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(54) Tool for bending metal sheets

(57) The invention proposes the construction of a tool for bending metal sheets without requiring the lubrication of the devices involved in said tool, but only exposing one surface of the tool to a particular hardening treatment that also guarantees a very low frictional resistance; said tool includes a first body (1) with a shaped seat (2) partially in the shape of a cylinder provided with a relative axis (X), and accessible from outside through a suitable mouth (4), a second elongate body (3) having a partially cylindrical external surface and housed in said seat (2) which is suitable to almost completely surround the first body (1) and to allow its rotation around an axis of rotation coinciding with the axis of the external cylindrical surface, and with the axis (X) of the first body, and wherein the second body is provided with a V-shaped groove that extends lengthwise and is open to the outside through said mouth (4) for at least one part of the rotation of the second body (3) within said seat (2) of the first body (1), wherein the external cylindrical surface of the second body (3) is provided with one or preferably two successive distinct coatings, achieved with the "PVD" technology. In the case in which two distinct coatings are provided one over the other, the first coating, bonded to said surface, has a hardness greater than the hardness of the second coating. The first coating includes one or at the same time more than one of the following hard substances: Titanium nitride (TiN), Chromium nitride (CrN), Titanium carbonitride (TiCN), Titanium and aluminium nitride (AlTiN).

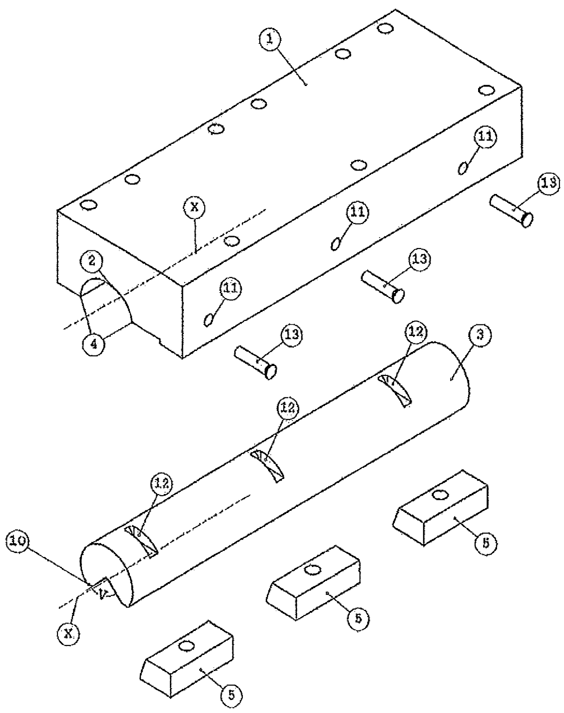

FIG. 1

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Description

[0001] The present invention relates to a tool for bending sheet metal or similar materials, and mainly comprises two distinct bodies, that is: a matrix tool provided with a suitable seat approximately cylindrical in shape formed in its body and accessible from outside; a rotating tool of substantially cylindrical shape and provided with a V-shaped groove, and suitable to be housed in said seat of said matrix tool and to rotate therein.

[0002] The forming of said groove in said rotating tool creates a pair of lateral sides suitable to engage with the metal sheet to bend, in which one of said sides acts as a means for locking the sheet, and the other side acts as a bending means.

[0003] These types of tools are well-known in the art, and are generally disclosed by Patents US 4,002,049, US 5,341,669, US 2005/0022574 A1, WO 2008/144237.

[0004] US 4,002,049 Patent discloses a basic solution, which does not provide for the lubrication of the surfaces, which must slide reciprocally between said matrix tool (called "holder" or "saddle" in the above-mentioned patents) and said rotary tool. The solution presented therein, although it is effective from the functional standpoint, still presents a fundamental limit that appears evident in an industrial scale production, and that is due to the fact that the lack of a specific lubrication generates a premature wear down of the surfaces that are designed to slide against each other, as well as a considerable increase in temperature between the devices involved, which in turn causes a natural thermal expansion that may, in the most serious cases, also cause the seizure between said surfaces, which must instead be able to slide freely on one another.

