(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 884 572 A1

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
06.02.2008 Bulletin 2008/06

(51) Int Cl.:
C14B 5/00 *(2006.01)* ***B26D 5/00*** *(2006.01)*

(21) Application number: **06118201.0**

(22) Date of filing: **31.07.2006**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IS IT LI LT LU LV MC NL PL PT RO SE SI SK TR
Designated Extension States:
AL BA HR MK YU

(71) Applicant: **Contechs Consulting Limited**
Warwick
Warwickshire CV34 5XH (GB)

(72) Inventor: **Chapman, Richard John Mercer**
Stratfor upon Avon CV37 8PX (GB)

(74) Representative: **Molony, Anna et al**
Chapman Molony
Thorpe House
17 Dormer Place
Leamington Spa CV32 5AA (GB)

(54) **Optimizing hide usage in leather cutting process**

(57) A leather cutting system 10 comprising seven CNC leather cutting tables 12, a first computer hard drive 14, a second computer hard drive 16, and a computer 18 comprising a third hard drive 19 and a microprocessor forming a sequencing engine 20. The first hard drive 14 has a production order database file stored therein, containing hide area, piece pattern template file names and locations, and a set of model specific cut sequence rules for each of a plurality of models. The second hard drive 16 has a plurality of piece pattern template files stored therein. The third hard drive 19 has a set of computer readable instructions stored therein for causing the microprocessor to perform a method for optimising hide usage in leather cutting processes. A method for optimising hide usage in leather cutting processes is also provided.

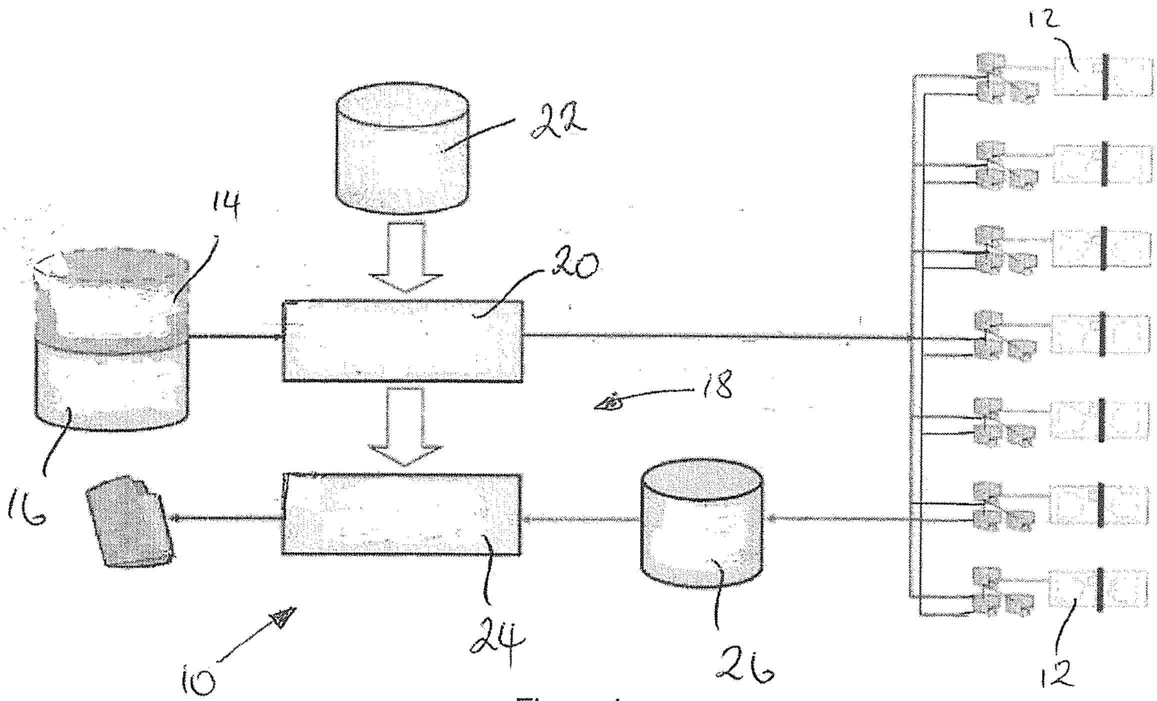

Figure 1

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Description

[0001] The invention relates to a method, a computer programme product and an article of manufacture for optimising hide usage in leather cutting processes and to a leather cutting system implementing the method.

[0002] Leather is used in the production of many products, including motor vehicle interiors, aircraft interiors, furniture and soft furnishings, clothing, footwear, and luggage. Leather is a natural material, and the size and quality of hides is therefore variable. In addition, some hides may include areas of surface damage which cannot be used. The leather dying process also presents a problem since only a set number of hides can be dyed in each batch, and, in order to ensure full colour matching within each item produced, product production must therefore also be batched to meet the available hide area within each colour batch. This presents a particular problem for products which are manufactured according to a production schedule sequenced by customer order, such as luxury vehicles and furniture, and large amounts of leather hide are typically currently wasted.

[0003] According to a first aspect of the invention there is provided a method for optimizing hide usage in leather cutting processes, the method comprising the steps of:

a) receiving production schedule data comprising a series of production orders, each order including model and leather colour information and an identifier;
b) building a parts list for each production order according to model and leather colour, the parts list including the piece pattern area for each part and the leather colour of each part;
c) selecting a sub-series of production orders from the series of received orders;
d) reorganizing the selected production orders into a cut sequence in which the maximum possible number of orders including the same colour leather are scheduled to be cut sequentially; and
e) sending the cut sequence of production orders to a computer controlled leather cutting table for the orders to be cut by the table in said cut sequence.

[0004] By scheduling the production orders within the sub-set in this manner, the maximum possible number of orders including the same colour leather are scheduled to be cut sequentially by the cutting table. Because the production orders are sequenced and cut according to leather colour rather than according to their sequence within the production order schedule, remnant leather from a first hide may be used to cut further pieces of the same colour within the same production order or may be used to cut pieces of the same colour in the subsequent production order and so on. Because hide remnants can thereby be used for at least some subsequent production orders, the amount of leather wastage is reduced as compared to the wastage that would occur if the orders were cut in the sequence in which they appear within the production schedule, where hide remnant transfer would not be possible between production orders.

[0005] Preferably, in step d) the selected production orders are reorganized into a plurality of cut sequences, each corresponding to a respective one of a plurality of cutting tables, the maximum possible number of orders including the same colour leather being scheduled to be cut sequentially within each cut sequence, and in step e) each cut sequence is sent to its respective cutting table.

