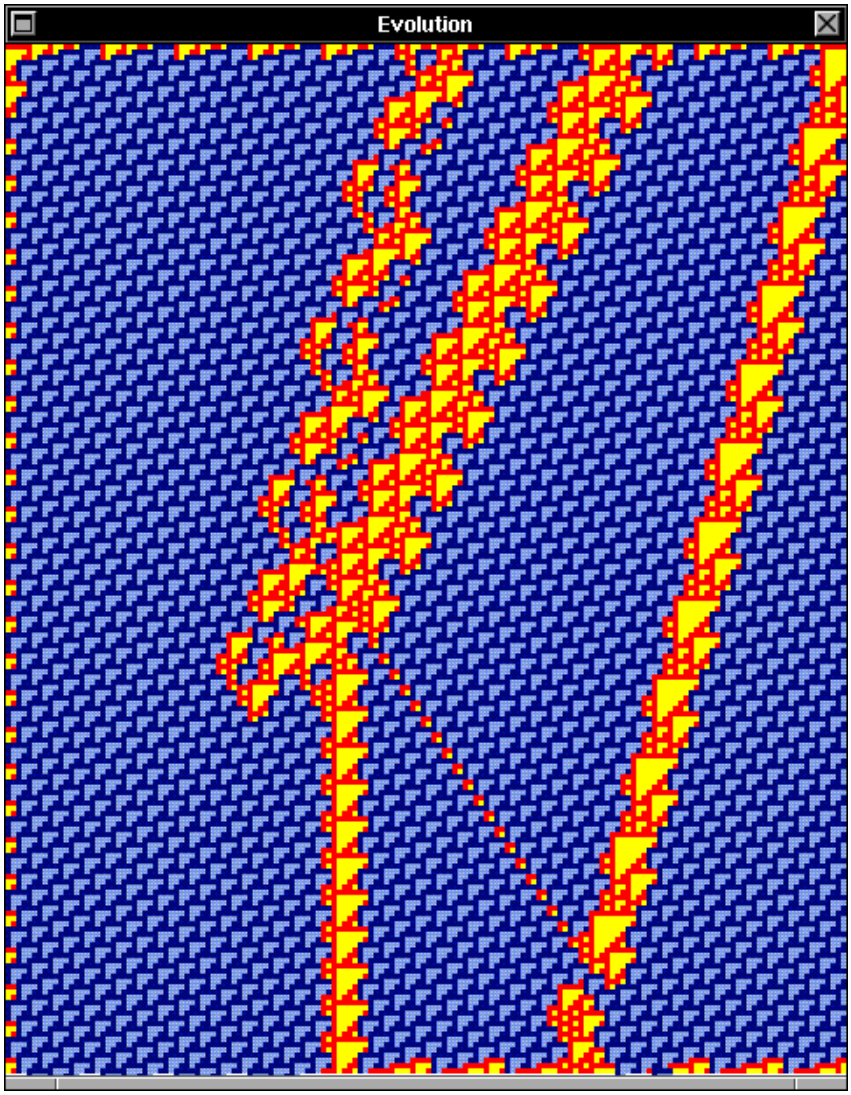


Figure 4.124: Collisions of glider Bbar, Ebar(p1)(F)-e(p1)-Bbar(p1)(C)=A,C2

4.4.8 Collisions of glider Bbar with glider F

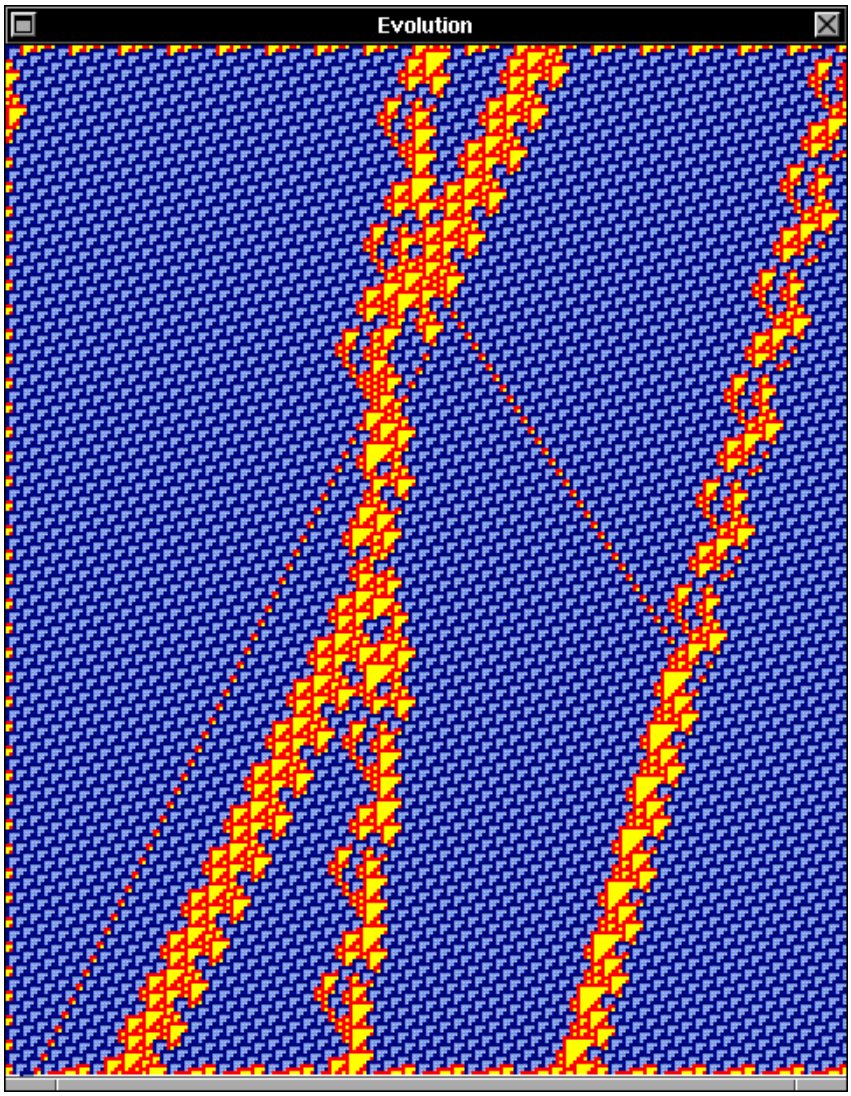


Figure 4.125: Collisions of glider Bbar, F(p1)(A)-e(p1)-Bbar(p1)(A)=A,B,Bbar,F

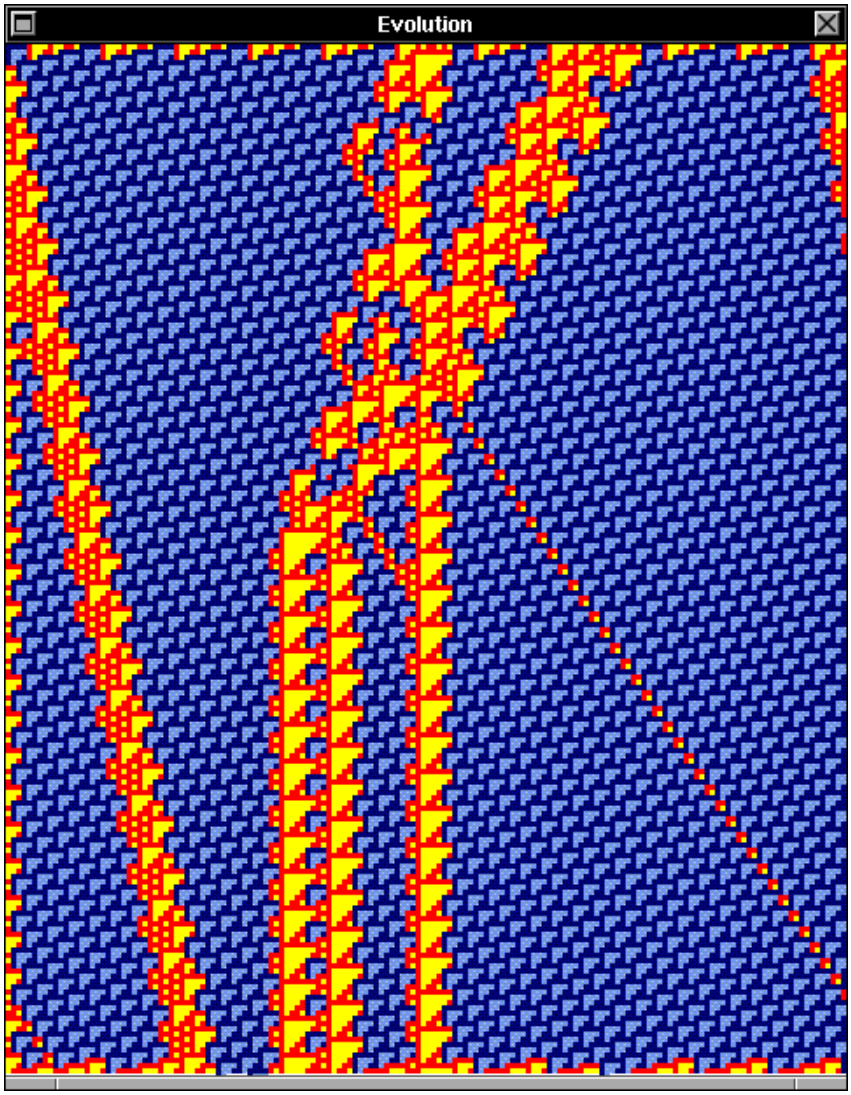


Figure 4.126: Collisions of glider Bbar, F(p1)(A)-e(p1)-Bbar(p1)(B)=A,2C3,C1

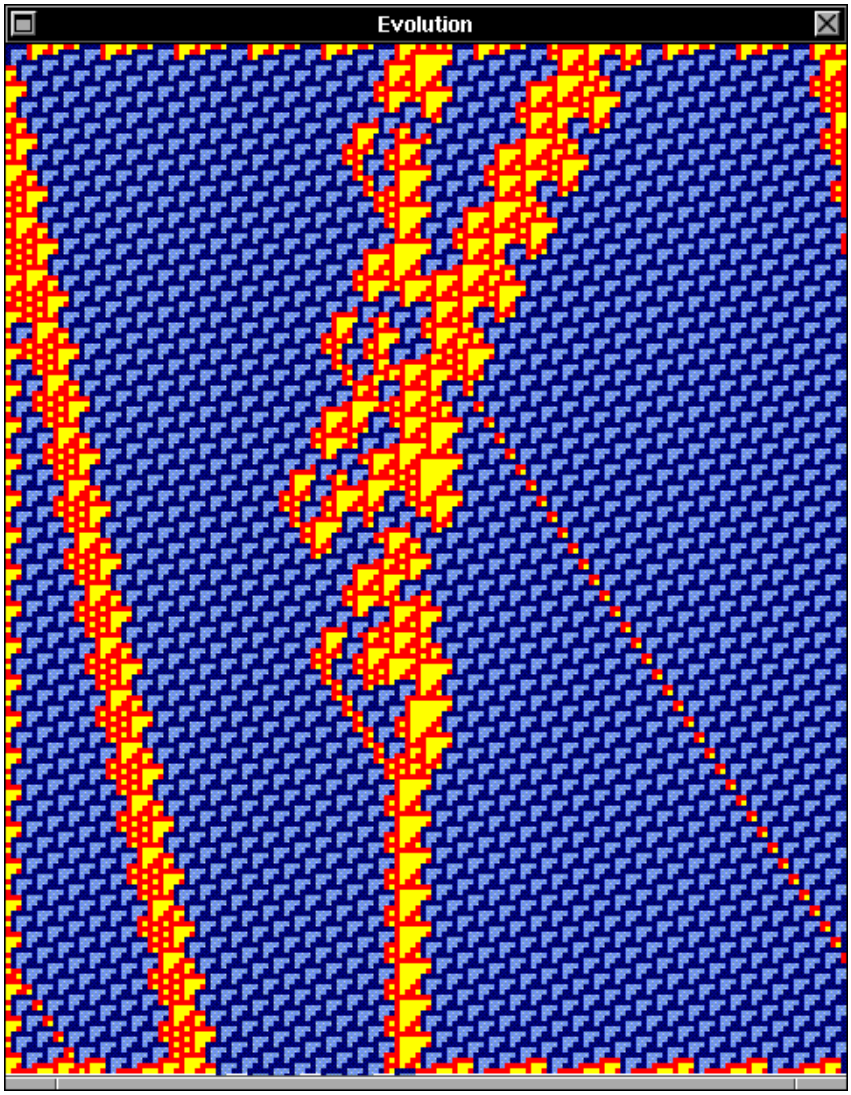


Figure 4.127: Collisions of glider Bbar, F(p1)(A)-e(p1)-Bbar(p1)(C)=A,C2

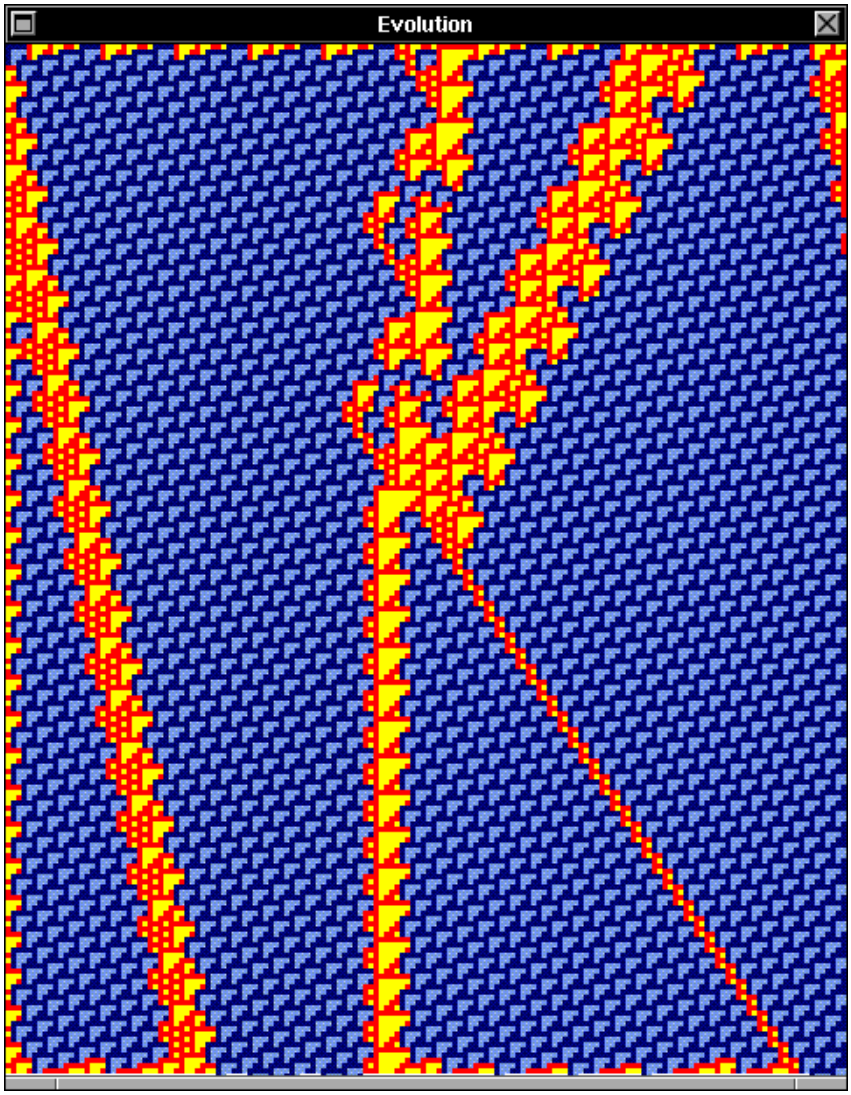


Figure 4.128: Collisions of glider Bbar, F(p1)(G)-e(p1)-Bbar(p1)(A)=C2,2A

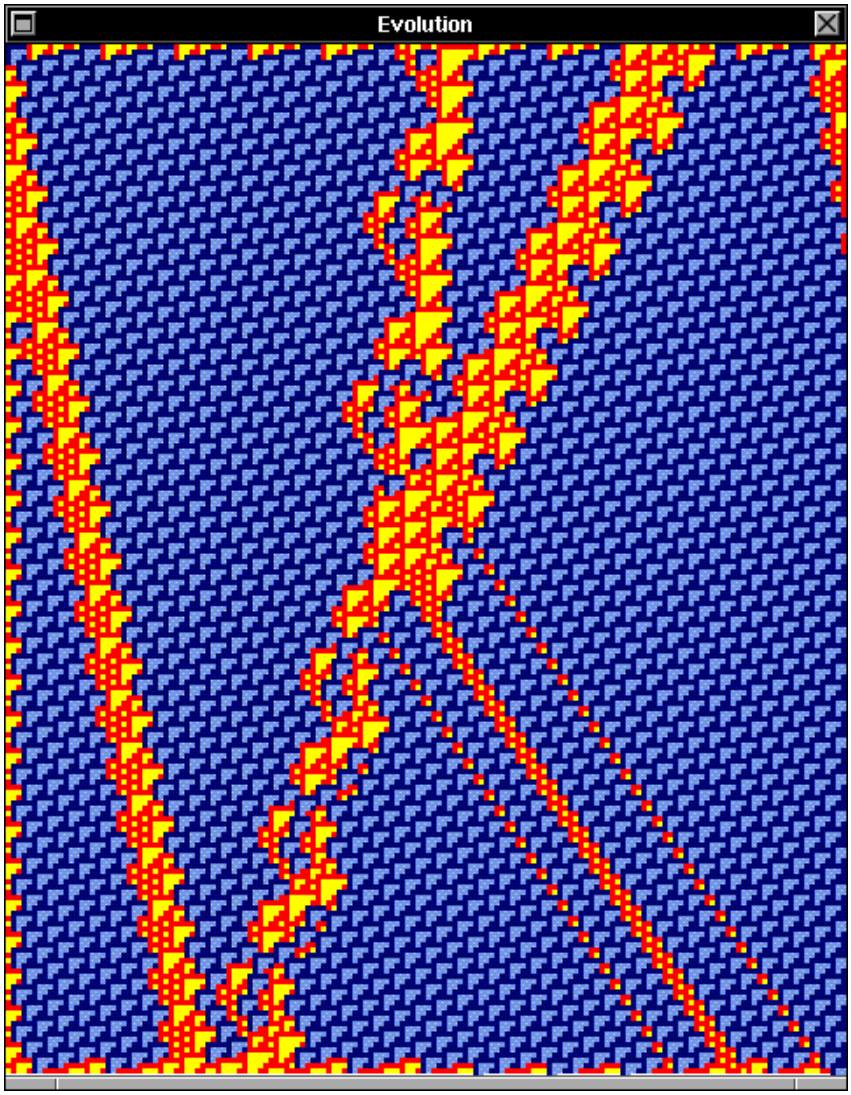


Figure 4.129: Collisions of glider Bbar, F(p1)(G)-e(p1)-Bbar(p1)(B)=A,3A,A,Ebar

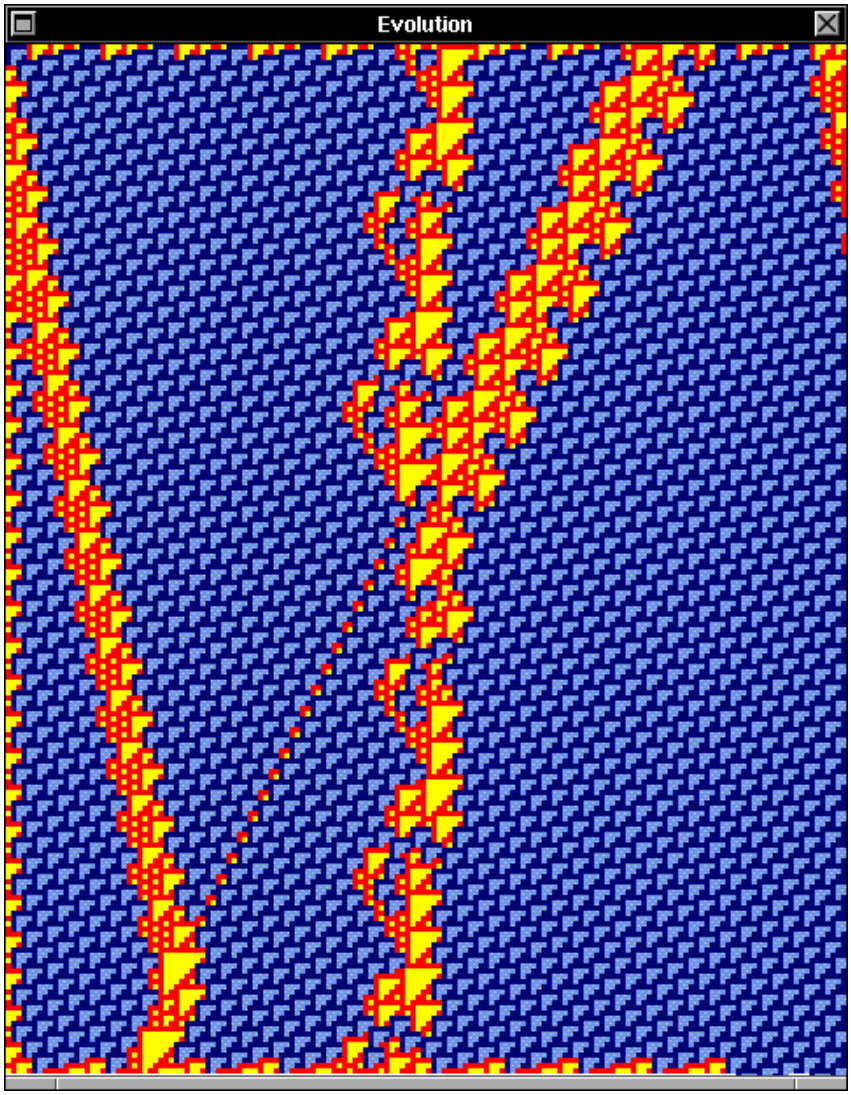


Figure 4.130: Collisions of glider Bbar, F(p1)(G)-e(p1)-Bbar(p1)(C)=B,F

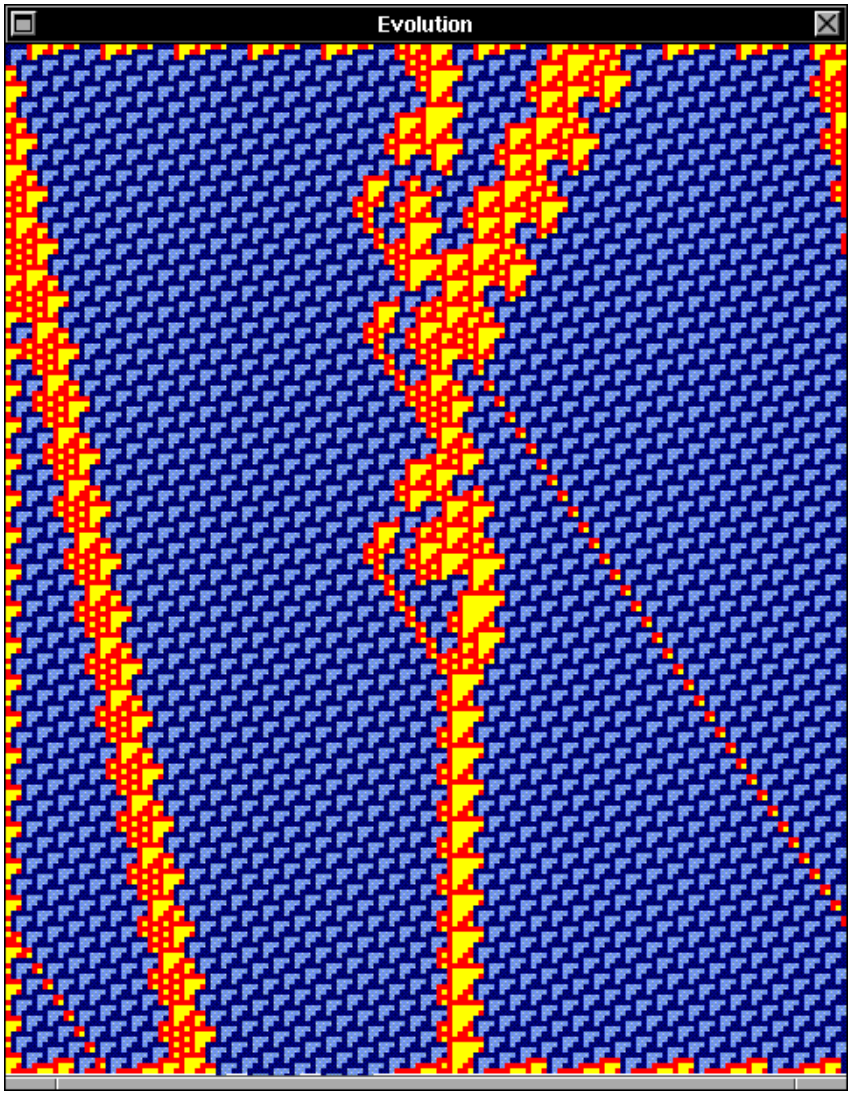


Figure 4.131: Collisions of glider Bbar, F(p1)(H)-e(p1)-Bbar(p1)(A)=A,C2

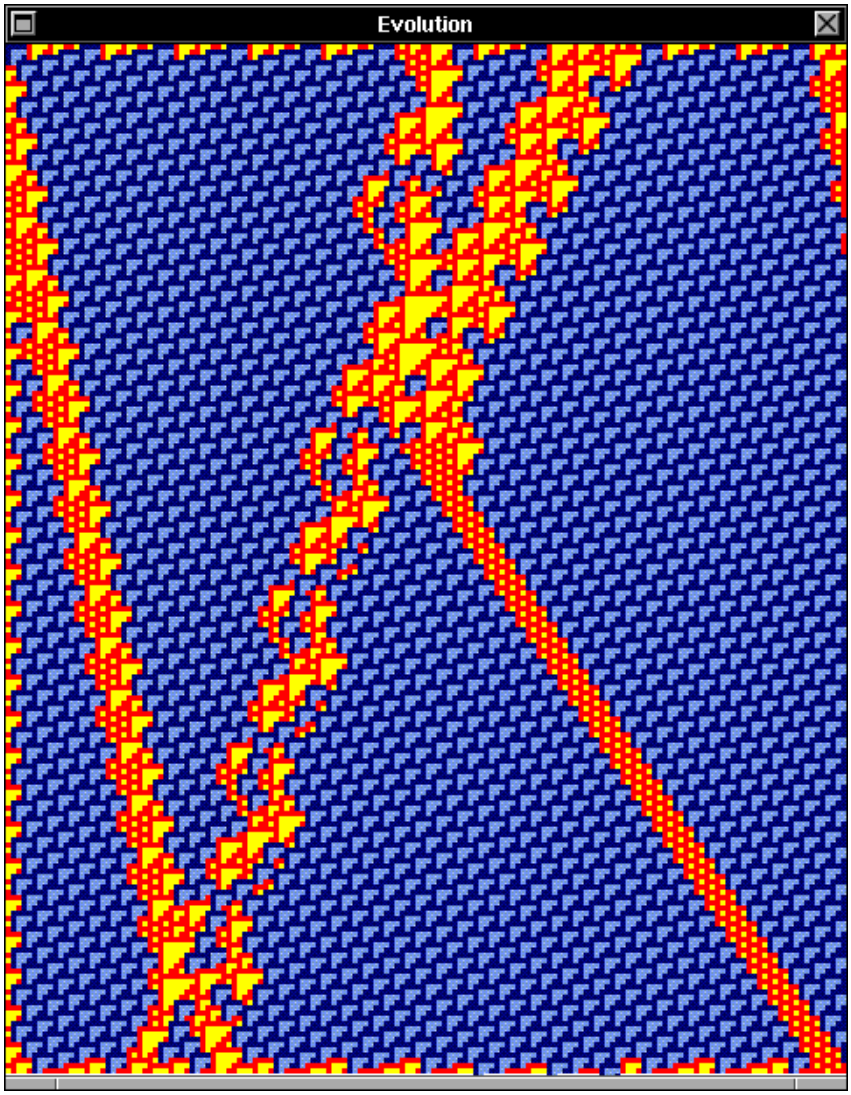


Figure 4.132: Collisions of glider Bbar, F(p1)(H)-e(p1)-Bbar(p1)(B)=5A,Ebar

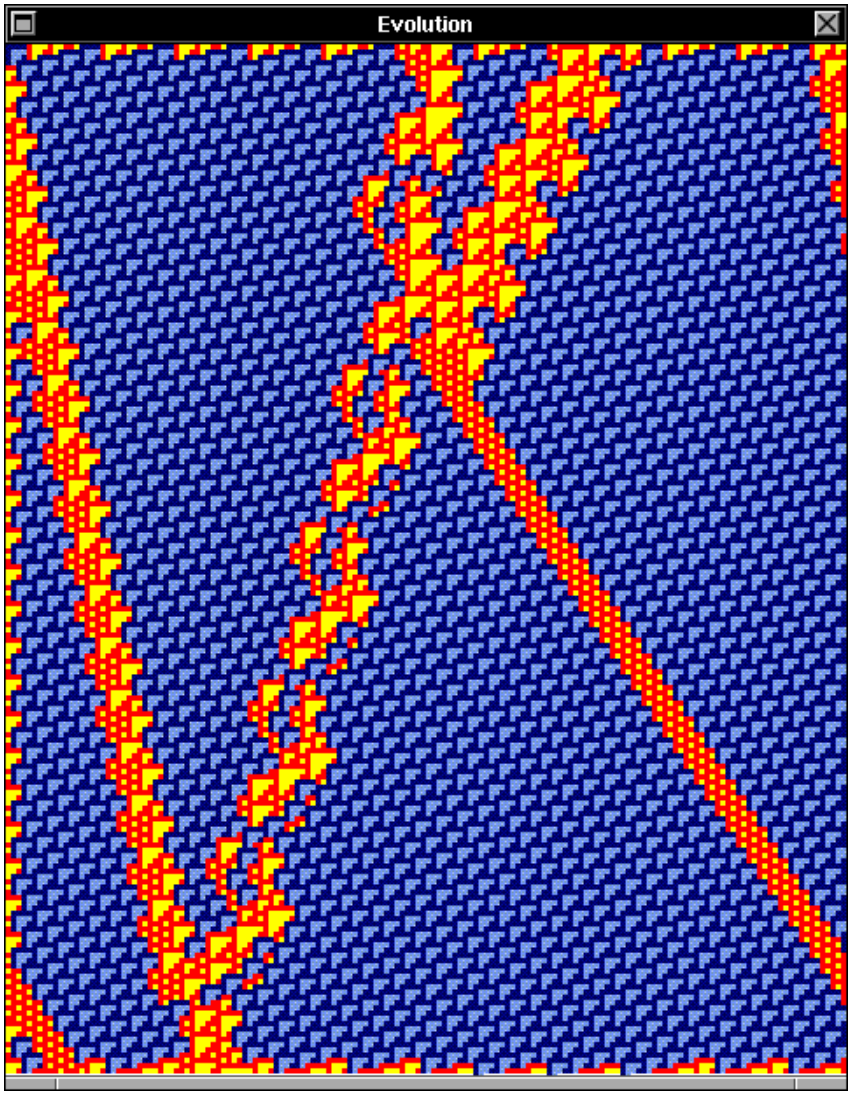


Figure 4.133: Collisions of glider Bbar, F(p1)(H)-e(p1)-Bbar(p1)(C)=5A,Ebar

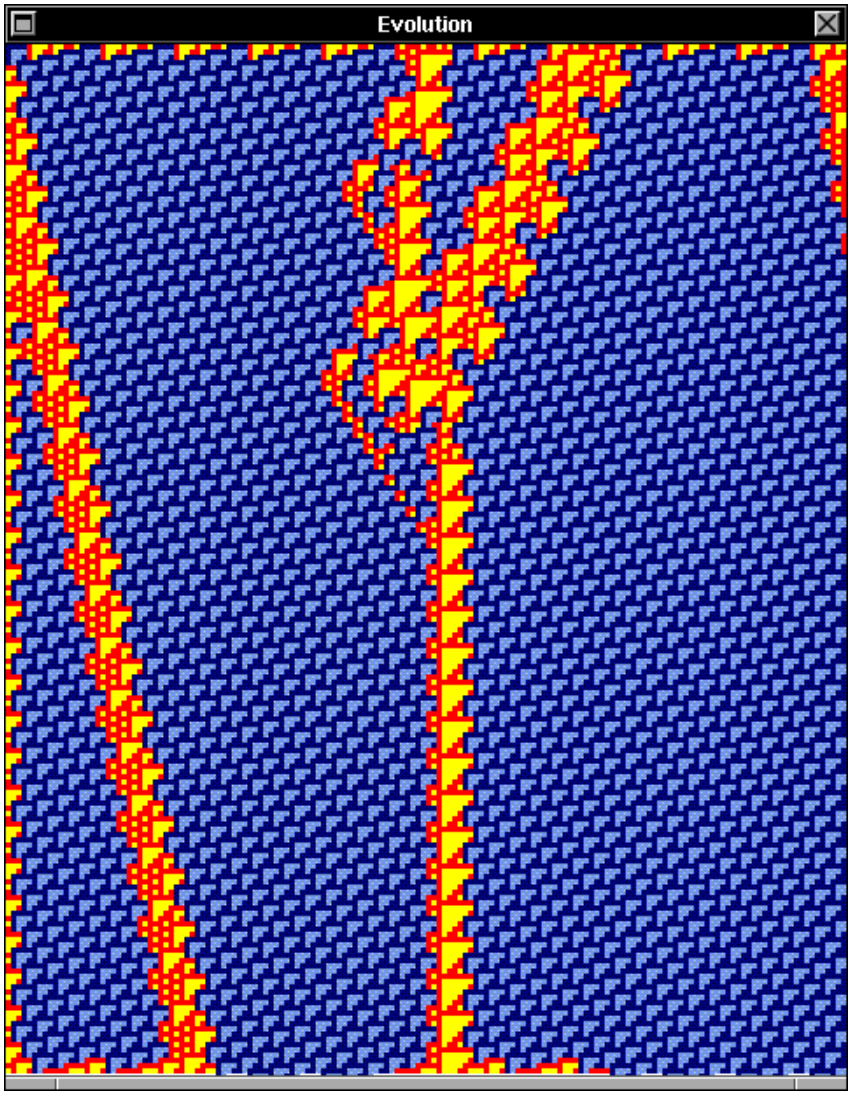


Figure 4.134: Collisions of glider Bbar, F(p1)(A2)-e(p1)-Bbar(p1)(A)=C1

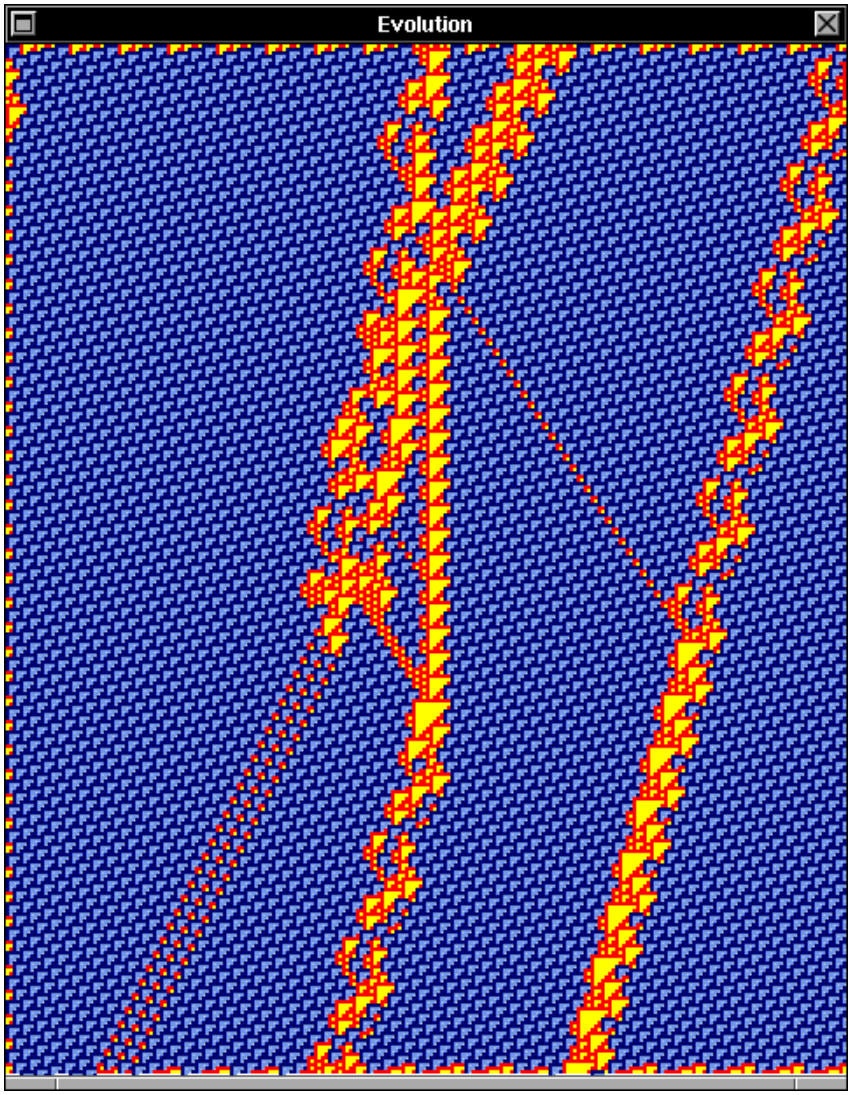


Figure 4.135: Collisions of glider Bbar, F(p1)(A2)-e(p1)-Bbar(p1)(B)=A,3B,Ebar

4.4.9 Collisions of glider Bbar with glider G

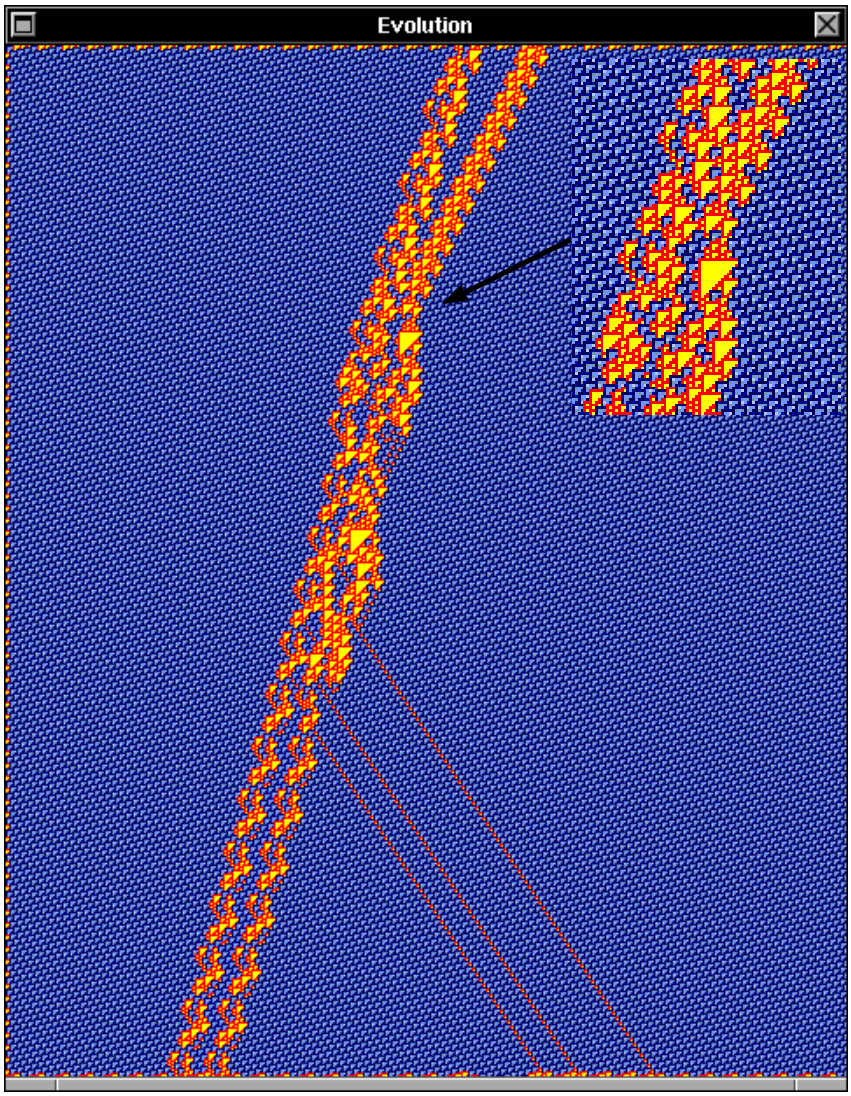


Figure 4.136: Collisions of glider Bbar, G(p1)(A)-e(p1)-Bbar(p1)(A)=A,A,Ebar,Ebar,A

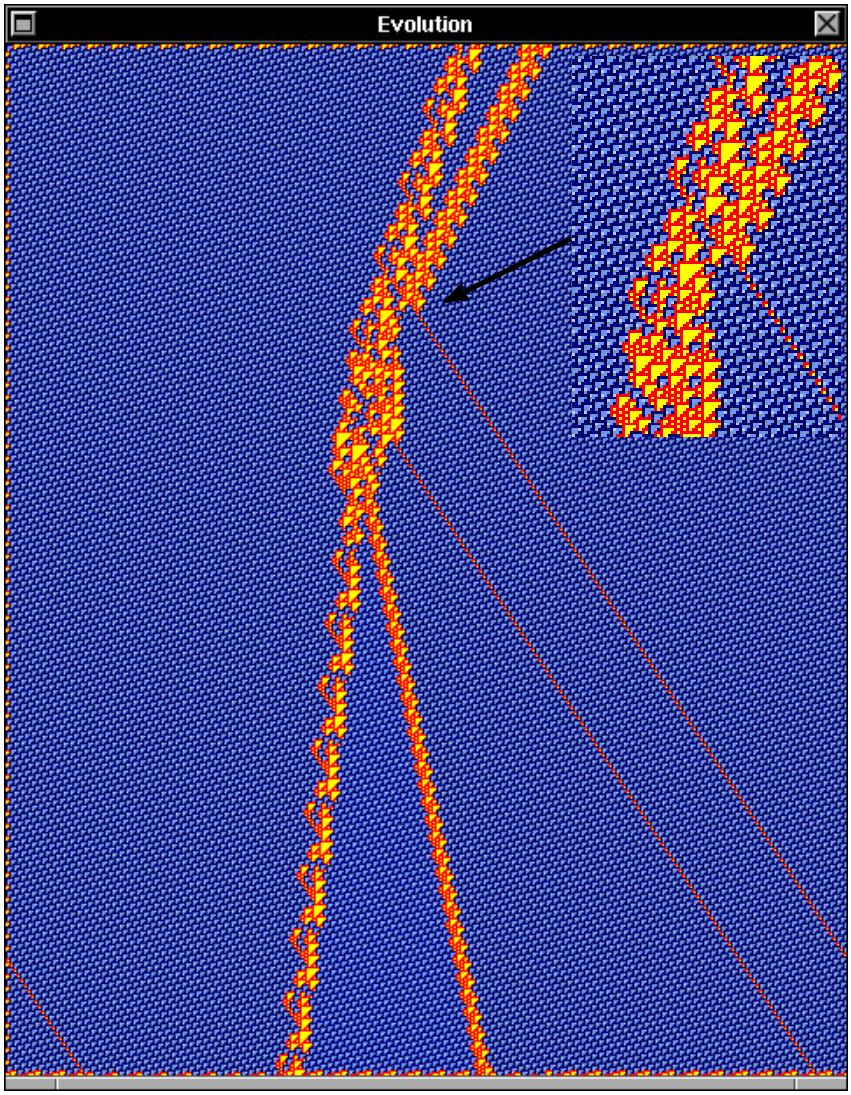


Figure 4.137: Collisions of glider Bbar, G(p1)(A)-e(p1)-Bbar(p1)(B)=A,A,D2,F

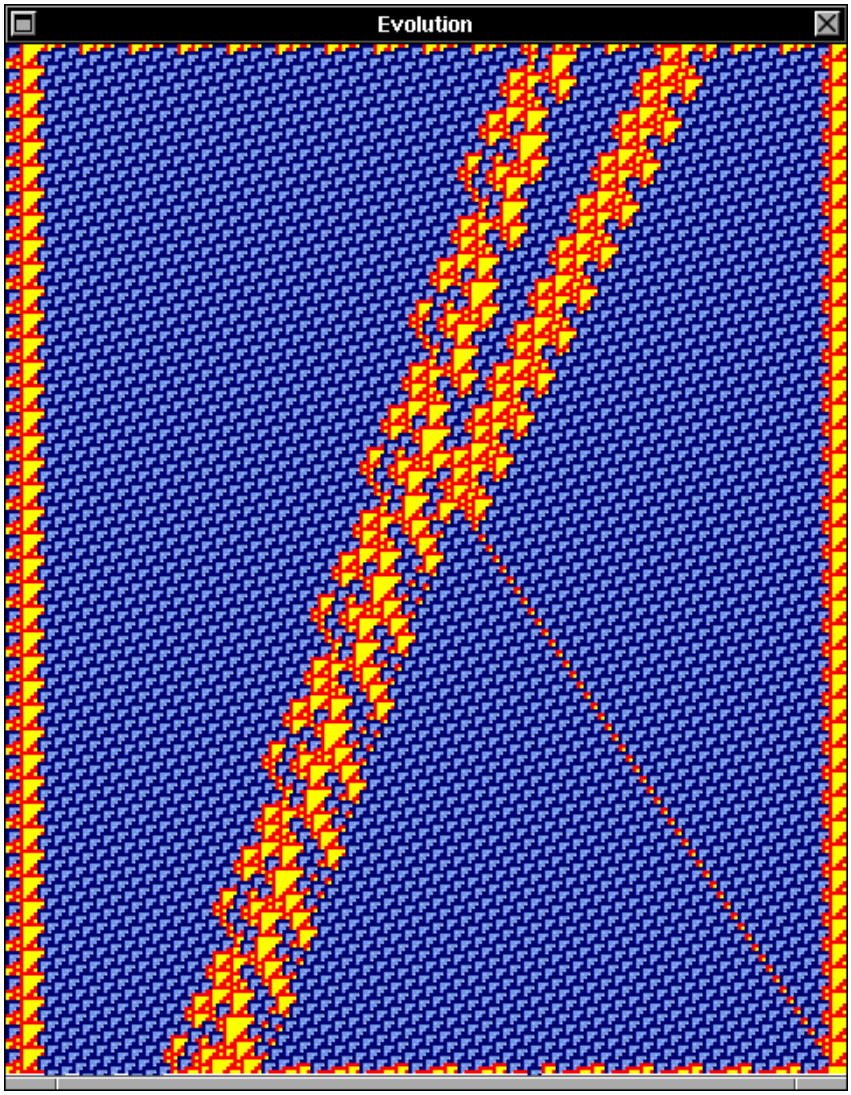


Figure 4.138: Collisions of glider Bbar, G(p1)(A)-e(p1)-Bbar(p1)(C)=A,G3

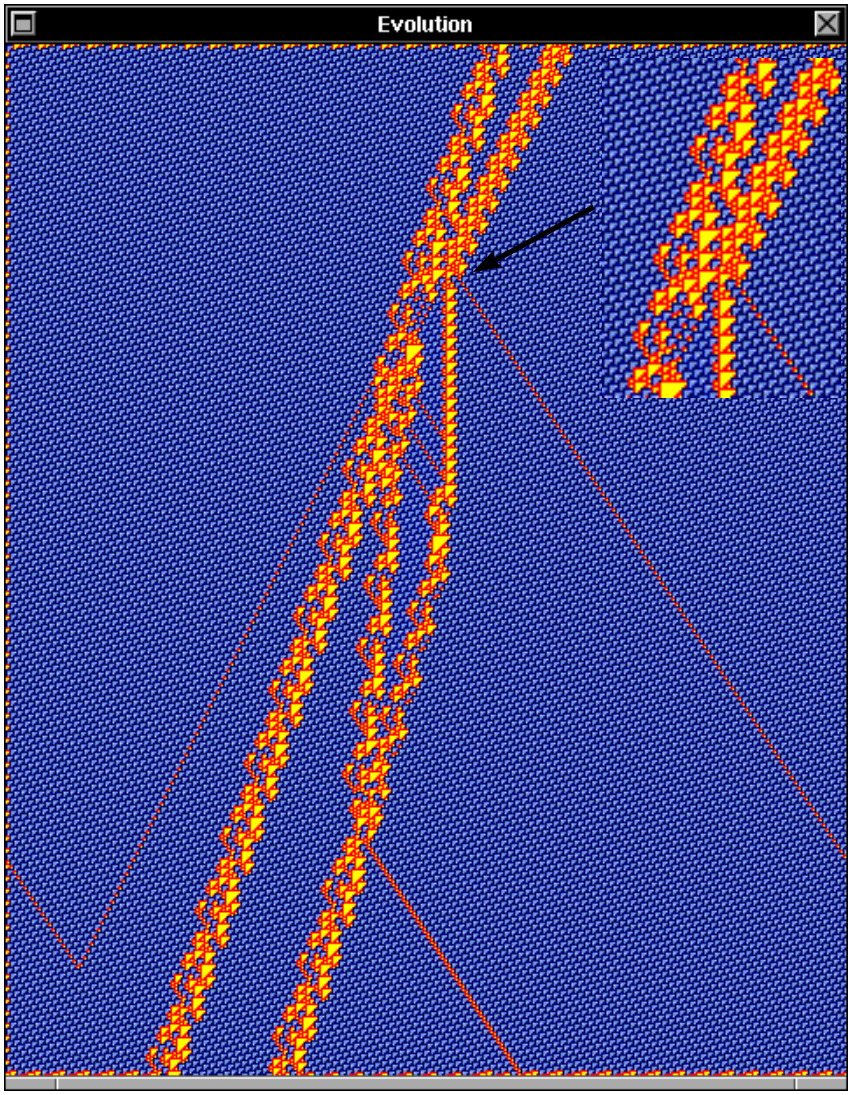


Figure 4.139: Collisions of glider Bbar, G(p1)(C2)-e(p1)-Bbar(p1)(A)=A,B,G,2A,G

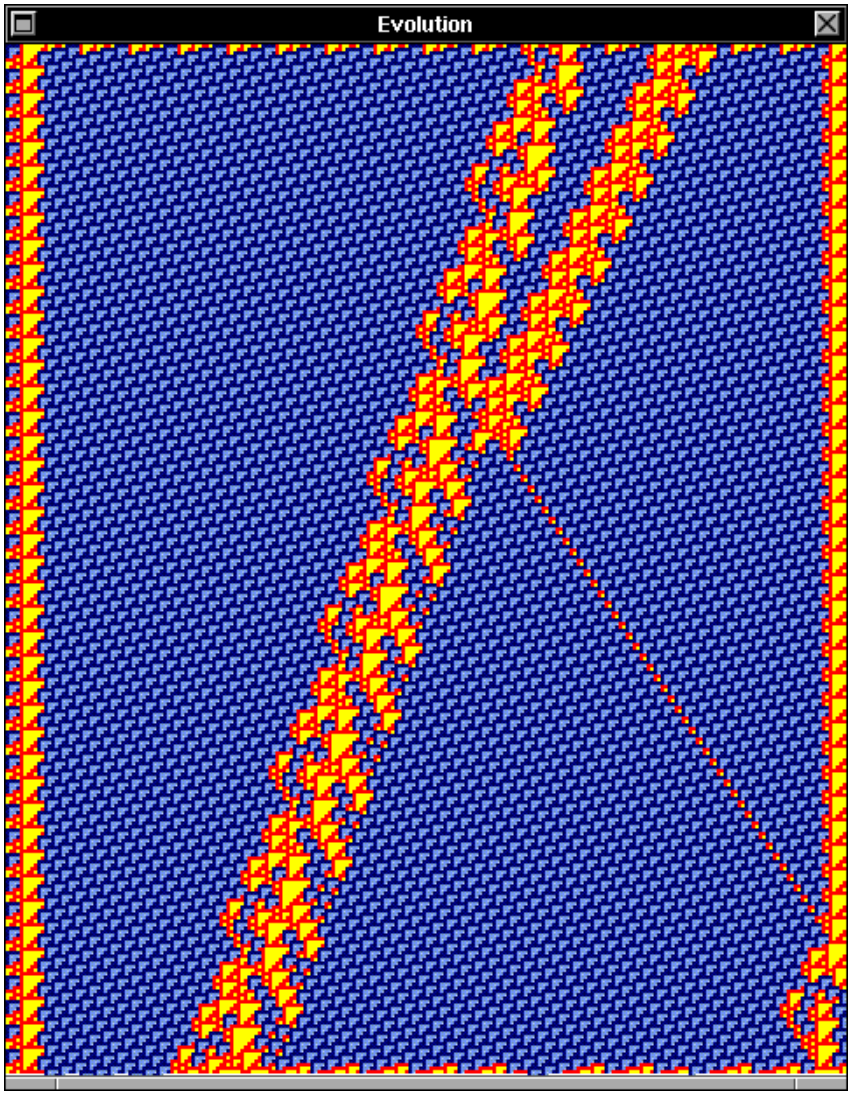


Figure 4.140: Collisions of glider Bbar, G(p1)(C2)-e(p1)-Bbar(p1)(B)=A,G3

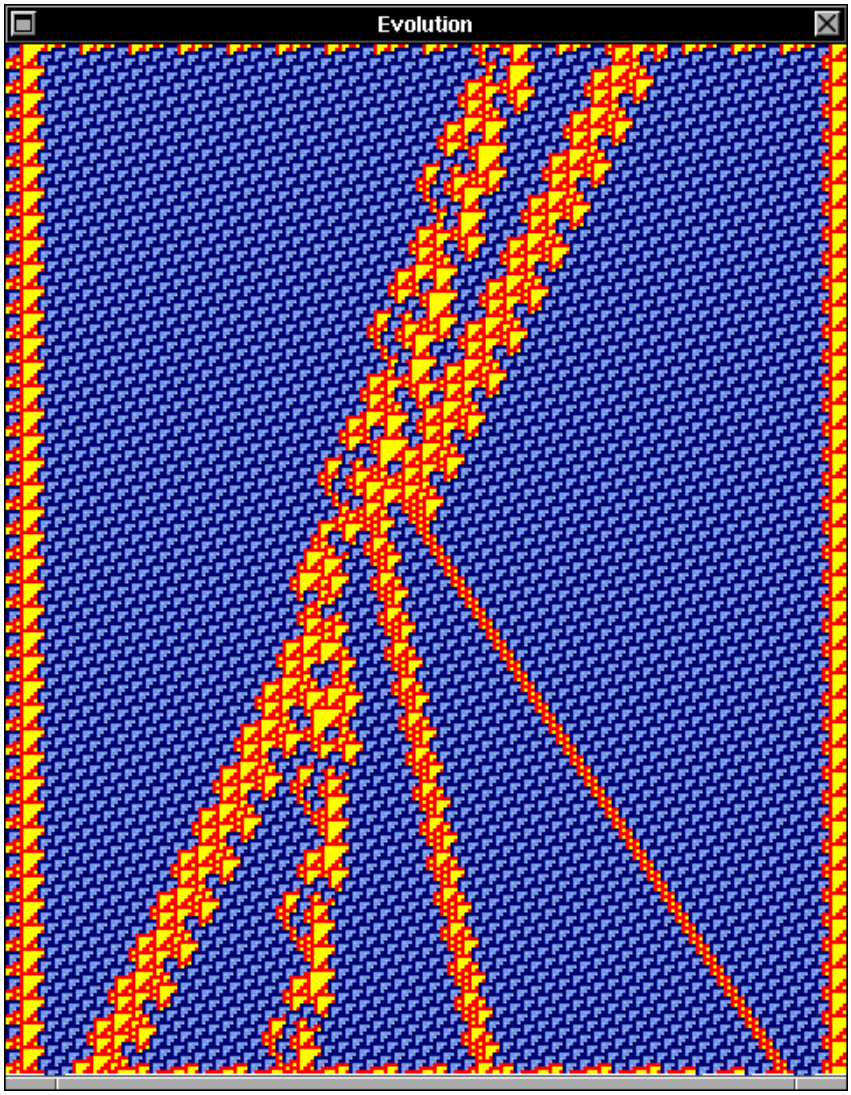
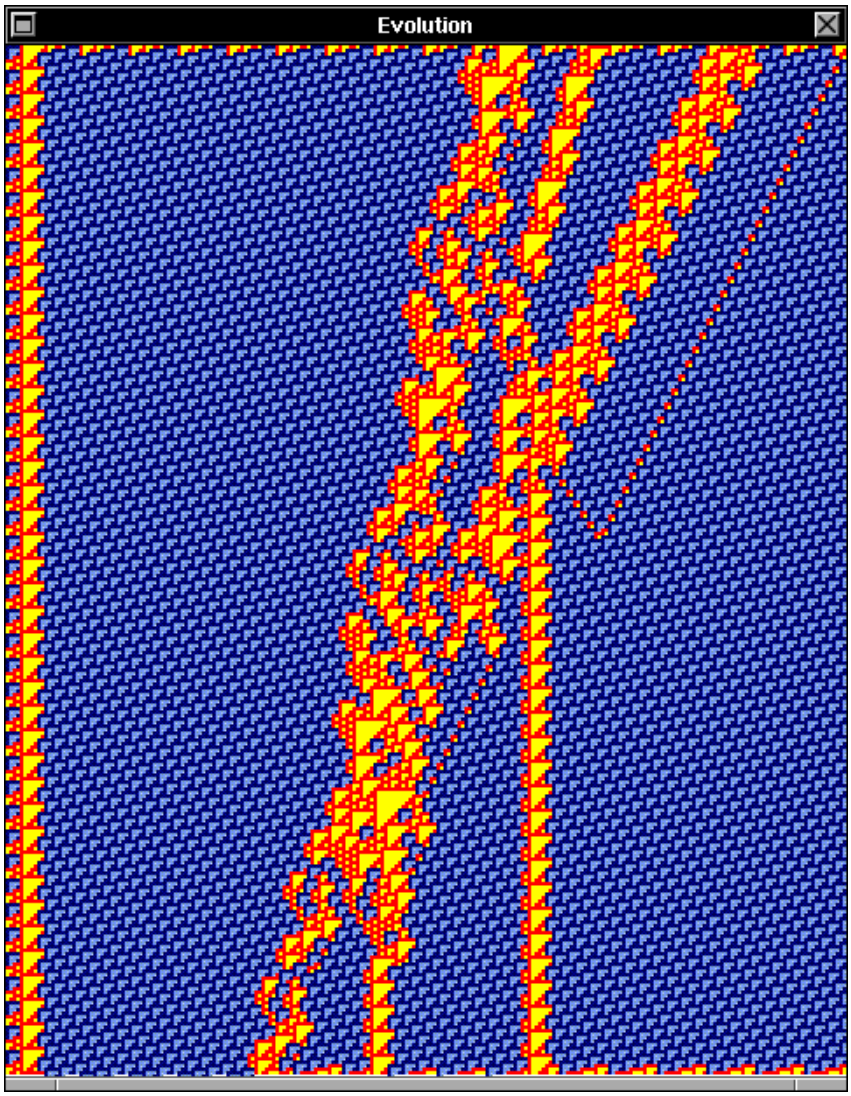


Figure 4.141: Collisions of glider Bbar, G(p1)(C2)-e(p1)-Bbar(p1)(C)=3A,D2,Bbar,F

4.4.10 Collisions of glider Bbar with glider H



vifig

Figure 4.142: Collisions of glider Bbar, H(p1)(A)-e(p1)-Bbar(p1)(A)=A,C2,Ebar,C2

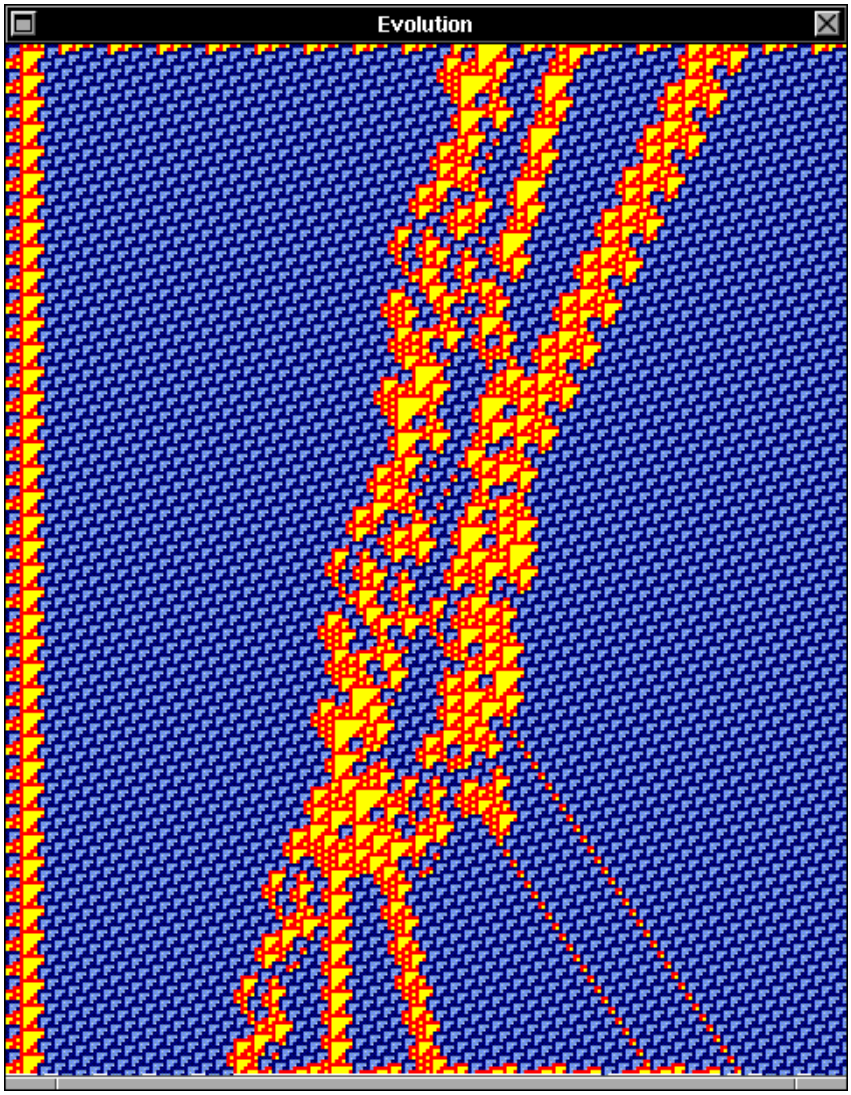


Figure 4.143: Collisions of glider Bbar, H(p1)(A)-e(p1)-Bbar(p1)(B)=A,A,Ebar,C1,D2

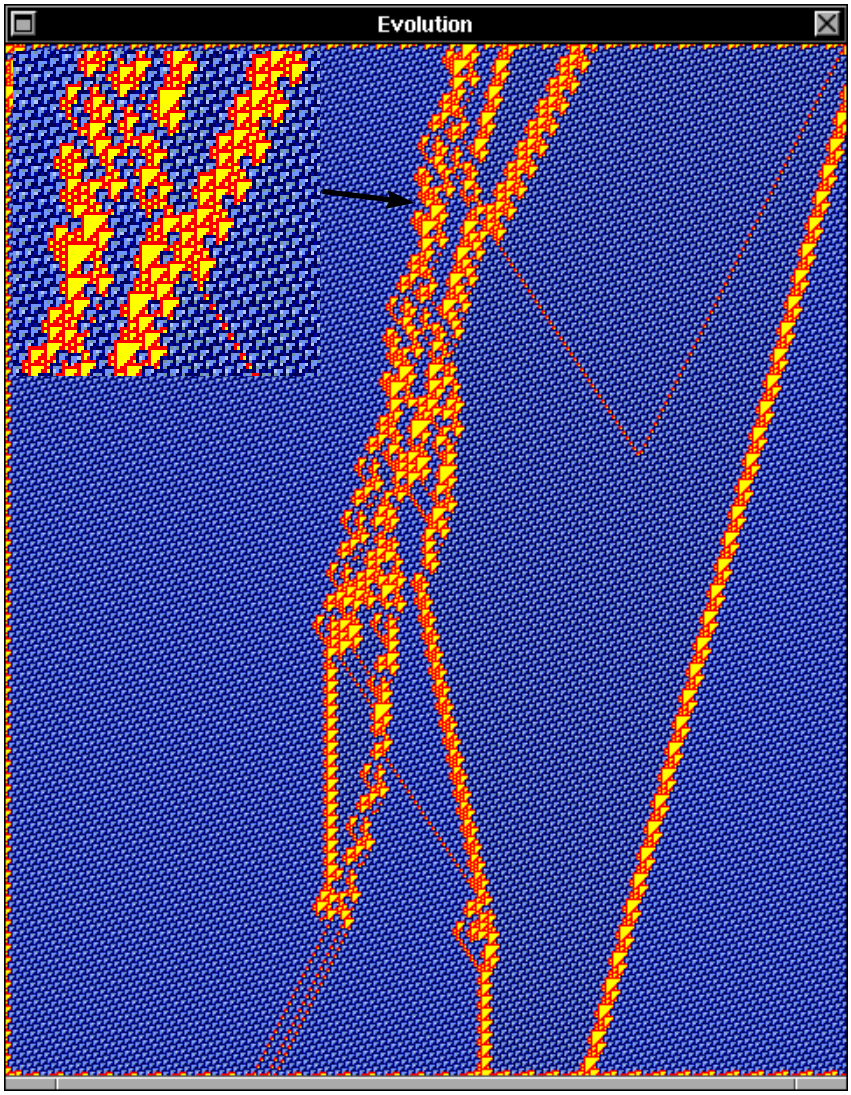


Figure 4.144: Collisions of glider Bbar, H(p1)(A)-e(p1)-Bbar(p1)(C)=A,B,2B,C2

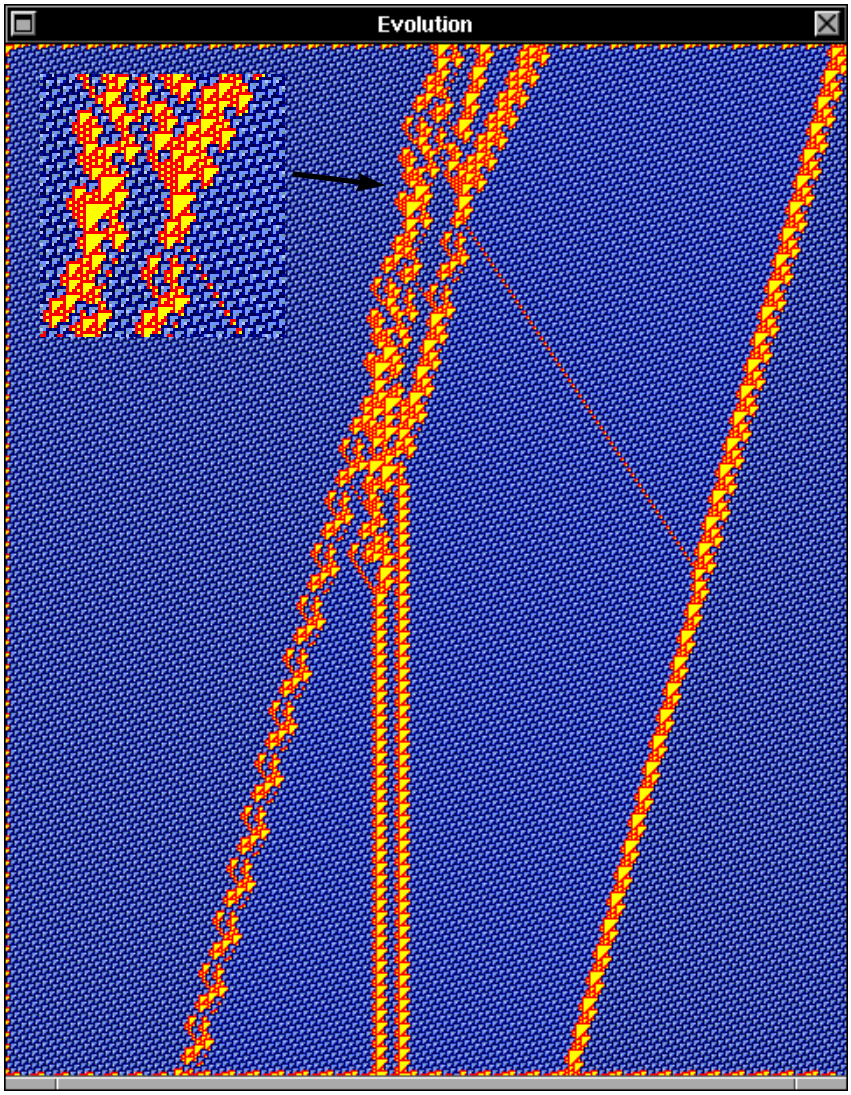


Figure 4.145: Collisions of glider Bbar, H(p1)(D)-e(p1)-Bbar(p1)(A)=A,Ebar,C2,C2

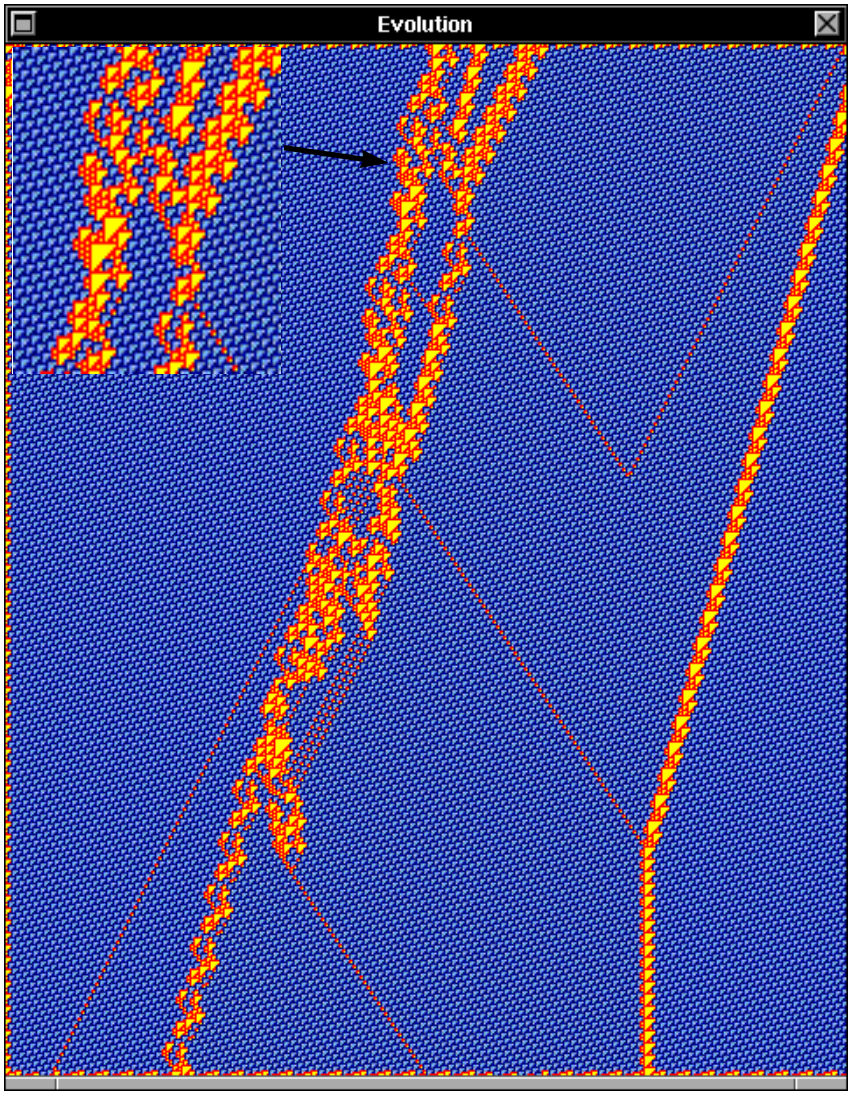


Figure 4.146: Collisions of glider Bbar, H(p1)(D)-e(p1)-Bbar(p1)(B)=A,A,B,Ebar,A

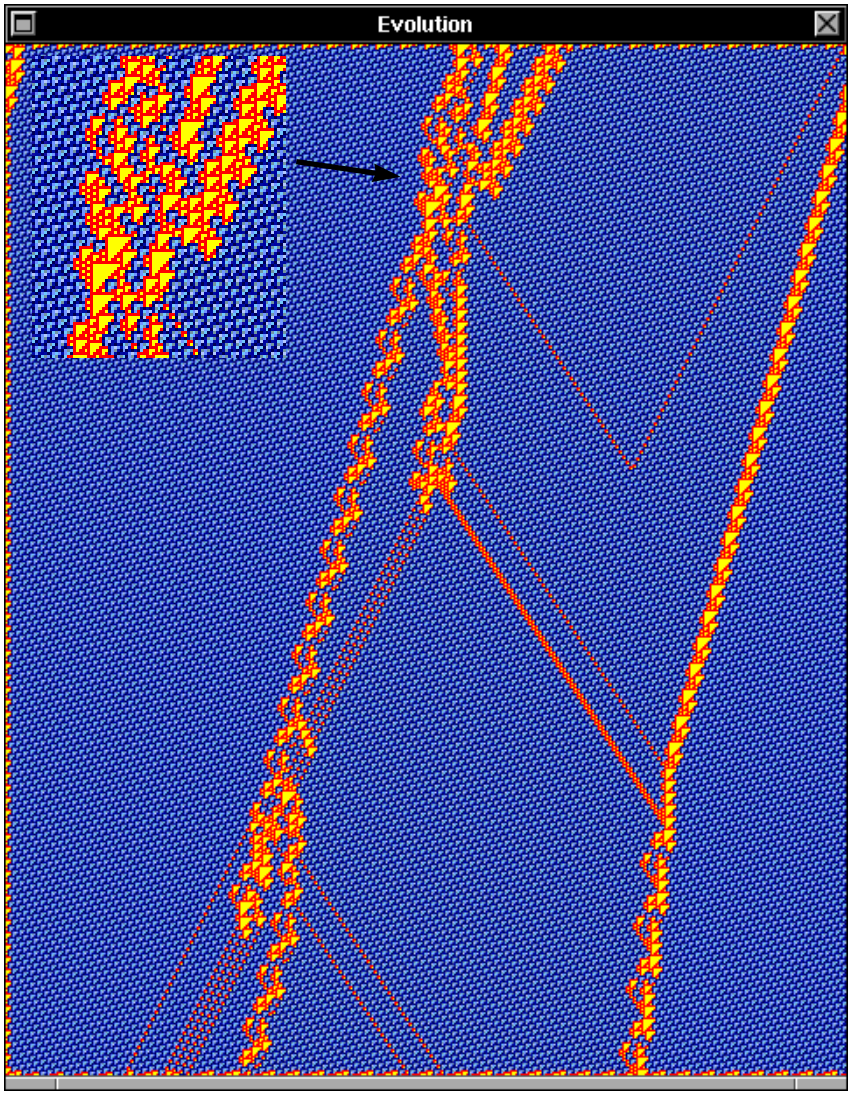


Figure 4.147: Collisions of glider Bbar, H(p1)(D)-e(p1)-Bbar(p1)(C)=A,A,3A,B,A,A,Ebar,4B

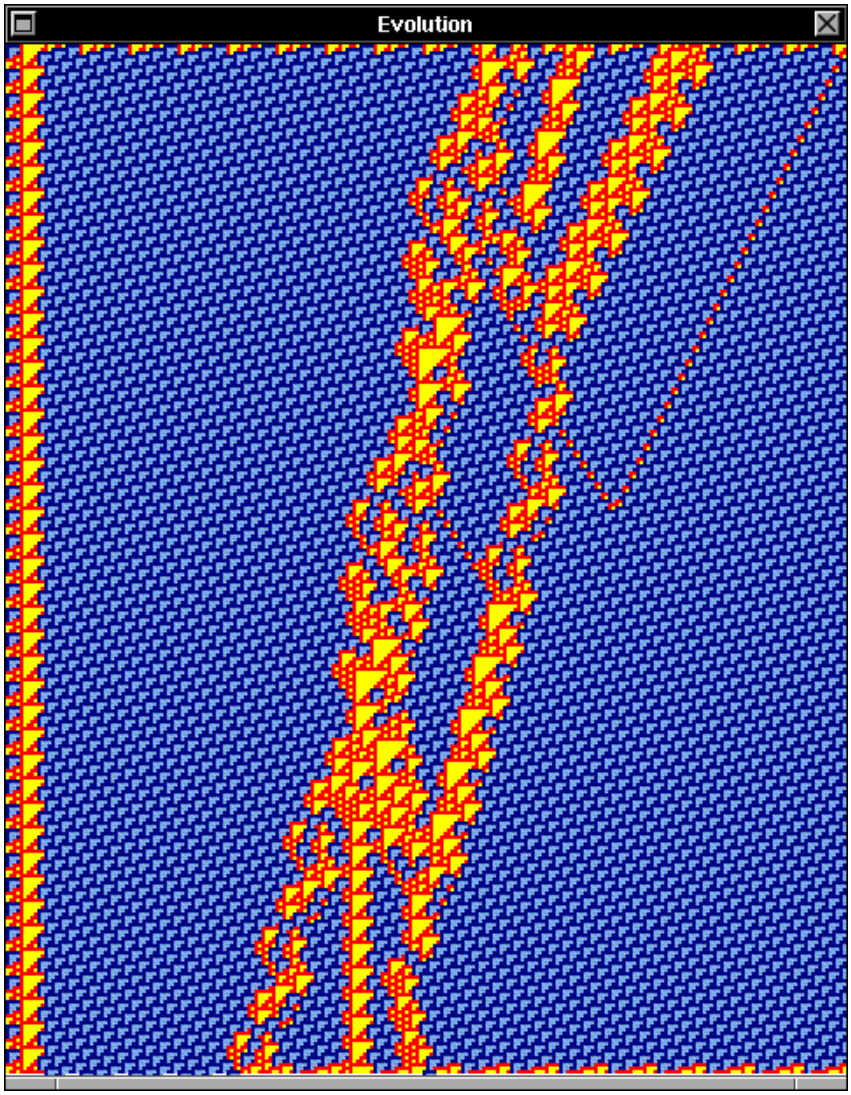


Figure 4.148: Collisions of glider Bbar, H(p1)(E)-e(p1)-Bbar(p1)(A)=A,Ebar,C1,D1

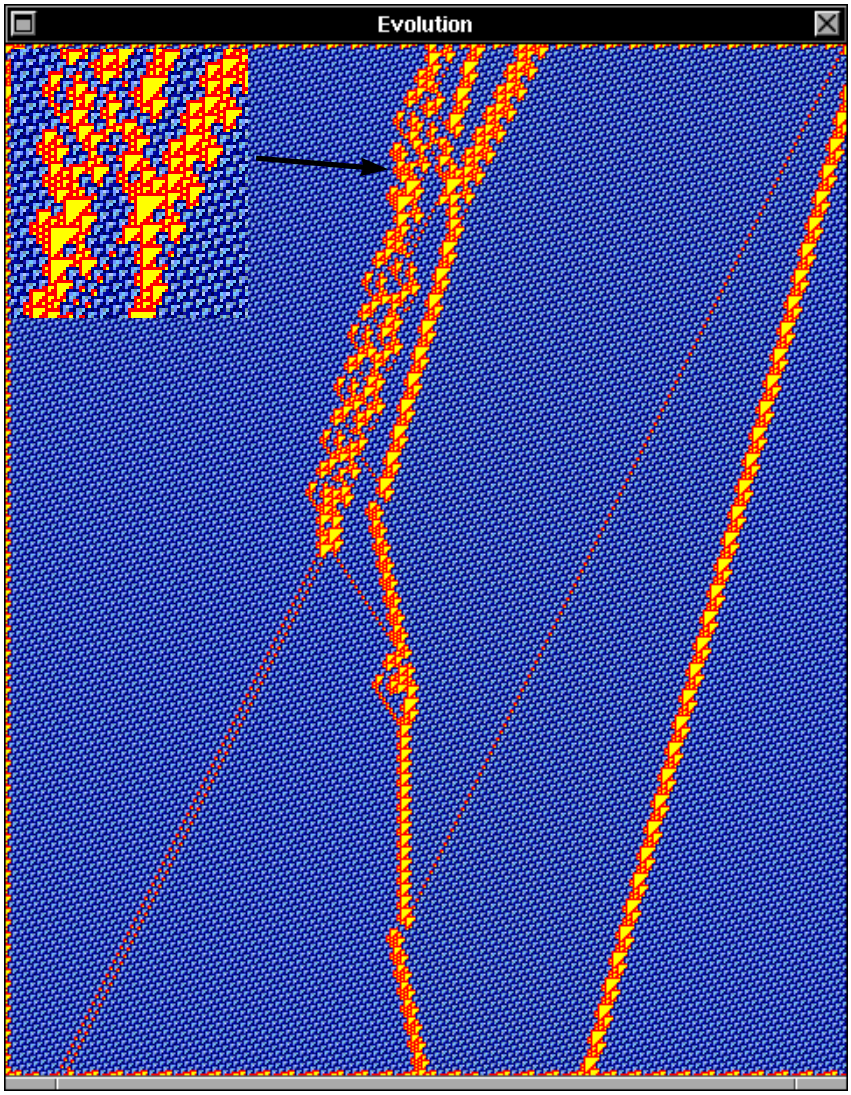


Figure 4.149: Collisions of glider Bbar, H(p1)(E)-e(p1)-Bbar(p1)(B)=2B,C2

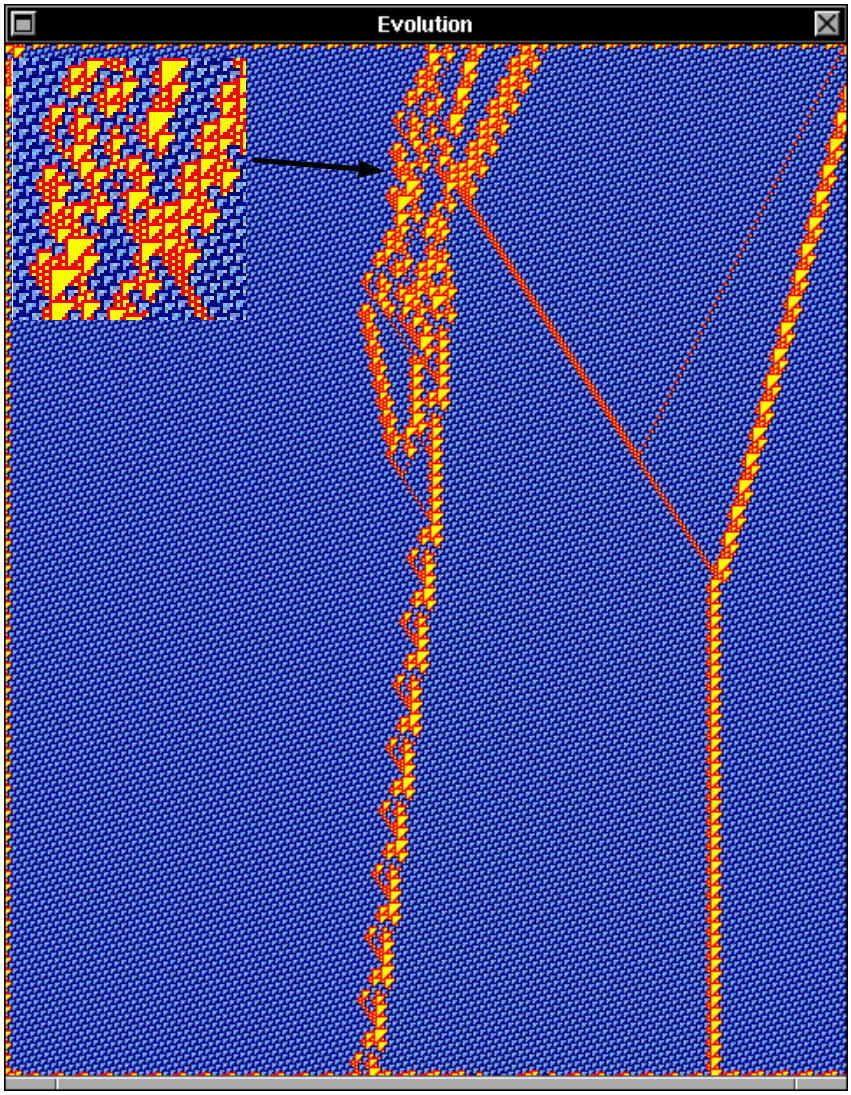


Figure 4.150: Collisions of glider Bbar, H(p1)(E)-e(p1)-Bbar(p1)(C)=3A,F

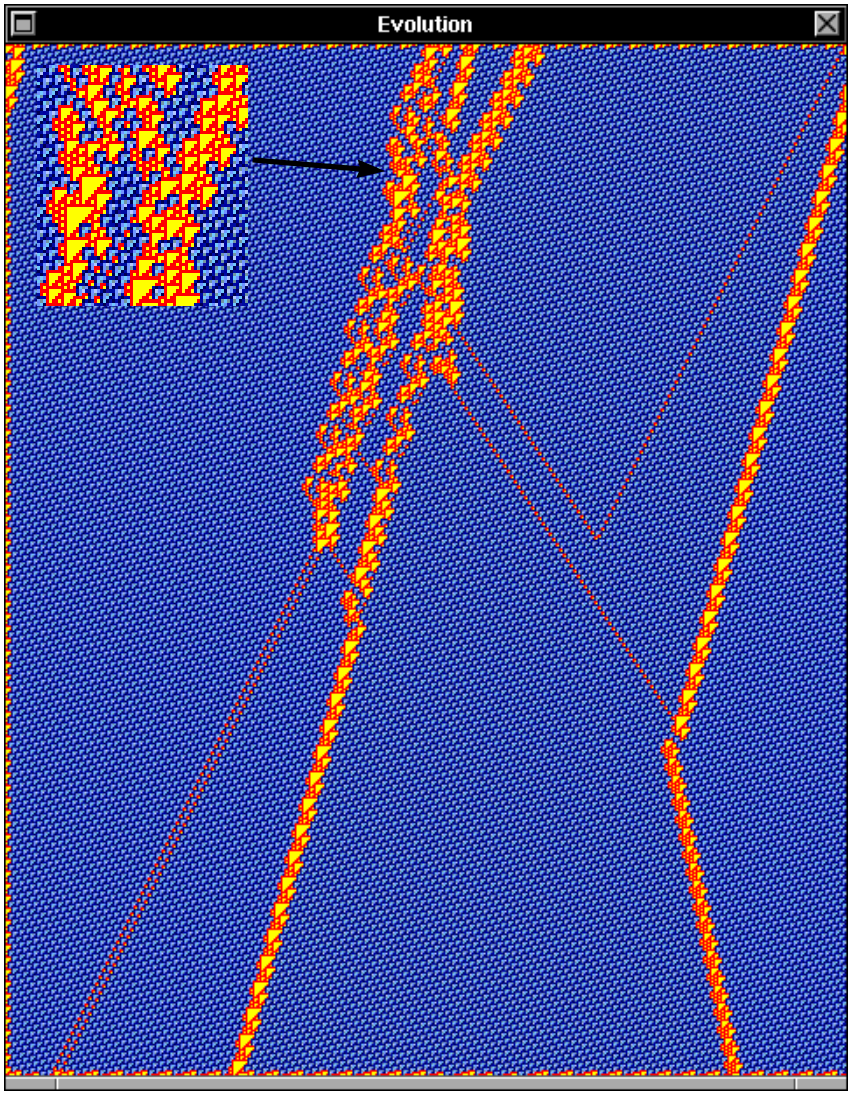


Figure 4.151: Collisions of glider Bbar, H(p1)(F)-e(p1)-Bbar(p1)(A)=A,A,2B,E

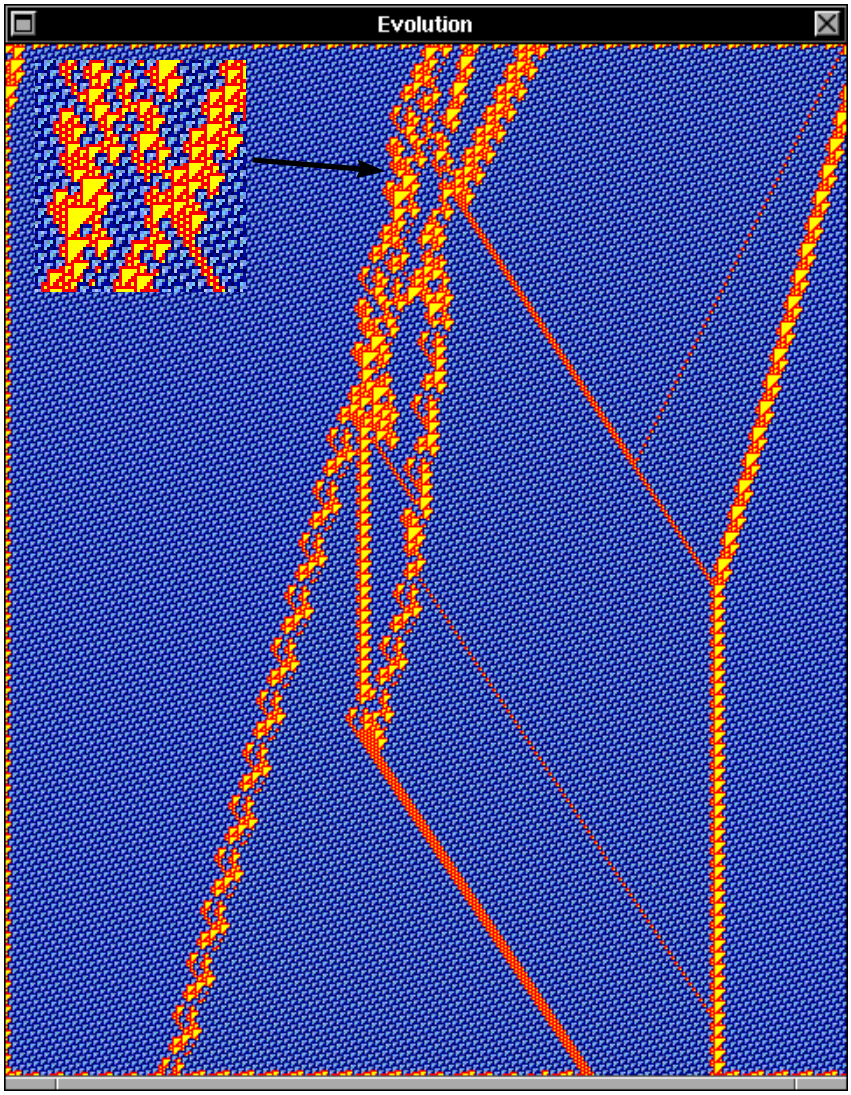


Figure 4.152: Collisions of glider Bbar, H(p1)(F)-e(p1)-Bbar(p1)(B)=3A,Ebar,A,5A

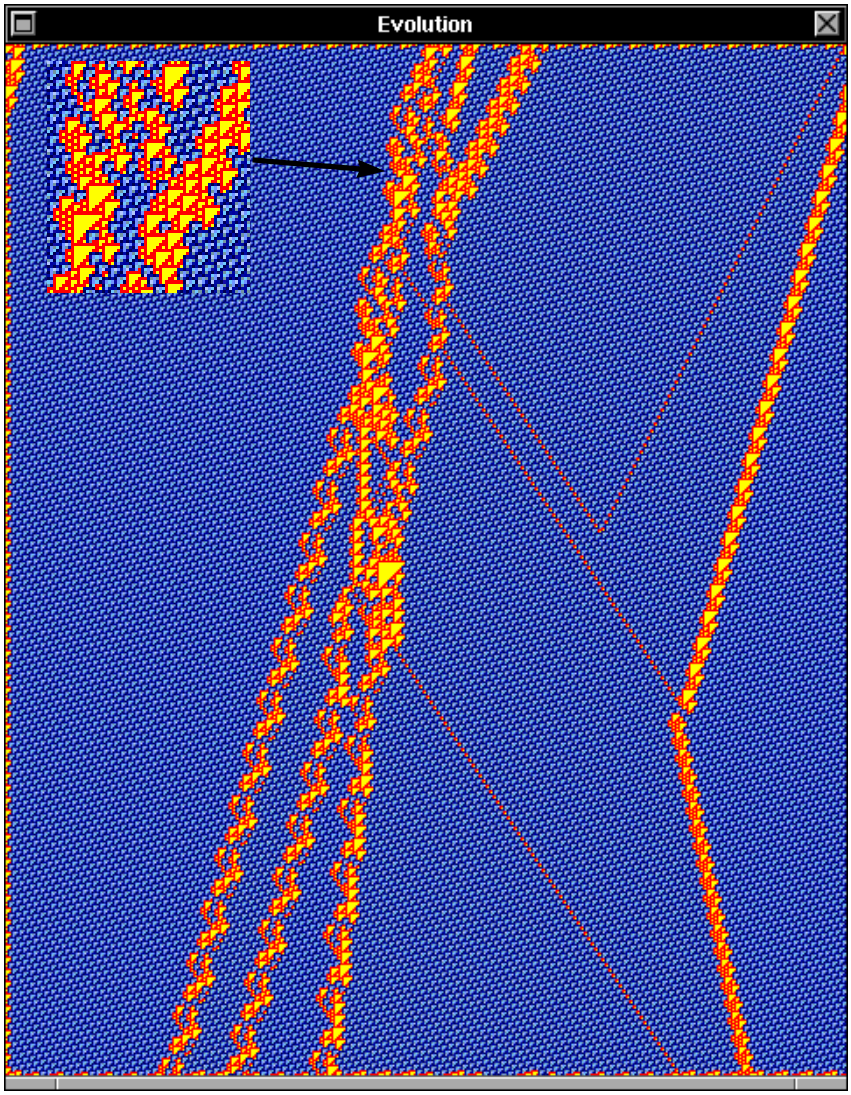


Figure 4.153: Collisions of glider Bbar, H(p1)(F)-e(p1)-Bbar(p1)(C)=A,A,Ebar,A,Ebar,F

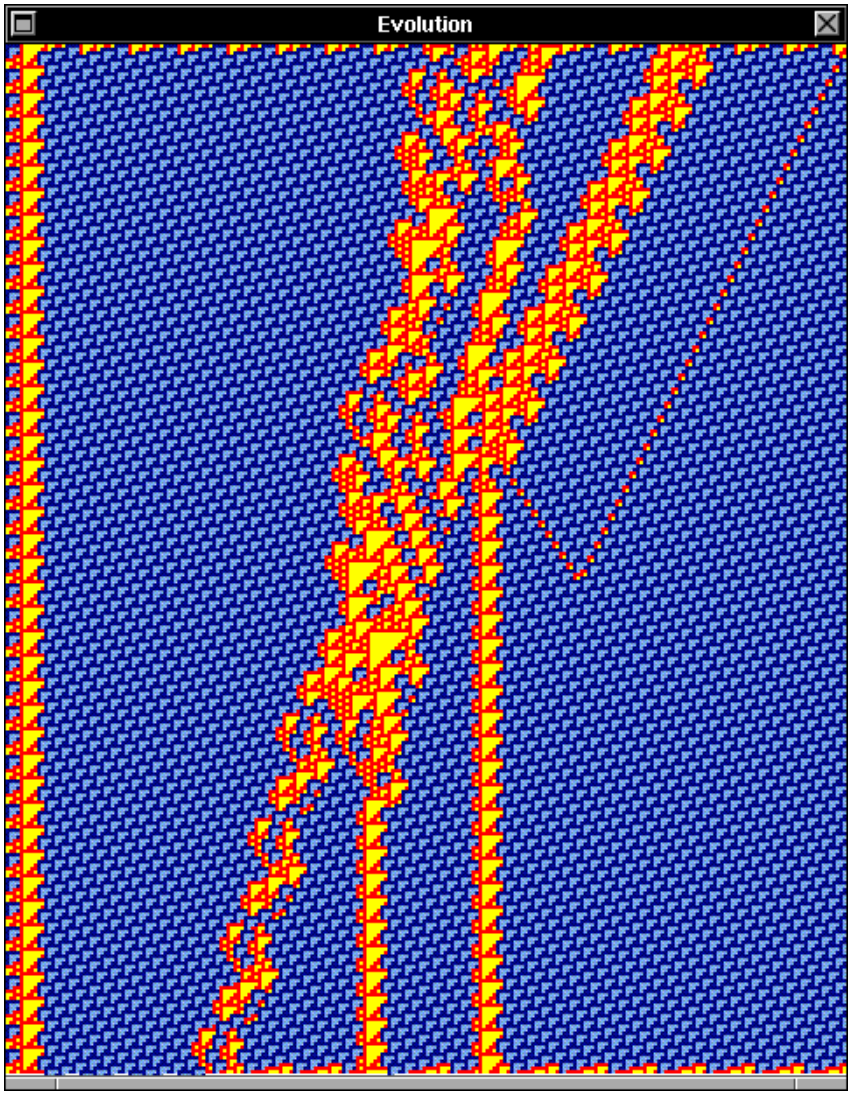


Figure 4.154: Collisions of glider Bbar, H(p1)(E2)-e(p1)-Bbar(p1)(A)=A,C2,Ebar,C2

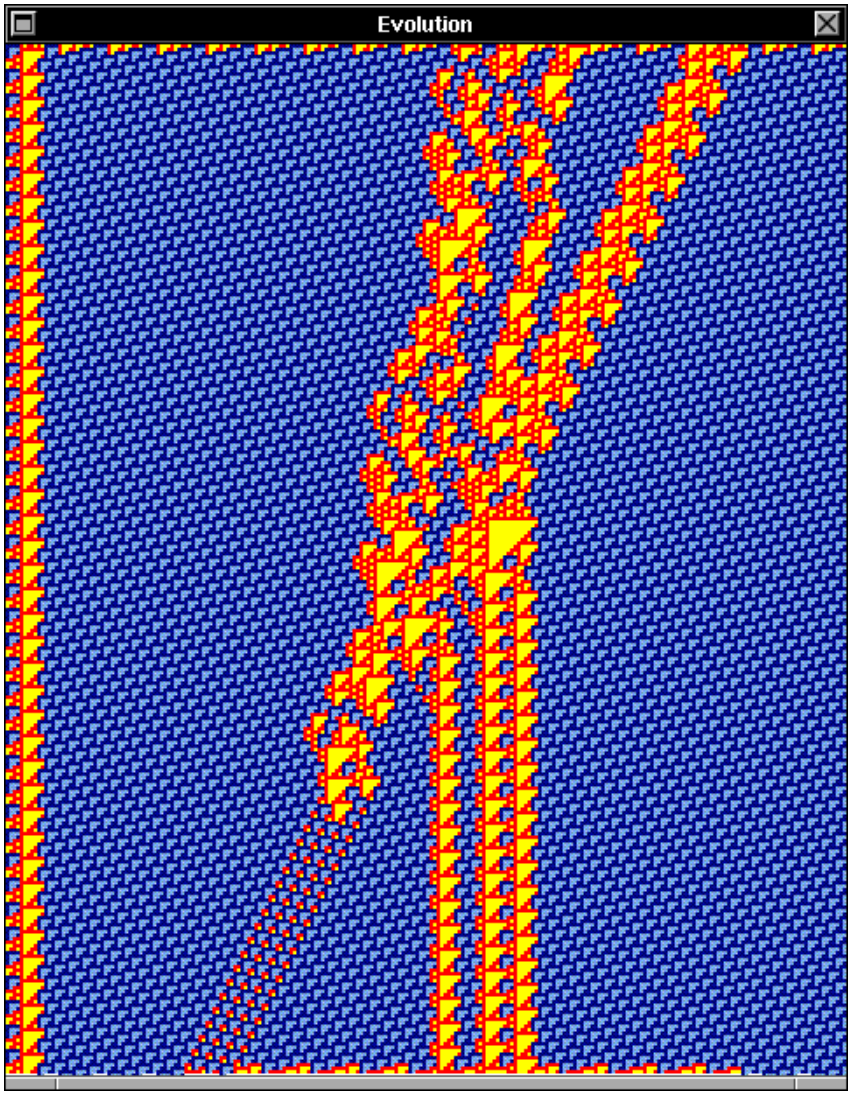


Figure 4.155: Collisions of glider Bbar, H(p1)(E2)-e(p1)-Bbar(p1)(B)=C3,C1,C1,4B

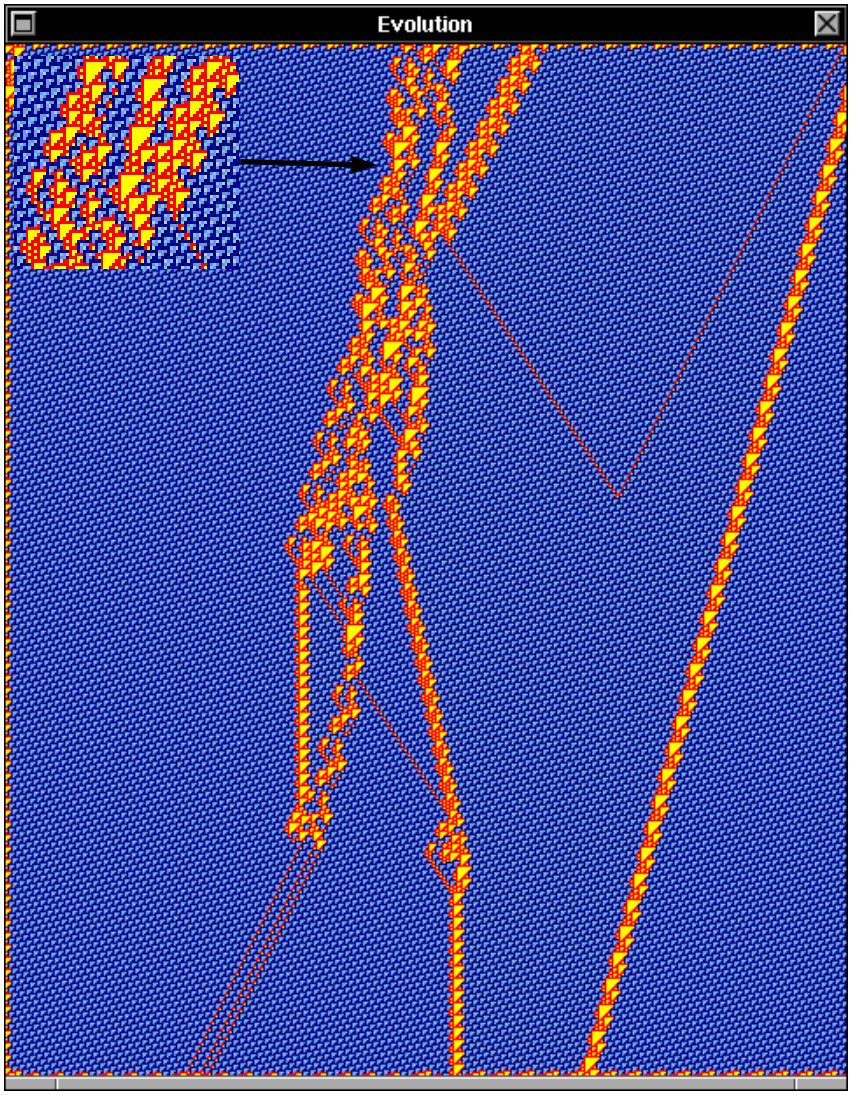


Figure 4.156: Collisions of glider Bbar, H(p1)(E2)-e(p1)-Bbar(p1)(C)=A,B,2B,C2

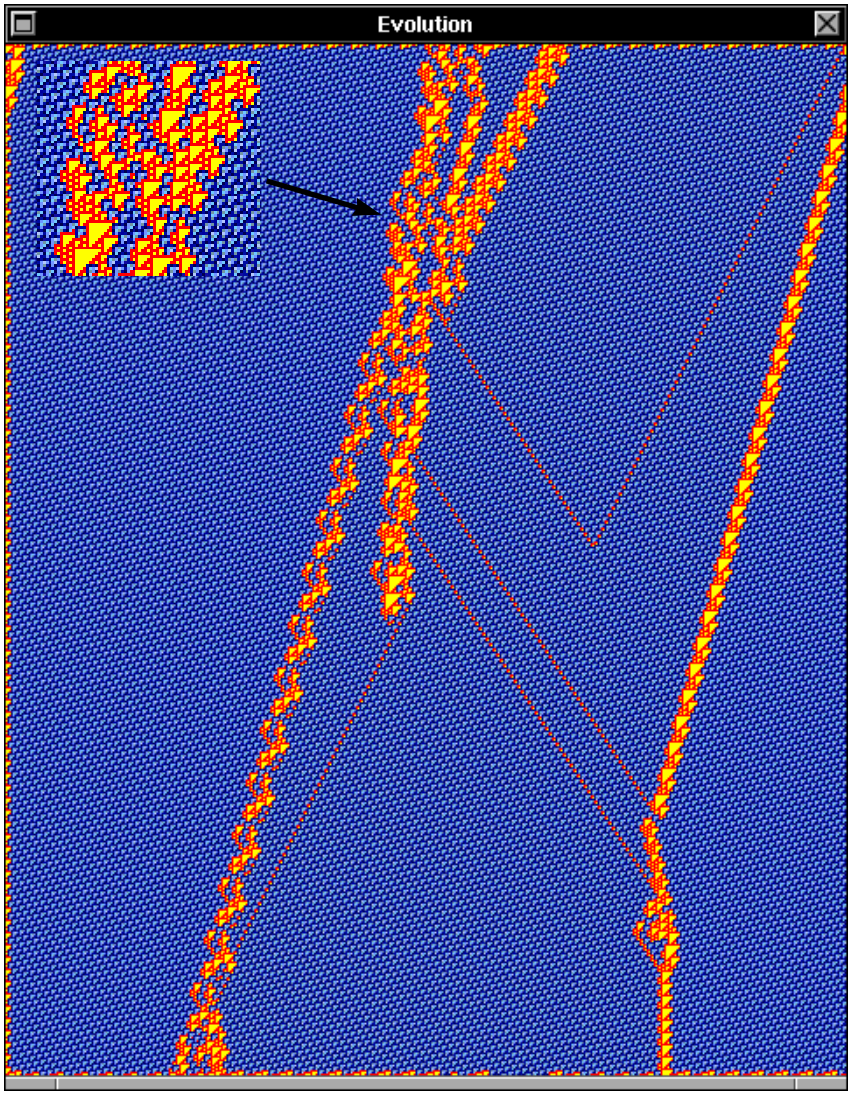


Figure 4.157: Collisions of glider Bbar, H(p1)(A3)-e(p1)-Bbar(p1)(A)=A,A,A,3B,A,A,Ebar

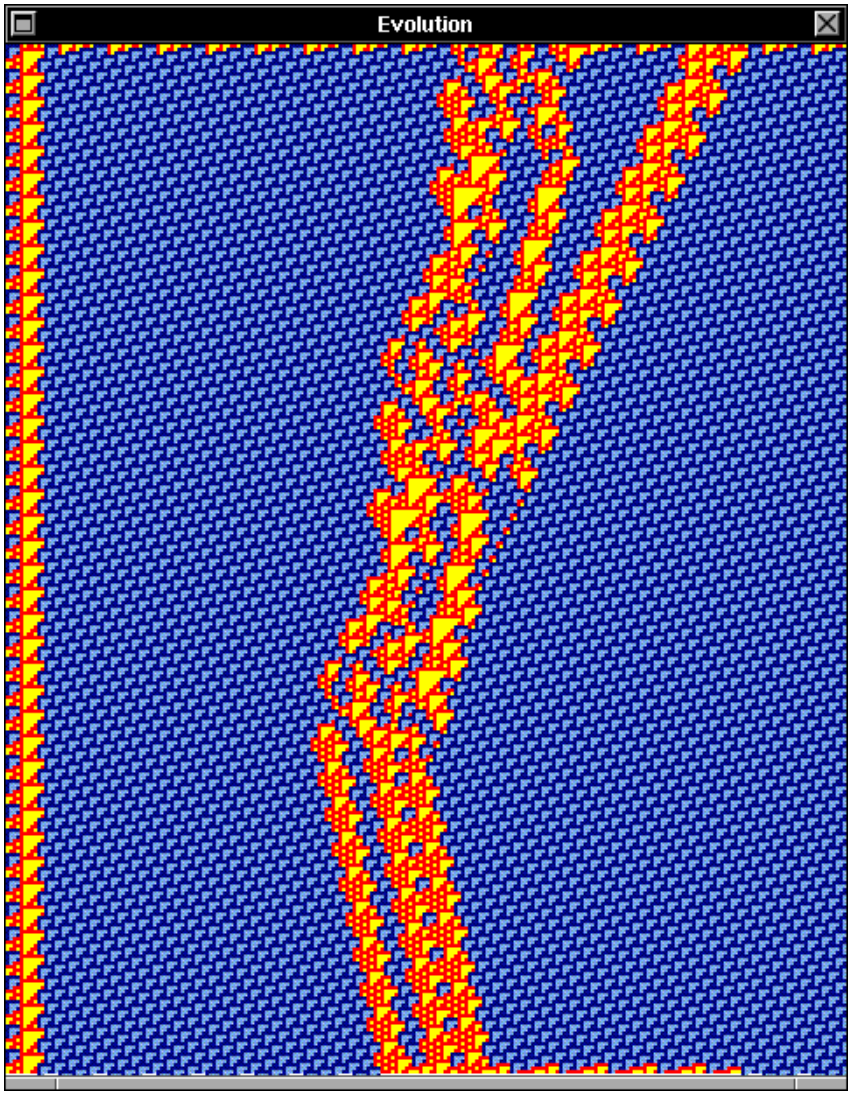


Figure 4.158: Collisions of glider Bbar, H(p1)(A3)-e(p1)-Bbar(p1)(B)=D1,2D1

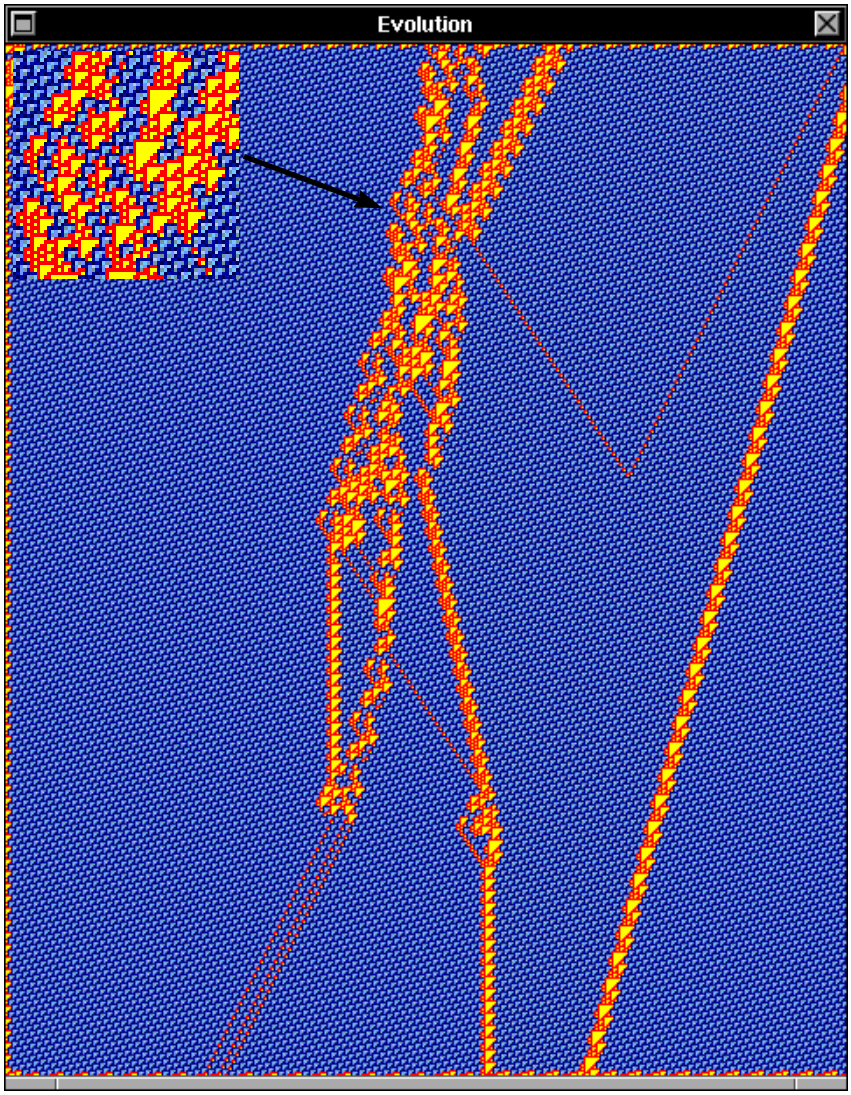


Figure 4.159: Collisions of glider Bbar, H(p1)(A3)-e(p1)-Bbar(p1)(C)=A,B,2B,C2

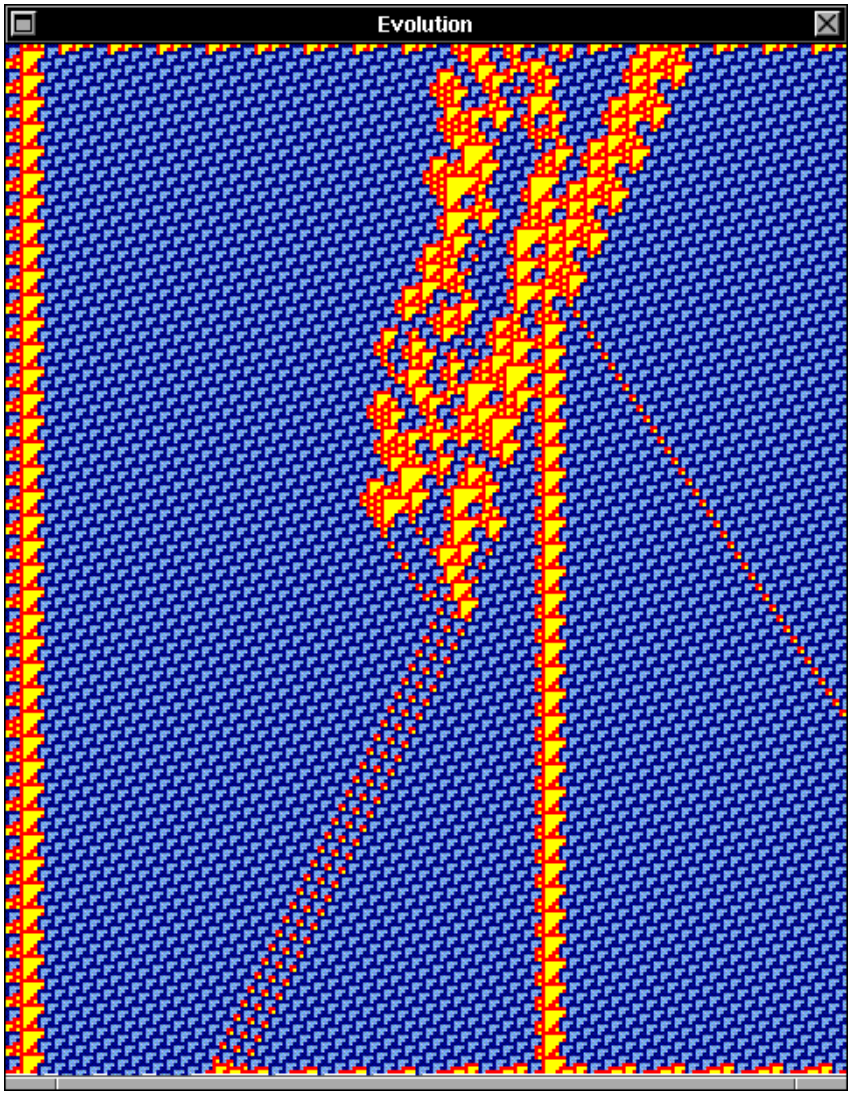


Figure 4.160: Collisions of glider Bbar, H(p1)(B3)-e(p1)-Bbar(p1)(A)=A,3B,C2

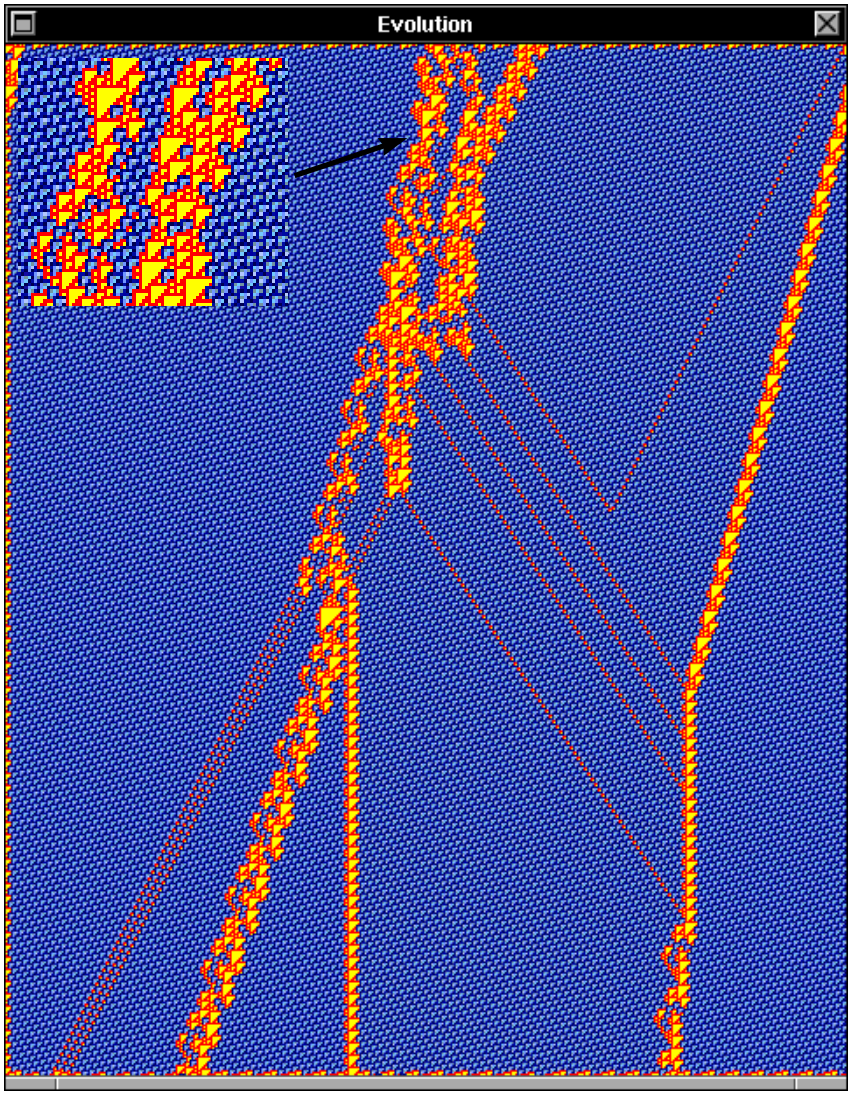


Figure 4.161: Collisions of glider Bbar, H(p1)(B3)-e(p1)-Bbar(p1)(B)=A,A,A,A,A,4B,C3,G

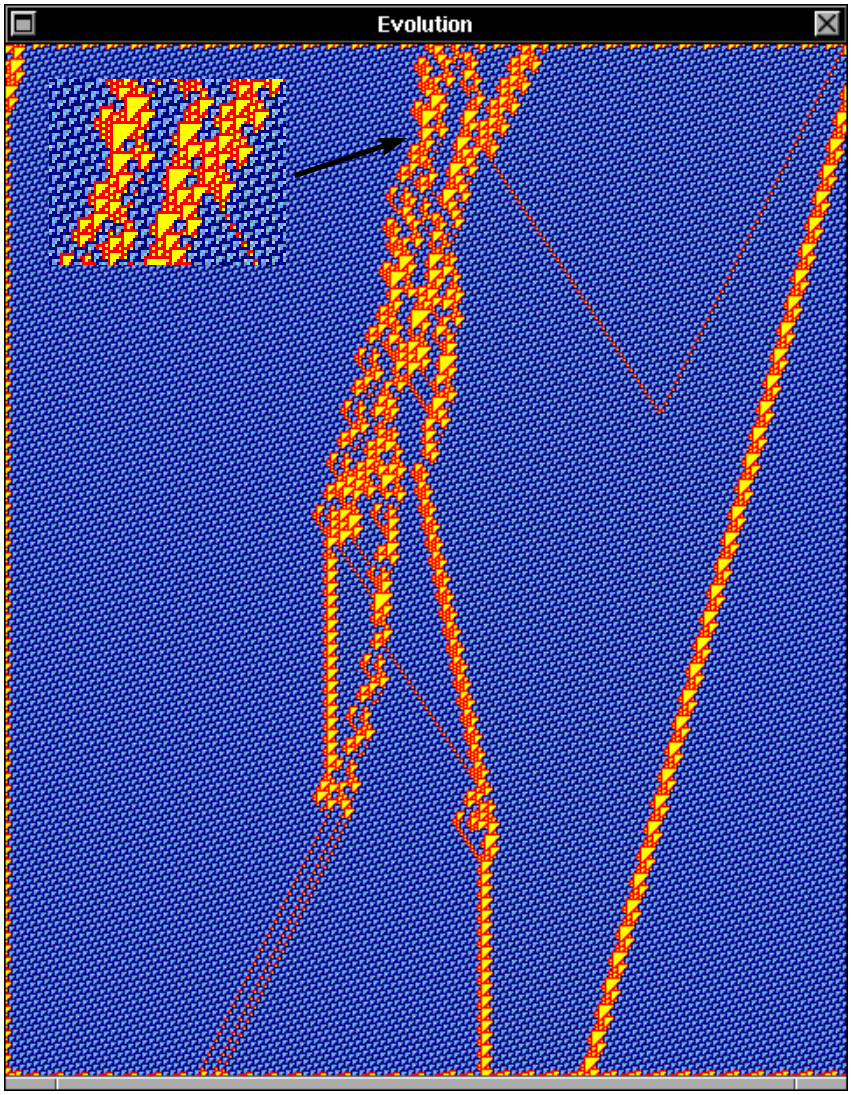


Figure 4.162: Collisions of glider Bbar, H(p1)(B3)-e(p1)-Bbar(p1)(C)=A,B,2B,C2

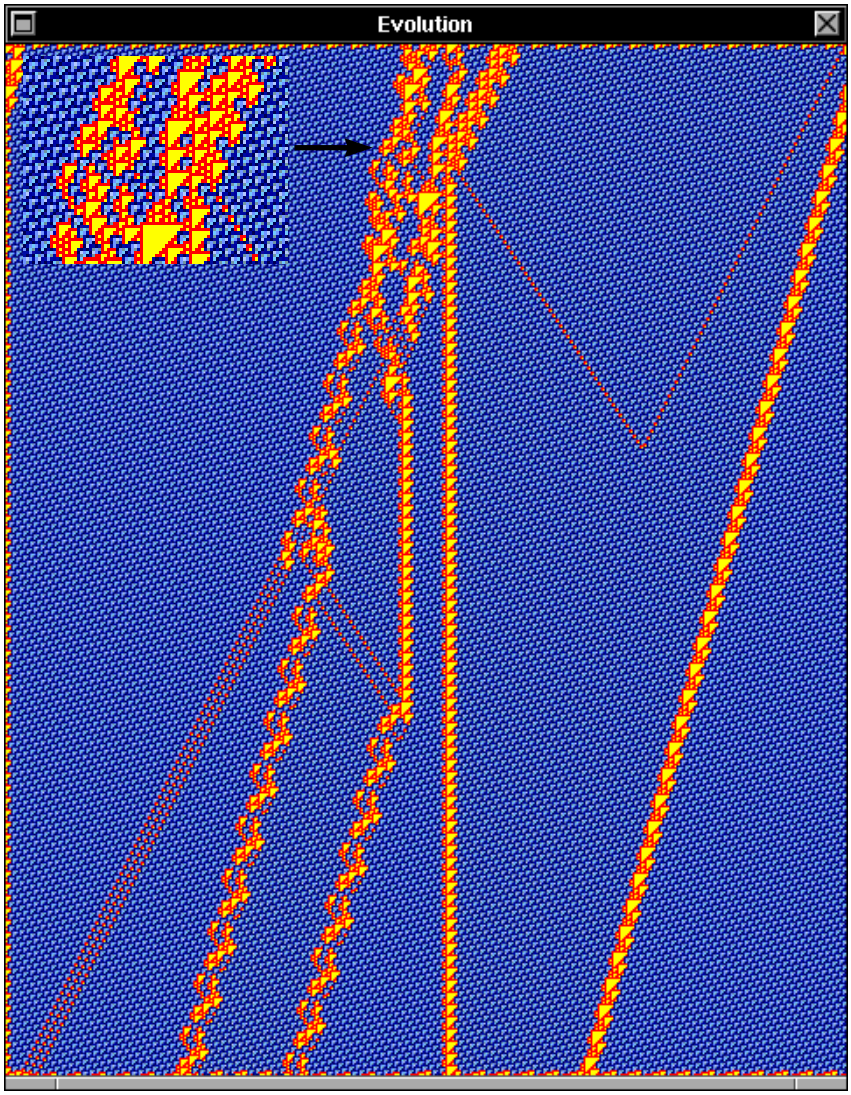


Figure 4.163: Collisions of glider Bbar, H(p1)(F3)-e(p1)-Bbar(p1)(A)=A,C2,3B,Ebar,Ebar

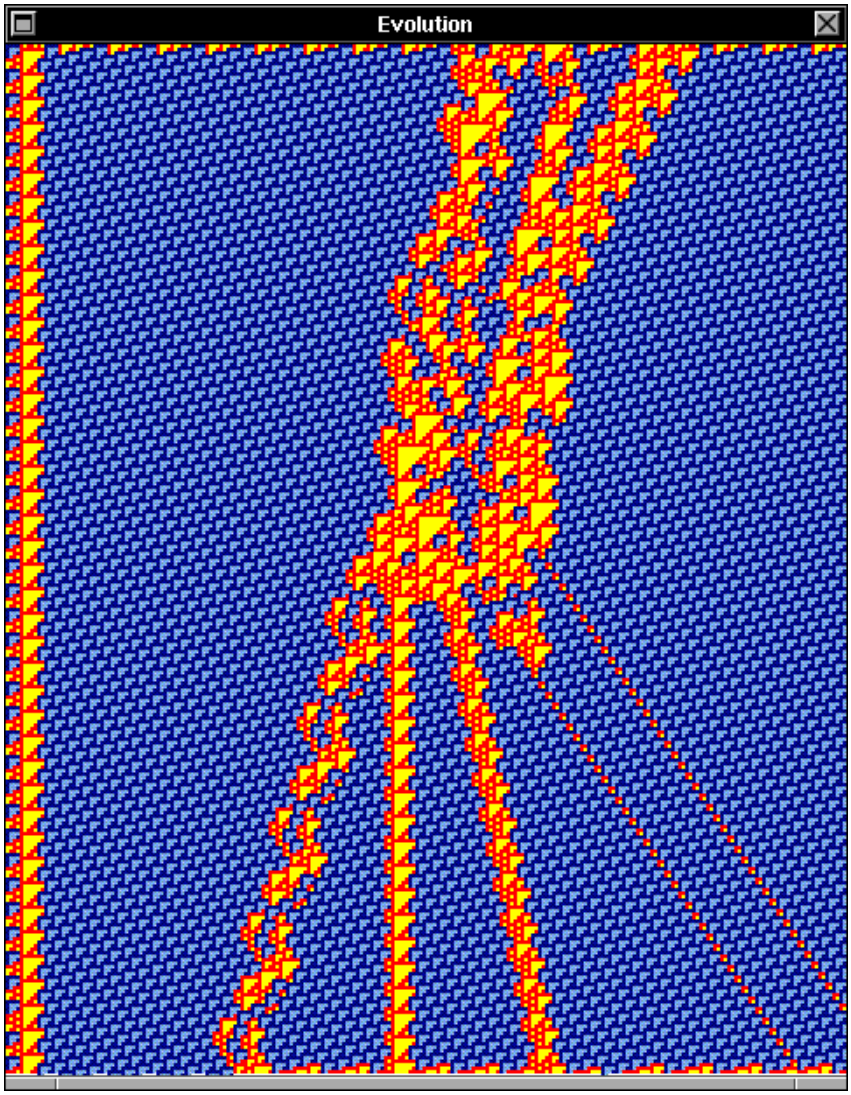


Figure 4.164: Collisions of glider Bbar, H(p1)(F3)-e(p1)-Bbar(p1)(B)=A,Ebar,C1,D2,A

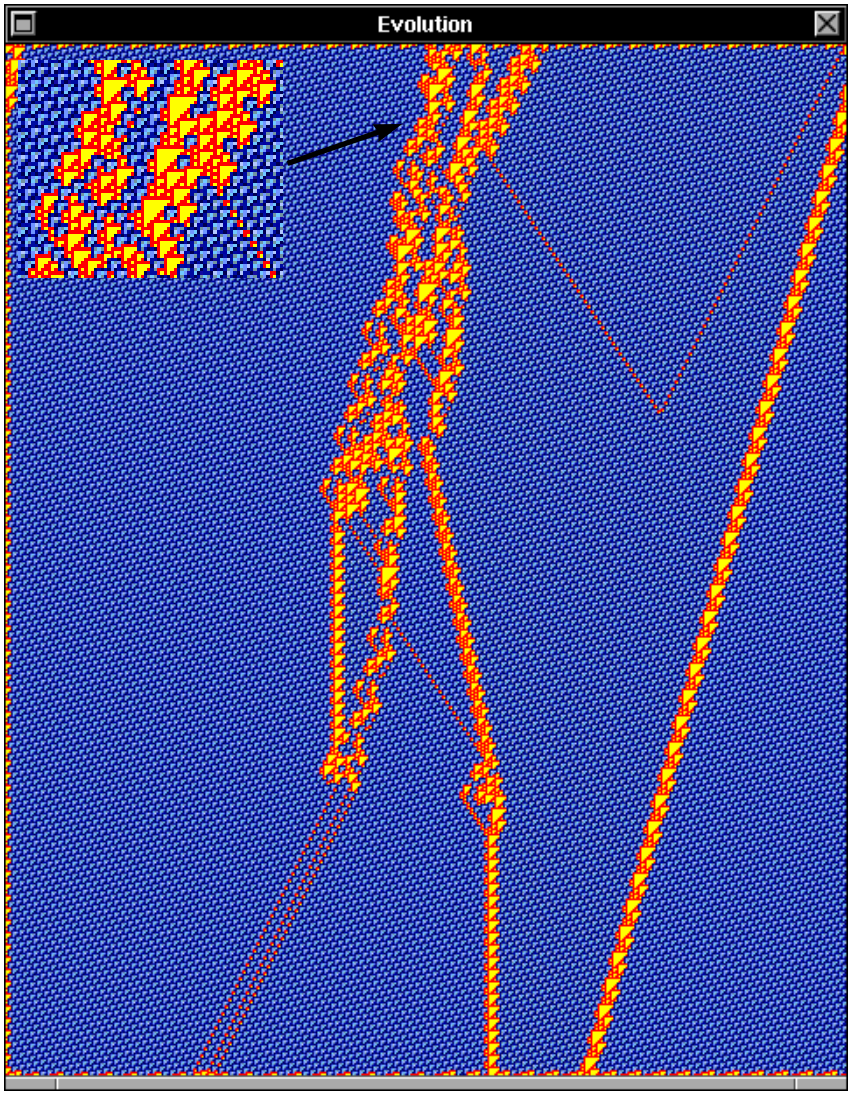


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Figure 4.165: Collisions of glider Bbar, H(p1)(F3)-e(p1)-Bbar(p1)(C)=A,B,2B,C2

4.5 Collisions of glider Bbar8

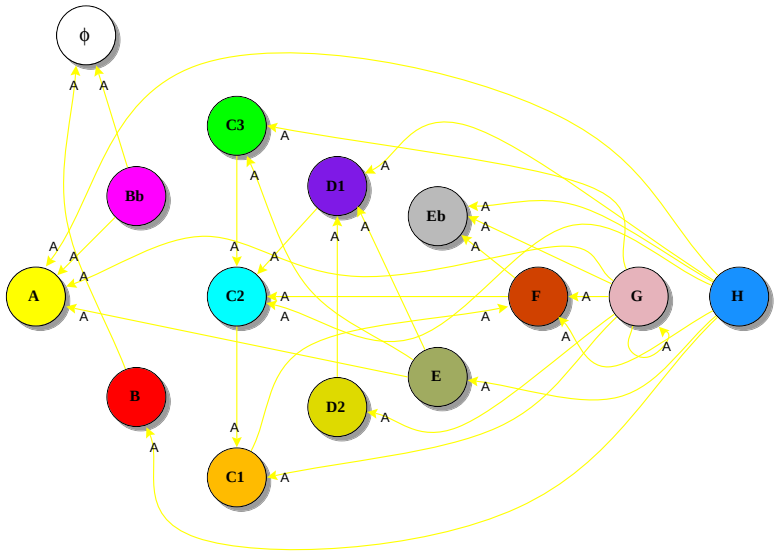

Figure 4.166: Collisions of glider Bbar8

	ϕ	A	B	$Bbar$	$C3$	$C2$	$C1$	$D2$	$D1$	E	$Ebar$	F	G	H
ϕ	.	1	.	.	.	.	.	.	.	.	.	.	.	.
A	.	1	.	.	1	1	1	1	.	1	1	1	1	1
B	.	.	.	.	.	.	.	1	.	1	1	1	1	.
$Bbar$	.	.	.	.	.	1	.	.	.	.	.	1	.	.
$C3$	.	.	.	.	.	.	.	.	.	.	.	.	.	1
$C2$	.	.	.	.	.	.	.	1	.	1	1	1	.	1
$C1$	.	.	.	.	.	.	.	.	.	.	1	1	.	1
$D2$	.	.	.	.	.	.	.	.	.	.	.	.	1	1
$D1$	.	.	.	.	.	.	1	1	.	.	.	.	.	1
E	.	.	.	.	.	1	.	1	.	.	.	.	.	1
$Ebar$	.	.	.	.	1	1	1	1	.	1	1	.	1	1
F	.	.	.	.	.	.	1	1	.	.	1	1	1	1
G	.	.	.	.	.	.	.	.	.	.	1	.	1	1
H	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Table 4.4: Matrix connection of collisions glider Bbar8

4.5.1 Collisions of glider Bbar8 with glider C1

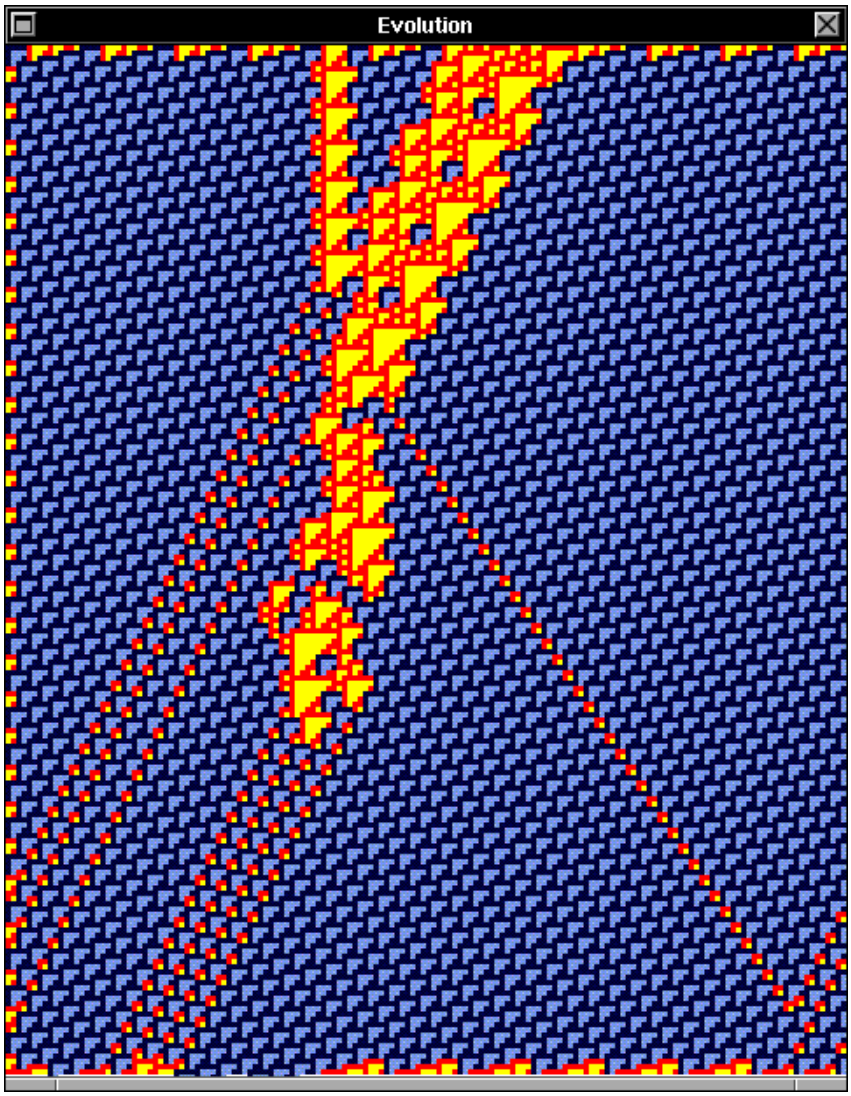

Figure 4.167: Collisions of glider Bbar8, C1(p1)(A)-e(p1)-Bbar8(p1)(A)=2B,A,B,4B

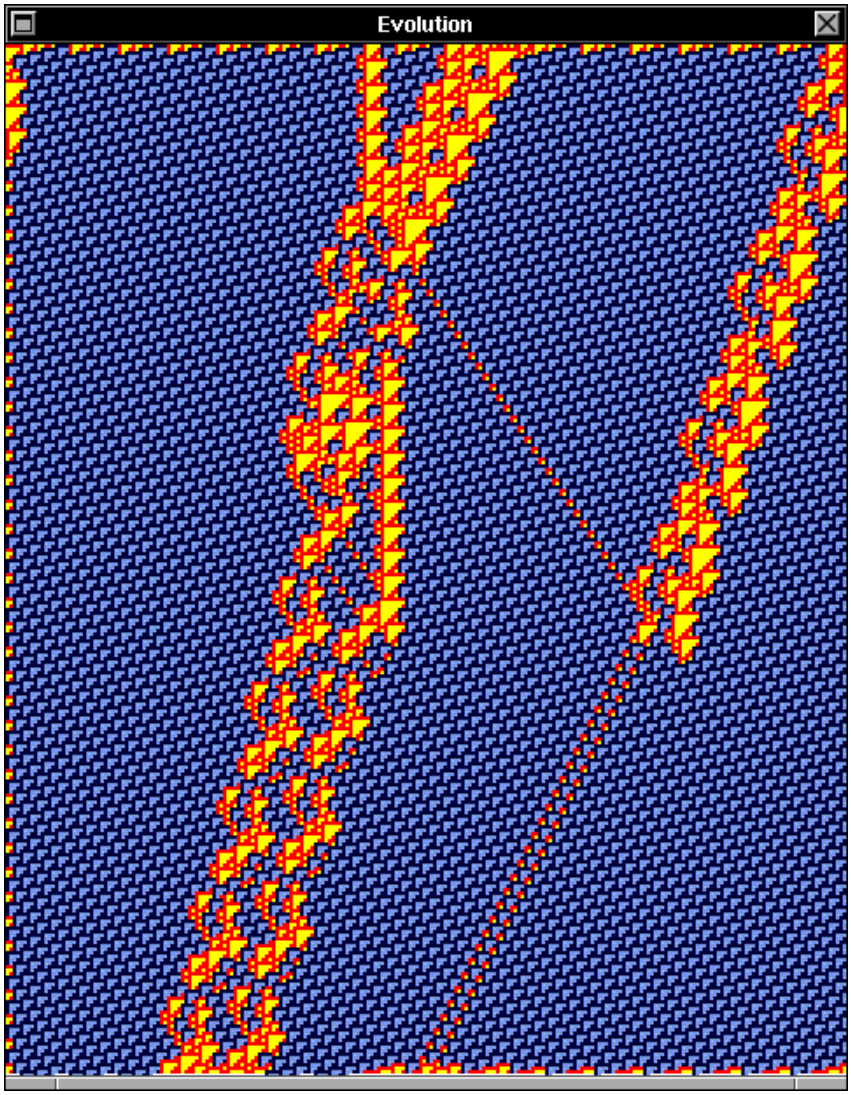

Figure 4.168: Collisions of glider Bbar8, C1(p1)(A)-e(p1)-Bbar8(p1)(B)=A,Ebar,Ebar

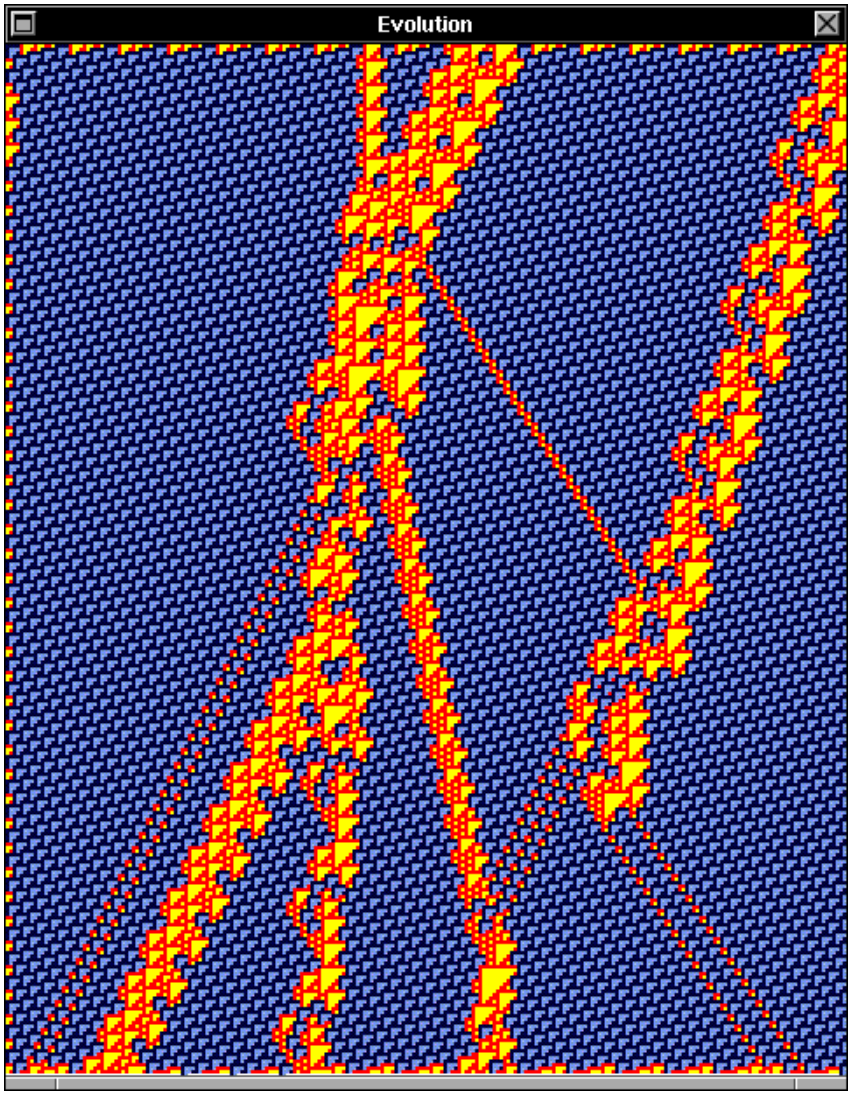

Figure 4.169: Collisions of glider Bbar8, C1(p1)(A)-e(p1)-Bbar8(p1)(C)=2A,D1,2B,Bbar,F

4.5.2 Collisions of glider Bbar8 with glider C2

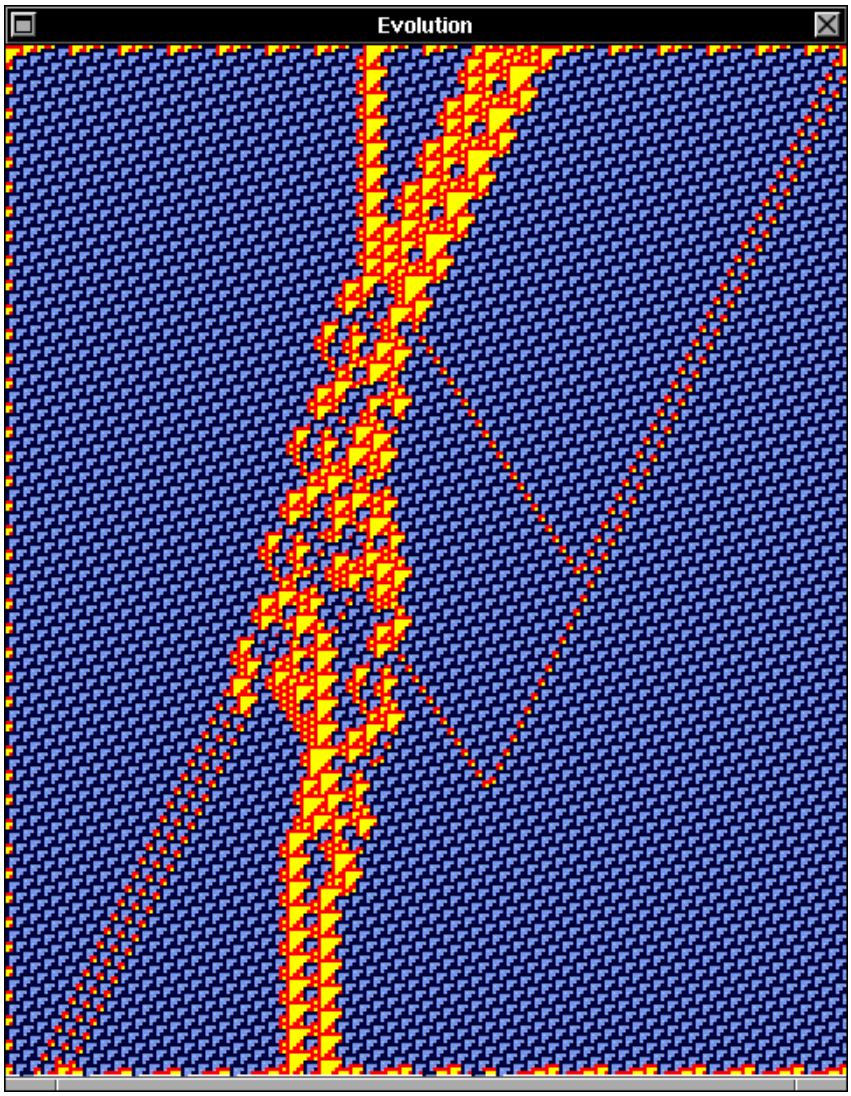

Figure 4.170: Collisions of glider Bbar8, C2(p1)(A)-e(p1)-Bbar8(p1)(A)=A,A,3B,2C2

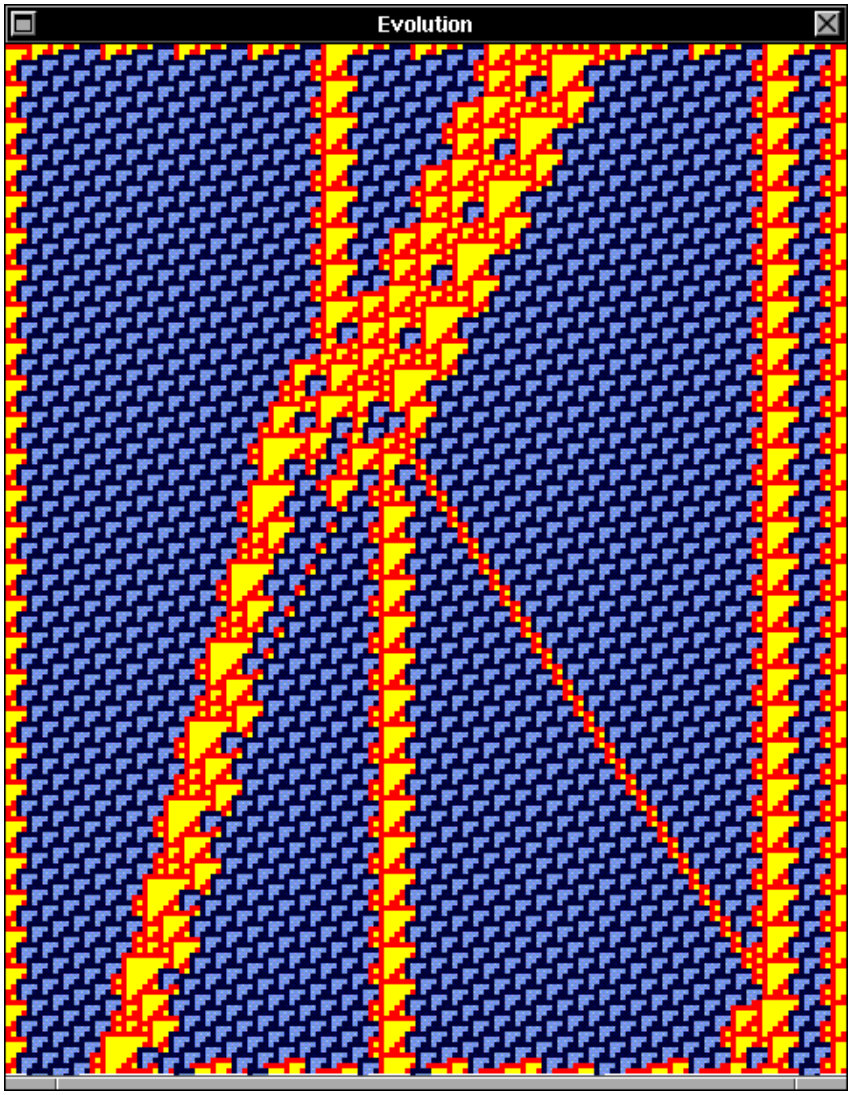

Figure 4.171: Collisions of glider Bbar8, C2(p1)(A)-e(p1)-Bbar8(p1)(B)=2A,C2,E2

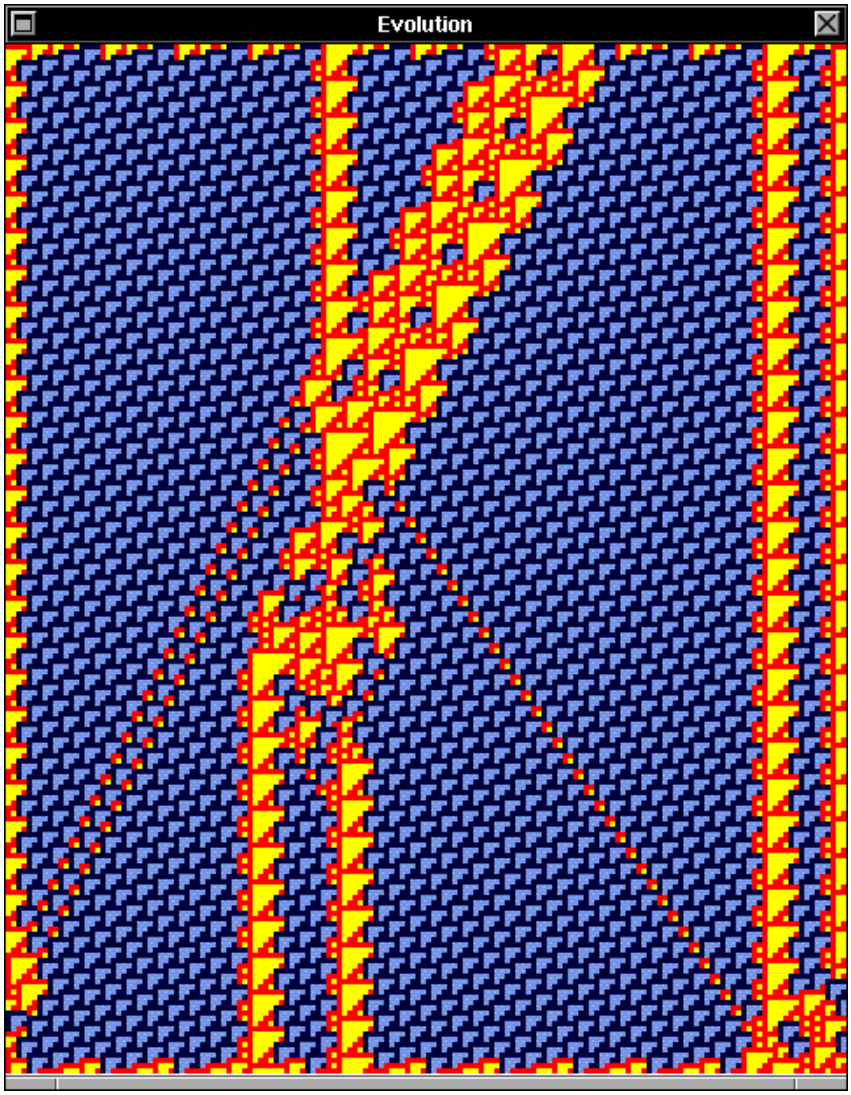

Figure 4.172: Collisions of glider Bbar8, C2(p1)(A)-e(p1)-Bbar8(p1)(C)=2B,A,C3,C1

4.5.3 Collisions of glider Bbar8 with glider C3

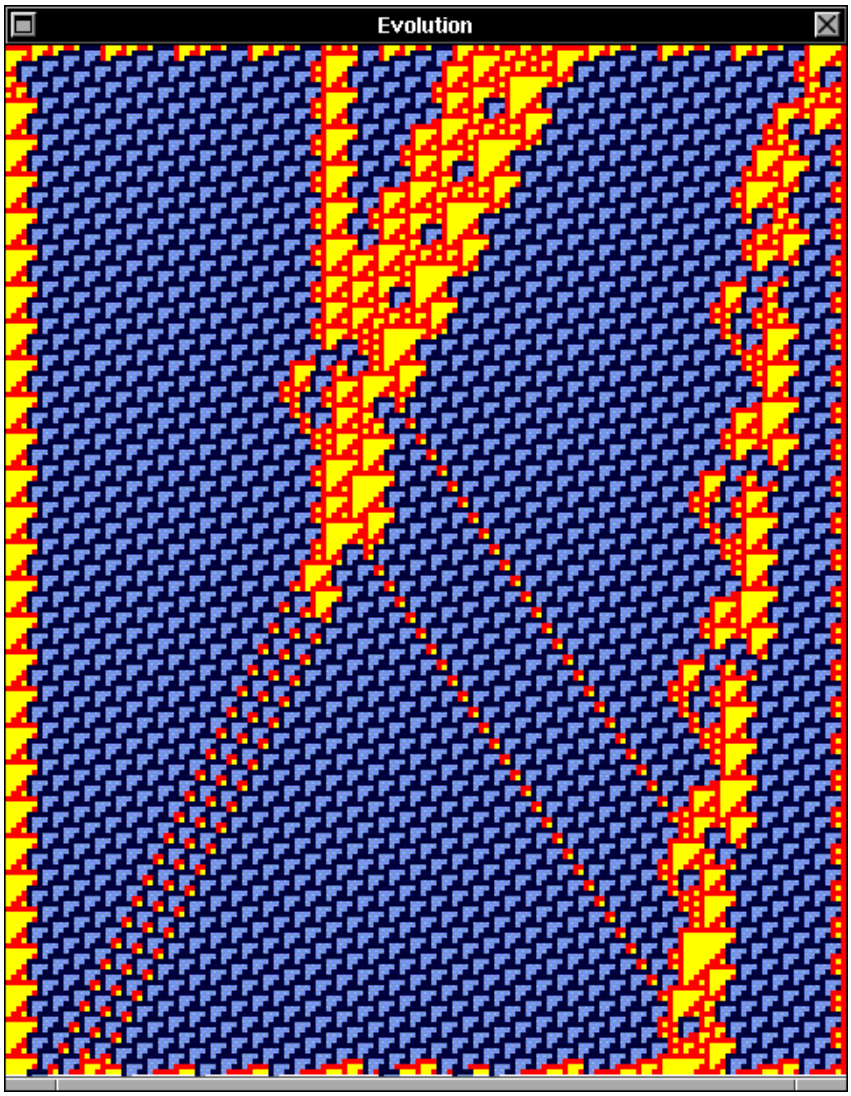

Figure 4.173: Collisions of glider Bbar8, C3(p1)(A)-e(p1)-Bbar8(p1)(A)=A,A,3B

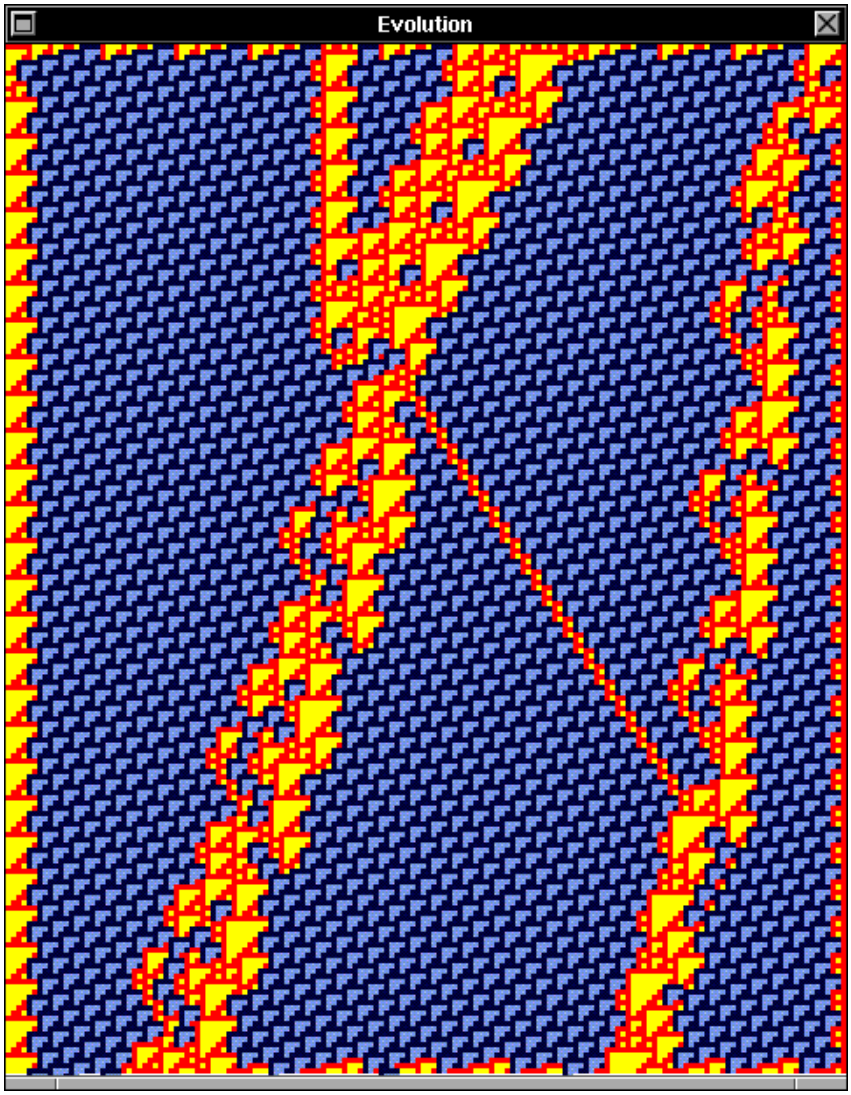

Figure 4.174: Collisions of glider Bbar8, C3(p1)(A)-e(p1)-Bbar8(p1)(B)=2A,G

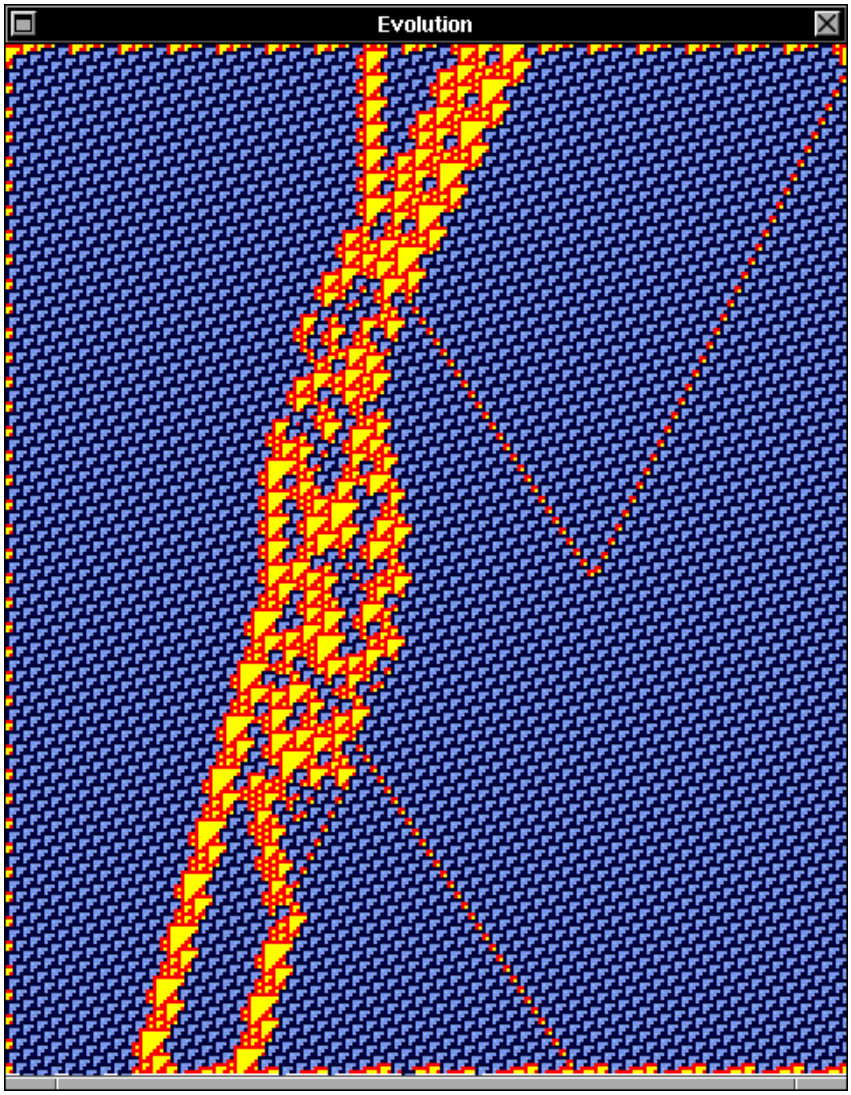

Figure 4.175: Collisions of glider Bbar8, C3(p1)(A)-e(p1)-Bbar8(p1)(C)=A,E,A,E

4.5.4 Collisions of glider Bbar8 with glider D1

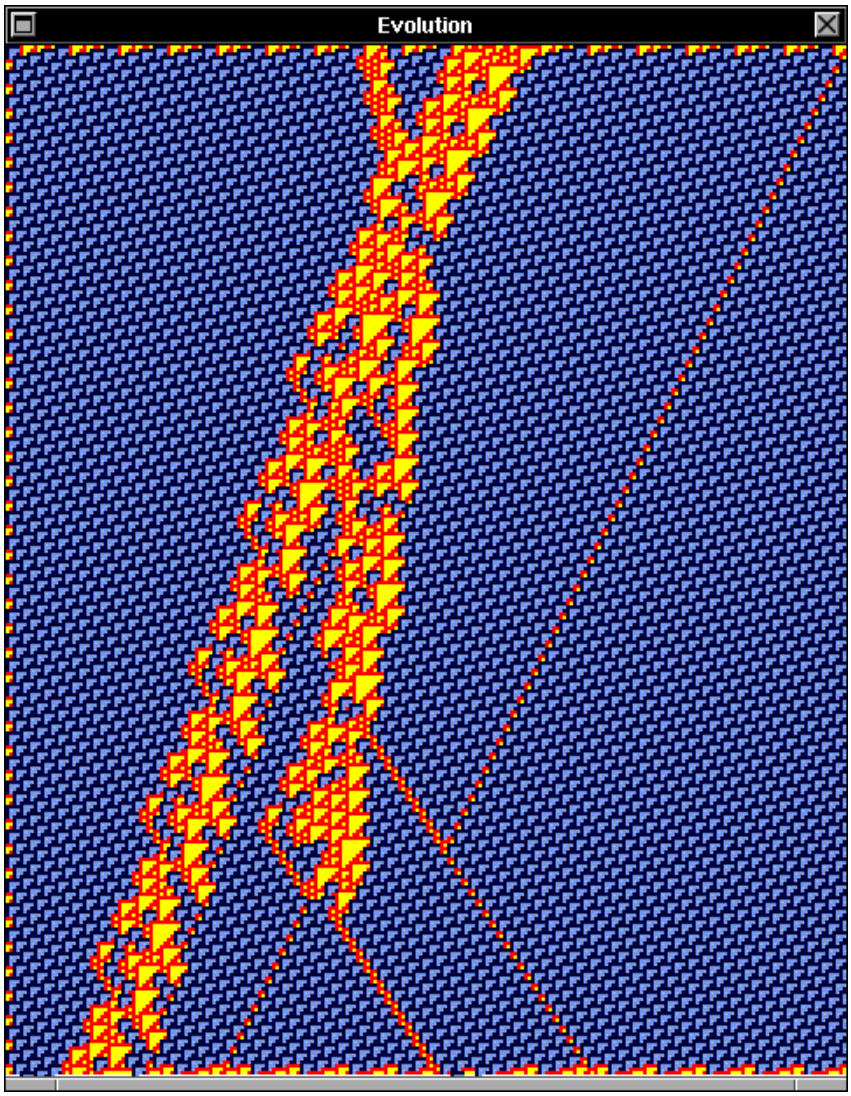

Figure 4.176: Collisions of glider Bbar8, D1(p1)(A)-e(p1)-Bbar8(p1)(A)=G2,2A,B,2A

