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(19) **United States**(12) **Patent Application Publication**  
**Bartels**(10) **Pub. No.: US 2022/0111632 A1**(43) **Pub. Date: Apr. 14, 2022**(54) **DIGITAL HALFTONING WITH CLUSTERED  
MICRODOTS****B41M 1/04** (2006.01)**B41M 1/06** (2006.01)**B41M 1/14** (2006.01)(71) Applicant: **AGFA NV**, Mortsel (BE)(52) **U.S. Cl.**(72) Inventor: **Rudolf Bartels**, Mortsel (BE)CPC ..... **B41F 33/0072** (2013.01); **H04N 1/4055**  
(2013.01); **B41M 1/14** (2013.01); **B41M 1/06**  
(2013.01); **B41M 1/04** (2013.01)(21) Appl. No.: **17/264,449**(22) PCT Filed: **Apr. 30, 2019**(57) **ABSTRACT**(86) PCT No.: **PCT/EP2019/061087**

§ 371 (c)(1),

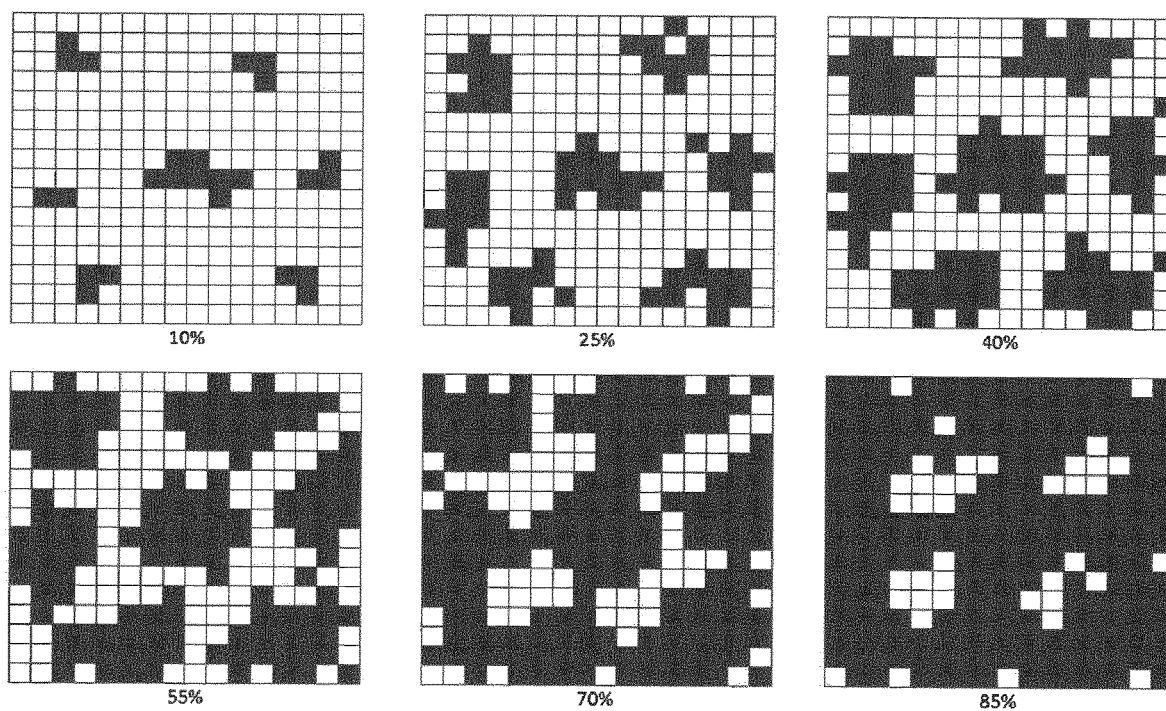
(2) Date: **Jan. 29, 2021**(30) **Foreign Application Priority Data**

Aug. 10, 2018 (EP) ..... 18188424.8

Oct. 23, 2018 (EP) ..... PCT/EP2018/079011

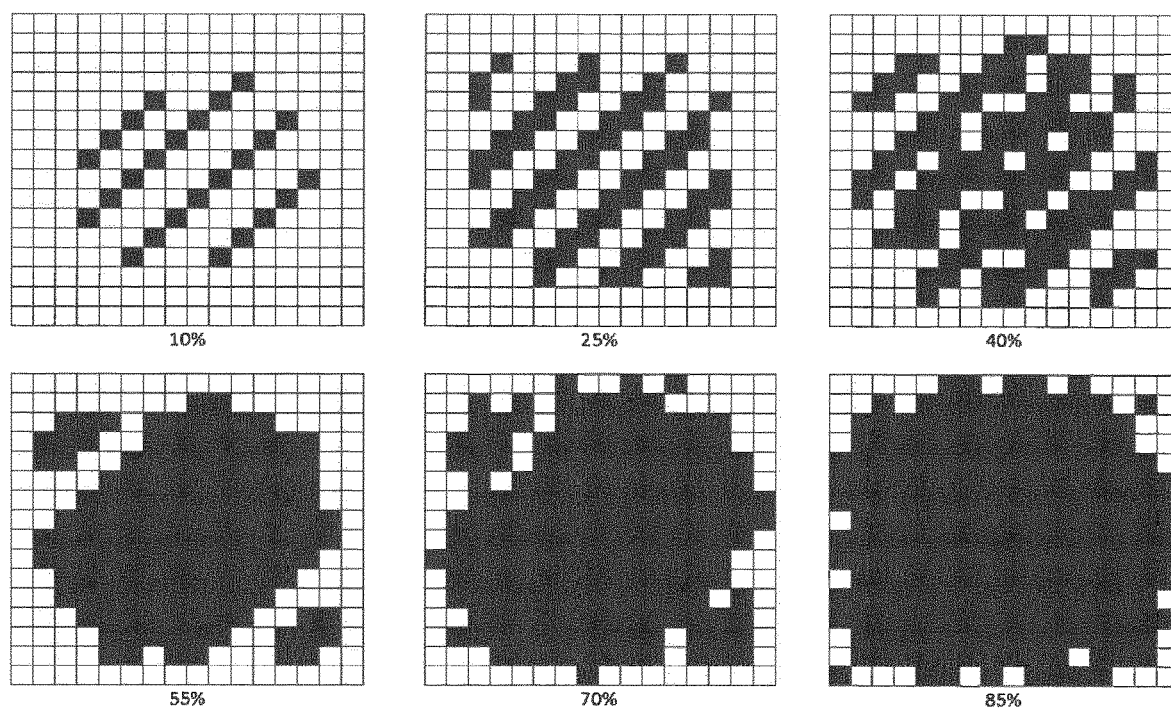
**Publication Classification**(51) **Int. Cl.****B41F 33/00** (2006.01)**H04N 1/405** (2006.01)

A method of reproducing a continuous-tone image with a printing press comprises the step of making a printing plate having a halftone raster image comprising regularly tiled halftone cells which consist of a grid of image pixels and non-image pixels; the halftone cells are obtained by digital halftoning with a single threshold array and at least a portion of the halftone cells in the raster image comprise multiple image clusters, image clusters being defined as mutually separated groups of more than 4 adjacent image pixels; the image clusters allow to obtain a printed image of the same image density with less ink than with conventional screens wherein the image pixels are grouped into a single cluster.



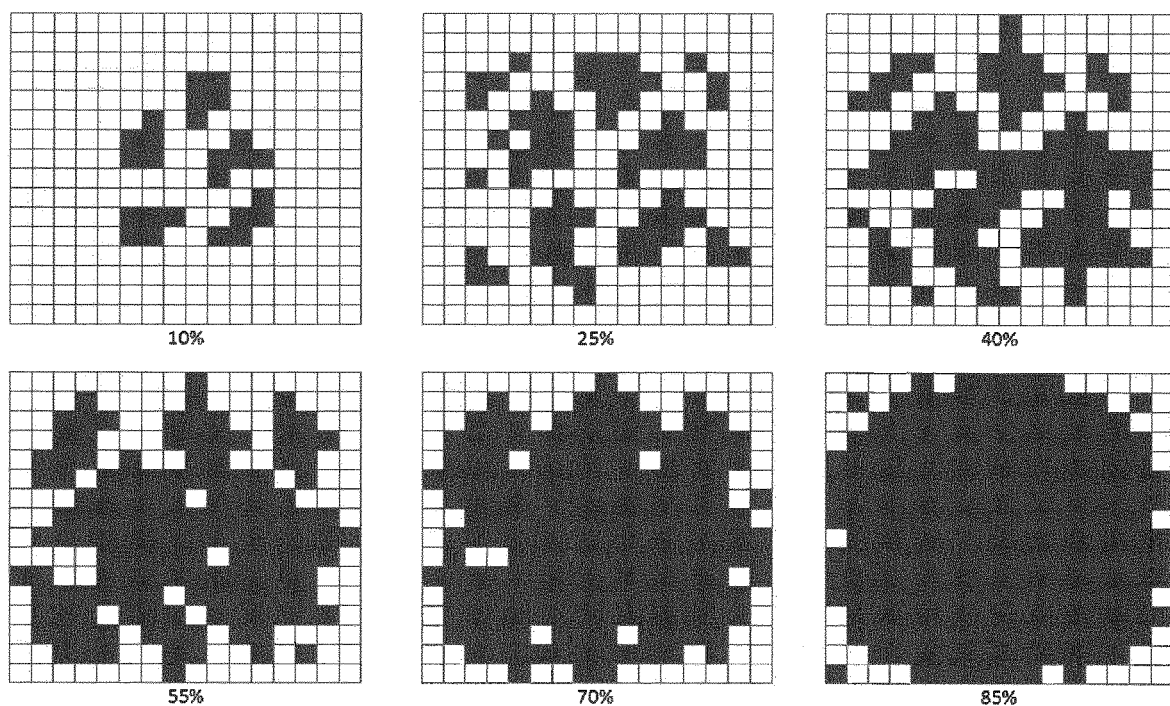
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| 171 | 180 | 121 | 233 | 141 | 181 | 184 | 213 | 150 | 96  | 145 | 45  | 203 | 156 | 253 | 152 |
| 125 | 95  | 19  | 108 | 132 | 190 | 174 | 115 | 116 | 58  | 40  | 70  | 26  | 65  | 137 | 189 |
| 66  | 33  | 8   | 13  | 88  | 246 | 170 | 119 | 84  | 102 | 10  | 21  | 49  | 129 | 196 | 192 |
| 112 | 79  | 38  | 54  | 161 | 210 | 216 | 195 | 138 | 126 | 109 | 18  | 239 | 212 | 198 | 133 |
| 188 | 61  | 48  | 44  | 243 | 204 | 228 | 231 | 155 | 166 | 122 | 219 | 223 | 238 | 104 | 92  |
| 151 | 199 | 207 | 249 | 255 | 222 | 235 | 69  | 149 | 131 | 248 | 251 | 227 | 89  | 78  | 110 |
| 208 | 136 | 179 | 220 | 237 | 241 | 100 | 29  | 81  | 74  | 183 | 173 | 63  | 71  | 32  | 113 |
| 178 | 87  | 76  | 98  | 185 | 158 | 64  | 1   | 2   | 94  | 123 | 186 | 128 | 55  | 17  | 42  |
| 82  | 27  | 53  | 91  | 164 | 85  | 12  | 3   | 4   | 6   | 7   | 200 | 167 | 22  | 11  | 143 |
| 106 | 14  | 24  | 72  | 142 | 232 | 50  | 139 | 59  | 5   | 160 | 236 | 194 | 191 | 35  | 242 |
| 36  | 30  | 39  | 252 | 226 | 234 | 215 | 172 | 169 | 127 | 247 | 209 | 225 | 140 | 153 | 162 |
| 148 | 47  | 103 | 254 | 244 | 221 | 193 | 118 | 211 | 224 | 256 | 83  | 157 | 177 | 114 | 197 |
| 214 | 62  | 163 | 201 | 240 | 43  | 78  | 80  | 205 | 217 | 229 | 68  | 31  | 134 | 105 | 99  |
| 206 | 144 | 130 | 9   | 15  | 28  | 73  | 101 | 154 | 182 | 75  | 41  | 25  | 23  | 37  | 147 |
| 168 | 176 | 124 | 20  | 34  | 67  | 51  | 86  | 175 | 111 | 56  | 46  | 97  | 16  | 52  | 187 |
| 245 | 202 | 107 | 218 | 57  | 120 | 93  | 159 | 250 | 165 | 135 | 146 | 90  | 60  | 230 | 117 |