[0006] Preferably, in step a) each production order comprises two leather colours, most preferably a main leather colour and a secondary leather colour. The production schedule data is preferably received within a spreadsheet file or a text file.

[0007] The selected production orders are preferably reorganized into the plurality of cut sequences by the following steps:

i. selecting the first cutting table and scheduling a production order to the table's cut sequence;
ii. selecting the next cutting table and scheduling a production order to the table's cut sequence; and
iii. repeating step ii. until all of the production orders in the sub-set have been scheduled to a cutting table, where the number of production orders in the sub-set is greater than the number of tables, once the last cutting table has had a production order scheduled to it the scheduling of orders to the cutting tables recommences at the first cutting table and for each cutting table the remaining production orders within the sub-set are searched to find a production order of the same leather colour as the production order previously scheduled to that table, where a colour matched production order is found it is scheduled to the cut sequence.

[0008] Preferably, in step iii., where no colour matched production order is found the sub-set if searched to find a production order of a preferred follow on leather colour and where no preferred follow on colour matched production order is found the next production order is scheduled to the cut sequence.

[0009] Each cutting table is preferably allocated an operating percentage indicating the percentage of its full capacity that is available for cutting production orders. Each table may also be allocated an operating efficiency indicating the number of hides that can be cut by the table in a given time period. Preferably, the scheduling of production orders to the cutting table cut sequences is controlled to ensure that substantially the same number of leather hides are to be cut by each cutting table, factored by the operating percentage and operating efficiency of each cutting table.

[0010] The selected production orders may alternatively be reorganized into the plurality of cut sequences by the following steps:

1. selecting the first production order in the sub-set and scheduling it to the cut sequence of the first cutting table;
2. selecting the next production order and scheduling it to the cut sequence of the next cutting table;
3. repeating step 2. until each cutting table has had a production order scheduled to it; and
where the number of production orders in the sub-set is greater than the number of cutting tables,
4. selecting the next production order and searching the last production order allocated to the cut sequence of each cutting table to find a production order of the same colour of leather, where a colour match is found scheduling the production order to that cut sequence and where no colour match is found restarting step 4.; and
5. repeating step 4. until all of the production orders in the sub-set have been considered, then scheduling the remaining unscheduled production orders in the sub-set according to the scheduling steps of paragraphs 7 and 8 above.

[0011] The production orders may be searched by main leather colour or by secondary leather colour.

[0012] The series of production orders preferably comprises a leading group of cut only productions orders followed by a main group of cut and inspect production orders, the sub-set being selected to include all of the cut only production orders followed by a first part in series of the cut and inspect production orders. A number of inspect only production orders may be added to the end of the sub-set of production orders, the inspect only production orders being scheduled to cutting table cut sequences according to steps i to iii above only after the last cut and inspect production order has been scheduled.

[0013] The number of cut only production orders plus cut and inspect production orders is preferably equal to the number of production orders that can be cut by the cutting tables within a production shift or within a group of two or more consecutive production shifts. The number of cut only production orders is preferably equal to the number of inspect only production orders processed by the previous production shift or group of shifts.

[0014] In step b), the parts list preferably further comprises hide type information for each part. Each production order may comprise up to two hide types, most preferably shrink optimised leather and/or fine nappa leather.

[0015] Preferably, step b) further comprises: calculating the part area for each leather colour and leather type for each production order; increasing the total part area of each leather type and colour by a nesting buffer percentage to provide a bulk area for each leather type and colour for each production order; and dividing the bulk area for each leather type and colour for each production order by an average hide size to provide the number of hides required of each leather type and colour for each order.

[0016] Step b) preferably further comprises retrieving one or more of the following cut sequence rules for each production order according to model and adding that information to the respective order: two colour leather production orders start and finish the cutting process with a fine nappa leather hide or hide remnant, and any shrink optimised leather hide is located between the fine nappa leather within the cut sequence; single colour leather production orders to be allowed to be sequenced with shrink optimised hide leather colour being matched between orders; the preferred leather colour and/or leather type of the following production order within the cut sequence, and allow that where there is no production order remaining available within the sub-set that meets the cut sequence rule, the next order may be selected from any of the remaining available production orders; and whether is it permissible to upgrade the leather type used to cut a piece pattern from a first hide type to a higher quality hide type in order to increase the utilised area of a hide, and assign an upgrade priority level to identify piece patterns most preferred for leather type upgrade.

[0017] The method preferably additionally comprises retrieving the piece pattern template for each part within a production order according to model and adding that information to the respective order, the piece pattern templates being retrieved for each production order according to model in step b), or after step c) or step d) and that information added to the respective order.

[0018] Step e) preferably further comprises compiling and printing a summary of the work orders for the or each cutting table, for use by leather inspectors and/or as a checklist for cutting table operators.

[0019] The method preferably further comprises the following further step:

f) receiving completed hide cutting information from the or each cutting table, the information including one or more of: the size of each hide cut; the colour of each hide cut; hide quality; the size of remnant hides used for a subsequent work order; piece pattern nesting strategies used; time taken to scan each hide prior to cutting; time taken to nest piece patterns to be cut from each hide; and total time taken to cut piece patterns from each hide.

[0020] The information received within step f) is preferably received at the end of the or each production shift, and may additionally be received at regularly spaced intervals during the or each production shift. The hide quality information is preferably provided for the second hide of the main leather colour of each production order.

[0021] The method preferably further comprises the following further step:

g) analysing the information received in step f) to obtain one or more of the following: average total hide area used for each model; average amount of hide used for re-cutting piece patterns for each production order; total hide area used during a specified time period; variation of hide quality across a specified time period; variation in the number of hides used of a specified colour across a specified time period; variation in hide size across a specified time period.

[0022] The variation in hide quality is preferably provided for each hide colour and/or for each hide supplier. The variation in hide size is preferably provided for each hide colour and/or for each hide supplier.

[0023] Step g) is preferably carried out weekly.

[0024] Availability of hide colour is an important factor in the prediction of remnant transfer opportunities and therefore has a bearing on the cut sequence; this information can therefore be used to modify the cut sequence rules. The frequency of colour used may also be fed-back into a hide ordering system, in order to control stock levels. Hide size is also an important factor in the prediction of remnant transfer opportunities and therefore has a bearing on the cut sequence; this information can therefore also be used to modify the cut sequence rules.

[0025] According to a second aspect of the present invention there is provided a computer programme product comprising programme code for performing the steps of the method as described above.