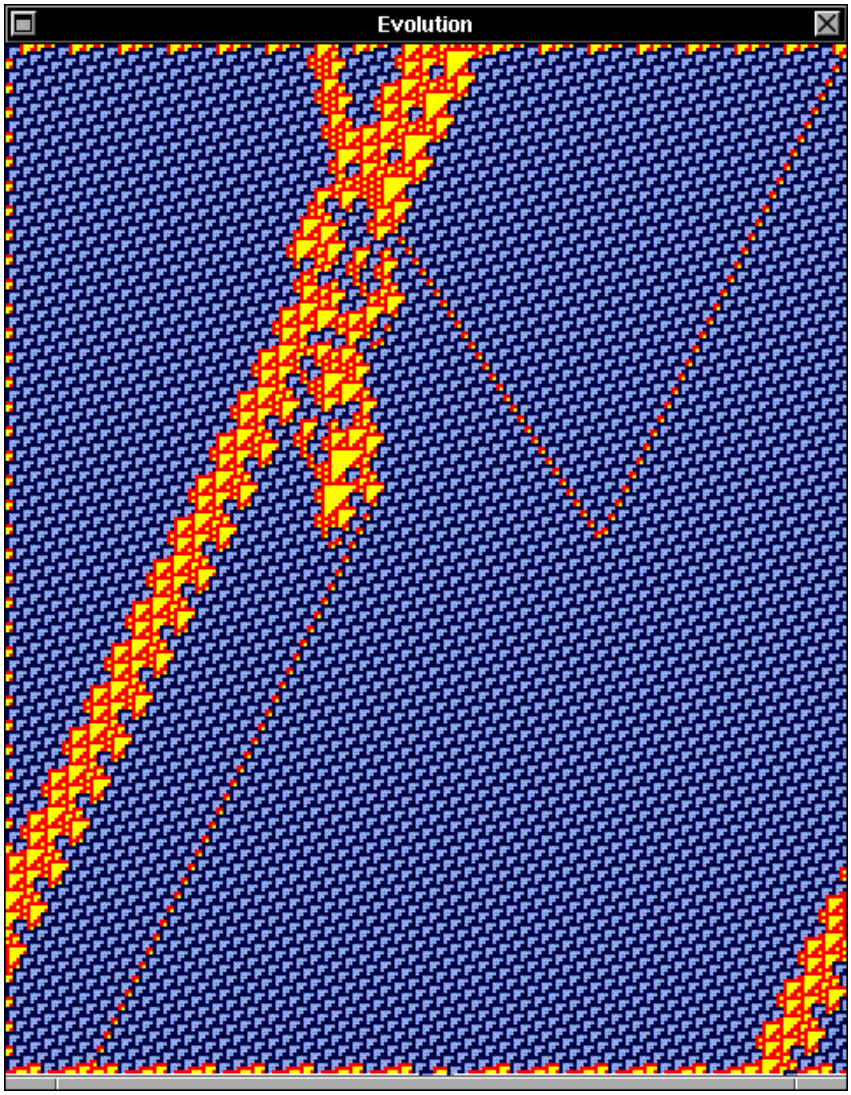

Figure 4.177: Collisions of glider Bbar8, D1(p1)(A)-e(p1)-Bbar8(p1)(B)=A,Bbar,B

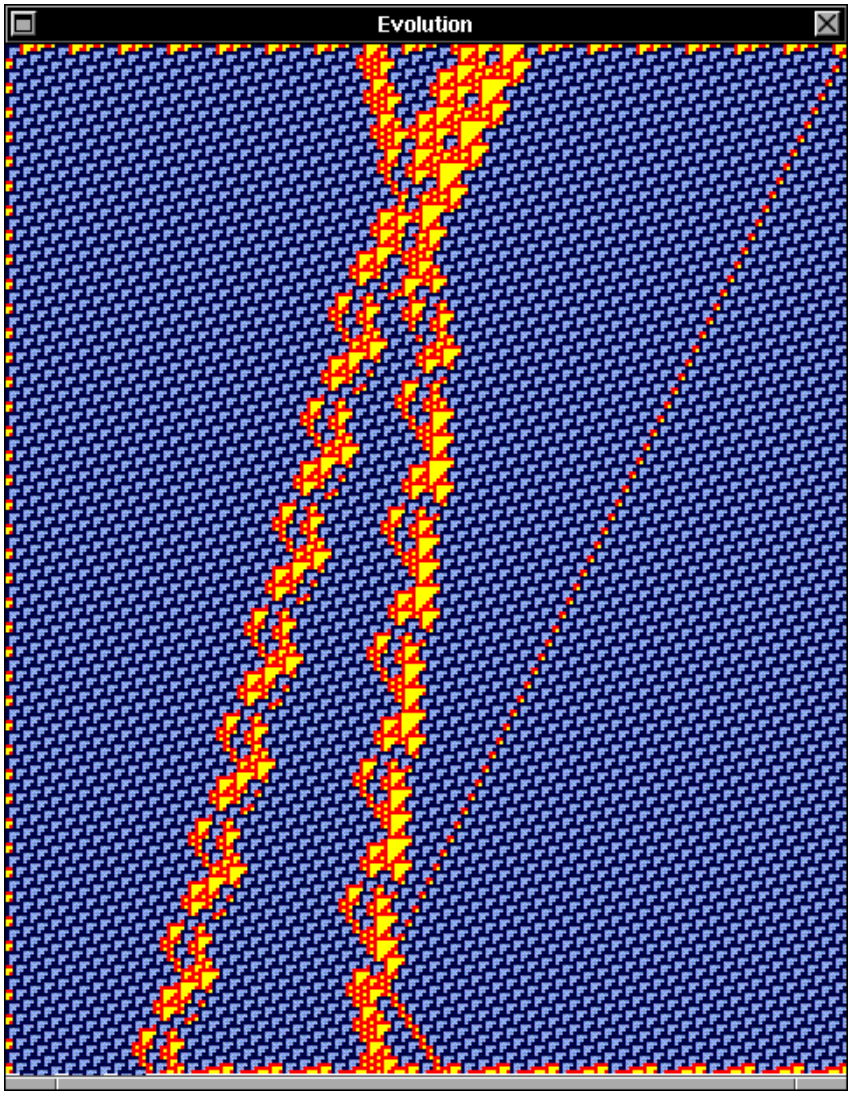

Figure 4.178: Collisions of glider Bbar8, D1(p1)(A)-e(p1)-Bbar8(p1)(C)=Ebar,F

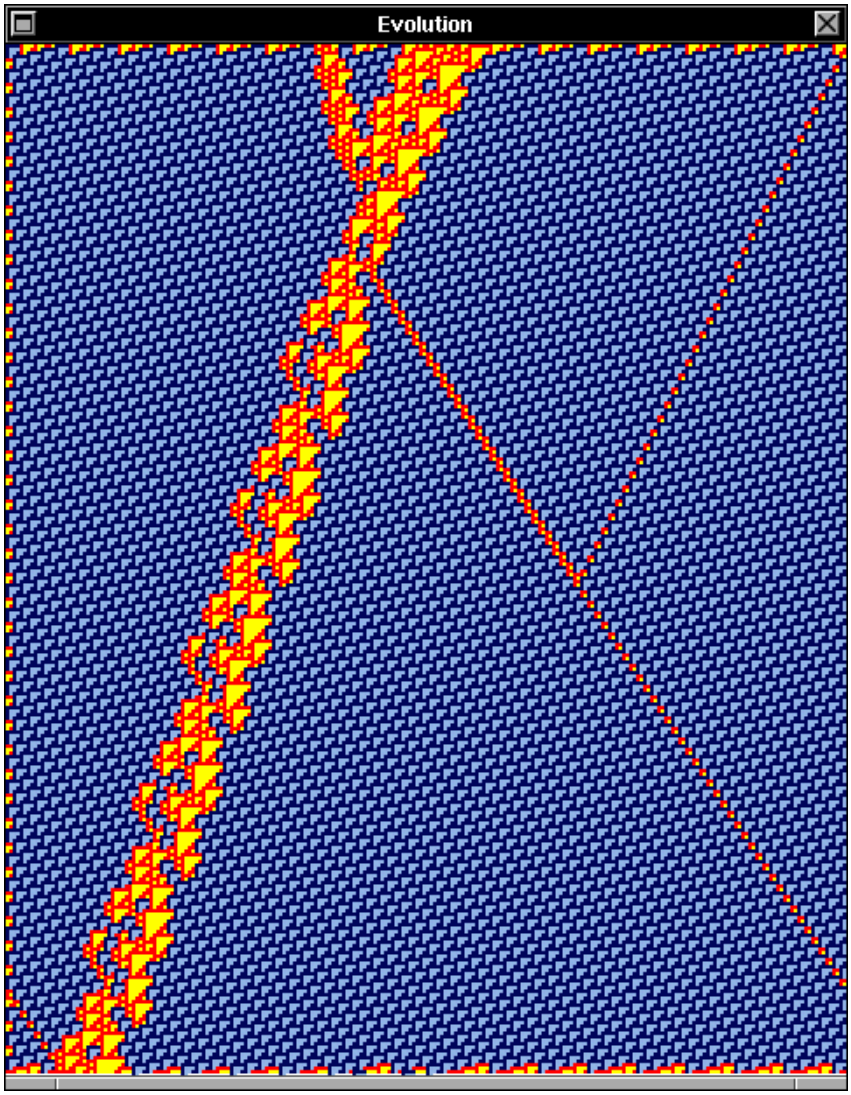

Figure 4.179: Collisions of glider Bbar8, D1(p1)(C)-e(p1)-Bbar8(p1)(A)=G,2A

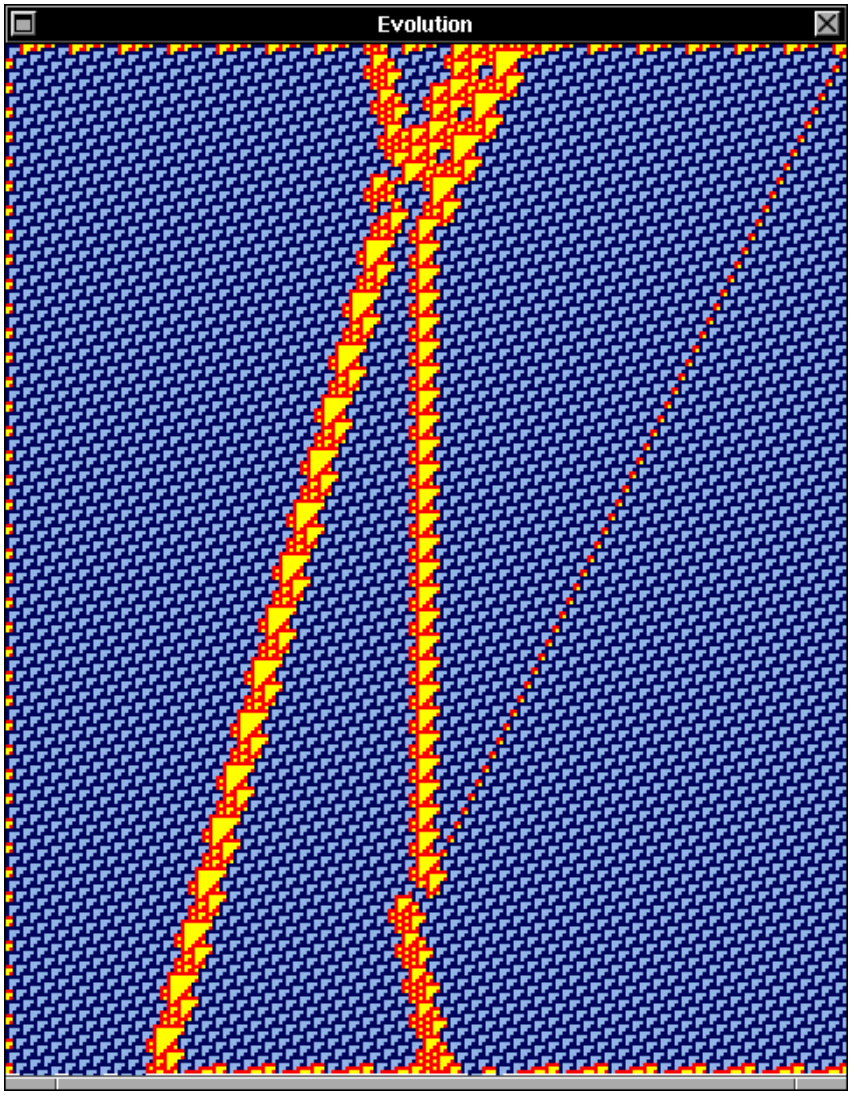

Figure 4.180: Collisions of glider Bbar8, D1(p1)(C)-e(p1)-Bbar8(p1)(B)=E,C2

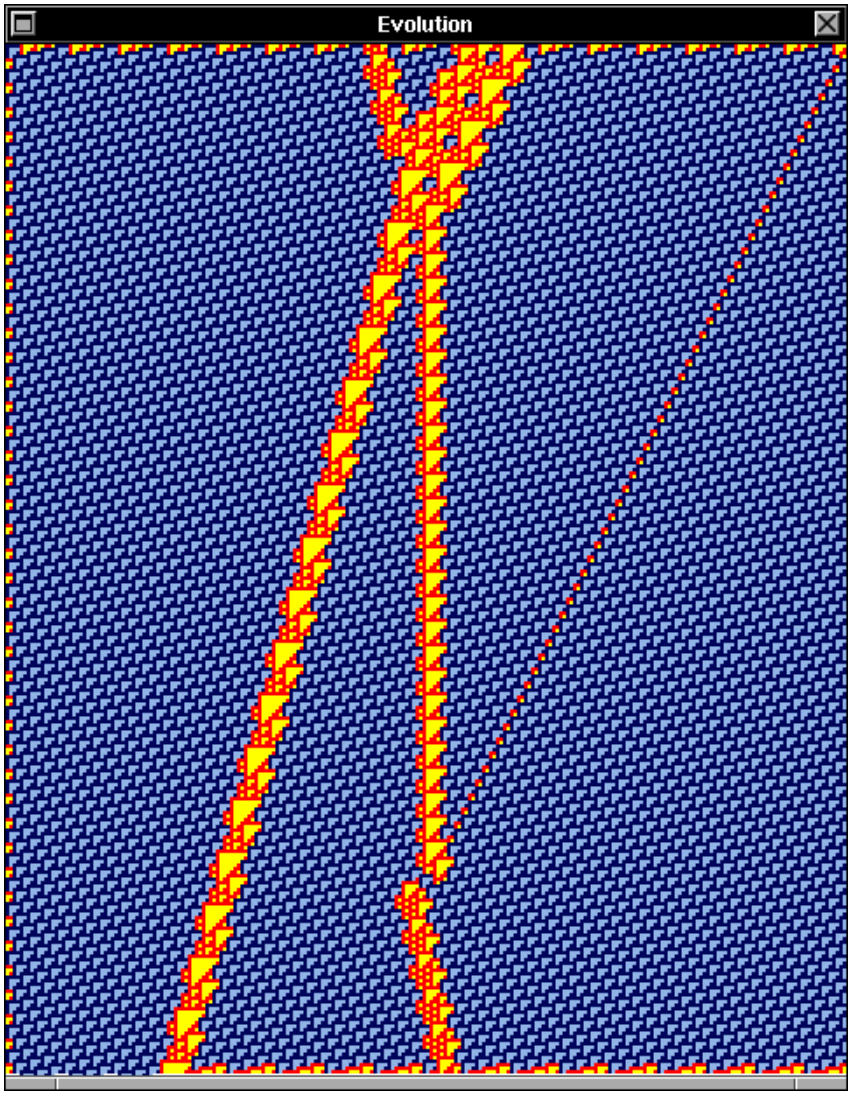

Figure 4.181: Collisions of glider Bbar8, D1(p1)(C)-e(p1)-Bbar8(p1)(C)=E,C2

4.5.5 Collisions of glider Bbar8 with glider D2

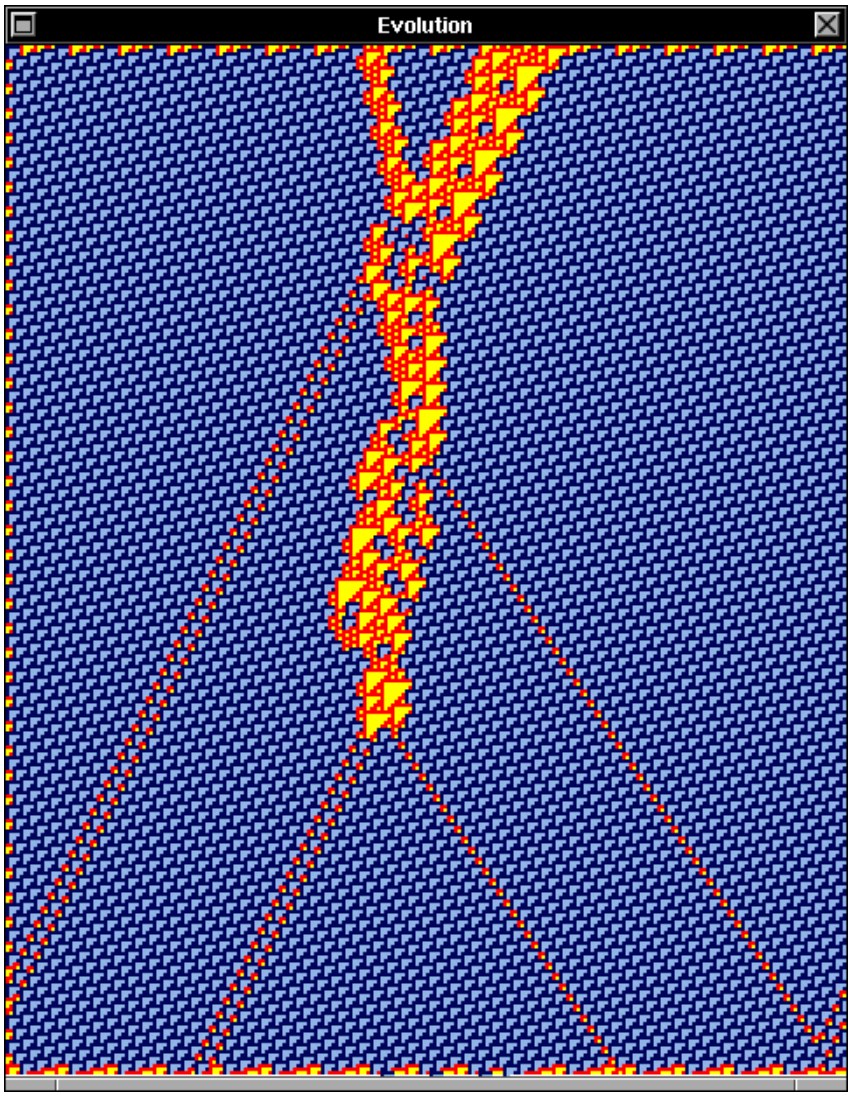

Figure 4.182: Collisions of glider Bbar8, D2(p1)(A)-e(p1)-Bbar8(p1)(A)=2B,A,2B,A

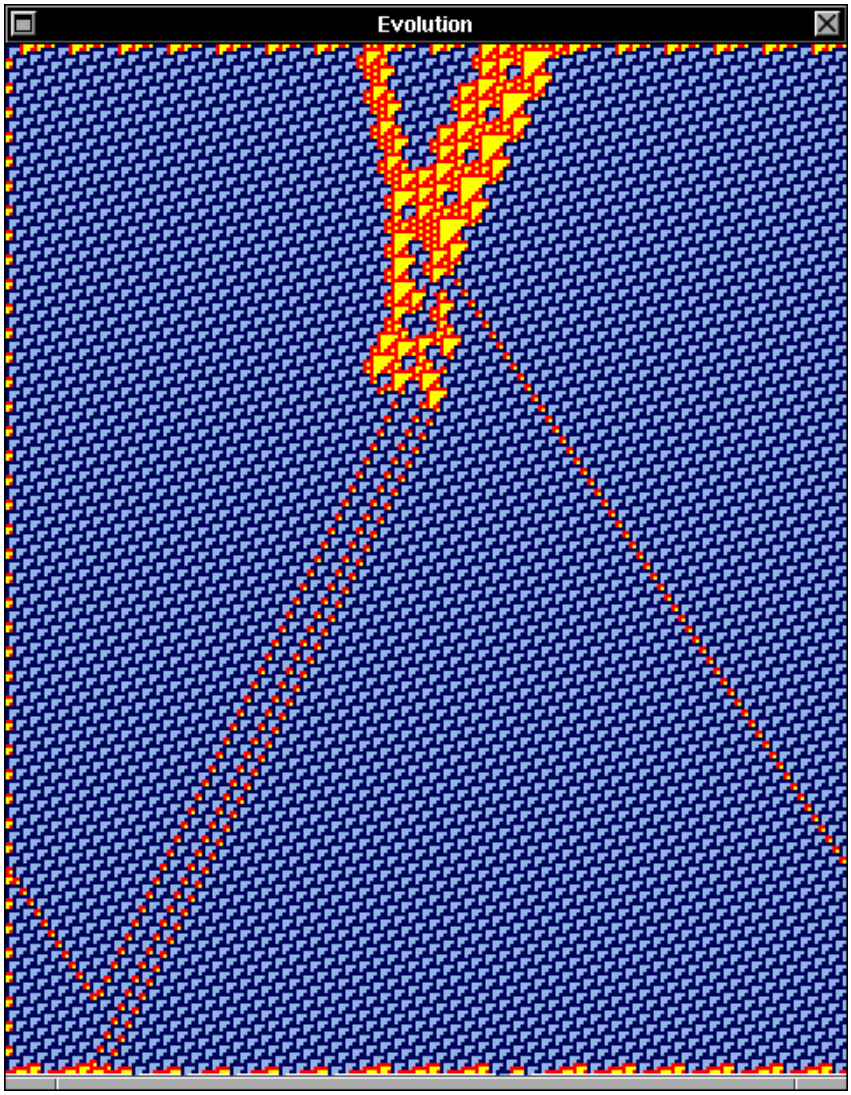

Figure 4.183: Collisions of glider Bbar8, D2(p1)(A)-e(p1)-Bbar8(p1)(B)=A,B,2B

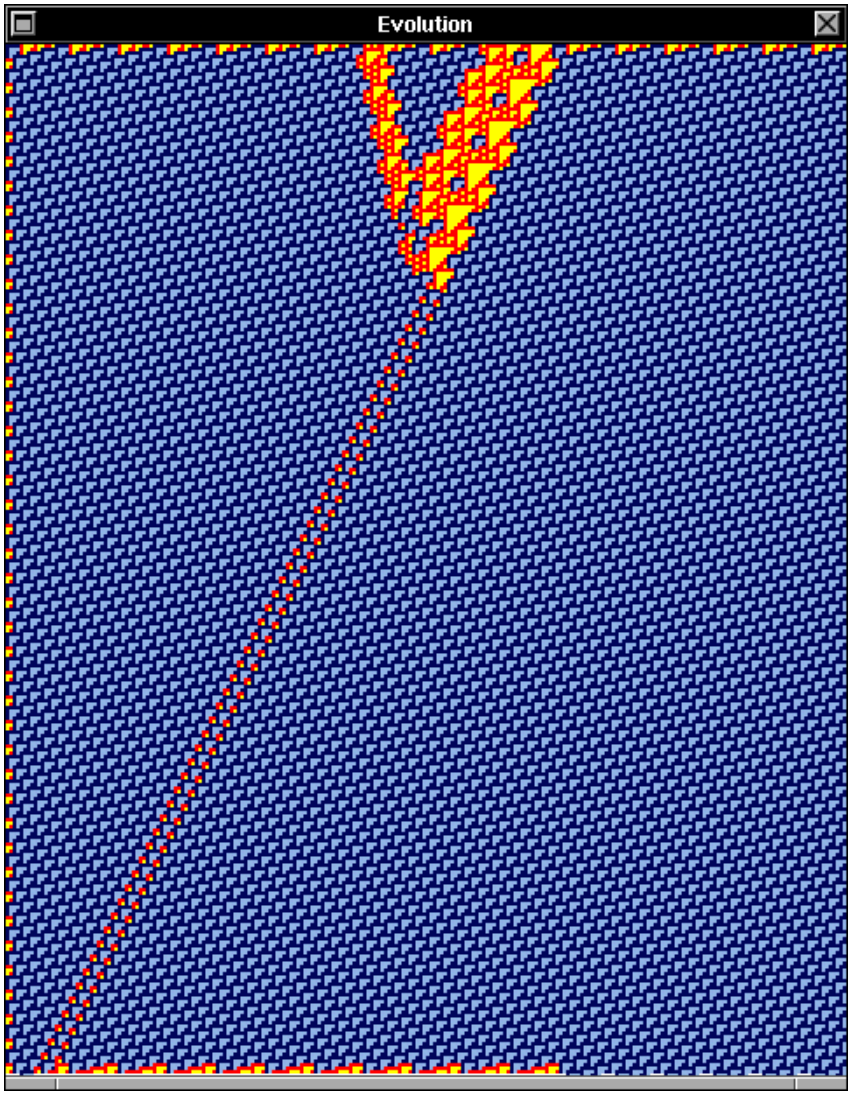

Figure 4.184: Collisions of glider Bbar8, D2(p1)(A)-e(p1)-Bbar8(p1)(C)=2B

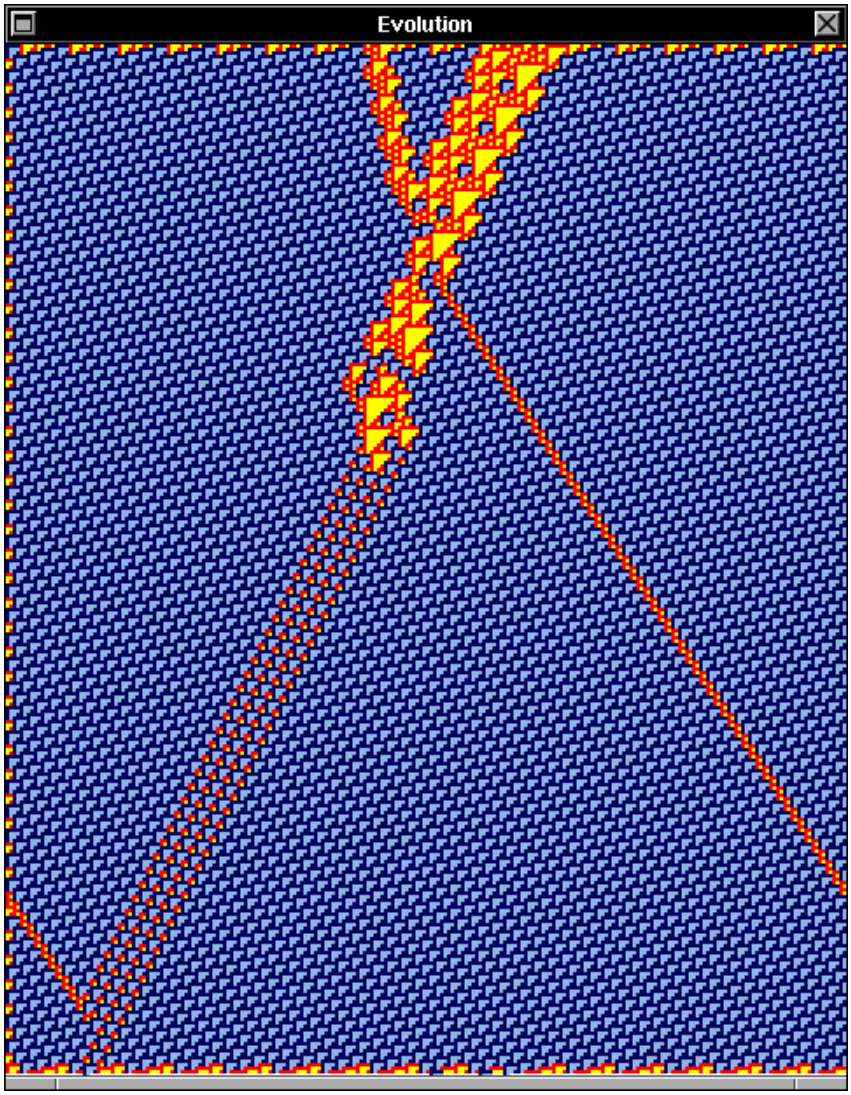

Figure 4.185: Collisions of glider Bbar8, D2(p1)(C)-e(p1)-Bbar8(p1)(A)=2A,4B

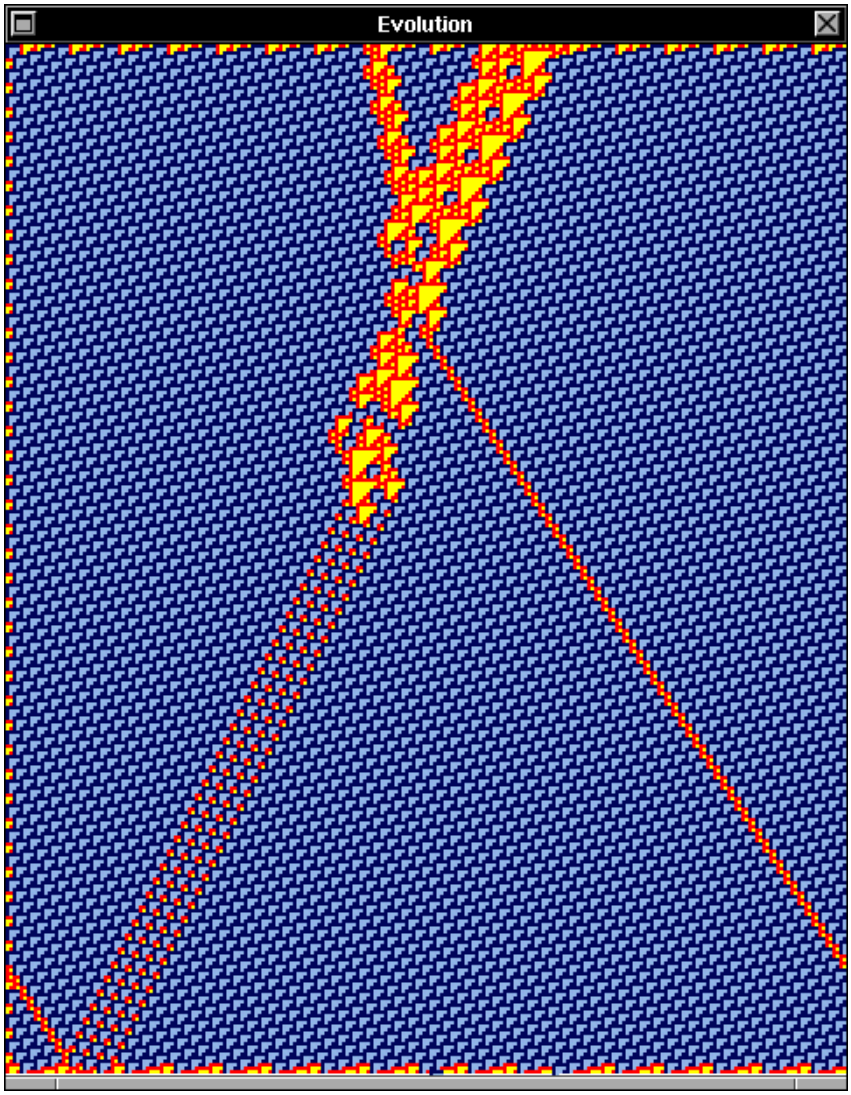

Figure 4.186: Collisions of glider Bbar8, D2(p1)(C)-e(p1)-Bbar8(p1)(B)=2A,4B

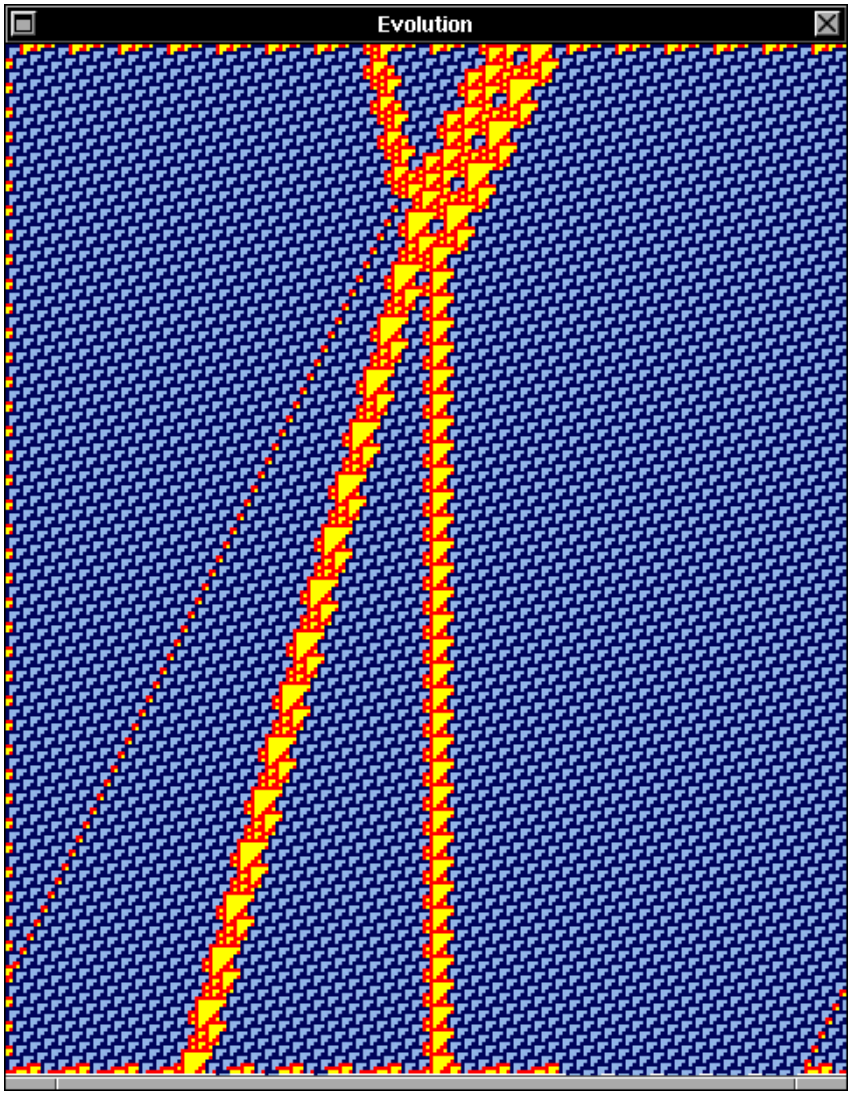

Figure 4.187: Collisions of glider Bbar8, D2(p1)(C)-e(p1)-Bbar8(p1)(C)=B,E,C2

4.5.6 Collisions of glider Bbar8 with glider E

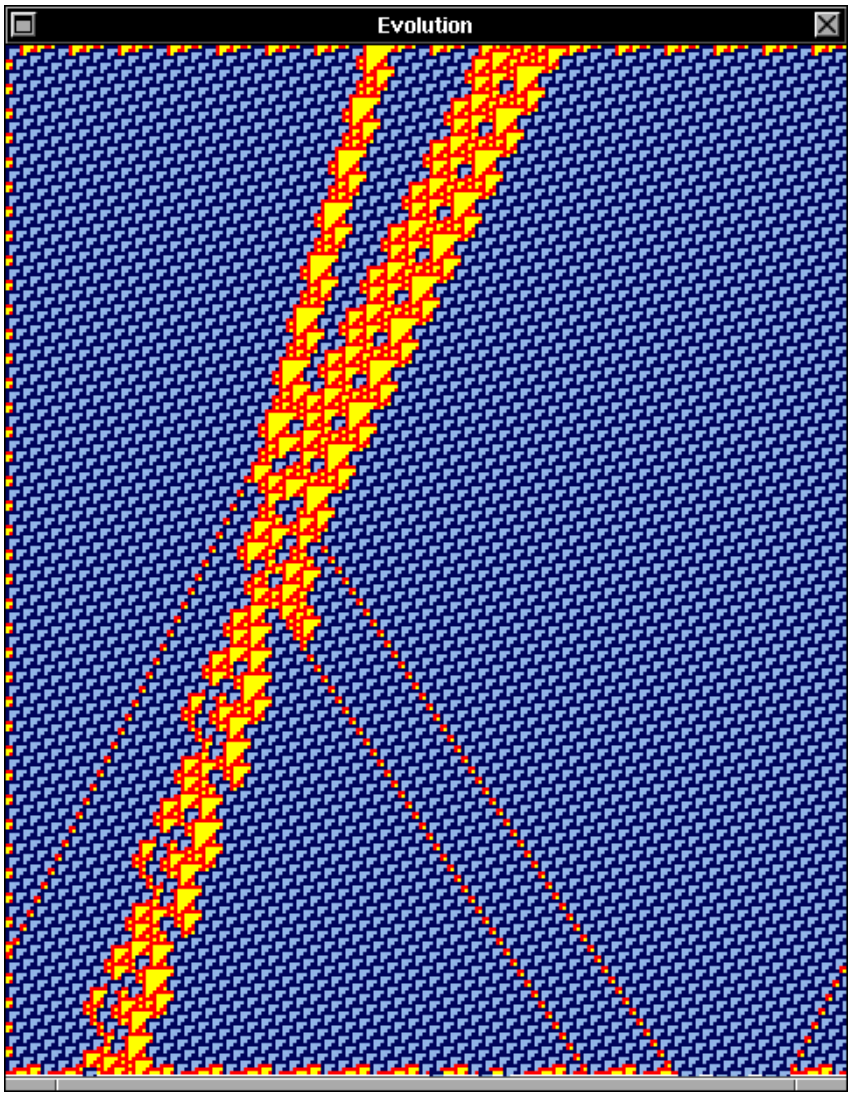

Figure 4.188: Collisions of glider Bbar8, E(p1)(A)-e(p1)-Bbar8(p1)(A)=B,A,G,A

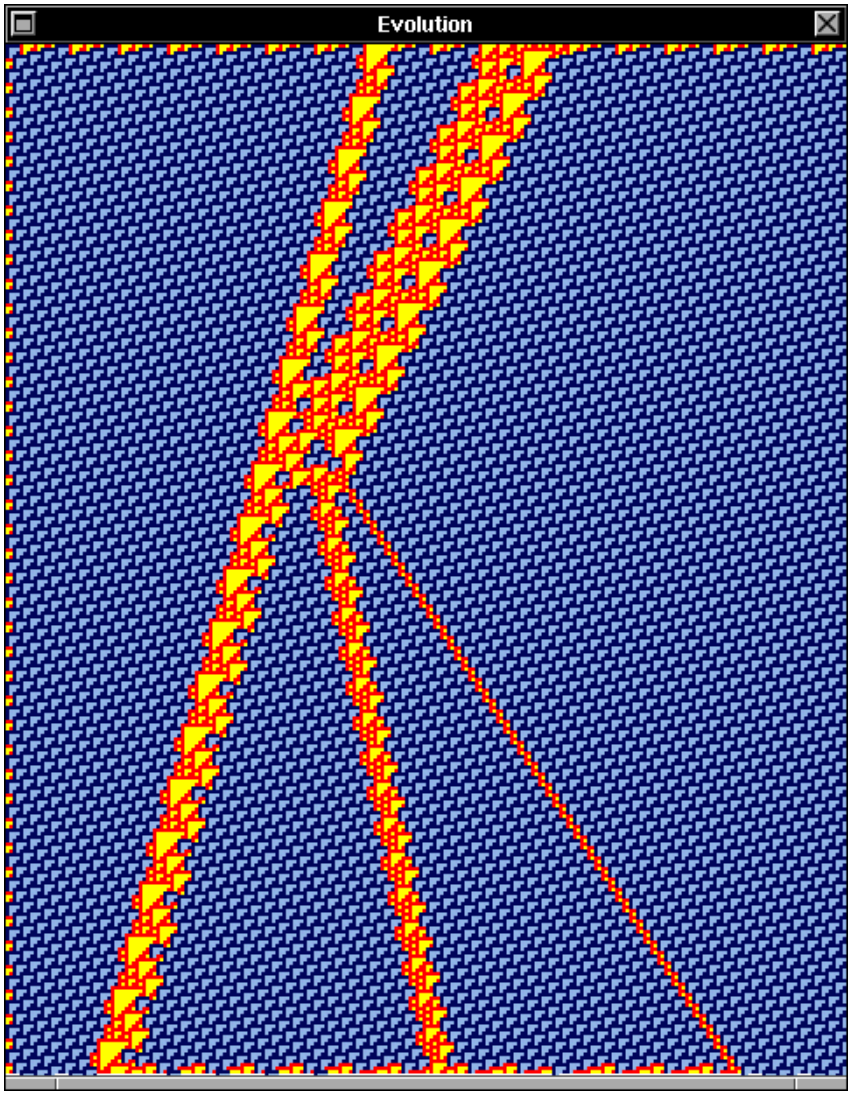

Figure 4.189: Collisions of glider Bbar8, E(p1)(A)-e(p1)-Bbar8(p1)(B)=E2,D2,2A

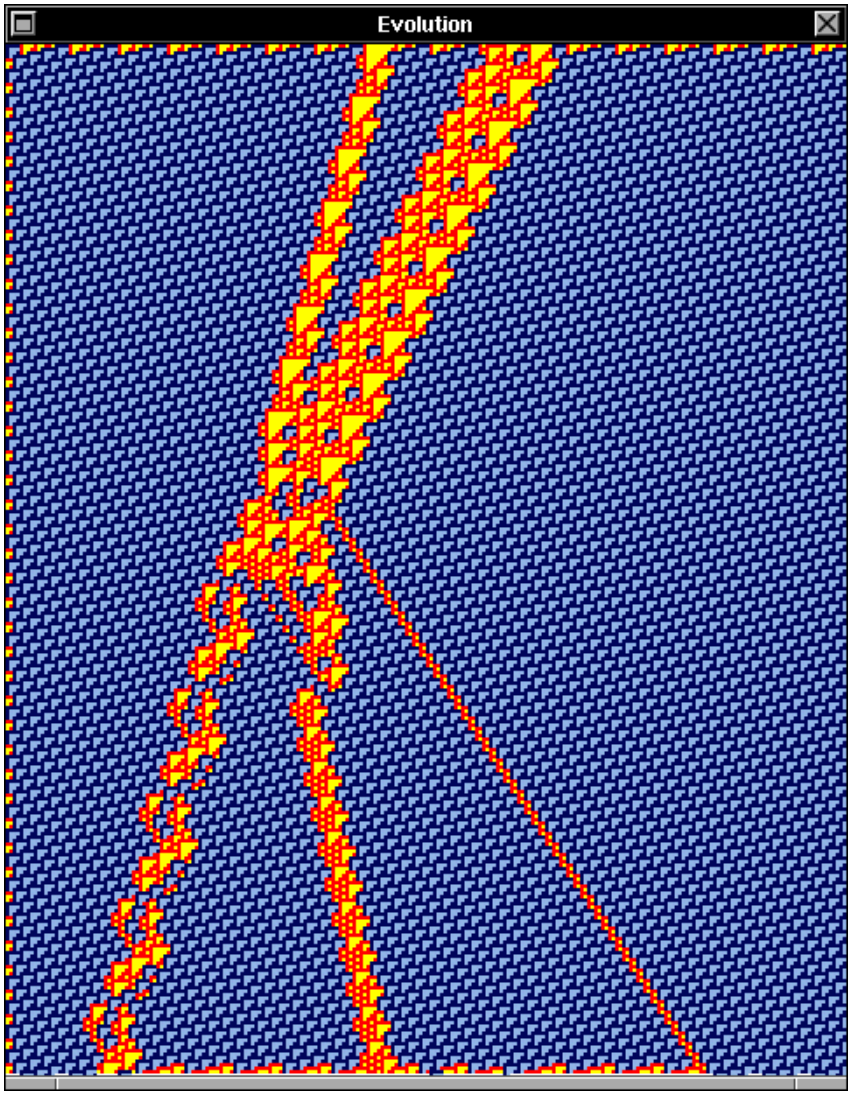

Figure 4.190: Collisions of glider Bbar8, E(p1)(A)-e(p1)-Bbar8(p1)(C)=2A,Ebar,D1

4.5.7 Collisions of glider Bbar8 with glider Ebar

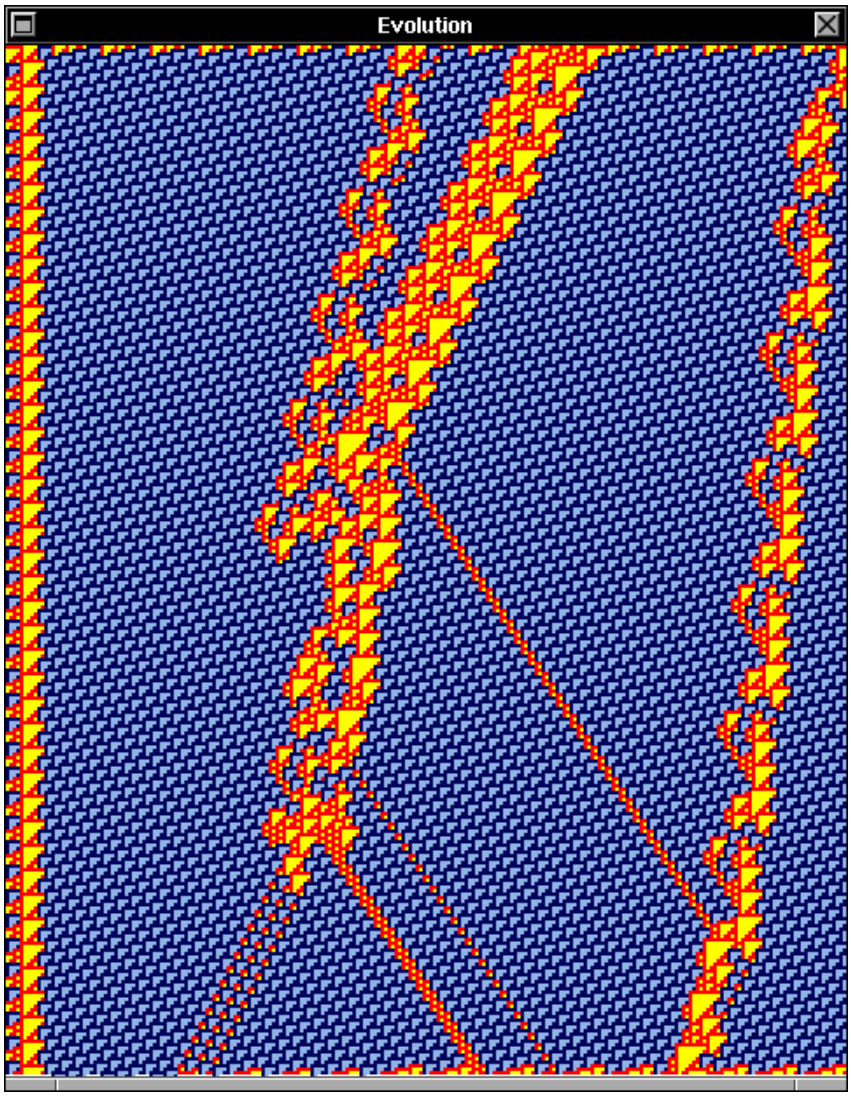

Figure 4.191: Collisions of glider Bbar8, Ebar(p1)(A)-e(p1)-Bbar8(p1)(A)=2A,A,3B,3A

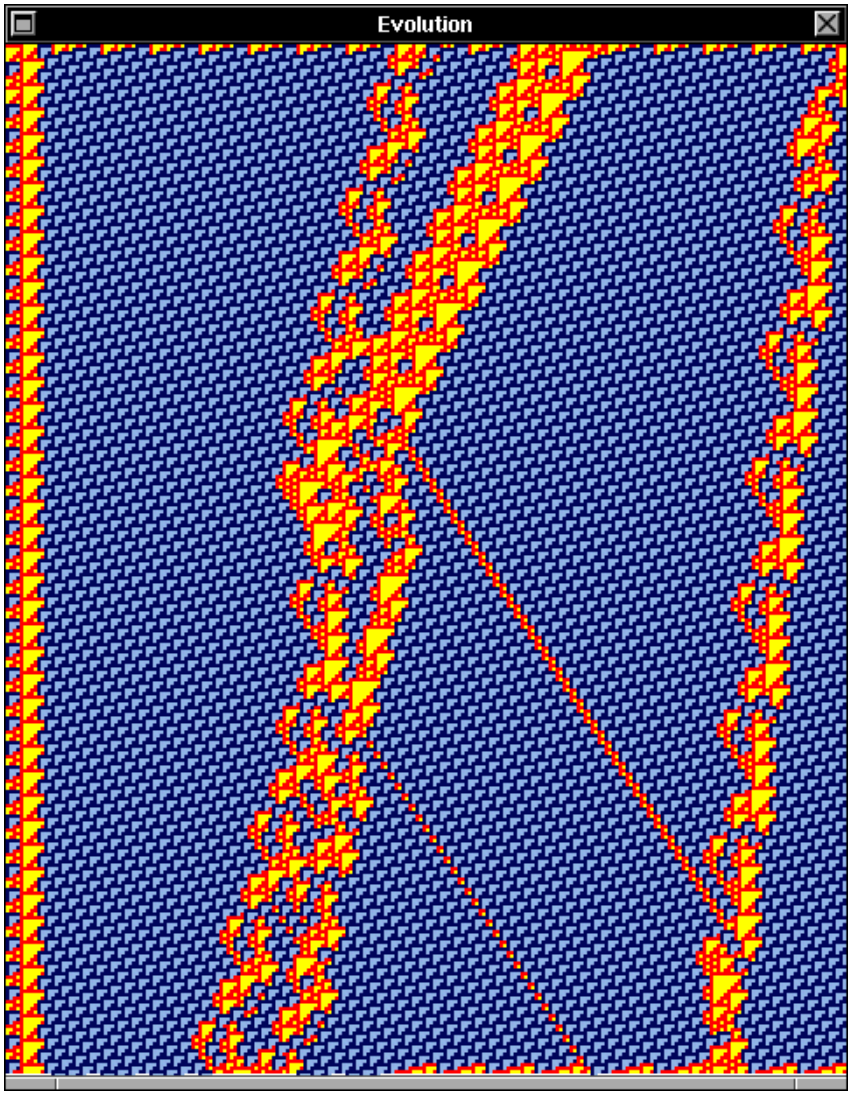

Figure 4.192: Collisions of glider Bbar8, Ebar(p1)(A)-e(p1)-Bbar8(p1)(B)=2A,A,2Ebar

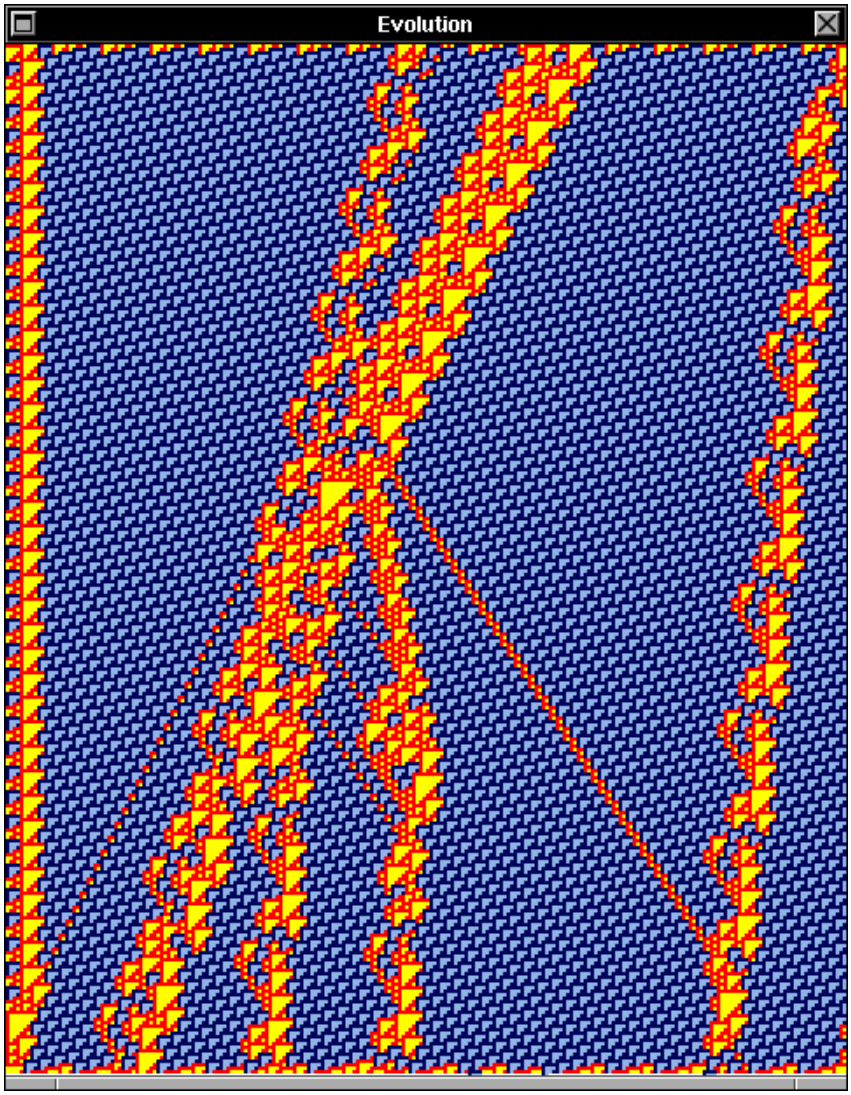

Figure 4.193: Collisions of glider Bbar8, Ebar(p1)(A)-e(p1)-Bbar8(p1)(C)=2A,B,G,F,F

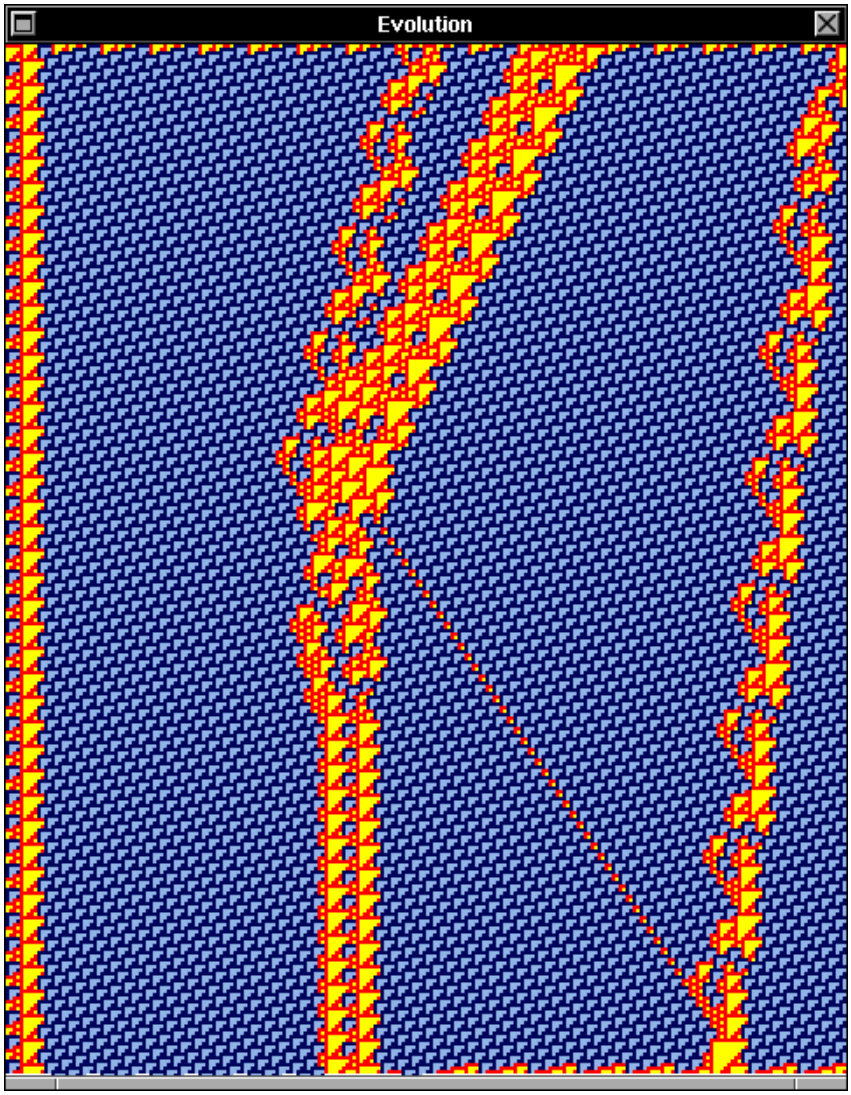

Figure 4.194: Collisions of glider Bbar8, Ebar(p1)(F)-e(p1)-Bbar8(p1)(A)=A,C1,C2

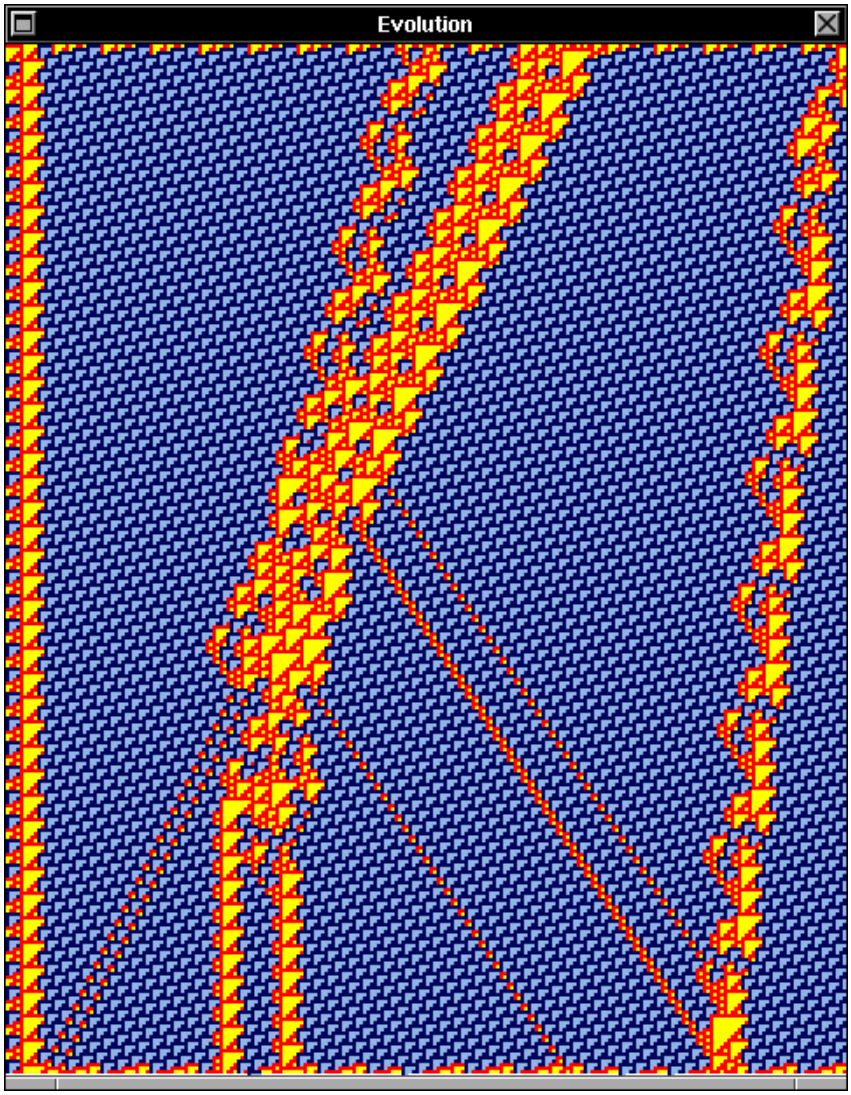

Figure 4.195: Collisions of glider Bbar8, Ebar(p1)(F)-e(p1)-Bbar8(p1)(B)=A,2A,2B,A,C3,C1

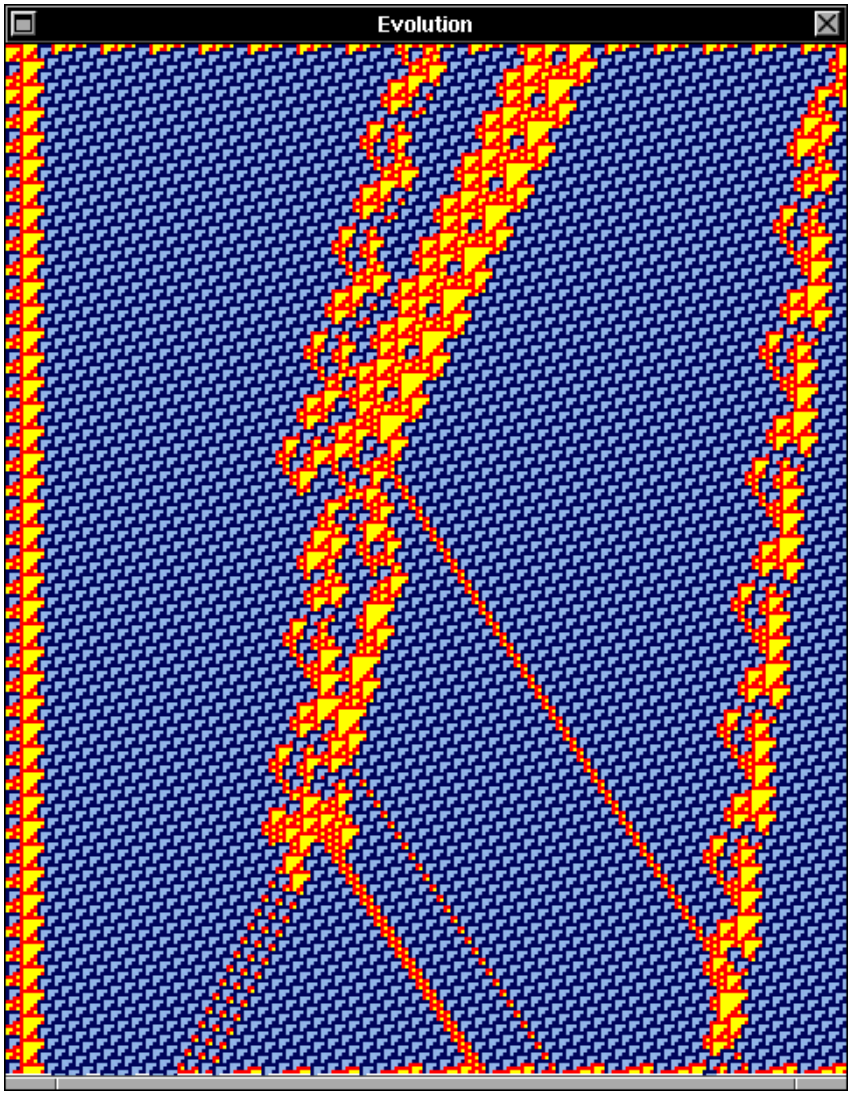

Figure 4.196: Collisions of glider Bbar8, Ebar(p1)(F)-e(p1)-Bbar8(p1)(C)=2A,A,3A,3B

4.5.8 Collisions of glider Bbar8 with glider F

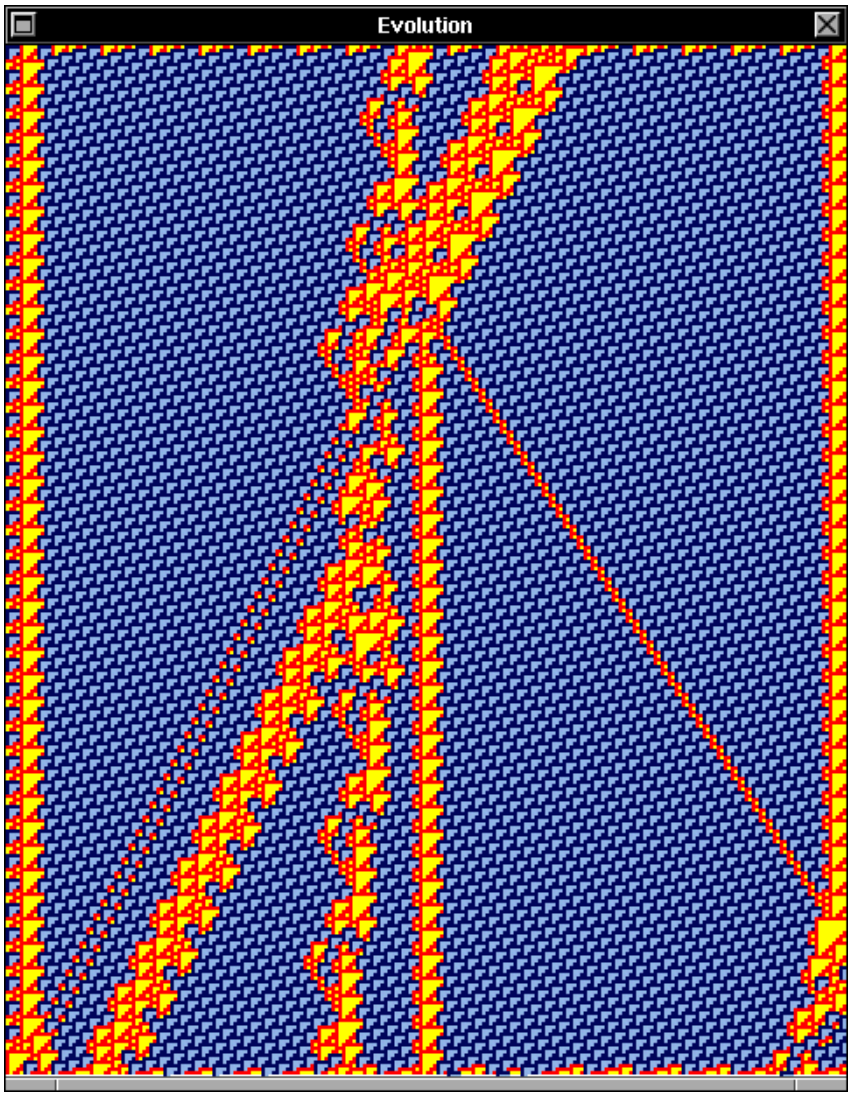

Figure 4.197: Collisions of glider Bbar8, F(p1)(A)-e(p1)-Bbar8(p1)(A)=2A,C2,2B,Bbar,F

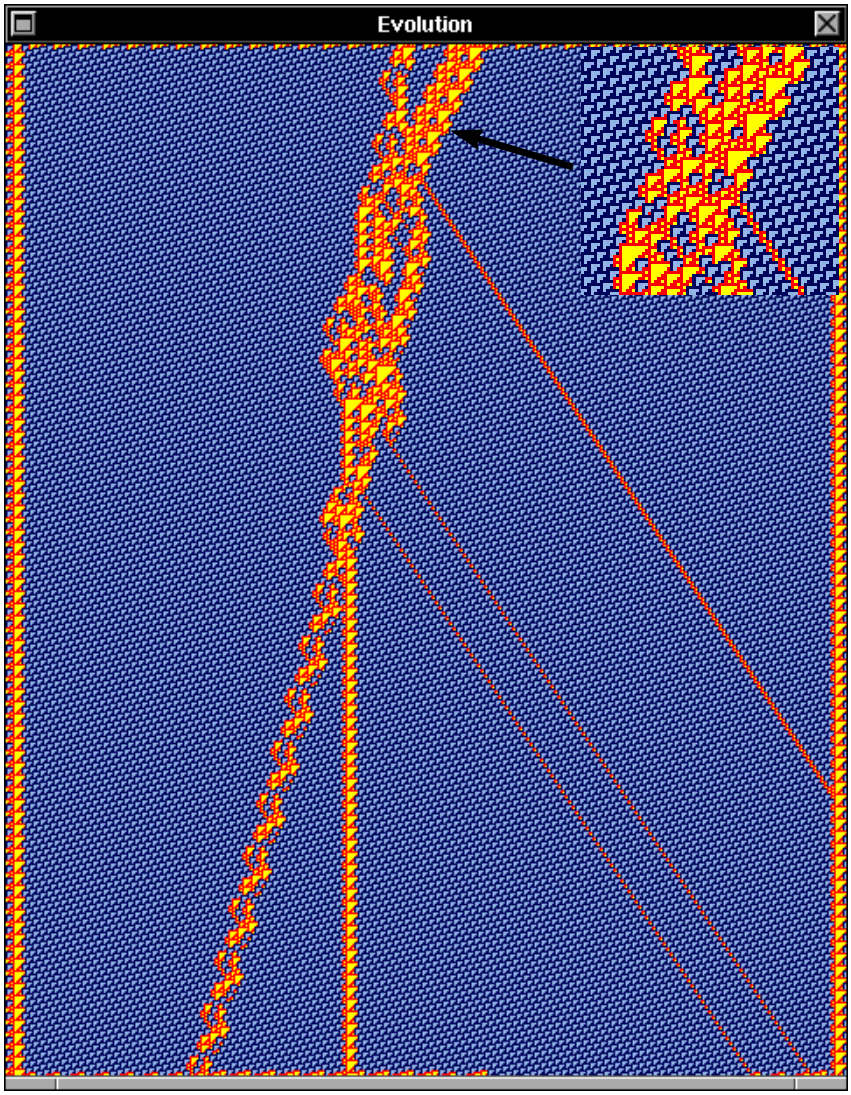

Figure 4.198: Collisions of glider Bbar8, F(p1)(A)-e(p1)-Bbar8(p1)(B)=2A,A,A,Ebar,C1

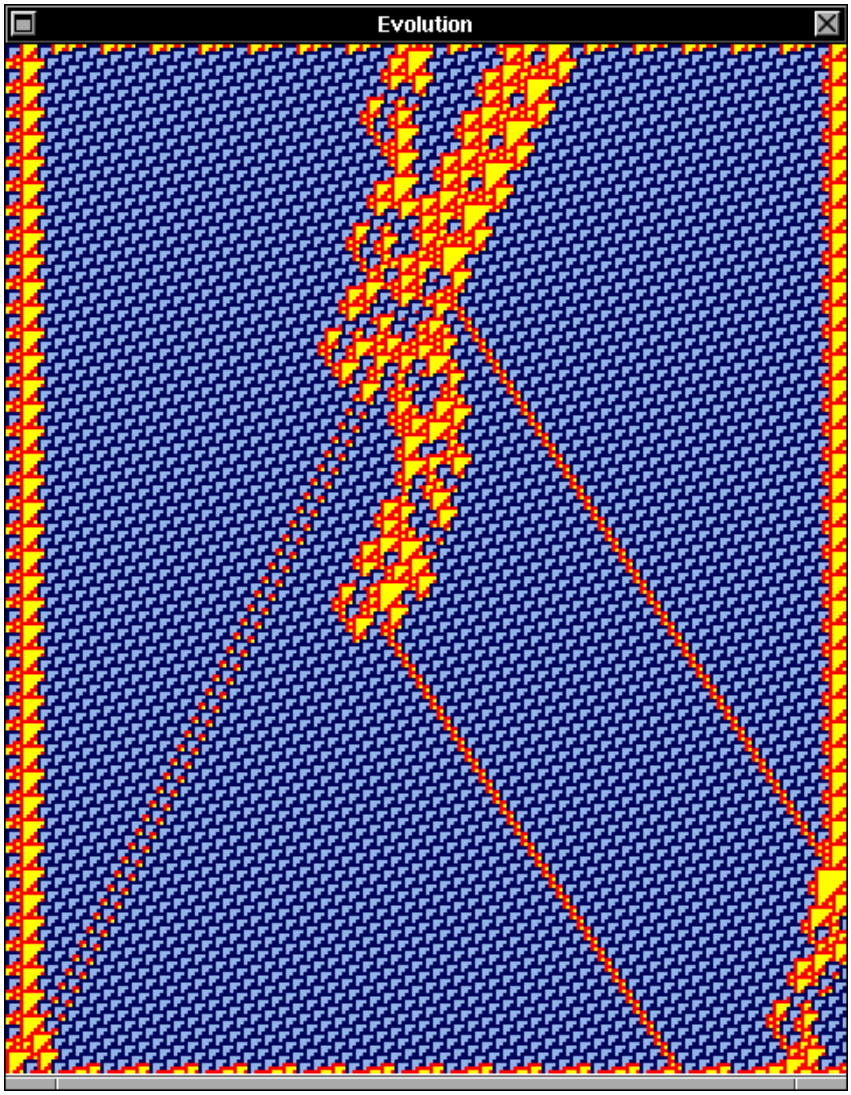

Figure 4.199: Collisions of glider Bbar8, F(p1)(A)-e(p1)-Bbar8(p1)(C)=2A,2B,2A

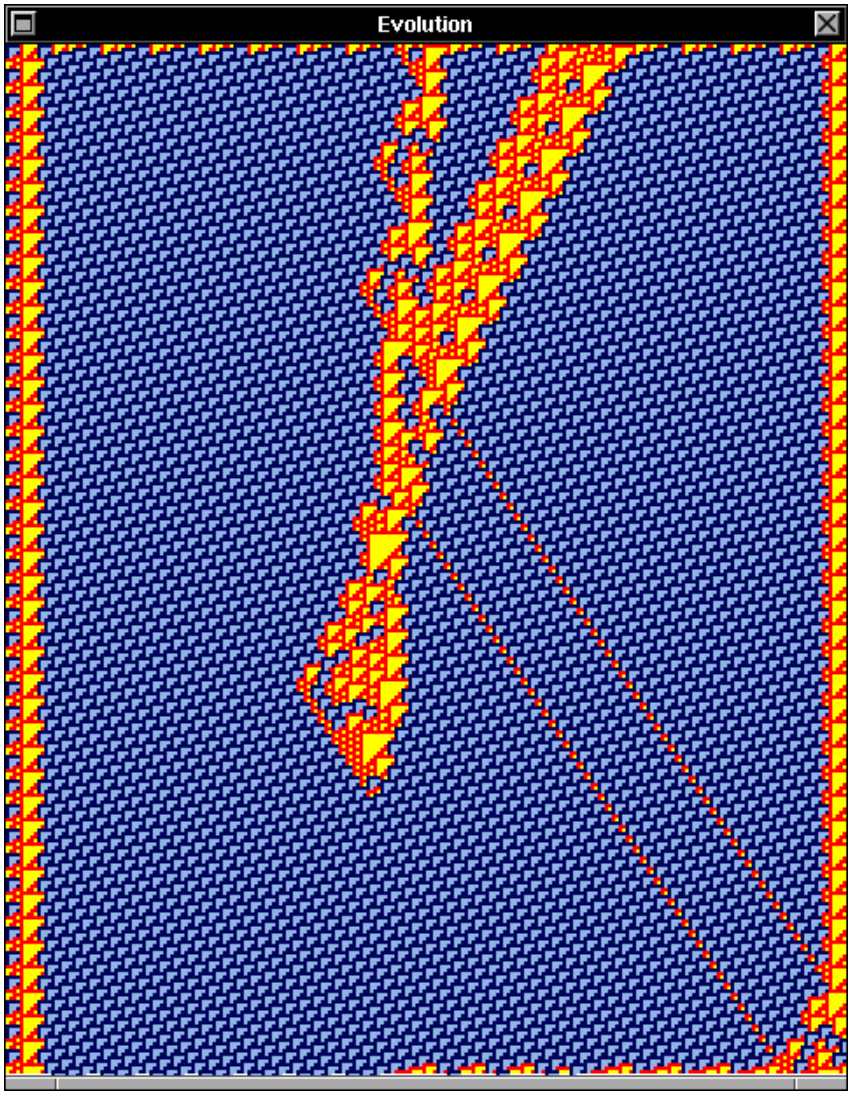

Figure 4.200: Collisions of glider Bbar8, F(p1)(G)-e(p1)-Bbar8(p1)(A)=A,A

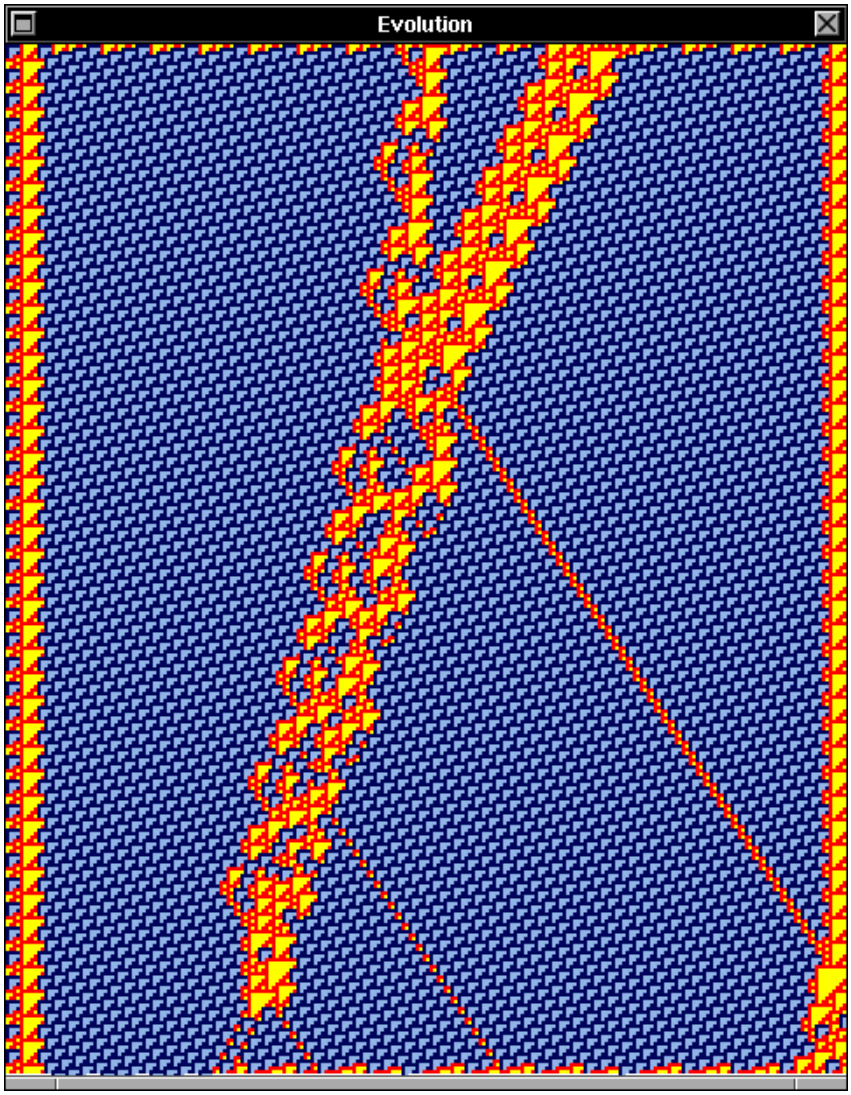

Figure 4.201: Collisions of glider Bbar8, F(p1)(G)-e(p1)-Bbar8(p1)(B)=2A,A,2B,A

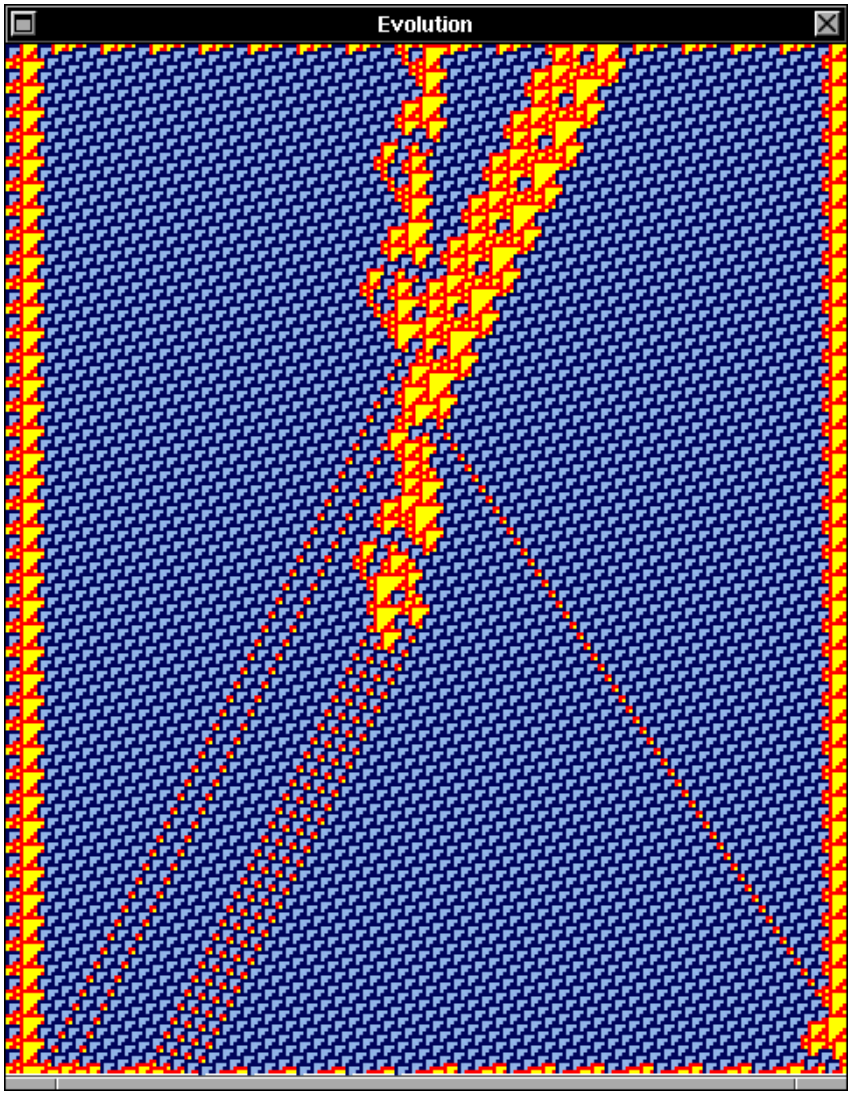

Figure 4.202: Collisions of glider Bbar8, F(p1)(G)-e(p1)-Bbar8(p1)(C)=B,B,A,4B

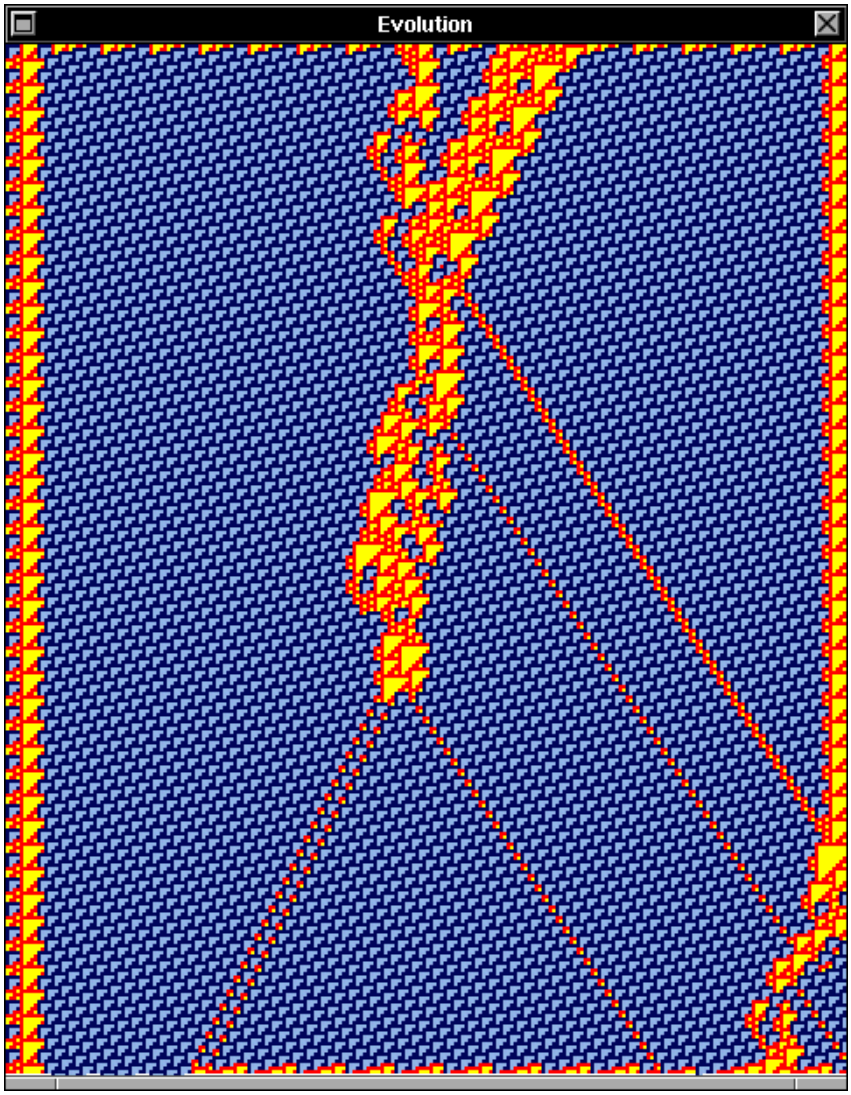

Figure 4.203: Collisions of glider Bbar8, F(p1)(H)-e(p1)-Bbar8(p1)(A)=2A,A,2B,A

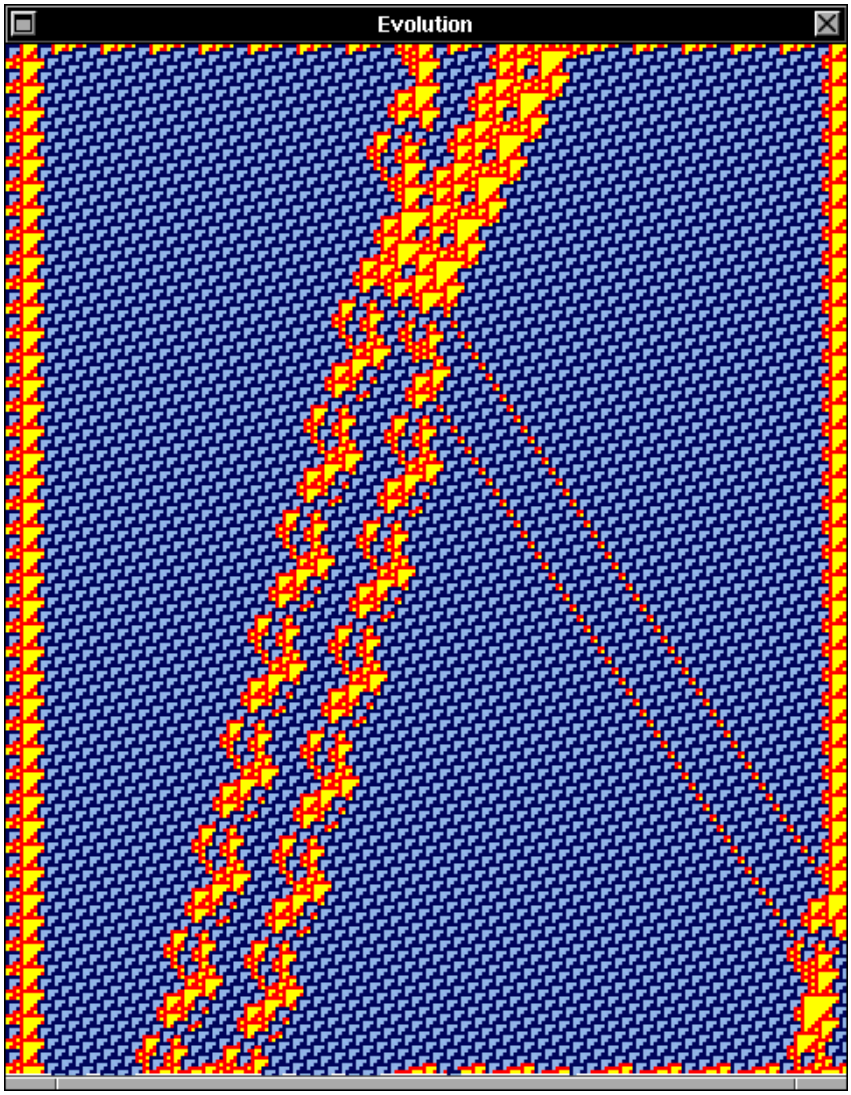

Figure 4.204: Collisions of glider Bbar8, F(p1)(H)-e(p1)-Bbar8(p1)(B)=Ebar,A,A,Ebar

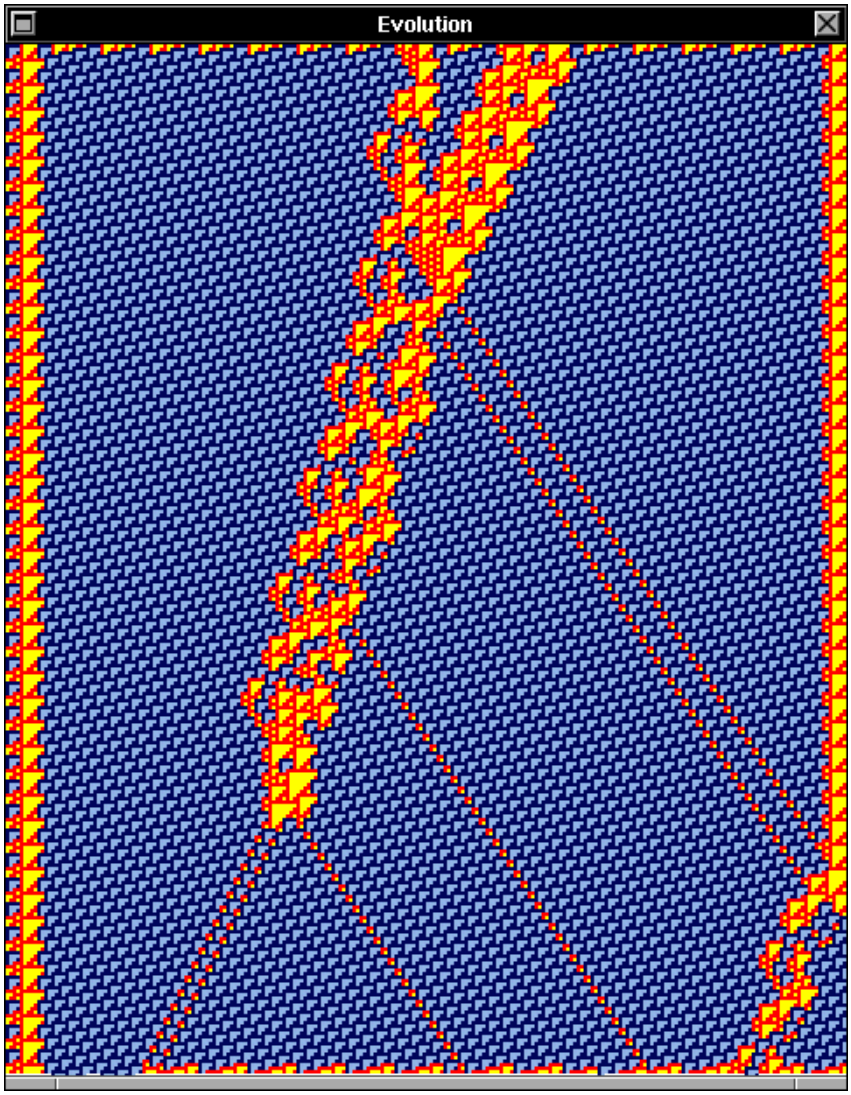

Figure 4.205: Collisions of glider Bbar8, F(p1)(H)-e(p1)-Bbar8(p1)(C)=A,A,A,2B,A

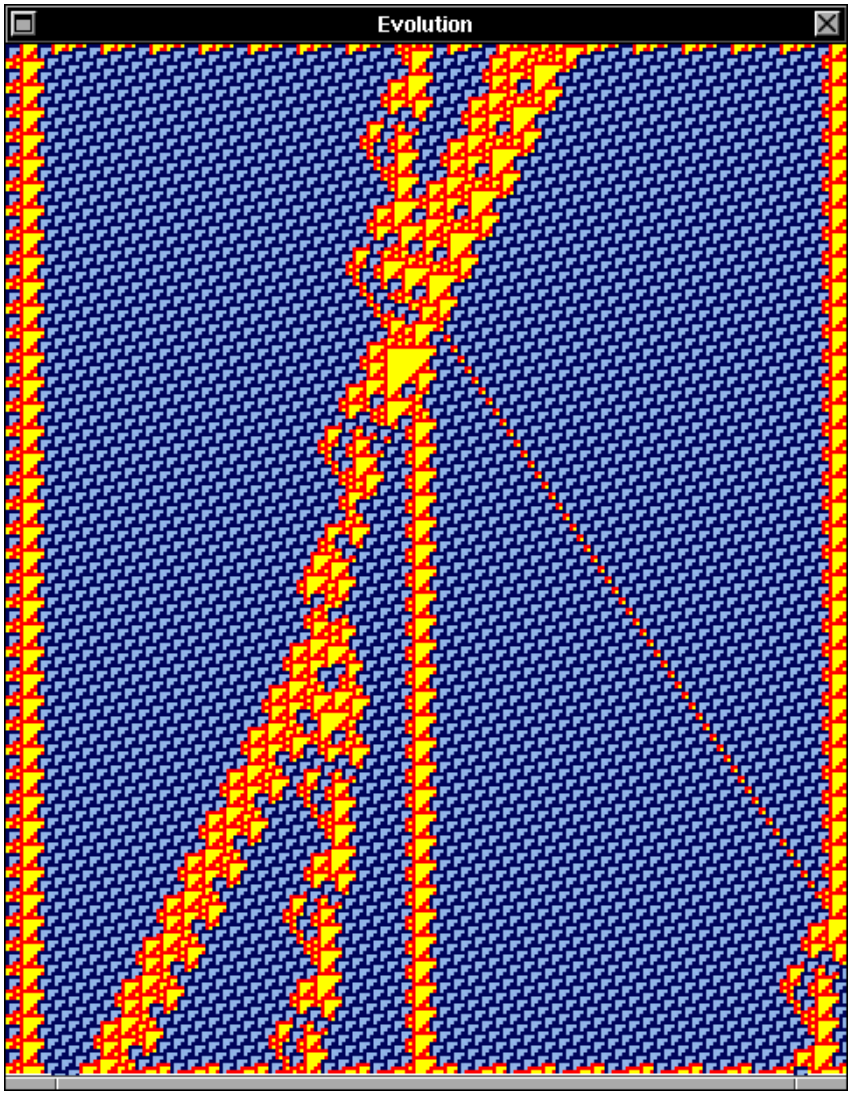

Figure 4.206: Collisions of glider Bbar8, F(p1)(A2)-e(p1)-Bbar8(p1)(A)=A,C3,Bbar,F

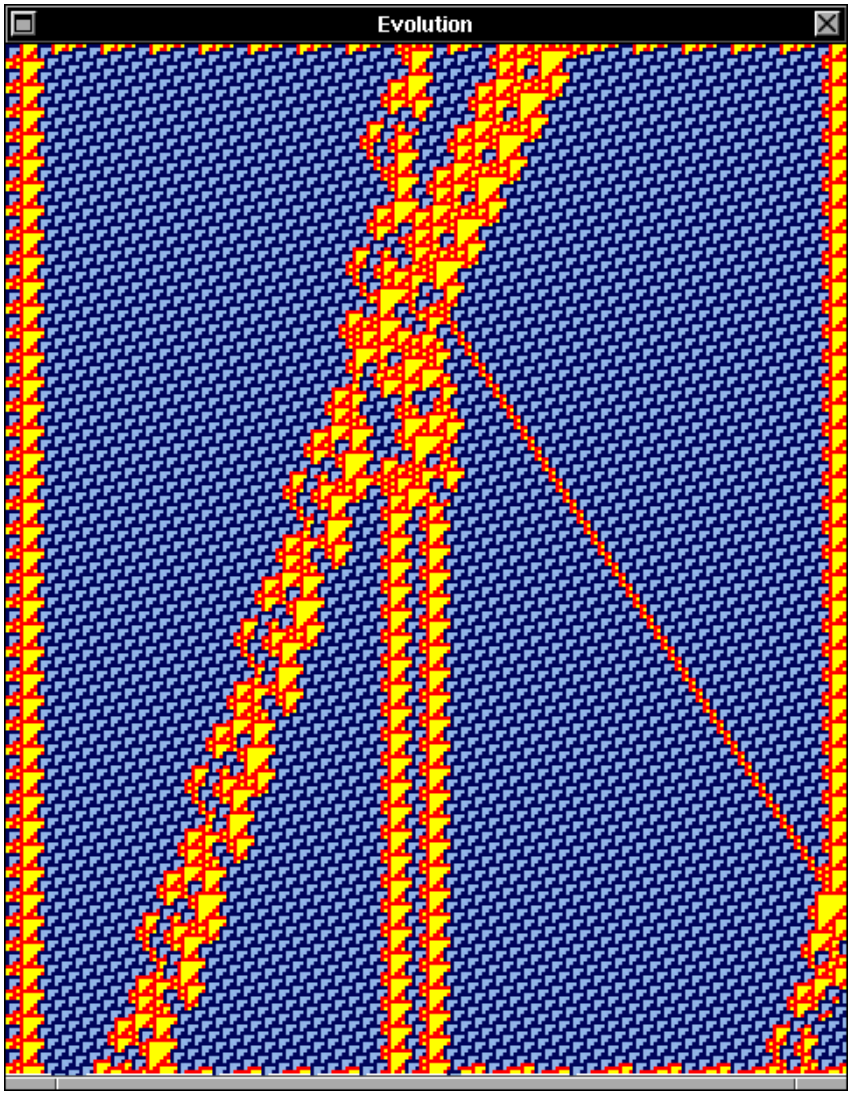

Figure 4.207: Collisions of glider Bbar8, F(p1)(A2)-e(p1)-Bbar8(p1)(B)=2A,G,C1,C1

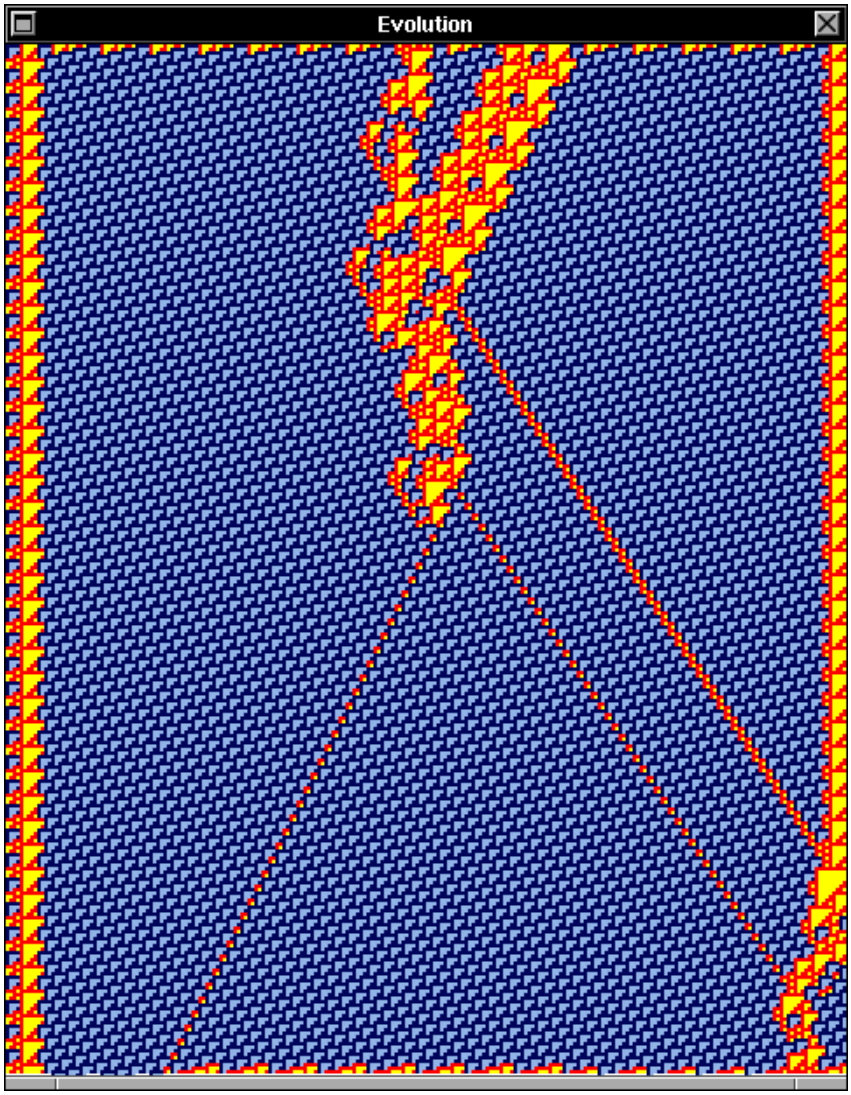

Figure 4.208: Collisions of glider Bbar8, F(p1)(A2)-e(p1)-Bbar8(p1)(C)=2A,A,B

4.5.9 Collisions of glider Bbar8 with glider G

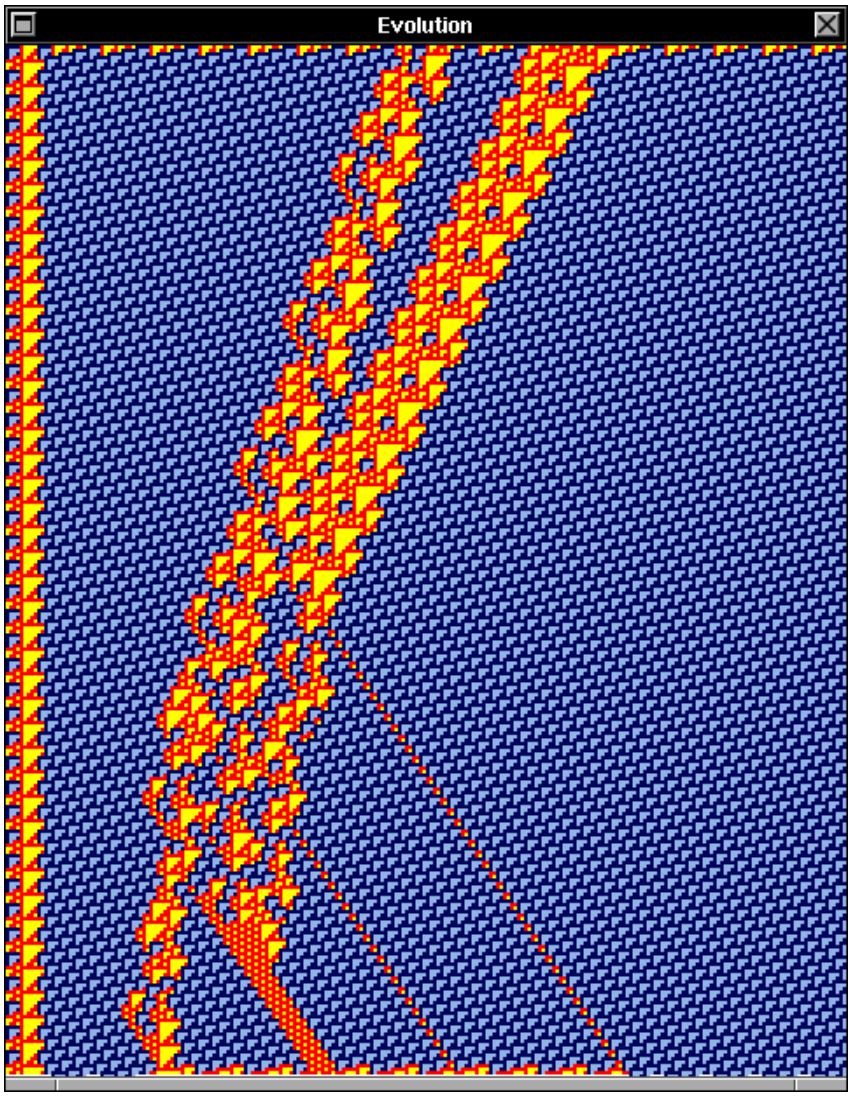

Figure 4.209: Collisions of glider Bbar8, G(p1)(A)-e(p1)-Bbar8(p1)(A)=A,A,6A,F

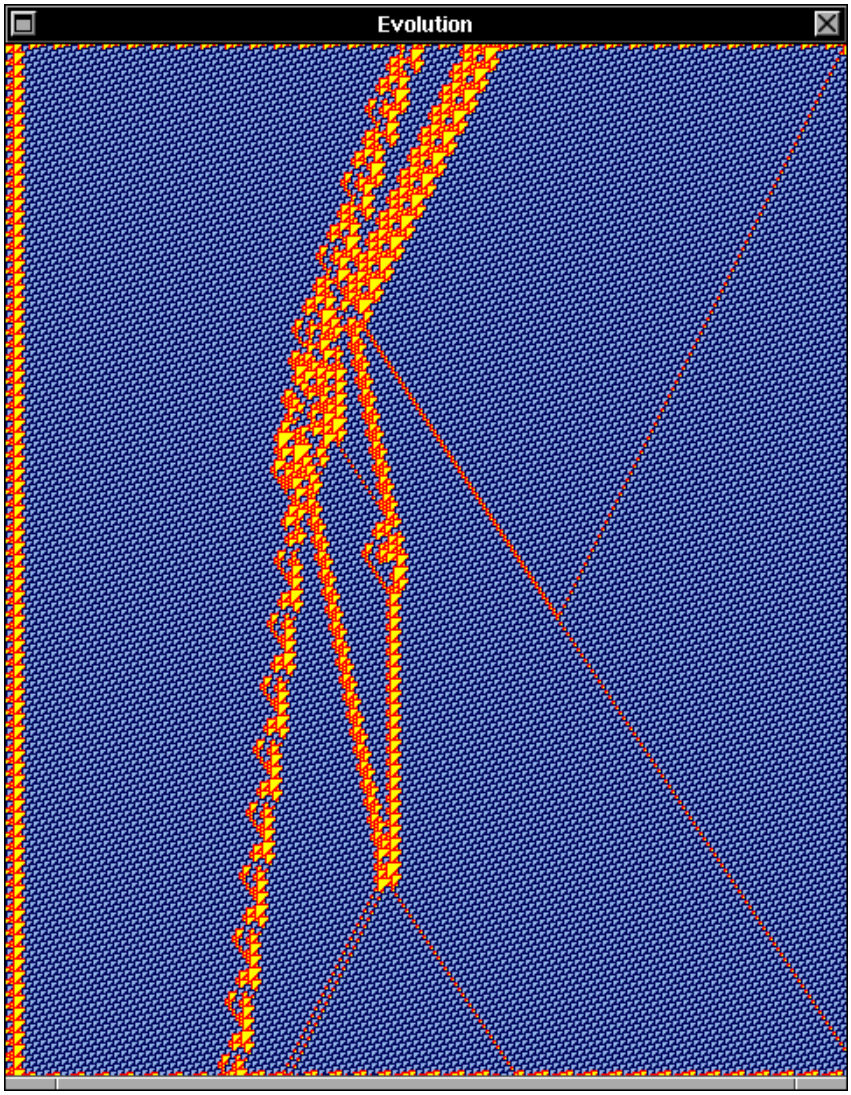

Figure 4.210: Collisions of glider Bbar8, G(p1)(A)-e(p1)-Bbar8(p1)(B)=2A,A,C2

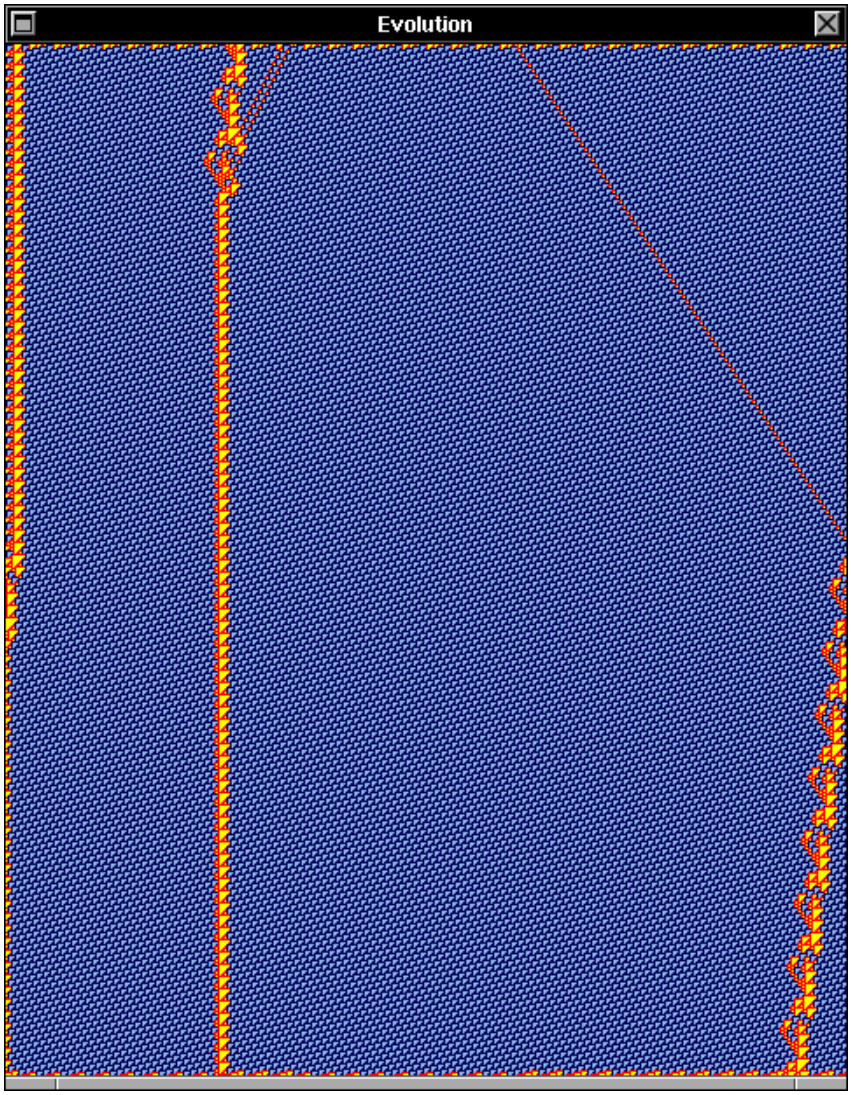

Figure 4.211: continue collision, G(p1)(A)-e(p1)-Bbar8(p1)(B)

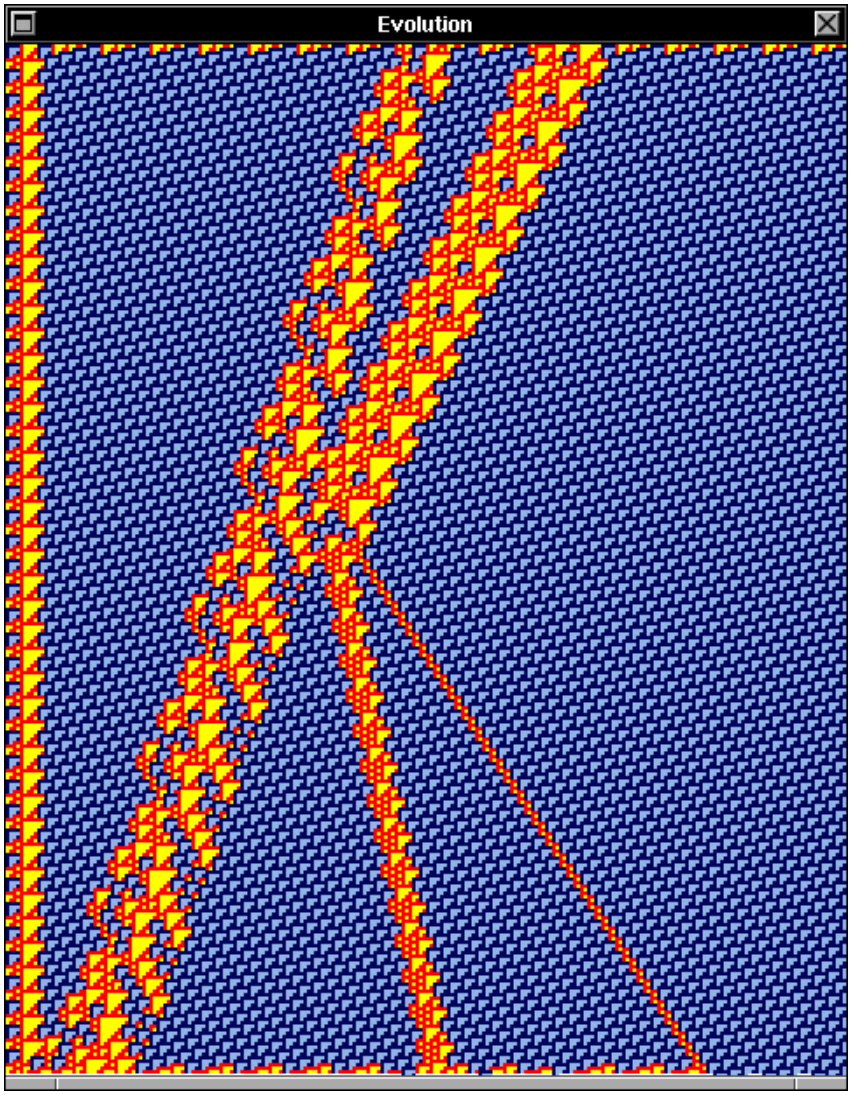

Figure 4.212: Collisions of glider Bbar8, G(p1)(A)-e(p1)-Bbar8(p1)(C)=G3,D1,2A

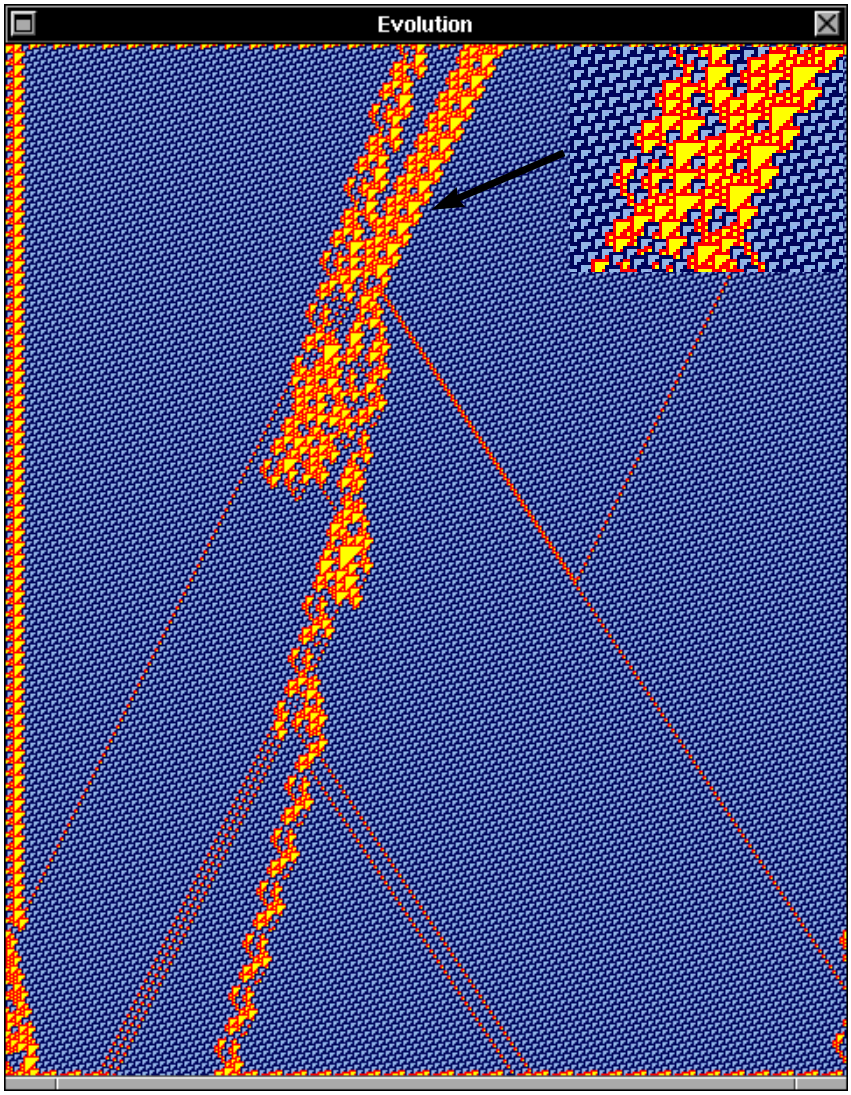

Figure 4.213: Collisions of glider Bbar8, G(p1)(C2)-e(p1)-Bbar8(p1)(A)=2A,B,3B,A,A,Ebar

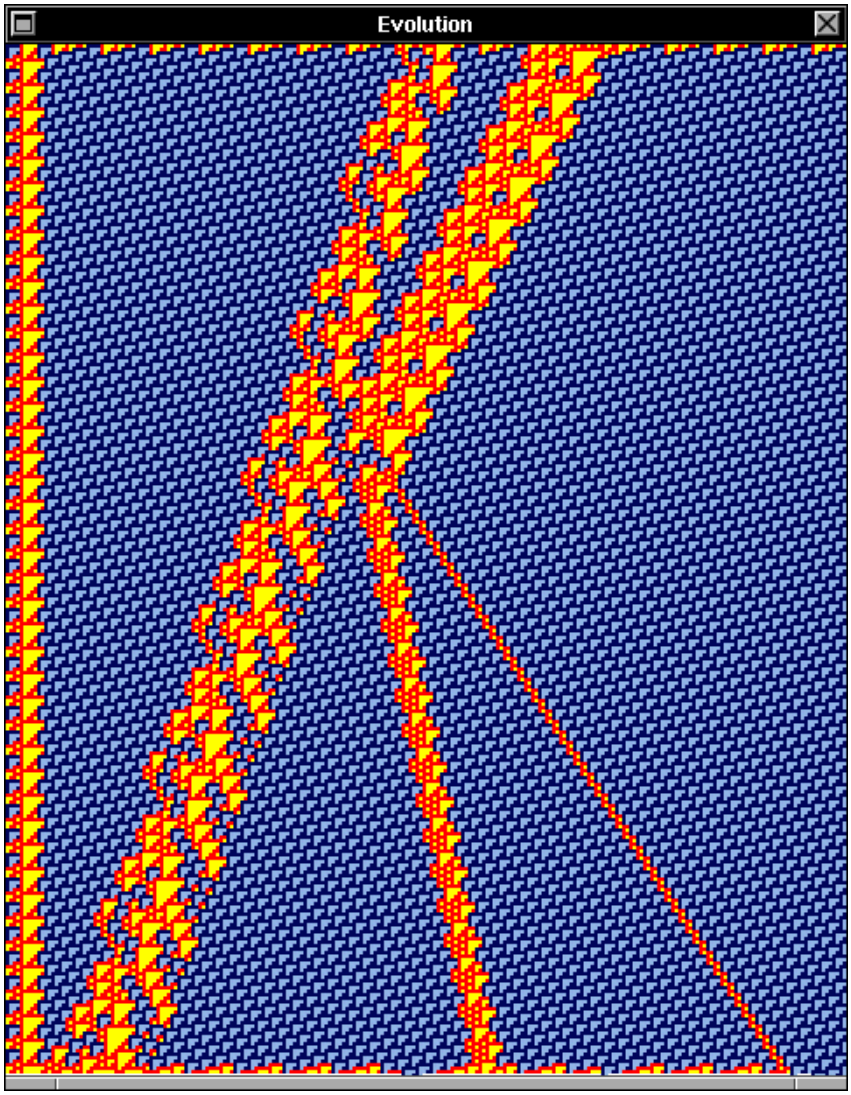

Figure 4.214: Collisions of glider Bbar8, G(p1)(C2)-e(p1)-Bbar8(p1)(B)=G3,D1,2A

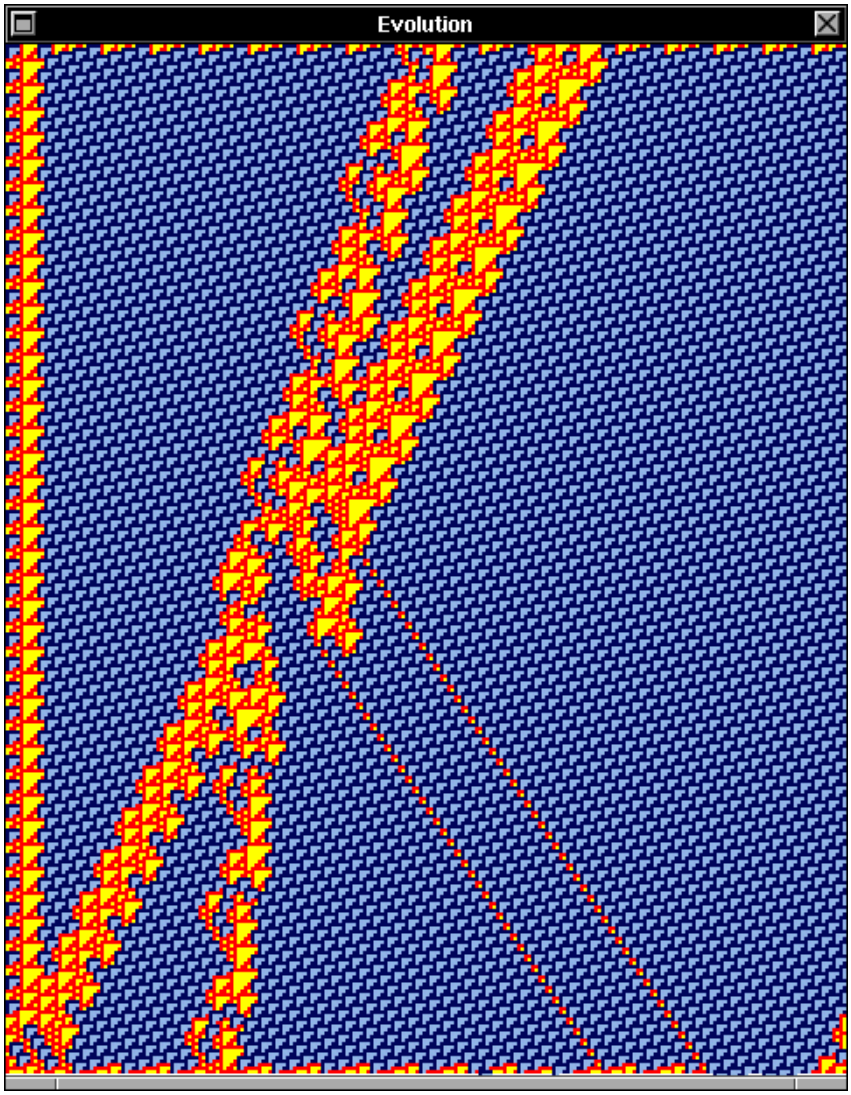

Figure 4.215: Collisions of glider Bbar8, G(p1)(C2)-e(p1)-Bbar8(p1)(C)=A,Bbar,A,F

4.5.10 Collisions of glider Bbar8 with glider H

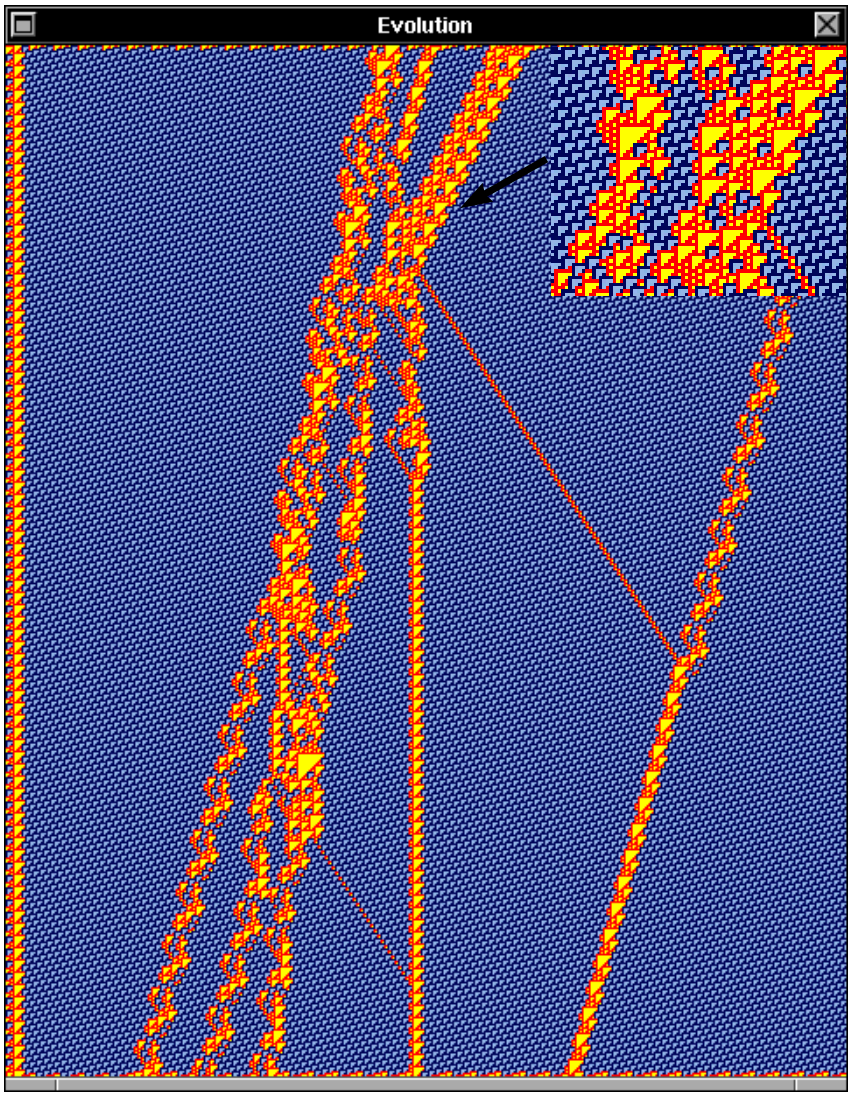

Figure 4.216: Collisions of glider Bbar8, H(p1)(A)-e(p1)-Bbar8(p1)(A)=2A,Ebar,Ebar,F,C1

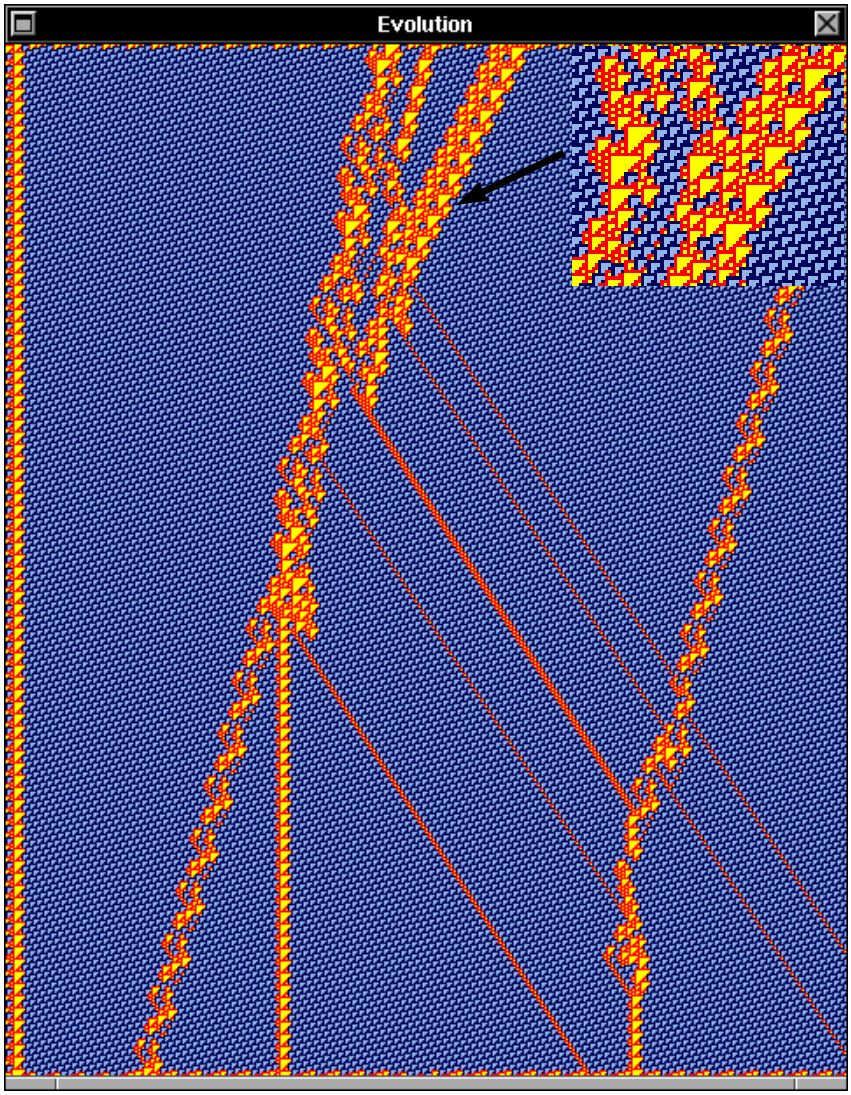

Figure 4.217: Collisions of glider Bbar8, H(p1)(A)-e(p1)-Bbar8(p1)(B)=A,A,3A,A,Ebar,C1,2A

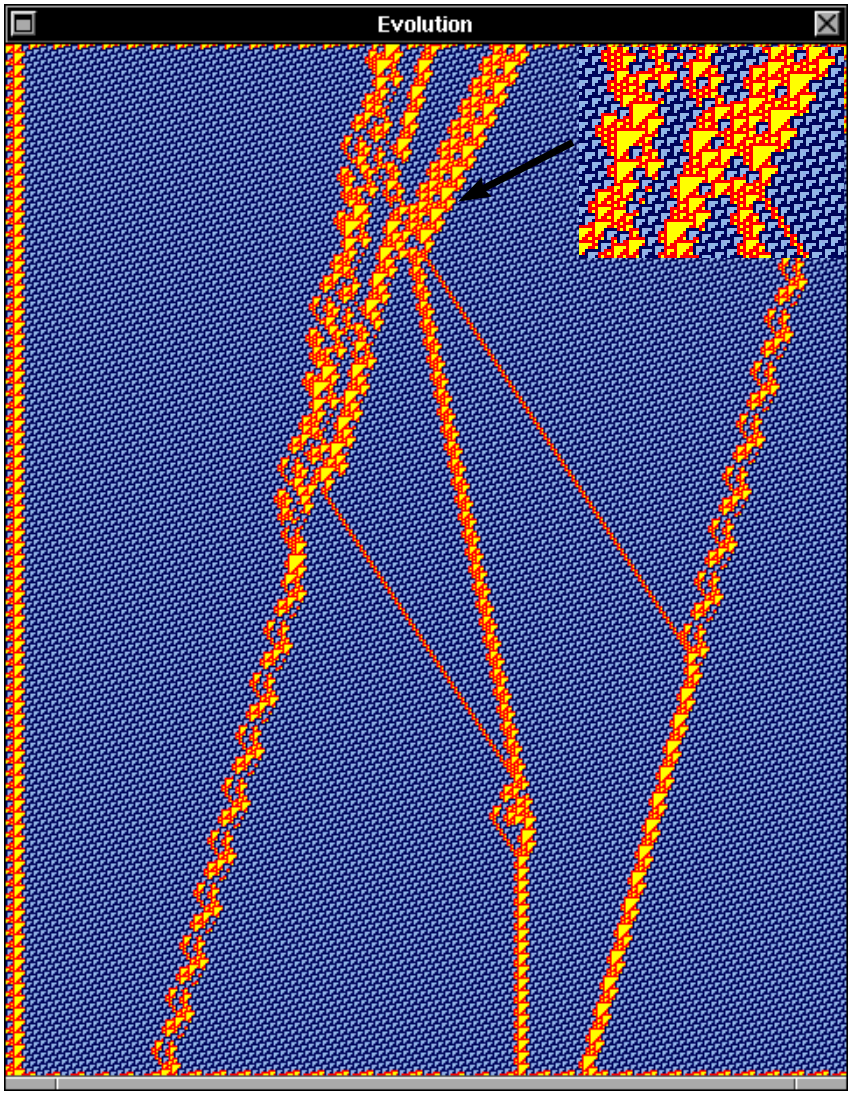

Figure 4.218: Collisions of glider Bbar8, H(p1)(A)-e(p1)-Bbar8(p1)(C)=2A,Ebar,C2

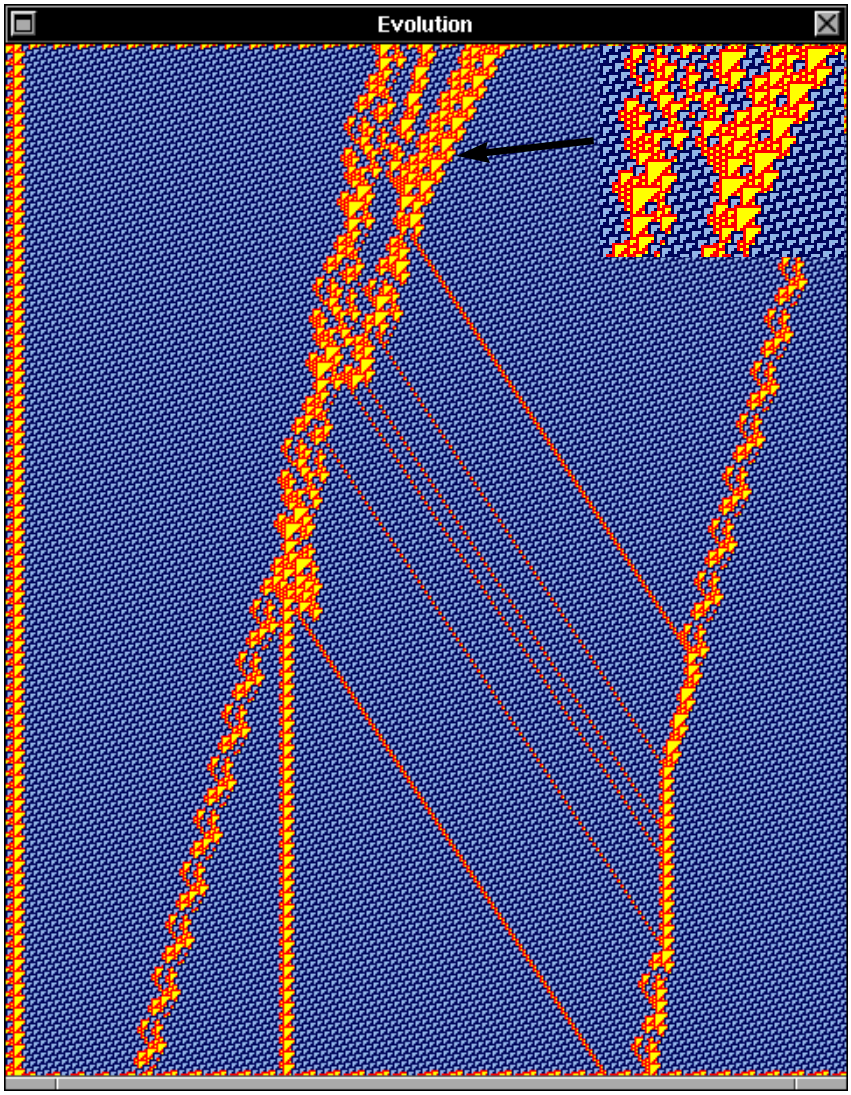

Figure 4.219: Collisions of glider Bbar8, H(p1)(D)-e(p1)-Bbar8(p1)(A)=2A,A,A,A,A,Ebar,C1,2A

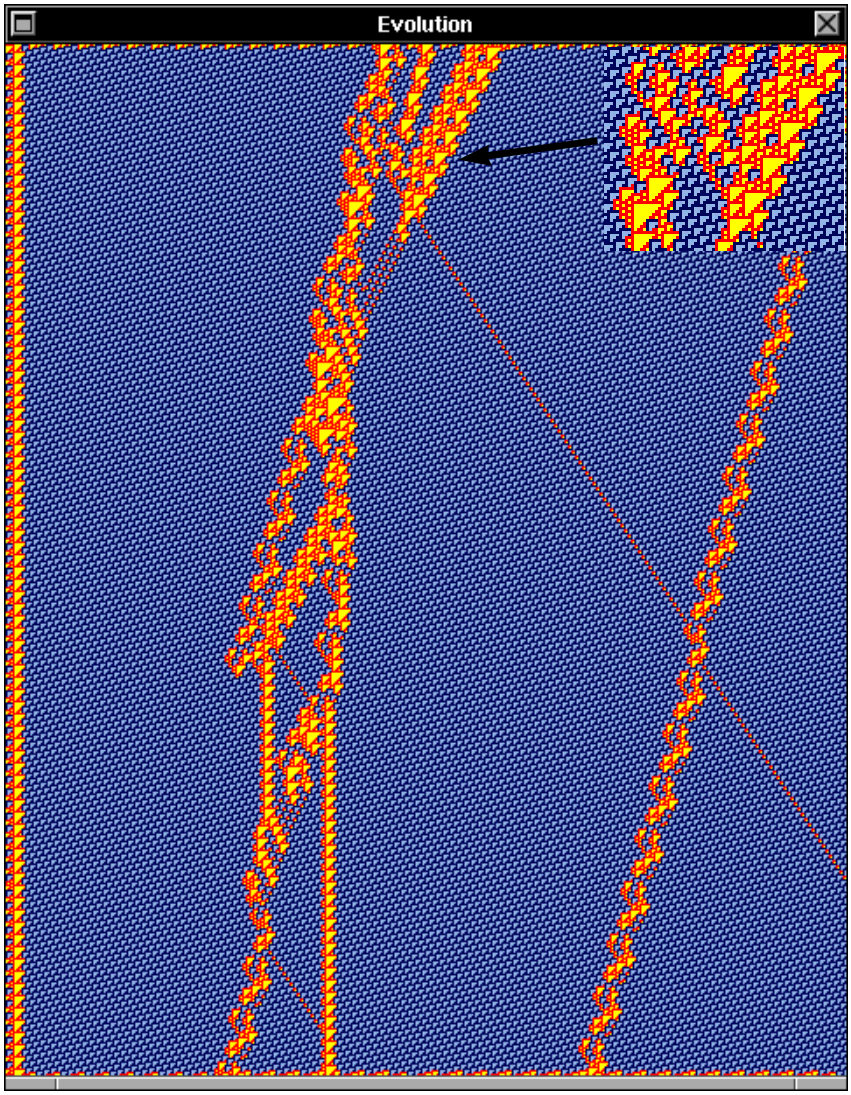

Figure 4.220: Collisions of glider Bbar8, H(p1)(D)-e(p1)-Bbar8(p1)(A)=A,Ebar,C1

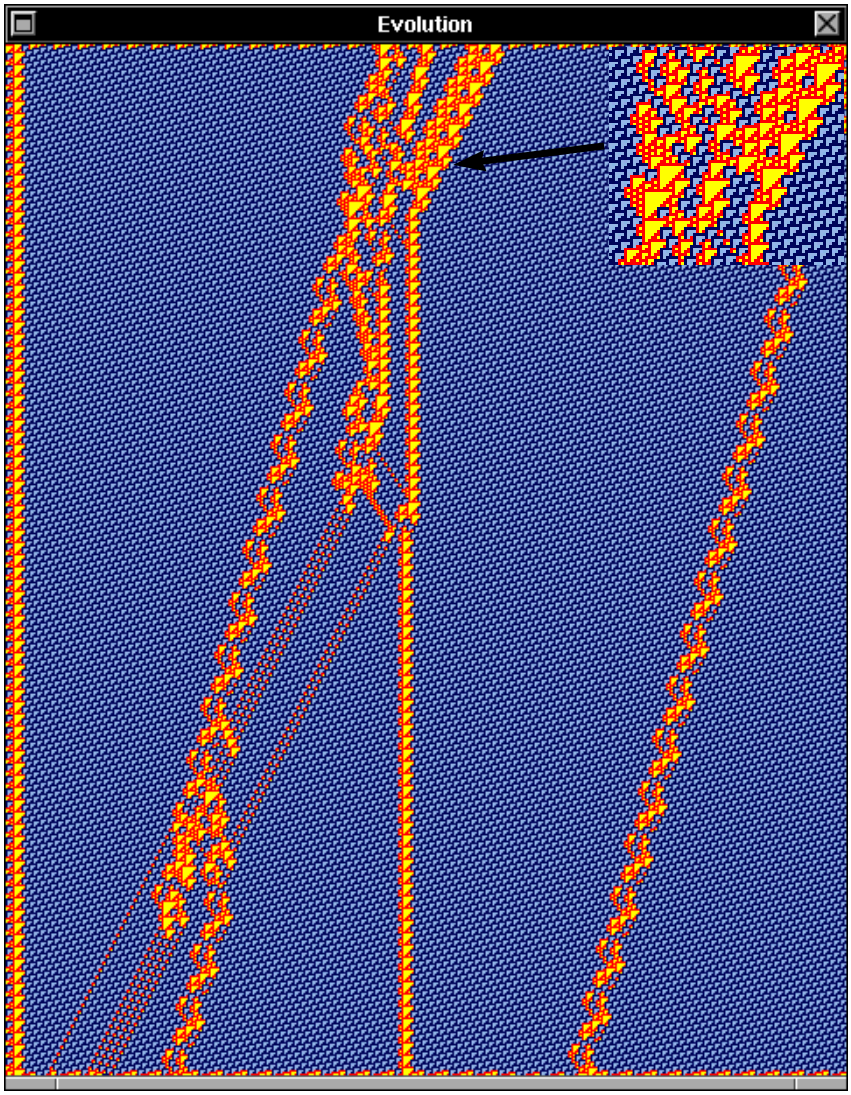

Figure 4.221: Collisions of glider Bbar8, H(p1)(D)-e(p1)-Bbar8(p1)(C)=C2,B,Ebar,4B

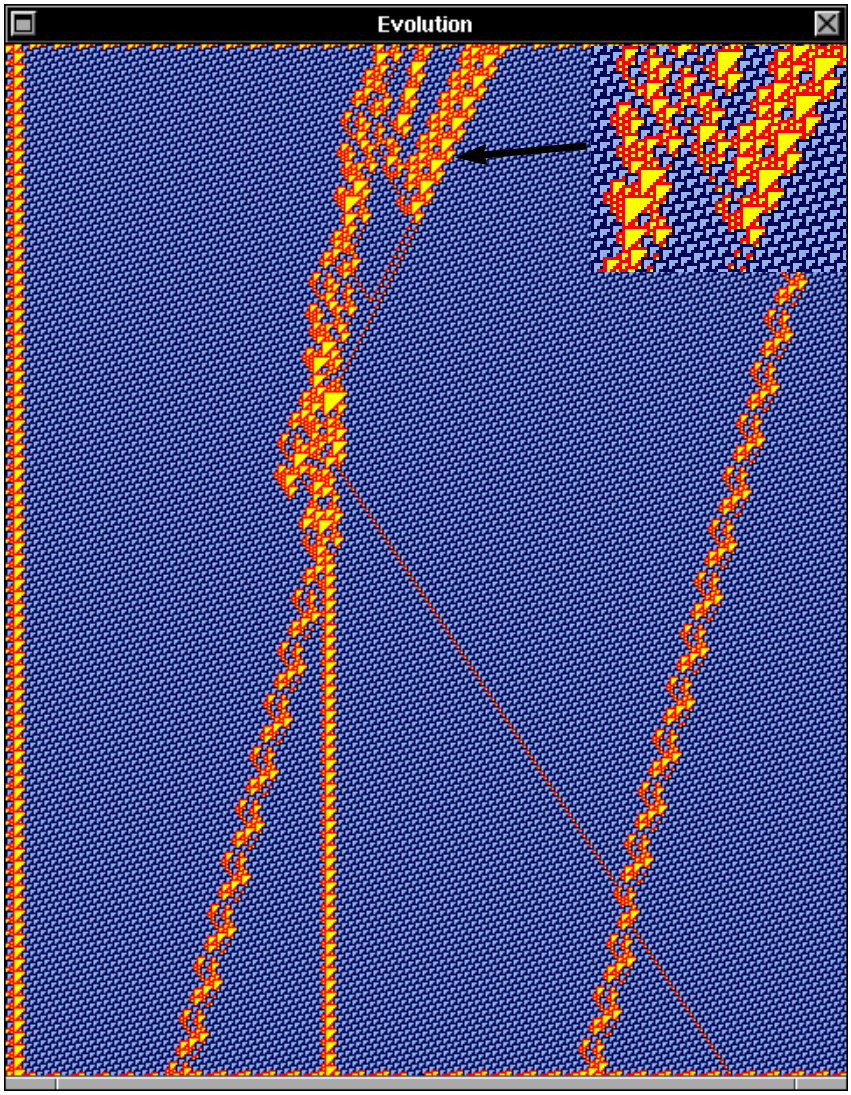

Figure 4.222: Collisions of glider Bbar8, H(p1)(E)-e(p1)-Bbar8(p1)(A)=A,Ebar,C1

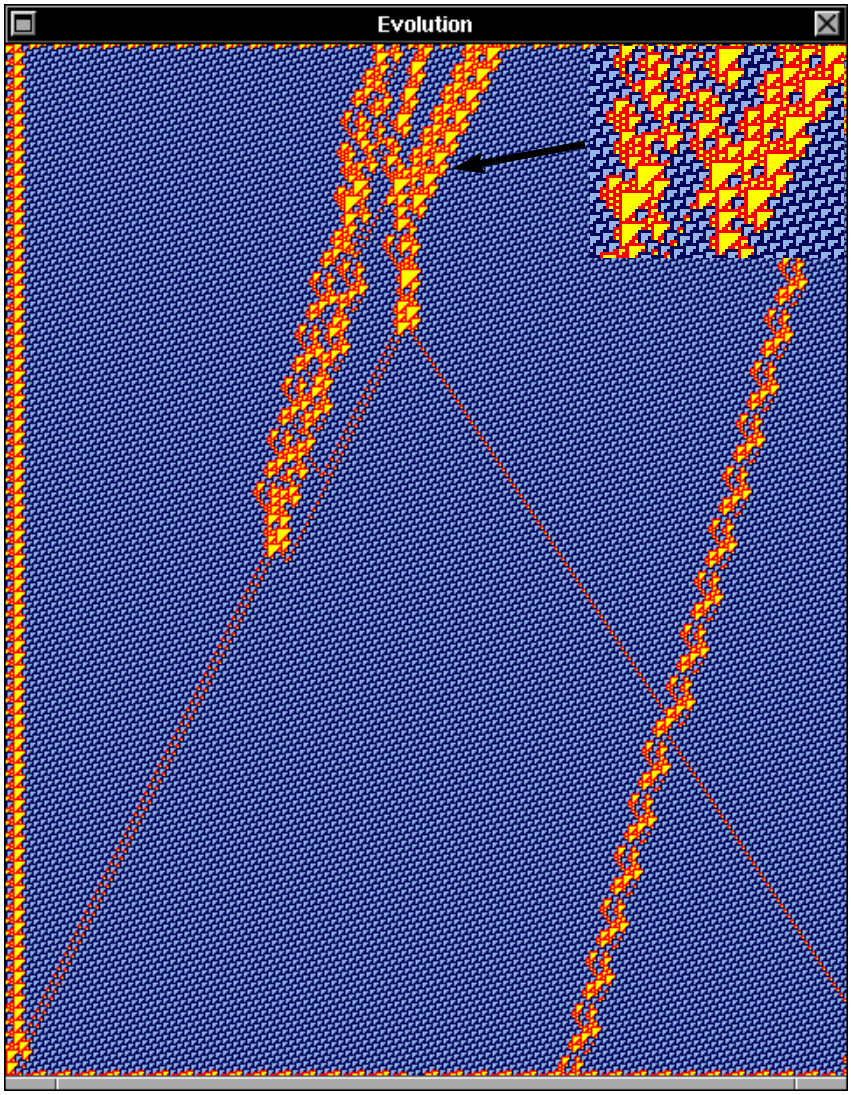

Figure 4.223: Collisions of glider Bbar8, H(p1)(E)-e(p1)-Bbar8(p1)(B)=A,2B

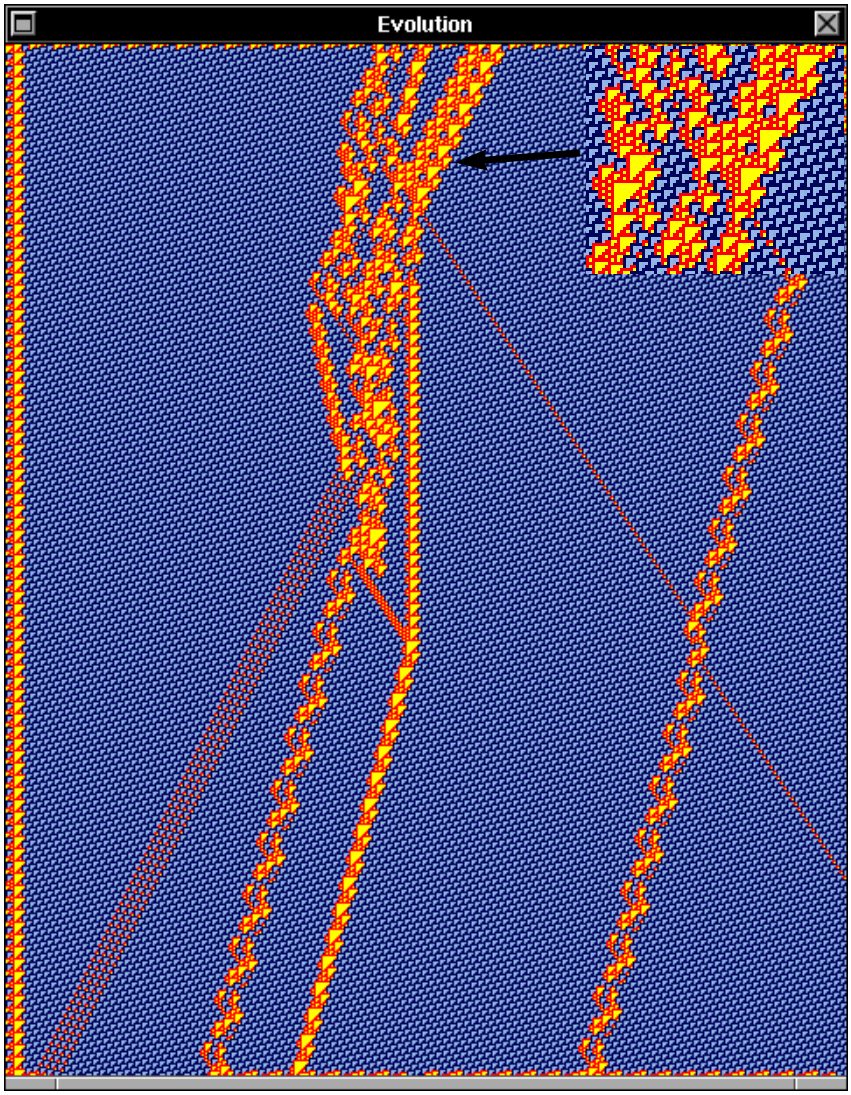

Figure 4.224: Collisions of glider Bbar8, H(p1)(E)-e(p1)-Bbar8(p1)(B)=A,4B,Ebar,E

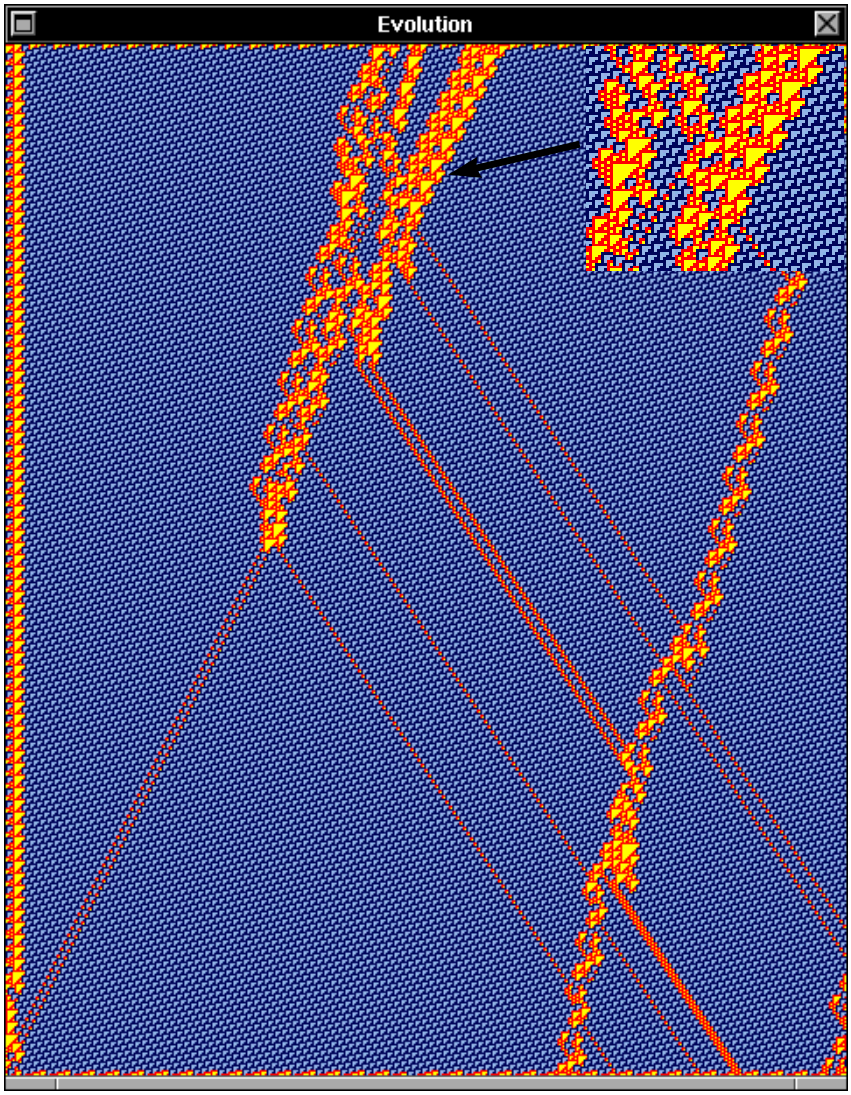

Figure 4.225: Collisions of glider Bbar8, H(p1)(F)-e(p1)-Bbar8(p1)(A)=A,A,2A,2A,A,2B,A

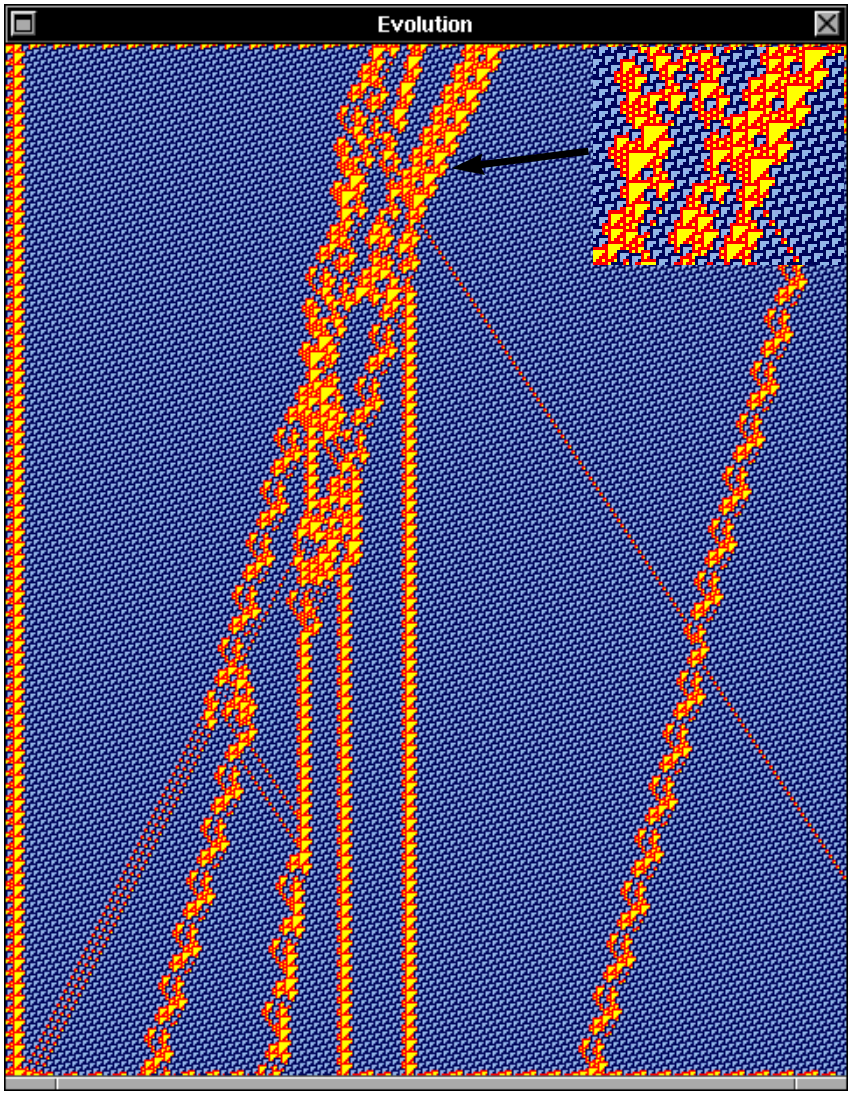

Figure 4.226: Collisions of glider Bbar8, H(p1)(F)-e(p1)-Bbar8(p1)(B)=A,C1,C2,3B,Ebar,F

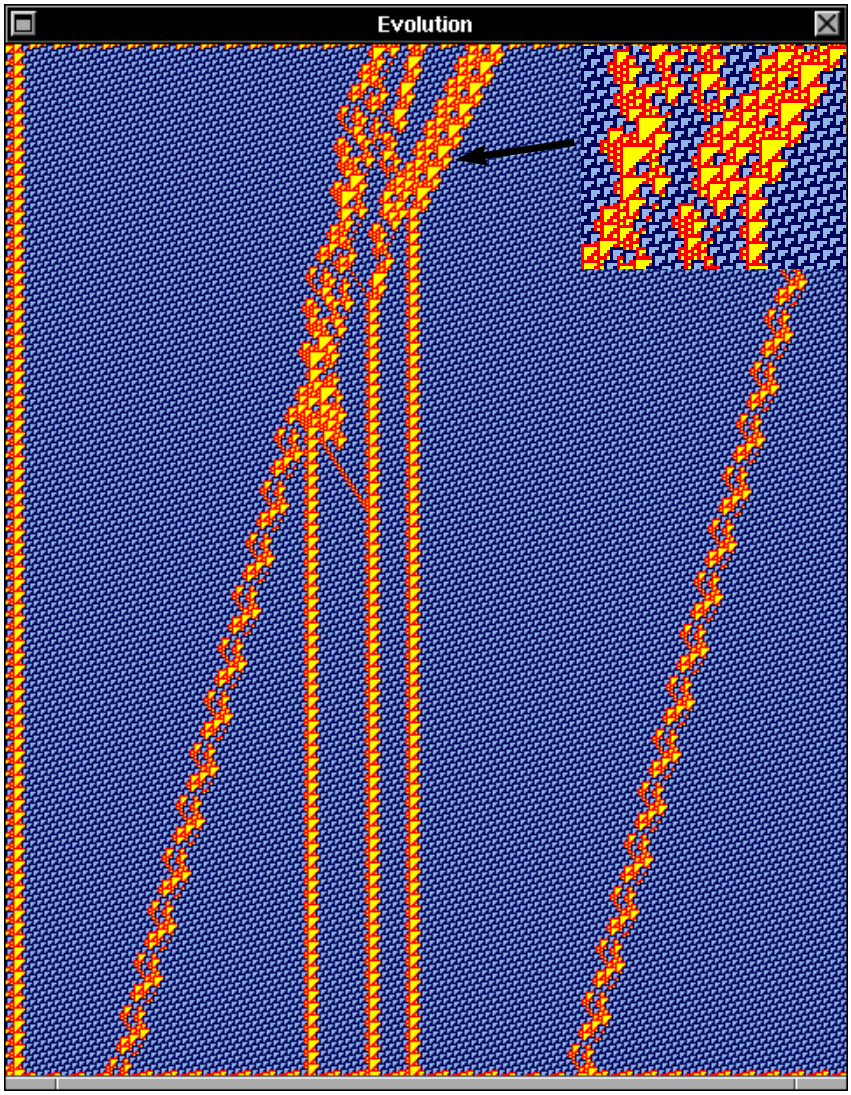

Figure 4.227: Collisions of glider Bbar8, H(p1)(F)-e(p1)-Bbar8(p1)(C)=C3,Ebar,C1,C1

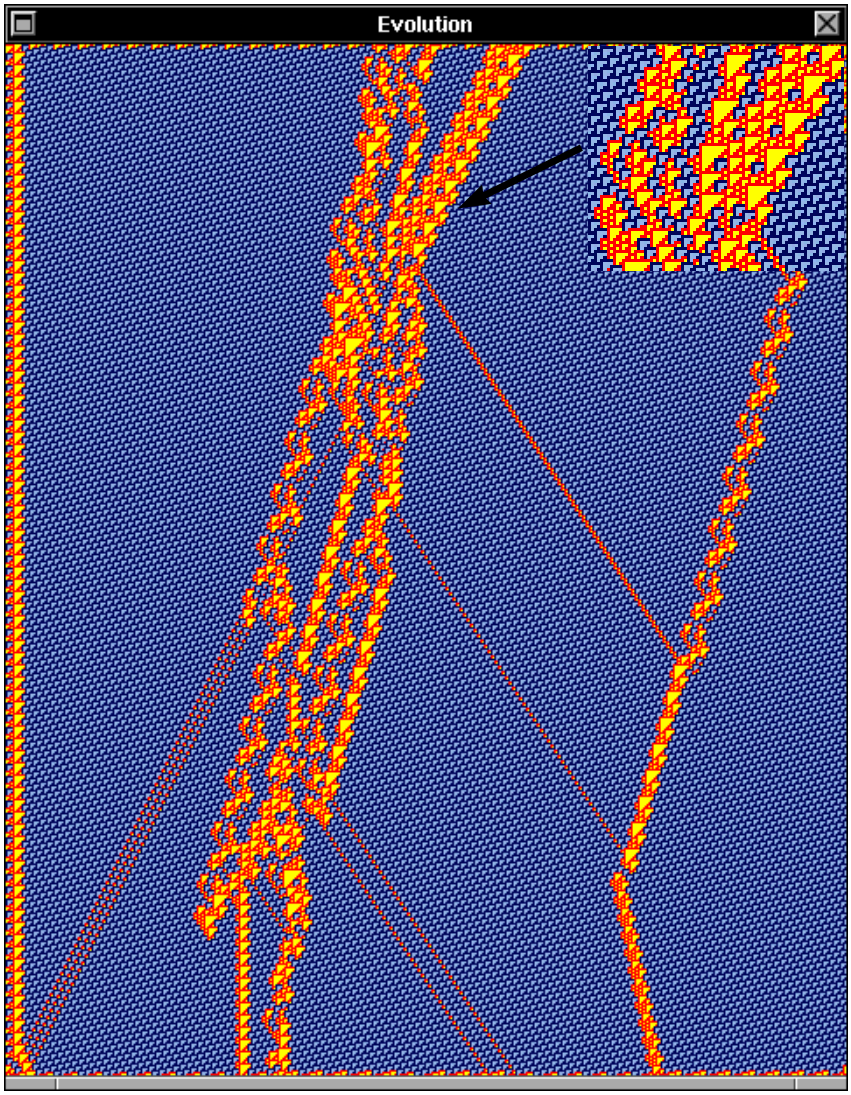

Figure 4.228: Collisions of glider Bbar8, H(p1)(E2)-e(p1)-Bbar8(p1)(A)=2A,A,3B,A,A,F,C1

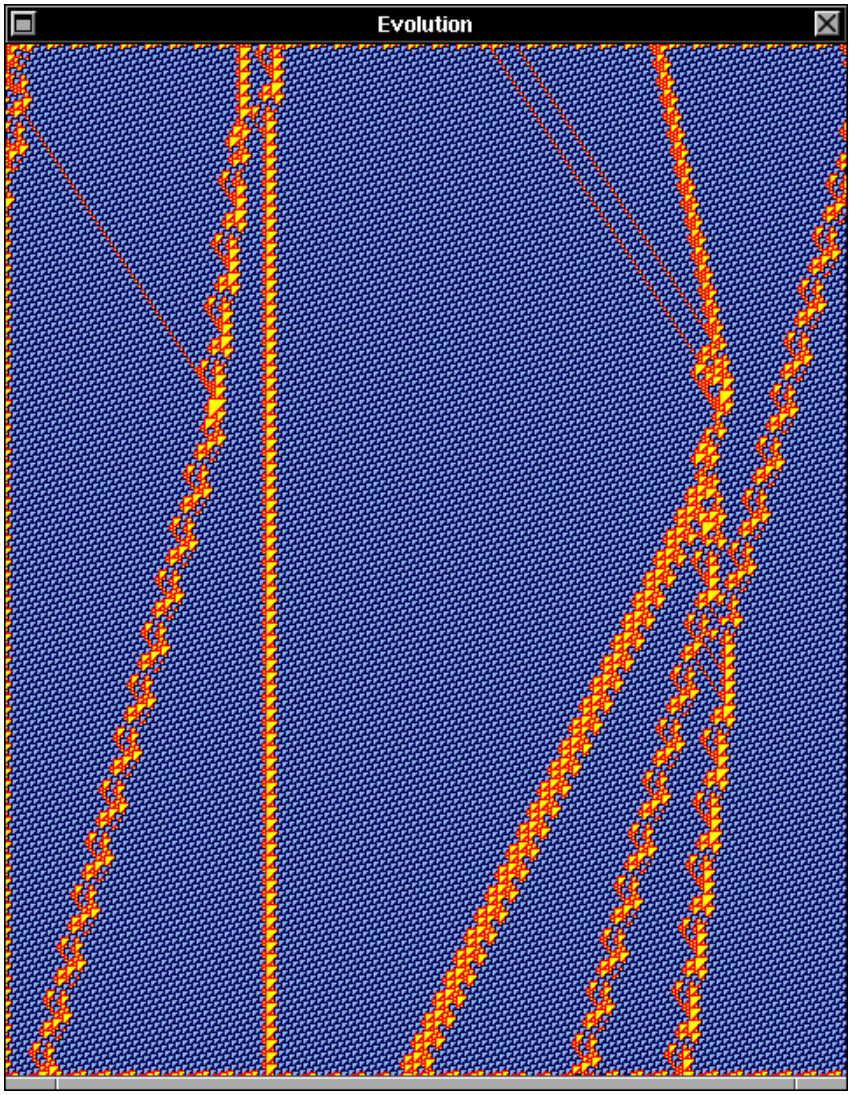

Figure 4.229: continue collision, H(p1)(E2)-e(p1)-Bbar8(p1)(A)

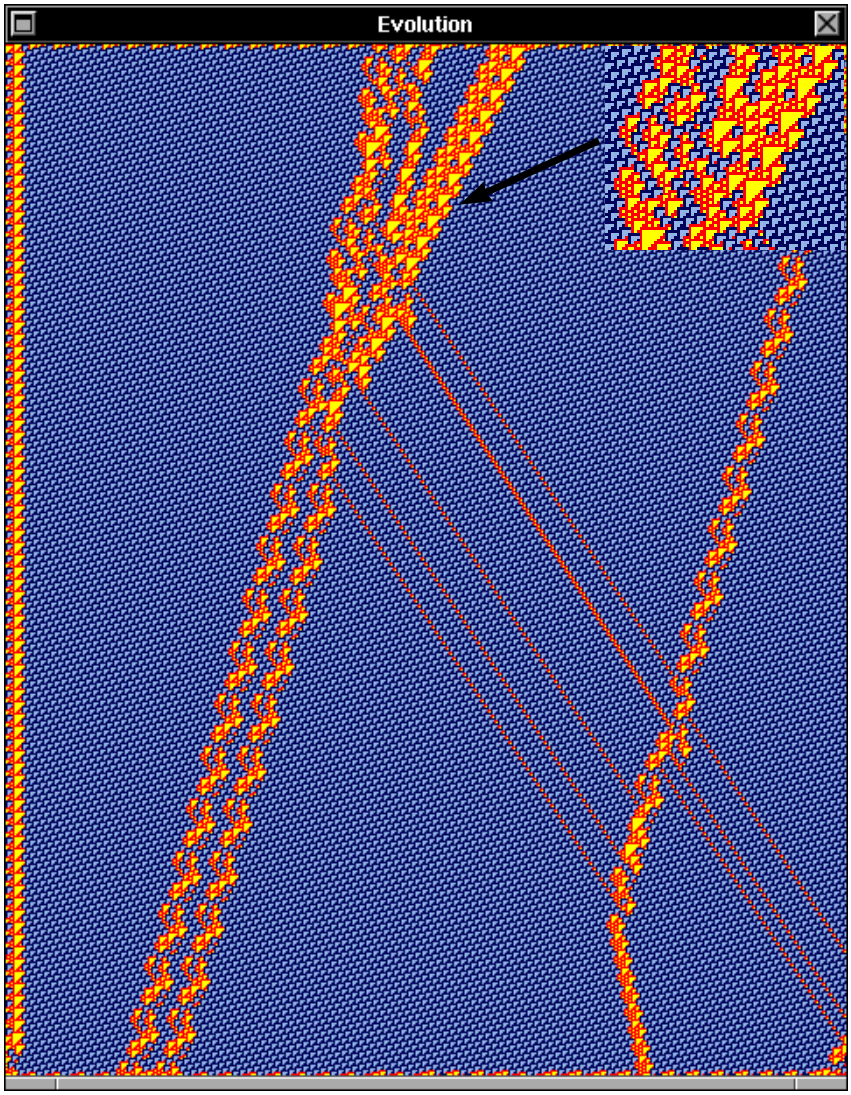

Figure 4.230: Collisions of glider Bbar8, H(p1)(E2)-e(p1)-Bbar8(p1)(B)=A,2A,A,A,A,Ebar,Ebar

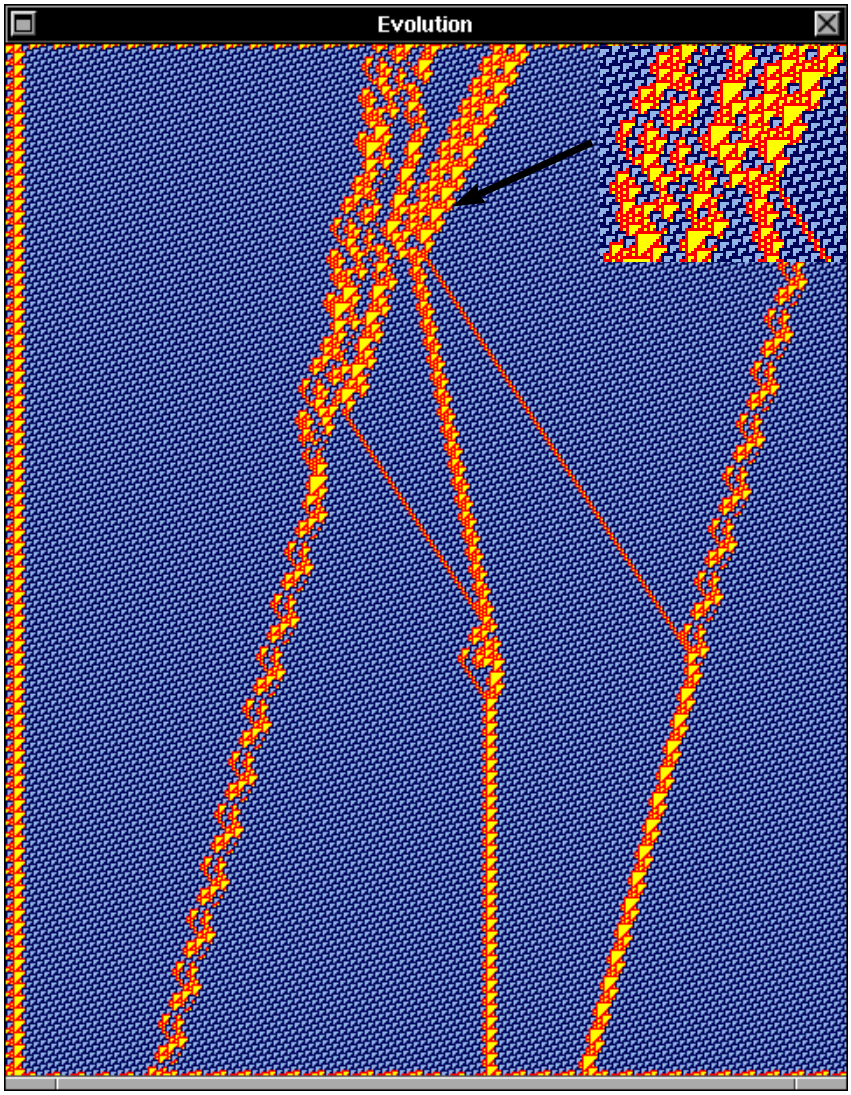

Figure 4.231: Collisions of glider Bbar8, H(p1)(E2)-e(p1)-Bbar8(p1)(C)=2A,Ebar,C2

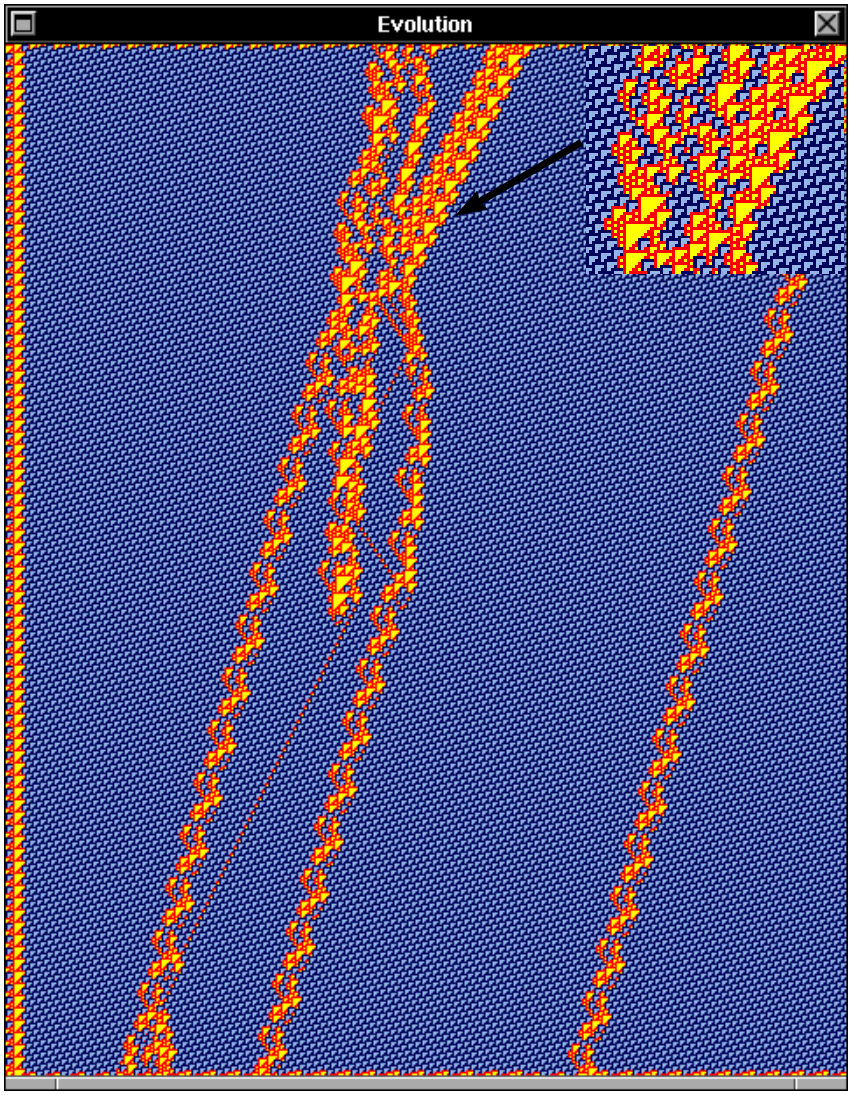

Figure 4.232: Collisions of glider Bbar8, H(p1)(A3)-e(p1)-Bbar8(p1)(A)=3B,Ebar,E

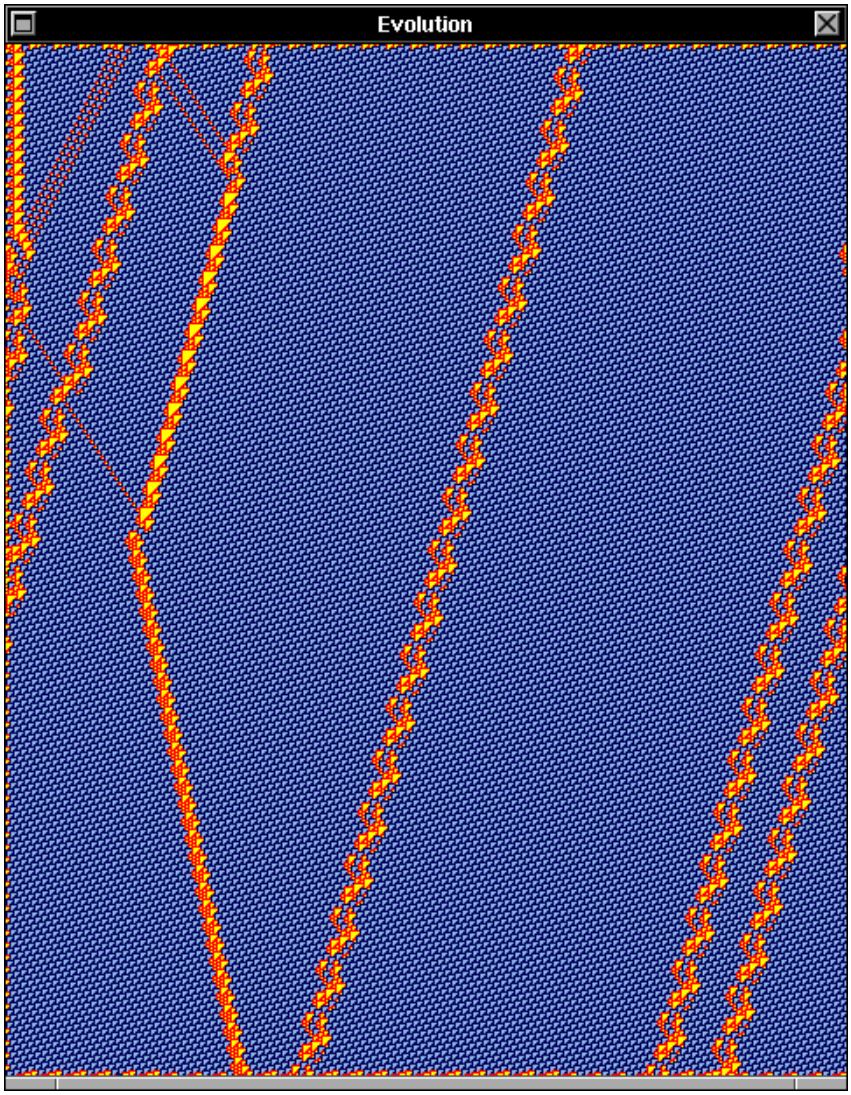

Figure 4.233: continue collision, H(p1)(A3)-e(p1)-Bbar8(p1)(A)

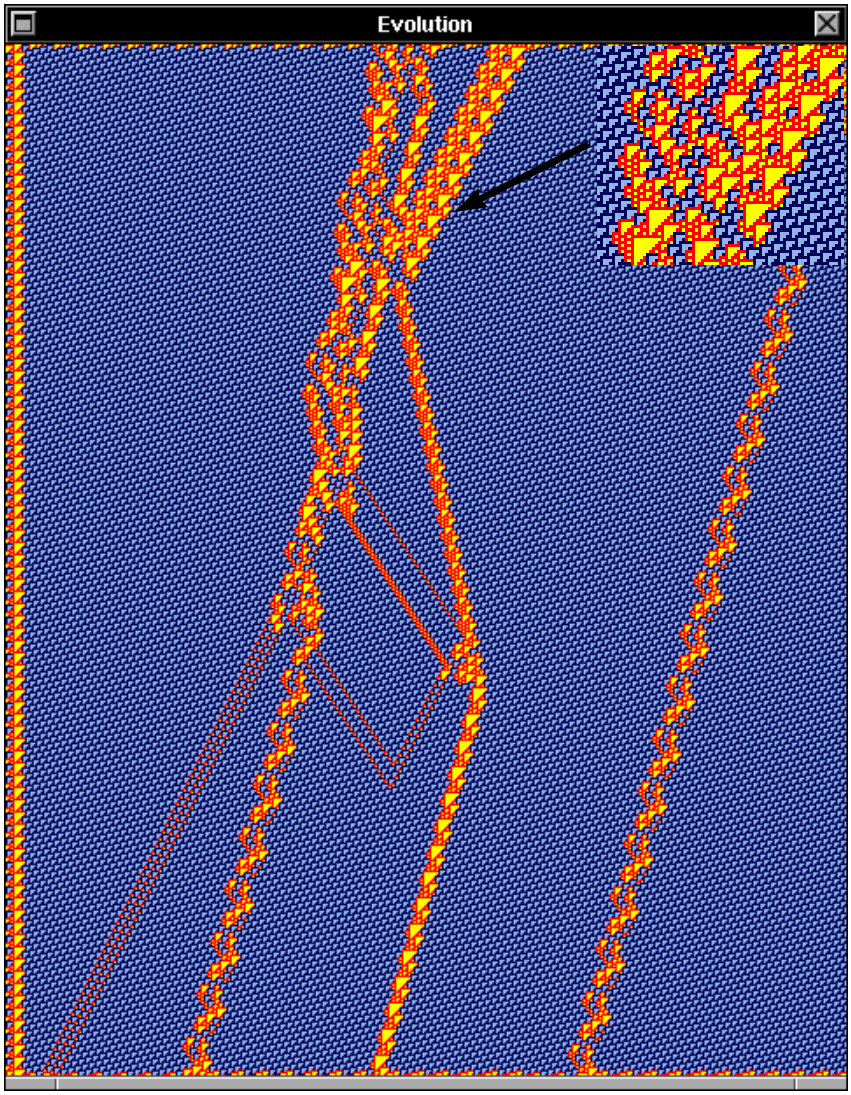

Figure 4.234: Collisions of glider Bbar8, H(p1)(A3)-e(p1)-Bbar8(p1)(B)=3B,Ebar,E

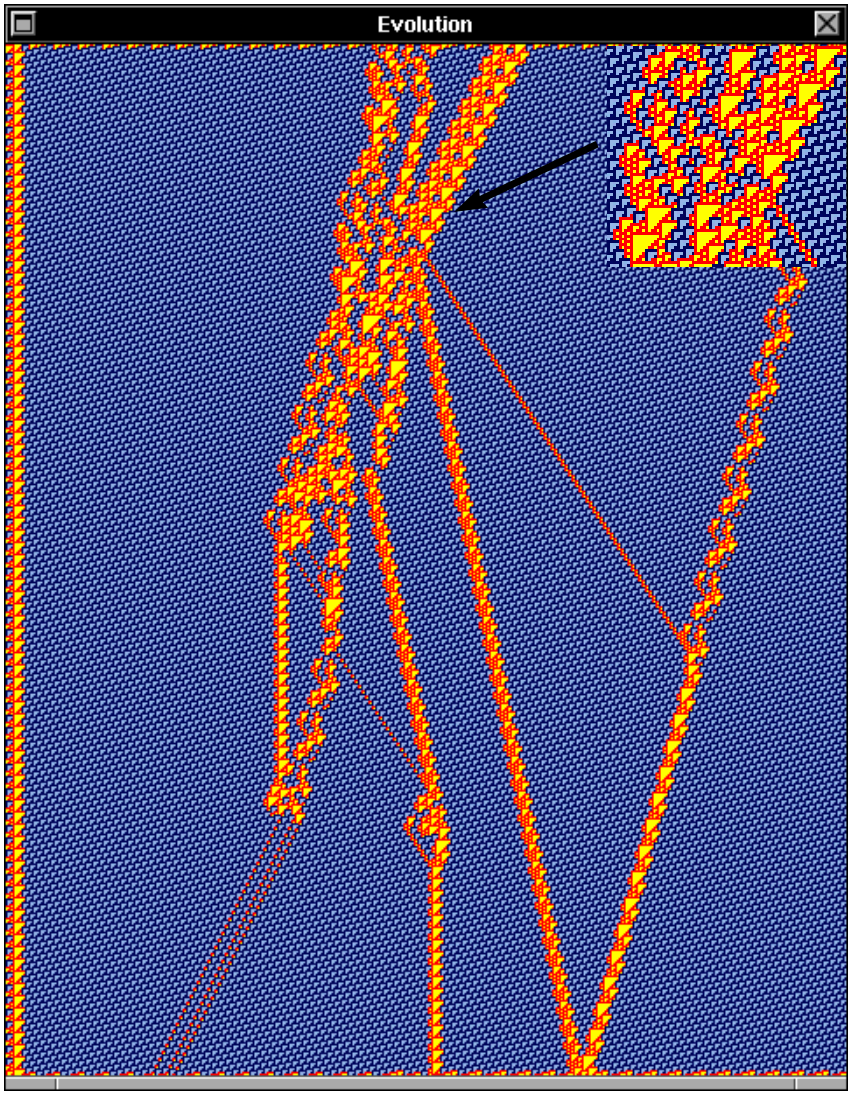

Figure 4.235: Collisions of glider Bbar8, H(p1)(A3)-e(p1)-Bbar8(p1)(C)=2A,D1,B,2B,C2

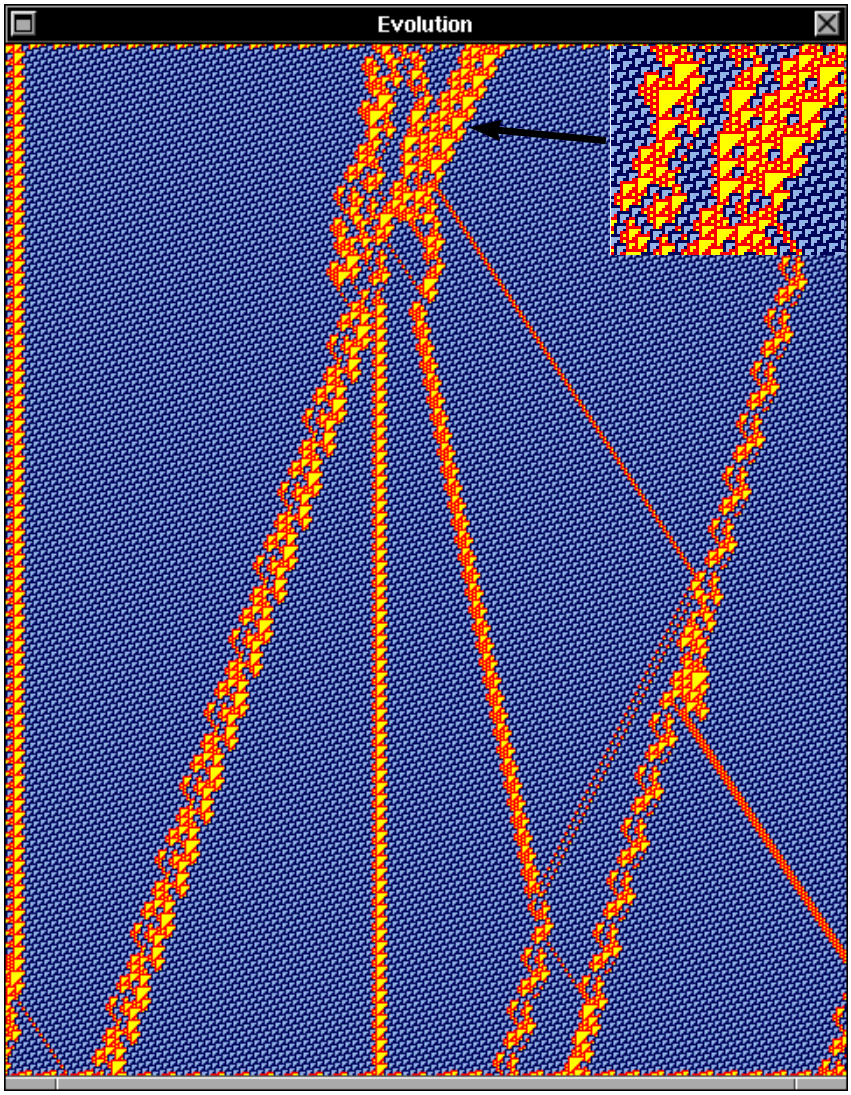

Figure 4.236: Collisions of glider Bbar8, H(p1)(B3)-e(p1)-Bbar8(p1)(A)=3A,G,C2,D1

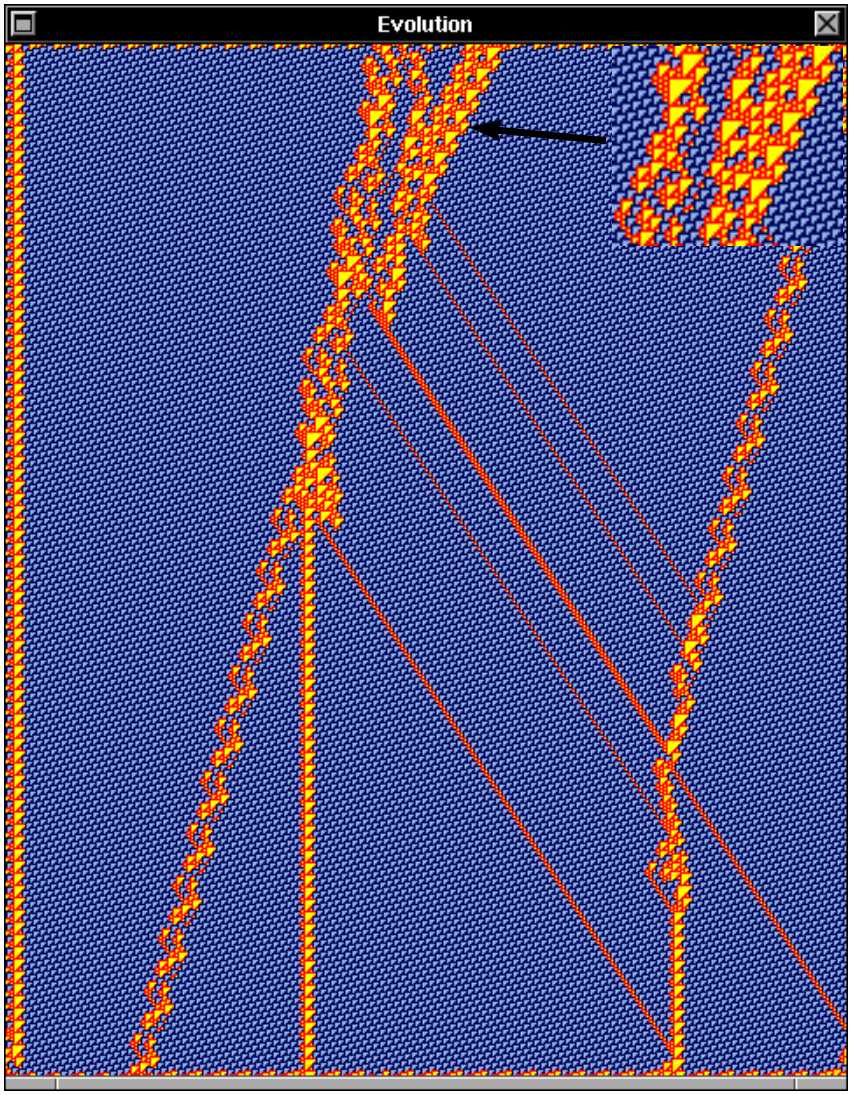

Figure 4.237: Collisions of glider Bbar8, H(p1)(B3)-e(p1)-Bbar8(p1)(B)=A,A,3A,A,Ebar,C1,2A

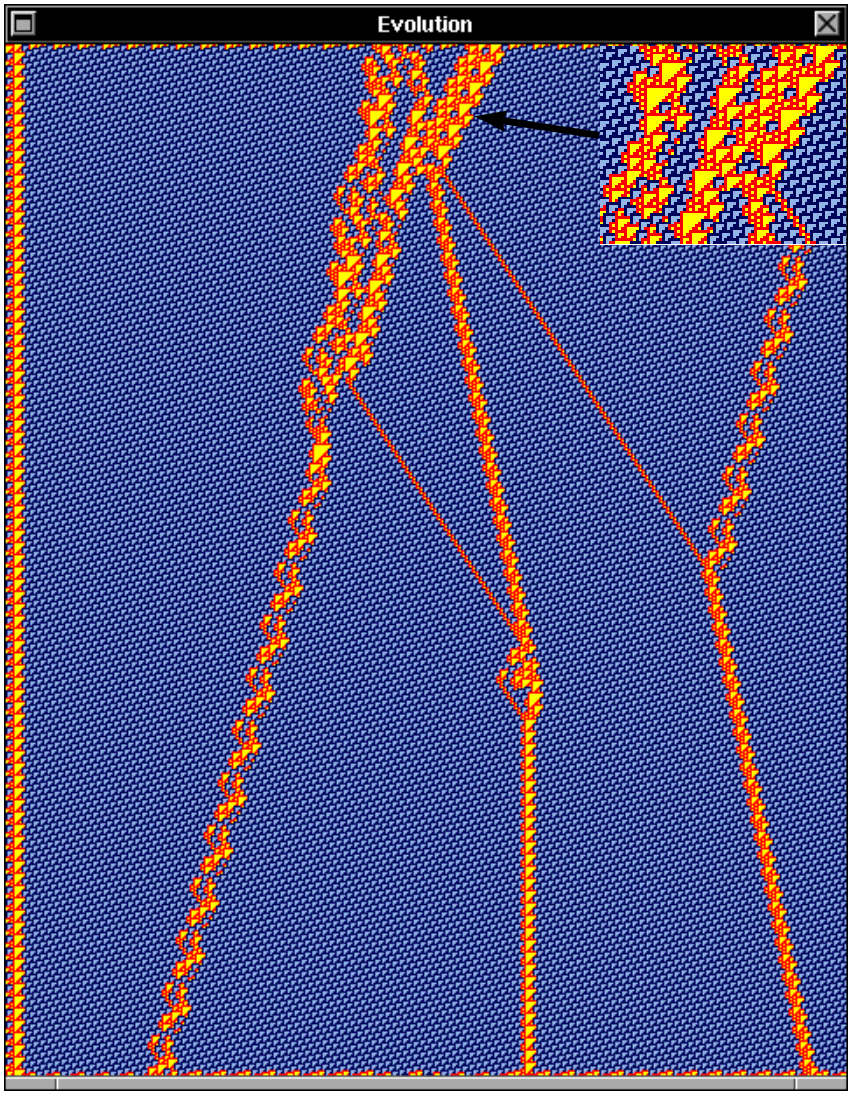

Figure 4.238: Collisions of glider Bbar8, H(p1)(B3)-e(p1)-Bbar8(p1)(C)=3A,Ebar,C2

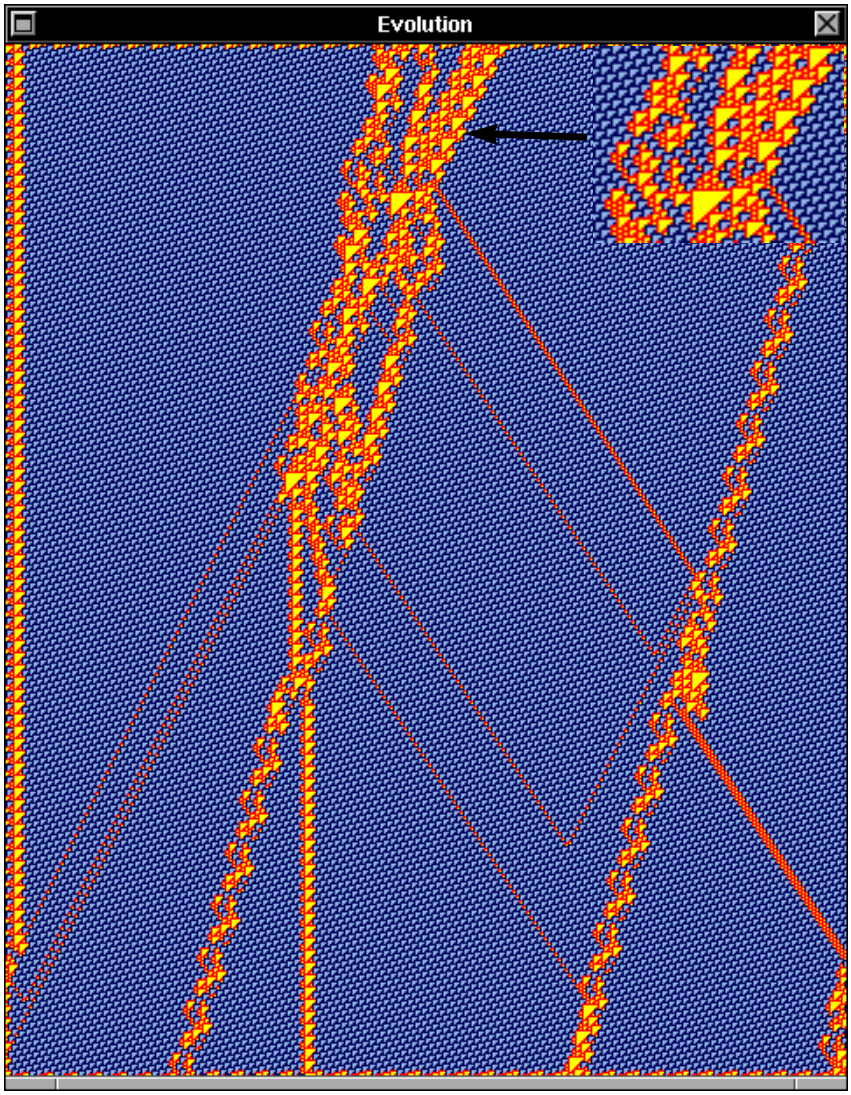

Figure 4.239: Collisions of glider Bbar8, H(p1)(F3)-e(p1)-Bbar8(p1)(A)=2A,A,B,2B,A,Ebar,C2

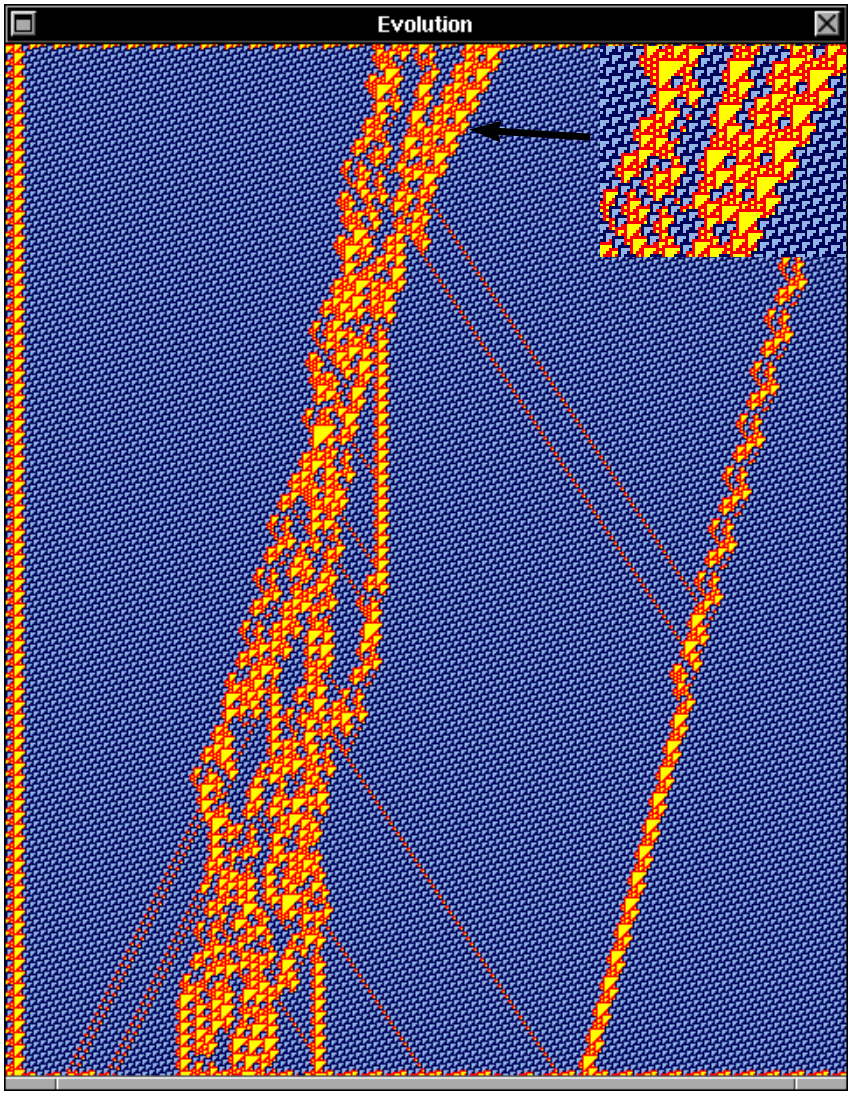

Figure 4.240: Collisions of glider Bbar8, H(p1)(F3)-e(p1)-Bbar8(p1)(B)=A,A,A,2B,2B,A,E4,Ebar

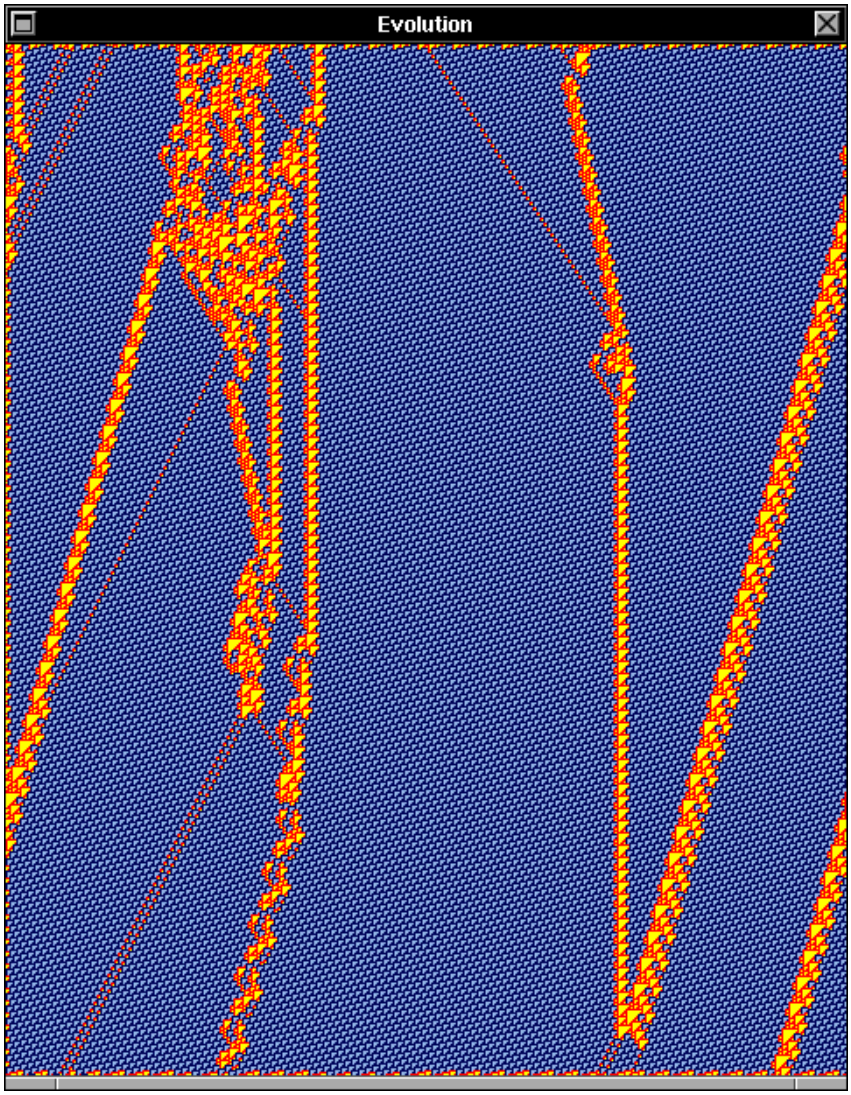

Figure 4.241: continue collision, H(p1)(F3)-e(p1)-Bbar8(p1)(B)

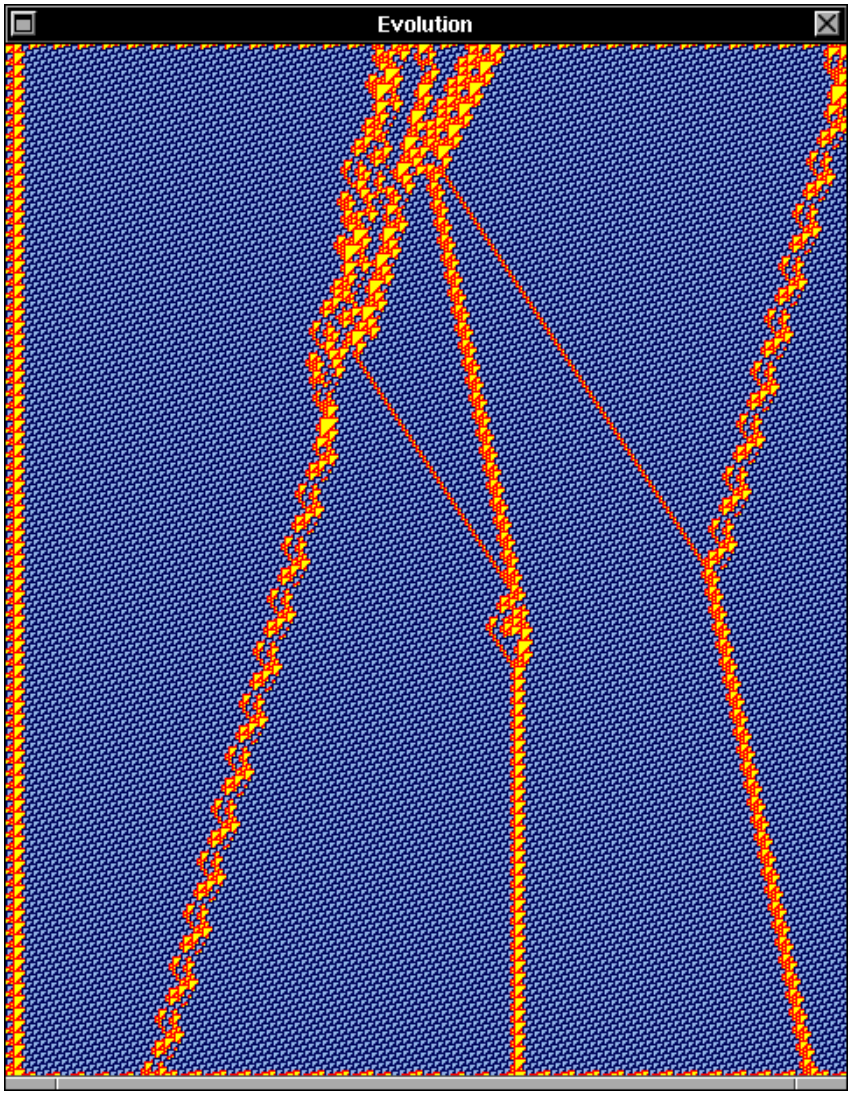

Figure 4.242: Collisions of glider Bbar8, H(p1)(F3)-e(p1)-Bbar8(p1)(C)=2A,Ebar,C2

4.6 Collisions of glider C1

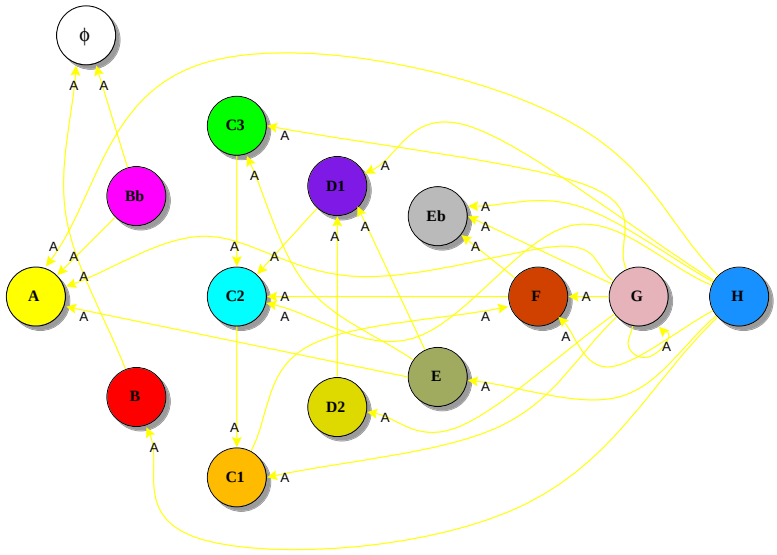

Figure 4.243: Collisions of glider C1

	ϕ	A	B	$Bbar$	$C3$	$C2$	$C1$	$D2$	$D1$	E	$Ebar$	F	G	H
ϕ	.	.	.	.	.	.	.	.	.	.	.	.	.	.
A	.	.	.	.	.	.	.	.	.	.	.	.	.	.
B	.	.	.	.	.	.	.	.	.	.	.	.	.	.
$Bbar$	.	.	.	.	.	.	.	.	.	.	.	.	.	.
$C3$	.	.	.	.	.	.	.	.	.	.	.	.	.	.
$C2$	.	.	.	.	.	.	.	.	.	.	.	.	.	.
$C1$	.	.	.	.	.	.	.	.	.	.	.	.	.	.
$D2$	.	.	.	.	.	.	.	.	.	.	.	.	.	.
$D1$	.	.	.	.	.	.	.	.	.	.	.	.	.	.
E	.	.	.	.	.	.	.	.	.	.	.	.	.	.
$Ebar$	.	.	.	.	.	.	.	.	.	.	.	.	.	.
F	.	.	.	.	.	.	.	.	.	.	.	.	.	.
G	.	.	.	.	.	.	.	.	.	.	.	.	.	.
H	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Table 4.5: Matrix connection of collisions glider C1

