

LOCKING SYSTEM WITH SECURITY TURNING KEYS

The invention is related to a locking system with security reversible keys and with assigned cylinders in accordance with the preamble of claim 1, as well as to corresponding key blanks and security reversible keys in accordance with the preamble of claim 11 and a method for manufacturing these in accordance with the
5 preamble of claim 10.

In locking technology there are the fundamental and continuous problems, on the one hand to make the unauthorised copying of keys more difficult and to prevent it with better and better means and on the other hand to increase the number of possible
10 permutations of a key and with this also the security of the locking systems.

From US 5 438 857 a key of this type is known with an insertion prevention as additional security element. Here there is an additional control face on the key, which with an assigned control pin at the cylinder entrance prevents the insertion of a
15 wrong key. This control pin is longer than a coding pin and extends beyond the central bisecting plane of the key. The control face at the key tip is designed as a rising inclined lead-in surface. It also extends beyond the central plane of the key and lifts the control pin and by means of this pushes it out of the way. This control pin therefore prevents the insertion of keys without the correct control face. These
20 control faces may already be applied to the key blank and with this make a key blank protection possible. These inclined control faces, while making for an additional

impediment, are, however, still not difficult to copy. It is therefore very important to create a significantly higher copy protection by means of new methods.

From WO 01/77466 on the other hand a key system with security reversible keys is
5 known, which at the tip of the key comprise a horizontal blocking groove (BN) with a coded blocking depth. In the assigned cylinder at the rearmost coding position there is a pair of blocking tumbler pins with a lengthened blocking counter pin, which prevent the complete insertion of a key with an insufficiently deep blocking groove. This blocking groove coding results in higher permutation capacities. A horizontal
10 blocking groove of this type, however, is still not difficult to copy.

It is therefore the objective of the invention presented here to create a system with security reversible keys and with assigned cylinders, which overcomes the disadvantages of known systems and which comprises an improved copy protection
15 for keys and key blanks with a shaping, which is already present on the key blank and which is very difficult to define and to copy, and which in addition makes possible higher permutation capacities for any applications.

Over and above, a reliable functioning during a long period of use and
20 insusceptibility to wear should be achieved and an efficient, economical series production should be possible.

This objective is achieved in accordance with the invention by a locking system with security reversible keys with assigned cylinder according to claim 1, by key blanks
25 and security reversible keys with assigned cylinder according to claim 11, as well as by a method for manufacturing such keys in accordance with claim 10.

The concave recesses at the tips of the keys hereby so interact with a convex formation on a counterpart in an assigned cylinder, so that the concave recess in case of a fully inserted key lies flat on the convex formation on the counterpart, and a key
30 blank, resp., a key without this concave recess is locked out by the convex formation

of the counterpart, i.e., a complete insertion is prevented. These concave recesses are difficult to define and correspondingly very difficult is an unauthorised copying of them as well as of the convex formations in the cylinder. The concave recesses may be implemented in a multitude of different shape variants, so that with this it is also possible to achieve a correspondingly significantly higher permutation capacity.

The dependent claims are related to advantageous further developments of the invention, which make possible further advantages with respect to the security of a locking system, the security against copying of key blanks, keys and cylinders, with respect to a long service life and low wear as well as to a higher number of permutations and applications.

In the following the invention is described on the basis of examples of embodiments and Figures. These illustrate:

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| 15 | Fig. 1 | A reversible key blank or key with concave recesses at the tip of the key and convex formations on a counterpart in the cylinder according to the invention, |
| | Fig. 2a, b, c, d | examples of concave recesses with a rounded area, |
| | Fig. 3a | an example of a concave recess with additional straight sections, |
| 20 | Fig. 3b, 4 | a creating milling cutter, for example, of Fig. 3a, |
| | Fig. 5 | the creation of a widened concave recess, |
| | Fig. 6a, b | arrangements of concave recesses in various parts of a cross-section of a key, |
| | Fig. 7a, b, c | concave recesses on an asymmetrical tip of a key, |
| 25 | Fig. 8 | an assignment of different variants of concave recesses to different market areas and application segments, |
| | Fig. 9a, b, c | a concave recess with lead-in areas for tumbler pins and with a blocking groove in three views, |
| | Fig. 10 | a double cylinder lock with concave recesses on the key and |
| 30 | | convex formations in the cylinder, |

- Fig. 11a, b, c, d concave recesses, which have been created with a milling cutter with the milling cutter axis parallel to the y-axis, in different views,
Fig. 12 a concave recess, which has been created by a milling cutter with an angle to the y-axis,
5 Fig. 13 a further example of a milling cutter profile and the concave recess created with it,
Fig. 14a, b, c a concave recess, which has been created by a milling cutter with the milling cutter axis parallel to the z-axis in three views.
- 10 Fig. 1 illustrates the locking system in accordance with the invention with a security reversible key S, rep., a key blank S' with at least two coding pin rows Ai on the flat sides and with an assigned cylinder Za, Zb (illustrated in Fig. 10) and with tumbler pins 3 (illustrated, e.g., in Figs. 6 and 7a), wherein by turning the cylinder a locking - or switching function 9 is carried out. The key tips 11 comprise a concave recess 10,
15 which interacts with a convex formation 20a, 20b on a displaceable counterpart 21a, 21b, so that the concave recess 10 in case of a completely inserted key lies flat on the convex formation 20a, 20b on the counterpart and a key blank, resp., a key without this concave recess 10 is locked out by the convex formation 20 on the counterpart, so that a complete insertion is prevented and wherein with the counterpart 21 a
20 coupling element is capable of being displaced in x-direction into a locking - or switching position.

