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## (54) Plate folding device.

(57) The present invention relates to a plate folding device which comprises a folding blade (2) and a folding counter-blade (3) which can be moved mutually closer, wherein the blade is constituted by an element (11) for the abutment of a portion of the plate which is adjacent to its folding edge, and the counter-blade is constituted by a supporting cradle which accommodates a folding tool (4). The tool is substantially constituted by a roller having a longitudinal groove which defines in the roller two mutually angularly spaced longitudinal edge portions (9, 10). A plate presser element (15) is slidably mounted between the abutment element and the tool so as to interact with one of the longitudinal edge portions to rotate the tool (4) in a first direction which tends to move the other of its longitudinal edge portions into contact with the plate.

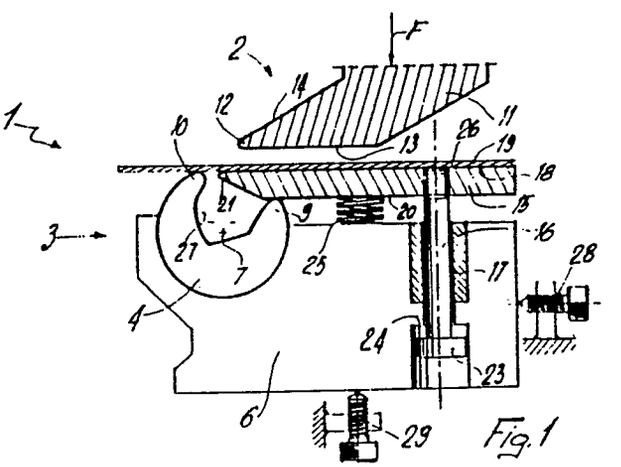

Fig. 1

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# PLATE FOLDING DEVICE

The present invention relates to a plate folding device. In particular, the field of application of the present invention is the field of folding devices with a blade and a counter-blade which have respective active portions which cooperate to fold a plate; said devices are used in the manufacture of panels with folded edges intended for the production of metallic furniture, refrigerators, washing machines, radiators, convectors and similar products.

In a known folding device of this kind, the plate is supported by a steel profiled element which is upwardly provided with a plurality of grooves which define forming seats or dies which can he coupled to a series of complementarily shaped punches so as to draw an interposed plate. In said known device the plate is manually retained against the die, in a more or less stable manner, and the final folding angle being determined by the shape of the die and of the punch and by the value of the stroke of the two coupling elements. Though said known device is considerably simple from a constructive point of view, it is not free from disadvantages, among which mention is made of its difficult adjustment, the need to frequently replace its dies and respective punches, the slowness of the process and the employment of specialized personnel with consequent high production costs and considerable risks for the personnel assigned to the handling of the plates.

Another known device comprises a plate clamping structure, constituted by a pair of opposite jaws actuated by one or more hydraulic cylinders and by a folding blade which is mounted so as to be slidable laterally to said clamping structure and is adapted to interfere with the plate during its relative sliding motion, thus deforming said plate by flexing. The final folding angle may be modified either by varying the distance of the blade with respect to the clamping structure and the useful stroke of said forming blade. In a variated aspect of said known device, the folding blade can also move perpendicularly to the main sliding direction, so that it can partially overlap the folding edge, thus allowing folding angles greater than 90°. This variated aspect, however, has the disadvantage that up to three hydraulic cylinders are required to actuate the device, the first of which is required to actuate the clamping structure, the second to move the forming tool along the main sliding direction and the third to move the forming blade transversely to the main sliding direction. Owing to the considerable complexity of the resulting motion of the blade and of the considerable forces involved, the correct operation of said device requires sophisticated and delicate control means which have a very high cost and are extremely difficult as regards maintenance.

From US patent application US-A-4002049 in the name of Allan is known a folding device associable with a conventional press which comprises all the features stated in the pre-characterizing part, of claim 1. In particular, said known device has a folding blade which comprises a rotating tool consisting of a roller with a lateral groove, both edges whereof act on the plate, which is at least partially urged by a fixed counter-blade. In order to retain the plate during its machining, a plate presser acts laterally to the folding surfaces.