Fig. 1



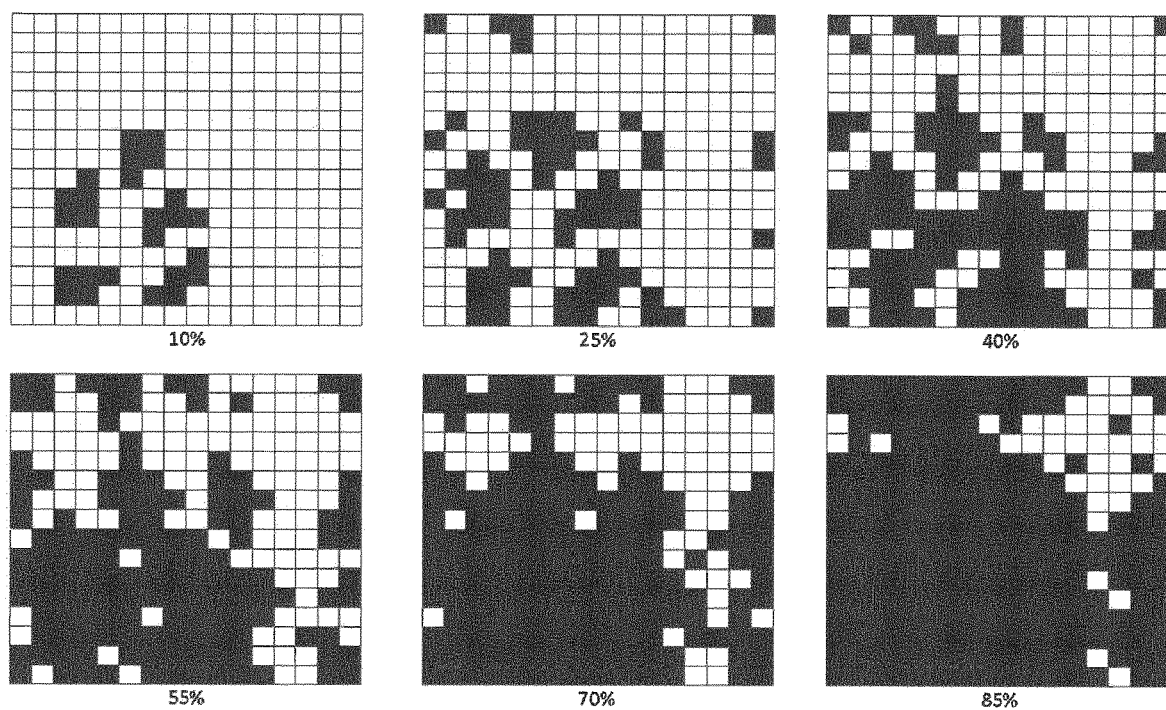
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| 248 | 254 | 226 | 220 | 236 | 198 | 172 | 227 | 213 | 163 | 222 | 173 | 234 | 244 | 256 | 247 |
| 240 | 224 | 161 | 219 | 159 | 194 | 144 | 148 | 75  | 76  | 160 | 184 | 187 | 218 | 202 | 253 |
| 233 | 190 | 129 | 60  | 92  | 192 | 134 | 57  | 73  | 136 | 91  | 48  | 167 | 157 | 238 | 241 |
| 229 | 127 | 27  | 71  | 185 | 179 | 55  | 29  | 87  | 105 | 17  | 81  | 135 | 65  | 223 | 231 |
| 196 | 94  | 62  | 168 | 181 | 51  | 19  | 103 | 121 | 11  | 41  | 110 | 124 | 47  | 174 | 228 |
| 203 | 191 | 176 | 189 | 49  | 7   | 108 | 85  | 5   | 39  | 80  | 102 | 22  | 133 | 153 | 211 |
| 208 | 206 | 142 | 53  | 15  | 83  | 114 | 1   | 35  | 99  | 116 | 12  | 45  | 117 | 151 | 150 |
| 232 | 154 | 59  | 23  | 118 | 97  | 2   | 31  | 113 | 78  | 6   | 40  | 112 | 138 | 69  | 177 |
| 197 | 67  | 26  | 123 | 89  | 9   | 33  | 77  | 100 | 4   | 36  | 107 | 122 | 24  | 68  | 216 |
| 149 | 70  | 109 | 101 | 13  | 38  | 115 | 104 | 3   | 32  | 119 | 88  | 20  | 58  | 182 | 207 |
| 230 | 152 | 125 | 21  | 43  | 106 | 79  | 10  | 34  | 139 | 84  | 8   | 54  | 156 | 200 | 188 |
| 209 | 166 | 64  | 44  | 82  | 120 | 14  | 37  | 86  | 98  | 16  | 50  | 178 | 195 | 170 | 250 |
| 205 | 217 | 158 | 126 | 131 | 18  | 42  | 111 | 132 | 25  | 52  | 175 | 169 | 28  | 93  | 204 |
| 245 | 162 | 165 | 155 | 66  | 46  | 137 | 90  | 30  | 56  | 143 | 180 | 61  | 63  | 128 | 243 |
| 249 | 215 | 183 | 171 | 95  | 140 | 145 | 72  | 74  | 141 | 146 | 235 | 96  | 130 | 164 | 246 |
| 201 | 255 | 242 | 237 | 193 | 186 | 221 | 147 | 225 | 210 | 199 | 212 | 214 | 239 | 252 | 251 |

Fig. 2



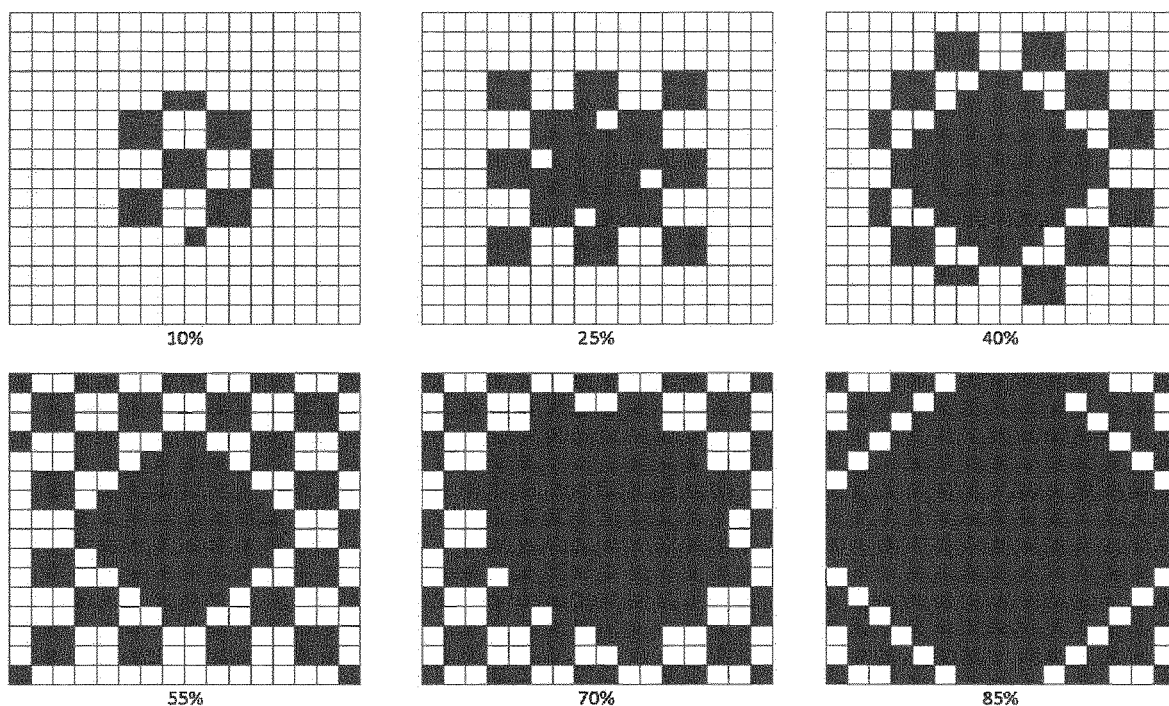
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| 248 | 254 | 226 | 220 | 236 | 198 | 172 | 227 | 213 | 163 | 222 | 173 | 234 | 244 | 256 | 247 |
| 240 | 224 | 161 | 219 | 159 | 194 | 144 | 148 | 75  | 76  | 160 | 184 | 187 | 218 | 202 | 253 |
| 233 | 190 | 129 | 60  | 92  | 192 | 134 | 57  | 73  | 136 | 91  | 48  | 167 | 157 | 238 | 241 |
| 229 | 127 | 27  | 71  | 185 | 179 | 55  | 29  | 87  | 105 | 17  | 81  | 135 | 65  | 223 | 231 |
| 196 | 94  | 62  | 168 | 181 | 51  | 19  | 103 | 121 | 11  | 41  | 110 | 124 | 47  | 174 | 228 |
| 203 | 191 | 176 | 189 | 49  | 7   | 108 | 85  | 5   | 39  | 80  | 102 | 22  | 133 | 153 | 211 |
| 208 | 206 | 142 | 53  | 15  | 83  | 114 | 1   | 35  | 99  | 116 | 12  | 45  | 117 | 151 | 150 |
| 232 | 154 | 59  | 23  | 118 | 97  | 2   | 31  | 113 | 78  | 6   | 40  | 112 | 138 | 69  | 177 |
| 197 | 67  | 26  | 123 | 89  | 9   | 33  | 77  | 100 | 4   | 36  | 107 | 122 | 24  | 68  | 216 |
| 149 | 70  | 109 | 101 | 13  | 38  | 115 | 104 | 3   | 32  | 119 | 88  | 20  | 58  | 182 | 207 |
| 230 | 152 | 125 | 21  | 43  | 106 | 79  | 10  | 34  | 139 | 84  | 8   | 54  | 156 | 200 | 188 |
| 209 | 166 | 64  | 44  | 82  | 120 | 14  | 37  | 86  | 98  | 16  | 50  | 178 | 195 | 170 | 250 |
| 205 | 217 | 158 | 126 | 131 | 18  | 42  | 111 | 132 | 25  | 52  | 175 | 169 | 28  | 93  | 204 |
| 245 | 162 | 165 | 155 | 66  | 46  | 137 | 90  | 30  | 56  | 143 | 180 | 61  | 63  | 128 | 243 |
| 249 | 215 | 183 | 171 | 95  | 140 | 145 | 72  | 74  | 141 | 146 | 235 | 96  | 130 | 164 | 246 |
| 201 | 255 | 242 | 237 | 193 | 186 | 221 | 147 | 225 | 210 | 199 | 212 | 214 | 239 | 252 | 251 |