As will be further illustrated in the Figs. 2a - d, the concave recess 10, starting out from the key tip and extending in the direction of the key axis x, at the beginning
25 comprises a first inclination N1 and subsequently a second inclination N2 to the key axis, wherein the second inclination is greater than the first inclination ($N2 > N1$).

The Figs. 1 and 10, as an example, illustrate a double cylinder Za, Zb, wherein by the insertion of a key with a correct concave recess 10 the counterpart 21a, which here is
30 designed as a displaceable coupling element 22a, is slid into a locking - or switching

element 23 with positive engagement. By subsequent turning of the completely inserted key S, the locking - or switching element 23 is turned and with this a locking - or switching function 9 is carried out, e.g., locking of a lock or an actuation of an electrical contact in an as such known manner.

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As the Figs. 1 and 10 illustrate, the counterpart 21, besides the convex formation 20, may also comprise a concave seating area 25, which corresponds to a convex shape of the key tip 11 next to the concave recess 10. With this the seating area can be enlarged.

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The concave recesses 10 at the key tip 11 in accordance with the invention and the assigned convex formations 20 in the cylinder are further explained in the following Figs. 2 – 5.

The Figs. 2a – d on keys S or key blanks S' with a central plane 5 in cross-section in x-direction illustrate various shapes of concave recesses 10.1 – 10.3 with a rounded concave area 13, departing from a slight first inclination N1 relative to the x-axis, which changes to a significantly greater inclination N2. Assigned to these concave recesses are convex formations 20.1 – 20.3 on the counterparts 21.1 – 21.3 in the cylinder, so that the concave recesses 10 in case of a completely inserted key lie on the convex formations 20. A key blank or key without the concave recess 10 on the contrary with its lead-in area 35 on the key tip will bump against the convex formation 20 and by doing so is blocked, resp., stopped at a lock-out distance a, so that it is not possible for the key to be inserted further (completely) and with this the cylinder therefore cannot be turned.

25 It is possible to create these concave recesses 10 with a milling cutter 40, the milling cutter axis 41.1 of which is vertical to the x-axis, which here extends parallel to the y-axis. In doing so, the milling cutter 40 is moved on a milling track 42. The radius R of the milling cutter then also corresponds to the radius R of the rounded concave areas 13 of the concave recesses 10.

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Fig. 2a illustrates a concave recess 10.1 with a small radius $R1$ of, e.g., 1 mm for a key thickness $d = 2.5$ mm. This corresponds to a ratio of $R1/d = 0.4$. The first and the second inclination here amount to $N1 = 0^\circ$, $N2 = 90^\circ$ and the difference of the inclinations $N2 - N1 = 90^\circ$. This concave recess 10.1 can only be arranged outside
5 the lead-in areas 7 of the tumbler pins 3, because the inclination N in the lead-in area should amount to at most approx. 45° (see Fig. 6), resp., correspond to the lead-in angle Nz of the tumbler pins 3 at the key tip 11. For this purpose, in a lead-in area of tumbler pins lead-in faces 31 may be formed (Fig. 2d). The maximum inclination $N2$ here may also be limited by a blocking groove BN (see Fig. 7c). P1 here designates
10 the next coding position with coding steps C1 – C4. The milling tool movement 42 extends parallel to the x-axis and the lock-out path, resp., the lock-out distance a of a key without a concave recess 10.1 here, e.g., amounts to $a = 1.1$ mm, which is caused by an assigned convex formation 20.1 on a counterpart 21.1 in the cylinder.

15 Fig. 2b illustrates the milling tool 40.1 creating the recess 10.1 with a milling cutter axis 41.1, which extends parallel to the z-axis. In the z-y-plane the milling cutter 40.1 comprises a width $b1$, which here corresponds to the width $b1$ of the recess 10 and wherein $b1$ is greater than the depth $t1$ of the recess 10. The recess 10 comprises a surface area $F1$ in cross-section and a length $l1$ in x-direction.

20 Fig. 2c illustrates an example with greater radius $R2$ of, e.g., $R2 = 2$ mm and correspondingly with a ratio $R2/d = 0.8$. The milling cutter movement 42 here first takes place parallel to the x-axis and then in a 45° direction. The concave recess 10.2 with the inclinations $N1 = 0^\circ$, $N2 = 45^\circ$ is rounded over an area 13 with an inclination of $N = 0^\circ - 45^\circ$. This recess 10.2 may be arranged in the lead-in area 7, if
25 the maximum inclination N of the concave recess in preference amounts to a maximum of 45° . The lock-out distance here is smaller, with, e.g., only $a = 0.7$ mm.