4.6.1 Collisions of glider C1 with glider D1

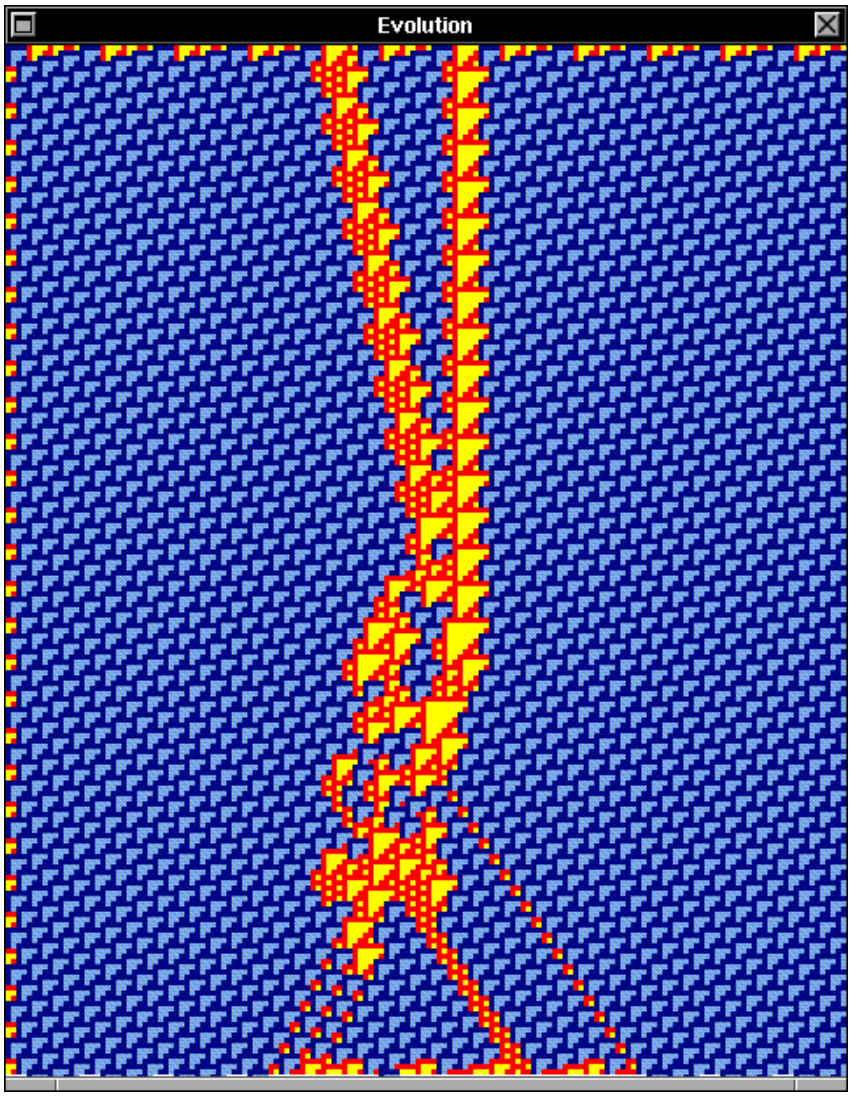

Figure 4.244: Collisions of glider C1, D1(p1)(A)-e(p1)-C1(p1)(A)=A,3A,3B

4.6.2 Collisions of glider C1 with glider D2

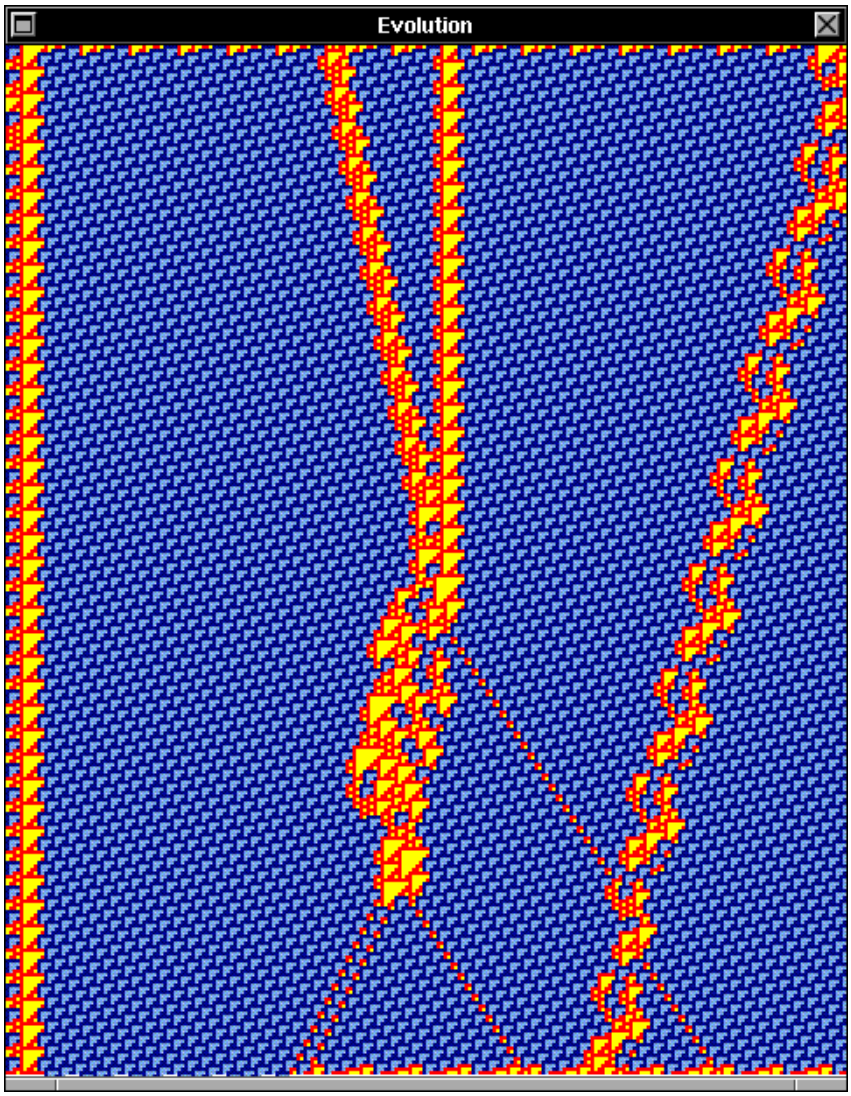

Figure 4.245: Collisions of glider C1, D2(p1)(A)-e(p1)-C1(p1)(A)=A,2B,A

4.6.3 Collisions of glider C1 with glider E

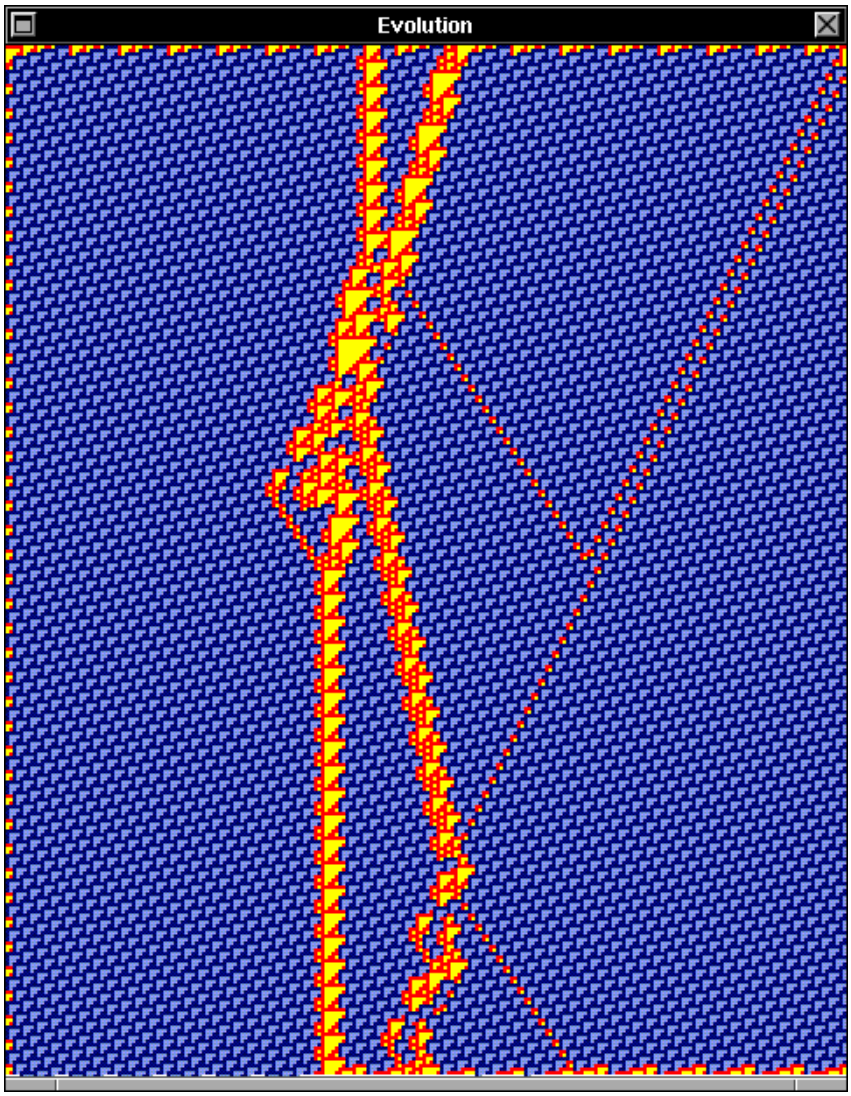

Figure 4.246: Collisions of glider C1, C1(p1)(A)-e(p1)-E(p1)(A)=A,D2,C2

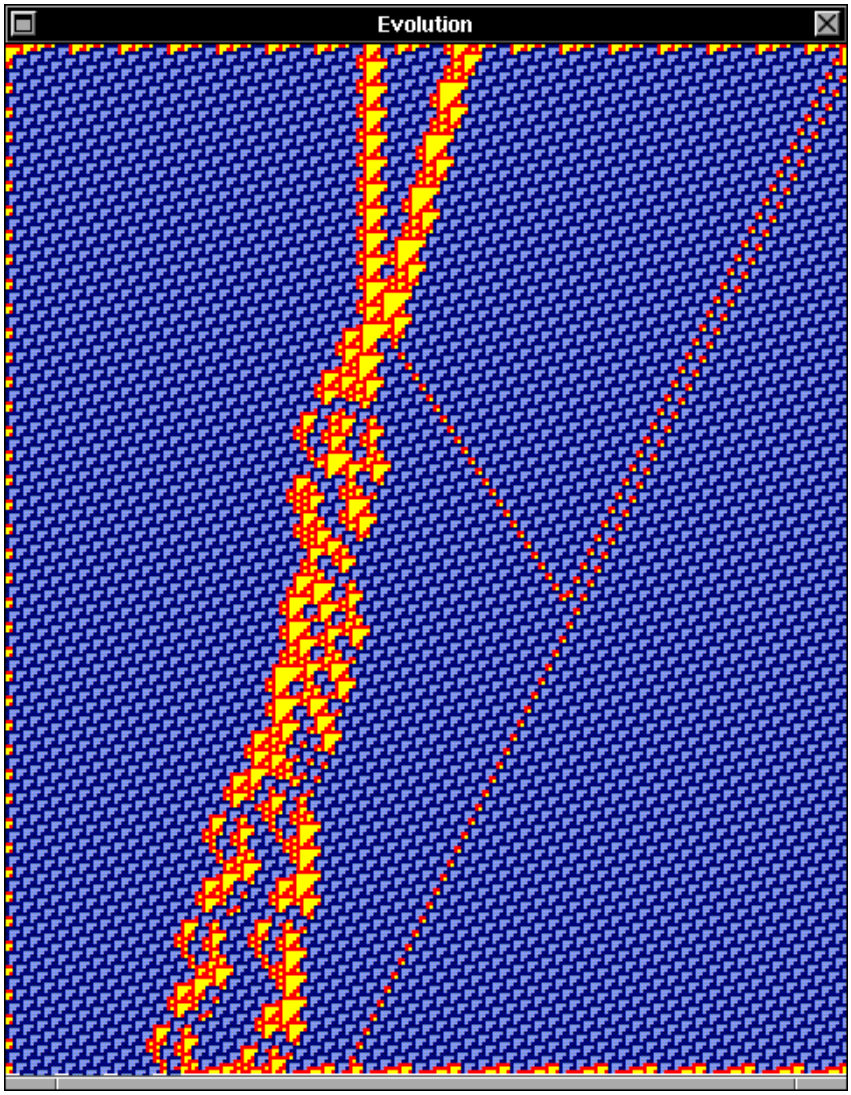

Figure 4.247: Collisions of glider C1, C1(p1)(A)-e(p1)-E(p1)(B)=A,Ebar,F

4.6.4 Collisions of glider C1 with glider Ebar

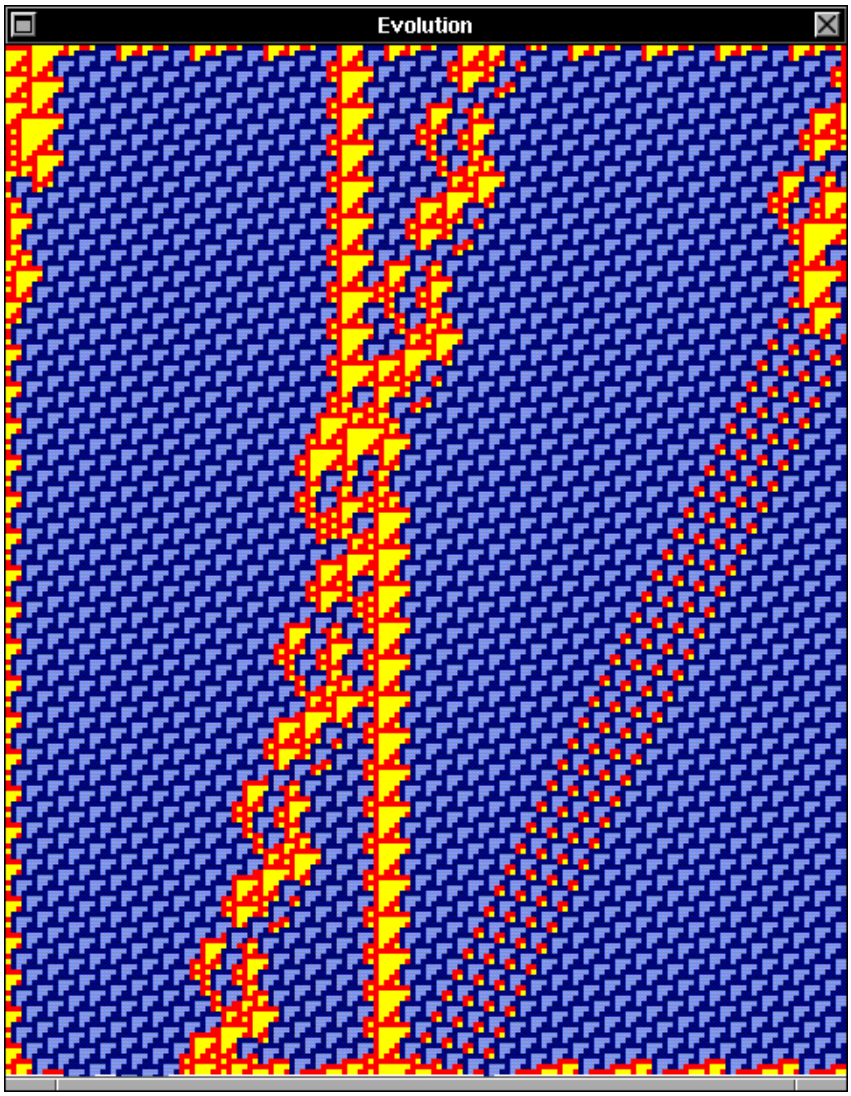

Figure 4.248: Collisions of glider C1, C1(p1)(A)-e(p1)-Ebar(p1)(A)=Ebar,C1; across

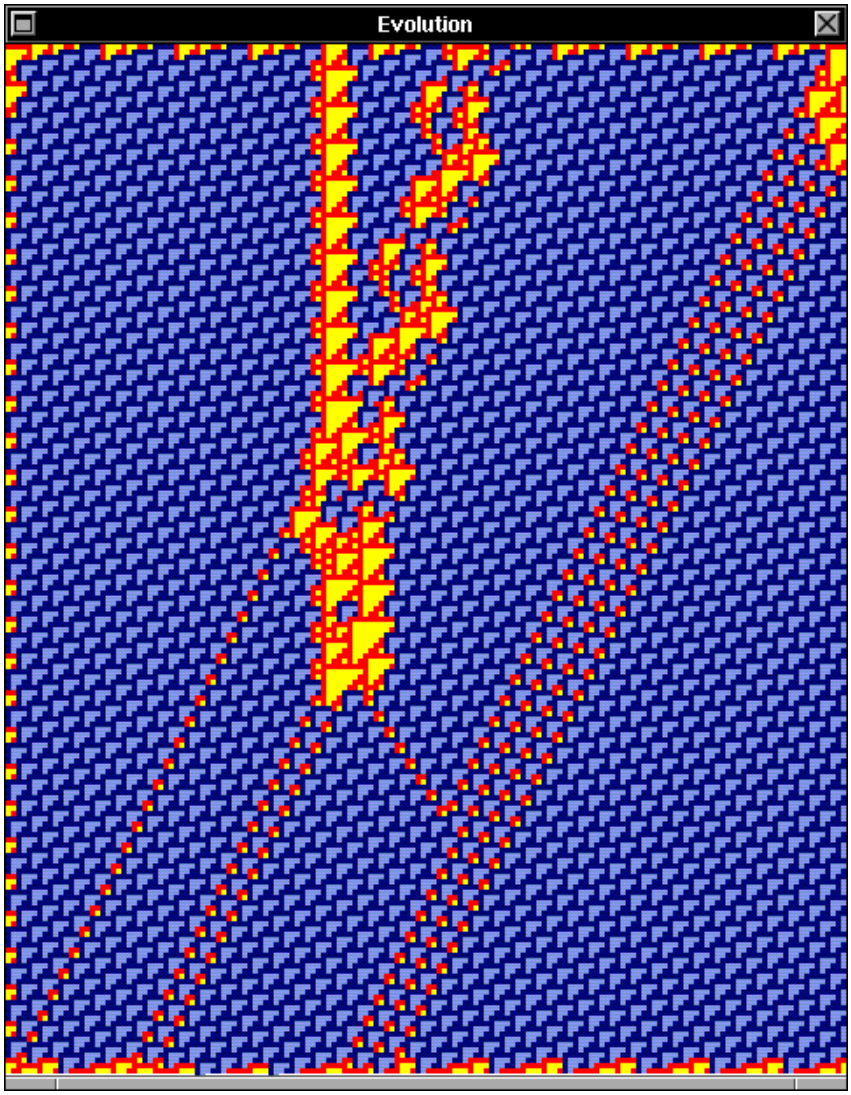

Figure 4.249: Collisions of glider C1, C1(p1)(A)-e(p1)-Ebar(p1)(B)=B,2B,A

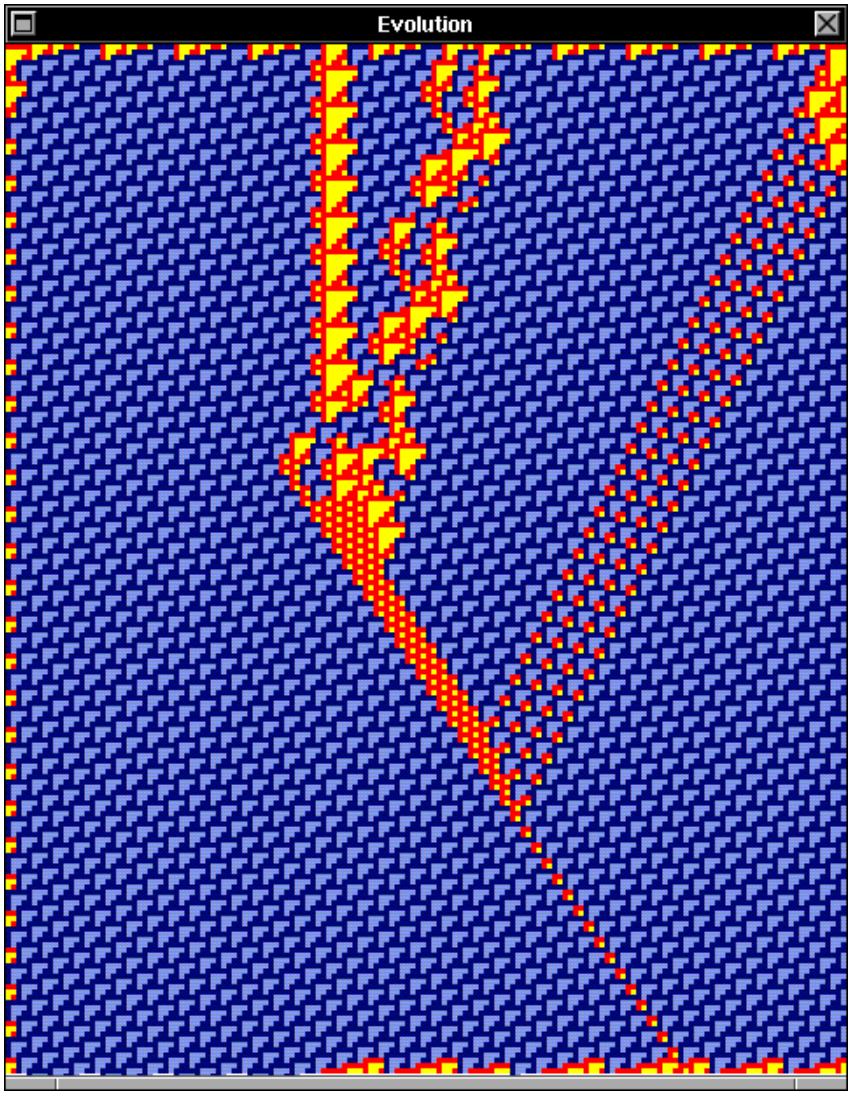

Figure 4.250: Collisions of glider C1, C1(p1)(A)-e(p1)-Ebar(p1)(C)=5A

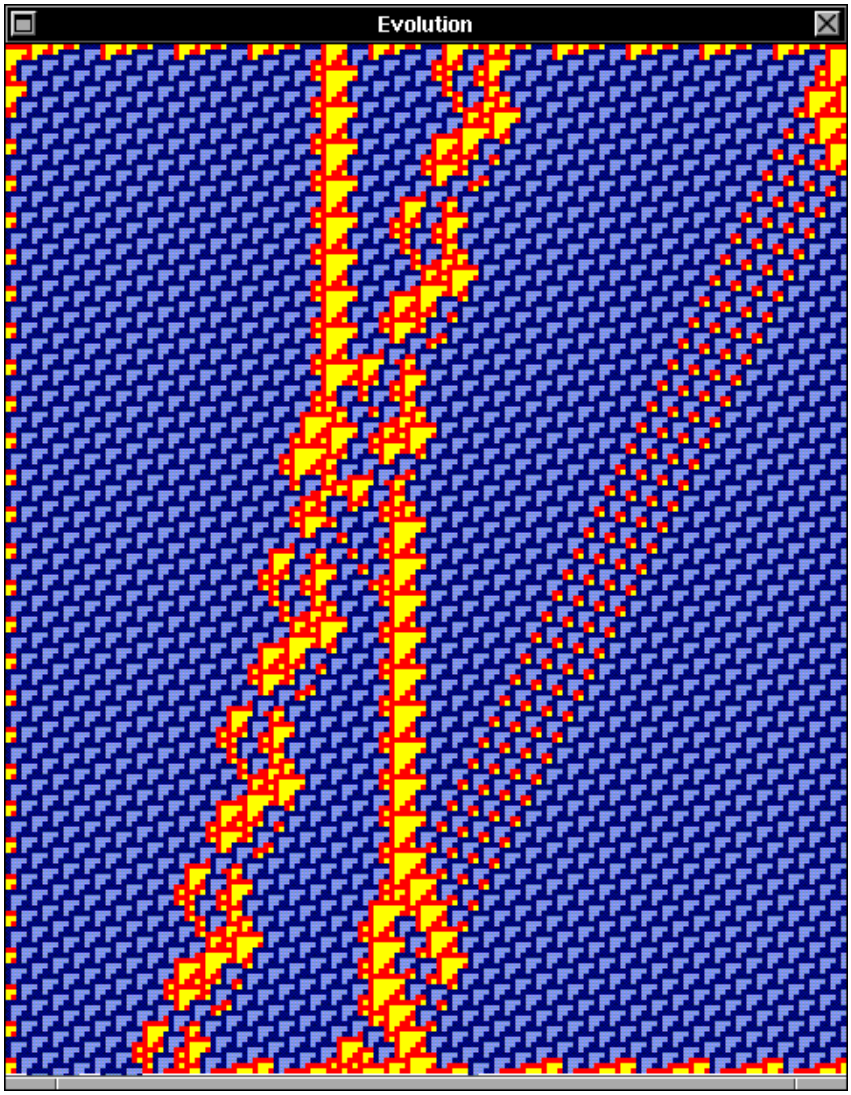

Figure 4.251: Collisions of glider C1, C1(p1)(A)-e(p1)-Ebar(p1)(D)=Ebar,C1; across

4.6.5 Collisions of glider C1 with glider F

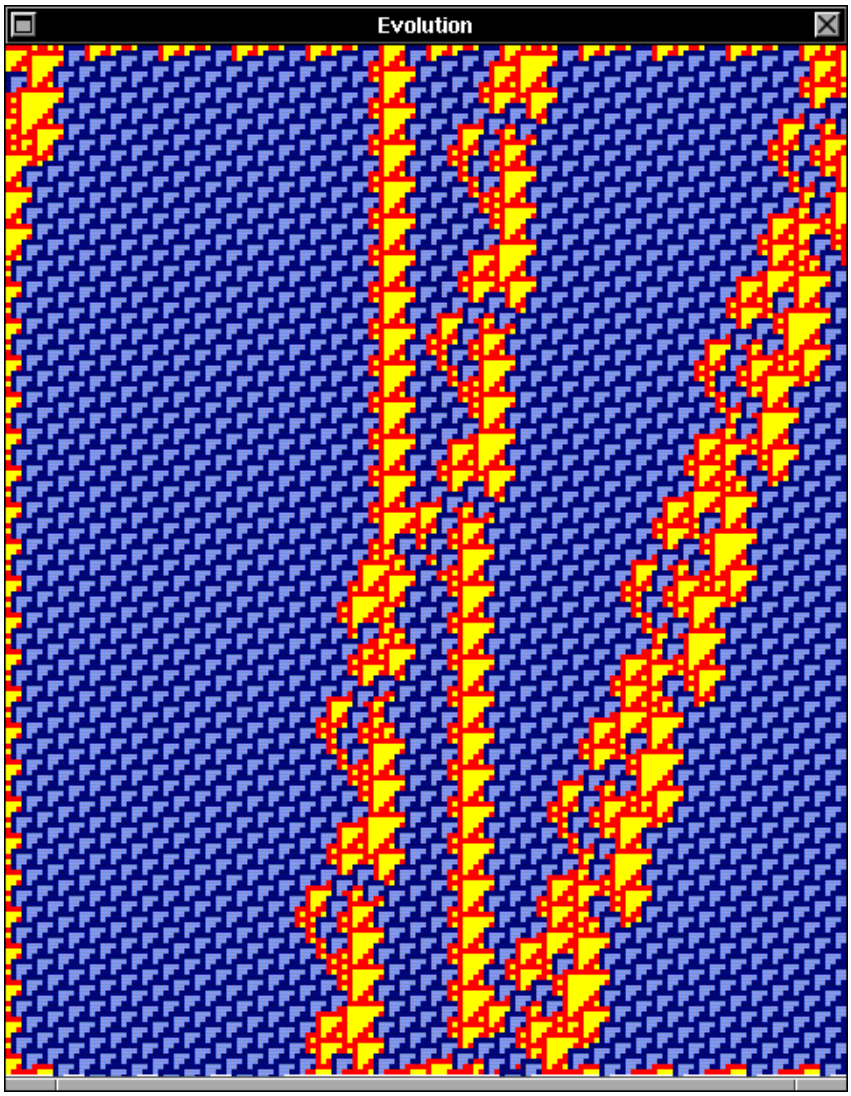

Figure 4.252: Collisions of glider C1, C1(p1)(A)-e(p1)-F(p1)(A)=F,C1; across

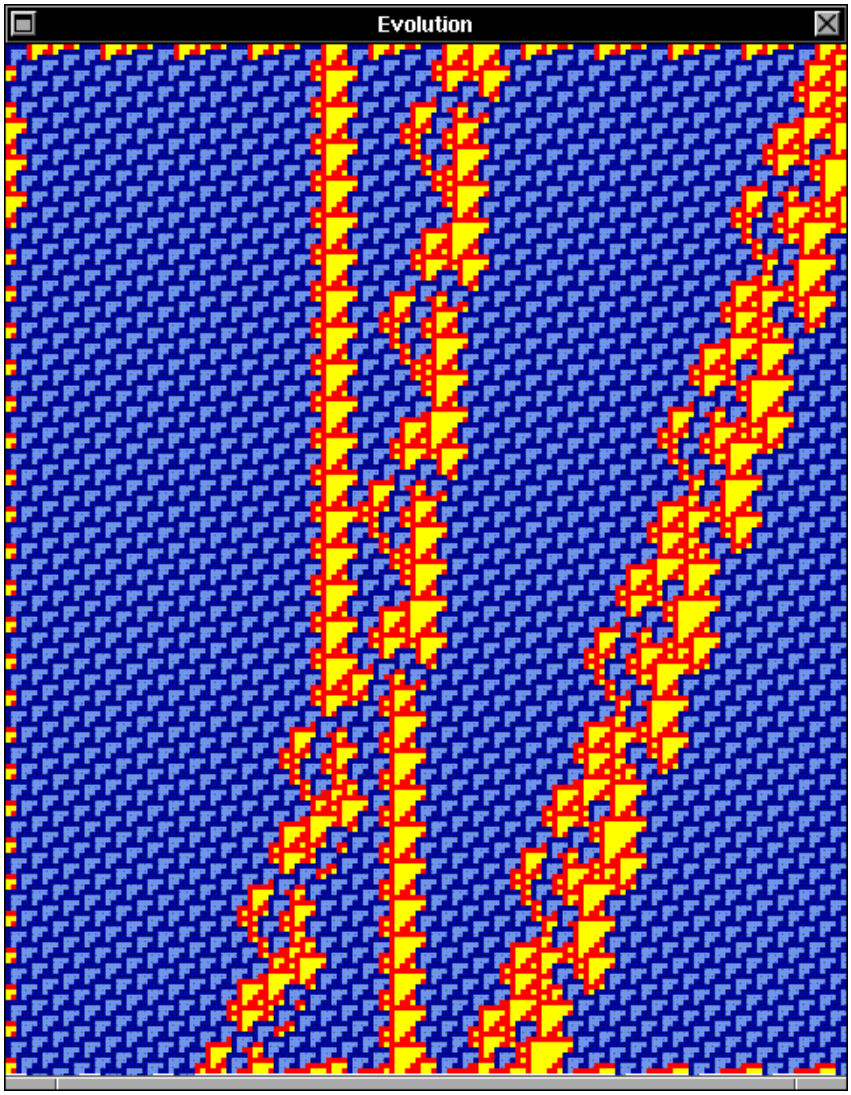

Figure 4.253: Collisions of glider C1, C1(p1)(A)-e(p1)-F(p1)(B)=C2,Ebar

4.6.6 Collisions of glider C1 with glider G

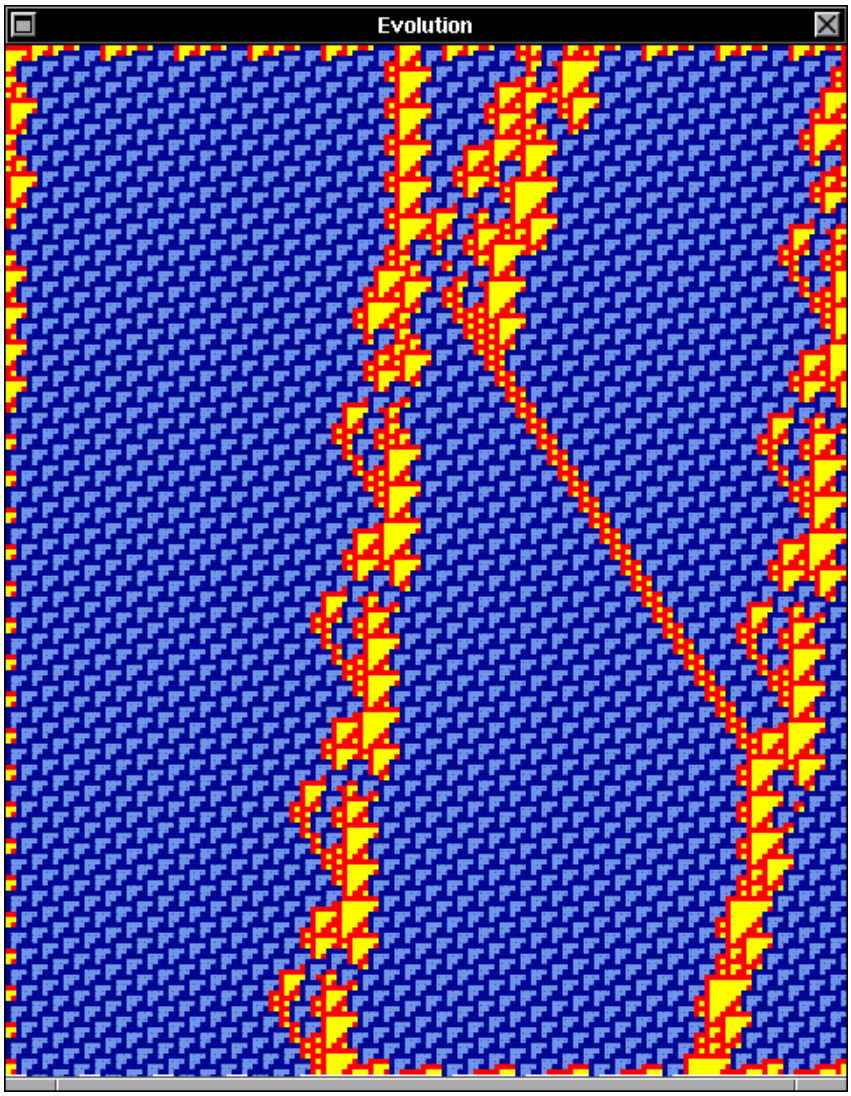

Figure 4.254: Collisions of glider C1, C1(p1)(A)-e(p1)-G(p1)(A)=F,3A

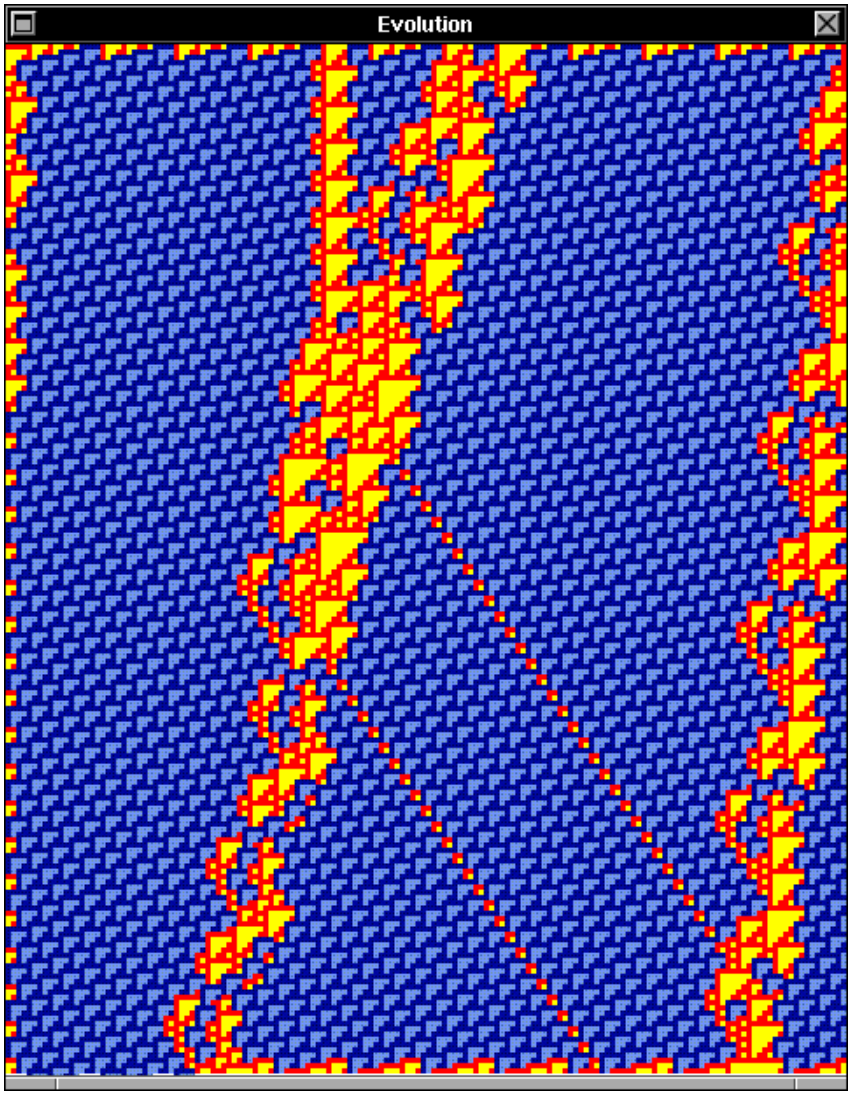

Figure 4.255: Collisions of glider C1, C1(p1)(A)-e(p1)-G(p1)(B)=A,A,Ebar

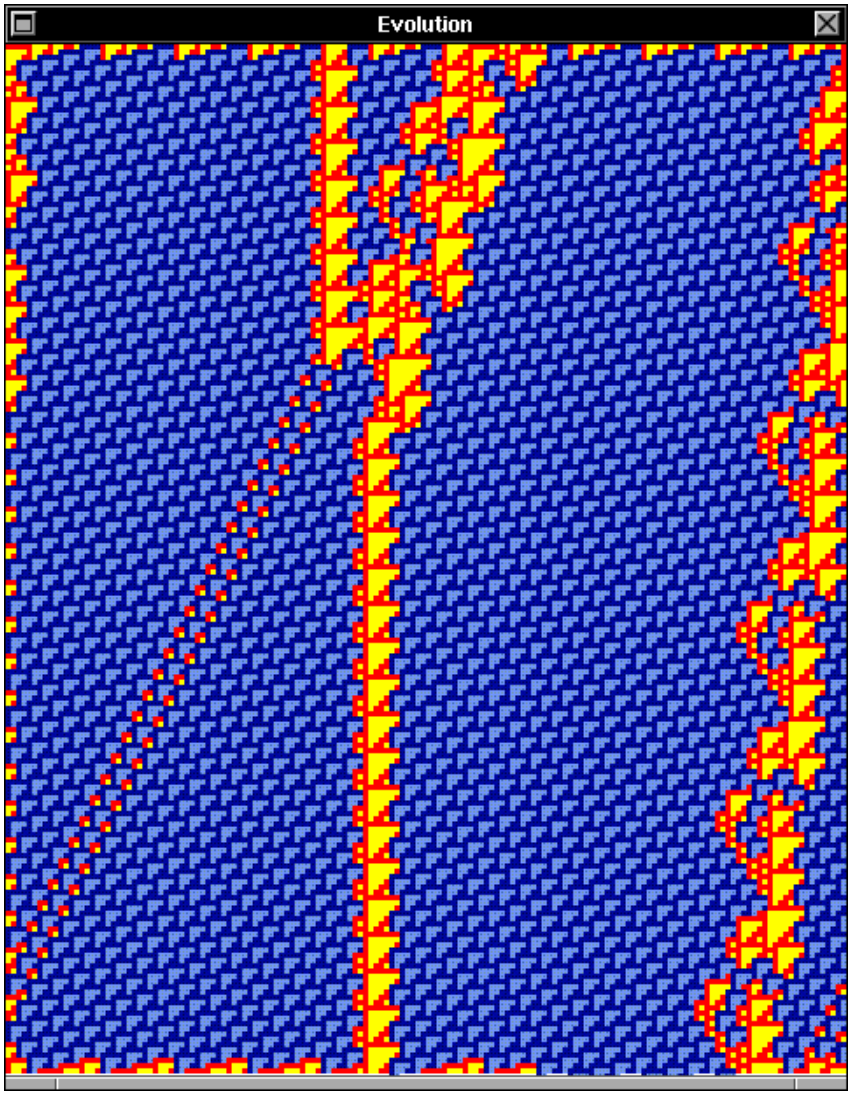

Figure 4.256: Collisions of glider C1, C1(p1)(A)-e(p1)-G(p1)(C)=2B,C2

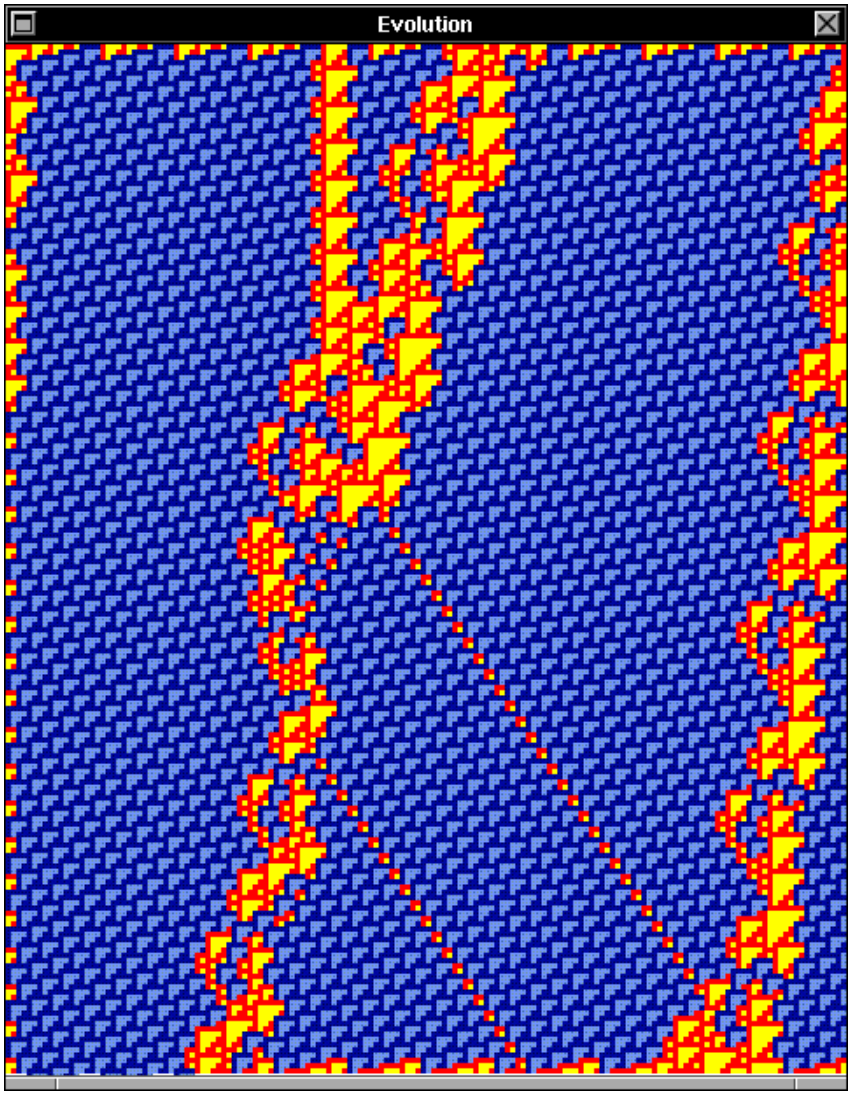

Figure 4.257: Collisions of glider C1, C1(p1)(A)-e(p1)-G(p1)(D)=A,A,Ebar

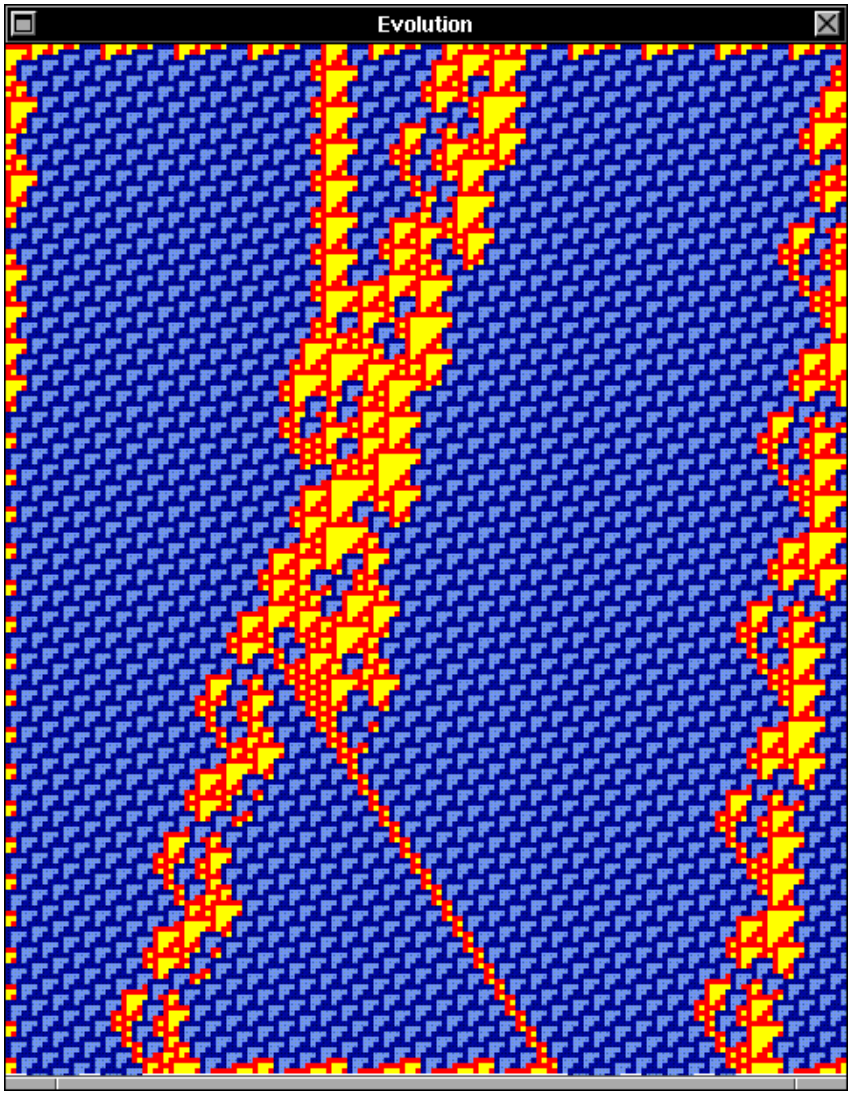

Figure 4.258: Collisions of glider C1, C1(p1)(A)-e(p1)-G(p1)(E)=Ebar,2A

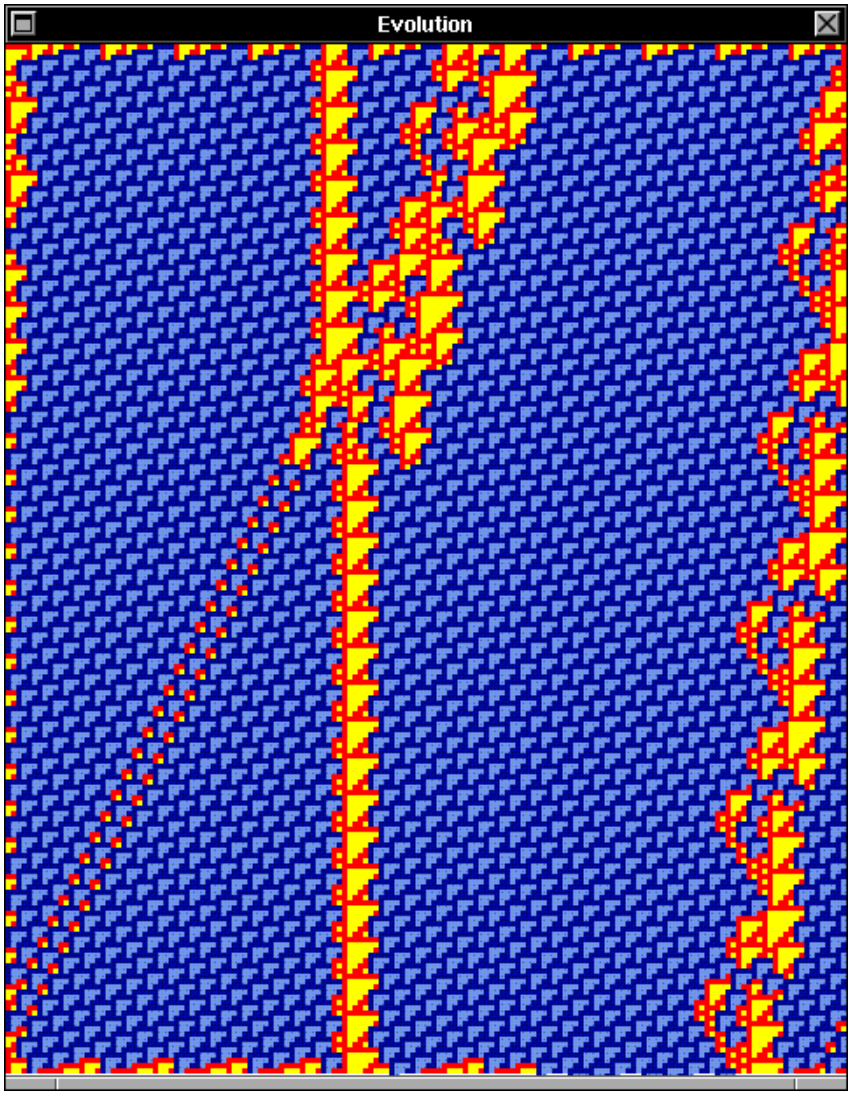

Figure 4.259: Collisions of glider C1, C1(p1)(A)-e(p1)-G(p1)(F)=2B,C2

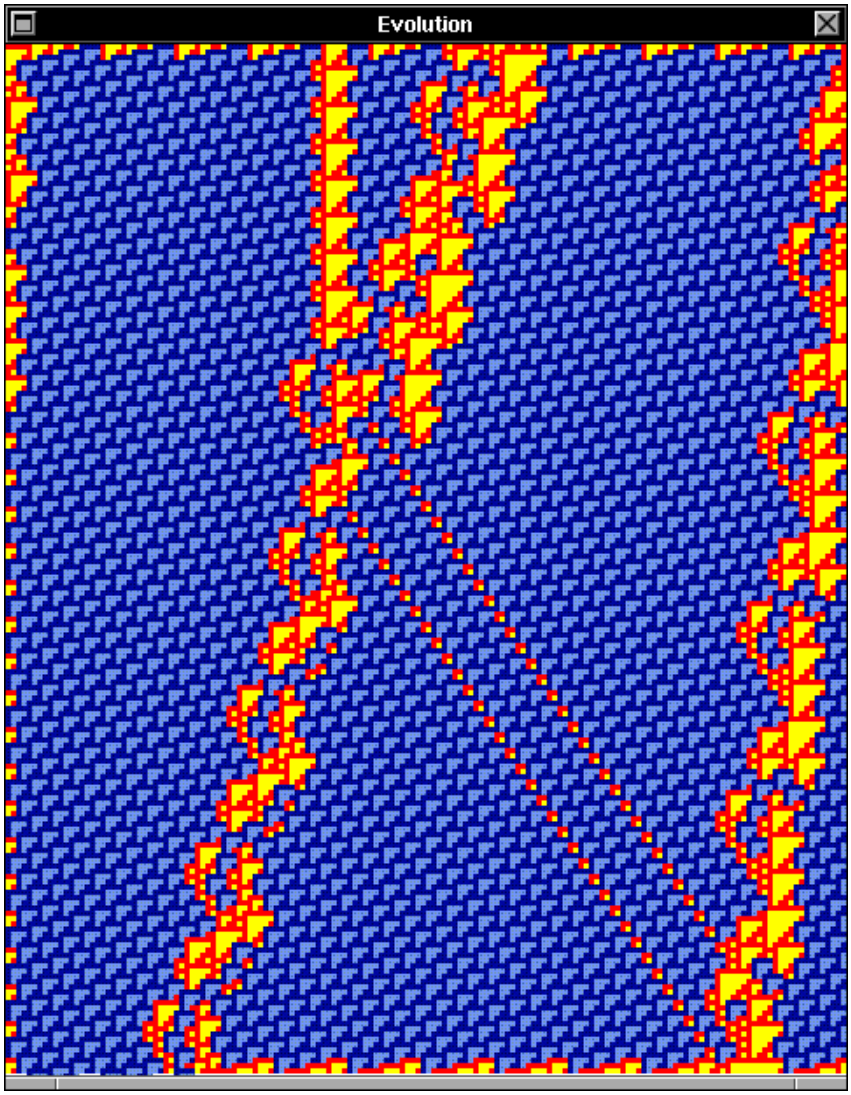

Figure 4.260: Collisions of glider C1, C1(p1)(A)-e(p1)-G(p1)(G)=A,A,Ebar

4.6.7 Collisions of glider C1 with glider H

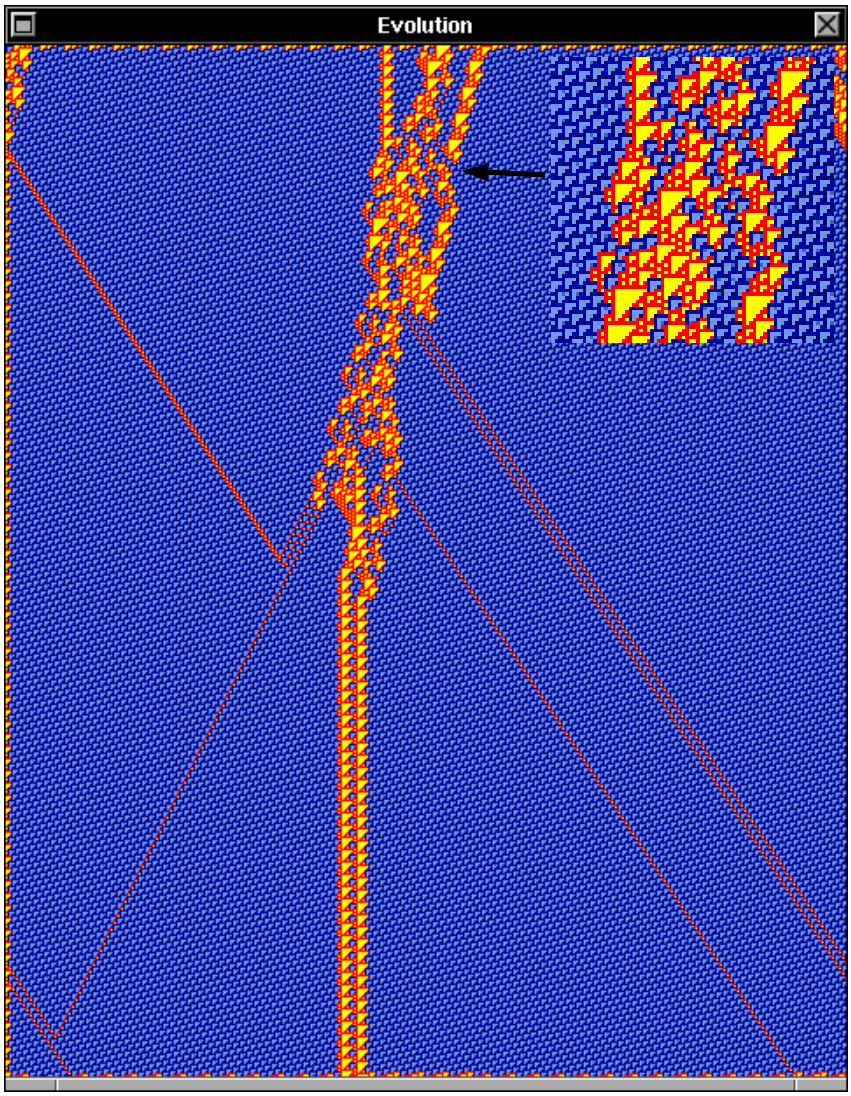

Figure 4.261: Collisions of glider C1, C1(p1)(A)-e(p1)-H(p1)(A)=A,A,3B,A,2C2

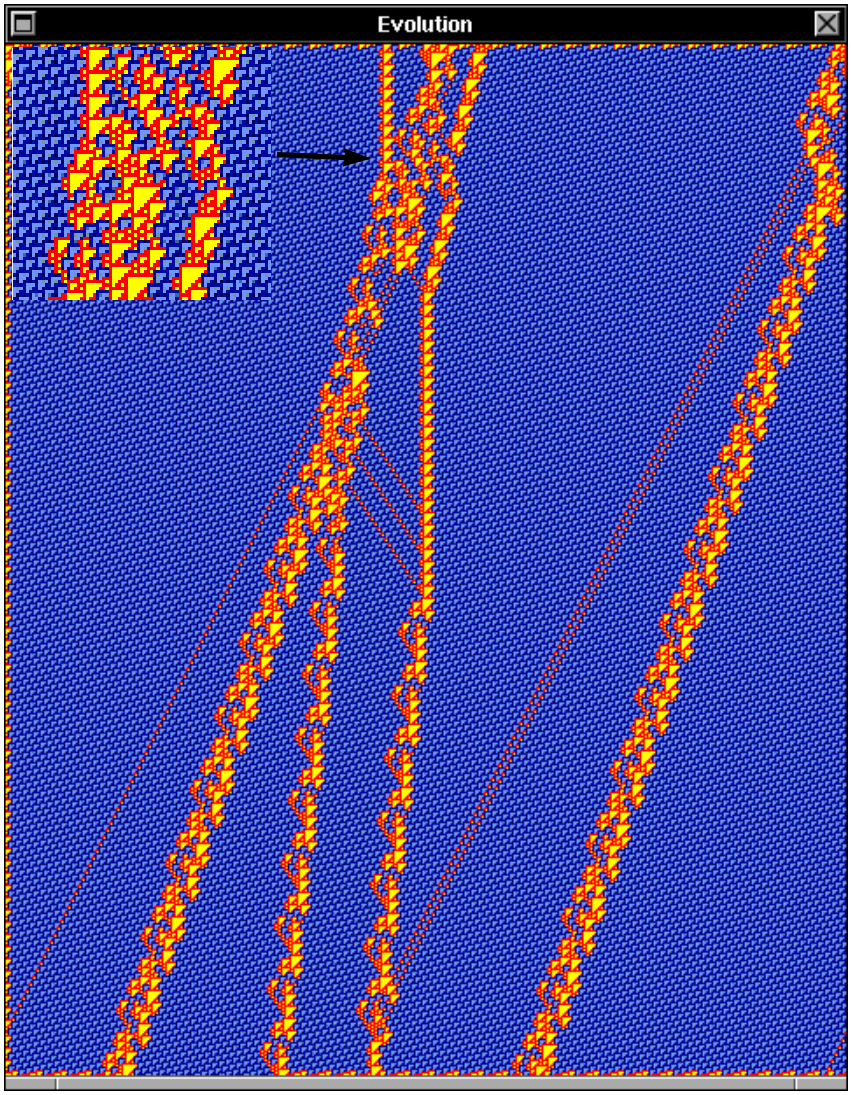

Figure 4.262: Collisions of glider C1, C1(p1)(A)-e(p1)-H(p1)(B)=B,G,F,F

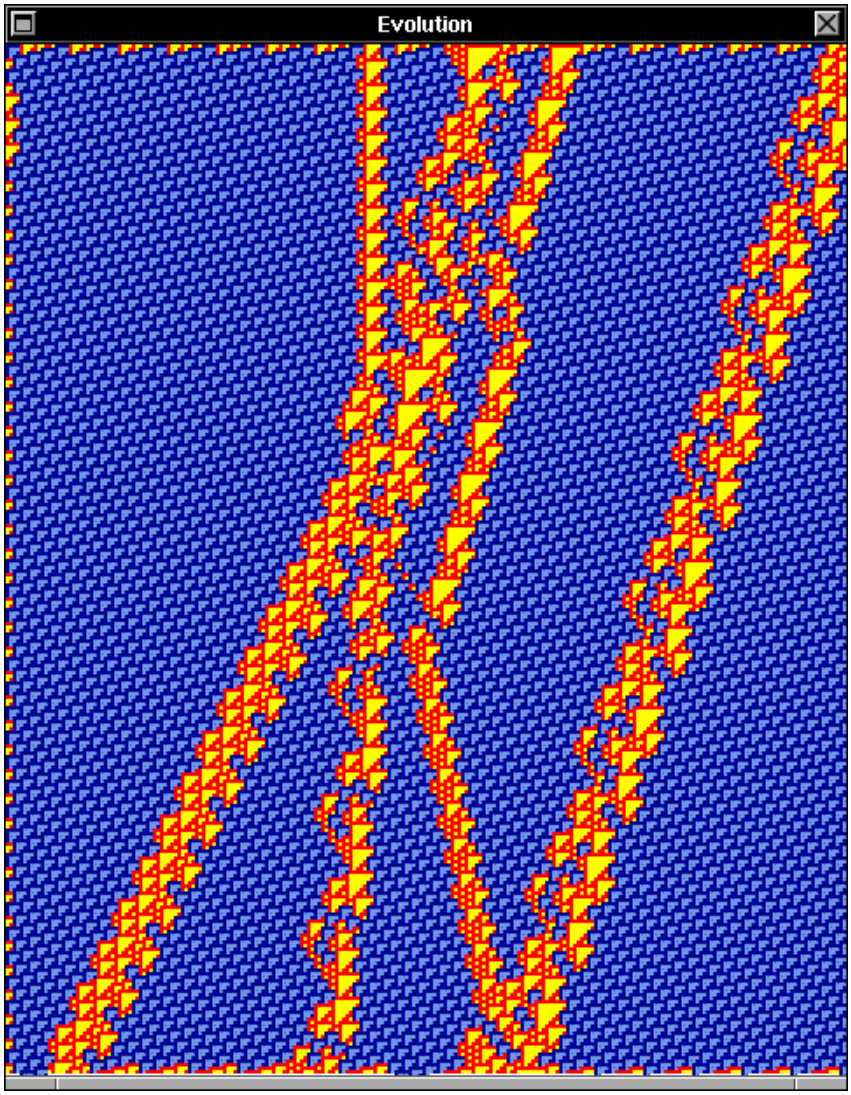

Figure 4.263: Collisions of glider C1, C1(p1)(A)-e(p1)-H(p1)(C)=Bbar,F,D1

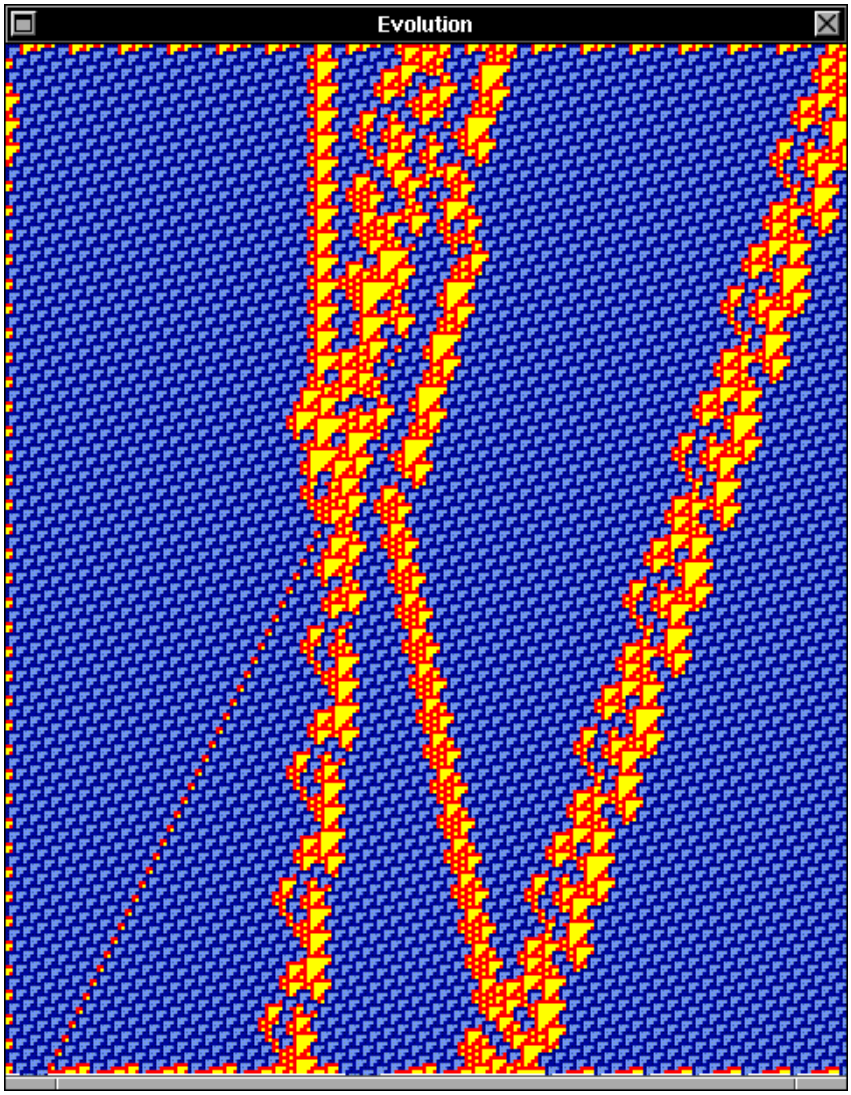

Figure 4.264: Collisions of glider C1, C1(p1)(A)-e(p1)-H(p1)(B2)=B,F,D1

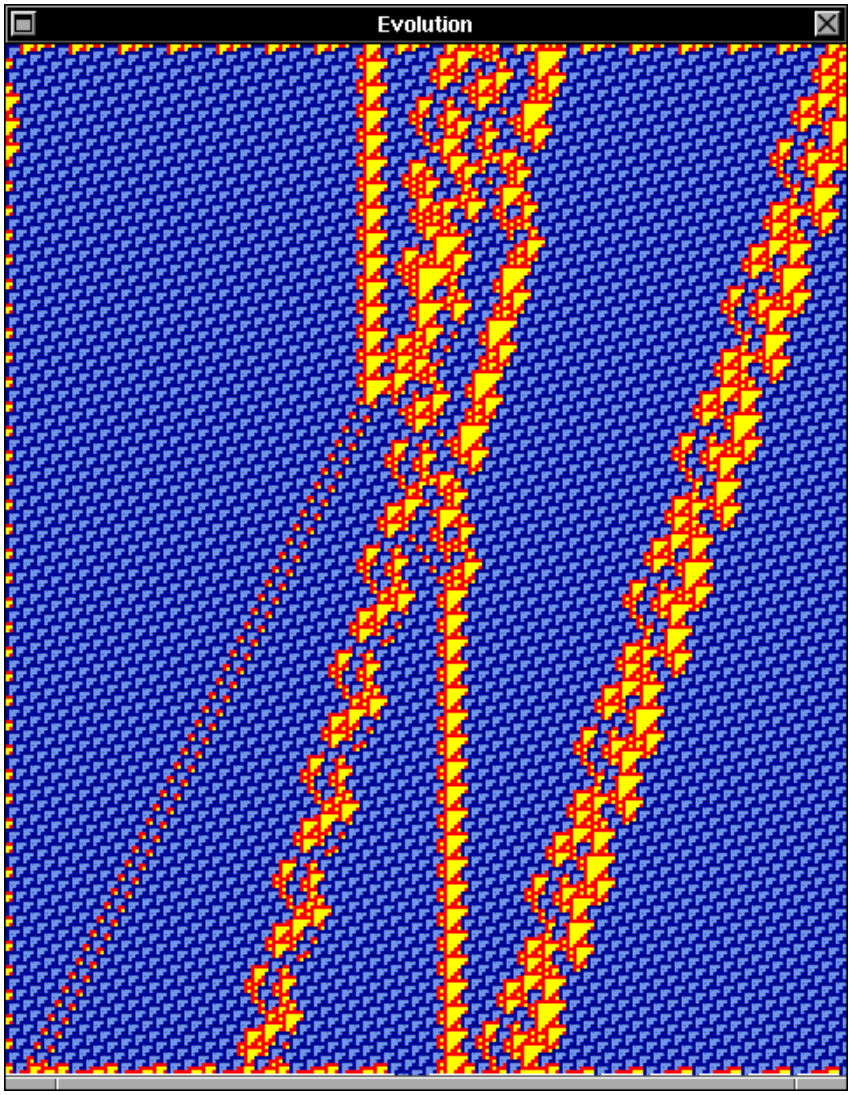

Figure 4.265: Collisions of glider C1, C1(p1)(A)-e(p1)-H(p1)(C2)=2B,Ebar,C3

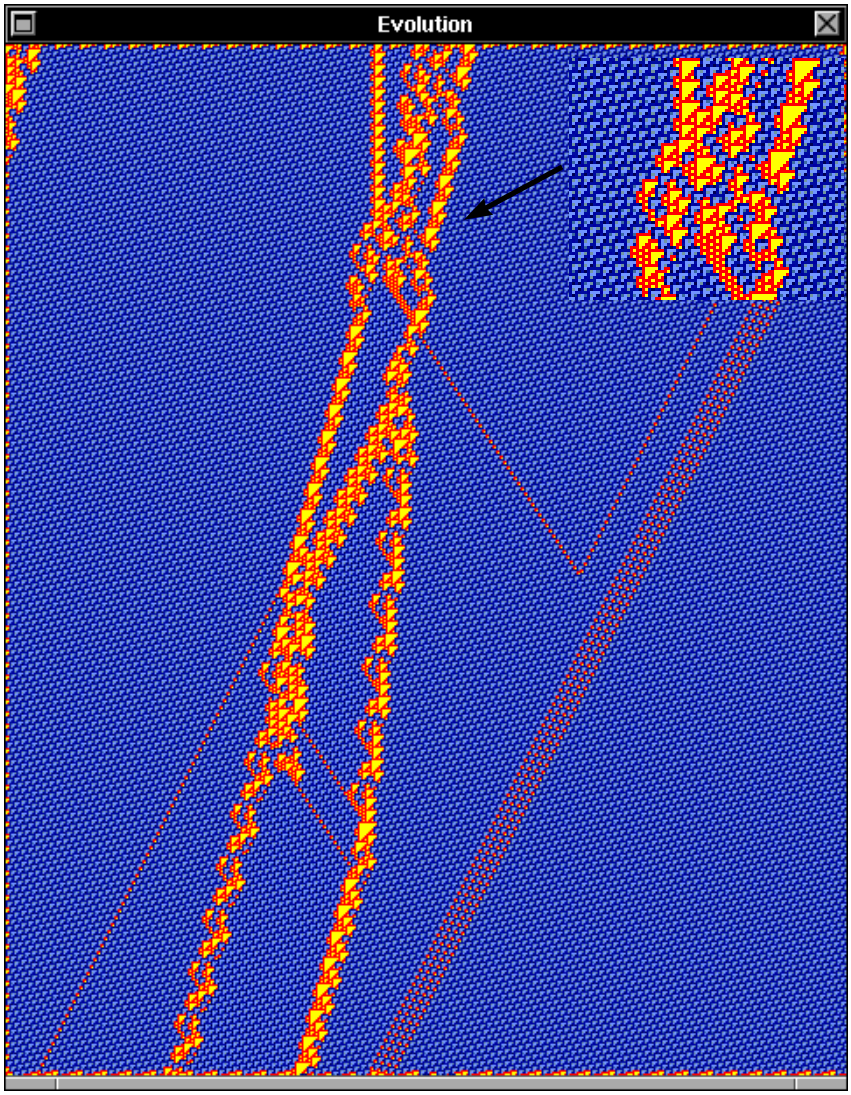

Figure 4.266: Collisions of glider C1, C1(p1)(A)-e(p1)-H(p1)(D2)=A,B,Ebar,E2

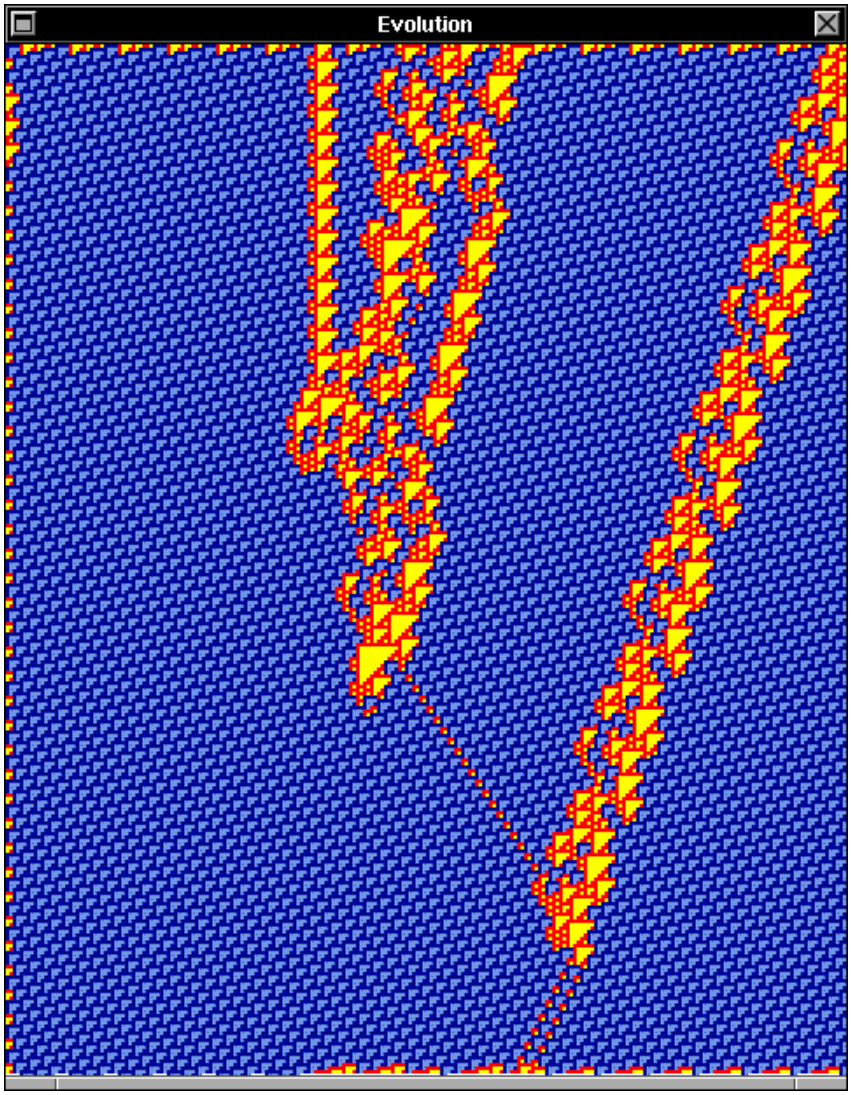

Figure 4.267: Collisions of glider C1, C1(p1)(A)-e(p1)-H(p1)(E2)=A

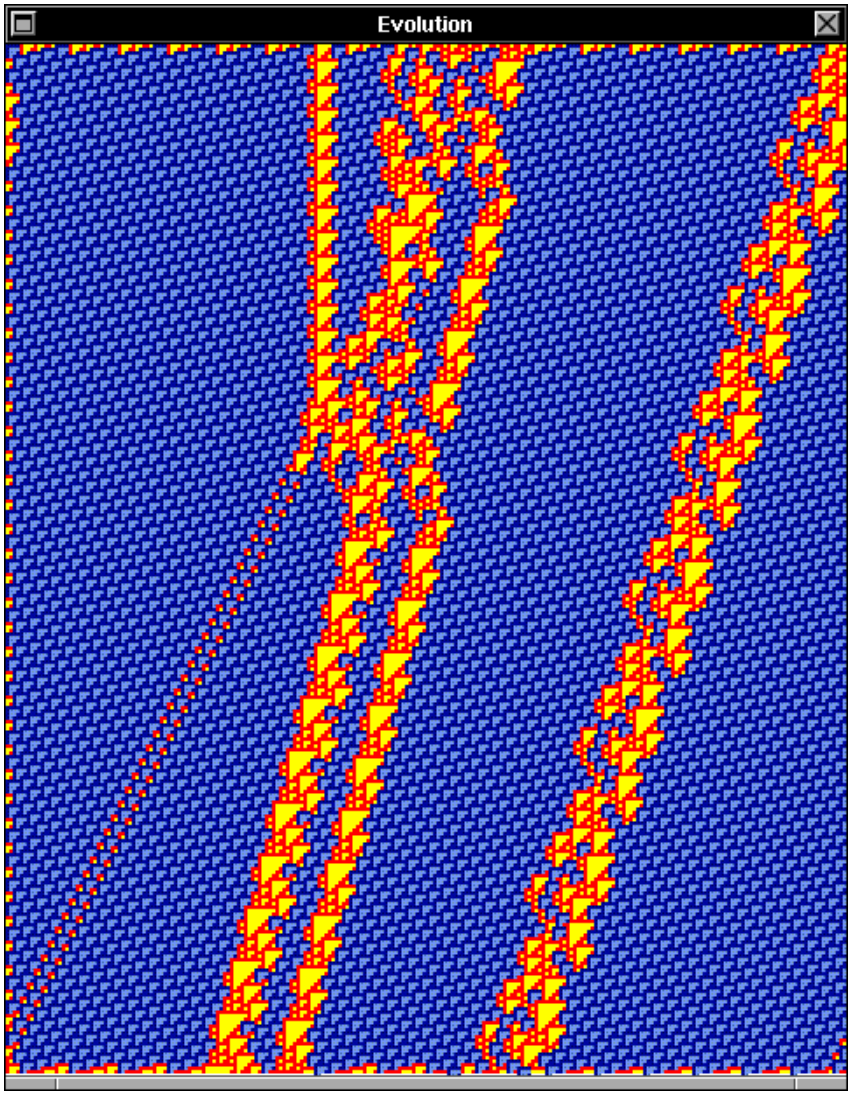

Figure 4.268: Collisions of glider C1, C1(p1)(A)-e(p1)-H(p1)(F2)=2B,E2,E

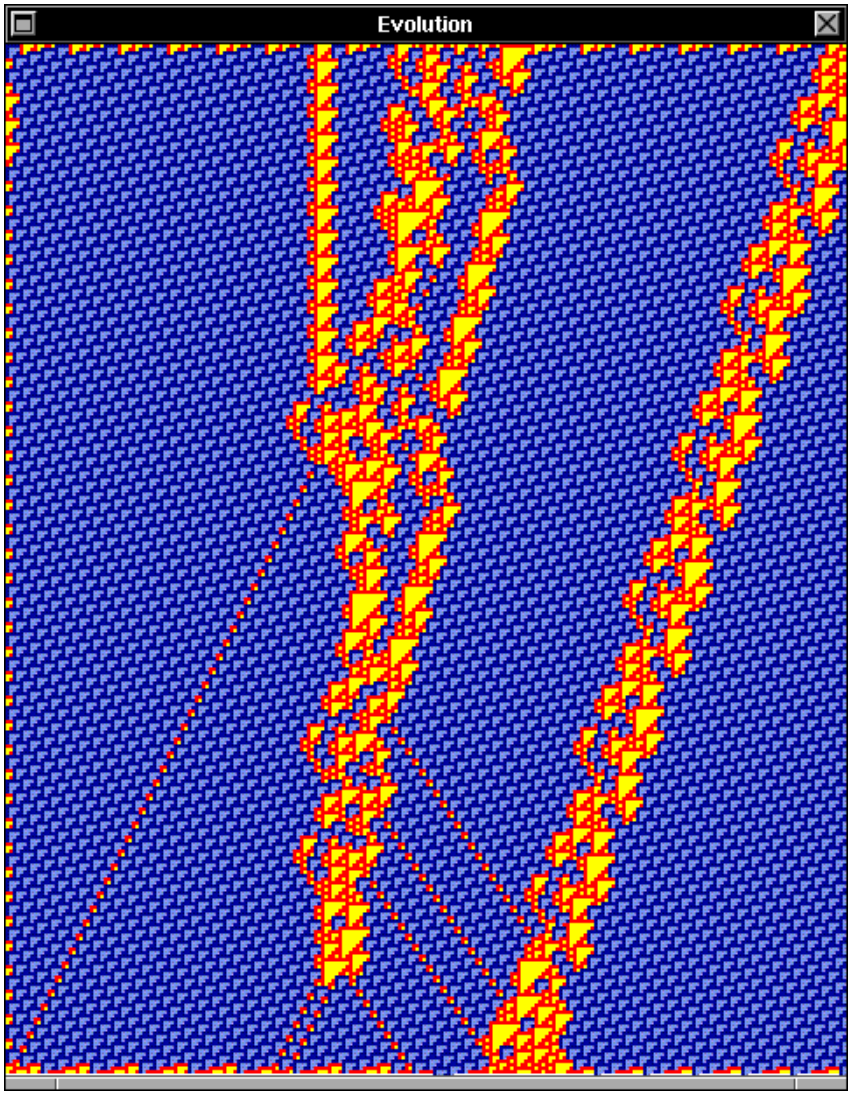

Figure 4.269: Collisions of glider C1, C1(p1)(A)-e(p1)-H(p1)(G2)=B,A,A,A,2B,A

4.7 Collisions of glider C2

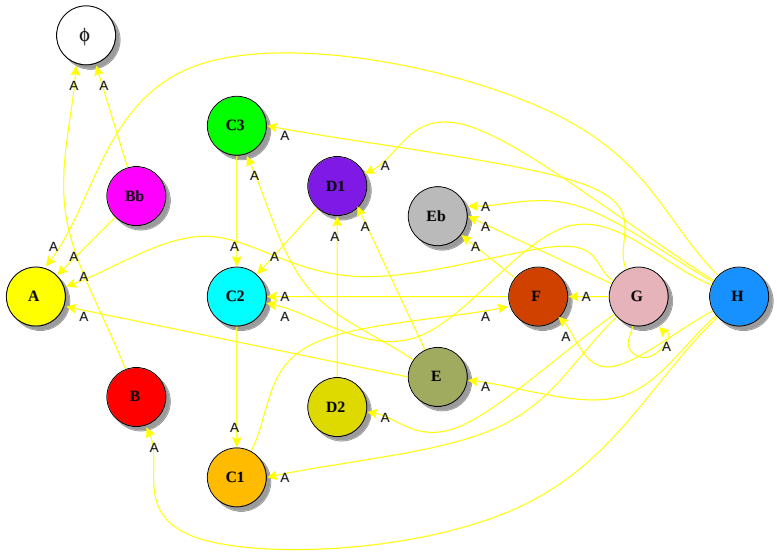

Figure 4.270: Collisions of glider C2

	ϕ	A	B	$Bbar$	$C3$	$C2$	$C1$	$D2$	$D1$	E	$Ebar$	F	G	H
ϕ	.	.	.	.	.	.	.	.	.	.	.	.	.	.
A	.	.	.	.	.	.	.	.	.	.	.	.	.	.
B	.	.	.	.	.	.	.	.	.	.	.	.	.	.
$Bbar$	.	.	.	.	.	.	.	.	.	.	.	.	.	.
$C3$	.	.	.	.	.	.	.	.	.	.	.	.	.	.
$C2$	.	.	.	.	.	.	.	.	.	.	.	.	.	.
$C1$	.	.	.	.	.	.	.	.	.	.	.	.	.	.
$D2$	.	.	.	.	.	.	.	.	.	.	.	.	.	.
$D1$	.	.	.	.	.	.	.	.	.	.	.	.	.	.
E	.	.	.	.	.	.	.	.	.	.	.	.	.	.
$Ebar$	.	.	.	.	.	.	.	.	.	.	.	.	.	.
F	.	.	.	.	.	.	.	.	.	.	.	.	.	.
G	.	.	.	.	.	.	.	.	.	.	.	.	.	.
H	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Table 4.6: Matrix connection of collisions glider C2

4.7.1 Collisions of glider C2 with glider D1

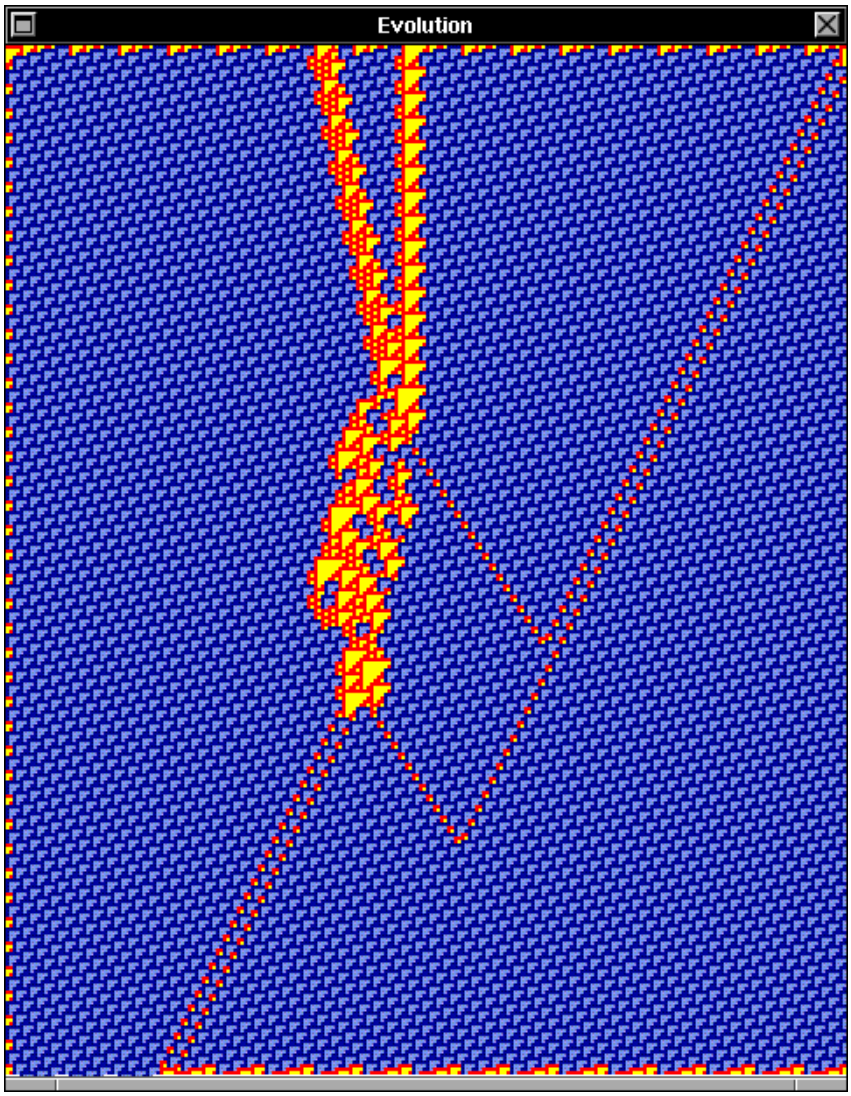

Figure 4.271: Collisions of glider C2, D1(p1)(A)-e(p1)-C2(p1)(A)=A,2B,A

4.7.2 Collisions of glider C2 with glider D2

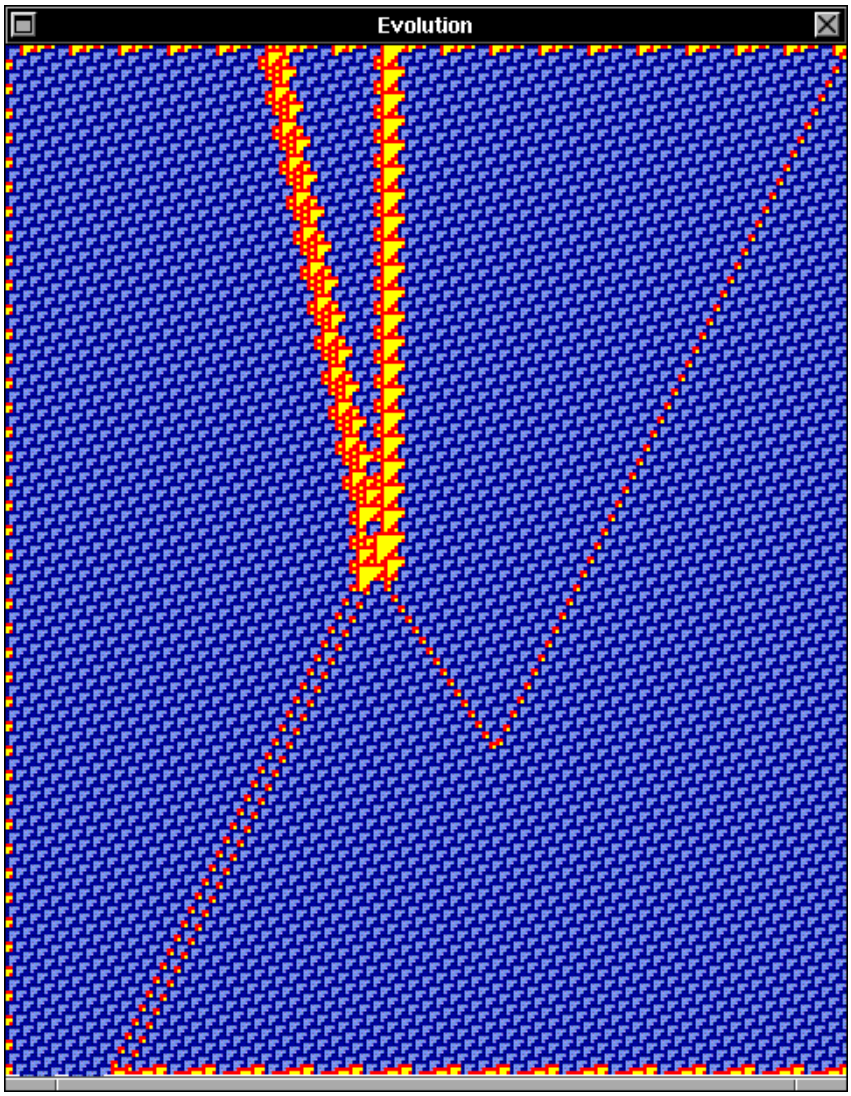

Figure 4.272: Collisions of glider C2, D2(p1)(A)-e(p1)-C2(p1)(A)=2B,A

4.7.3 Collisions of glider C2 with glider E

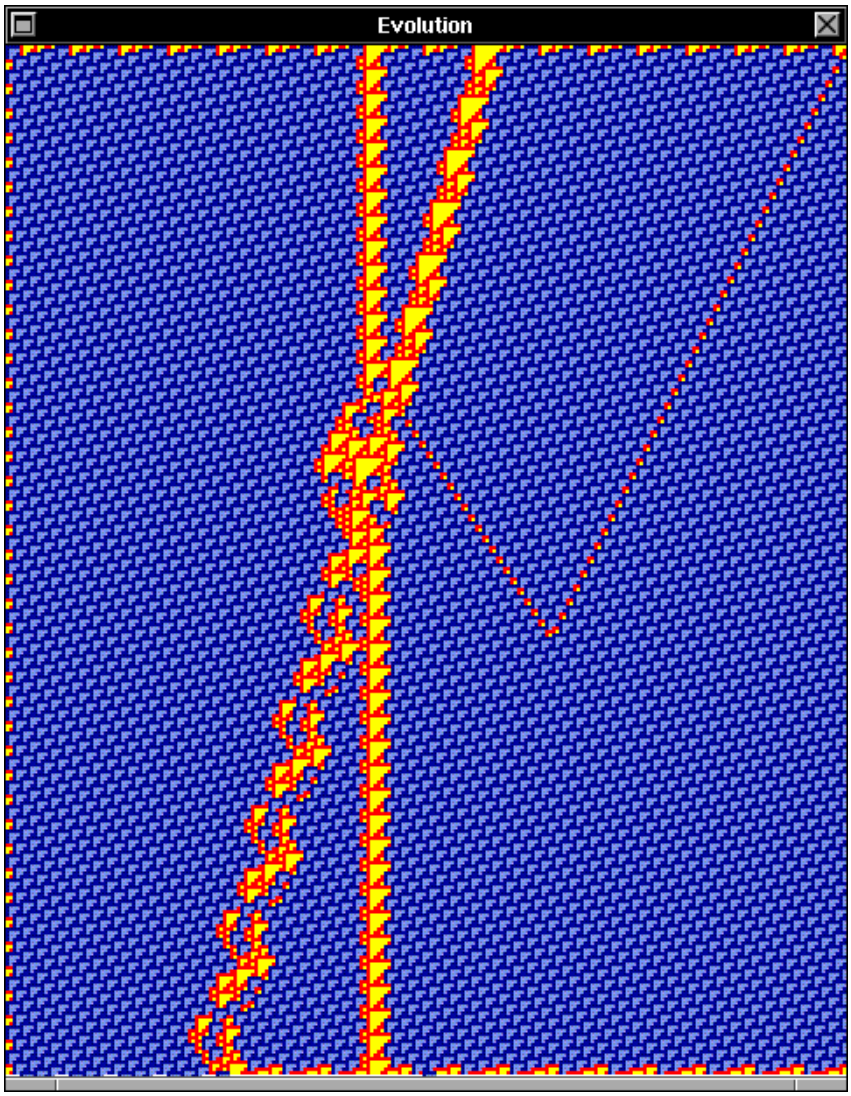

Figure 4.273: Collisions of glider C2, C2(p1)(A)-e(p1)-E(p1)(A)=A,Ebar,C1

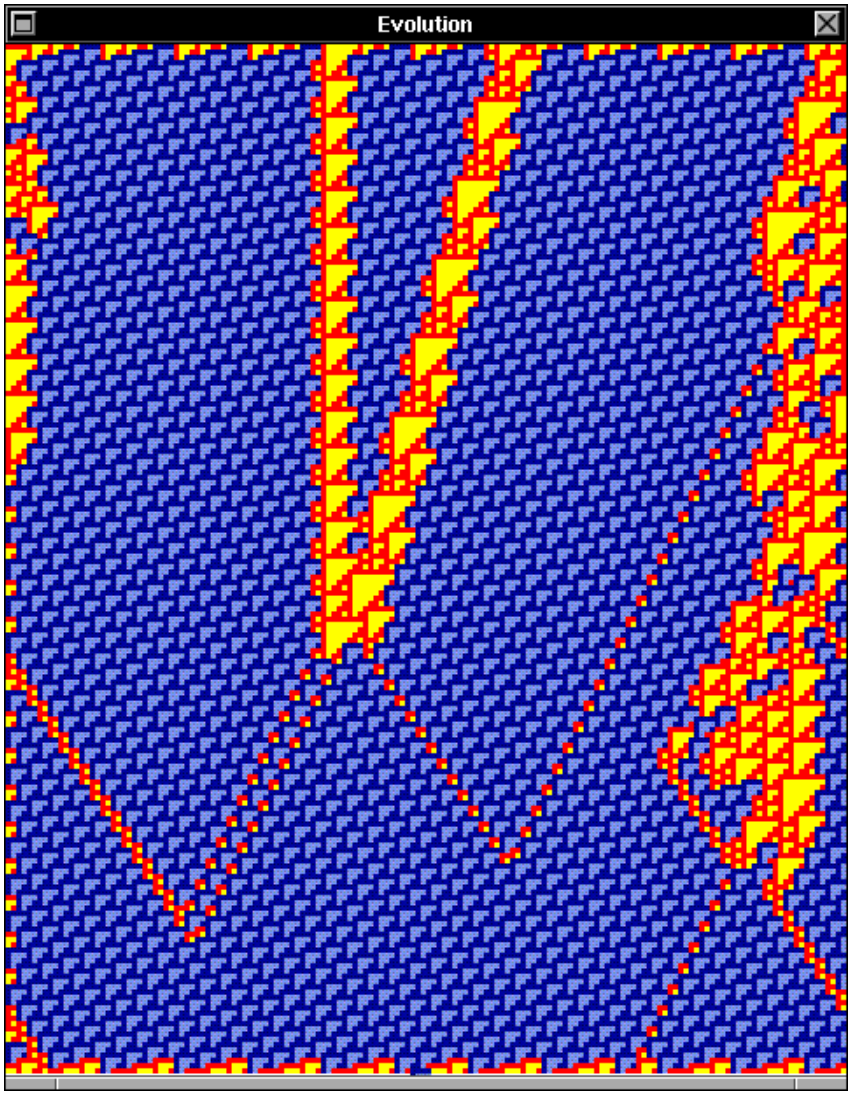

Figure 4.274: Collisions of glider C2, C2(p1)(A)-e(p1)-E(p1)(B)=2B,A

4.7.4 Collisions of glider C2 with glider Ebar

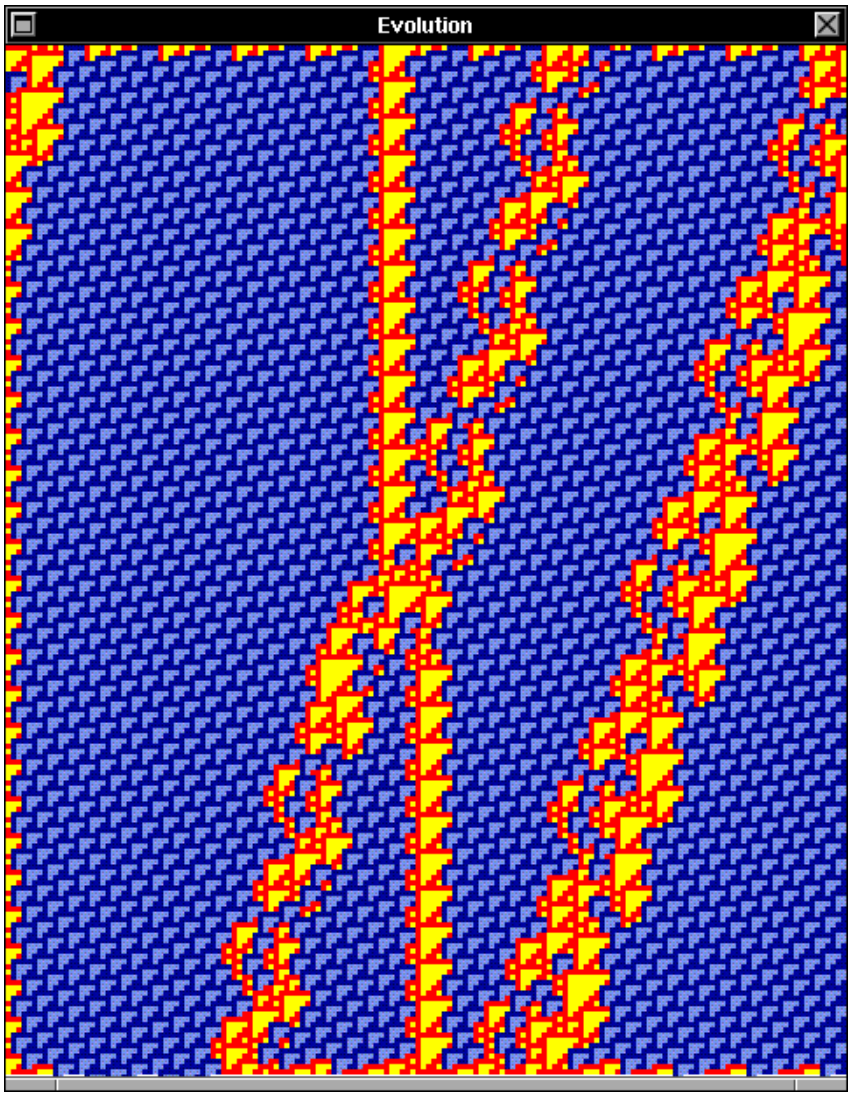

Figure 4.275: Collisions of glider C2, C2(p1)(A)-e(p1)-Ebar(p1)(A)=Ebar,C2; across

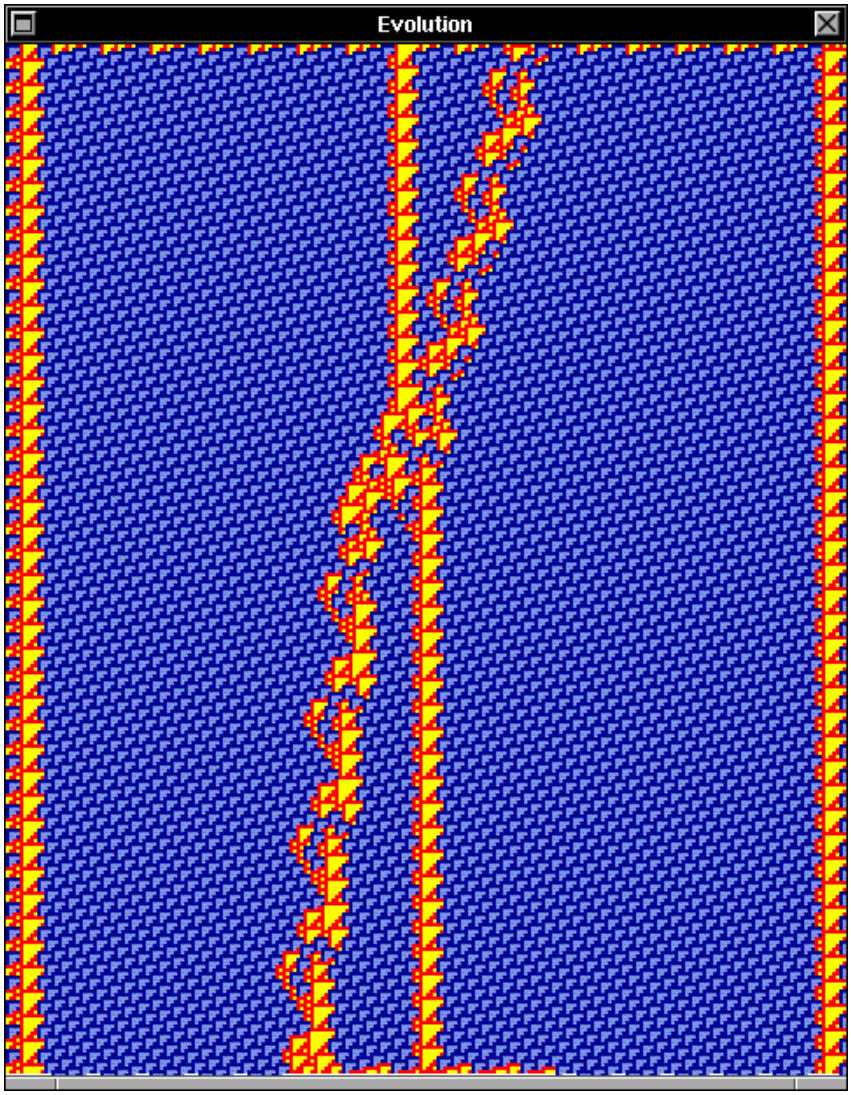

Figure 4.276: Collisions of glider C2, C2(p1)(A)-e(p1)-Ebar(p1)(B)=F,C1

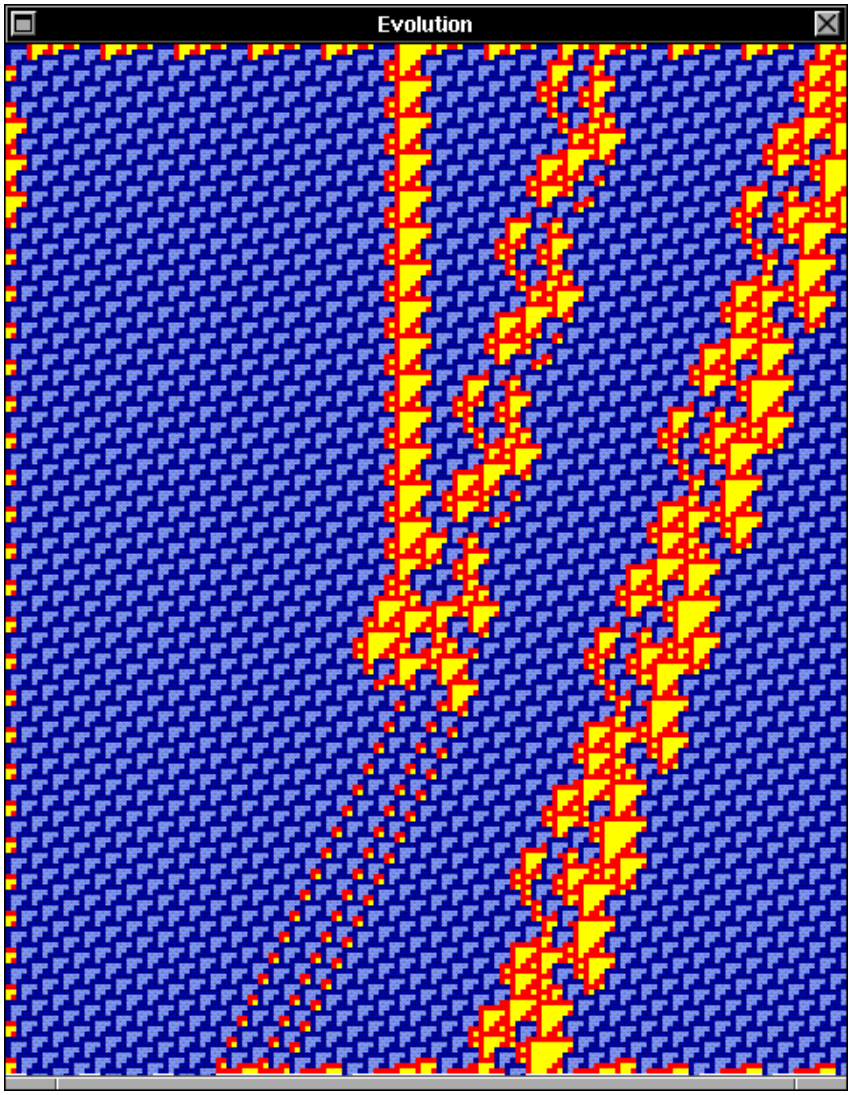

Figure 4.277: Collisions of glider C2, C2(p1)(A)-e(p1)-Ebar(p1)(C)=B,2B

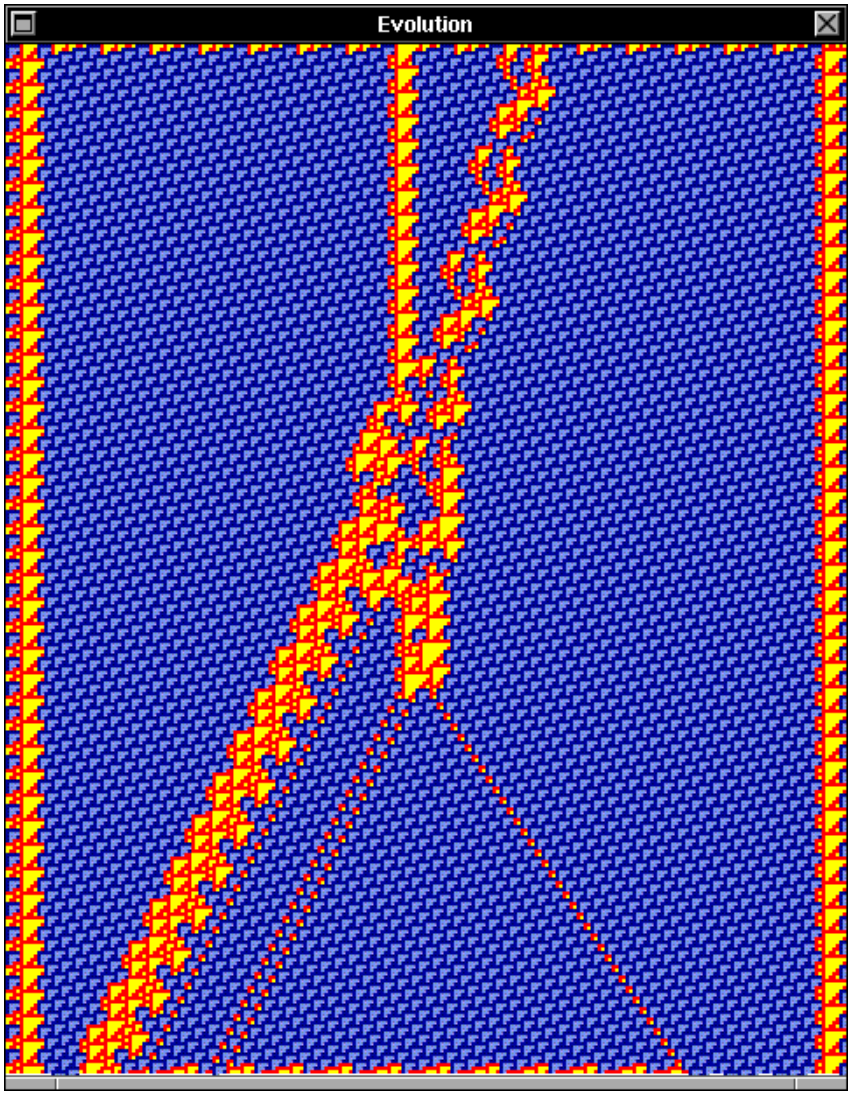

Figure 4.278: Collisions of glider C2, C2(p1)(A)-e(p1)-Ebar(p1)(D)=Bbar,B,2B,A

4.7.5 Collisions of glider C2 with glider F

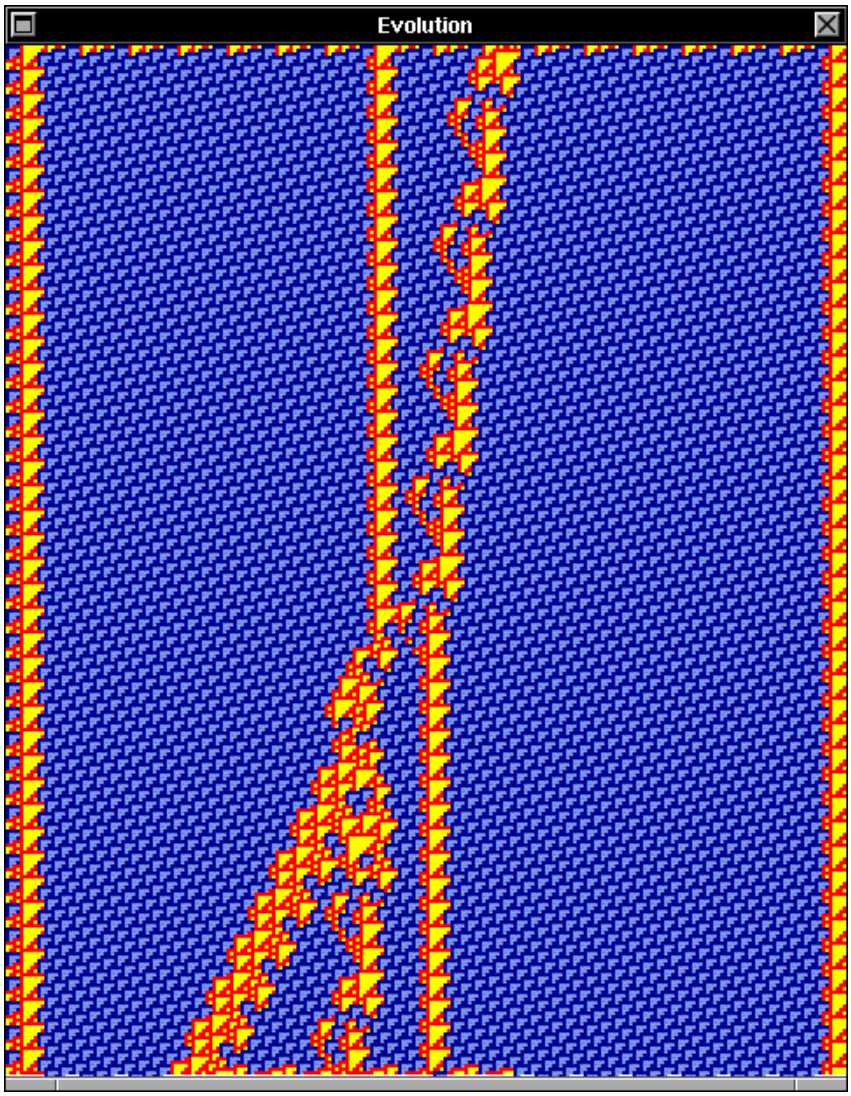

Figure 4.279: Collisions of glider C2, C2(p1)(A)-e(p1)-F(p1)(A)=C1,Bbar,F

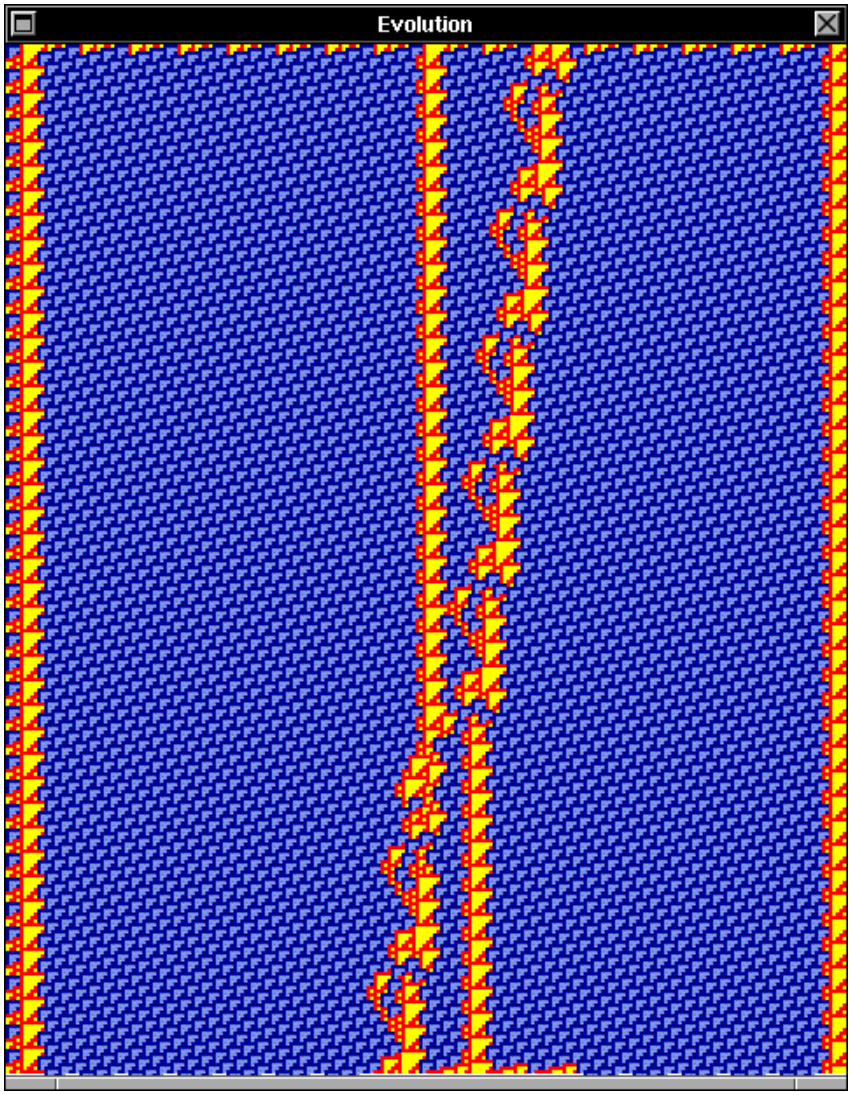

Figure 4.280: Collisions of glider C2, C2(p1)(A)-e(p1)-F(p1)(B)=F,C2; across

4.7.6 Collisions of glider C2 with glider G

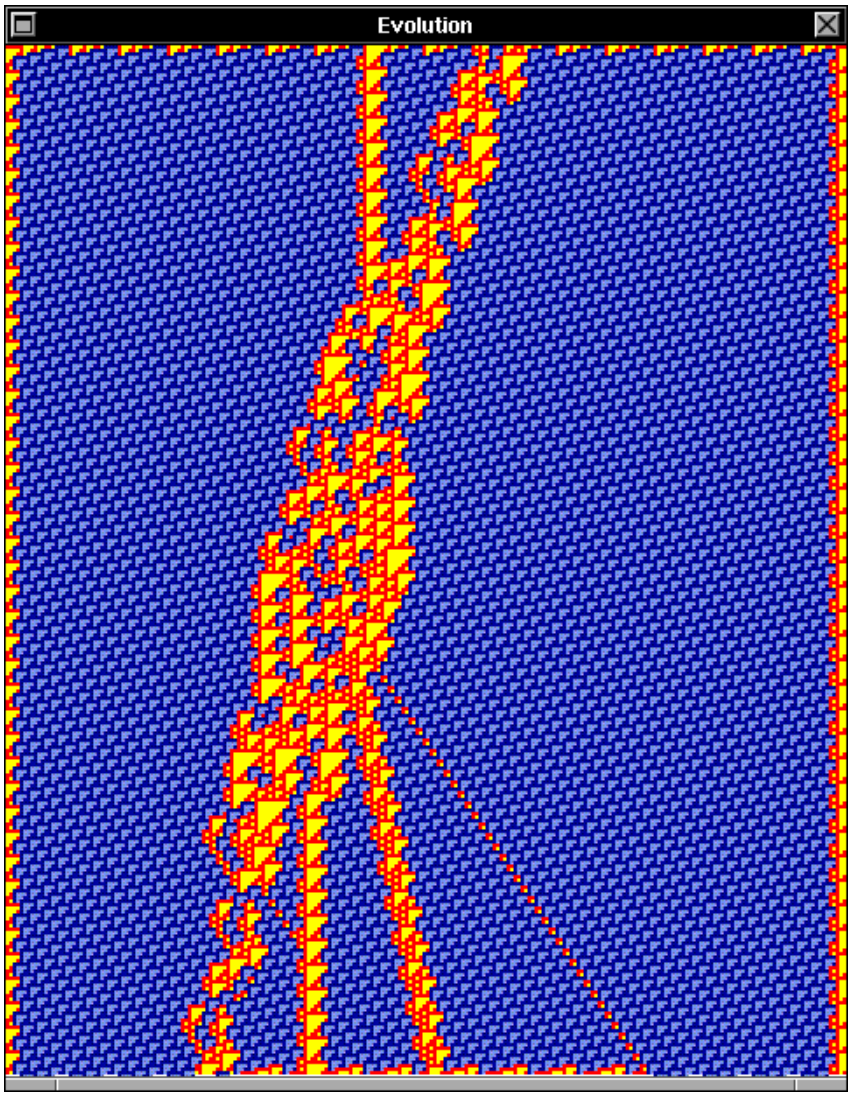

Figure 4.281: Collisions of glider C2, C2(p1)(A)-e(p1)-G(p1)(A)=A,D2,Ebar,C1

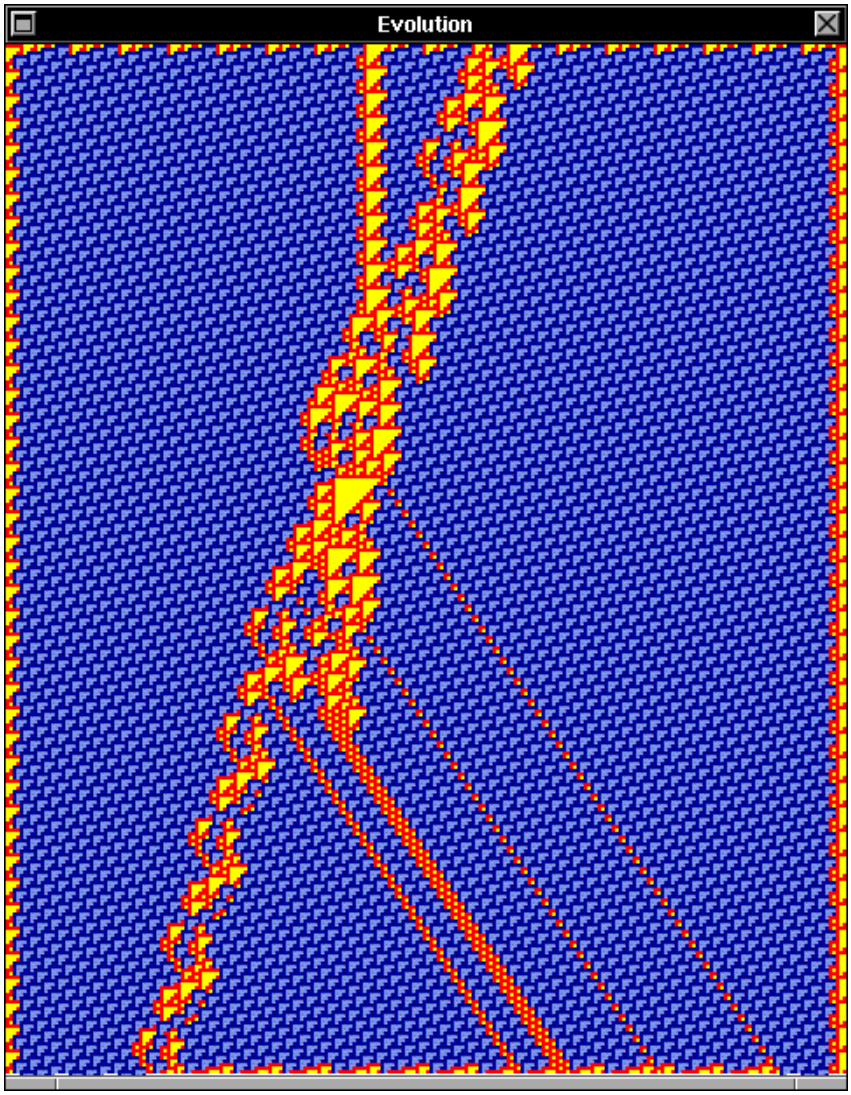

Figure 4.282: Collisions of glider C2, C2(p1)(A)-e(p1)-G(p1)(B)=A,A,4A,2A,Ebar

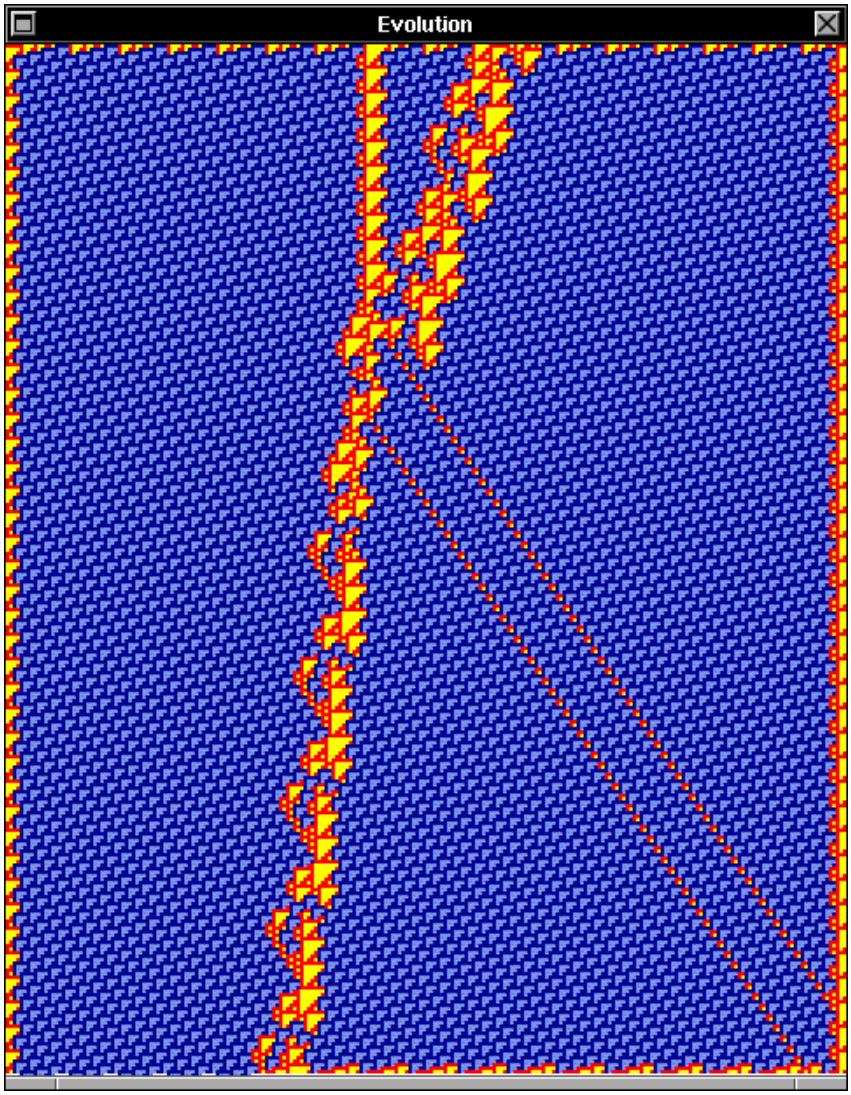

Figure 4.283: Collisions of glider C2, C2(p1)(A)-e(p1)-G(p1)(C)=A,A,F

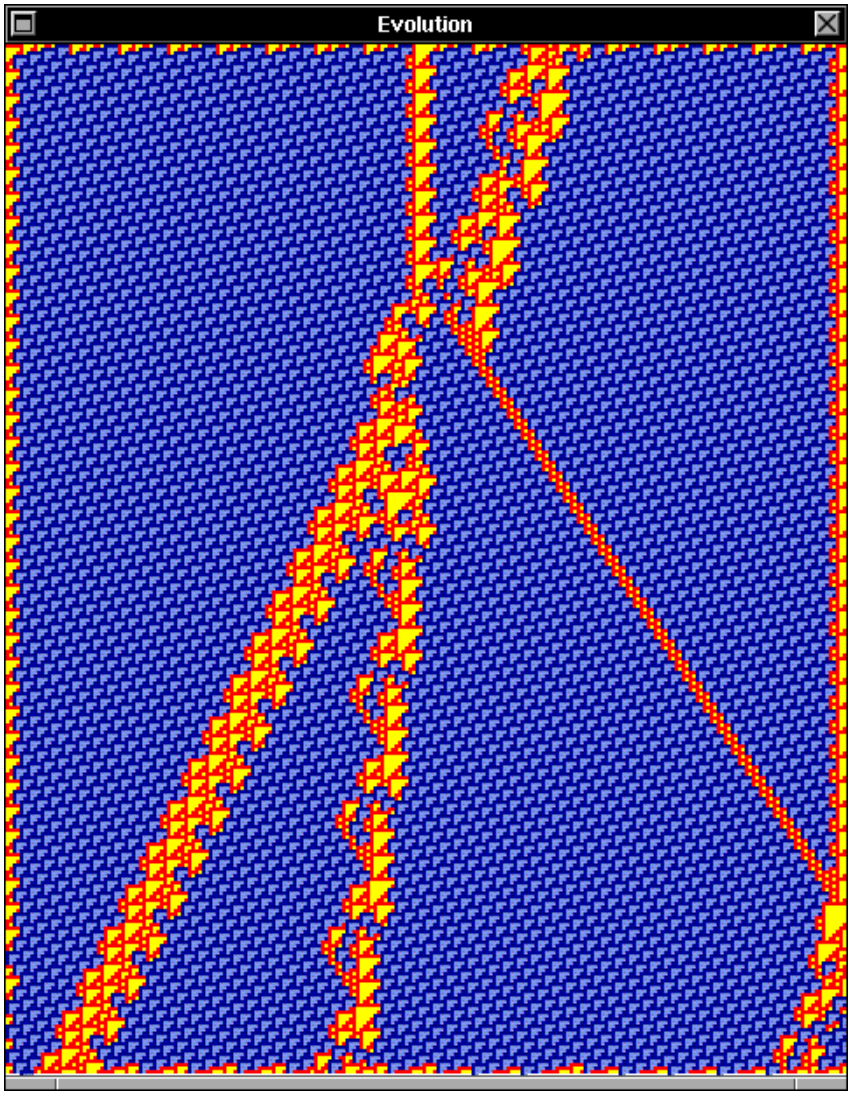

Figure 4.284: Collisions of glider C2, C2(p1)(A)-e(p1)-G(p1)(D)=3A,Bbar,F

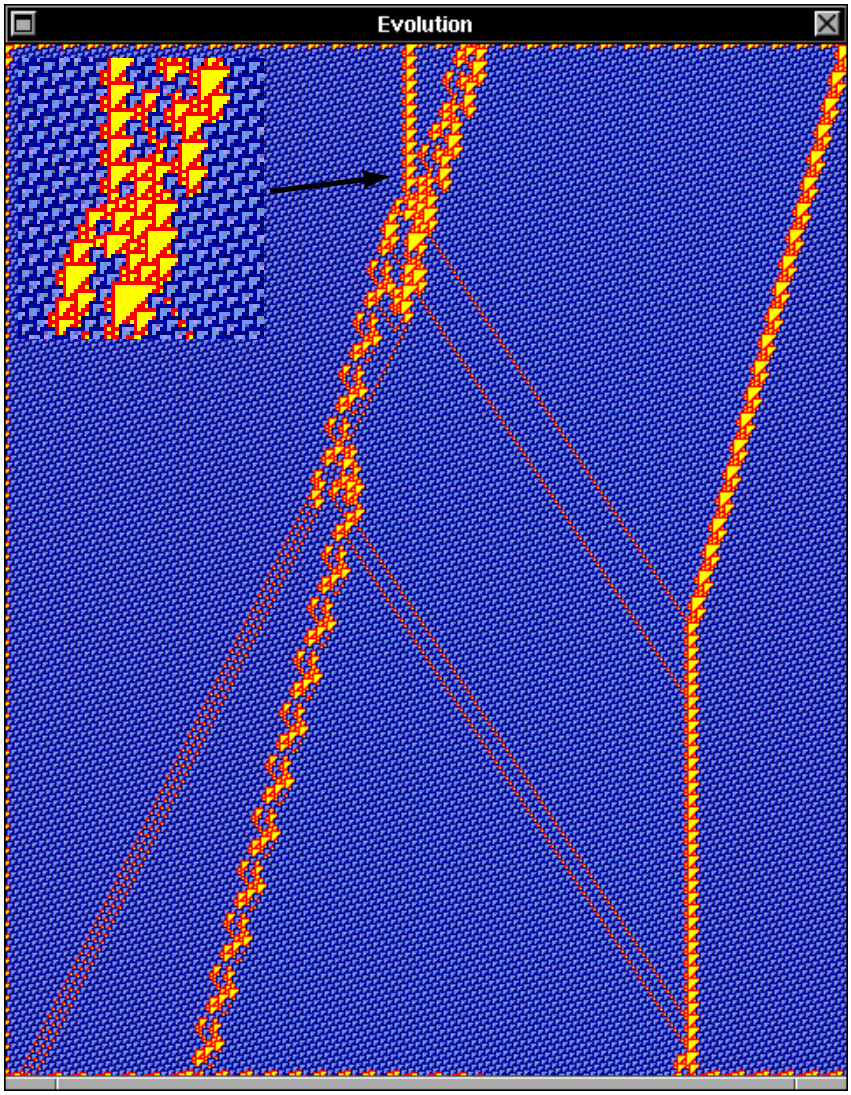

Figure 4.285: Collisions of glider C2, C2(p1)(A)-e(p1)-G(p1)(E)=A,A,3B,A,A,Ebar

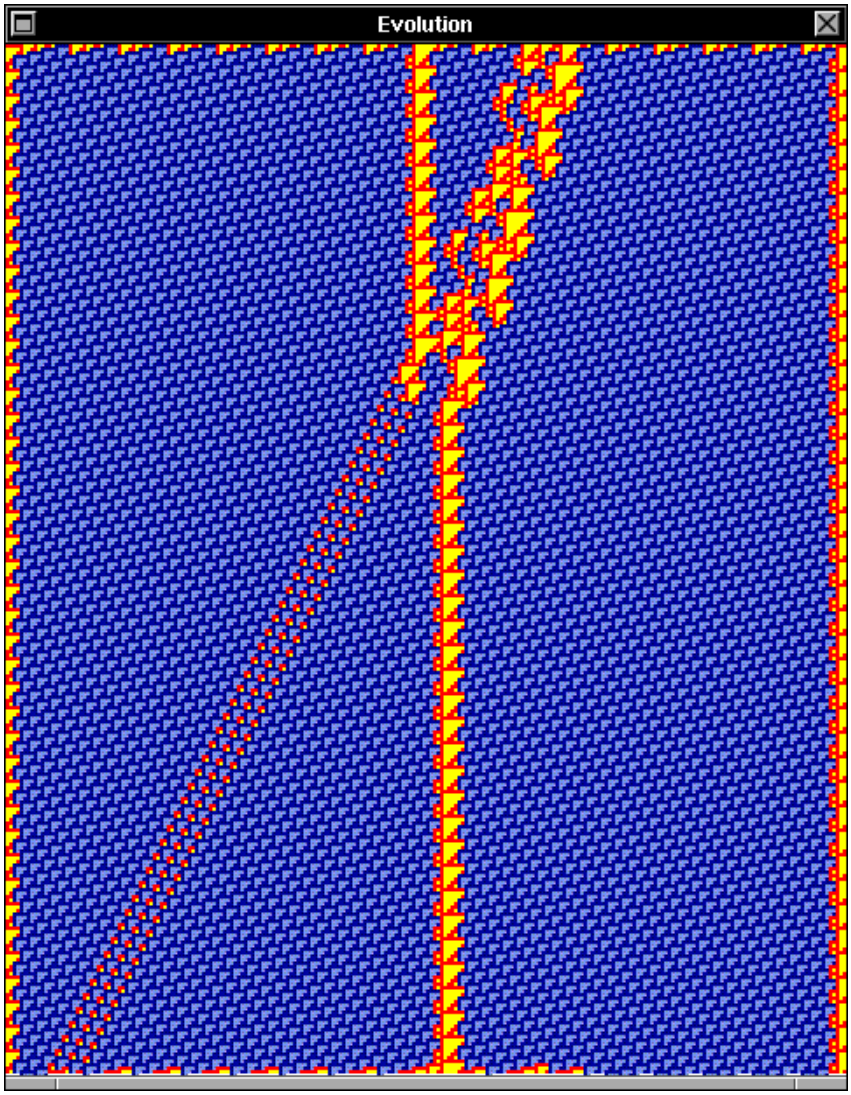

Figure 4.286: Collisions of glider C2, C2(p1)(A)-e(p1)-G(p1)(F)=3B,C2

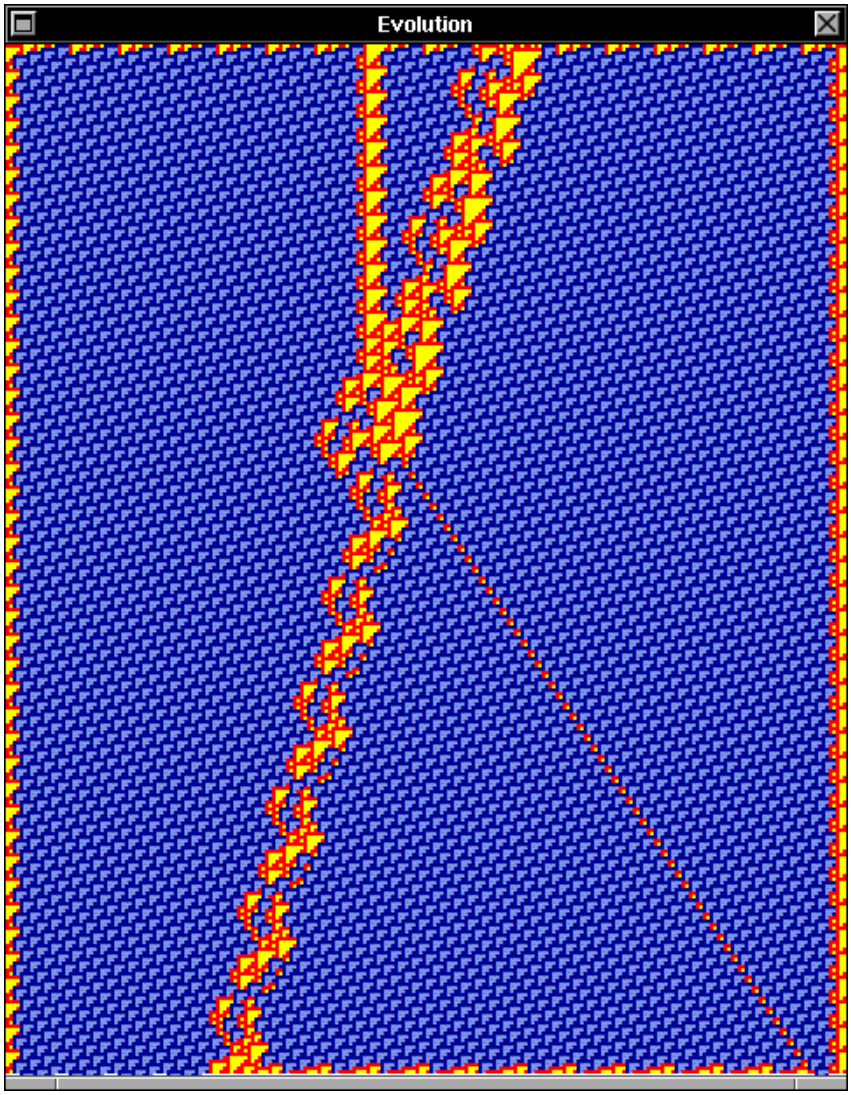

Figure 4.287: Collisions of glider C2, C2(p1)(A)-e(p1)-G(p1)(G)=A,Ebar

4.7.7 Collisions of glider C2 with glider H

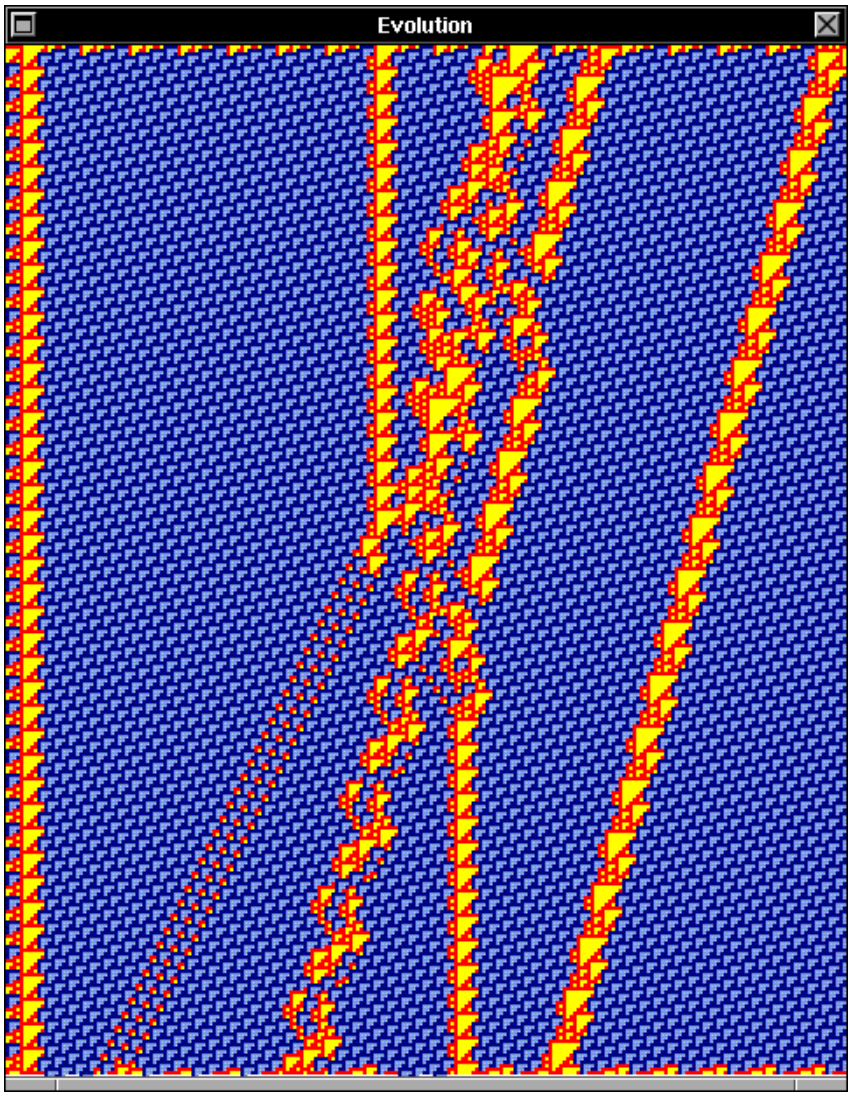

Figure 4.288: Collisions of glider C2, C2(p1)(A)-e(p1)-H(p1)(A)=3B,Ebar,C3

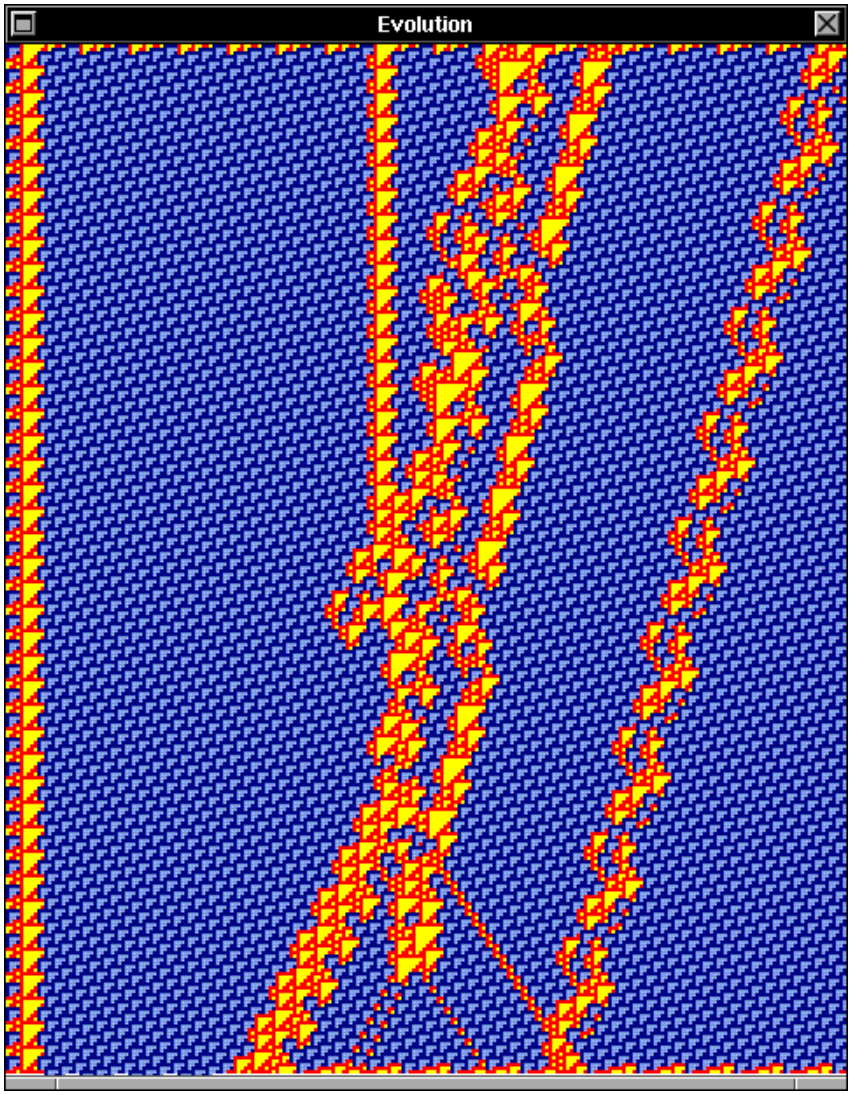

Figure 4.289: Collisions of glider C2, C2(p1)(A)-e(p1)-H(p1)(B)=Bbar,2A,2B,A

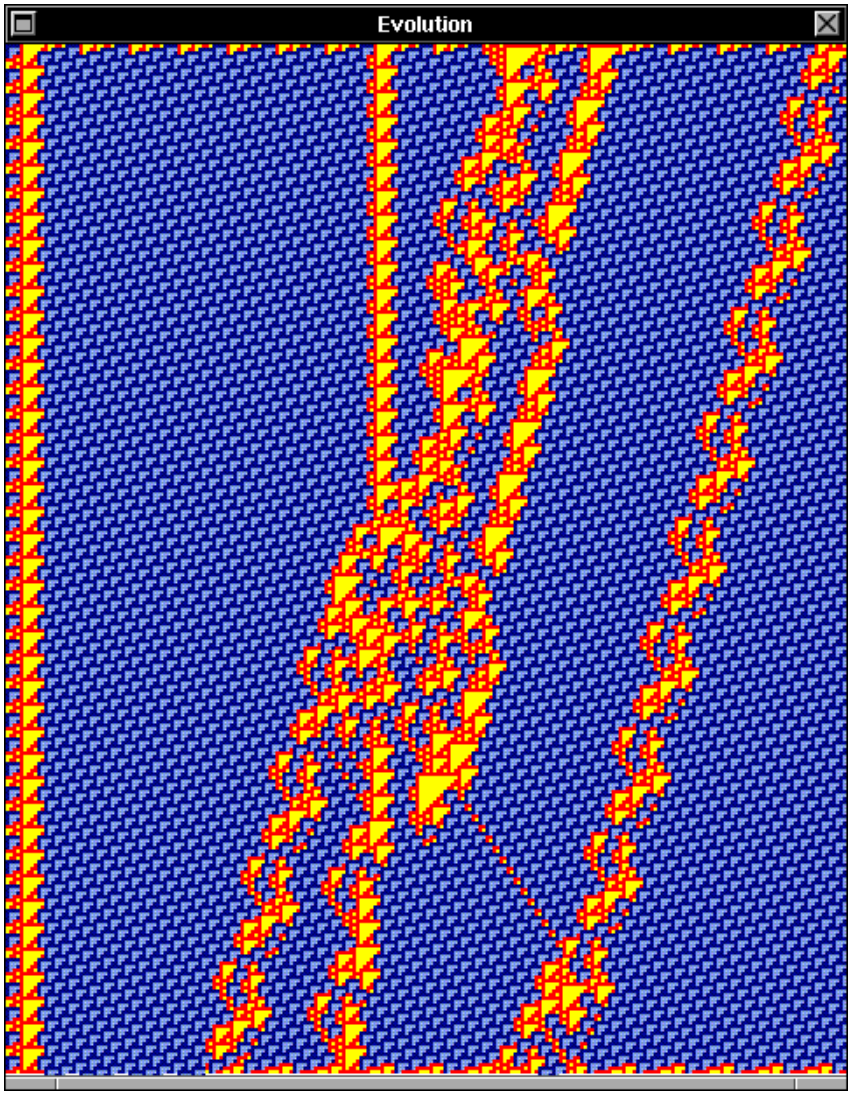

Figure 4.290: Collisions of glider C2, C2(p1)(A)-e(p1)-H(p1)(C)=Ebar,F,A

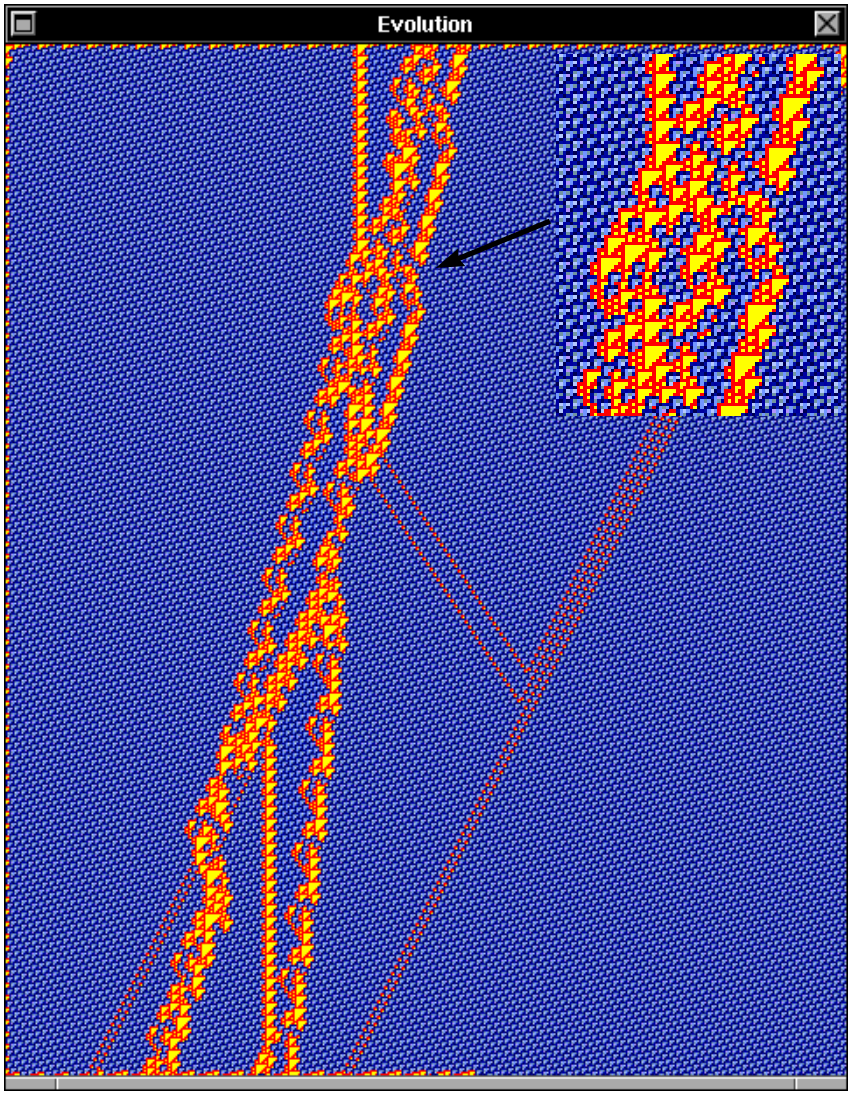

Figure 4.291: Collisions of glider C2, C2(p1)(A)-e(p1)-H(p1)(B2)=A,A,2B,G,F,C2

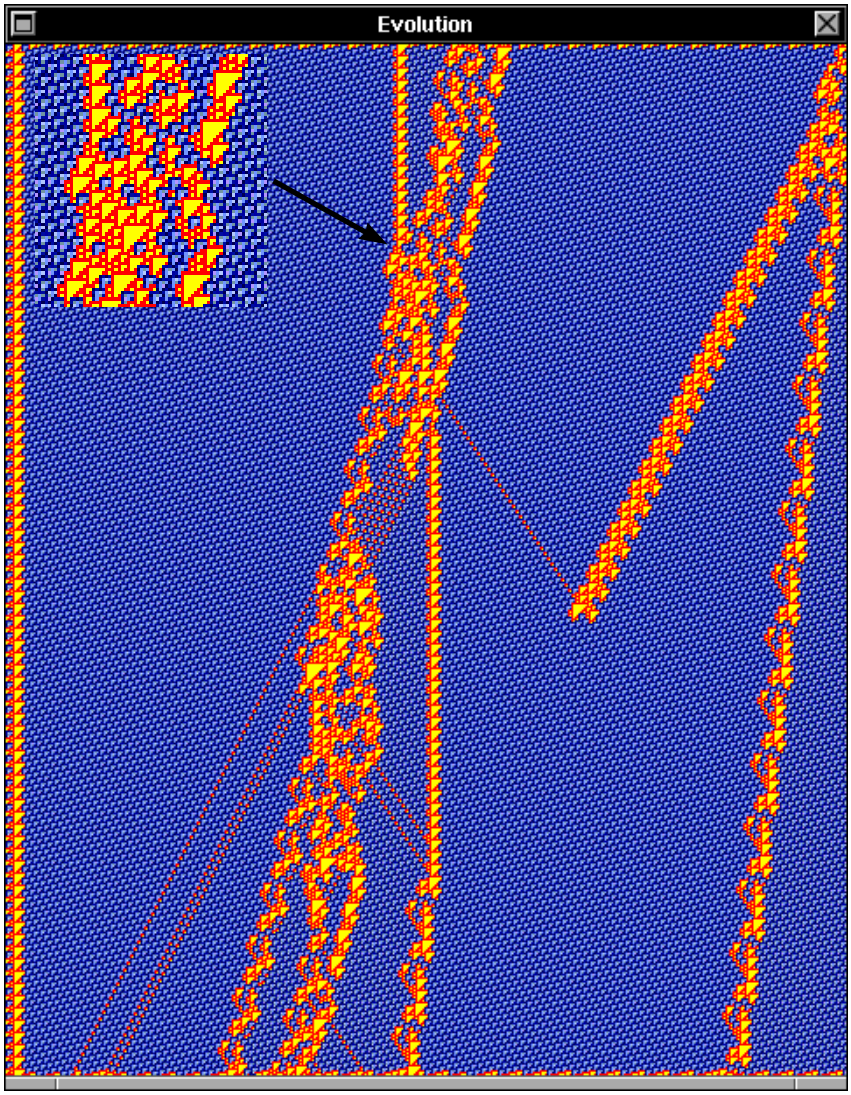

Figure 4.292: Collisions of glider C2, C2(p1)(A)-e(p1)-H(p1)(C2)=A,B,2B,B,G,F,Ebar

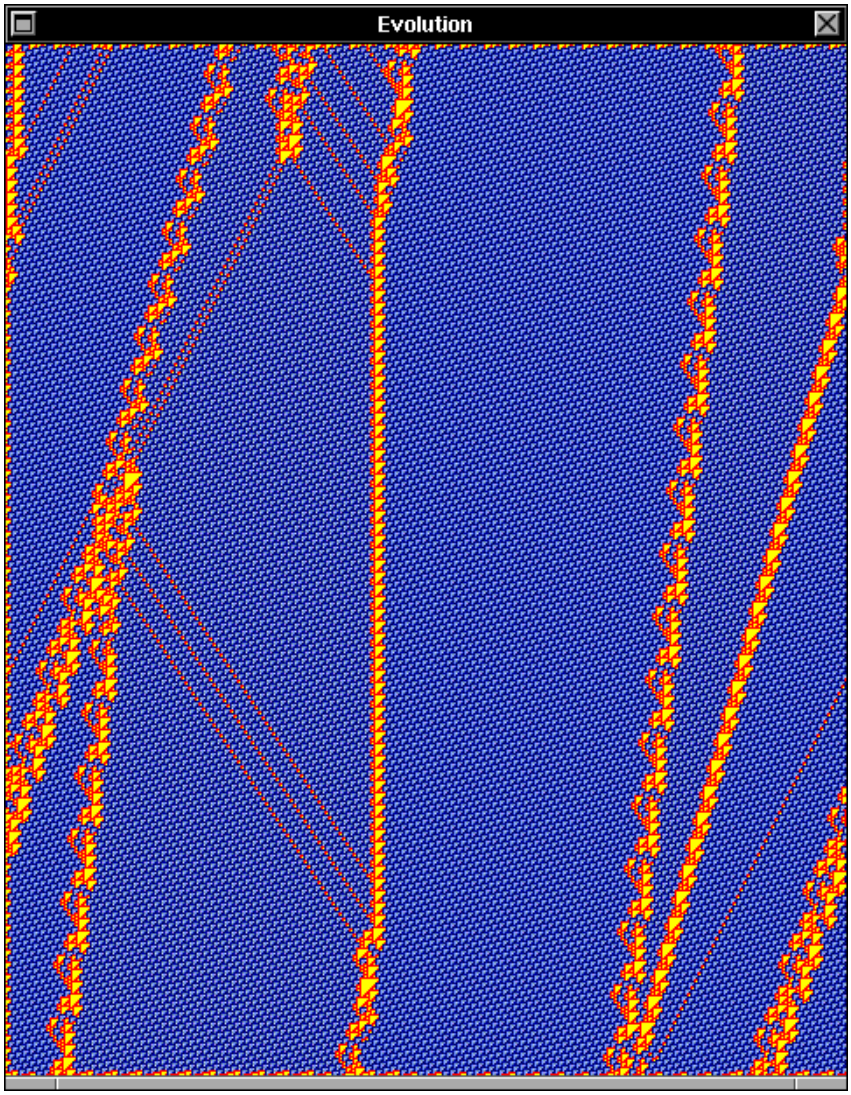

Figure 4.293: continue collision, C2(p1)(A)-e(p1)-H(p1)(C2)

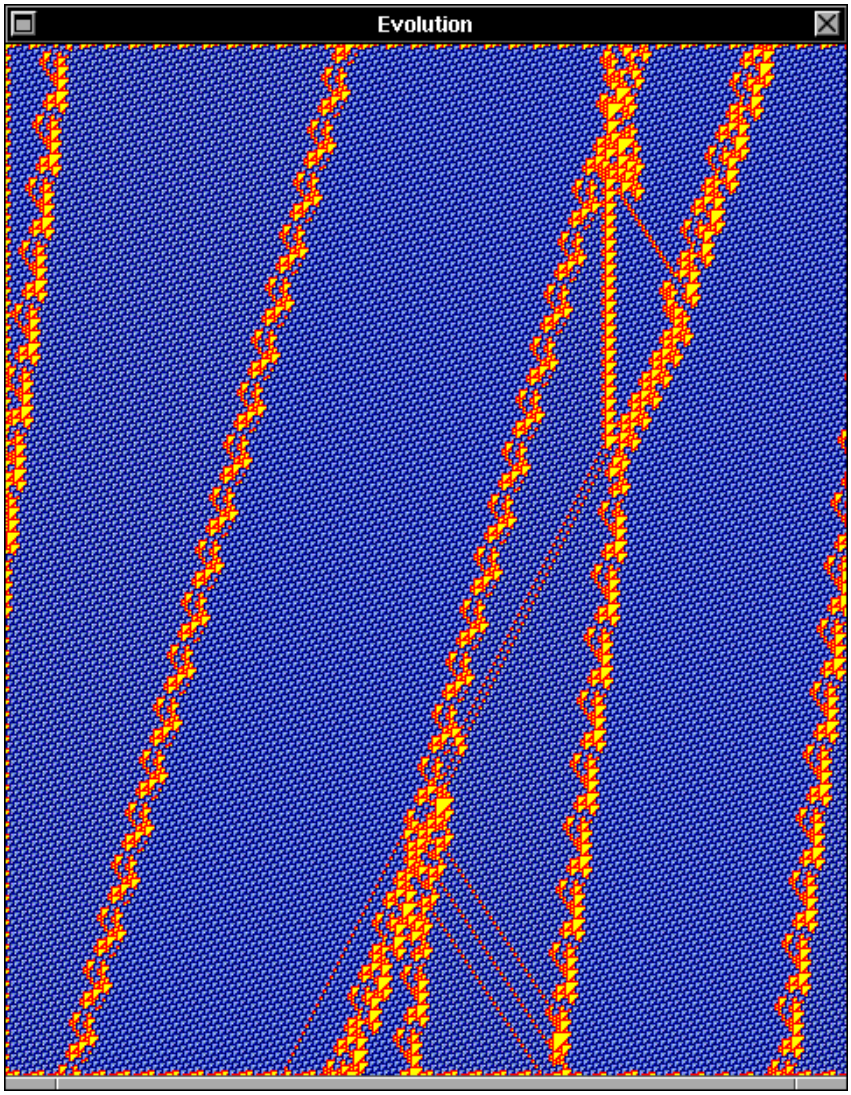

Figure 4.294: continue collision, C2(p1)(A)-e(p1)-H(p1)(C2)

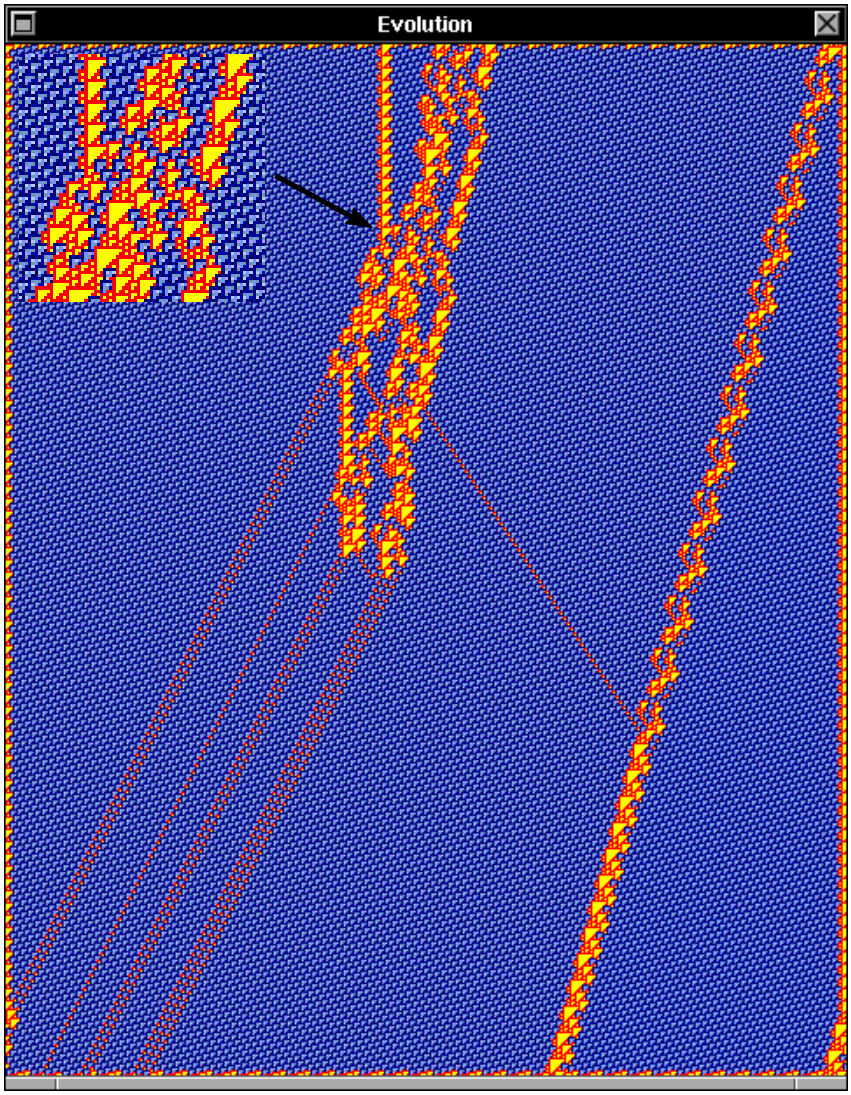

Figure 4.295: Collisions of glider C2, C2(p1)(A)-e(p1)-H(p1)(D2)=2B,A,B,2B,3B

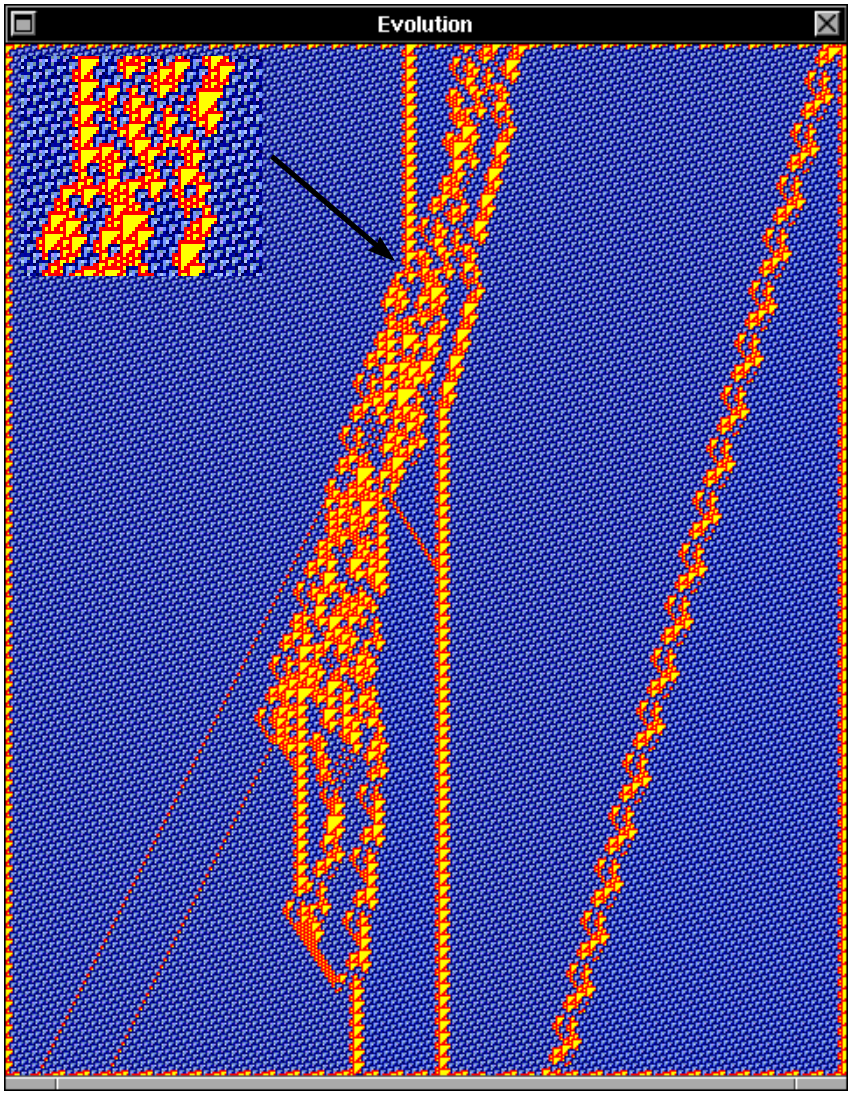

Figure 4.296: Collisions of glider C2, C2(p1)(A)-e(p1)-H(p1)(E2)=B,C1,B,C2

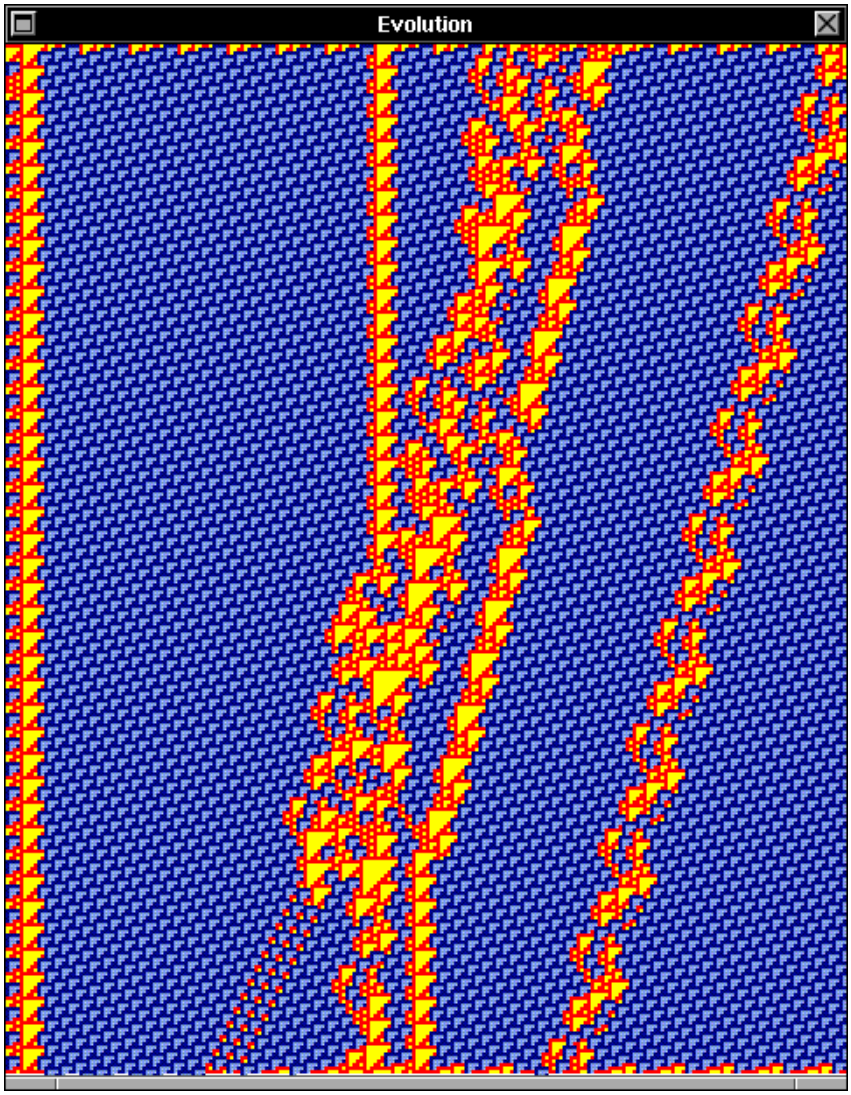

Figure 4.297: Collisions of glider C2, C2(p1)(A)-e(p1)-H(p1)(F2)=3B,F,C2

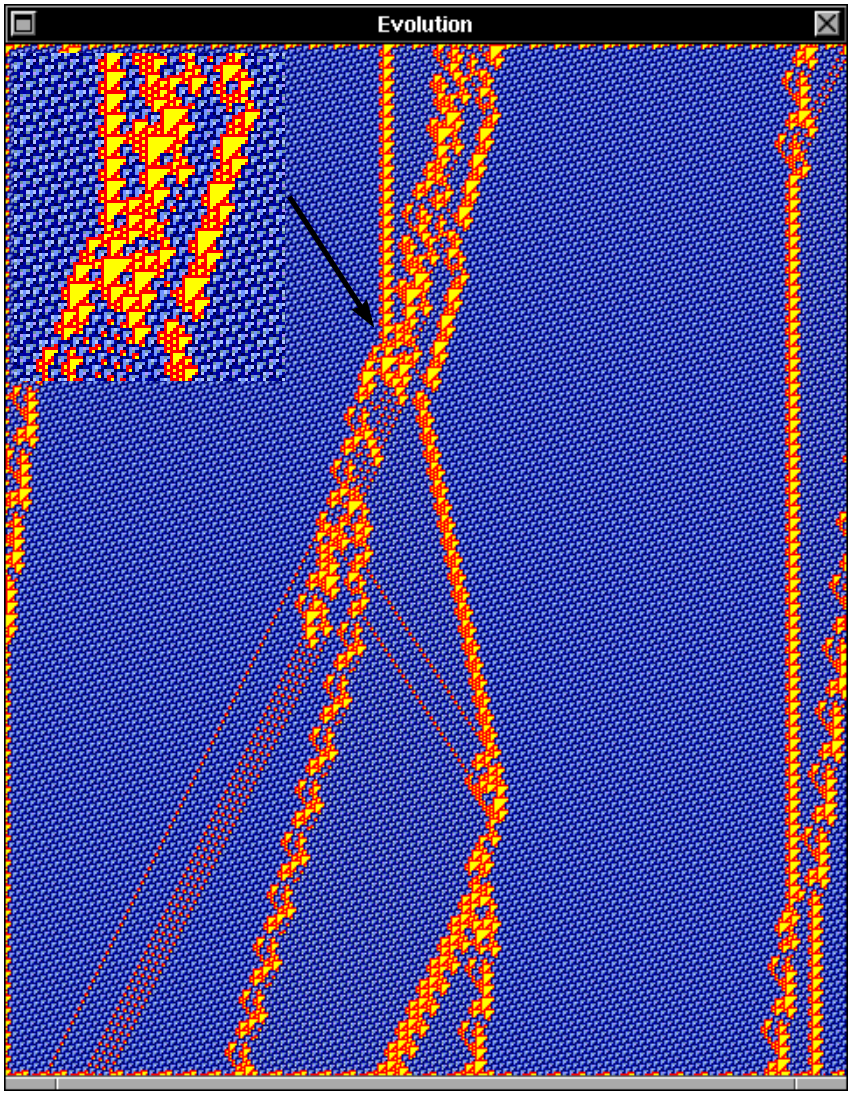

Figure 4.298: Collisions of glider C2, C2(p1)(A)-e(p1)-H(p1)(G2)=B,4B,Ebar,C1

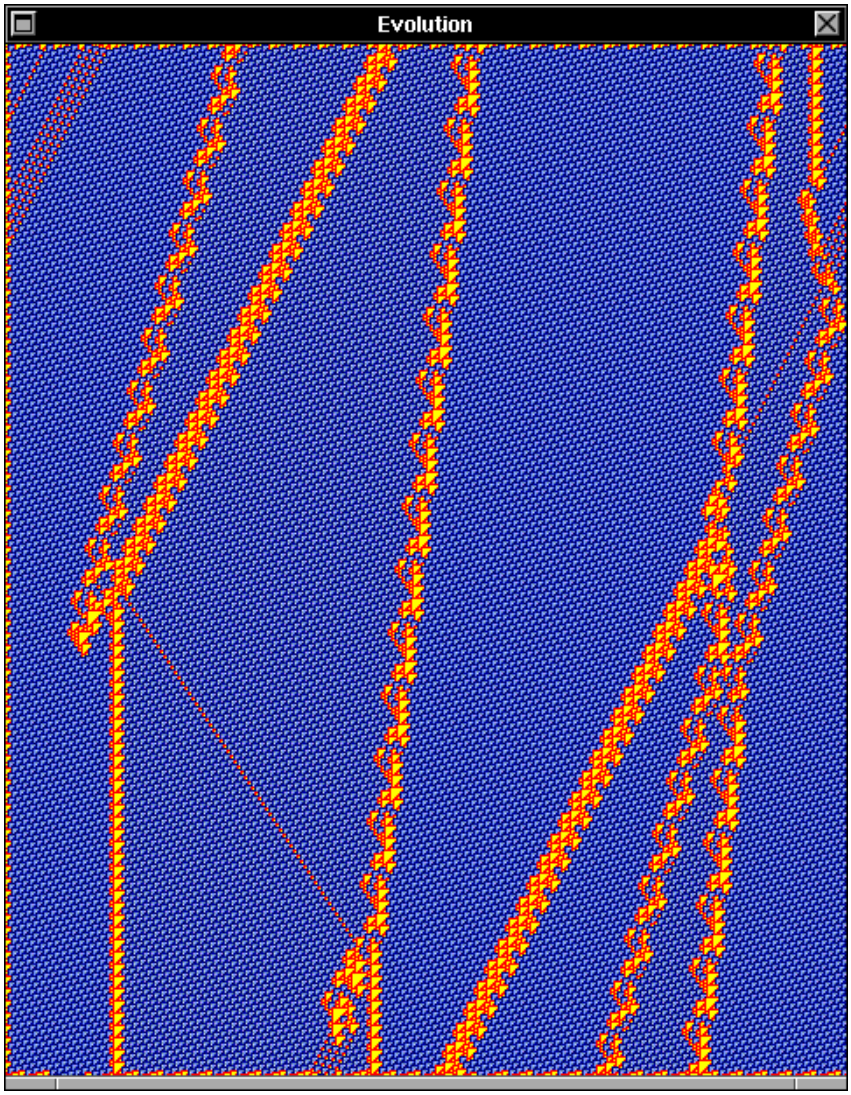

Figure 4.299: continue collision, C2(p1)(A)-e(p1)-H(p1)(G2)

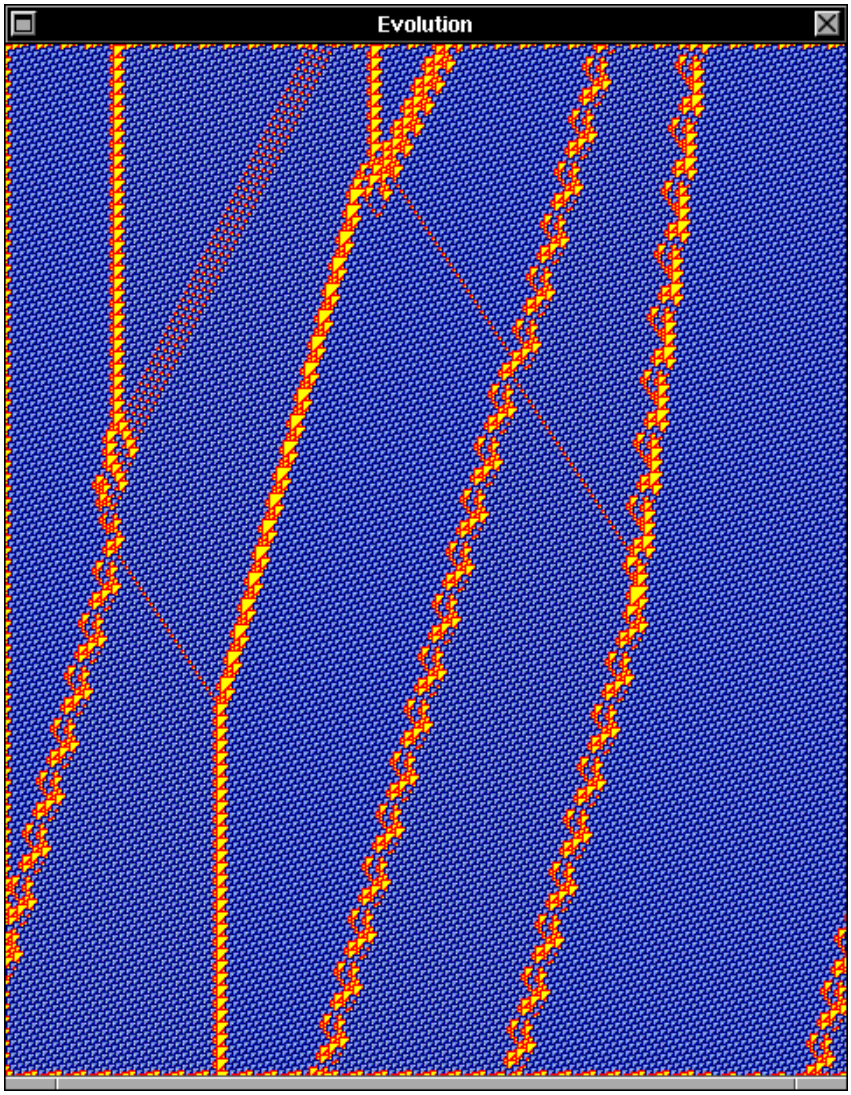

Figure 4.300: continue collision, C2(p1)(A)-e(p1)-H(p1)(G2)

4.8 Collisions of glider C3

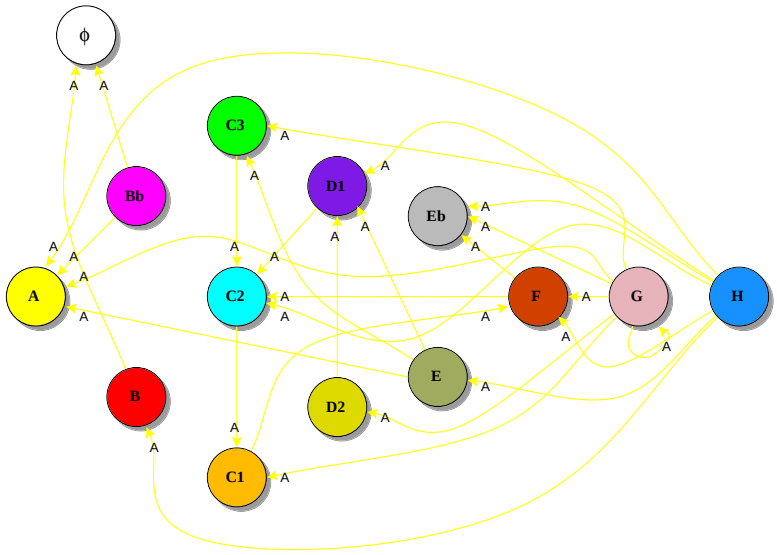

Figure 4.301: Collisions of glider C3

	ϕ	A	B	$Bbar$	$C3$	$C2$	$C1$	$D2$	$D1$	E	$Ebar$	F	G	H
ϕ	.	.	.	.	.	.	.	.	.	.	.	.	.	.
A	.	.	.	.	.	.	.	.	.	.	.	.	.	.
B	.	.	.	.	.	.	.	.	.	.	.	.	.	.
$Bbar$	.	.	.	.	.	.	.	.	.	.	.	.	.	.
$C3$	.	.	.	.	.	.	.	.	.	.	.	.	.	.
$C2$	.	.	.	.	.	.	.	.	.	.	.	.	.	.
$C1$	.	.	.	.	.	.	.	.	.	.	.	.	.	.
$D2$	.	.	.	.	.	.	.	.	.	.	.	.	.	.
$D1$	.	.	.	.	.	.	.	.	.	.	.	.	.	.
E	.	.	.	.	.	.	.	.	.	.	.	.	.	.
$Ebar$	.	.	.	.	.	.	.	.	.	.	.	.	.	.
F	.	.	.	.	.	.	.	.	.	.	.	.	.	.
G	.	.	.	.	.	.	.	.	.	.	.	.	.	.
H	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Table 4.7: Matrix connection of collisions glider C3