Fig. 3



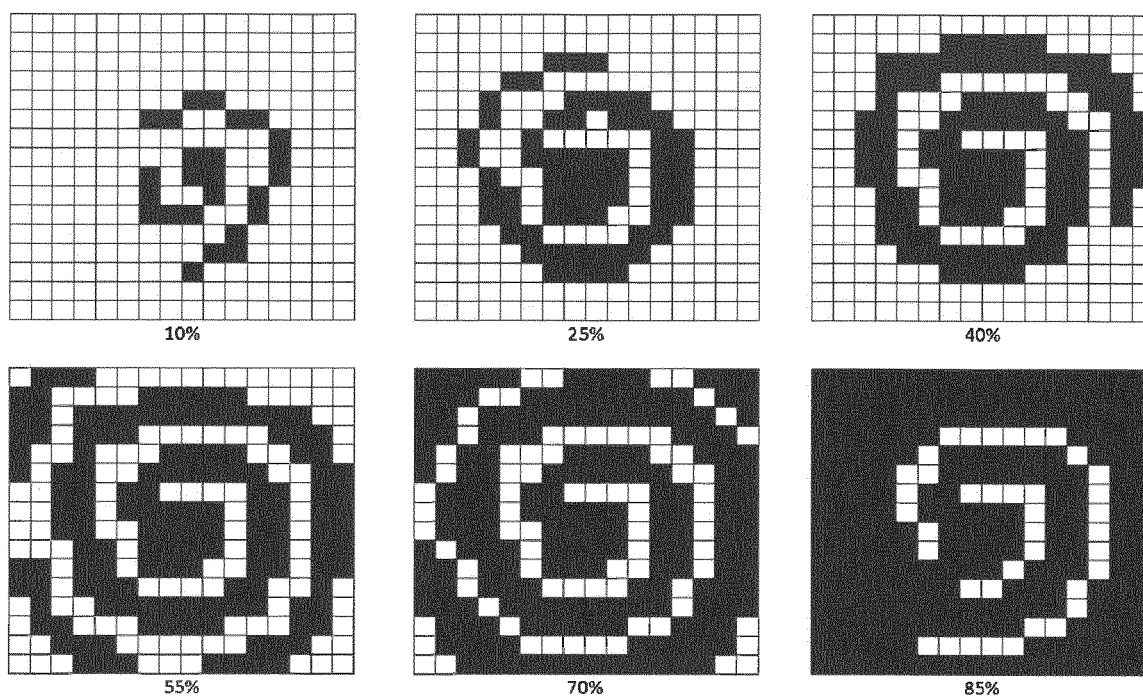
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| 54  | 137 | 191 | 58  | 41  | 104 | 193 | 107 | 83  | 162 | 174 | 186 | 232 | 247 | 128 | 46  |
| 129 | 81  | 165 | 167 | 62  | 67  | 156 | 176 | 85  | 211 | 123 | 241 | 254 | 249 | 237 | 132 |
| 220 | 148 | 214 | 205 | 108 | 177 | 184 | 227 | 206 | 221 | 244 | 250 | 229 | 202 | 253 | 243 |
| 233 | 201 | 228 | 189 | 210 | 96  | 217 | 208 | 219 | 248 | 218 | 255 | 234 | 246 | 252 | 242 |
| 112 | 185 | 199 | 195 | 170 | 68  | 178 | 181 | 212 | 130 | 236 | 203 | 251 | 240 | 216 | 239 |
| 80  | 63  | 187 | 175 | 60  | 33  | 43  | 166 | 198 | 56  | 124 | 235 | 245 | 256 | 230 | 125 |
| 47  | 157 | 164 | 149 | 28  | 18  | 23  | 38  | 155 | 86  | 48  | 116 | 238 | 231 | 173 | 55  |
| 131 | 192 | 59  | 146 | 161 | 8   | 13  | 190 | 154 | 135 | 52  | 159 | 222 | 215 | 100 | 50  |
| 153 | 37  | 42  | 17  | 119 | 2   | 140 | 127 | 34  | 179 | 139 | 180 | 213 | 158 | 117 | 138 |
| 61  | 79  | 22  | 6   | 105 | 143 | 113 | 5   | 29  | 44  | 171 | 200 | 172 | 204 | 168 | 147 |
| 70  | 27  | 12  | 1   | 87  | 102 | 9   | 14  | 24  | 39  | 75  | 77  | 223 | 182 | 194 | 76  |
| 99  | 32  | 136 | 106 | 90  | 84  | 19  | 73  | 69  | 65  | 92  | 101 | 103 | 226 | 93  | 64  |
| 183 | 109 | 74  | 31  | 88  | 89  | 144 | 126 | 10  | 91  | 120 | 95  | 169 | 207 | 150 | 188 |
| 160 | 72  | 16  | 11  | 3   | 118 | 121 | 4   | 25  | 45  | 114 | 197 | 142 | 111 | 98  | 141 |
| 134 | 133 | 21  | 7   | 145 | 110 | 20  | 15  | 35  | 82  | 53  | 151 | 225 | 196 | 115 | 94  |
| 71  | 152 | 26  | 36  | 78  | 163 | 40  | 30  | 66  | 97  | 49  | 57  | 209 | 224 | 122 | 51  |

Fig. 4



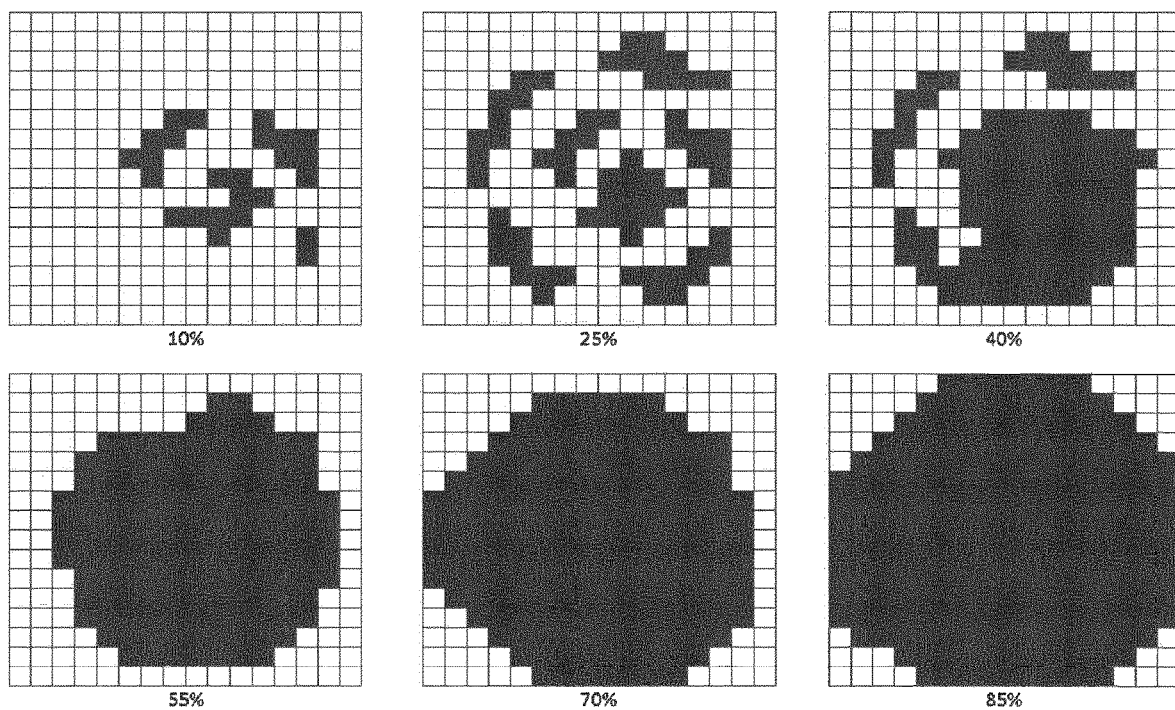
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| 125 | 253 | 248 | 130 | 131 | 240 | 206 | 132 | 133 | 207 | 217 | 134 | 135 | 241 | 249 | 126 |
| 252 | 113 | 117 | 193 | 239 | 93  | 94  | 197 | 198 | 95  | 96  | 218 | 194 | 118 | 114 | 254 |
| 247 | 121 | 109 | 238 | 186 | 69  | 70  | 171 | 172 | 71  | 72  | 187 | 219 | 110 | 122 | 242 |
| 129 | 205 | 237 | 49  | 53  | 170 | 160 | 29  | 30  | 161 | 173 | 54  | 50  | 220 | 208 | 136 |
| 152 | 236 | 185 | 57  | 45  | 159 | 86  | 21  | 22  | 87  | 162 | 46  | 58  | 188 | 221 | 137 |
| 235 | 108 | 84  | 169 | 158 | 12  | 20  | 61  | 65  | 17  | 9   | 163 | 174 | 73  | 97  | 222 |
| 216 | 107 | 83  | 157 | 85  | 16  | 8   | 37  | 38  | 5   | 13  | 88  | 164 | 74  | 98  | 209 |
| 151 | 204 | 184 | 36  | 28  | 68  | 44  | 1   | 2   | 39  | 62  | 23  | 31  | 175 | 199 | 138 |
| 150 | 203 | 183 | 35  | 27  | 64  | 43  | 3   | 4   | 40  | 66  | 24  | 32  | 176 | 200 | 139 |
| 215 | 106 | 82  | 156 | 92  | 15  | 7   | 42  | 41  | 6   | 14  | 89  | 165 | 75  | 99  | 210 |
| 234 | 105 | 81  | 182 | 155 | 11  | 19  | 67  | 63  | 18  | 10  | 166 | 177 | 76  | 100 | 223 |
| 149 | 233 | 192 | 60  | 48  | 154 | 91  | 26  | 25  | 90  | 167 | 47  | 59  | 189 | 224 | 140 |
| 148 | 214 | 232 | 52  | 56  | 181 | 153 | 34  | 33  | 168 | 178 | 55  | 51  | 225 | 211 | 141 |
| 246 | 124 | 112 | 231 | 191 | 80  | 79  | 180 | 179 | 78  | 77  | 190 | 226 | 111 | 123 | 243 |
| 256 | 116 | 120 | 196 | 230 | 104 | 103 | 202 | 201 | 102 | 101 | 227 | 195 | 119 | 115 | 250 |
| 128 | 251 | 245 | 147 | 146 | 229 | 213 | 145 | 144 | 212 | 228 | 143 | 142 | 244 | 255 | 127 |

Fig. 5



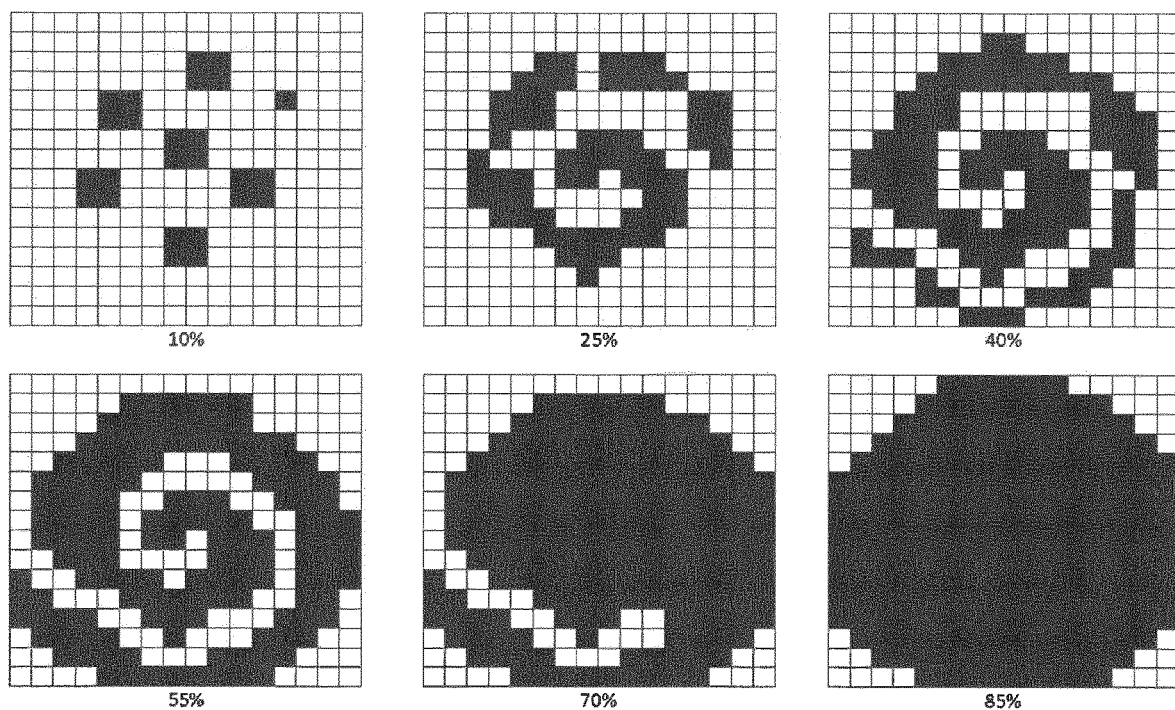
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| 157 | 139 | 136 | 140 | 155 | 203 | 202 | 153 | 141 | 151 | 152 | 197 | 196 | 142 | 143 | 144 |
| 138 | 135 | 156 | 205 | 204 | 154 | 72  | 73  | 75  | 77  | 79  | 149 | 150 | 195 | 148 | 145 |
| 137 | 134 | 206 | 91  | 70  | 71  | 39  | 40  | 41  | 74  | 76  | 78  | 80  | 92  | 194 | 147 |
| 133 | 132 | 207 | 69  | 37  | 38  | 239 | 238 | 237 | 236 | 235 | 234 | 81  | 83  | 95  | 193 |
| 131 | 208 | 158 | 36  | 183 | 240 | 182 | 49  | 13  | 14  | 52  | 181 | 233 | 82  | 93  | 146 |
| 130 | 209 | 68  | 35  | 241 | 246 | 11  | 12  | 99  | 50  | 15  | 16  | 180 | 232 | 84  | 96  |
| 210 | 159 | 34  | 67  | 242 | 44  | 94  | 256 | 255 | 254 | 253 | 51  | 17  | 231 | 85  | 97  |
| 211 | 160 | 33  | 65  | 243 | 54  | 47  | 43  | 1   | 2   | 252 | 62  | 18  | 230 | 86  | 98  |
| 212 | 161 | 66  | 32  | 184 | 244 | 8   | 42  | 6   | 3   | 251 | 53  | 19  | 229 | 87  | 101 |
| 162 | 213 | 163 | 31  | 64  | 245 | 7   | 46  | 45  | 4   | 250 | 20  | 60  | 228 | 100 | 127 |
| 123 | 122 | 214 | 63  | 30  | 185 | 9   | 10  | 5   | 249 | 188 | 21  | 61  | 227 | 102 | 128 |
| 121 | 120 | 215 | 90  | 29  | 57  | 186 | 247 | 248 | 187 | 22  | 48  | 226 | 175 | 103 | 178 |
| 166 | 119 | 164 | 216 | 89  | 28  | 27  | 56  | 55  | 24  | 23  | 88  | 225 | 104 | 107 | 179 |
| 190 | 124 | 118 | 165 | 217 | 169 | 58  | 26  | 25  | 59  | 223 | 224 | 174 | 105 | 129 | 191 |
| 198 | 167 | 117 | 116 | 115 | 218 | 219 | 220 | 221 | 222 | 173 | 109 | 106 | 108 | 177 | 201 |
| 189 | 199 | 168 | 125 | 114 | 113 | 170 | 171 | 172 | 112 | 111 | 110 | 126 | 176 | 200 | 192 |