Though said known tool allows to correctly provide folding angles of up to 90°, and requires the use of a single actuator cylinder, it is not easy to adjust and does not allow to execute folds with an excessively low radius. Both edges of the groove furthermore act locally on the plate, causing strains and stress concentrations proximate to the folding edge, with consequent risks of cracks in the material.

The aim of the present invention is to provide a folding device which is very easy to manufacture and precise in operation, eliminating the above described disadvantages of the prior art.

Within the scope of the above described aim, an object of the invention is to provide a device which allows to produce folds with a wide range of curvature radii and of folding angles, even considerably greater than 90°, by means of extremely limited replacements of its basic components.

Another object of the invention is to provide a folding device which ensures the accurate adjustment of the folding parameters.

A further object of the invention is to provide a highly reliable device with easy maintenance, obtained starting from commonly commercially available components.

This aim, as well as these and other objects which will become apparent hereinafter, are achieved by a plate folding device comprising a folding blade and a folding counter-blade which can be moved mutually closer or further apart, to determine, upon coupling thereof, the folding of a plate, said blade being consisting of an abutment element for a plate portion adjacent to the folding edge, said counter-blade being consisting of a supporting cradle which rotatably supports a folding tool, said tool substantially comprising a roller which has a longitudinal groove which defines, peripherally to said roller, two longitudinal and mutually angularly spaced edge portions, characterized in that it comprises a plate presser element slidably mounted between said abutment element and

said tool so as to result at least partially aligned with both, said plate presser element interacting, when said blade and counter-blade approach one another, simultaneously with the plate on one side, to lock it against said abutment element, and with one of said longitudinal edge portions of said tool on the other, to cause said tool to rotate in a first direction which tends to move the other of said longitudinal edge portions to act on the plate so as to fold it.

Further characteristics and advantages of the invention will become apparent from the description of a preferred but not exclusive embodiment of the device according to the invention, illustrated only by way of non-limitative example in the accompanying drawings, wherein:

figure 1 is a general sectional side view of the device according to the invention in its initial position, with the plate still to be folded;

figure 2 is a detail view, in slightly enlarged scale, of the general view of figure 1, with the plate already partially folded, illustrating several dimensional parameters of the device;

figures 3a) to 3d) are schematic views of the device of figure 1 in successive operative steps of the folding process.

With reference to the above cited drawings, in an embodiment illustrated by way of example the device according to the invention, generally indicated by the reference numeral 1, comprises a folding blade, generally indicated by 2, and a folding counter-blade, generally indicated by 3. The blade 2 comprises an abutment element 11 which is adapted to contrast a portion of the plate and is generally wedge-shaped with a substantially horizontal wall 13 and an inclined wall 12 with an angle which is smaller than the final folding angle of the plate to be obtained, to take into account the elastic hysteresis of the material. The tip edge 12 is rounded, and its radius of curvature is indicated by RC in figure 2.

The counter-blade 3 is defined by a folding tool 4 which is substantially constituted by a roller with an outer diameter DS, which can rotate freely about its own axis 7 in a cradle 5 provided in a rigid support 6.

The roller 4 advantageously has a lateral groove 8 which extends parallel to its axis of rotation. Said groove 8 has a curved profile which will be described in greater detail hereinafter, so that the tool has, as a whole, an approximately "C"-shaped transverse cross section. The longitudinal edge portions 9, 10 formed by the groove 8 are angularly spaced and conveniently rounded with curvature radii respectively indicated by RL and RR in figure 2. The blade 2 and the counter-blade 3 may be associated with a conventional press or with a machine conceived specifically for this purpose, which are not illustrated in the figures since they do not relate to the present invention.

The blade 2 may be conveniently fixed to the movable punch-holder of the press, while the counter-blade 3 can be rigidly fixed to its fixed table. A kinematically reversed arrangement, in which the blade is fixed and the counter-blade is movable, is evidently to be considered technically equivalent and therefore equally acceptable in terms of the description of the invention.