4.8.1 Collisions of glider C3 with glider D1

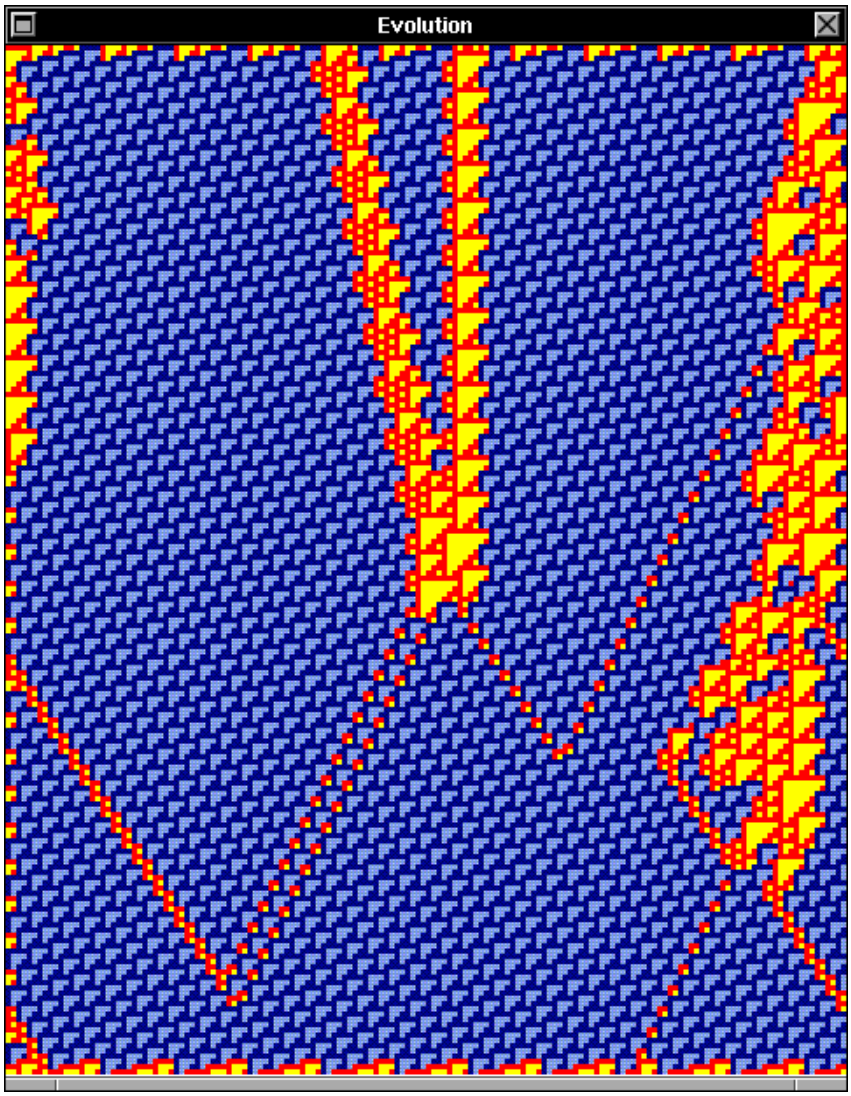

Figure 4.302: Collisions of glider C3, D1(p1)(A)-e(p1)-C3(p1)(A)=2B,A

4.8.2 Collisions of glider C3 with glider D2

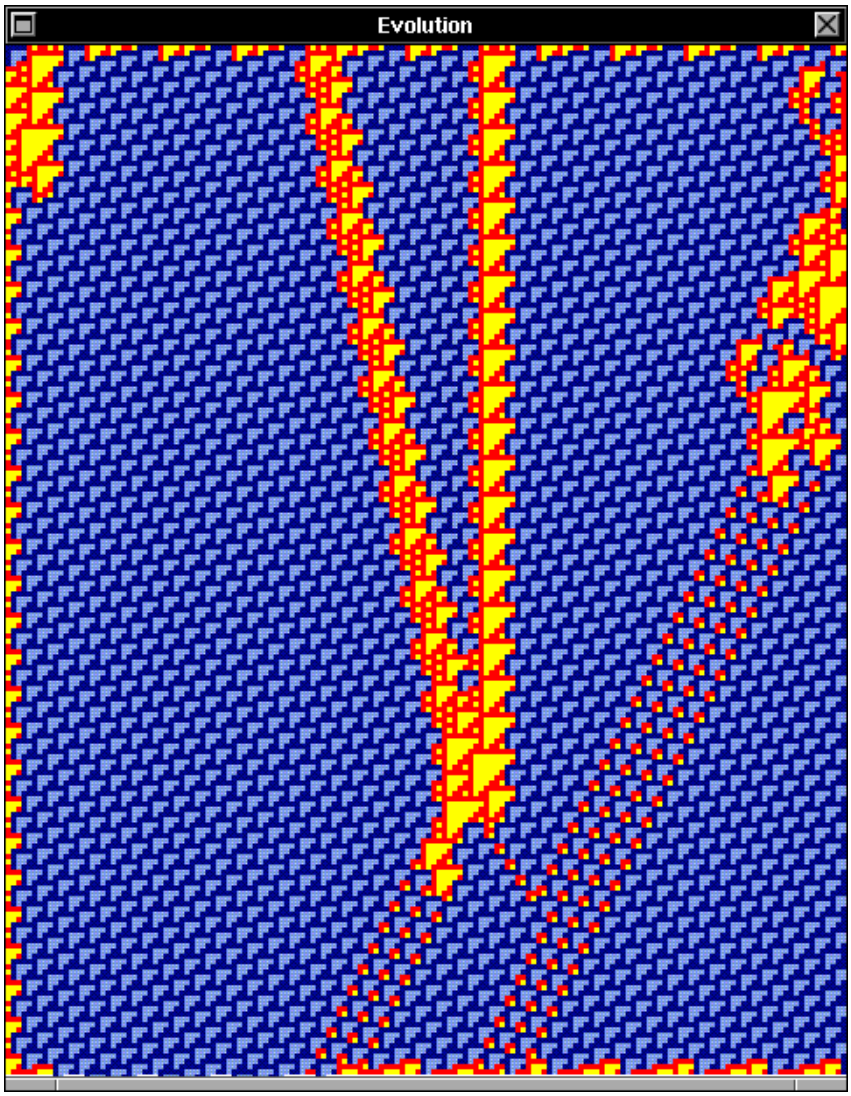

Figure 4.303: Collisions of glider C3, D2(p1)(A)-e(p1)-C3(p1)(A)=3B,A

4.8.3 Collisions of glider C3 with glider E

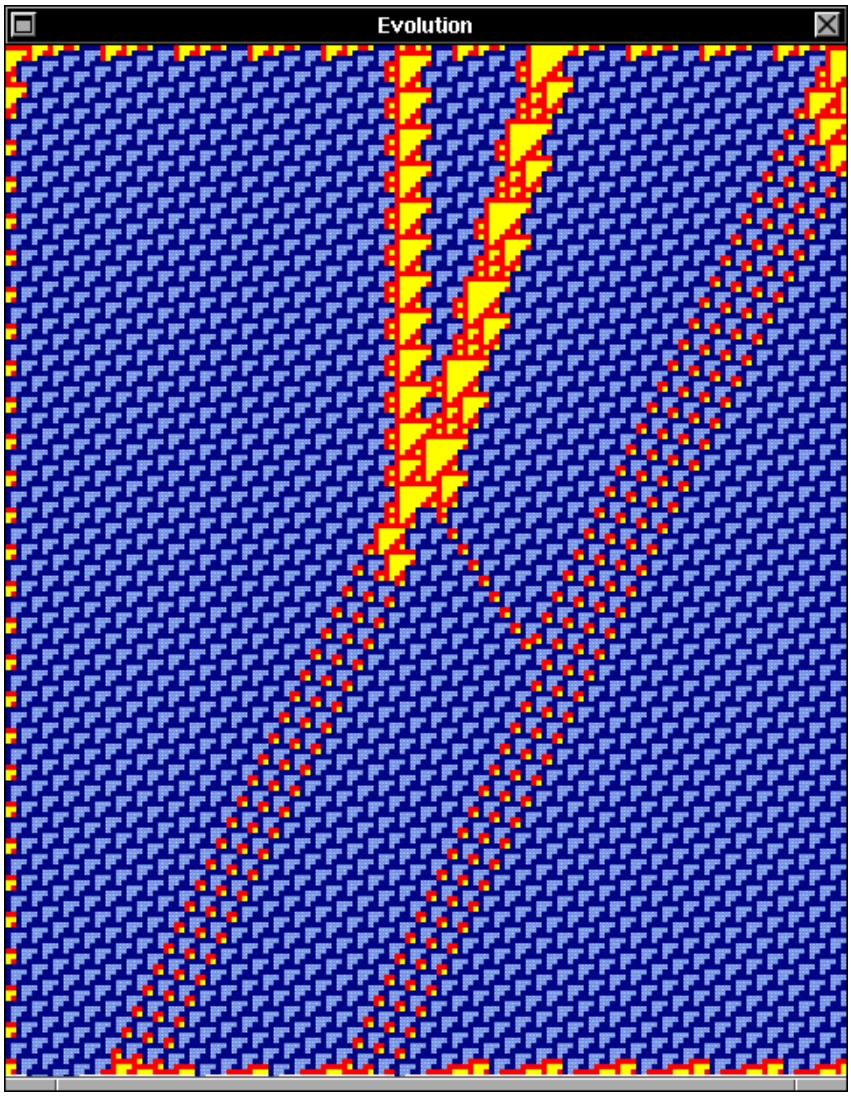

Figure 4.304: Collisions of glider C3, C3(p1)(A)-e(p1)-E(p1)(A)=3B,A

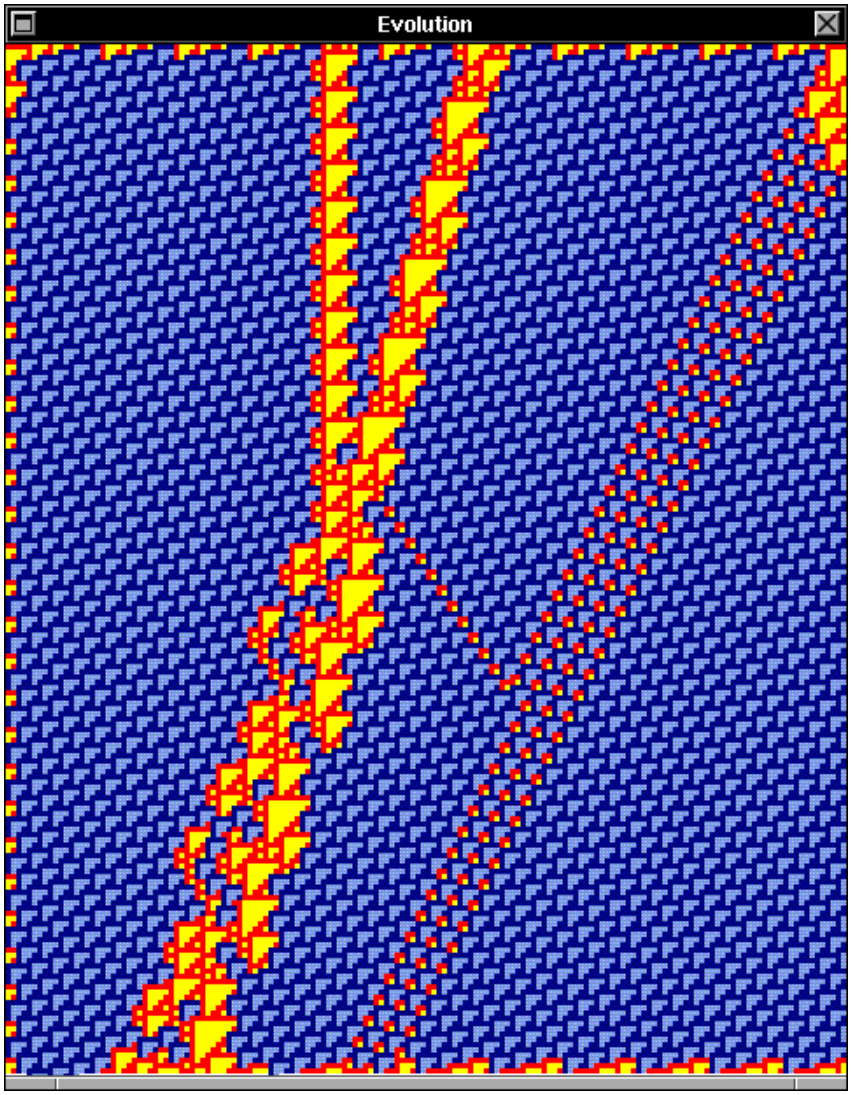

Figure 4.305: Collisions of glider C3, C3(p1)(A)-e(p1)-E(p1)(B)=A,G

4.8.4 Collisions of glider C3 with glider Ebar

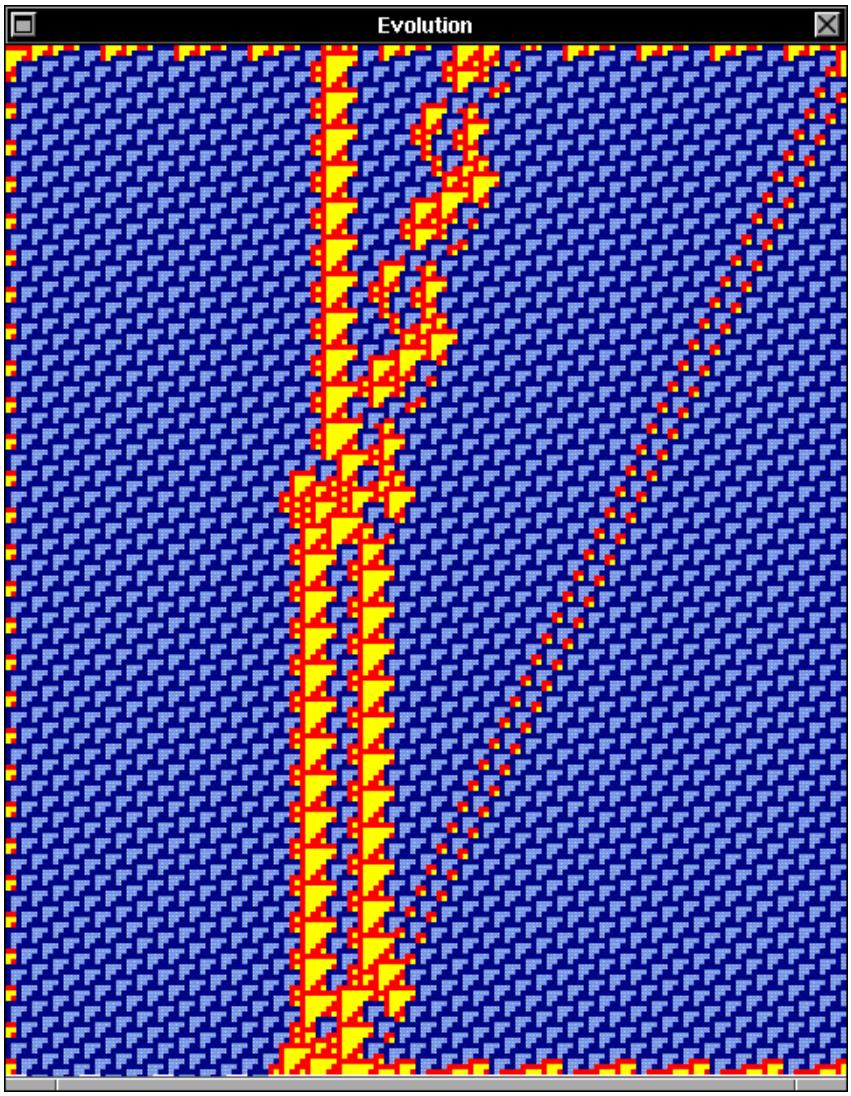

Figure 4.306: Collisions of glider C3, C3(p1)(A)-e(p1)-Ebar(p1)(A)=C1,C1

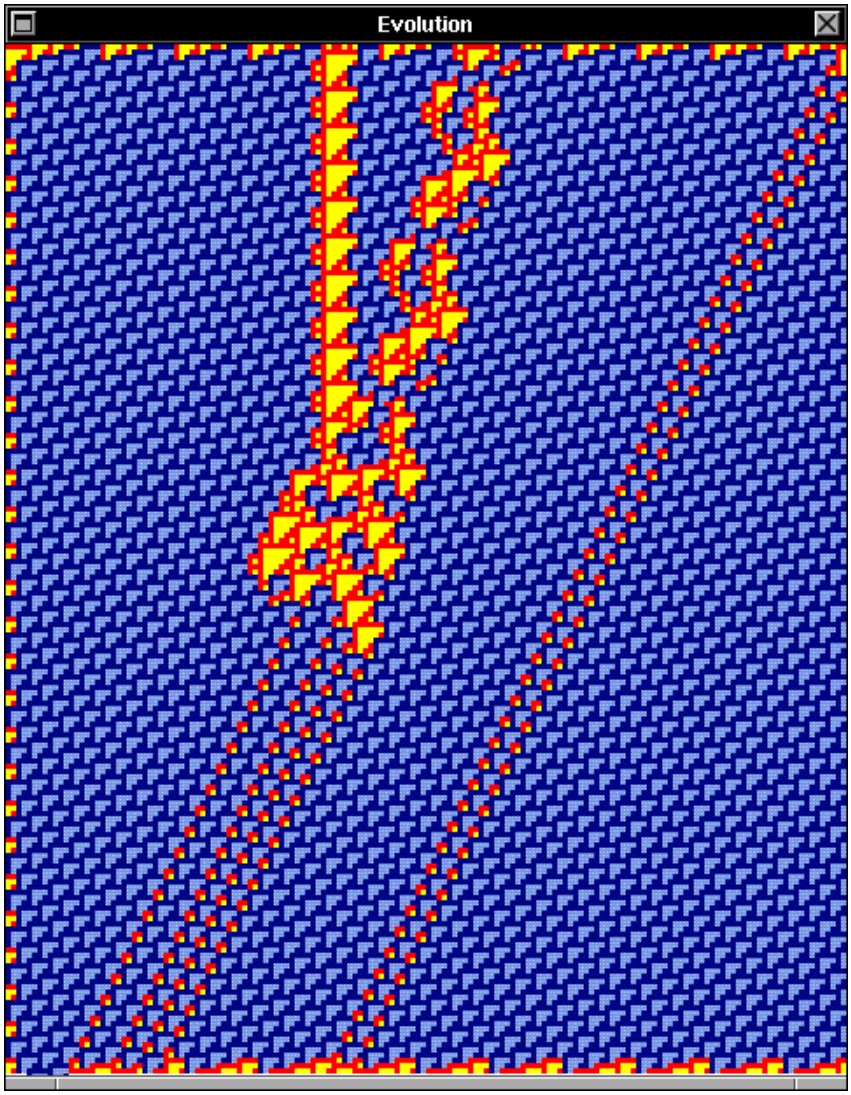

Figure 4.307: Collisions of glider C3, C3(p1)(A)-e(p1)-Ebar(p1)(B)=B,3B

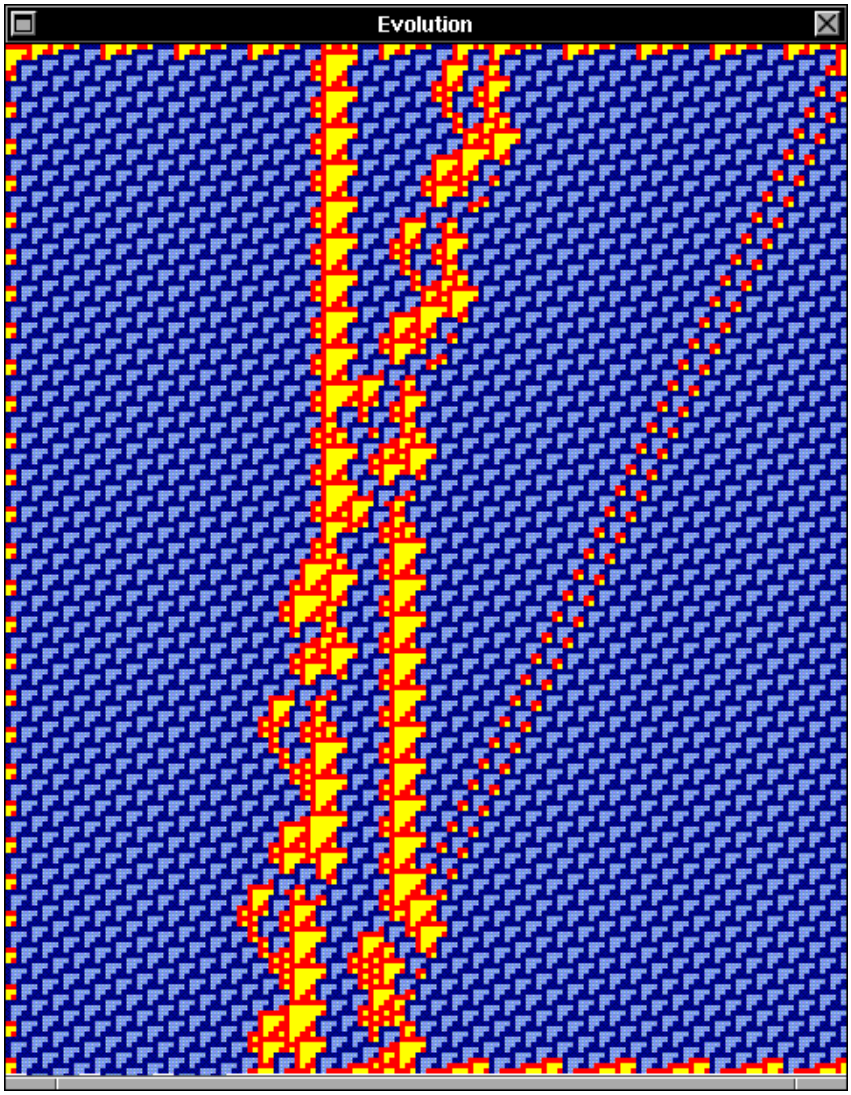

Figure 4.308: Collisions of glider C3, C3(p1)(A)-e(p1)-Ebar(p1)(C)=F,C2

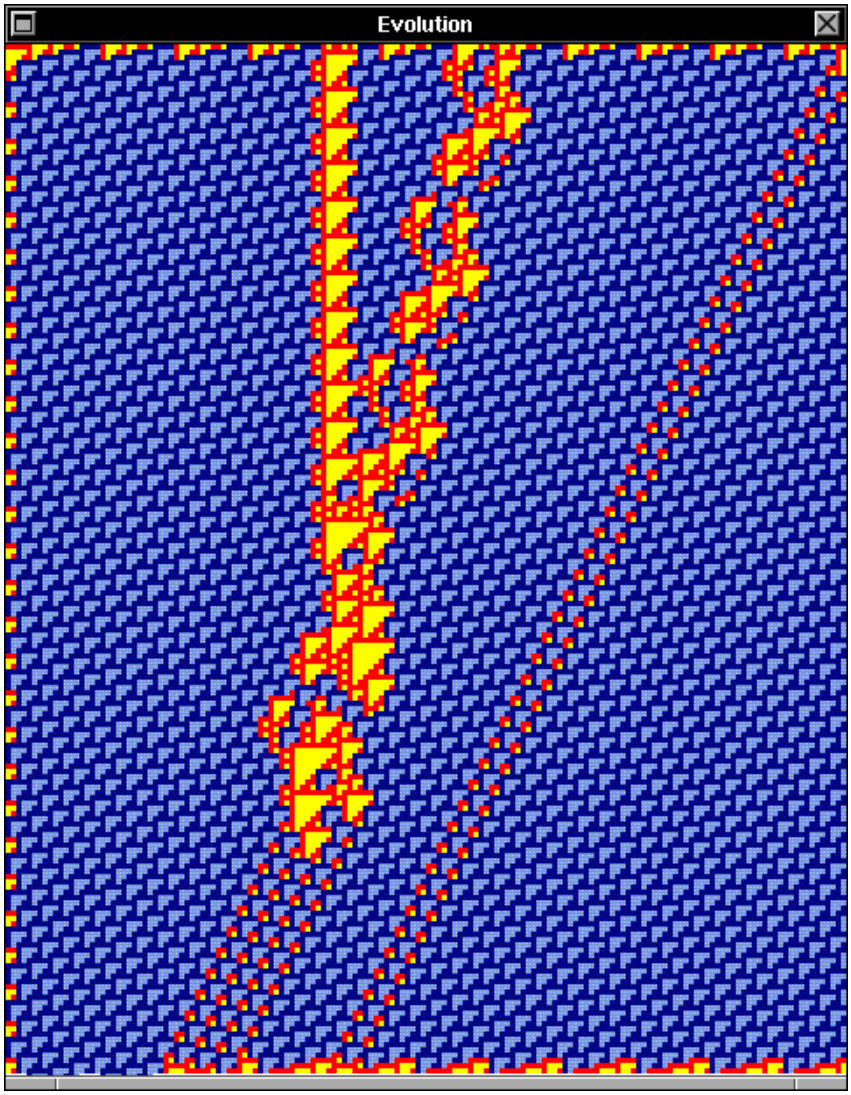

Figure 4.309: Collisions of glider C3, C3(p1)(A)-e(p1)-Ebar(p1)(D)=4B

4.8.5 Collisions of glider C3 with glider F

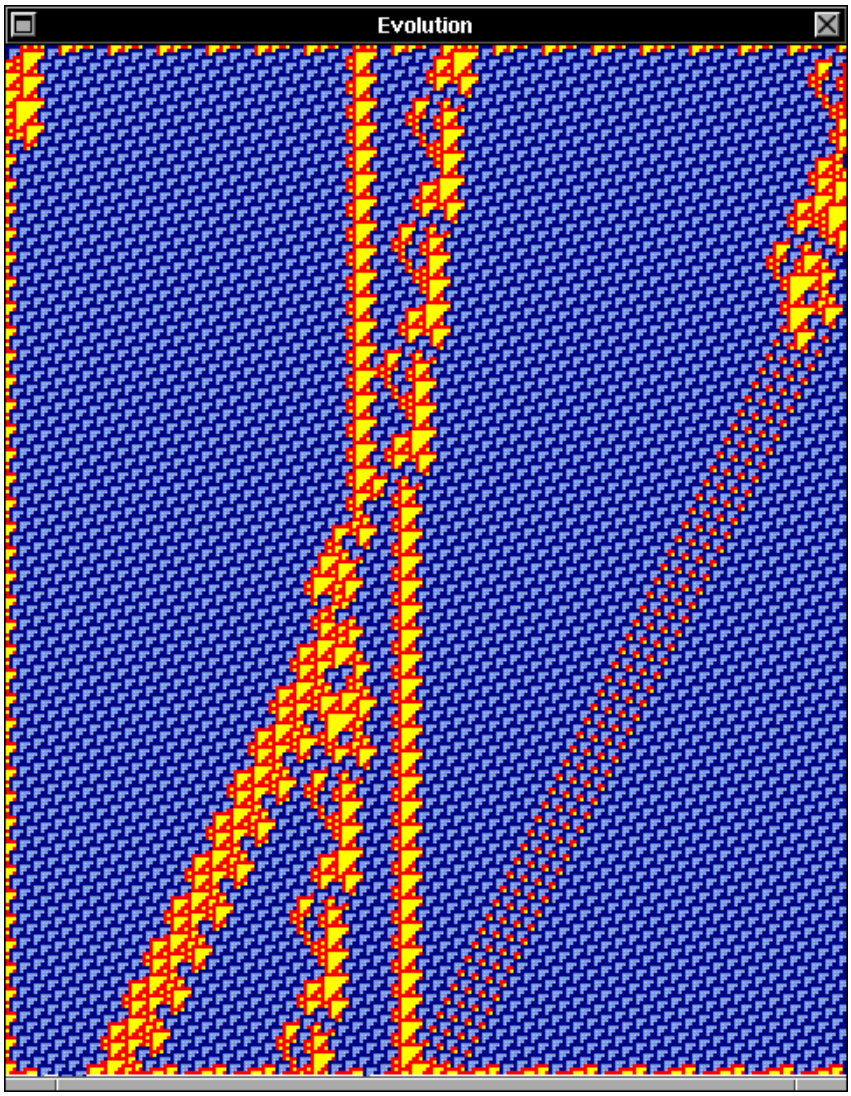

Figure 4.310: Collisions of glider C3, C3(p1)(A)-e(p1)-F(p1)(A)=Bbar,F,C2

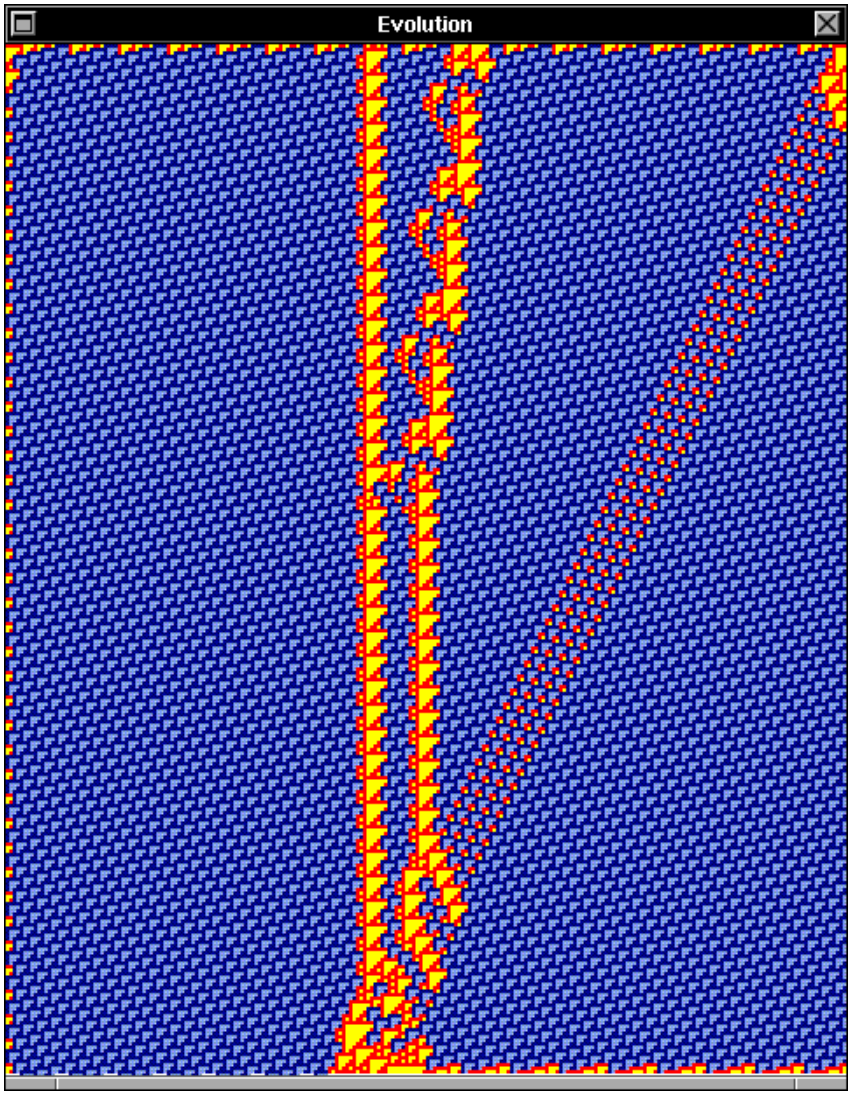

Figure 4.311: Collisions of glider C3, C3(p1)(A)-e(p1)-F(p1)(B)=C2,C1

4.8.6 Collisions of glider C3 with glider G

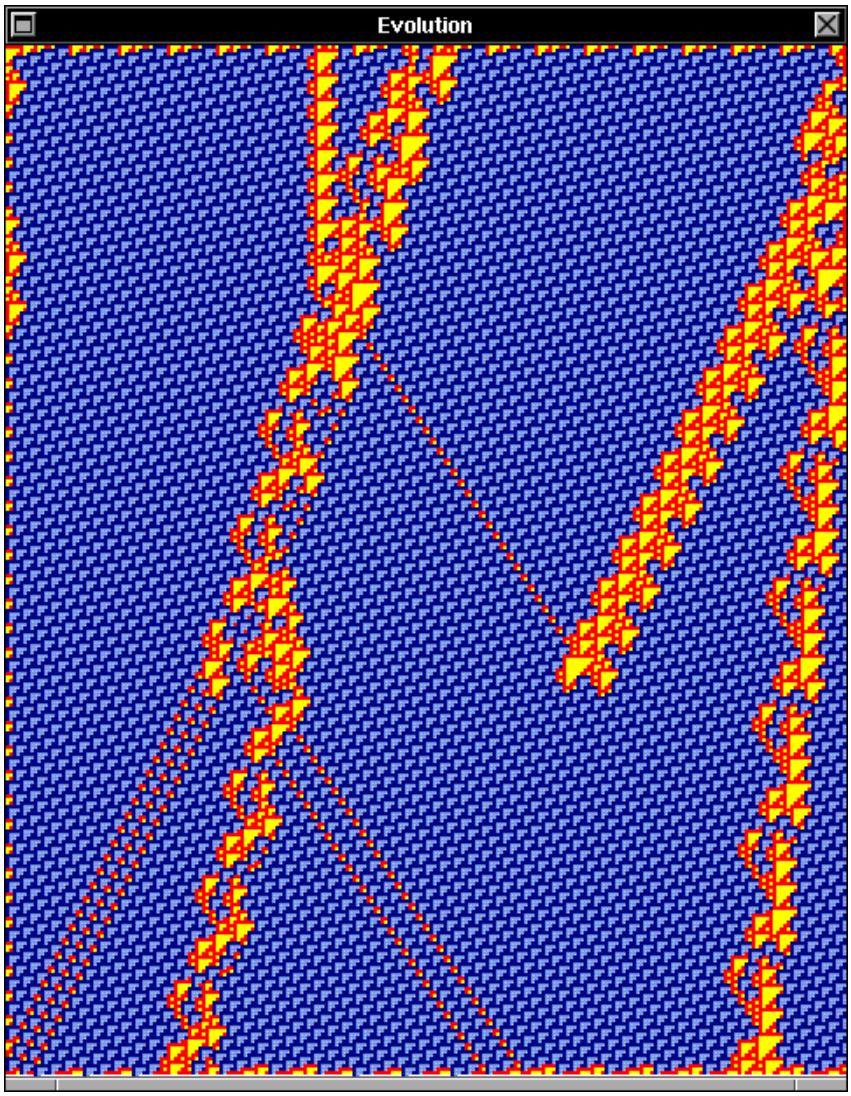

Figure 4.312: Collisions of glider C3, C3(p1)(A)-e(p1)-G(p1)(A)=A,3B,A,A,Ebar

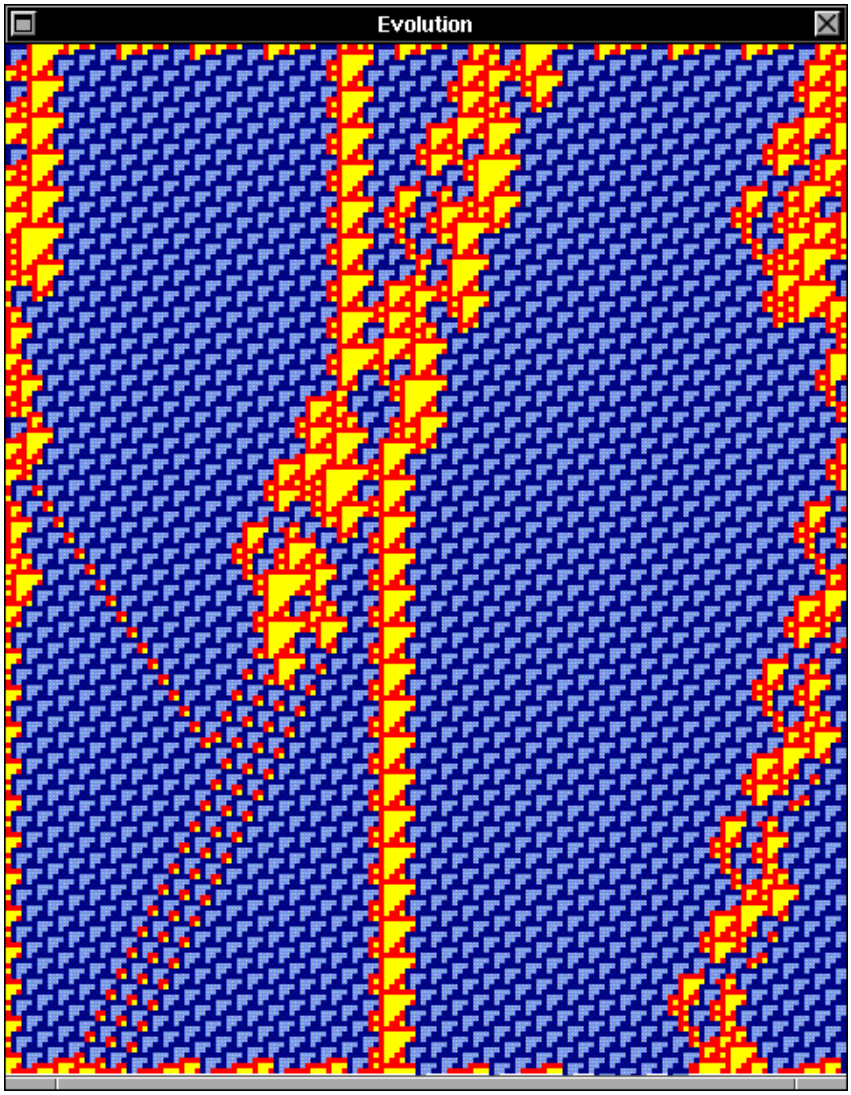

Figure 4.313: Collisions of glider C3, C3(p1)(A)-e(p1)-G(p1)(B)=C2,4B

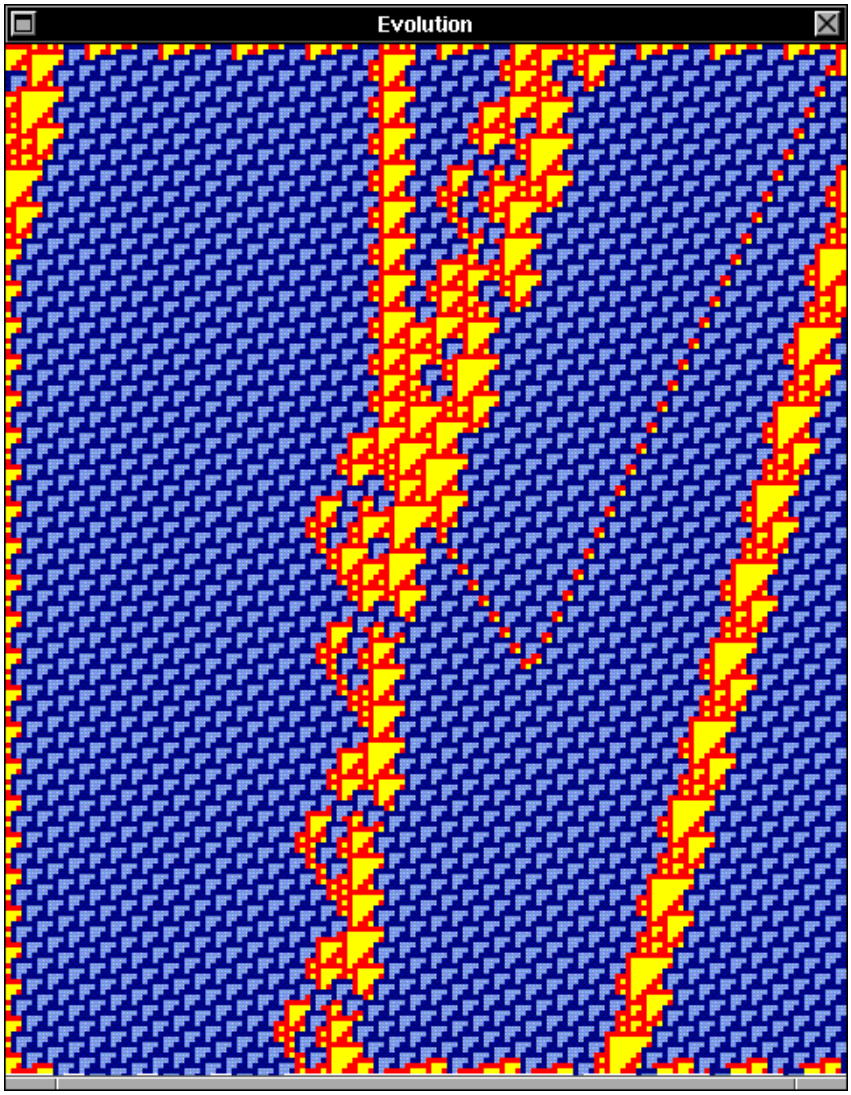

Figure 4.314: Collisions of glider C3, C3(p1)(A)-e(p1)-G(p1)(C)=A,F

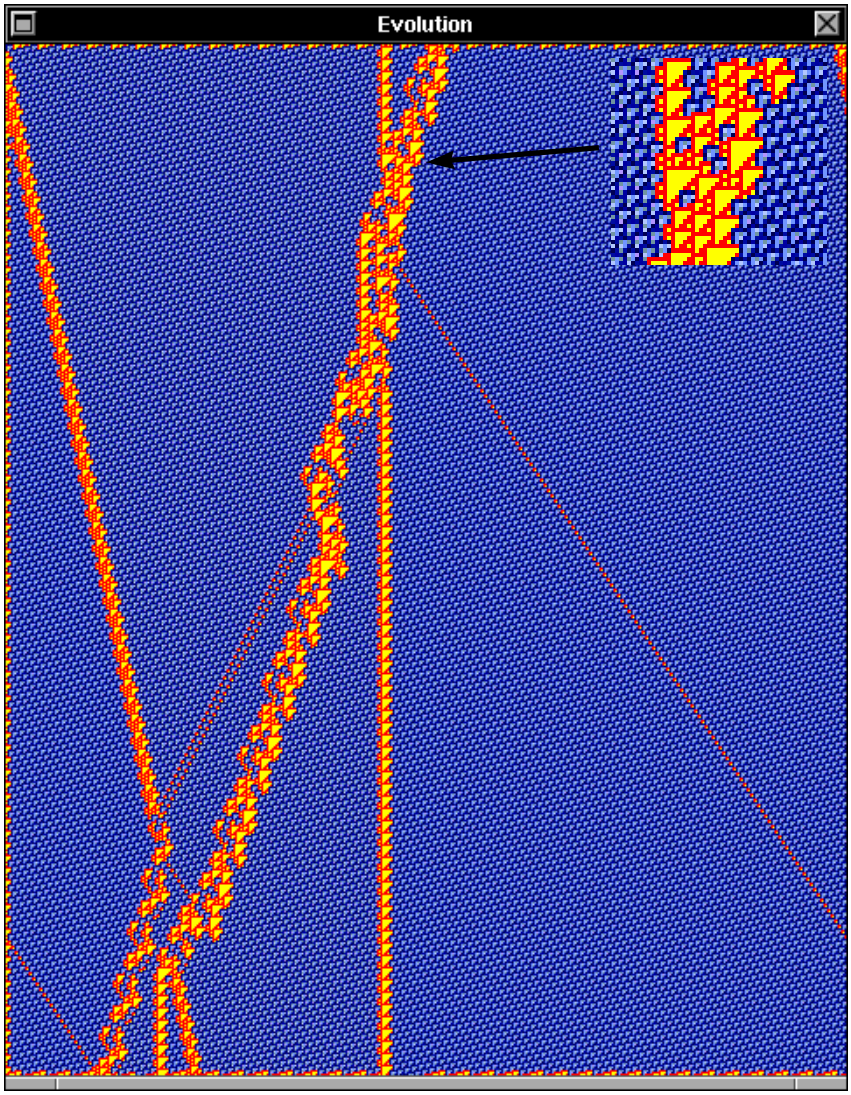

Figure 4.315: Collisions of glider C3, C3(p1)(A)-e(p1)-G(p1)(D)=A,C2,2B,G

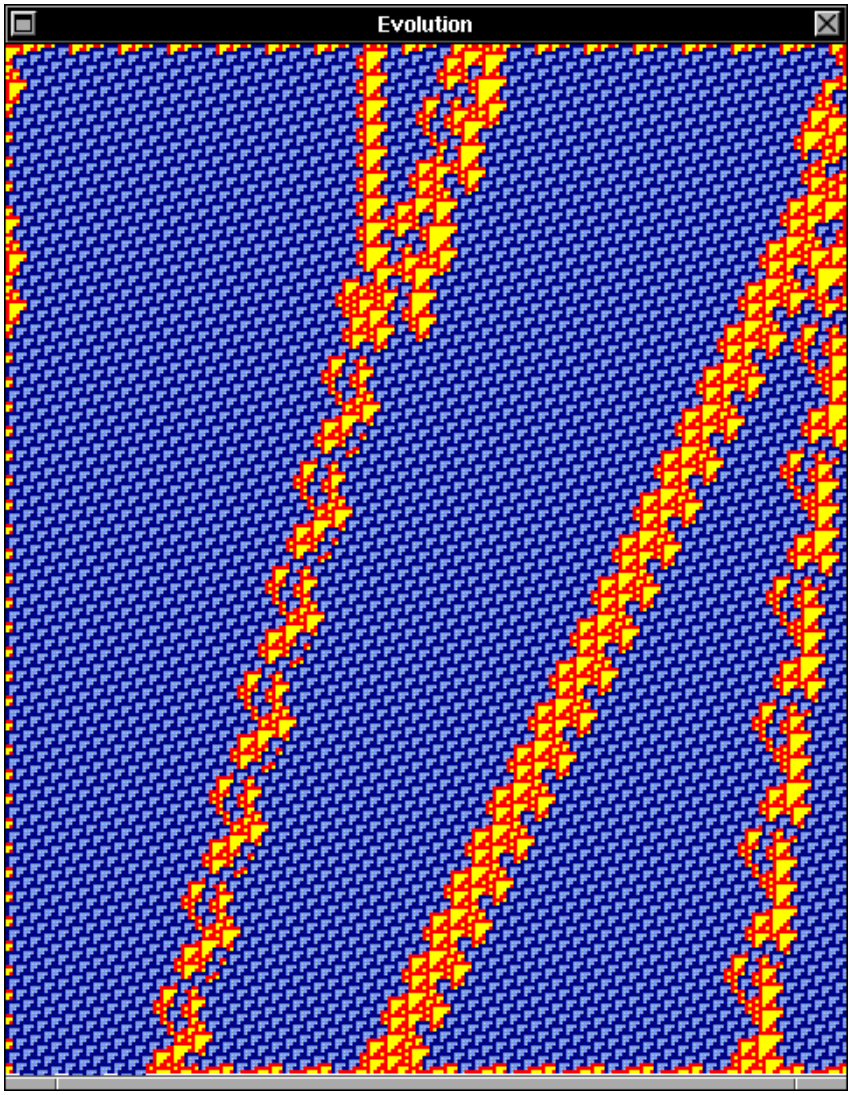

Figure 4.316: Collisions of glider C3, C3(p1)(A)-e(p1)-G(p1)(E)=Ebar

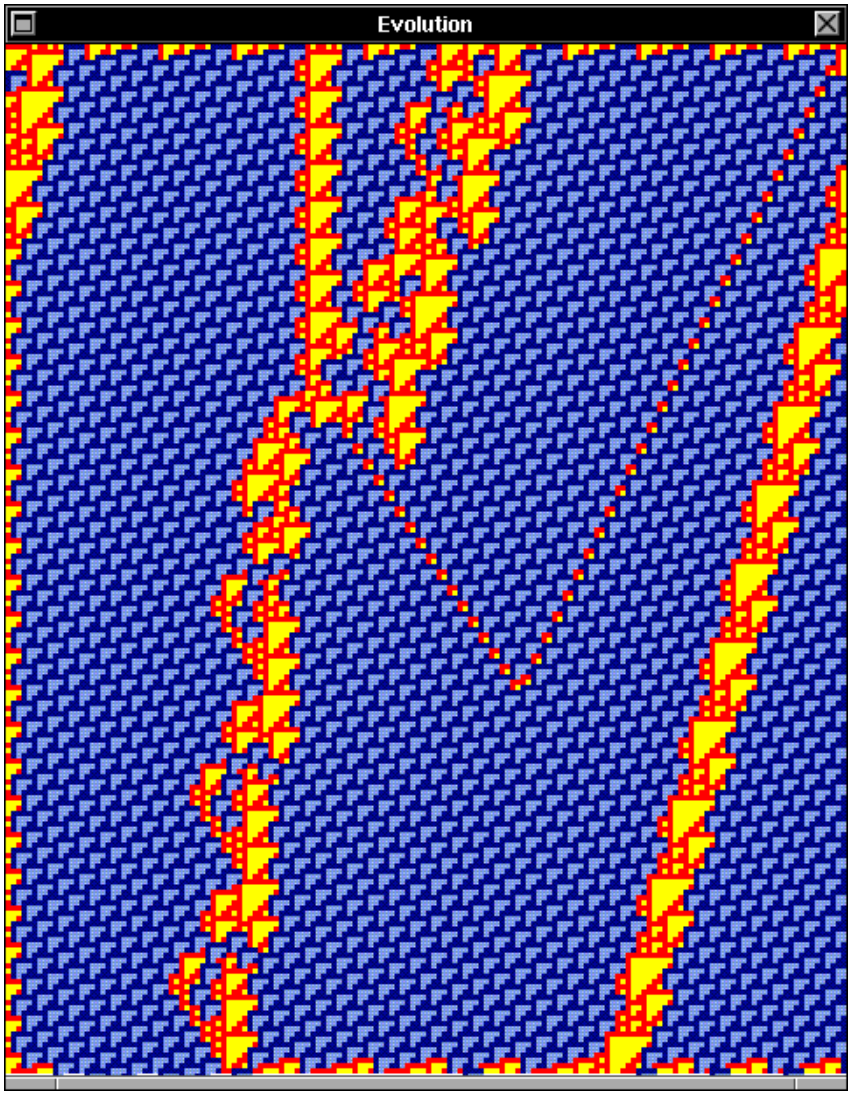

Figure 4.317: Collisions of glider C3, C3(p1)(A)-e(p1)-G(p1)(F)=A,F

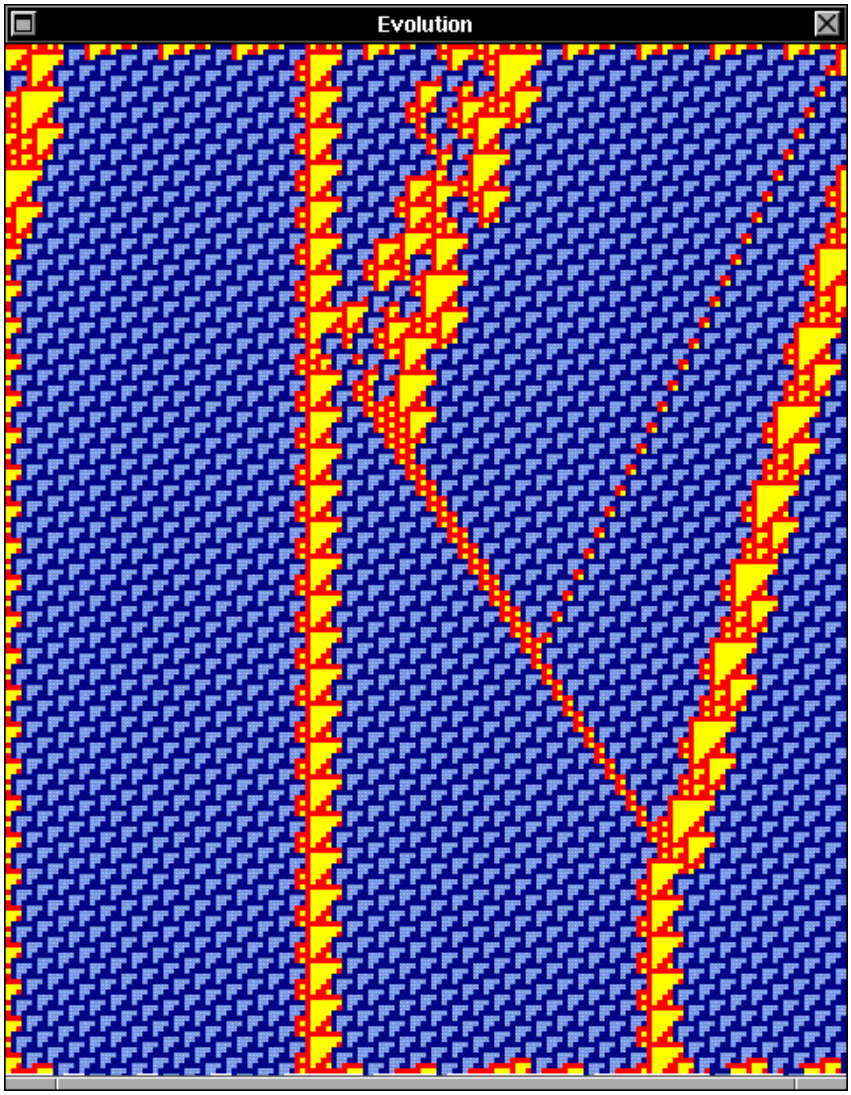

Figure 4.318: Collisions of glider C3, C3(p1)(A)-e(p1)-G(p1)(G)=C2,3A

4.8.7 Collisions of glider C3 with glider H

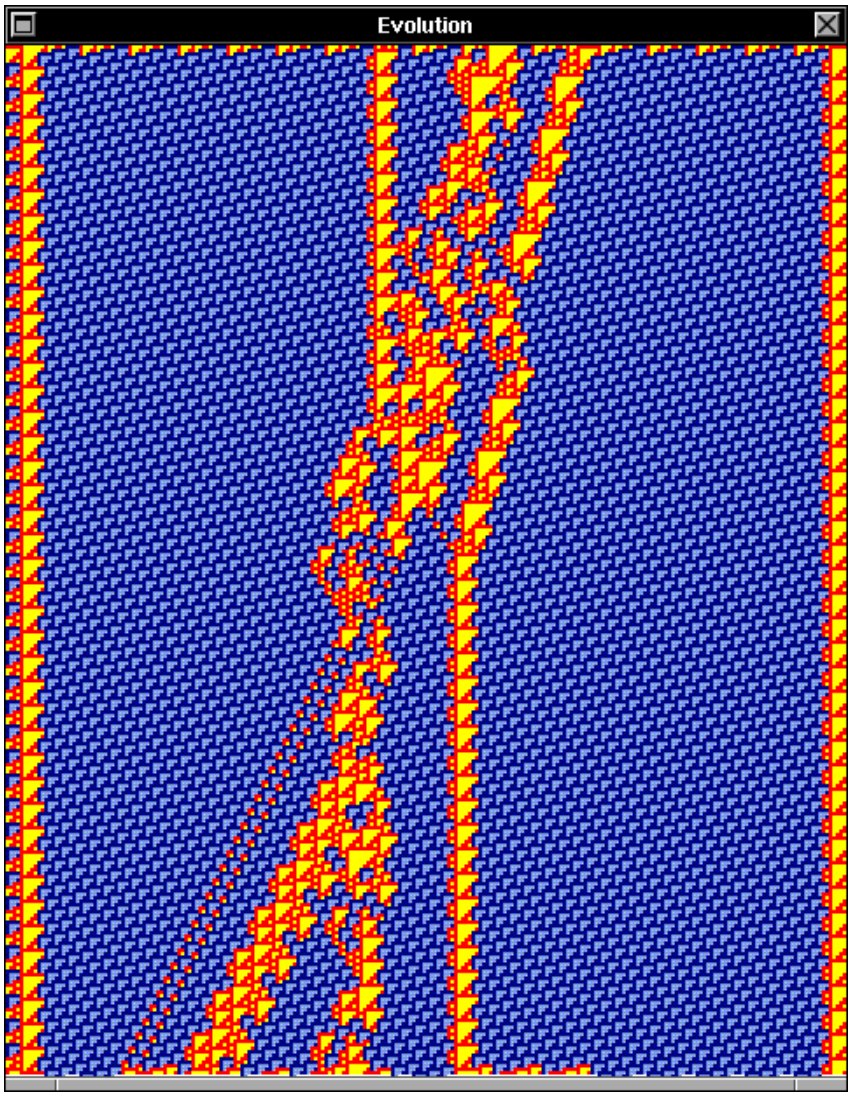

Figure 4.319: Collisions of glider C3, C3(p1)(A)-e(p1)-H(p1)(A)=C3,2B,Bbar,F

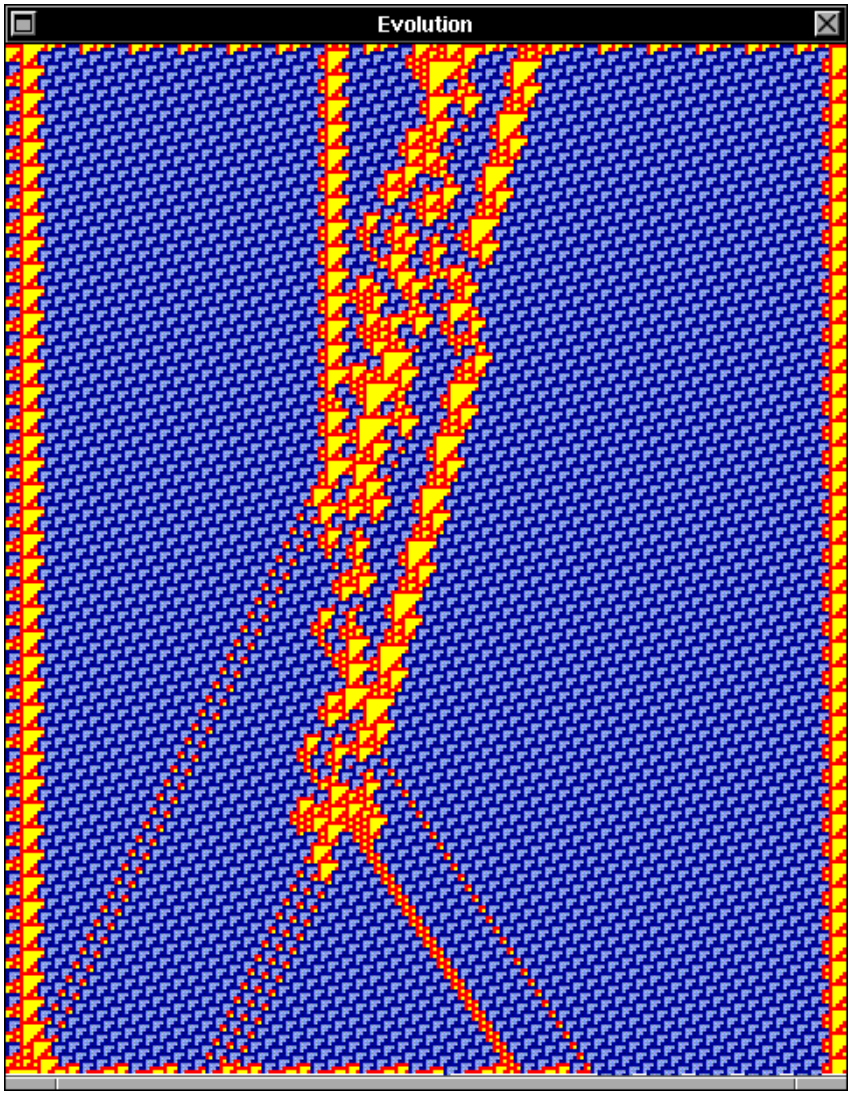

Figure 4.320: Collisions of glider C3, C3(p1)(A)-e(p1)-H(p1)(B)=2B,A,3A,3B

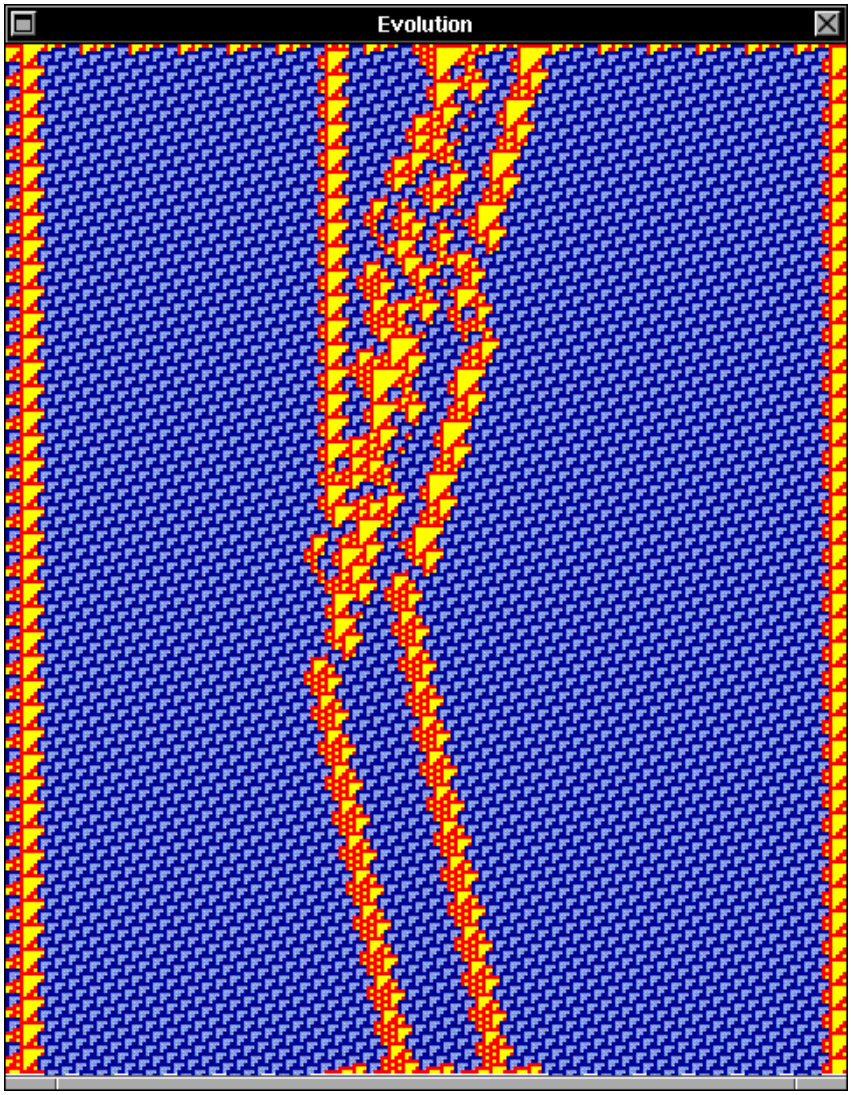

Figure 4.321: Collisions of glider C3, C3(p1)(A)-e(p1)-H(p1)(C)=D1,D1

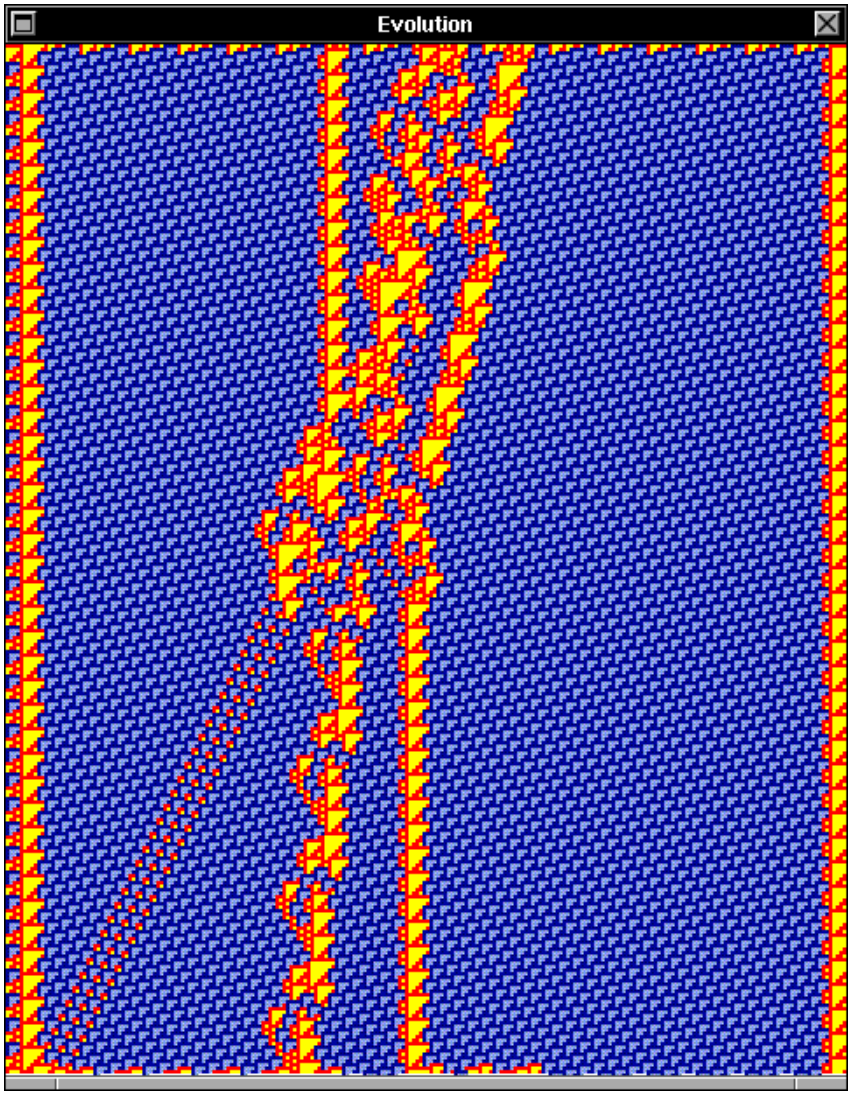

Figure 4.322: Collisions of glider C3, C3(p1)(A)-e(p1)-H(p1)(B2)=3B,F,C3

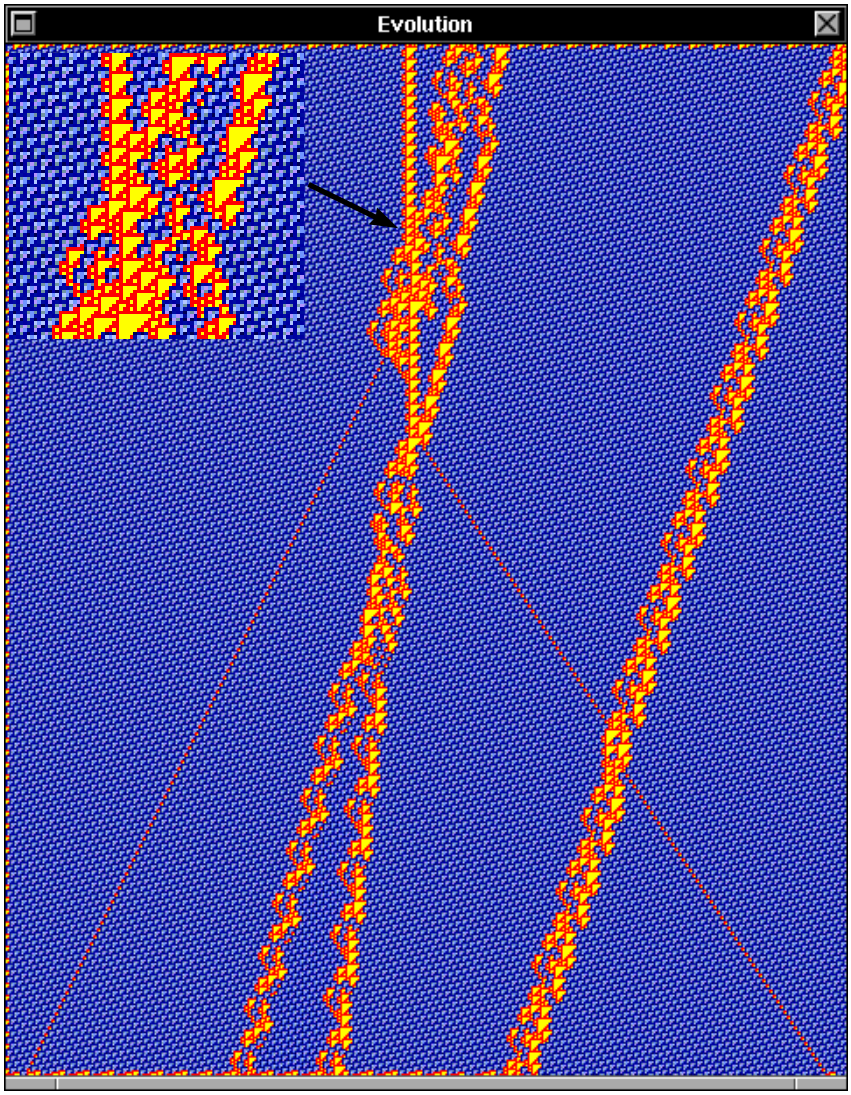

Figure 4.323: Collisions of glider C3, C3(p1)(A)-e(p1)-H(p1)(C2)=B,A,Ebar,F

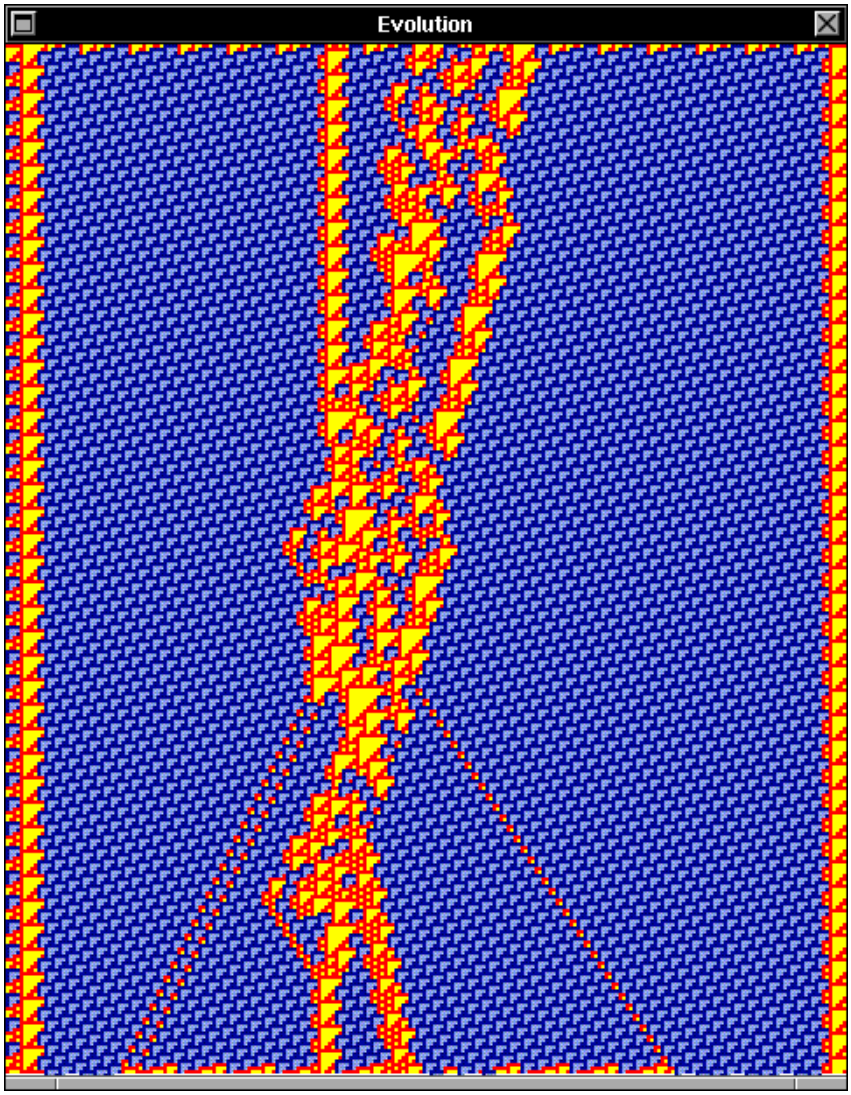

Figure 4.324: Collisions of glider C3, C3(p1)(A)-e(p1)-H(p1)(D2)=A,2B,D1,C2

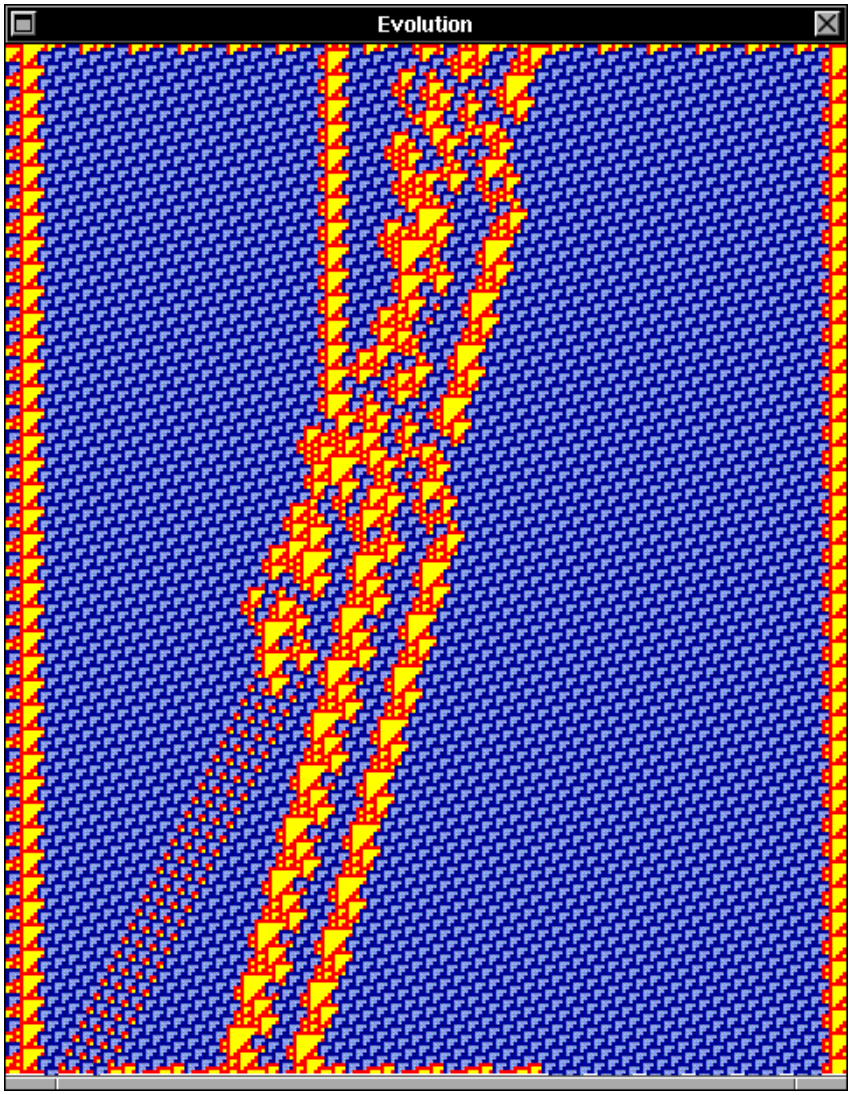

Figure 4.325: Collisions of glider C3, C3(p1)(A)-e(p1)-H(p1)(E2)=4B,E2,E

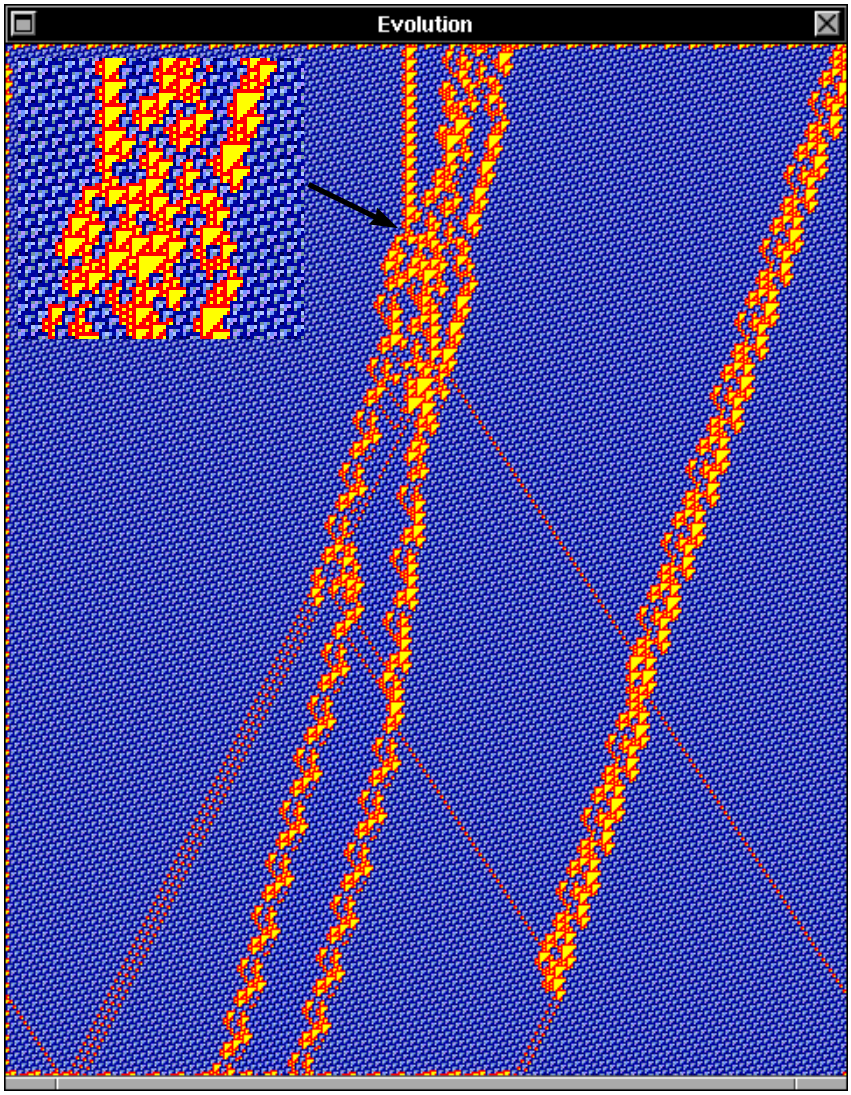

Figure 4.326: Collisions of glider C3, C3(p1)(A)-e(p1)-H(p1)(F2)=A,3B,Ebar,Ebar,A

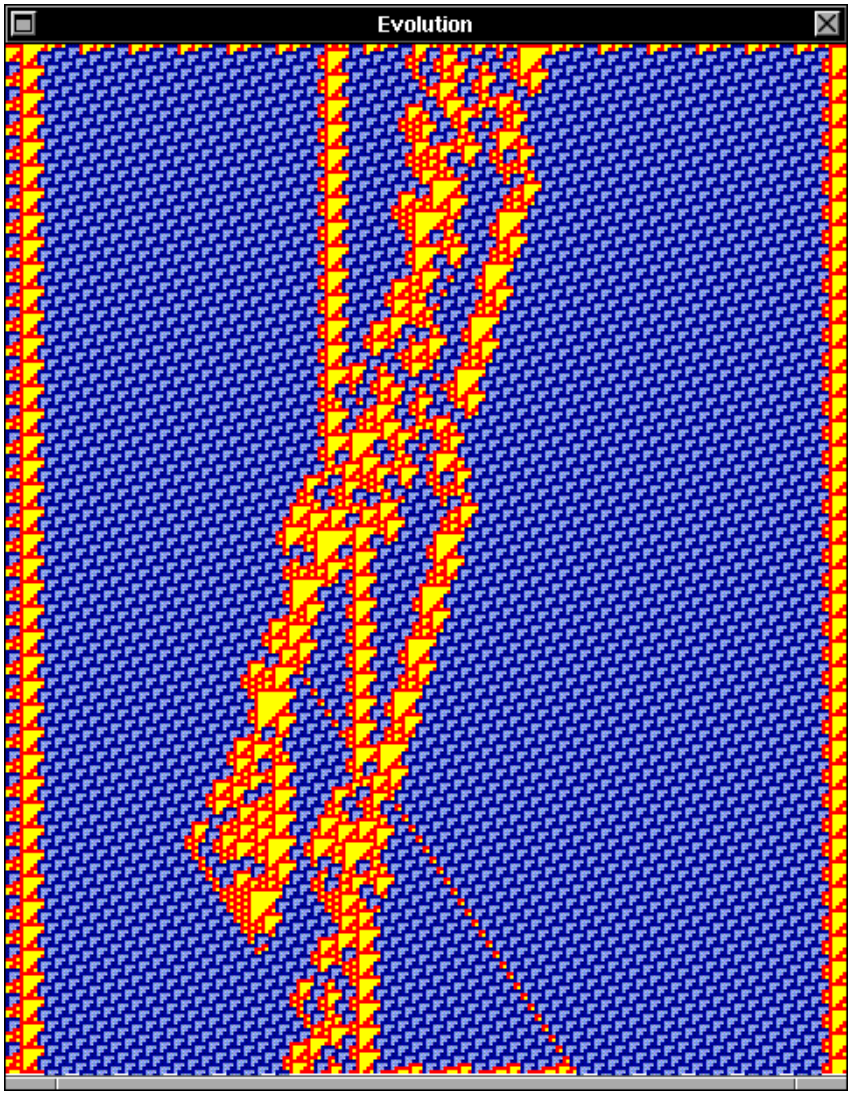

Figure 4.327: Collisions of glider C3, C3(p1)(A)-e(p1)-H(p1)(G2)=A,Ebar,C1

4.9 Collisions of glider D1

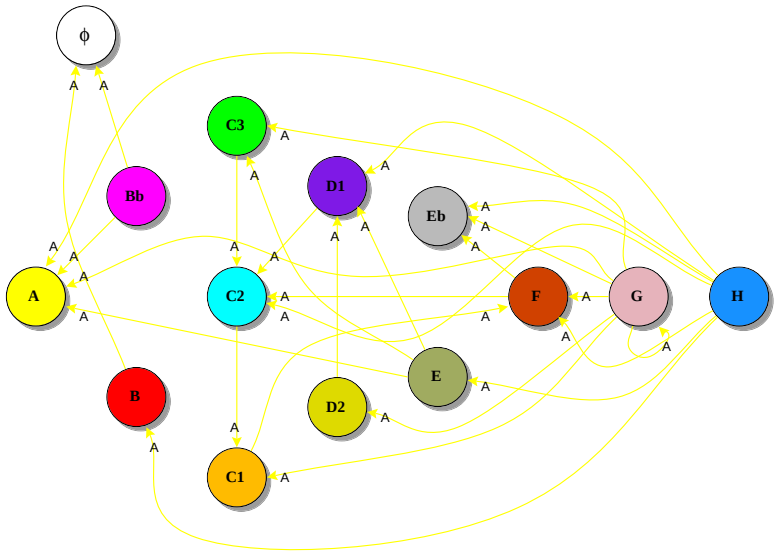

Figure 4.328: Collisions of glider D1

	ϕ	A	B	$Bbar$	$C3$	$C2$	$C1$	$D2$	$D1$	E	$Ebar$	F	G	H
ϕ	.	.	.	.	.	.	.	.	.	.	.	.	.	.
A	.	.	.	.	.	.	.	.	.	.	.	.	.	.
B	.	.	.	.	.	.	.	.	.	.	.	.	.	.
$Bbar$	.	.	.	.	.	.	.	.	.	.	.	.	.	.
$C3$	.	.	.	.	.	.	.	.	.	.	.	.	.	.
$C2$	.	.	.	.	.	.	.	.	.	.	.	.	.	.
$C1$	.	.	.	.	.	.	.	.	.	.	.	.	.	.
$D2$	.	.	.	.	.	.	.	.	.	.	.	.	.	.
$D1$	.	.	.	.	.	.	.	.	.	.	.	.	.	.
E	.	.	.	.	.	.	.	.	.	.	.	.	.	.
$Ebar$	.	.	.	.	.	.	.	.	.	.	.	.	.	.
F	.	.	.	.	.	.	.	.	.	.	.	.	.	.
G	.	.	.	.	.	.	.	.	.	.	.	.	.	.
H	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Table 4.8: Matrix connection of collisions glider D1

4.9.1 Collisions of glider D1 with glider E

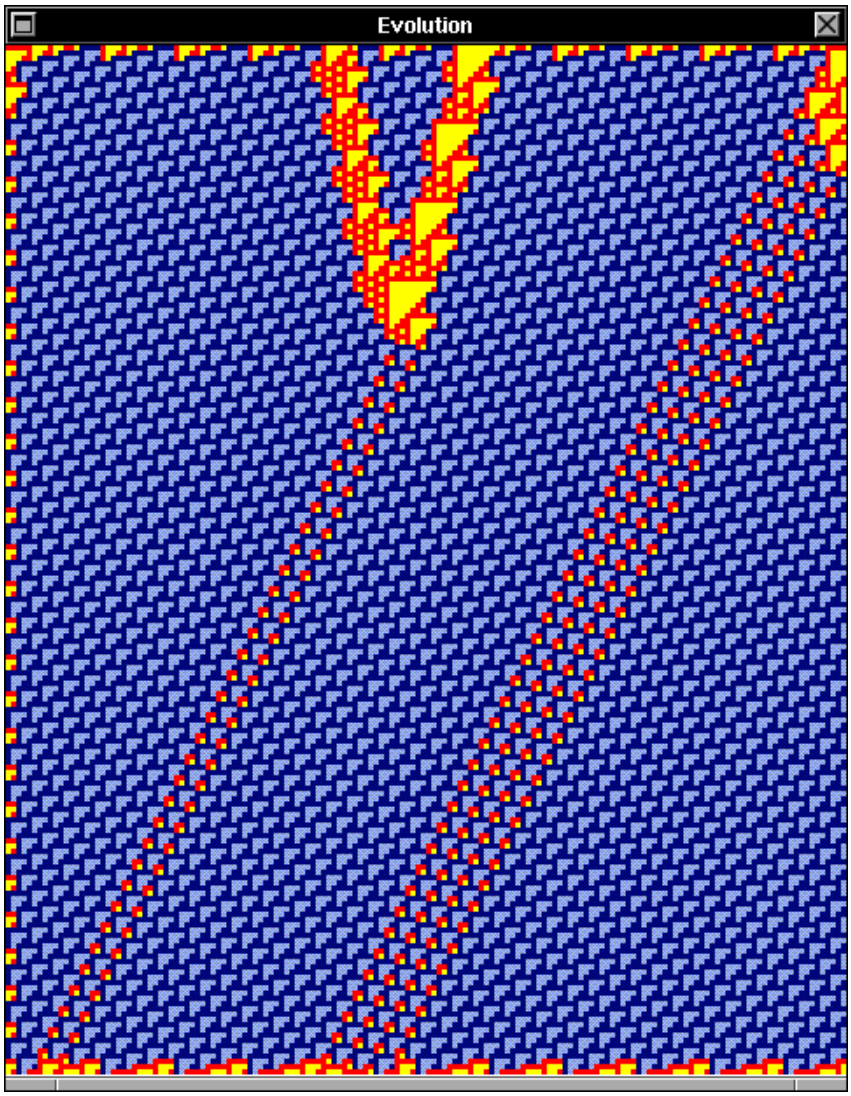

Figure 4.329: Collisions of glider D1, D1(p1)(A)-e(p1)-E(p1)(A)=2B

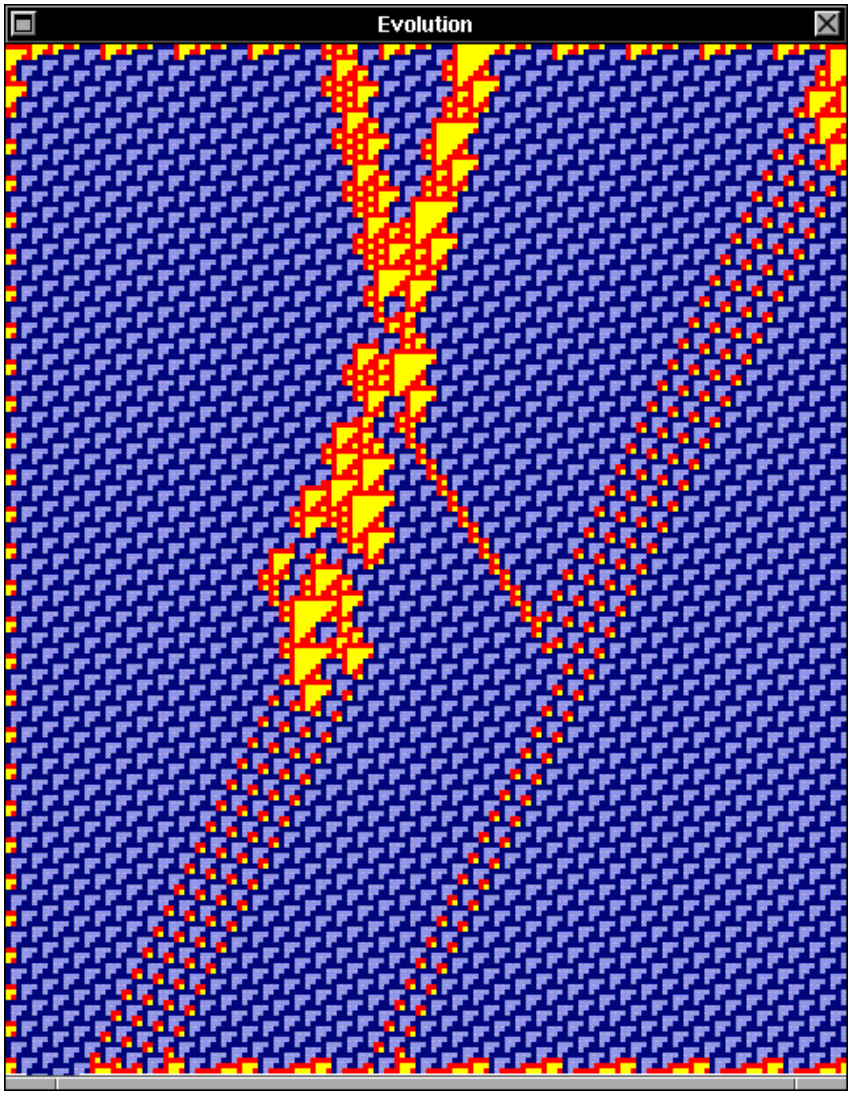

Figure 4.330: Collisions of glider D1, D1(p1)(C)-e(p1)-E(p1)(A)=2A,4B

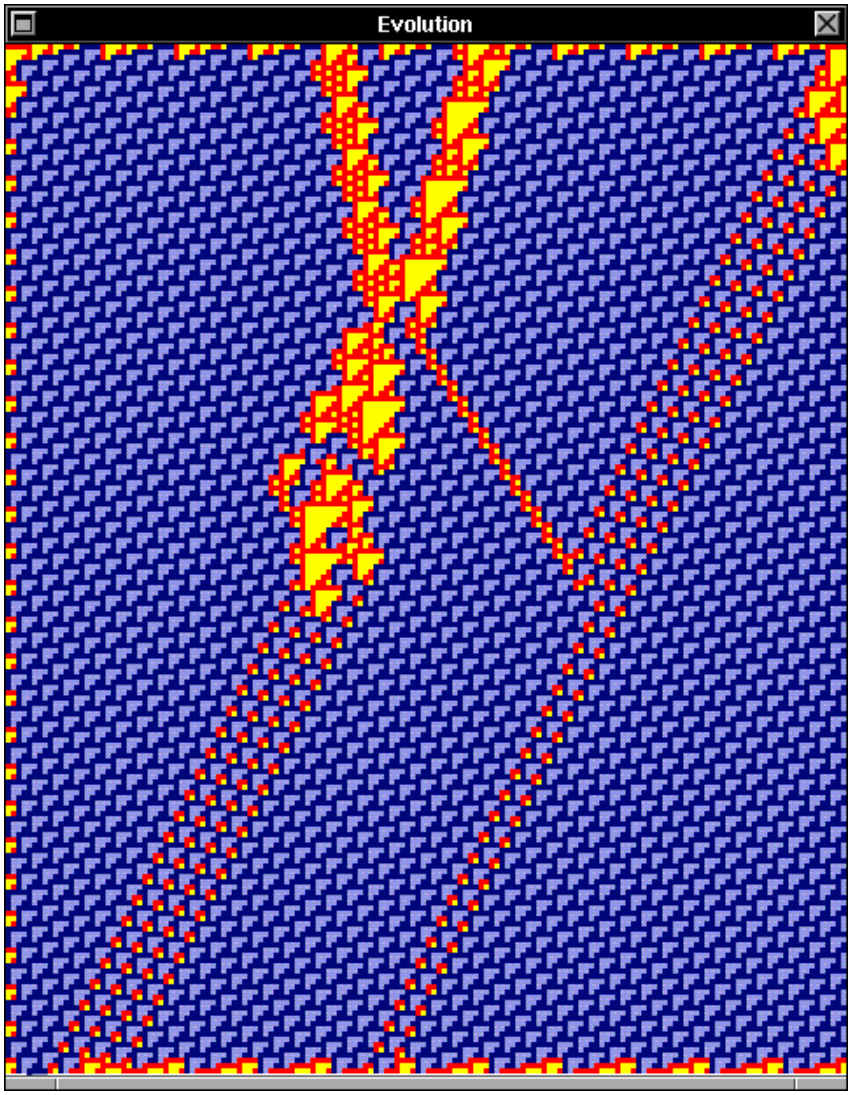

Figure 4.331: Collisions of glider D1, D1(p1)(A)-e(p1)-E(p1)(B)=2A,4B

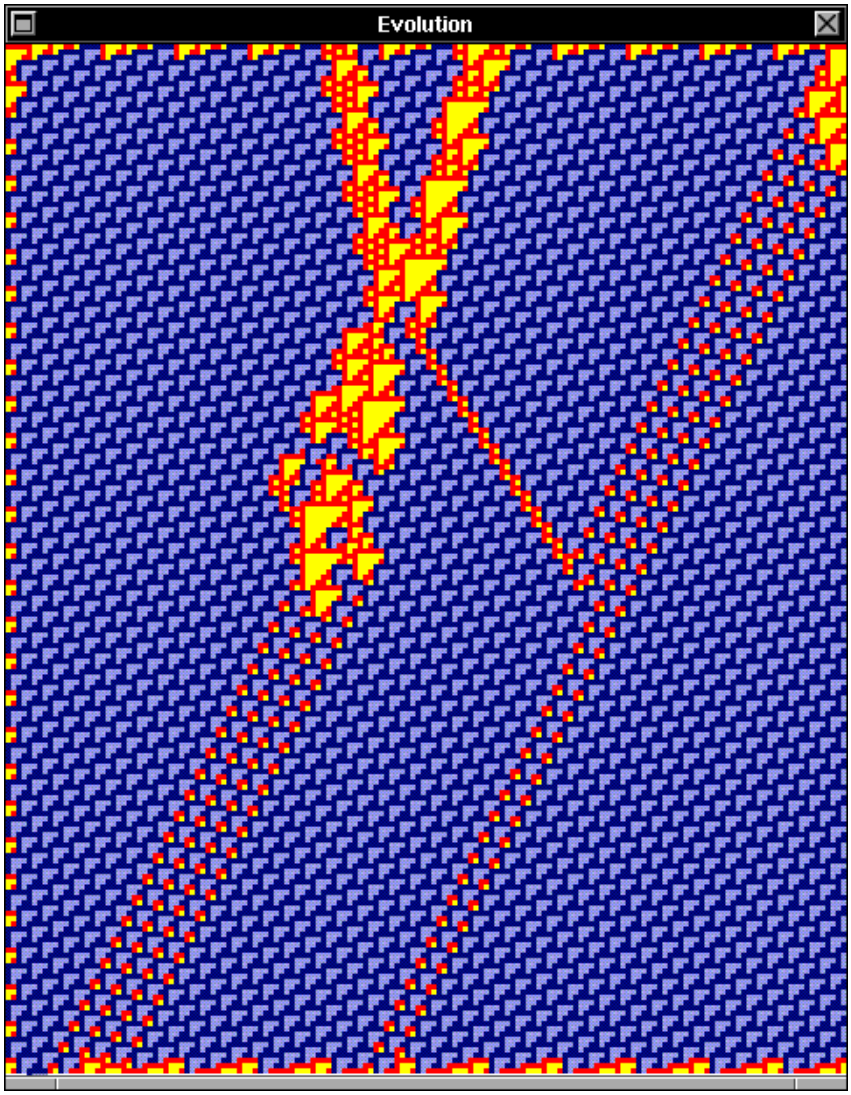

Figure 4.332: Collisions of glider D1, D1(p1)(C)-e(p1)-E(p1)(B)=2A,4B

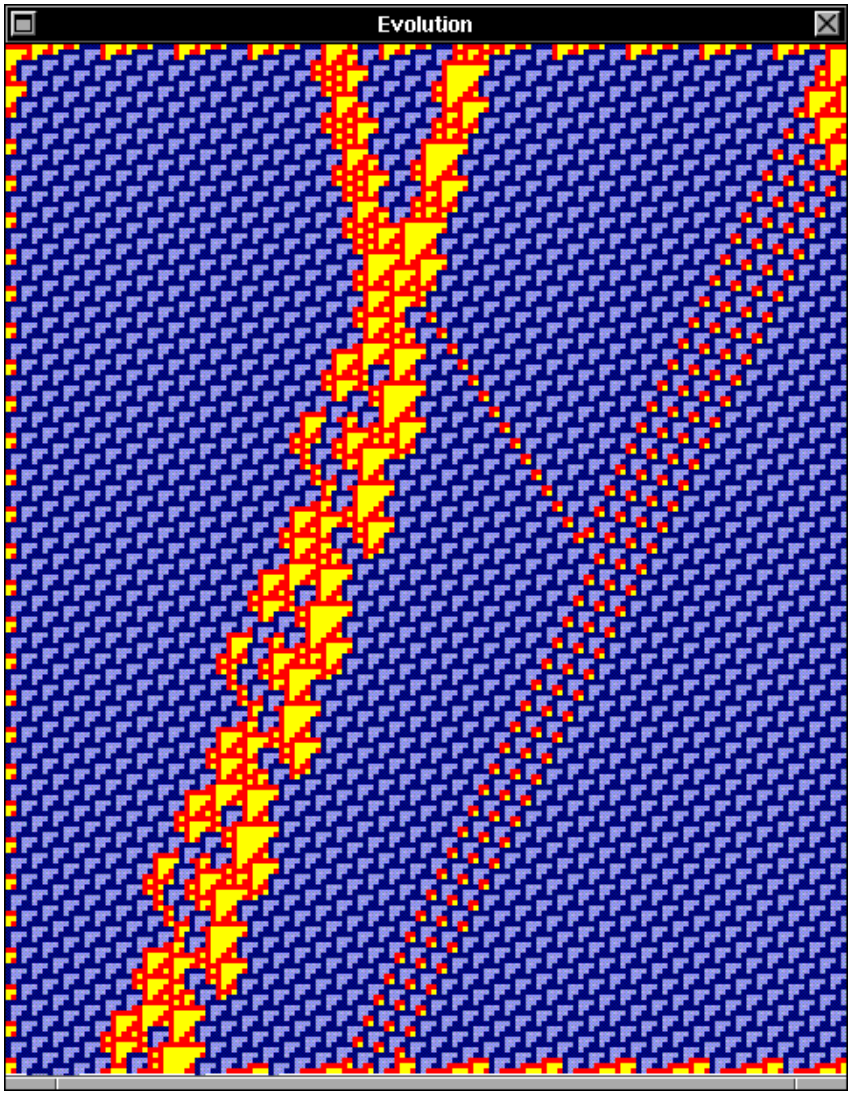

Figure 4.333: Collisions of glider D1, D1(p1)(A)-e(p1)-E(p1)(D)=A,G

4.9.2 Collisions of glider D1 with glider Ebar

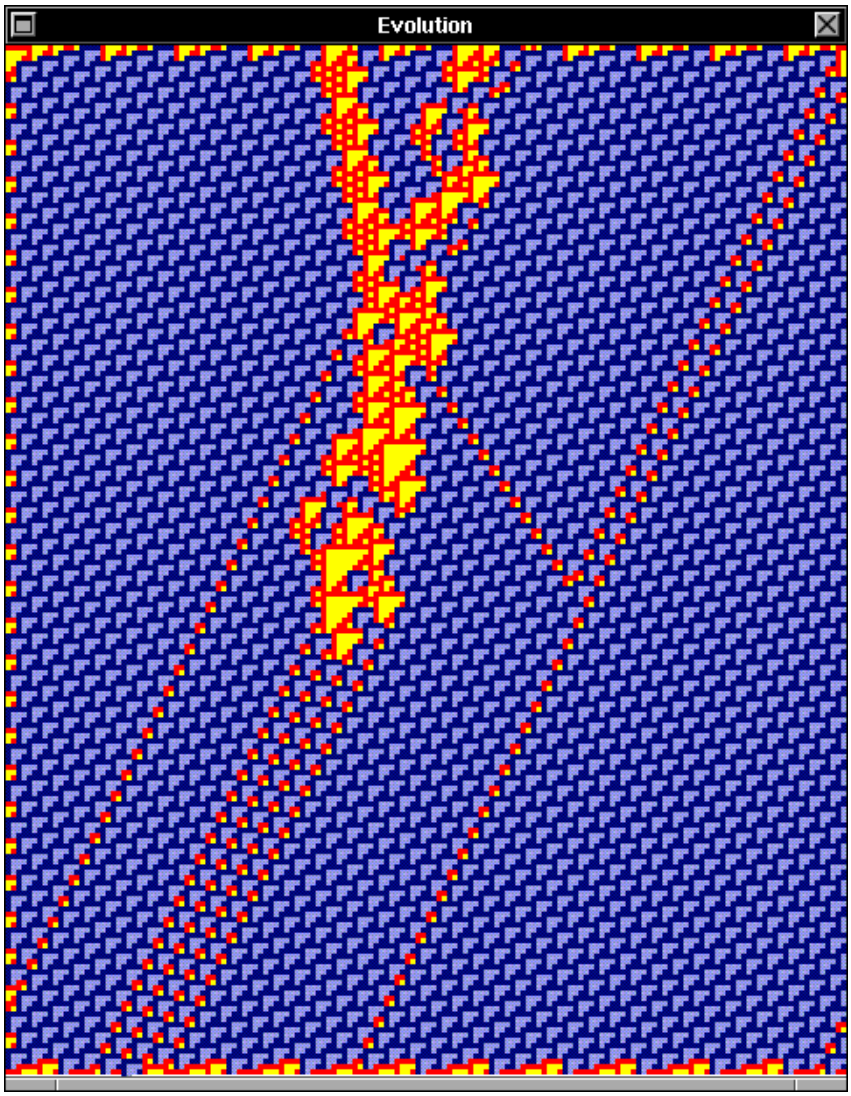

Figure 4.334: Collisions of glider D1, D1(p1)(A)-e(p1)-Ebar(p1)(A)=B,A,4B

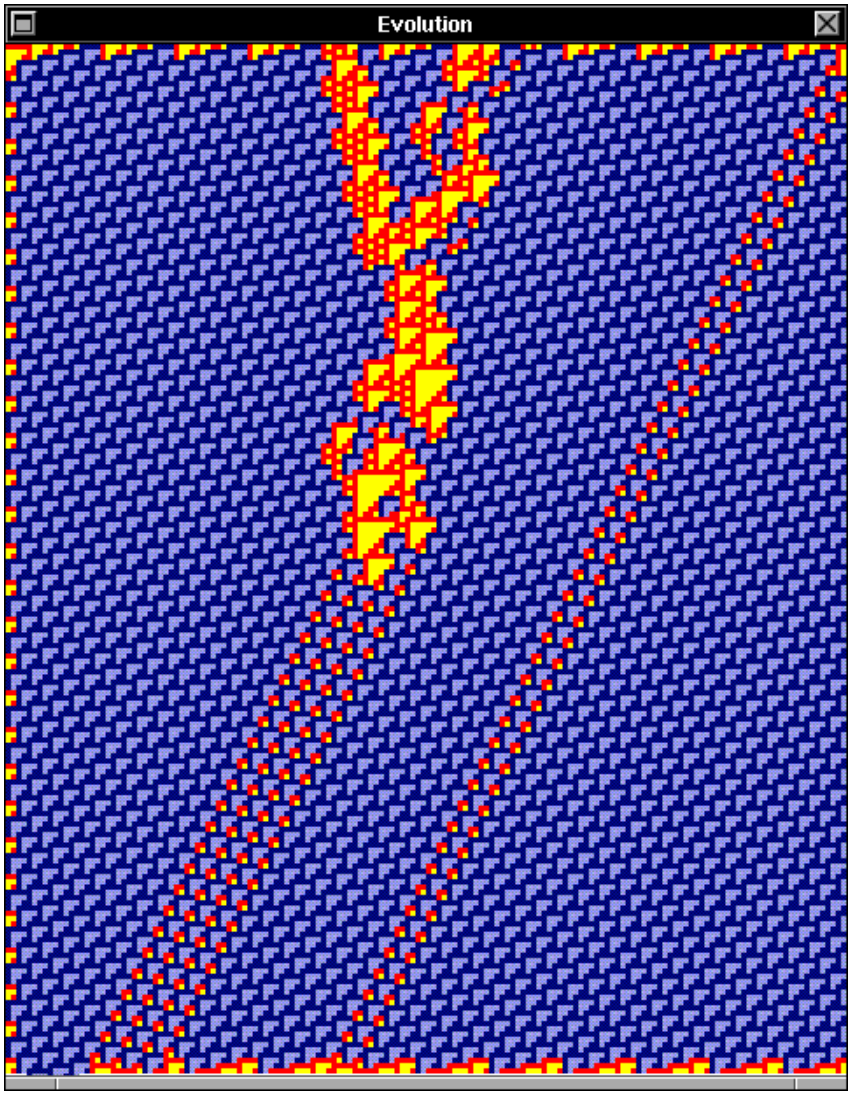

Figure 4.335: Collisions of glider D1, D1(p1)(C)-e(p1)-Ebar(p1)(A)=4B

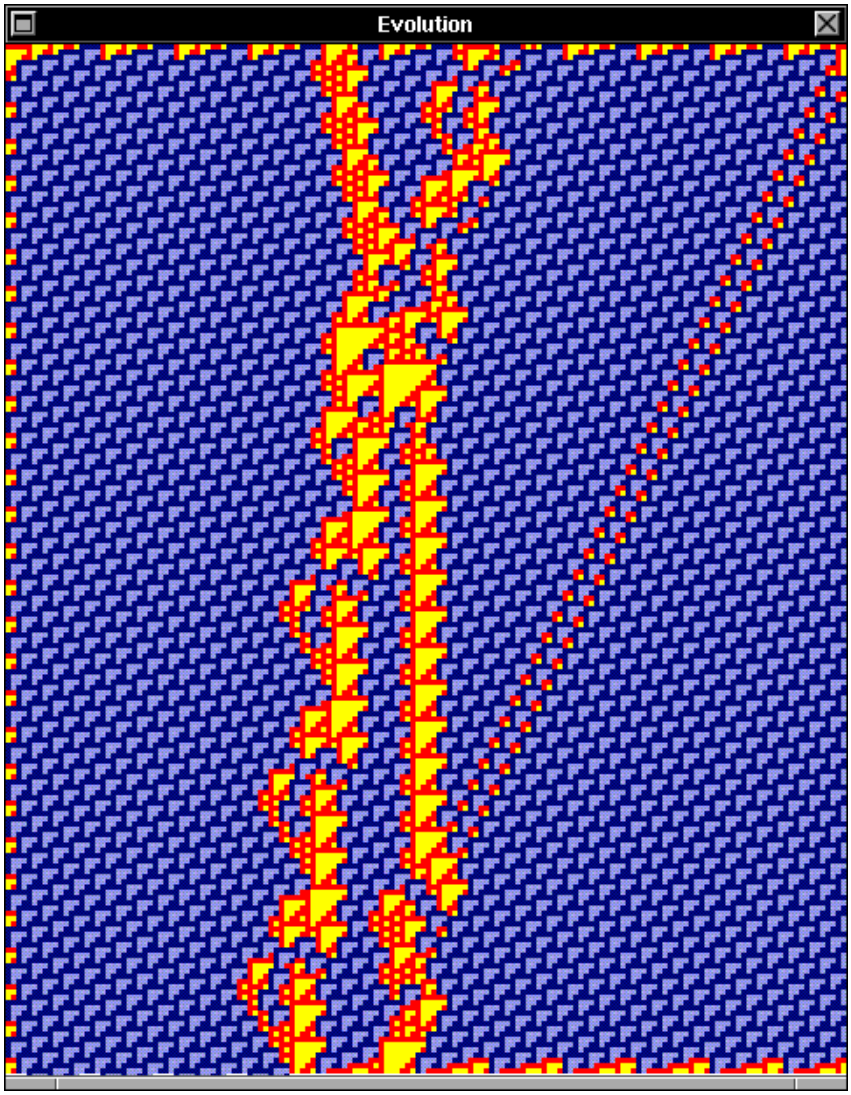

Figure 4.336: Collisions of glider D1, D1(p1)(A)-e(p1)-Ebar(p1)(B)=F,C2

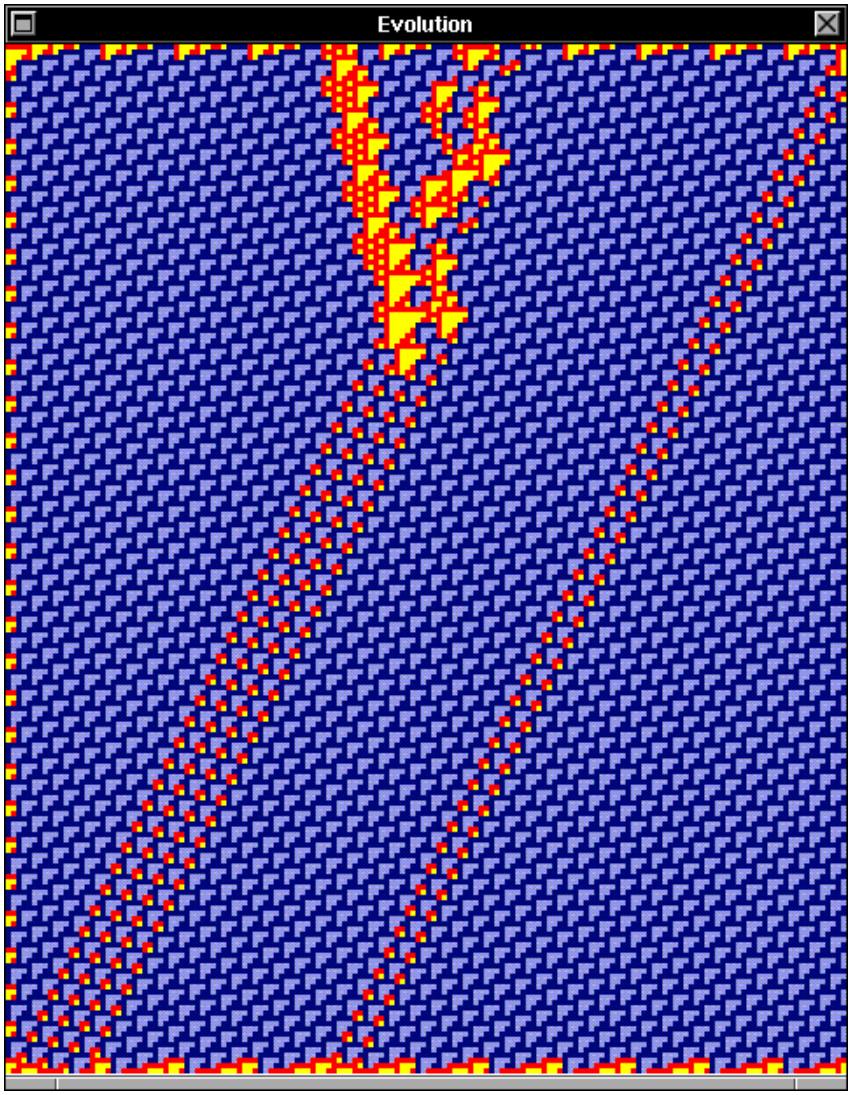

Figure 4.337: Collisions of glider D1, D1(p1)(C)-e(p1)-Ebar(p1)(B)=4B

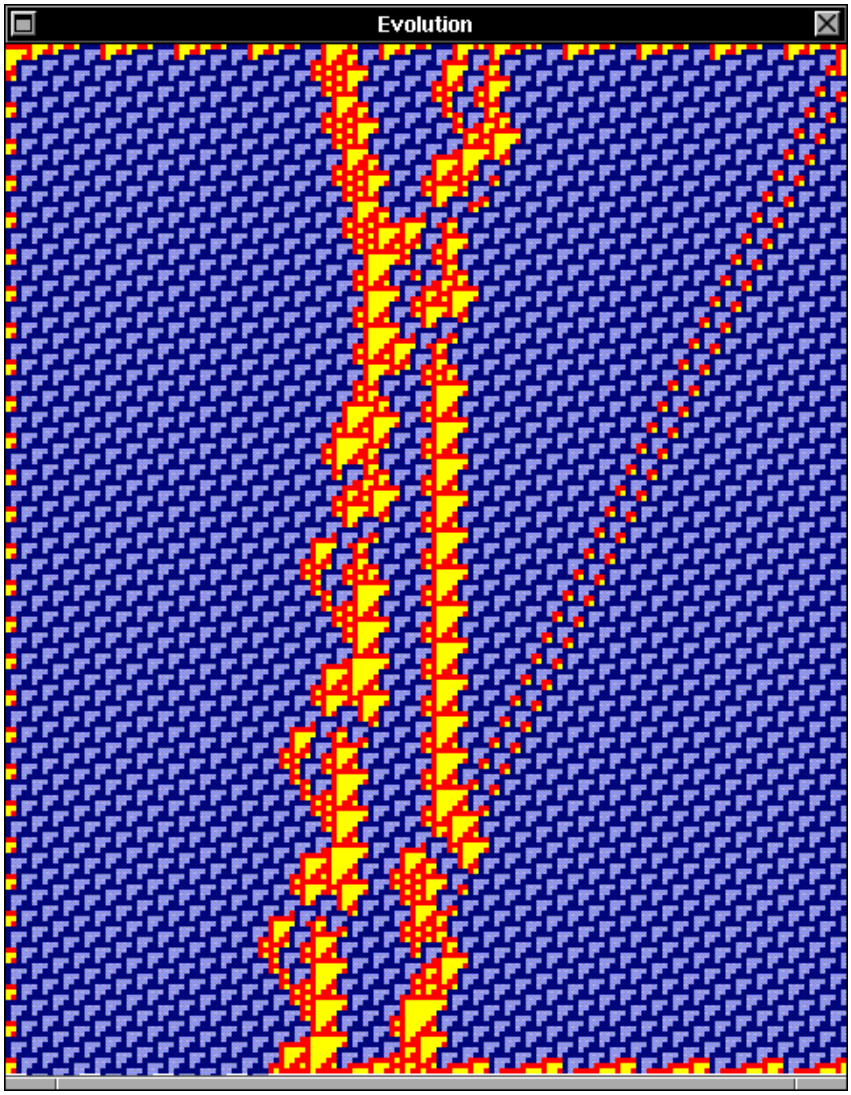

Figure 4.338: Collisions of glider D1, D1(p1)(A)-e(p1)-Ebar(p1)(C)=F,C2

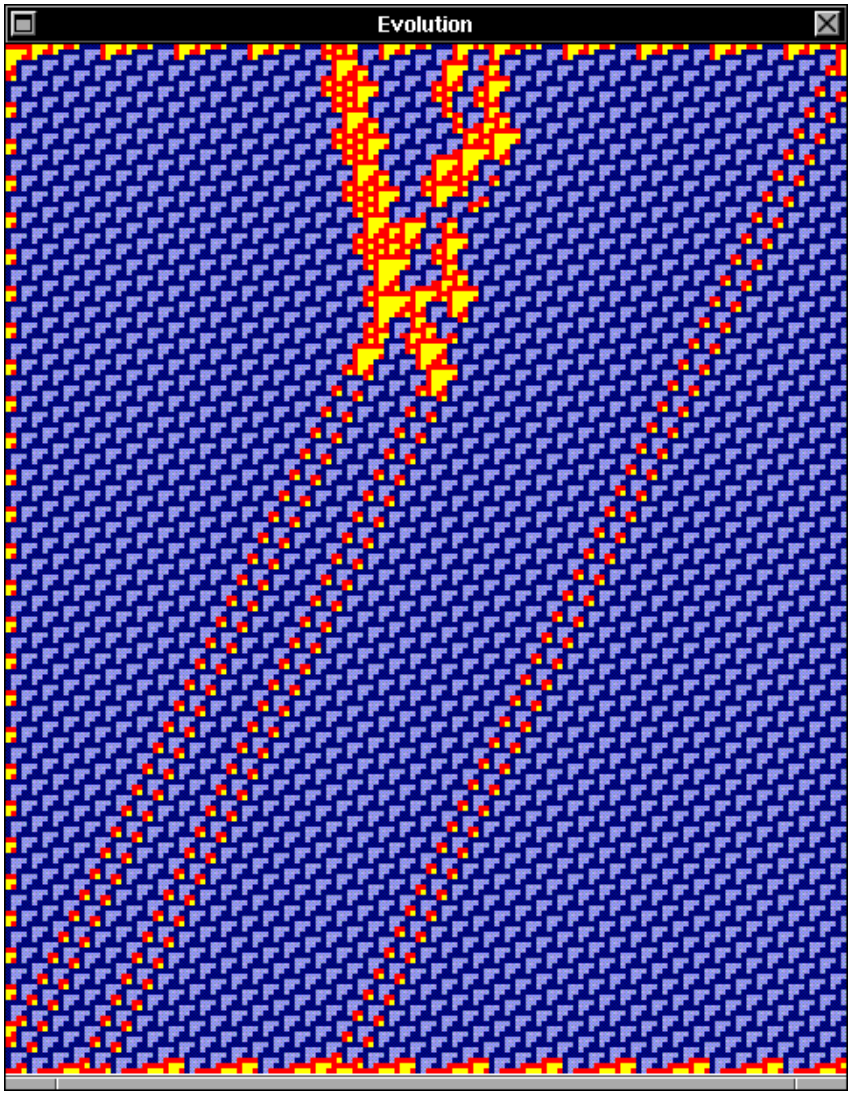

Figure 4.339: Collisions of glider D1, D1(p1)(C)-e(p1)-Ebar(p1)(C)=2B,2B

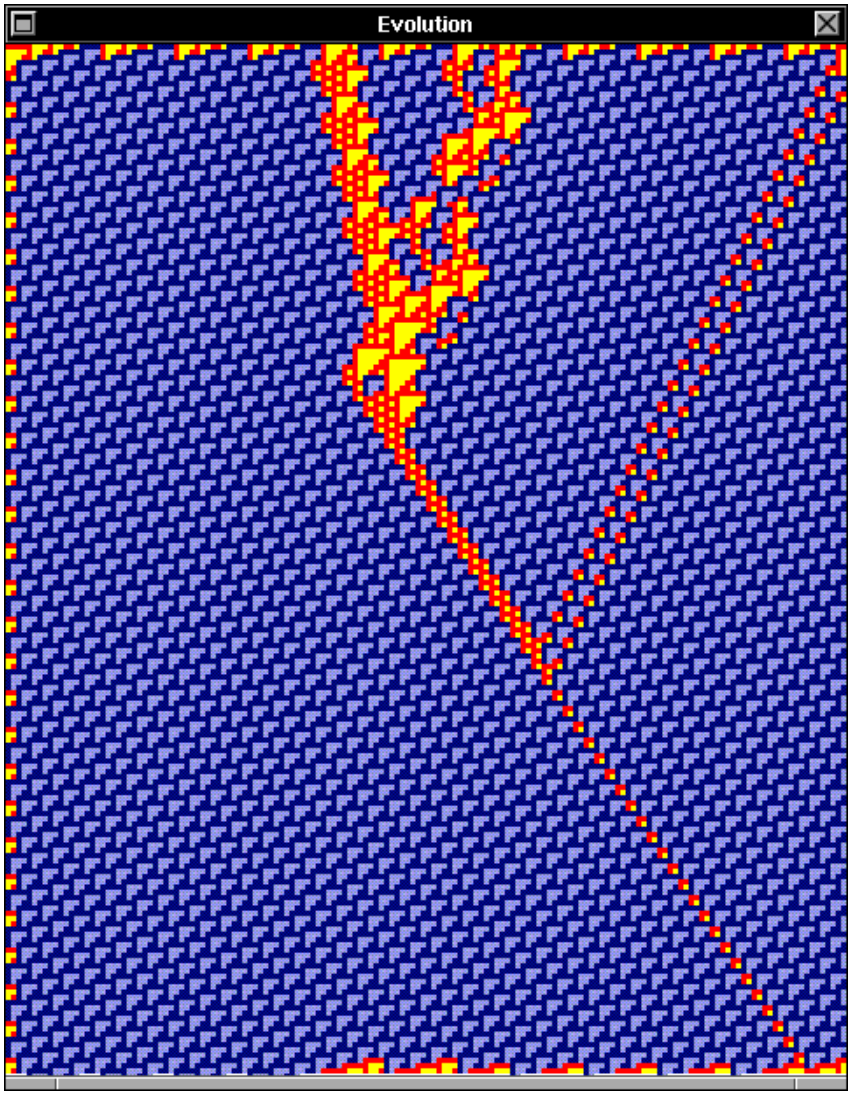

Figure 4.340: Collisions of glider D1, D1(p1)(A)-e(p1)-Ebar(p1)(D)=3A

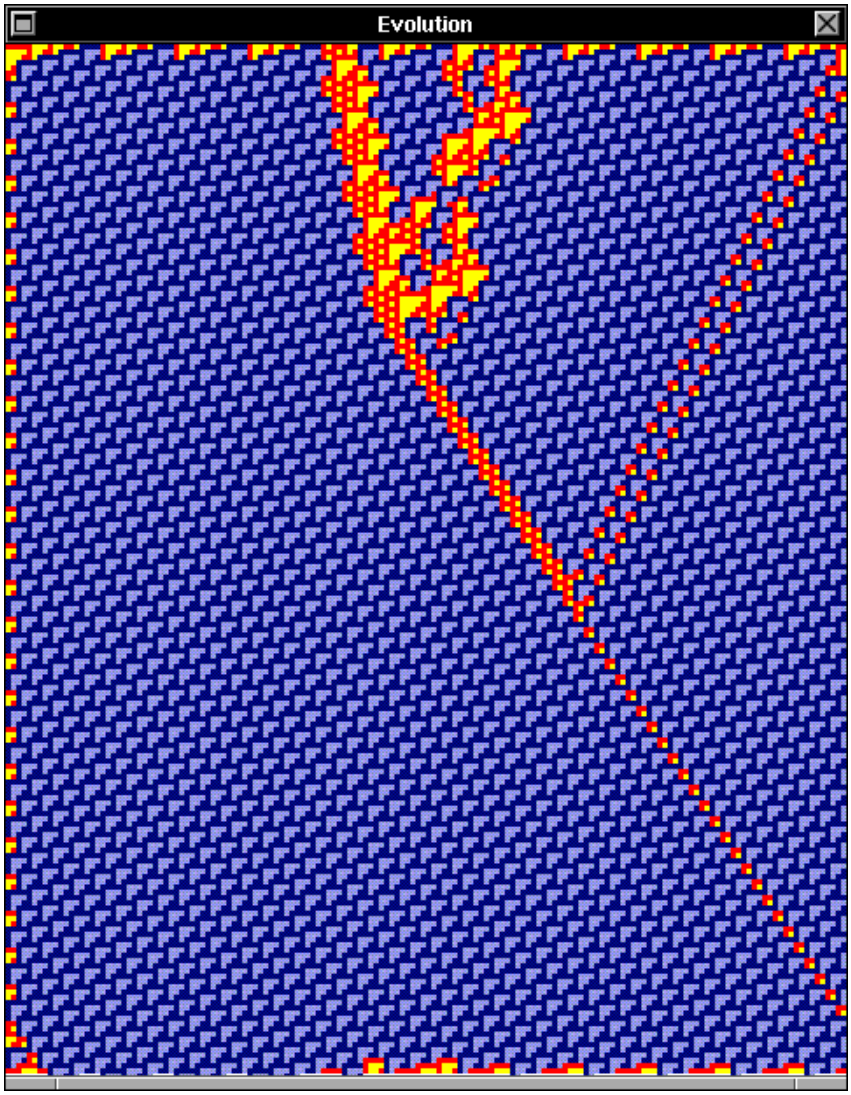

Figure 4.341: Collisions of glider D1, D1(p1)(C)-e(p1)-Ebar(p1)(D)=3A

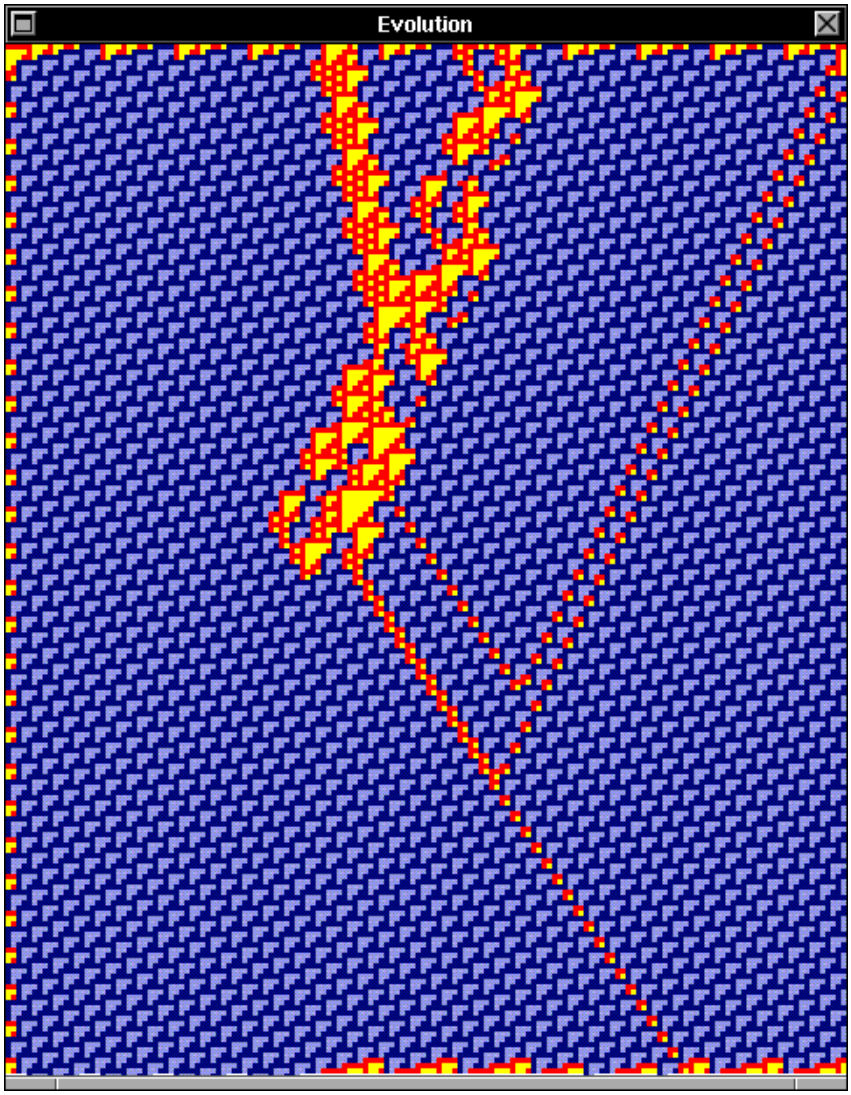

Figure 4.342: Collisions of glider D1, D1(p1)(A)-e(p1)-Ebar(p1)(E)=A,2A

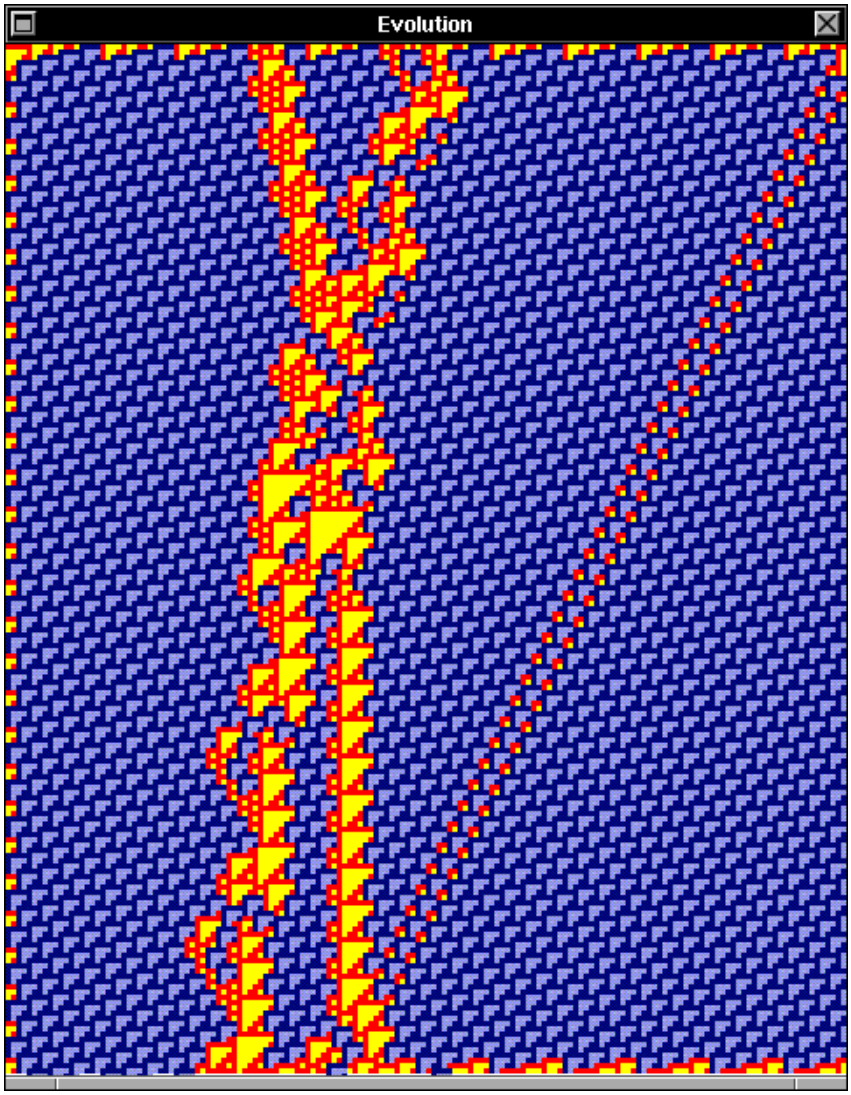

Figure 4.343: Collisions of glider D1, D1(p1)(C)-e(p1)-Ebar(p1)(E)=F,C2

4.9.3 Collisions of glider D1 with glider F

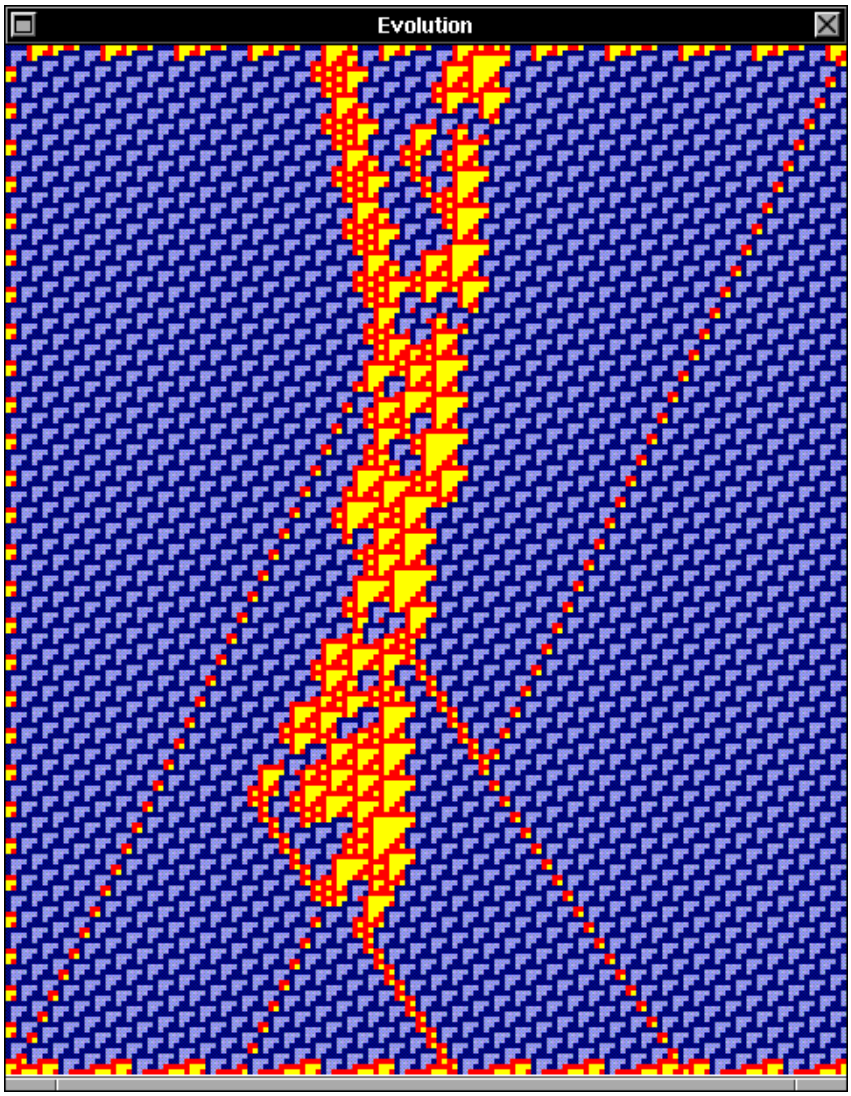

Figure 4.344: Collisions of glider D1, D1(p1)(A)-e(p1)-F(p1)(A)=B,2A,B,2A

4.9.4 Collisions of glider D1 with glider G

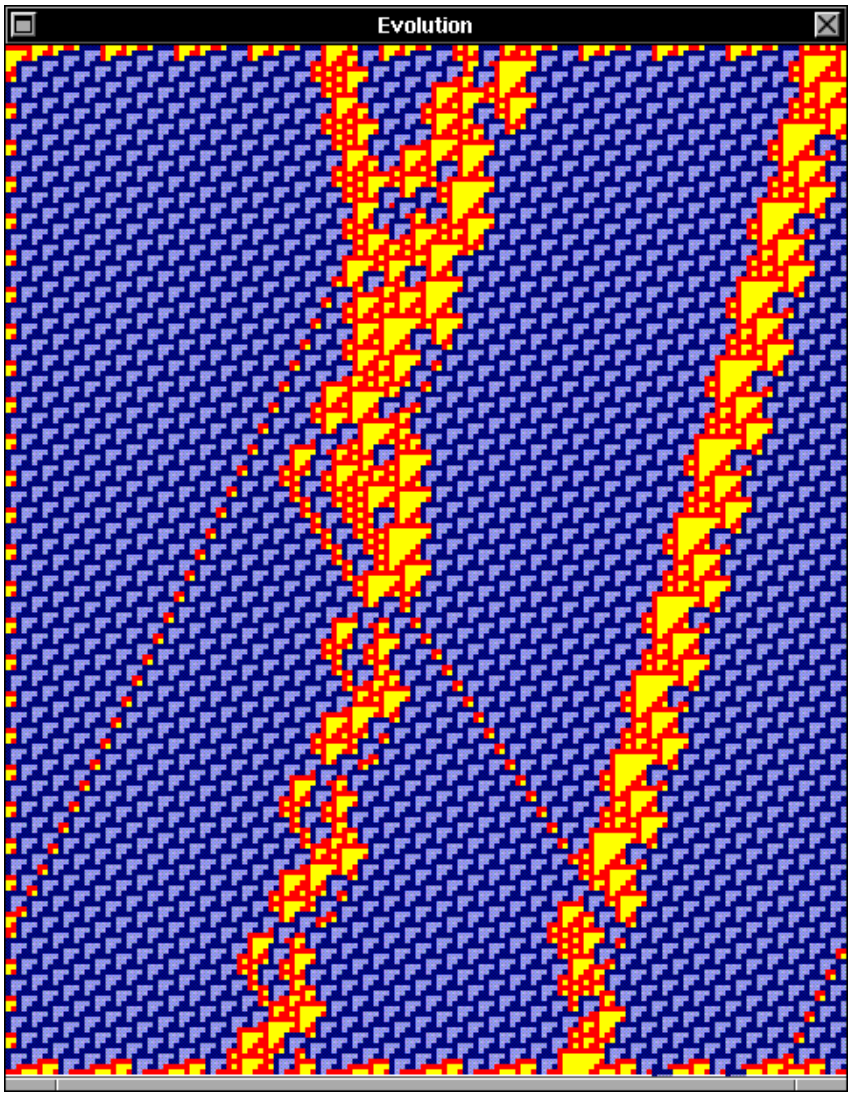

Figure 4.345: Collisions of glider D1, D1(p1)(A)-e(p1)-G(p1)(A)=B,A,Ebar

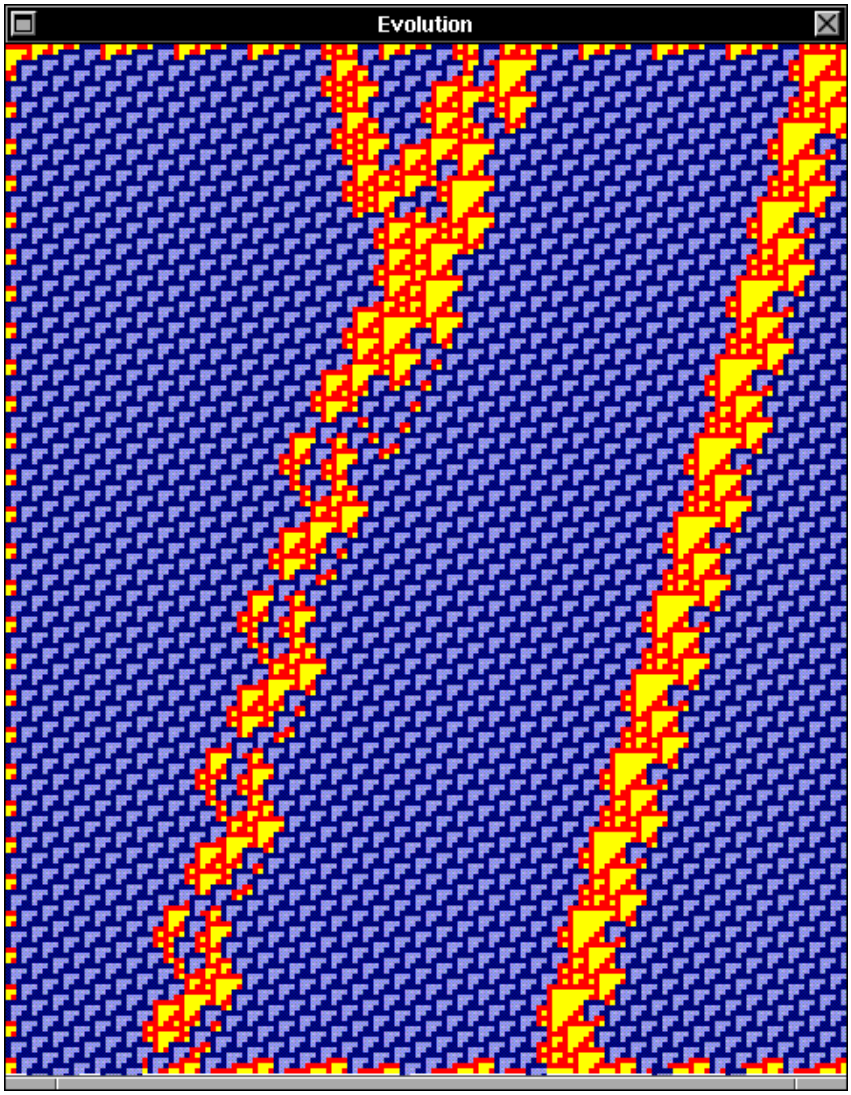

Figure 4.346: Collisions of glider D1, D1(p1)(C)-e(p1)-G(p1)(A)=Ebar

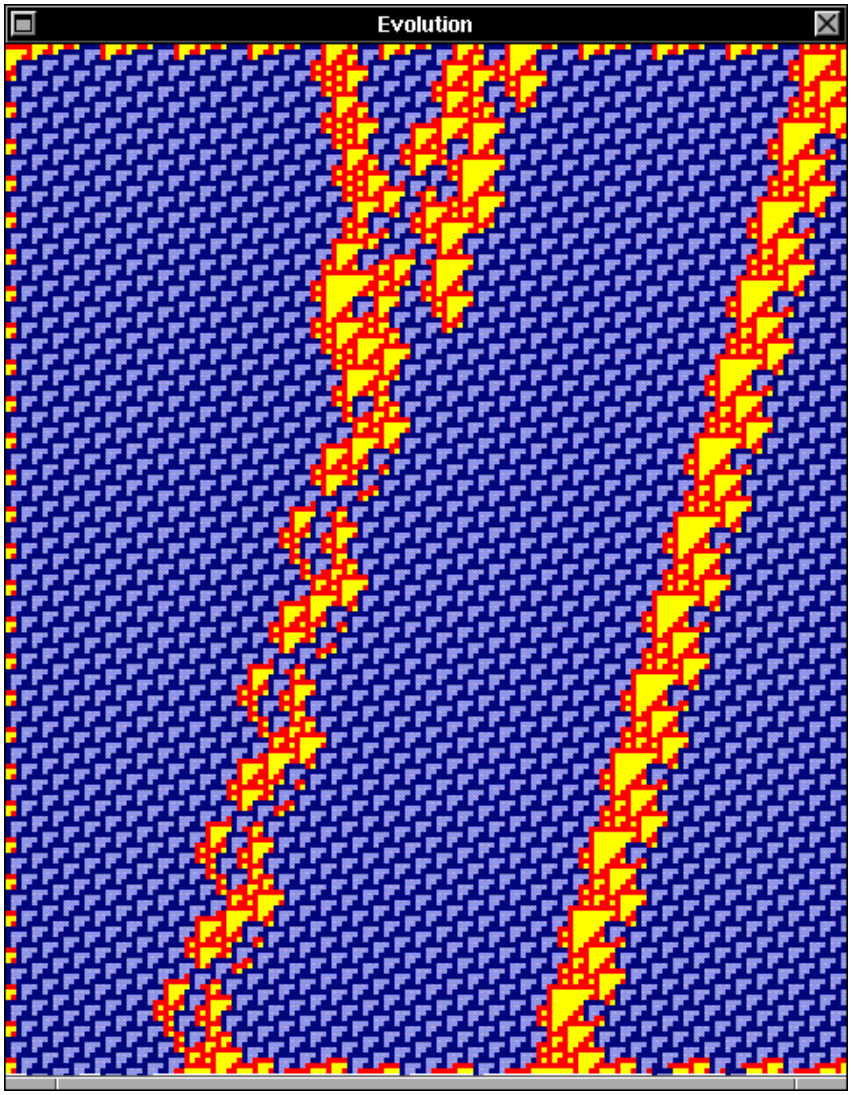

Figure 4.347: Collisions of glider D1, D1(p1)(A)-e(p1)-G(p1)(B)=Ebar

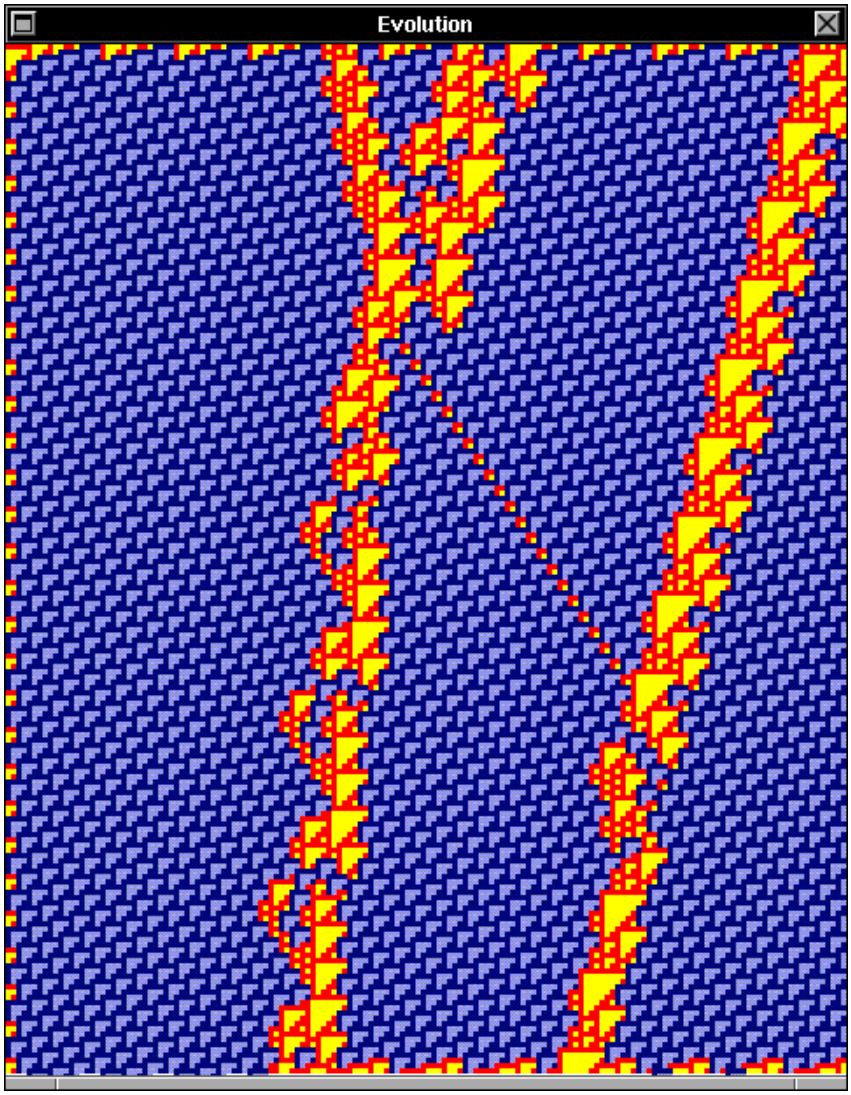

Figure 4.348: Collisions of glider D1, D1(p1)(C)-e(p1)-G(p1)(B)=A,F

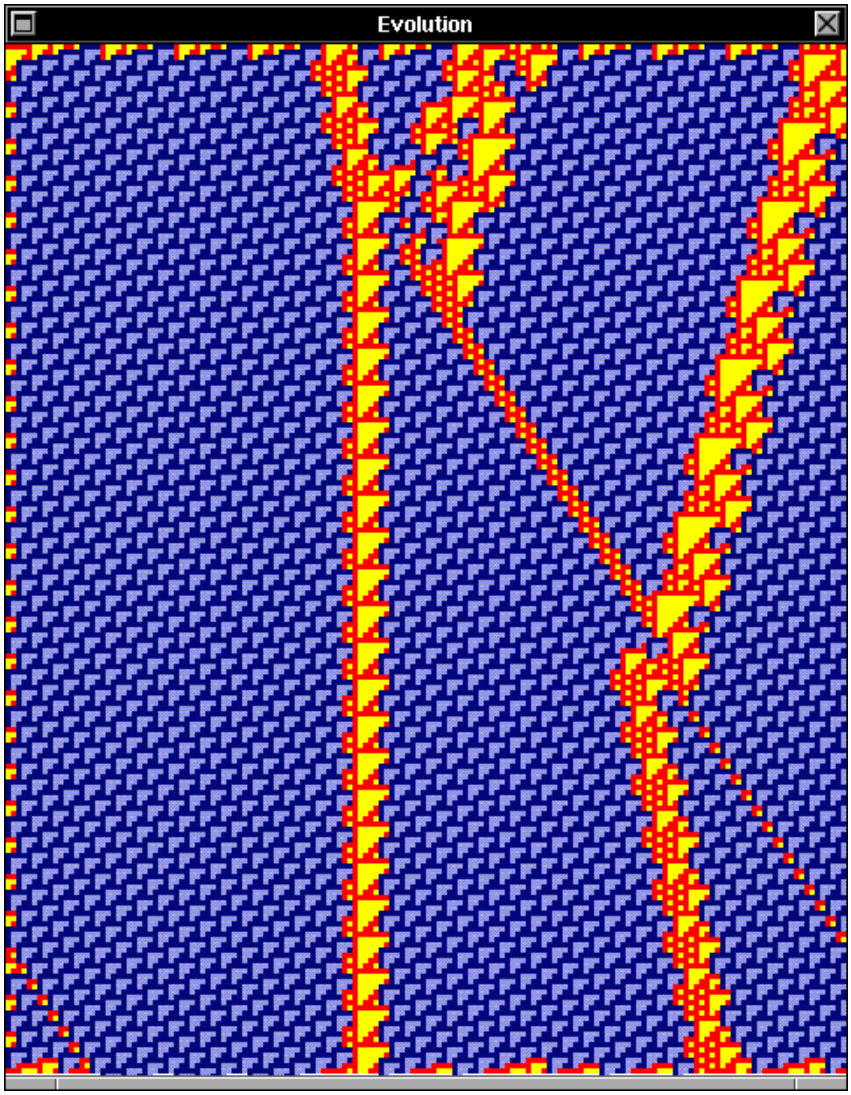

Figure 4.349: Collisions of glider D1, D1(p1)(A)-e(p1)-G(p1)(C)=C2,3A

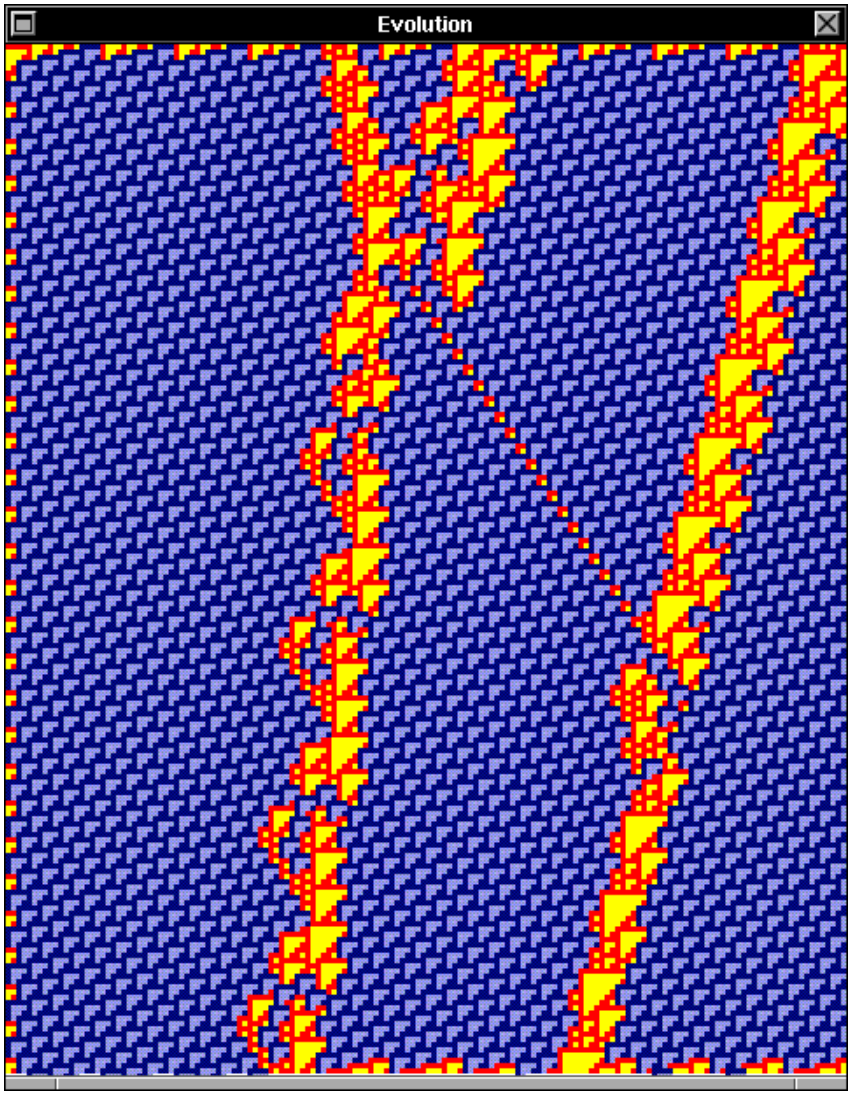

Figure 4.350: Collisions of glider D1, D1(p1)(C)-e(p1)-G(p1)(C)=A,F

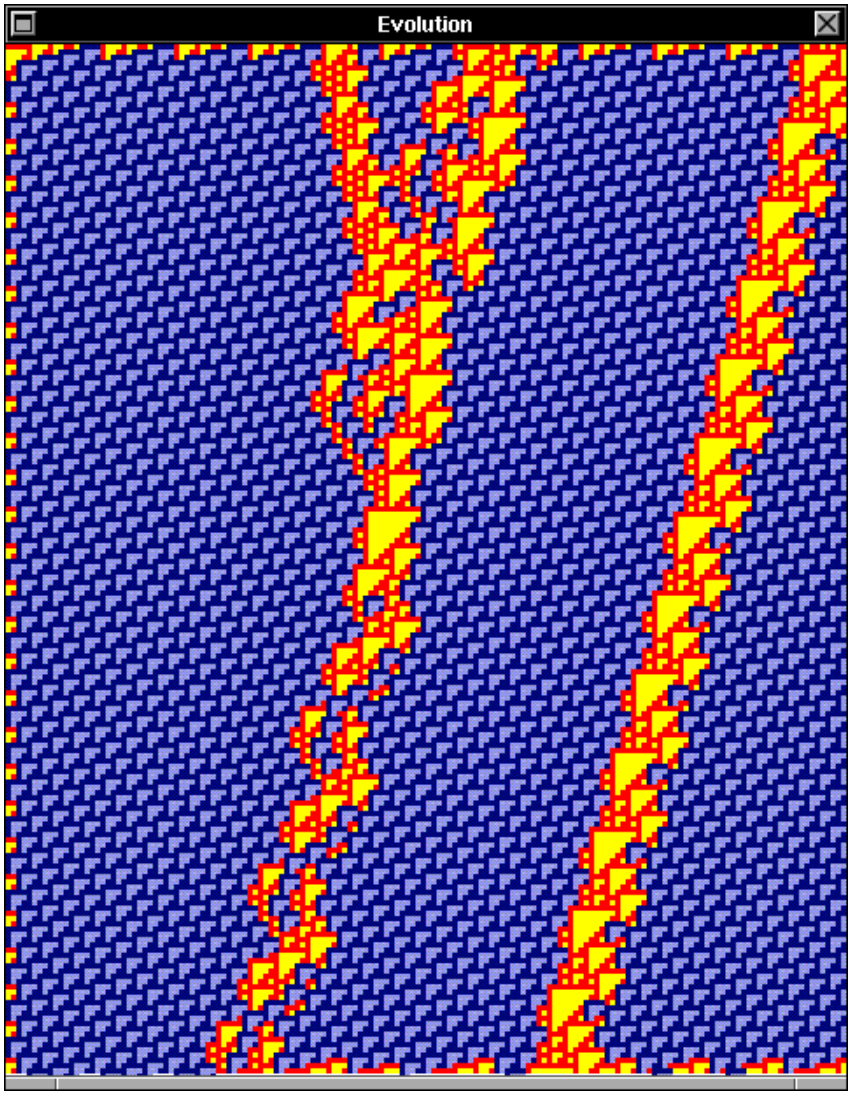

Figure 4.351: Collisions of glider D1, D1(p1)(A)-e(p1)-G(p1)(D)=Ebar

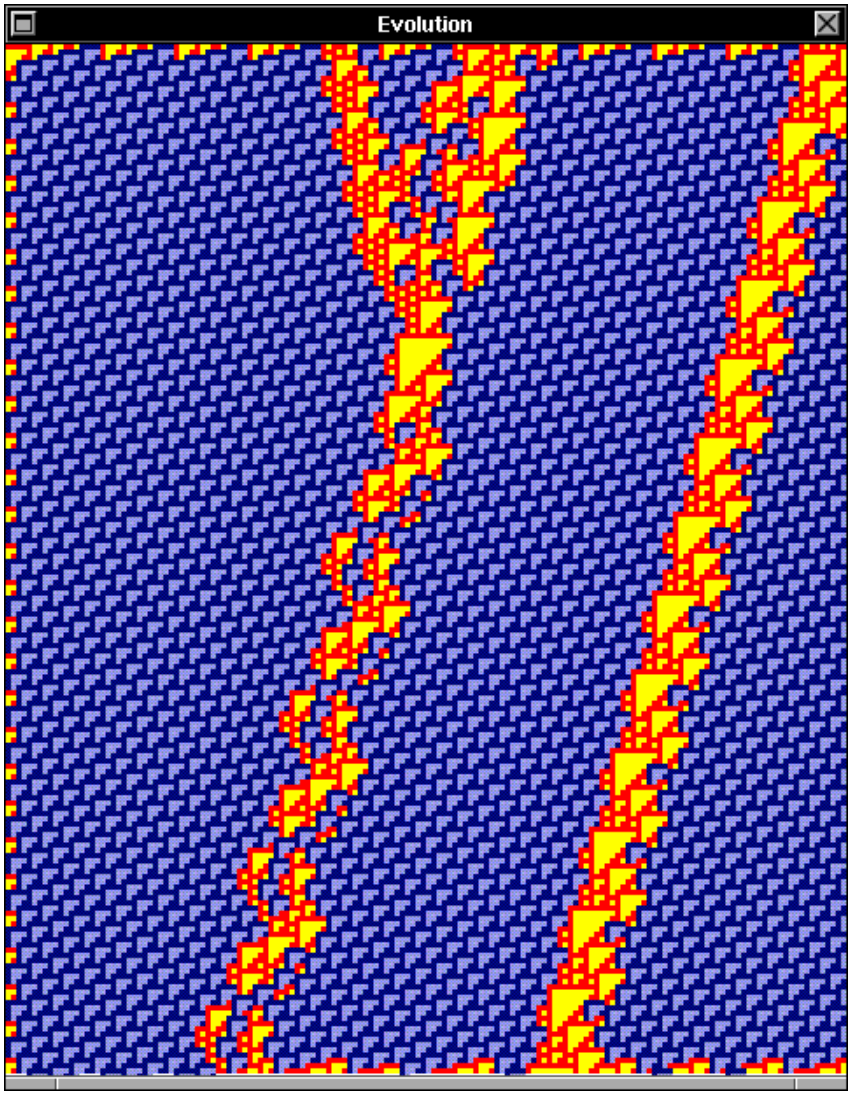

Figure 4.352: Collisions of glider D1, D1(p1)(C)-e(p1)-G(p1)(D)=Ebar

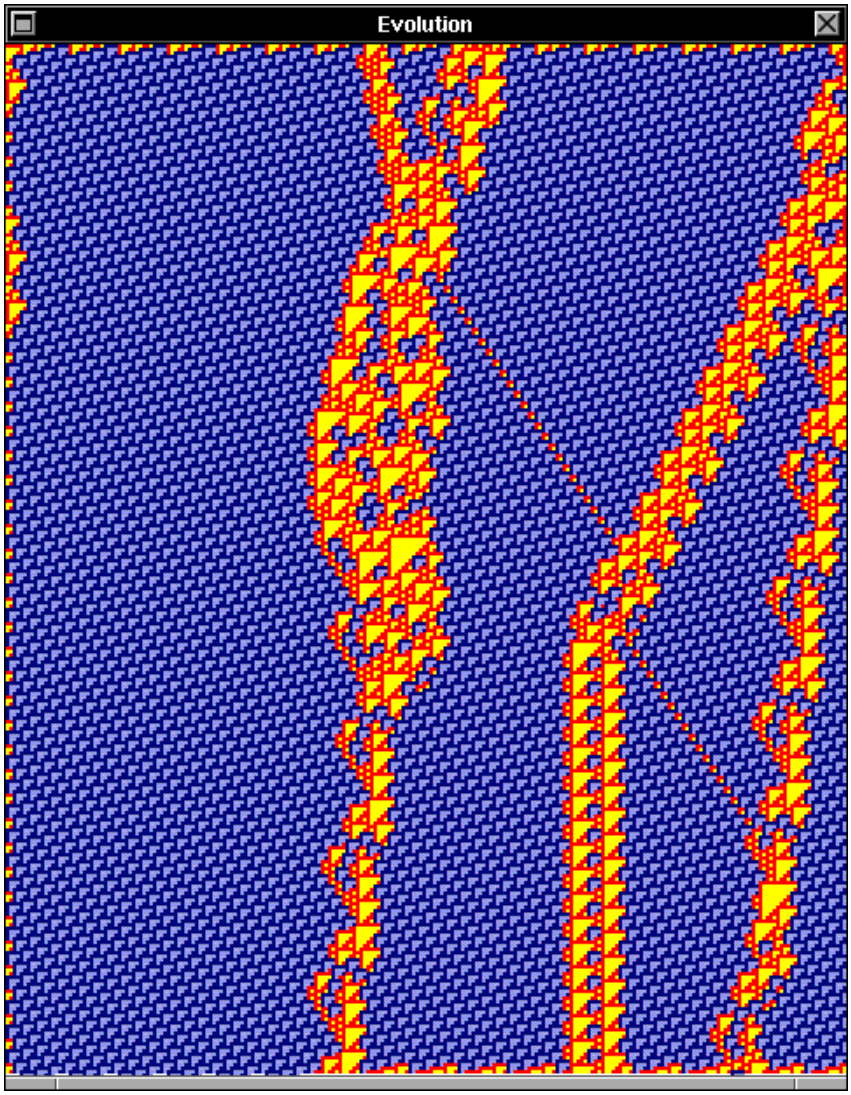

Figure 4.353: Collisions of glider D1, D1(p1)(A)-e(p1)-G(p1)(E)=A,F

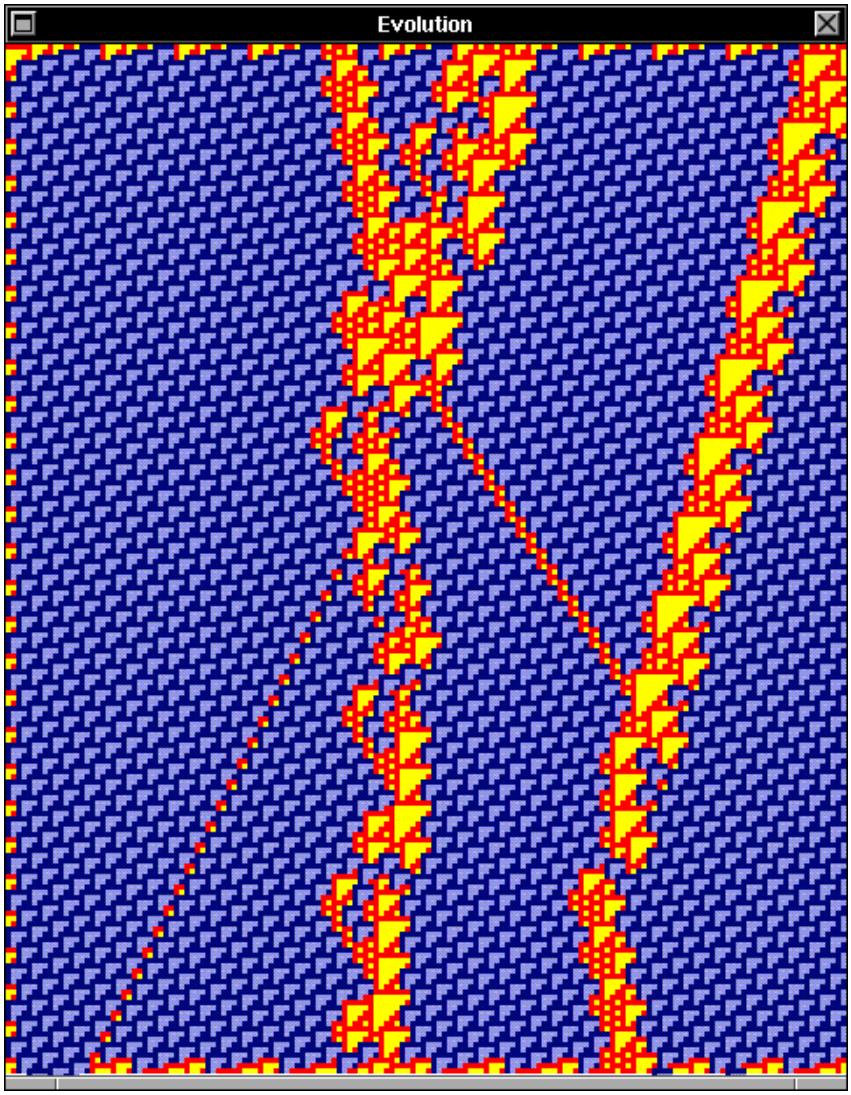

Figure 4.354: Collisions of glider D1, D1(p1)(C)-e(p1)-G(p1)(E)=2A,F,B

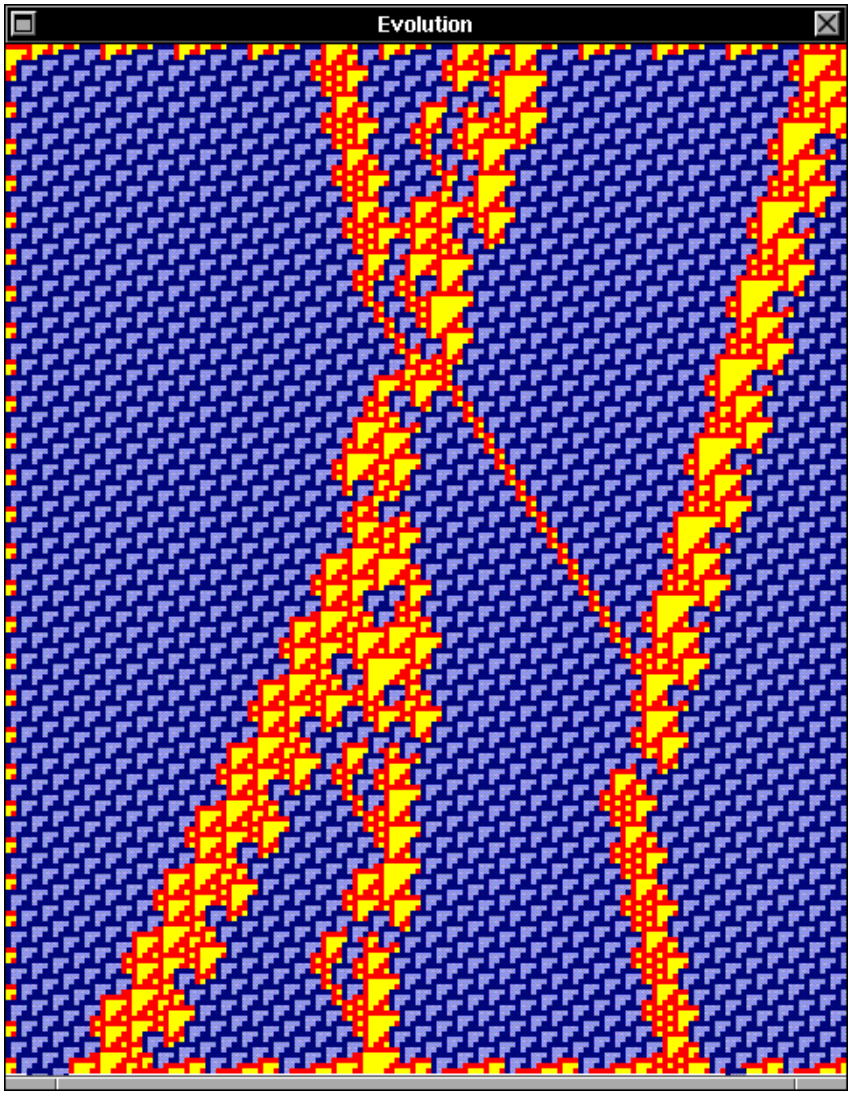

Figure 4.355: Collisions of glider D1, D1(p1)(A)-e(p1)-G(p1)(F)=2A,Bbar,F

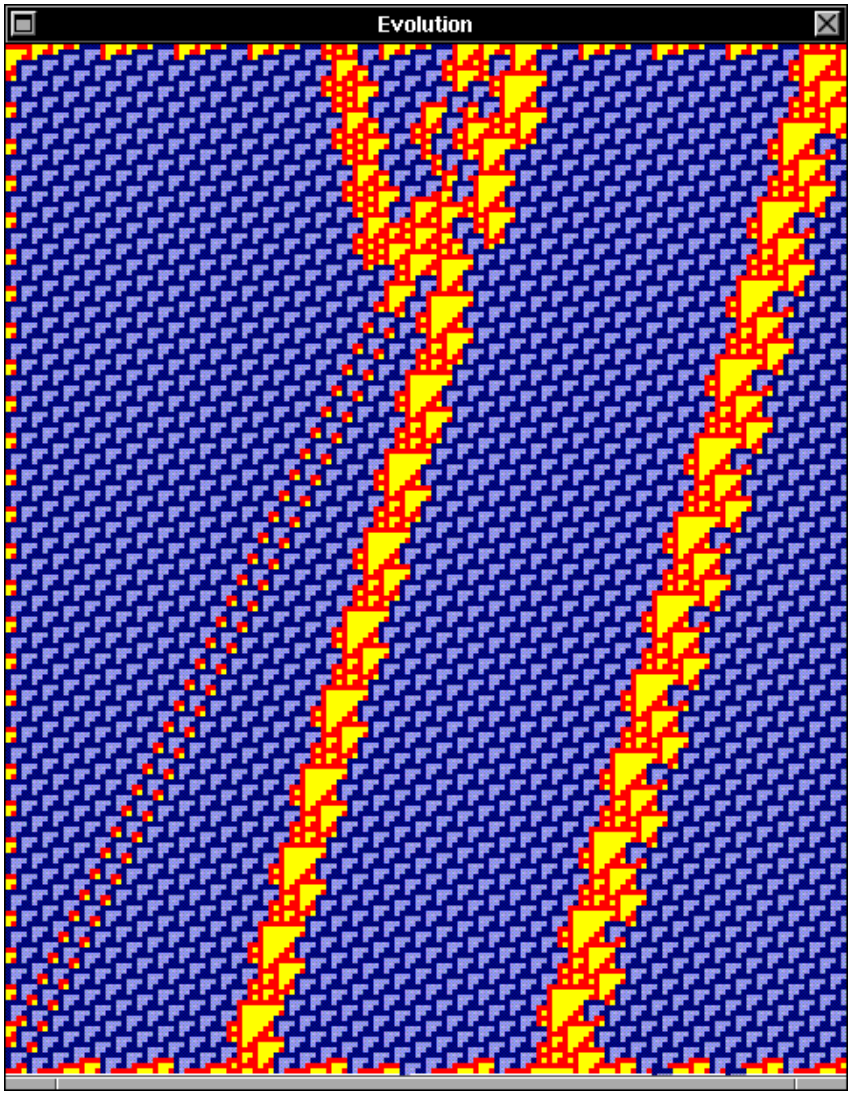

Figure 4.356: Collisions of glider D1, D1(p1)(C)-e(p1)-G(p1)(F)=2B,E

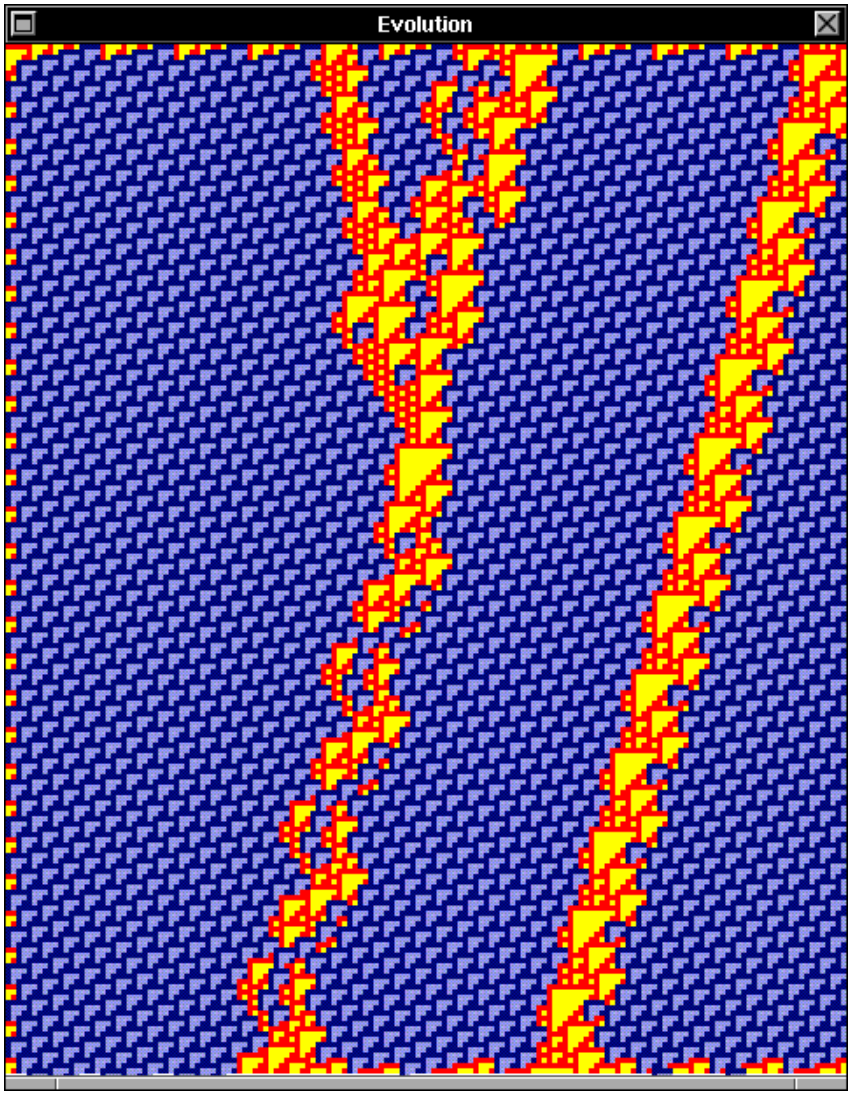

Figure 4.357: Collisions of glider D1, D1(p1)(A)-e(p1)-G(p1)(G)=Ebar

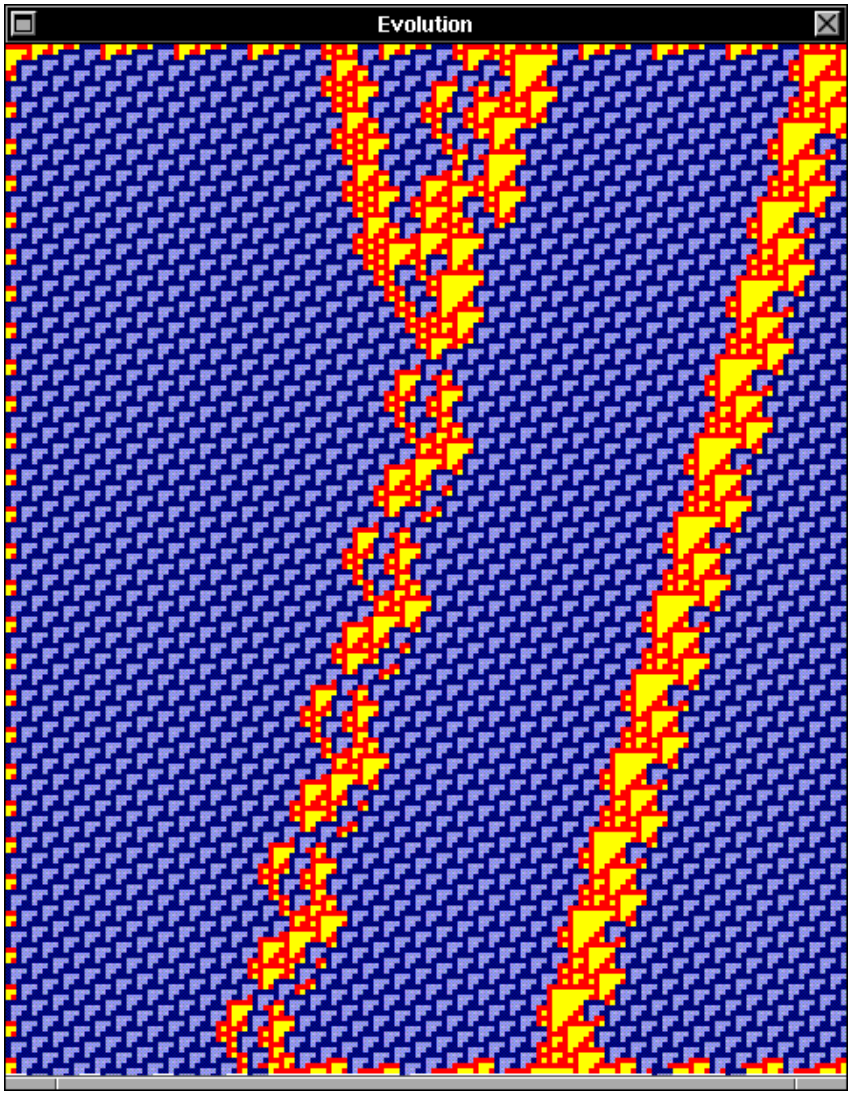

Figure 4.358: Collisions of glider D1, D1(p1)(C)-e(p1)-G(p1)(G)=Ebar

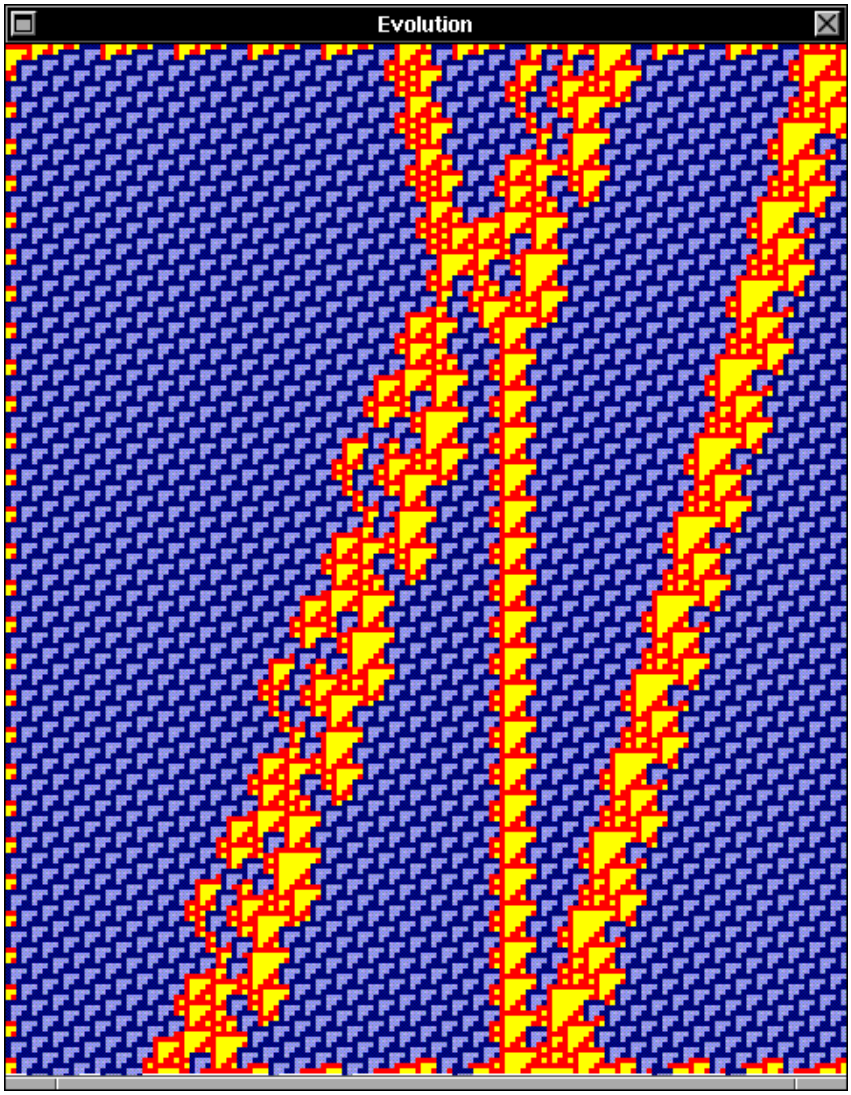

Figure 4.359: Collisions of glider D1, D1(p1)(A)-e(p1)-G(p1)(H)=G,C3

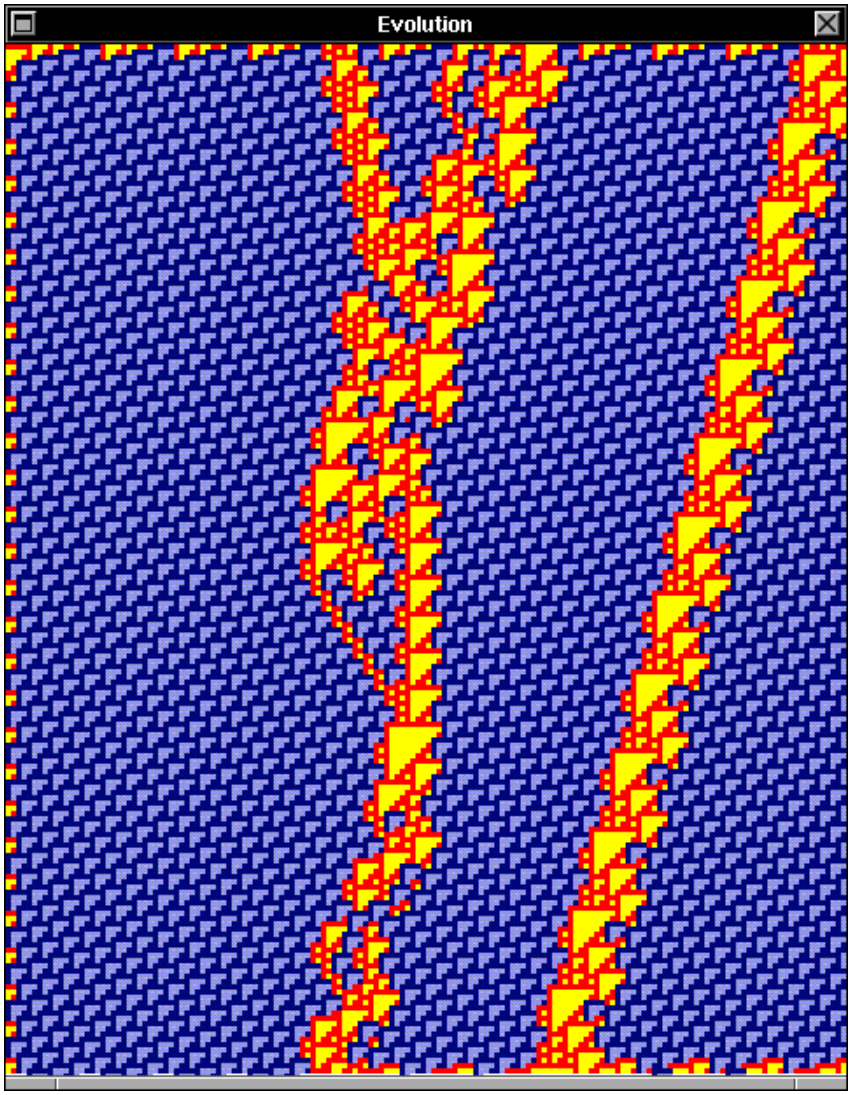

Figure 4.360: Collisions of glider D1, D1(p1)(C)-e(p1)-G(p1)(H)=Ebar

4.9.5 Collisions of glider D1 with glider H

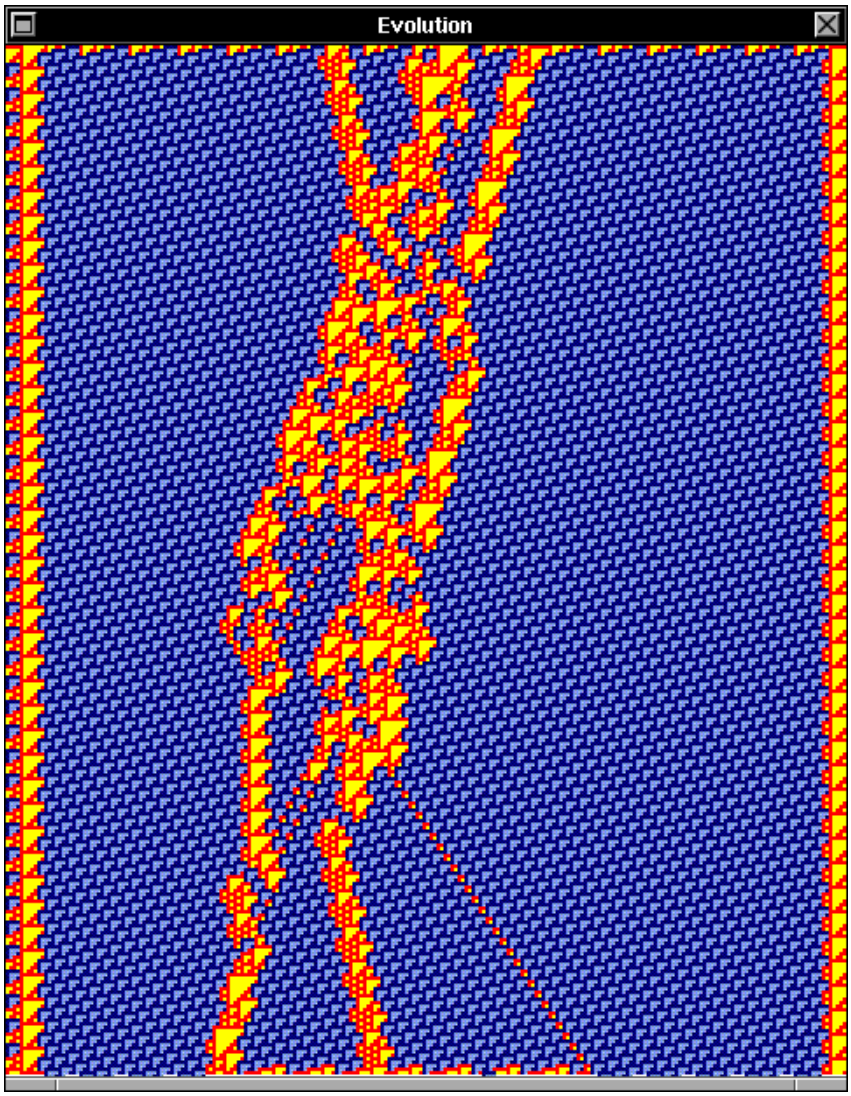

Figure 4.361: Collisions of glider D1, D1(p1)(A)-e(p1)-H(p1)(A)=A,D1,E

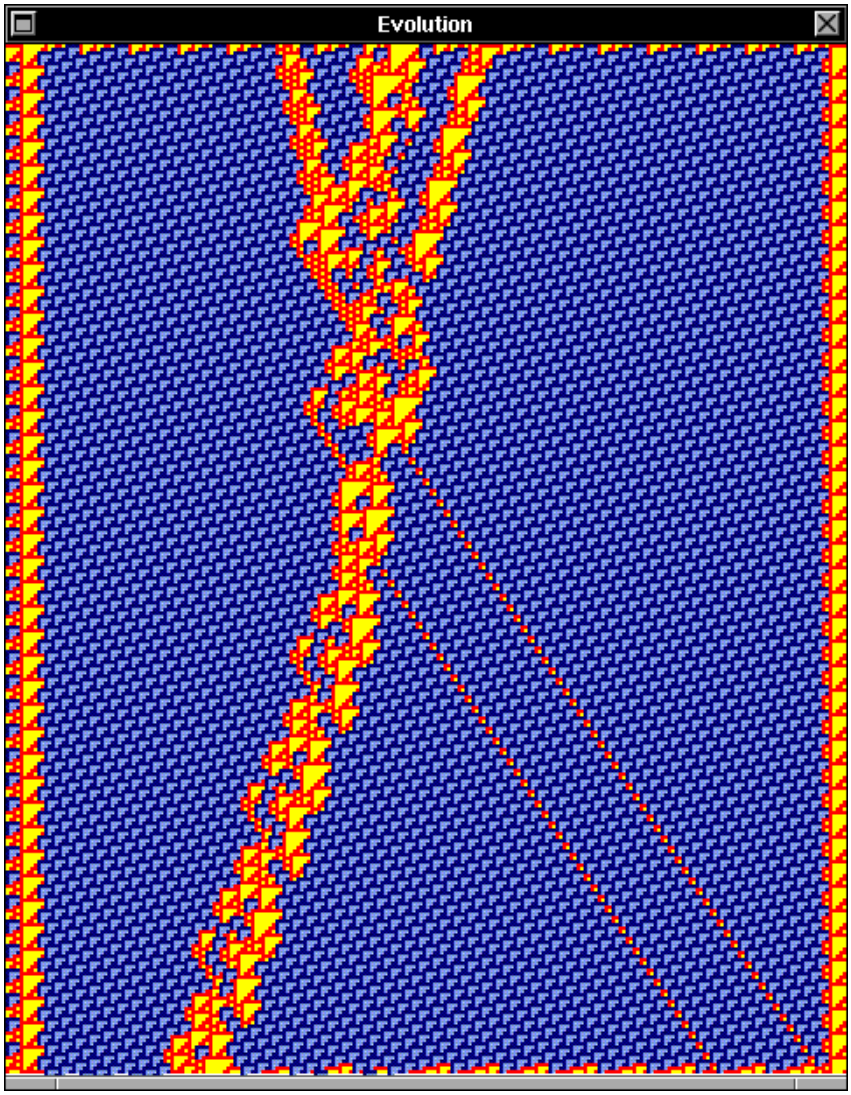

Figure 4.362: Collisions of glider D1, D1(p1)(C)-e(p1)-H(p1)(A)=A,A,G

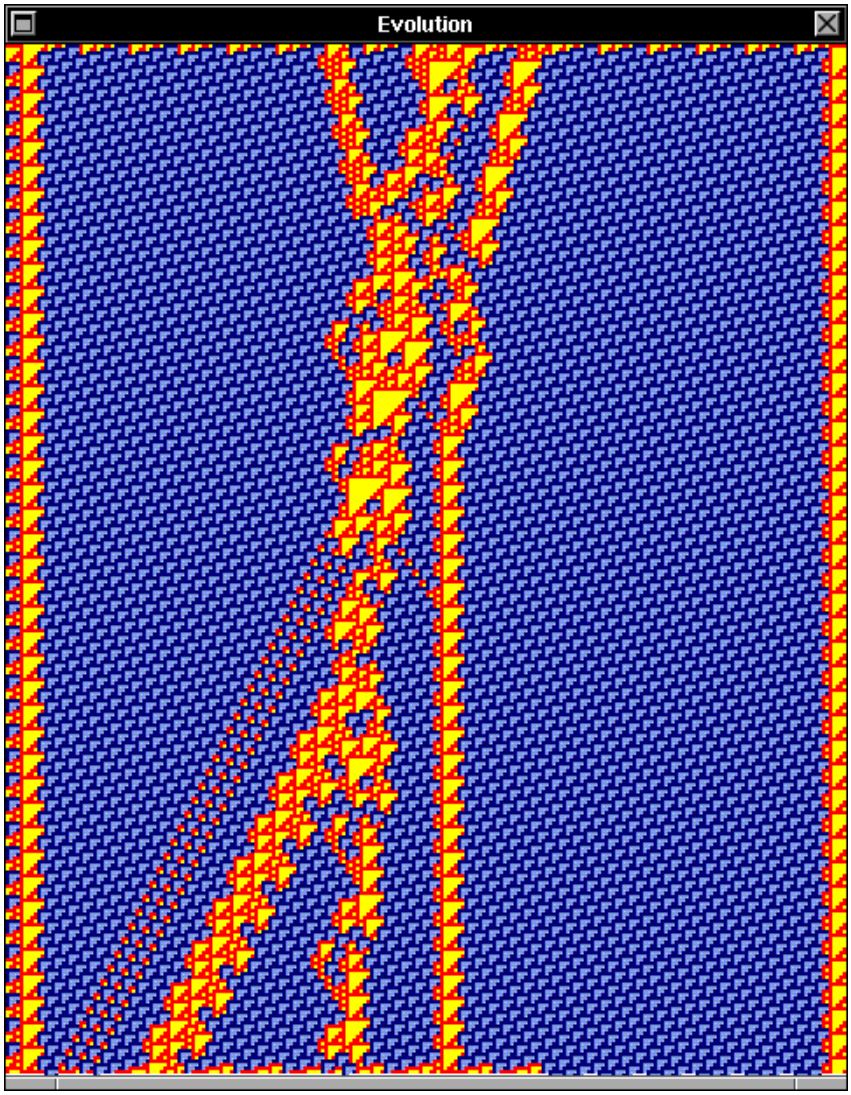

Figure 4.363: Collisions of glider D1, D1(p1)(A)-e(p1)-H(p1)(B)=3B,C2,Bbar,F

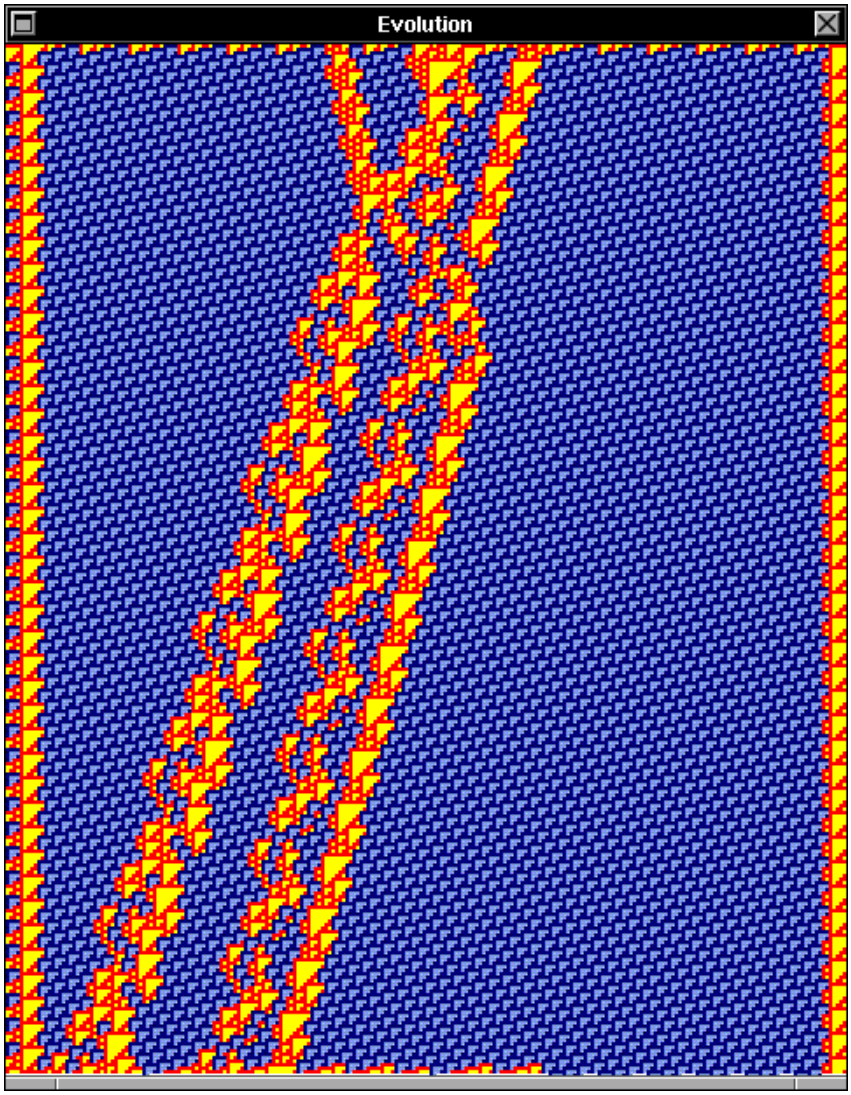

Figure 4.364: Collisions of glider D1, D1(p1)(C)-e(p1)-H(p1)(B)=G,Ebar,E

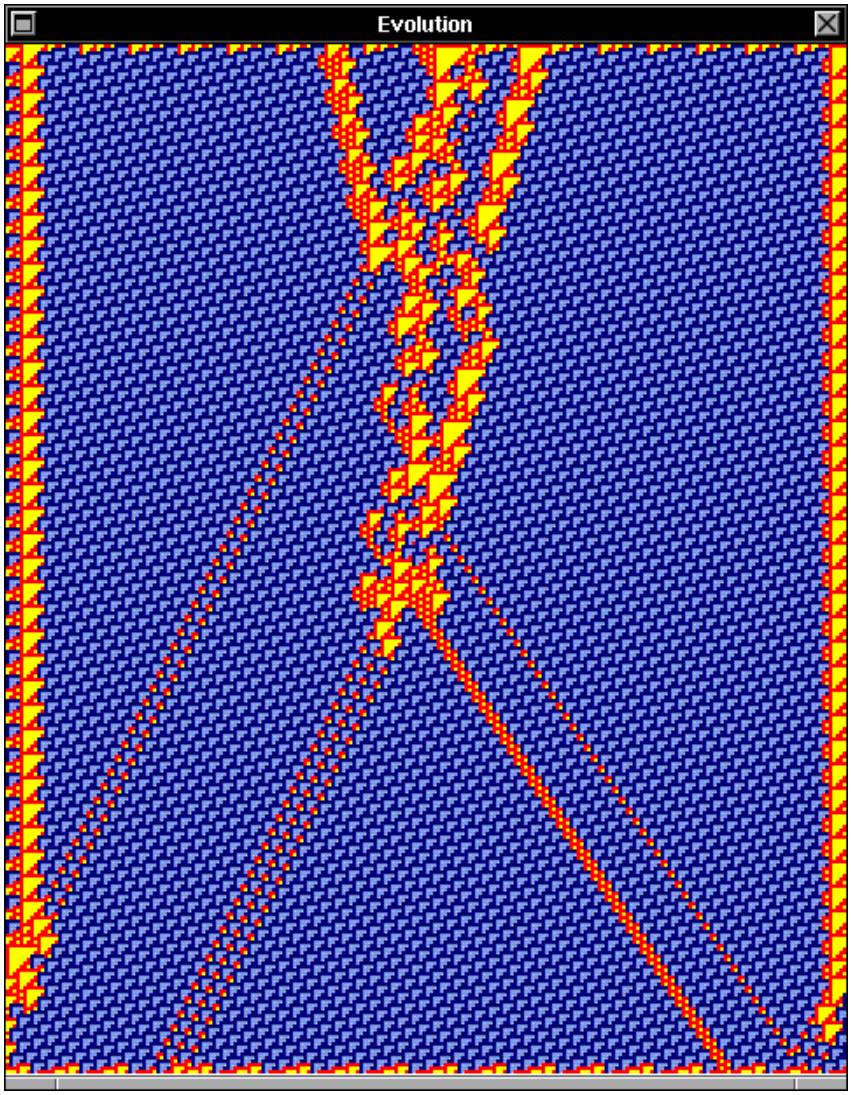

Figure 4.365: Collisions of glider D1, D1(p1)(A)-e(p1)-H(p1)(C)=2B,A,3A,3B

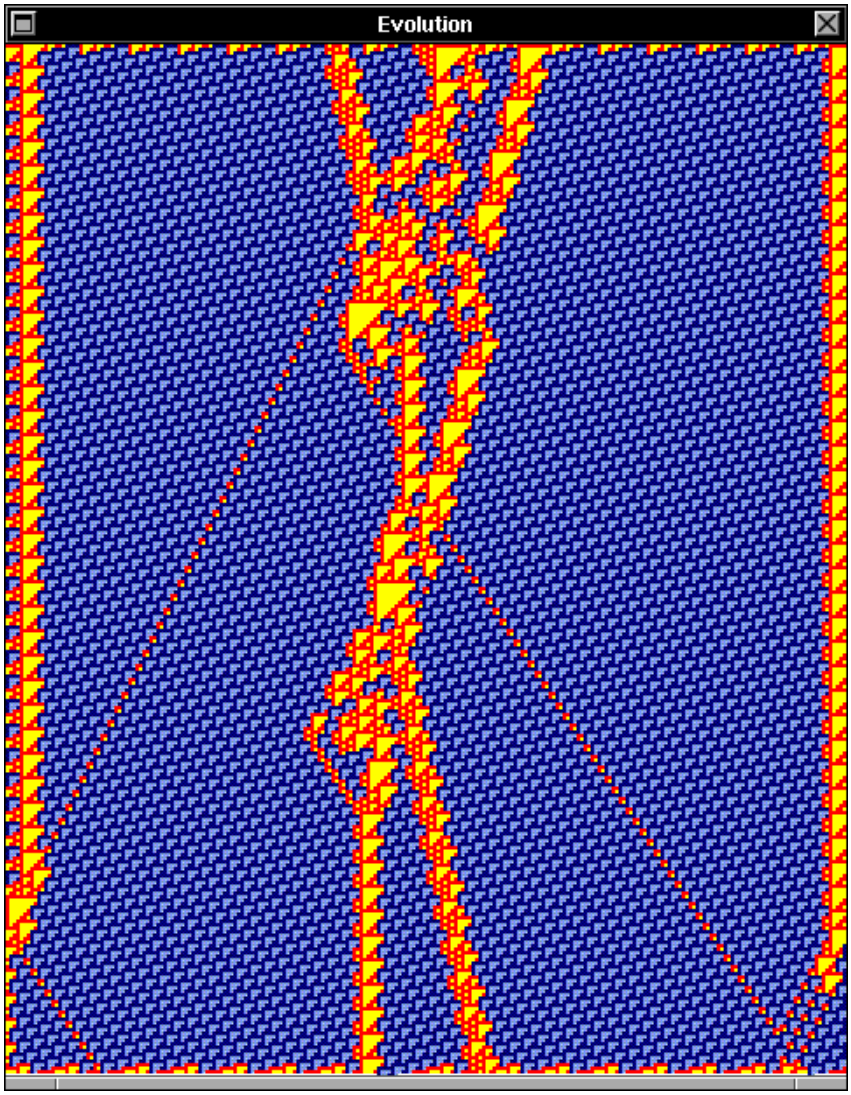

Figure 4.366: Collisions of glider D1, D1(p1)(C)-e(p1)-H(p1)(C)=B,A,D2,C2

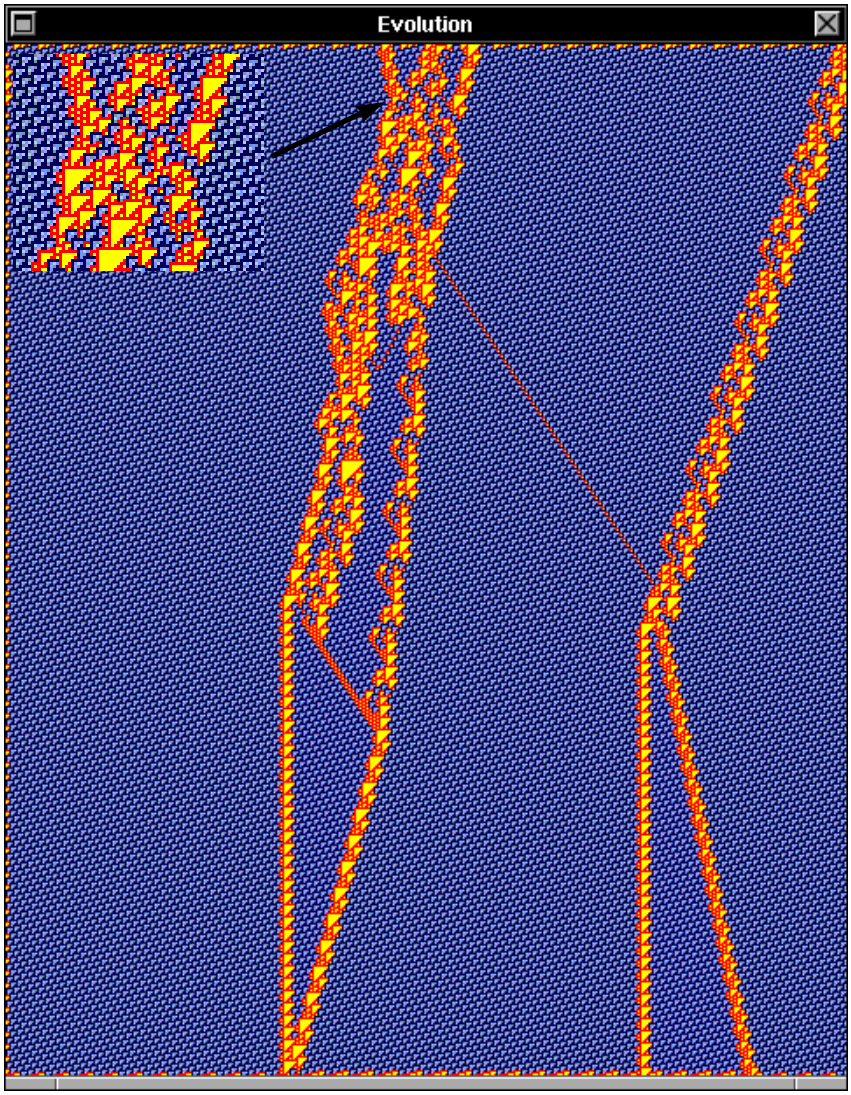

Figure 4.367: Collisions of glider D1, D1(p1)(A)-e(p1)-H(p1)(H)=A,A,3B

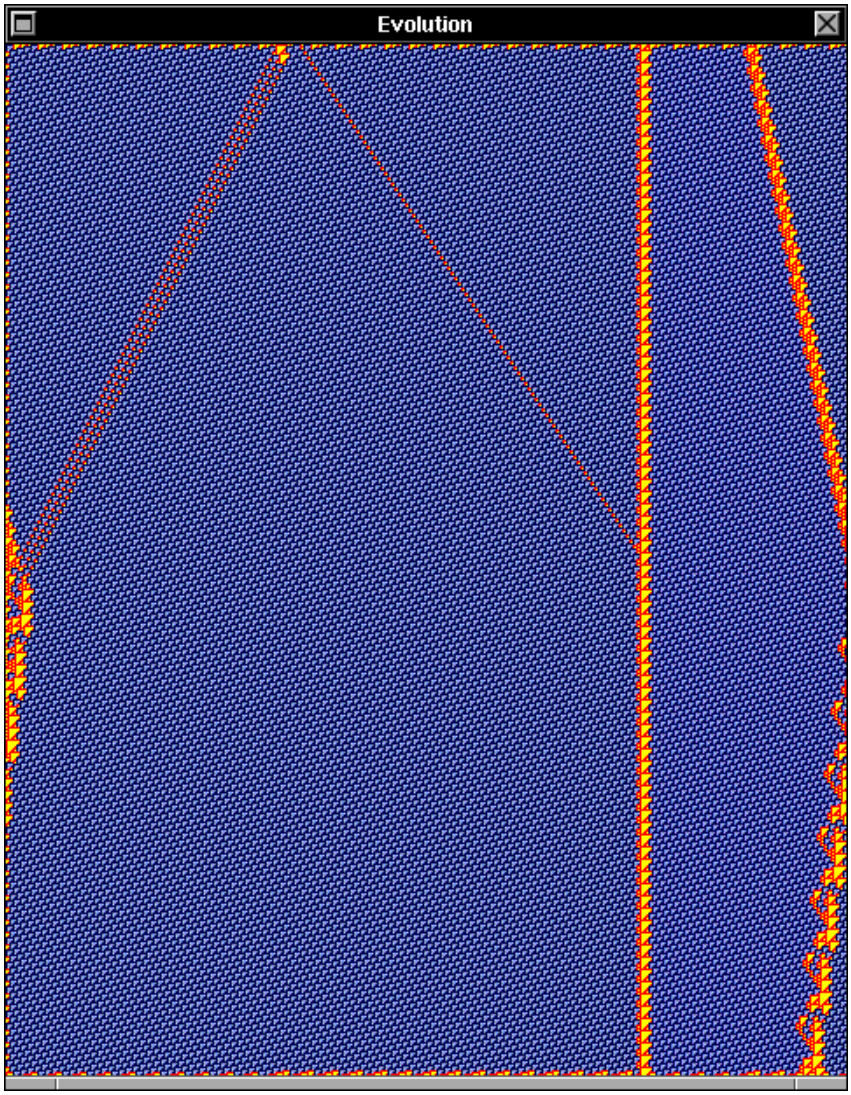

Figure 4.368: continue collision, D1(p1)(A)-e(p1)-H(p1)(H)