Fig. 6



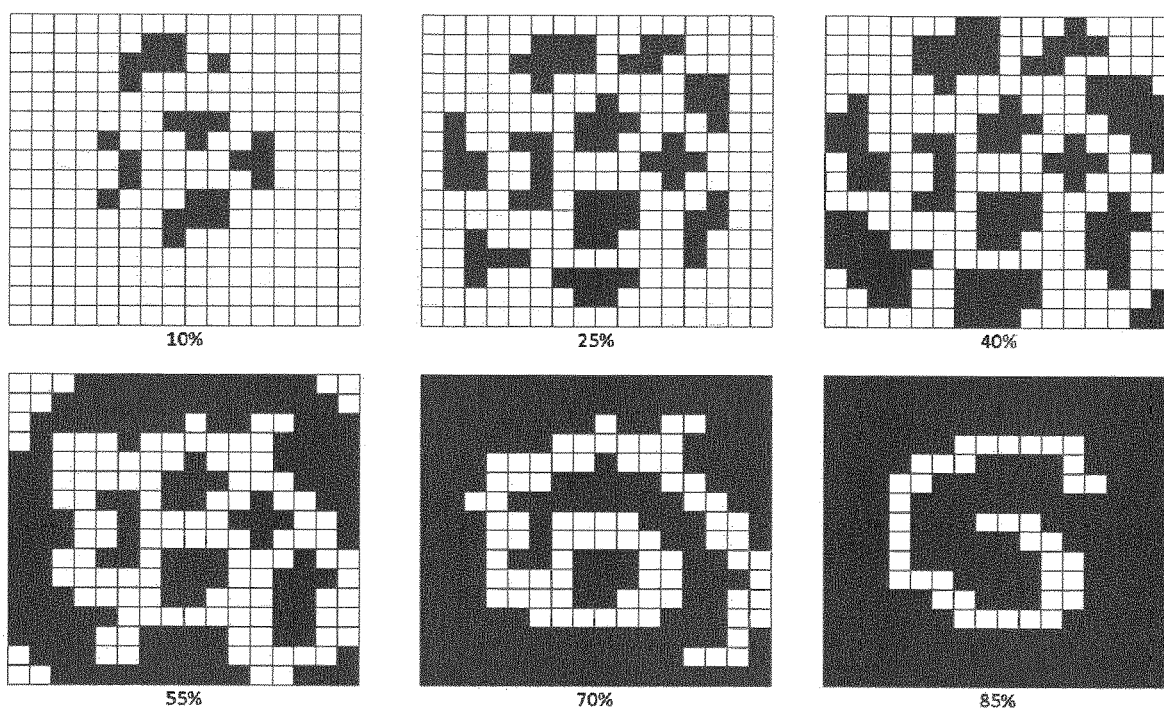
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| 256 | 254 | 249 | 240 | 227 | 210 | 209 | 208 | 207 | 206 | 205 | 204 | 226 | 239 | 248 | 253 |
| 255 | 250 | 241 | 228 | 211 | 170 | 169 | 168 | 167 | 60  | 59  | 202 | 203 | 225 | 238 | 247 |
| 251 | 242 | 229 | 212 | 171 | 164 | 165 | 166 | 51  | 52  | 53  | 58  | 201 | 200 | 224 | 237 |
| 243 | 230 | 213 | 172 | 50  | 49  | 126 | 127 | 129 | 130 | 54  | 55  | 56  | 57  | 199 | 223 |
| 231 | 214 | 173 | 47  | 48  | 122 | 123 | 125 | 128 | 131 | 132 | 133 | 134 | 135 | 197 | 198 |
| 215 | 174 | 163 | 46  | 121 | 120 | 119 | 15  | 16  | 76  | 77  | 17  | 124 | 136 | 195 | 196 |
| 175 | 162 | 44  | 45  | 117 | 118 | 13  | 14  | 74  | 75  | 78  | 18  | 19  | 20  | 137 | 194 |
| 176 | 161 | 43  | 116 | 115 | 12  | 11  | 72  | 73  | 64  | 79  | 80  | 21  | 22  | 85  | 193 |
| 177 | 160 | 42  | 113 | 114 | 109 | 10  | 71  | 63  | 1   | 2   | 81  | 82  | 23  | 138 | 192 |
| 178 | 159 | 112 | 111 | 110 | 108 | 70  | 69  | 62  | 61  | 3   | 4   | 83  | 84  | 139 | 191 |
| 179 | 158 | 154 | 41  | 107 | 106 | 68  | 9   | 8   | 6   | 5   | 89  | 87  | 86  | 140 | 190 |
| 180 | 157 | 155 | 38  | 36  | 105 | 103 | 67  | 66  | 7   | 65  | 90  | 88  | 24  | 141 | 189 |
| 216 | 181 | 156 | 39  | 35  | 104 | 102 | 101 | 94  | 93  | 92  | 91  | 26  | 25  | 142 | 188 |
| 232 | 217 | 182 | 153 | 37  | 34  | 33  | 98  | 95  | 30  | 29  | 28  | 27  | 143 | 187 | 222 |
| 244 | 233 | 218 | 183 | 152 | 40  | 100 | 99  | 97  | 96  | 32  | 31  | 144 | 186 | 221 | 236 |
| 252 | 245 | 234 | 219 | 184 | 151 | 150 | 149 | 148 | 147 | 146 | 145 | 185 | 220 | 235 | 246 |

Fig. 7



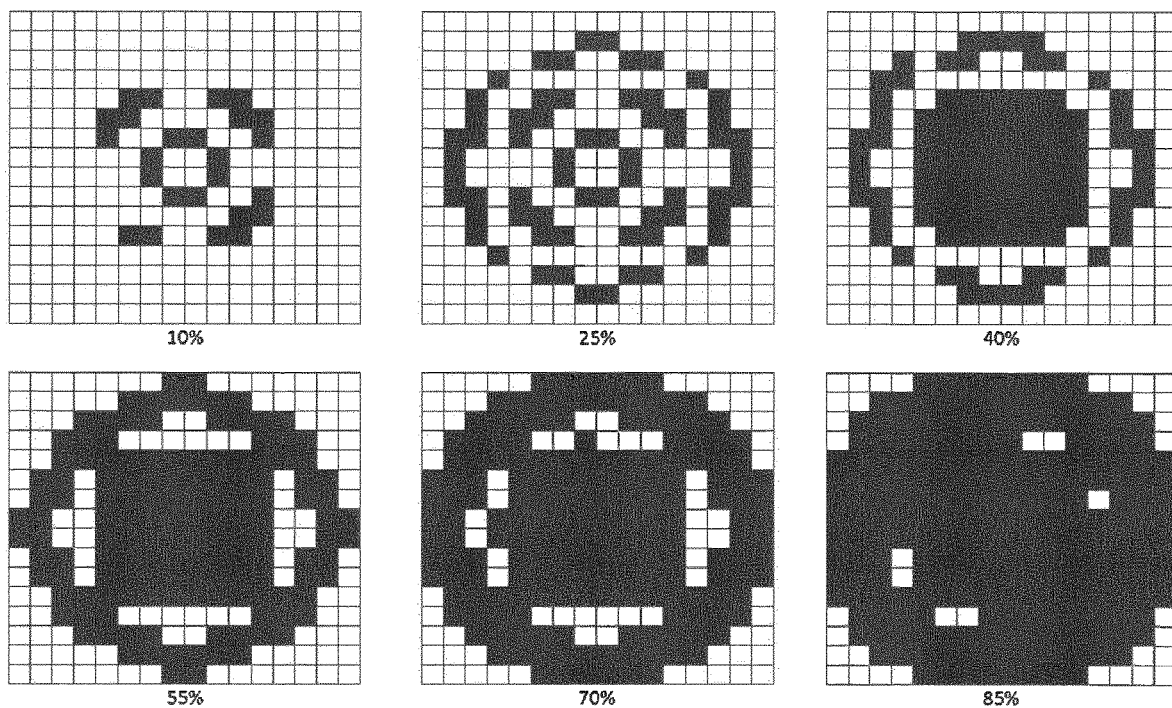
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| 256 | 254 | 250 | 242 | 229 | 207 | 208 | 209 | 210 | 211 | 212 | 230 | 231 | 243 | 251 | 255 |
| 253 | 249 | 241 | 228 | 206 | 137 | 138 | 65  | 66  | 139 | 140 | 213 | 214 | 232 | 244 | 252 |
| 248 | 240 | 227 | 205 | 136 | 55  | 50  | 76  | 23  | 24  | 39  | 141 | 142 | 215 | 233 | 245 |
| 239 | 226 | 204 | 135 | 37  | 38  | 49  | 77  | 22  | 21  | 40  | 51  | 67  | 143 | 216 | 234 |
| 225 | 203 | 134 | 64  | 19  | 20  | 104 | 163 | 164 | 165 | 105 | 106 | 25  | 26  | 144 | 217 |
| 202 | 133 | 103 | 63  | 17  | 18  | 162 | 166 | 167 | 168 | 169 | 107 | 27  | 28  | 68  | 146 |
| 201 | 132 | 102 | 48  | 75  | 160 | 161 | 1   | 2   | 29  | 170 | 171 | 41  | 42  | 69  | 145 |
| 200 | 101 | 47  | 73  | 74  | 159 | 56  | 3   | 4   | 30  | 43  | 172 | 173 | 52  | 78  | 121 |
| 199 | 100 | 62  | 15  | 16  | 158 | 57  | 58  | 152 | 59  | 5   | 6   | 174 | 108 | 79  | 122 |
| 198 | 197 | 61  | 13  | 14  | 157 | 156 | 155 | 153 | 70  | 7   | 8   | 175 | 80  | 109 | 123 |
| 131 | 196 | 195 | 35  | 36  | 54  | 72  | 154 | 71  | 53  | 31  | 32  | 176 | 81  | 110 | 124 |
| 130 | 99  | 194 | 193 | 192 | 46  | 33  | 10  | 9   | 45  | 44  | 178 | 177 | 82  | 111 | 147 |
| 129 | 98  | 97  | 96  | 191 | 190 | 34  | 11  | 12  | 182 | 180 | 179 | 83  | 84  | 112 | 148 |
| 224 | 128 | 120 | 119 | 95  | 189 | 188 | 60  | 184 | 183 | 181 | 86  | 85  | 113 | 149 | 218 |
| 238 | 223 | 127 | 126 | 94  | 93  | 187 | 186 | 185 | 89  | 88  | 87  | 114 | 150 | 219 | 235 |
| 247 | 237 | 222 | 221 | 125 | 118 | 92  | 91  | 90  | 115 | 116 | 117 | 151 | 220 | 236 | 246 |