The concave recesses 10 are designed in such a manner, that they do not at all or only as little as possible reach into the nearest coding position P1, so that no coding
30 steps Ci are omitted. On the other hand, the lock-out distance a shall be large enough

to effect a secure massive locking-out of a wrong key. For this purpose, the lock-out distance a may lie within a range of 0.5 – 1.5 mm, in preference of 0.8 – 1.2 mm, resp., comprise a ratio a/d of 0.25 – 0.6, in preference of 0.3 – 0.5. In preference the concave recess 10 is cut-out relatively deeply (t_1) and may extend up to close to the central bisecting plane 5, so that the minimum distance e to the central bisecting plane preferably amounts to at most 10 – 15% of the key thickness d . The distance e , however, may also amount to 0% of d (Fig. 7).

Fig. 2d illustrates a concave recess 10.3 with a small radius R_1 , which first extends parallel to the x -axis with a first inclination of $N_1 = 0^\circ$, then with a rounded area 13 of $N = 0^\circ$ to 45° and finally with a second inclination $N_2 = 45^\circ$, which forms a lead-in face 31 for tumbler pins 3. The lock-out distance here amounts to $a = 1.1$ mm, created by the convex formation 20.3 on the counterpart 21.3.

The Figs. 2a and 2d represent more advantageous variants than the Fig. 2c, with a greater lock-out distance a .

The shaping of the concave recesses 10 in preference is selected in such a manner, that a secure lock-out of wrong keys is achieved, that, however, they do not extend into the coding steps C_i of the closest coding position P_1 and so that they are difficult to define and to copy.

For this purpose the first inclination N_1 of the concave recess 10 relative to the key axis can lie between 0° and 10° , i.e., be very small and the second inclination N_2 of the concave recess can amount to at least 40° , i.e., in preference may be selected as large. The difference between the first and the second inclination $N_2 - N_1$ should amount to at least 30° .

It is possible to achieve this by a rounded area 13 with a relatively small, tight radius R relative to the key thickness d .

In doing so, the concave recess 10 in the direction of the key axis x can comprise a rounded area with a radius of at most 2 mm. And the concave recess can comprise a

rounded area with a radius R , which is smaller than the thickness d of the key. In this, the ratio of radius to key thickness R/d may be between 0.4 and 0.8.

- The Figs. 3a, 3b, 4 and 5 illustrate further examples 10.11 with rounded (13) and with conical, resp., straight areas, which are created with a milling cutter 40.11 with conical sections, with a milling cutter axis 41.11 and with a milling cutter movement 42 parallel to the x-axis, as well as the assigned convex formation 20.11 on the counterpart 21.11 in the cylinder. In the cross-sectional representation of Fig. 3a the concave recess 10.11 comprises straight sections with inclinations $N1$ and $N2$.
- 10 In preference such concave recesses 10 in the cross section in x-direction may also comprise at least one inclined straight section, resp., comprise at least three differing straight and rounded sections, resp., areas.

- Fig. 3a illustrates a concave recess 10.11, which can be created with a milling cutter 40.11, with a straight section with a first inclination of, e.g. $N1 = 10^\circ$ and a subsequent rounding with a radius R , which passes over into a straight section with a second inclination $N2$ of approx. 60° . An assigned convex formation 20.11 in case of a key S without this concave recess 10.11 results in a lock-out over the distance a .
- 20 Fig. 3b illustrates the creating milling cutter 40.11 in the x-z-plane and Fig. 4 in the y-z-plane, wherein here the milling cutter axis 41.11 lies in the surface of the key S , S' . The created recess 10.11 lies within the semi-circle 40.11 of Fig. 4.

- Fig. 5 illustrates, how with a milling cutter 40.12 with a milling cutter axis 41.12 in x-direction it is possible to create a widening of the concave recess in y-direction. For this purpose, the milling cutter is first moved in the direction of the x-axis as in Fig. 3a and subsequently is displaced parallel in y-direction by the distance 42. By this a corresponding widening of the recess 10 is produced, which, e.g., may form lead-in faces 31 for coding tumbler pins 3 with a corresponding inclination.

In order to achieve all the objectives of the invention as well as a secure functioning, the concave recesses 10 in accordance with the invention are optimally positioned and shaped as relatively large and compact: relatively wide and deep and short with respect to the key size and the very limited space at the tip of the key; i.e., in order to
5 fulfil additional security functions, without reducing the space for the coding functions of a high-performance key.

For this purpose, the length l_1 in x-direction, the width b_1 and the depth t_1 as well as the surface area F_1 in the cross section of the concave recesses 10 in preference may
10 comprise the following relative sizes:

- The width b_1 of the concave recess 10 is at least 20 – 40% greater than the width b_2 of the tumbler pins 3,
- the width b_1 of the concave recess 10 amounts to at least 50% of their length l_1 ,
- 15 – the cross-sectional surface area F_1 of the concave recess 10 amounts to at least 6% of the cross-sectional surface area F of the key, in preference to at least 8% - 10 % ,
- the cross-sectional surface area F_1 of the concave recess 10 is greater than the cross-sectional surface area F_2 of the tumbler pins 3, in preference at least
20 20 – 50% greater,
- the width b_1 of the concave recess 10 in preference amounts to at least 25 – 30 % of the width of the key.