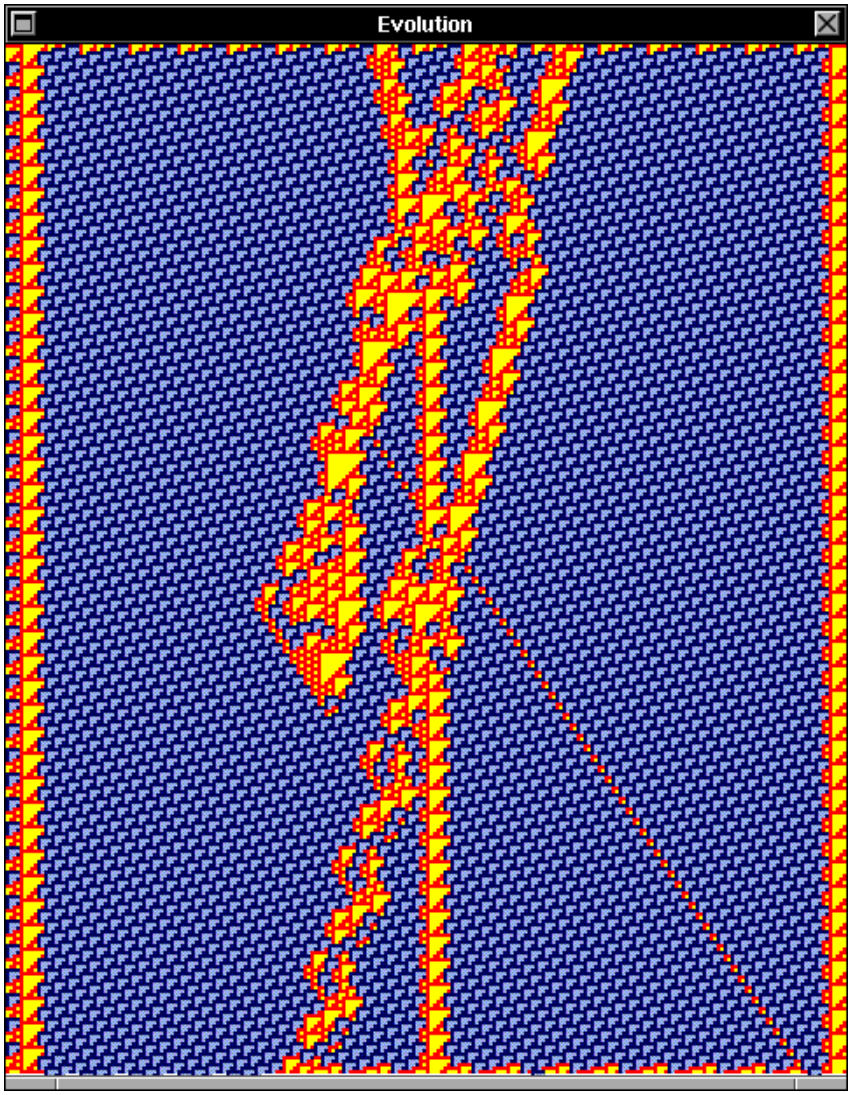

Figure 4.369: Collisions of glider D1, D1(p1)(A)-e(p1)-H(p1)(A2)=A,Ebar,C1

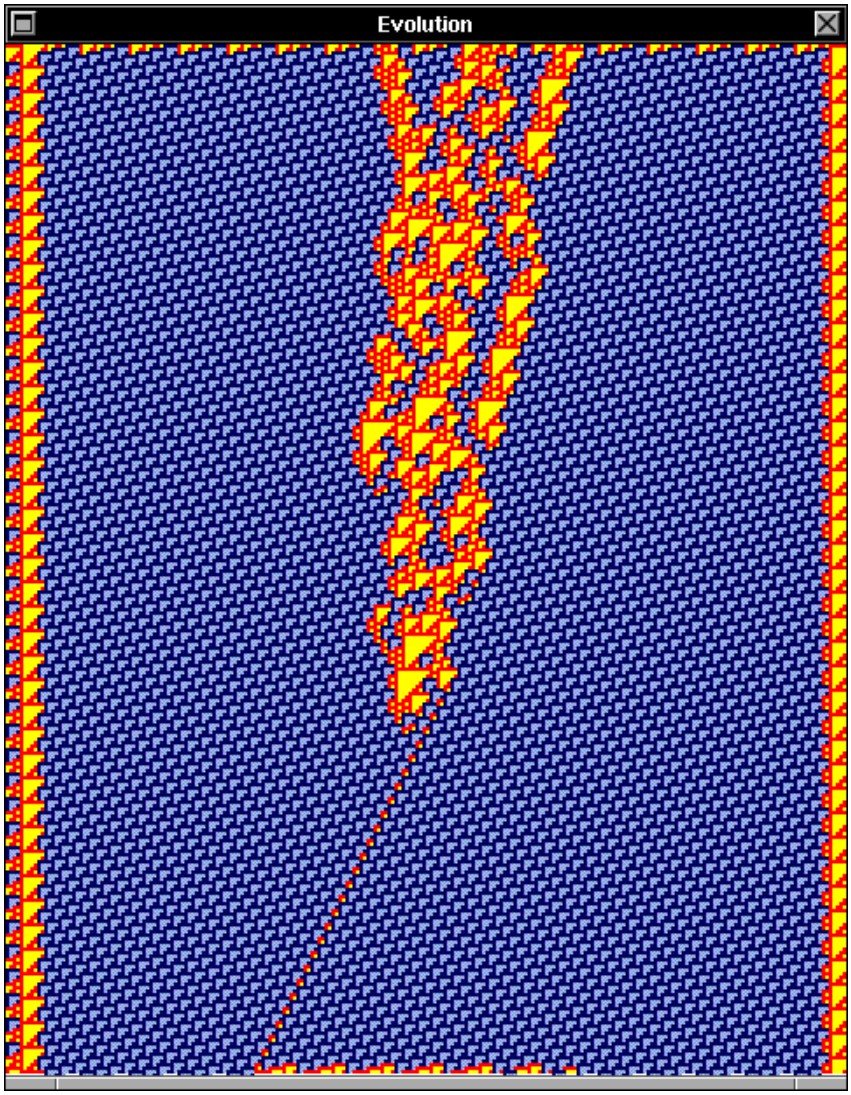

Figure 4.370: Collisions of glider D1, D1(p1)(C)-e(p1)-H(p1)(A2)=B

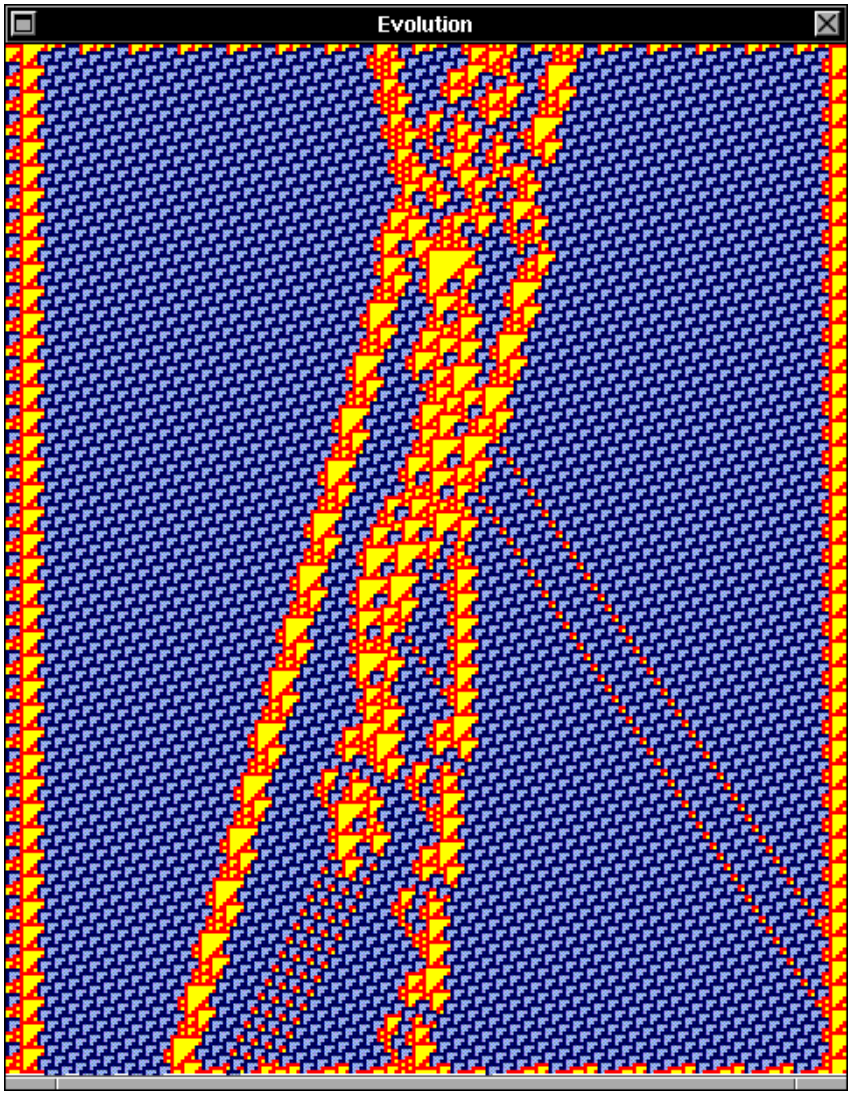

Figure 4.371: Collisions of glider D1, D1(p1)(A)-e(p1)-H(p1)(B2)=B,B,F,E5

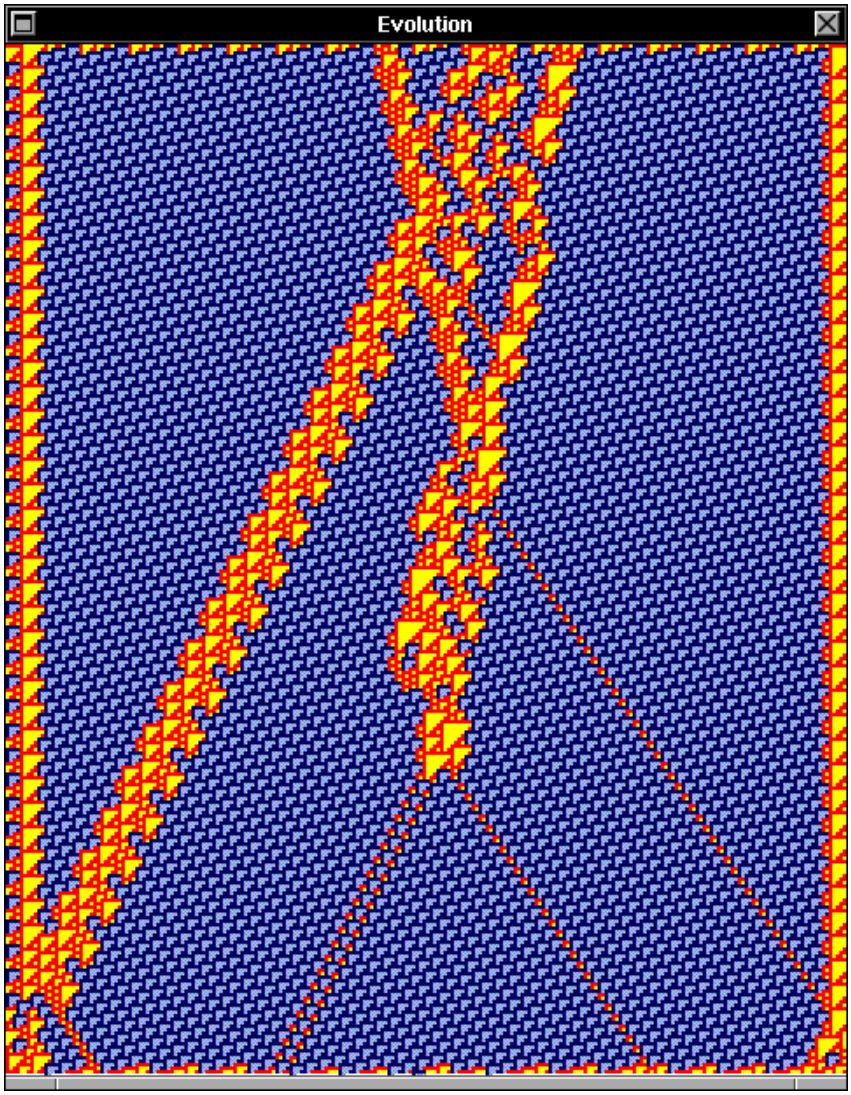

Figure 4.372: Collisions of glider D1, D1(p1)(C)-e(p1)-H(p1)(B2)=Bbar,A,2B,A

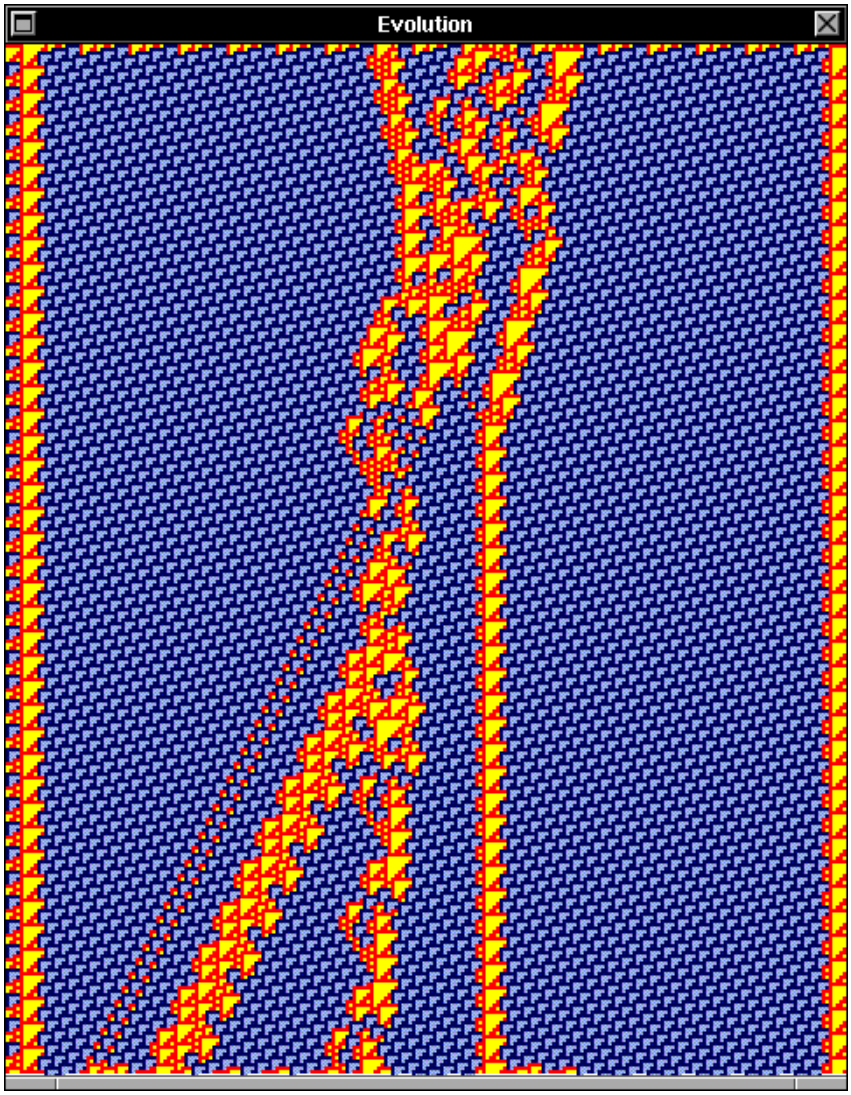

Figure 4.373: Collisions of glider D1, D1(p1)(A)-e(p1)-H(p1)(C2)=C3,2B,Bbar,F

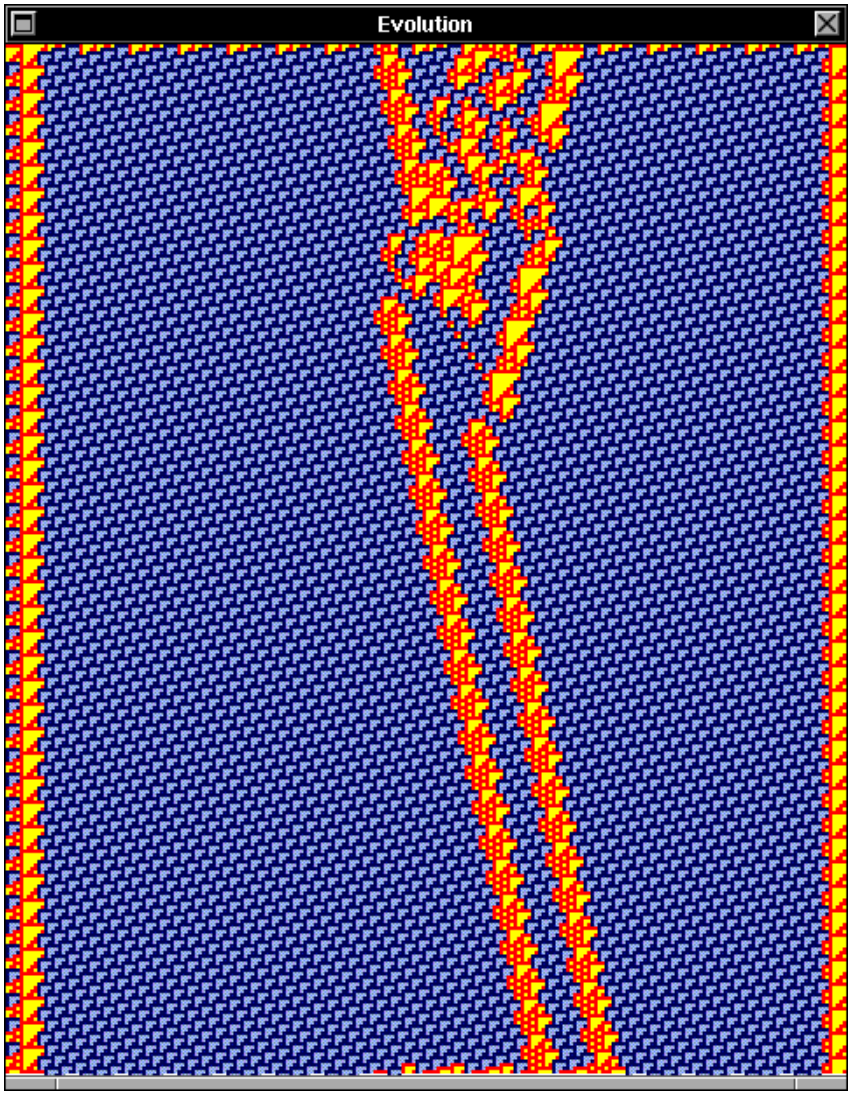

Figure 4.374: Collisions of glider D1, D1(p1)(C)-e(p1)-H(p1)(C2)=D1,D1

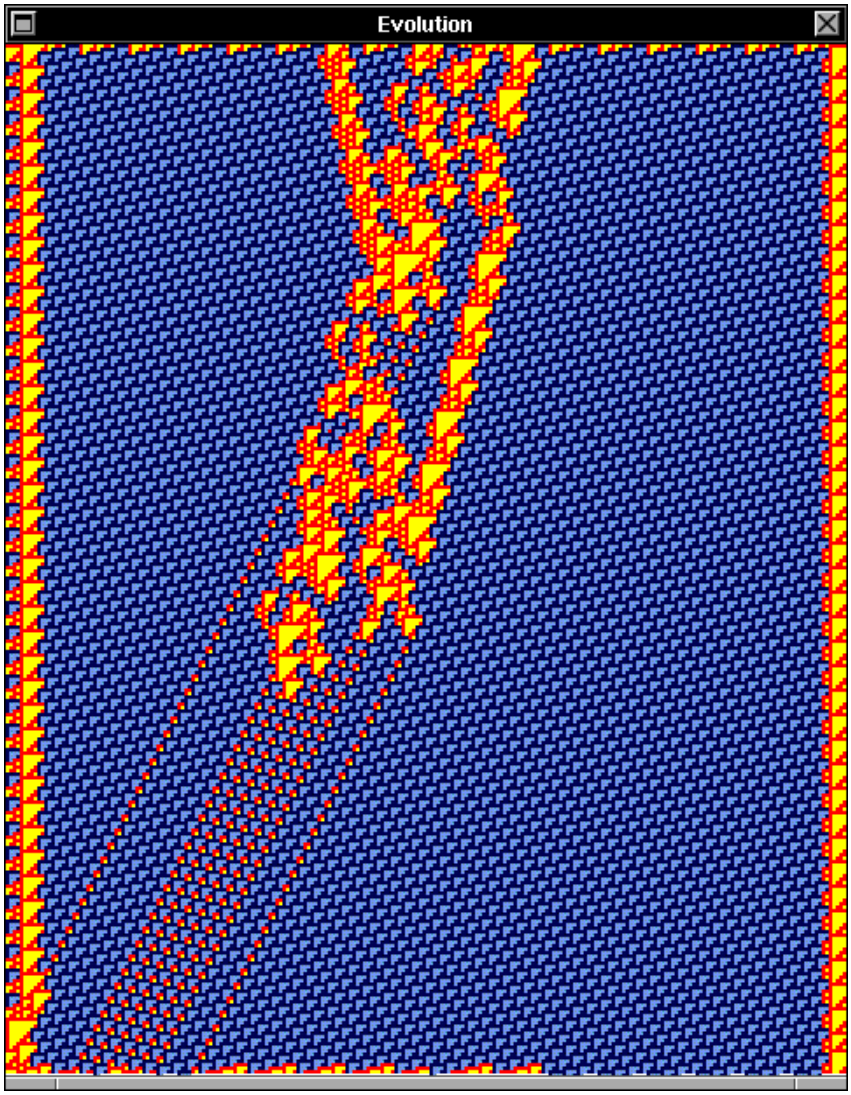

Figure 4.375: Collisions of glider D1, D1(p1)(A)-e(p1)-H(p1)(D2)=B,6B,B

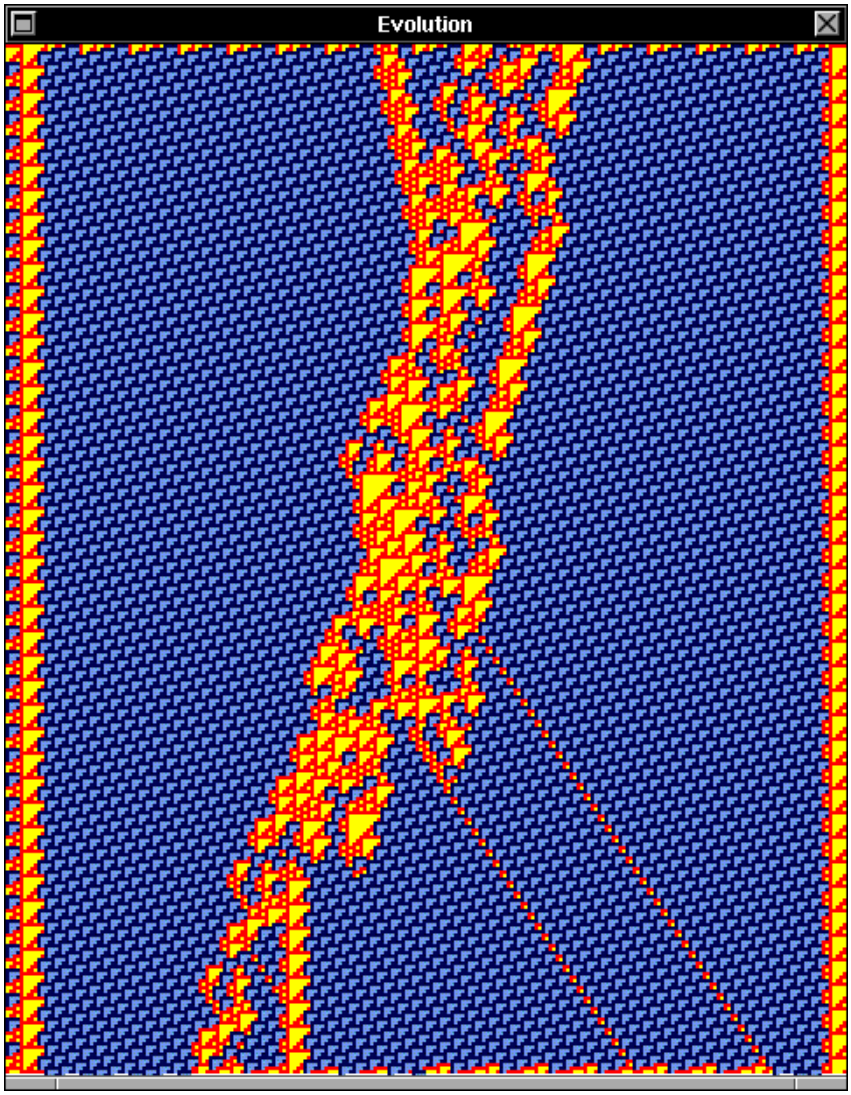

Figure 4.376: Collisions of glider D1, D1(p1)(C)-e(p1)-H(p1)(D2)=A,A,Ebar,C2

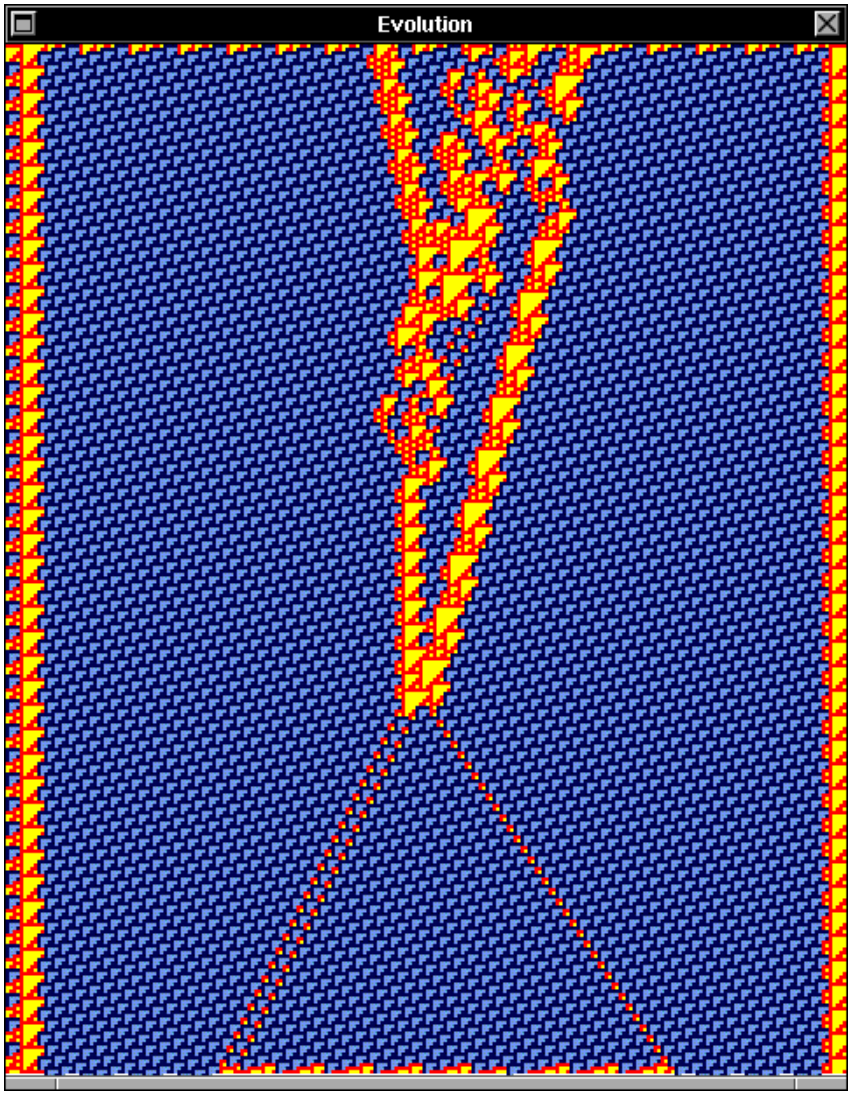

Figure 4.377: Collisions of glider D1, D1(p1)(A)-e(p1)-H(p1)(E2)=2B,A

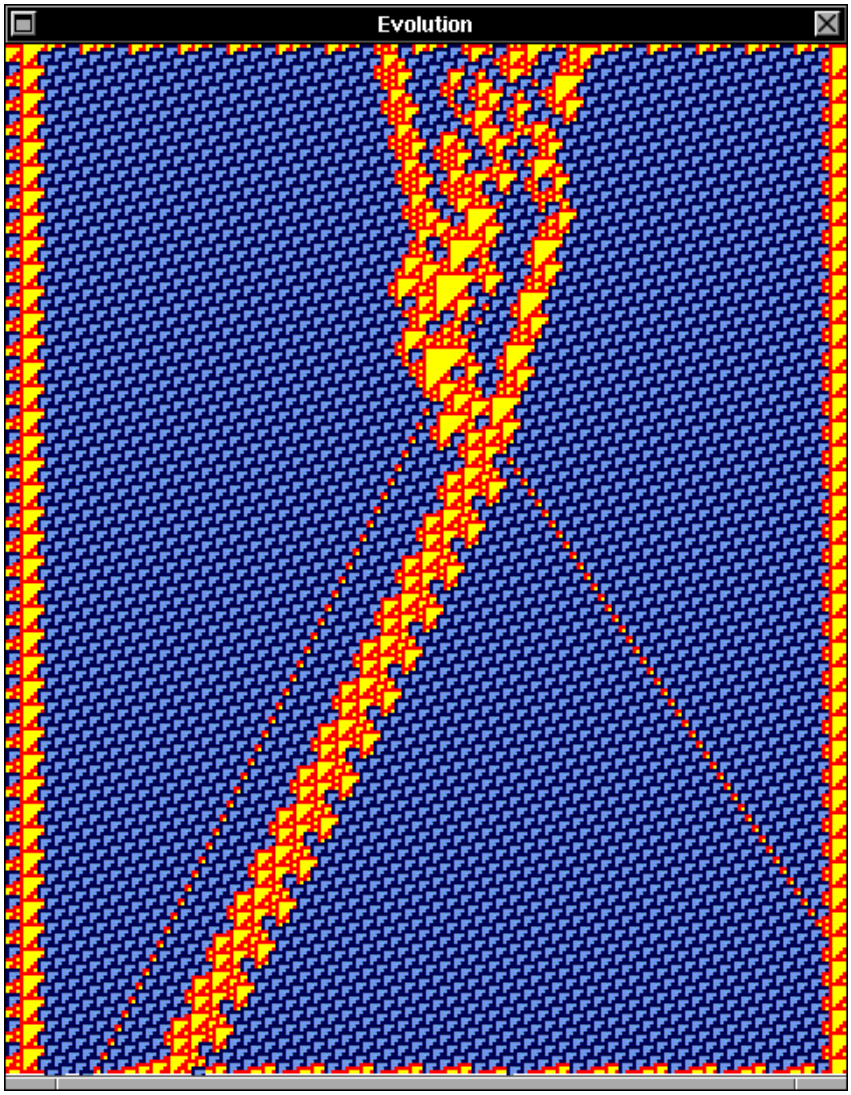

Figure 4.378: Collisions of glider D1, D1(p1)(C)-e(p1)-H(p1)(E2)=B,Bbar,A

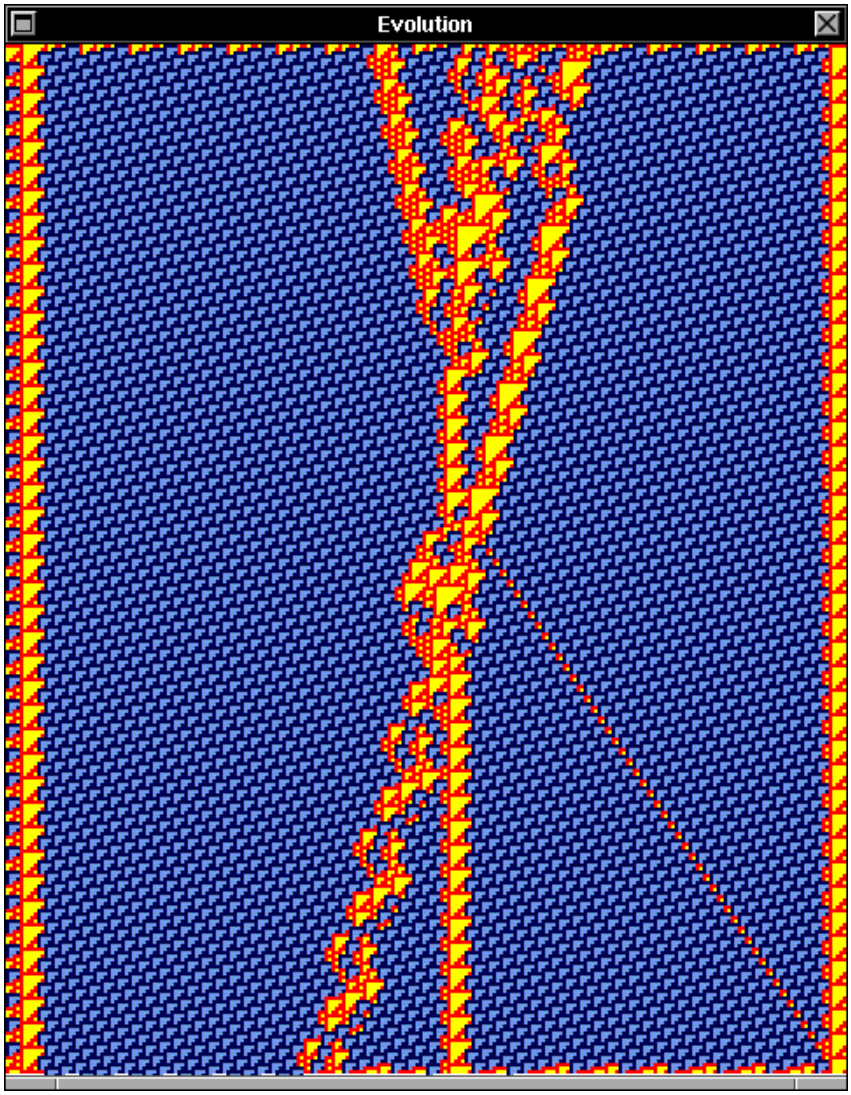

Figure 4.379: Collisions of glider D1, D1(p1)(A)-e(p1)-H(p1)(F2)=A,Ebar,C1

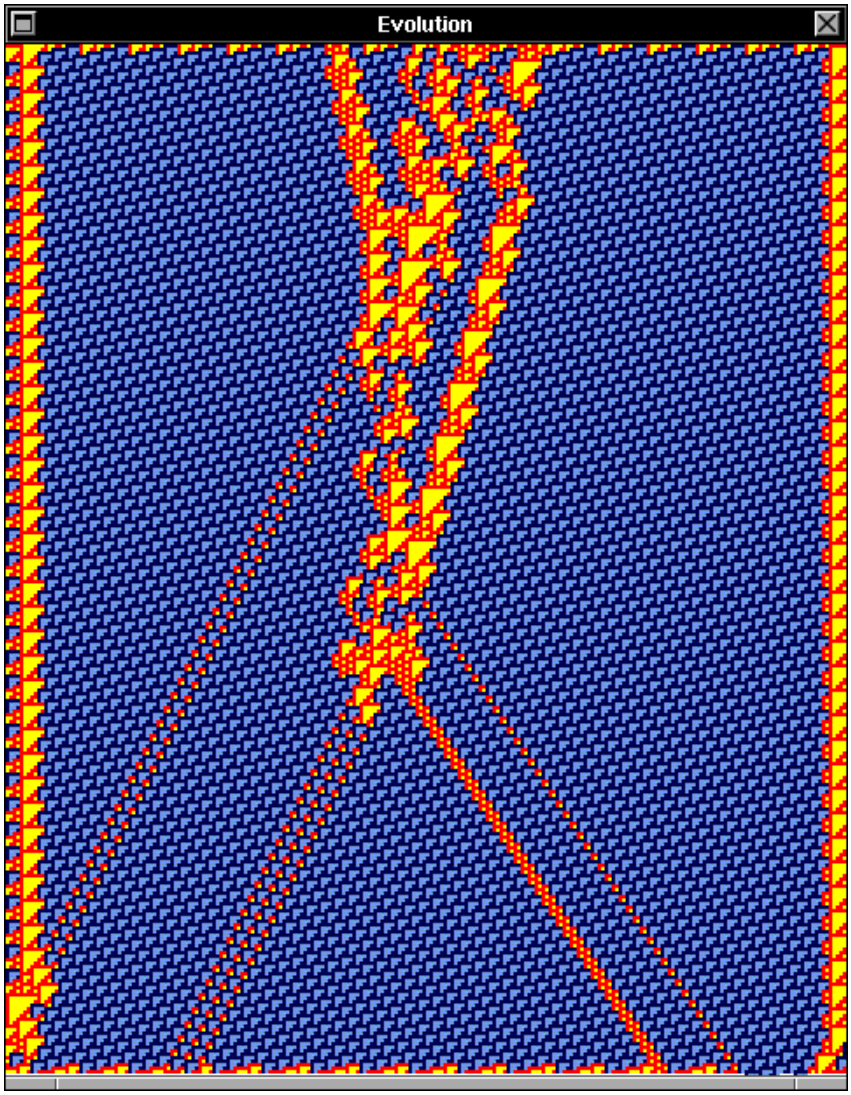

Figure 4.380: Collisions of glider D1, D1(p1)(C)-e(p1)-H(p1)(F2)=2B,A,3B,3A

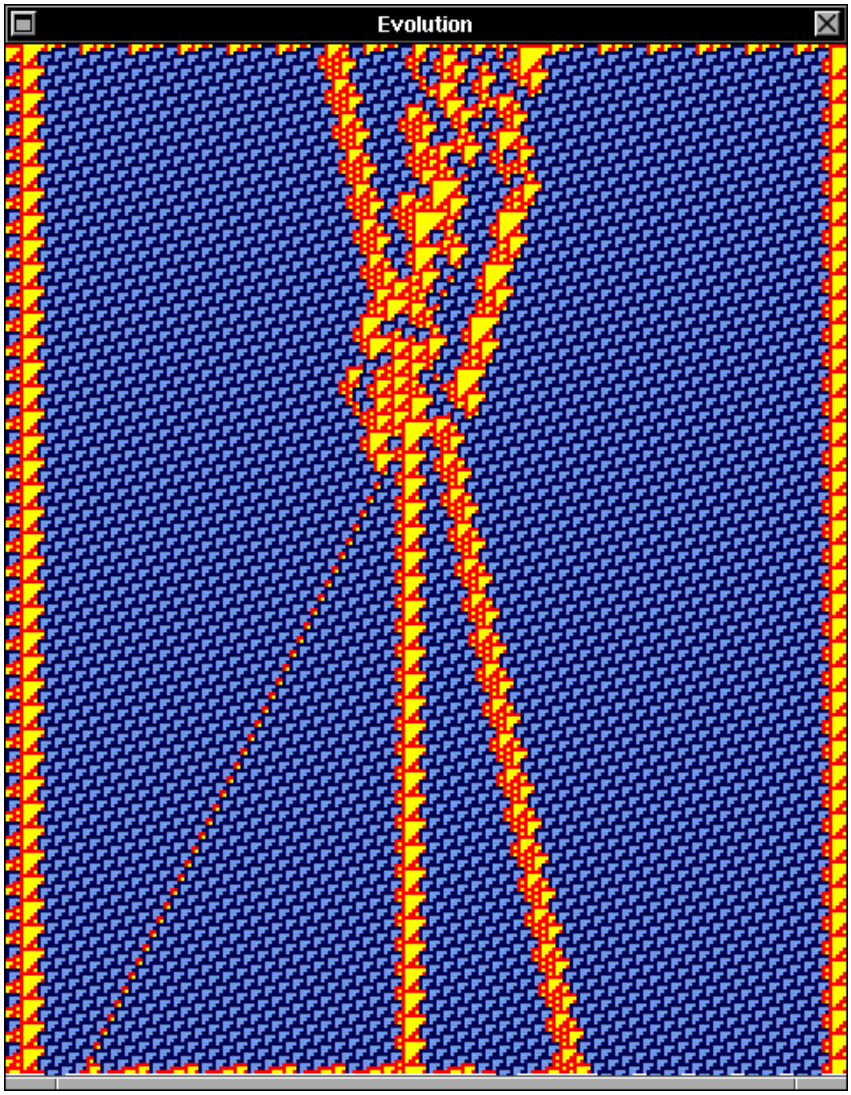

Figure 4.381: Collisions of glider D1, D1(p1)(A)-e(p1)-H(p1)(G2)=B,C1,D2

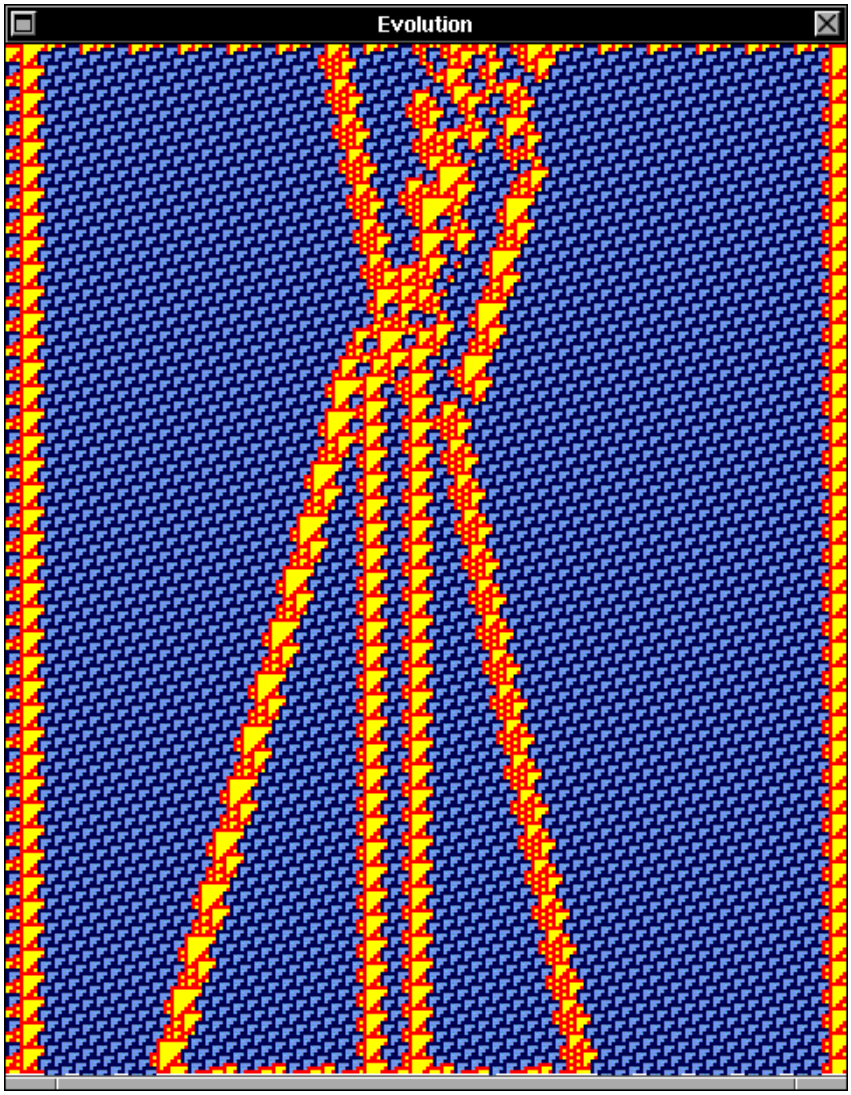

Figure 4.382: Collisions of glider D1, D1(p1)(A)-e(p1)-H(p1)(H2)=E,C3,C1,D1

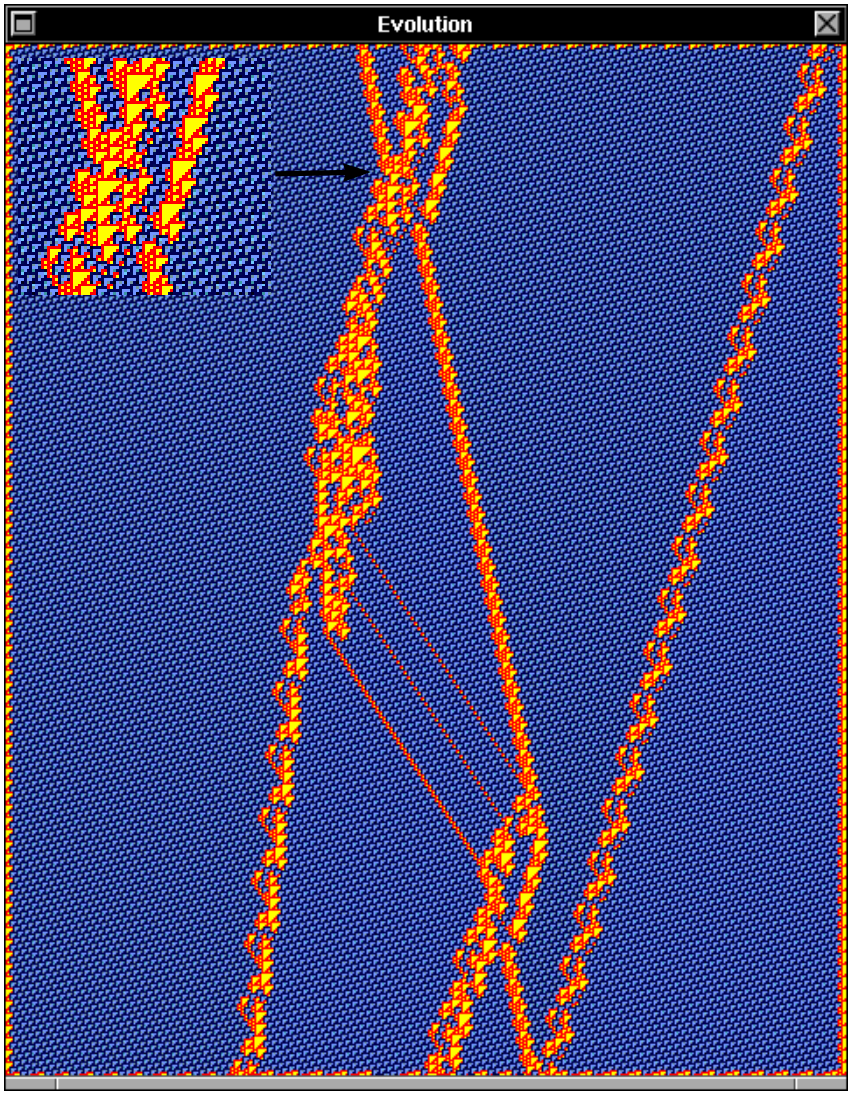

Figure 4.383: Collisions of glider D1, D1(p1)(C)-e(p1)-H(p1)(H2)=F,G,D1

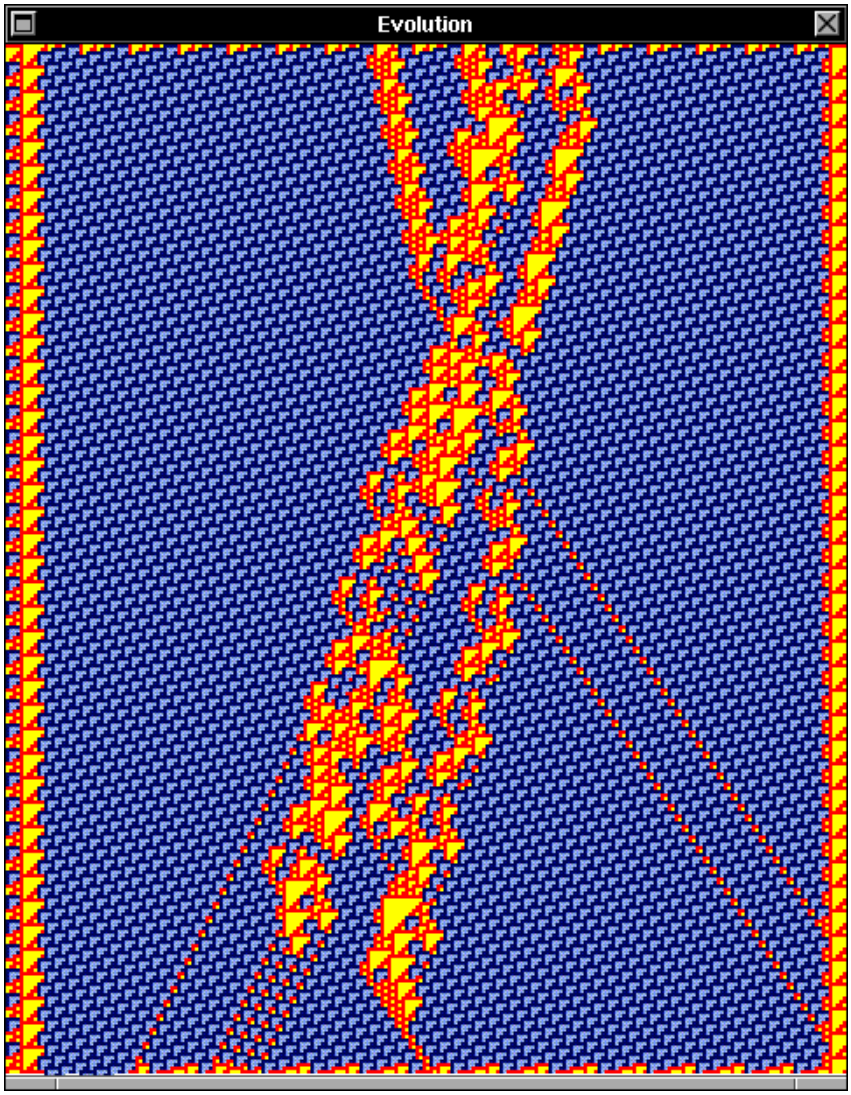

Figure 4.384: Collisions of glider D1, D1(p1)(A)-e(p1)-H(p1)(D3)=A,A,B,4B,2A

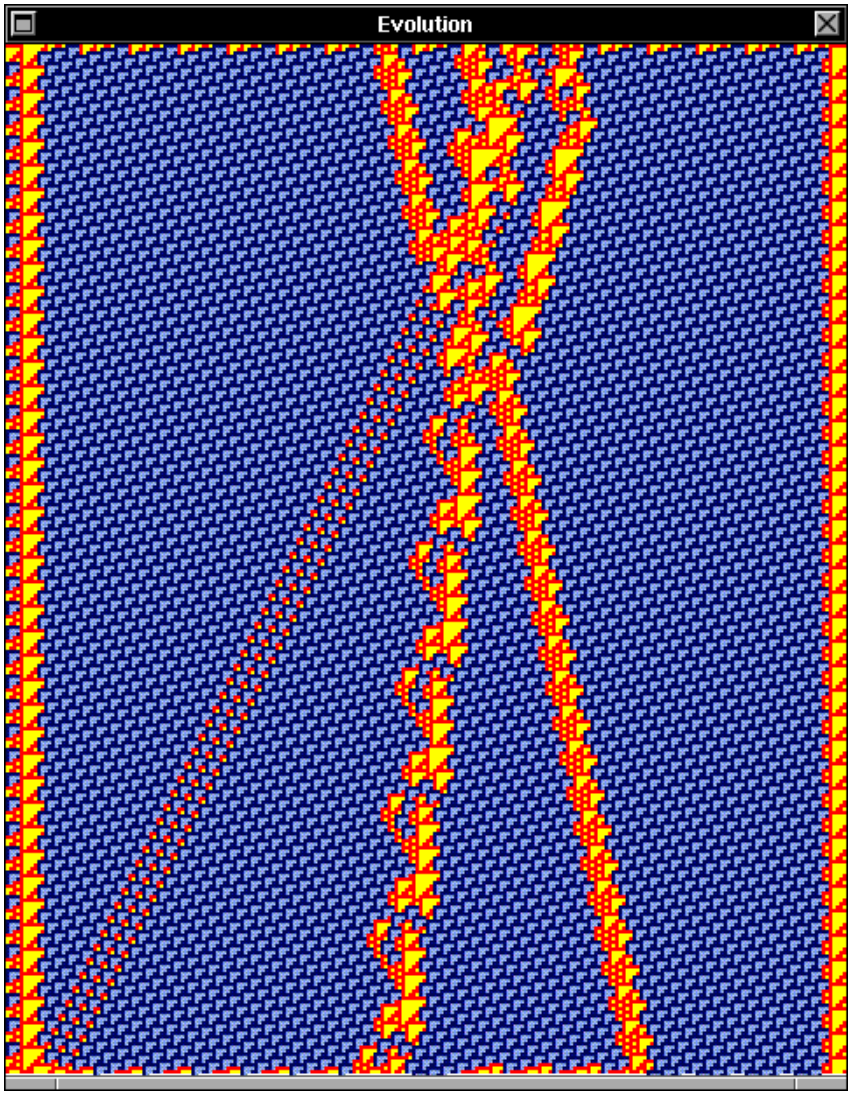

Figure 4.385: Collisions of glider D1, D1(p1)(C)-e(p1)-H(p1)(D3)=3B,F,D1

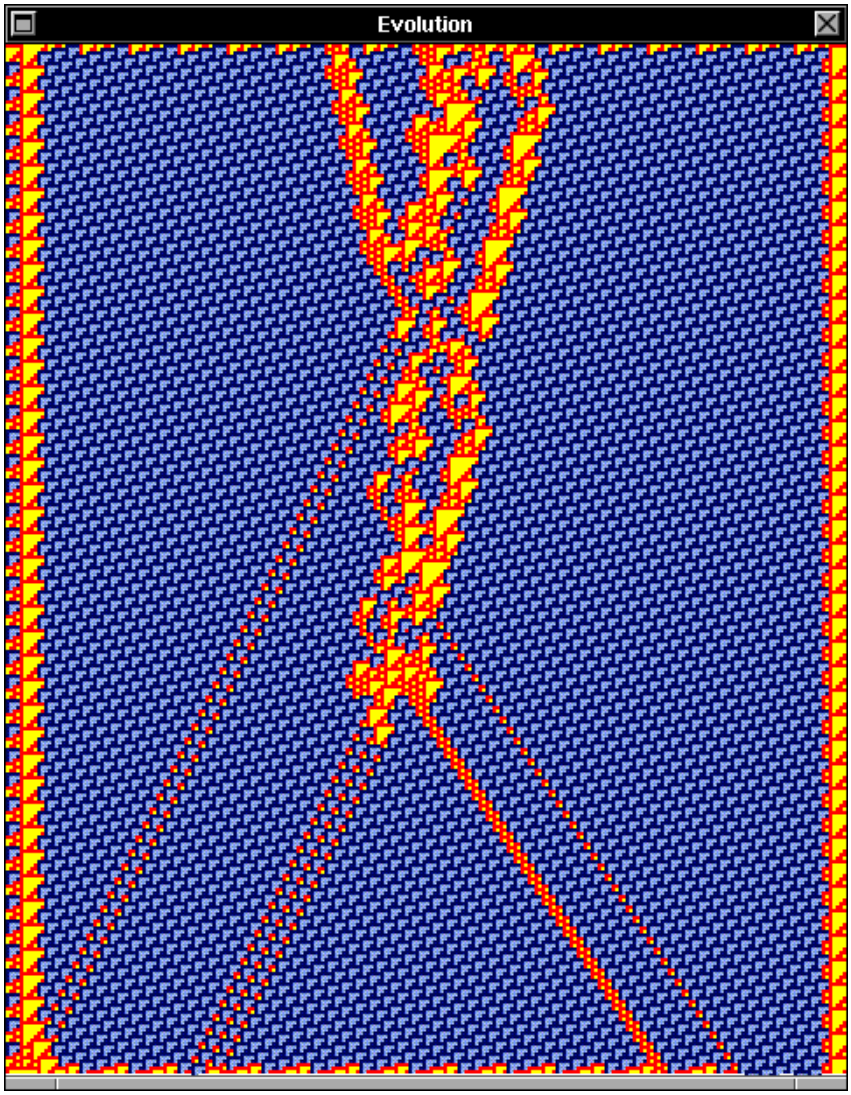

Figure 4.386: Collisions of glider D1, D1(p1)(C)-e(p1)-H(p1)(E3)=2B,A,3B,3A

4.10 Collisions of glider D2

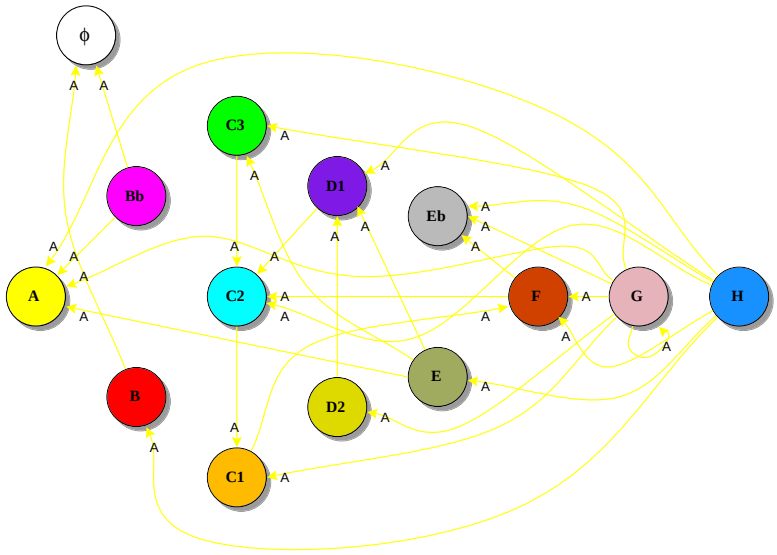

Figure 4.387: Collisions of glider D2

	ϕ	A	B	$Bbar$	$C3$	$C2$	$C1$	$D2$	$D1$	E	$Ebar$	F	G	H
ϕ	.	.	.	.	.	.	.	.	.	.	.	.	.	.
A	.	.	.	.	.	.	.	.	.	.	.	.	.	.
B	.	.	.	.	.	.	.	.	.	.	.	.	.	.
$Bbar$	.	.	.	.	.	.	.	.	.	.	.	.	.	.
$C3$	.	.	.	.	.	.	.	.	.	.	.	.	.	.
$C2$	.	.	.	.	.	.	.	.	.	.	.	.	.	.
$C1$	.	.	.	.	.	.	.	.	.	.	.	.	.	.
$D2$	.	.	.	.	.	.	.	.	.	.	.	.	.	.
$D1$	.	.	.	.	.	.	.	.	.	.	.	.	.	.
E	.	.	.	.	.	.	.	.	.	.	.	.	.	.
$Ebar$	.	.	.	.	.	.	.	.	.	.	.	.	.	.
F	.	.	.	.	.	.	.	.	.	.	.	.	.	.
G	.	.	.	.	.	.	.	.	.	.	.	.	.	.
H	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Table 4.9: Matrix connection of collisions glider D2

4.10.1 Collisions of glider D2 with glider E

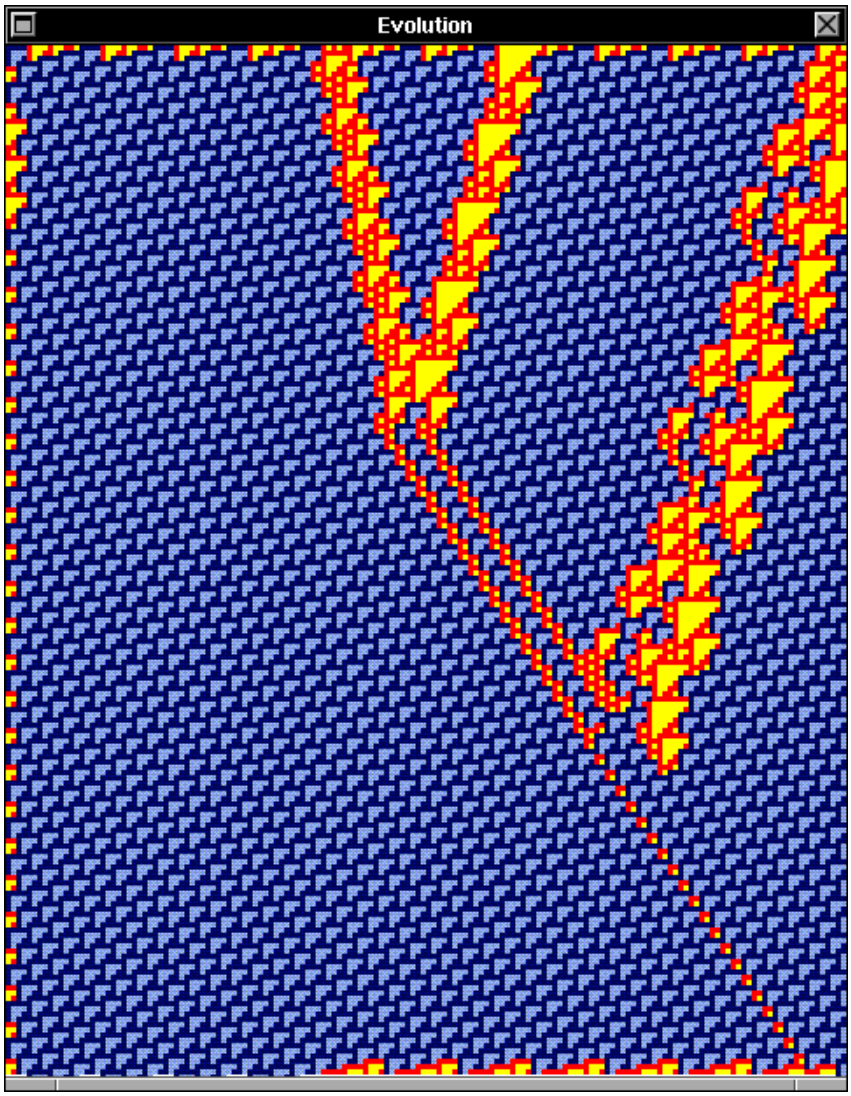

Figure 4.388: Collisions of glider D2, D2(p1)(A)-e(p1)-E(p1)(A)=2A,2A

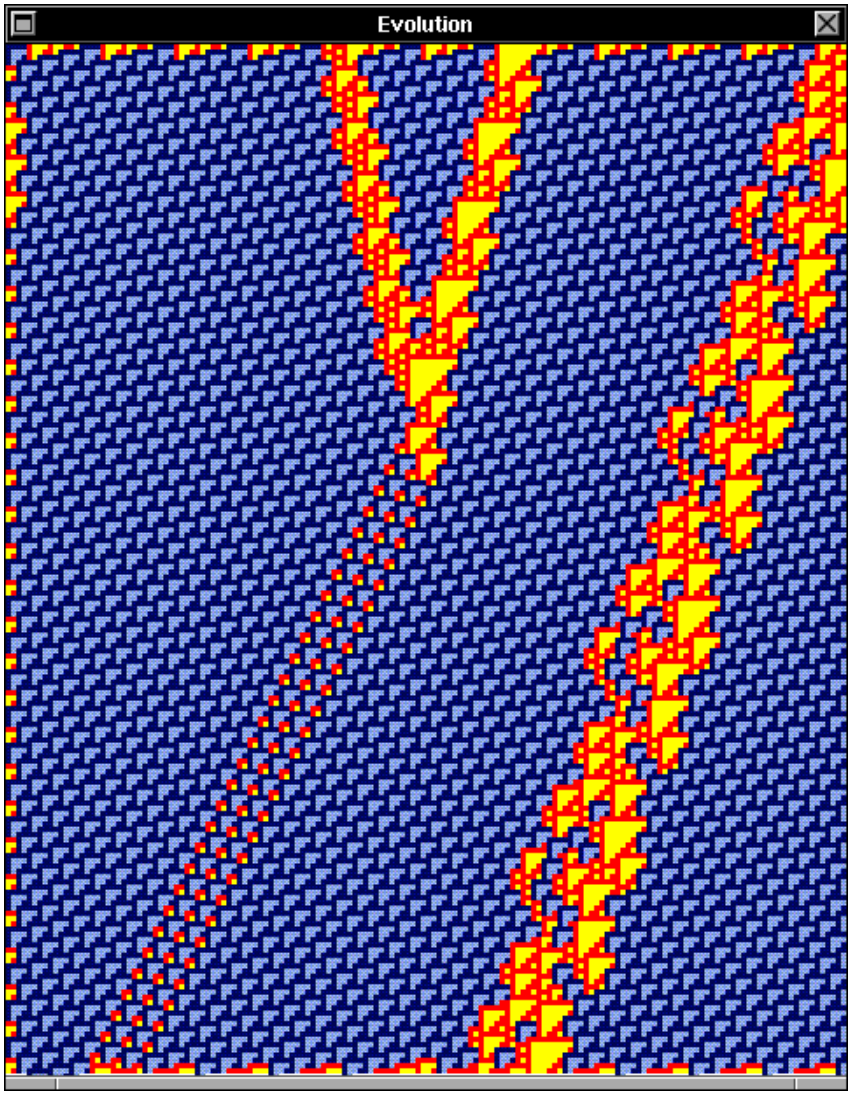

Figure 4.389: Collisions of glider D2, D2(p1)(C)-e(p1)-E(p1)(A)=3B

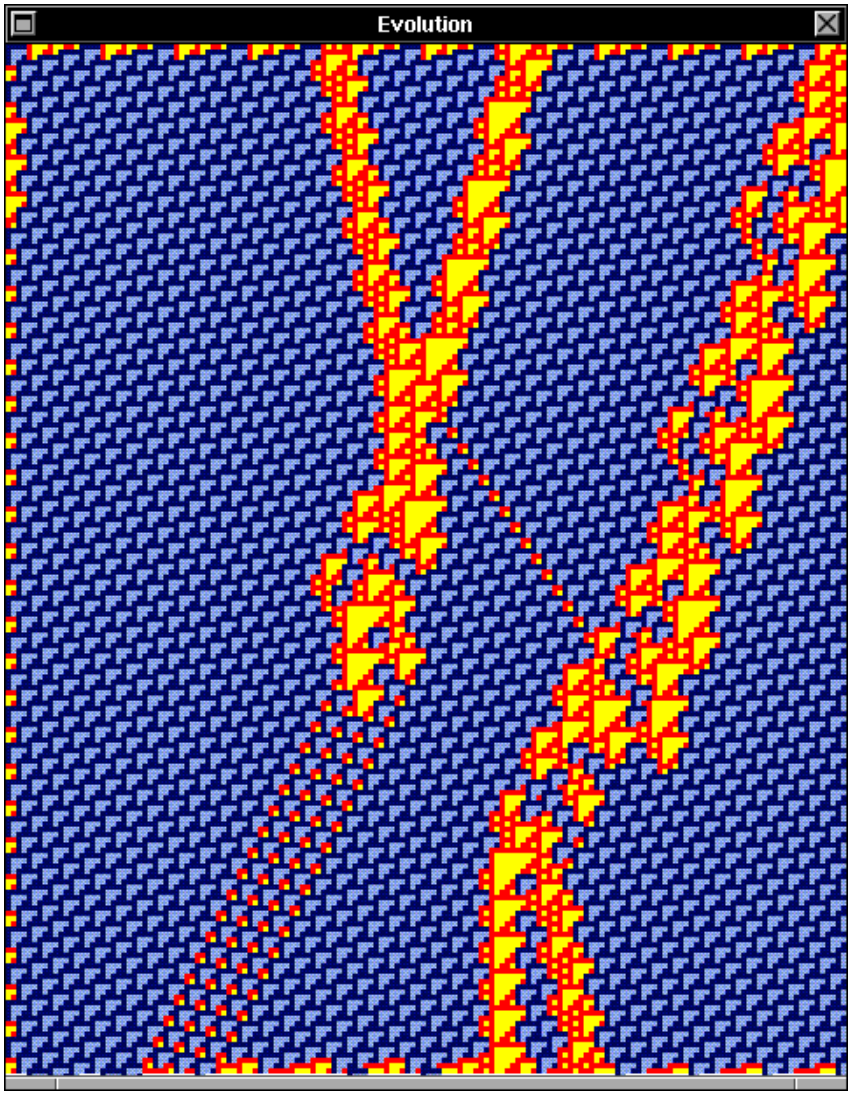

Figure 4.390: Collisions of glider D2, D2(p1)(A)-e(p1)-E(p1)(B)=A,4B

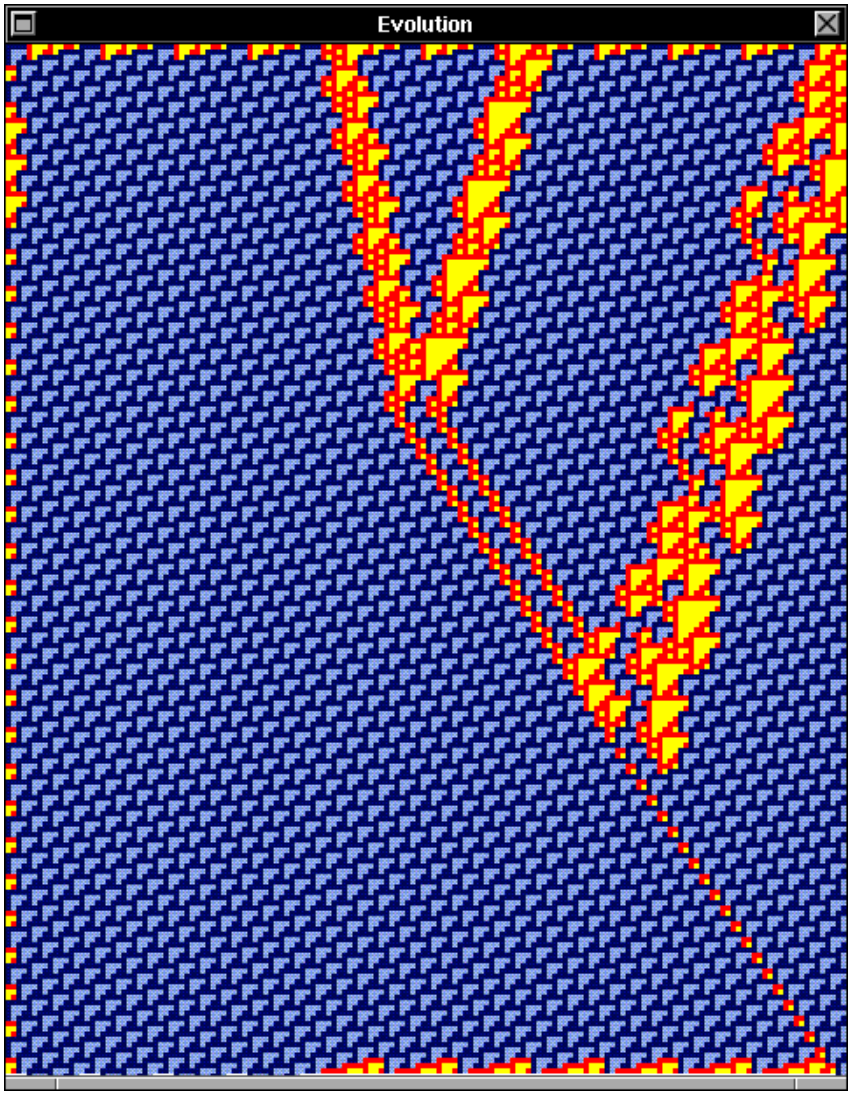

Figure 4.391: Collisions of glider D2, D2(p1)(C)-e(p1)-E(p1)(B)=2A,2A

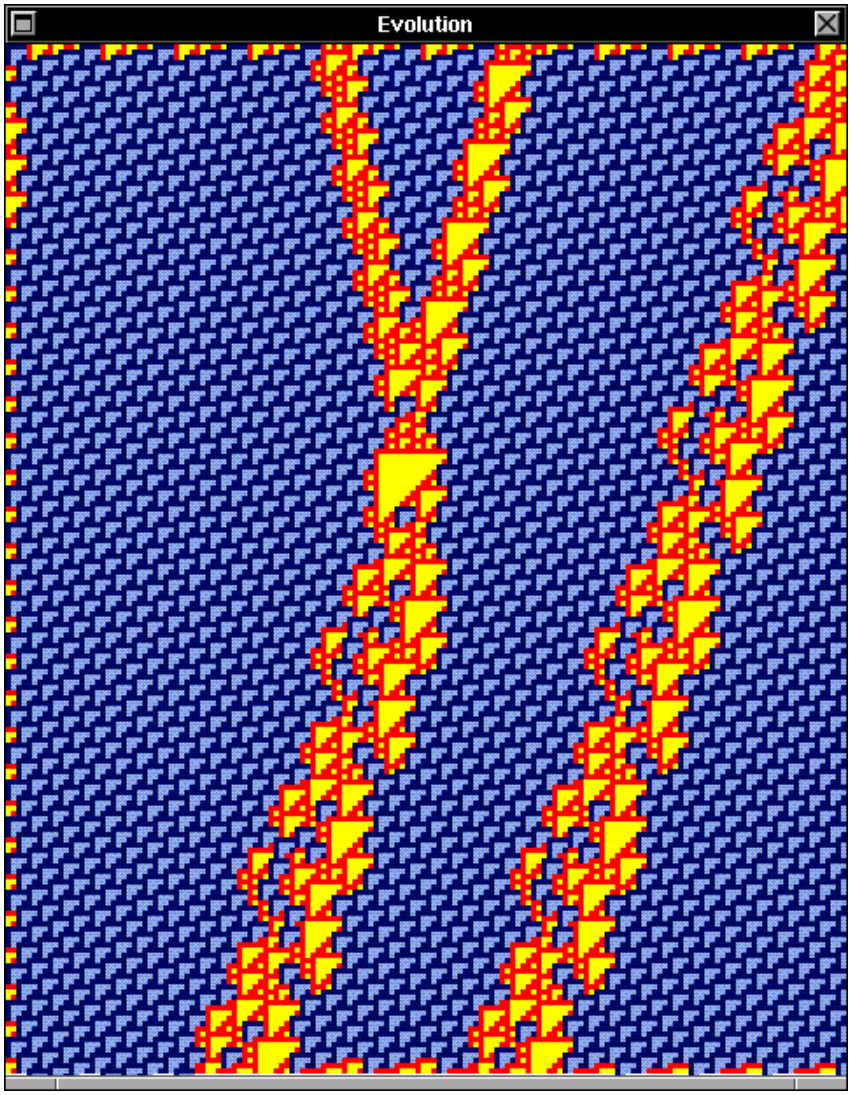

Figure 4.392: Collisions of glider D2, D2(p1)(A)-e(p1)-E(p1)(D)=G

4.10.2 Collisions of glider D2 with glider Ebar

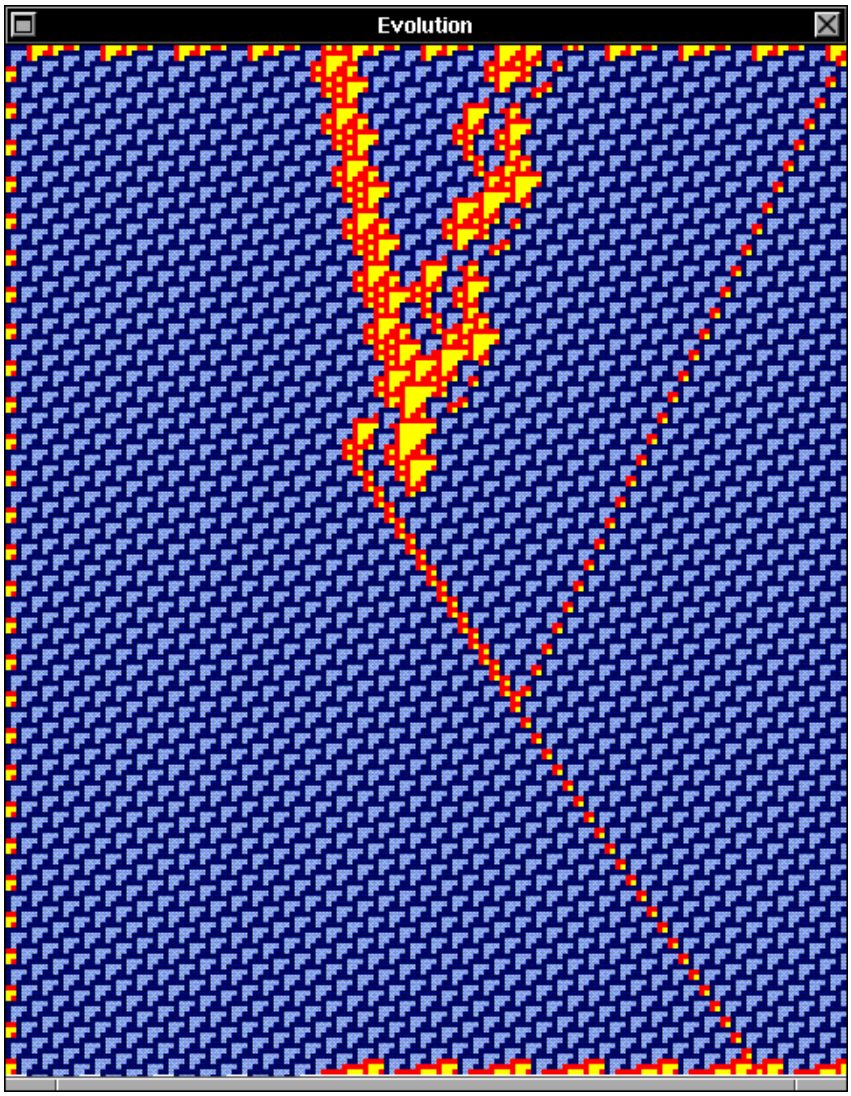

Figure 4.393: Collisions of glider D2, D2(p1)(A)-e(p1)-Ebar(p1)(A)=2A

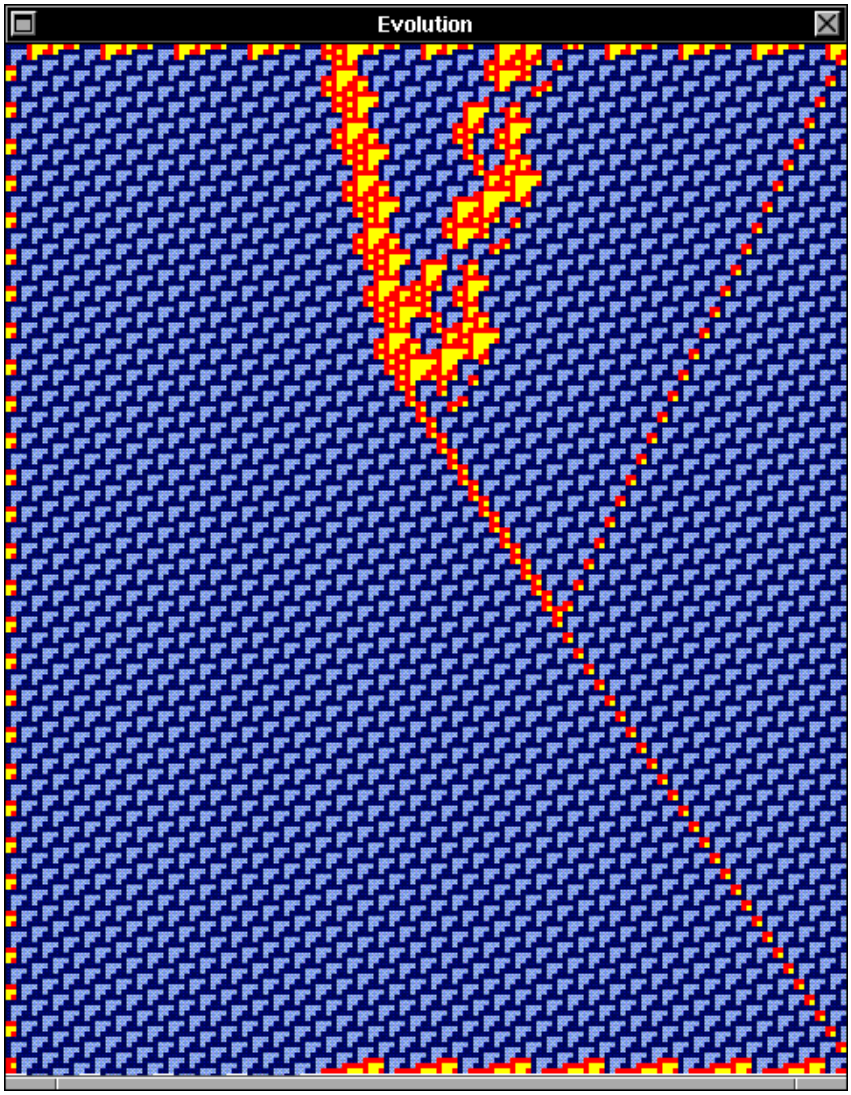

Figure 4.394: Collisions of glider D2, D2(p1)(C)-e(p1)-Ebar(p1)(A)=2A

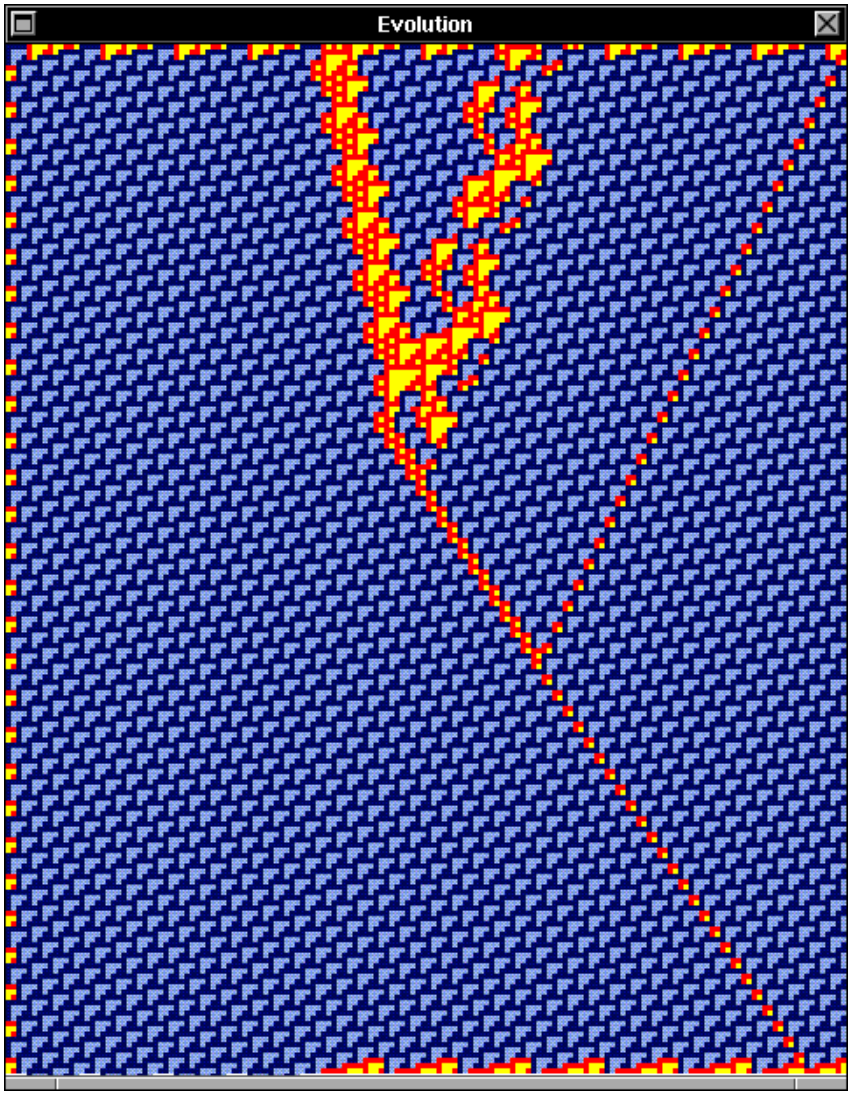

Figure 4.395: Collisions of glider D2, D2(p1)(A)-e(p1)-Ebar(p1)(B)=2A

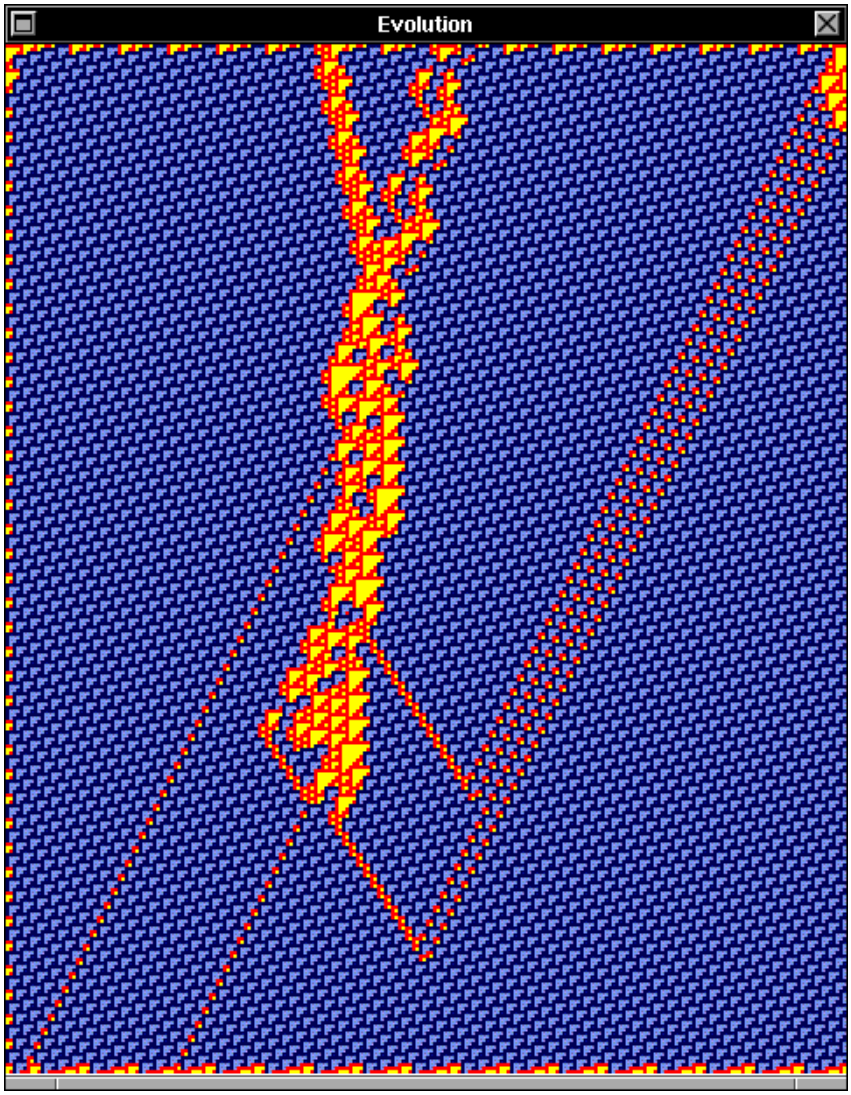

Figure 4.396: Collisions of glider D2, D2(p1)(C)-e(p1)-Ebar(p1)(B)=B,2A,B,2A

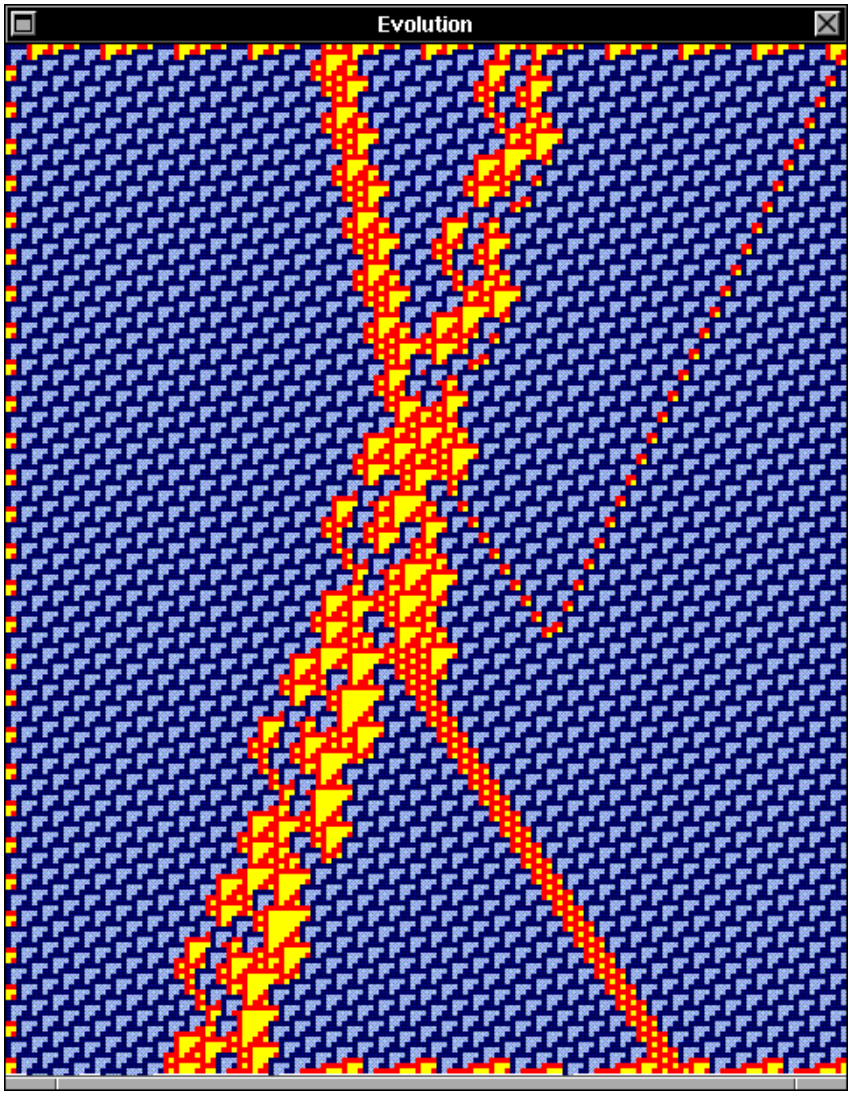

Figure 4.397: Collisions of glider D2, D2(p1)(A)-e(p1)-Ebar(p1)(C)=A,G,4A

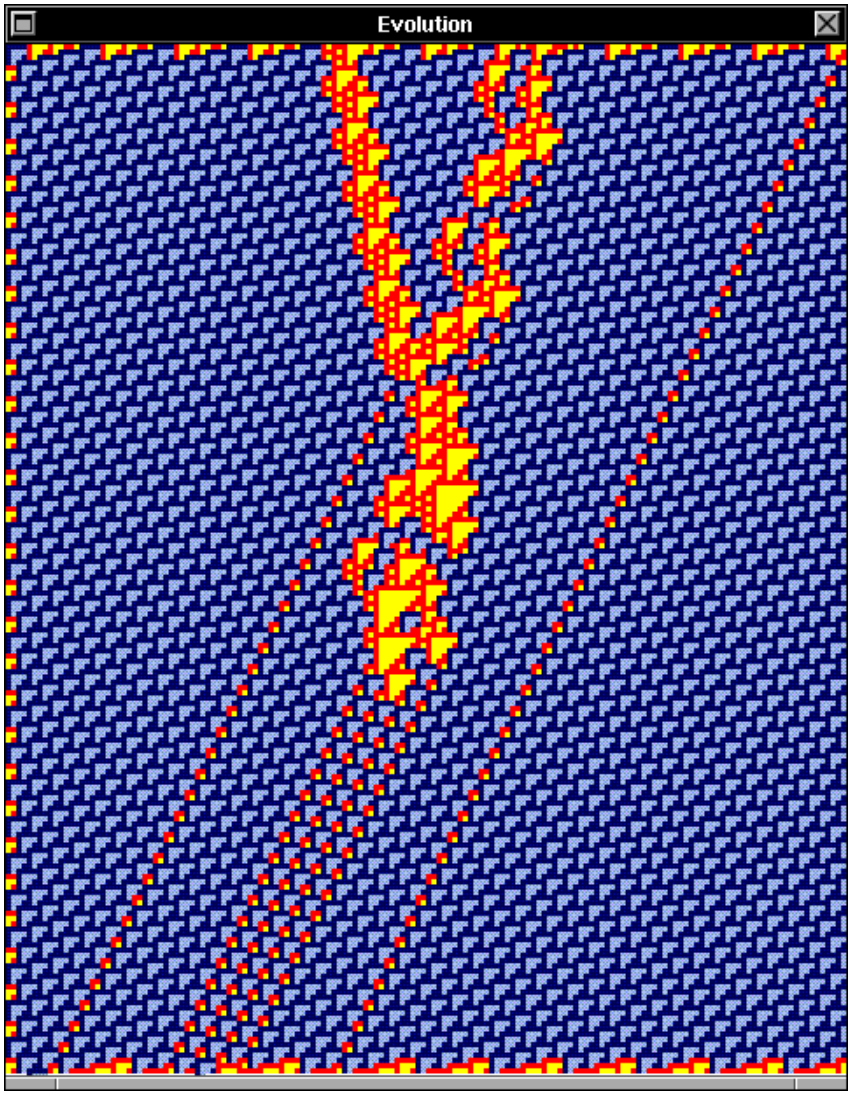

Figure 4.398: Collisions of glider D2, D2(p1)(C)-e(p1)-Ebar(p1)(C)=B,4B

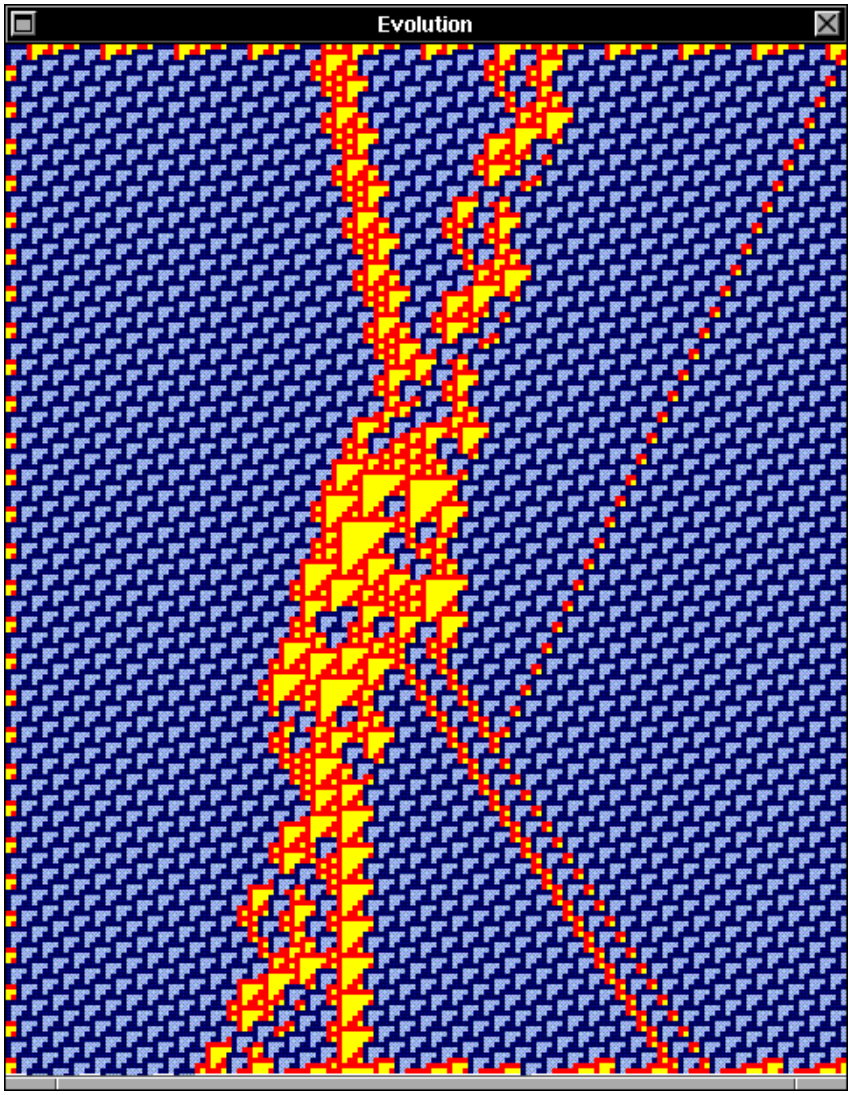

Figure 4.399: Collisions of glider D2, D2(p1)(A)-e(p1)-Ebar(p1)(D)=2A,2A,Ebar,C1

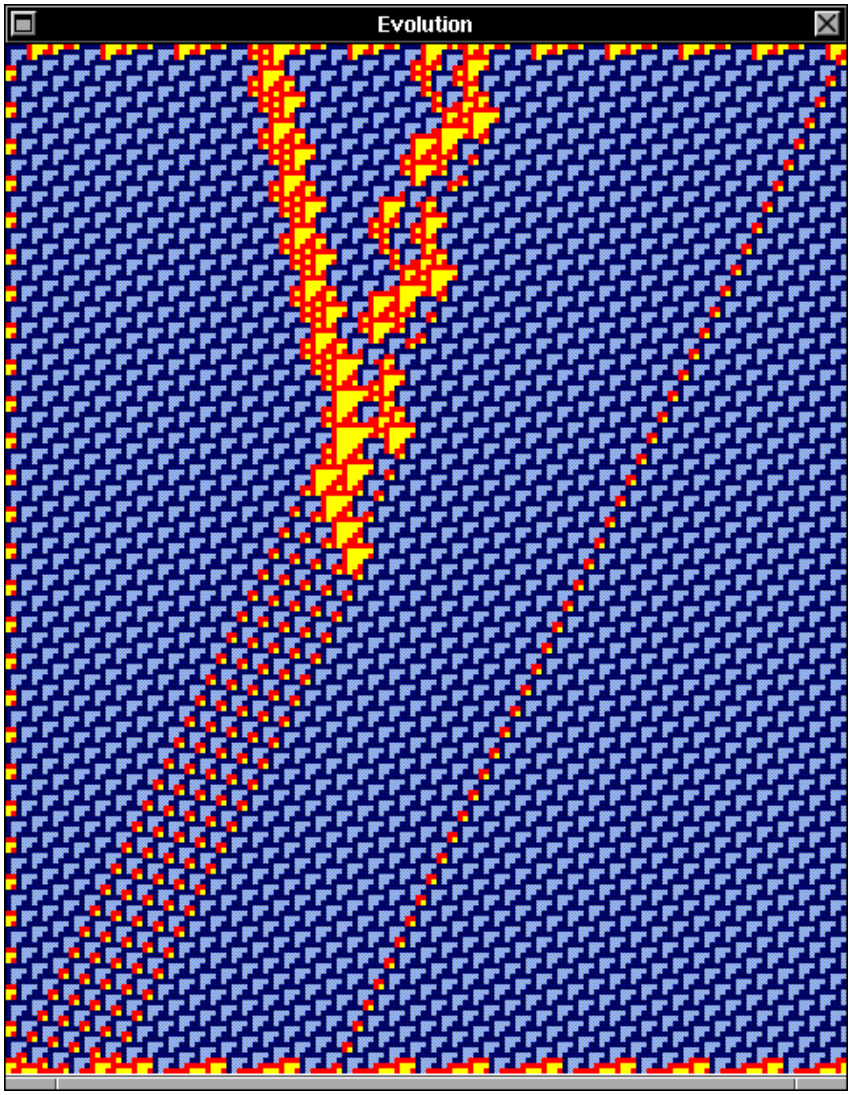

Figure 4.400: Collisions of glider D2, D2(p1)(C)-e(p1)-Ebar(p1)(D)=5B

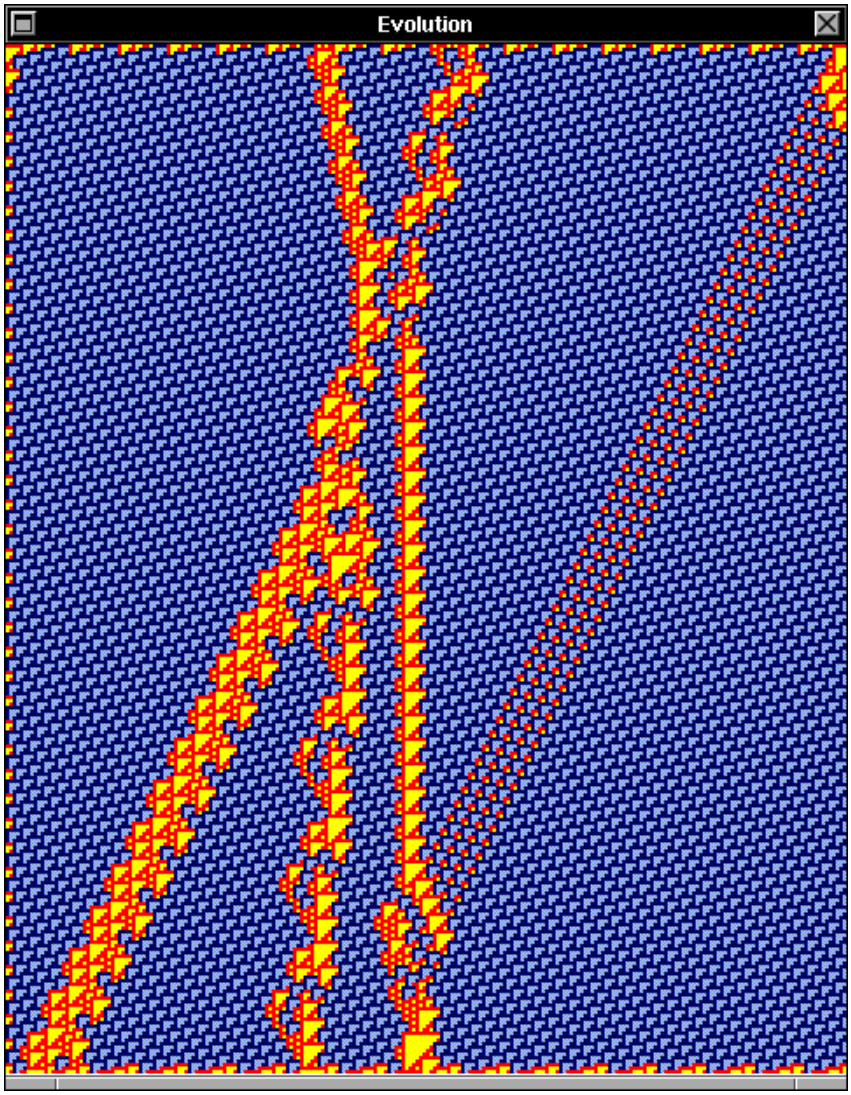

Figure 4.401: Collisions of glider D2, D2(p1)(A)-e(p1)-Ebar(p1)(E)=C2,Bbar,F

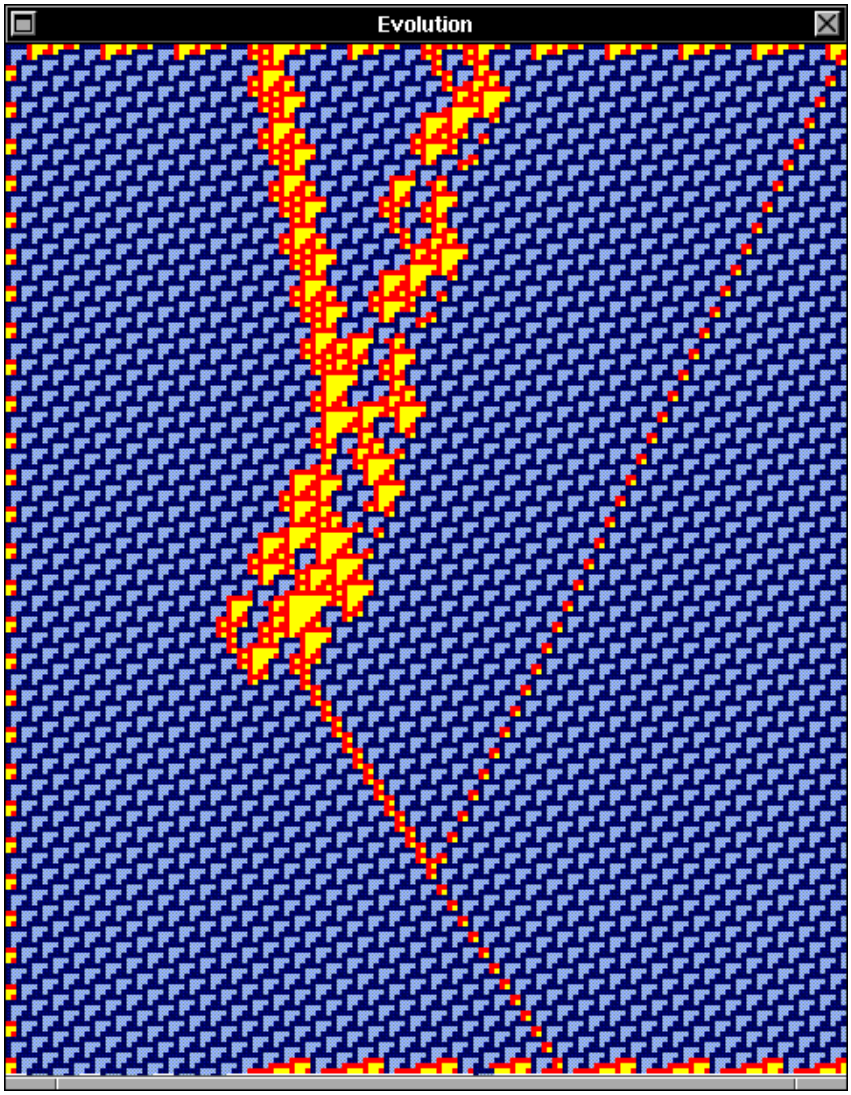

Figure 4.402: Collisions of glider D2, D2(p1)(C)-e(p1)-Ebar(p1)(E)=2A

4.10.3 Collisions of glider D2 with glider F

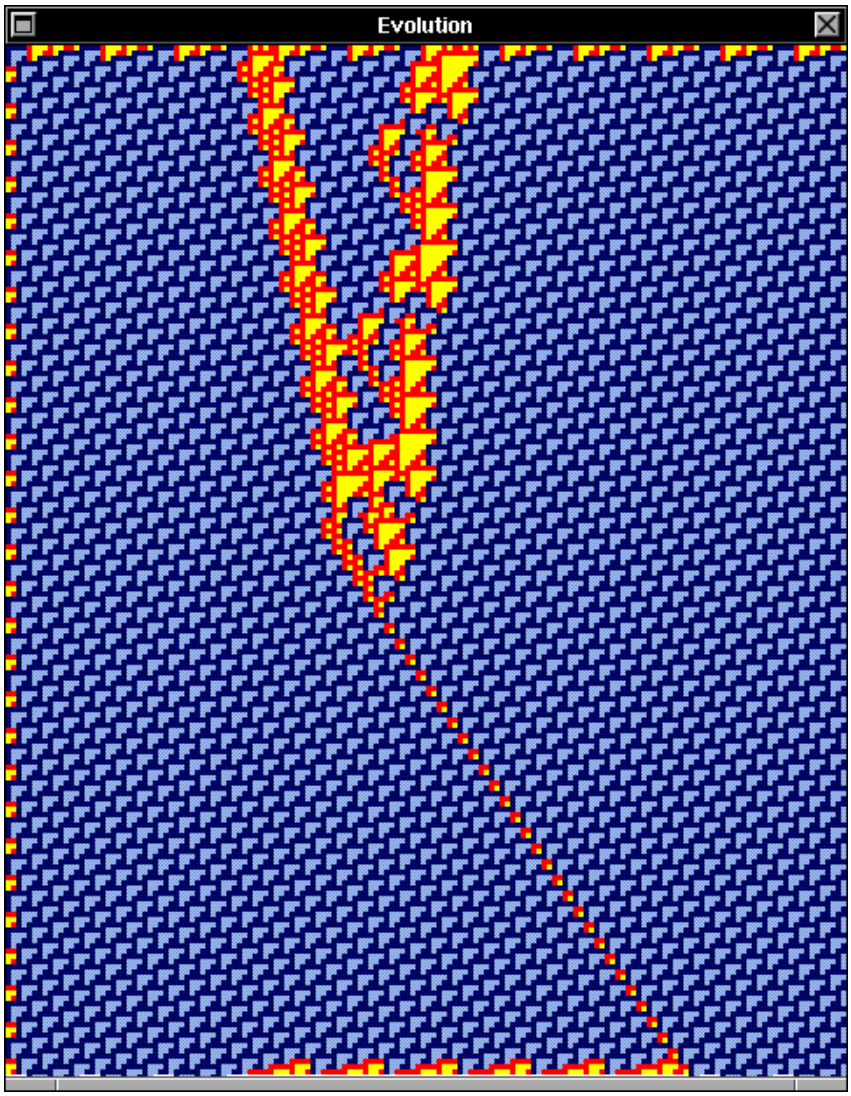

Figure 4.403: Collisions of glider D2, D2(p1)(A)-e(p1)-F(p1)(A)=A

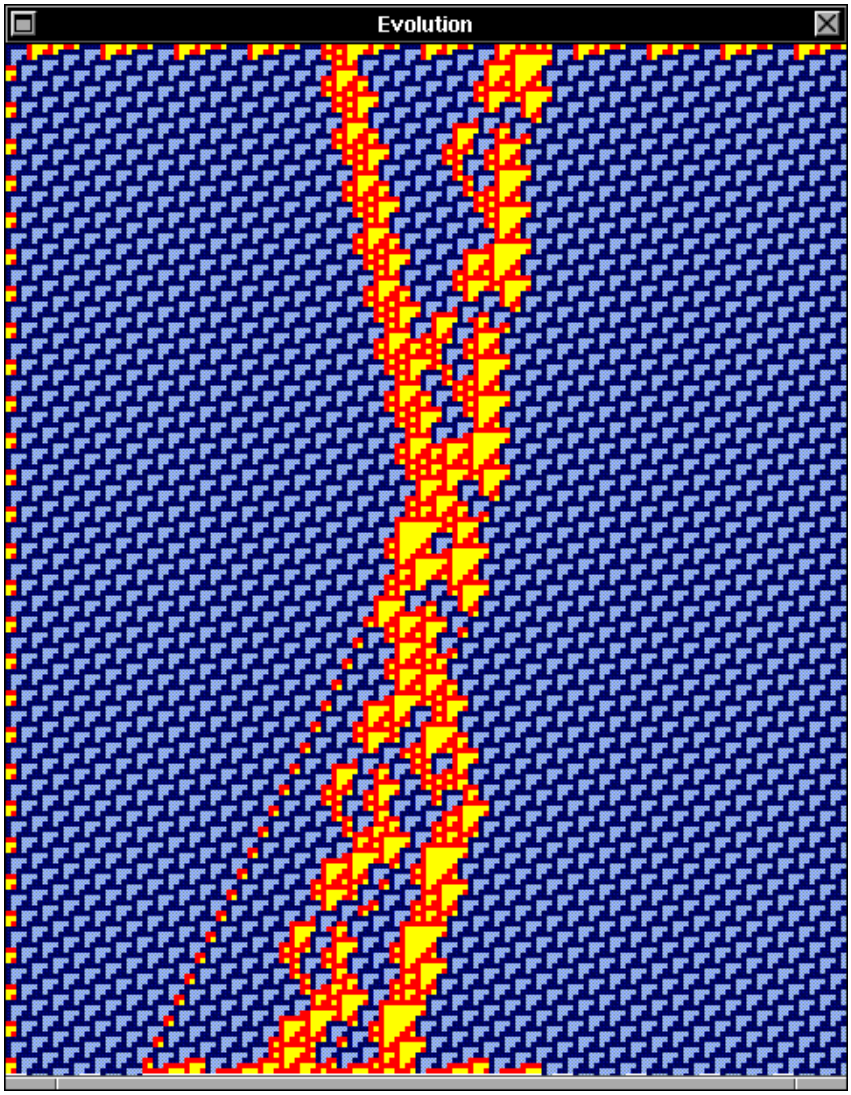

Figure 4.404: Collisions of glider D2, D2(p1)(C)-e(p1)-F(p1)(A)=B,Ebar,E

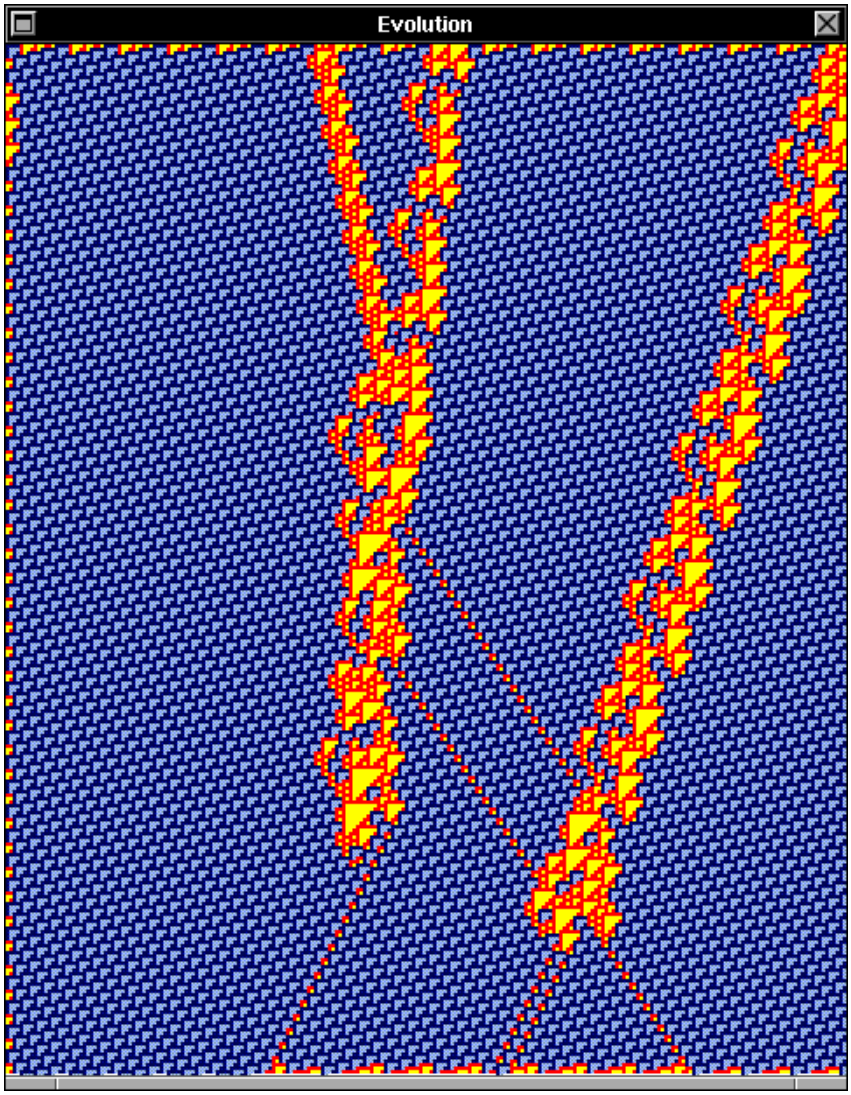

Figure 4.405: Collisions of glider D2, D2(p1)(A)-e(p1)-F(p1)(B)=A,A,B

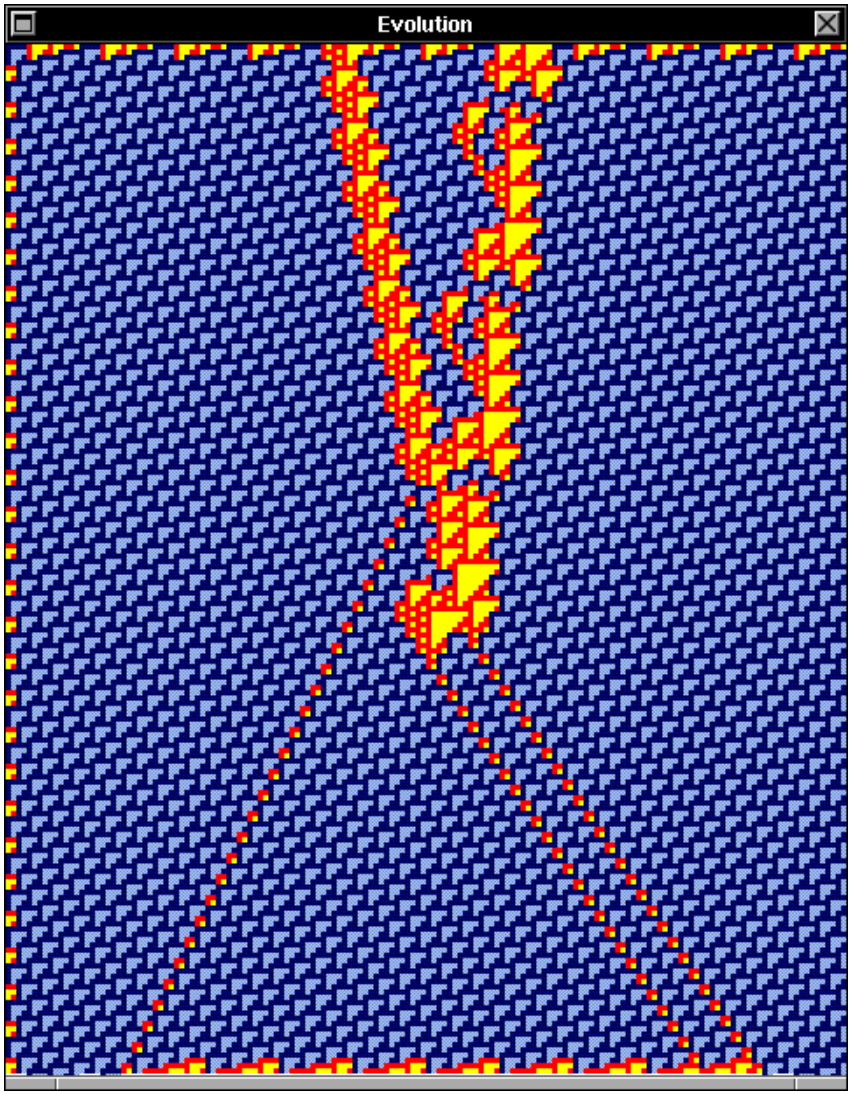

Figure 4.406: Collisions of glider D2, D2(p1)(C)-e(p1)-F(p1)(B)=B,A,A

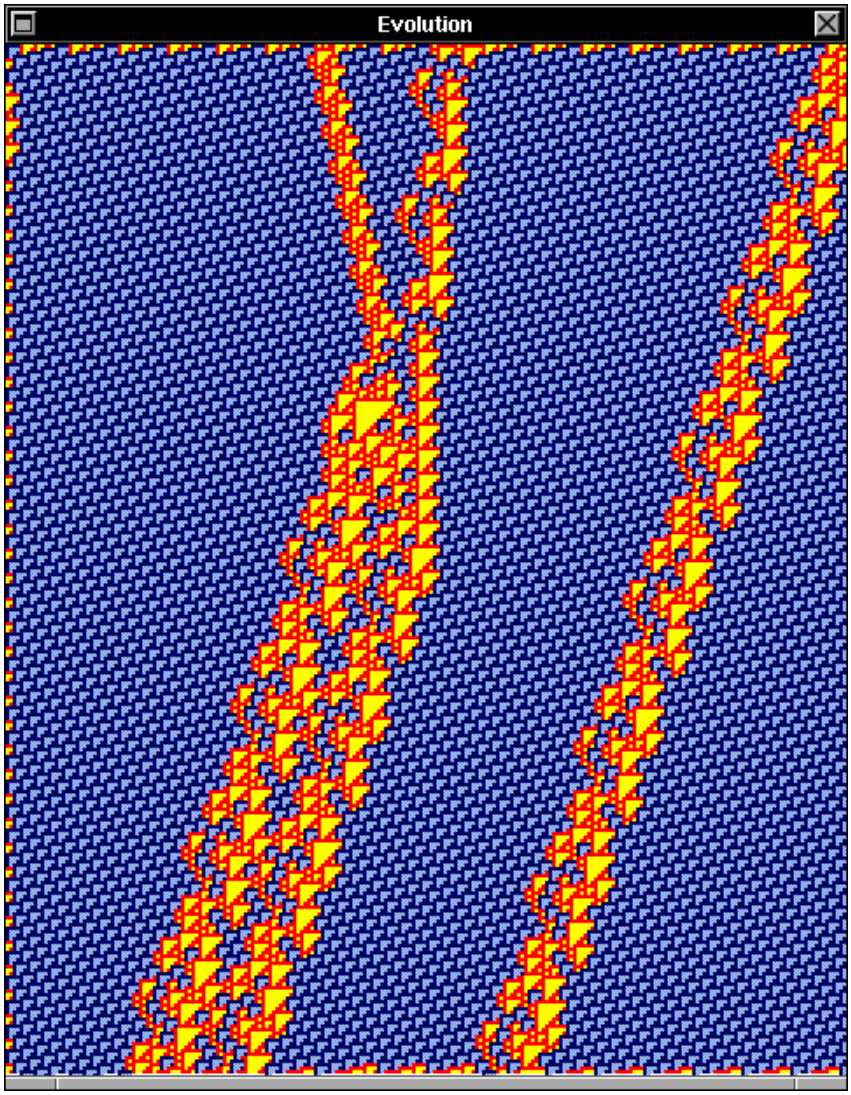

Figure 4.407: Collisions of glider D2, D2(p1)(A)-e(p1)-F(p1)(C)=2G

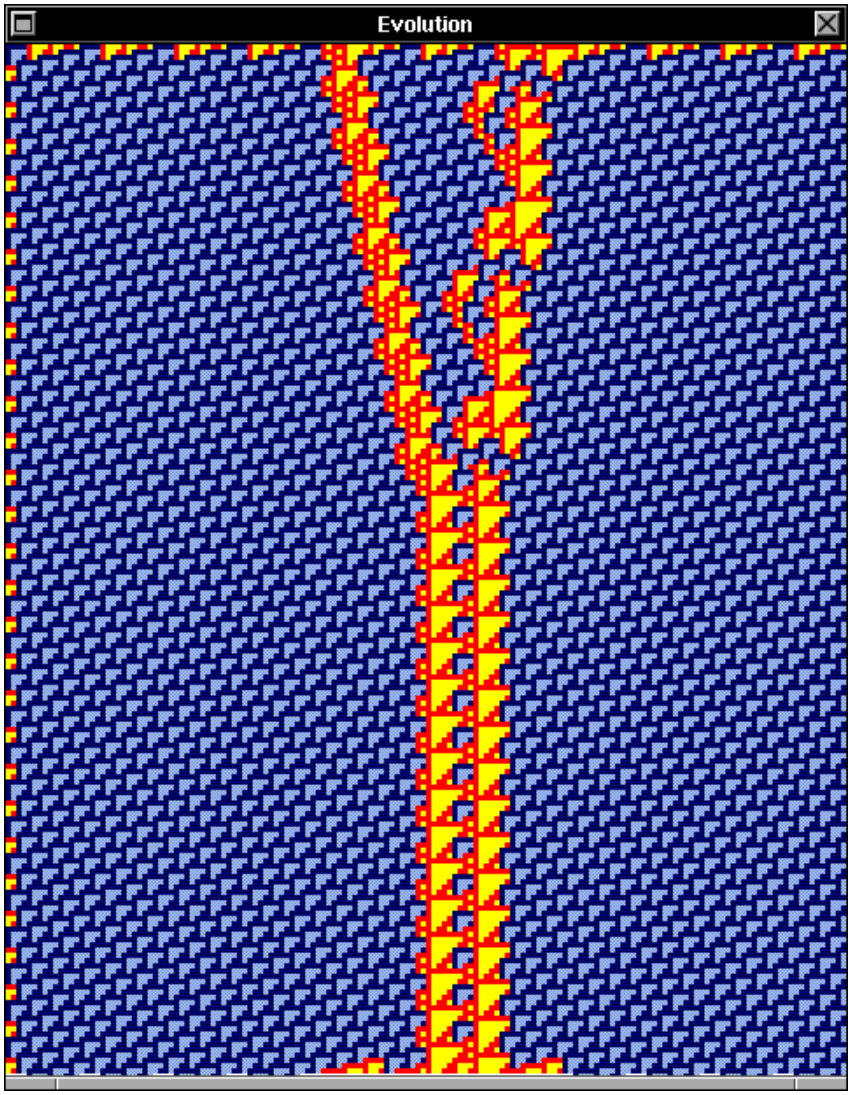

Figure 4.408: Collisions of glider D2, D2(p1)(C)-e(p1)-F(p1)(C)=2C2

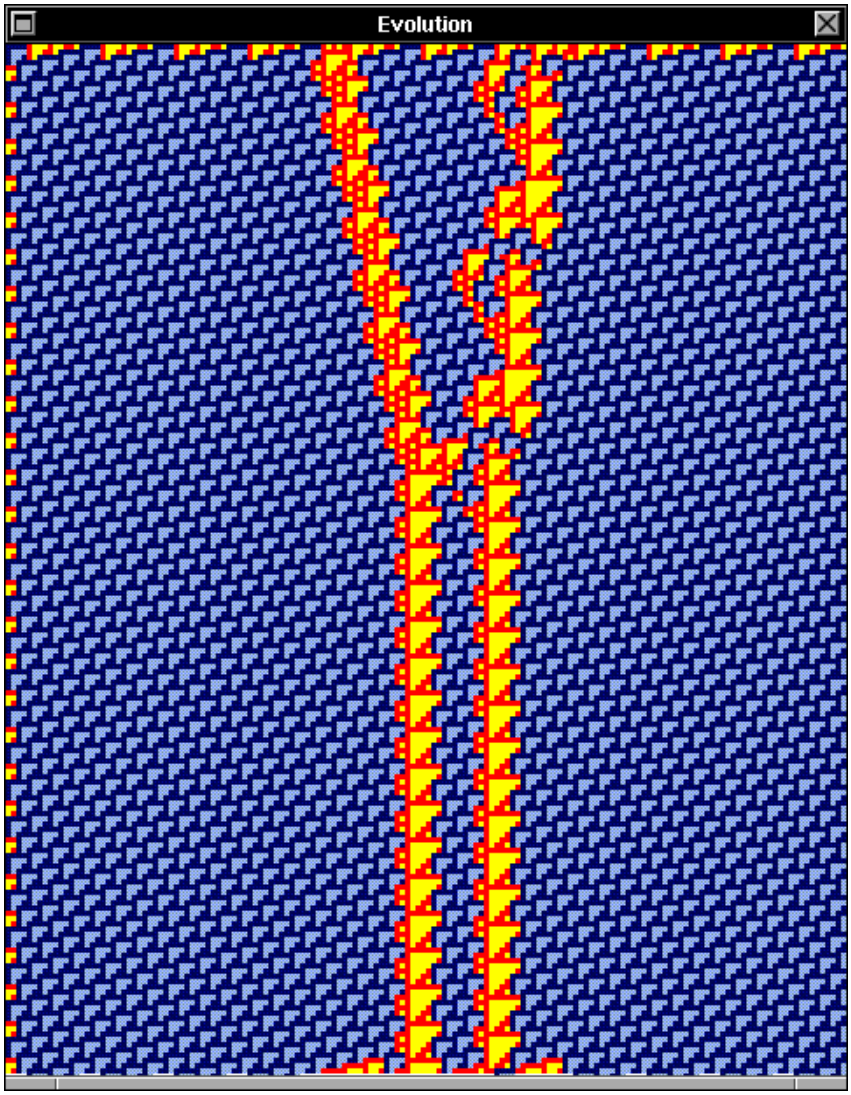

Figure 4.409: Collisions of glider D2, D2(p1)(A)-e(p1)-F(p1)(D)=C3,C1

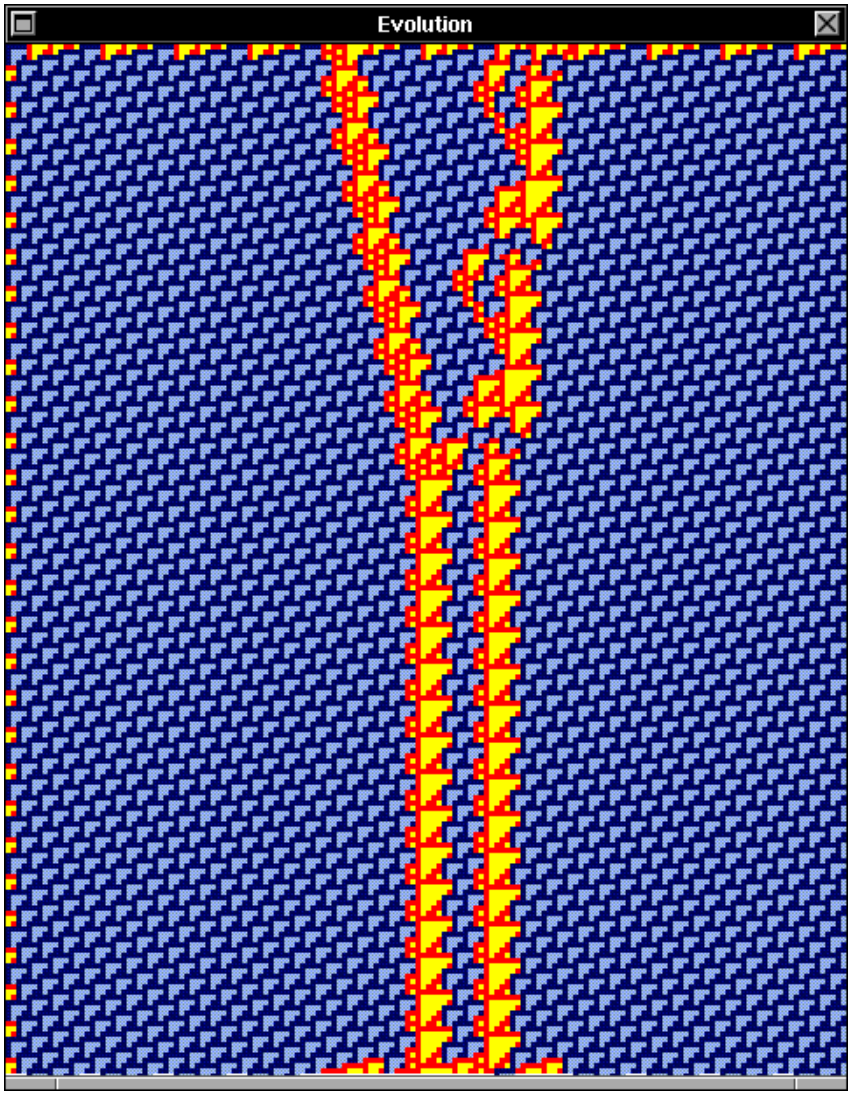

Figure 4.410: Collisions of glider D2, D2(p1)(C)-e(p1)-F(p1)(D)=C2,C2

4.10.4 Collisions of glider D2 with glider G

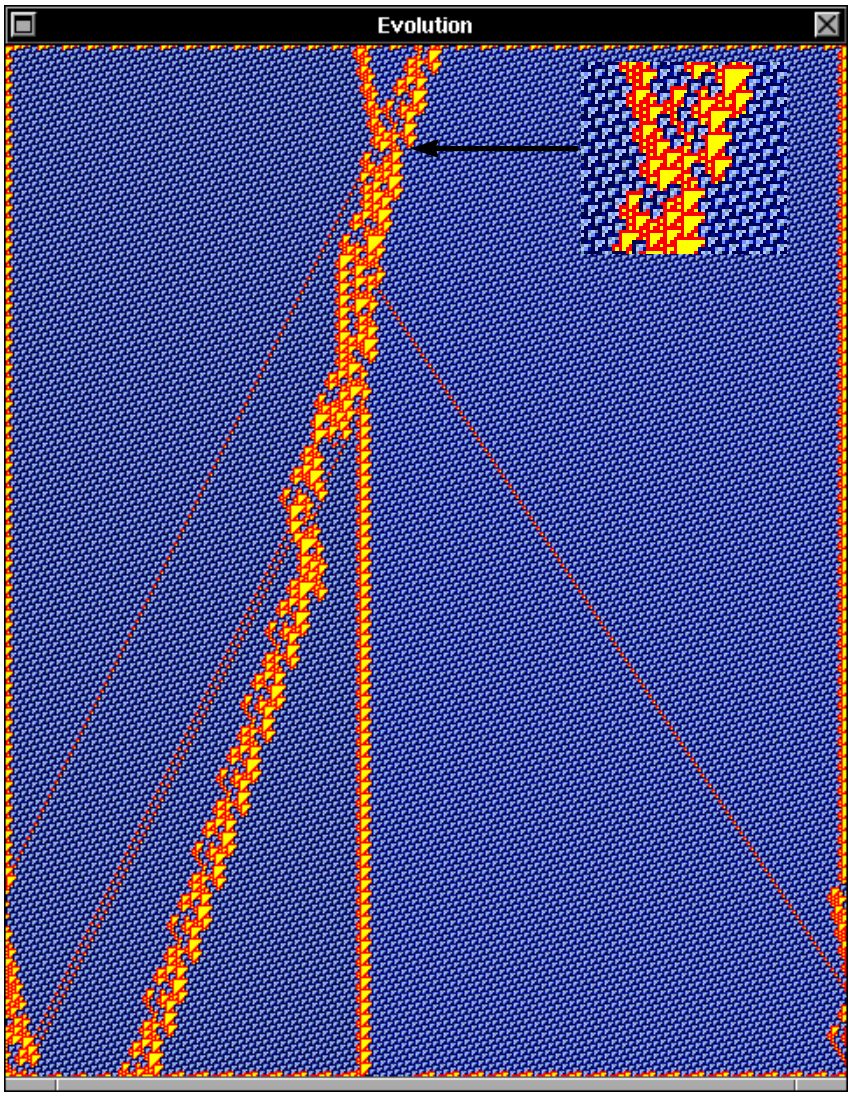

Figure 4.411: Collisions of glider D2, D2(p1)(A)-e(p1)-G(p1)(A)=B,A,C2,2B,G

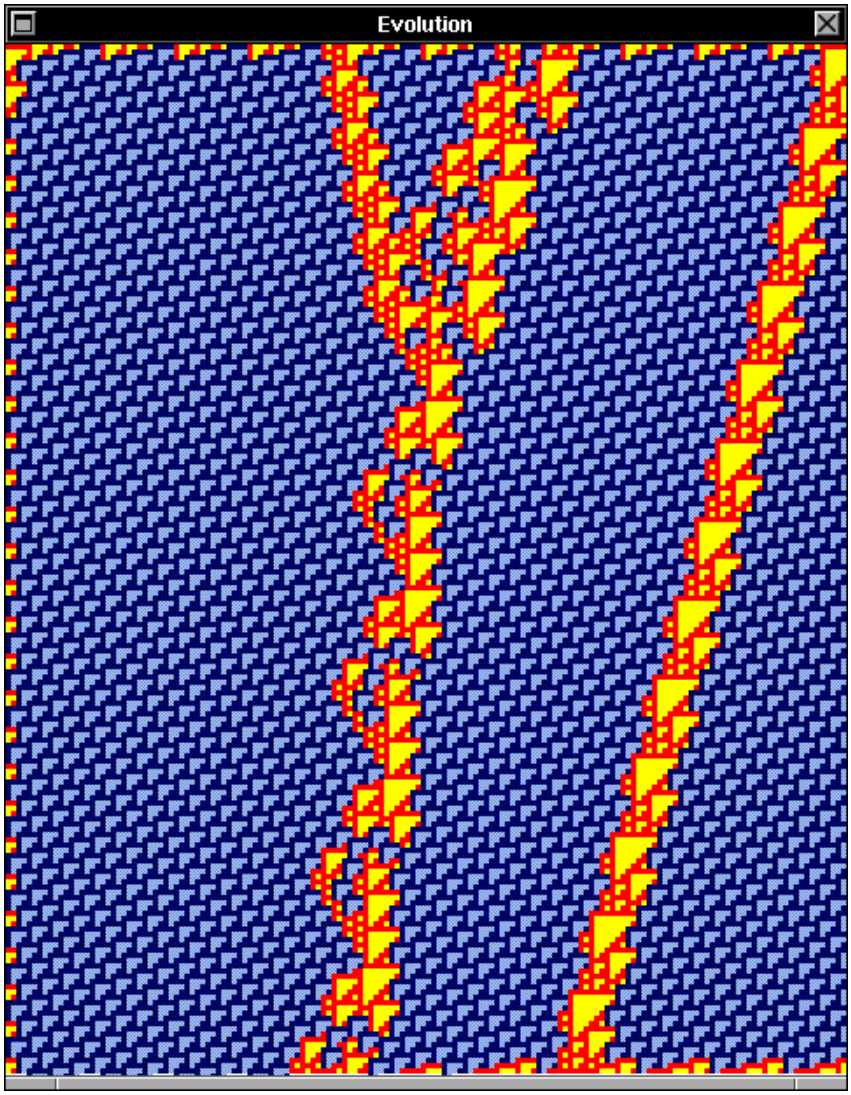

Figure 4.412: Collisions of glider D2, D2(p1)(C)-e(p1)-G(p1)(A)=F

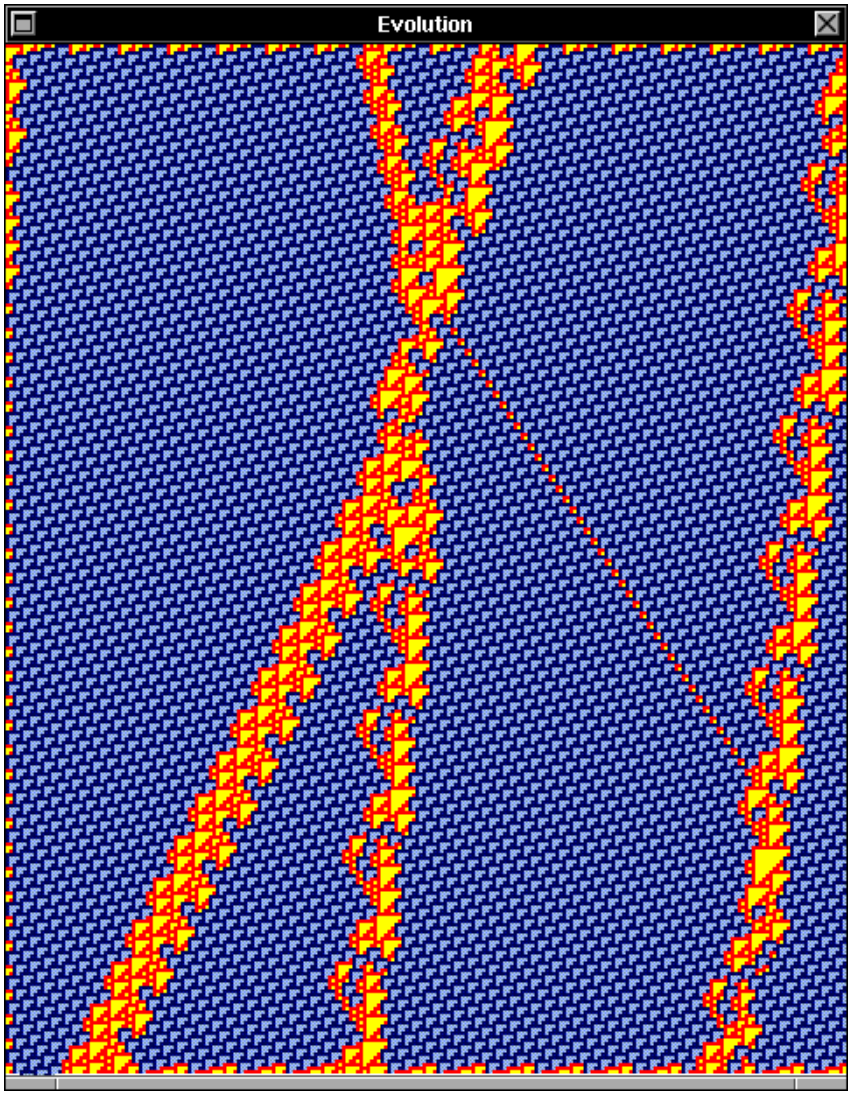

Figure 4.413: Collisions of glider D2, D2(p1)(A)-e(p1)-G(p1)(B)=A,Bbar,F

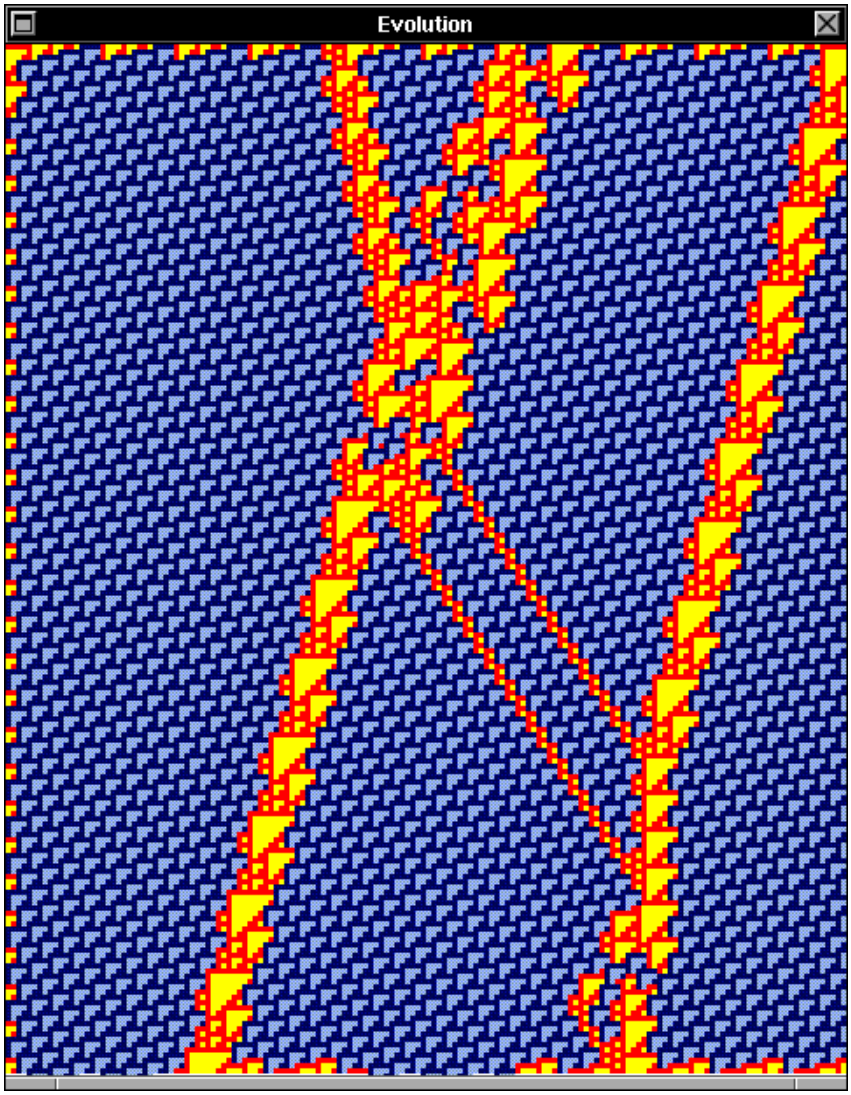

Figure 4.414: Collisions of glider D2, D2(p1)(C)-e(p1)-G(p1)(B)=2A,2A,E

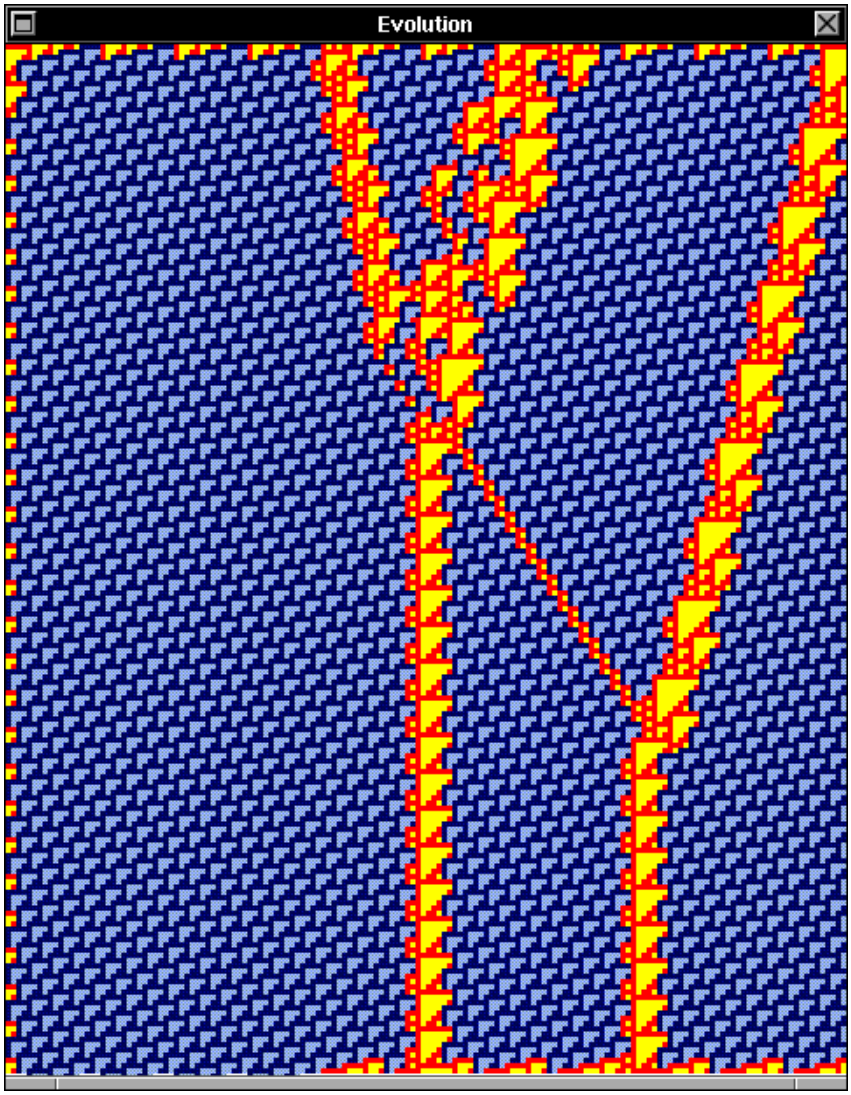

Figure 4.415: Collisions of glider D2, D2(p1)(A)-e(p1)-G(p1)(C)=2A,C2

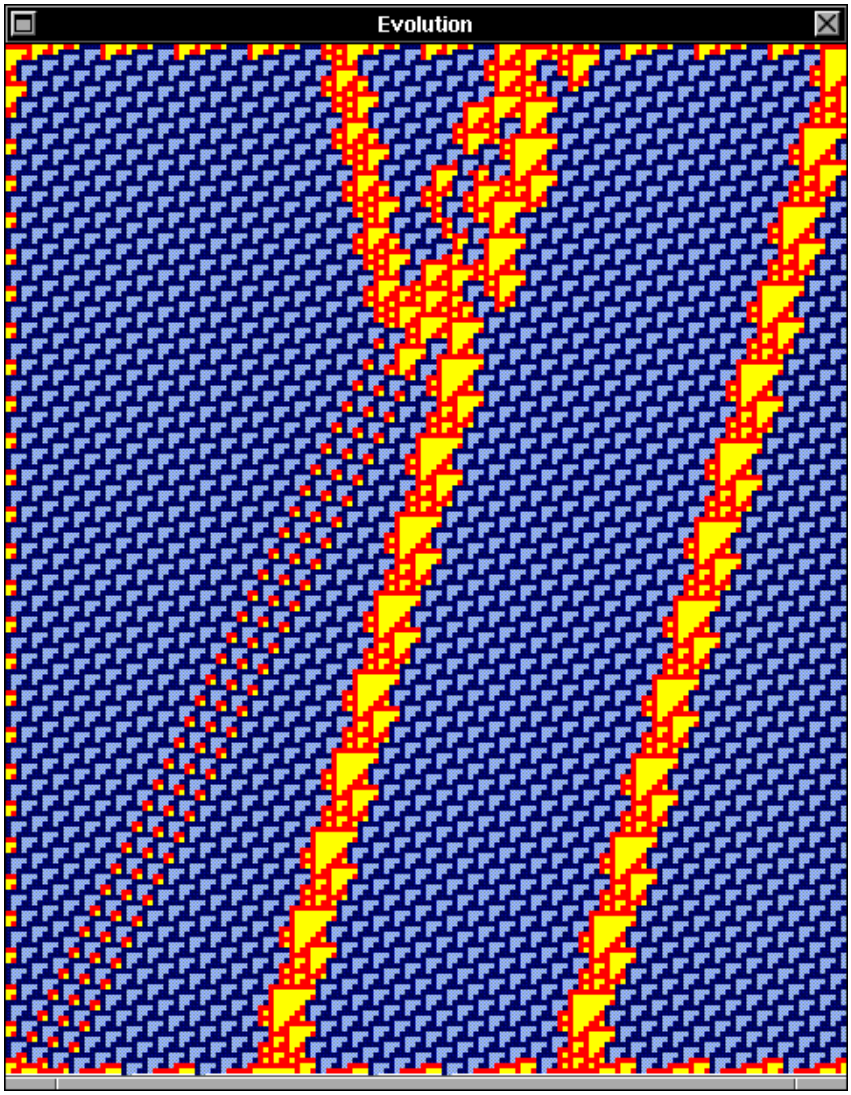

Figure 4.416: Collisions of glider D2, D2(p1)(C)-e(p1)-G(p1)(C)=3B,E

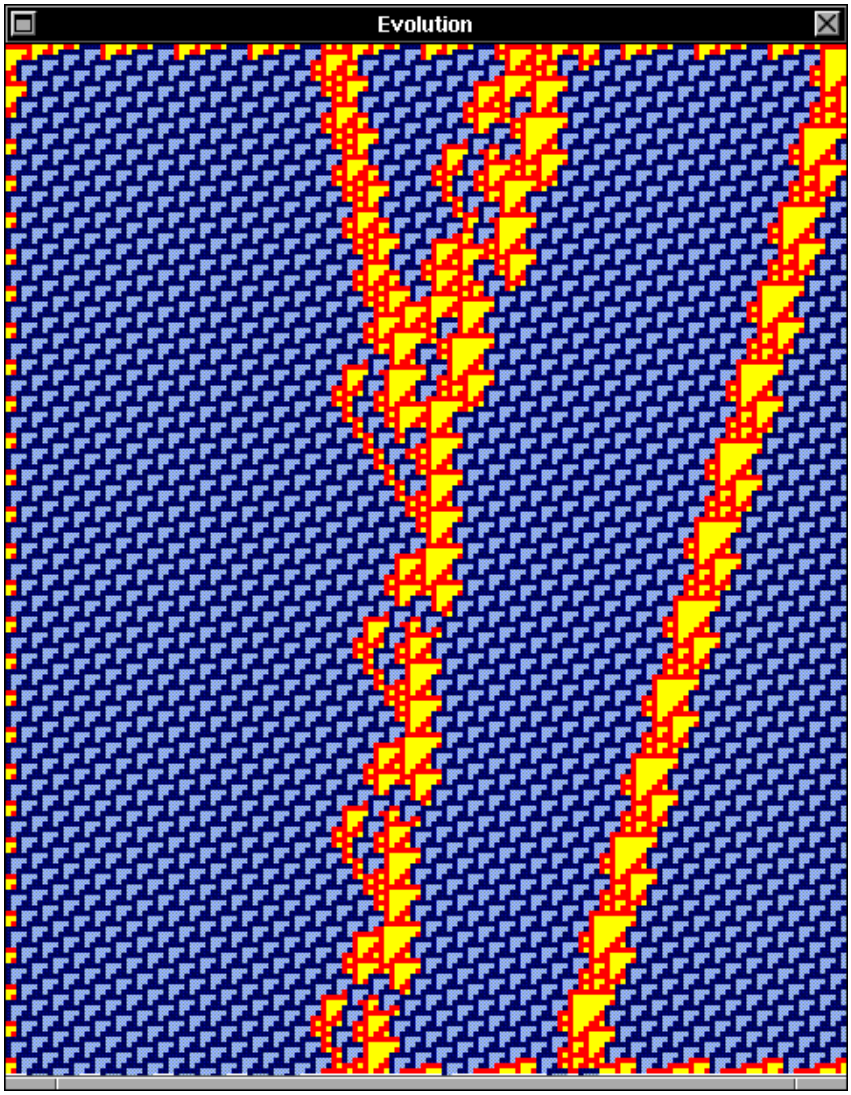

Figure 4.417: Collisions of glider D2, D2(p1)(A)-e(p1)-G(p1)(D)=F

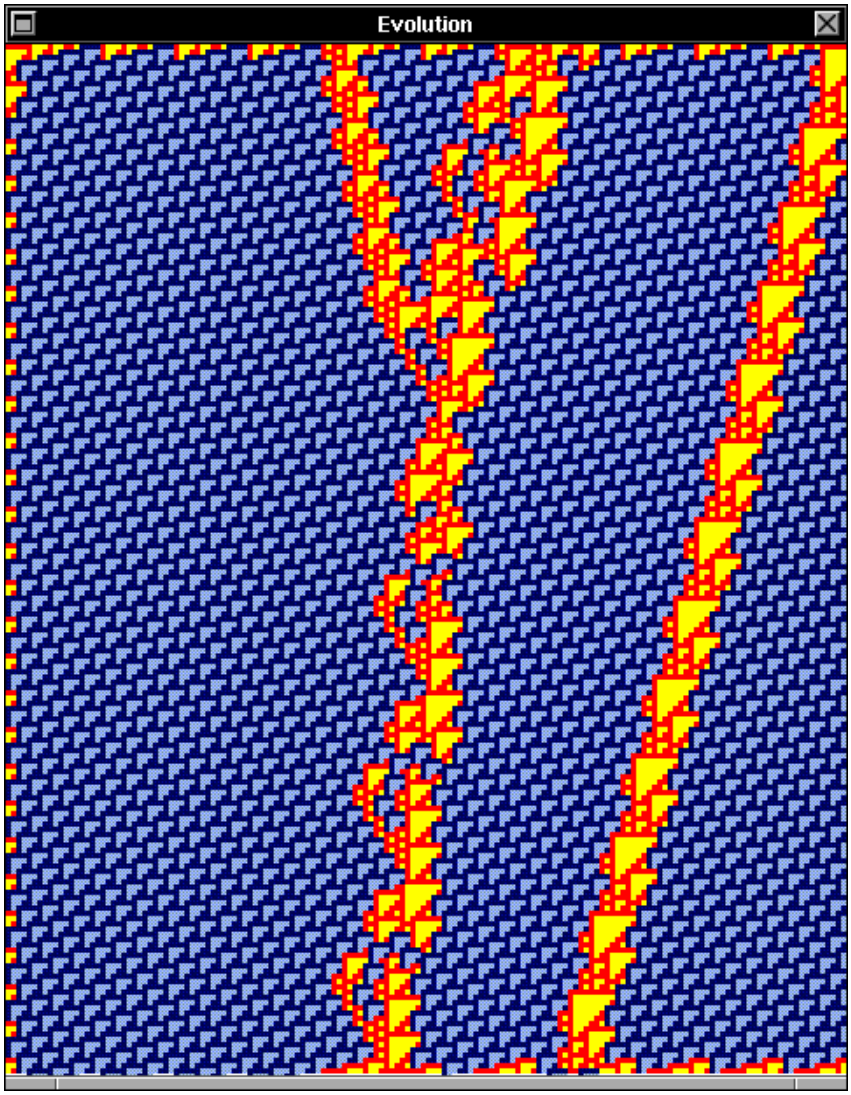

Figure 4.418: Collisions of glider D2, D2(p1)(C)-e(p1)-G(p1)(D)=F

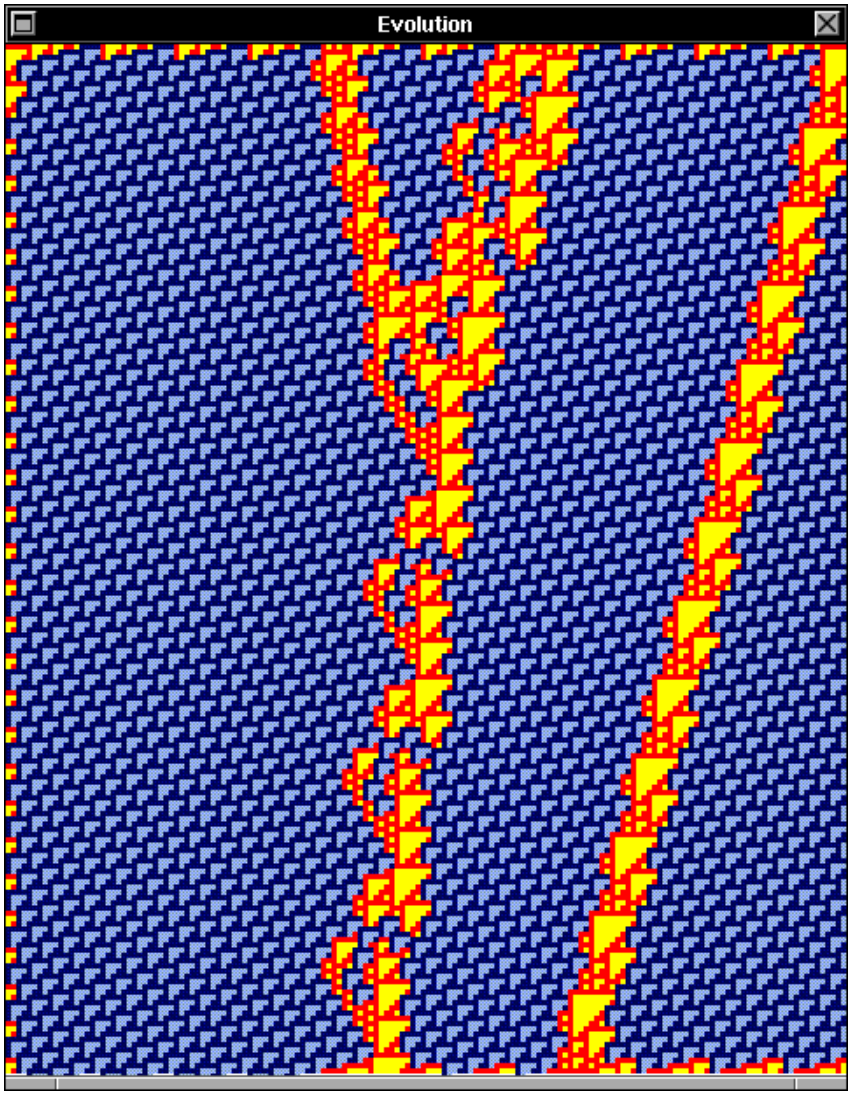

Figure 4.419: Collisions of glider D2, D2(p1)(A)-e(p1)-G(p1)(E)=F

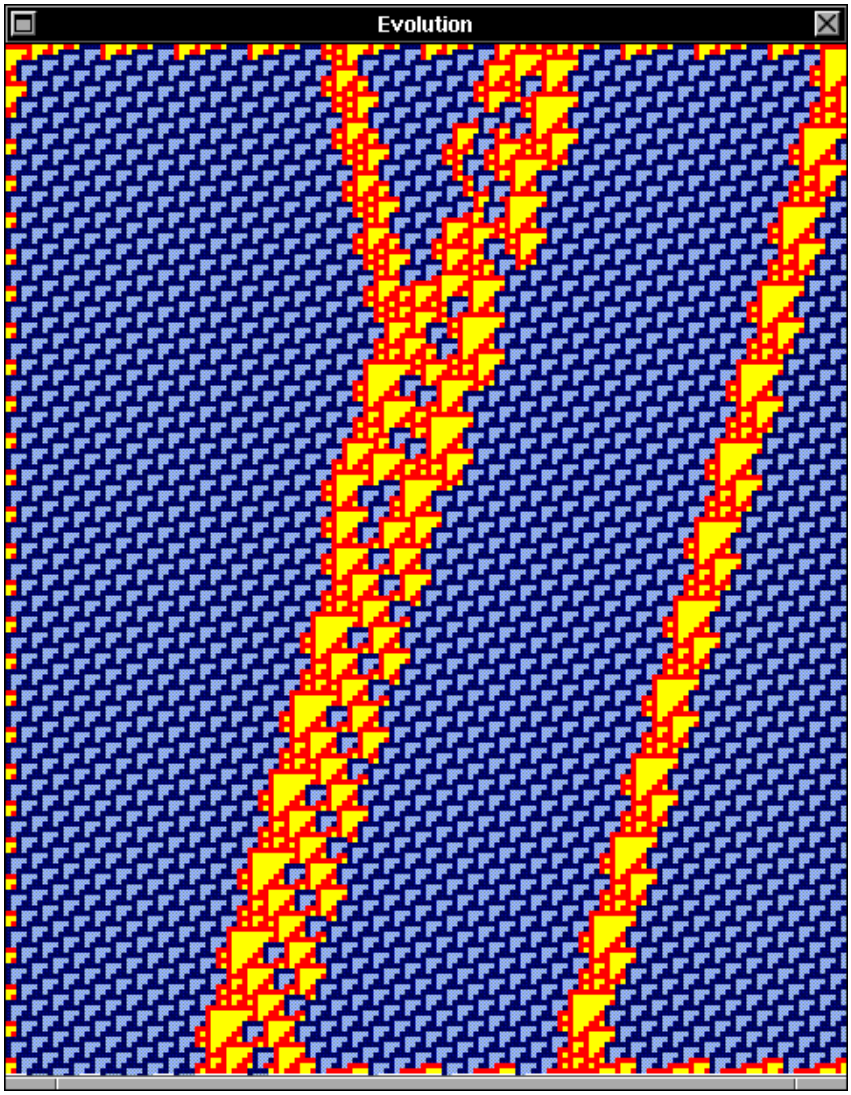

Figure 4.420: Collisions of glider D2, D2(p1)(C)-e(p1)-G(p1)(E)=E4

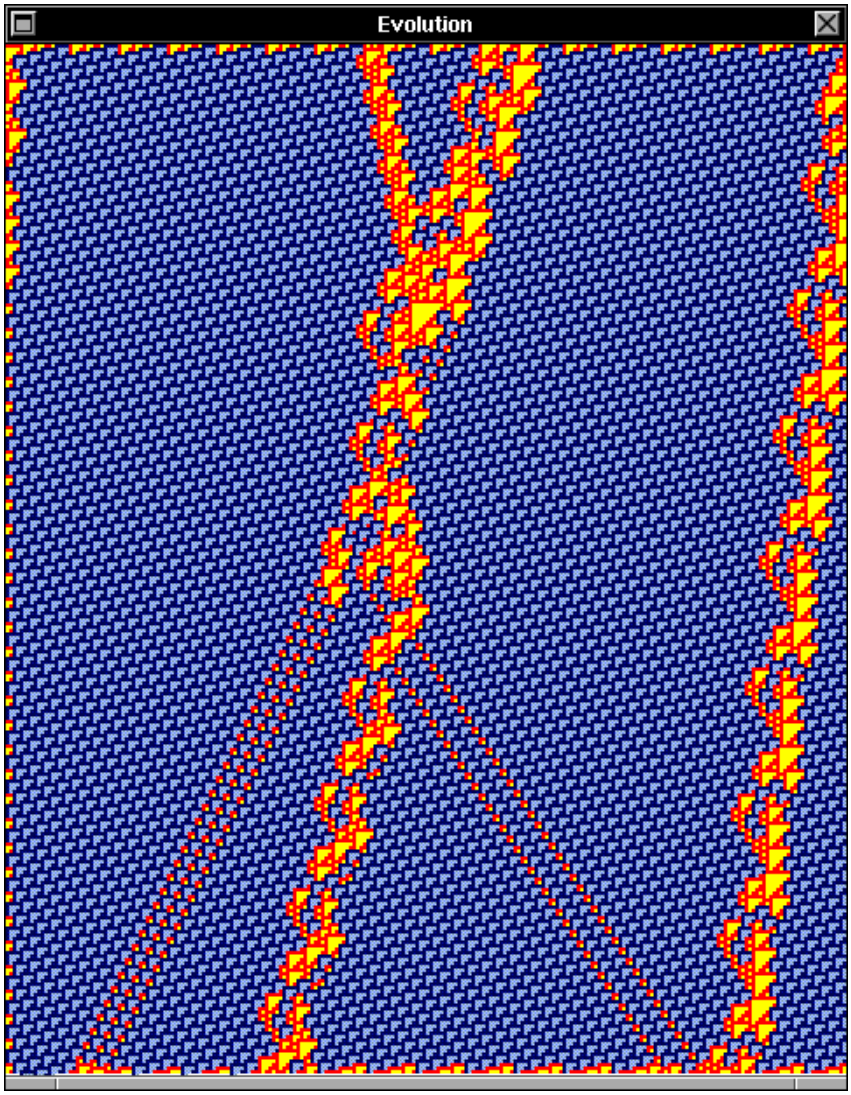

Figure 4.421: Collisions of glider D2, D2(p1)(A)-e(p1)-G(p1)(F)=3B,A,A,Ebar

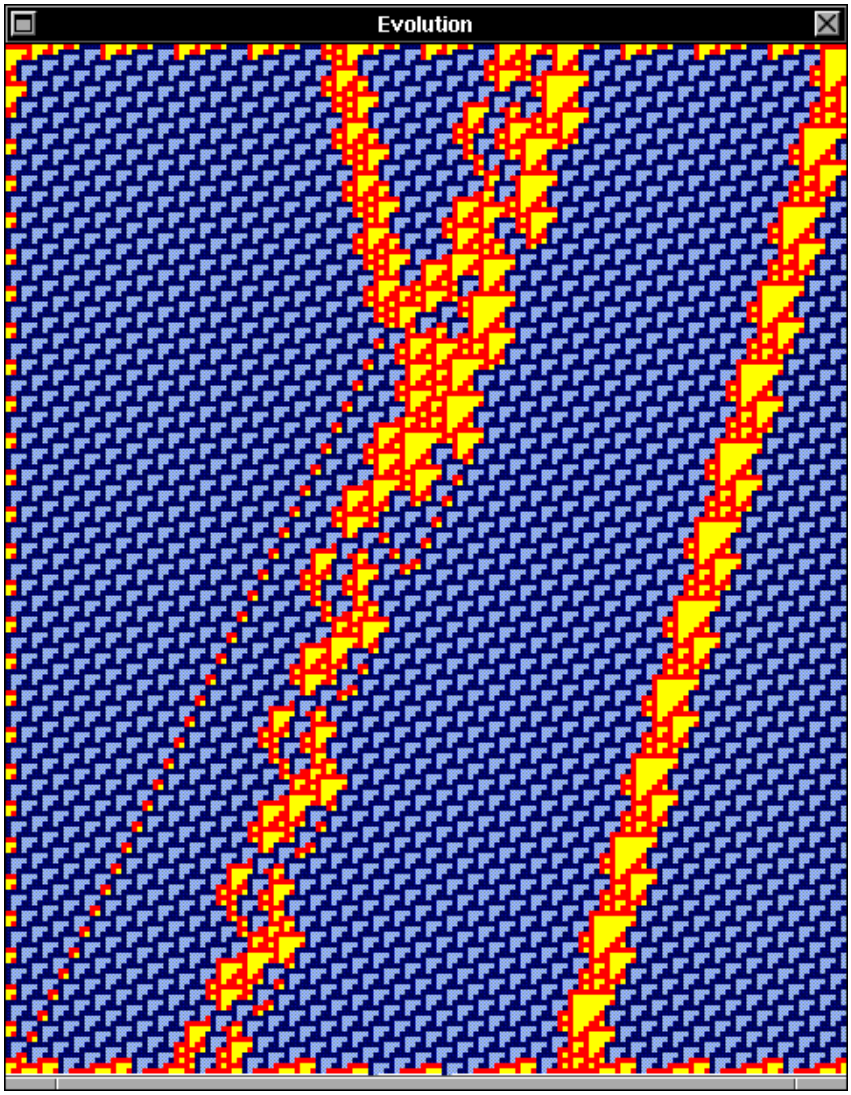

Figure 4.422: Collisions of glider D2, D2(p1)(C)-e(p1)-G(p1)(F)=B,Ebar

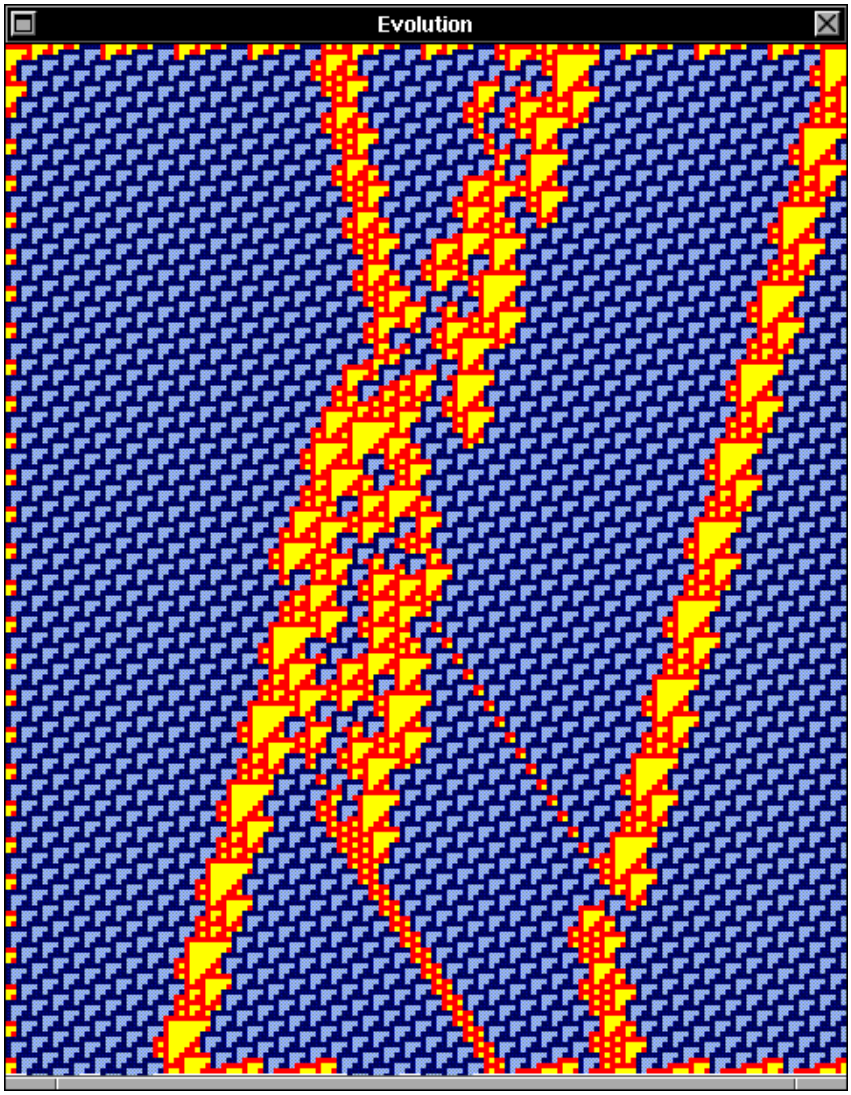

Figure 4.423: Collisions of glider D2, D2(p1)(A)-e(p1)-G(p1)(G)=A,E,3A

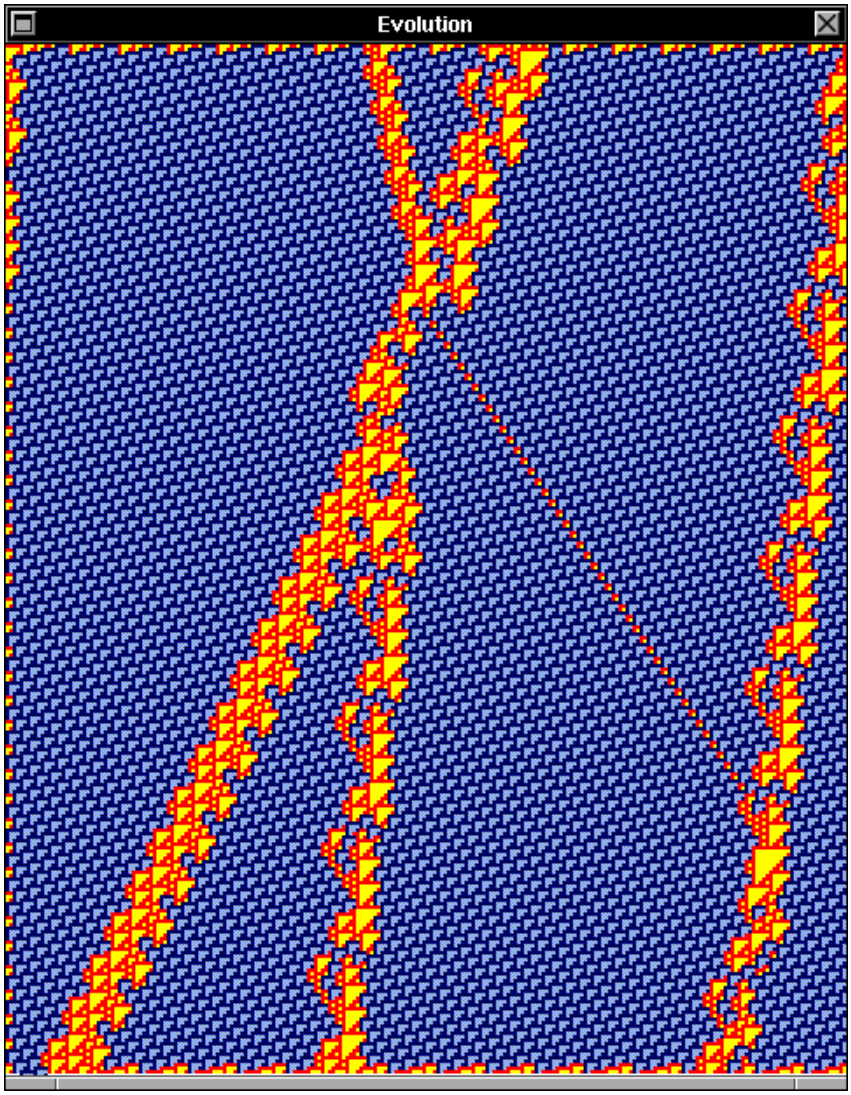

Figure 4.424: Collisions of glider D2, D2(p1)(C)-e(p1)-G(p1)(G)=A,Bbar,F

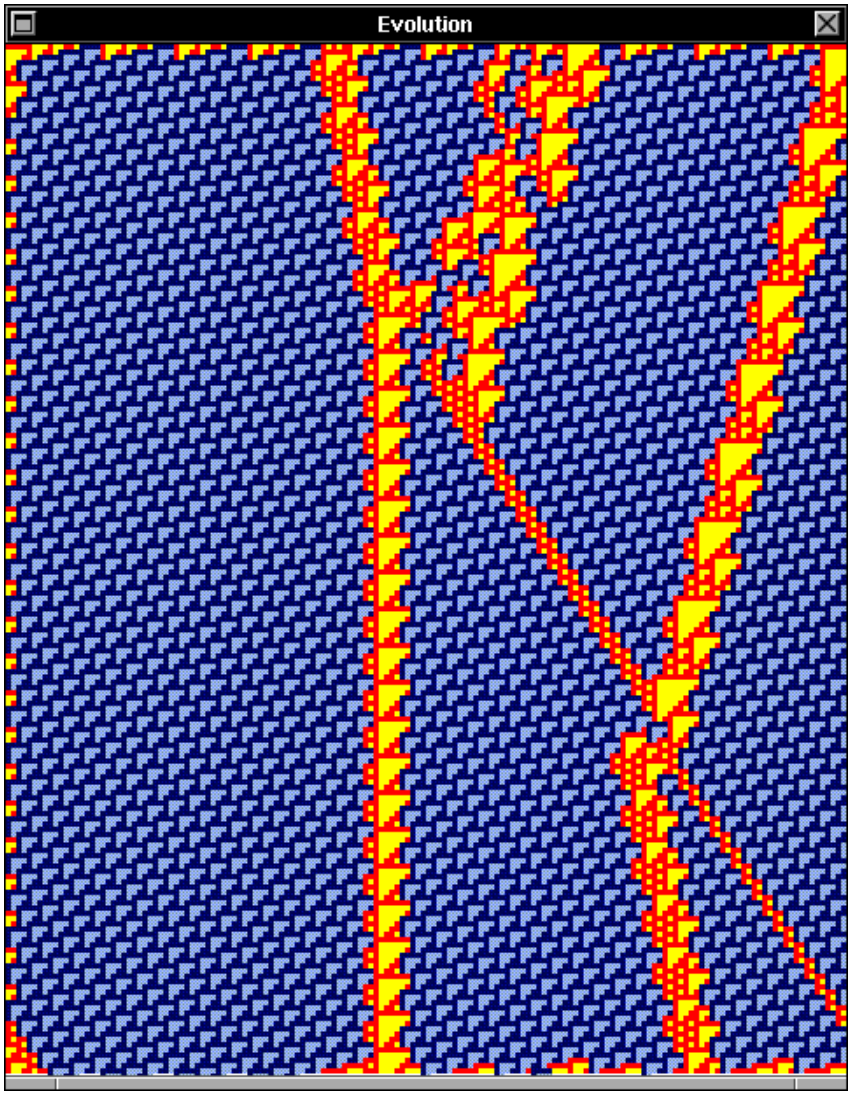

Figure 4.425: Collisions of glider D2, D2(p1)(A)-e(p1)-G(p1)(H)=C3,3A

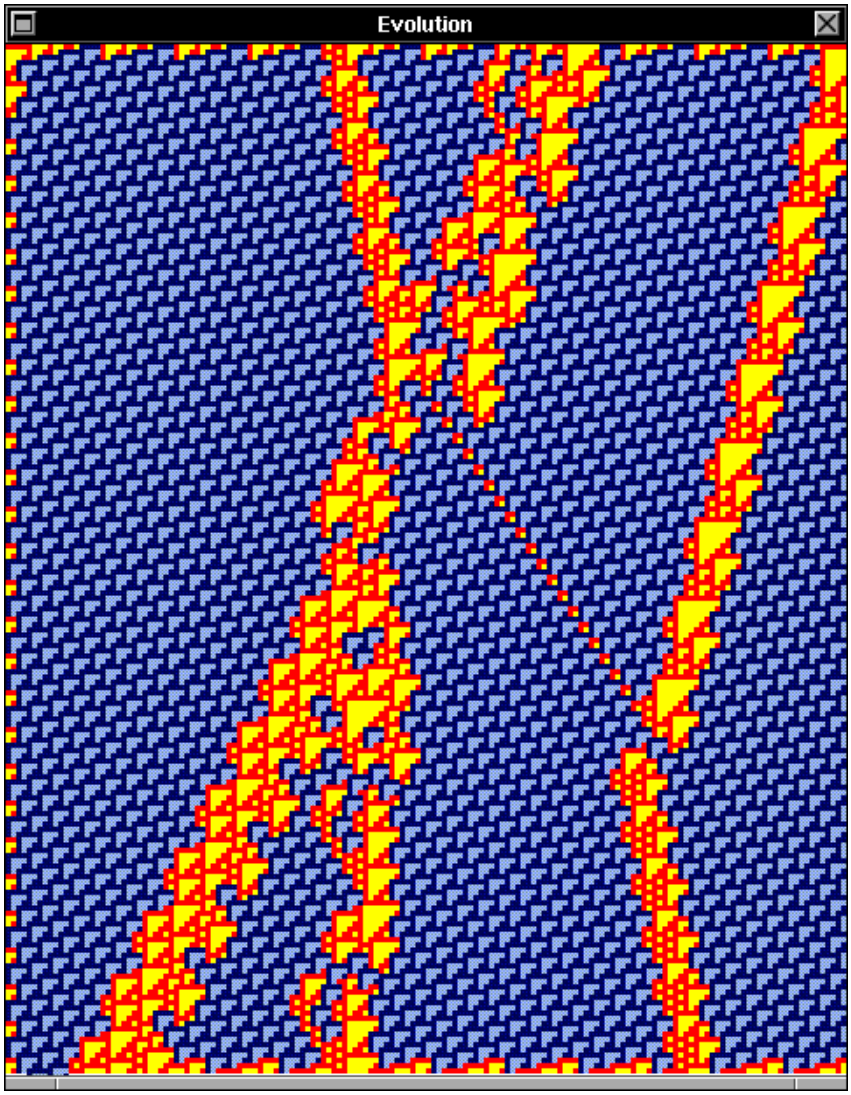

Figure 4.426: Collisions of glider D2, D2(p1)(C)-e(p1)-G(p1)(H)=A,Bbar,F

4.10.5 Collisions of glider D2 with glider H

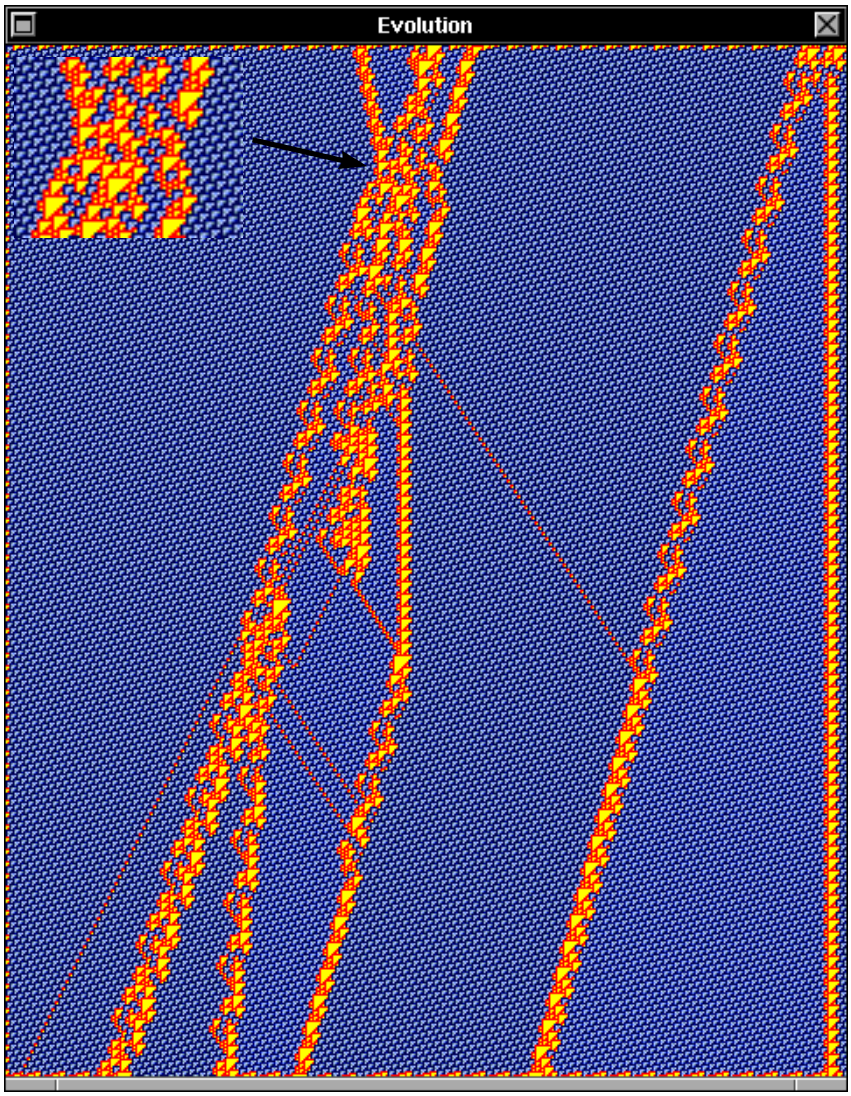

Figure 4.427: Collisions of glider D2, D2(p1)(A)-e(p1)-H(p1)(A)=A,B,A,3A,G3

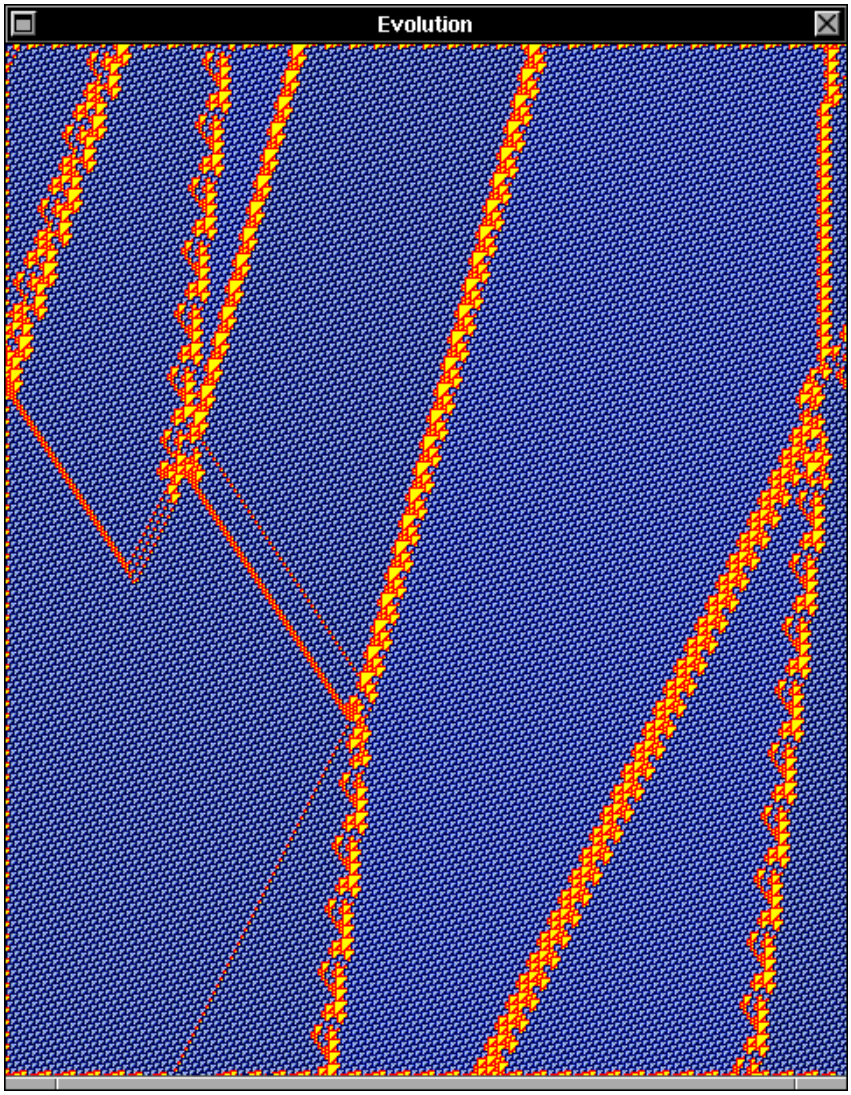

Figure 4.428: continue collision, D2(p1)(A)-e(p1)-H(p1)(A)