Fig. 8



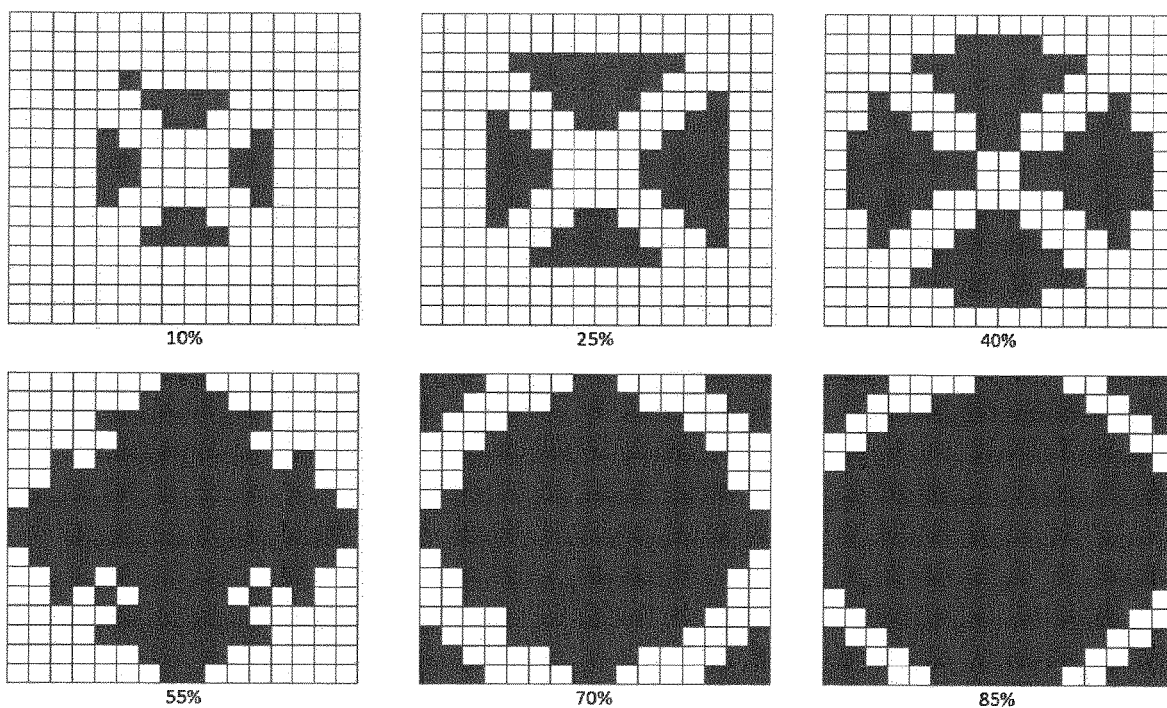
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| 177 | 176 | 169 | 132 | 111 | 110 | 84  | 85  | 112 | 134 | 135 | 86  | 114 | 136 | 170 | 178 |
| 175 | 168 | 131 | 109 | 83  | 61  | 24  | 23  | 133 | 113 | 62  | 63  | 87  | 115 | 116 | 171 |
| 167 | 129 | 130 | 108 | 60  | 20  | 21  | 22  | 203 | 25  | 26  | 202 | 201 | 138 | 137 | 117 |
| 166 | 107 | 150 | 151 | 152 | 19  | 226 | 225 | 224 | 223 | 222 | 221 | 27  | 28  | 88  | 139 |
| 128 | 80  | 149 | 204 | 229 | 228 | 227 | 197 | 54  | 196 | 195 | 220 | 29  | 64  | 65  | 89  |
| 82  | 51  | 148 | 231 | 230 | 198 | 157 | 1   | 2   | 4   | 156 | 219 | 218 | 30  | 66  | 90  |
| 81  | 52  | 205 | 232 | 18  | 59  | 153 | 53  | 3   | 154 | 155 | 5   | 217 | 216 | 67  | 91  |
| 106 | 49  | 50  | 233 | 199 | 17  | 191 | 256 | 255 | 254 | 7   | 6   | 55  | 215 | 214 | 92  |
| 105 | 47  | 48  | 234 | 200 | 16  | 192 | 193 | 209 | 253 | 252 | 8   | 158 | 194 | 213 | 118 |
| 103 | 104 | 147 | 235 | 15  | 58  | 190 | 57  | 11  | 12  | 251 | 248 | 159 | 31  | 212 | 189 |
| 102 | 79  | 146 | 236 | 237 | 238 | 211 | 13  | 10  | 9   | 250 | 247 | 33  | 32  | 68  | 188 |
| 101 | 78  | 46  | 206 | 207 | 239 | 240 | 14  | 56  | 210 | 249 | 246 | 34  | 69  | 186 | 187 |
| 100 | 77  | 44  | 43  | 42  | 208 | 241 | 242 | 243 | 244 | 245 | 160 | 35  | 70  | 185 | 184 |
| 127 | 99  | 45  | 76  | 145 | 162 | 39  | 38  | 37  | 36  | 161 | 141 | 140 | 71  | 183 | 172 |
| 165 | 126 | 98  | 97  | 144 | 143 | 75  | 40  | 41  | 72  | 142 | 179 | 180 | 181 | 182 | 93  |
| 164 | 163 | 125 | 124 | 123 | 122 | 96  | 74  | 73  | 121 | 120 | 174 | 173 | 119 | 95  | 94  |

Fig. 9



|     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 253 | 246 | 238 | 227 | 200 | 164 | 145 | 135 | 136 | 146 | 165 | 185 | 228 | 239 | 247 | 254 |
| 245 | 226 | 199 | 163 | 144 | 104 | 81  | 36  | 37  | 82  | 105 | 147 | 166 | 186 | 229 | 248 |
| 237 | 198 | 143 | 102 | 103 | 34  | 35  | 201 | 202 | 38  | 39  | 106 | 107 | 148 | 187 | 240 |
| 225 | 162 | 101 | 33  | 126 | 215 | 216 | 179 | 180 | 223 | 224 | 127 | 40  | 108 | 167 | 230 |
| 197 | 142 | 32  | 125 | 121 | 12  | 13  | 85  | 86  | 14  | 15  | 122 | 128 | 41  | 149 | 188 |
| 161 | 120 | 31  | 211 | 10  | 11  | 100 | 71  | 72  | 87  | 16  | 17  | 217 | 42  | 109 | 168 |
| 141 | 29  | 30  | 212 | 9   | 99  | 70  | 1   | 2   | 73  | 88  | 18  | 218 | 43  | 44  | 150 |
| 134 | 64  | 206 | 178 | 98  | 69  | 8   | 65  | 66  | 3   | 74  | 89  | 181 | 207 | 45  | 137 |
| 133 | 63  | 205 | 177 | 97  | 80  | 7   | 68  | 67  | 4   | 75  | 90  | 182 | 208 | 46  | 138 |
| 160 | 62  | 61  | 219 | 28  | 96  | 79  | 6   | 5   | 76  | 91  | 19  | 209 | 48  | 47  | 151 |
| 176 | 119 | 60  | 220 | 27  | 26  | 95  | 78  | 77  | 92  | 21  | 20  | 210 | 49  | 110 | 169 |
| 196 | 159 | 59  | 132 | 124 | 25  | 24  | 94  | 93  | 23  | 22  | 123 | 129 | 50  | 152 | 189 |
| 236 | 175 | 118 | 58  | 131 | 221 | 222 | 184 | 183 | 213 | 214 | 130 | 51  | 111 | 170 | 231 |
| 244 | 195 | 158 | 117 | 116 | 57  | 56  | 204 | 203 | 53  | 52  | 113 | 112 | 153 | 190 | 241 |
| 252 | 235 | 194 | 174 | 157 | 115 | 84  | 55  | 54  | 83  | 114 | 154 | 171 | 191 | 232 | 249 |
| 256 | 251 | 243 | 234 | 193 | 173 | 156 | 140 | 139 | 155 | 172 | 192 | 233 | 242 | 250 | 255 |

Fig. 10



|     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 153 | 157 | 166 | 256 | 240 | 220 | 219 | 127 | 128 | 197 | 198 | 221 | 241 | 167 | 158 | 154 |
| 164 | 165 | 255 | 239 | 218 | 184 | 81  | 82  | 83  | 84  | 185 | 199 | 222 | 242 | 168 | 159 |
| 176 | 254 | 238 | 183 | 49  | 50  | 51  | 52  | 53  | 54  | 55  | 56  | 186 | 223 | 243 | 169 |
| 253 | 237 | 182 | 177 | 146 | 25  | 26  | 27  | 28  | 29  | 30  | 147 | 178 | 187 | 224 | 244 |
| 236 | 217 | 80  | 145 | 133 | 138 | 9   | 10  | 11  | 12  | 139 | 134 | 148 | 57  | 200 | 225 |
| 216 | 181 | 79  | 48  | 137 | 121 | 111 | 7   | 8   | 112 | 122 | 140 | 31  | 58  | 188 | 201 |
| 215 | 96  | 78  | 47  | 24  | 110 | 116 | 101 | 102 | 113 | 105 | 13  | 32  | 59  | 85  | 202 |
| 125 | 95  | 77  | 46  | 23  | 6   | 97  | 117 | 118 | 99  | 1   | 14  | 33  | 60  | 86  | 129 |
| 126 | 94  | 76  | 45  | 22  | 5   | 98  | 119 | 120 | 100 | 2   | 15  | 34  | 61  | 87  | 130 |
| 214 | 93  | 75  | 44  | 21  | 109 | 115 | 103 | 104 | 114 | 106 | 16  | 35  | 62  | 88  | 203 |
| 213 | 196 | 74  | 43  | 144 | 124 | 108 | 4   | 3   | 107 | 123 | 141 | 36  | 63  | 189 | 204 |
| 235 | 212 | 73  | 152 | 136 | 143 | 20  | 19  | 18  | 17  | 142 | 135 | 149 | 64  | 205 | 226 |
| 252 | 234 | 190 | 180 | 151 | 42  | 41  | 40  | 39  | 38  | 37  | 150 | 179 | 191 | 227 | 245 |
| 175 | 251 | 233 | 195 | 72  | 71  | 70  | 69  | 68  | 67  | 66  | 65  | 192 | 228 | 246 | 170 |
| 163 | 174 | 250 | 232 | 211 | 194 | 92  | 91  | 90  | 89  | 193 | 206 | 229 | 247 | 171 | 160 |
| 156 | 162 | 173 | 249 | 231 | 210 | 209 | 132 | 131 | 208 | 207 | 230 | 248 | 172 | 161 | 155 |