[0026] According to a third aspect of the present invention there is provided an article of manufacture with a computer useable medium having computer readable instructions embodied therein for providing access to resources available on that computer, the computer readable instructions comprising instructions to cause the computer to perform the steps of the method as described above.

[0027] According to a fourth aspect of the present invention there is provided a leather cutting system comprising:

a computer controlled leather cutting table;
first computer readable memory means having a production order database file embodied therein, the database file containing part information for each part for a plurality of models;
second computer readable memory means having a plurality of piece pattern template files embodied therein;

characterised by:

the part information for each part including the piece pattern area, leather colour, piece pattern template file name and location, and any model specific cut order sequencing rules;
and
the system further comprising a computer comprising a computer readable memory means and a sequencing engine, and computer readable instructions to cause the sequencing engine to perform the method according to the first aspect of the invention being embodied within the memory means, and the computer being communicatively connected to the computer controlled cutting table, the first computer readable memory means, and the second computer readable memory means.

[0028] The leather cutting system preferably comprises a plurality of computer controlled cutting tables, each being communicatively connected to the computer. The or each computer controlled cutting table is preferably operable to scan each hide placed thereon to determine the size, edges and any flawed un-useable hide areas, nest received pattern piece templates within the useable hide area, and cut the nested pattern piece templates from the hide. The or each computer controlled cutting table is preferably further operable to nest the received piece pattern templates to maximise any remnant hide area. The or each computer controlled cutting table is preferably further operable to determine remnant hide area. The or each computer operated cutting table is preferably further operable to store one or more of the following sets of information for each hide cut thereon: colour; size; flawed area; nesting strategy used; cutting time; and remnant hide area.

[0029] The model specific cut sequence rules preferably comprise one or more of the following rules: two colour leather production orders start and finish the cutting process with a fine nappa leather hide or hide remnant, and any shrink optimised leather hide is located between the fine nappa leather within the cut sequence; single colour leather production orders to be allowed to be sequenced with shrink optimised hide leather colour being matched between orders; the preferred leather colour and/or leather type of the following production order within the cut sequence, and allow that where there is no production order remaining available within the sub-set that meets the cut sequence rule, the next order may be selected from any of the remaining available production orders; and whether is it permissible to upgrade the leather type used to cut a piece pattern from a first hide type to a higher quality hide type in order to increase the utilised area of a hide, and assign an upgrade priority level to identify piece patterns most preferred for leather type upgrade.

[0030] By the term "model" in the foregoing it will be appreciated that this means the general design of a product model, for example, in the case of a vehicle, the vehicle model, together with any model variants, such as the number of seats, left or right hand drive, and optional features, such as whether a vehicle is to have a sunroof or sports trim, child seat fixings, etc.

[0031] According to a fifth embodiment of the invention there is provided leather cutting apparatus arranged to:

(a) receive production schedule data comprising a series of production orders, each order including model and leather colour information and an identifier;

(b) build a parts list for each production order according to model and leather colour, the parts list including the piece pattern area for each part and the leather colour of each part;

(c) select a sub-series of production orders from the series of received orders;

(d) reorganize the selected production orders into a cut sequence in which the maximum possible number of orders including the same colour leather are scheduled to be cut sequentially; and

(e) send the cut sequence of production orders to a computer controlled leather cutting table for the orders to be cut by the table in said cut sequence.

[0032] Preferably, the apparatus is arranged to in step d) reorganize the selected production orders into a plurality of cut sequences, each corresponding to a respective one of a plurality of cutting tables, the maximum possible number of orders including the same colour leather being scheduled to be cut sequentially within each cut sequence, and in step e) to send each cut sequence to its respective cutting table.

[0033] Embodiments of the invention will now be described in detail, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 is a schematic representation of a leather cutting system according to a first embodiment of the invention;

Figure 2 is a schematic representation of part of a leather cutting system according to a second embodiment of the invention;

Figure 3 is a block diagram illustrating the steps of a method according to a third embodiment of the invention for optimising hide usage in leather cutting processes, shown in the context of a complete leather cutting process; and

Figure 4 is a diagrammatic illustration of hide sequencing (a) obtained using prior art cutting according to production list order, and (b) obtained using the method of the present invention.

[0034] Referring to Figure 1, a first embodiment of the invention provides a leather cutting system 10 comprising seven computer numerical control (CNC) leather cutting tables 12, first computer readable memory means in the form of a first computer hard drive 14, second computer readable memory means in the form of a second computer hard drive 16, and a computer 18 comprising a third hard drive 19 (shown in Figure 3) and a microprocessor forming the sequencing engine 20.

[0035] The first computer hard drive 14 has a production order database file stored therein, the database file containing hide area, piece pattern template file names and locations, and a set of model specific cut sequence rules for each of a plurality of models. The model specific cut sequence rules are as follows:

1. two colour leather production orders start and finish the cutting process with a fine nappa leather hide or hide remnant, and any shrink optimised leather hide is located between the fine nappa leather within the cut sequence;
2. single colour leather production orders to be allowed to be sequenced with shrink optimised hide leather colour being matched between orders;
3. the preferred leather colour and/or leather type of the following production order within the cut sequence, and where there is no production order remaining available within the sub-set that meets the cut sequence rule, the next order may be selected from any of the remaining available production orders;
4. whether is it permissible to upgrade the leather type used to cut a piece pattern from a first hide type to a higher quality hide type in order to increase the utilised area of a hide, and assign an upgrade priority level to identify piece patterns most preferred for leather type upgrade.

[0036] The second computer hard drive 16 has a plurality of piece pattern template files stored therein.

[0037] The third hard drive 19 has a set of general cut sequence rules stored therein and computer readable instructions stored therein for causing the microprocessor to operate as a sequencing engine to perform a method for optimising hide usage in leather cutting processes, as will be described in detail below. The general cut sequence rules are as follows:

1. work orders must be sequenced so as to make the largest estimated area of hide remnant available from a first production order for use in cutting leather of the same hide colour in the subsequent production order, where the subsequent order includes the same leather colour;
2. all orders must be scheduled;
3. where there is more than one production shift, the cut sequence for the subsequent production shift should follow on in colour from the cut sequence of the preceding production shift;
4. where there is more than one production shift, the colour sequence of the cut sequence should follow on from the colour sequence of the cut sequence of the previous production shift, and that the cut sequence should include as its last order the first order for leather inspection for the subsequent production shift (inspect only order); and
5. the leather colours of work in progress should be matched to the leather colours of production orders due to commence production during the following shift.

[0038] In this example, the production orders for one working day, comprising two production shifts, are to be scheduled according to the method to be described below.