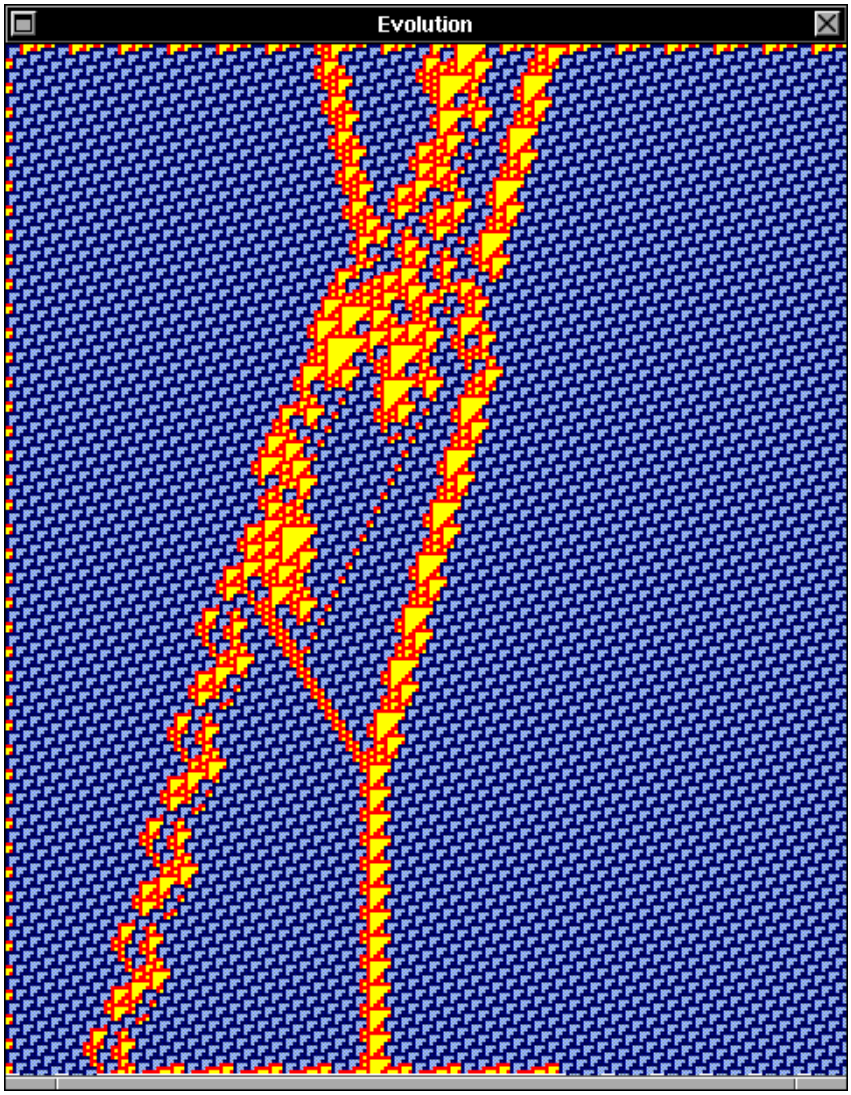

Figure 4.429: Collisions of glider D2, D2(p1)(C)-e(p1)-H(p1)(A)=Ebar,C1

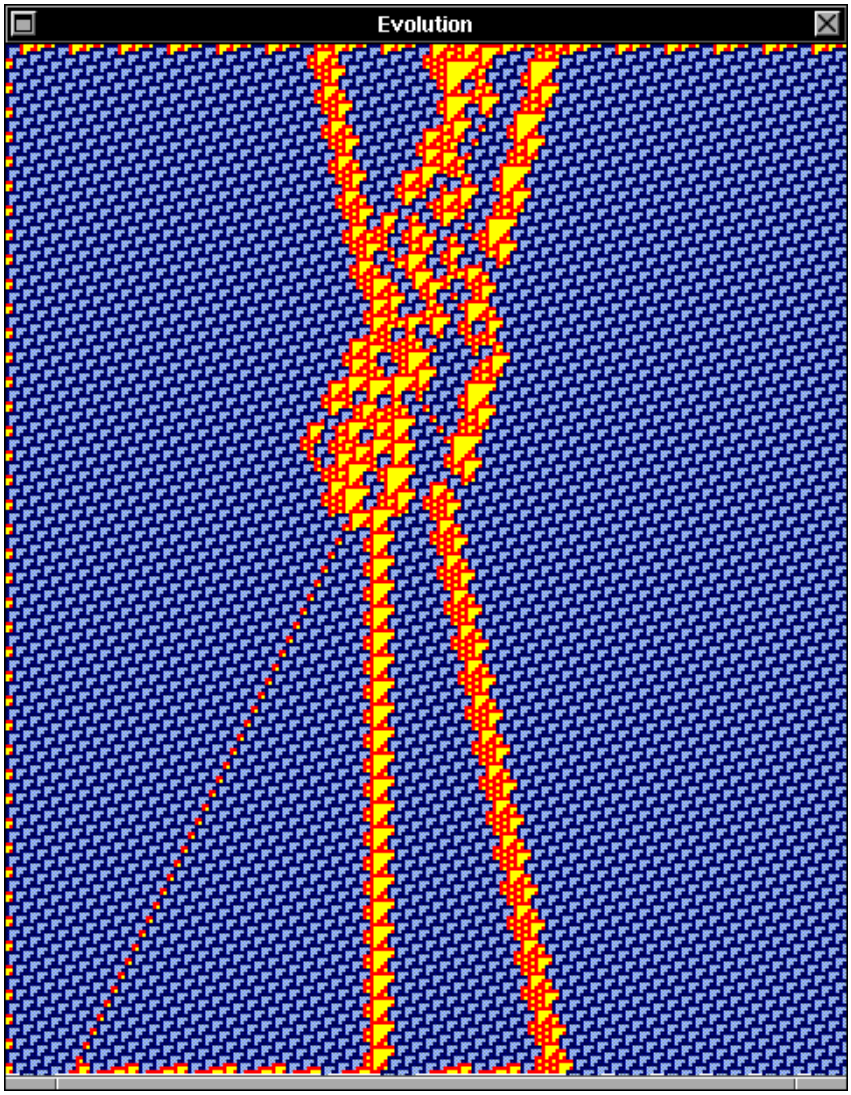

Figure 4.430: Collisions of glider D2, D2(p1)(A)-e(p1)-H(p1)(B)=B,C3,D1

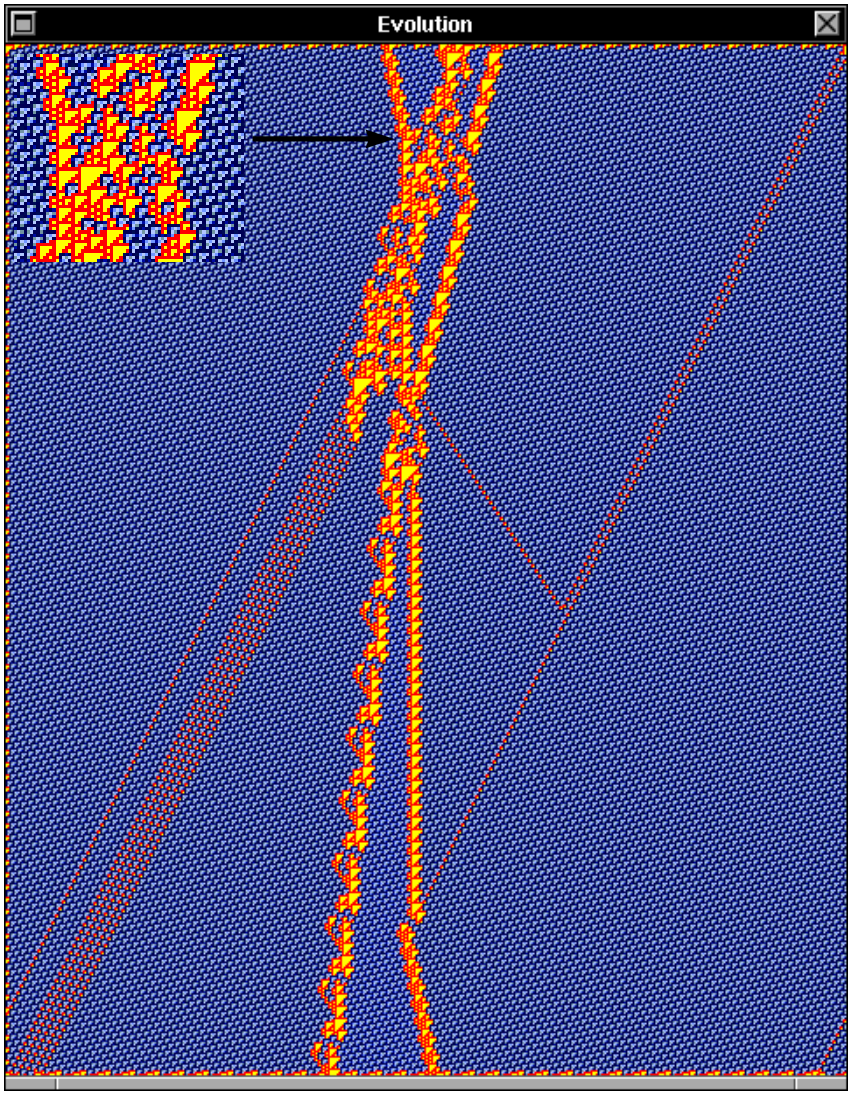

Figure 4.431: Collisions of glider D2, D2(p1)(C)-e(p1)-H(p1)(B)=B,5B,A,F,C2

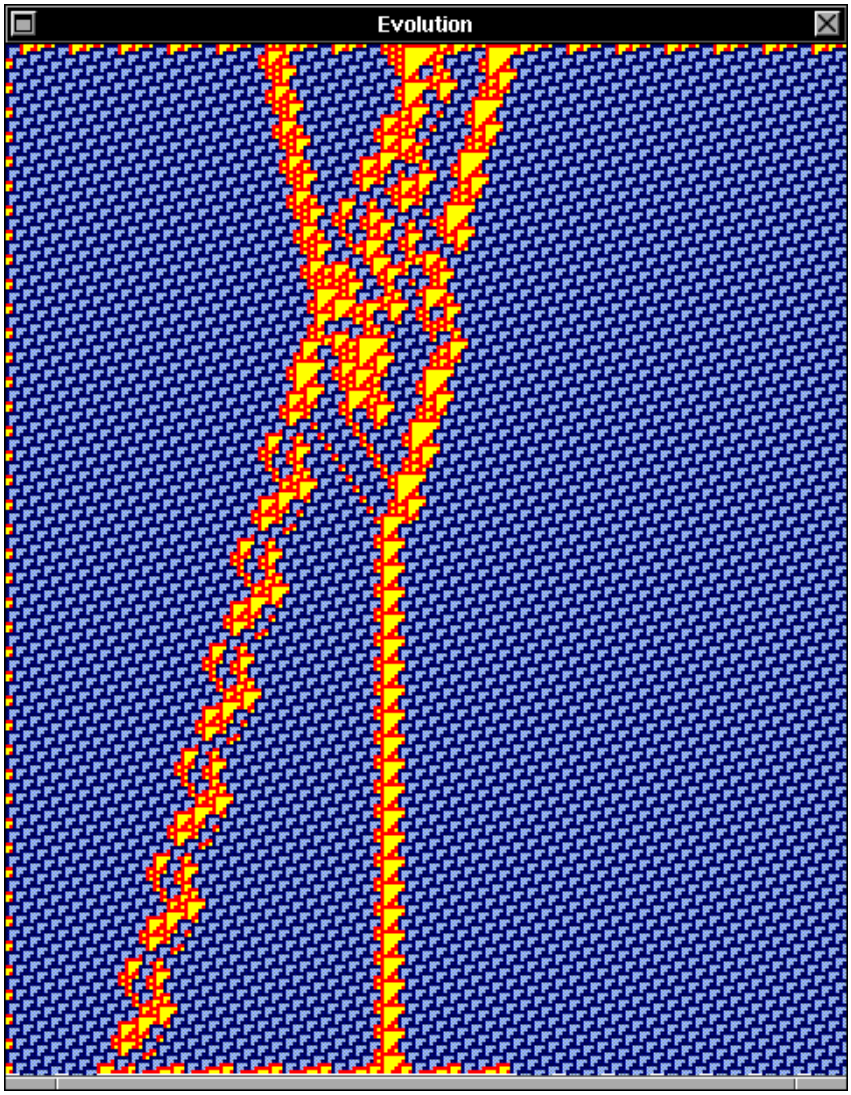

Figure 4.432: Collisions of glider D2, D2(p1)(A)-e(p1)-H(p1)(C)=Ebar,C1

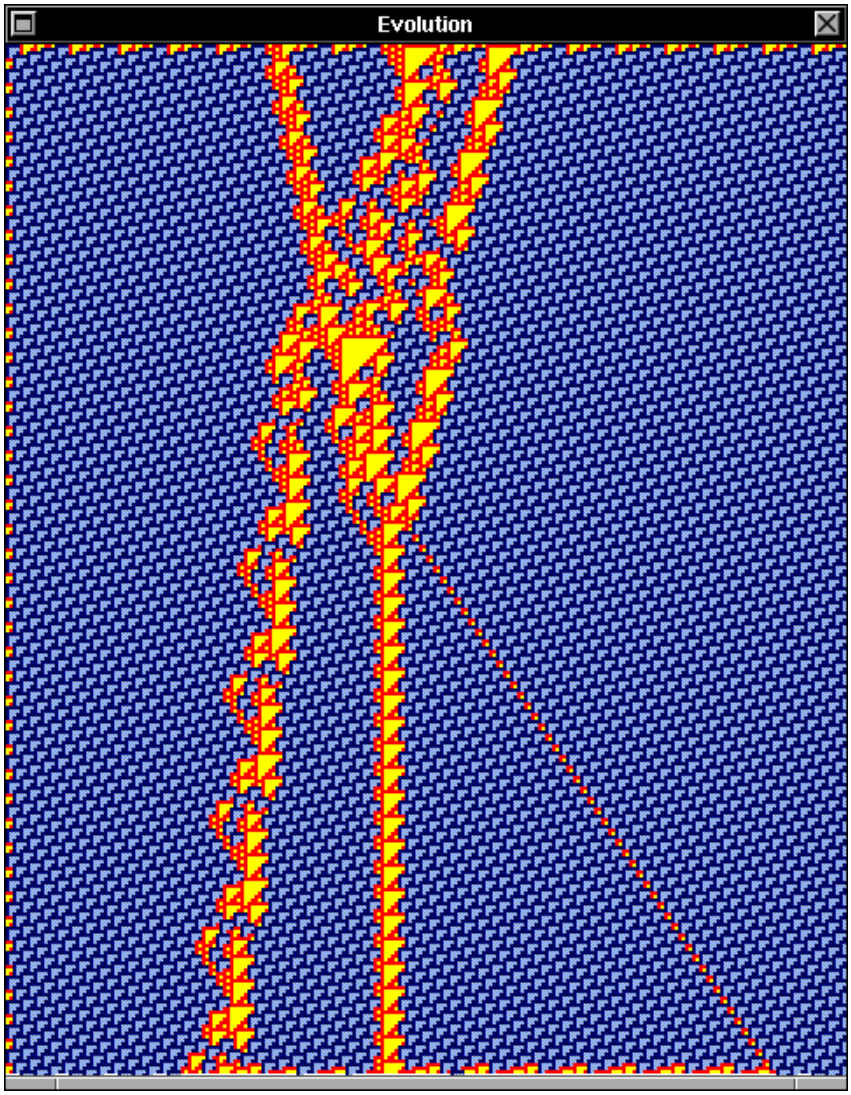

Figure 4.433: Collisions of glider D2, D2(p1)(C)-e(p1)-H(p1)(C)=F,C1,A

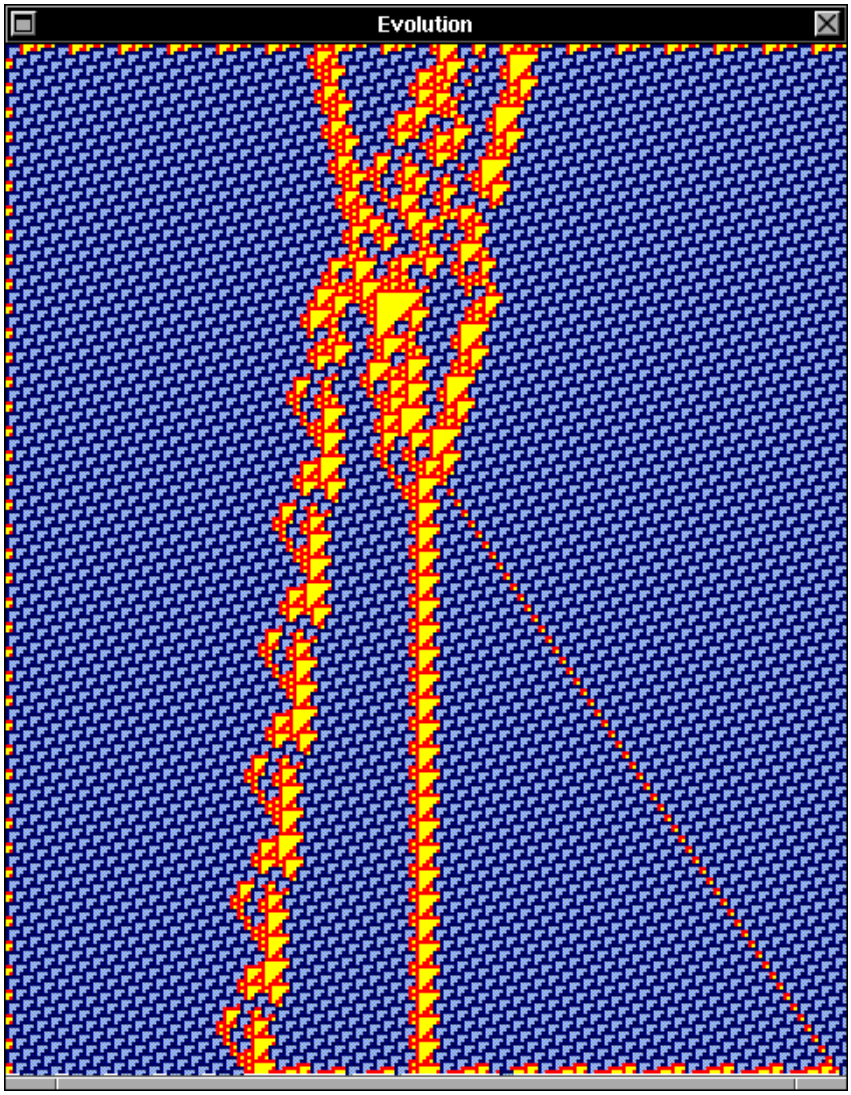

Figure 4.434: Collisions of glider D2, D2(p1)(A)-e(p1)-H(p1)(G)=F,C1,A

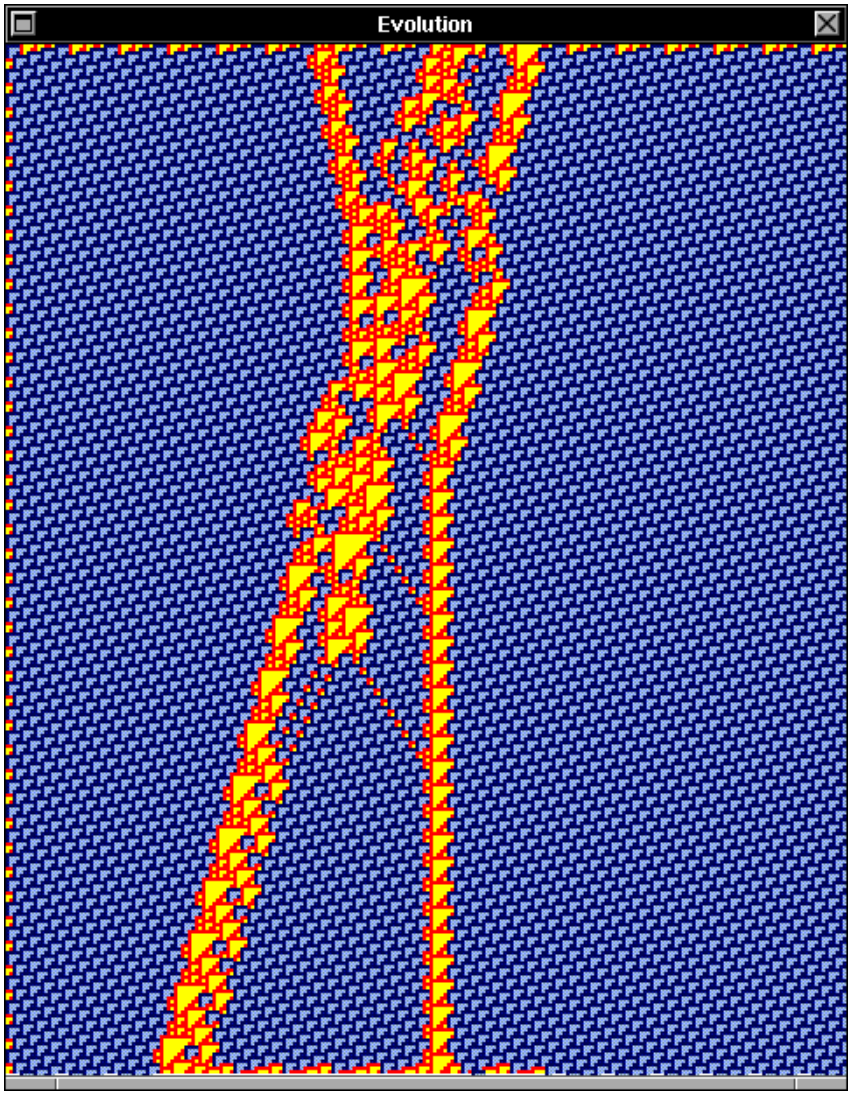

Figure 4.435: Collisions of glider D2, D2(p1)(A)-e(p1)-H(p1)(H)=E3,C1

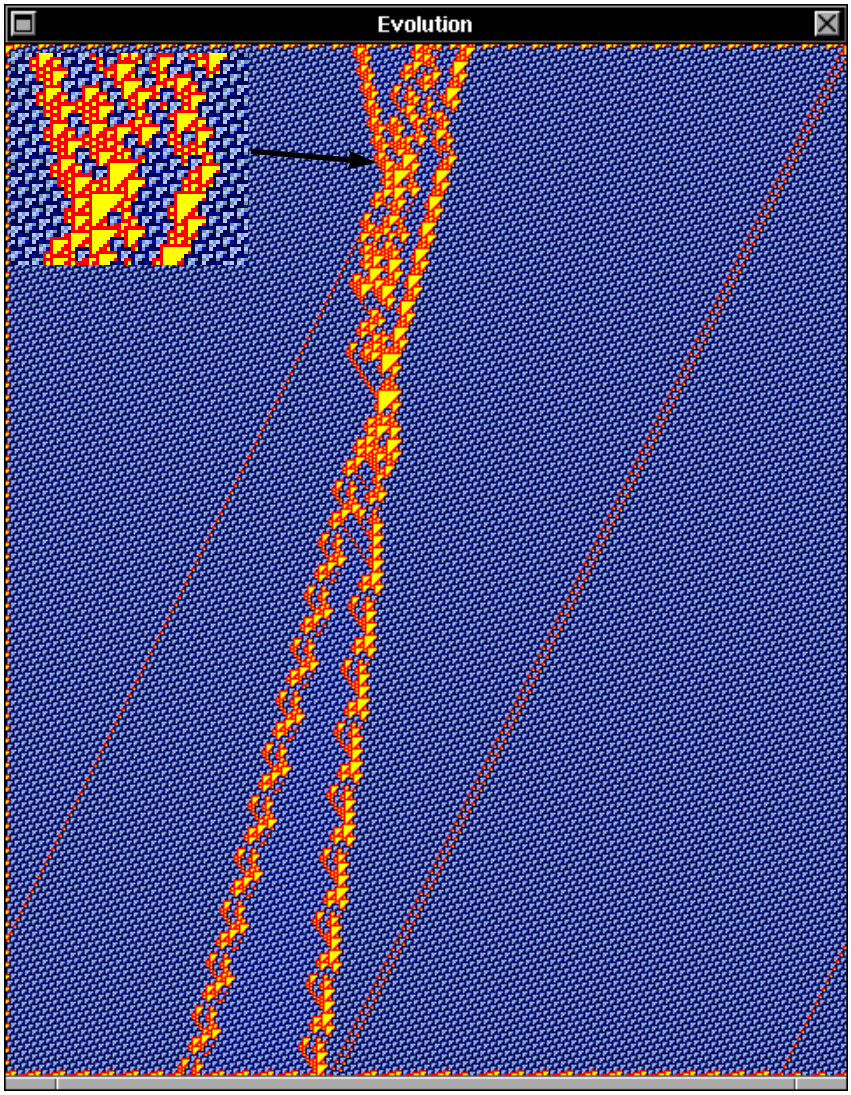

Figure 4.436: Collisions of glider D2, D2(p1)(A)-e(p1)-H(p1)(A2)=B,Ebar,F

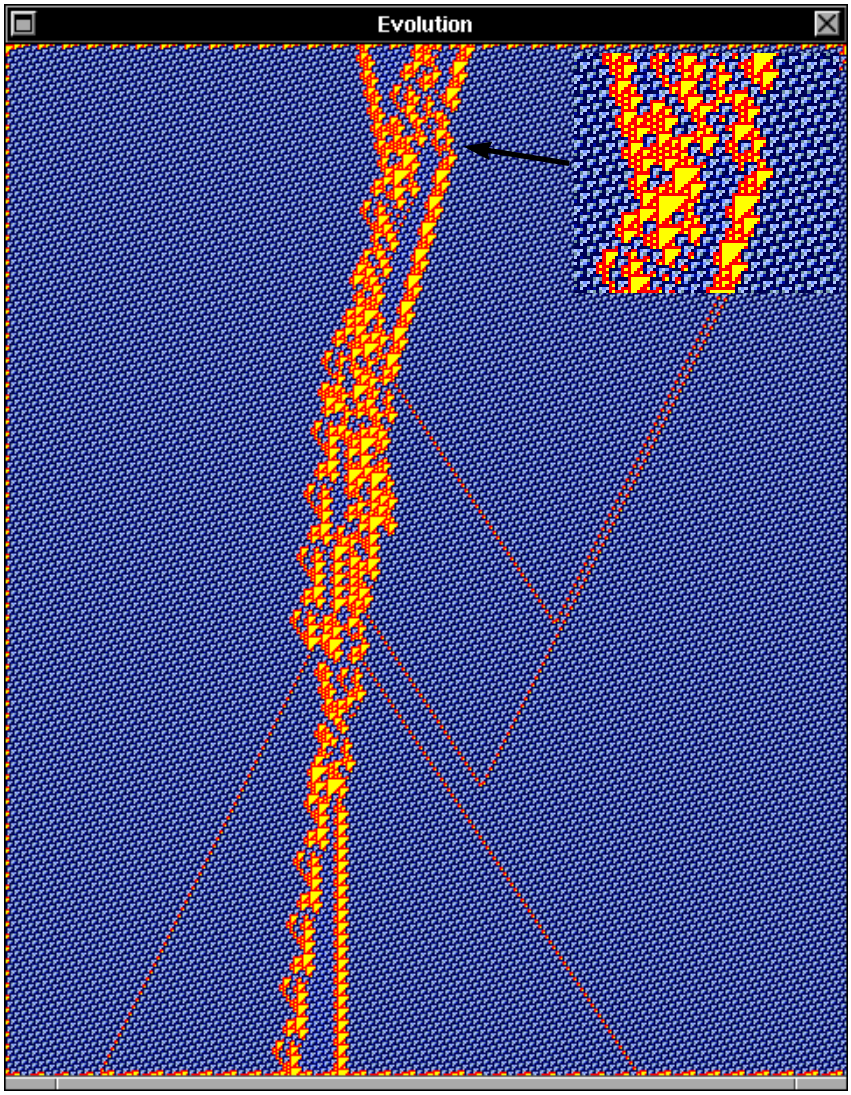

Figure 4.437: Collisions of glider D2, D2(p1)(C)-e(p1)-H(p1)(A2)=A,A,B,A,F,C2

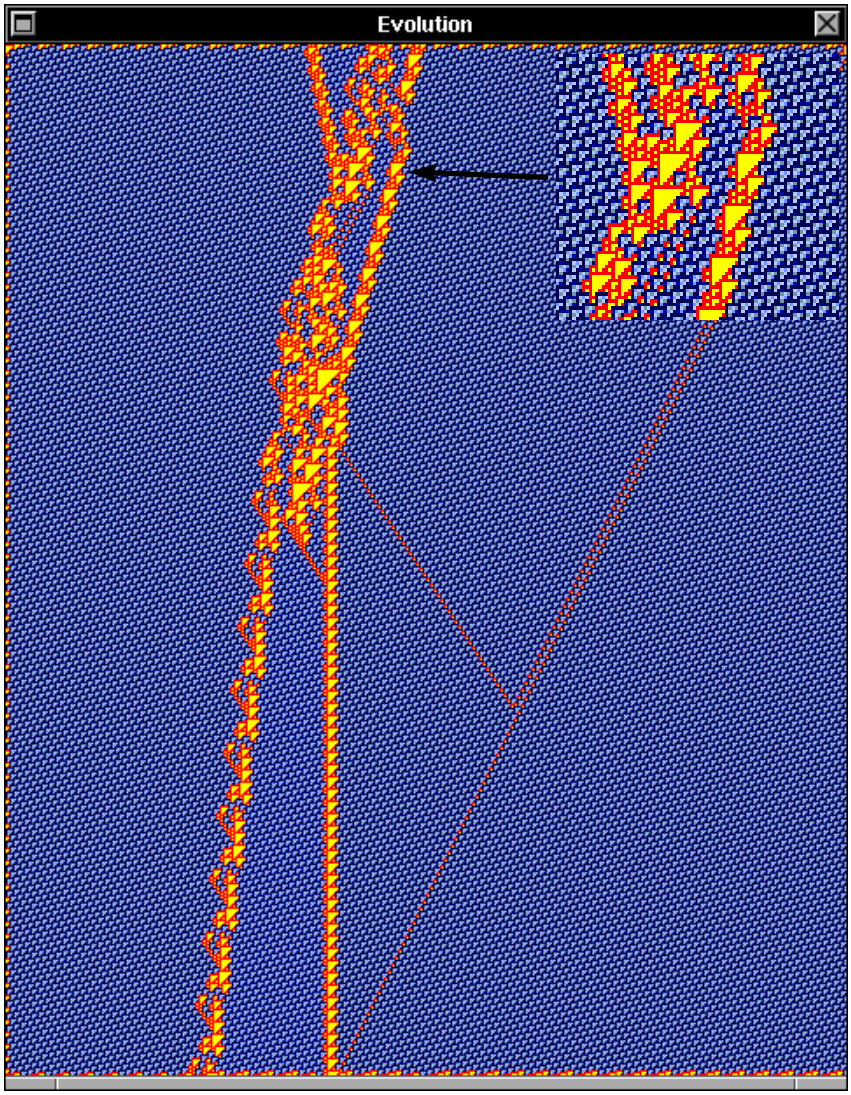

Figure 4.438: Collisions of glider D2, D2(p1)(A)-e(p1)-H(p1)(B2)=A,F,C1

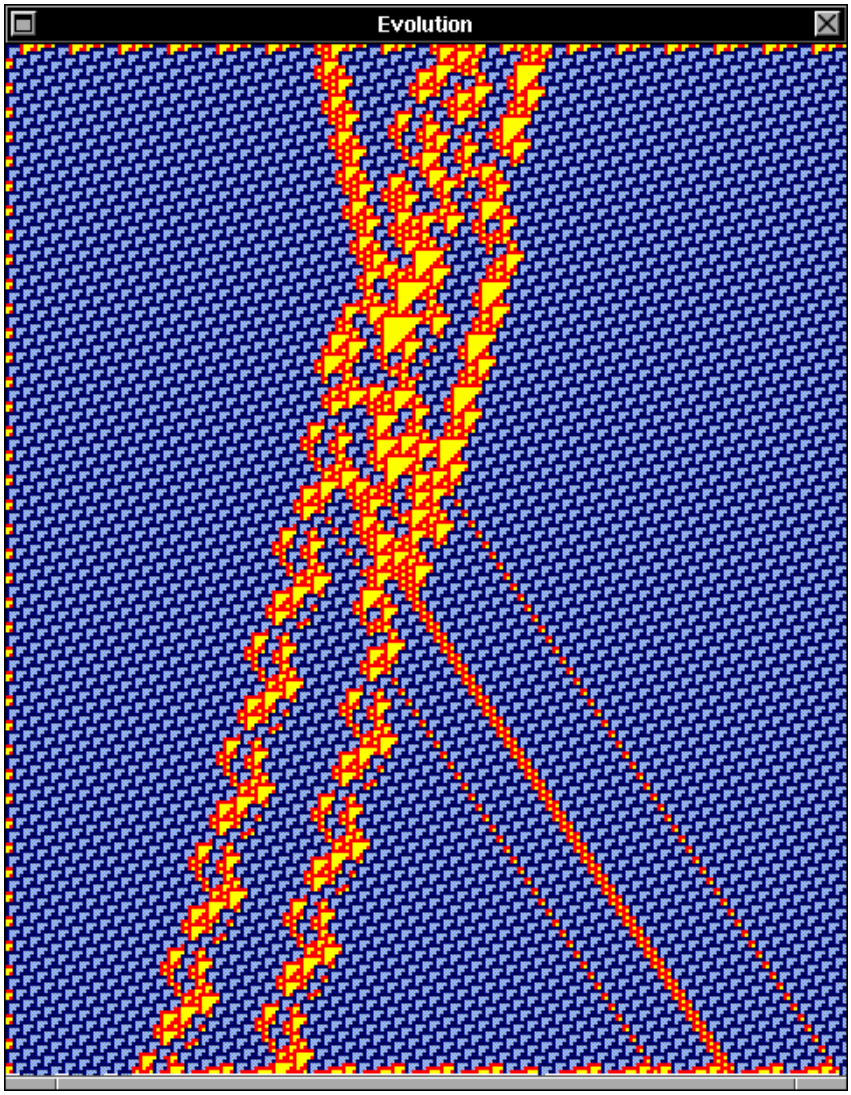

Figure 4.439: Collisions of glider D2, D2(p1)(C)-e(p1)-H(p1)(B2)=A,Ebar,3A,A,Ebar

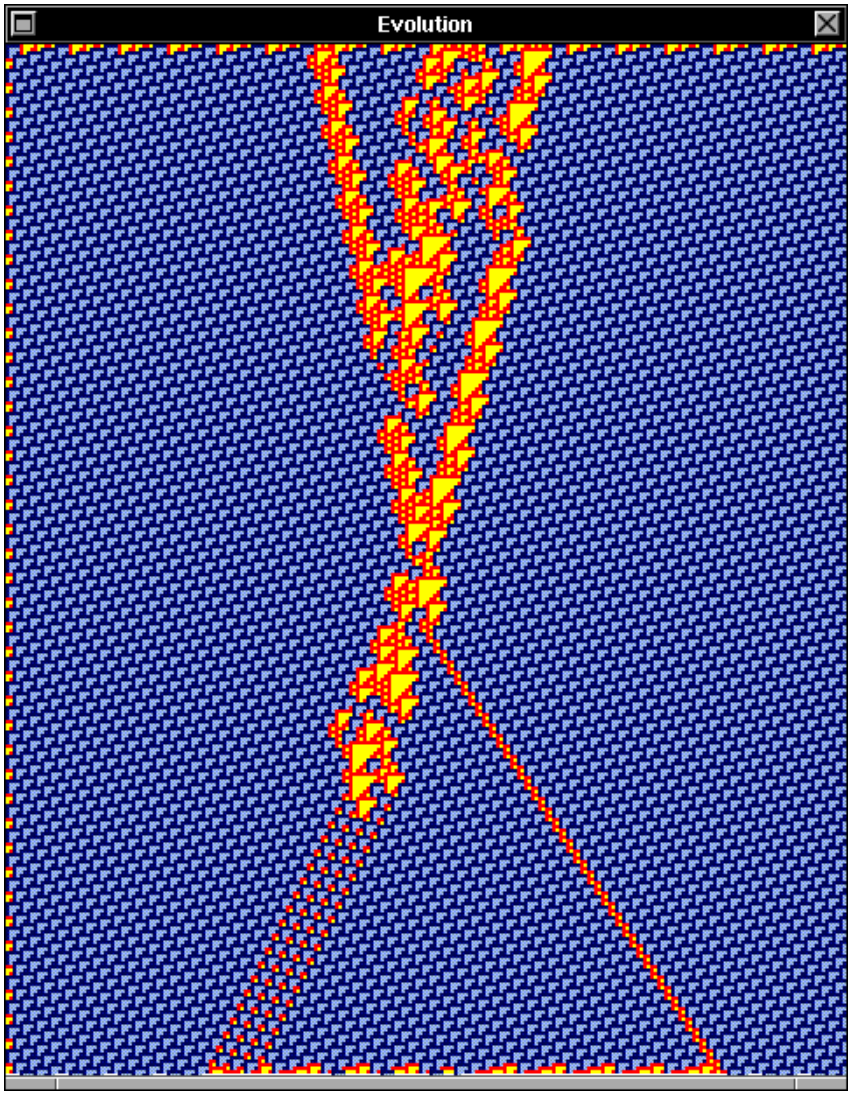

Figure 4.440: Collisions of glider D2, D2(p1)(A)-e(p1)-H(p1)(C2)=2A,4B

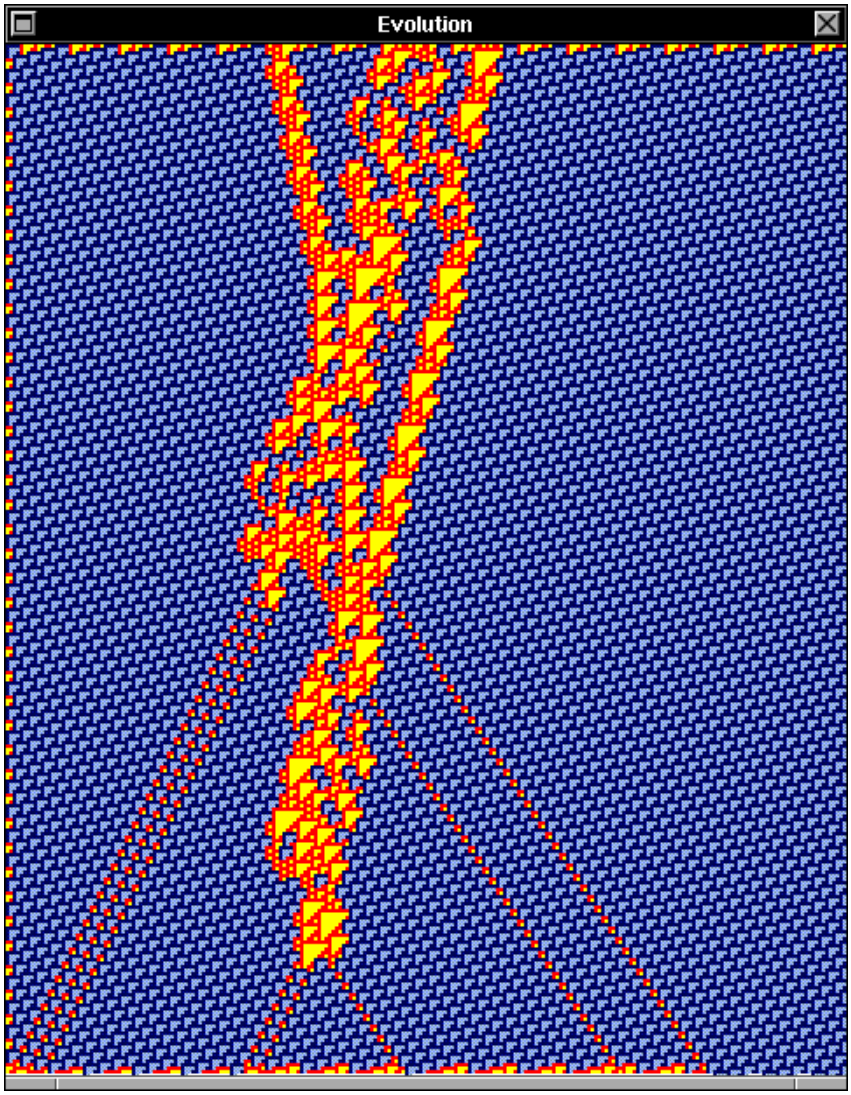

Figure 4.441: Collisions of glider D2, D2(p1)(C)-e(p1)-H(p1)(C2)=3B,A,A,2B,A

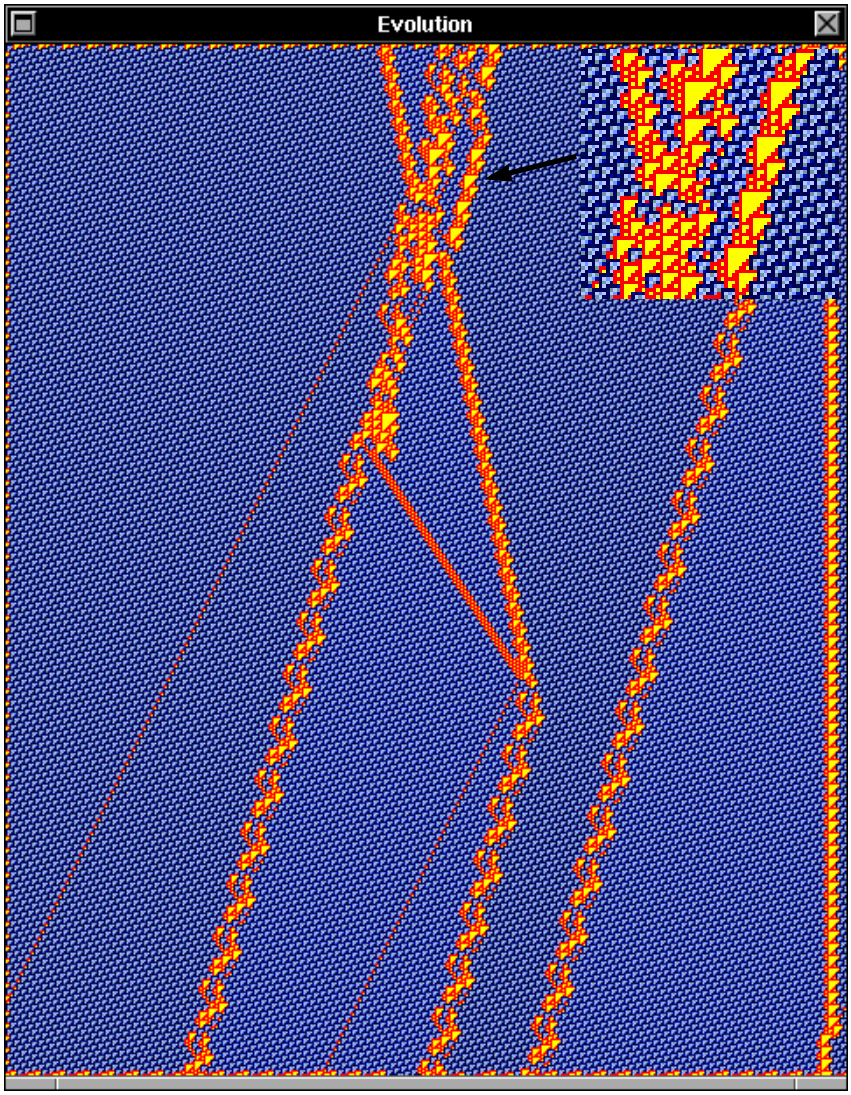

Figure 4.442: Collisions of glider D2, D2(p1)(A)-e(p1)-H(p1)(D2)=A,3B,Ebar,E

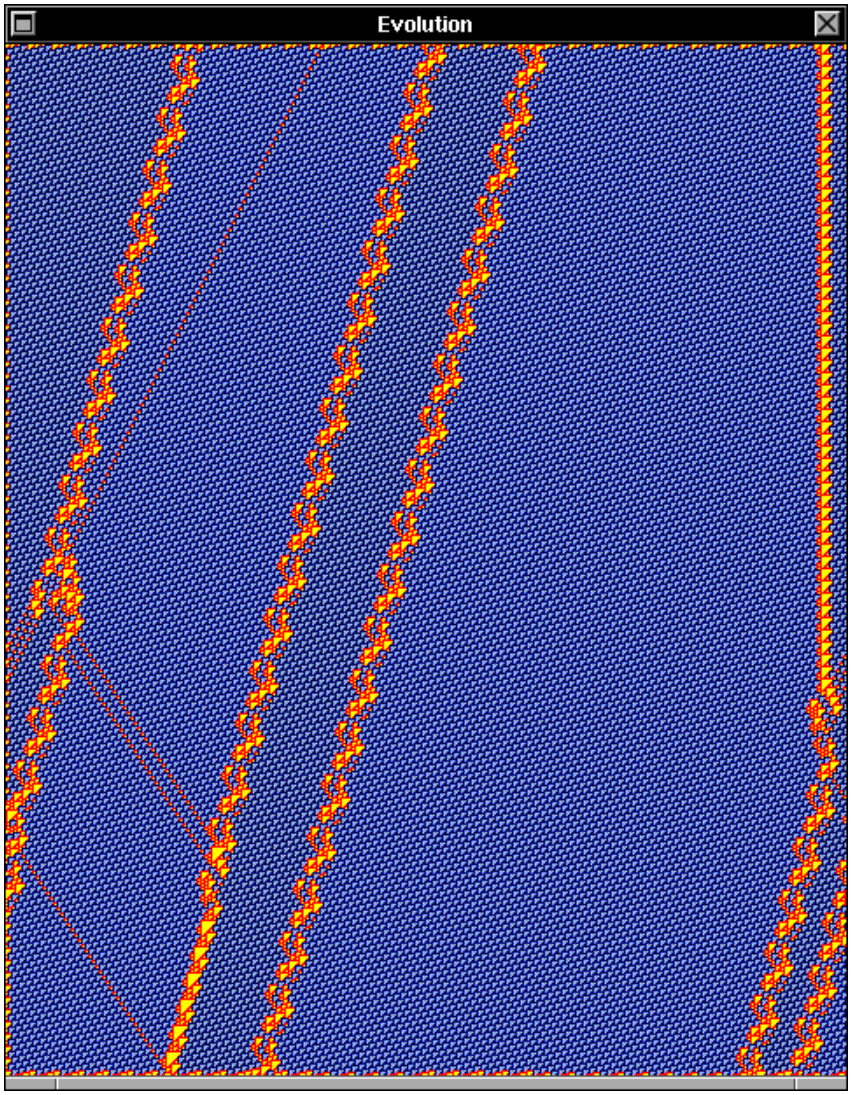

Figure 4.443: continue collision, D2(p1)(A)-e(p1)-H(p1)(D2)

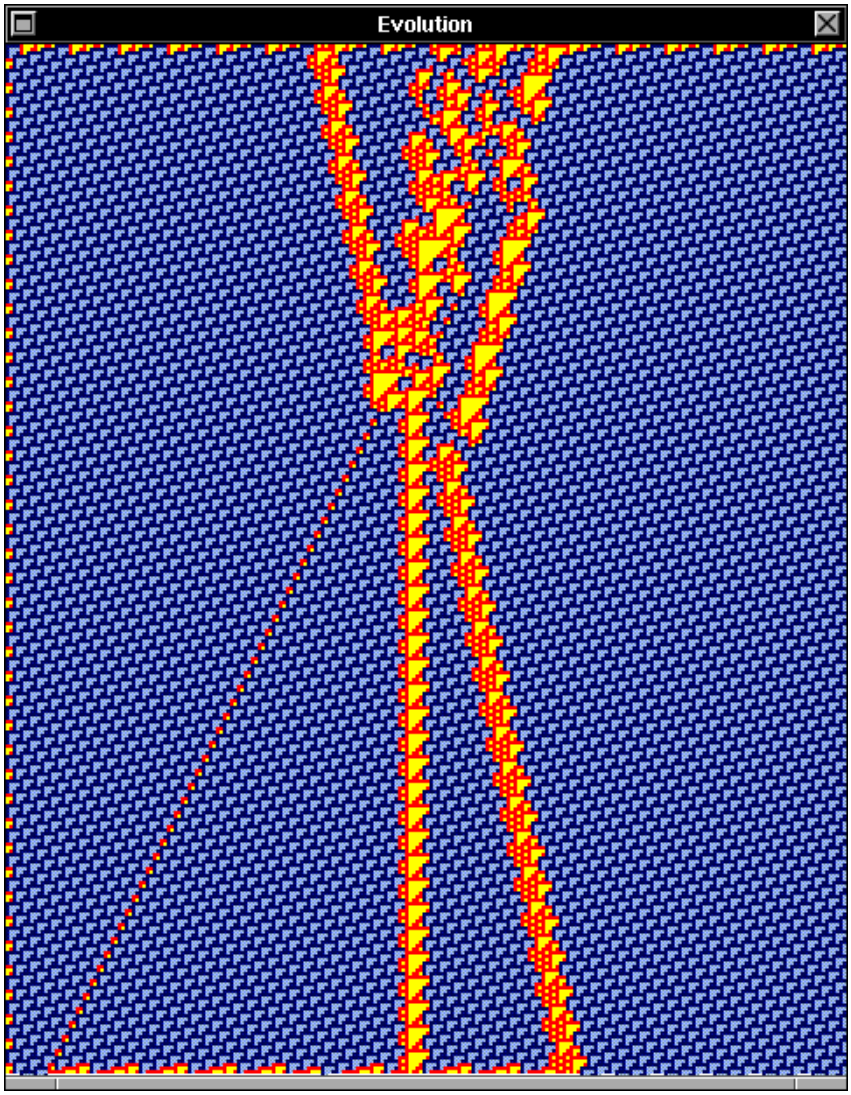

Figure 4.444: continue collision, D2(p1)(A)-e(p1)-H(p1)(E2)=B,C3,D1

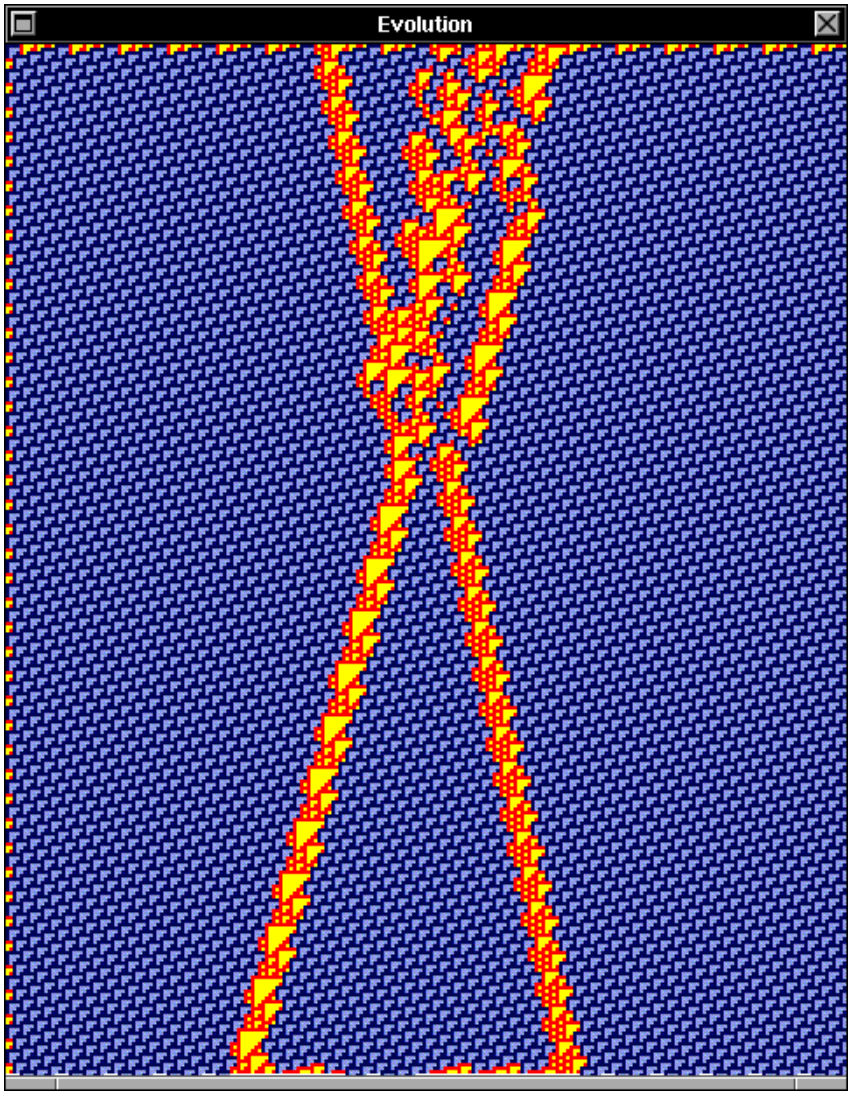

Figure 4.445: continue collision, D2(p1)(C)-e(p1)-H(p1)(E2)=E,D1

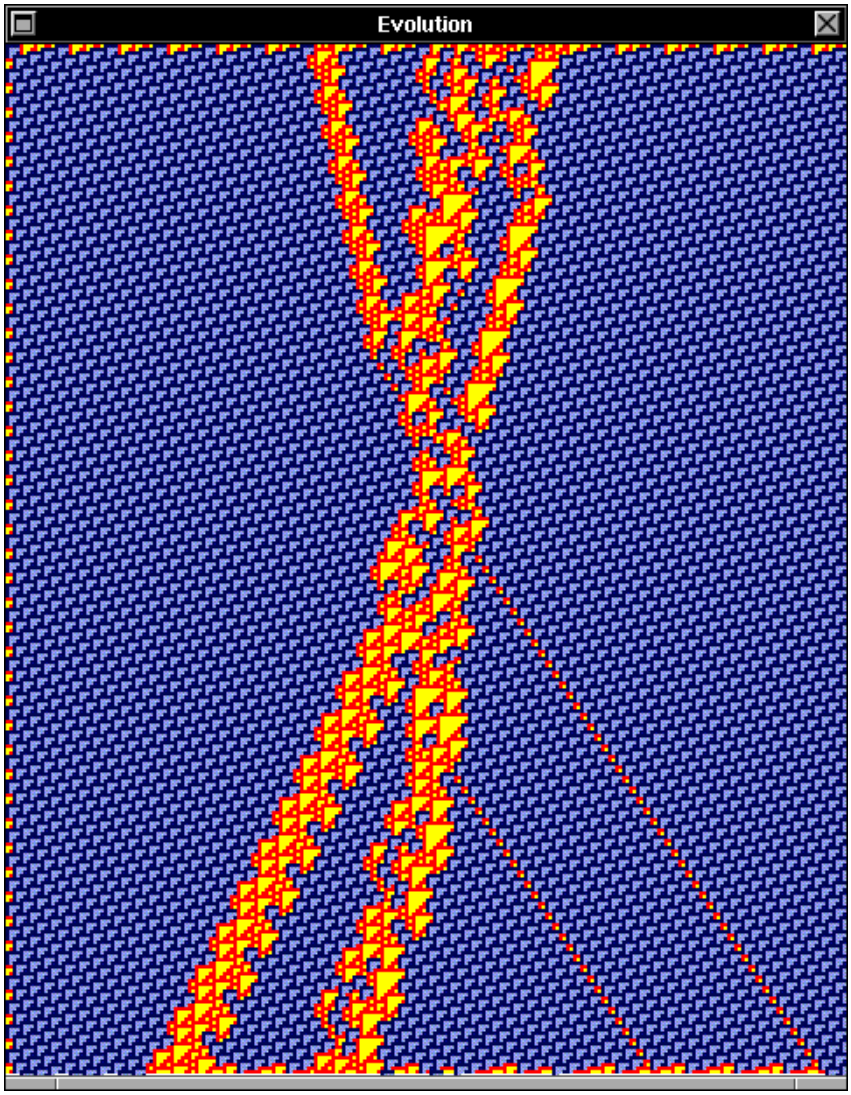

Figure 4.446: continue collision, D2(p1)(A)-e(p1)-H(p1)(F2)=A,Bbar,A,G

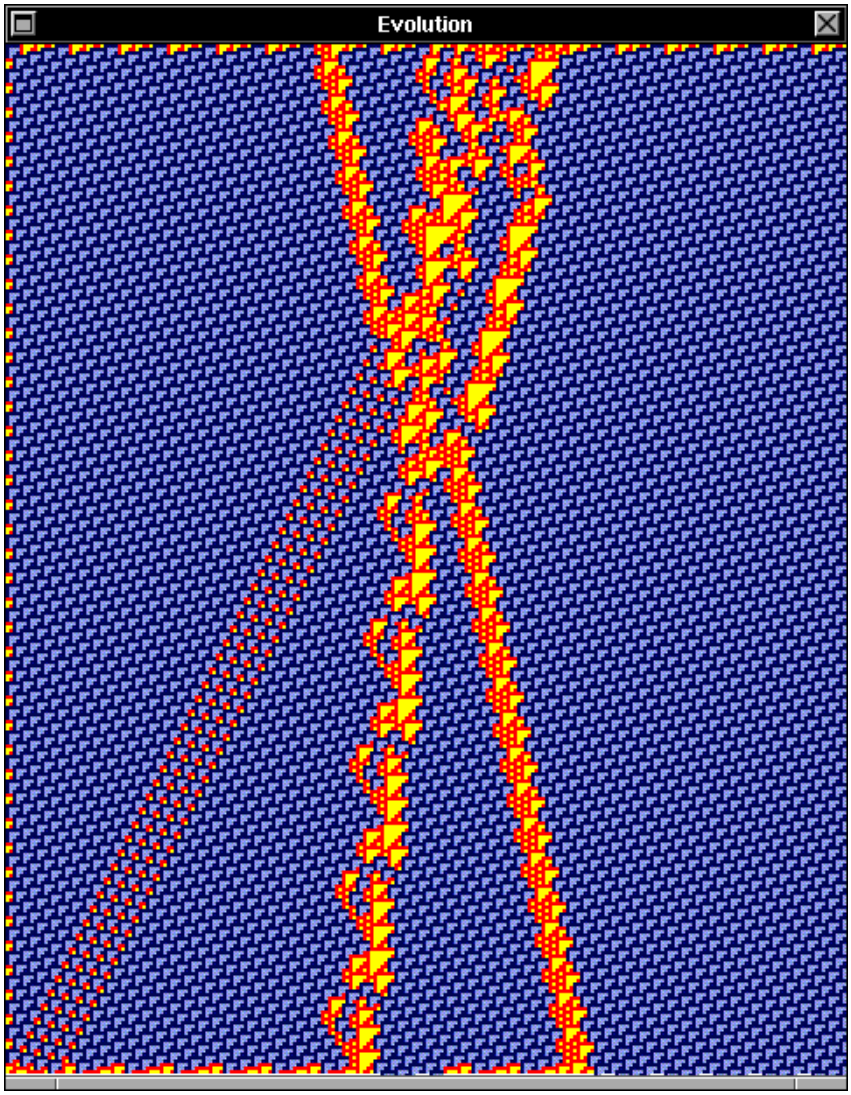

Figure 4.447: continue collision, D2(p1)(C)-e(p1)-H(p1)(F2)=4B,F,D1

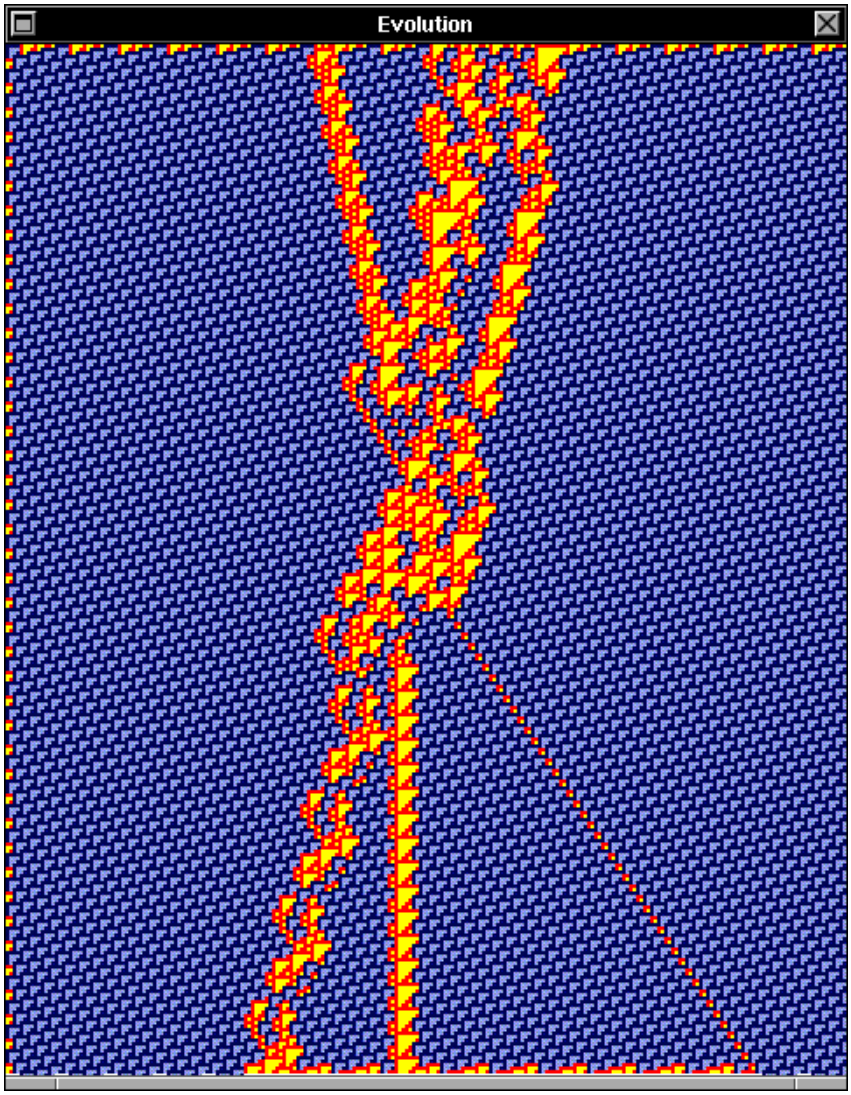

Figure 4.448: continue collision, D2(p1)(A)-e(p1)-H(p1)(G2)=Ebar,C2,A

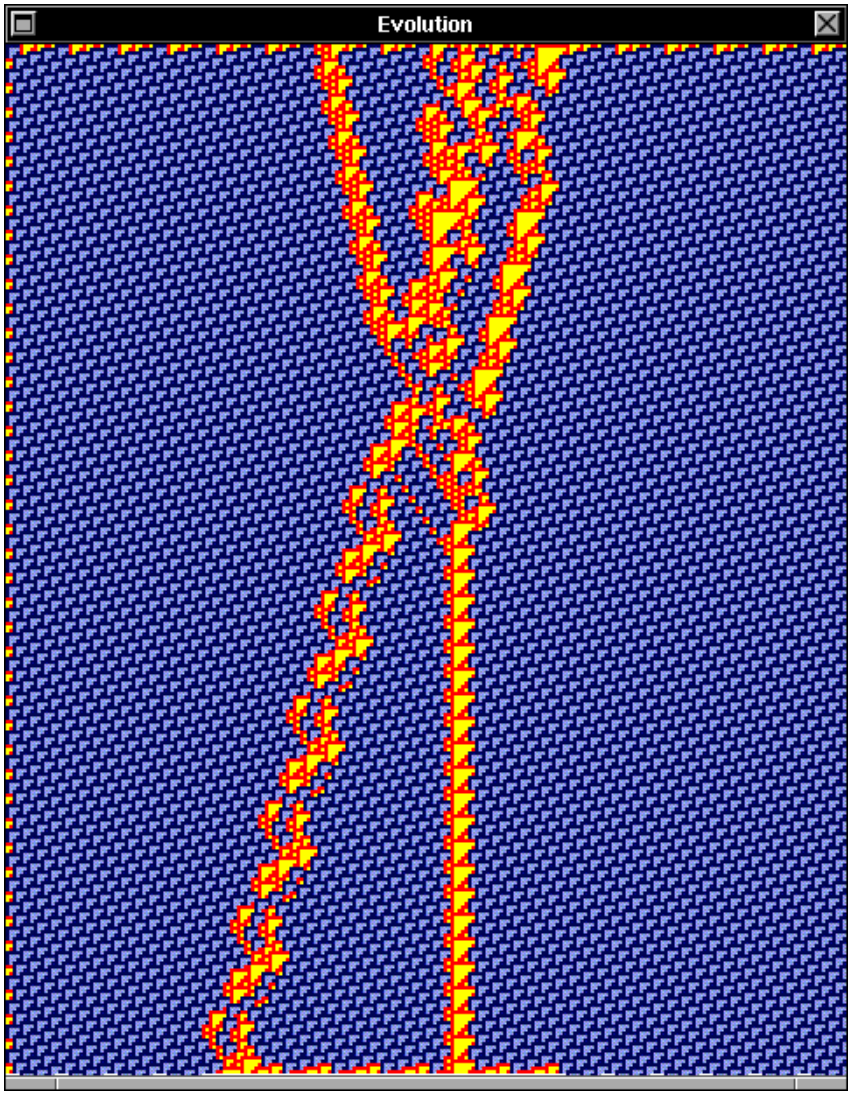

Figure 4.449: continue collision, D2(p1)(C)-e(p1)-H(p1)(G2)=Ebar,C1

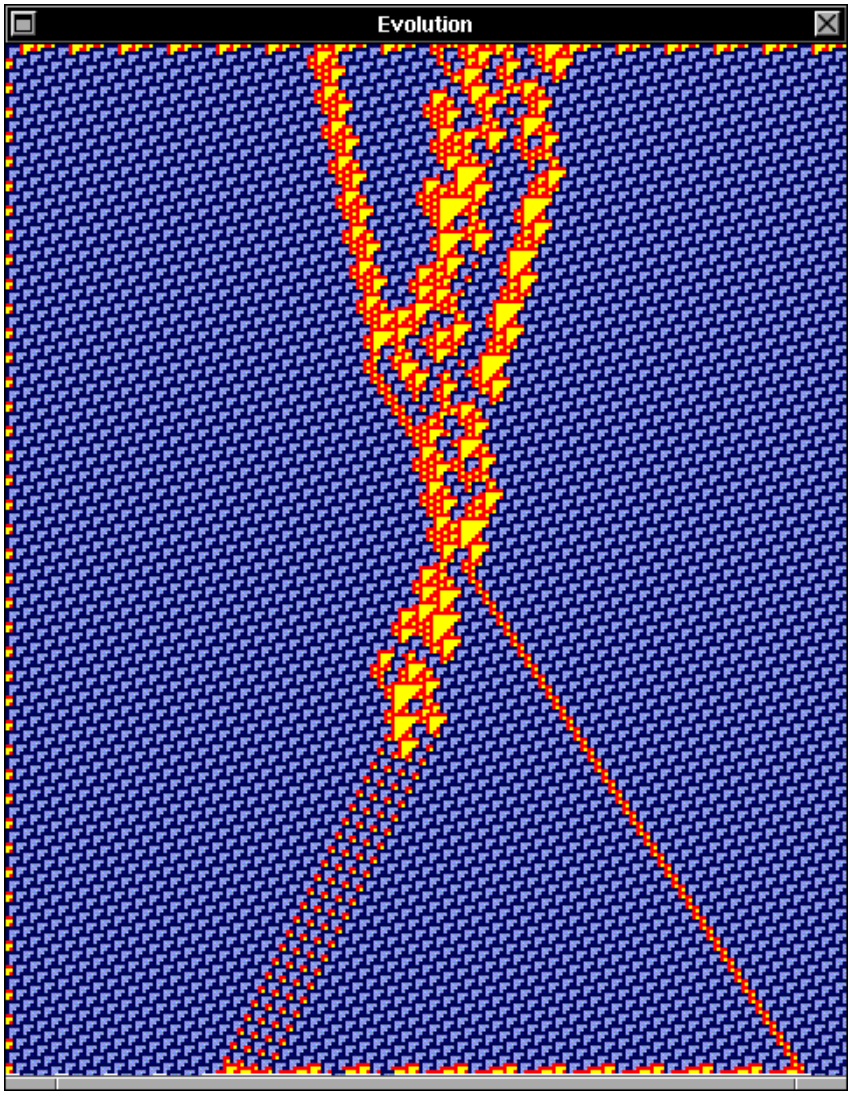

Figure 4.450: continue collision, D2(p1)(A)-e(p1)-H(p1)(H2)=2A,4B

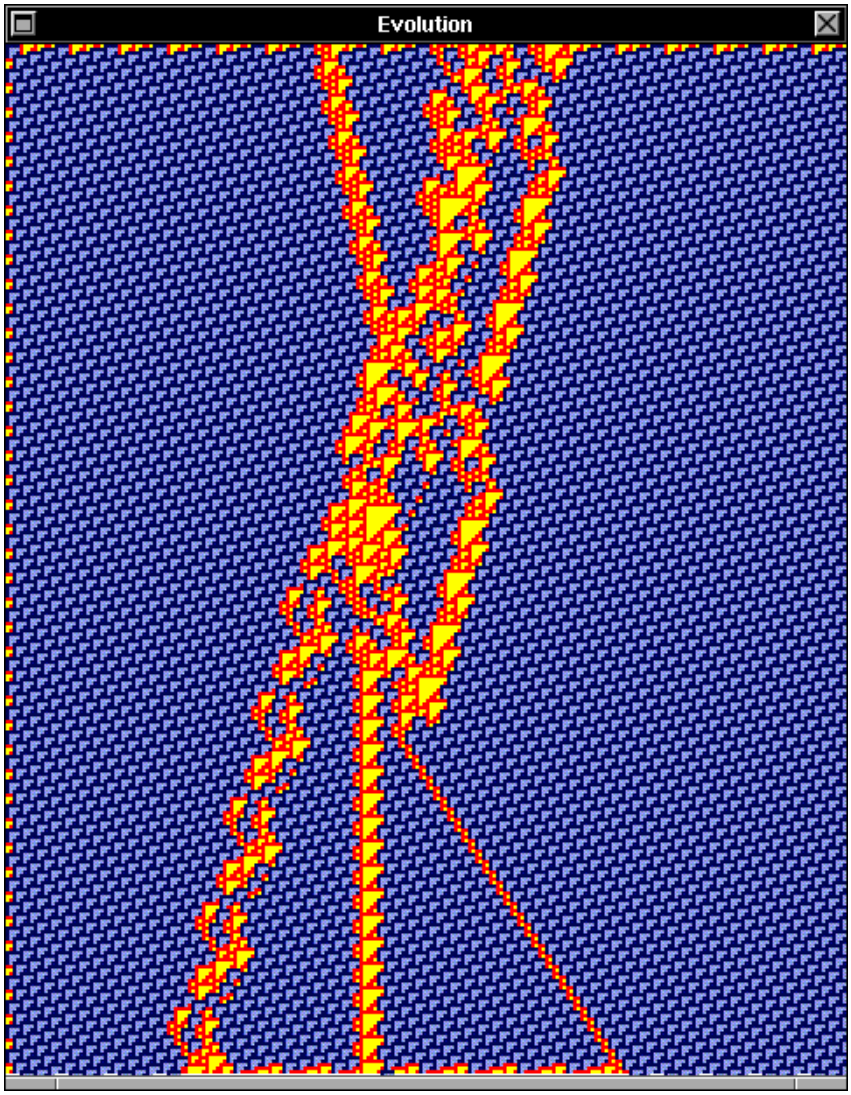

Figure 4.451: continue collision, D2(p1)(C)-e(p1)-H(p1)(H2)=Ebar,C3,2A

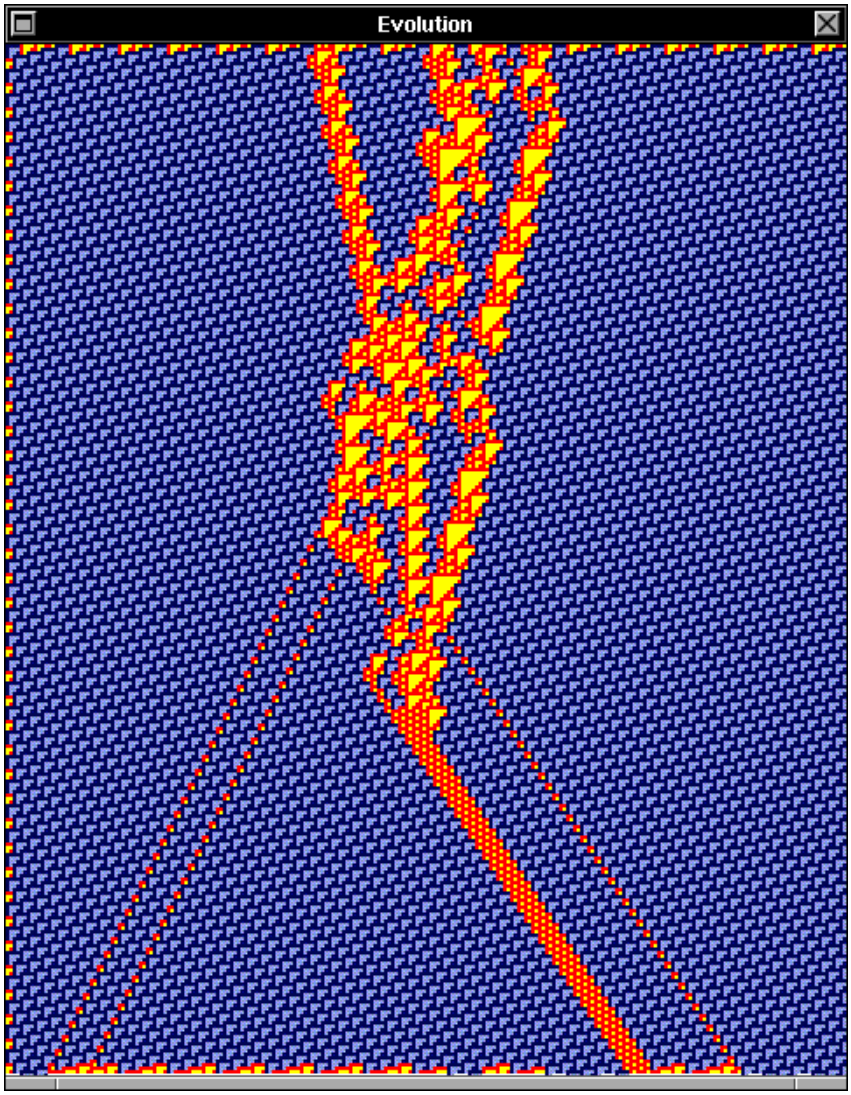

Figure 4.452: continue collision, D2(p1)(A)-e(p1)-H(p1)(D3)=B,B,A,5A

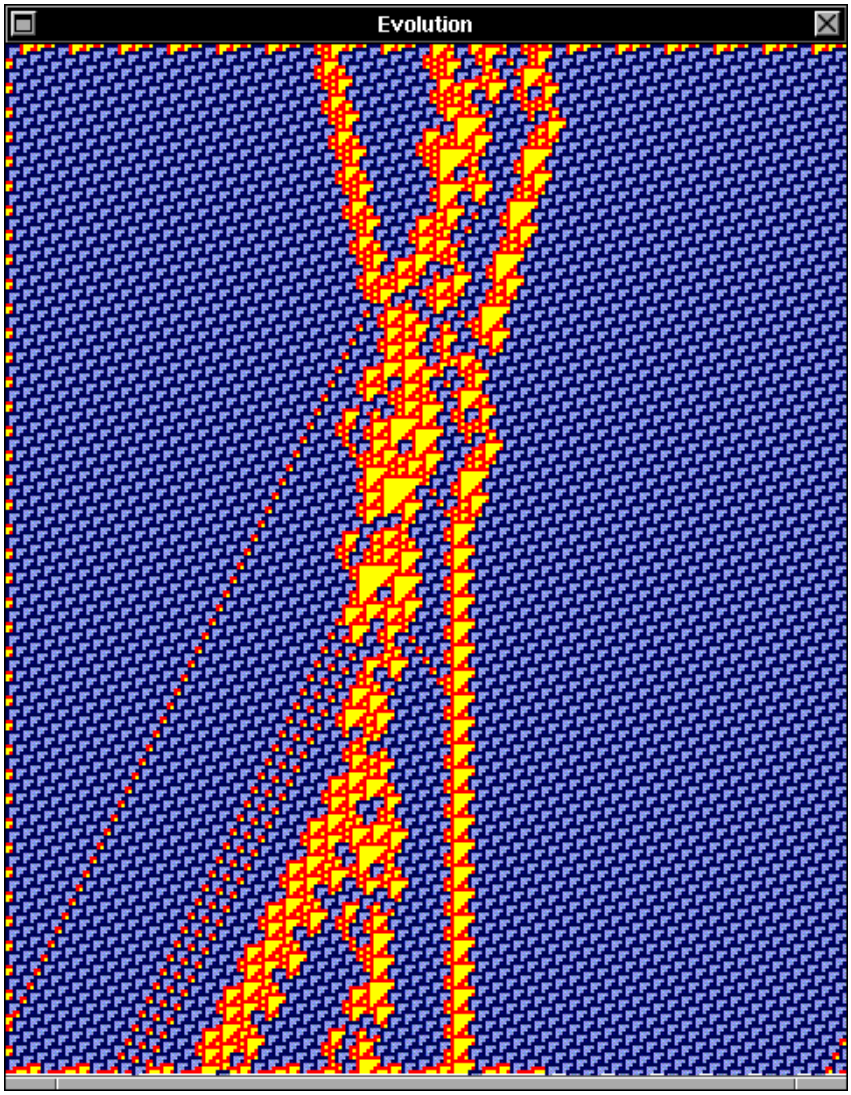

Figure 4.453: continue collision, D2(p1)(C)-e(p1)-H(p1)(D3)=B,3B,C2,Bbar,F

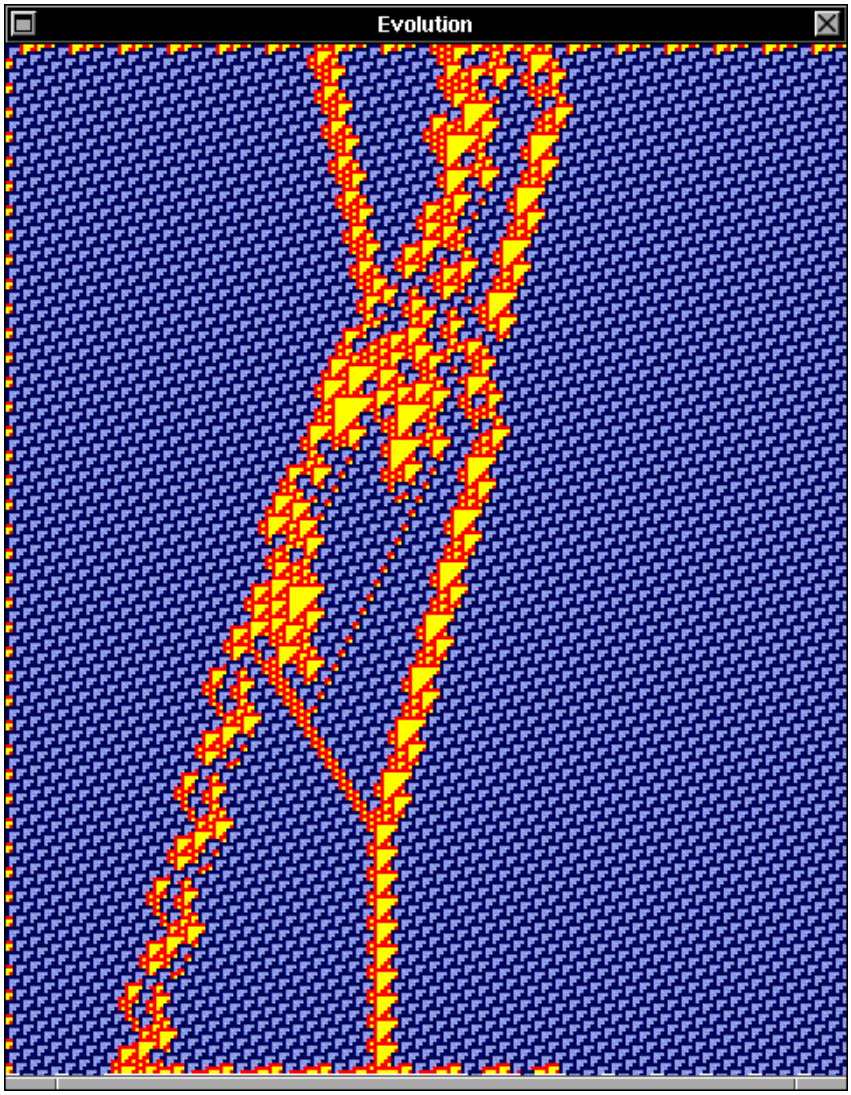

Figure 4.454: continue collision, D2(p1)(A)-e(p1)-H(p1)(E3)=Ebar,C1

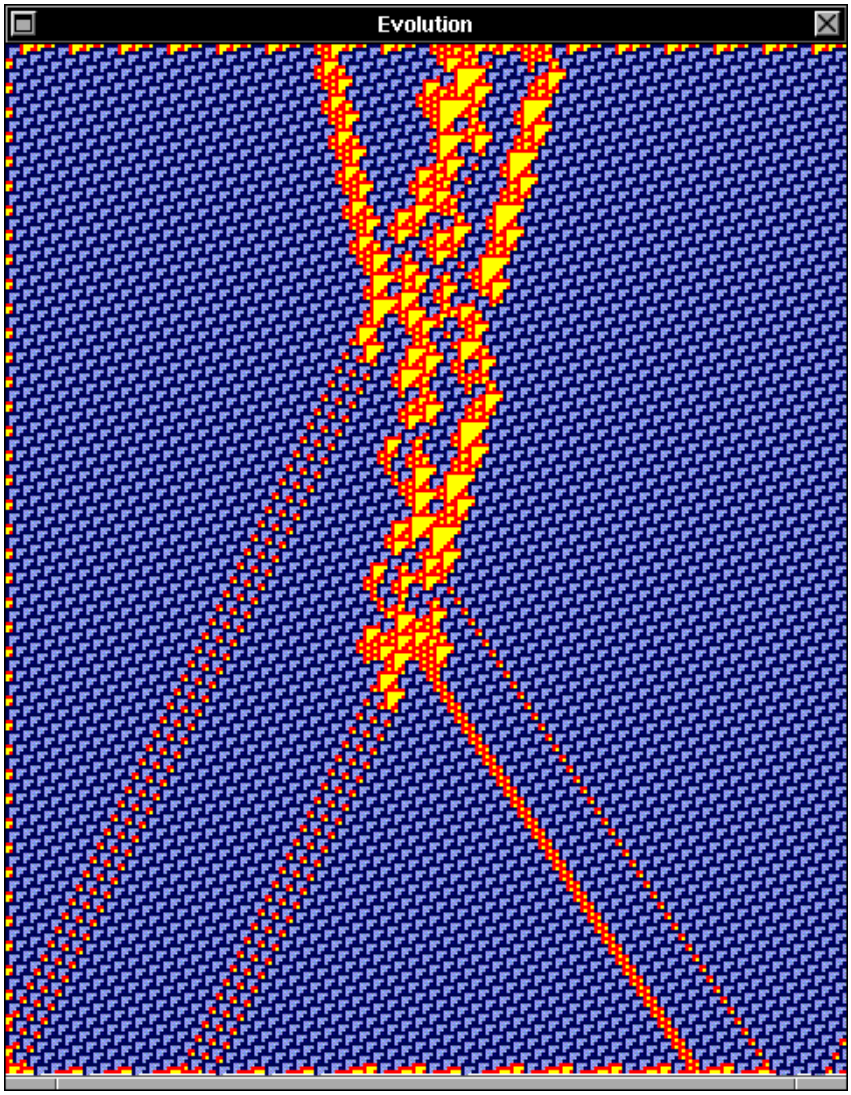

Figure 4.455: continue collision, D2(p1)(C)-e(p1)-H(p1)(E3)=3B,A,3B,3A

4.11 Collisions of glider E

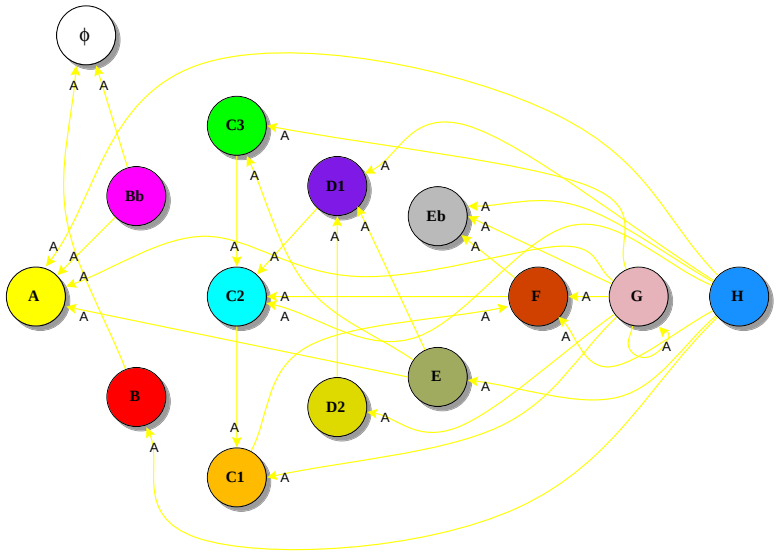

Figure 4.456: Collisions of glider E

	ϕ	A	B	$Bbar$	$C3$	$C2$	$C1$	$D2$	$D1$	E	$Ebar$	F	G	H
ϕ	.	.	.	.	.	.	.	.	.	.	.	.	.	.
A	.	.	.	.	.	.	.	.	.	.	.	.	.	.
B	.	.	.	.	.	.	.	.	.	.	.	.	.	.
$Bbar$	.	.	.	.	.	.	.	.	.	.	.	.	.	.
$C3$	.	.	.	.	.	.	.	.	.	.	.	.	.	.
$C2$	.	.	.	.	.	.	.	.	.	.	.	.	.	.
$C1$	.	.	.	.	.	.	.	.	.	.	.	.	.	.
$D2$	.	.	.	.	.	.	.	.	.	.	.	.	.	.
$D1$	.	.	.	.	.	.	.	.	.	.	.	.	.	.
E	.	.	.	.	.	.	.	.	.	.	.	.	.	.
$Ebar$	.	.	.	.	.	.	.	.	.	.	.	.	.	.
F	.	.	.	.	.	.	.	.	.	.	.	.	.	.
G	.	.	.	.	.	.	.	.	.	.	.	.	.	.
H	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Table 4.10: Matrix connection of collisions glider E

4.11.1 Collisions of glider E with glider F

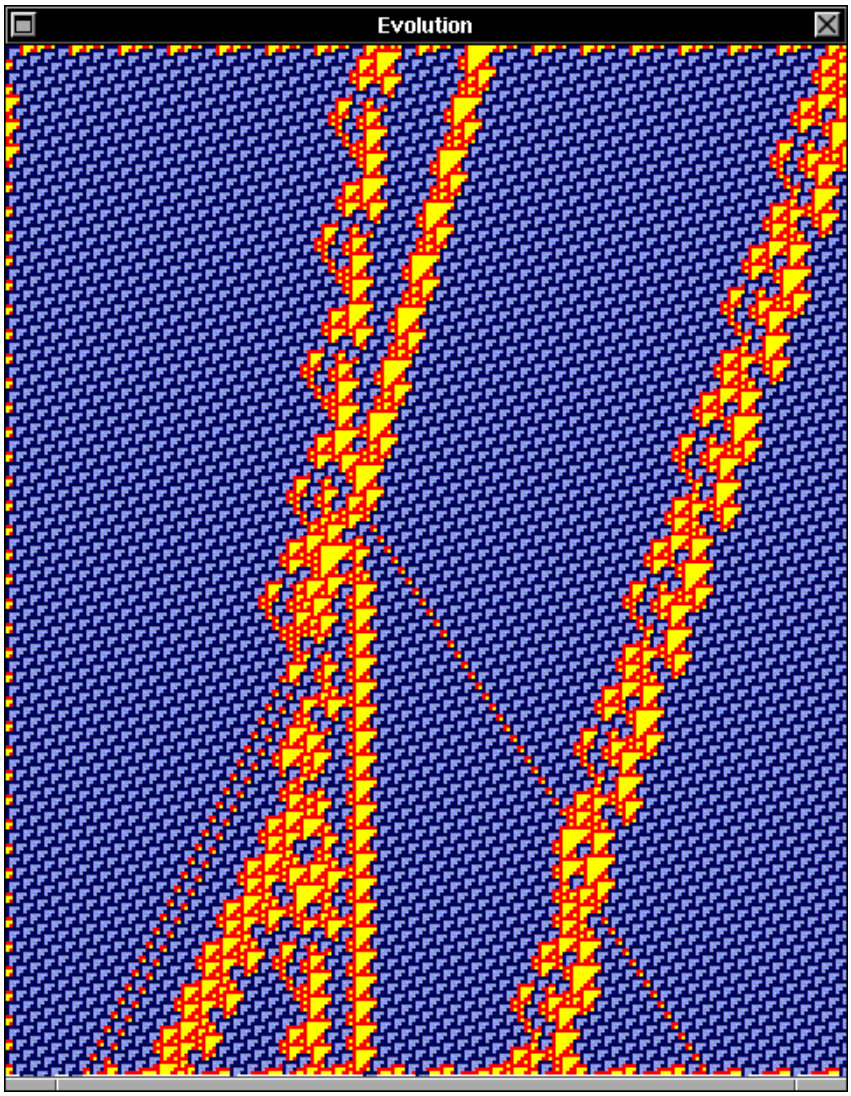

Figure 4.457: Collisions of glider E, F(p1)(A)-e(p1)-E(p1)(A)=A,C2,2B,Bbar,F

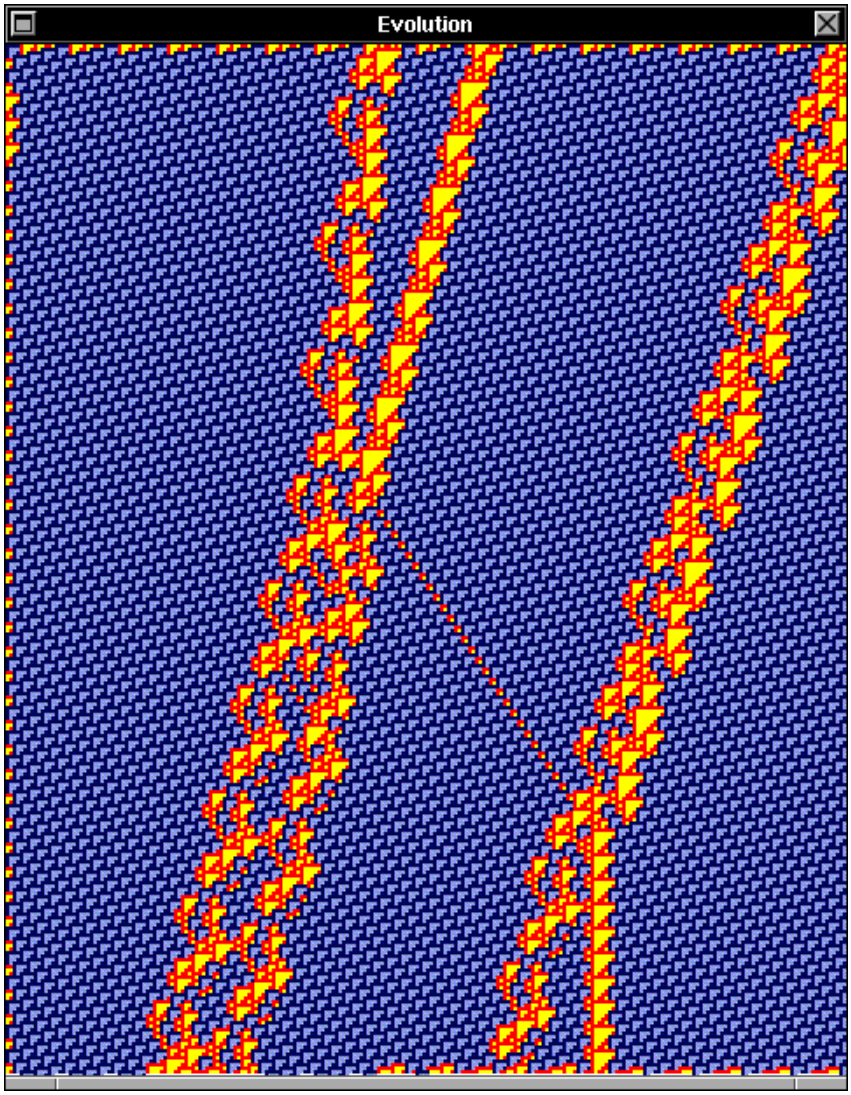

Figure 4.458: Collisions of glider E, F(p1)(A)-e(p1)-E(p1)(B)=A,2Ebar

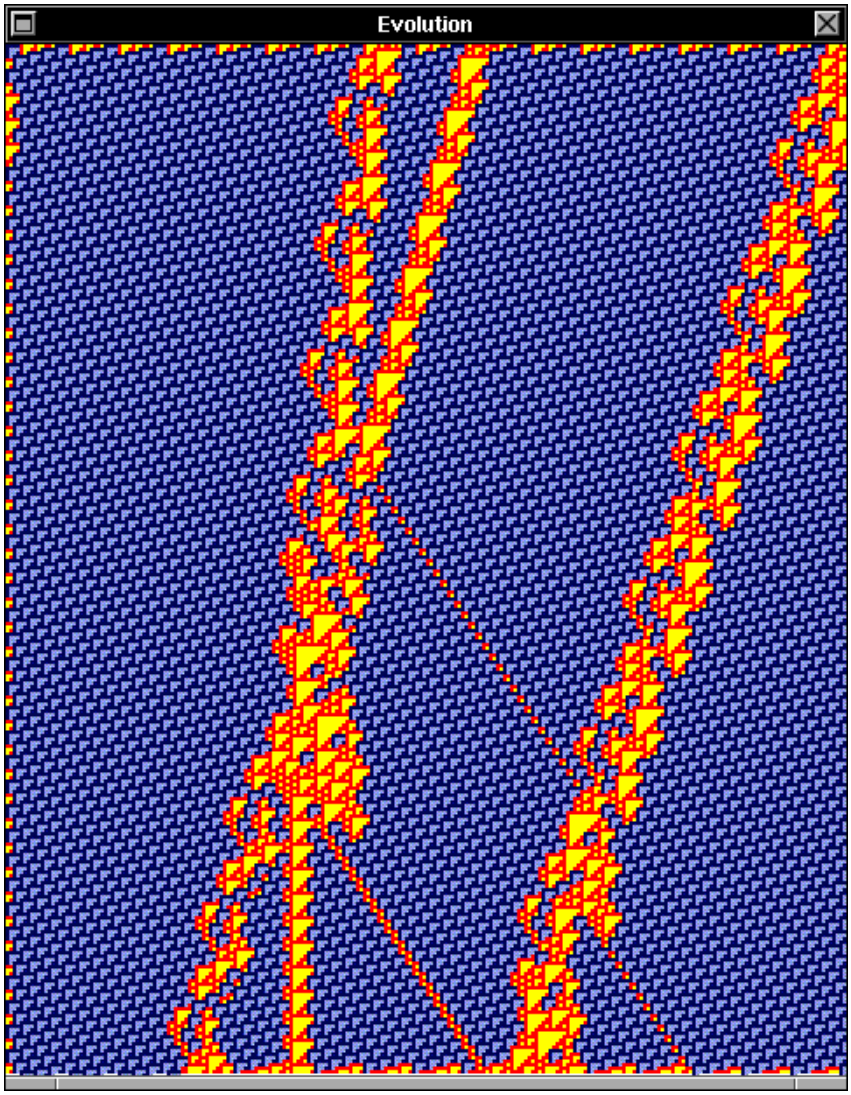

Figure 4.459: Collisions of glider E, F(p1)(A)-e(p1)-E(p1)(D)=A,Ebar,C1,2A

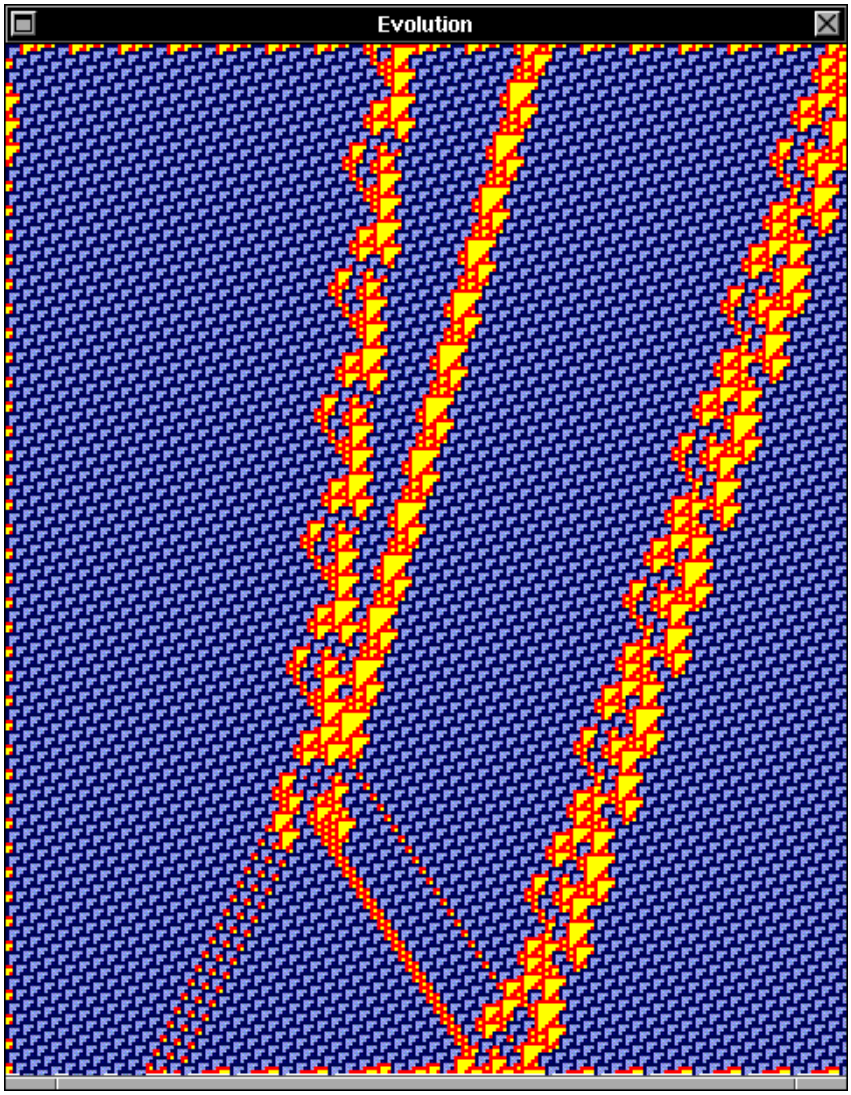

Figure 4.460: Collisions of glider E, F(p1)(G)-e(p1)-E(p1)(B)=A,3B,3A

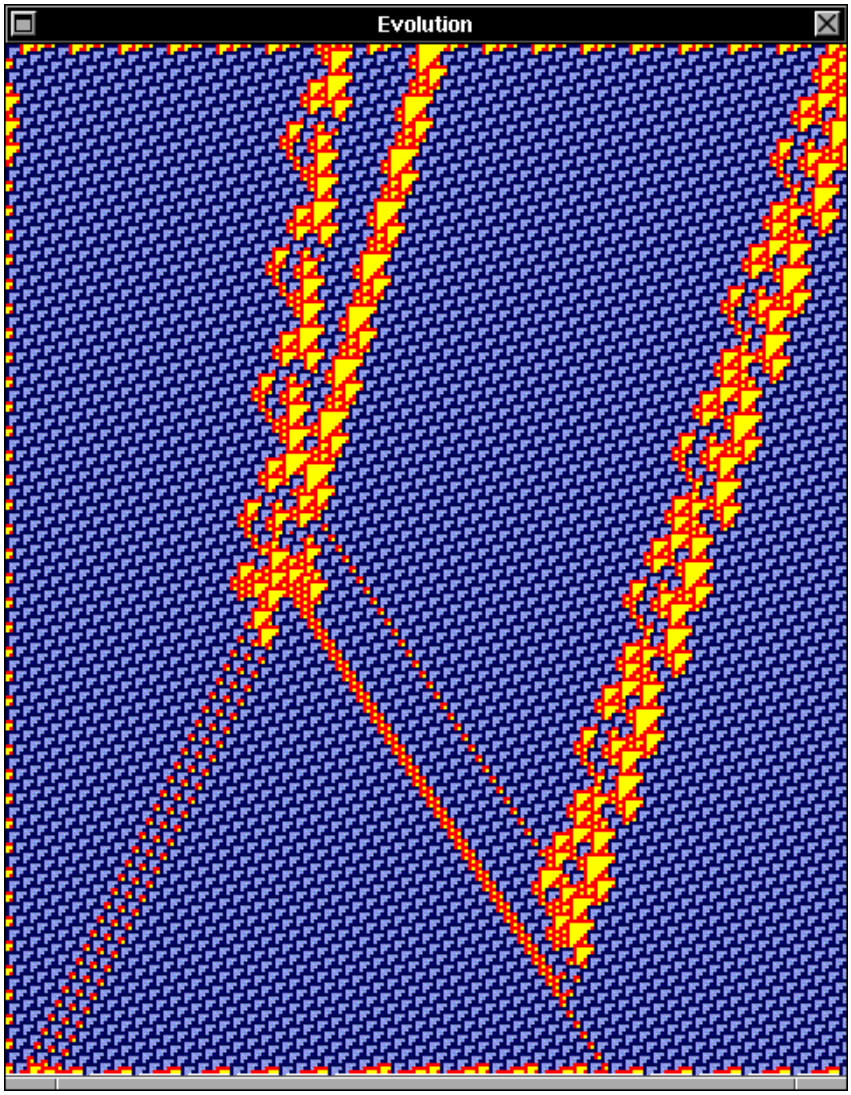

Figure 4.461: Collisions of glider E, F(p1)(A2)-e(p1)-E(p1)(A)=A,3B,3A

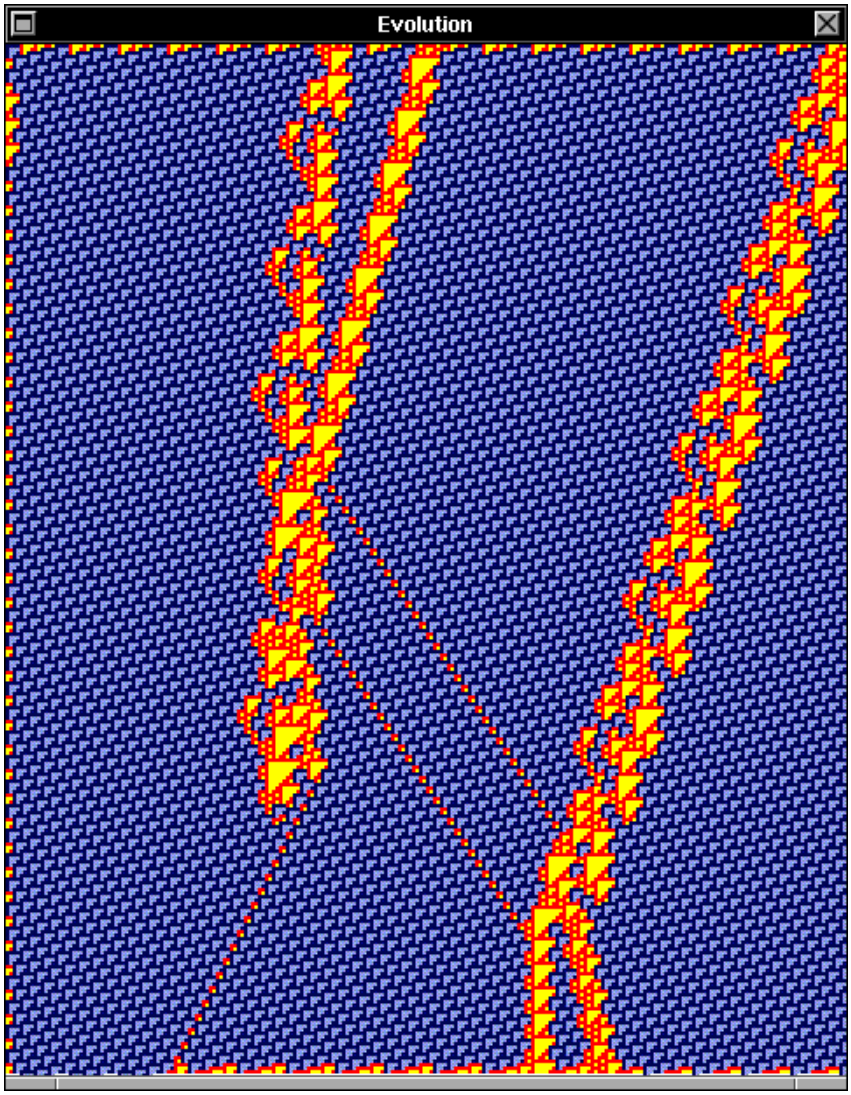

Figure 4.462: Collisions of glider E, F(p1)(A2)-e(p1)-E(p1)(D)=A,A,B

4.11.2 Collisions of glider E with glider G

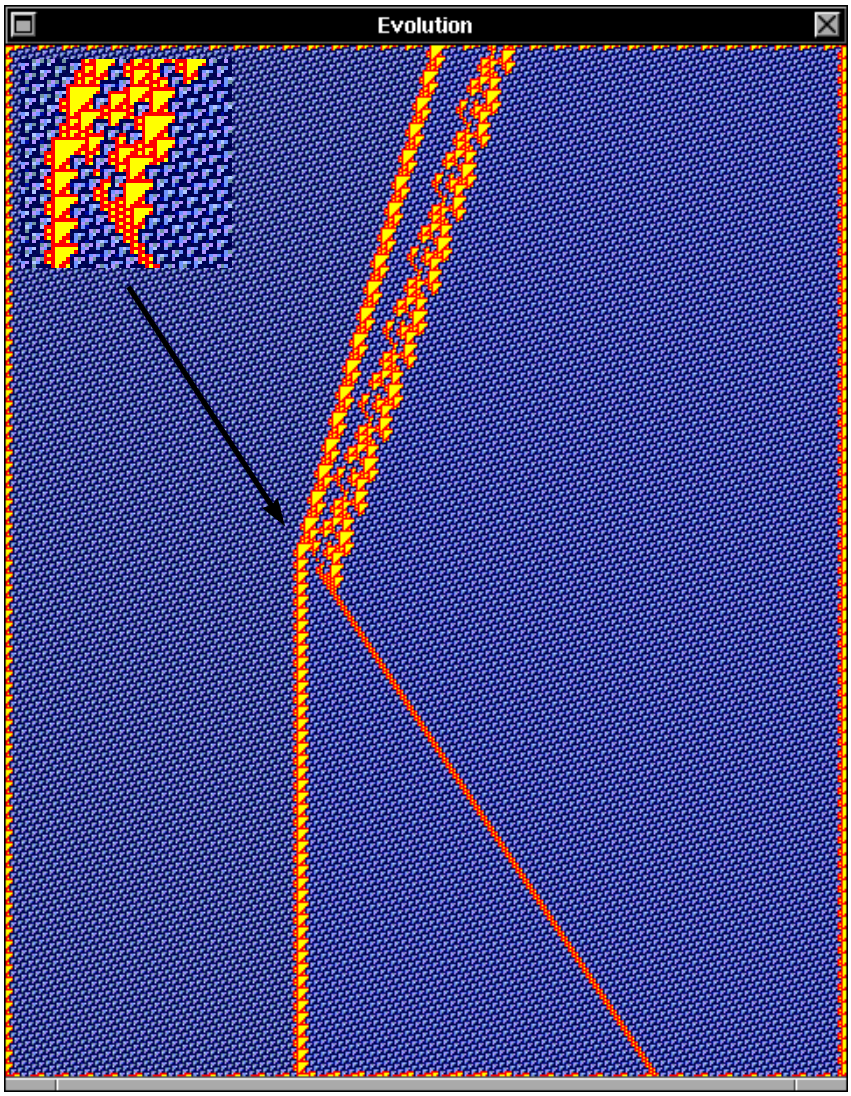

Figure 4.463: Collisions of glider E, E(p1)(A)-e(p1)-G(p1)(A)=C3,3A

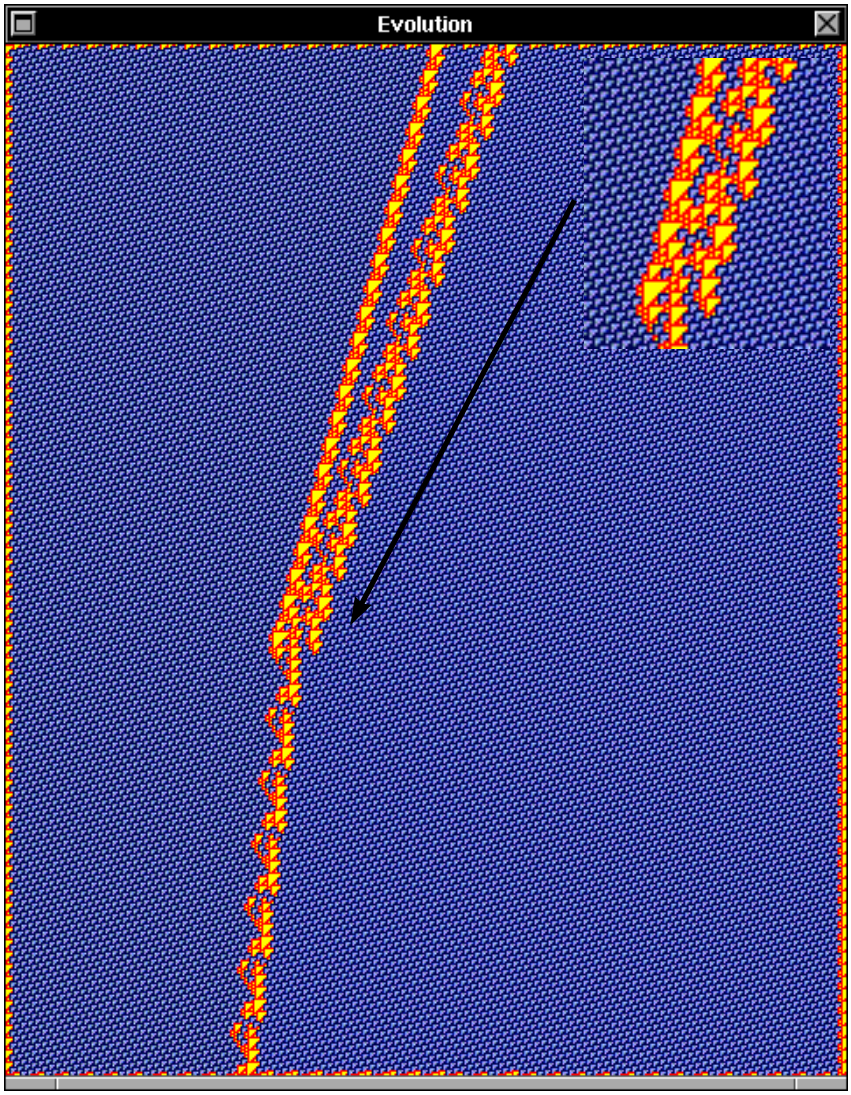

Figure 4.464: Collisions of glider E, E(p1)(A)-e(p1)-G(p1)(B)=F

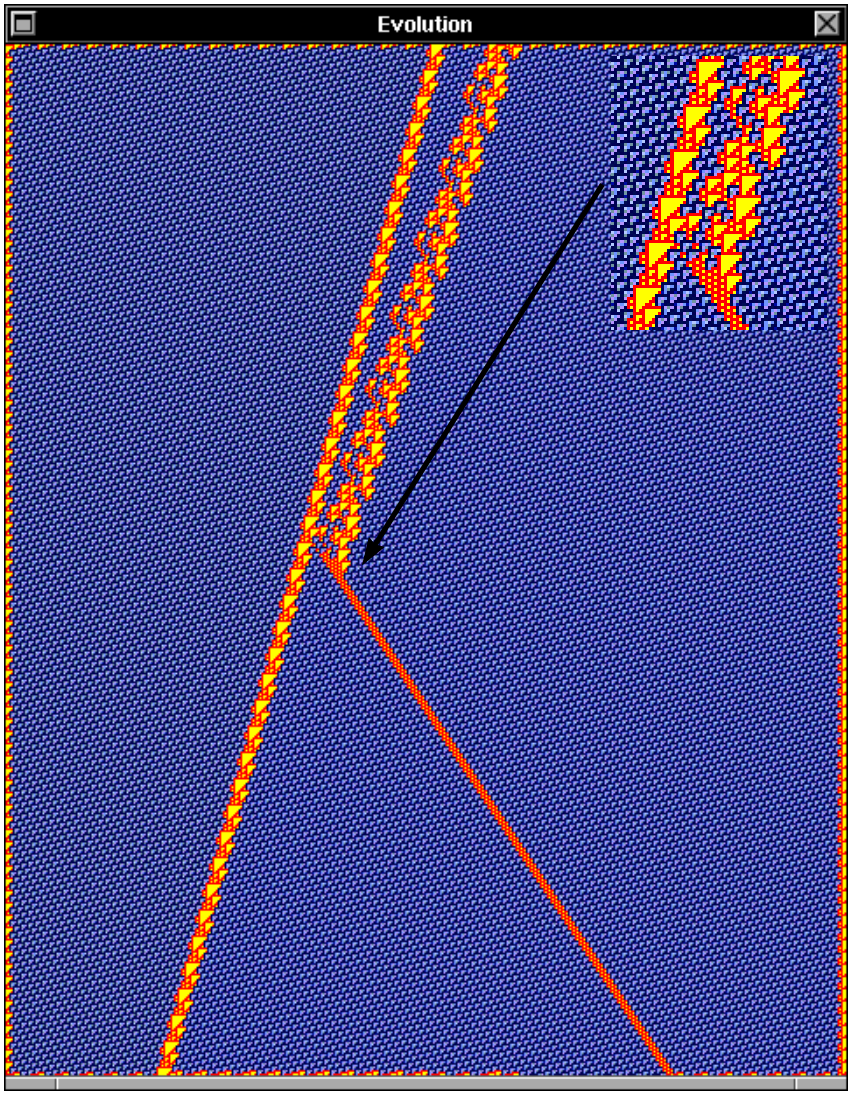

Figure 4.465: Collisions of glider E, E(p1)(A)-e(p1)-G(p1)(C)=E,4A

4.11.3 Collisions of glider E with glider H

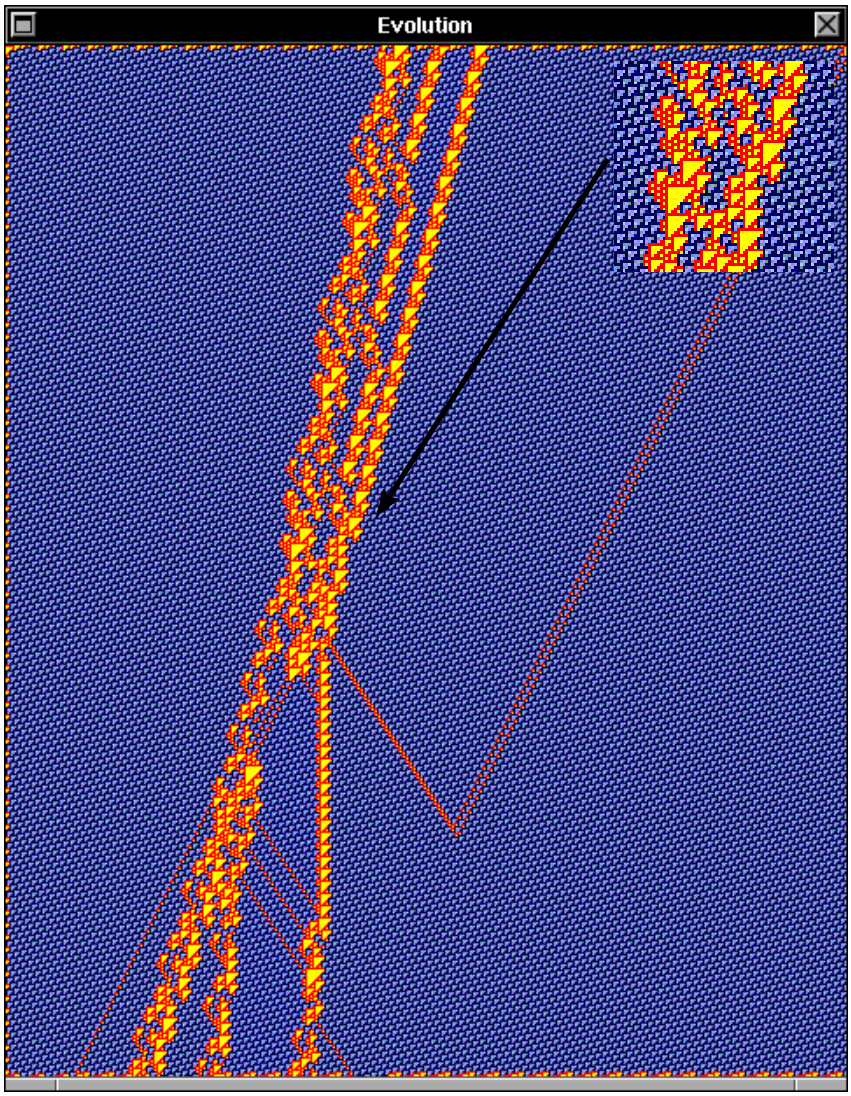

Figure 4.466: Collisions of glider E, H(p1)(A)-E(p1)(A)=2A,B,A,G3,A,3A,3B

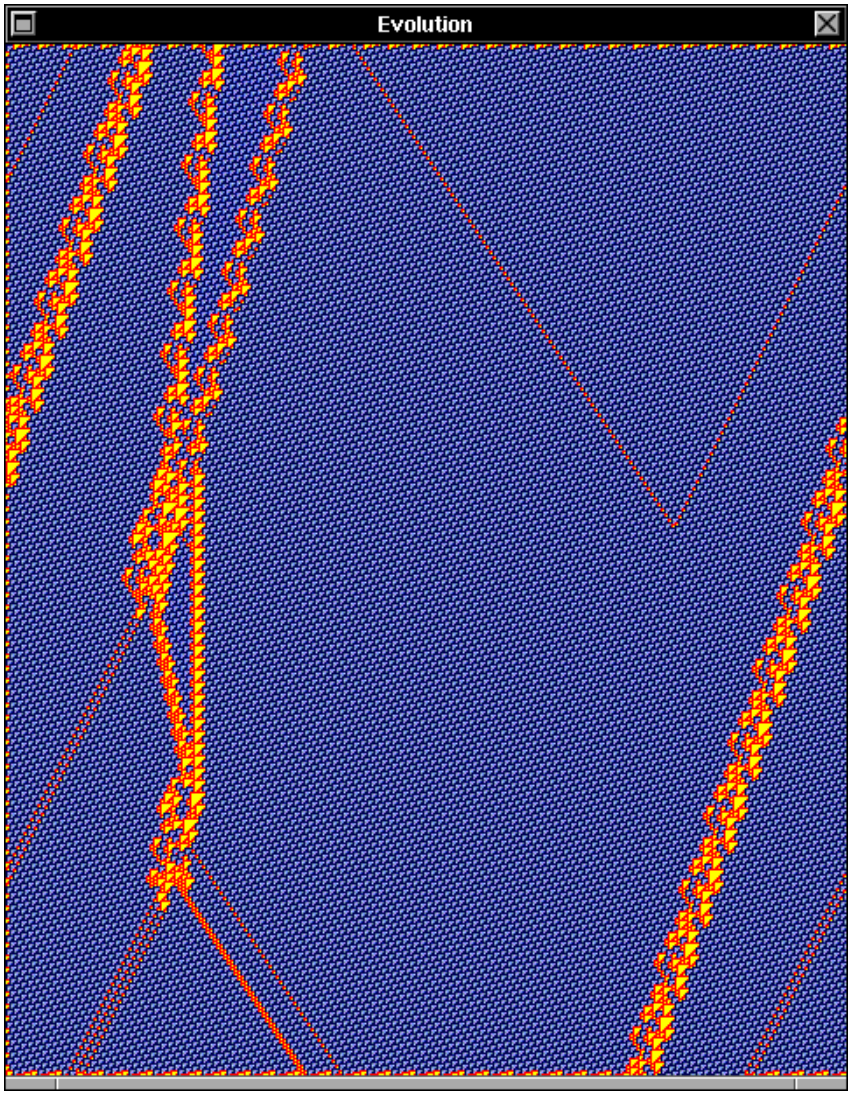

Figure 4.467: continue collision, H(p1)(A)-E(p1)(A)

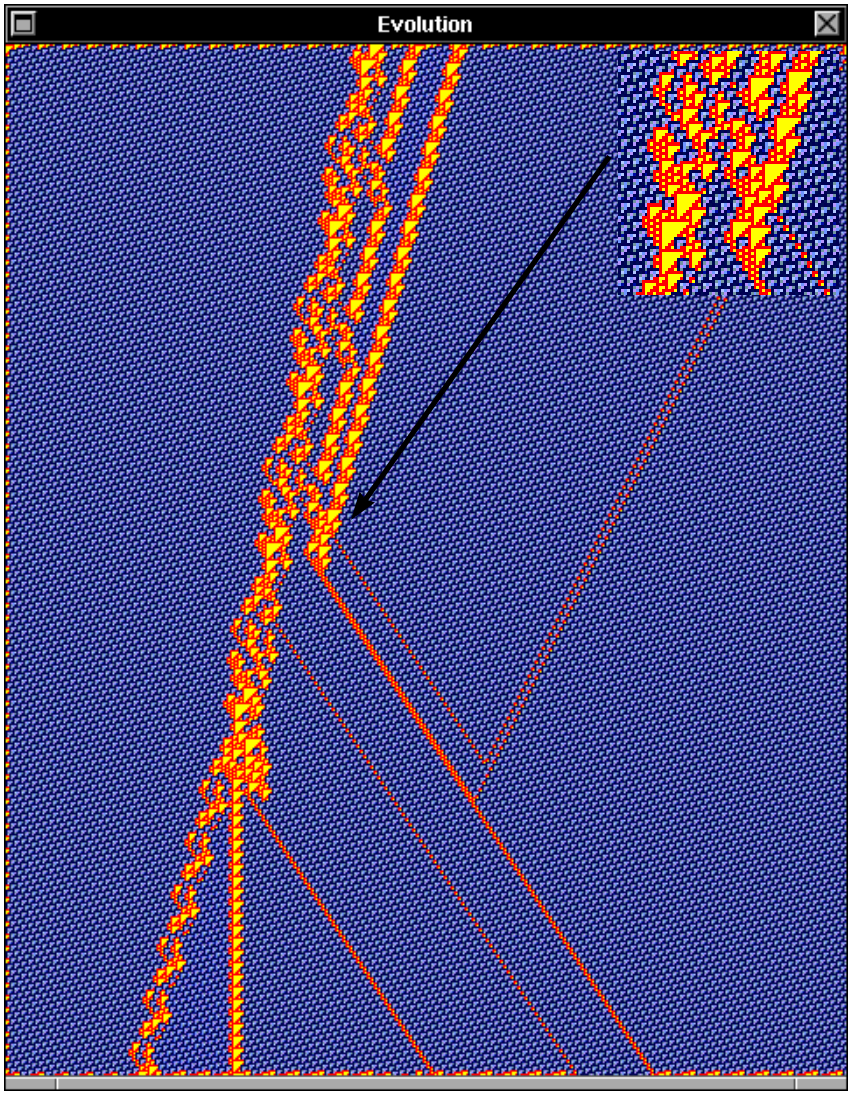

Figure 4.468: Collisions of glider E, H(p1)(A)-E(p1)(B)=A,3A,A,Ebar,C1,2A

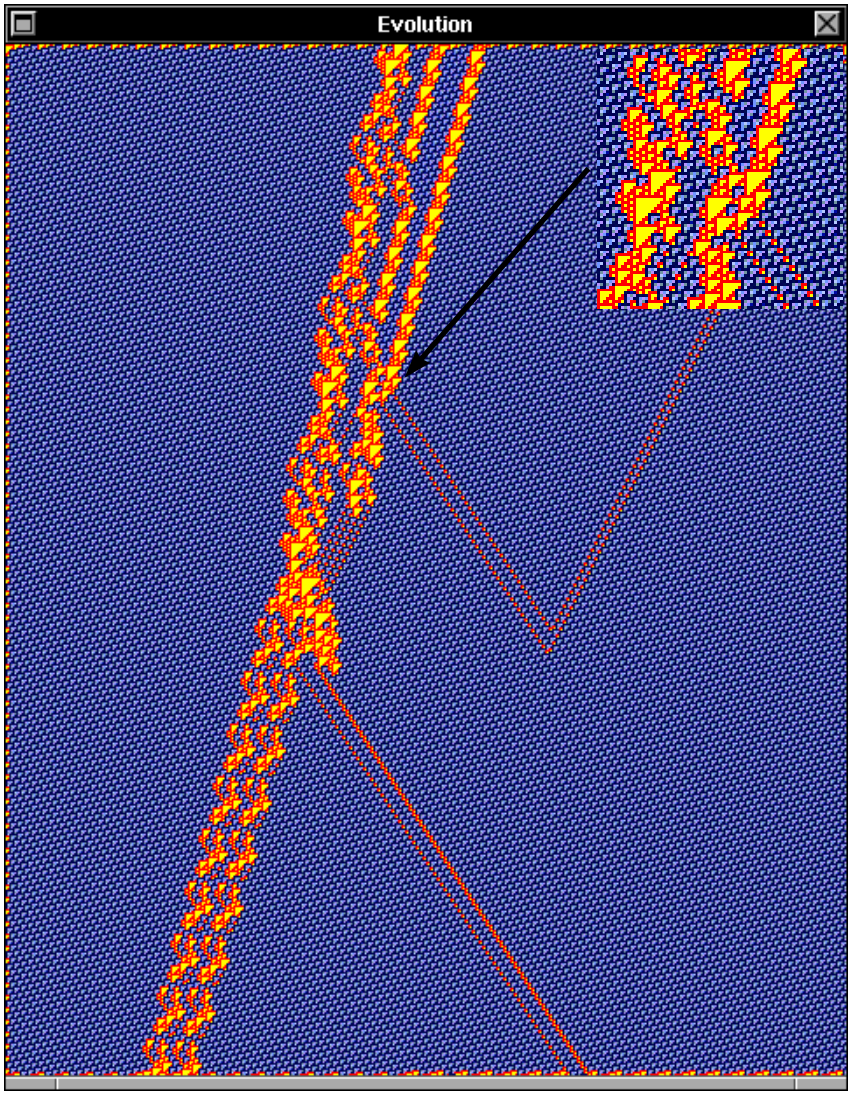

Figure 4.469: Collisions of glider E, H(p1)(A)-E(p1)(D)=A,A,Ebar,Ebar,A,2A

4.12 Collisions of glider Ebar

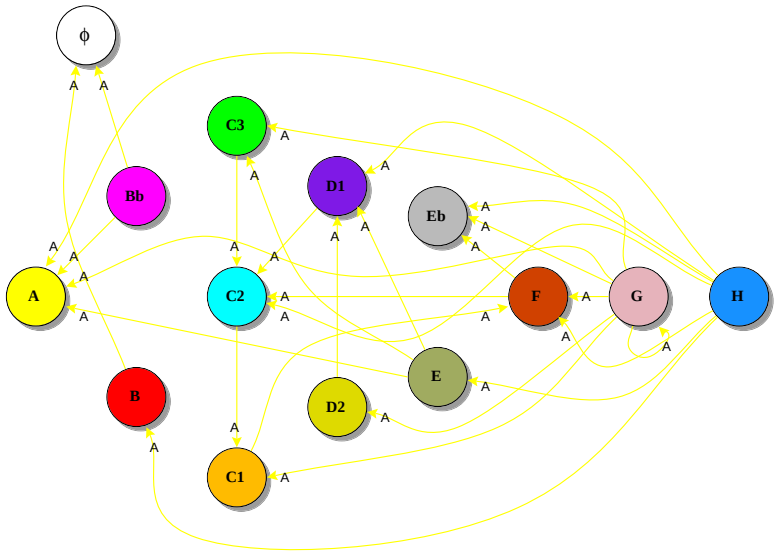

Figure 4.470: Collisions of glider Ebar

	ϕ	A	B	$Bbar$	$C3$	$C2$	$C1$	$D2$	$D1$	E	$Ebar$	F	G	H
ϕ	.	.	.	.	.	.	.	.	.	.	.	.	.	.
A	.	.	.	.	.	.	.	.	.	.	.	.	.	.
B	.	.	.	.	.	.	.	.	.	.	.	.	.	.
$Bbar$	.	.	.	.	.	.	.	.	.	.	.	.	.	.
$C3$	.	.	.	.	.	.	.	.	.	.	.	.	.	.
$C2$	.	.	.	.	.	.	.	.	.	.	.	.	.	.
$C1$	.	.	.	.	.	.	.	.	.	.	.	.	.	.
$D2$	.	.	.	.	.	.	.	.	.	.	.	.	.	.
$D1$	.	.	.	.	.	.	.	.	.	.	.	.	.	.
E	.	.	.	.	.	.	.	.	.	.	.	.	.	.
$Ebar$	.	.	.	.	.	.	.	.	.	.	.	.	.	.
F	.	.	.	.	.	.	.	.	.	.	.	.	.	.
G	.	.	.	.	.	.	.	.	.	.	.	.	.	.
H	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Table 4.11: Matrix connection of collisions glider Ebar

4.12.1 Collisions of glider Ebar with glider F

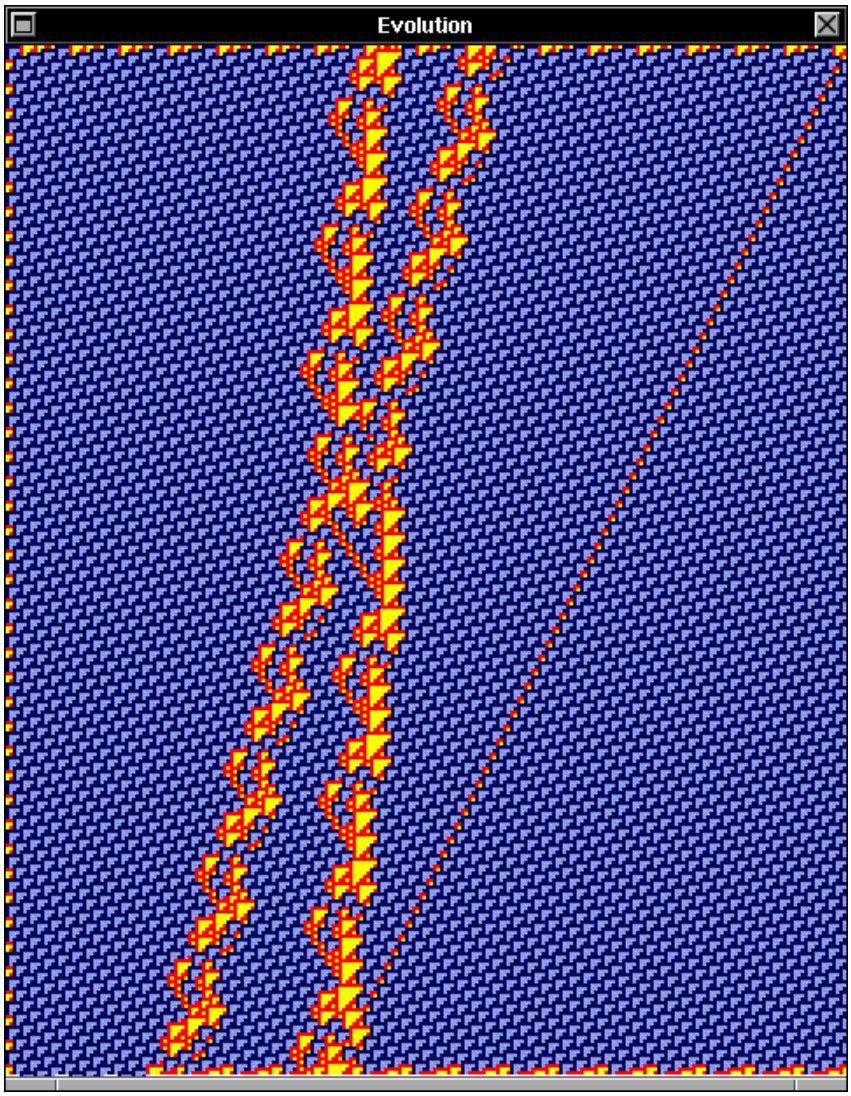

Figure 4.471: Collisions of glider Ebar, F(p1)(A)-e(p1)-Ebar(p1)(A)=Ebar,F; across

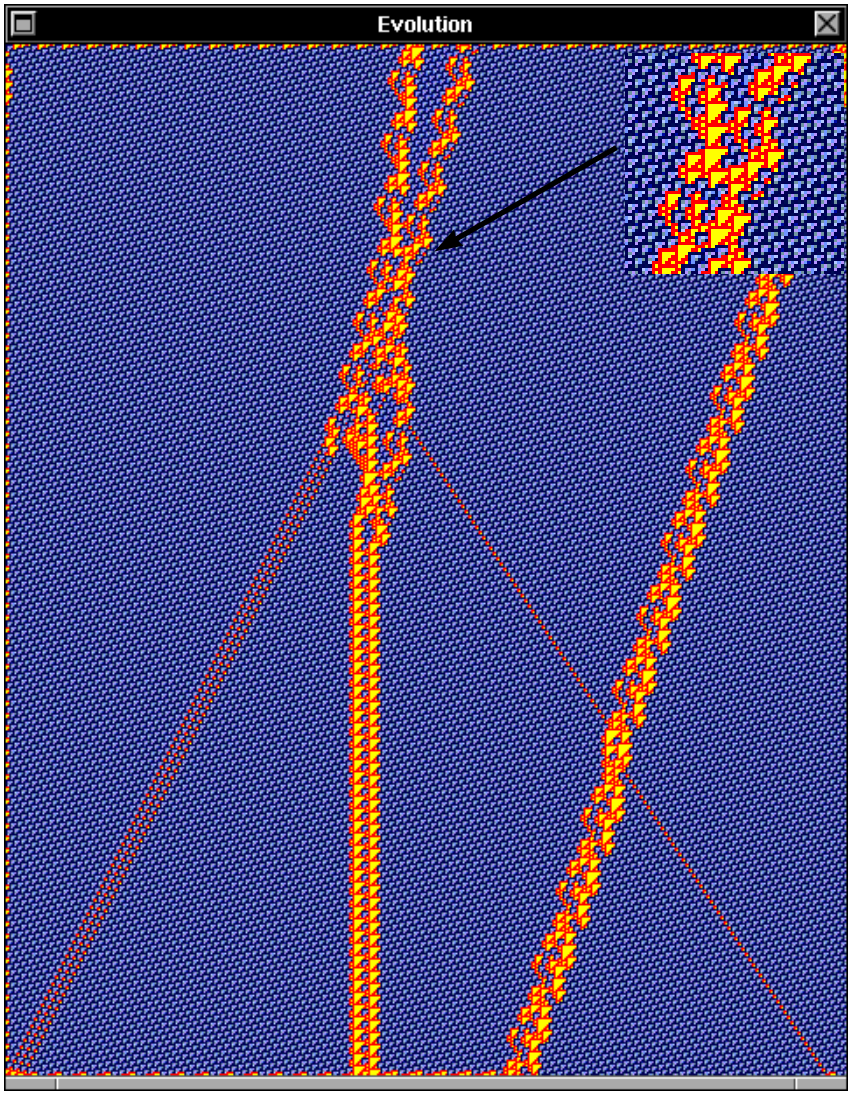

Figure 4.472: Collisions of glider Ebar, F(p1)(A)-e(p1)-Ebar(p1)(B)=3B,A,2C2

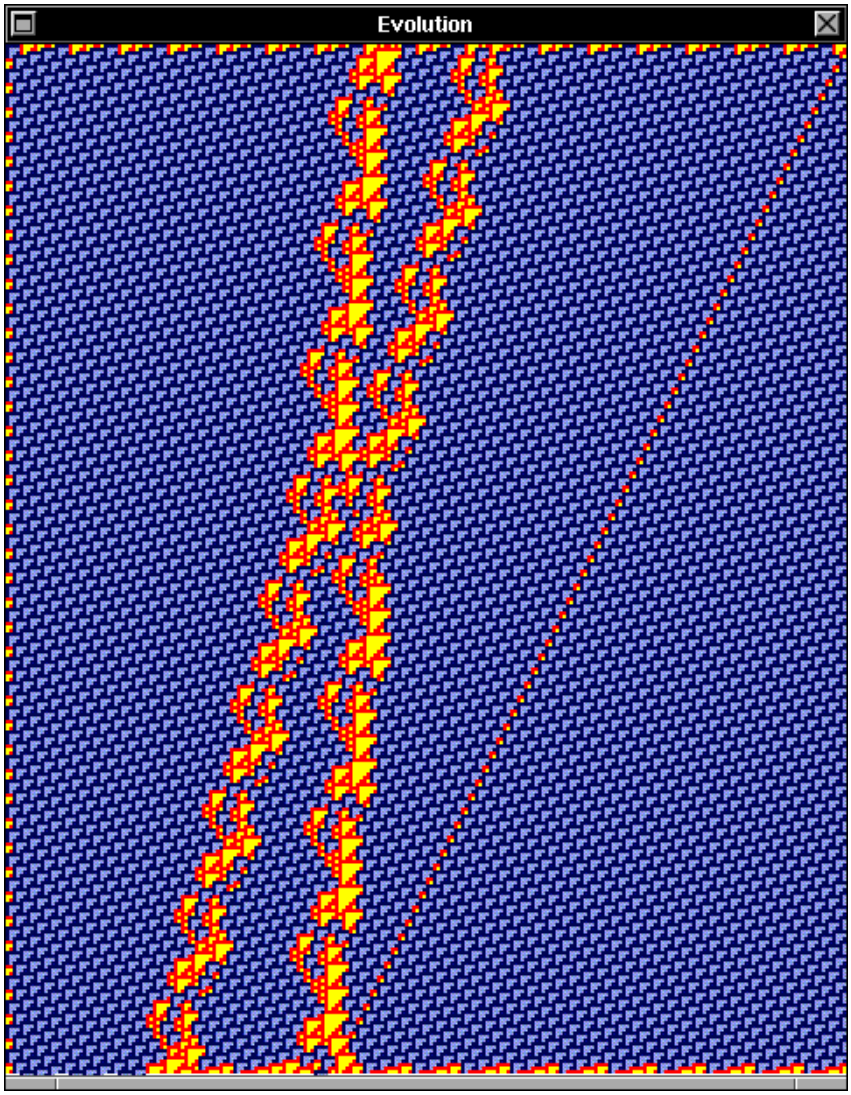

Figure 4.473: Collisions of glider Ebar, F(p1)(A)-e(p1)-Ebar(p1)(C)=Ebar,F; across

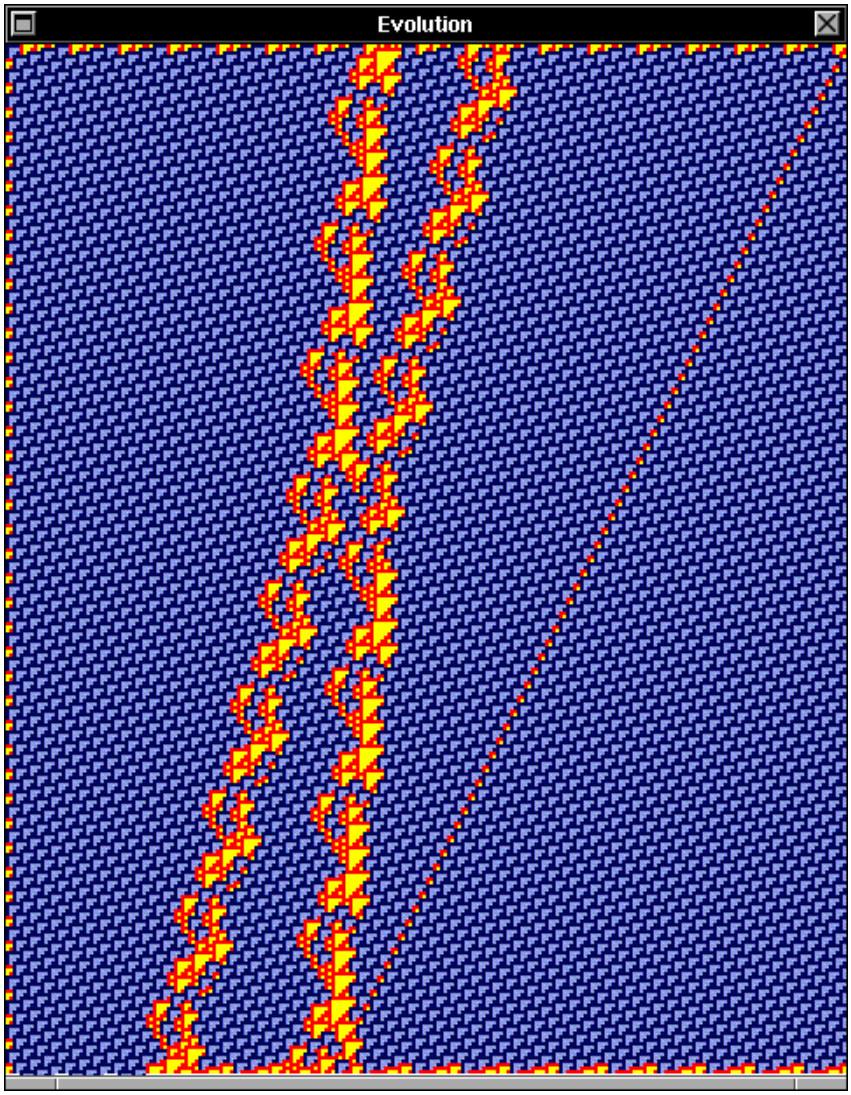

Figure 4.474: Collisions of glider Ebar, F(p1)(A)-e(p1)-Ebar(p1)(D)=Ebar,F; across

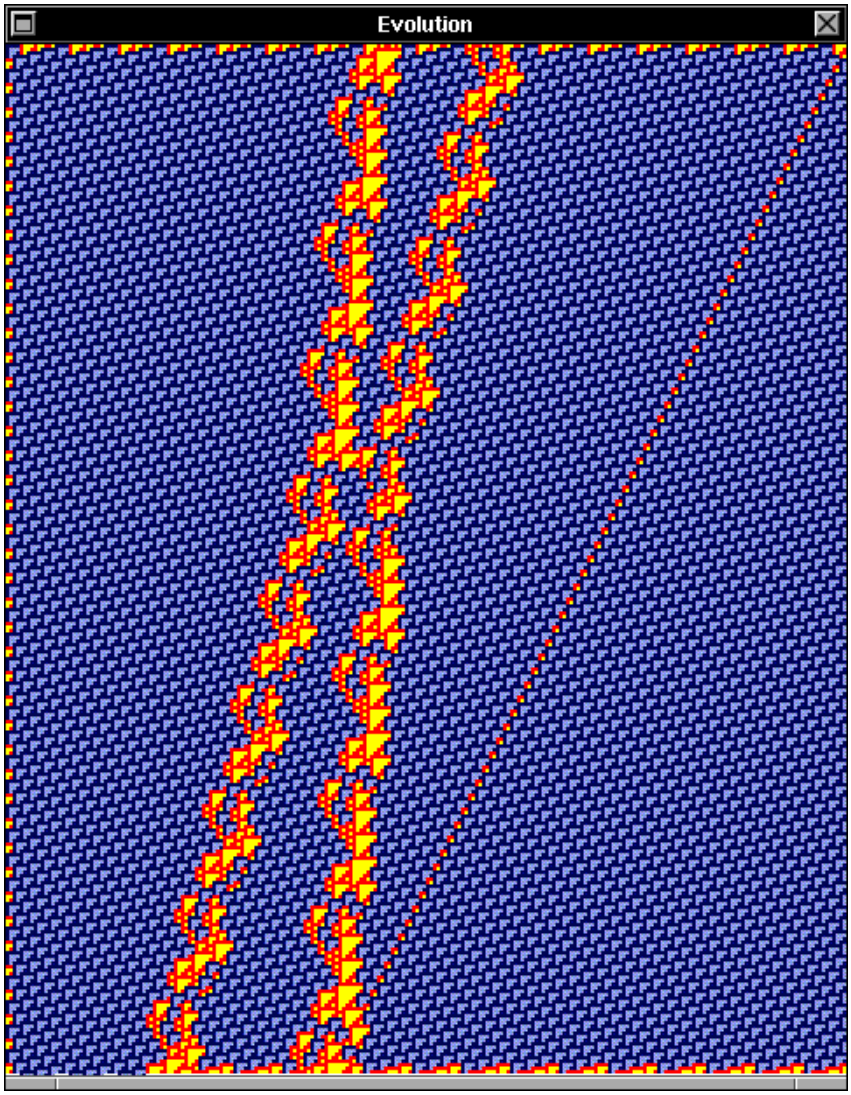

Figure 4.475: Collisions of glider Ebar, F(p1)(A)-e(p1)-Ebar(p1)(E)=Ebar,F; across

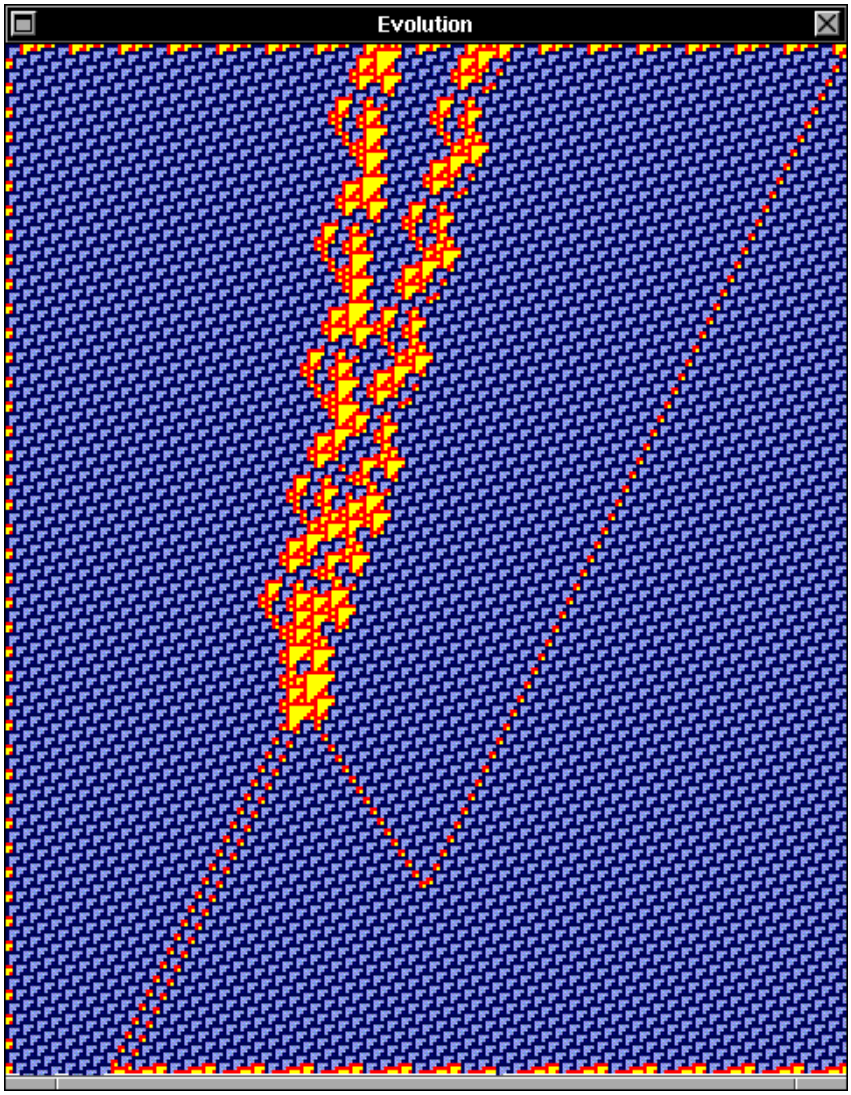

Figure 4.476: Collisions of glider Ebar, F(p1)(A)-e(p1)-Ebar(p1)(H)=2B,A

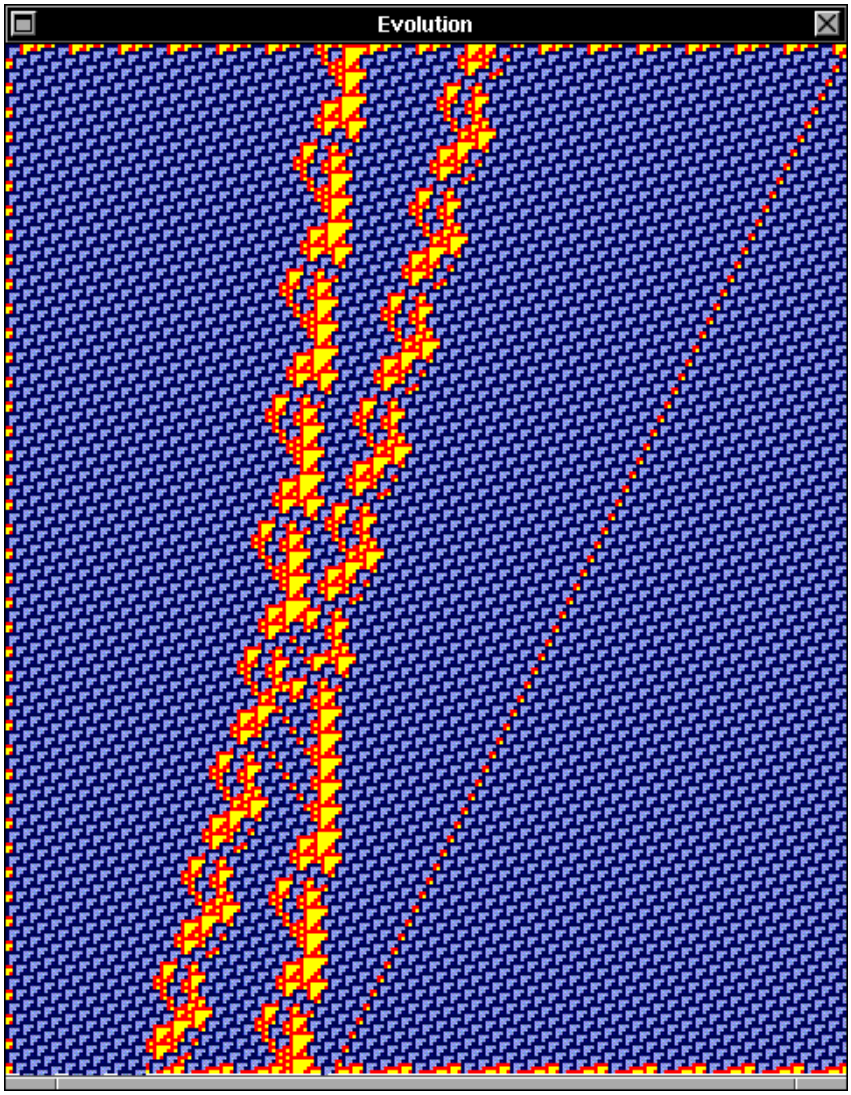

Figure 4.477: Collisions of glider Ebar, F(p1)(G)-e(p1)-Ebar(p1)(A)=Ebar,F; across

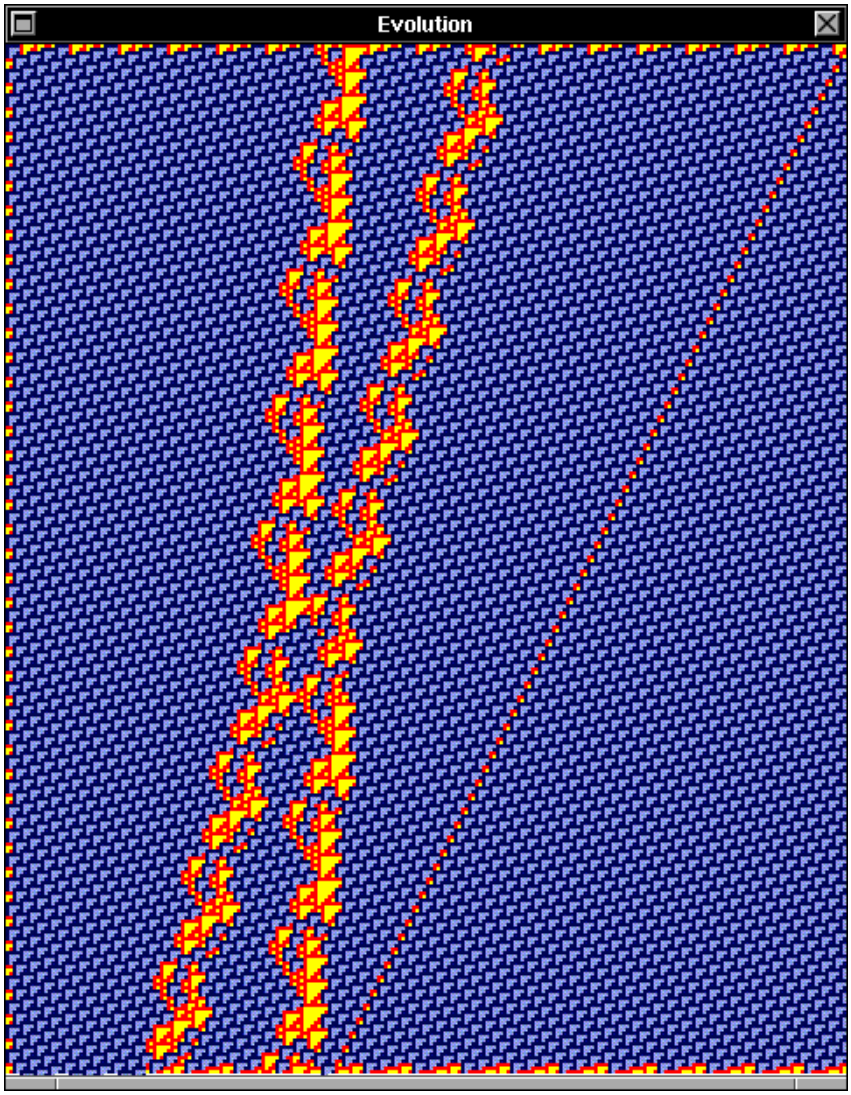

Figure 4.478: Collisions of glider Ebar, F(p1)(G)-e(p1)-Ebar(p1)(B)=Ebar,F; across

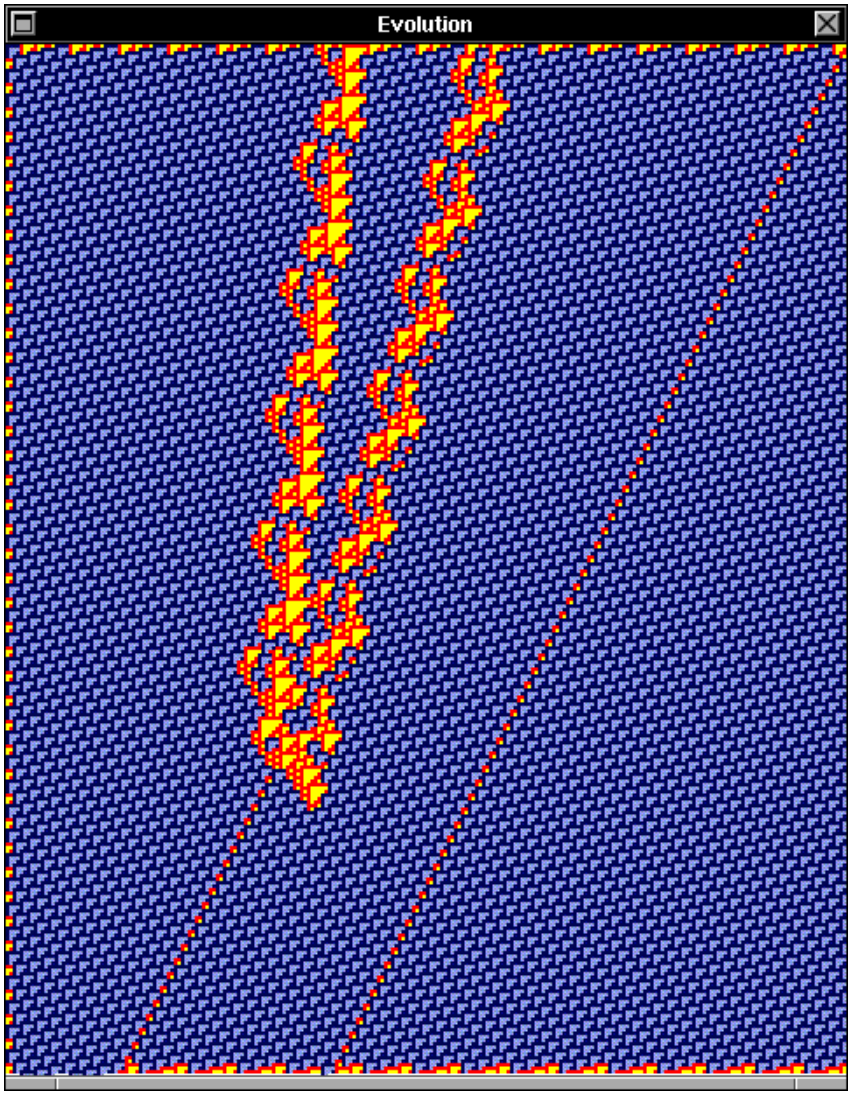

Figure 4.479: Collisions of glider Ebar, F(p1)(G)-e(p1)-Ebar(p1)(C)=B

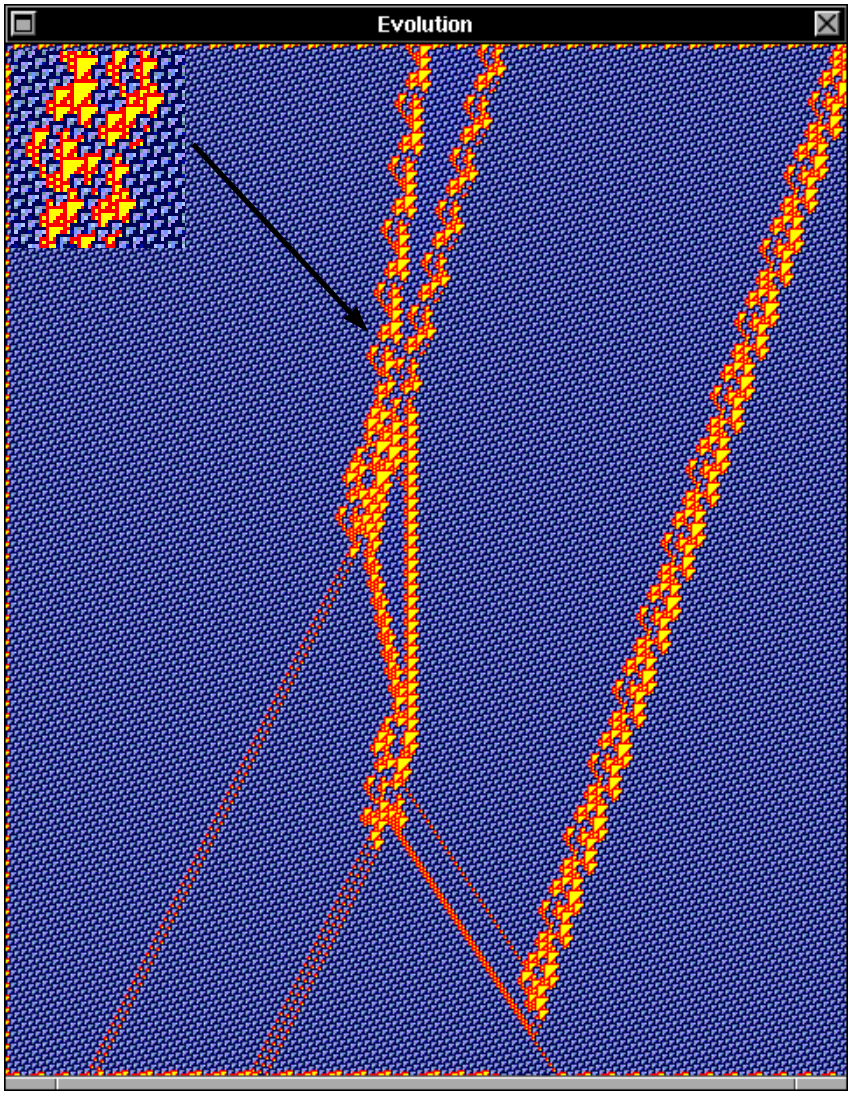

Figure 4.480: Collisions of glider Ebar, F(p1)(G)-e(p1)-Ebar(p1)(D)=2B,A,3B,3A

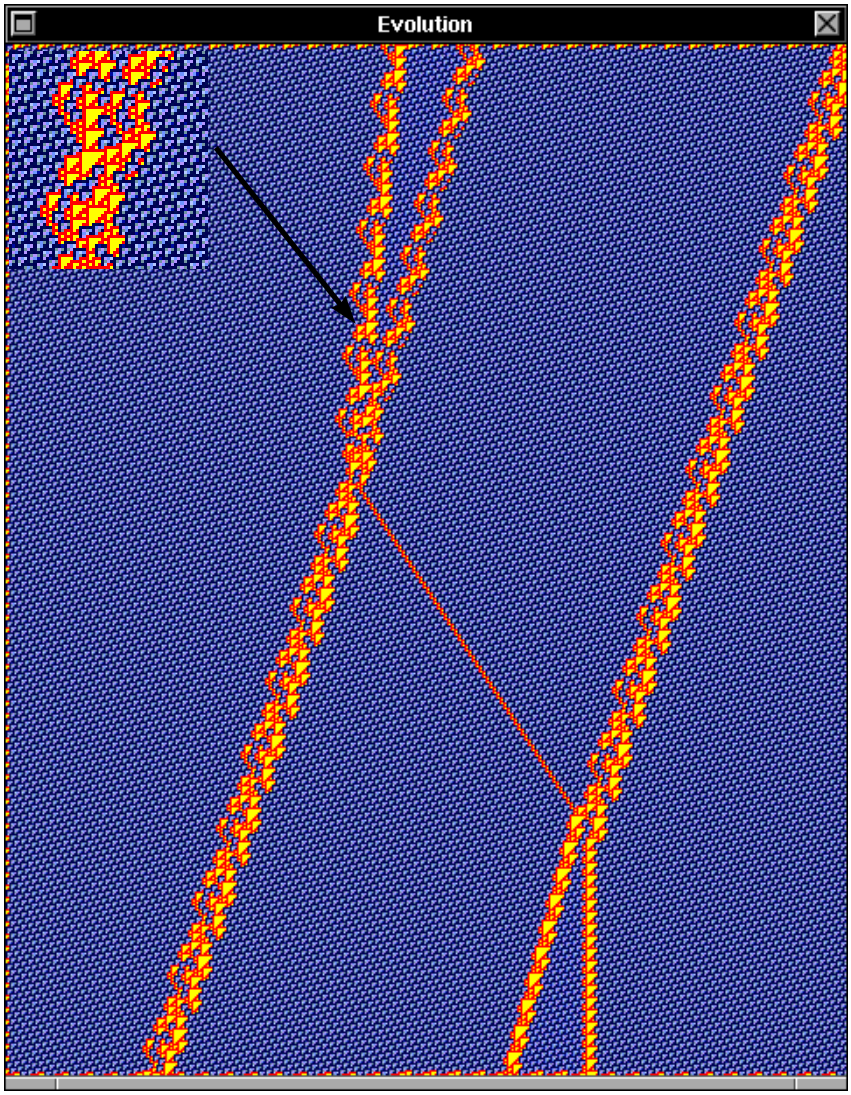

Figure 4.481: Collisions of glider Ebar, F(p1)(G)-e(p1)-Ebar(p1)(E)=G,2A

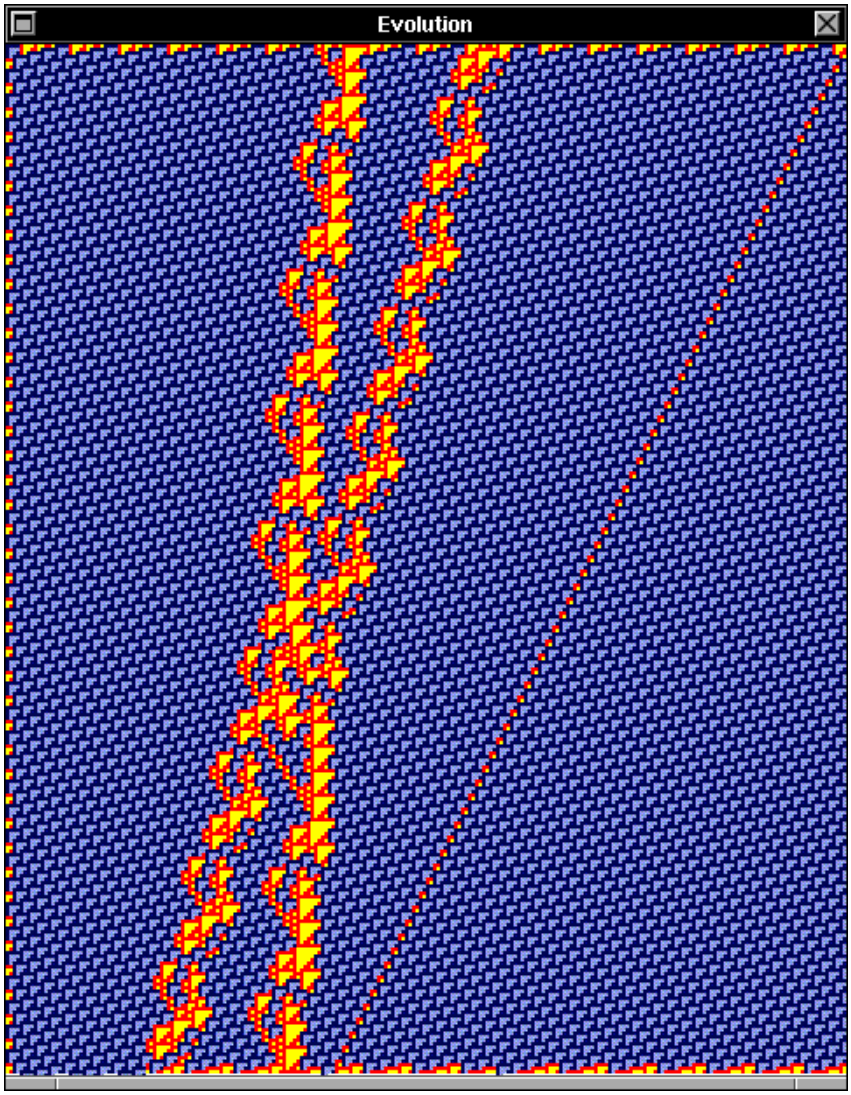

Figure 4.482: Collisions of glider Ebar, F(p1)(G)-e(p1)-Ebar(p1)(H)=Ebar,F; across

4.12.2 Collisions of glider Ebar with glider G

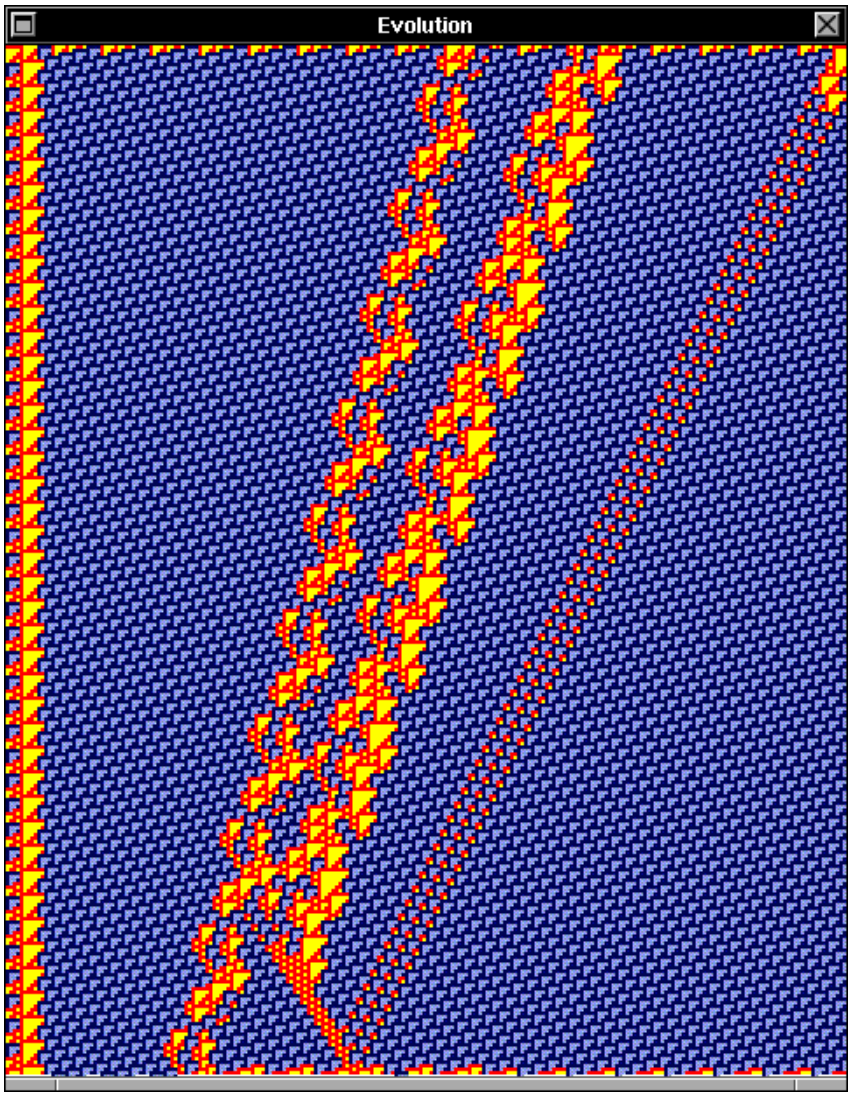

Figure 4.483: Collisions of glider Ebar, Ebar(p1)(A)-e(p1)-G(p1)(A)=Ebar,4A

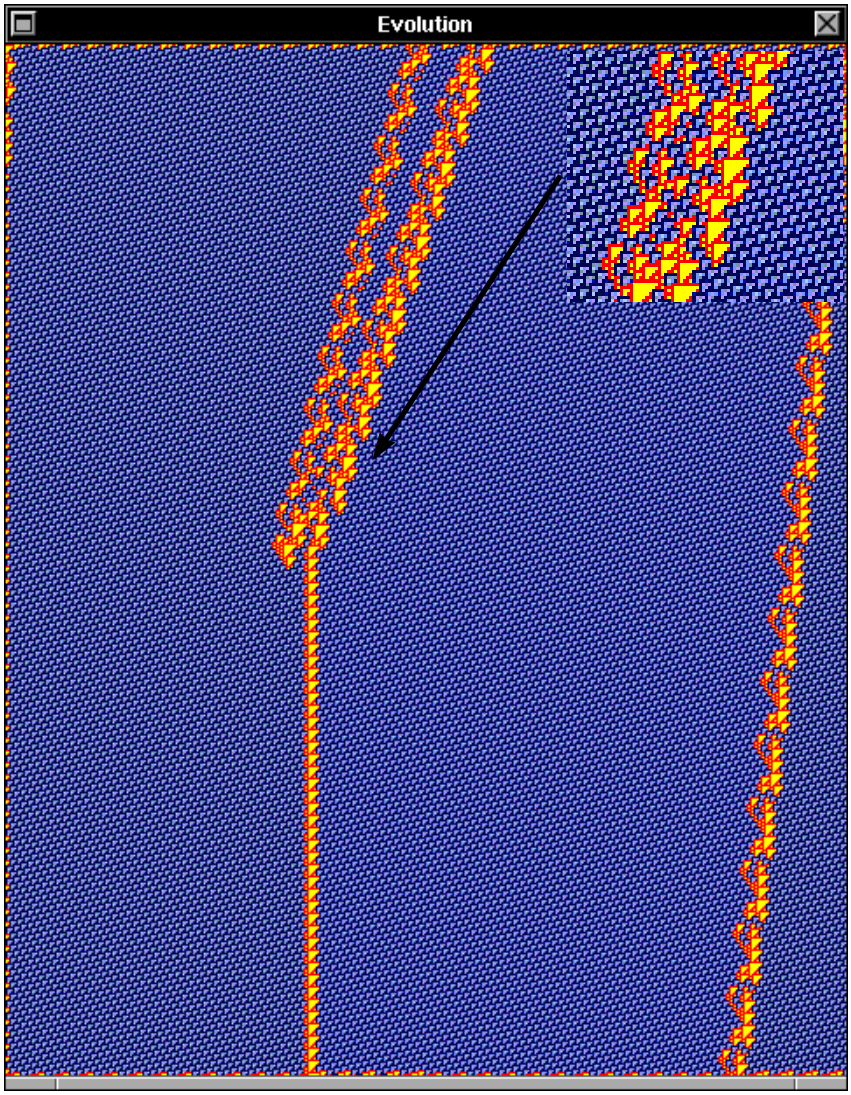

Figure 4.484: Collisions of glider Ebar, Ebar(p1)(F)-e(p1)-G(p1)(A)=C2

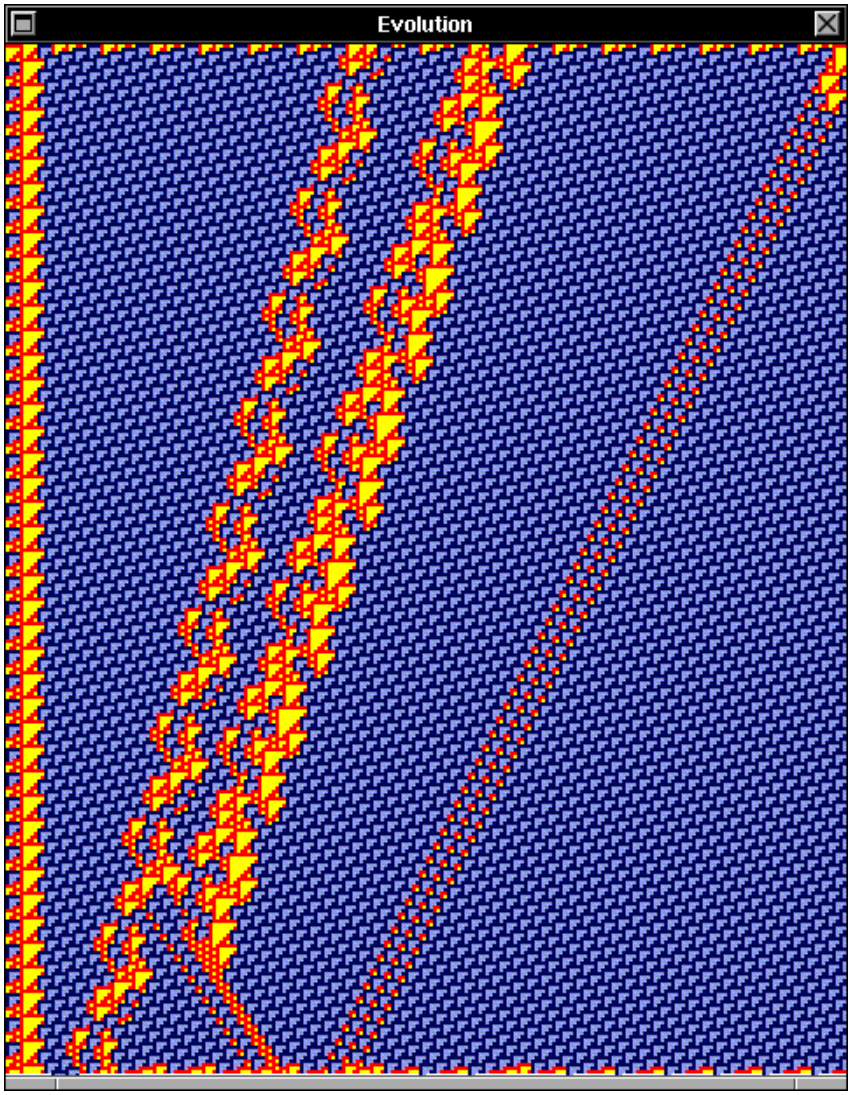

Figure 4.485: Collisions of glider Ebar, Ebar(p1)(A)-e(p1)-G(p1)(B)=Ebar,A,3A

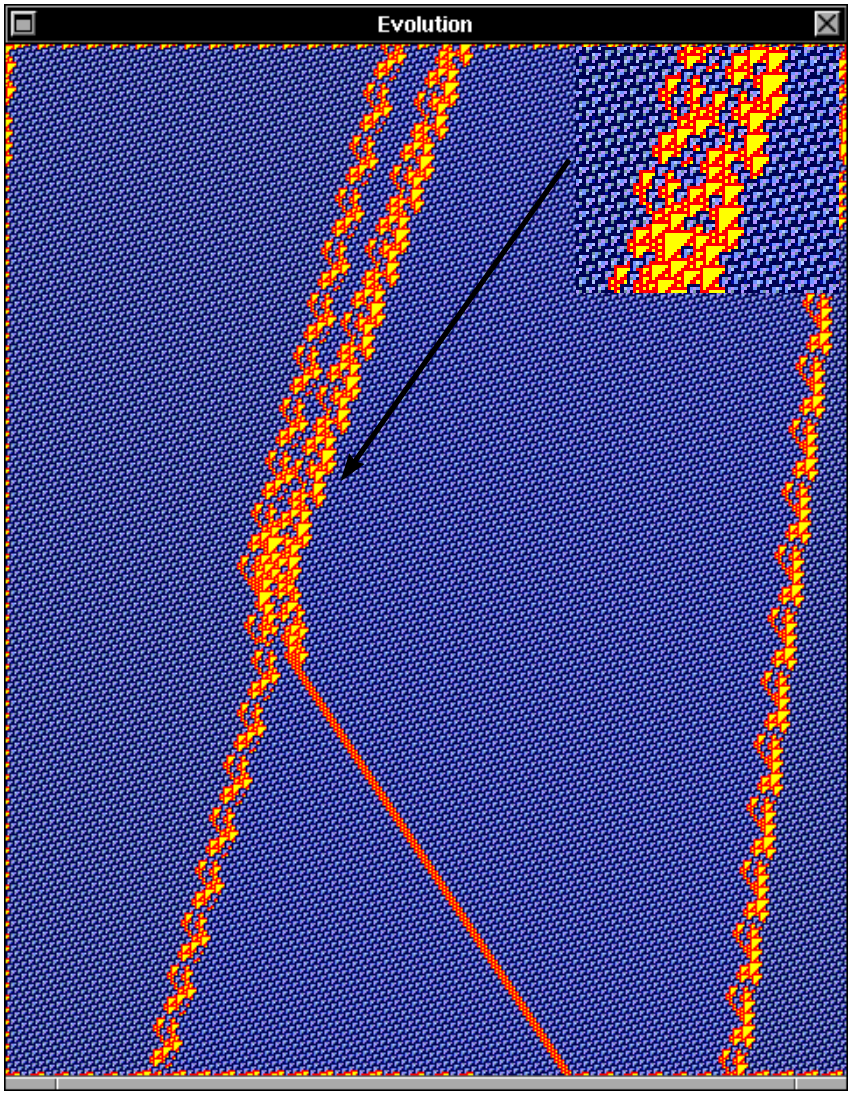

Figure 4.486: Collisions of glider Ebar, Ebar(p1)(F)-e(p1)-G(p1)(B)=Ebar,4A

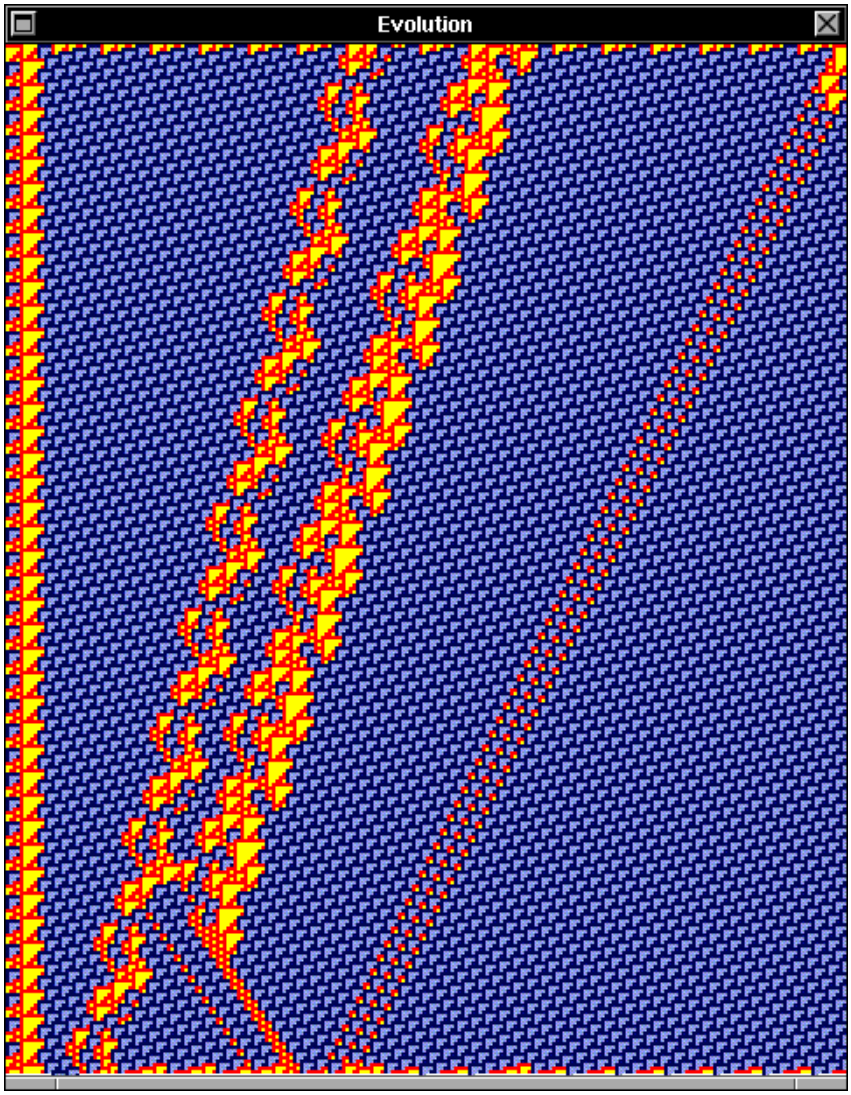

Figure 4.487: Collisions of glider Ebar, Ebar(p1)(A)-e(p1)-G(p1)(C)=Ebar,A,3A

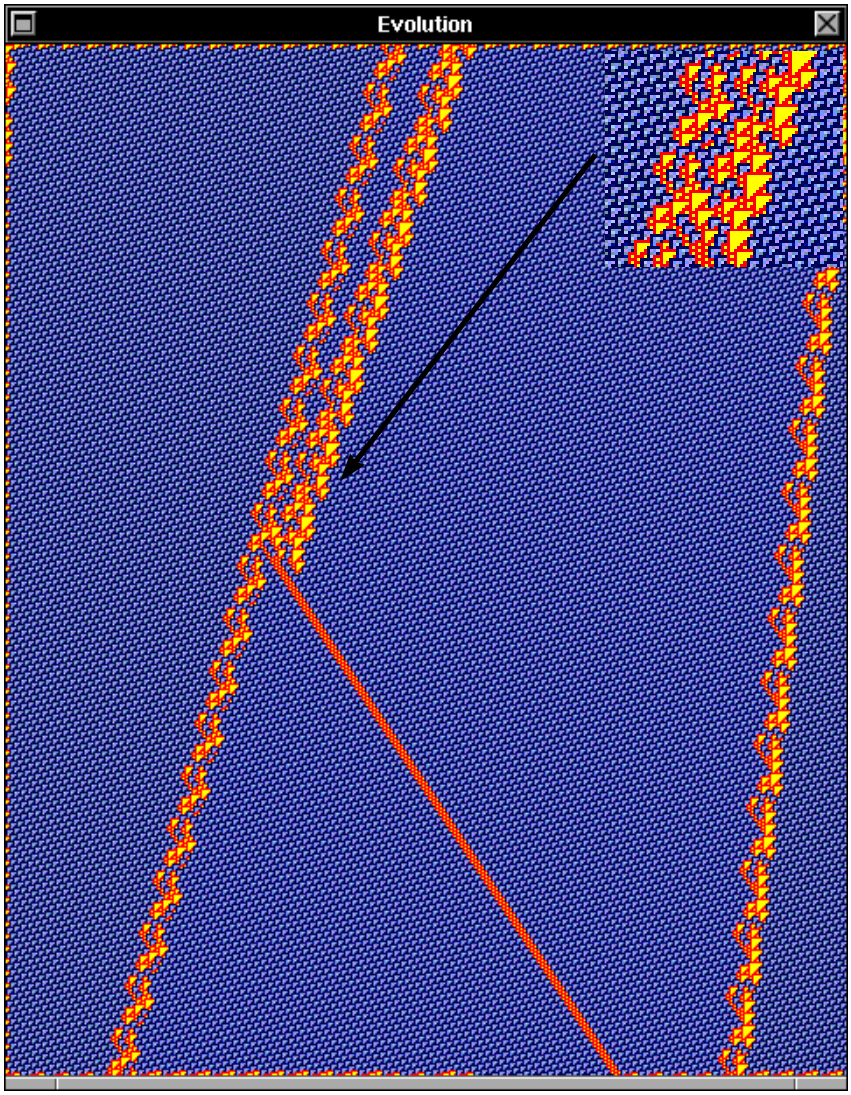

Figure 4.488: Collisions of glider Ebar, Ebar(p1)(F)-e(p1)-G(p1)(C)=Ebar,4A

4.12.3 Collisions of glider Ebar with glider H

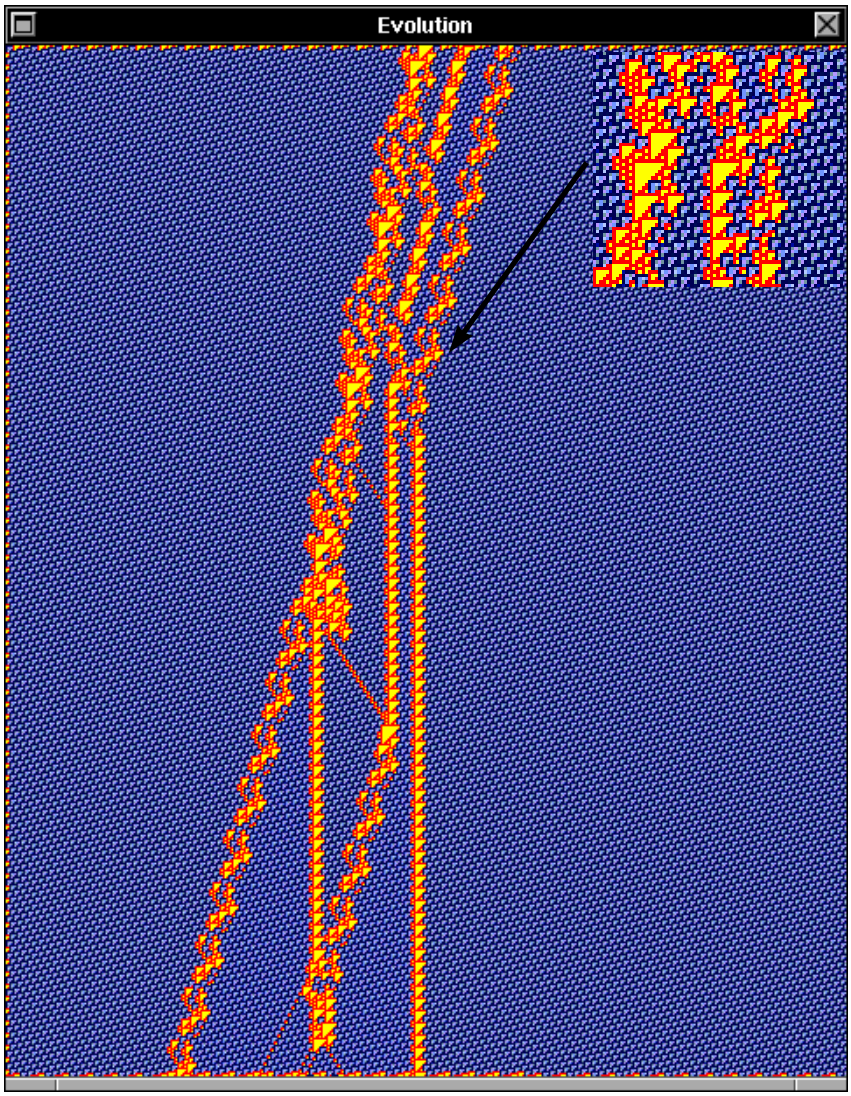

Figure 4.489: Collisions of glider Ebar, H(p1)(A)-Ebar(p1)(A)=F,3B,4B,C2

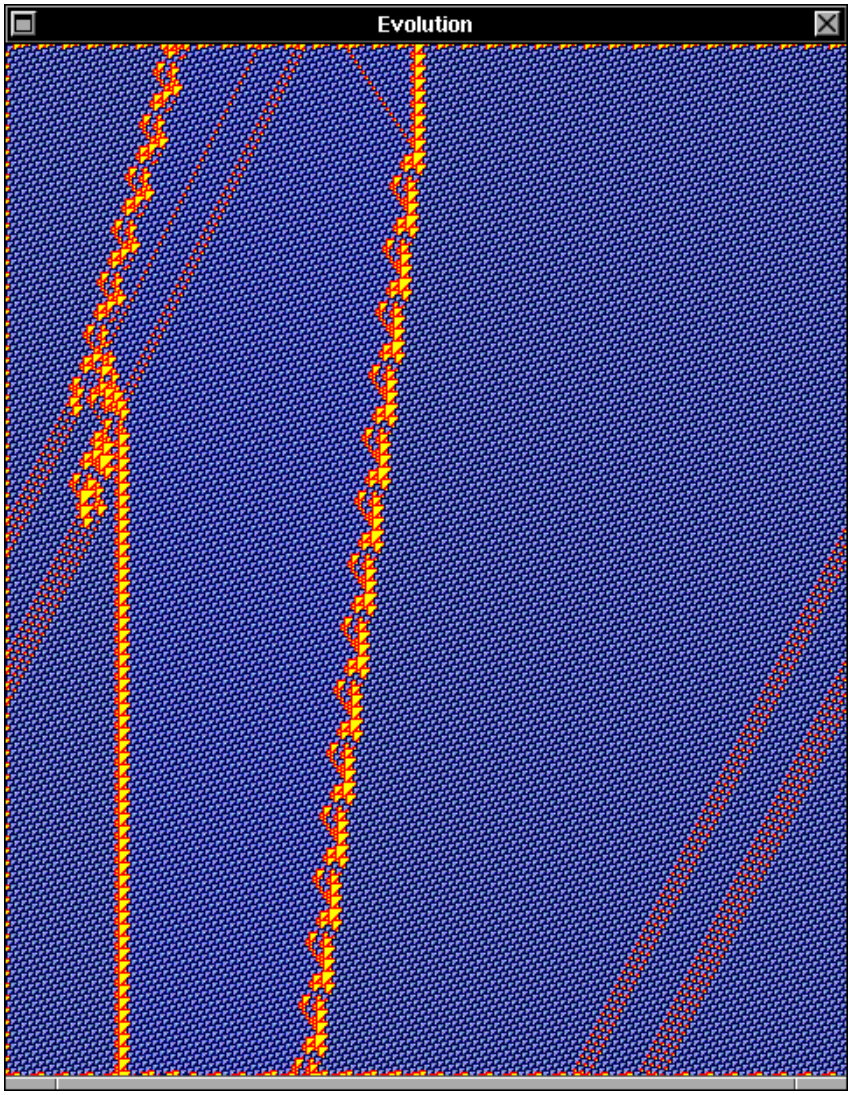

Figure 4.490: continue collision, H(p1)(A)-Ebar(p1)(A)