Fig. 11

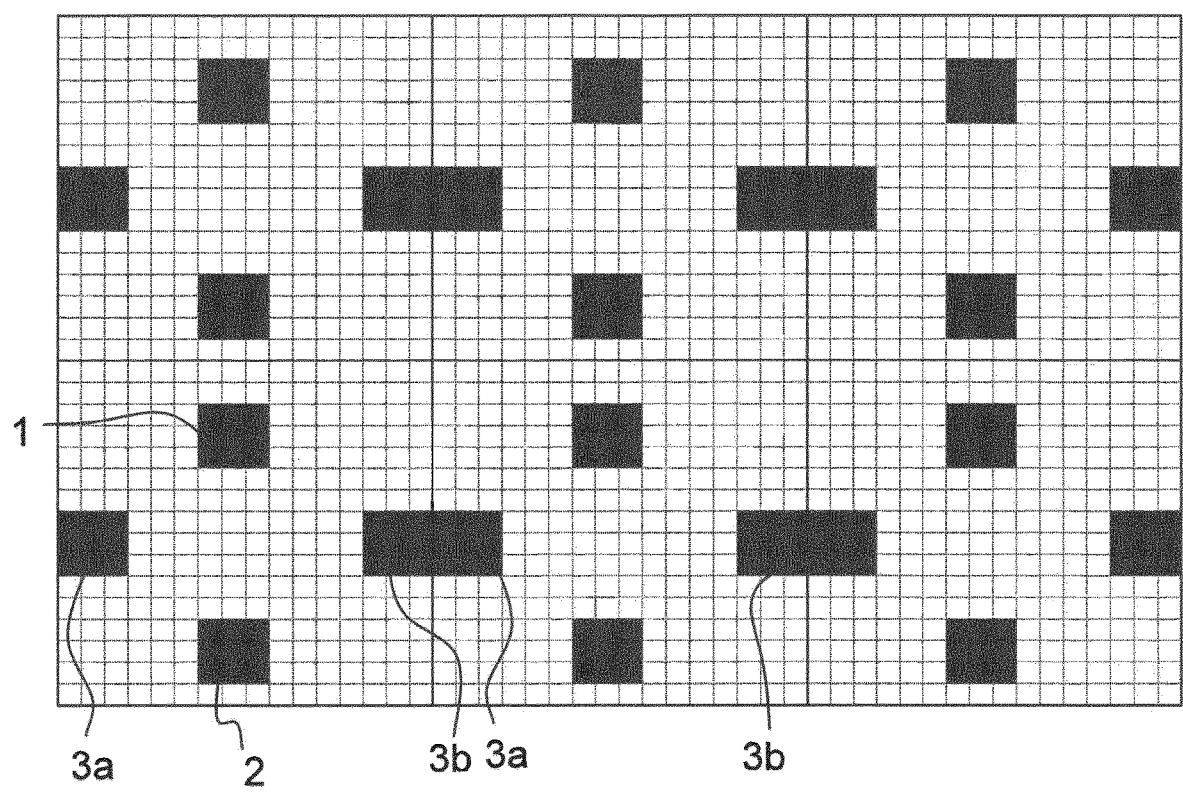


Fig. 12

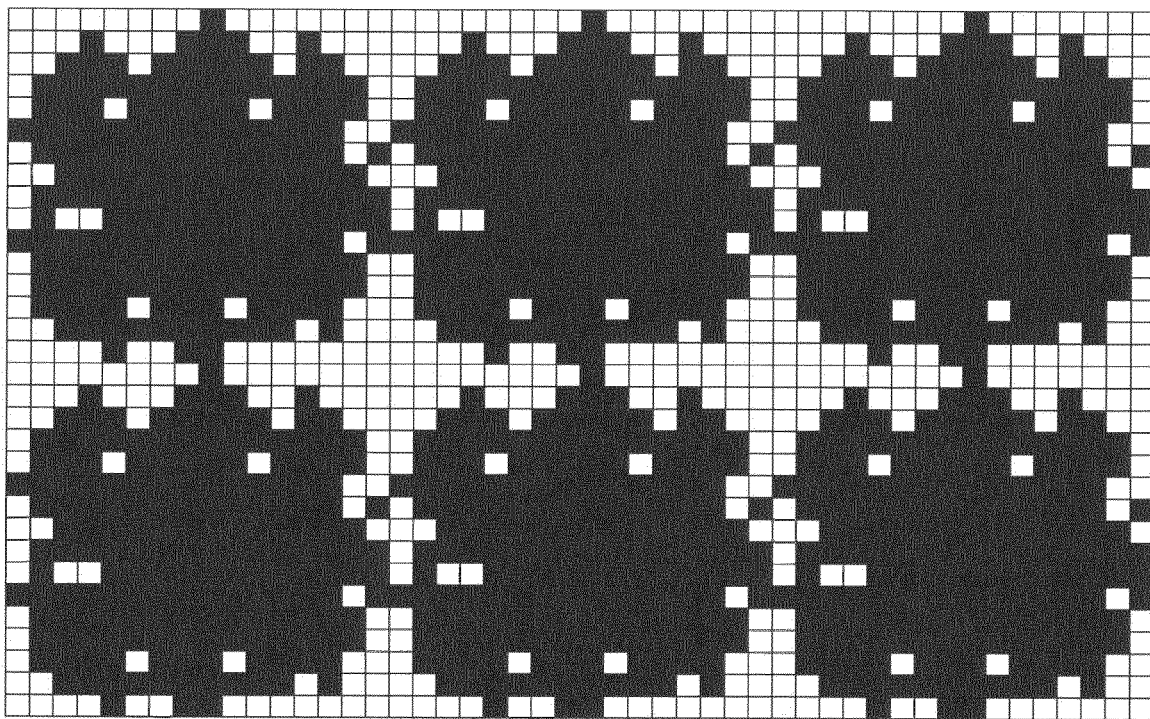


Fig. 13

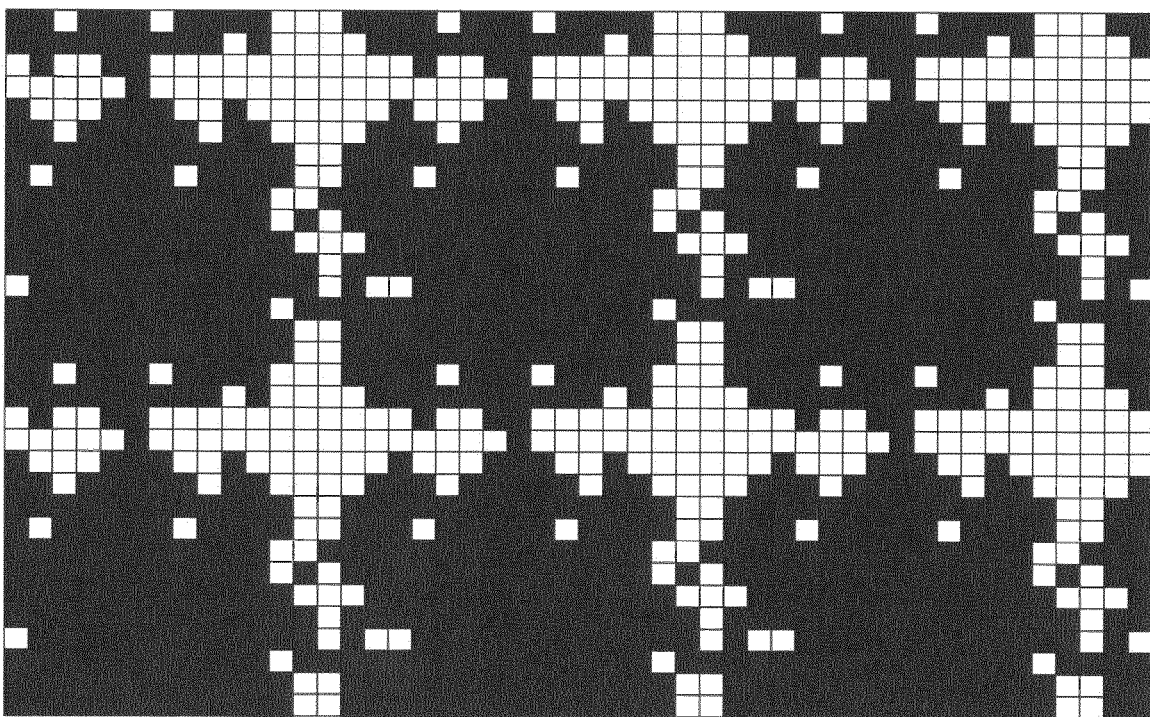


Fig. 14

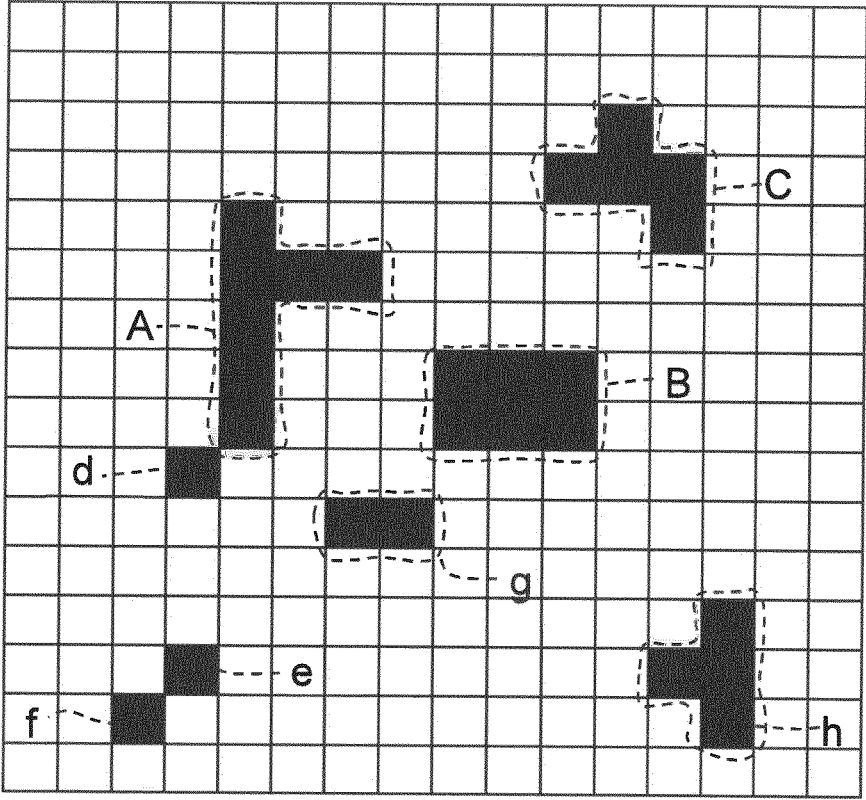
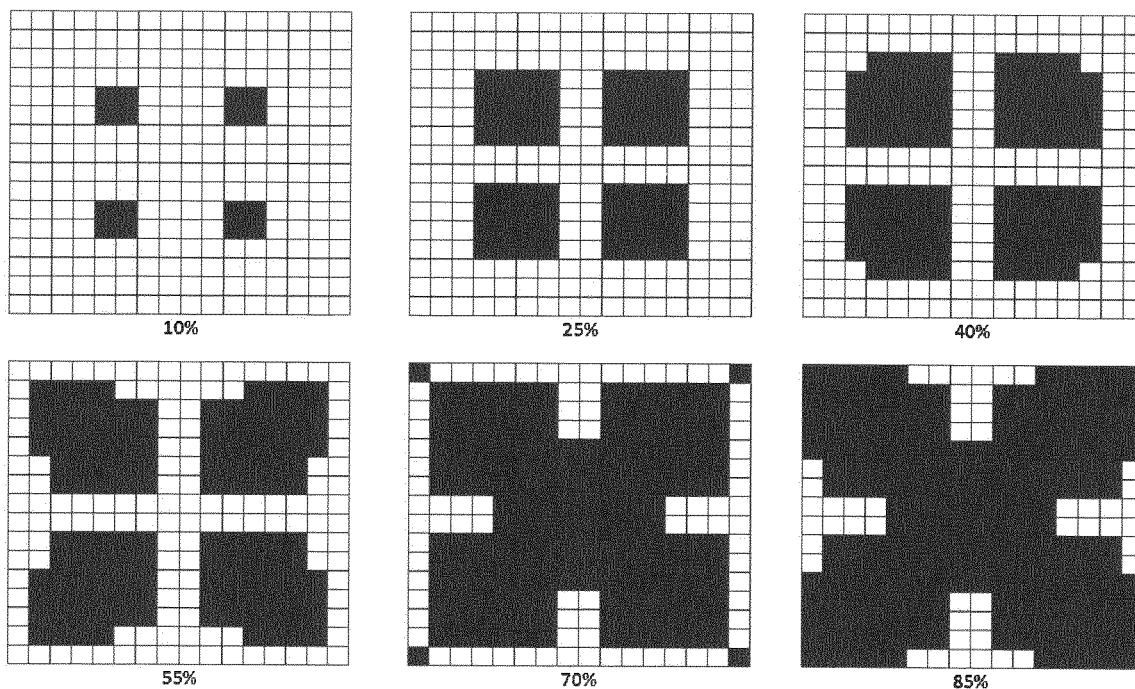


Fig. 15



|    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| 11 | 12 | 12 | 13 | 13 | 14 | 15 | 16 | 16 | 15 | 14 | 13 | 13 | 12 | 12 | 11 |
| 12 | 7  | 7  | 8  | 8  | 9  | 9  | 16 | 16 | 9  | 9  | 8  | 8  | 7  | 7  | 12 |
| 12 | 7  | 7  | 6  | 5  | 5  | 6  | 15 | 15 | 6  | 5  | 5  | 6  | 7  | 7  | 12 |
| 13 | 8  | 6  | 4  | 3  | 3  | 4  | 14 | 14 | 4  | 3  | 3  | 4  | 6  | 8  | 13 |
| 13 | 8  | 5  | 3  | 1  | 1  | 2  | 11 | 11 | 2  | 1  | 1  | 3  | 5  | 8  | 13 |
| 14 | 9  | 5  | 3  | 1  | 1  | 2  | 10 | 10 | 2  | 1  | 1  | 3  | 5  | 9  | 14 |
| 15 | 9  | 6  | 4  | 2  | 2  | 4  | 10 | 10 | 4  | 2  | 2  | 4  | 6  | 9  | 15 |
| 16 | 16 | 15 | 14 | 11 | 11 | 10 | 10 | 10 | 10 | 11 | 11 | 14 | 15 | 16 | 16 |
| 16 | 16 | 15 | 14 | 11 | 11 | 10 | 10 | 10 | 10 | 11 | 11 | 14 | 15 | 16 | 16 |
| 15 | 9  | 6  | 4  | 2  | 2  | 4  | 10 | 10 | 4  | 2  | 2  | 4  | 6  | 9  | 15 |
| 14 | 9  | 5  | 3  | 1  | 1  | 2  | 10 | 10 | 2  | 1  | 1  | 3  | 5  | 9  | 14 |
| 13 | 8  | 5  | 3  | 1  | 1  | 2  | 11 | 11 | 2  | 1  | 1  | 3  | 5  | 8  | 13 |
| 13 | 8  | 6  | 4  | 3  | 3  | 4  | 14 | 14 | 4  | 3  | 3  | 4  | 6  | 8  | 13 |
| 12 | 7  | 7  | 6  | 5  | 5  | 6  | 15 | 15 | 6  | 5  | 5  | 6  | 7  | 7  | 12 |
| 12 | 7  | 7  | 8  | 8  | 9  | 9  | 16 | 16 | 9  | 9  | 8  | 8  | 7  | 7  | 12 |
| 11 | 12 | 12 | 13 | 13 | 14 | 15 | 16 | 16 | 15 | 14 | 13 | 13 | 12 | 12 | 11 |

Fig. 16

## DIGITAL HALFTONING WITH CLUSTERED MICRODOTS

### TECHNICAL FIELD

**[0001]** The invention relates to the field of digital halftoning methods used for printing images, in particular by means of lithographic or flexographic printing presses.