[0005] This requirement of providing suitable means of lubrication between the surfaces involved has been extensively treated in the above-mentioned patents, to which reference is made herein for brevity.

[0006] In each of these documents, the problem of lubrication is solved with respectively different procedures and means:

- in US 5,341,669, a lubrication chamber is arranged in the matrix tool in communication with said sliding surfaces, and is connected with a suitable lubrication duct in which lubricant is fed from outside; this solution, though effective, creates in turn the obvious drawback of a complication in construction and in operation, and naturally relative additional costs, which is an extremely undesirable aspect in an industrial environment that needs to operate in a highly competitive context;
- US 2005/0022574 A1 proposes and discloses a solution of a similar matrix-tool and rotary-tool assembly housed in a cavity of the matrix tool; in order to lubricate the surface of the rotary tool, two linear sets of pins or tampons impregnated with graphite are inserted into suitable pockets formed in said matrix tool, in an area accessible to said rotary tool; the external portions of said tampons are machined in such a way as to give the tampons curved profiles, so that they can perfectly match the cylindrical profile of the rotary tool.

[0007] This solution has proved to be perfectly capable of solving the lubrication problems mentioned above. However, some drawbacks will also be met in this case: the first concerns the cost and the installation of said tampons, and naturally the forming of said pockets.

[0008] The second and most serious problem is caused by the fact that said tampons naturally wear down or deplete the lubricant, and thus it is necessary, after a not particularly large number of operating cycles (about 100,000 cycles), to remove completely the matrix-tool + rotary-tool assembly and to remove the spent tampons and replace them with new ones.

[0009] It is evident that in this case, too, it is necessary to bear some general burdens of machine down time and new components, and of the labour required, which affect and therefore compromise the productive and economic advantage of this solution.

- WO 2008/144237 discloses a solution of the lubrication problem discussed above, which consists essentially of providing a limited and substantially annular interspace between the two quasi-cylindrical surfaces of the matrix tool and of the rotary tool, and of applying a suitable jacket made of antifriction material on the quasi-cylindrical surface of said matrix tool, so that it occupies the space of said interspace.

[0010] It is evident that in this case the lubricating efficiency is improved; but nevertheless the consequent costs, both in terms of materials and labour, as well as maintenance, are also further aggravated.

[0011] The solutions claimed in said documents bear witness to the great concern, common among operators in the field, of finding an effective and at the same time also generally advantageous solution, that is also acceptable on the industrial plane. Even so, none of the solutions described, although valid from the point of view of the functional lubricating efficiency alone, solves in a generally satisfactory manner the problem expressed.

[0012] Therefore it would be desirable, and it is the main objective of the present invention, to be able to create a tool assembly of the type generally described suitable to substantially reduce the drawbacks mentioned above.

[0013] This objective is achieved by a tool assembly and a relative method realized and operating according to the appended claims.

[0014] Characteristics and advantages of the invention will become evident from the following description, given by way of non-limiting example, with reference to the enclosed drawings, wherein:

- Fig. 1 illustrates an exploded view in perspective of a tool set according to the invention;
- Figures 2A, 2B and 2C illustrate respective views, along the cross sectional plane A - A of Fig. 1, in three successive operating phases of the set of tools of the invention.

[0015] With reference to the figures, an improved tool according to the invention comprises:

- a matrix tool or first body 1 provided with an elongate seat 2 partially shaped in a form similar to a cylinder having a relative axis "X", and accessible from outside through a suitable mouth 4;
- a second body 3, rotating with respect to said first body, and
  - formed like an elongate element and having a partially cylindrical external surface and suitable to be housed in said seat 2 of said first body,
  - and provided with a V-shaped groove that extends lengthwise and is open outwardly through said mouth 4 for at least one portion of the rotation of said second body 3 within said seat 2 of said first body 1.

[0016] Both said first and second body are made of high-strength metal materials or alloys, usually used for tools.

[0017] The end portions of said second body are engaged in suitable recesses incurved into its own body, and are not shown because they are already known.