According to a peculiar characteristic of the invention, a plate presser element 15 is interposed between the blade 2 and the counter-blade 3, said presser element being movable vertically, for example by means of a sliding rod 16 which is fixed to the element 15 by means of a threaded coupling 26 and is guided by a through hole 17 provided in the support 6. The plate presser element 15 has an upper plate-supporting surface 18 which is substantially parallel to the wall 13 of the abutment element 11 so as to lock a plate 19 there against, a lower surface 20, intended to interact with the edge 9 of the folding tool 4, and an end portion 21 adapted to co-operate with the groove 8 of the tool 4. The contact between the surface 20 and the edge 9 of the tool occurs substantially along a generatrix of said edge and is a partially rolling, partially scraping contact. From this arrangement it is evident that the lowering of the plate presser element 15 causes the tool 4 to rotate clockwise. Between the plate presser element 15 and the support 6 may be interposed an elastic return means, consisting for example, of a compression spring 25 which raises the plate presser element 15 when the blade 2 moves away from the counter-blade 3 so as to prepare the device for a next folding operation. The upward stroke of the plate presser element 15 is limited by an enlarged end portion 23 of the guiding rod 16 which abuts against the annular edge 24 of the guiding hole 17, the distance of said enlarged portion 23 from the surface 20 being adjustable by rotating it about its axis.

The groove 8 of the folding tool 4 has a curved profile 27 determined by the envelope of the successive positions of the end portion 21 of the plate presser element 15 during the rotation of the tool up to a final position in which the end portion 21 perfectly matches the bottom of the groove. In this manner, when the plate presser element 15 rises due to the spacing of the blade 2 from the counter-blade 3, the end portion 21 exerts on the tool 4 an anti-clockwise rotational torque which tends to lower the edge 10 of the tool to the same level as the upper face 17 of the plate presser element 15.

The aperture angle $\alpha$ defined by a pair of radial planes which are tangent to the longitudinal edges 9, 10 may be determined according to the folding

angle and to the diameter of the tool, and depends on the thickness P of the plate presser element.

It should be noted that in order to minimize friction forces the contact surfaces of the edges 9, 10 and of the surface 20 are formed with such a surface finish as to ensure a friction coefficient of approximately 0,15 between the tool and the plate presser and of approximately 0,25 between the tool and the plate.

On the basis of calculations and tests, optimum values have been determined for the previously defined shape parameters. In particular, it has been deemed appropriate to contain the value of the diameter DS of the tool 4 within the smallest possible values for reasons of bulk and structural resistance. More specifically, for metal sheets with a relatively low thickness, in any case lower than 1,5 mm and for considerable final folding angles up to 145°, the optimum ratio between the average thickness of the plate and the diameter DS is comprised between 0,12 and 0,30.

Similarly, for relatively high plate thicknesses, in any case higher than 1.5 mm, and for curvature angles contained within 90°, the optimum ratio between the average thickness S of the plate and the diameter DS has been found to be comprised between 0,20 and 0,50.

As regards the radii of curvature RL and RR of the longitudinal edges 9, 10, greater values of said radii correspond to smaller values of the pressures of contact with the contiguous elements, however, excessive values of said radii limit the width of the related folding angles, all other factors being equal. In particular it has been calculated that optimum values of said radii may be comprised between 1/8th and 1/24th of the diameter DS of the tool, and preferably between 1/12th and 1/20th of said diameter.

Expediently, according to the invention, the position of the abutment element 11 may be conveniently changed to provide a considerable range of folding angles obtainable with the same geometry of the abutment element 11. For this purpose, the abutment element 11 can be moved horizontally and vertically by means of appropriate adjustment means, in order to modify, respectively, the distances XC and YC of the center of the radius of curvature RC of the vertex 12. It is evident that the same effect may be achieved by moving the support 6 at rest along horizontal and vertical directions by virtue of adjustment means schematically indicated by the actuation screws 28 and 29 in figure 1.

It has been found that the optimum values of the distance XC oscillate between 15% and 40% of the diameter of the tool, lower values being appropriate for high folding angles and thin plates, higher values being preferable for high-thickness plates and for small folding angles.

Finally, the radius RC at the vertex of the abutment element 11 may vary according to the required folding angle and is mostly determined according to the properties of the material to be folded. With materials which have a modest increase in resistance immediately after the yield phase, the radius RC must in fact be preset rather accurately, while with materials which have a high increase in resistance with work-hardening immediately after yielding, such as normal steels with a high carbon content, the radius RC may even be close to zero, since the work-hardened material itself progressively "creates" successive folding edges.