This corresponds to the examples described in the Figs.

25 The locking system in accordance with the invention may comprise keys and key blanks with two or several differing variants of concave recesses 10_i on the key tip 11 and of corresponding convex formations 20_i on the counterparts 21 in the cylinders. With this, it is possible to further increase the permutation capacity and also the copying security of the locking system. In doing so, these variants may
30 comprise differing shapings of the concave recesses 10_i .

The Figs. 6a, b schematically illustrate examples of the arrangement of concave recesses 10.1, 10.2 in different partial sections 12.1, 12.2, 12.3 of the key cross-section 12 relative to the position of the coding pin rows A_i and the coding tumbler pins 3 with the tumbler pin axes 4, which are situated in the planes of the coding pin rows A_i .

Fig. 6a illustrates an example with three coding pin rows A_1, A_2, A_3 , wherein the planes of A_1 and A_2 lie parallel to the z-axis and the plane of A_3 parallel to the y-axis. The concave recesses 10.1 in a partial section 12.1 here are outside the lead-in faces 31 of the tumbler pins 3 of the coding pin rows A_i and the concave recesses 10.2 in the partial section 12.3 lie in the lead-in face 31 of the coding pin row A_1 , for which reason their maximum inclination N in the lead-in area 7 of the tumbler pins amount to at most 45° , resp., should correspond to N_z .

As a further variant, a locking system, e.g., can also comprise two equal concave recesses 10.2, which, however, are arranged on different sides, left or right of a key (viewed from above on to the key tip, l = left side, r = right side): Here on the right in the cross-section 12.2 and/or on the left symmetrically in the cross-section 12.3. With this, for example, keys with a recess 10.2 in the cross-section 12.2 for cylinders of a first installation and keys with a recess 10.2 in cross-section 12.3 for a second installation as well as keys with recesses 10.2 in cross-section 12.2 and in cross-section 12.3 for both installations can be created, as well as for a third installation with cylinders, which comprise assigned convex formations 20.2 in both cross-sections 12.2 and 12.3.

Fig. 6b illustrates an example with inclined coding -, resp., tumbler pin rows $A_1 - A_5$ with the angles Wa_1, Wa_2 between the tumbler pin axes 4, resp., the coding planes A_1, A_2 and the z-axis. Here too, a concave recess 10.1 lies in a partial section 12.1 outside the lead-in areas 7 of the tumbler pins. One concave recess 10.2 in a partial section 12.2 partially lies in a lead-in area 7 of the coding pin row A_2 .

In this manner, it is possible to create locking systems with different variants of concave recesses, which are formed in different partial sections 12.1, 12.2 of the key cross-section 12.

- 5 The recesses 10.1 located opposite one another in the key centre 6 in the cross-sections 12.1, however, are very unfavourably situated, because their depth t_1 here is very limited.

10 The further examples of the Figs. 7 – 14 illustrate advantageous recesses 10, which are arranged besides the key centre 6 and which are designed as particularly large with respect to cross section surface area F_1 , width b_1 and depth t_1 , resp., minimum distance e from the central bisecting plane 5 of the key. In addition, here the recesses 10 optimally are positioned in such a manner, that they comprise a coding pin row A, wherein they with respect to shaping are adapted to the tumbler pins 3 of this coding
15 pin row (32 in Fig. 7).

For this the concave recess 10 can:

- Comprise a lead-in area 7 of a coding pin row A,
- or it may comprise a lead-in area 7, 31 for the tumbler pins 3,
- and besides the lead-in area 7, 31 it can also comprise an area with a greater
20 inclination $N_{2.2}$ of in preference at least 55° ,
- and the inclination N of the concave recess 10 in the lead-in area 7, 31 of the coding pin row A can correspond to the lead-in angle N_z of the tumbler pins 3, resp., amount to at most 45° ,
- or the concave recess 10 may comprise a lead-in face 31, which has been
25 created with a coding milling cutter,
 (which is particularly efficiently producible),
- or the concave recess 10 may additionally comprise a horizontal blocking
 groove milling BN,
 (which limits the maximum inclination $N_{2.1}$ (in Fig. 7c) in the lead-in area 7,
30 31 to a value N_z .)

The concave recess 10 may comprise a coding pin row A with narrow tumbler pins 3.1, wherein their width b_2 in preference amounts to at most 50 - 55 % of the key thickness d . The surface area F_2 of these tumbler pins 3.1 is then correspondingly small (in Figs. 7a, b and 9c). With this, the ratio F_1/F_2 becomes correspondingly greater (F_1 = surface area of 10) and with this the inclination $N_{2.2}$ of the concave recesses 10 next to the lead-in areas 7, 31 is capable of being formed as greater and $N_{2.2}$ may there amount to, e.g., 60° to 90° (Fig. 7c).