[0018] Said second body 3 is inserted in said seat 2 of the first body through said mouth 4, and to stabilize its position a plurality of closing blocks 5 are arranged in such size and positioning as to partially close said mouth 4 so that the second body stays constantly inserted and in contact with said seat 2. It will be obvious, also because it is in itself known, that the inside diameter of the seat 2 is slightly greater than the outside diameter of the second body 3, so as to allow its rotation without interference within the seat 2.

[0019] From the figures it will be clear, and it is the preferred embodiment, that the "X" axis of the cylindrical shape of said seat 2 coincides with the axis of the cylindrical shape of said second body 3, which therefore also necessarily coincides with the axis of its rotation within said seat 2.

[0020] Said second body is provided with a groove in the shape of a "V" that extends lengthwise and that is open outward through said mouth 4 for at least one part of the rotation of said second body 3 within said seat 2 of said first body 1.

[0021] Said tool, made up of said two bodies 1 and 2, is usually installed in a press comprising an upper die 6, and a bottom die 7, around an edge 8 of which is bent the material to be bent, in a manner known in the art and which therefore will not be explained.

[0022] As shown in the figures, the second body 3 is partially surrounded by said seat 2 to a sufficient extent to engage it so as to allow it to turn freely around said axis "X", since, as explained above, the respective dimensions are such as to make said rotation possible.

[0023] The operation of the tool made up of said two bodies is entirely similar to what is disclosed and illustrated in the US 4,002,049 and EP 1 502 671 A1 patents, and therefore for the sake of brevity it will not be repeated herein.

[0024] The present invention consists of building said second body 3 so that its external surface is treated in such a manner as to have absolutely new and advantageous characteristics both from the point of view of resistance to abrasion, and from the point of view of reduction of friction against external surfaces, and thus of its slidability on such surfaces. Thus, these characteristics, combined together on the surface of said second body 3, make it possible to achieve said tool, comprising said two bodies, and in particular the second body 3, so as to avoid any form of lubrication, thus eliminating all the consequent burdens, costs and complications explained above.

[0025] After thorough and repeated experiments, including in a combined manner following the method of fractioned factorial experiments, it was seen that there was an excellent combination between the treatment costs and the results that can be achieved if said external surface of said second body 3 is subjected to two different treatments, but both being of "PVD" type.

[0026] These "PVD" treatments are widely known in the art; however, to assist the reader's comprehension, they are briefly referred to here.

[0027] The Physical Vapour Deposition (PVD) is a common method of deposition of thin films under vacuum. Normally, a thin film is defined as one in which the thickness in the order of microns or less; in this case, there is often the influence of the substrate for what concerns the chemical and physical properties of the thin film.

[0028] The PVD processes are methods of atomic deposition in which the material is evaporated from a solid or liquid source in the form of atoms or molecules and carried in vapour phase through a vacuum environment or plasma to the substrate, where it condenses, at temperatures ranging from 250°C to 450°C, and in some cases even beyond, to avoid softening the material of which the substrate is composed.

[0029] Generally, PVD is used to create coatings of a few tens or hundreds of nanometers for films composed of variable percentage alloys, and with deposition speeds of 1 to 10 nm per second.

[0030] The main stages of a PVD film deposition process are the following:

* sublimation of a solid or evaporation of a liquid to form a gaseous species, similar to plasma;
* transportation of the atoms or molecules from the source to the substrate to be coated;

* deposition of the particles on the substrate, and thus growth of the film.

[0031] The methods for obtaining these procedures are varied and well known in the field.

[0032] However, they share some common characteristics, whose advantages are well known, and specifically:

- excellent resistance to wear and abrasion;
- reduction of friction coefficient;
- good corrosion resistance;
- high surface hardness;
- good resistance to oxidation under heat.

[0033] » Turning now to the present invention, it has been found that the external surface of the second body 3 develops special properties of resistance to abrasion if it is treated with a specific procedure consisting of providing on it a coating formed by a PVD deposition, in which is generated a series of successive layers of material or hard compounds, and having an ultra-thin thickness (and which for this reason are termed nanolayers).