From what has been described above the operation of the device is substantially evident. A plate 19 is initially deposited on the plate presser 15, the upper surface whereof is approximately at the same level as the edge 10 of the tool, and the lower surface 20 whereof is kept raised by the spring 25 and skims the edge 9 of the tool 4. In this step the abutment element 11 is spaced from the plate 18. The abutment element 11 is subsequently lowered by exerting appropriate compression forces, indicated by the arrow F in figure 1, and locks the plate 18 against the plate presser element 15. Said plate presser element in turn moves the edge 9 of the tool 4 downwards, transmitting thereto a clockwise rotational torque, so that its edge 10 bends the plate along the folding edge defined by the tip edge 12 of the abutment element 11. The angle of the fold and its inner profile may be preset by appropriately locating the vertex 12 of the abutment element 11 by means of adjustments of the actuation screws 28 and 29.

In practice it has been observed that the device according to the invention fully achieves the intended aim, since it is very simple in construction and very precise in operation, and it furthermore allows to produce folds with a wide range of folding angles, using a very limited series of abutment elements 11 and tools 4. The final configuration of the executed fold is furthermore easily and precisely adjustable, while friction is minimized, consequently reducing operating power.

The device thus conceived is susceptible to numerous modifications and variations, all of which are within the scope of the inventive concept as defined by the accompanying claims; all the details may furthermore be replaced with technically equivalent elements. In practice the materials employed, so long as compatible with the specified use, as well as the dimensions, may be any according to the requirements and to the state of the art.

## Claims

1. Plate folding device, comprising a folding blade and a folding counter-blade which can be moved mutually closer or further apart, to determine, upon coupling thereof, the folding of a plate, said blade being consisting of an abutment element for a plate portion adjacent to the folding edge, said counter-blade being consisting of a supporting cradle which rotatably supports a folding tool, said tool substantially comprising a roller which has a longitudinal groove which defines, peripherally to said roller, two longitudinal and mutually angularly spaced edge portions, characterized in that it comprises a plate presser element slidably mounted between said abutment element and said tool so as to result at least partially aligned with both, said plate presser element interacting, when said blade and counter-blade approach one another, simultaneously with the plate on one side, to lock it against said abutment element, and with one of said longitudinal edge portions of said tool on the other, to cause said tool to rotate in a first direction, which tends to move the other of said longitudinal edge portions to act on the plate so as to fold it.

2. Plate folding device, according to claim 1, characterized in that the inner wall of said longitudinal groove is curved and defines, in said tool, a substantially C-shaped transverse cross section, said longitudinal edge portions being rounded with predetermined curvature radii.

3. Plate folding device, according to claim 2, characterized in that the profile of said inner wall of said groove is substantially determined by the envelope of the successive positions occupied by an end portion of said plate presser element adjacent to said tool during the rotation of said tool.

4. Plate folding device, according to claim 2, characterized in that the regions of contact between said tool on one side and said plate presser element and said plate on the other are substantially linear and correspond to generatrices of said rounded longitudinal edge portions.

5. Plate folding device, according to claim 1, characterized in that elastic return means may be interposed between said plate presser element and said tool, said means tending to keep them separate when said blade moves away from said counter-blade.

6. Plate folding device, according to claim 5, characterized in that said end portion of said plate presser element acts on said inner wall of said groove to rotate said tool in a second direction, opposite to the first, when said blade moves away from said counter-blade and by virtue of the action of said elastic return means.

7. Plate folding device, according to claim 2, characterized in that the aperture angle comprised between two radial planes which are tangent to said longitudinal edge portions may be comprised between 70° and 100° and is preferably comprised between 70° and 80°.

8. Plate folding device, according to claim 2, characterized in that for thin plates with an average thickness of up to 1,5 mm and for folding angles up to 145° the ratio between the average thickness of the plate to be folded and the diameter of said folding tool is approximately comprised between 0,12 and 0,30.

9. Plate folding device, according to claim 2, characterized in that for plate. with a thickness of more than 1,5 mm and for folding angles up to approximately 90° the ratio between the average thickness of the plate to be folded and the diameter of said folding tool is approximately comprised between 0,20 and 0,50.

10. Plate folding device, according to claim 2, characterized in that the curvature radius of said longitudinal edge portions may be comprised between 1/24th and 1/8th of the diameter of said folding tool, and is preferably comprised between 1/20th and 1/12th of the diameter of said tool.