These advantageous variants of concave recesses 10 with a tumbler pin row A are further explained in the Figs. 7 – 14.

The Figs 7a, b illustrate an example with an asymmetrical formation of the lead-in faces 35 on the key tip 11, in that the cross-section plane 36 of the lead-in faces forms an angle W_2 of e.g., 10° to the central bisecting plane 5 of the key S, resp., of a key blank S'. In preference, this angle W_2 may lie within a range of between 5° and 20° . In this manner it is possible to create a locking system with an increased permutation capacity, e.g., by five variants with the angles $W_2 = 0^\circ, +10^\circ, -10^\circ, +20^\circ, -20^\circ$. Furthermore, with an asymmetrical shape of the lead-in faces 35, e.g., in accordance with Fig. 7, also more space for the formation of concave recesses 10 right up to the central bisection plane 5 can be created. This makes a large surface area F_1 of the concave recess 10 in the cross-section 12 possible.

A symmetrical formation of the lead-in surfaces 35 at the key tip is illustrated, e.g., in Fig. 6 with an angle $W_2 = 0^\circ$ to the cross-section plane 36.

The Figs. 7a, 7b illustrate a key cross-section 12 with the coding pin rows A1 – A5 as well as with a tumbler pin 3 in the coding pin row A1. A concave recess 10.8, which here is shaped as almost symmetrical to the coding pin row A1, may here be created with a milling cutter 40.8, the profile of which corresponds to the concave recess shape 10.8 and with a milling cutter axis 41.2, which lying in the plane y-z comprises an angle W_1 to the y-axis. When the same milling cutter 40.8 is utilised with a milling cutter axis 41.1 parallel to the y-axis, a correspondingly different

shape variant of the concave recess is created. In order to with a milling cutter axis 41.1 (with $W1 = 0^\circ$) achieve essentially the same shape 10.8 of the concave recess, a correspondingly different profile shape of the milling cutter 40 would have to be utilised. With the milling cutter 40.8 here also lead-in faces 32 in the lead-in area of the coding pin row A1 are created, which are adapted to the shape of the tumbler pins 3.

The lead-in area for the tumbler pins 3, 3.1 consists of lead-in faces 7 with a width of b7 (Fig. 9a, b, c), so that the lead-in angle for the tumbler pins in the concave recess 10 nowhere does exceed the value N_z .

Lead-in surfaces 7, 31 of this kind, however, may also be created on the key blank after the creation of the concave recesses 10 on the key blank with a first milling cutter 40 and subsequently (decentrally) with a second coding milling cutter in the lead-in area 7, 31, so that there a desired maximum inclination N of, e.g., $42^\circ - 45^\circ$ is not exceeded.

Fig. 7c illustrates a further possibility of not exceeding the permissible inclination N of the concave recesses 10 in the lead-in area 7, 31 of the tumbler pins. Here the concave recess 10.8 in addition may comprise a horizontal blocking groove BN. A blocking groove of this kind is described in WO 01/77466. With it, an additional coding in the form of a blocking code can be implemented.

Fig. 7c in perspective view illustrates a cross-section with a cross-section plane, which corresponds to the coding plane A1, on a key tip 11 in analogy to the example of Fig. 9 with a concave recess 10.9. In the cross-section plane A1 (in the lead-in area 7, 31) this recess 10.8 comprises a first inclination of $N1 = 0^\circ$ and subsequently a rounded concave area 13 with a maximum second inclination of $N2.1 = N_z$.

Thereupon follows a horizontal blocking groove BN, which, e.g., is created with a coding milling cutter. Outside the lead-in face 7 the concave recess 10.8 comprises a greater second inclination, which here, e.g., amounts to $N2.2 = 60^\circ$ – i.e., here it is

possible that the second inclination in preference amounts to considerably more than 45°.

Fig. 8 illustrates an assignment of different variants of concave recesses 10 on the
5 keys S and on the key blanks S' to different market - and application areas Mi. In this
manner, with a locking system with several differing variants of concave recesses 10i
it is possible to define an unequivocal segmentation into independent market - and
application areas Mi. These may be geographically different market areas, e.g., for
individual countries or representatives or also technically differing application areas,
10 e.g., of technically differing systems with differing permutation capacities for
different application areas and differing security requirements.

This segmentation into market - and application areas by means of differing variants
of concave recesses 10i may be implemented in an analogous manner, as is explained
in WO 01/77466 for an additional blocking groove coding.

15 With these differing variants of concave recesses 10i, however, it is also possible to
create additional coding permutations (Cod). Thus in a system with 40 different
variants, for example, 20 different market areas can be unequivocally differentiated
between and in addition 20 new coding permutations can be created.

20 The locking system in accordance with the invention also makes possible the
manufacturing of keys and cylinders in two steps, wherein in a first superimposed
more difficult step the concave recesses 10 on the key tips and the convex formations
20 on the counterparts of the cylinders are centrally manufactured by the system
owner and in a simpler second step the further coding of the keys and the assembly
25 of the cylinders with counterparts may take place decentrally.