[0034] According to the present invention, a great variety of combinations of possible substances has been tested, and thus was selected the combination that offers the optimal characteristics of hardness, strength and producibility.

[0035] Said optimal and selected combination consists of the deposition of a number of nanolayers, in which:

a) one generic nanolayer includes any one of the following PVD-coated compounds

- Titanium nitride (TiN);
- Chromium nitride (CrN);
- Titanium and aluminium nitride (AlTiN);

b) and in which each of said compounds is present in at least one of said nanolayers.

[0036] It must be specified that this coating consists of depositing a plurality of nanolayers of composite material made up of the above-mentioned substances, in which the various nanolayers, taken all together, include all the compounds listed above.

[0037] The choice as to what type of solution to choose must naturally be made on the basis of the effective operating requirements, also taking into consideration the cost of each of the possible solutions.

[0038] Nonetheless, it has been verified that said coating, regardless of how it is achieved, must have a thickness of between 0.5 and 5.0 micron, and a minimum hardness of 3500 HV.

[0039] It has also been tested and determined that the optimal thickness for a use of the tool of the type described, and that may exceed a useful life of 500,000 cycles, is most precisely included between 3.5 and 4.5 micron.

[0040] » In the course of the experiments, carried out according to the statistical method of the fractioned factorial experiments, it was also seen that the overall characteristics of said coating were significantly variable, depending on the more external nanolayers.

[0041] This phenomenon was further studied and examined, particularly for the purpose of realizing a general treatment that could guarantee in a combined manner two basic properties, specifically:

- a high hardness of the treatment, that is its resistance to abrasion;
- and a reduced resistance to friction.

[0042] During these experiments, carried out through many hundreds of thousands of cycles, an optimal compromise was observed and selected between the various operating and productive restrictions and requirements, which consists of plating not only one but two distinct subsequent coatings, both achieved with respective PVD coating processes, in which the first coating, adherent to the surface, has an appreciably superior hardness with respect to the hardness of the second coating.

[0043] Ex post, this is easily explainable when considering the fact that the first coating must substantially protect the underlying surface from wear, and therefore it must be very hard, also to guarantee an easy "grip" on that surface; unlike this, the second or upper coating must ensure above all a reduction of the friction coefficient toward external surfaces that slide on it, and therefore this characteristic is preferred, although it also is not best for its hardness.

[0044] It has thus been experimented and verified in various ways that the first coating must advantageously include a plurality of layers deposited in succession, and whose thickness is ultra thin (and which for this reason are called nanolayers), and that coincides with the type of coating (previously described in the fundamental case of deposition of a single coating).

[0045] Thus, a generic nanolayer of the first coating includes any one of the following compounds deposited in PVD:

- Titanium nitride (TiN);
- Chromium nitride (CrN);
- Titanium and aluminium nitride (AlTiN),
- and in which each of said compounds is present in at least one of said nanolayers.

[0046] Naturally, in this case too this first coating consists of the deposition of a plurality of nanolayers of material made up of the substances listed above, in which the various nanolayers, taken all together, include all the above-mentioned compounds.

[0047] The choice of the various components of the various nanolayers and their combination and succession lies, also in this case, with the expert in the field on the basis of the various applicable restrictions.

[0048] Naturally, in this case too it has been verified that the preferred and optimal characteristics of hardness and thickness are substantially identical to those previously described in the case of a single coating, and that for the sake of brevity are not repeated here.

[0049] For what concerns the second coating, it was shown by experiment that it must be produced by forming at least one nanolayer of Chromium nitride (CrN) on said first coating, after which on top of this is added a final layer that includes, prevalently or exclusively, a layer of amorphous carbon, which offers the well-known properties of low friction resistance.

[0050] Essentially, a second coating of the CBC type (Carbon Based Coating), itself generally known in the art, is provided.

[0051] Also for what concerns this second coating it has been found that its optimal thickness for a use of the tool of the type described above, and in combination with the first coating as defined above, lies between 0.5 and 2.5 micron.

[0052] Further, its hardness must be appreciably lower than 3500 HV, that is, lower than the hardness of the first layer, but it must however be substantially greater than 2000 HV, in order to avoid compromising with an excessive wear the useful life of said tool assembly.