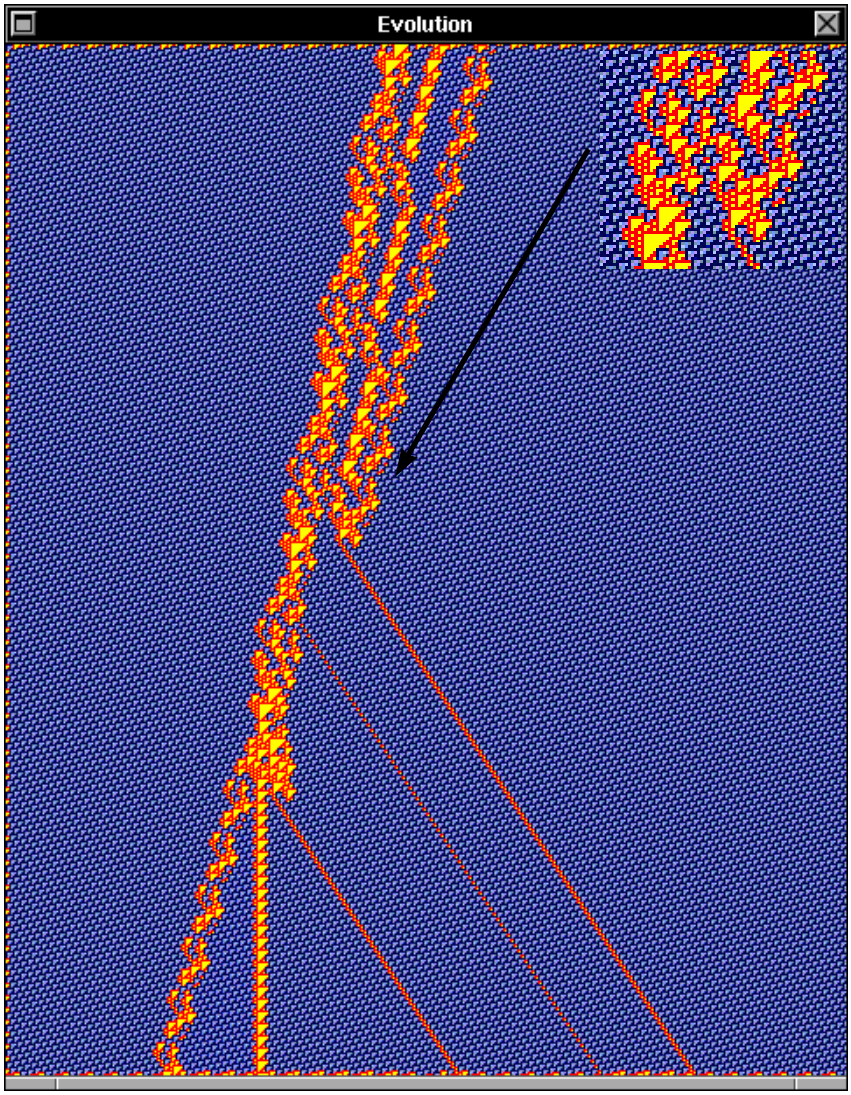

Figure 4.491: Collisions of glider Ebar, H(p1)(A)-Ebar(p1)(B)=2A,A,Ebar,C1,2A

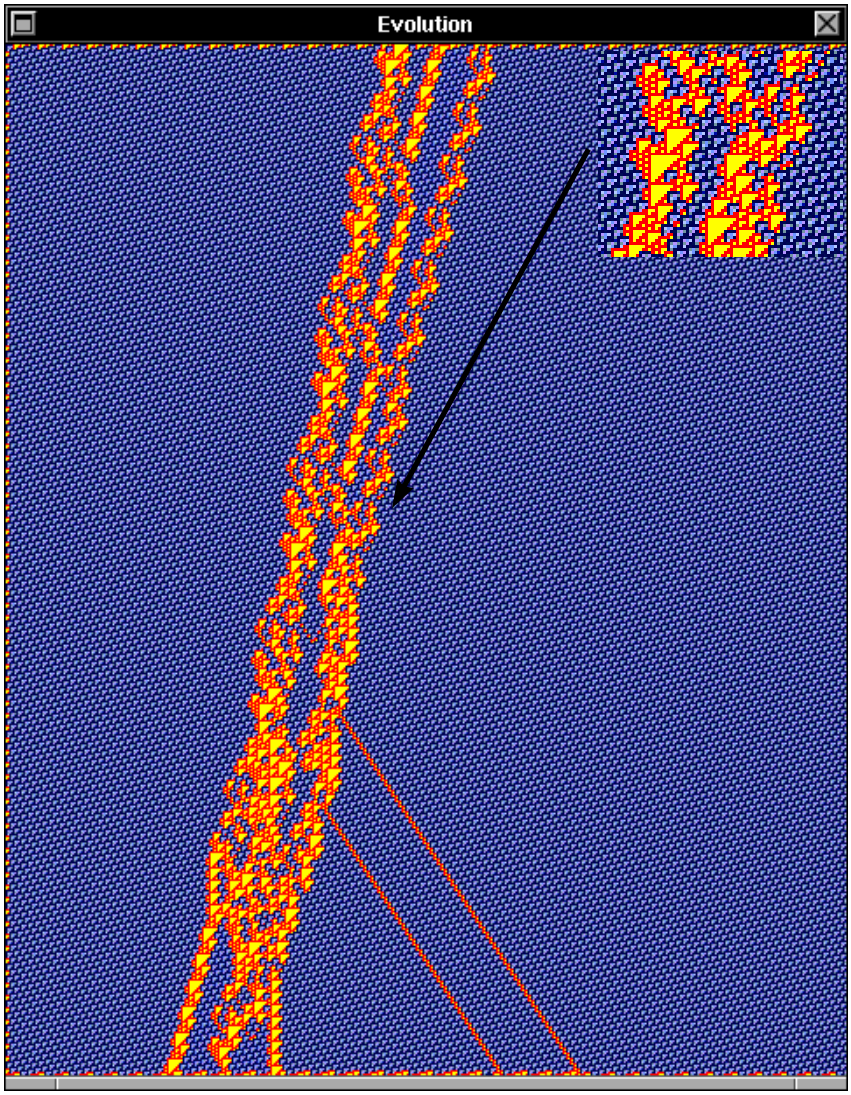

Figure 4.492: Collisions of glider Ebar, H(p1)(A)-Ebar(p1)(C)=2A,2A,E,C2

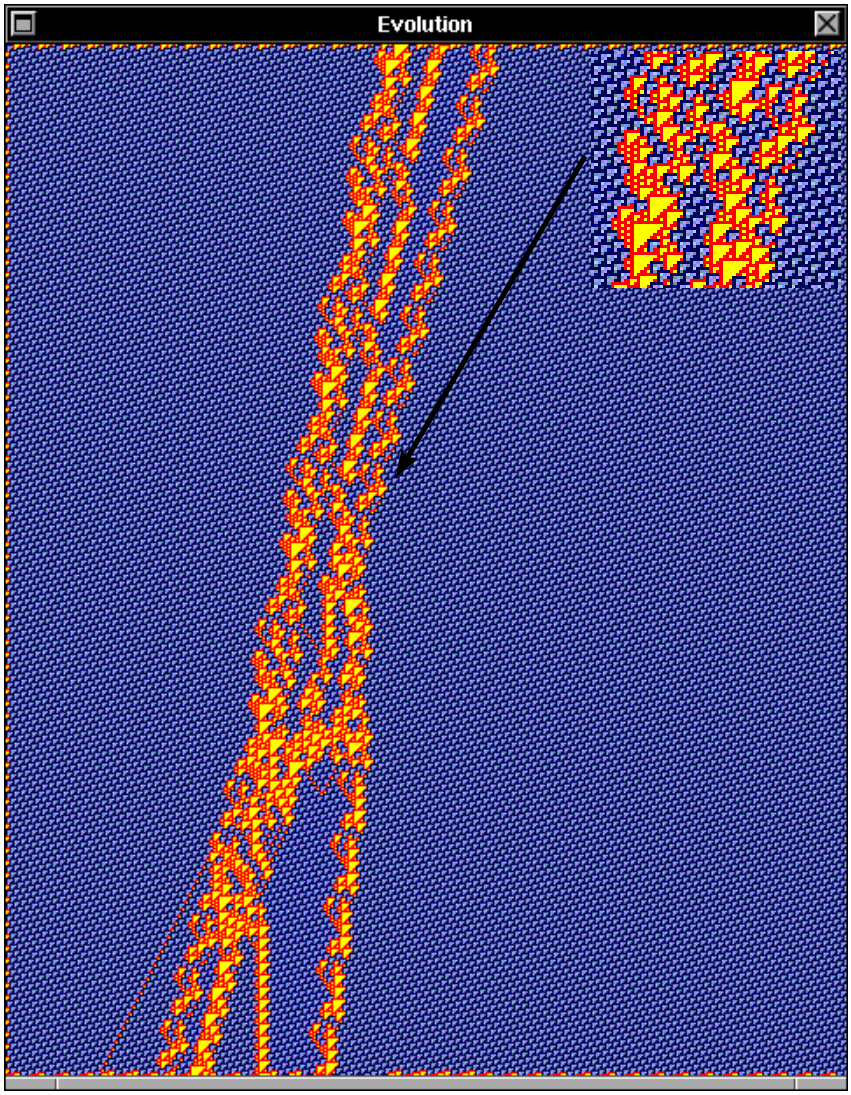

Figure 4.493: Collisions of glider Ebar, H(p1)(A)-Ebar(p1)(D)=B,Ebar,C1,F,F

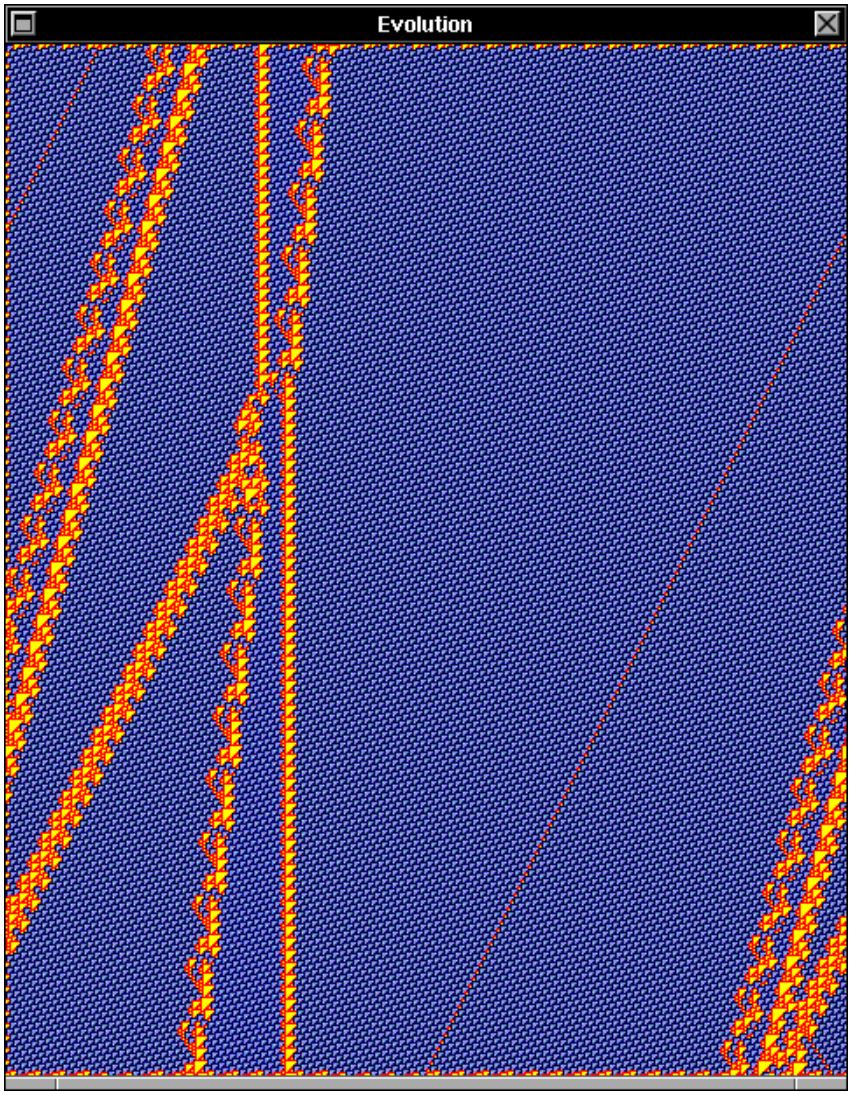

Figure 4.494: continue collision, H(p1)(A)-Ebar(p1)(D)

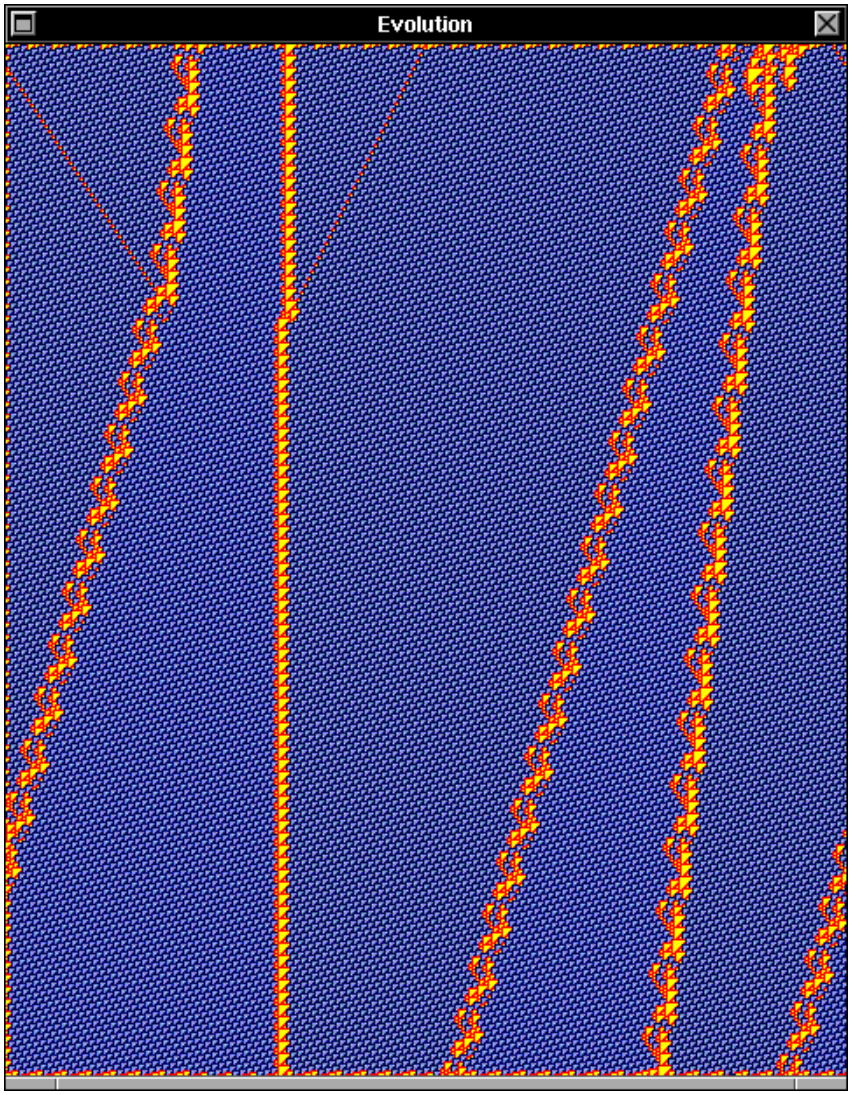

Figure 4.495: continue collision, H(p1)(A)-Ebar(p1)(D)

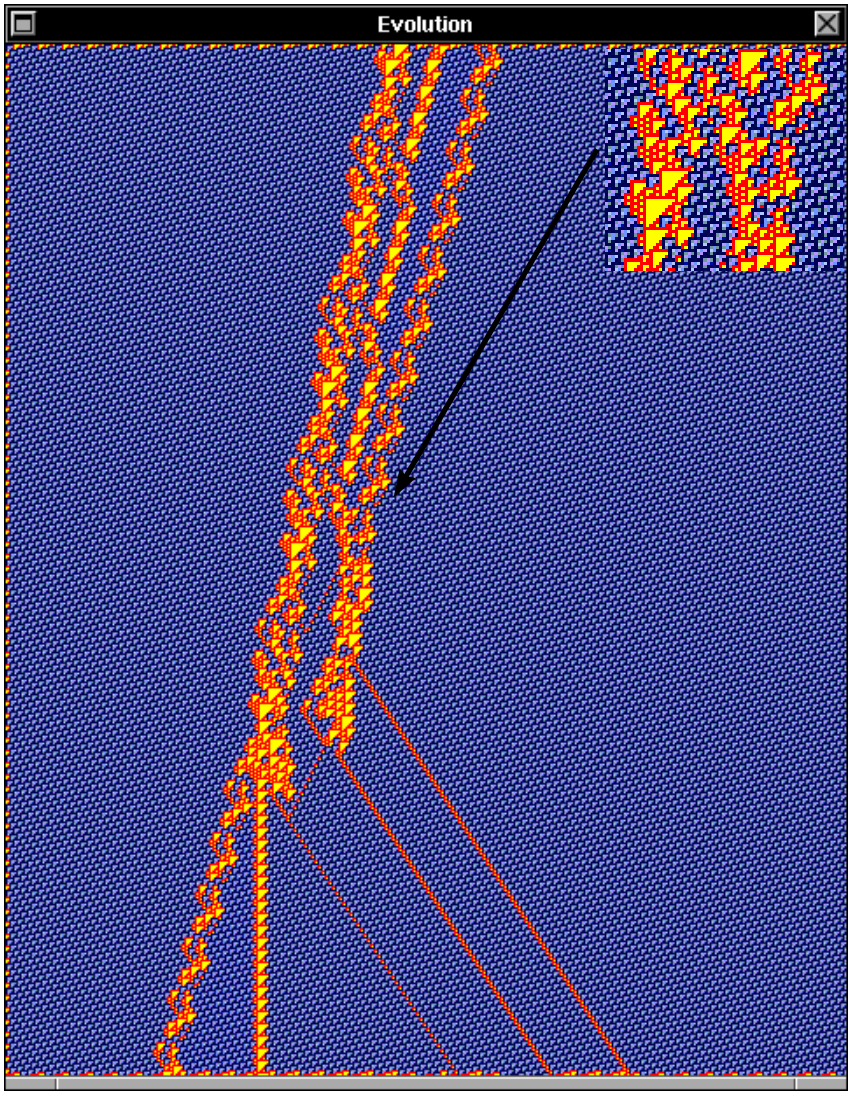

Figure 4.496: Collisions of glider Ebar, H(p1)(A)-Ebar(p1)(E)=2A,2A,Ebar,C1,A

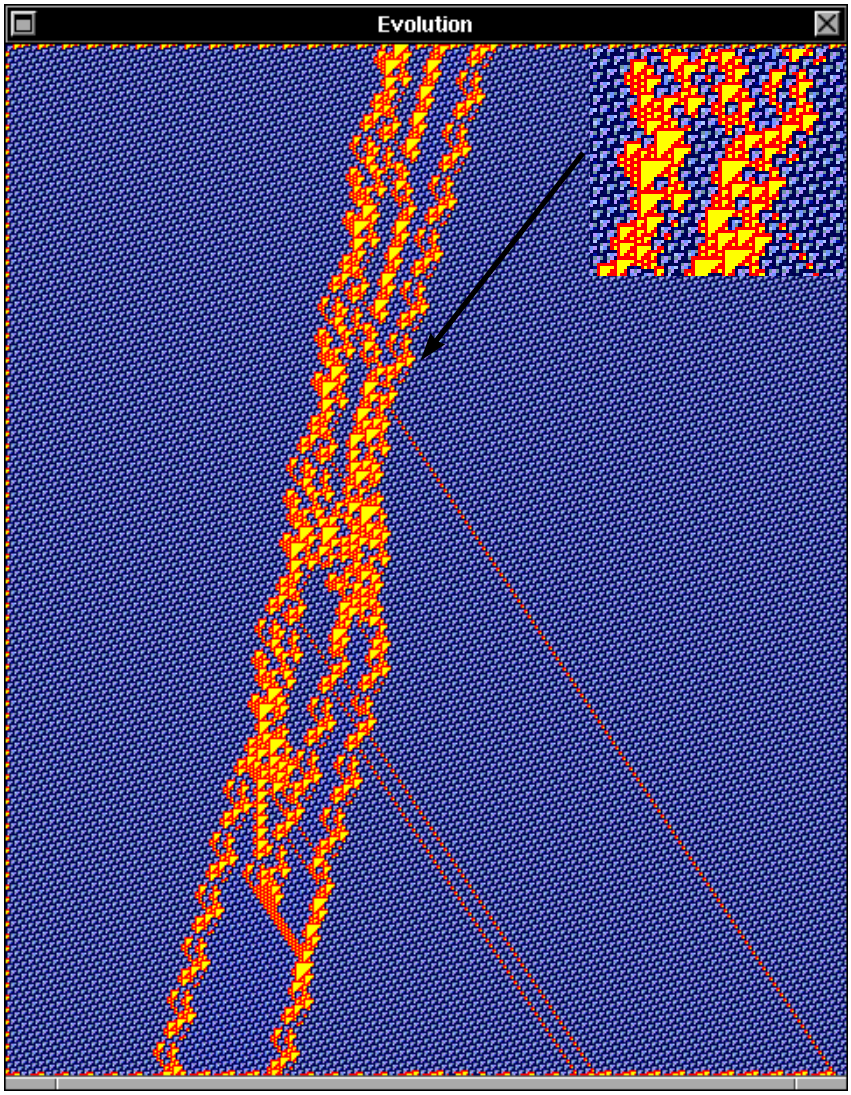

Figure 4.497: Collisions of glider Ebar, H(p1)(A)-Ebar(p1)(H)=A,A,A,Ebar,Ebar

4.13 Collisions of glider F

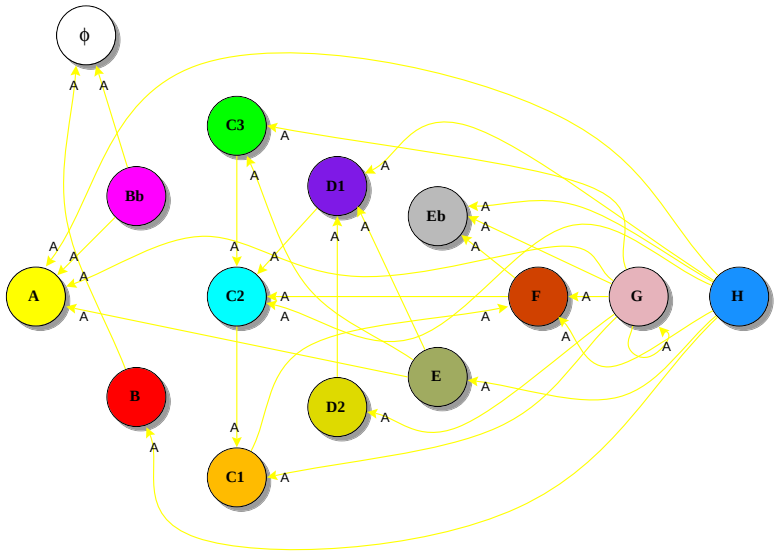

Figure 4.498: Collisions of glider F

	ϕ	A	B	$Bbar$	$C3$	$C2$	$C1$	$D2$	$D1$	E	$Ebar$	F	G	H
ϕ	.	.	.	.	.	.	.	.	.	.	.	.	.	.
A	.	.	.	.	.	.	.	.	.	.	.	.	.	.
B	.	.	.	.	.	.	.	.	.	.	.	.	.	.
$Bbar$	.	.	.	.	.	.	.	.	.	.	.	.	.	.
$C3$	.	.	.	.	.	.	.	.	.	.	.	.	.	.
$C2$	.	.	.	.	.	.	.	.	.	.	.	.	.	.
$C1$	.	.	.	.	.	.	.	.	.	.	.	.	.	.
$D2$	.	.	.	.	.	.	.	.	.	.	.	.	.	.
$D1$	.	.	.	.	.	.	.	.	.	.	.	.	.	.
E	.	.	.	.	.	.	.	.	.	.	.	.	.	.
$Ebar$	.	.	.	.	.	.	.	.	.	.	.	.	.	.
F	.	.	.	.	.	.	.	.	.	.	.	.	.	.
G	.	.	.	.	.	.	.	.	.	.	.	.	.	.
H	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Table 4.12: Matrix connection of collisions glider F

4.13.1 Collisions of glider F with glider G

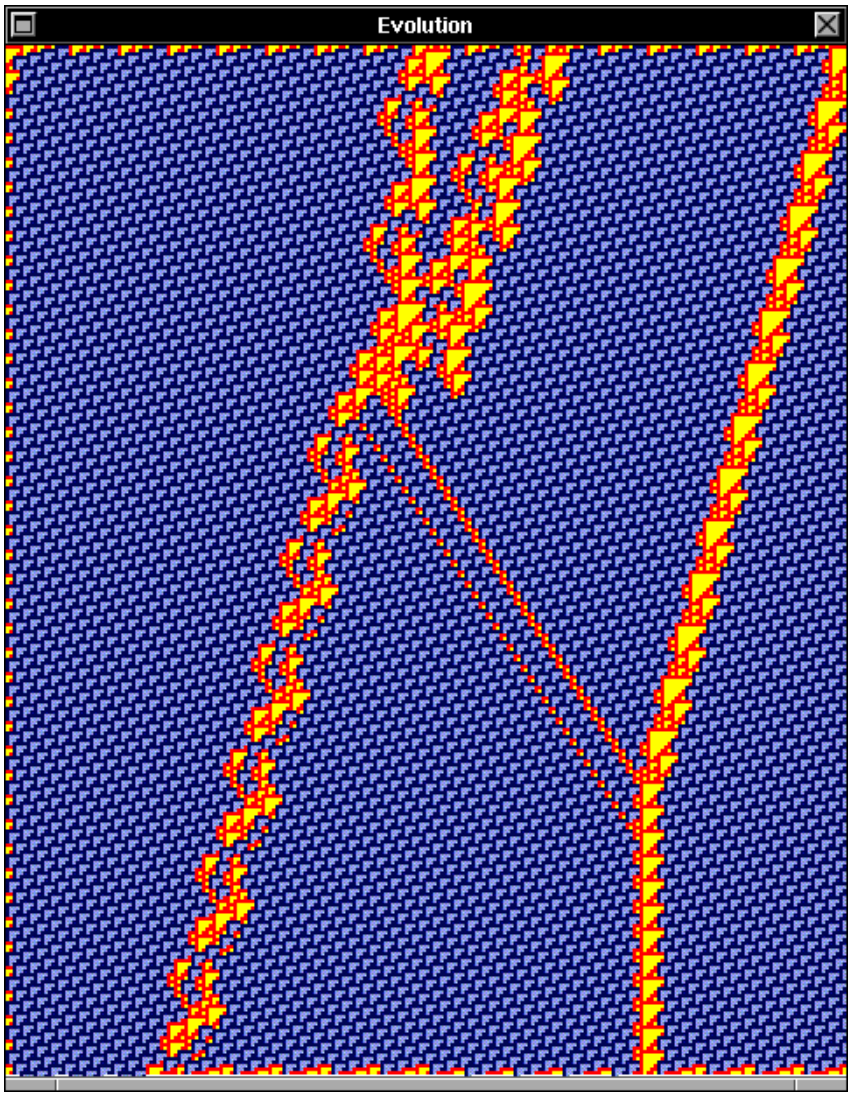

Figure 4.499: Collisions of glider F, F(p1)(A)-e(p1)-G(p1)(A)=2A,A,Ebar

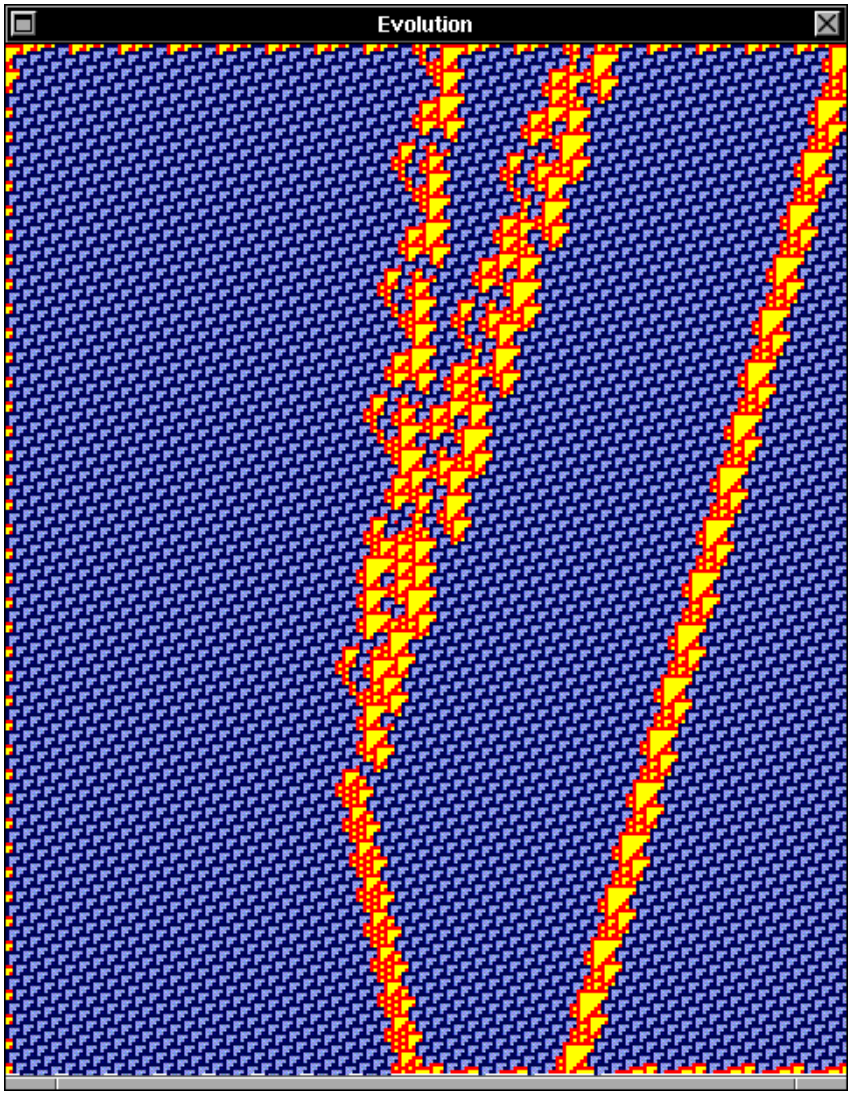

Figure 4.500: Collisions of glider F, F(p1)(G)-e(p1)-G(p1)(A)=D1

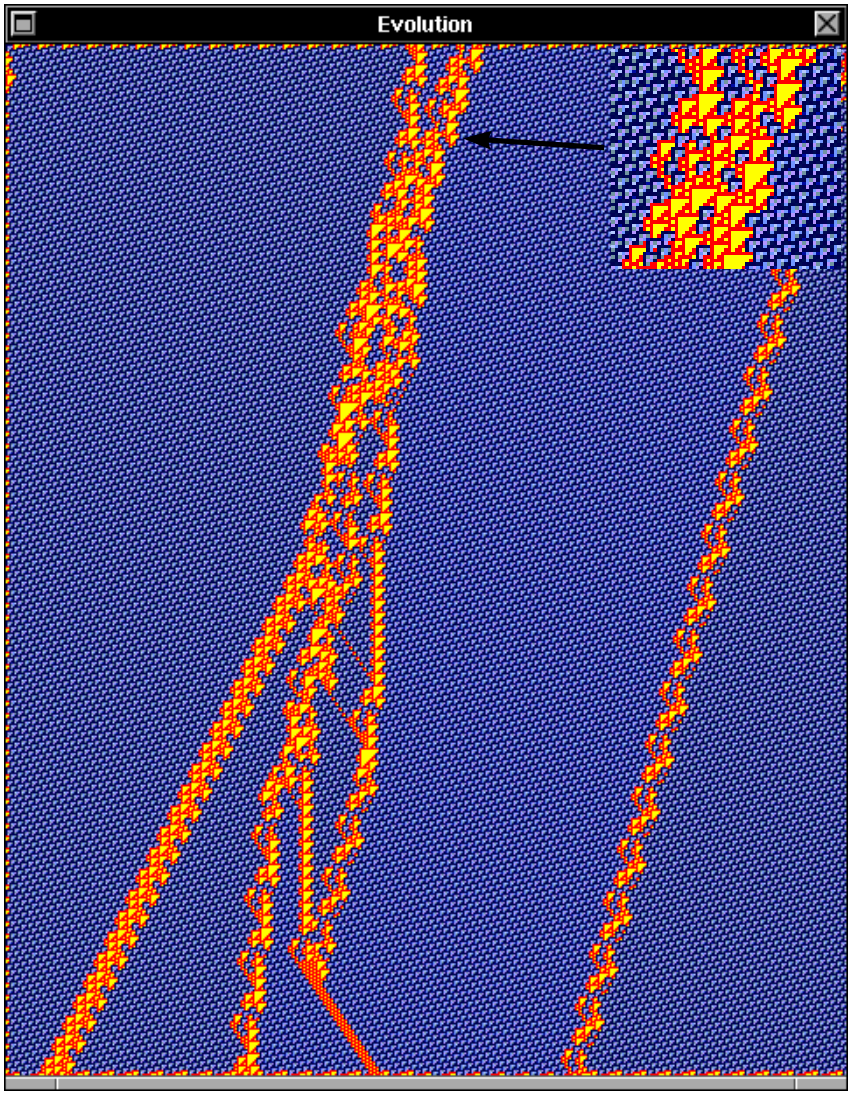

Figure 4.501: Collisions of glider F, F(p1)(G)-e(p1)-G(p1)(A)=Bbar,F,5A

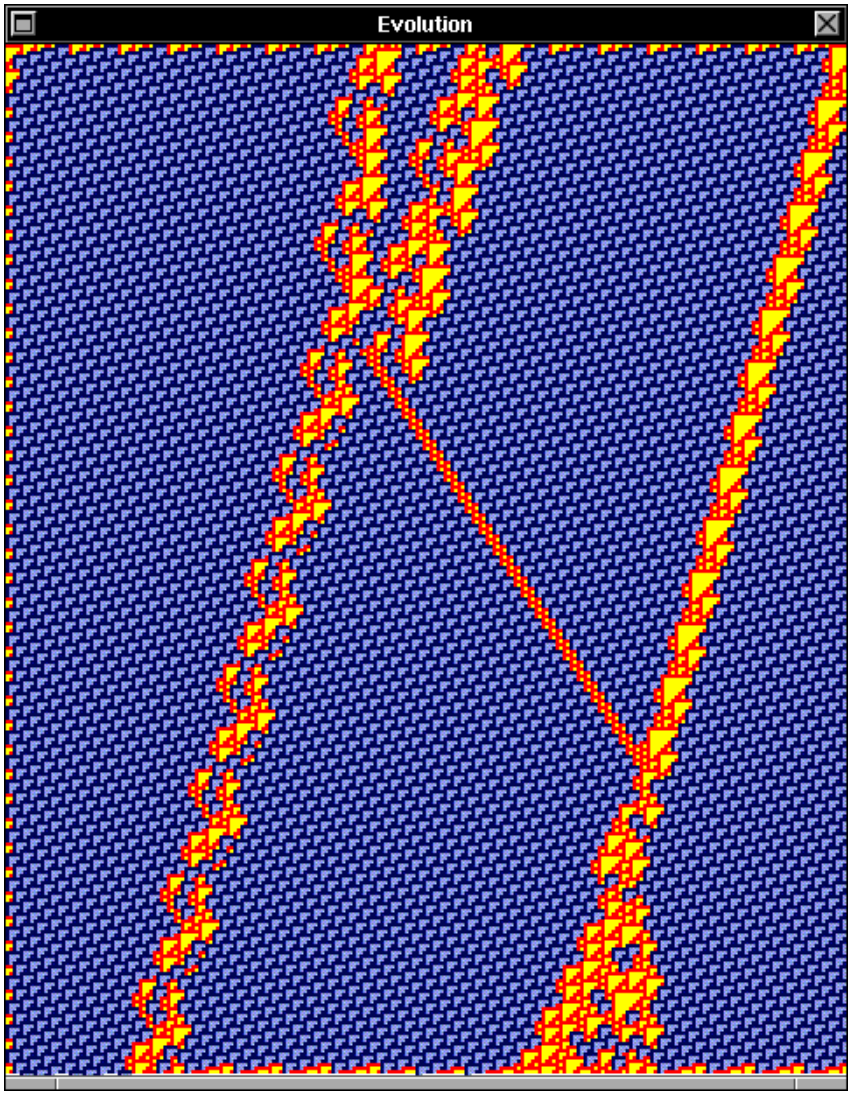

Figure 4.502: Collisions of glider F, F(p1)(A)-e(p1)-G(p1)(B)=Ebar,3A

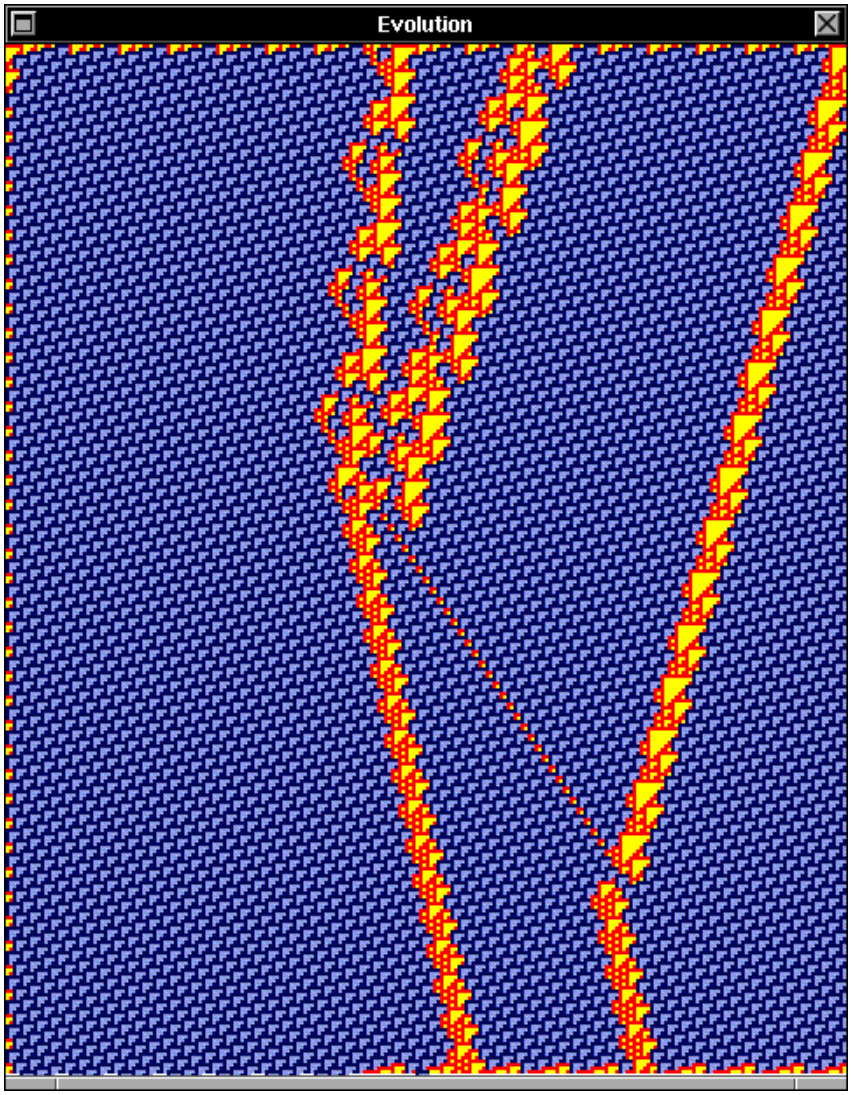

Figure 4.503: Collisions of glider F, F(p1)(G)-e(p1)-G(p1)(B)=D2,A

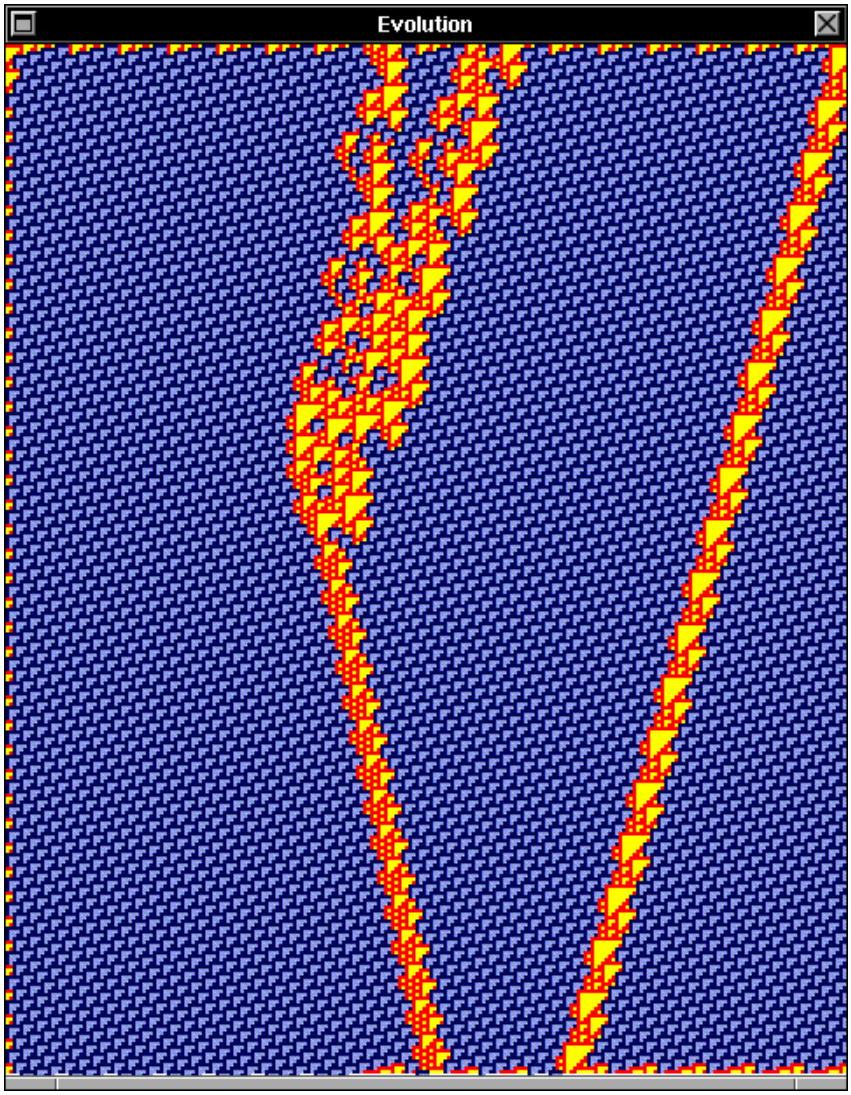

Figure 4.504: Collisions of glider F, F(p1)(H)-e(p1)-G(p1)(B)=D1

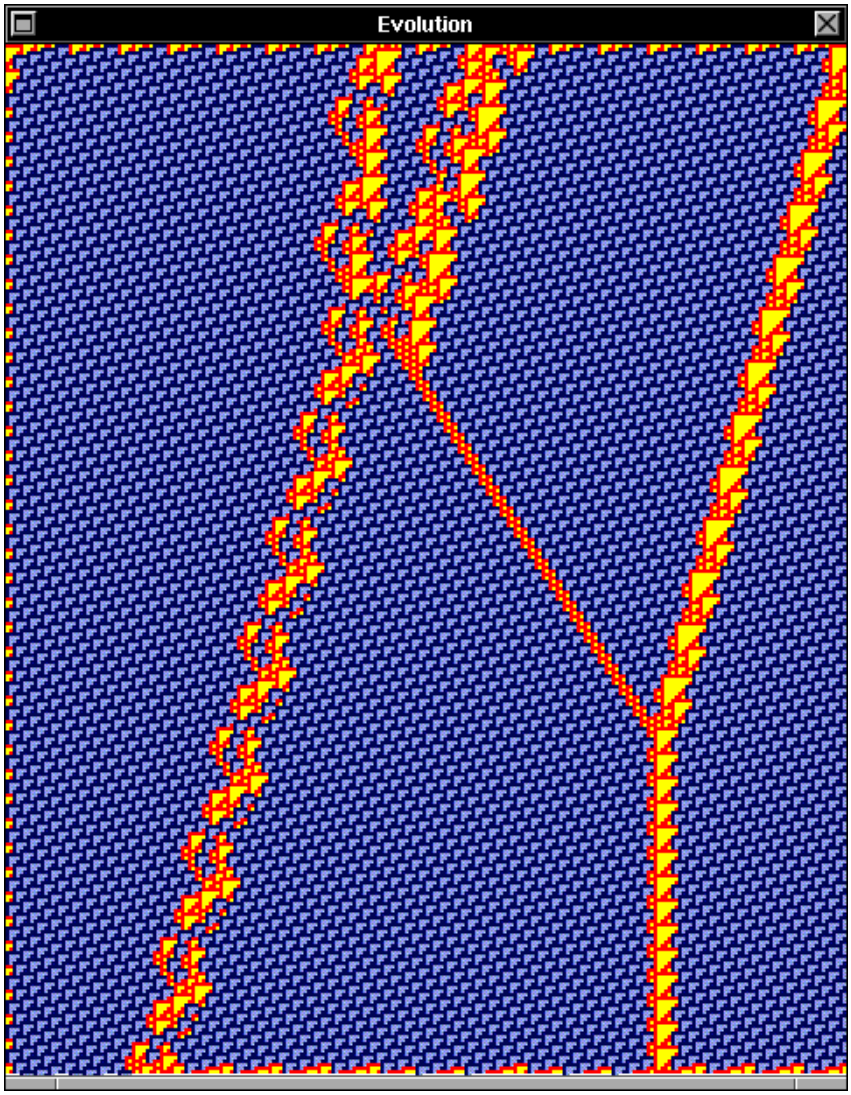

Figure 4.505: Collisions of glider F, F(p1)(A)-e(p1)-G(p1)(C)=Ebar,3A

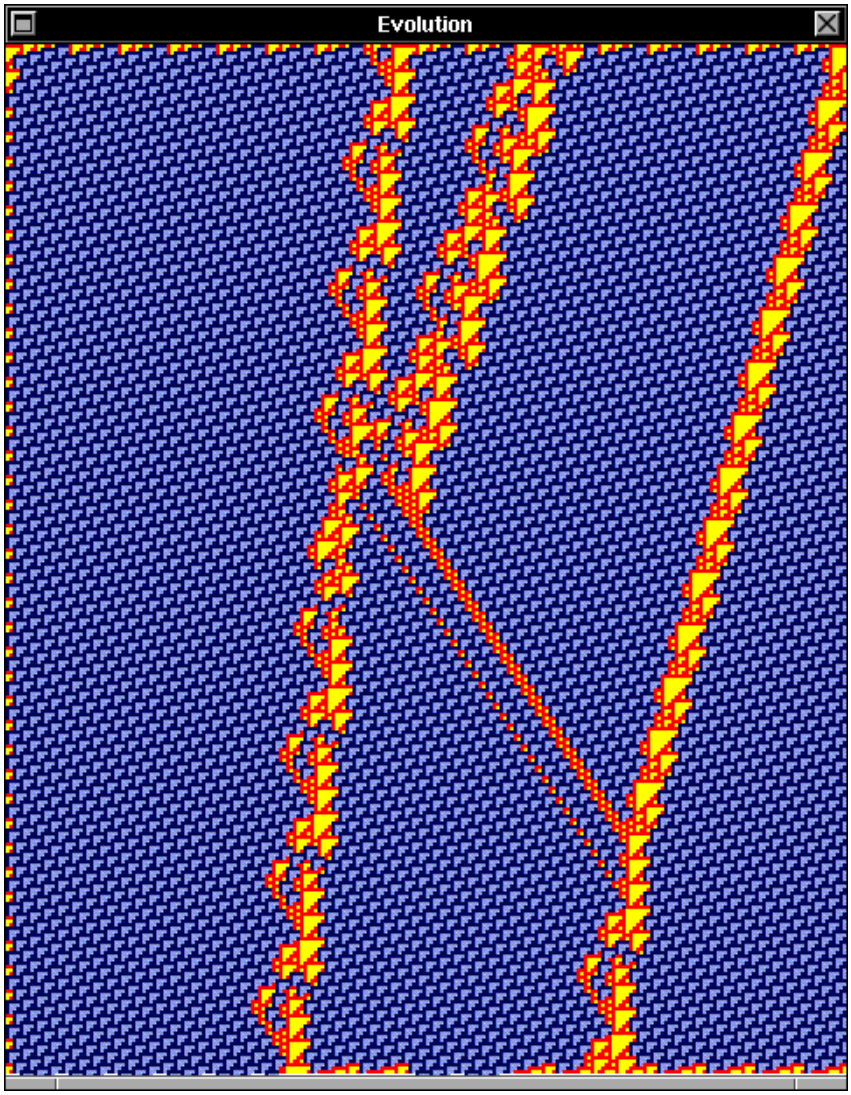

Figure 4.506: Collisions of glider F, F(p1)(G)-e(p1)-G(p1)(C)=3A,A,F

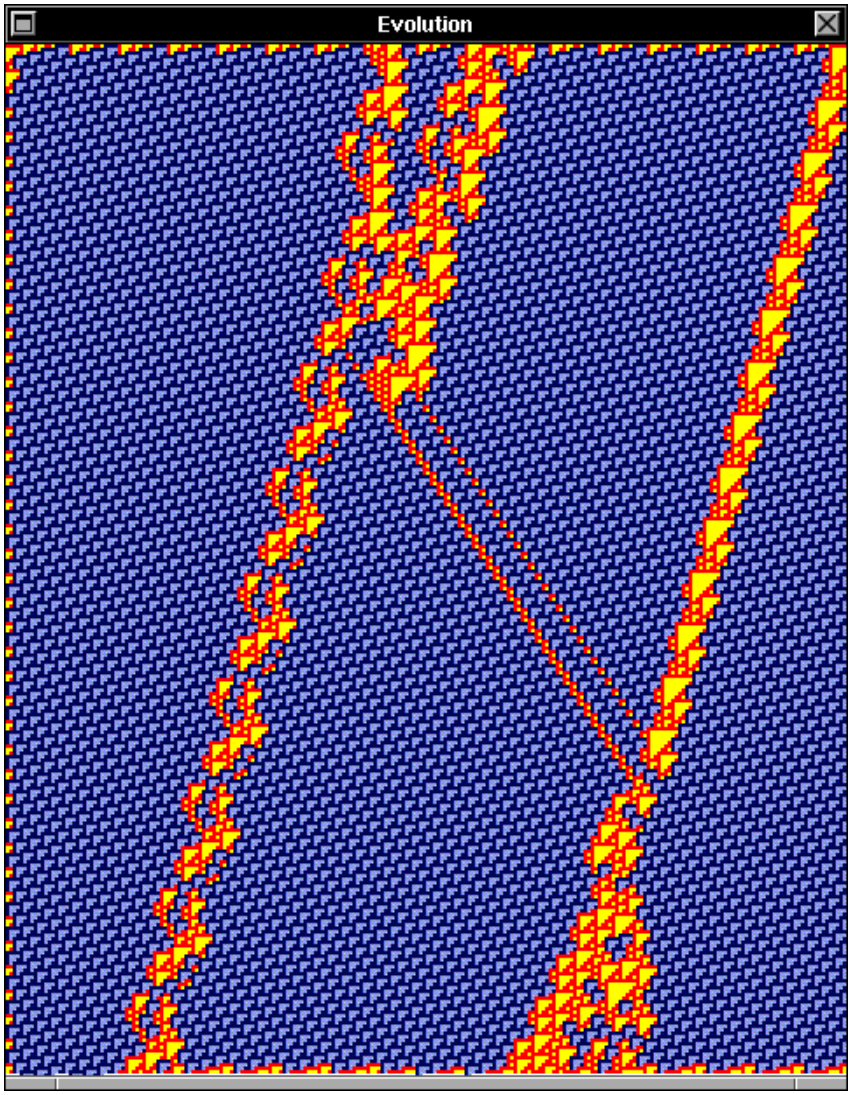

Figure 4.507: Collisions of glider F, F(p1)(H)-e(p1)-G(p1)(C)=Ebar,2A,A

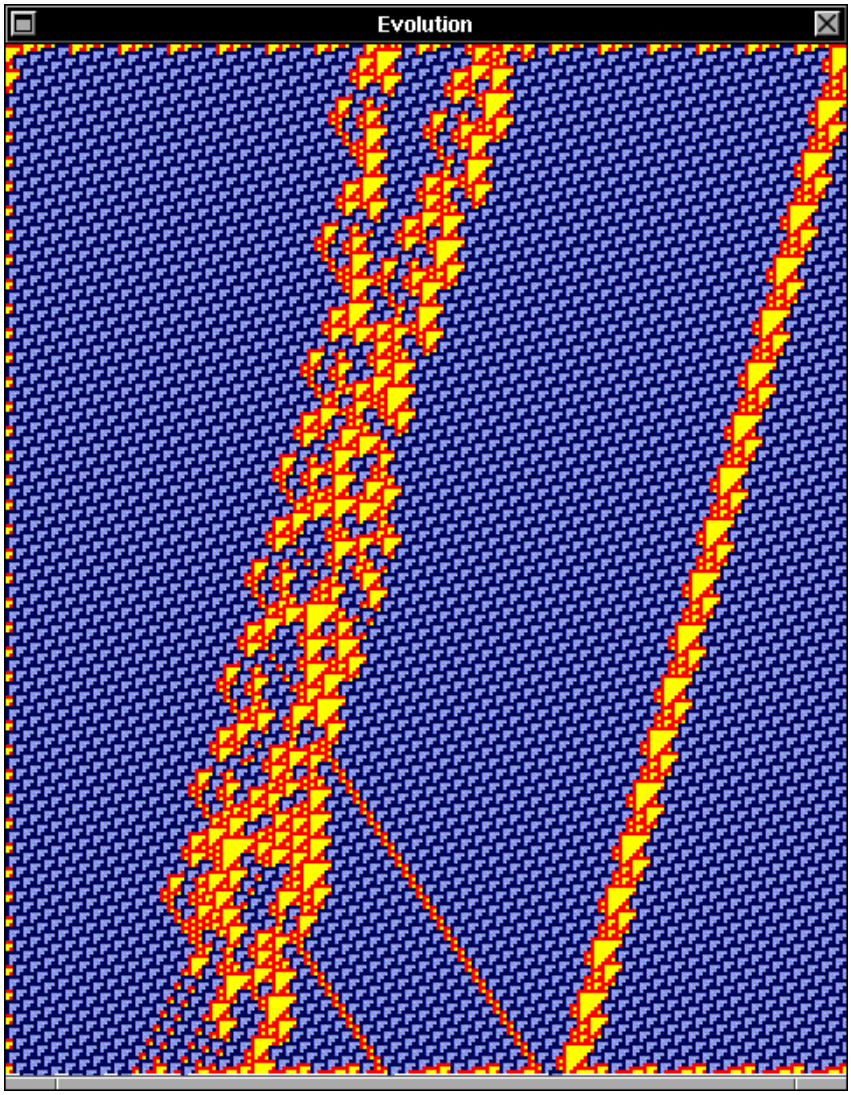

Figure 4.508: Collisions of glider F, F(p1)(A)-e(p1)-G(p1)(D)=2A,2A,2B,3B,C2

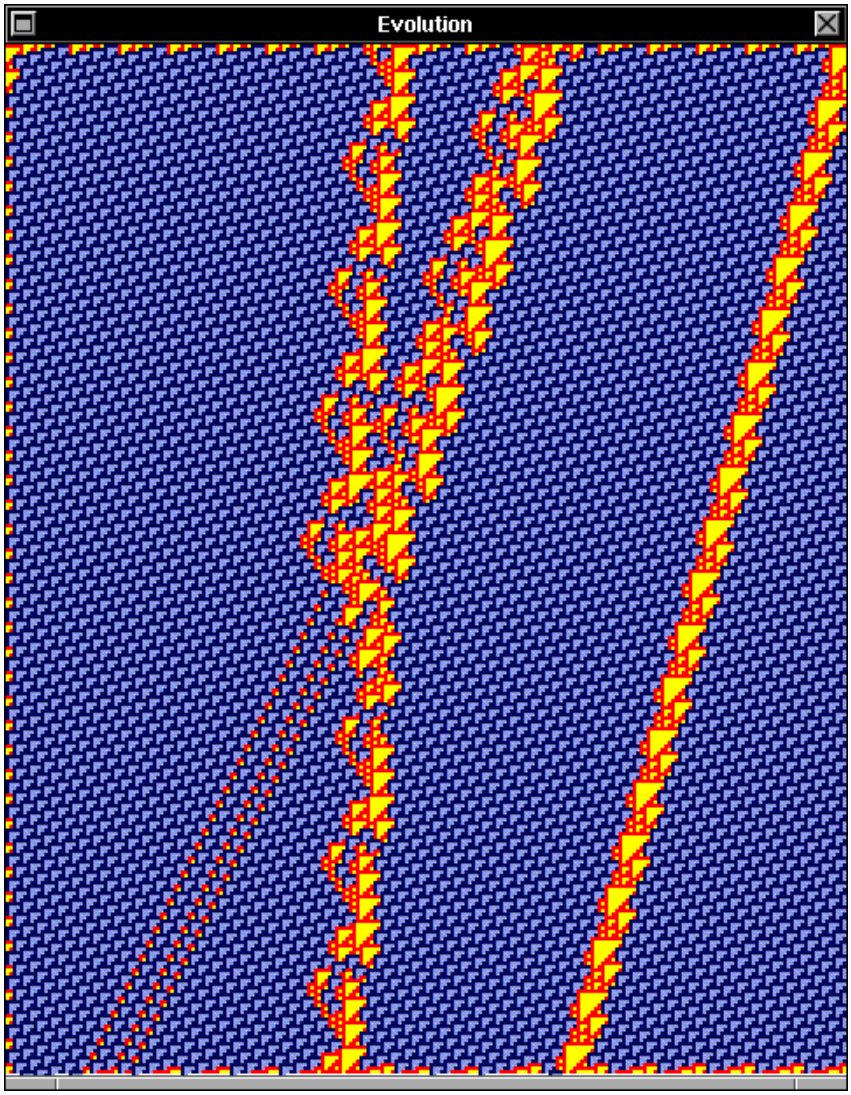

Figure 4.509: Collisions of glider F, F(p1)(G)-e(p1)-G(p1)(D)=B,2B,F

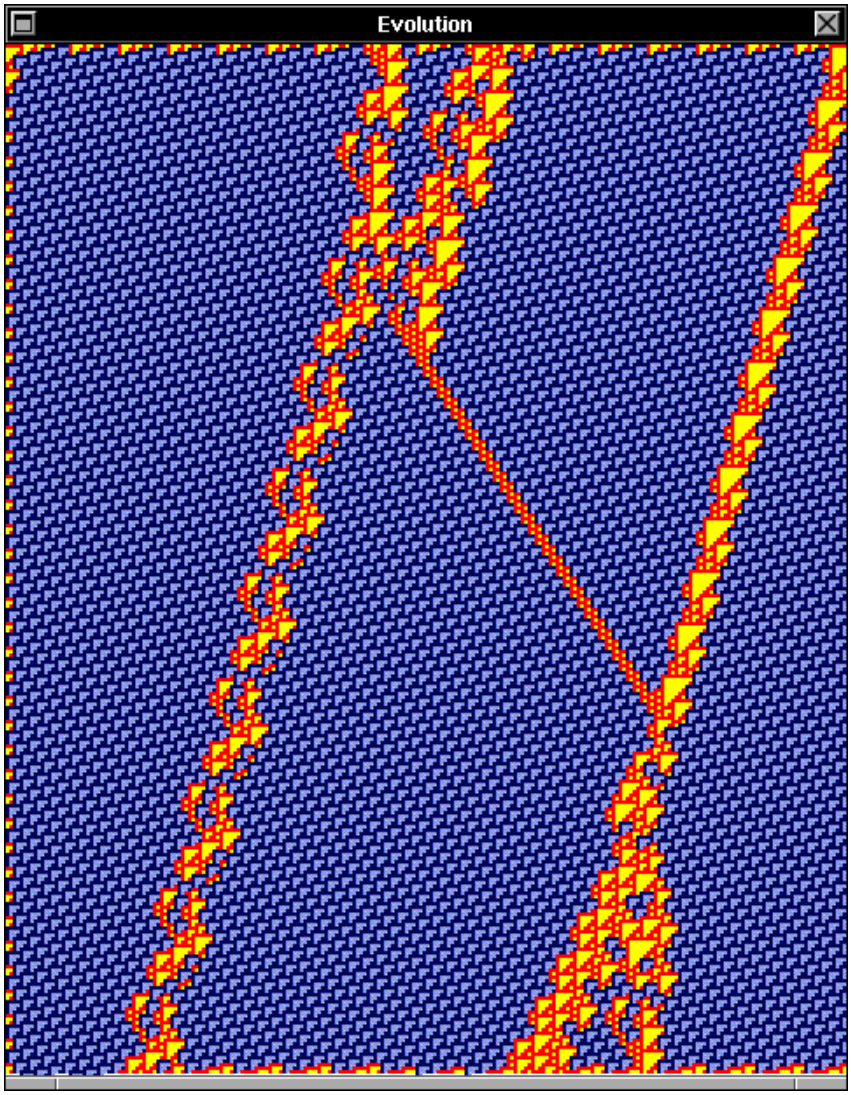

Figure 4.510: Collisions of glider F, F(p1)(H)-e(p1)-G(p1)(D)=Ebar,3A

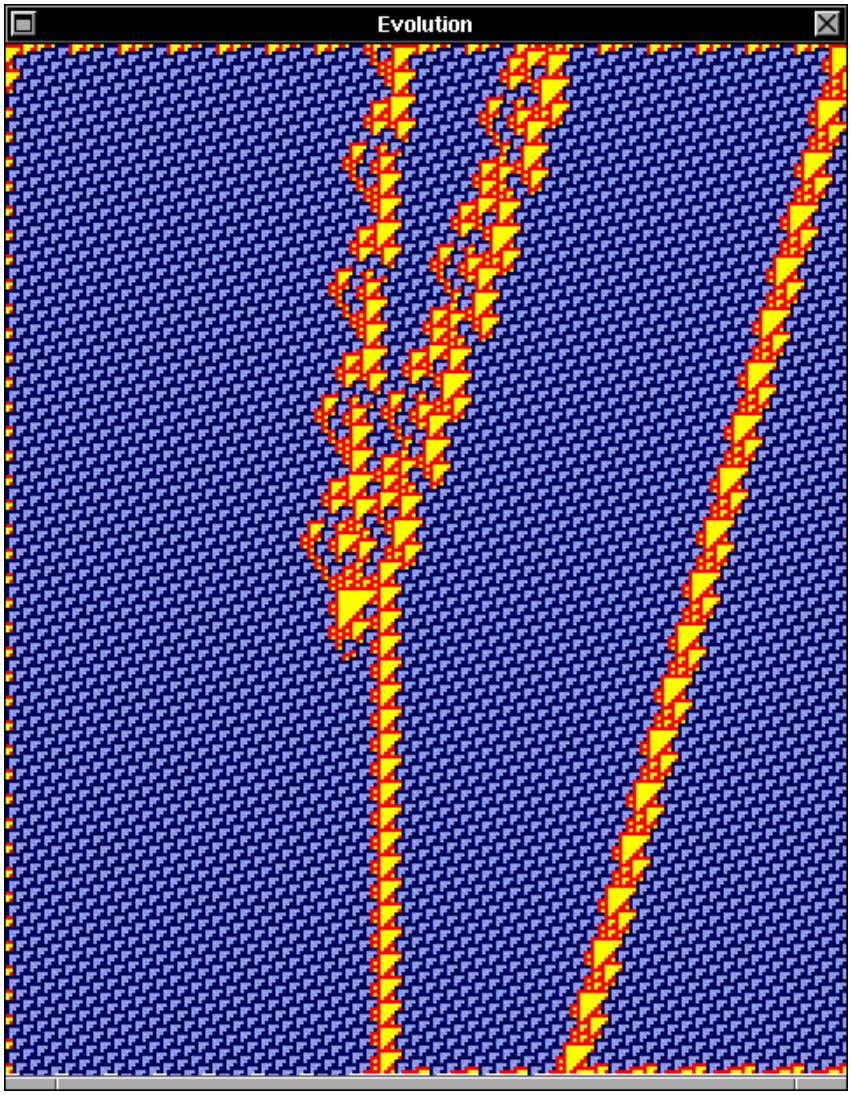

Figure 4.511: Collisions of glider F, F(p1)(G)-e(p1)-G(p1)(E)=C3

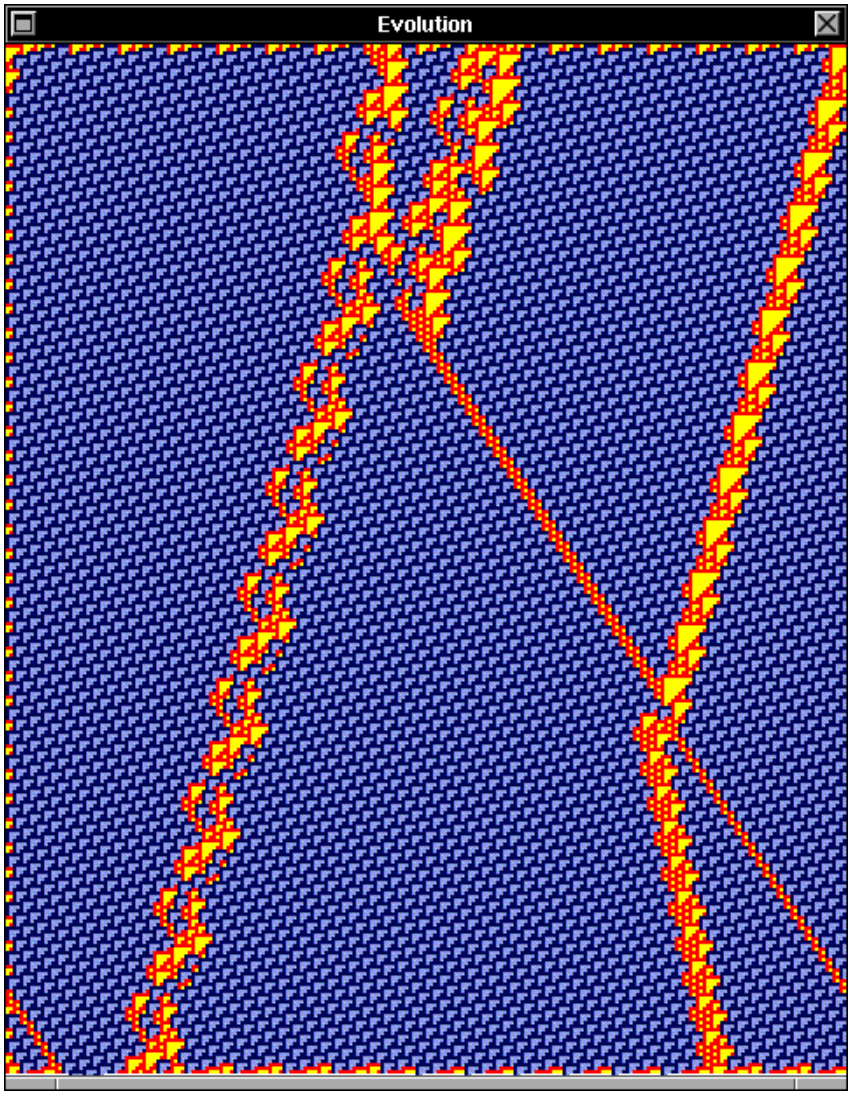

Figure 4.512: Collisions of glider F, F(p1)(H)-e(p1)-G(p1)(E)=Ebar,3A

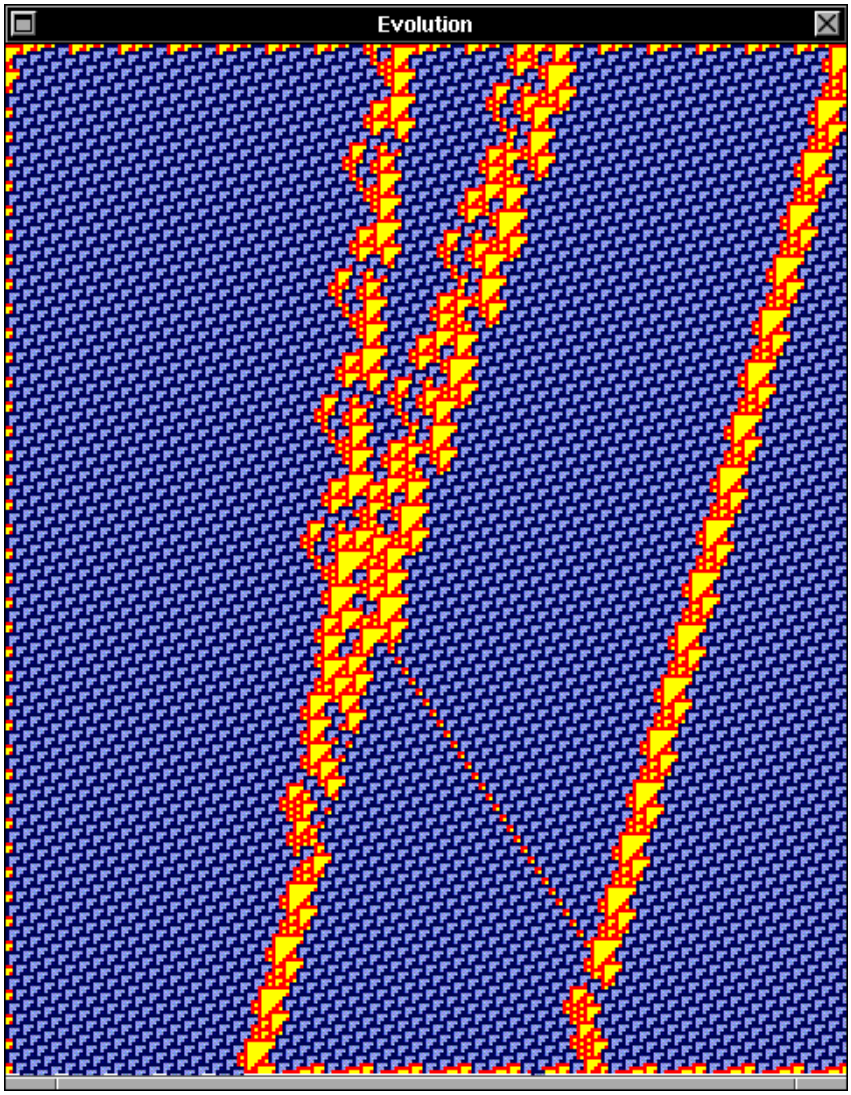

Figure 4.513: Collisions of glider F, F(p1)(G)-e(p1)-G(p1)(F)=A,E

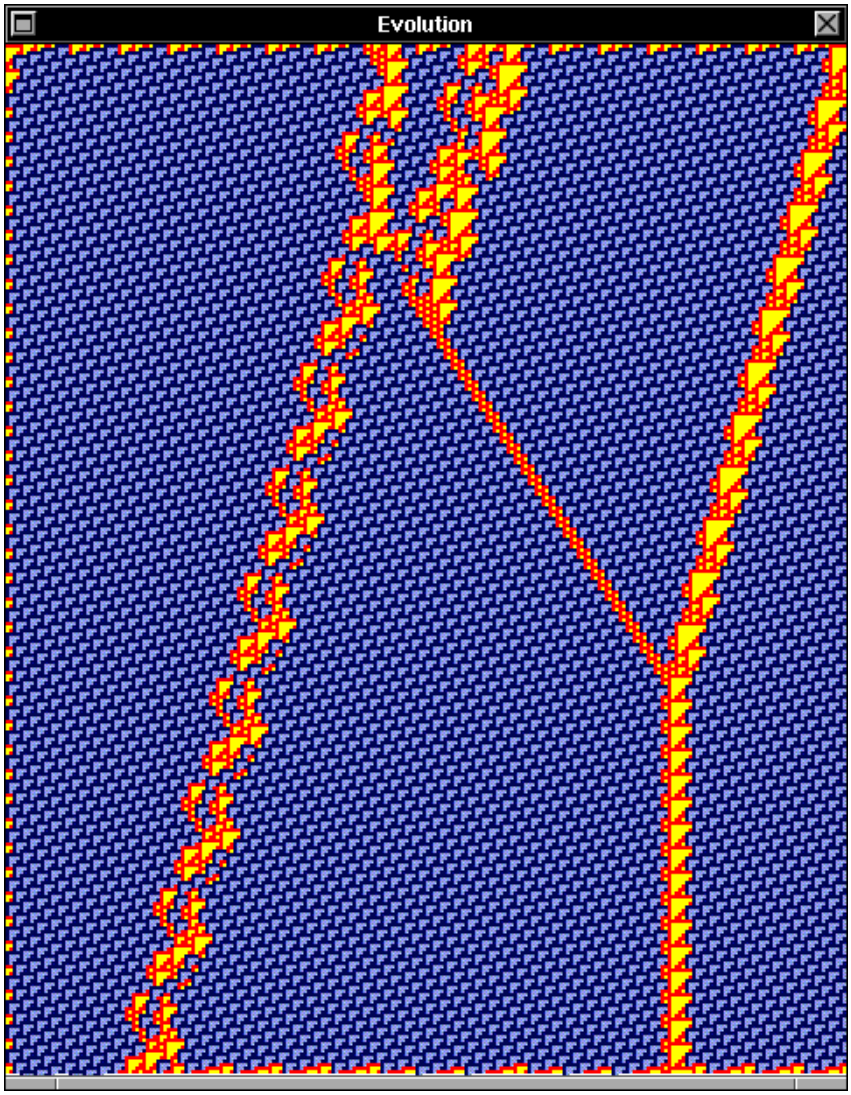

Figure 4.514: Collisions of glider F, F(p1)(H)-e(p1)-G(p1)(F)=Ebar,3A

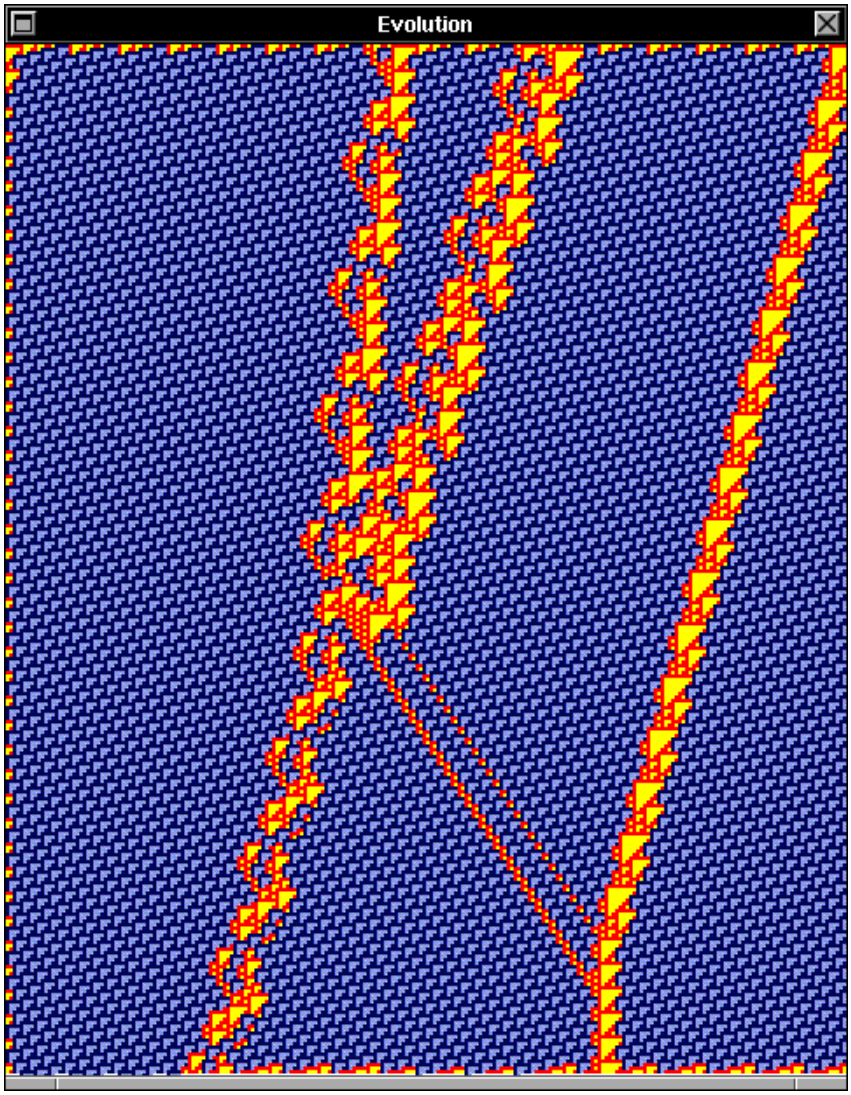

Figure 4.515: Collisions of glider F, F(p1)(G)-e(p1)-G(p1)(G)=Ebar,2A,A

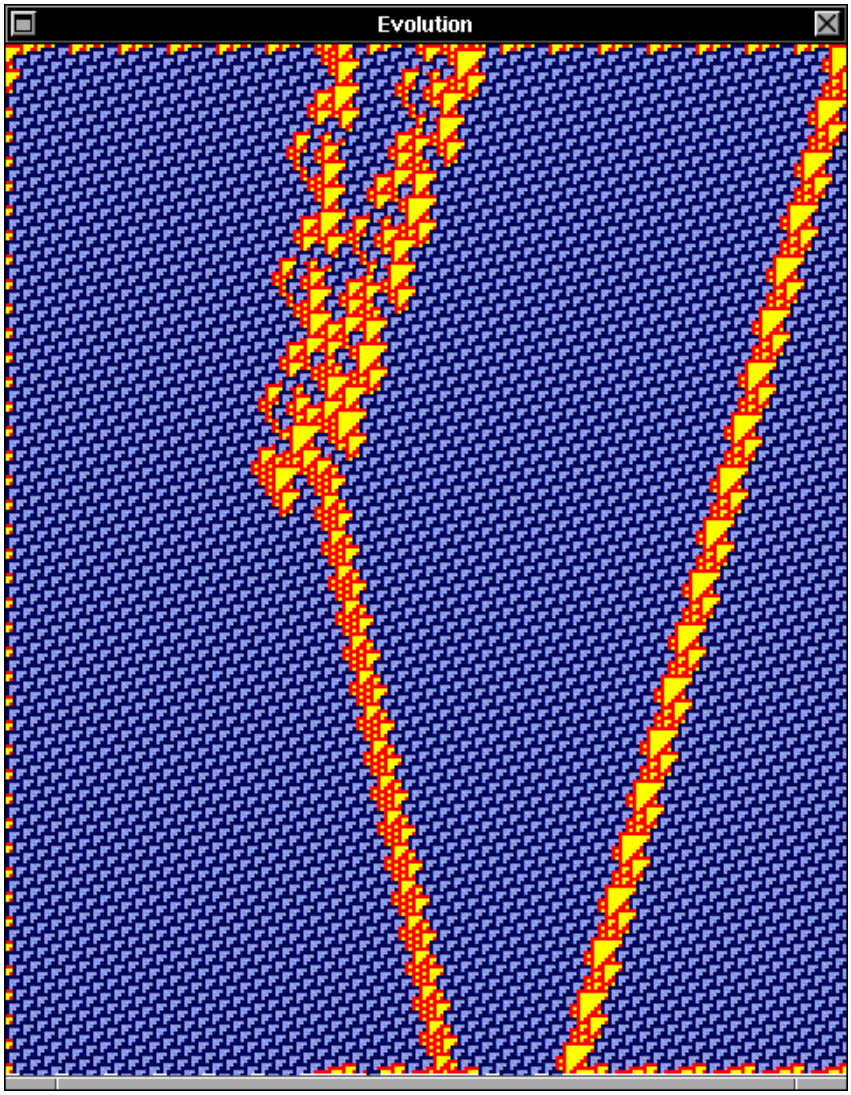

Figure 4.516: Collisions of glider F, F(p1)(H)-e(p1)-G(p1)(G)=D1

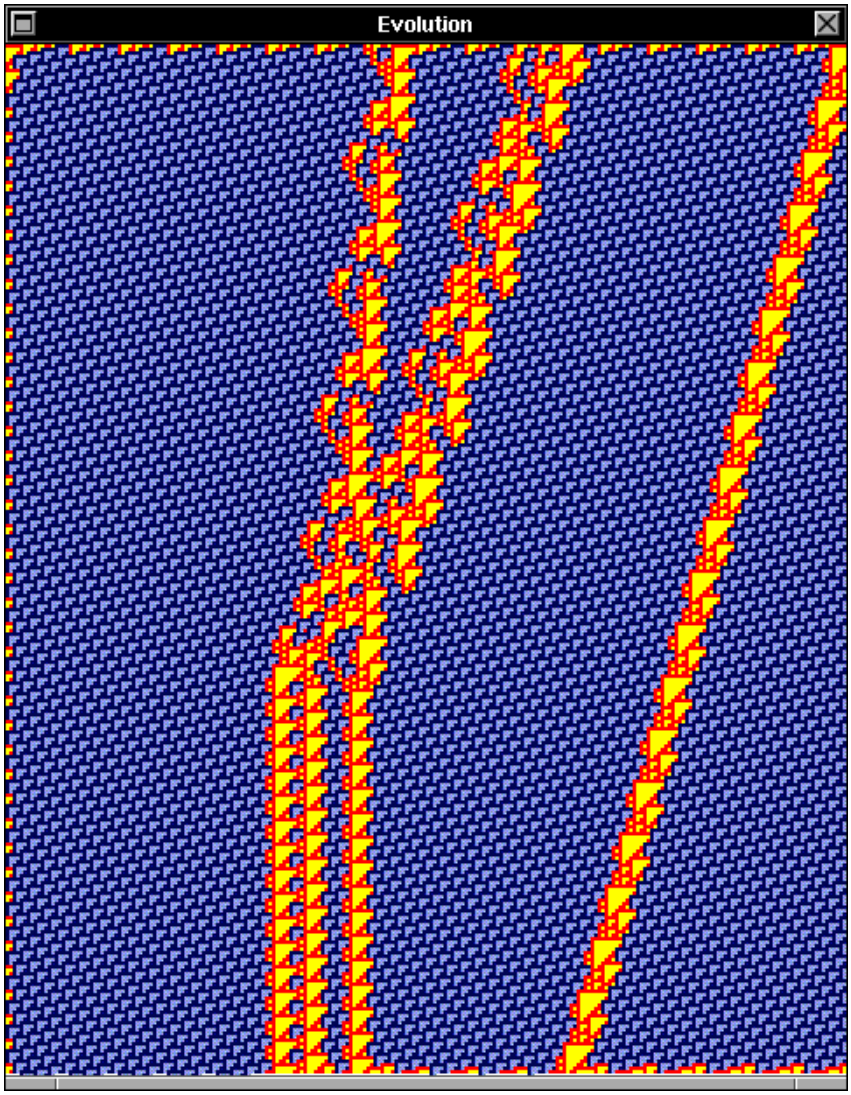

Figure 4.517: Collisions of glider F, F(p1)(G)-e(p1)-G(p1)(H)=2C3,C2

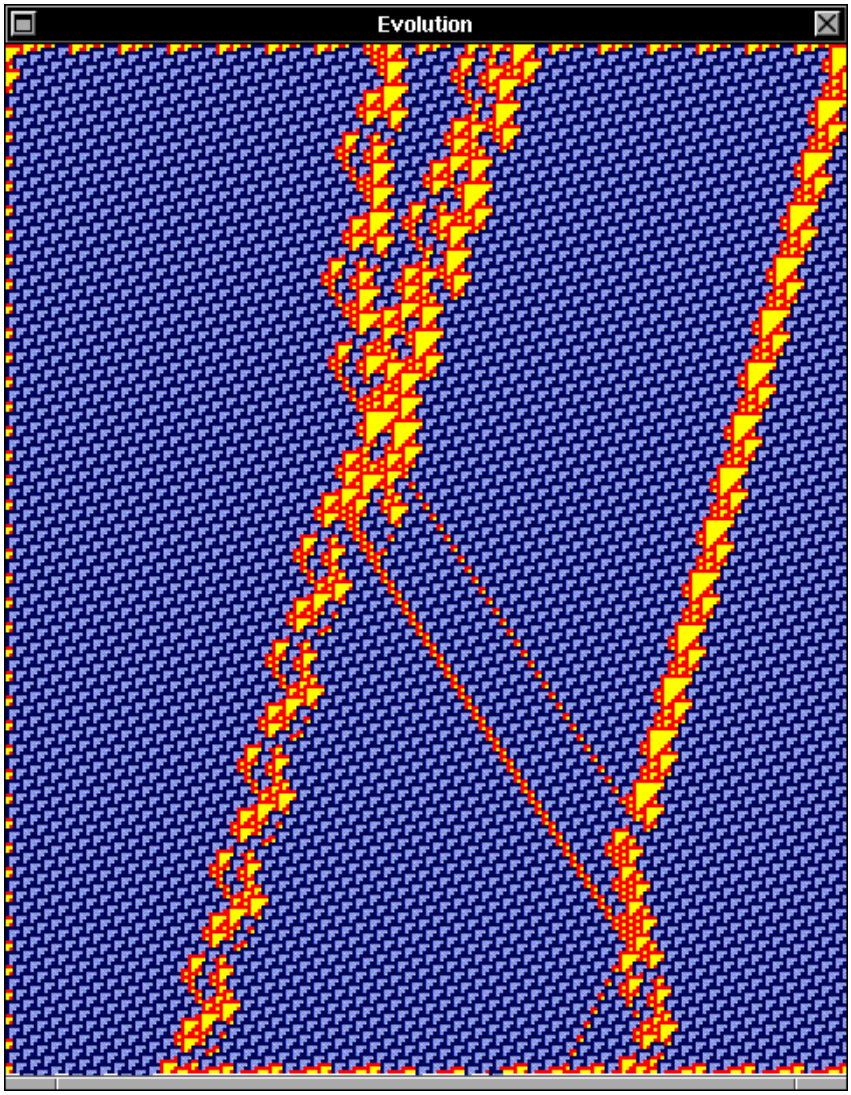

Figure 4.518: Collisions of glider F, F(p1)(H)-e(p1)-G(p1)(H)=A,2A,Ebar

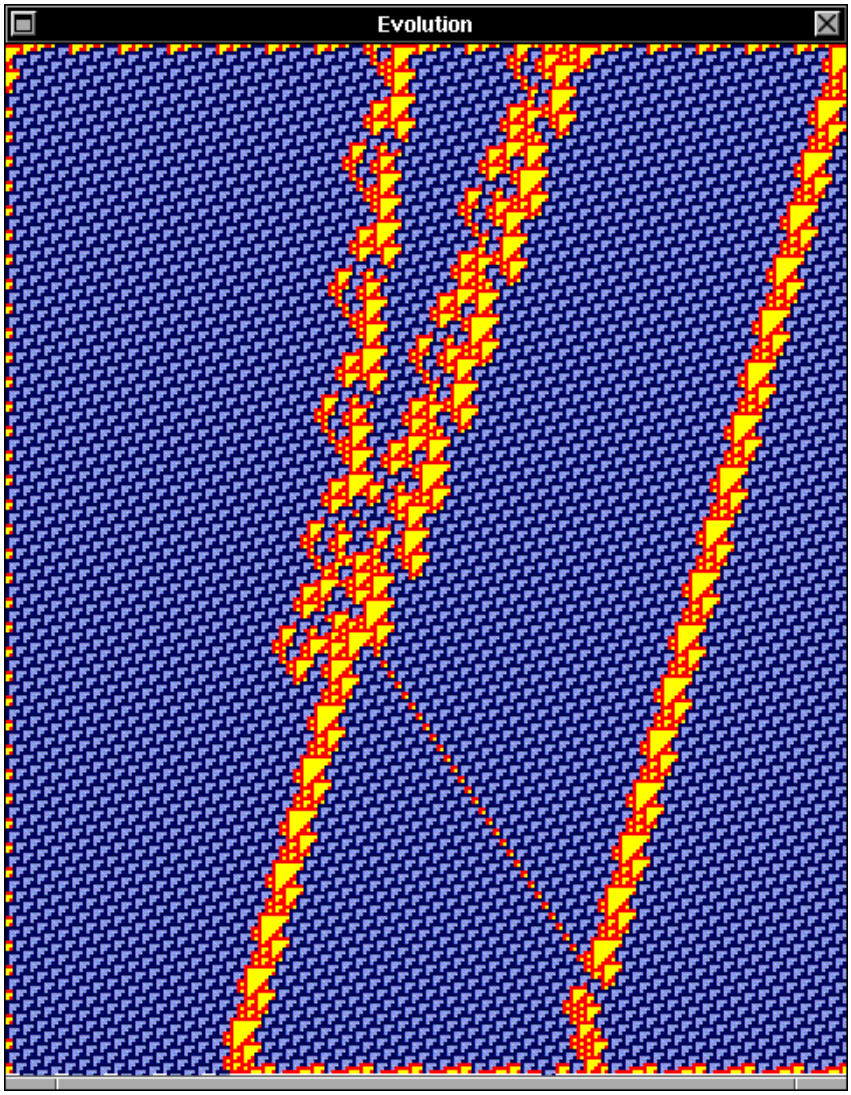

Figure 4.519: Collisions of glider F, F(p1)(G)-e(p1)-G(p1)(A2)=A,E

4.13.2 Collisions of glider F with glider H

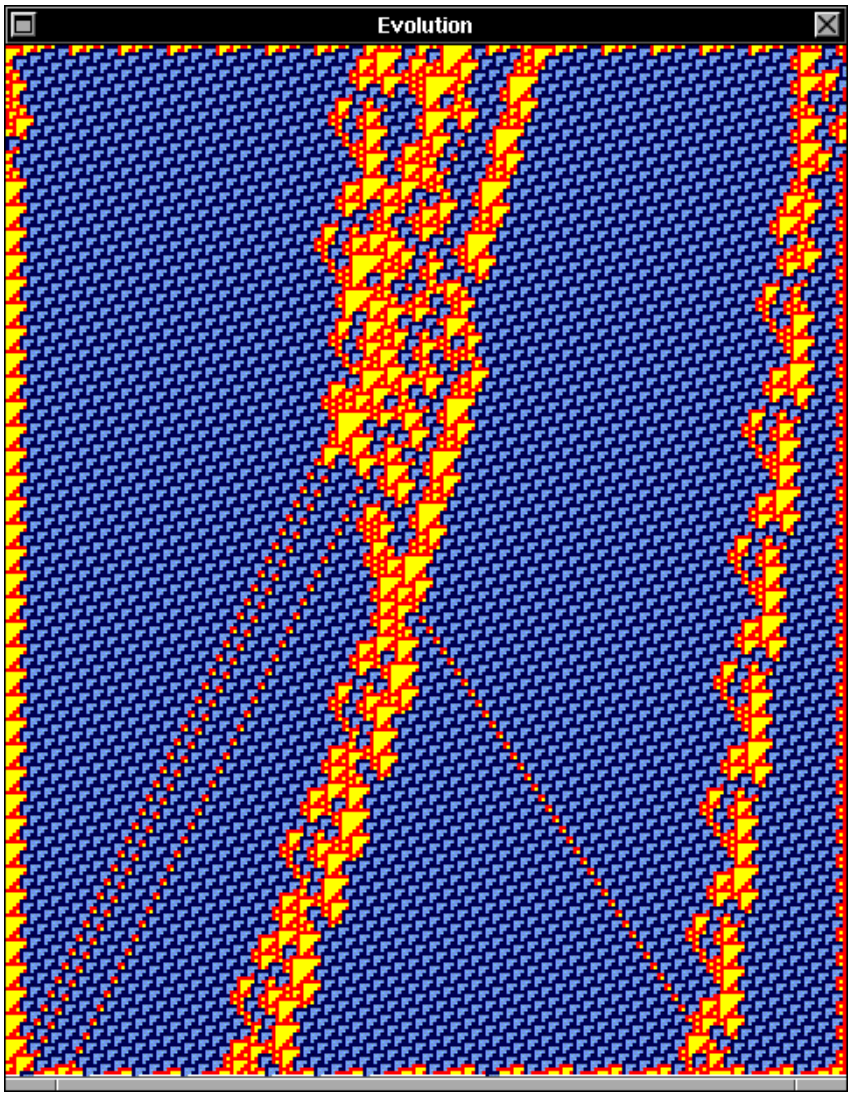

Figure 4.520: Collisions of glider F, F(p1)(A)-H(p1)(A)=2B,B,A,G

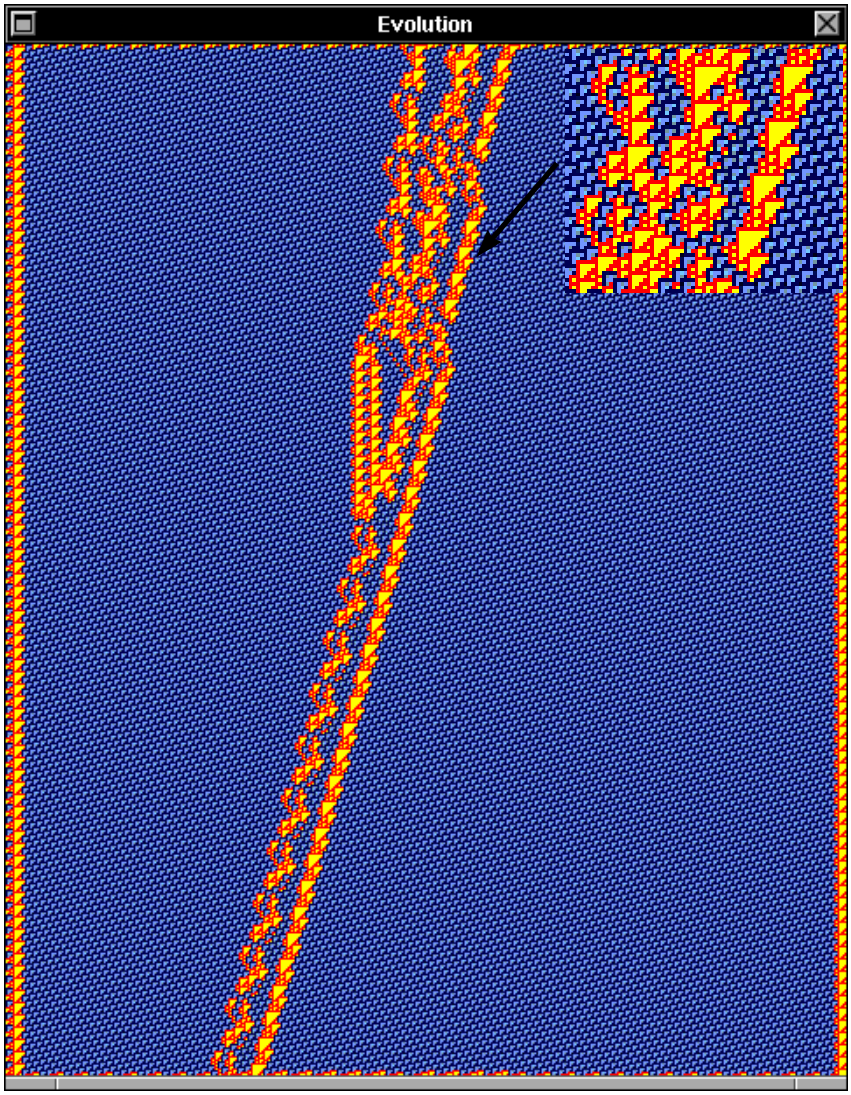

Figure 4.521: Collisions of glider F, F(p1)(G)-H(p1)(A)=E,Ebar

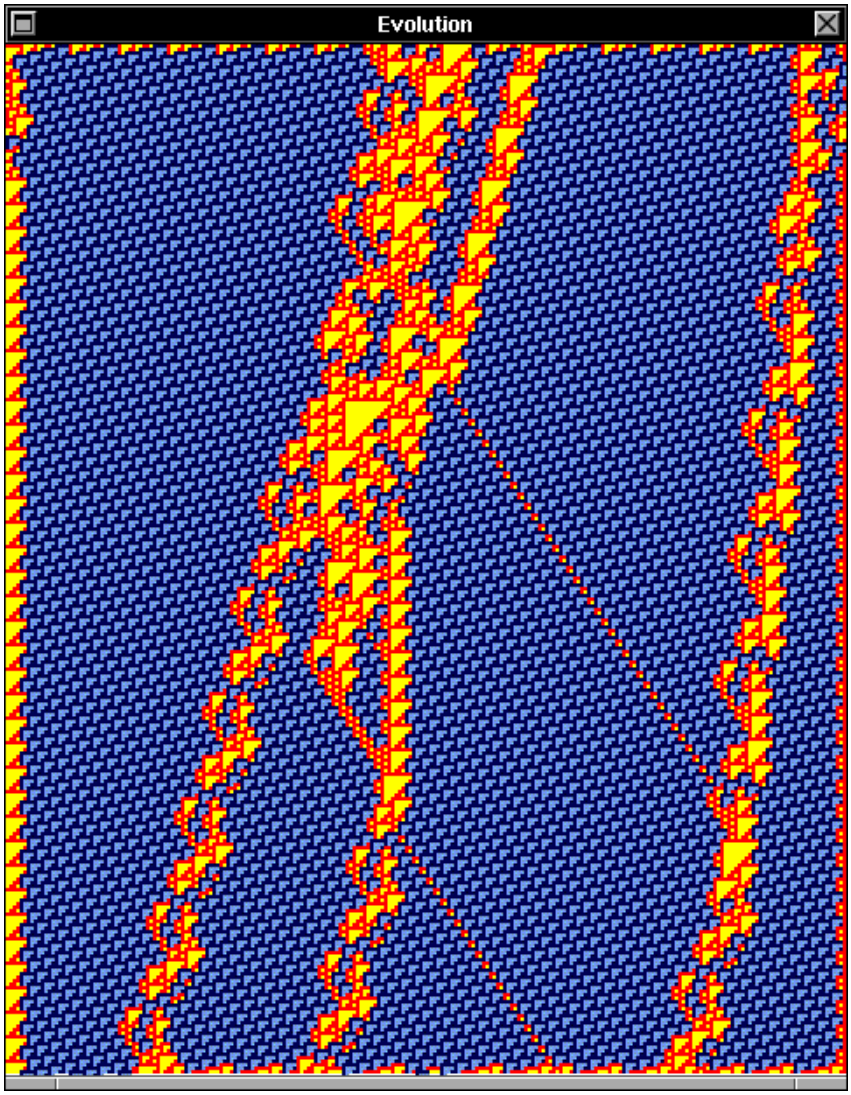

Figure 4.522: Collisions of glider F, F(p1)(G)-H(p1)(A)=A,Ebar,Ebar,A

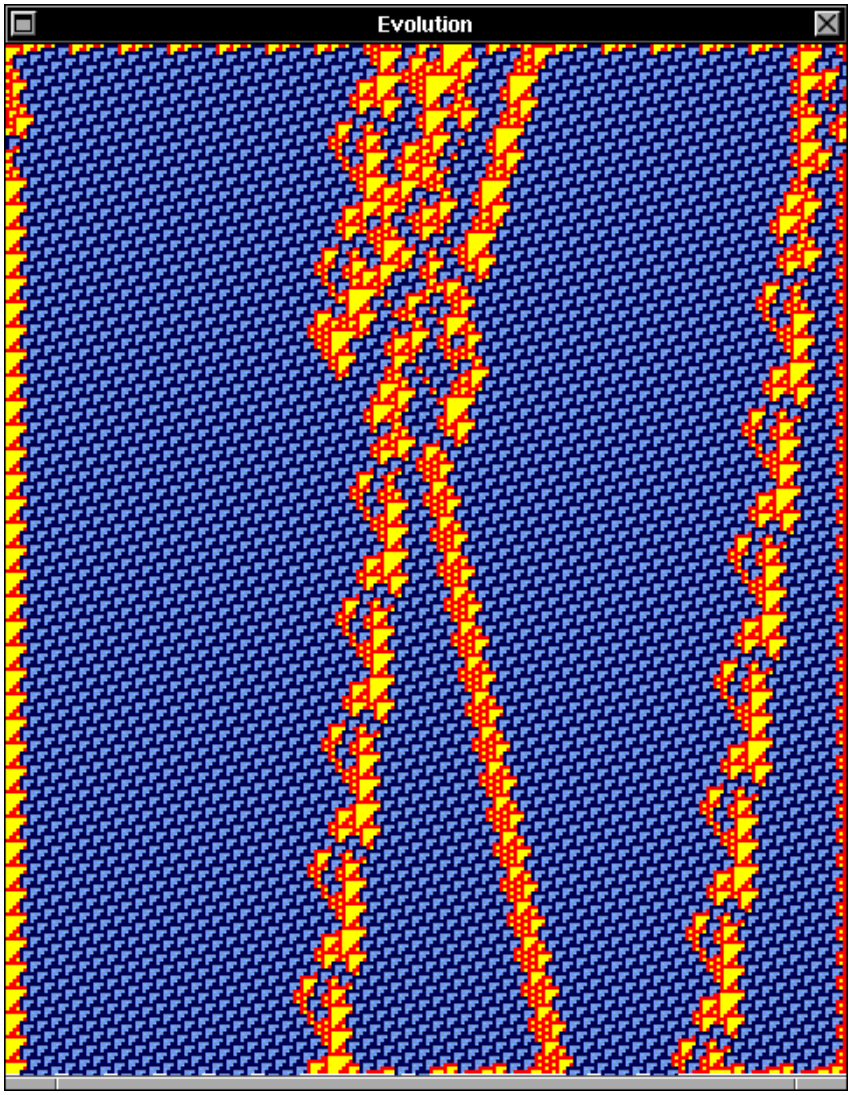

Figure 4.523: Collisions of glider F, F(p1)(A2)-H(p1)(A)=F,D1

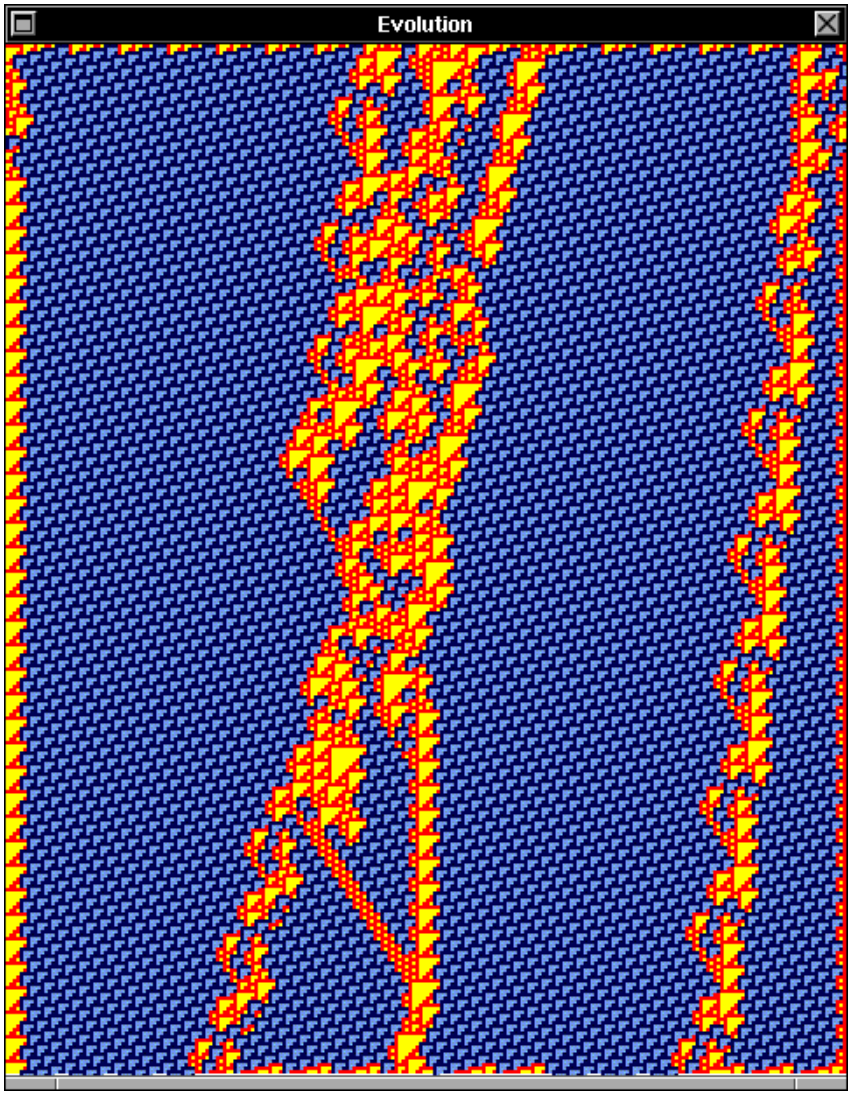

Figure 4.524: Collisions of glider F, F(p1)(A)-H(p1)(B)=Ebar,E

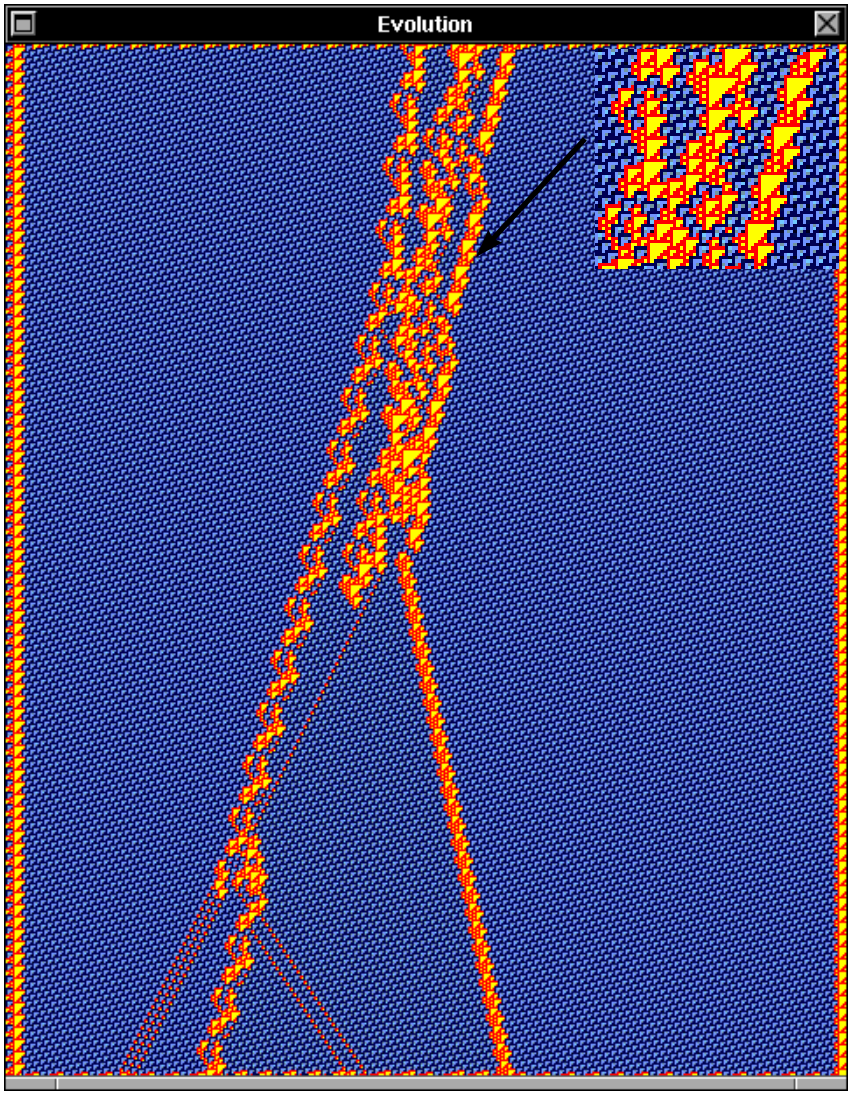

Figure 4.525: Collisions of glider F, F(p1)(G)-H(p1)(B)=3B,Ebar

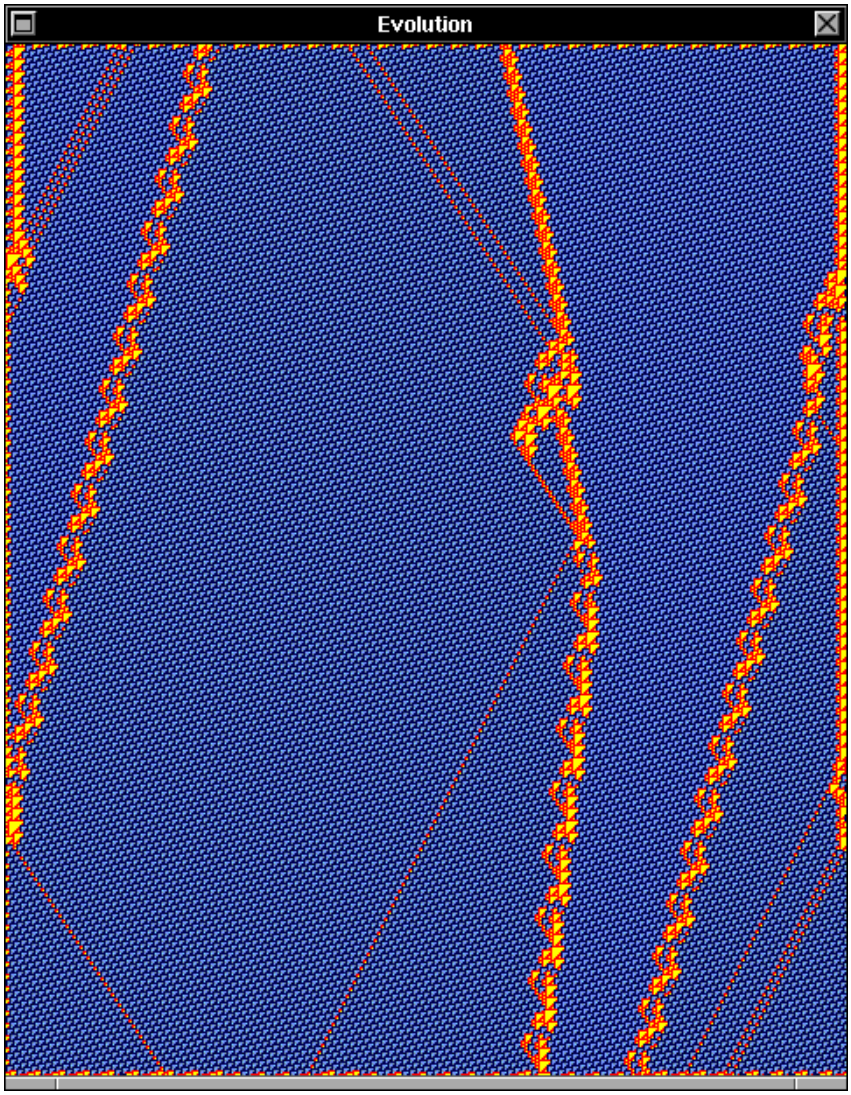

Figure 4.526: continue collision, F(p1)(G)-H(p1)(B)

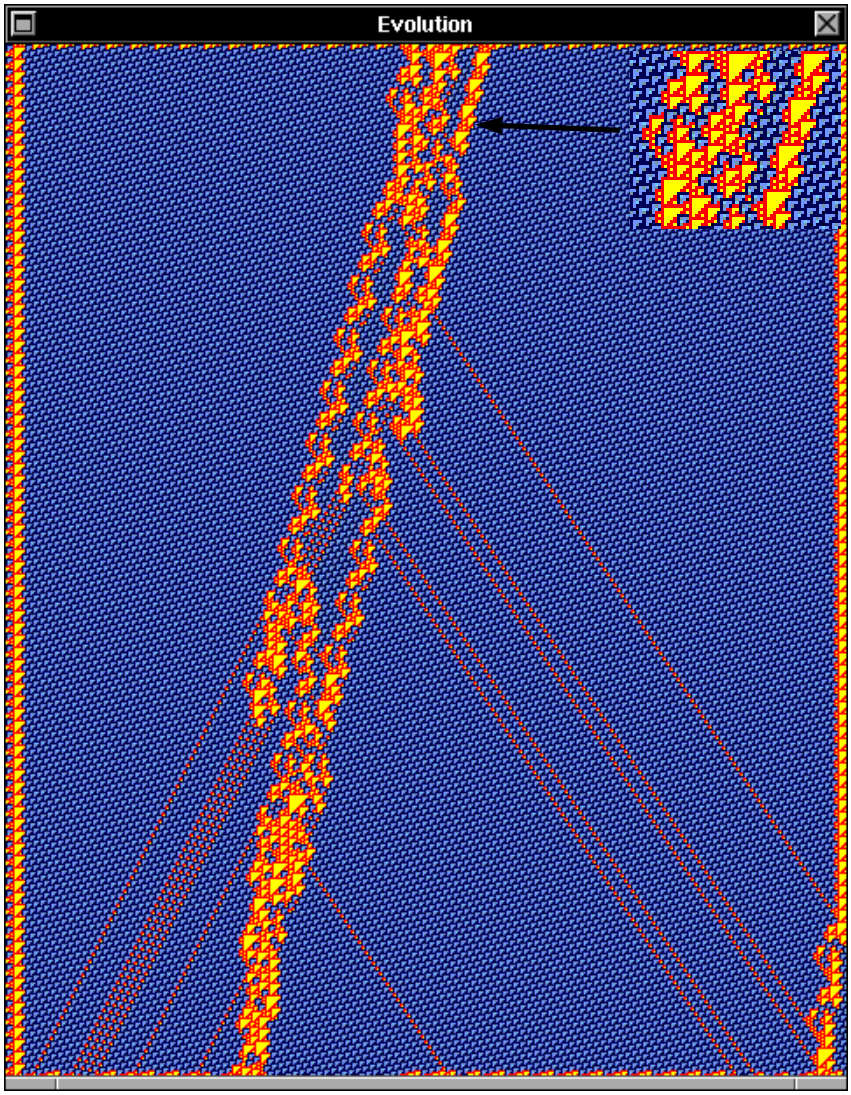

Figure 4.527: Collisions of glider F, F(p1)(H)-H(p1)(B)=A,2A,2A,B,4B,B,A,B,2A,B,2A

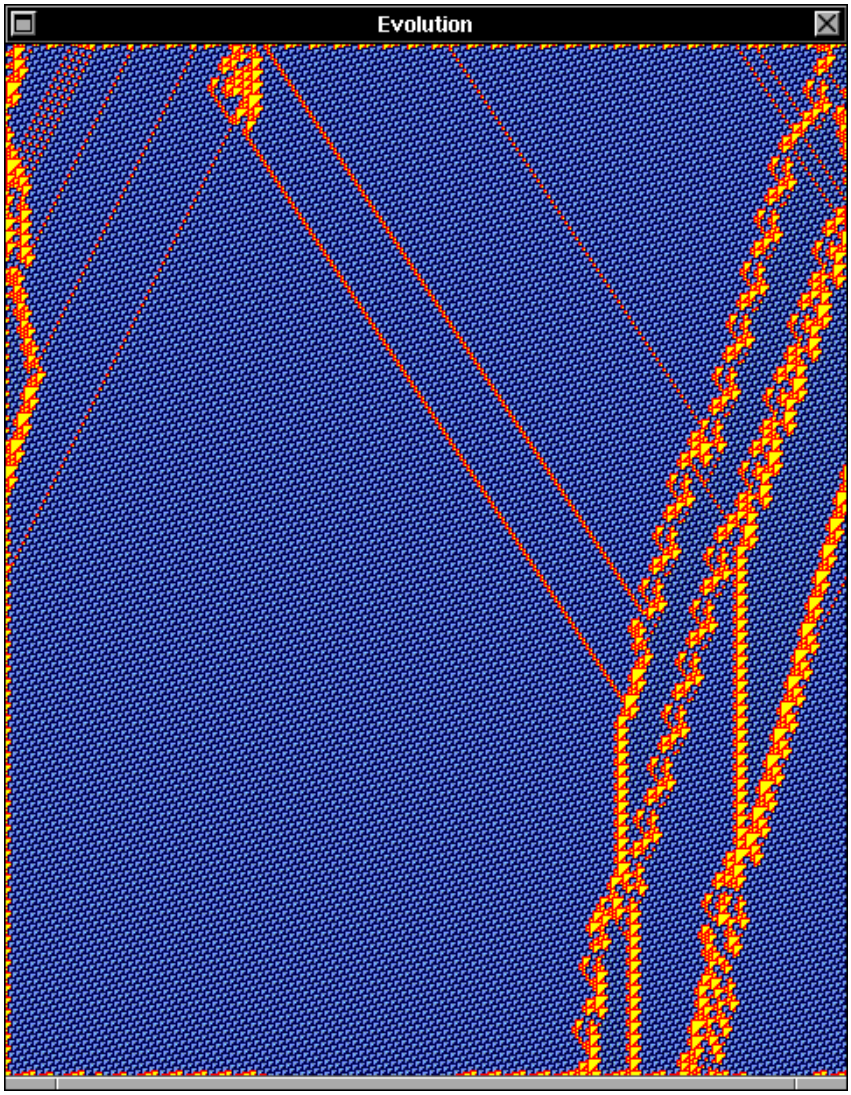

Figure 4.528: continue collision, F(p1)(H)-H(p1)(B)

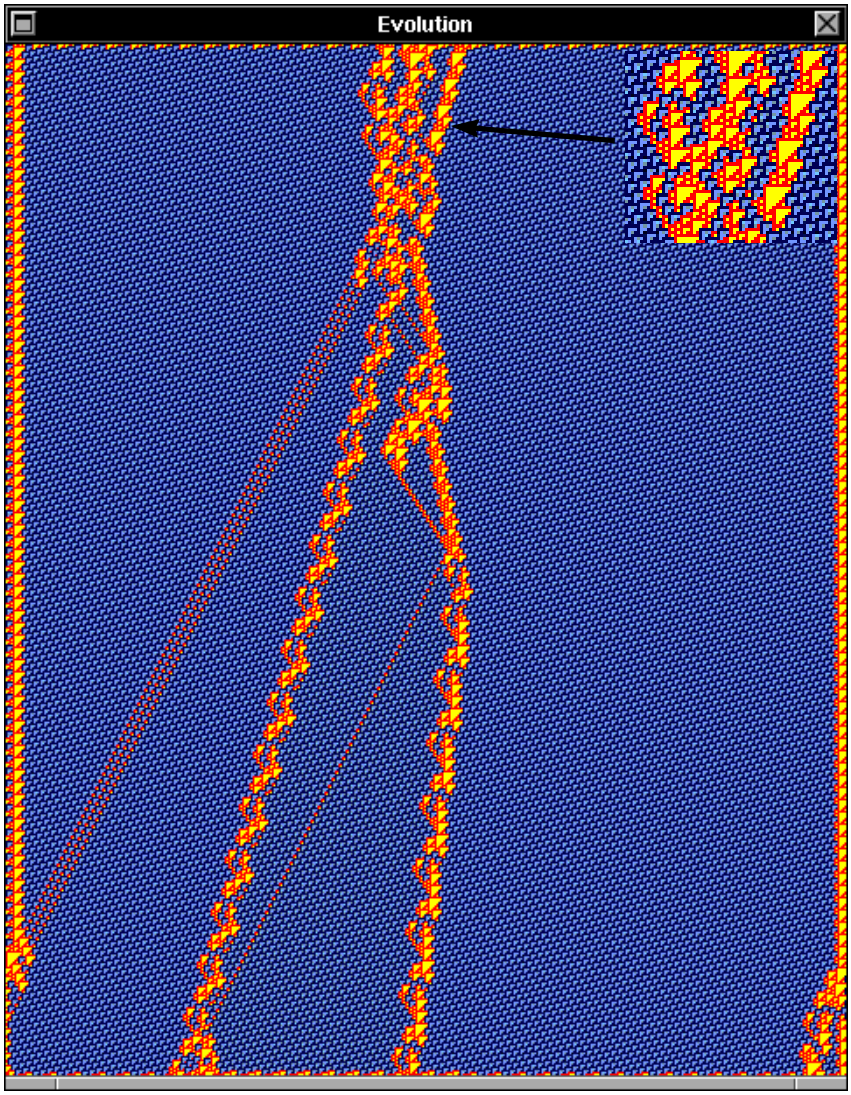

Figure 4.529: Collisions of glider F, F(p1)(A2)-H(p1)(B)=3B,Ebar,Ebar,A

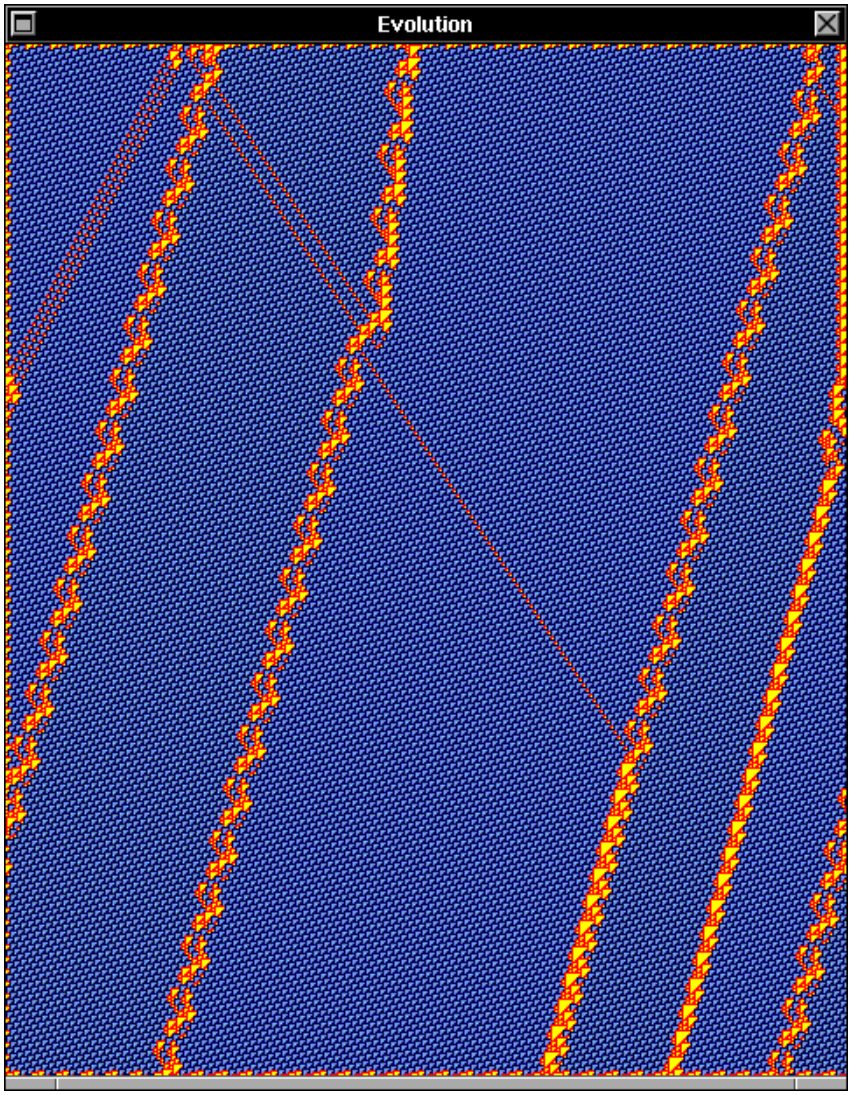

Figure 4.530: continue collision, F(p1)(A2)-H(p1)(B)

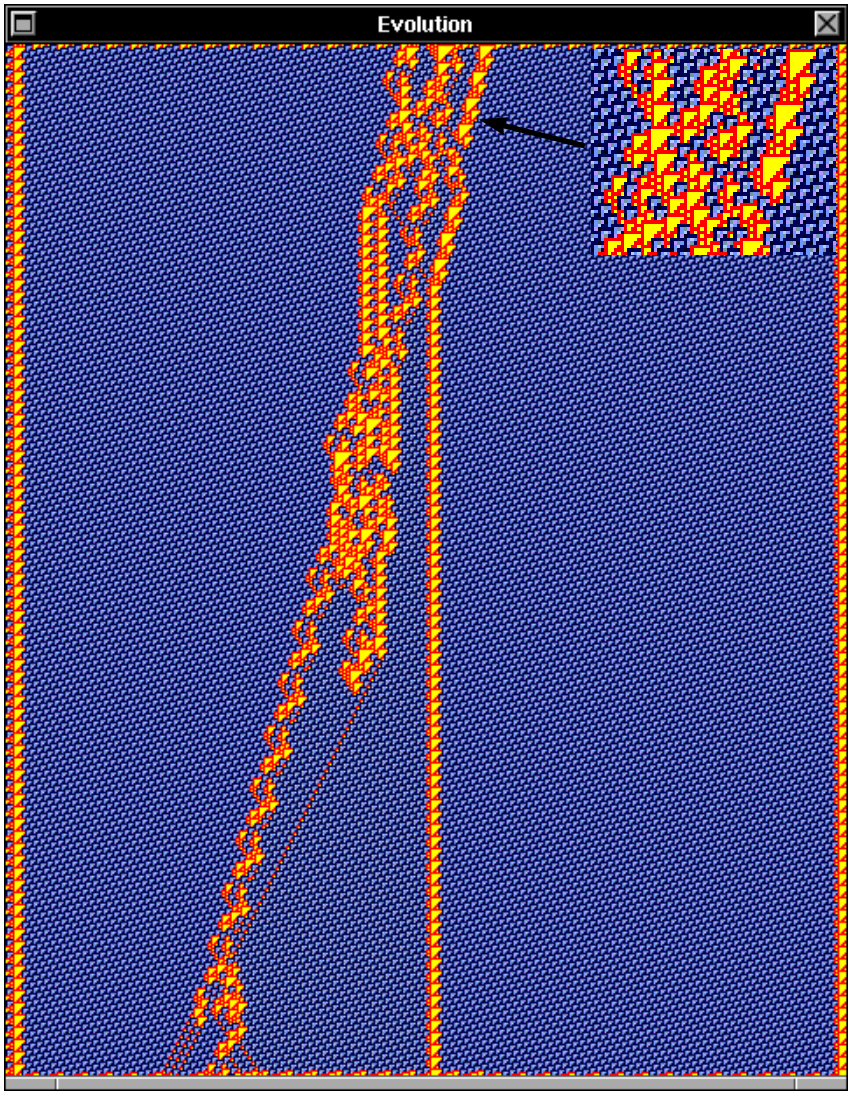

Figure 4.531: Collisions of glider F, F(p1)(A)-H(p1)(C)=3B,Ebar,C1

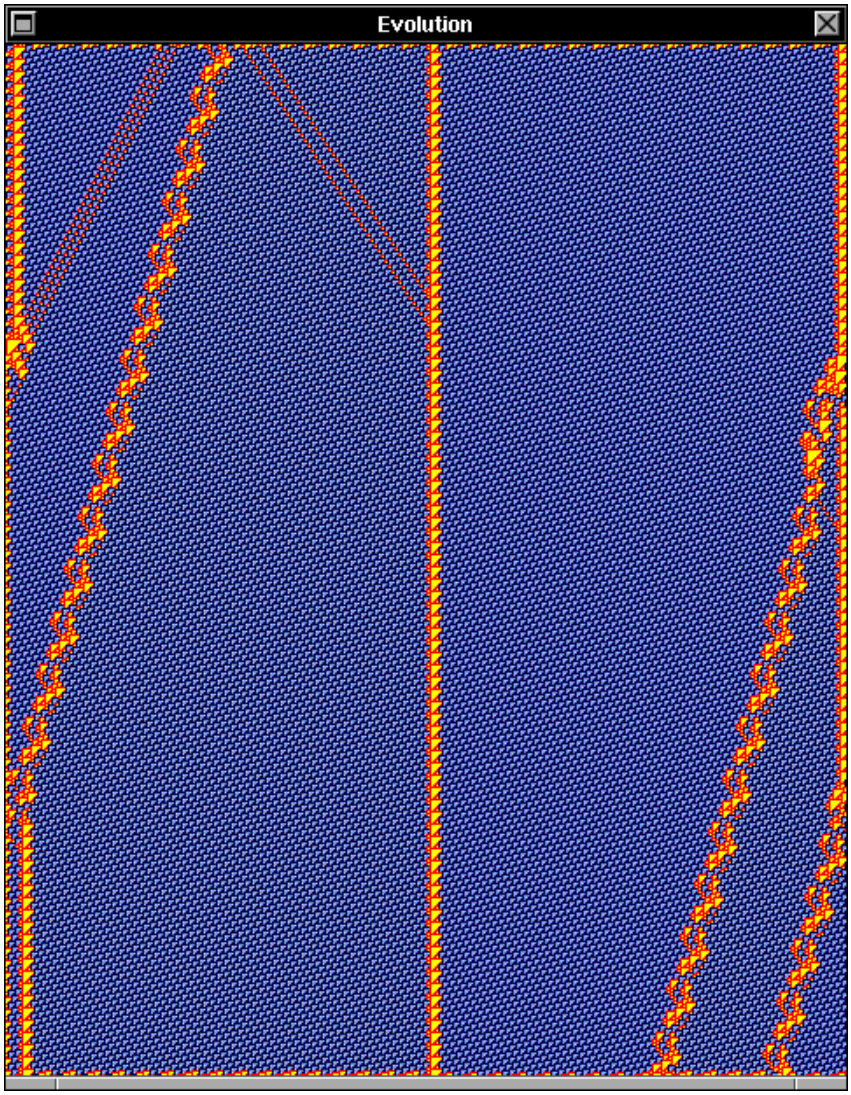

Figure 4.532: continue collision, F(p1)(A)-H(p1)(C)

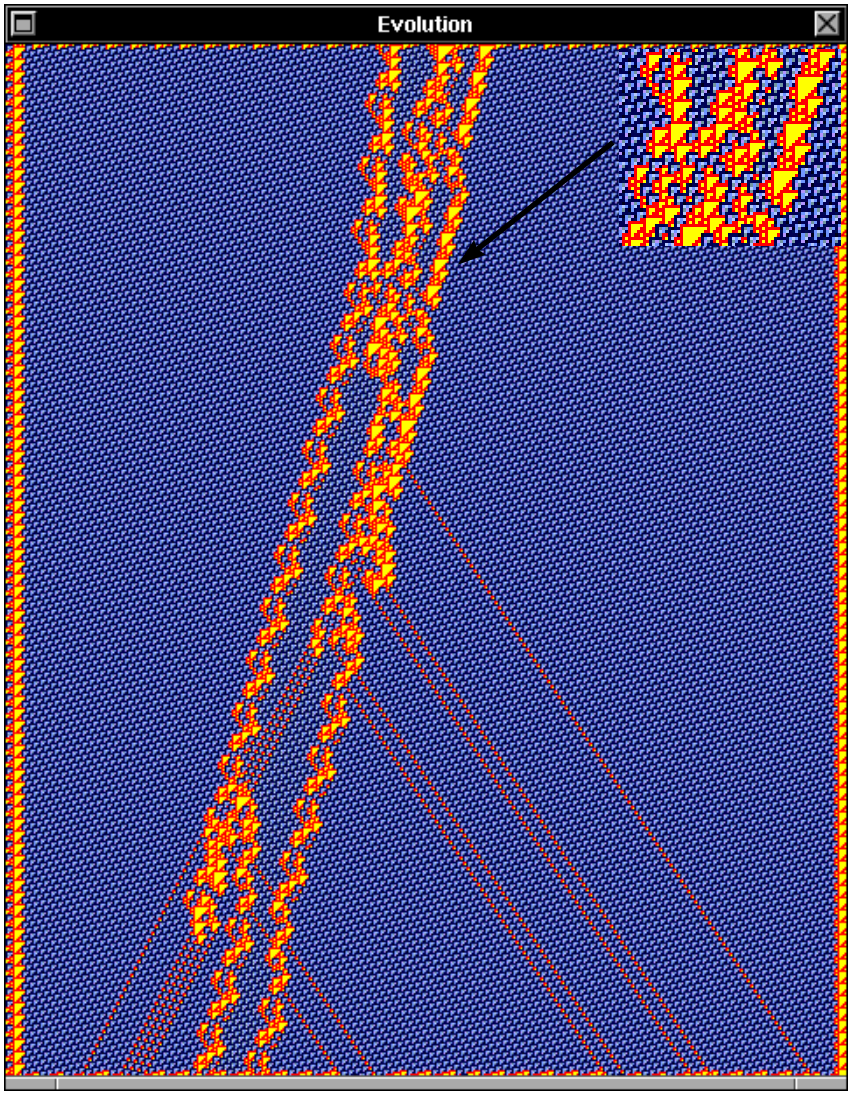

Figure 4.533: Collisions of glider F, F(p1)(G)-H(p1)(C)=A,2A,2A,B,4B,Ebar,A,A,Ebar

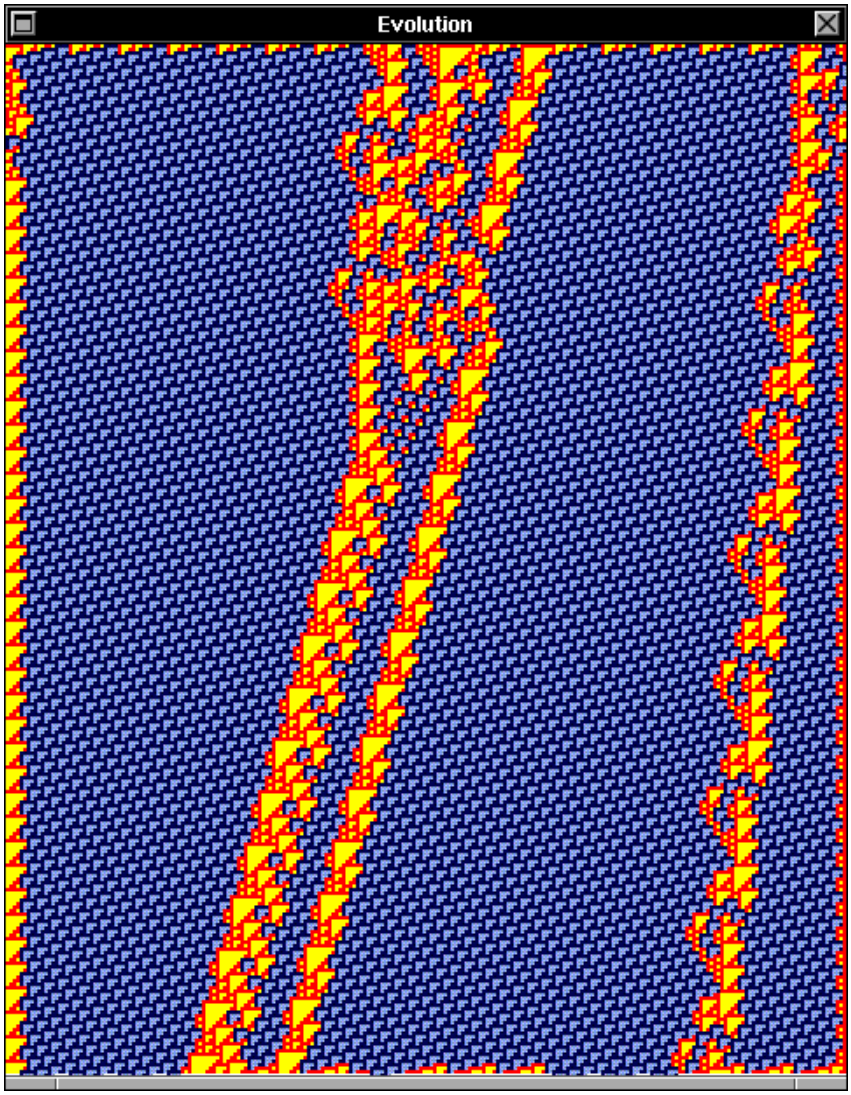

Figure 4.534: Collisions of glider F, F(p1)(H)-H(p1)(C)=E,E3

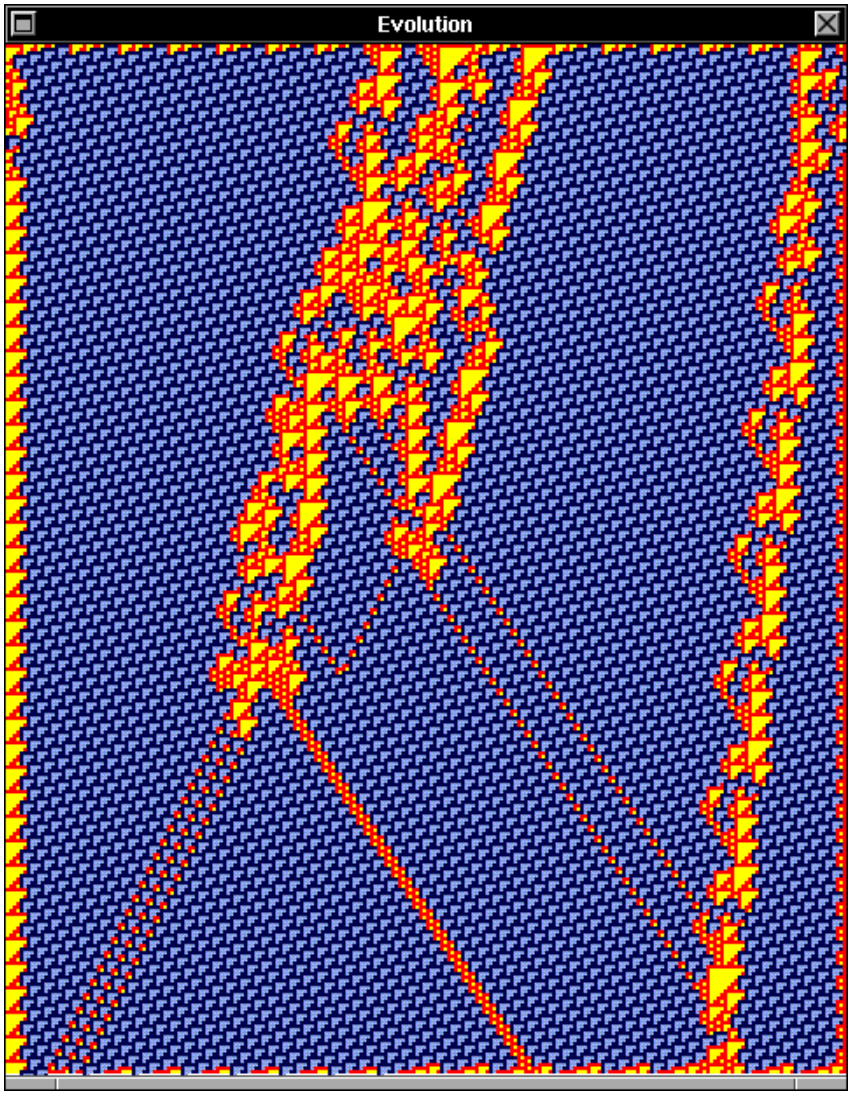

Figure 4.535: Collisions of glider F, F(p1)(A2)-H(p1)(C)=A,A,3B,3A

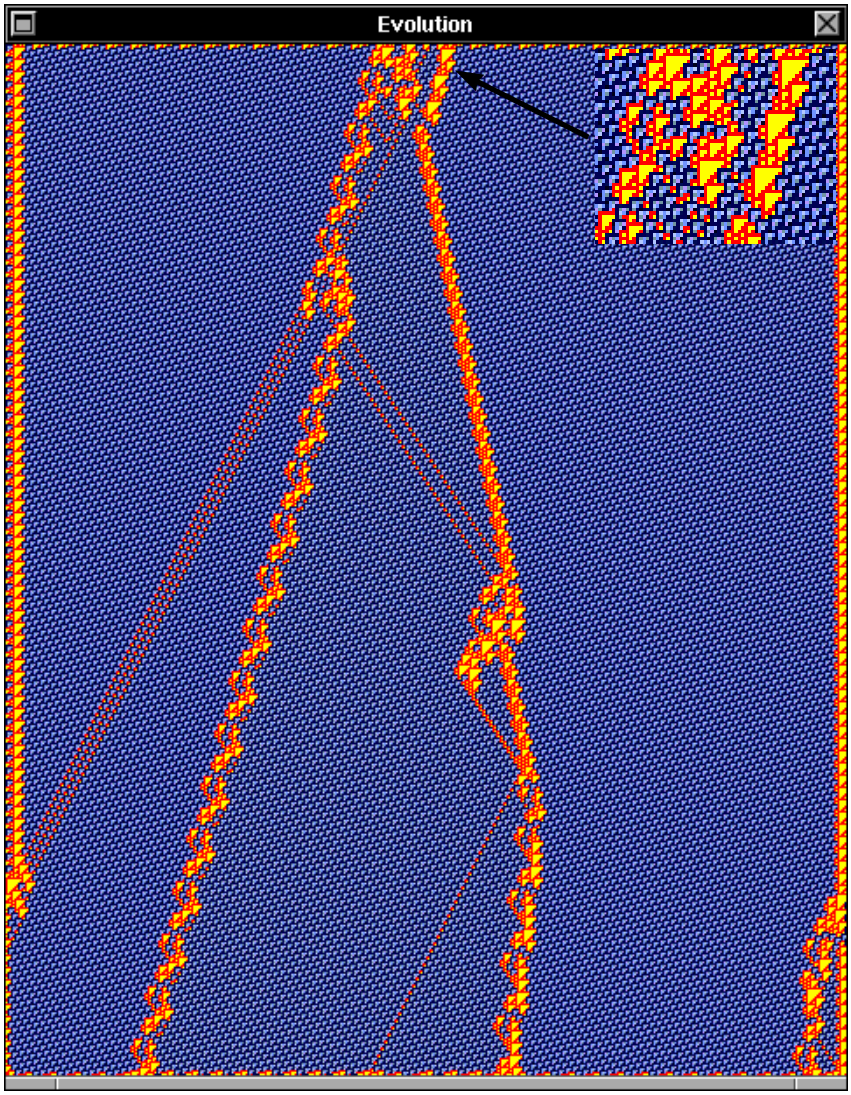

Figure 4.536: Collisions of glider F, F(p1)(A)-H(p1)(G)=3B,Ebar

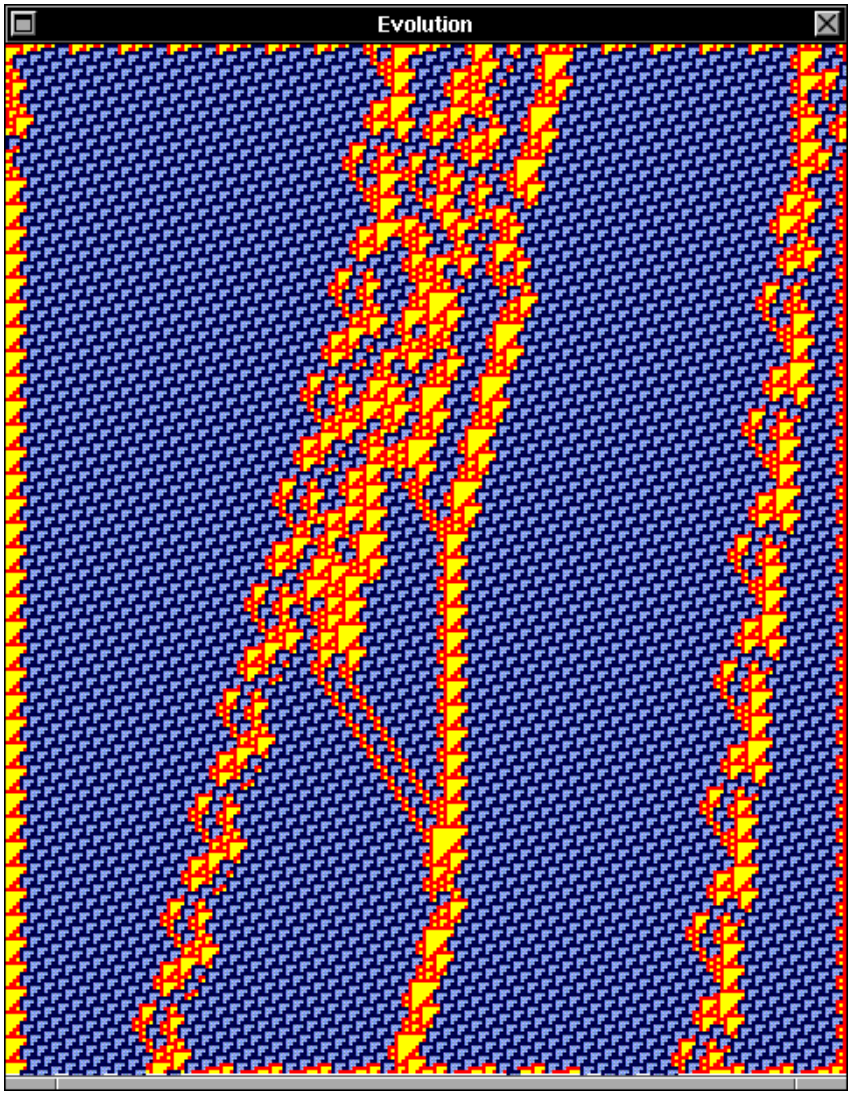

Figure 4.537: Collisions of glider F, F(p1)(G)-H(p1)(G)=Ebar,E

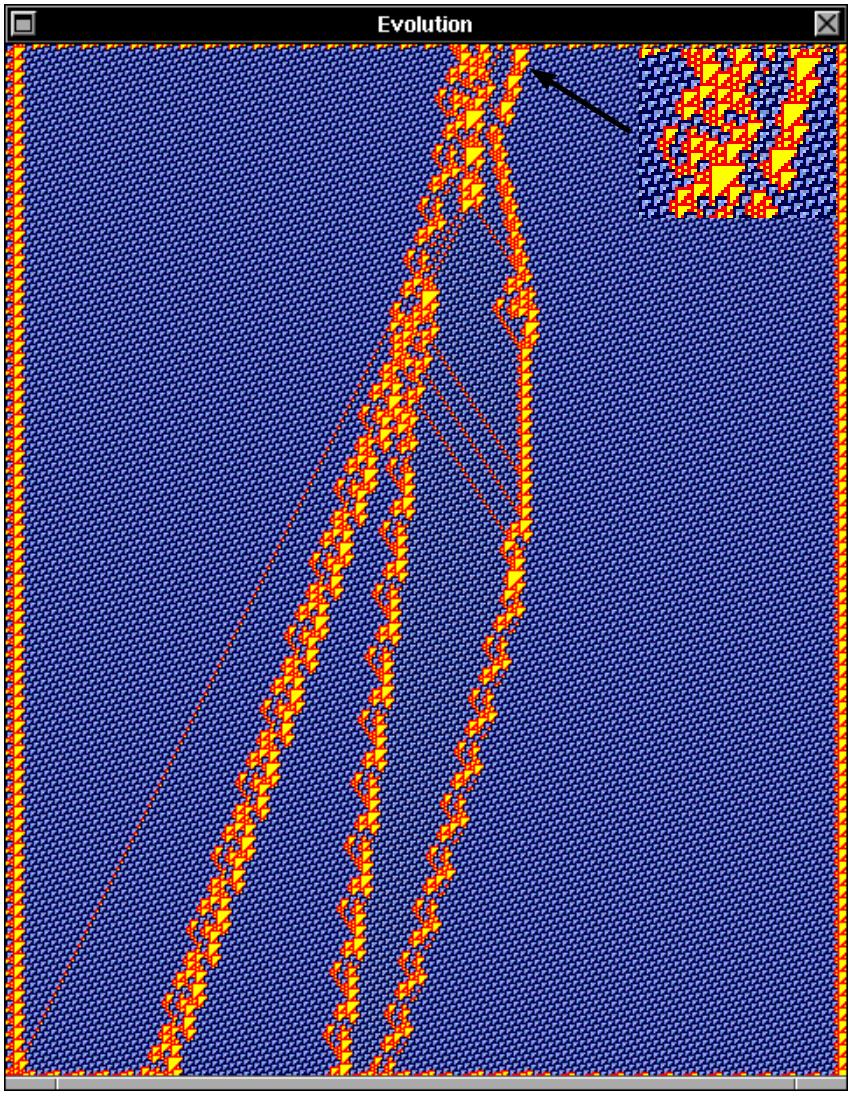

Figure 4.538: Collisions of glider F, F(p1)(H)-H(p1)(G)=B,G,Ebar,F

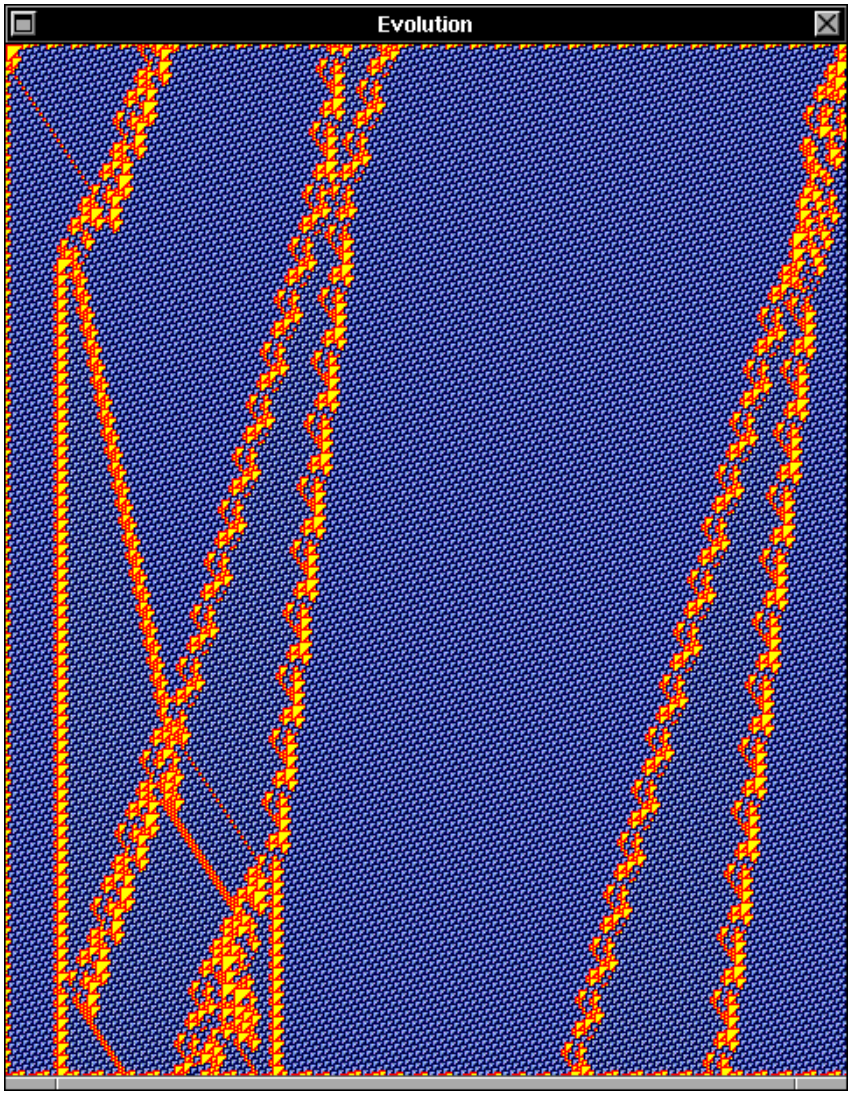

Figure 4.539: continue collision, F(p1)(H)-H(p1)(G)

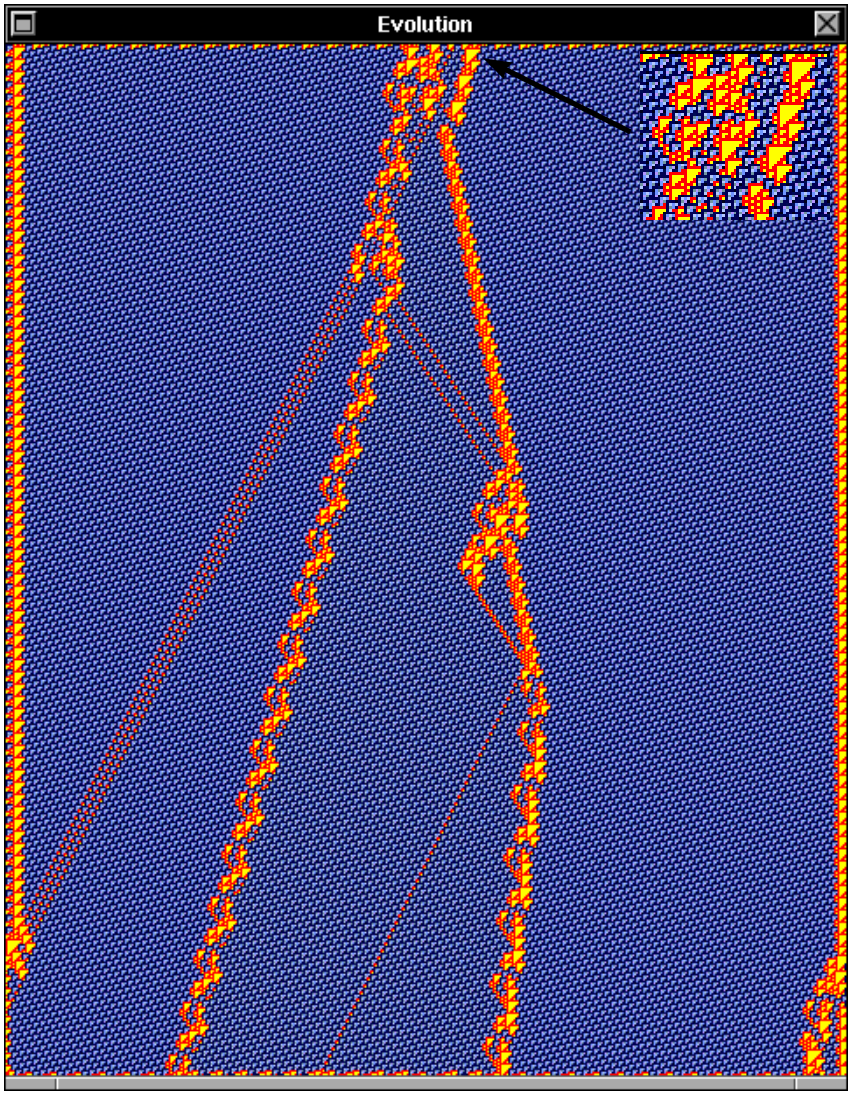

Figure 4.540: Collisions of glider F, F(p1)(A2)-H(p1)(G)=3B,Ebar

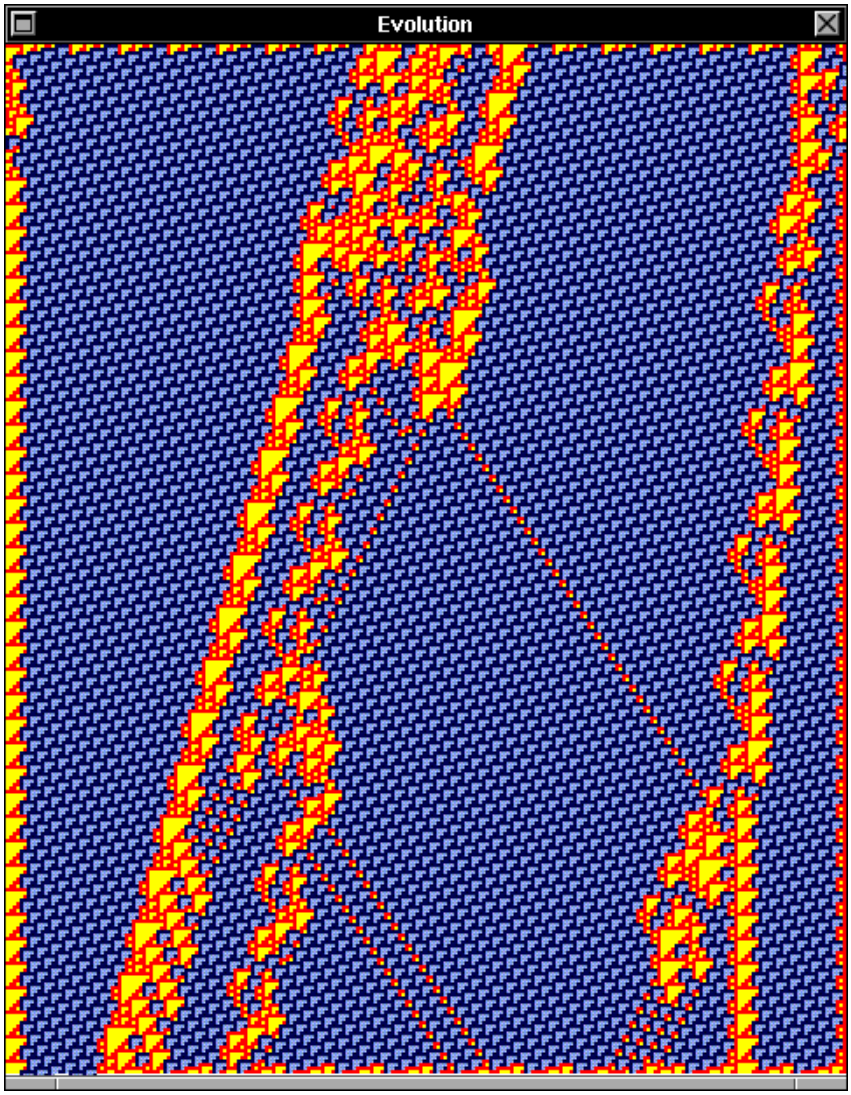

Figure 4.541: Collisions of glider F, F(p1)(A)-H(p1)(H)=A,Ebar,A,A,E4

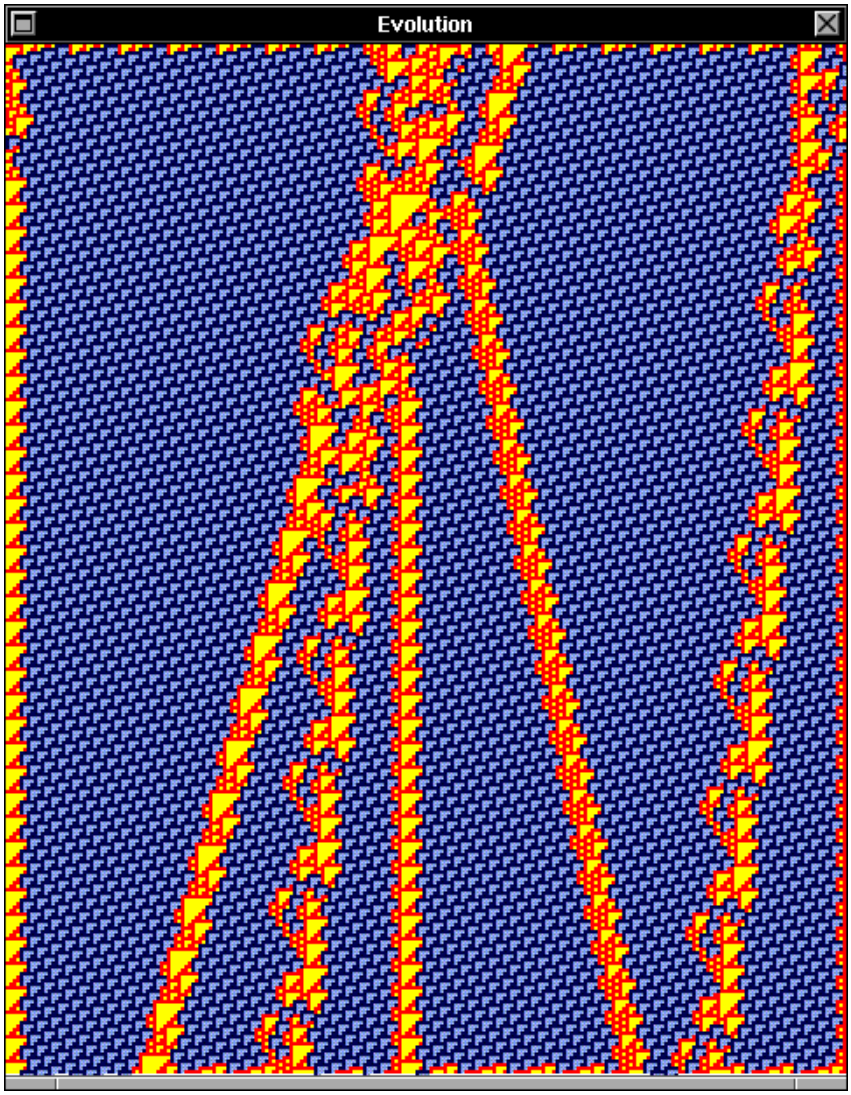

Figure 4.542: Collisions of glider F, F(p1)(H)-H(p1)(H)=D1,E,F,C1

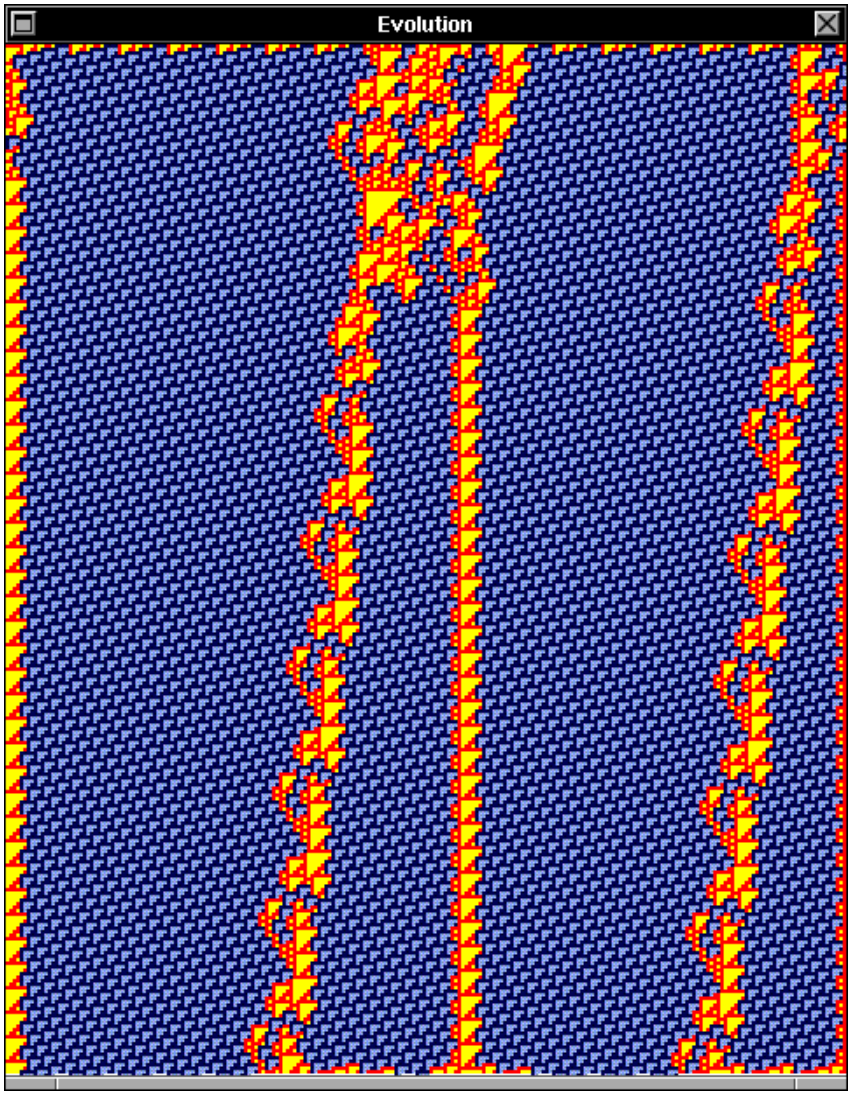

Figure 4.543: Collisions of glider F, F(p1)(A2)-H(p1)(H)=F,C3

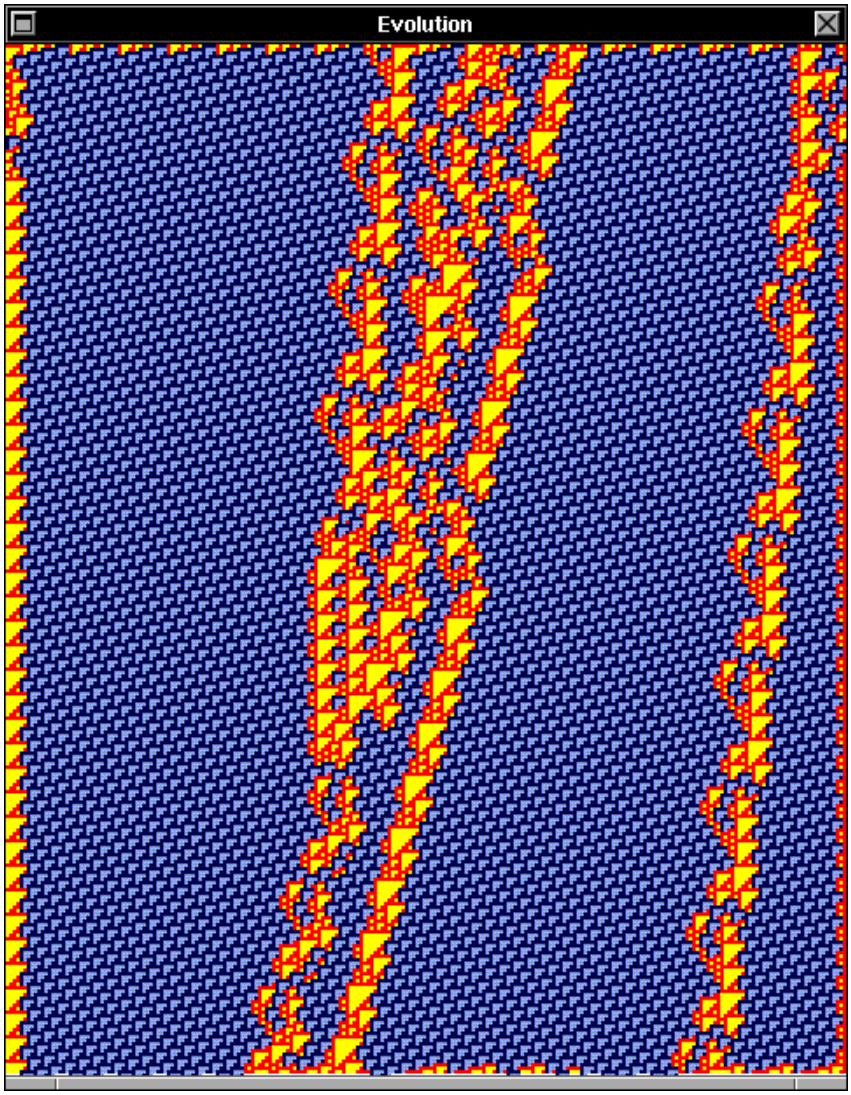

Figure 4.544: Collisions of glider F, F(p1)(G)-H(p1)(A2)=E,Ebar

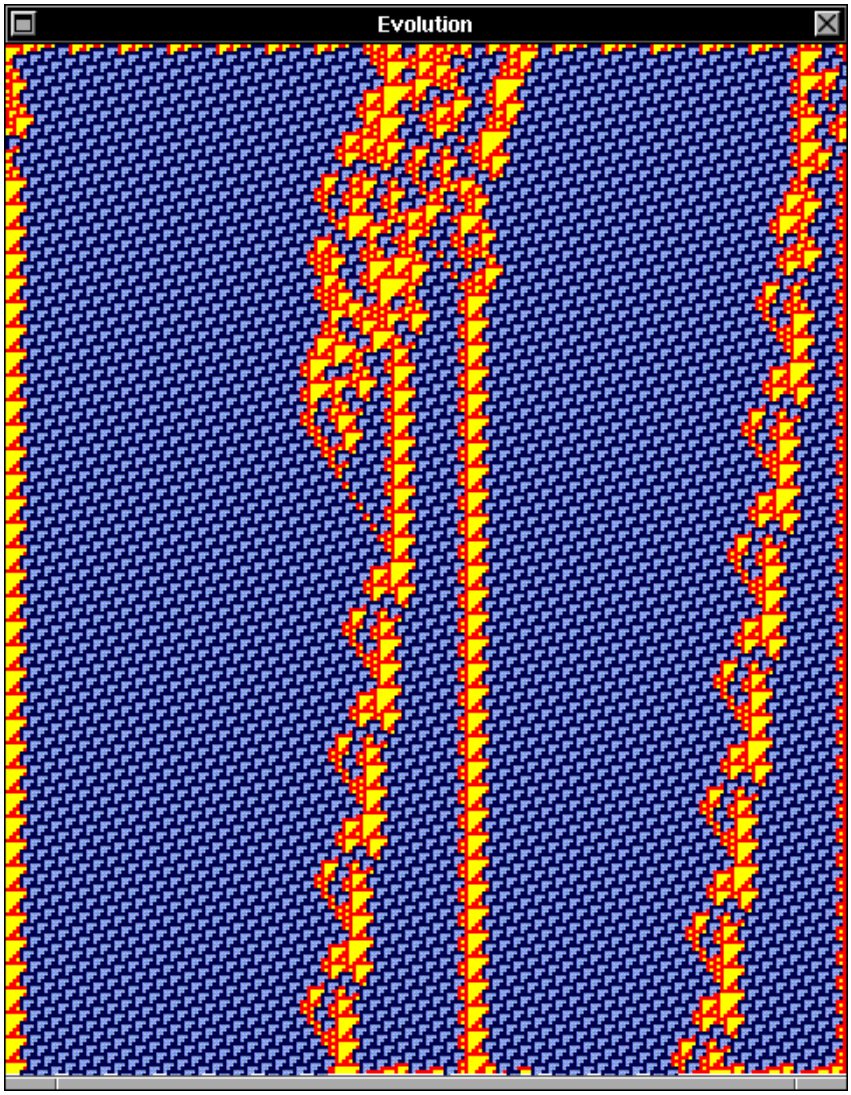

Figure 4.545: Collisions of glider F, F(p1)(H)-H(p1)(A2)=C3,F

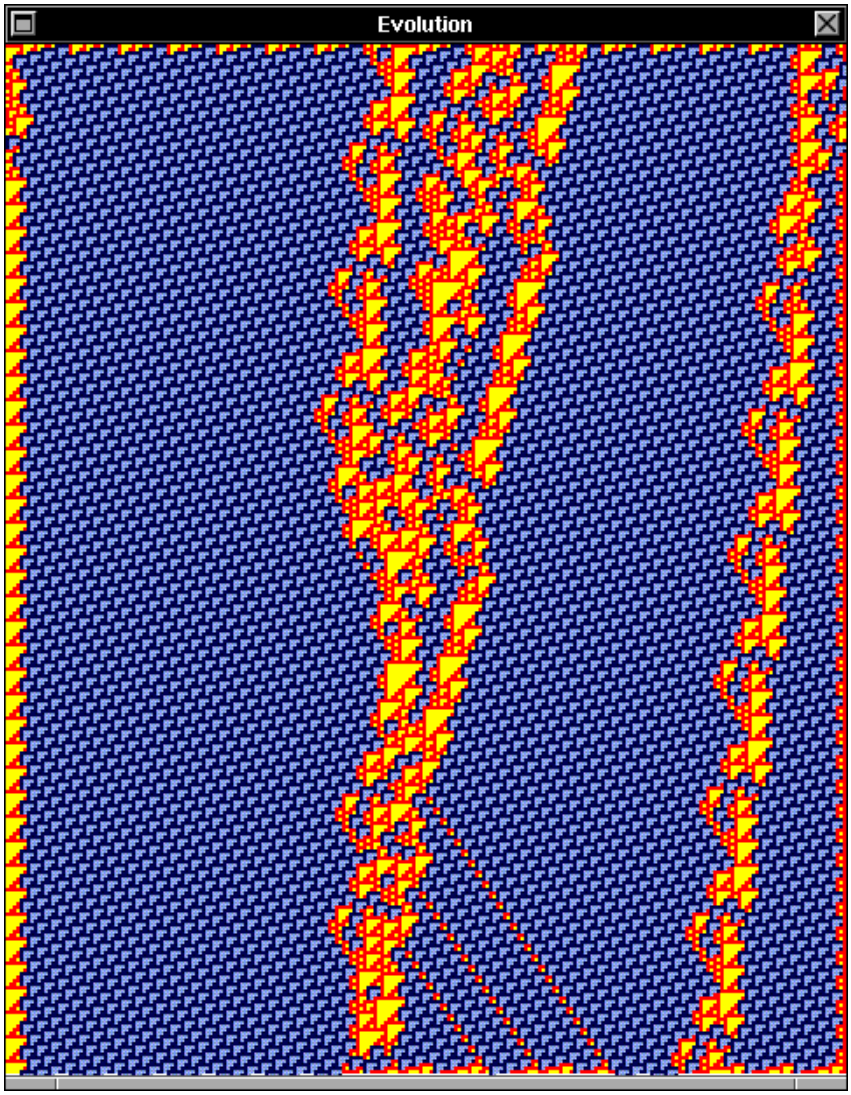

Figure 4.546: Collisions of glider F, F(p1)(G)-H(p1)(B2)=A,A,A,2B,A

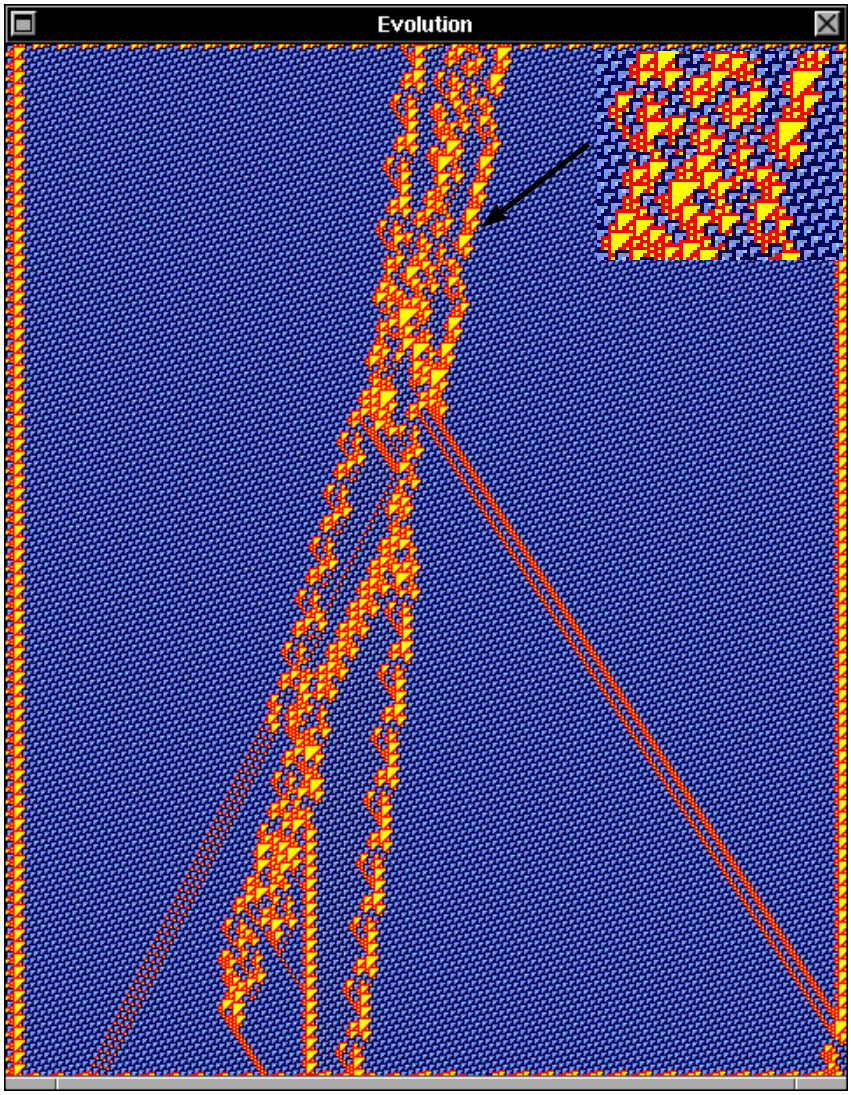

Figure 4.547: Collisions of glider F, F(p1)(G)-H(p1)(C2)=3A,2A,3B,Ebar,Ebar

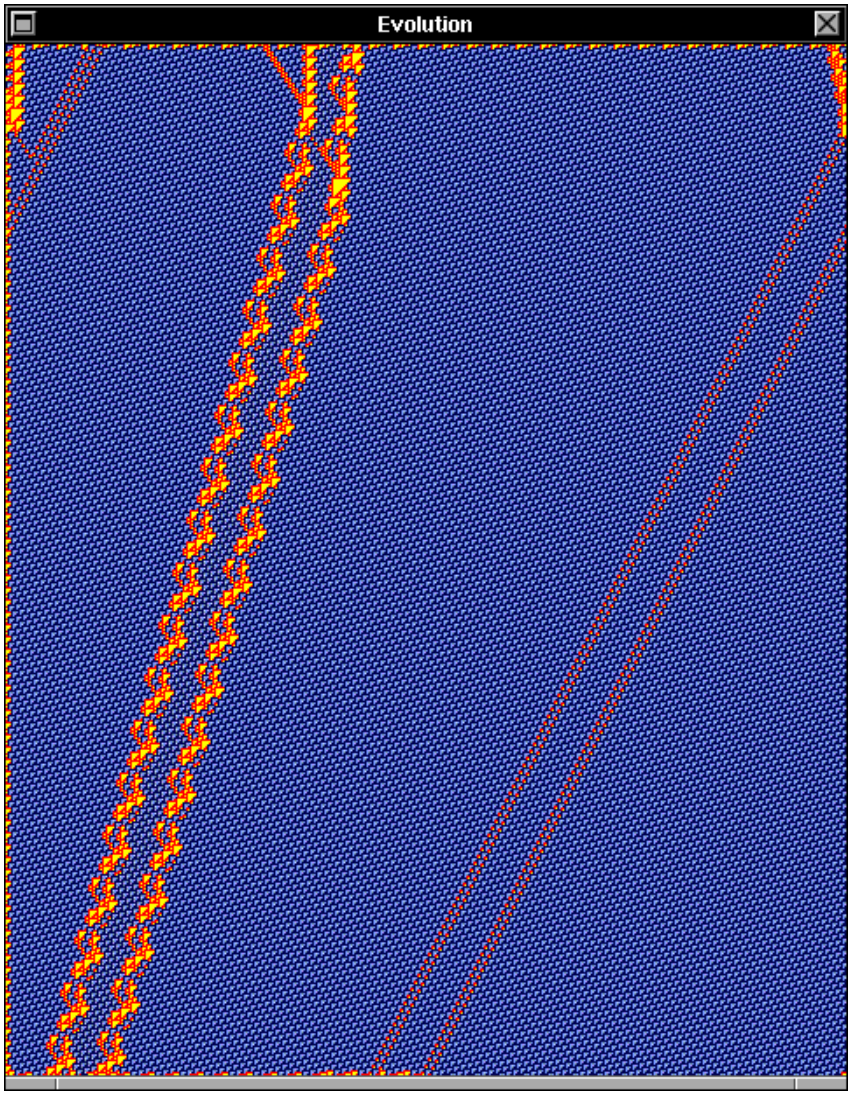

Figure 4.548: continue collision, F(p1)(G)-H(p1)(C2)