### BACKGROUND ART

**[0002]** Printing presses and digital printers cannot vary the amount of ink or toner that is applied to particular image areas except through digital halftoning, also called dithering or screening. Binary digital halftoning is the process of rendering the illusion of a continuous-tone image by means of a halftone raster image (also called “screen”) which consists of pixels (also called “microdots”), which are either “on” (image pixels) or “off” (non-image pixels), i.e. which correspond respectively to image areas and background areas of the image.

**[0003]** These pixels are typically arranged as a grid in so-called halftone cells. The ratio of image pixels versus non-image pixels in a halftone cell defines the relative image density, also dot percentage, of the halftone cell. A halftone cell wherein half of the pixels are image pixels and half are non-image pixels, has a relative image density of 50%. Halftone cells which represent highlights (white areas) of the image, have an image density which is lower than 50% and halftone cells which represent shadows (darker areas) of the image, have an image density which is higher than 50%.

**[0004]** Digital halftoning is a well-known technique, which is explained in e.g. “Digital Halftoning”, MIT Press, 1987, ISBN 0-262-21009-6, wherein chapter 5 about ‘clustered-dot ordered dither’ is background art for the present invention including the use of threshold arrays for rendering continuous-tone images. Another overview of digital halftoning methods is disclosed in the article “Recent trends in digital halftoning”, Proc. SPIE 2949, Imaging Sciences and Display Technologies, (7 Feb. 1997); doi: 10.1117/12.266335 wherein also multilevel digital halftoning is explained.

**[0005]** The most commonly used screening technique produces so called amplitude-modulated (AM) screens. AM screens consist of halftone cells wherein the image pixels are grouped in a single cluster, which is often called a “(half-tone) dot” or “AM dot”, not to be confused with the above mentioned microdot (=pixel). In AM screening, a higher relative image density is obtained by growing the size of the dot cluster. When printing an AM image, e.g. with a printing press or a digital inkjet printer, each AM dot corresponds to a certain amount of ink, called further a blob, which is pressed or jetted onto the substrate to be printed, dried and/or cured. Especially when multiple inks (colour selections) are to be printed on top of each other, whether wet-on-wet or wet-on-(semi)dry, the spreading of the ink, which is determined by the thickness of the blob and the local (de)wetting on and/or the absorption of the ink by the substrate, renders the printed blob locally uncontrollable. As a result, the printed image may show noise, and this problem is often depended on the nature of the substrate.

**[0006]** Such problems can be addressed by other screening technologies such as FM (frequency modulated) screening or techniques involving error diffusion. In both these techniques, the microdots are not grouped into clusters but

spread more or less randomly over the image. The local image density is modulated by the frequency of the microdots. However also these techniques are characterized by other issues like print stability, poor smoothness of flat tones, higher dot gain and higher wear of printing plates in long print runs.

**[0007]** Hybrid screening techniques are available which combine AM and FM methods so as to obtain the advantages of both. Said screening techniques however involve the use of multiple threshold arrays for rendering a continuous-tone image, which requires more memory space to store these multiple threshold arrays, for example a threshold array with FM method in the highlights, a threshold array with AM method in the midtones and another threshold array with FM method in the shadows. In addition, the transitions from one threshold array to another may produce density jumps in the printed image whereby calibration of said screening techniques also takes more service time than AM and FM.

**[0008]** US2007/0002384 discloses a method of controlling thickness of an ink blob in an AM halftone region of a printing plate or an intermediate image carrier on a digital press. The method generates a raster image of regularly tiled halftone cells wherein the image pixels are arranged to form concentric rings, which enclose an area of non-image pixels. As a result, the extent at which the ink can spread within the cell remains limited because no further spreading of the ink is possible as soon as the enclosed area is filled.

**[0009]** The latter problem is solved in copending application PCT/EP2018/079011, which was filed on 23 Oct. 2018, and which discloses a halftone raster image comprising a plurality of spiral halftone dots, wherein said spiral halftone dots comprise

- (i) image pixels arranged as a first arc or as a plurality of arcs which together represent a first spiral, and
- (ii) non-image pixels arranged as a second arc or as a plurality of arcs which together represent a second spiral.

**[0010]** Compared to the concentric rings of US2007/0002384, the spiral dots contain a longer, preferably open-ended ink channel, defined by the second arc or second spiral, which enables a better spreading of the ink.

**[0011]** EP3461116 discloses a digital halftone screening method wherein a conventional halftone dot is split into separate clusters by a dot function and pixels are turned on or off within the clusters by a cluster function. This method involves complex mathematics and can therefore not be implemented in the wide installed base of prepress systems having a limited data memory and/or processing power.

### SUMMARY OF THE INVENTION

**[0012]** It is an object of the present invention to provide a method of reproducing a continuous-tone image with a printing press by means of a halftone raster image having similar advantages as the raster image comprising spiral dots which is disclosed in copending application PCT/EP2018/079011, in particular a method which allows to save ink in the lithographic or flexographic printing process and which can be implemented in the wide installed base of prepress computer systems with a limited amount of memory and/or processing power.

**[0013]** This problem is solved by the method defined in claim 1, wherein a single threshold array is used for the rendering of a continuous-tone image, i.e. transforming a continuous-tone image to a halftone raster image which comprises regularly tiled halftone cells consisting of a grid

of image pixels and non-image pixels. When the raster image is exposed on the coating of a printing plate precursor, the image pixels correspond to the printing (ink-accepting) areas of the plate, while the non-image pixels correspond to the non-printing areas of the plate. In at least a portion of the halftone cells, the image pixels are arranged as multiple image clusters, which are defined herein as mutually separated groups of more than 4 adjacent image pixels. The image clusters allow to obtain a printed image of the same image density with less ink than with conventional screens wherein the image pixels are grouped into a single cluster.

#### BRIEF DESCRIPTION OF THE DRAWINGS

**[0014]** FIG. 1 shows 6 halftone cells, each consisting of a 16×16 grid of pixels, in the upper half of the figure. These halftone cells were each generated by the same threshold array in accordance with the method of the present invention. Said threshold array is the matrix shown in the lower half of the figure. Each halftone cell represents another relative image density, as indicated by the dot percentage shown below each halftone cell. The image pixels are represented by the black areas in the figures, while the non-image pixels are represented by the white areas.

**[0015]** FIGS. 2 to 11 differ from FIG. 1 only therein that another threshold array is used in each figure.

**[0016]** FIG. 12 shows 6 tiled halftone cells, each comprising 4 groups of 3×3 image pixels.

**[0017]** FIG. 13 and FIG. 14 show 6 tiled halftone cells which are identical to the 70% halftone cells in FIG. 3 and FIG. 4 respectively.

**[0018]** FIG. 15 shows a halftone cell which comprises 3 image clusters, designated by the dashed lines A-C; the image pixels designated d-h do not form a group of more than 4 adjacent pixels and therefore do not comply with the definition of an image cluster in accordance with the present invention.

**[0019]** FIG. 16 shows 6 halftone cells, each consisting of a 16×16 grid of pixels, in the upper half of the figure and the threshold array which was used to generate these cells in the lower half. The threshold values in the array range from 1 to 16, contrary to the values in FIGS. 1-11 which range from 1 to 256.

#### DESCRIPTION OF PREFERRED EMBODIMENTS

##### Raster Image

**[0020]** The raster image produced in the method of the present invention is suitable for rendering a continuous-tone image (CT), i.e. it creates the illusion of a continuous-tone image (CT) on a printed copy. This requirement implies that the screen frequency, i.e. the number of halftone cells arranged next to each other per length unit in the direction that yields the greatest value, is above 40 lines per inch (LPI; 15.7 lines/cm), more preferably above 60 LPI (23.6 lines/cm) and most preferably above 100 LPI (39.4 lines/cm). If the screen frequency is below 40 LPI, the halftone dots become visible at viewing distance, also called reading distance, which is about 20 cm. Such low screen frequencies are typically used in artistic screening, which is used for decorative purposes such as patterned illustrations, wherein it is intended that the individual dots are visible to the naked eye. Raster images wherein the halftone dots are clearly

visible at viewing distance are therefore not suitable in the method of the present invention.

**[0021]** The above mentioned screen frequency defines the spatial frequency of the halftone cells comprised in the raster image. As explained above, a halftone cell on its turn consists of a grid of pixels and the spatial frequency thereof, called resolution, is expressed as dots per inch (DPI) or pixels per inch (PPI). In case the raster image is written by means of a scanning laser on e.g. a film or a printing plate, the pixels are also called laser dots and the resolution then refers to the number of laser lines per inch. The raster image produced in the method of the present invention has preferably a resolution larger than 600 DPI, more preferably larger than 1200 DPI. Higher resolutions up to 9600 DPI may also be used, e.g. for the printing of security features.

**[0022]** Since a printing plate can transfer only a single colour, it is evident that the halftone raster image used in the method of the present invention is a monochrome image, which may represent a colour selection of a multi-colour printing process, e.g. one of the 4 basic colours in CMYK printing.

**[0023]** The quality of the printed image is preferably checked with colour density measurement. The colour density values can then be used as input parameters of the prepress computer system which produces the raster image, which is thereby adjusted so that the quality of the printed image is improved in a subsequent press run and/or so that more ink is saved in a subsequent press run.

##### Halftone Cells

**[0024]** The raster image produced in the method of the present invention comprises regularly tiled halftone cells. The cells may be tiled along a triangular, rectangular or hexagonal grid and more preferably along a square grid. FIGS. 13 and 14 each show examples of the preferred embodiment wherein 6 halftone cells are tiled as a square grid.

**[0025]** The halftone cells themselves also consist of a grid, more particularly a grid of pixels, which may be image pixels or non-image pixels. These pixels preferably have the shape of a regular polygon or convex polygon, e.g. a triangle, a square, a rectangle, a rhombus or a hexagon. The Figures show examples of preferred embodiments, wherein the halftone cells consist of a grid of square pixels.

**[0026]** The raster image produced in the method of the present invention comprises halftone cells which have 2 or more image clusters, i.e. mutually separated groups of more than 4 adjacent image pixels. In a more preferred embodiment, the raster image comprises halftone cells having more than 2 image clusters, e.g. at least 3 or 4 image clusters, more preferably at least 5 and most preferably at least 6 image clusters.

**[0027]** In the above definition of 'image cluster', the image pixels are considered to be adjacent if they share at least one edge of the polygon. FIG. 15 shows three such image clusters: cluster A consists of 7 adjacent image pixels; cluster B consists of 6 adjacent image pixels; and cluster C consists of 5 adjacent image pixels. The image pixels d, e and f are in contact with another image pixel but only by a corner of the square; as these pixels are not sharing an edge, they are not considered to be adjacent, as defined above. Groups of 4 or less image pixels like group h neither constitute an image cluster in accordance with the above definition.

**[0028]** FIG. 12 illustrates a further refinement of the definition of an image cluster used herein. When halftone cells are tiled, groups of image pixels in one halftone cell may connect with one or more adjacent edges to another group of image pixels in another halftone cell. FIG. 12 shows an example wherein the group of image pixels designated 3a connects to the group designated 3b. In accordance with the present invention, such groups shall not be regarded as separate clusters but together represent a single cluster. As a result, the halftone cells represented in FIG. 12 each contain only 3 image clusters.

**[0029]** Contrary to conventional AM dots which represent the same dot percentage, the image clusters used in the present invention allow to obtain a printed image of the same image density with less ink. The reasons for this advantage are not completely understood but the inventor of the present invention have systematically measured that press runs according to the method of the present invention consume significantly less ink compared to press runs with plates exposed with a conventional AM screen of the same original image. When compared with FM screens, it is observed that a higher run length can be obtained, because the clusters are larger than the FM microdots and therefore less susceptible to wear on the press. FM screens consist either of a plurality of single image pixels or a group of four (2x2) image pixels, which degrade more easily than the image clusters used in the present invention.