The differing variants of concave recesses 10i can be created by:

- Differing profile shapes of a creating milling cutter 40, e.g., with the milling
30 cutters 40.8 of Fig. 7, 40.9 of Fig. 11, 40.6 of Fig. 13 and 40.7 of Fig. 14,

- as well as different positions of the milling cutter axes 41: E.g., the axis positions 41.1 and 41.2 in the Figs. 7a and 11, the positions 41.3 in Fig. 12, 41.4 in Fig. 14, 41.11 in Fig. 3 and 41.12 in Fig. 5. These milling cutter axes are:
 - 41.1 in the y – z plane, parallel to the y-axis
 - 41.2 in the y – z plane, with angle W1 to the y-axis
 - 41.3 in the x – y plane, with W3 to the y-axis
 - 41.4 in the x – z plane, parallel to the z-axis
 - 41.11 in the x – z plane, parallel to the x-axis.
- 10 The milling cutter axes 41 may be vertical to the x-axis with an angle W1 of 0° to 20° to the y-axis or be vertical to the z-axis with an angle W3 of 0° to 20° to the y-axis or be vertical to the x-axis with an angle W4 of 0° to 20° to the z-axis.
- With this, e.g., the following variants of differing shaped concave recesses 10 are created:
 - 10.1 – 10.13 of the Figs. 2, 3, 5, 7, 9, 11 – 14.
- In addition, it is possible that the concave recesses 10i are provided in differing parts 12.1, 12.2, 12.3 (Fig. 6) on the left or right side of the key - l or r -
- and the cross-section planes 36 of the lead-in faces 35 on the key tip may form differing angles W2 to the central bisecting plane 5.

By means of combinations of these factors therefore it is possible, for example, with two different milling cutter shapes 40, three different positions of the milling cutter axes 41, arrangement in three different cross-section parts 12i and with three different angles W2 of the lead-in faces 35, theoretically in total $2 \times 3 \times 3 \times 3 = 54$ different variants of concave recesses 10i can be created.

This also signifies, that a specific variant of it is very difficult to define and to copy.

The Figs. 9a, b, c illustrate a further example of a concave recess 10.9 with a horizontal blocking groove BN in three views in analogy to the example of Fig. 7c.

The blocking groove BN is situated in the lead-in area 7, 31 of the tumbler pins 3, the coding plane A1 of which, as in the example of Fig. 7a, b, comprises an angle of W_{a1} of, e.g., 15° to the z-axis.

- 5 Fig. 10 illustrates a double cylinder lock 1 with the cylinders Za, Zb for keys S, resp., key blanks S' with a concave recess 10 at the tip of the key 11 and with assigned convex formations 20 on counterparts 21a, 21b in the cylinders Za, Zb. As is also illustrated in Fig. 1, these counterparts are arranged on displaceable coupling elements 22a, 22b for actuating a locking - or switching element 23. These
- 10 counterparts 21 may also be designed as a separate part, e.g., as extension elements or they may be designed as an insert and utilised in a modular system. It is also possible that a coupling element 22 can be displaced into a locking - or switching position in a half cylinder with the counterpart 21.
- 15 The Figs. 11a – d illustrate a key S, or a key blank S' with a concave recess 10.9, which has been created with a milling cutter 40.9. Its milling cutter axis 41.1 here is parallel to the y-axis. If the same milling cutter 40.9 with an axis position 41.2 with an angle W_1 to the y-axis is utilised, correspondingly a new variant with a different shape of the concave recess 10 is created. The angle W_1 may amount to, e.g., 10° -
- 20 20° .

- Fig. 12 illustrates a further variant with a concave recess 10.5, which has been created with the milling cutter 40.9 of Fig. 11, with, however, a milling cutter axis 41.3, which lies in the x – y-plane and which comprises an angle W_3 of, e.g., 10° -
- 25 20° to the y-axis.

- Fig. 13 illustrates a further variant of a concave recess 10.6, which has been created with a milling cutter 40.6. This comprises a different profile shape, but the same position of the milling cutter axis 41.1 parallel to the y-axis as in the example of Fig.
- 30 11b.

The Figs. 14a, b, c illustrate in three views a further variant of a concave recess 10.7, which has been created with a milling cutter 40.7, the axis 41.4 of which lying in the $x - z$ -plane, extends vertical to the y -axis and parallel to the z -axis. The views of Fig. 14b and c illustrate the concave recess 10.7, which is situated partially in a lead-in area 7, 31 of a coding pin row A_i and which there forms a lead-in face 31 with an inclination N_2 to the x -axis of at most 45° . This can be created, e.g., with a milling track 42, which extends first with a 0° - and then with a 45° -direction to the x -axis. This example comprises a strongly distinctive, deep concave recess 10.7, which extends almost to the central bisecting plane 5 with a minimum distance e of a few percent of the key thickness d . This results in a secure locking out of wrong keys. A different milling cutter axis might also comprise an angle W_4 of, e.g., $5^\circ - 20^\circ$ to the z -axis.