[0039] Each of the CNC cutting tables 12, hard drives, 14, 16 and the computer 18 are connected via communications adapters to a local area network (LAN), to thereby enable communication between the computer 18 and each of the CNC cutting tables 12, the first hard drive 14, and the second hard drive 16. The LAN connection also enables the computer 18 to receive production schedule data from a production orders database 22.

[0040] The system 10 also includes a report generator engine 24, which in this example is implemented by the microprocessor of the computer 18, and a fourth computer hard drive 26 having a report database file stored therein. The fourth computer hard drive 26 is connected via communications adapters to the LAN to enable it to receive cutting data from each of the CNC cutting tables 12 and to forward the cutting data to the report generator engine 24.

[0041] Figure 2 shows part of a leather cutting system 30 according to a second embodiment of the invention. The leather cutting system 30 of this embodiment is generally the same as the system 10 of the first embodiment, with the following modifications. The same reference numbers are retained for corresponding features.

[0042] In this embodiment, the system 30 comprises three different types of CNC cutting table 32, 34, 36, there being three of the first type 32, three of the second type 34 and one of the third type 36. The different types are different generations of the same CNC cutting table. The system 30 further comprises three computers 38a, 38b, 38c which receive the cutting data from each of the sets of CNC cutting tables 32, 34, 36. A database is provided on each computer 38 for receiving and storing the cutting data, for later forwarding to the report generator engine 24. The provision of three cutting data databases enables a larger number of simultaneous operations to be processed by the databases.

[0043] Referring to Figure 3, a third embodiment of the invention provides a method for optimising hide usage in leather cutting processes, which will be described here as a computer programme product comprising programme code for performing the steps of the method running on the computer 18 of the leather cutting system 10 of the first embodiment. The same reference numbers are retained for corresponding features. The method is described in the context of a complete leather cutting process.

[0044] In this example, production orders are continuously added to the production schedule, in the order that they are received from customers. At the start of a working day comprising two production shifts, production schedule data comprising the entire series of production orders is received from the production orders database 22 by the computer 18. The orders are received as text files by a shared file area within the computer 18. Each text file comprises model, model version/variant, features and colour options for that work order.

[0045] The shared area is watched by the computer 18 until a file is placed in it. The file is then collected by a production order collector/decoder 40 and interrogated to ensure that the file is of a recognised format, it is not a duplicate of a previously received order text file, and it is not an update of a previous order. The text files are then decoded to obtain model, feature options, colour options and work order identifier.

[0046] The data contained within the file is identified by its position in the text string. Certain characters in certain positions will denote "Option X" and different characters, or the absence of characters in that location will denote "Option Y". The size of each data field and the various forms of the data which can be received are provided within an Administration look-up table 42. The first field in the file identifies the version of the file, this enables new fields to be introduced in the text string to denote new options as a product line matures.

[0047] The sequencing engine 20 then selects a sub-set of the series of production orders, the sub-set containing 50 production orders in this example, each production shift being expected to inspect and cut 25 production orders. The first 7 production orders are cut only production orders that have already been inspected. A further 7 inspect only production orders are added to the end of the sub-set; these then become the cut only production orders at the start of the next sub-set (for the next working day).

[0048] The sub-set of production orders is then passed to the sequencing engine 20 of the computer. The sequencing engine 20 comprises a production order builder 20a and a production order sequencer 20b. The builder 20a builds a parts list for each order according to model, feature options and leather colour options. A list of standard parts required for each model and model version is stored in a model administration look-up table or database 44. A list of parts for each optional feature (such as left/right-hand drive, child seat fixings, sun roof, steering wheel trim style) is stored in a feature administration look-up table or database 46.

[0049] A list of colour options (primary and secondary colour) and which colour group each part belongs to is stored in a colour administration look-up table or database 48. Certain areas of a vehicle interior may be colour co-ordinated, or colour contrasted - according to the customer's preference. Discrete areas may include a number of individual parts that will always be included in the same colour group. The colour of these groups of parts will vary from one Colour Option to the next, either according to a fixed Option Number, or, for certain parts, by a specific customer choice. By organising the parts into groups the colour options can be managed according to interior feature sub-assembly (e.g. arm rest, steering wheel, driver's seat, etc.). This enables a direct link to be formed between the colour options available to a customer and the impact of that selection to a production cell.

[0050] Each part within the parts list for each order is given an identifier, information about how it is to be used and model specific cut sequence rules is added to the work order; the information is stored within a parts administration look-up table or database 50. The following information is provided for each part: unique part name / version; piece pattern template location; grade of leather (shrink optimised or fine nappa); whether it is permissible to upgrade the leather to improve hide utilisation; the colour group the part belongs to; how many of each part is required; how many symmetrically opposite parts are required; area of the part; applicability of the part to each model version; applicability of the part to each feature option; and nesting buffer size.

[0051] Once the parts list has been completed for each work order, the builder 20a sends the orders to the sequencer 20b. The sequencer 20b then performs the following steps:

i. the part area is calculated for each leather colour and leather type (for two colour work orders) or for each leather type (for single colour work orders) for each work order;
ii. the total part area of each leather type and/or colour is increased by a nesting buffer percentage to provide a bulk area for each leather type and/or colour for each work order; and
iii. the bulk area for each leather type and/or colour for each work order is divided by an average hide size to provide the number of hides required of each leather type and/or colour for each work order.

[0052] The sequencer 20b then schedules the production orders to the cut sequence of each of the 7 cutting tables 12 as follows:

i. the first cutting table is selected and the first production order (i.e. the first cut only production order) is scheduled to the table's cut sequence;
ii. the next cutting table is then selected and the next production order is scheduled to the table's cut sequence;
iii. step ii. is repeated until all of the cut only production orders have been scheduled to a cutting table (the cut sequence of each cutting table therefore has one cut only production order scheduled to it);
iv. the first cutting table is then selected and the remaining production orders (i.e. the inspect and cut orders) within the sub-set are searched to find a production order of the same leather colour as the production order previously allocated to that table, where a colour match is found the matching production order is scheduled to the cut sequence of the cutting table, where no match is found the sub-set is searched to find a production order of the preferred follow on leather colour, which is then scheduled to the cut sequence, and where no preferred follow on colour matched production order is found the next production order is scheduled to the cut sequence;
v. once the last cutting table has had an order scheduled to its cut sequence the scheduling of orders recommences at the first cutting table and steps iv. and v. are repeated until all of the cut and inspect production orders have been scheduled; and
vi. the inspect only production orders are then scheduled following steps i. to iii until all of the inspect only production orders have been scheduled.