**[0030]** Without being limited by the underlying mechanism, it is at present assumed that the halftone cells having clustered image pixels as described above, when compared to a conventional AM halftone dot representing the same relative image density, either absorb a thinner ink film on the ink accepting areas of the plate and/or provide a better spreading of the ink film into the empty (non-image) areas between the image clusters. The ink saving effect has been observed with various images and various plates. Ink savings of about 10% were frequently obtained. Ink and paper are the major cost factors of a printer, so even a reduction of the ink consumption by a few percent represents a high cost saving. Optimization of the raster image in relation to the substrate that is to be printed, e.g. by adjusting the number, size, shape and/or distribution of image clusters in the halftone cells, can lead to even more ink saving, in the range from 10 to 20% compared to conventional AM screening.

**[0031]** Less consumption of ink provides additional advantages resulting therefrom, e.g. faster drying and/or less energy consumption by drying equipment such as curing units and ovens. Faster drying is particularly beneficial for printing on uncoated plastic foils and in newspaper printing. The better spreading of the ink also reduces ink setoff, i.e. the transfer of ink from one printed copy to the back side of another copy lying on top of it, for example in the press delivery tray. Shine-through, also called print-through, whereby images become visible at the backside of the substrate, e.g. a thin, ink absorbing substrate as used for the printing of newspapers, is reduced as well. For all these reasons, the method of the present invention is especially advantageous when performed on a perfecting press, i.e. a press that allows the simultaneous printing on both sides of the substrate in one pass through the press.

**[0032]** In a preferred embodiment, the image clusters are not distributed randomly over the halftone cell, but are concentrated locally, so that the image clusters together mimic a conventional AM dot and the method maintains

the advantages of AM screens as much as possible. The image clusters may be concentrated in e.g. a quarter section of the halftone cell. As a result, that quarter section represents a higher relative image density than the other sections of the halftone cell. More preferably, one quarter section of the halftone cell has a relative image density which is at least twice the relative image density represented by the halftone cell as a whole. FIG. 5 shows an example of such an arrangement: the 8x8 pixels around the centre of the cell define a quarter section, indicated by thick lines, which has a much higher density of image pixels than the cell as a whole. The higher concentration of image pixels should not necessarily be positioned near the centre of the cell: FIG. 3 and FIG. 4 show different local concentrations of image pixels, which however represent the same halftone image when these cells are tiled next to each other, as shown in FIGS. 13 and 14 respectively.

**[0033]** The halftone raster image used in the present invention may contain a combination of different types of halftone cells, e.g. halftone cells with multiple image clusters, as defined above, combined with conventional halftone cells, e.g. AM halftone cells wherein all image pixels are grouped in a single cluster. One or more parts of the image may also be represented by FM screens. In a highly preferred embodiment of the present invention, the highlights and midtones of the image, i.e. the subset of all the halftone cells in the image which represent a relative image density of less than 50%, consist entirely of halftone cells having 2 or more image clusters as defined above. In another embodiment, only a portion of the halftone cells which represent highlights and midtones of the image contain 2 or more image clusters. Said portion may be as low as 5%. Preferably, said portion is at least 10%, more preferably at least 25% and even more preferably at least 50%.

**[0034]** In another preferred embodiment of the present invention, the image clusters are arranged along a path which represents a loop or a spiral. The loop may be a square, a rectangle, a ring or an ellipse. FIG. 10 represents halftone cells wherein the clusters are arranged along the path of a ring, while FIGS. 6-9 represent halftone cells wherein the clusters are arranged along the path of a spiral, which are referred to hereafter as "spiral dots". The image pixels and clusters represent a first spiral of ink-accepting areas and thereby also define a second spiral of non-image pixels represented by the empty space between the windings of the first spiral. Without being bound by theory, it is assumed that the ink, which is transferred from the spiral dot onto a substrate such as a paper sheet, can flow into the second spiral, which seems to act as an ink-accepting channel. A spiral dot has the unique characteristic that all its non-image pixels are in contact with one another so that a higher extent of ink spreading is obtained than with the concentric rings of US2007/0002384. In the midtones and highlights of the image, the second spiral is preferably open ended, so that it can act as an ink channel that guides the ink out of the spiral dot: when the ink is pressed onto the substrate, part of the ink may be expelled from the second spiral and becomes visible upon magnification of printed images as the release of a small quantity of ink at the outlet of the channel. The open channel enables a further spreading of the ink and, as a result, more ink saving and still faster drying. A similar effect can be obtained by the halftone cells represented in FIG. 10, wherein the ring has gaps between the clusters which allow to evacuate ink.

**[0035]** It shall be clear to the skilled person that the same dot coverage can be produced with different spiral dots of the same overall size: a dot consisting of just one winding of a first spiral of a certain thickness produces the same coverage as a dot with more windings of a first spiral of a lower thickness. The thickness of the first spiral may also vary within the same dot, e.g. smaller at the centre than at the edge of the dot. The winding of the spirals may be clockwise or counter clockwise, and both these embodiments can be combined in the same raster image. The start angle of first spiral, at the centre of the dot, is preferably the same for all spiral dots in the image or can be chosen randomly by a random number generator. More details of suitable spiral dots are disclosed in copending application no. PCT/EP2018/079011, filed on 23 Oct. 2018.

#### Threshold Array

**[0036]** According to the present invention, the raster image is generated by a single threshold array. Digital halftoning by means of a threshold array, sometimes also called threshold matrix or threshold tile, is known in the art. When used for multi-colour printing, the number of threshold arrays is preferably the same as the number of colour channels in the original continuous-tone image. Digital halftoning with a threshold array typically implies that the original image is sampled into cells which are mapped on the threshold array. The local density value of the original image is then compared with each of the values in the array (if necessary, the density range of the original image is adjusted so that it is equal to the range in the array). The output pixel is set to 0 if the original density value is lower than the threshold value of said pixel. Otherwise, if the density value is equal to or exceeds the threshold value, the output pixel is set to 1. These steps are repeated for all cells in the image.

**[0037]** The dimension of the array, i.e. the number of pixels per halftone cell, may depend on various factors such as the resolution of the image setter and the desired quality of the printed image. The array is preferably arranged as a square ( $n \times n$  dimension) or a rectangle ( $m \times n$ , with  $m > n$ ). FIGS. 1-6 show examples of square threshold arrays having a dimension of  $16 \times 16$  locations, wherein each location contains a threshold value in a certain range. In these particular examples, the threshold value range (1-256) is equal to the number of locations ( $16 \times 16$ ) in the array; in other embodiments, such as the example shown in FIG. 16, the value range may be lower than the number of locations and then each individual value may occur at multiple locations of the array.

**[0038]** In order to produce higher relative image densities, the threshold array is designed in such a way that the number and/or the size of the image clusters increases in line with the corresponding density of the original image. For example, FIG. 1 shows a cell which represents a relative image density of 25% with 7 image clusters, of which the size grows at increasing image densities. FIG. 3 shows a 10% cell with 5 image clusters, wherein both the size and the number of clusters grow at higher image densities. While the image density of the halftone cell grows by adding image pixels, it is preferred to keep the non-image pixels together in non-image clusters, which are defined as mutually separated groups of adjacent non-image pixels. By keeping the number of non-image clusters as low as possible in the shadows of the image, the ink can spread to a higher extent than when the non-image pixels are isolated or distributed

over multiple clusters. In that way, ink can also be saved in the shadow areas of the image.

**[0039]** In the preferred embodiment using spiral dots, the relative image density can be increased by growing the length and/or the thickness of the first spiral (which comprises the image pixels), as shown in FIG. 6, or by inserting image pixels inside the second spiral; or by a combination of any of these methods. In the shadows of the image, more image pixels are added to the halftone cell in such a way that the ink channel formed by the second spiral (which comprises the non-image pixels) shrinks and/or becomes thinner, as shown in FIGS. 6 and 9.

#### Printing Plate

**[0040]** The printing plates used in the method of the present invention are obtained by the exposure of the halftone raster image on a light- or heat-sensitive material called printing plate precursor. The plate precursor can be positive or negative working. A positive plate precursor has a coating which after exposure and development accepts ink at non-exposed areas and no ink at exposed areas. A negative plate accepts ink at exposed areas and no ink at non-exposed areas. The image pixels shown in the Figures define ink-accepting areas of the plate and thus correspond to exposed or non-exposed areas of a negative or positive plate precursor respectively.

**[0041]** The plates used in the method of the present invention are preferably lithographic or flexographic printing plates. Lithographic plates are typically obtained by exposing the halftone raster image on the light- or heat-sensitive coating of a printing plate precursor by means of a scanning laser, preferably a violet or a near infrared laser, or another digitally modulated light source, such as a digital mirror device, LCD or LED display. After processing the exposed precursor with a suitable development liquid, a lithographic printing plate carrying the raster image of the present invention is obtained. That plate can then be mounted on a lithographic printing press, preferably an offset press, wherein ink is supplied to the plate which is then transferred onto the substrate to be printed. Alternatively, the exposed precursor can be mounted directly on the press, i.e. without any preceding liquid treatment or other development, and the development of the image may then occur by means of the ink and/or fountain which is supplied to the plate at the start of the press.

**[0042]** Flexographic plates are generally obtained by UV exposure of a photopolymer coating, typically with a UV lamp through a mask which can be a graphic film in contact with the photopolymer coating or an in-situ mask that is present on top of the photopolymer coating. The mask is preferably obtained by exposing the halftone raster image on the film or on the in-situ mask layer by means of a scanning laser, preferably a near infrared laser.

**[0043]** The substrate on which the raster image may be printed can be of any kind, e.g. plastic films or foils, release liner, textiles, metal, glass, leather, hide, cotton and of course a variety of paper substrates (lightweight, heavyweight, coated, uncoated, paperboard, cardboard, etc.). The substrate may be a rigid work piece or a flexible sheet, roll or sleeve. Preferred flexible materials include e.g. paper, transparency foils, adhesive PVC sheets, etc., which may have a thickness less than 100 micrometres and preferably less than 50 micrometres. Preferred rigid substrates include e.g. hard board, PVC, carton, wood or ink-receivers, which may have

a thickness up to 2 centimetres and more preferably up to 5 centimetres. The substrate may also be a flexible web material (e.g. paper, adhesive vinyl, fabrics, PVC, textile). A receiving layer, for example an ink-receiving layer, may be applied on the substrate for a good adhesion of the reproduced image on the substrate.

**1-10.** (canceled)

**11.** A method of reproducing a continuous-tone image with a printing press, the method comprising the steps of:

- (i) digital halftoning by transforming the continuous-tone image into a halftone raster image comprising regularly tiled halftone cells which consist of a grid of image pixels and non-image pixels;
- (ii) exposing the halftone raster image on a printing plate precursor;
- (iii) developing the printing plate precursor into a printing plate;
- (iv) mounting the printing plate on a printing press;
- (v) supplying ink to the printing plate and transferring the ink from the printing plate to a substrate;

wherein

step (i) is carried out by sampling the continuous-tone image into cells which are mapped onto a single threshold array and at least a portion of all the halftone cells in the raster image comprise 2 or more image clusters, image clusters being defined as mutually separated groups of more than 4 adjacent image pixels.

**12.** The method of claim 11, wherein step (iii) is carried out after step (iv).

**13.** The method of claim 11, wherein the portion comprises at least about 10% of all the halftone cells having a relative image density of less than about 50%.

**14.** The method of claim 11, wherein the portion comprises at least about 50% of all the halftone cells having a relative image density of less than about 50%.

**15.** The method of claim 11, wherein the portion consists essentially of all the halftone cells having a relative image density of less than about 50%.

**16.** The method of claim 11, wherein the halftone cells of the portion comprise at least 4 image clusters.

**17.** The method of claim 13, wherein the halftone cells of said portion comprise at least 4 image clusters.

**18.** The method of claim 16, wherein the image clusters in the halftone cells of the portion are arranged along a path which represents a loop or a spiral.

**19.** The method of claim 16, wherein the halftone cells of the portion comprise quarter section which represents a relative image density which is at least twice the relative image density represented by the halftone cell as a whole.

**20.** The method of claim 11, wherein the printing plate is a lithographic or a flexographic printing plate.

**21.** The method of claim 12, wherein the printing plate is a lithographic or a flexographic printing plate.

**22.** The method of claim 16, wherein the printing plate is a lithographic or a flexographic printing plate.

**23.** The method of claim 16, further comprising a step (vi) wherein colour density values are measured on the substrate and the colour density values are used in step (i) to adjust the halftone raster image.

**24.** The method of claim 20, further comprising a step (vi) wherein colour density values are measured on the substrate and wherein the colour density values are used in step (i) to adjust the halftone raster image.

**25.** The method of claim 23, wherein the image clusters are adjusted in step (vi) by changing their number, size, shape and/or distribution in the halftone cells.

**26.** The method of claim 24, wherein the image clusters are adjusted in step (vi) by changing their number, size, shape and/or distribution in the halftone cells.

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