Within the framework of this description, the following designations are utilised:

15	S	Key
	S'	Key blank
	Z	Cylinder
	x	Key axis
	x, y, z	Directions in space
20	Pi	Coding positions
	Ai	Coding pin rows
	Ci	Coding steps
	Codi	Coding permutation
	N	Inclination of 10
25	N1	First inclination
	N2	Second inclination
	Nz	Lead-in angle of 3
	R	Radius of 10, resp., of 40
	F	Surface area of the key cross-section 12
30	b	Key width

	d	Key thickness
	a	Lock-out distance
	e	Minimum distance of 10 to 5
	F1	Surface area of 10 in cross-section
5	b1	Width of 10
	t1	Depth of 10
	l1	Length of 10 in x-direction
	F2	Surface area of 3 in cross-section (in 10 with C1)
	b2	Width of 3
10	b7	Width of the tip of the coding pin
	W1	Angle of 41 (in y-z-plane)
	W2	Angle of 35
	W3	Angle of 41 (in x-y-plane)
	W4	Angle of 41 (in y-z-plane)
15	Wa	Angle of 4 to z-direction
	l	Left side of S
	r	Right side of S
	BN	Blocking groove
	Mi	Market areas
20	1	Double cylinder lock
	3	Tumbler pins
	3.1	Narrow tumbler pin
	4	Axis of 3
	5	Central bisecting plane of S
25	6	Key centre (x-z-plane)
	7	Lead-in area, resp., lead-in face for the tumbler pin
	9	Locking - or switching function
	10, 10i	Concave recess
	10.1 – 10.13	Various shapes of 10
30	11	Key tip

	12	Cross-section of key
	12.1, 12.2	Parts of 12
	13	Rounded concave area of 10
	17	Lead-in face horizontal
5	20, 20i	Convex formation
	21	Counterpart in Z
	22	Coupling element, displaceable
	23	Locking - or switching element
	25	Concave seating area of 21 next to 20
10	31	Lead-in faces of 3 in 10
	32	Lead-in faces like shape of 3
	35	Lead-in faces, bevelled tip of key
	36	Cross-section plane of 35
	40	Milling cutter for 10
15	41	Milling cutter axis
	41.1	In y – z plane, parallel to y-axis
	41.2	In y – z plane, with W1 to y-axis
	41.3	In x – y plane, with W3 to y-axis
	41.4	In x – z plane, parallel to z-axis
20	41.5	In x – z plane, parallel to x-axis
	42	Milling track

CLAIMS

1. Locking system with security reversible keys (S) with at least two coding pin rows (Ai) on the flat sides and with assigned cylinders (Z) with tumbler pins (3), wherein by turning the cylinder a locking - or switching function (9) is carried out,
5 characterised by a concave recess (10) at the key tips (11), which interacts with a convex formation (20) on a displaceable counterpart (21) in the cylinders,
so that the concave recess (10) in case of an entirely inserted key rests flat on the convex formation (20) on the counterpart (21),
10 and a key without this concave recess is locked out (a) by the convex formation of the counterpart, whereby a complete insertion is prevented, and wherein the concave recess (10) starting out from the key tip in the direction of the key axis (x) initially comprises a first inclination (N1) and subsequently a second inclination (N2) to the key axis, wherein the second inclination is greater than the first inclination and the concave recess (10) in x-direction comprises a rounded concave area (13),
15 and wherein with the counterpart (21) a coupling element (22) is displaceable in x-direction into a locking - or switching position.
20
2. Locking system according to claim 1, characterised by at least two differing variants of concave recesses (10.1, 10.2) on the key tips (11) and by corresponding, matching convex formations (20.1, 20.2) on the counterparts (21) in the cylinder.
25

3. Locking system according to claim 2, characterised in that the variants comprise differing shapes of the concave recesses (10.1, 10.2) and/or are formed in different parts (12.1, 12.2) of the cross-section (12) of the key.
- 5 4. Locking system according to claim 1, characterised in that a cross-section plane (36) of lead-in faces (35) on the key tip forms an angle (W2) to the central bisecting plane (5) of the key, wherein the angle W2 amounts to at most 15° - 20°.
- 10 5. Locking system according to claim 1, characterised in that differing variants of concave recesses (10i) are defined by differing shapes and/or by arrangement in differing parts (12.1, 12.2) of the key cross-section and/or by differing angles (W2) of lead-in faces (35) on the key tip to the central bisecting plane (5) of the key.
- 15 6. Locking system according to claim 5, characterised in that with differing variants of concave recesses (10i) an unequivocal segmentation into independent market areas (Mi) is defined.
- 20 7. Locking system according to claim 5, characterised in that with differing variants of concave recesses (10i) additional coding permutations (Codi) are created.
8. Locking system according to one of the preceding claims, characterised in
25 that counterparts (21) are arranged on a displaceable coupling element (22) of a double cylinder or are formed as a separate part.
9. Locking system according to claim 1, characterised in that the counterpart (21) apart from the convex formation (20) also comprises a concave seating

area (25), which corresponds to a convex shape of the key tip (11) next to the concave recess (10).