[0053] Each cutting table 12 is allocated an operating percentage indicating the percentage of its full capacity that is available for cutting production orders; a percentage of the capacity of one or more tables may allocated for cutting pieces from production orders in previous shifts that require reworking or may be allocated for cutting pieces for product development work. Each table is also be allocated an operating efficiency indicating the number of hides that can be cut by the table per shift. The scheduling of production orders to the cutting table cut sequences is controlled to ensure that substantially the same number of leather hides are to be cut by each cutting table 12, factored by the operating percentage and operating efficiency of each cutting table. Operating percentage and efficiency must be considered when producing scheduling orders to the cut sequences so that none of the CNC cutting tables 12 are overloaded with orders within a given production shift.

[0054] The operating percentage of each CNC cutting table 12 by production shift and the operating efficiency of each cutting table 12 is stored in a tables administration look-up table or database 52 within the hard drive 19 of the computer 18.

[0055] The number of production orders within the subset, i.e. the sequencing depth, must be controlled to ensure that all of the production orders due for assembly (i.e. the assembly of the cut leather parts onto the respective vehicle) during the next working day must be cut by the end of the current working day, i.e. by the end of the two production shifts. Setting the sequence depth ensures that no production orders due to be cut during the current working day, for assembly the following day, are left to be cut during the next working day, deviation from the production schedule (i.e. the series in which orders are received from customers) is kept to a minimum, and maximises opportunities to optimize hide leather usage without compromising the overall functioning of the production facility within which the leather cutting system is located.

[0056] Once the production orders have been scheduled to the cut sequences of the cutting tables, nesting strategies are added to each order according to model, feature and leather type. The nesting strategies are stored in a strategy administration look-up table or database 56 stored within the hard drive 19 of the computer 18.

[0057] A batch file generator 58 then retrieves the part piece pattern template files from the second hard drive

16 for each production order and adds them to the order. The orders are now complete and the cut sequences are sent to their respective cutting tables where the production order files are opened and the CNC cutting tables nest and cut the parts according to the instructions and templates within each order.

[0058] The batch file generator 58 also creates checklists 60 for cutting table operators, which identify, for each production order; hide requirements; hide inspection order; and the nesting strategies.

[0059] Hides are inspected 62 and loaded 64 onto the CNC cutting tables 12 in a manner well known in the art, according to the check lists created by the batch file generator. The CNC cutting tables 12 scan each hide, nest parts into the hide area and cut the parts according to processes well known in the art.

[0060] Each CNC cutting table 12 stores the following information within an internal database: the size of each hide cut; the colour of each hide cut; hide quality (measured for the second hide of the main leather colour of each order); the size of remnant hides used for a subsequent order; piece pattern nesting strategies used; time taken to scan each hide prior to cutting; time taken to nest piece patterns to be cut from each hide; and total time taken to cut piece patterns from each hide.

[0061] The databases on the CNC cutting machines are interrogated by a report generator 24, to retrieve the stored information. The information is received by the report generator 24 at regularly spaced intervals during each production shift. The report generator 24 analyses the information received from the CNC cutting tables on a weekly basis to obtain the following: average total hide area used for each model; average amount of hide used for re-cutting piece patterns for each production order; total hide area used during a specified time period; variation of hide quality across a specified time period (for each hide colour and for each supplier); variation in the number of hides used of a specified colour across a specified time period; variation in hide size across a specified time period (for each hide colour and for each supplier); and average nesting efficiency.

[0062] The hide size and average nesting efficiency information is required in order to accurately estimate the hide requirements for cutting orders. This information is stored within a production statistics look-up table or database 66 and is provided to the sequencer 20b during sequencing of production orders in subsequent subsets.

[0063] The total hide area used for each production order is also calculated for each leather type and/or colour, thereby enabling a hide utilisation report 68 to be produced detailing the leather cost for each vehicle (work order), with cost breakdowns for optional features and colour options.

[0064] In an alternative arrangement, the scheduler 20b schedules the production orders to the cut sequences of the cutting tables 12 as follows:

1. the first production order (i.e. the first cut only production order) in the sub-set is selected and scheduled to the cut sequence of the first cutting table;
2. the next production order is selected and scheduled to the cut sequence of the next cutting table;
3. step 2. is repeated until each cutting table has had a cut only production order scheduled to it (so all the cut only production orders have been scheduled);
4. the next production order (i.e. the first inspect and cut production order) is selected and a search of the last production order (i.e. the cut only production order) allocated to the cut sequence of each cutting table is performed to find a production order of the same colour of leather, where a colour match is found the production order is scheduled to that cut sequence and where no colour match is found step 4. is recommenced;
5. step 4. is repeated until all of the cut and inspect production orders in the sub-set have been considered, then the remaining unscheduled production orders in the sub-set are scheduled according to the scheduling steps iv and v above; and
6. the inspect only production orders are then scheduled following steps 1. to 3. until all of the inspect only production orders have been scheduled.

[0065] Figure 4a provides an illustration of hide sequencing obtained using a prior art method of cutting production orders in which orders are cut in the sequence they are added to the production schedule, and Figure 4b shows an example hide sequence obtained using the above described method. As can be seen in Figure 4a, cutting hides in the order in which production orders are received by a production facility results in significant areas of hides being wasted, since an exact number of full hides is rarely required in order to cut a single work order. Due to the colour batch limitations of leather hides, leather from a hide used to cut a first order cannot be transferred to cut parts for a second work order since the transferred hide may not be from the same colour batch as the other hides used to cut the same colour in the second work order.

[0066] As shown in Figure 4b, reorganizing the selected production orders into a cut sequence in which the maximum possible number of orders including the same colour leather are scheduled to be cut sequentially as performed by the above method reduces the amount of hide wastage since remnant hides can now be transferred from a first production order to a subsequent order.

[0067] Various modifications may be made to the described embodiments without departing from the scope of the invention. For example, the leather cutting system may comprise a different number of CNC cutting tables to that described. Where the various databases are described as being embodied within different hard drives, it will be appreciated that the hard drives may be located within a single computer or the databases may alternatively be provided within a single hard drive.

[0068] The described methods may alternatively be used just to schedule cut and inspect production orders. The sub-set of production orders may comprise a different number of production orders to that described (which will at least in part depend upon the number of CNC cutting tables available) and may cover a different number of production shifts. Instead of cutting one day ahead of the production schedule (i.e. cutting the production orders the day before the orders are due to be assembled), the method may applied to cut orders two or more days ahead of the production schedule (i.e. cutting the production orders two or more days before the orders are due to be assembled), thereby providing a production facility with one or more days buffer of cut parts.