[0053] When made with the methods described above, the tool can also be made for a particularly demanding industrial use without needing any lubrication devices between the first body and the second rotary body, like external lubricant feeding ducts, or tampons wetted with lubricant, or a jacket of low-friction material, like graphite.

[0054] It should also be recognized that the present invention also applies in the case in which the coatings formed are more than two, that is, when the second coating too is in turn overlain with a third coating or subsequent coatings. Such different embodiments are naturally easily obtainable by the expert in the field, compatibly with existing requirements of cost, producibility and, naturally, greater or lesser performance characteristics desired, and in particular with the balance between the requirements of hardness and reduction of frictional resistance.

[0055] However, such different variant embodiments are at any rate protected by the present patent to the extent that the first coating or the first two coatings are in agreement with the subsequent claims.

[0056] With reference again to the figures, it has also been verified that the invention is compatible with further devices suitable to ensure the correct position of the tool at rest, shown in Fig. 1, and particularly with its automatic return in this position, after the lifting of the top press and therefore at the end of the compressive stress between the metal sheet 9 and an edge 10, that defines said V-shaped groove, which thus belongs to said second body 3.

[0057] Said devices thus include:

- a plurality of holes 11 parallel to each other and bored in said first body 1;
- a plurality of corresponding pockets 12 formed in said second body 3 and substantially open toward corresponding holes 11;
- a plurality of corresponding dowels or pins 13 suitable to be inserted into corresponding holes 11, and suitable to come into contact with one of the walls of said pockets 12,
- and a corresponding plurality of springs 14 inserted into said holes and behind respective said pins, and suitable, in manners in themselves known, to push the respective pins 13 so that the latter come into contact with the opposite wall of said pockets 12 so as to automatically rotate said second body 12 to the relative rest position.

Claims

1. Rotary bending tool for bending metal plates and comprising:

• a first body (1) provided with a prolonged seat (2), partially shaped as a cylinder and with a respective axis (X), and accessible from the outside through a suitable mouth (4),

• a second body (3) shaped as a prolonged member and having an outer surface which is partially cylindrical, and able of being lodged inside said seat (2) of said first body (1),

wherein said seat is able of encircling in an almost fully way said first body, and of allowing its rotation around an axis which coincides to the axis of said partially cylindrical outer surface, and to the axis of said first body,
and wherein said second body is provided with a "V" shaped cavity which extends in length and which is open to the outside throughout said mouth (4) for at least a portion of the rotation of said second body (3) within said seat (2) of said first body (1), **characterized in that** said partially cylindrical outer surface of said second body (3) is provided with a first coating implemented through the technology of PVD (Physical Vacuum Deposition), and comprises one of the following composition:

- Titanium Nitride (TiN),
- Chrome Nitride (CrN),
- Titanium and Aluminium Nitride (AlTiN).

2. Rotary bending tool according to claim 2, **characterized in that** said first coating shows a thickness between 0,5 and 5,0 micron.

3. Rotary bending tool according to claim 2, **characterized in that** said first coating shows a thickness between 3,5 and 4,5 micron.

4. Rotary bending tool according to any of the previous claims, **characterized in that** said first coating shows an hardness not lower than 3500 HV.

5. Rotary bending tool according any of the previous claims, **characterized in that** on and following said first coating, a second coating is laid, which is implemented through the technology of PVD (Physical Vacuum Deposition), wherein the first coating features an hardness which is higher than the hardness of said second coating.

6. Rotary bending tool according to Claim 5, **characterized in that** said second coating comprises a layer of Chrome Nitrite (CrN), on which a layer, prevailingly comprising Carbon in the amorphous state, is laid.

7. Rotary bending tool according to claim 6, **characterized in that** said second coating shows a thickness comprised between 0,5 and 2,5 microns.

8. Rotary bending tool according to claim 6 or 7, **characterized in that** said second coating shows an hardness not lower than 2000 HV.