11. Plate folding device, according to one or more of the preceding claims, characterized in that said abutment element has a substantially wedge-like shape, the side of said wedge-like element which abuts against the plate being substantially parallel to the opposite surface of said plate presser element, the other side being inclined by an angle, with respect to the horizontal, which is smaller than the inner final folding angle.

12. Plate folding device, according to claim 11, characterized in that the tip edge of said wedge-like abutment element determines the plate folding line, said vertex being connected with a predetermined curvature radius.

13. Plate folding device, according to claim 12, characterized in that said abutment element can be moved parallel to itself along horizontal and vertical directions, the horizontal and vertical offset of its tip edge with respect to the axis of rotation, consequent to tlie movements of said tool, determining the final folding angle of the plate.

14. Plate folding device, according to claim 13, characterized in that the horizontal offset of said tip edge is comprised between 15% and 40% of the diameter of ssaid tool and varies proportionally to the average thickness of the plate to be folded.

15. Plate folding device, according to claim 13, characterized in that the curvature radius of said tip edge is a function of the plastic deformation characteristic of the material forming the plate and of the value of said horizontal offset of the vertex of the abutment element.

16. Plate folding device, according to the pre-

ceding claims, characterized in that it comprises means for adjusting said horizontal and vertical offset of the tip edge of said abutment element with respect to said tool.

17. Plate folding device, characterized in that it comprises one or more of the described and/or illustrated characteristics.