[0069] It will be appreciated that although the leather cutting system and method are described in relation to a vehicle production process, the system and method may also be used for cutting leather in many different production processes, including for example, aircraft interiors and furniture.

Claims

1. A method for optimizing hide usage in leather cutting processes, the method comprising the steps of:

   i. receiving production schedule data comprising a series of production orders, each order including model and leather colour information and an identifier;
   ii. building a parts list for each production order according to model and leather colour, the parts list including the piece pattern area for each part and the leather colour of each part;
   iii. selecting a sub-series of production orders from the series of received orders;
   iv. reorganizing the selected production orders into a cut sequence in which the maximum possible number of orders including the same colour leather are scheduled to be cut sequentially; and
   v. sending the cut sequence of production orders to a computer controlled leather cutting table for the orders to be cut by the table in said cut sequence.

2. A method as claimed in claim 1, wherein in step d) the selected production orders are reorganized into a plurality of cut sequences, each corresponding to a respective one of a plurality of cutting tables, the maximum possible number of orders including the same colour leather being scheduled to be cut sequentially within each cut sequence, and in step e) each cut sequence is sent to its respective cutting table.

3. A method as claimed in claims 1 or 2, wherein in step a) each production order comprises a main leather colour and a secondary leather colour.

4. A method as claimed in claims 2 or 3, wherein the selected production orders are reorganized into the plurality of cut sequences by the following steps:

   i. selecting the first cutting table and scheduling a production order to the table's cut sequence;
   ii. selecting the next cutting table and scheduling a production order to the table's cut sequence; and
   iii. repeating step ii. until all of the production orders in the sub-set have been scheduled to a cutting table,

   where the number of production orders in the sub-set is greater than the number of tables, once the last cutting table has had a production order scheduled to it the scheduling of orders to the cutting tables recommences at the first cutting table and for each cutting table the remaining production orders within the sub-set are searched to find a production order of the same leather colour as the production order previously scheduled to that table, where a colour matched production order is found it is scheduled to the cut sequence.

5. A method as claimed in claim 4, wherein each cutting table is allocated an operating percentage indicating the percentage of its full capacity that is available for cutting production orders and an operating efficiency indicating the number of hides that can be cut by the table in a given time period, the scheduling of production orders to the cutting table cut sequences being controlled to ensure that substantially the same number of leather hides are to be cut by each cutting table, factored by the operating percentage and operating efficiency of each cutting table.

6. A method as claimed in claims 2 or 3, wherein the selected production orders are reorganized into the plurality of cut sequences by the following steps:

   1. selecting the first production order in the sub-set and scheduling it to the cut sequence of the first cutting table;
   2. selecting the next production order and scheduling it to the cut sequence of the next cutting table;
   3. repeating step 2. until each cutting table has had a production order scheduled to it; and
   4. where the number of production orders in the sub-set is greater than the number of cutting tables,
   5. selecting the next production order and searching the last production order allocated to the cut sequence of each cutting table to find a production order of the same colour of leather, where a colour match is found scheduling the production order to that cut sequence and where

no colour match is found restarting step 4.; and
6. repeating step 4. until all of the production orders in the sub-set have been considered, then scheduling the remaining unscheduled production orders in the sub-set according to the scheduling steps of paragraphs 7 and 8 above.

7. A method as claimed in claim 6, wherein the production orders are searched by main leather colour or by secondary leather colour.

8. A method as claimed in any preceding claim, wherein the series of production orders comprises a leading group of cut only productions orders followed by a main group of cut and inspect production orders, the sub-set being selected to include all of the cut only production orders followed by a first part in series of the cut and inspect production orders.

9. A method as claimed in any of claims 4 to 8, wherein a number of inspect only production orders are added to the end of the sub-set of production orders, the inspect only production orders being scheduled to cutting table cut sequences according to steps i to iii of claim 4 only after the last cut and inspect production order has been scheduled.

10. A method as claimed in claims 8 or 9, wherein the number of cut only production orders plus cut and inspect production orders is equal to the number of production orders that can be cut by the cutting tables within a production shift or within a group of two or more consecutive production shifts.

11. A method as claimed in claim 10, wherein the number of cut only production orders is equal to the number of inspect only production orders processed by the previous production shift or group of shifts.

12. A method as claimed in any preceding claim, wherein in step b), the parts list further comprises hide type information for each part.

13. A method as claimed in claim 12, wherein each production order comprises up to two hide types: shrink optimised leather and/or fine nappa leather.

14. A method as claimed in claims 12 or 13, wherein step b) further comprises:

calculating the part area for each leather colour and leather type for each production order; increasing the total part area of each leather type and colour by a nesting buffer percentage to provide a bulk area for each leather type and colour for each production order; and dividing the bulk area for each leather type and colour for each production order by an average hide size to provide the number of hides required of each leather type and colour for each order.

15. A method as claimed in claims 13 or 14, wherein step b) further comprises retrieving one or more of the following cut sequence rules for each production order according to model and adding that information to the respective order:

two colour leather production orders start and finish the cutting process with a fine nappa leather hide or hide remnant, and any shrink optimised leather hide is located between the fine nappa leather within the cut sequence; single colour leather production orders to be allowed to be sequenced with shrink optimised hide leather colour being matched between orders; the preferred leather colour and/or leather type of the following production order within the cut sequence, and allow that where there is no production order remaining available within the subset that meets the cut sequence rule, the next order may be selected from any of the remaining available production orders; and whether is it permissible to upgrade the leather type used to cut a piece pattern from a first hide type to a higher quality hide type in order to increase the utilised area of a hide, and assign an upgrade priority level to identify piece patterns most preferred for leather type upgrade.

16. A method as claimed in any preceding claim, wherein the method additionally comprises retrieving the piece pattern template for each part within a production order according to model and adding that information to the respective order, the piece pattern templates being retrieved for each production order according to model in step b), or after step c) or step d) and that information added to the respective order.

17. A method as claimed in any preceding claim, wherein step e) further comprises compiling and printing a summary of the work orders for the or each cutting table, for use by leather inspectors and/or as a checklist for cutting table operators.

18. A method as claimed in any preceding claim, wherein the method further comprises the following further step:

i. receiving completed hide cutting information from the or each cutting table, the information including one or more of: the size of each hide cut; the colour of each hide cut; hide quality; the size of remnant hides used for a subsequent work order; piece pattern nesting strategies used; time taken to scan each hide prior to cutting; time taken to nest piece patterns to be cut from each hide; and total time taken to cut piece patterns from each hide.