9. Rotary bending tool according to claim 1, **characterized in that** into said first body (1) a plurality of holes (11) is arranged, **in that** into said second body (3) a plurality of corresponding pockets (12) is arranged, **in that** inside each of said holes respective pins are introduced (13) which are urged by respective elastic means (14) so that said pins can push said second body (3) in a preferred and resting position inside said seat (2).

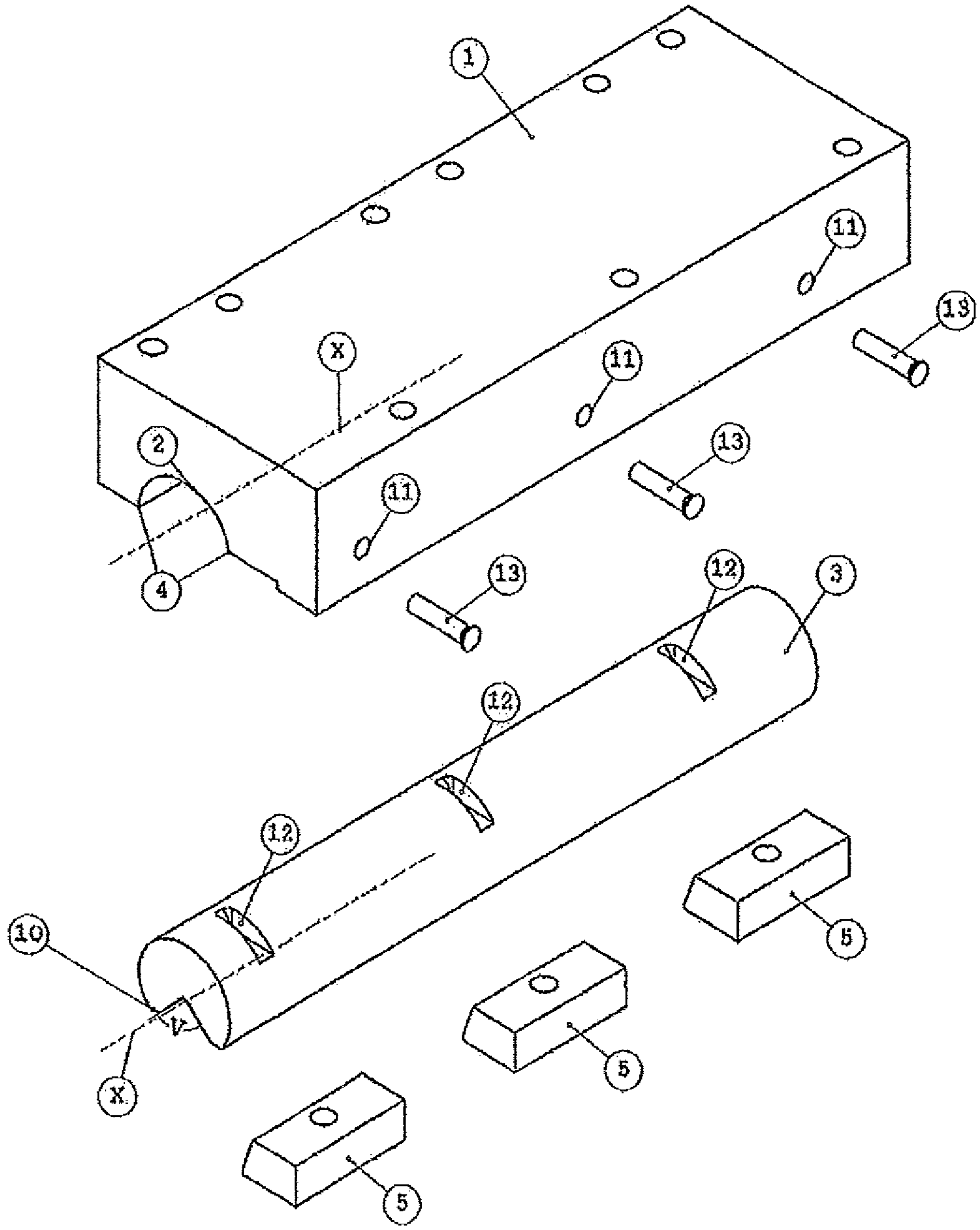


FIG. 1