10. Method for the manufacturing of keys and cylinders of a locking system
5 according to one of the preceding claims, characterised in that the concave recesses (10) on the key tips (11) and the convex formations (20) on the counterparts (21) are centrally manufactured or authorised and the further coding of the keys (S) and the assembly of the cylinders (Z) are capable of being carried out decentrally in further manufacturing steps.
- 10
11. Key blank (S') for a security reversible key (S) or security reversible key with at least two coding pin rows (Ai) on the flat sides with an assigned cylinder (Z) with tumbler pins (3), wherein by turning the cylinder a locking - or switching function (9) is carried out,
15 characterised by a concave recess (10) on the key tip (11), which interacts with a convex formation (20) on a displaceable counterpart (21) in the cylinder,
wherein the concave recess (10) is suitable for resting flat on the convex formation (20) on the counterpart (21) when the key is entirely inserted,
20 as a result of which a key blank or key without this concave recess is locked out (a) by the convex formation of the counterpart, whereby a complete insertion is prevented,
and wherein the concave recess (10) starting out from the key tip in the direction of the key axis (x) initially comprises a first inclination (N1) and
25 subsequently a second inclination (N2) to the key axis, wherein the second inclination is greater than the first inclination and the concave recess (10) in x-direction comprises a rounded concave area (13)
and wherein with the counterpart (21) a coupling element (22) is displaceable in x-direction into a locking - or switching position.
- 30

12. Key blank or key according to claim 1, characterised in that the first inclination (N1) of the concave recess (10) to the key axis lies between 0° and 10° and that the second inclination (N2) of the concave recess amounts to at least 40°.
- 5
13. Key blank or key according to claim 11, characterised in that the concave recess (10) comprises a lead-in area (7) of a coding pin row (A).
14. Key blank or key according to claim 13, characterised in that the concave recess (10) comprises a lead-in area (7, 31) for the tumbler pins (3).
- 10
15. Key blank or key according to claim 14, characterised in that the concave recess (10) apart from the lead-in area (7, 31) also comprises a section with a greater inclination (N2.2) of in preference at least 55°.
- 15
16. Key blank or key according to claim 13, characterised in that the inclination (N) of the concave recess (10) in the lead-in area (7, 31) of the coding pin row (A) corresponds to the lead-in angle (Nz) of the tumbler pins (3), or amounts to at most 45°.
- 20
17. Key blank or key according to claim 14, characterised in that the concave recess (10) comprises a lead-in face (31) which is created with a coding milling cutter.
- 25
18. Key blank or key according to claim 13, characterised in that the concave recess (10) also comprises a blocking-groove (BN).
19. Key blank or key according to claim 11, characterised in that the width (b1) of the concave recess (10) is at least 20 – 40% greater than the width (b2) of the tumbler pins (3).
- 30

20. Key blank or key according to claim 11, characterised in that the width (b1) of the concave recess (10) amounts to at least 50% of its length (l1).
- 5 21. Key blank or key according to claim 11, characterised in that the surface area of the cross-section (F1) of the concave recess (10) amounts to at least 8% of the surface area of the cross-section (F) of the key.
- 10 22. Key blank or key according to claim 13, characterised in that the surface area of the cross-section (F1) of the concave recess (10) is greater than the surface area of the cross-section (F2) of the tumbler pins (3), in preference at least 20 – 50%.
- 15 23. Key blank or key according to claim 13, characterised in that the concave recess (10) comprises a coding pin row (A) with narrow tumbler pins (3.1).
- 20 24. Key blank or key according to claim 11, characterised in that the concave recess (10) is created with a profiled milling cutter (40), the axis (41) of which is vertical to the x-axis and comprises an angle (W1) of between 0° and 20° to the y-axis.
- 25 25. Key blank or key according to claim 11, characterised in that the concave recess (10) is created with a profiled milling cutter (40), the axis (41) of which is vertical to the z-axis and comprises an angle (W3) of between 0° and 20° to the y-axis.
- 30 26. Key blank or key according to claim 11, characterised in that the concave recess (10) is created with a milling cutter (40), the axis (41) of which is vertical to the x-axis and comprises an angle (W4) of between 0° and 20° to the z-axis.

27. Key blank or key according to claim 11, characterised in that the concave recess (10) in the direction of the key axis (x) comprises a rounded concave area (13), the radius (R) of which is smaller than the thickness (d) of the key or that it amounts to 2 mm at most.
- 5
28. Key blank or key according to claim 27, characterised in that the ratio (R/d) of radius to the key thickness amounts to between 0.4 and 0.8.
29. Key blank or key according to claim 11, characterised in that the concave recess (10) in the cross-section in x-direction comprises at least three differing rounded or rounded and straight sections.
- 10
30. Key blank or key according to claim 11, characterised in that the concave recess (10) comprises a minimum distance (e) to a central bisecting plane (5) of the key blank or key, which amounts to at most 10% of the key thickness (d).
- 15
31. Key blank or key according to claim 11, characterised in that the concave recess (10) is dimensioned in such a manner, that a lock-out by a distance (a) of 0.5 to 1.5 mm results.
- 20