19. A method as claimed in claim 18, wherein the hide quality information is provided for the second hide of the main leather colour of each production order.

20. A method as claimed in claims 18 or 19, wherein the method further comprises the following further step:

i. analysing the information received in step f) to obtain one or more of the following: average total hide area used for each model; average amount of hide used for re-cutting piece patterns for each production order; total hide area used during a specified time period; variation of hide quality across a specified time period; variation in the number of hides used of a specified colour across a specified time period; variation in hide size across a specified time period.

21. A computer programme product comprising programme code for performing the steps of the method as claimed in any preceding claim.

22. An article of manufacture with a computer useable medium having computer readable instructions embodied therein for providing access to resources available on that computer, the computer readable instructions comprising instructions to cause the computer to perform the steps of the method as claimed in any preceding claim.

23. A leather cutting system comprising:

a computer controlled leather cutting table;
first computer readable memory means having a production order database file embodied therein, the database file containing part information for each part for a plurality of models;
second computer readable memory means having a plurality of piece pattern template files embodied therein;

characterised by:

the part information for each part including the piece pattern area, leather colour, piece pattern template file name and location, and any model specific cut order sequencing rules; and
the system further comprising a computer comprising a computer readable memory means and a sequencing engine, and computer readable instructions to cause the sequencing engine to perform the method as claimed in any of claims 1 to 20 being embodied within the memory means, and the computer being communicatively connected to the computer controlled cutting table, the first computer readable memory means, and the second computer readable memory means.

24. A leather cutting system as claimed in claim 23, wherein the leather cutting system comprises a plurality of computer controlled cutting tables, each being communicatively connected to the computer.

25. Leather cutting apparatus arranged to:

i. receive production schedule data comprising a series of production orders, each order including model and leather colour information and an identifier;
ii. build a parts list for each production order according to model and leather colour, the parts list including the piece pattern area for each part and the leather colour of each part;
iii. select a sub-series of production orders from the series of received orders;
iv. reorganize the selected production orders into a cut sequence in which the maximum possible number of orders including the same colour leather are scheduled to be cut sequentially; and
v. send the cut sequence of production orders to a computer controlled leather cutting table for the orders to be cut by the table in said cut sequence.

26. Leather cutting apparatus as claimed in claim 25, wherein the apparatus is arranged to in step d) reorganize the selected production orders into a plurality of cut sequences, each corresponding to a respective one of a plurality of cutting tables, the maximum possible number of orders including the same colour leather being scheduled to be cut sequentially within each cut sequence, and in step e) to send each cut sequence to its respective cutting table.