FIG. 2A

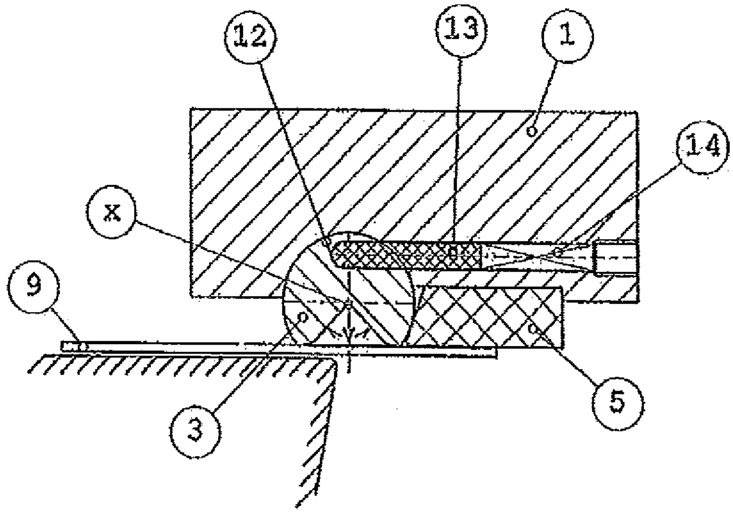


FIG. 2B

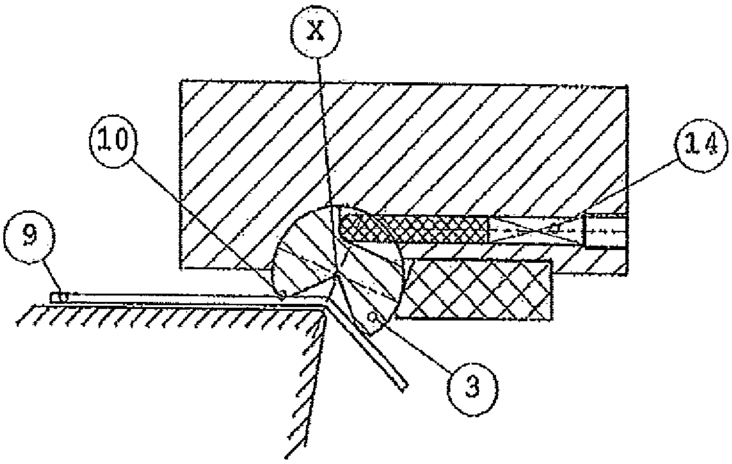
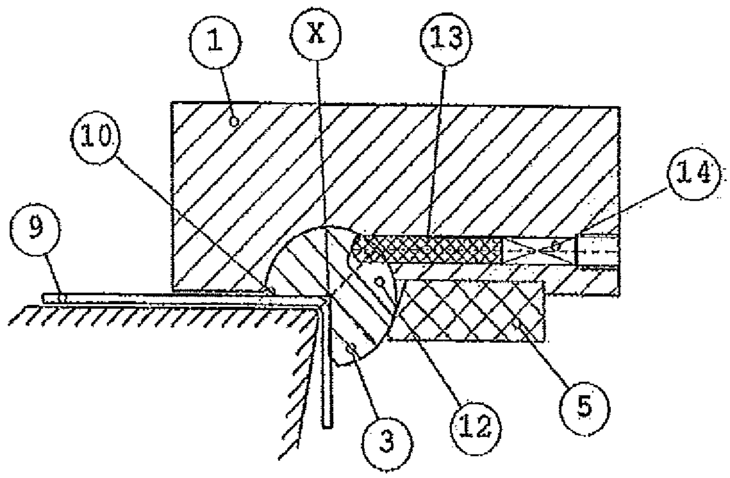


FIG. 2C



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EUROPEAN SEARCH REPORT

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Place of search	Date of completion of the search	Examiner
Munich	14 June 2011	Vinci, Vincenzo

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CATEGORY OF CITED DOCUMENTS

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