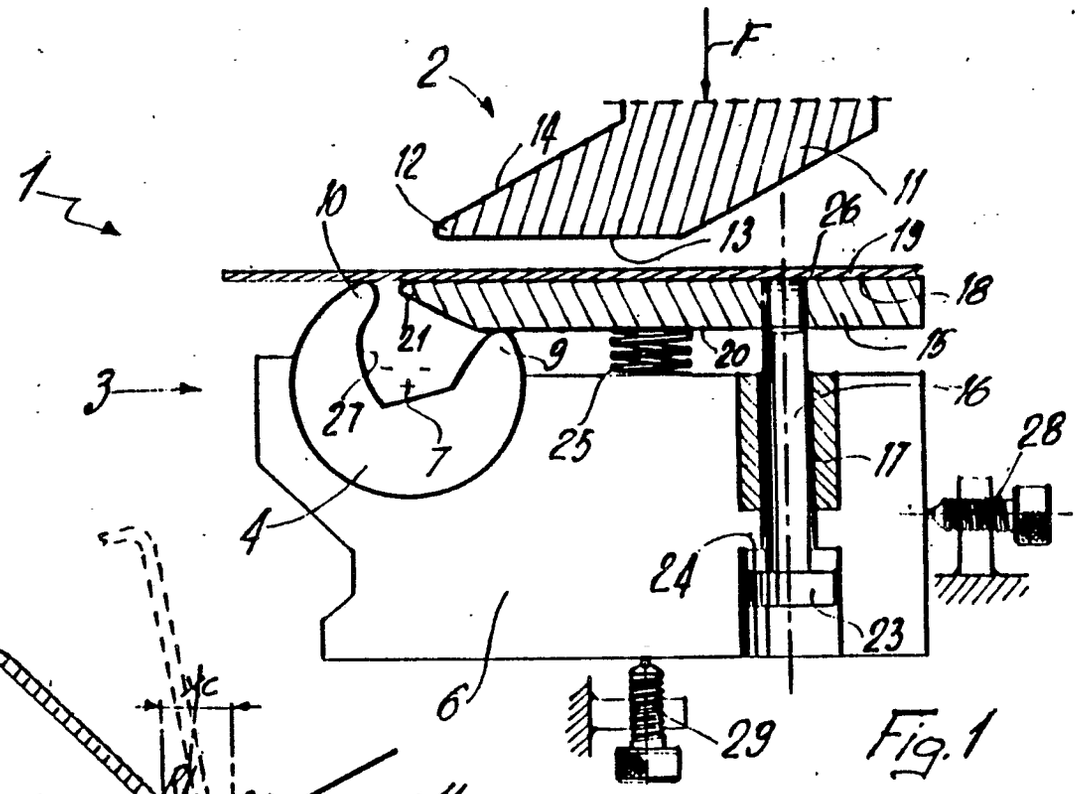



Fig. 1

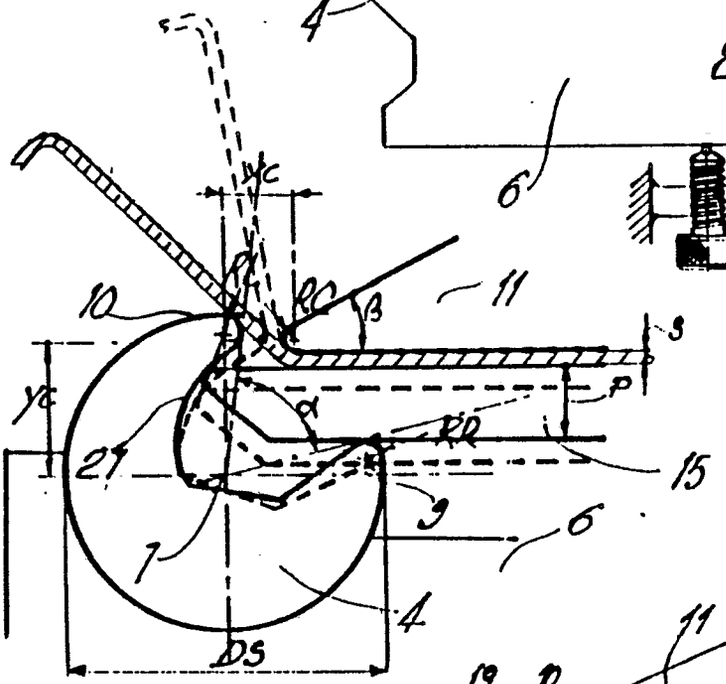



Fig. 2

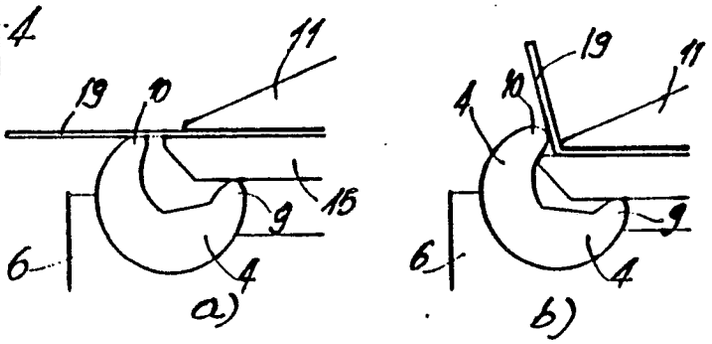
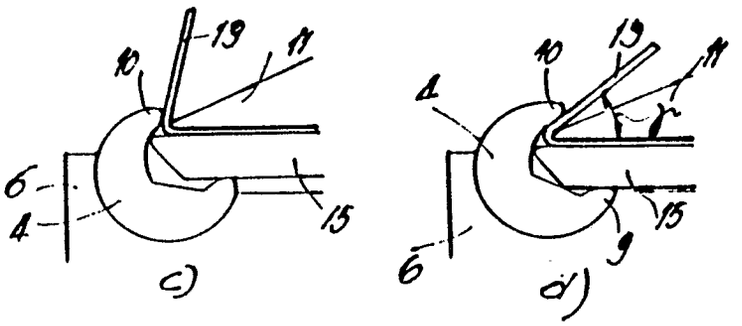



Fig. 3



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# EUROPEAN SEARCH REPORT

Application Number

EP 90 10 2389

## DOCUMENTS CONSIDERED TO BE RELEVANT

| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (Int. Cl.5) |
|---|---|---|---|
| A | FR-A-2 365 383 (WALTER ECKOLD VORRICHTUNGS- UND GERÄTEBAU)<br>* Figures 1-10; claim 1 * | 1 | B 21 D 5/04<br>B 21 D 19/08 |
| D,A | US-A-4 002 049 (RANDOLPH)<br>* Figures 1-8; abstract * | 1 | |
| A | DE-A-3 509 052 (UNIPLANUNG METALL- UND KUNSTSTOFFENGINEERING) | | |

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

B 21 D

The present search report has been drawn up for all claims

| Place of search | Date of completion of the search | Examiner |
|---|---|---|
| THE HAGUE | 14-05-1990 | SUENDERMANN R.O. |

CATEGORY OF CITED DOCUMENTS

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