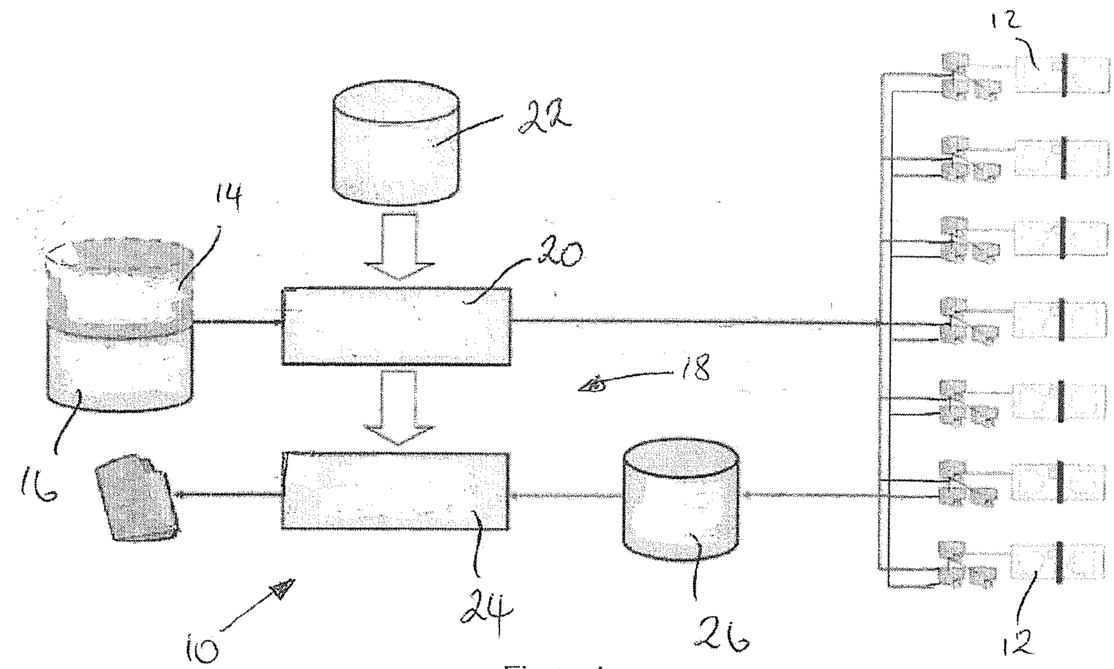

Figure 1

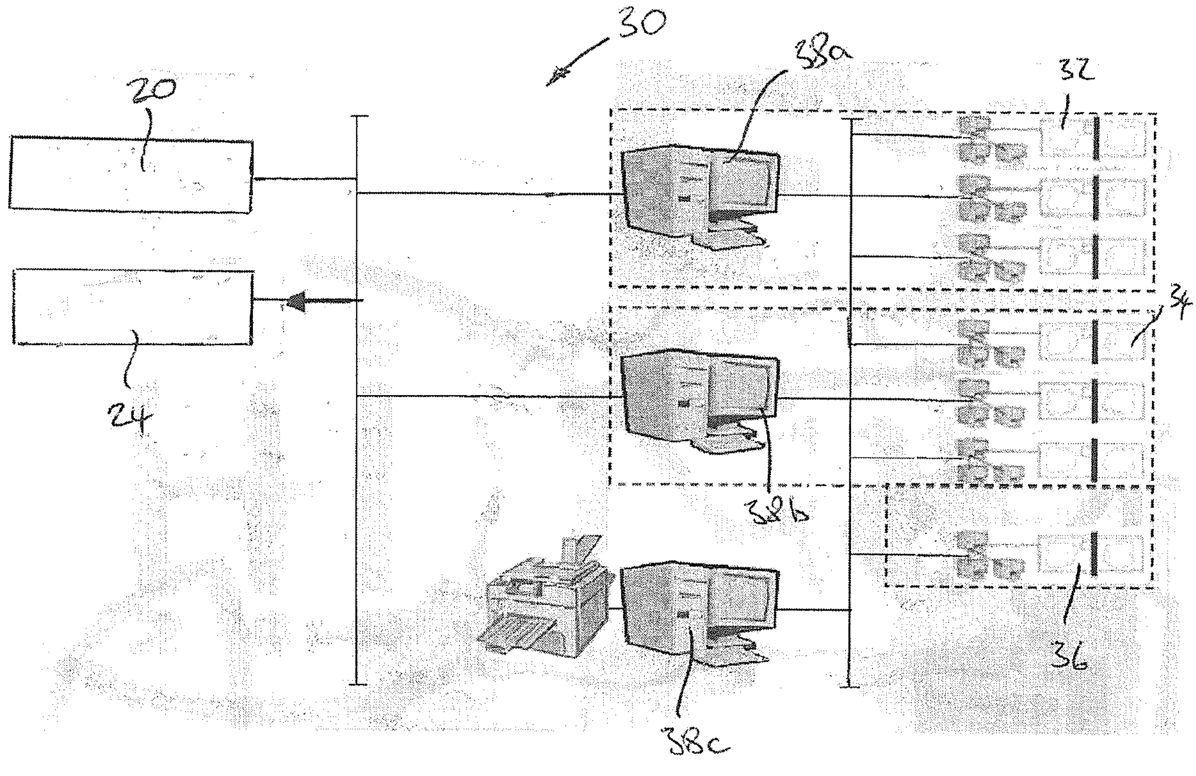

Figure 2

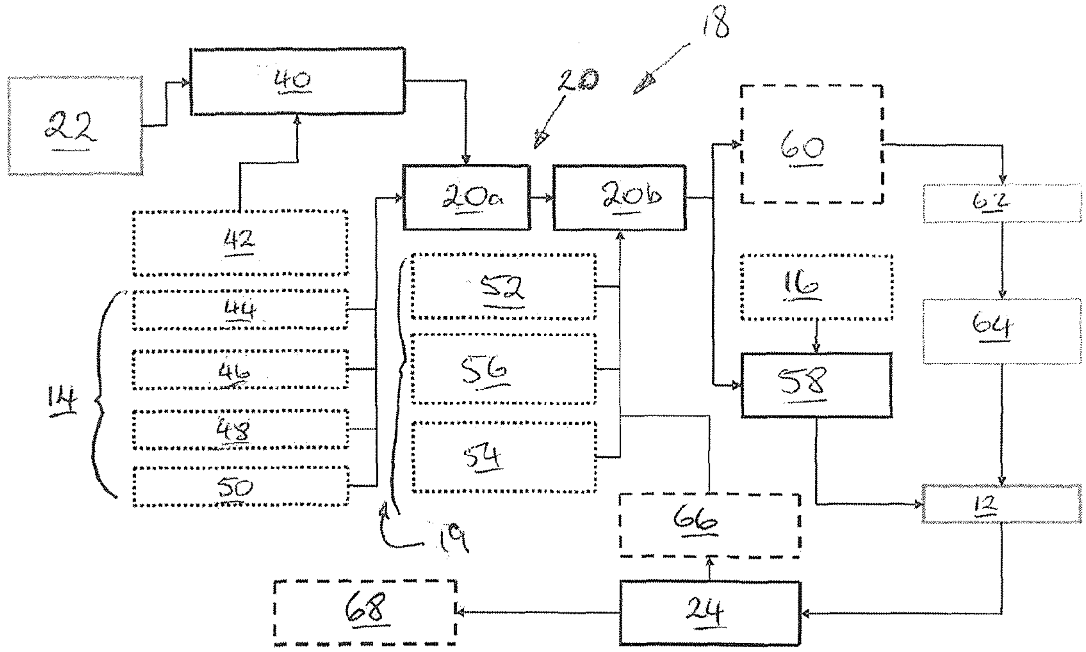

Figure 3

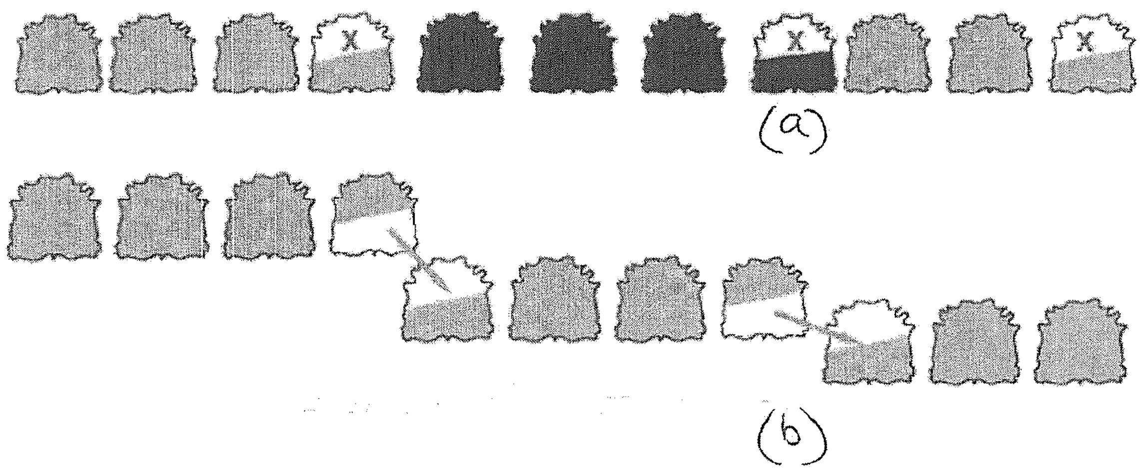

Figure 4

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 06 11 8201

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
Y	US 5 663 885 A (STAHL ANTON [DE]) 2 September 1997 (1997-09-02) * column 1, line 5 - line 10 * * column 3, line 35 - column 4, line 20 *	1-4,6-26	INV. C14B5/00 B26D5/00
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Y	"BUYERS-GUIDE CAD/CAM" MANUFACTURING CLOTHIER, UNITED TRADE PRESS LTD. LONDON, GB, vol. 69, no. 12, 1 December 1988 (1988-12-01), pages 39-41, XP000024830 * page 39, left-hand column, last paragraph * * page 40, left-hand column, paragraph 4 - right-hand column, paragraph 3 * * page 41, left-hand column, paragraph 1 *	21-26	TECHNICAL FIELDS SEARCHED (IPC) B26D
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The present search report has been drawn up for all claims

2

Place of search	Date of completion of the search	Examiner
The Hague	19 December 2006	Vaglienti, Giovanni

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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