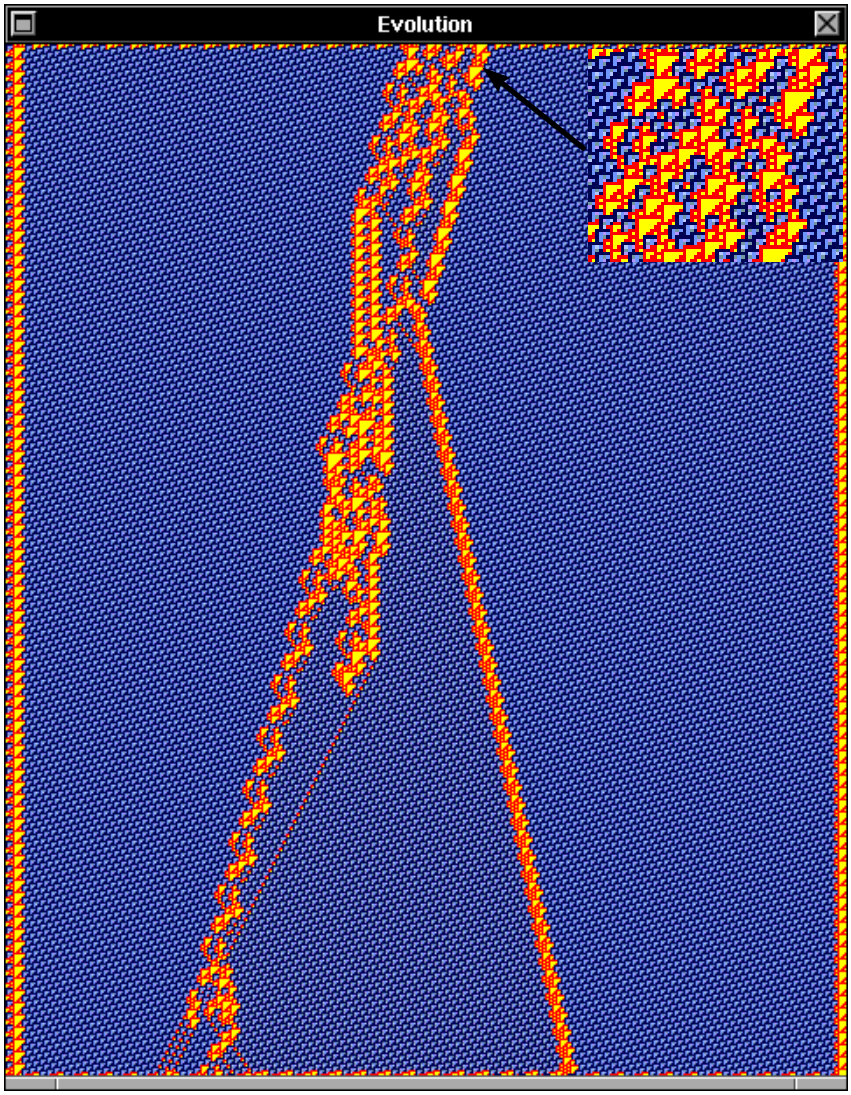

Figure 4.549: Collisions of glider F, F(p1)(A2)-H(p1)(D2)=3B,Ebar

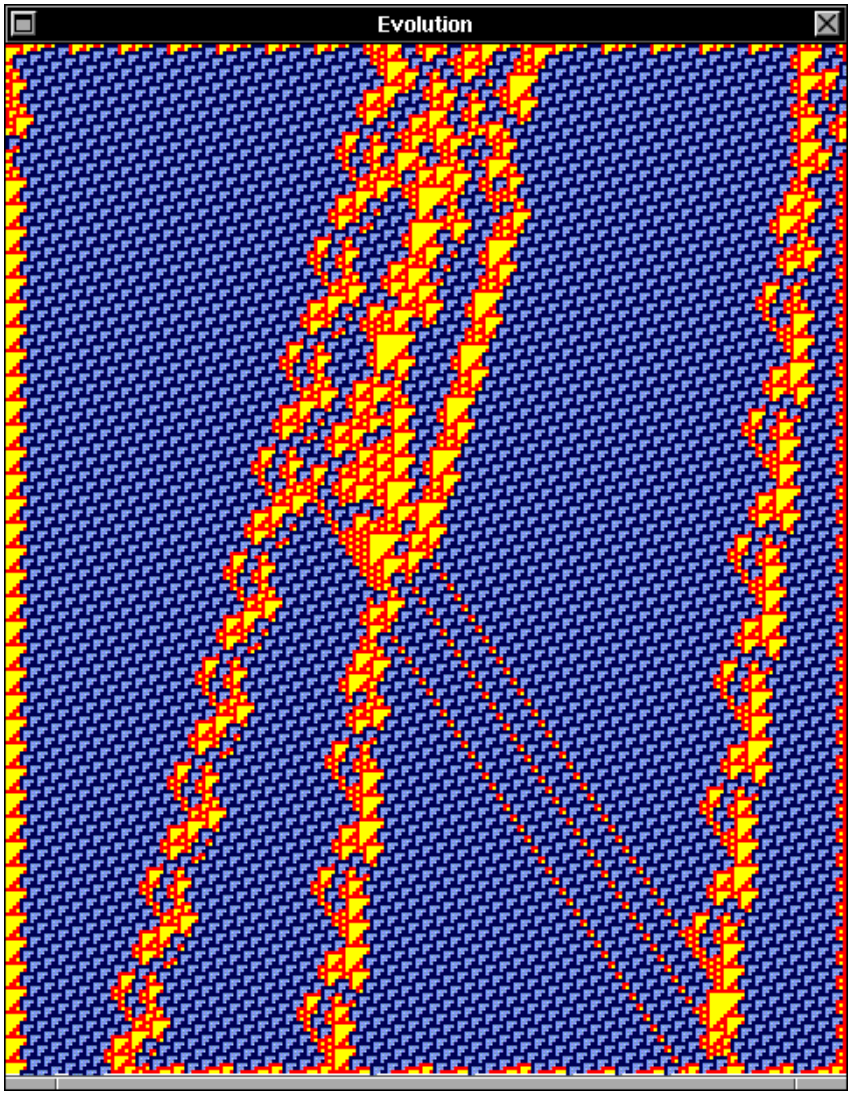

Figure 4.550: Collisions of glider F, F(p1)(H)-H(p1)(E2)=Ebar,A,A,A,F

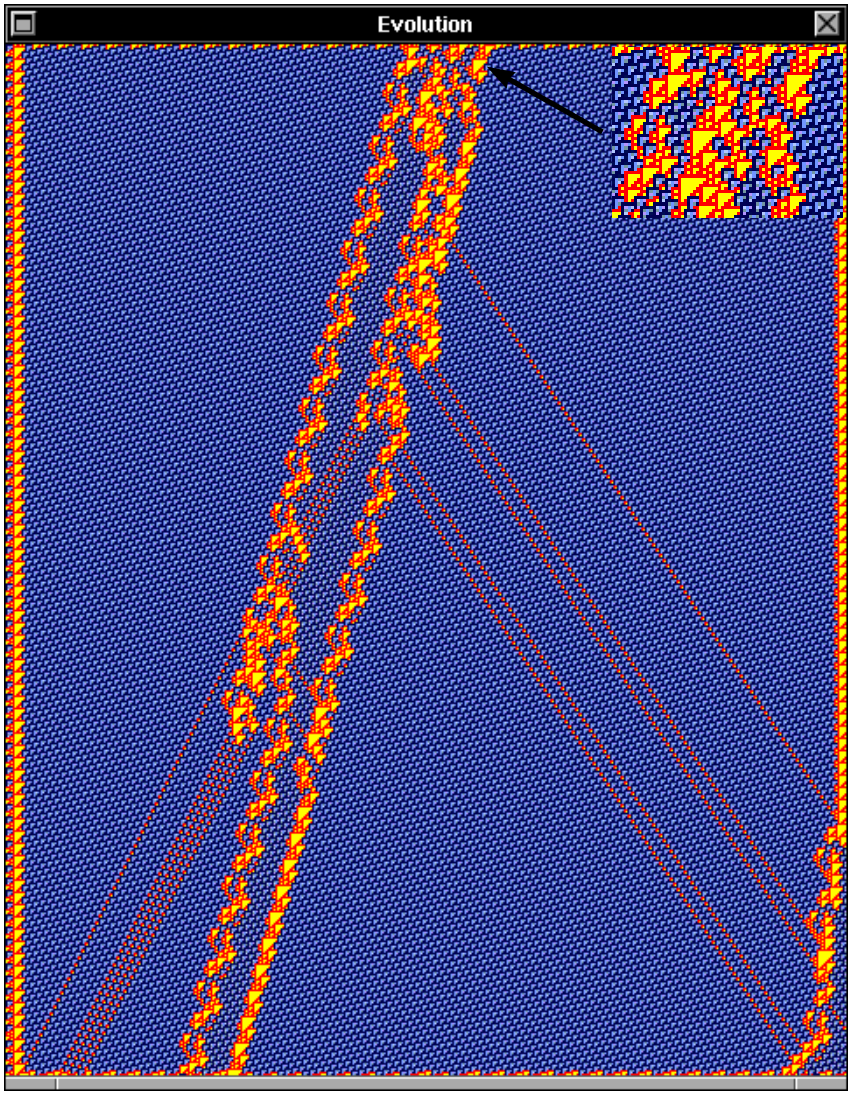

Figure 4.551: Collisions of glider F, F(p1)(A2)-H(p1)(E2)=A,A,A,A,A,B,4B,Ebar,E

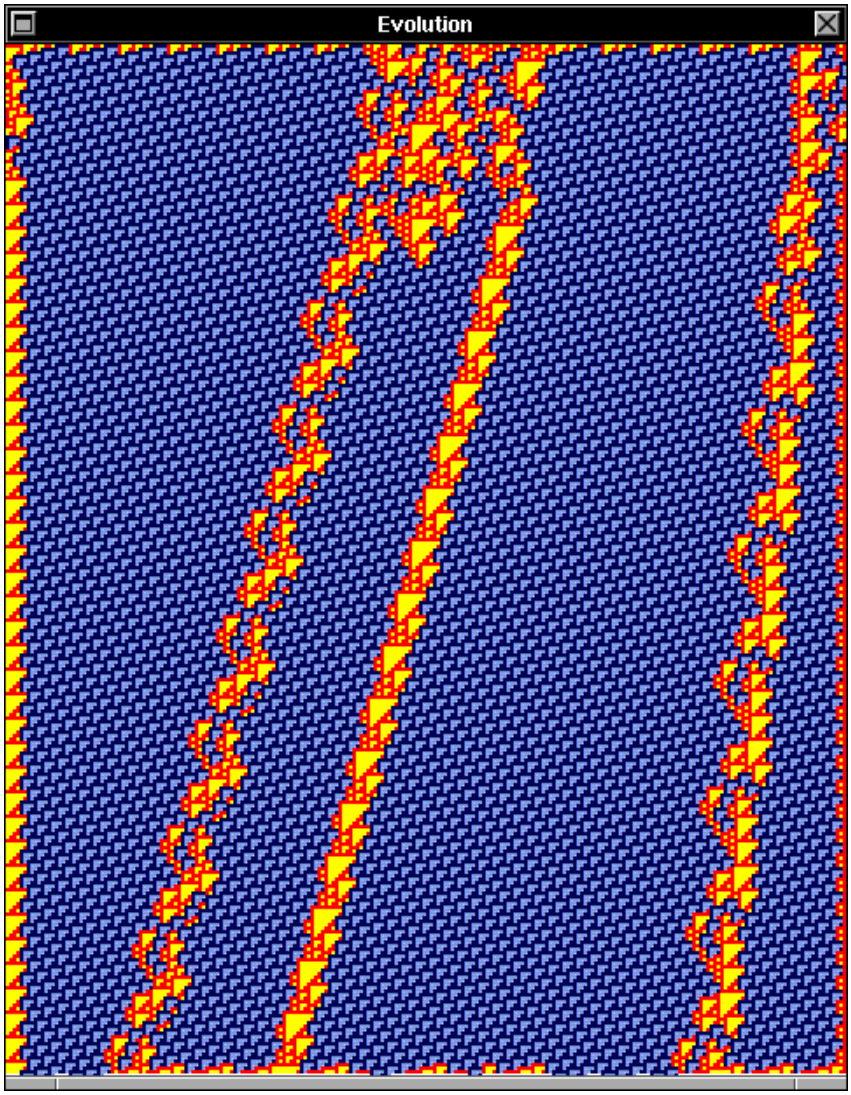

Figure 4.552: Collisions of glider F, F(p1)(H)-H(p1)(F2)=Ebar,E

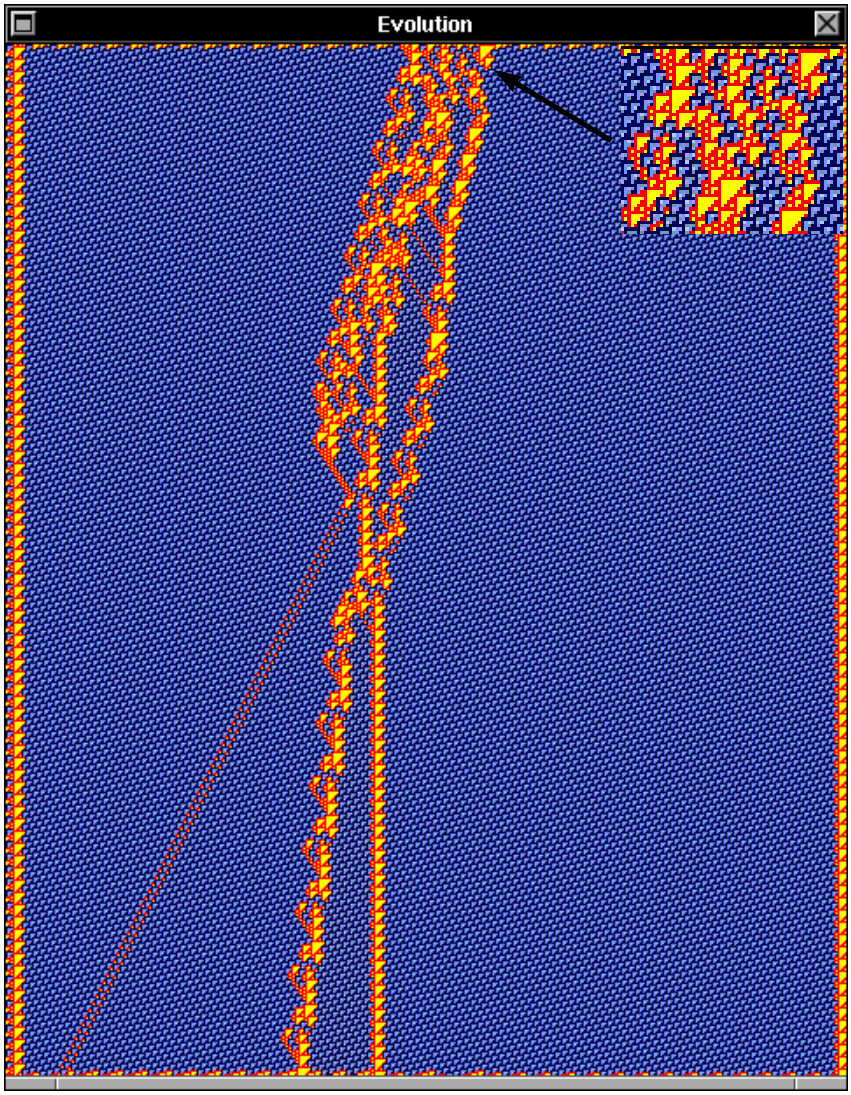

Figure 4.553: Collisions of glider F, F(p1)(H)-H(p1)(G2)=2B,F,C1

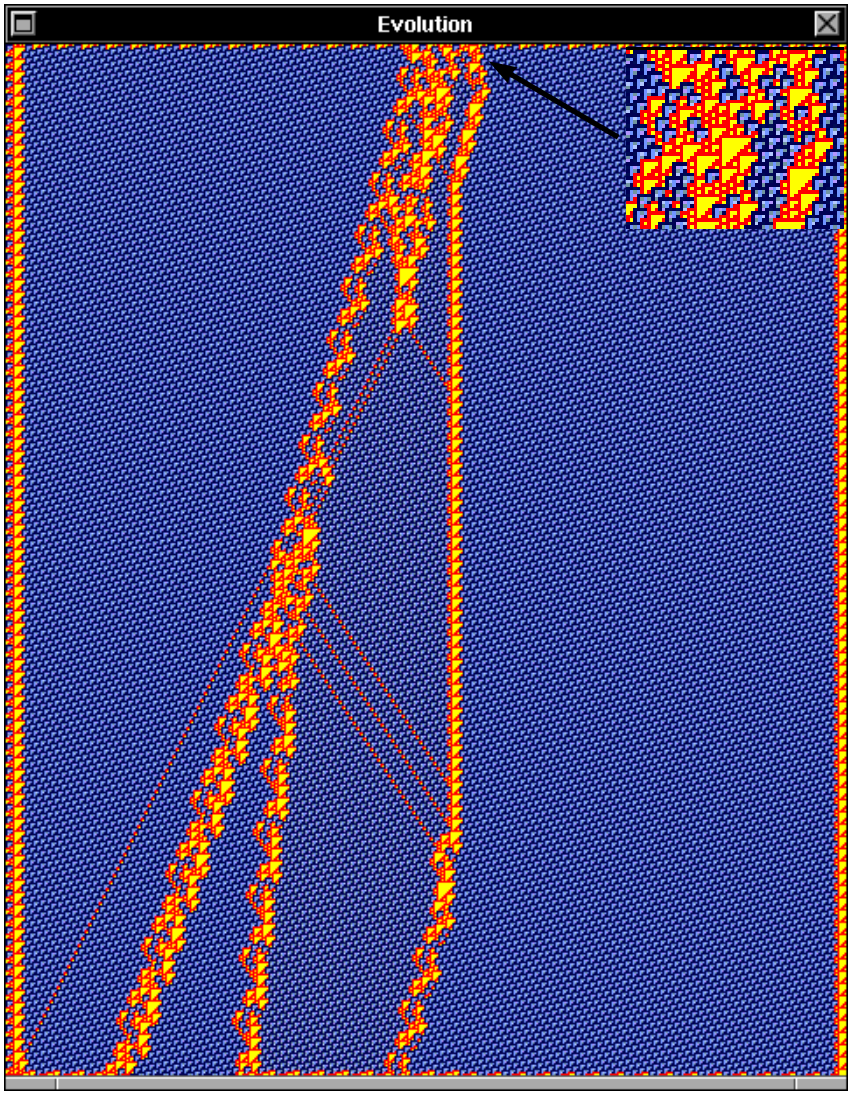

Figure 4.554: Collisions of glider F, F(p1)(H)-H(p1)(C3)=B,G,Ebar,F

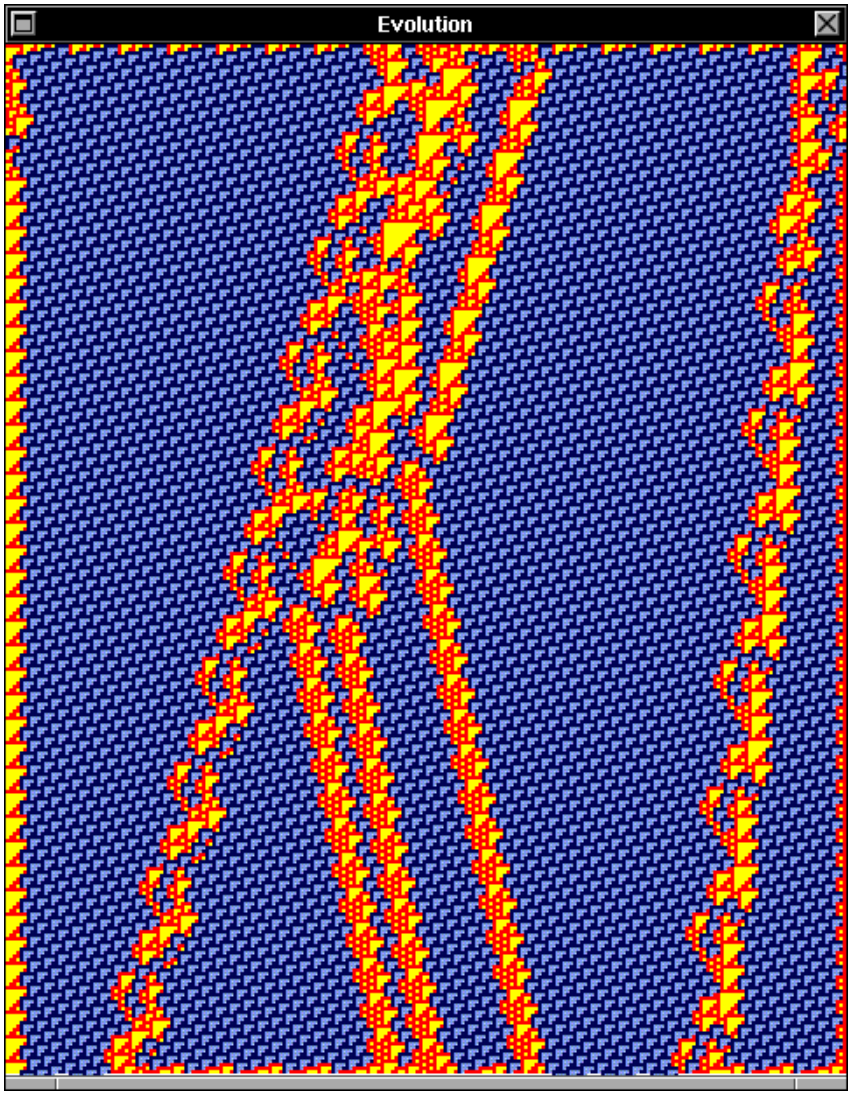

Figure 4.555: Collisions of glider F, F(p1)(H)-H(p1)(H3)=Ebar,D1,D1,D1

4.14 Collisions of glider G

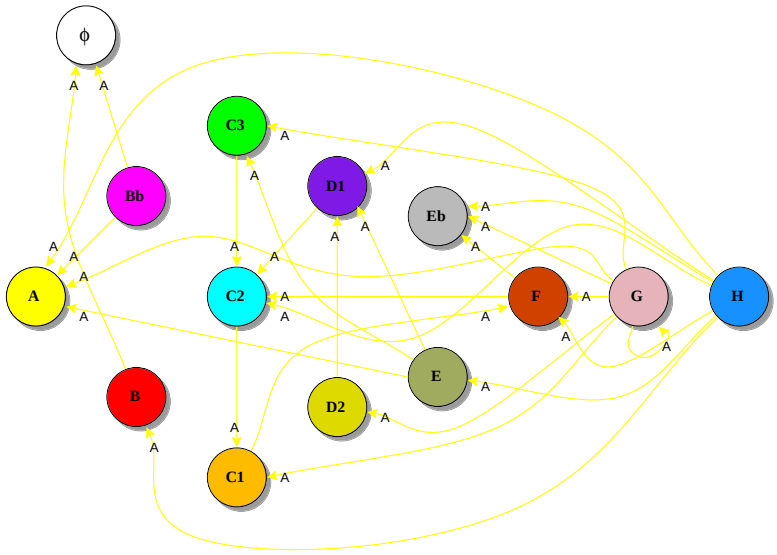

Figure 4.556: Collisions of glider G

	ϕ	A	B	$Bbar$	$C3$	$C2$	$C1$	$D2$	$D1$	E	$Ebar$	F	G	H
ϕ	.	.	.	.	.	.	.	.	.	.	.	.	.	.
A	.	.	.	.	.	.	.	.	.	.	.	.	.	.
B	.	.	.	.	.	.	.	.	.	.	.	.	.	.
$Bbar$	.	.	.	.	.	.	.	.	.	.	.	.	.	.
$C3$	.	.	.	.	.	.	.	.	.	.	.	.	.	.
$C2$	.	.	.	.	.	.	.	.	.	.	.	.	.	.
$C1$	.	.	.	.	.	.	.	.	.	.	.	.	.	.
$D2$	.	.	.	.	.	.	.	.	.	.	.	.	.	.
$D1$	.	.	.	.	.	.	.	.	.	.	.	.	.	.
E	.	.	.	.	.	.	.	.	.	.	.	.	.	.
$Ebar$	.	.	.	.	.	.	.	.	.	.	.	.	.	.
F	.	.	.	.	.	.	.	.	.	.	.	.	.	.
G	.	.	.	.	.	.	.	.	.	.	.	.	.	.
H	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Table 4.13: Matrix connection of collisions glider G

4.14.1 Collisions of glider G with glider H

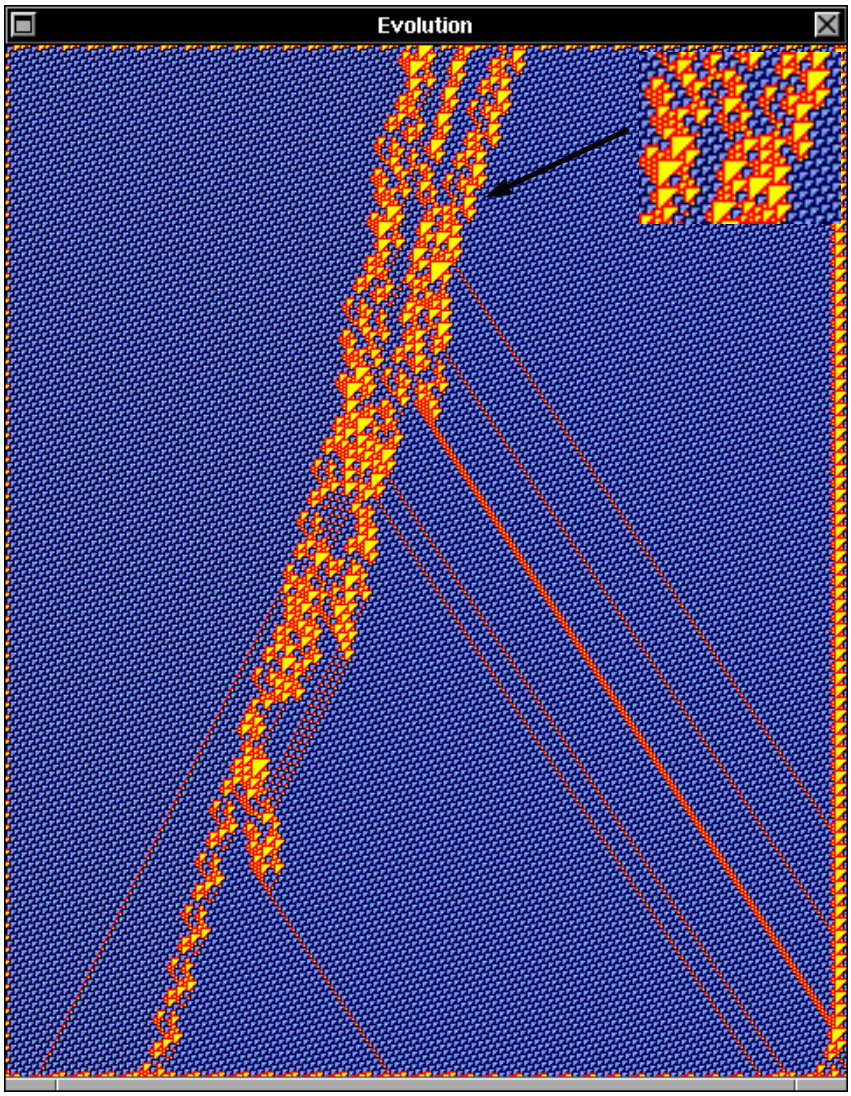

Figure 4.557: Collisions of glider G, H(p1)(A)-G(p1)(A)=A,A,3A,A,A,B,Ebar,A

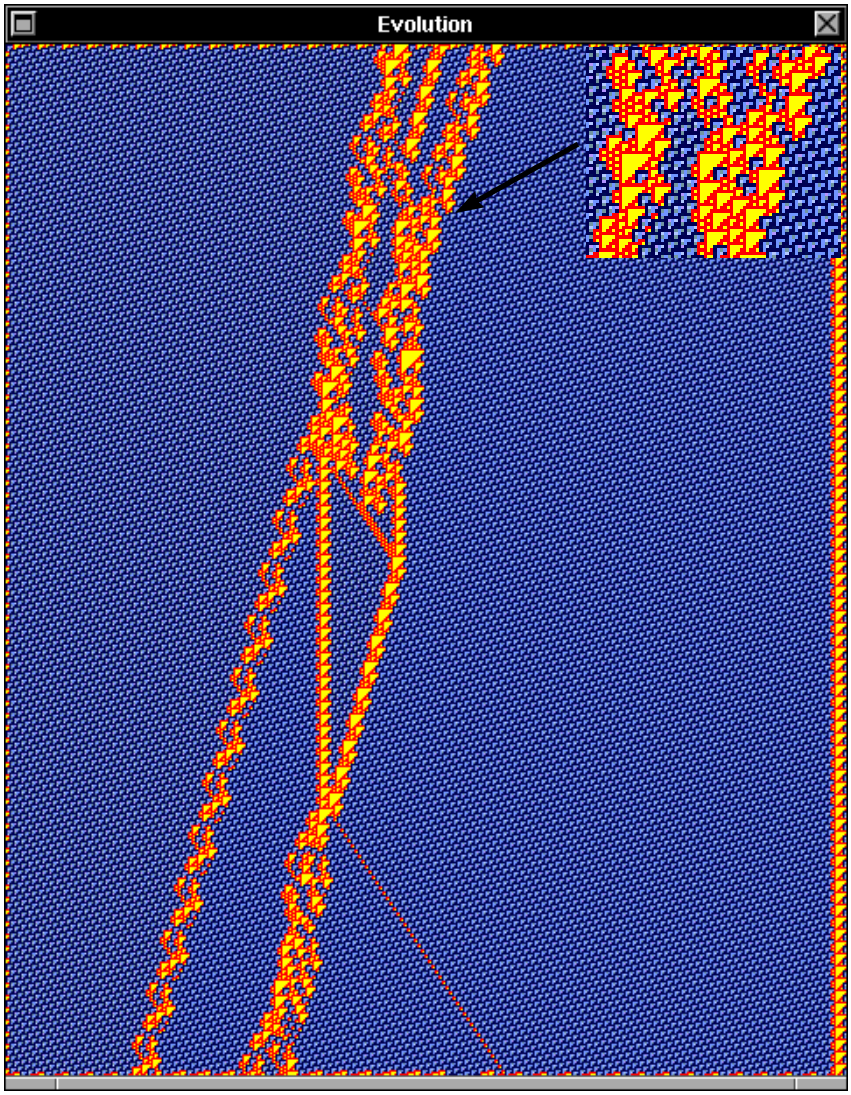

Figure 4.558: Collisions of glider G, H(p1)(A)-G(p1)(B)=Ebar,A,Ebar,F

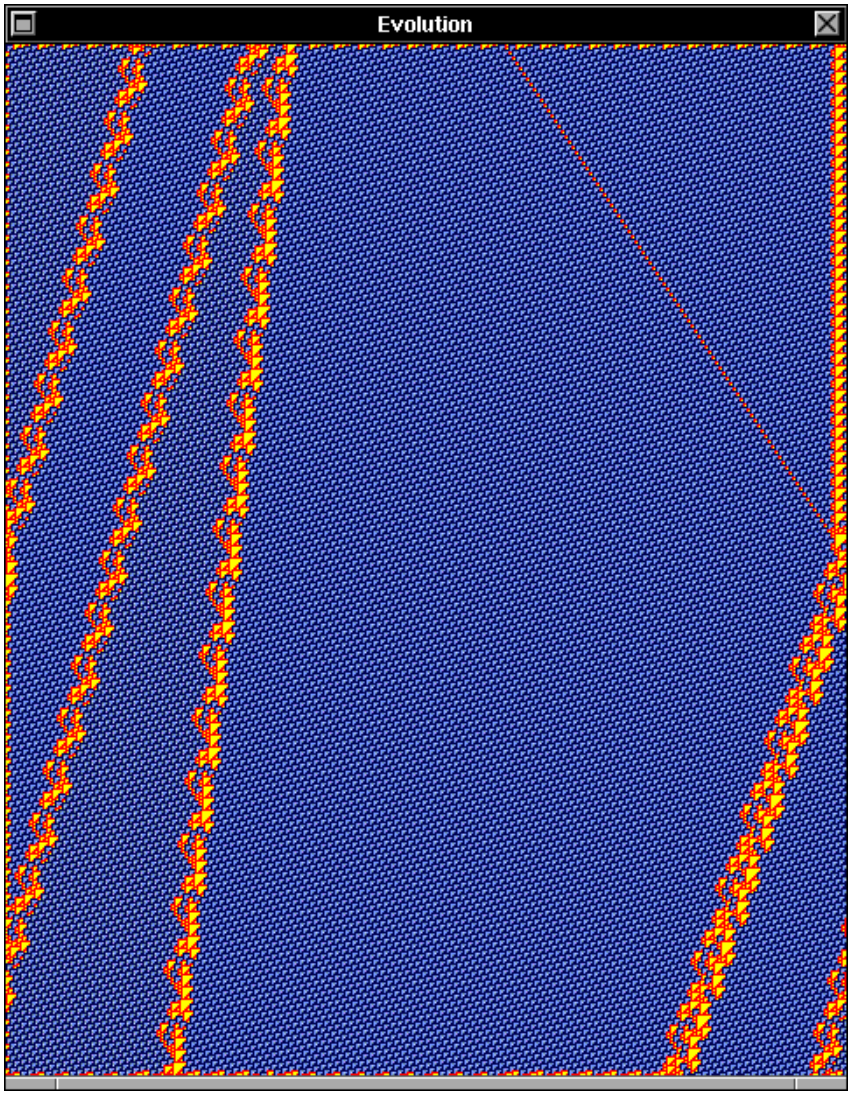

Figure 4.559: continue collision, H(p1)(A)-G(p1)(B)

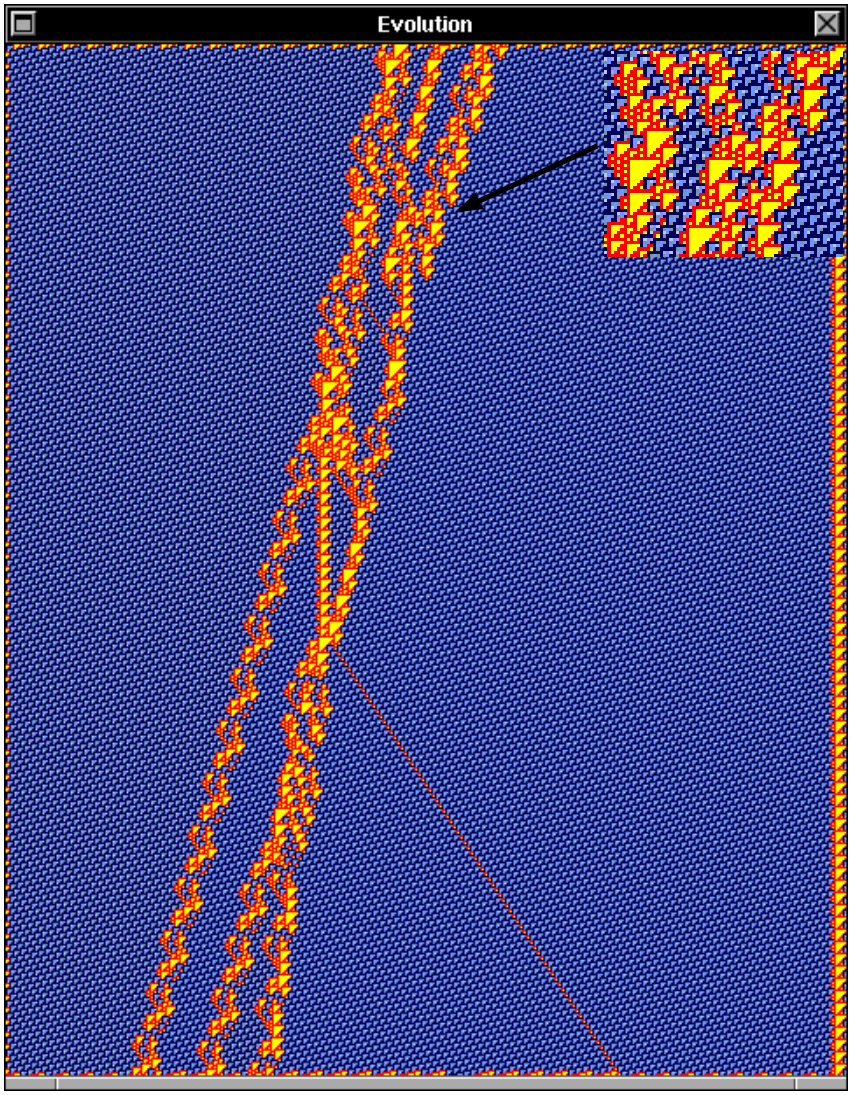

Figure 4.560: Collisions of glider G, H(p1)(A)-G(p1)(C)=Ebar,A,Ebar,F

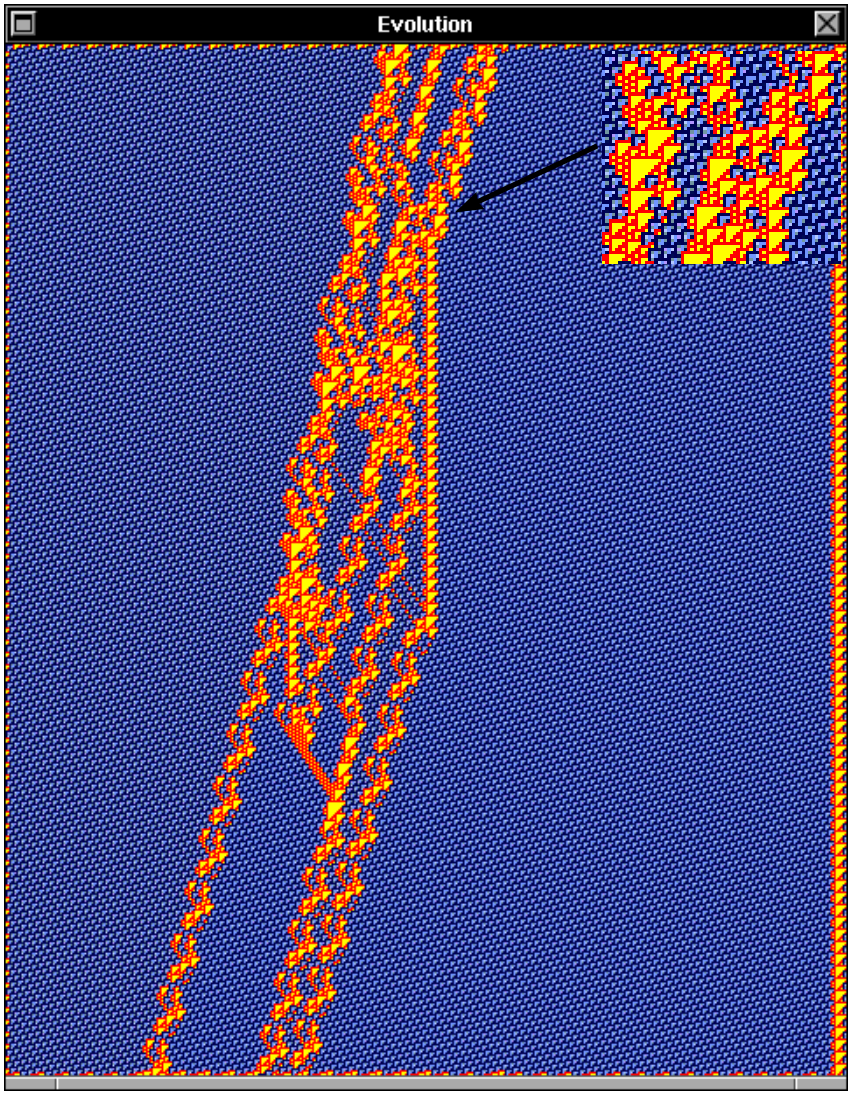

Figure 4.561: Collisions of glider G, H(p1)(A)-G(p1)(D)=Ebar,Ebar,Ebar

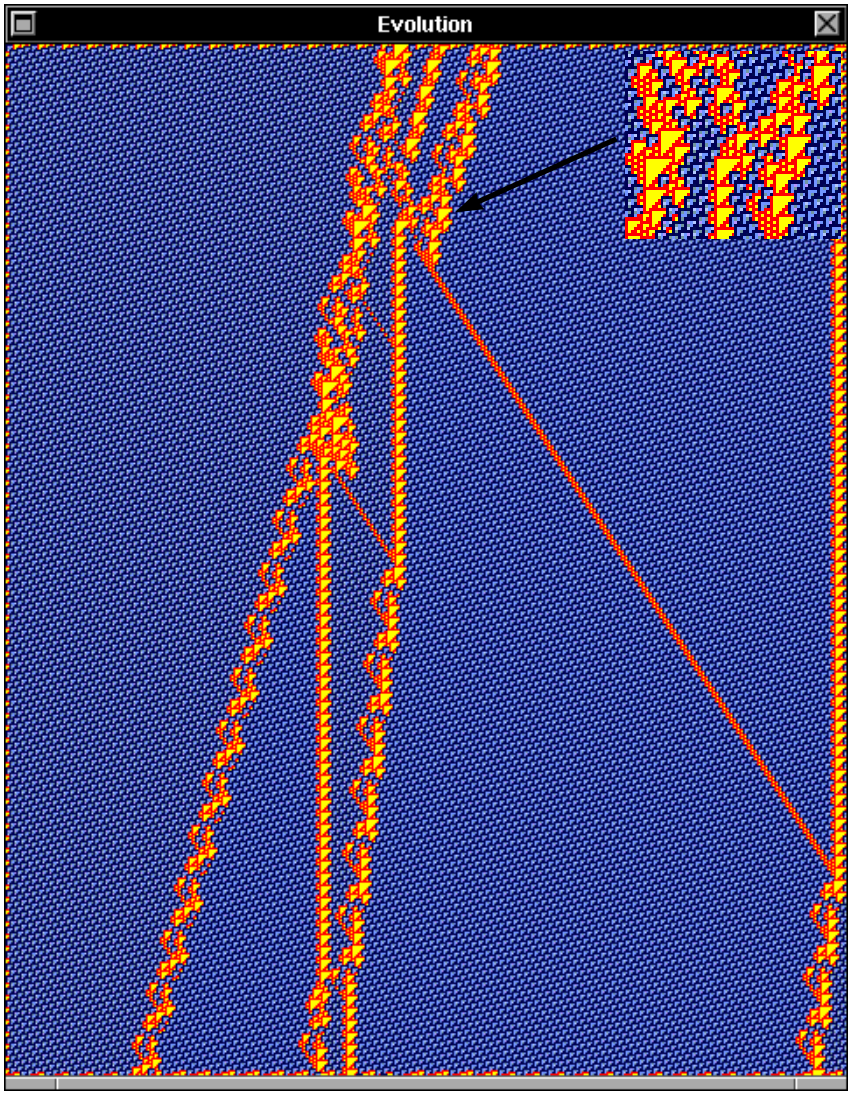

Figure 4.562: Collisions of glider G, H(p1)(A)-G(p1)(E)=Ebar,3A,F,C1

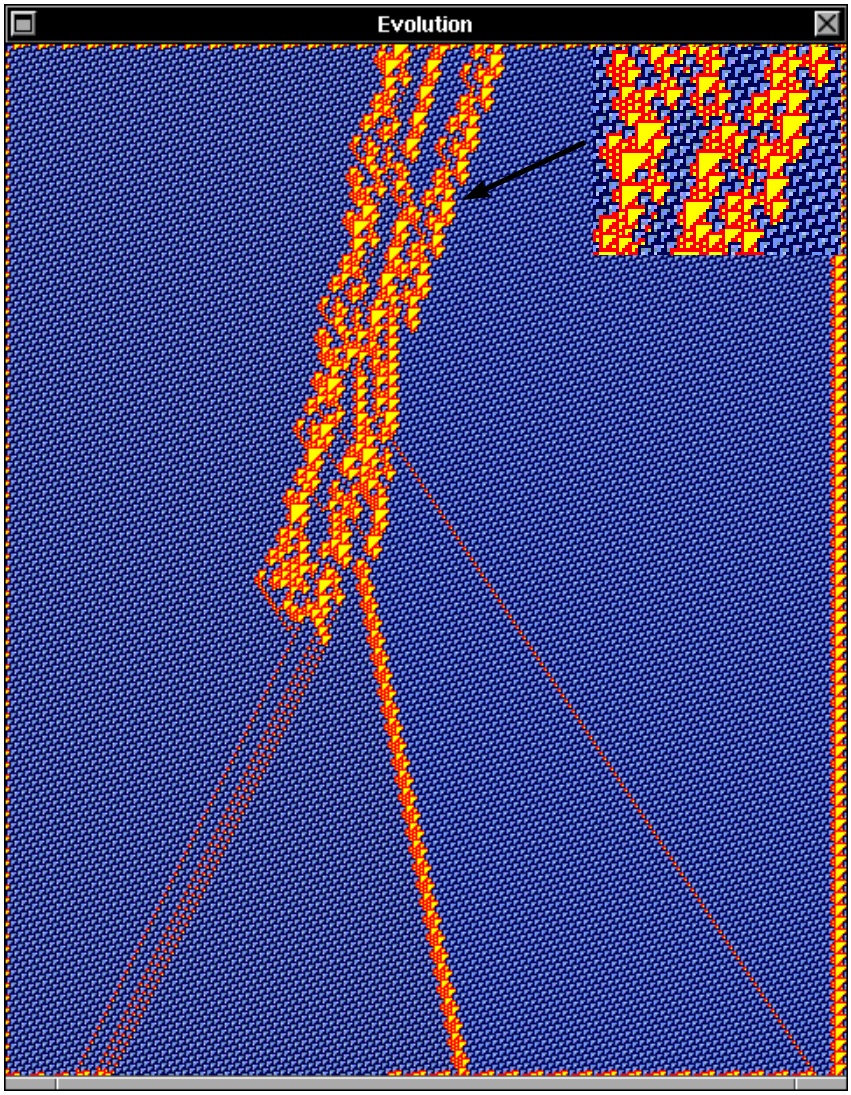

Figure 4.563: Collisions of glider G, H(p1)(A)-G(p1)(F)=A,D1,B,3B

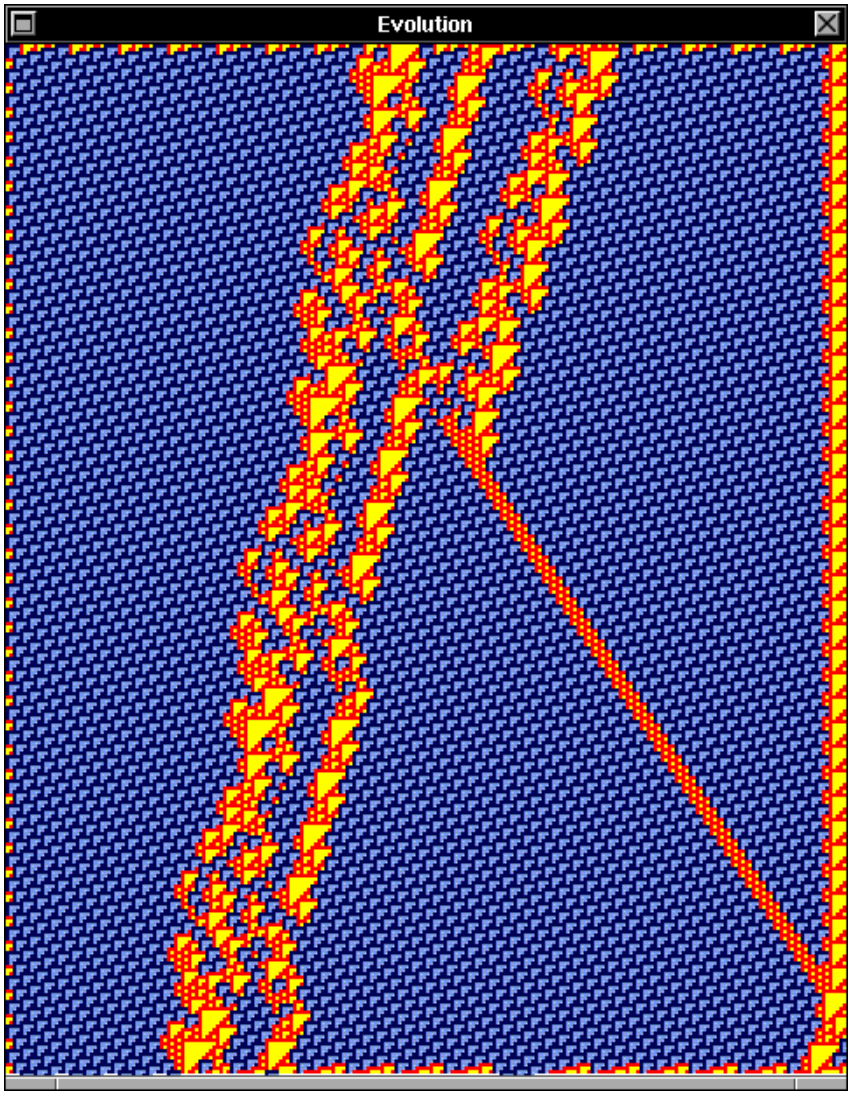

Figure 4.564: Collisions of glider G, H(p1)(A)-G(p1)(G)=H,4A

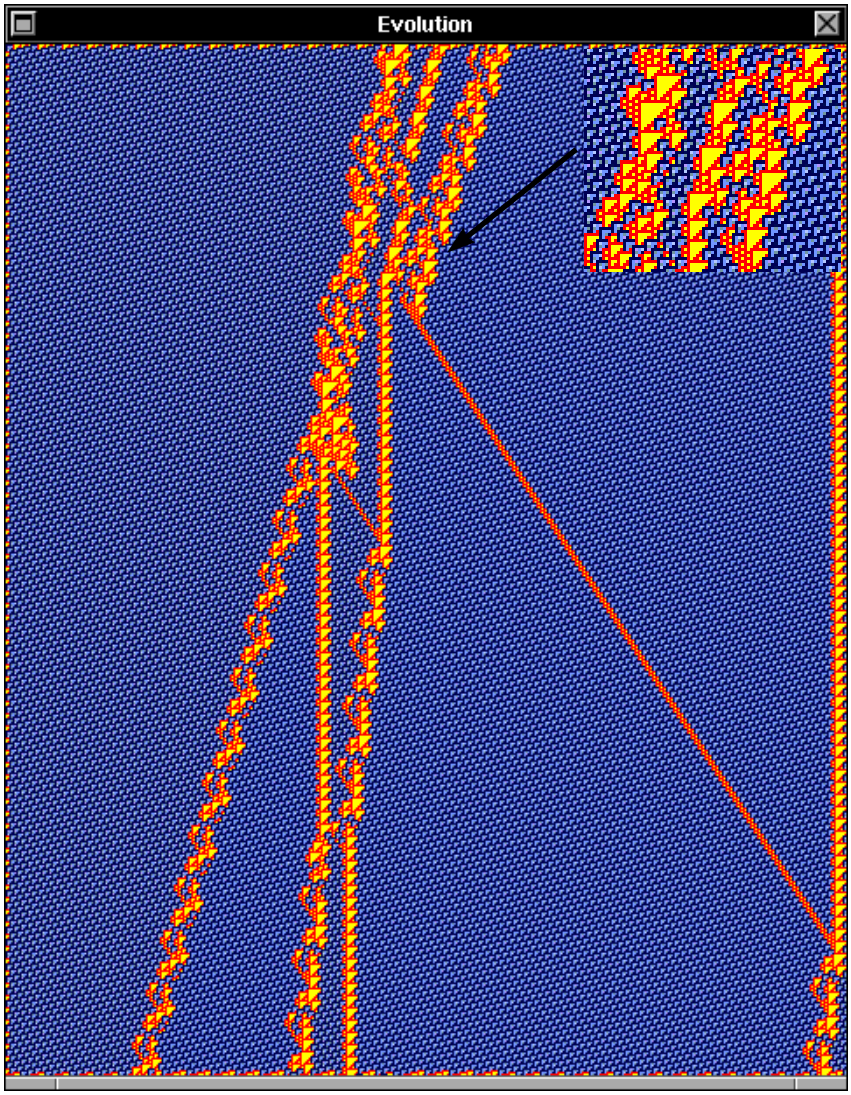

Figure 4.565: Collisions of glider G, H(p1)(A)-G(p1)(H)=3A,Ebar,F,C1

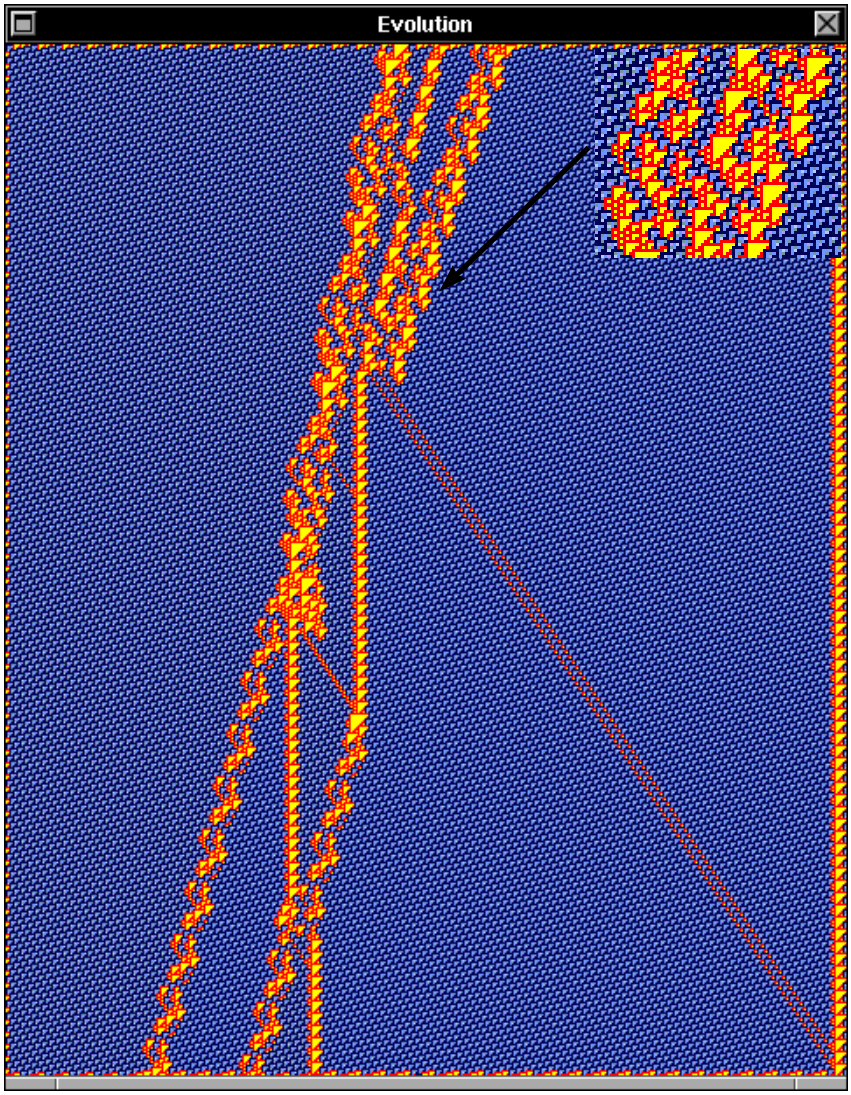

Figure 4.566: Collisions of glider G, H(p1)(A)-G(p1)(A2)=A,A,Ebar,Ebar,C1

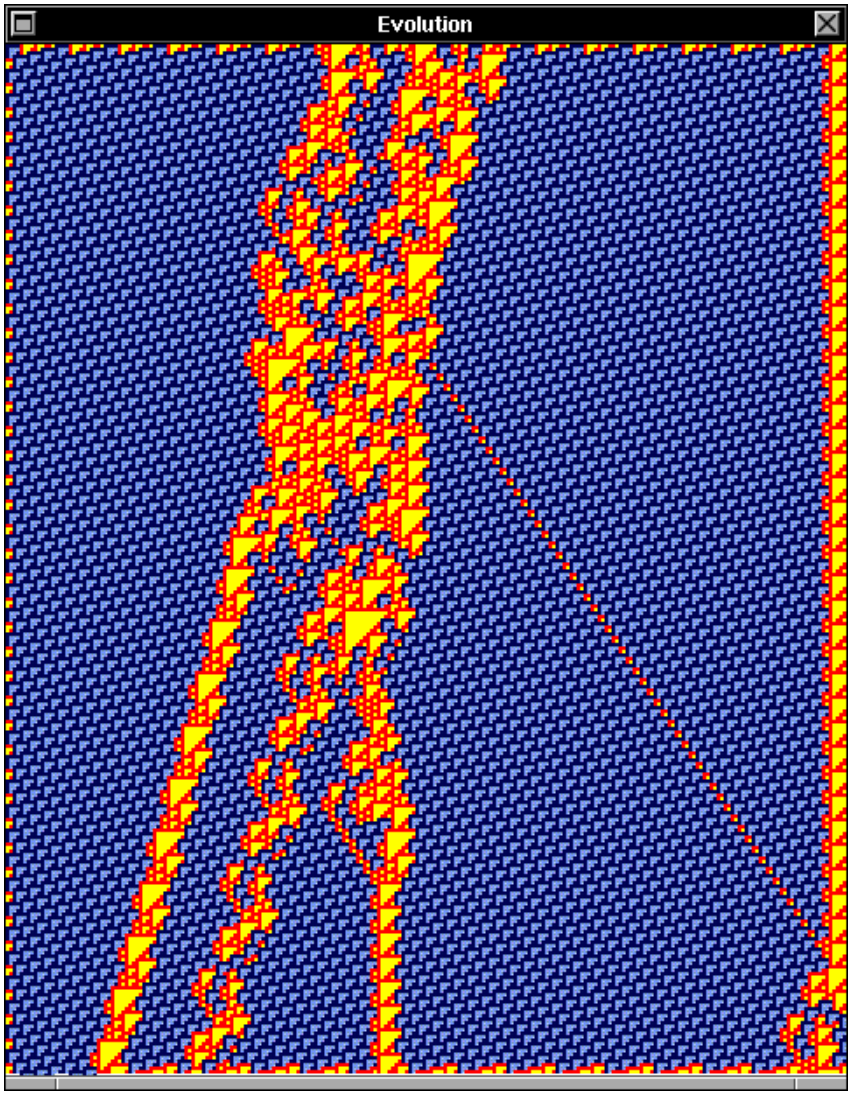

Figure 4.567: Collisions of glider G, H(p1)(D)-G(p1)(A)=A,E,Ebar,C2

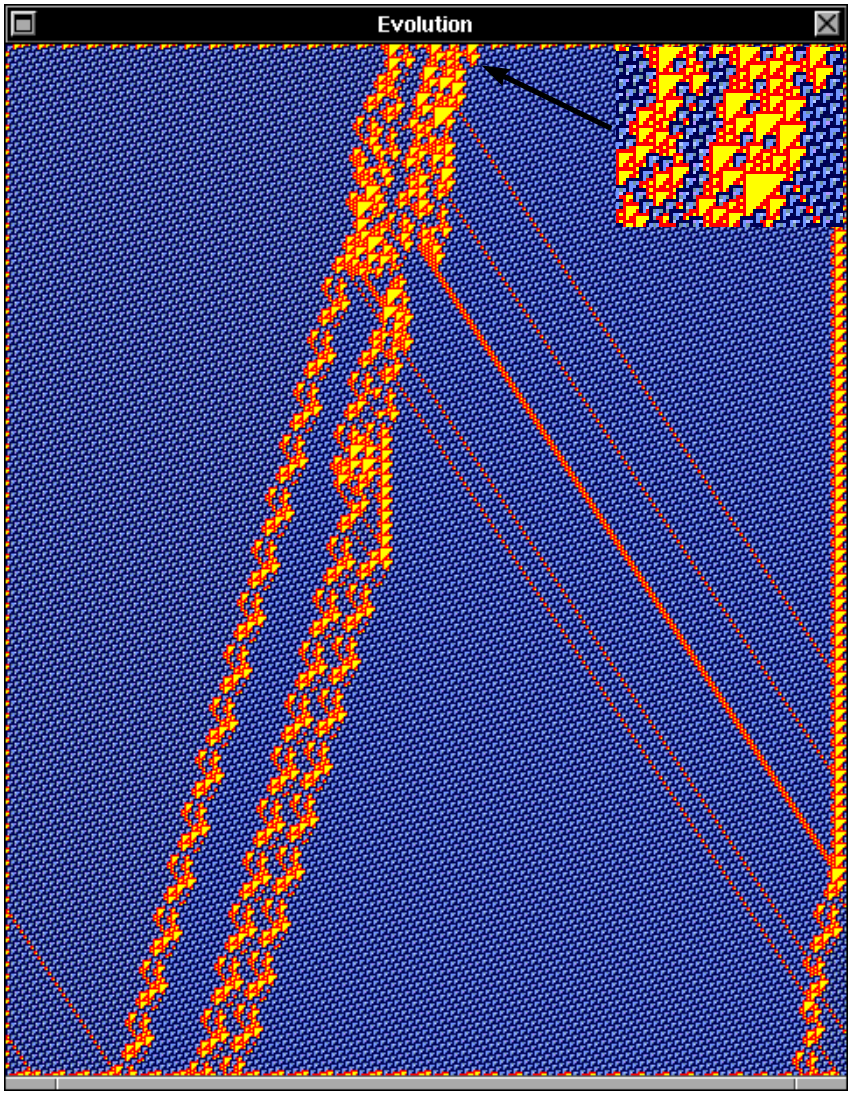

Figure 4.568: Collisions of glider G, H(p1)(D)-G(p1)(B)=A,A,3A,Ebar,A,A,Ebar,Ebar

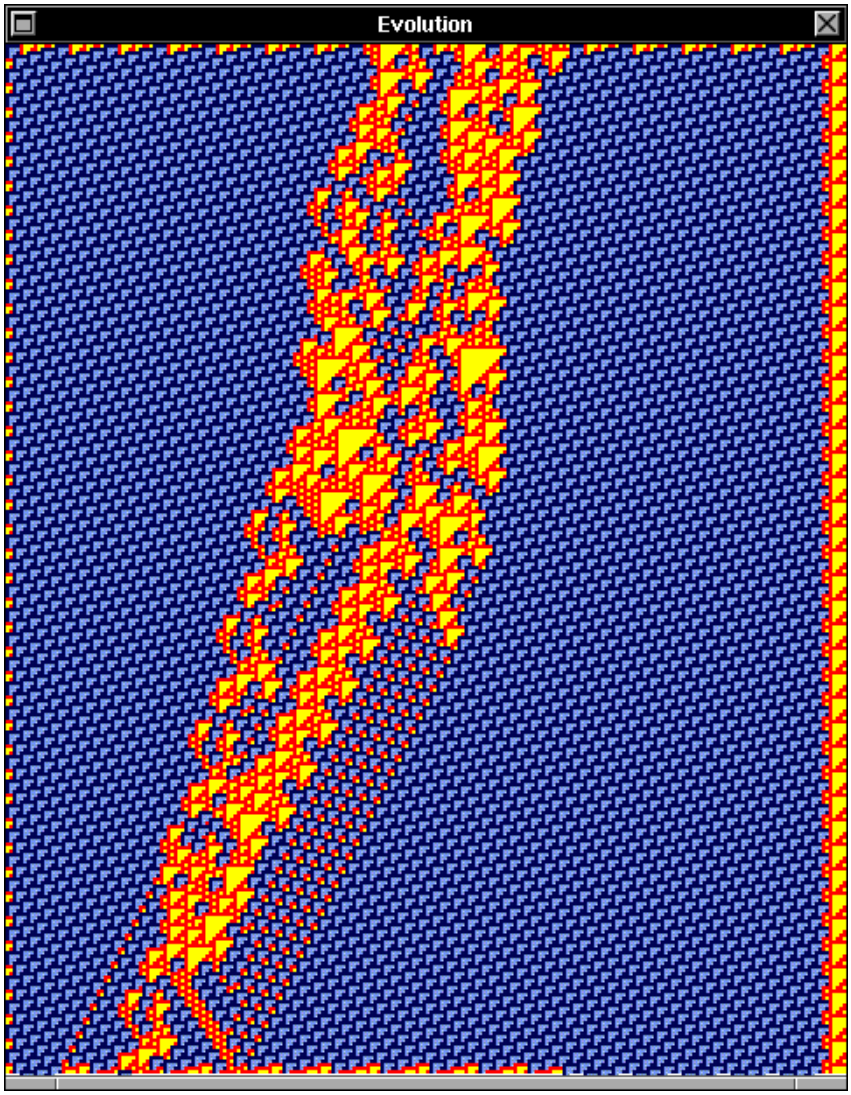

Figure 4.569: Collisions of glider G, H(p1)(D)-G(p1)(C)=B,Ebar,A

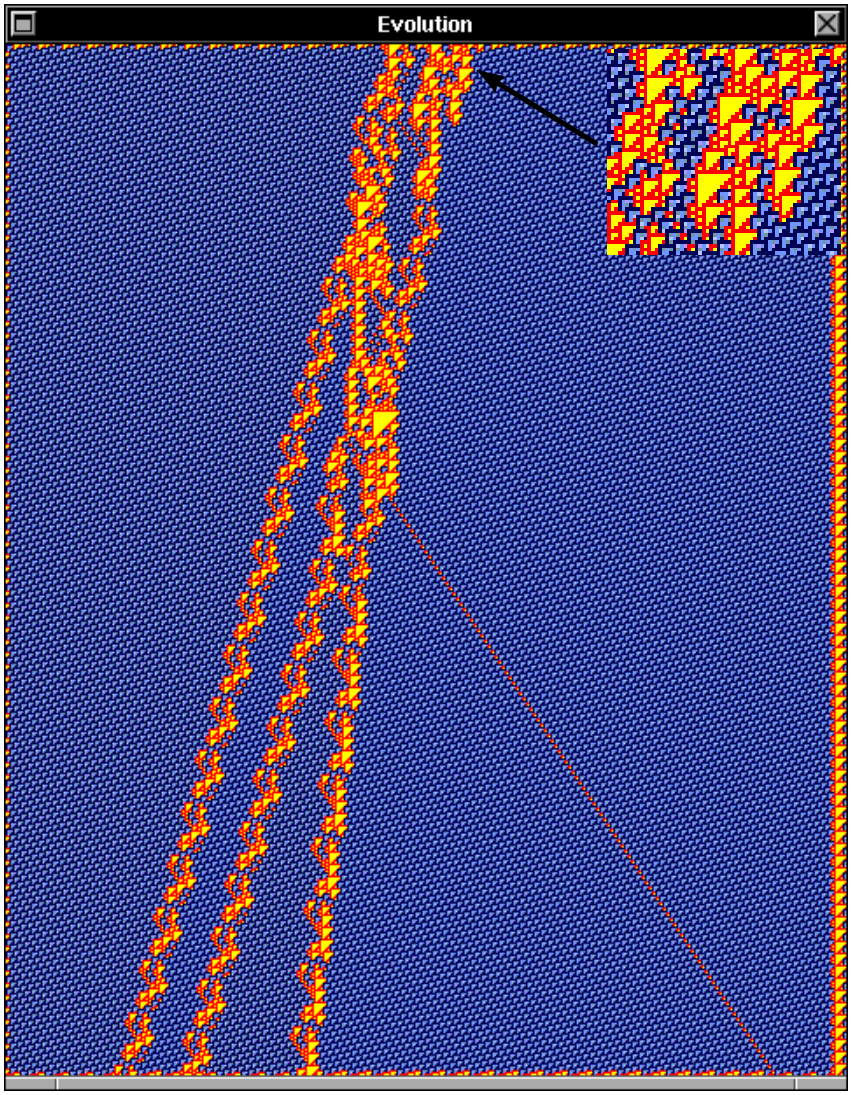

Figure 4.570: Collisions of glider G, H(p1)(D)-G(p1)(D)=Ebar,Ebar,F,A

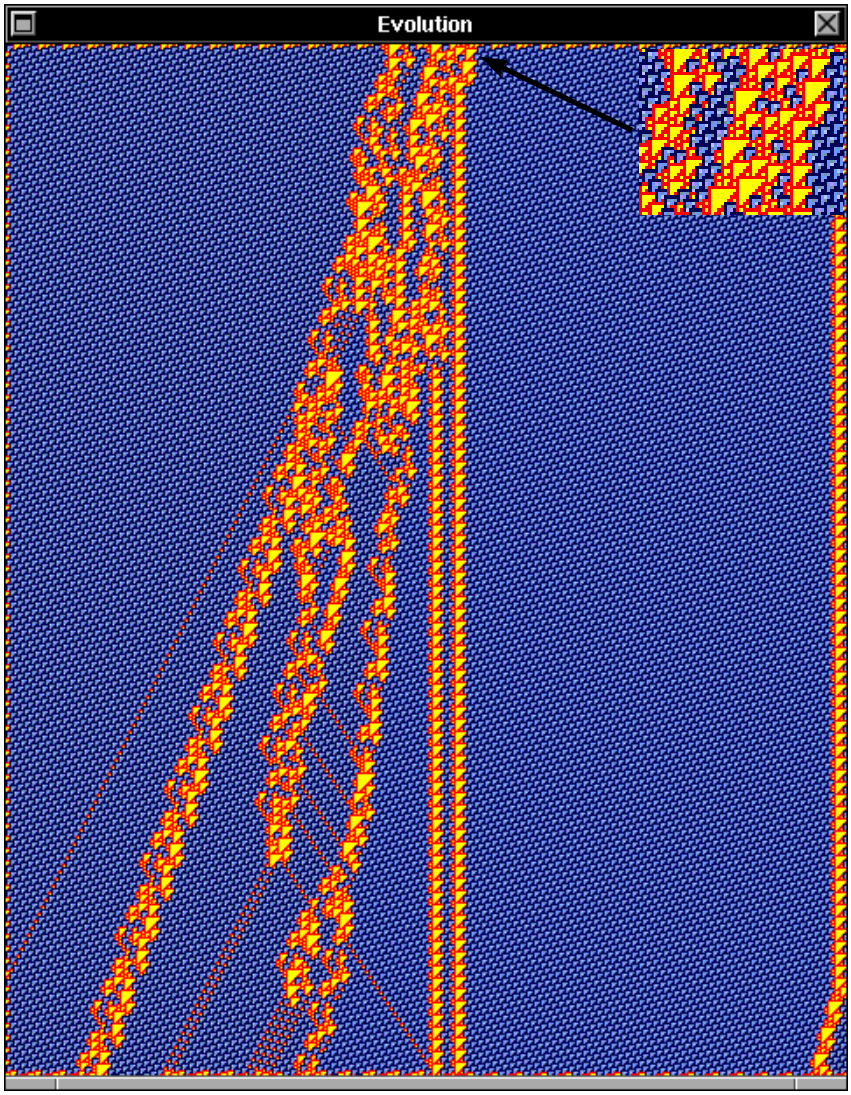

Figure 4.571: Collisions of glider G, H(p1)(D)-G(p1)(E)=C1,B,Ebar,C1,G7

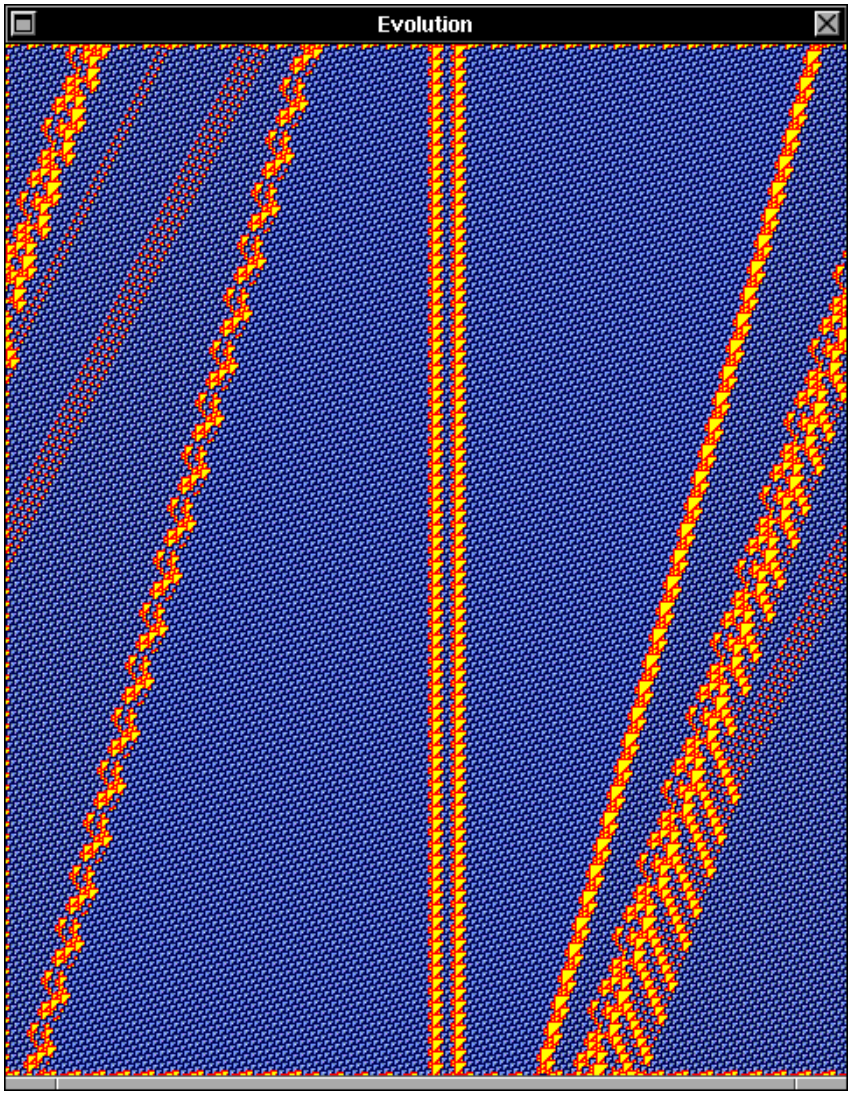

Figure 4.572: continue collision, H(p1)(D)-G(p1)(E)

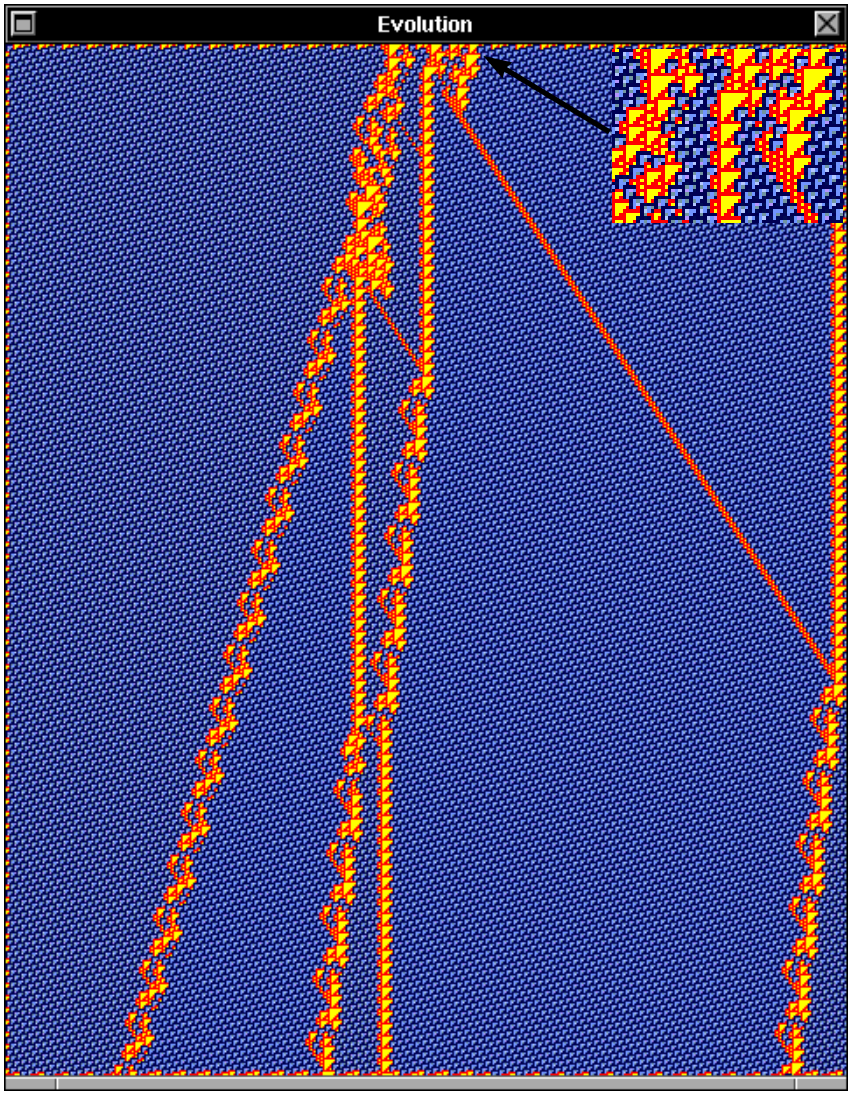

Figure 4.573: Collisions of glider G, H(p1)(D)-G(p1)(F)=3A,Ebar,F,C1

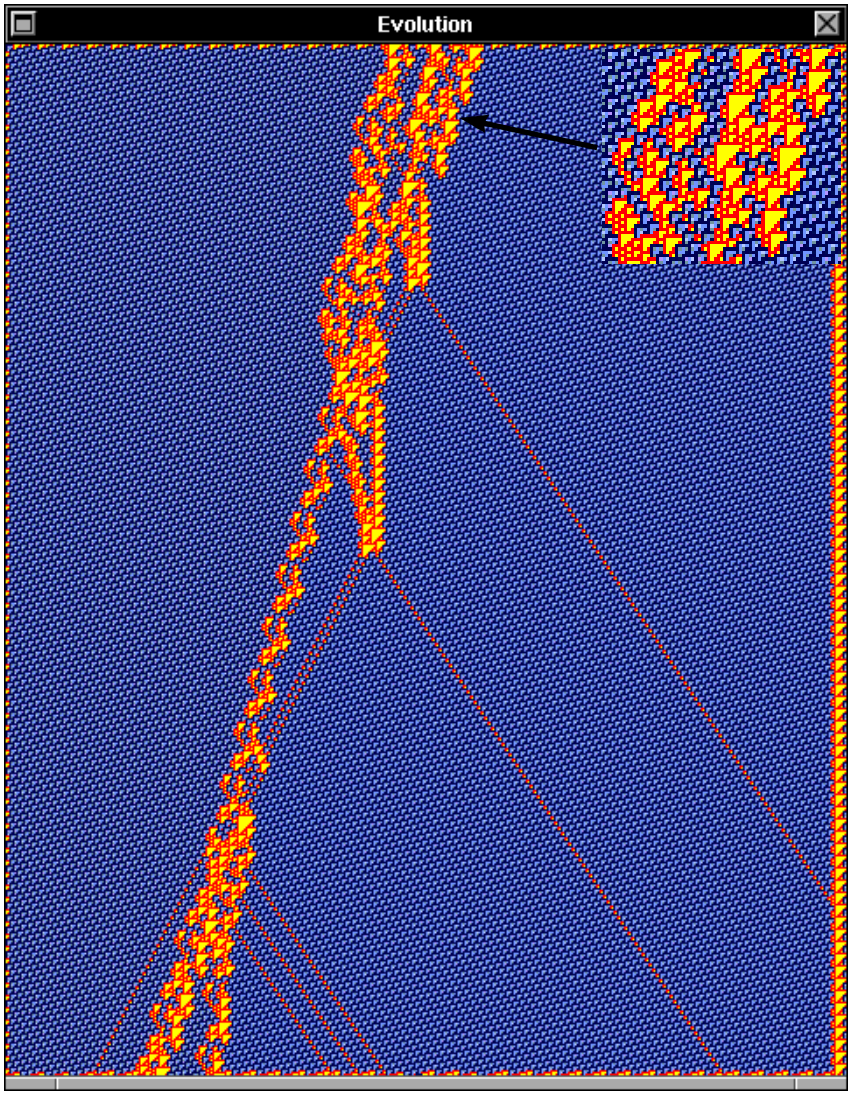

Figure 4.574: Collisions of glider G, H(p1)(D)-G(p1)(G)=A,A,B,A,A,G,A,F

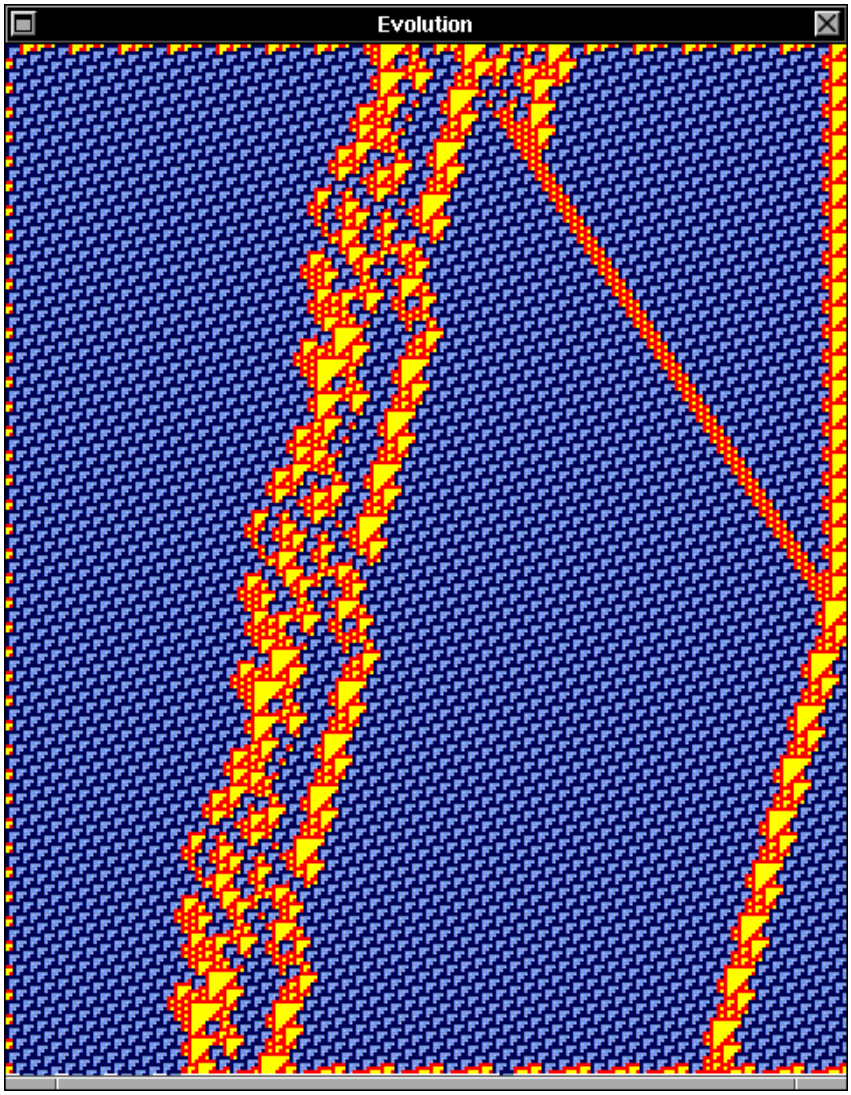

Figure 4.575: Collisions of glider G, H(p1)(D)-G(p1)(H)=H,4A

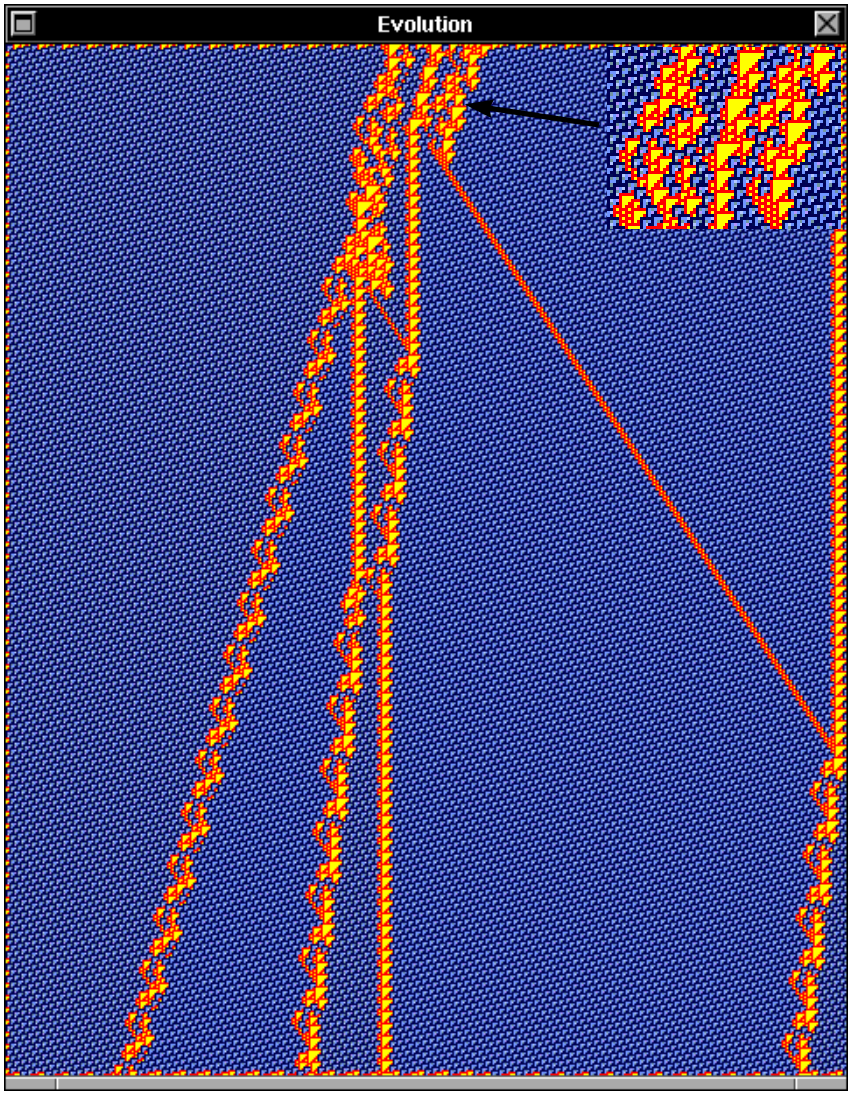

Figure 4.576: Collisions of glider G, H(p1)(D)-G(p1)(A2)=3A,Ebar,F,C1

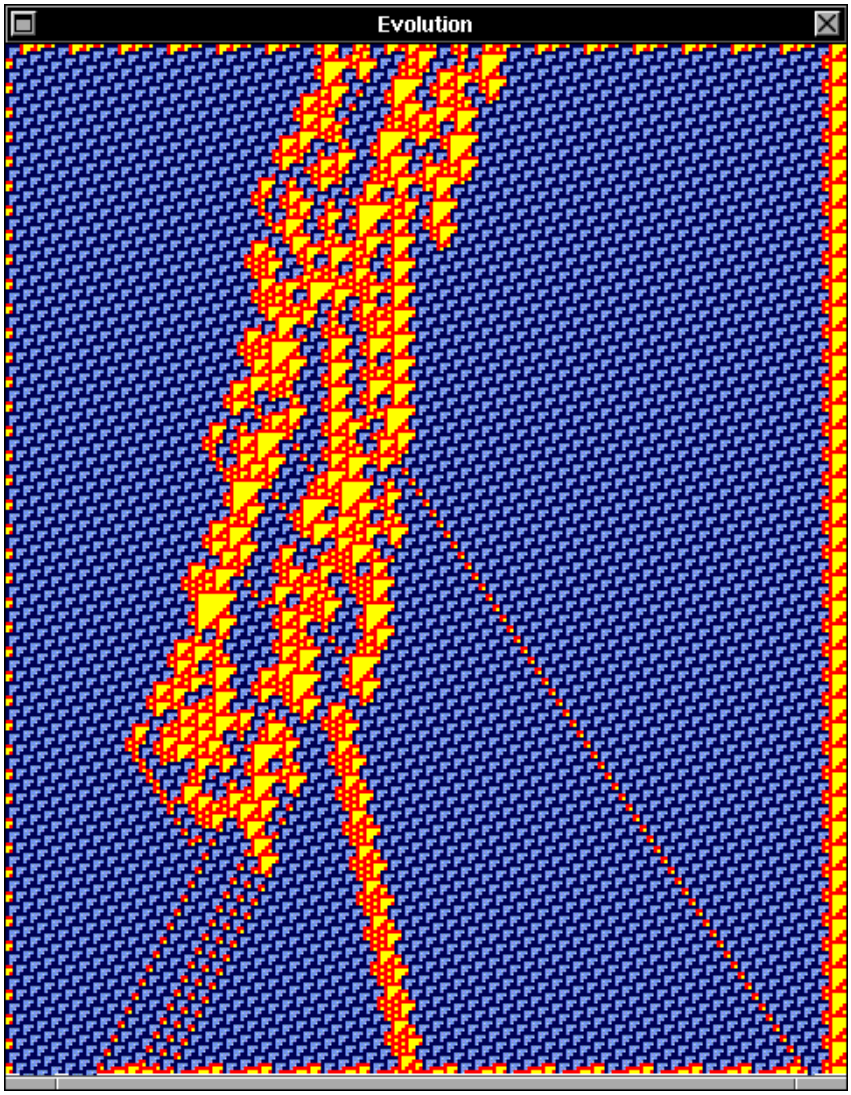

Figure 4.577: Collisions of glider G, H(p1)(E)-G(p1)(A)=A,D1,B,3B

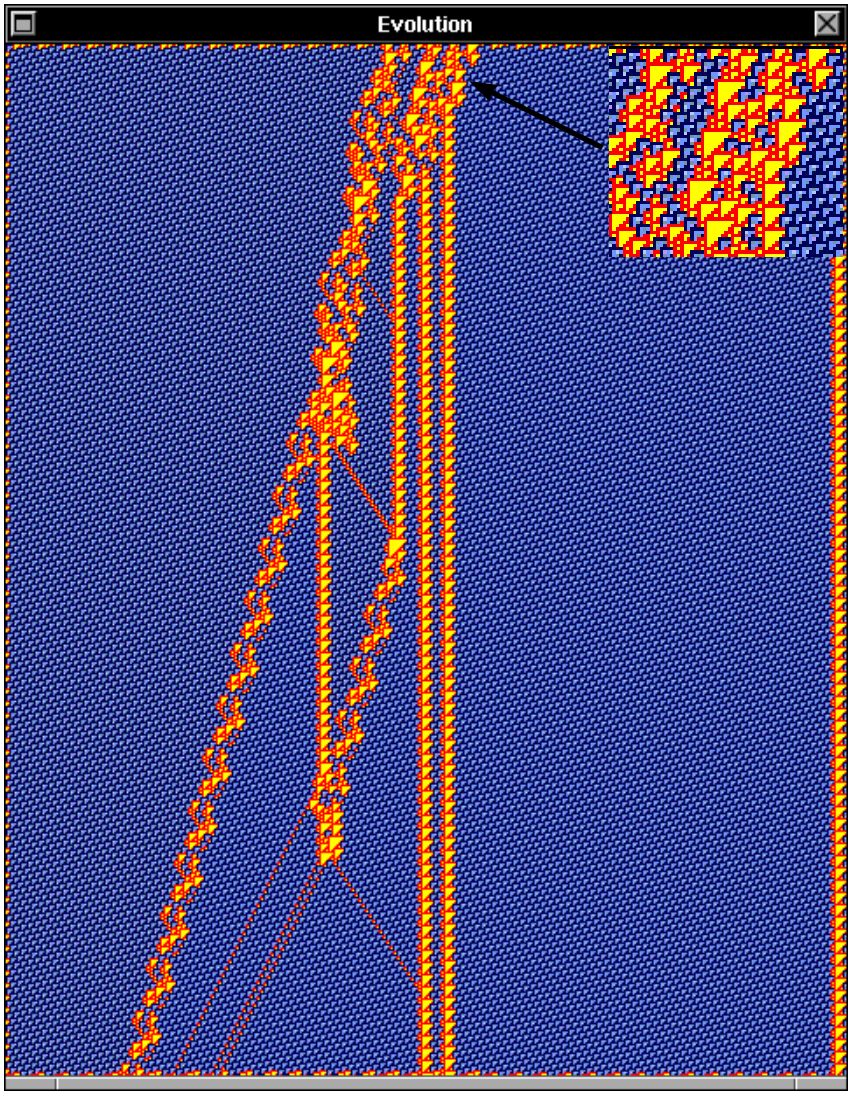

Figure 4.578: Collisions of glider G, H(p1)(E)-G(p1)(B)=C1,C1,3B,C2,4B

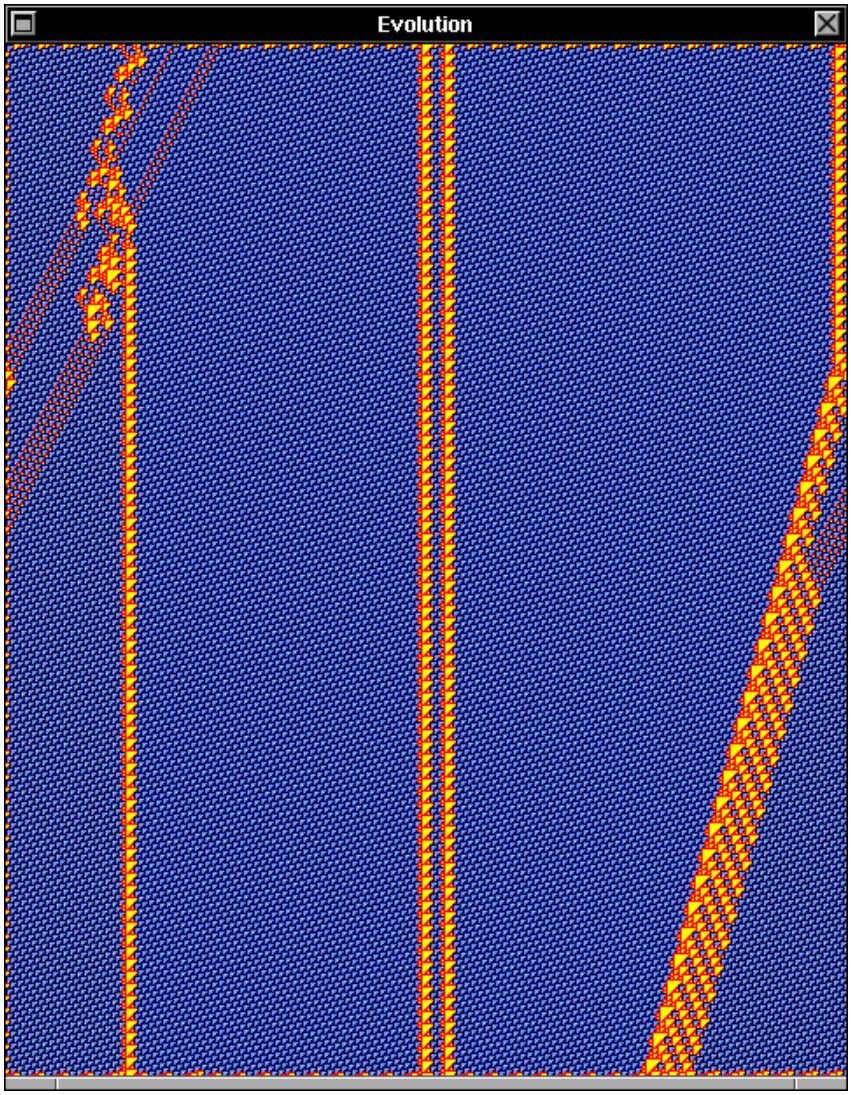

Figure 4.579: continue collision, H(p1)(E)-G(p1)(B)

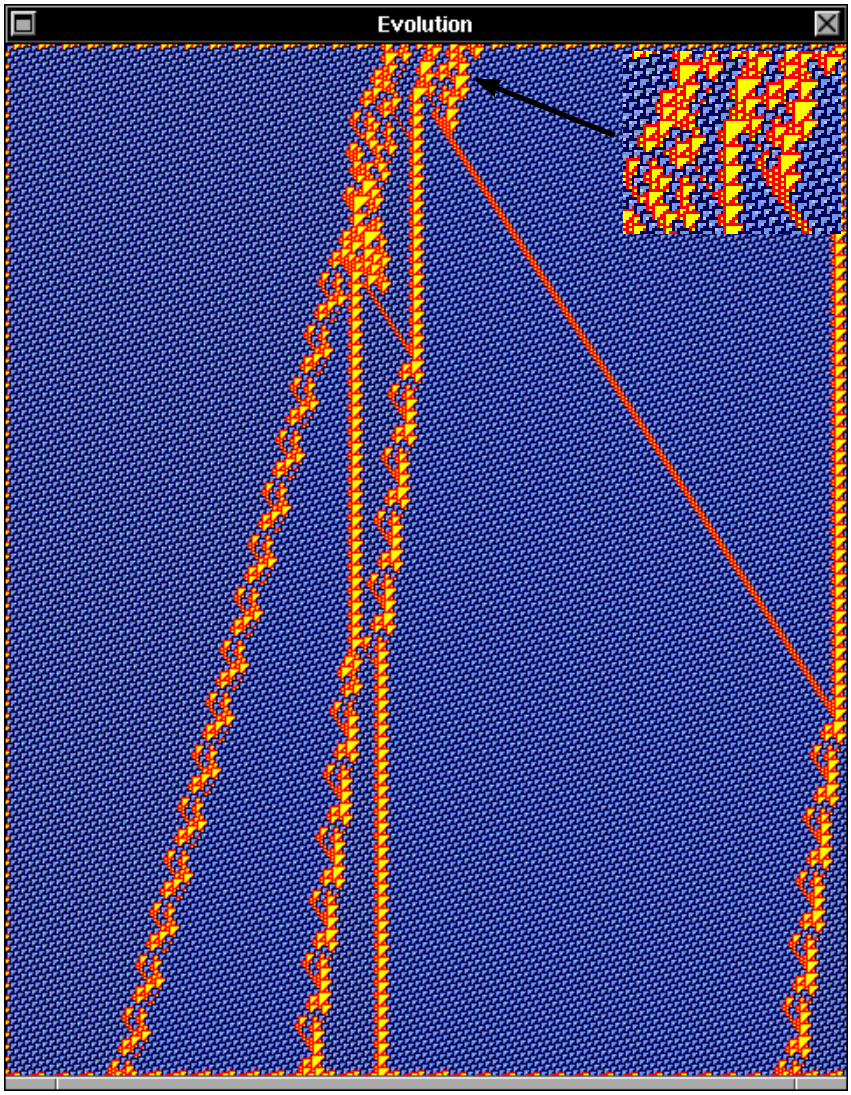

Figure 4.580: Collisions of glider G, H(p1)(E)-G(p1)(C)=3A,Ebar,F,C1

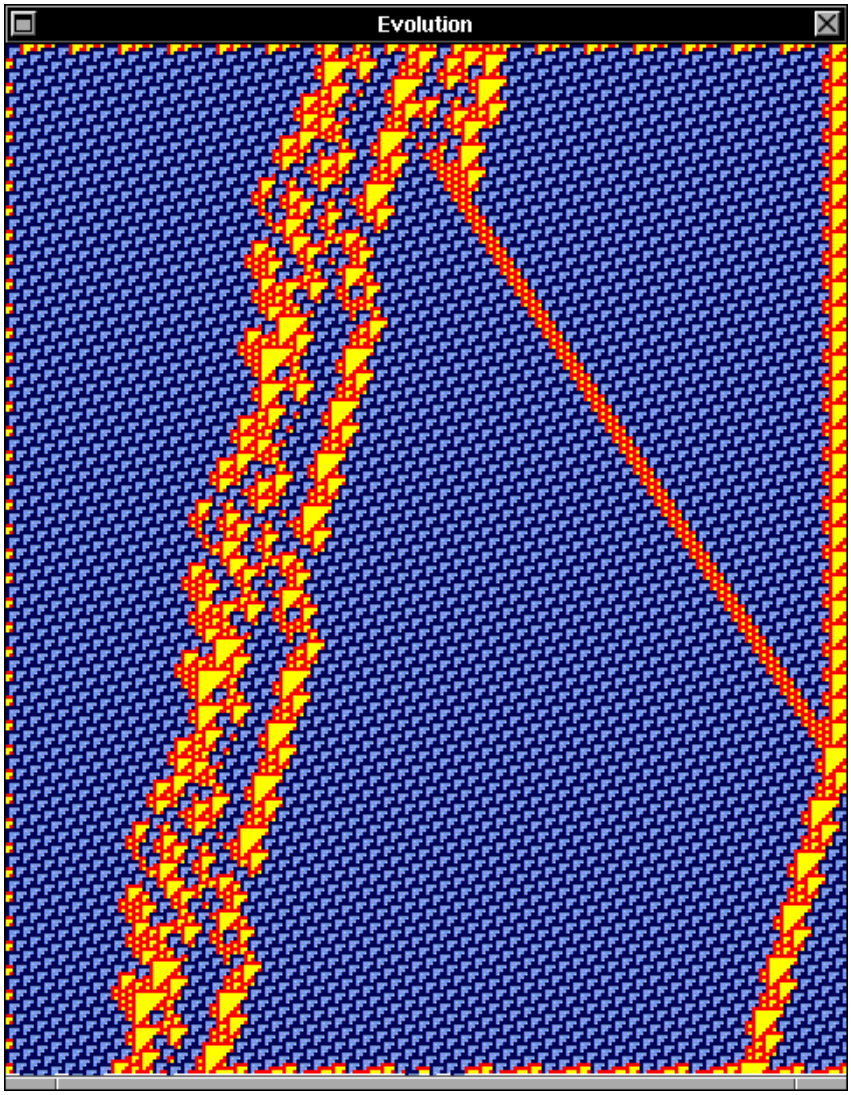

Figure 4.581: Collisions of glider G, H(p1)(E)-G(p1)(E)=H,4A

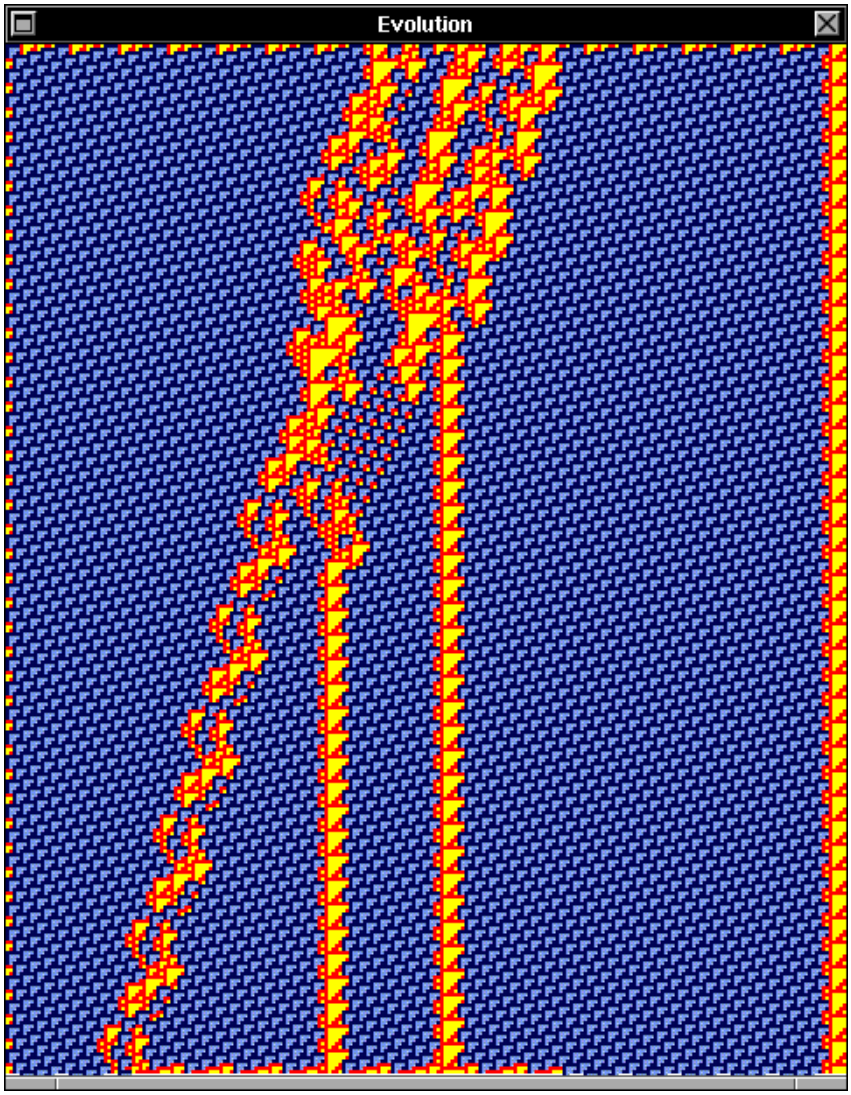

Figure 4.582: Collisions of glider G, H(p1)(E)-G(p1)(F)=C3,Ebar,C2

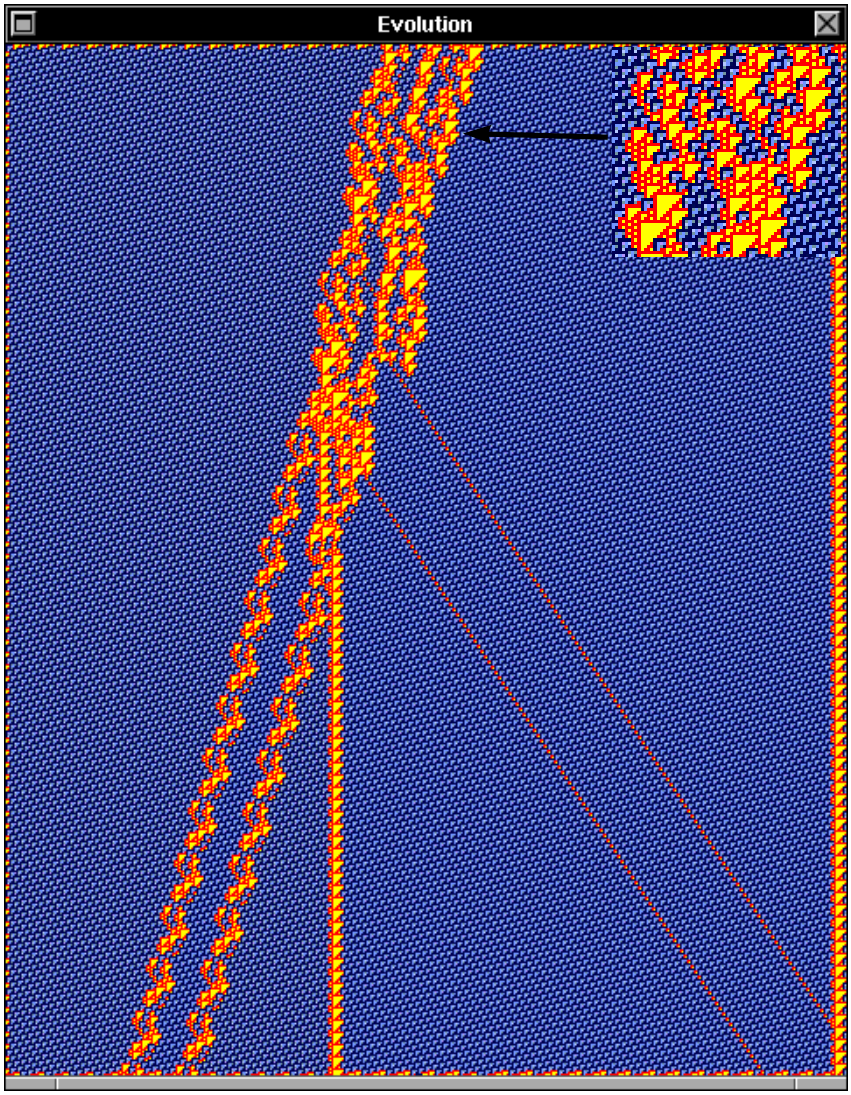

Figure 4.583: Collisions of glider G, H(p1)(E)-G(p1)(G)=A,Ebar,A,C1,Ebar

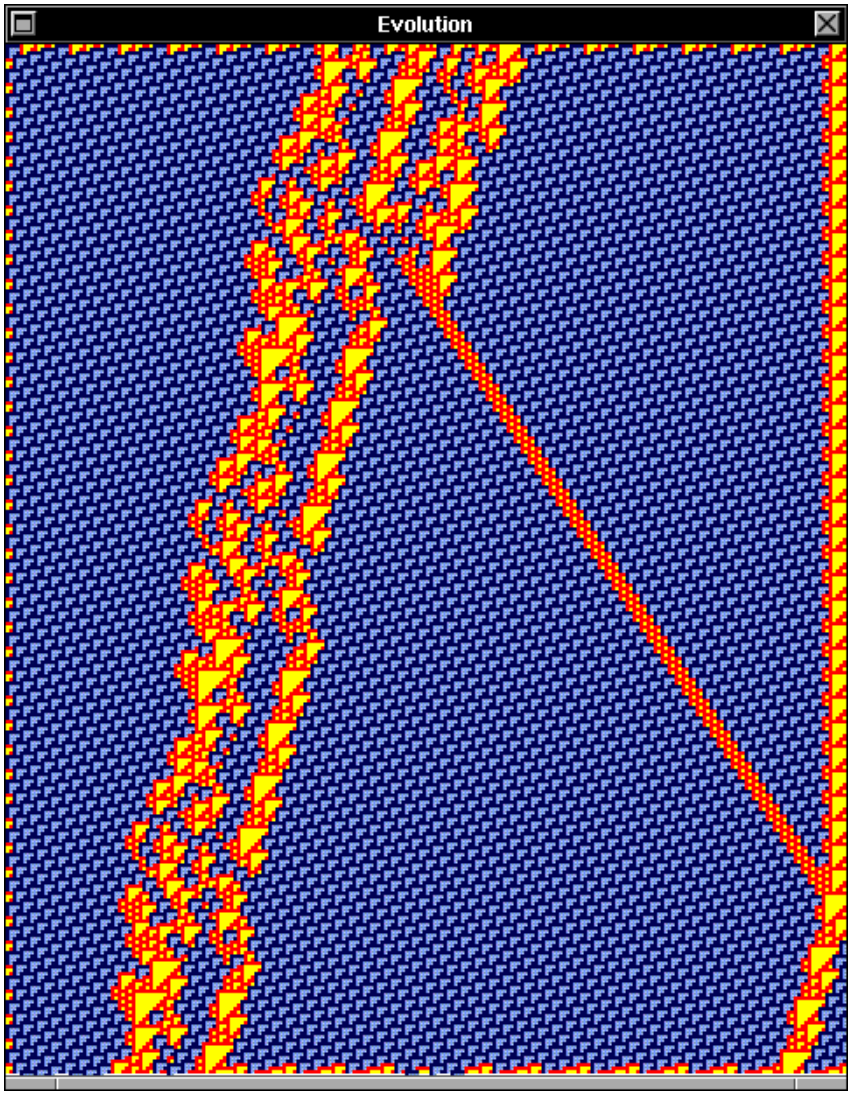

Figure 4.584: Collisions of glider G, H(p1)(E)-G(p1)(H)=H,4A

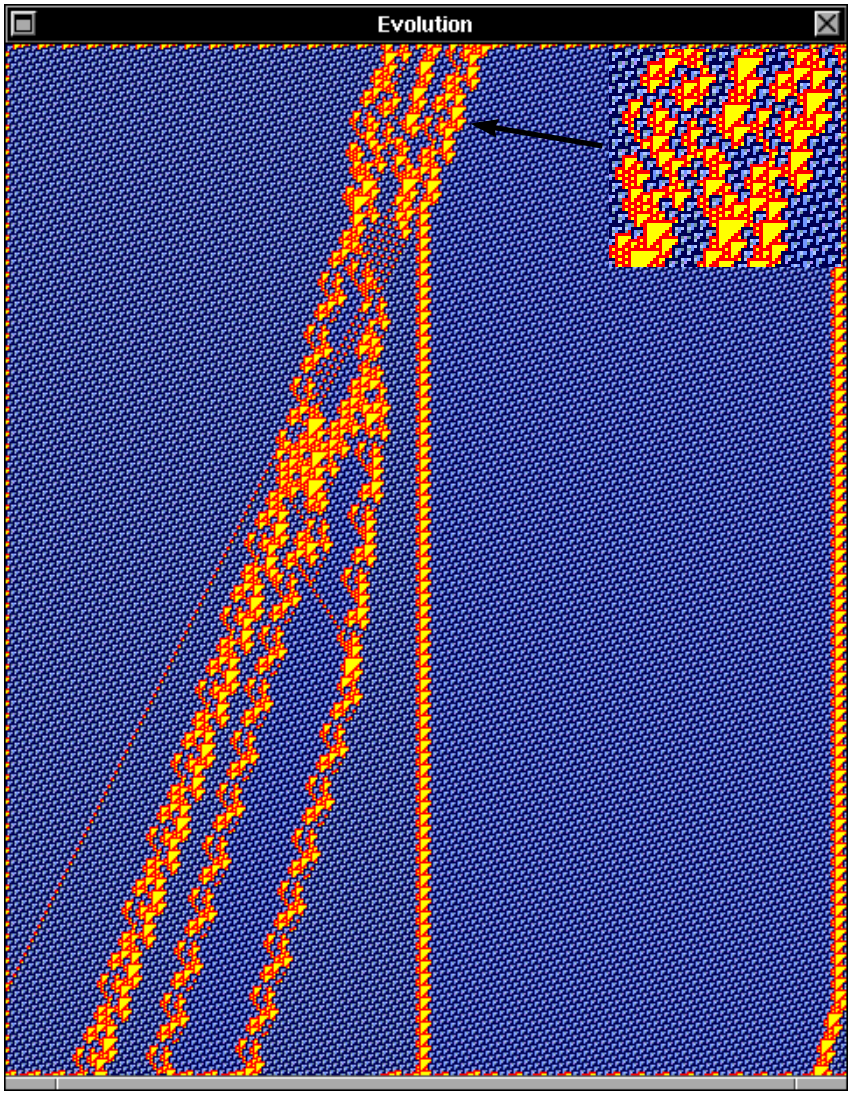

Figure 4.585: Collisions of glider G, H(p1)(E)-G(p1)(A2)=C2,B,G,Ebar,Ebar

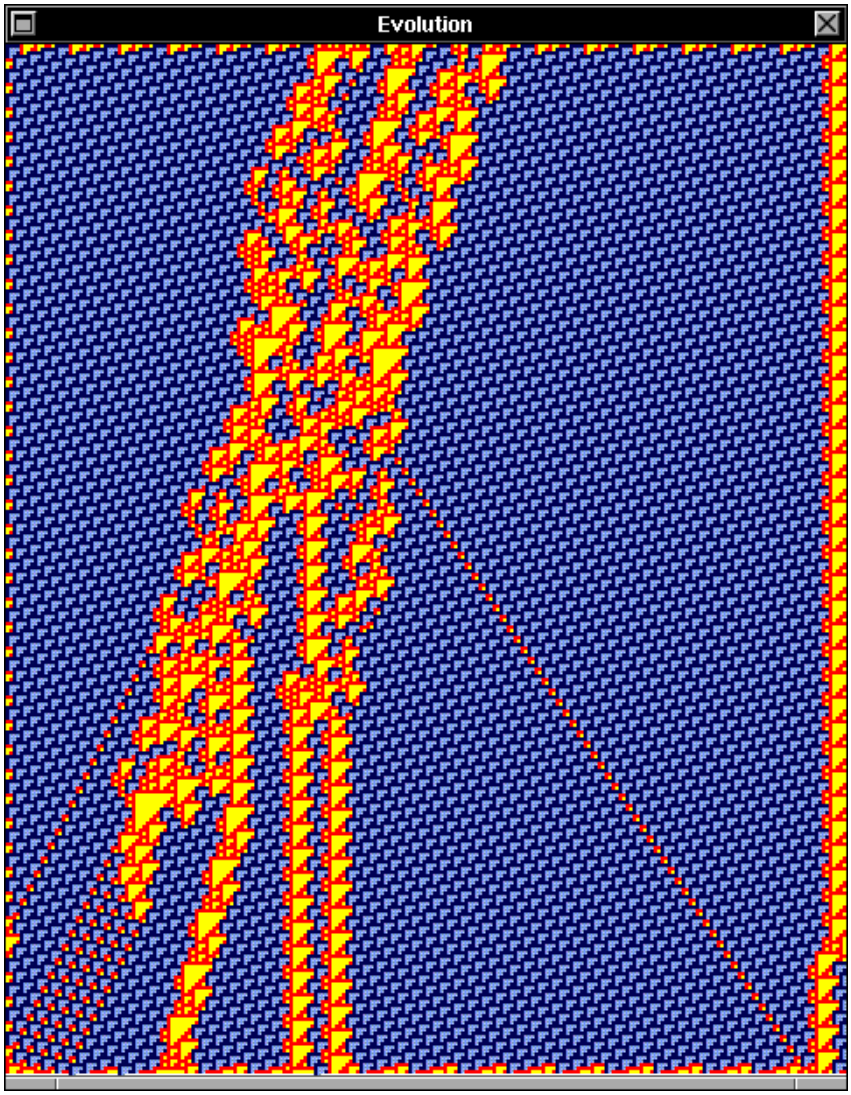

Figure 4.586: Collisions of glider G, H(p1)(F)-G(p1)(A)=A,B,C1,C1,E,5B

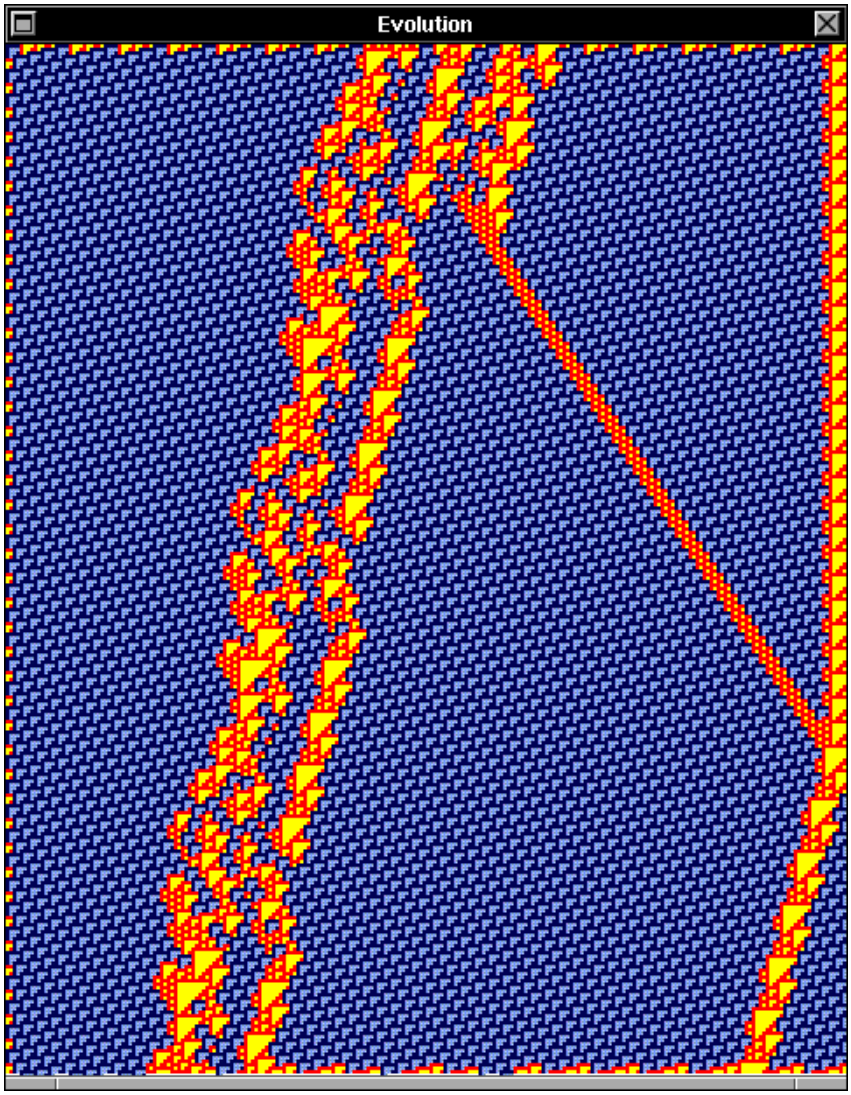

Figure 4.587: Collisions of glider G, H(p1)(F)-G(p1)(B)=H,4A

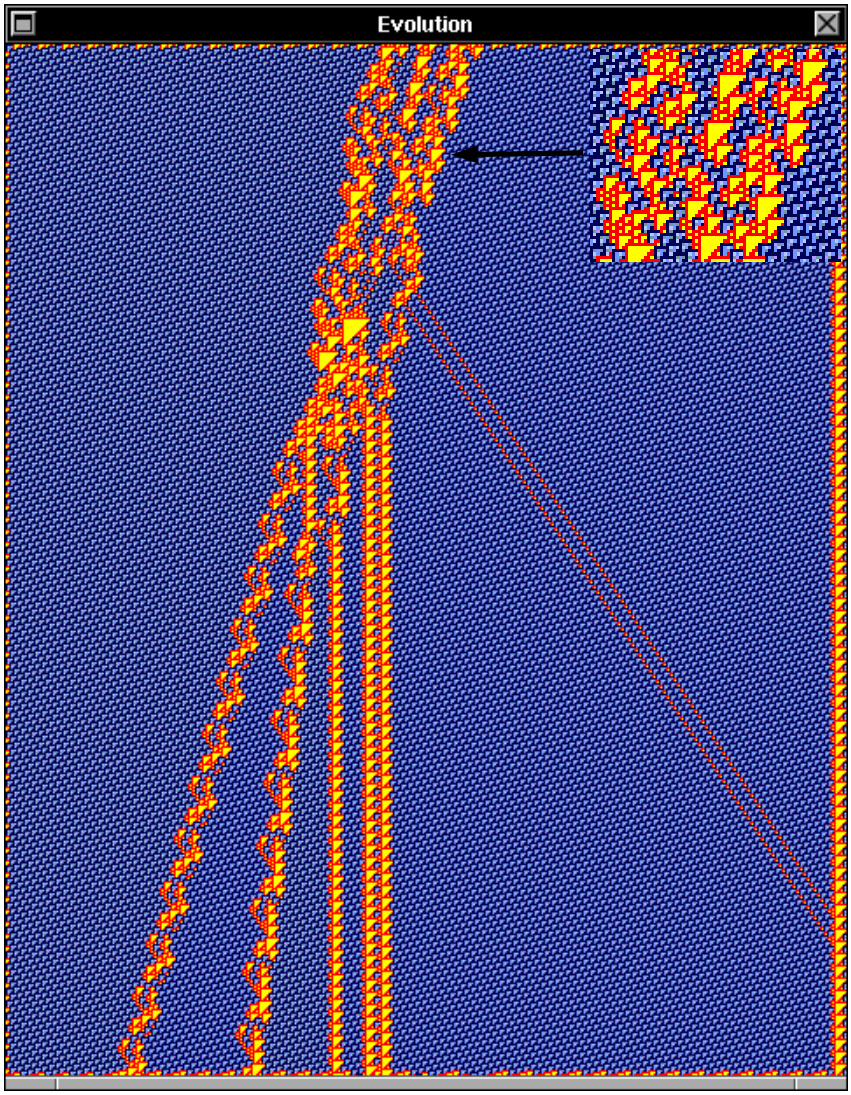

Figure 4.588: Collisions of glider G, H(p1)(F)-G(p1)(C)=A,A,2C2,Ebar,C1,F

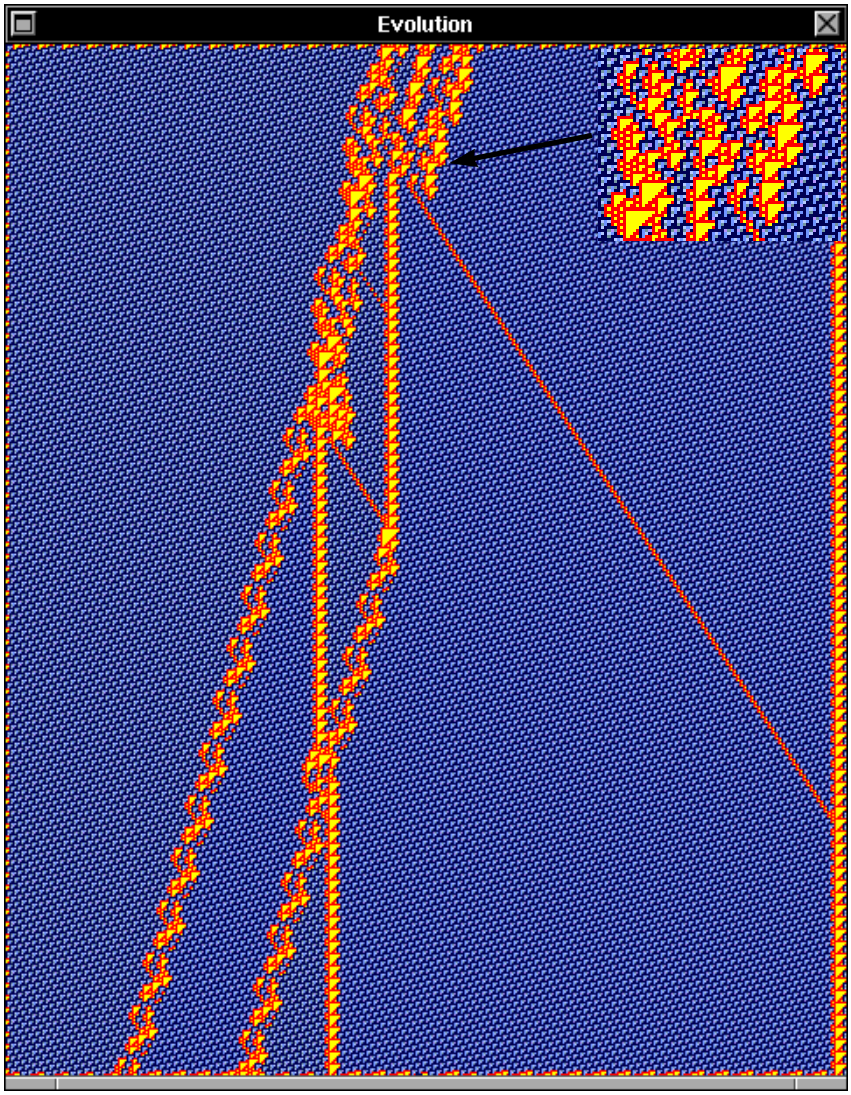

Figure 4.589: Collisions of glider G, H(p1)(F)-G(p1)(D)=2A,Ebar,C1,Ebar

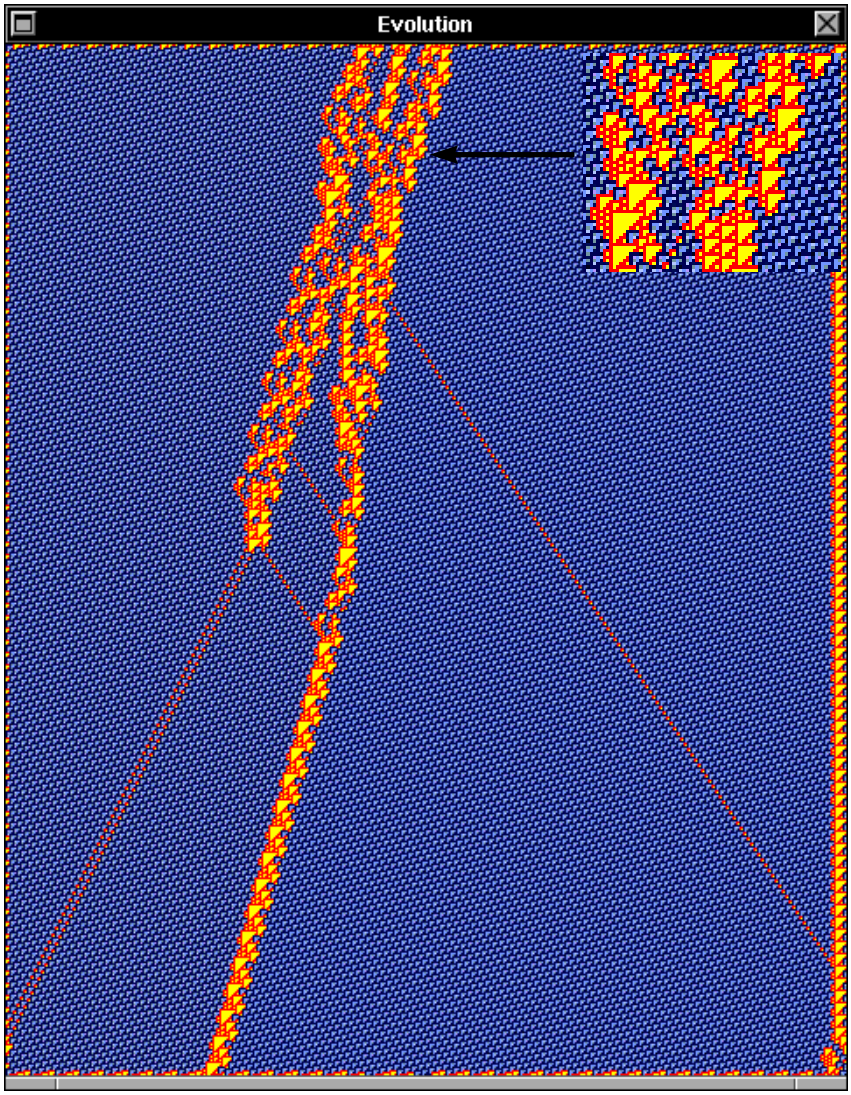

Figure 4.590: Collisions of glider G, H(p1)(F)-G(p1)(E)=A,2B,E2

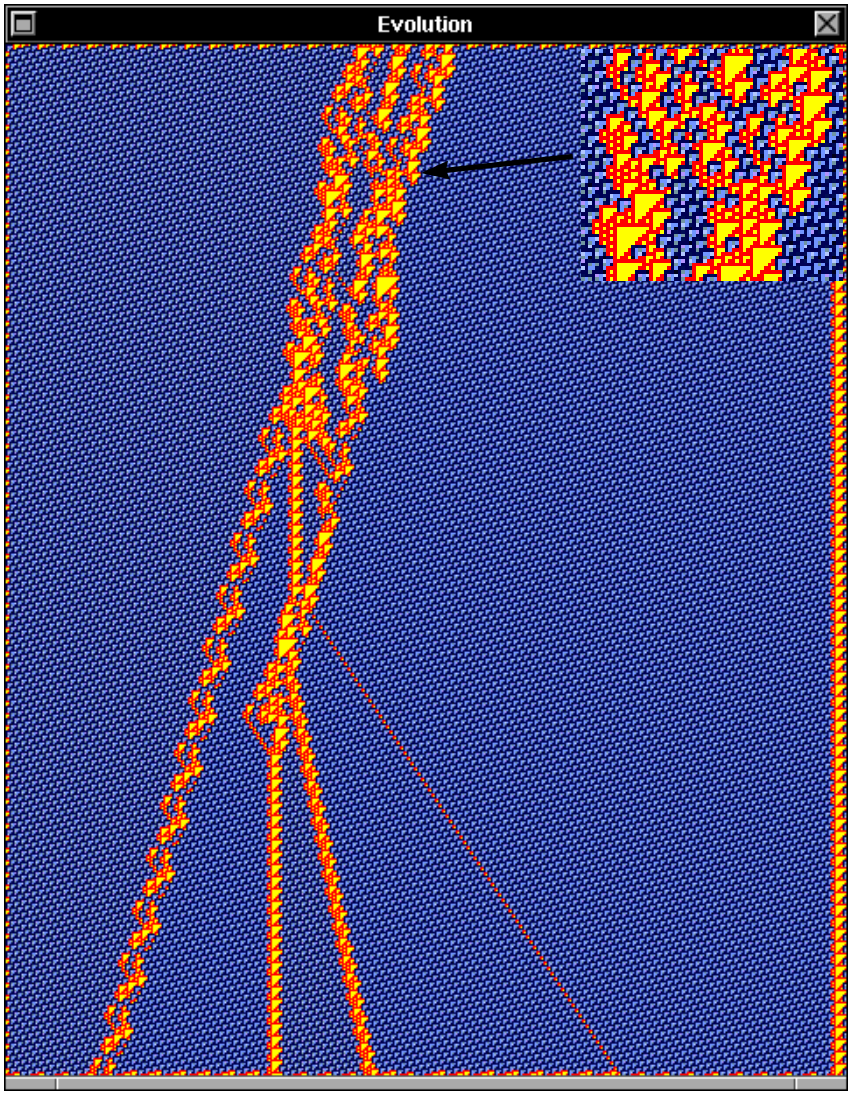

Figure 4.591: Collisions of glider G, H(p1)(F)-G(p1)(F)=Ebar,A,C2,D2

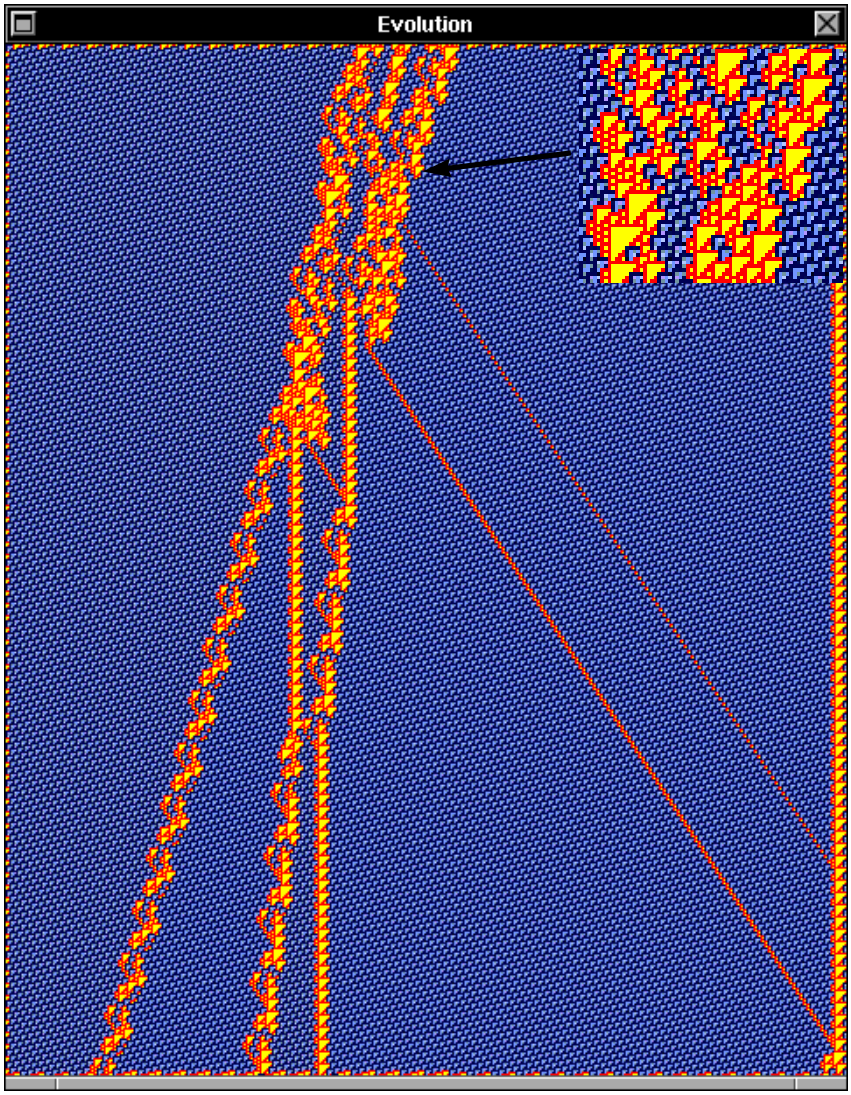

Figure 4.592: Collisions of glider G, H(p1)(F)-G(p1)(G)=A,2A,Ebar,C1,F

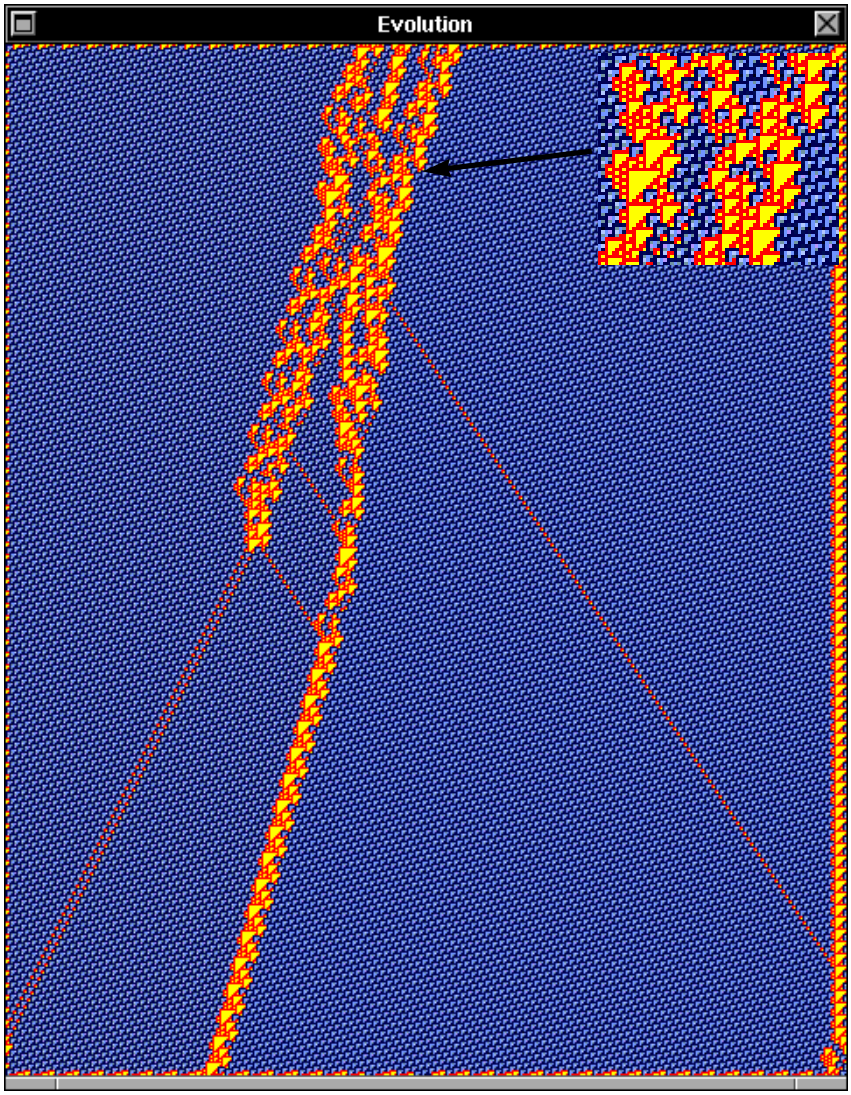

Figure 4.593: Collisions of glider G, H(p1)(F)-G(p1)(H)=A,2B,E2

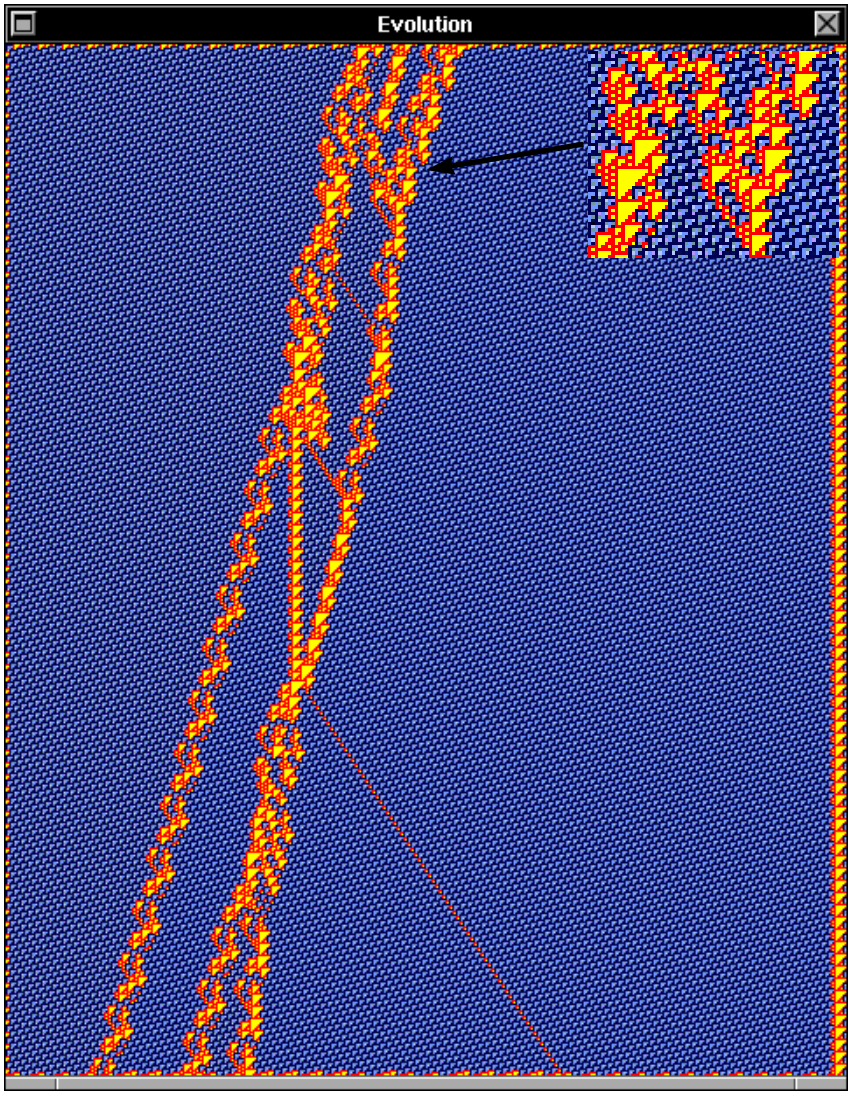

Figure 4.594: Collisions of glider G, H(p1)(F)-G(p1)(A2)=Ebar,A,Ebar,F

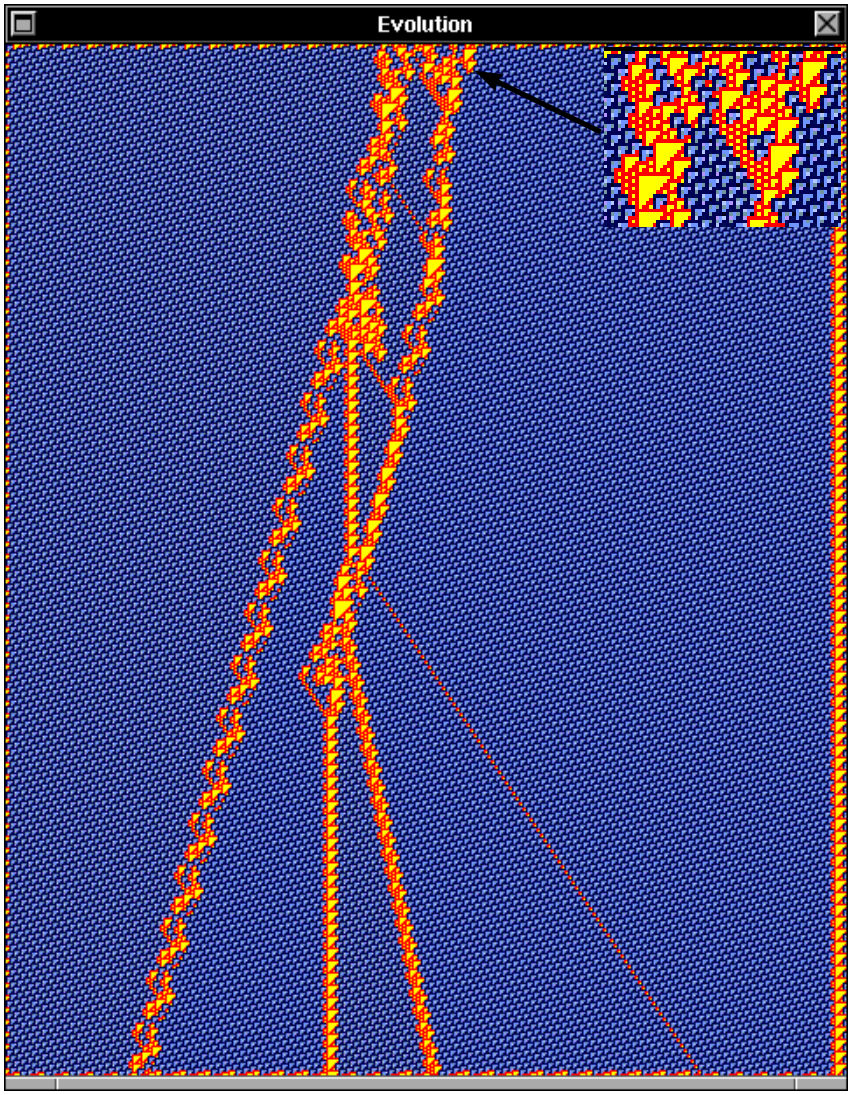

Figure 4.595: Collisions of glider G, H(p1)(C3)-G(p1)(A)=Ebar,A,D2,C2

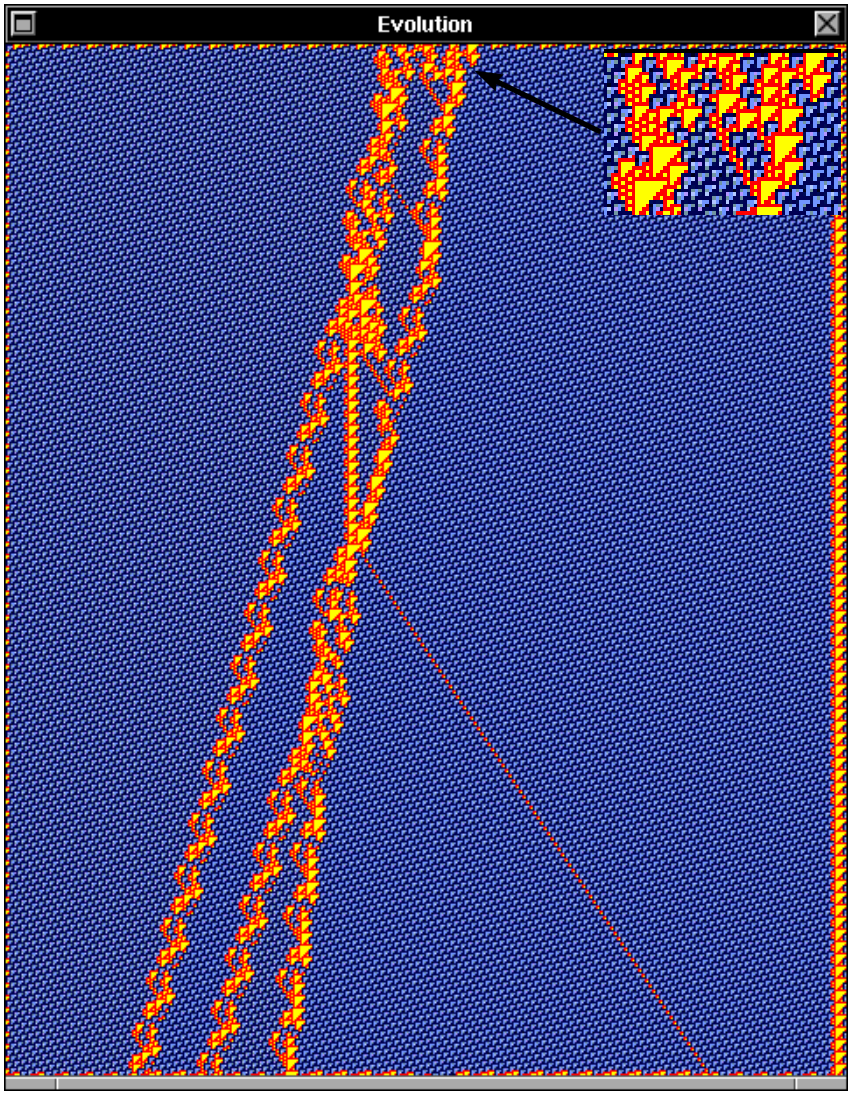

Figure 4.596: Collisions of glider G, H(p1)(C3)-G(p1)(B)=Ebar,A,Ebar,F

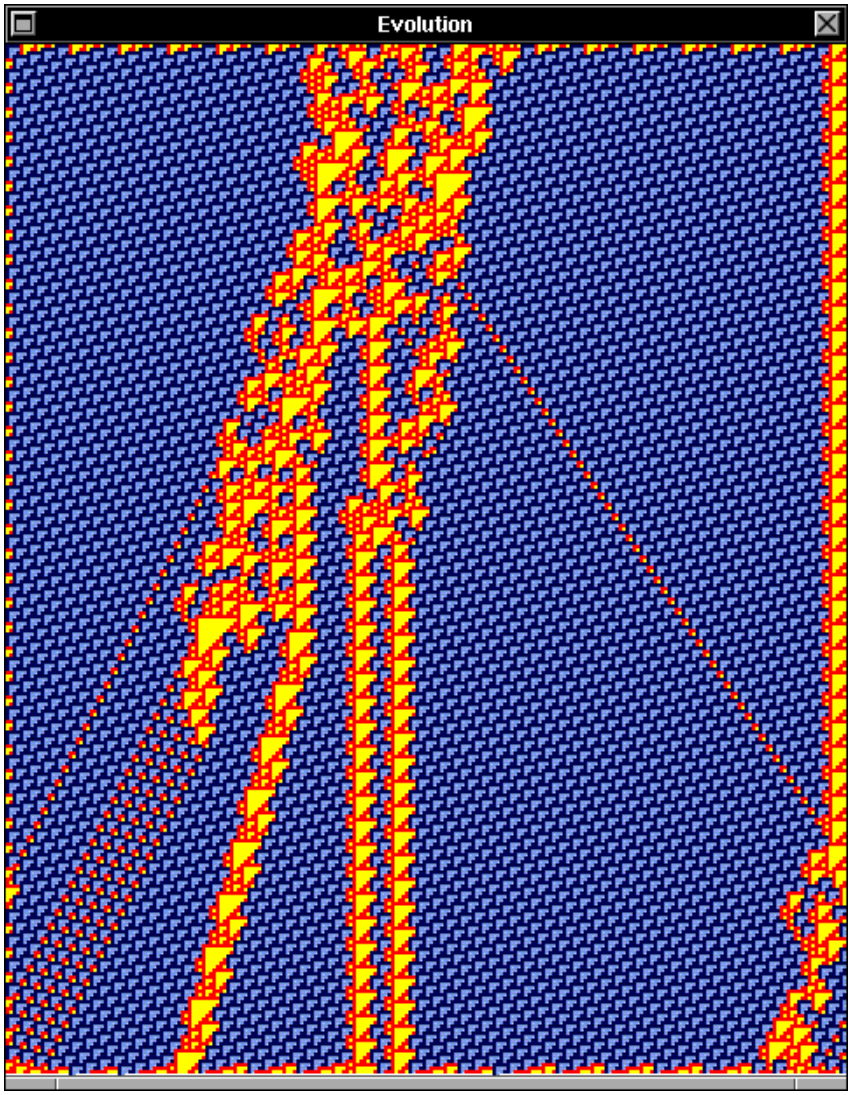

Figure 4.597: Collisions of glider G, H(p1)(C3)-G(p1)(C)=A,B,C1,C1,E,5B

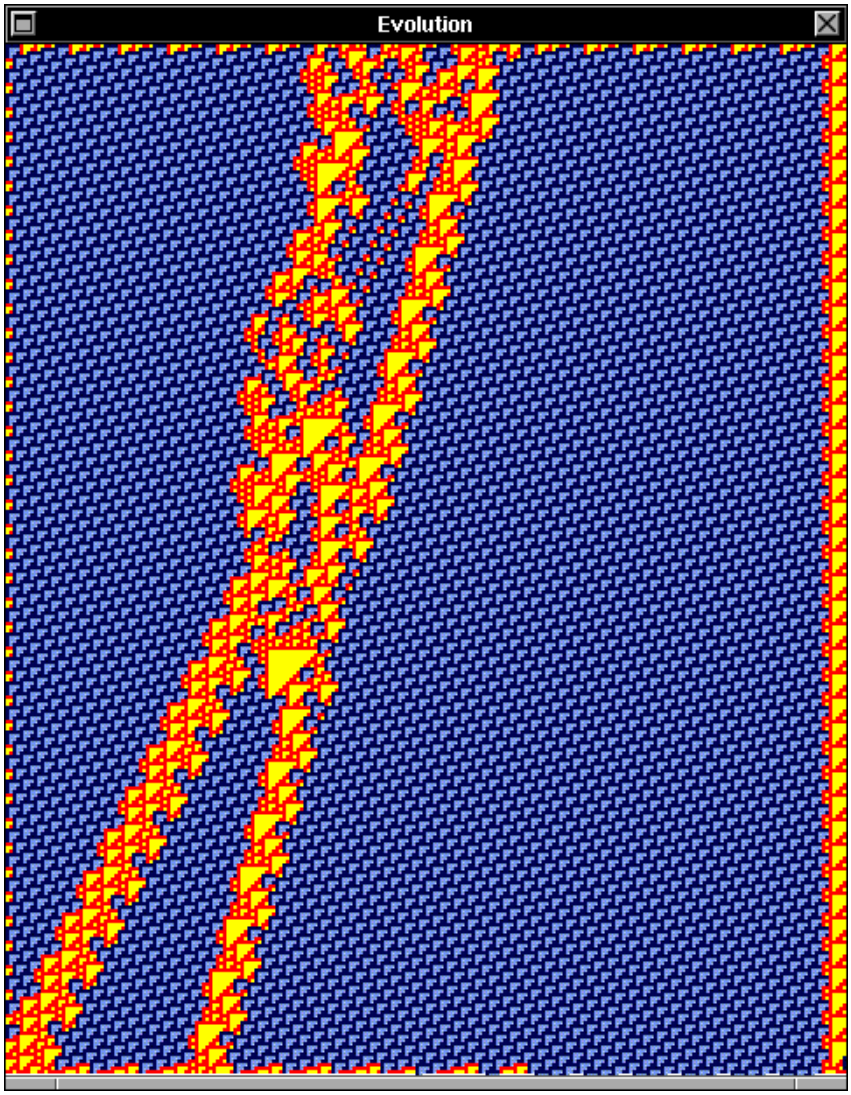

Figure 4.598: Collisions of glider G, H(p1)(C3)-G(p1)(D)=Bbar,E2

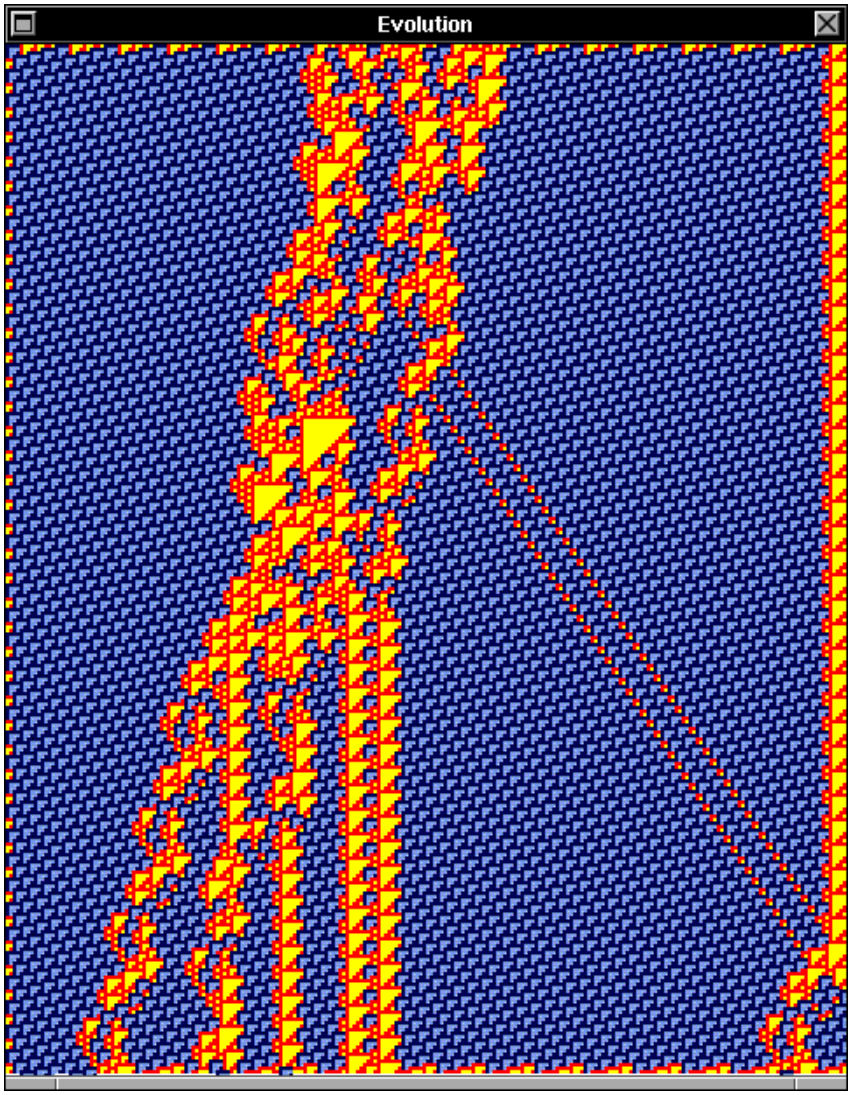

Figure 4.599: Collisions of glider G, H(p1)(C3)-G(p1)(E)=A,A,2C2,Ebar,C1,F

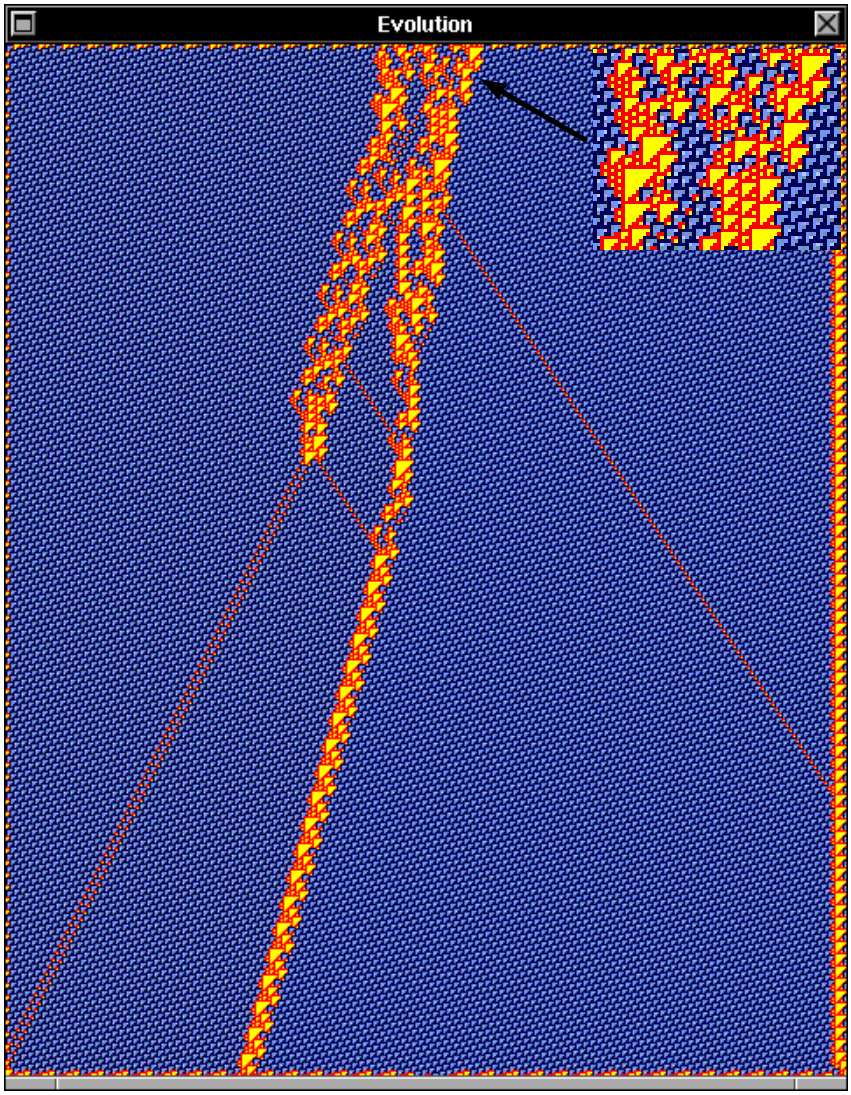

Figure 4.600: Collisions of glider G, H(p1)(C3)-G(p1)(G)=A,2B,E2

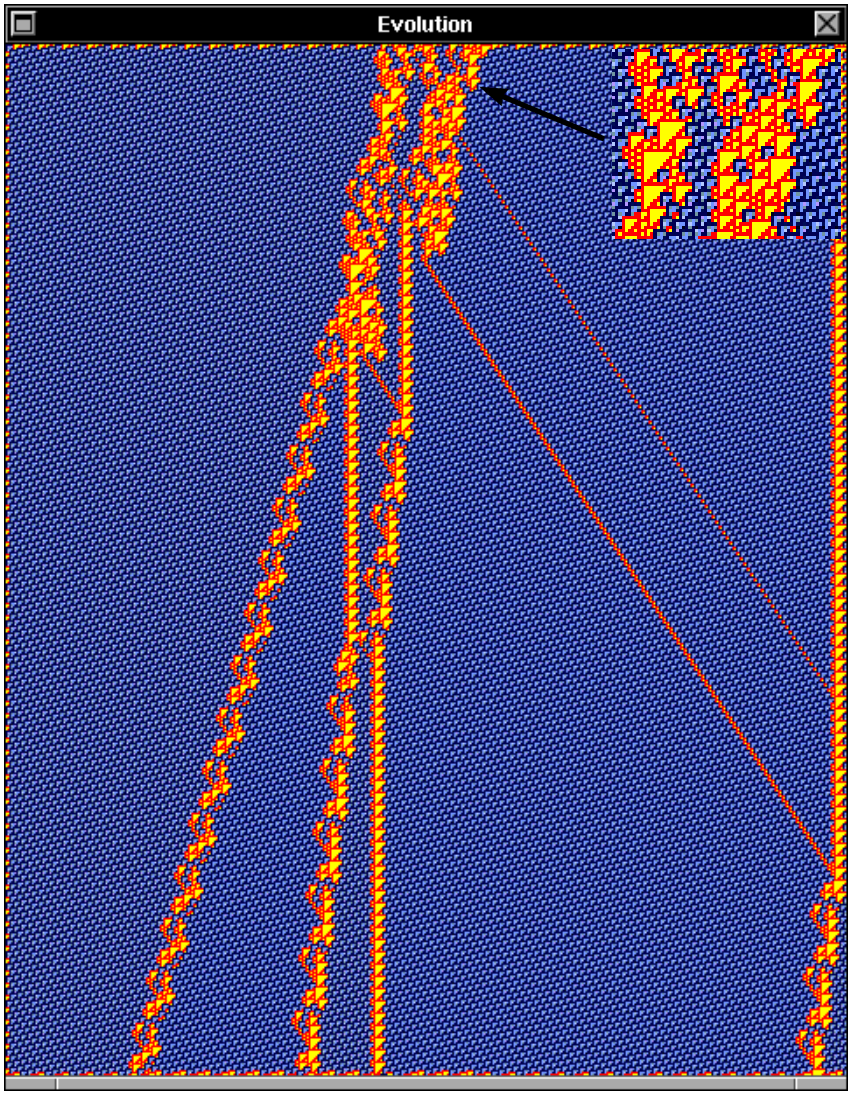

Figure 4.601: Collisions of glider G, H(p1)(C3)-G(p1)(A2)=A,2A,Ebar,C1,F

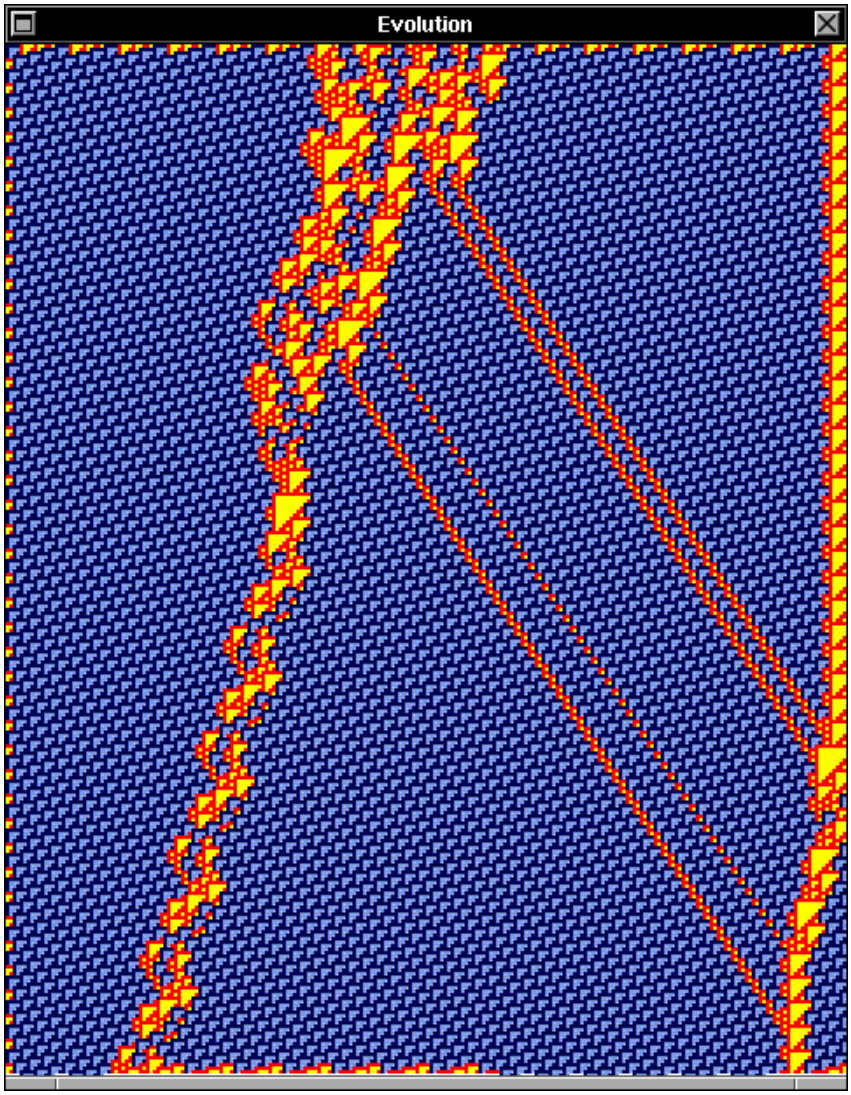

Figure 4.602: Collisions of glider G, H(p1)(D3)-G(p1)(A)=2A,2A,A,2A,Ebar

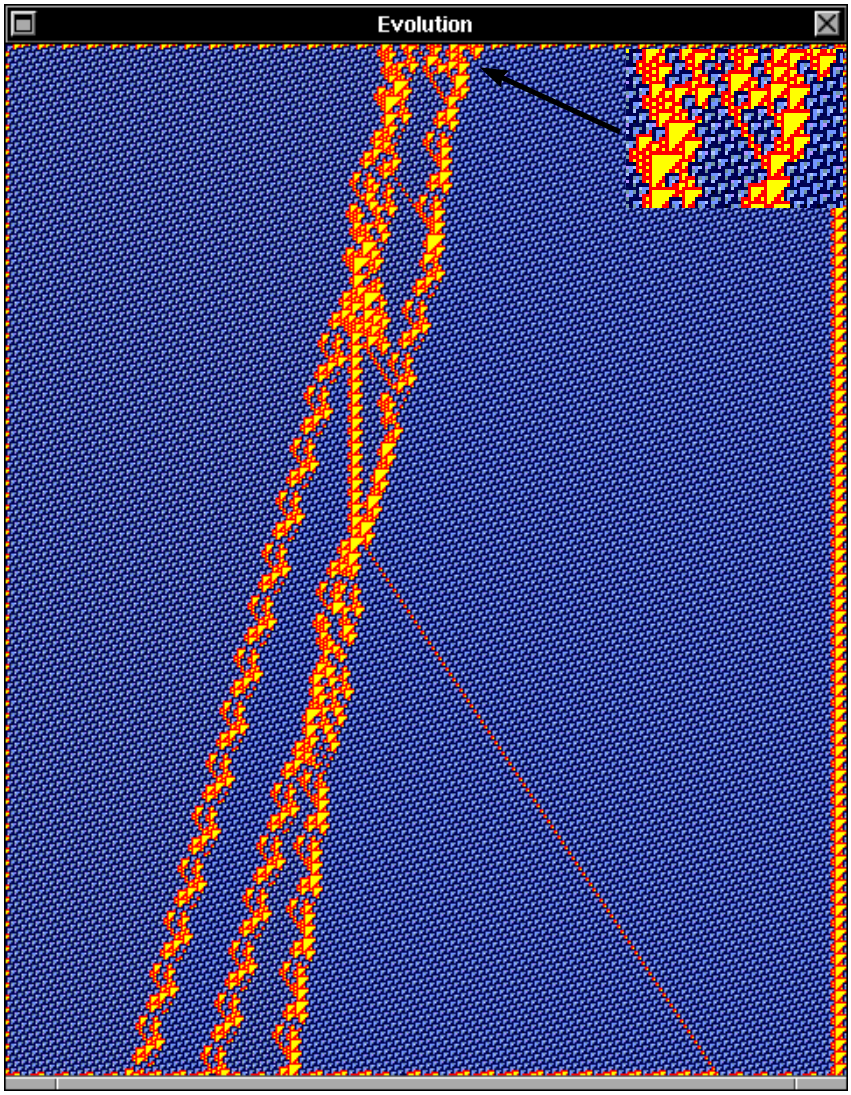

Figure 4.603: Collisions of glider G, H(p1)(D3)-G(p1)(C)=Ebar,A,Ebar,F

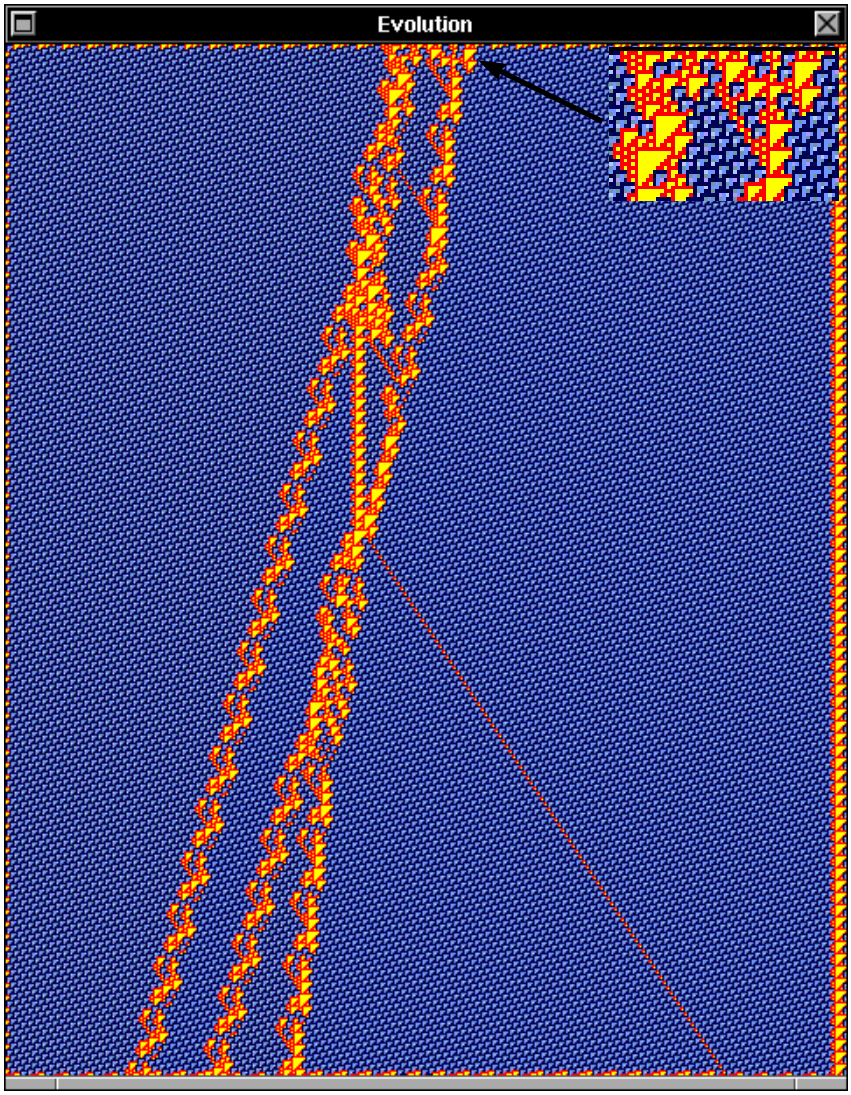

Figure 4.604: Collisions of glider G, H(p1)(E3)-G(p1)(A)=Ebar,A,Ebar,F

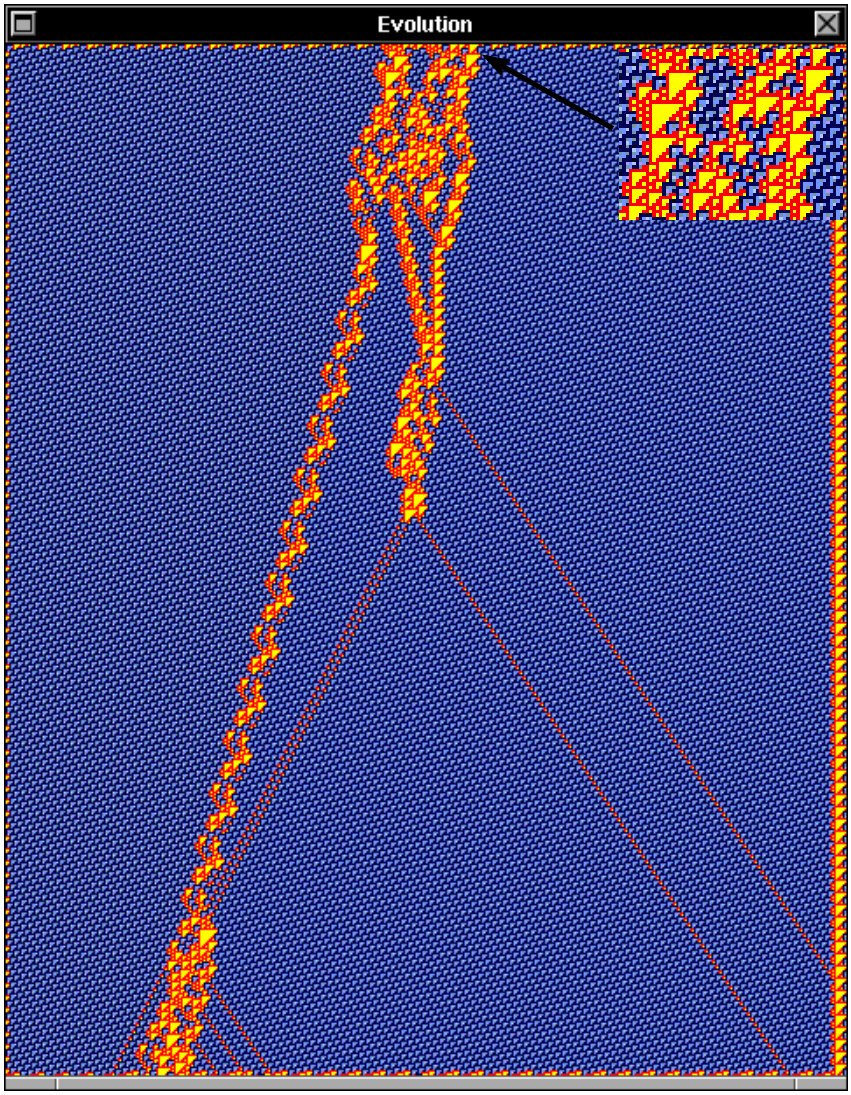

Figure 4.605: Collisions of glider G, H(p1)(H3)-G(p1)(F)=A,A,B,A,A,A,G,F

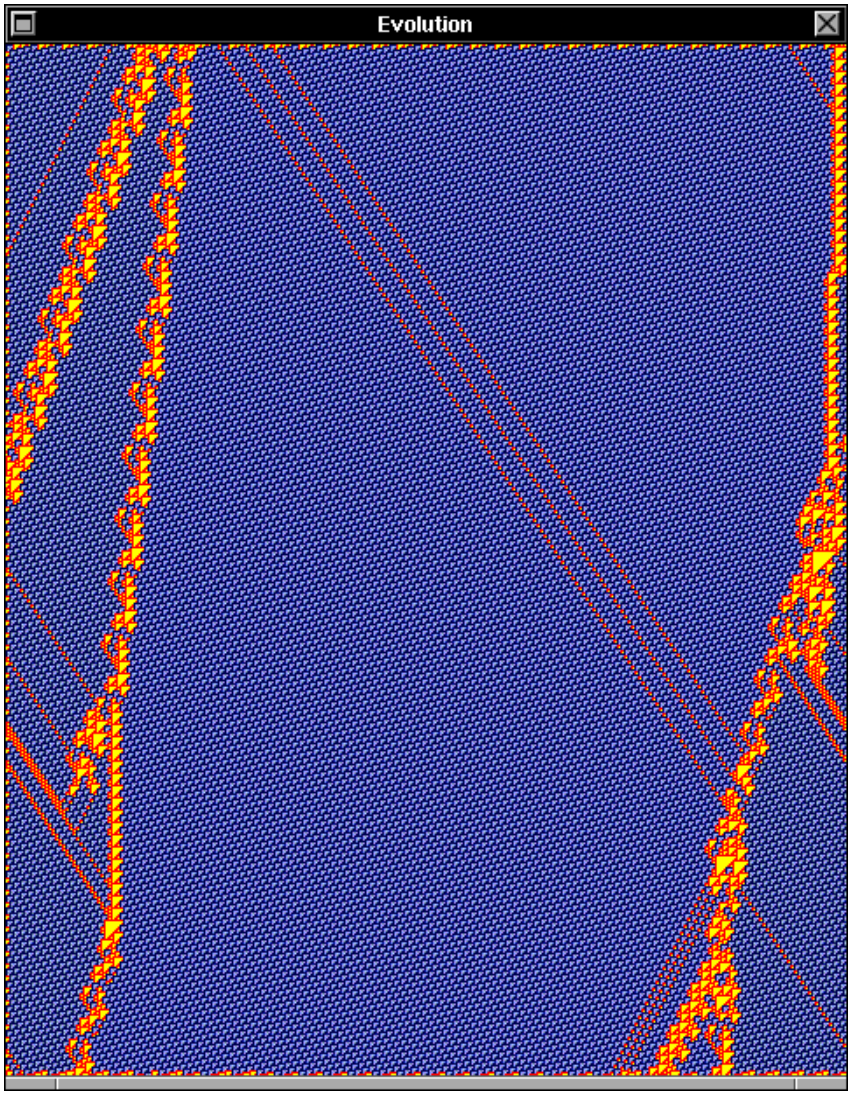

Figure 4.606: continue collision, H(p1)(H3)-G(p1)(F)

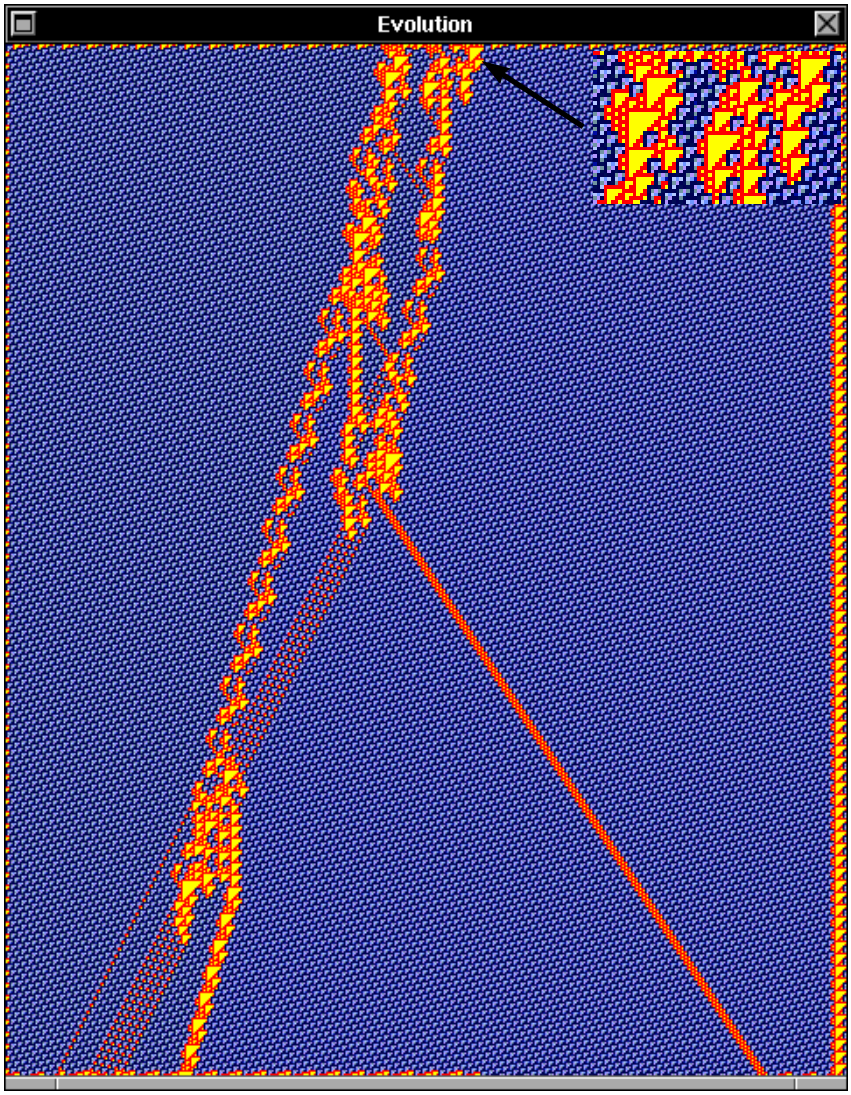

Figure 4.607: Collisions of glider G, H(p1)(H3)-G(p1)(G)=4A,B,E,5B

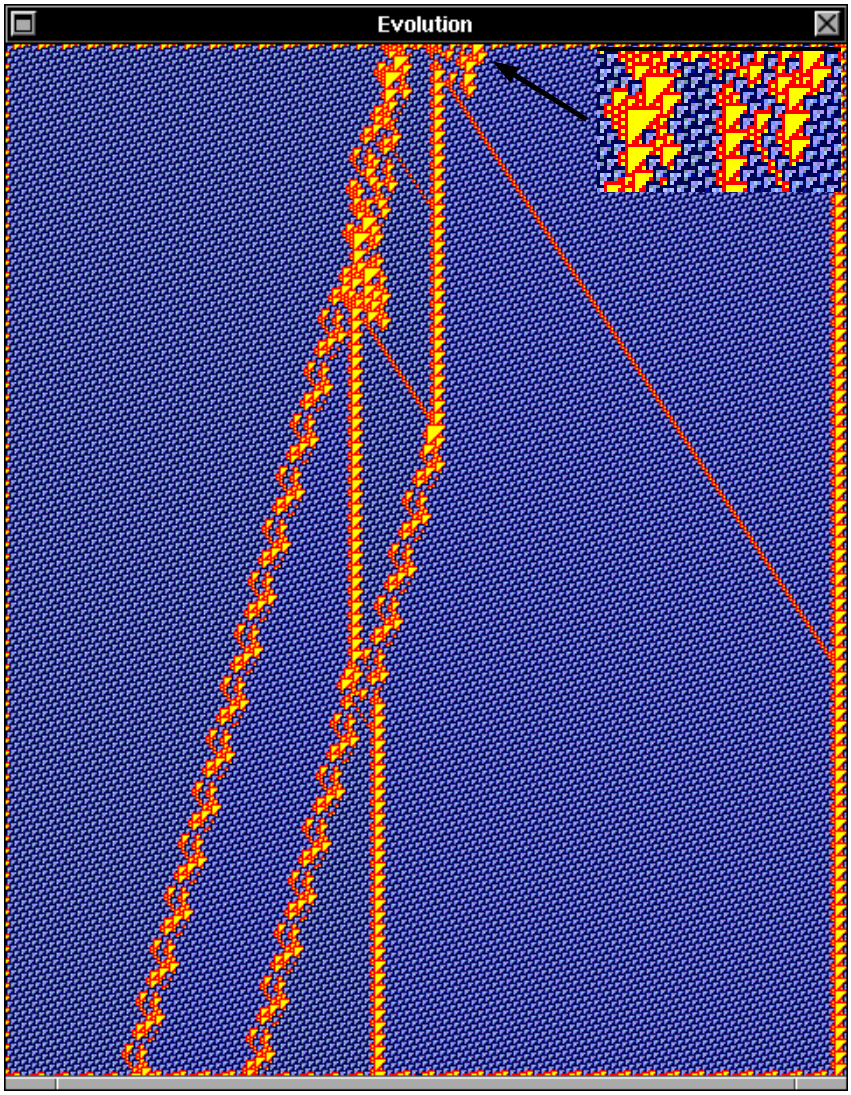

Figure 4.608: Collisions of glider G, H(p1)(H3)-G(p1)(H)=2A,Ebar,Ebar,C1

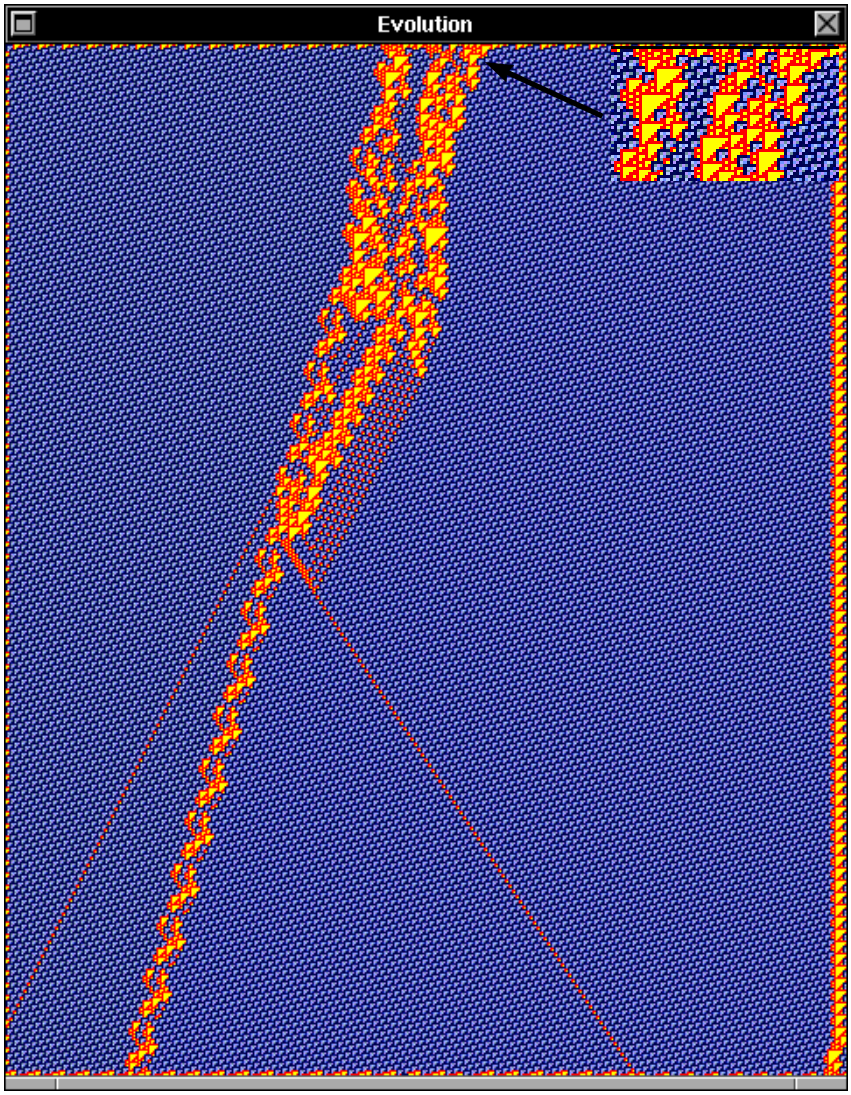

Figure 4.609: Collisions of glider G, H(p1)(H3)-G(p1)(A2)=B,Ebar,A

Chapter 5

Conclusions

Bibliography

[1] Elwyn Berlekamp, John Conway and Richard Gut, *Winning Ways for your Mathematical Plays*, Academic Press, vol 2, chapter 25, 1982.

[2] Matthew Cook, "Introduction to the activity of rule 110" (copyrigth 1994-1998 Matthew Cook), http://w3.datanet.hu/~cook/Workshop/CellAut/Elementary/Rule110/110pics.html, January 1998.

[3] Branko Grünbaum and G. C. Shephard, *Tilings and Patterns*, W. H. Freeman and Company, New York 1987 (ISBN 0-7167-1193-1).

[4] Genaro Juárez Martínez y Juan Carlos Seck Tuoh Mora, "Analizando gliders en la regla 110", Reporte de Investigación, Centro de Investigaciones y Estudios Avanzados del I.P.N., sin públicar, 1999.

[5] Wentian Li and Mats G. Nordahl, "Transient behavior of cellular automaton rule 110", *Physics Letters A* **166** 335-339 (1992).

[6] Harold V. McIntosh, "Rule 110 as it relates to the presence of gliders", http://delta.cs.cinvestav.mx/~mcintosh, January 1999.

[7] Harold V. McIntosh, "A Concordance for Rule 110", http://delta.cs.cinvestav.mx/~mcintosh, April 2000.

[8] John von Neumann, *Theory of Self-reproducing Automata*, University of Illinois Press, 1966.

[9] Stephen Wolfram, *Theory and Aplications of Cellular Automata*, World Scientific Press, Singapore 1986 (ISBN 9971-50-124-4 pbk).