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(56) Documents Cited:
EP 1321988 A2 **EP 0577527 A1**
WO 1996/032291 A1 **US 6344103 A**

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INT CL **B05C, B41F, B41L, B41M, D06P**
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(54) Abstract Title: **Heat transfer printing**

(57) Thermal transfer printing apparatus for heating a patterned carrier film and drawing the heated film over an object to be printed comprises a housing 10 defining a well to receive the object and a heater system comprising a hood defining an airbox 26 and means to form a seal between the well and the hood 36, and heating means 24, 28 to blow warm air onto a carrier film carrying heat transfer dye to be drawn over the object. The film is held at a loading area 32.

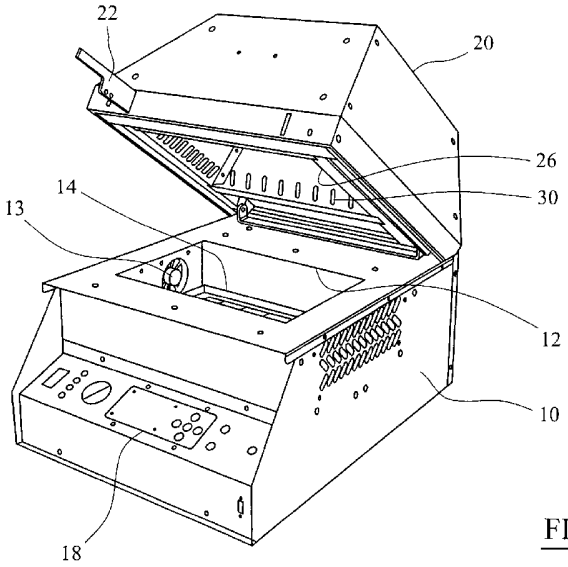

FIG. 2

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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

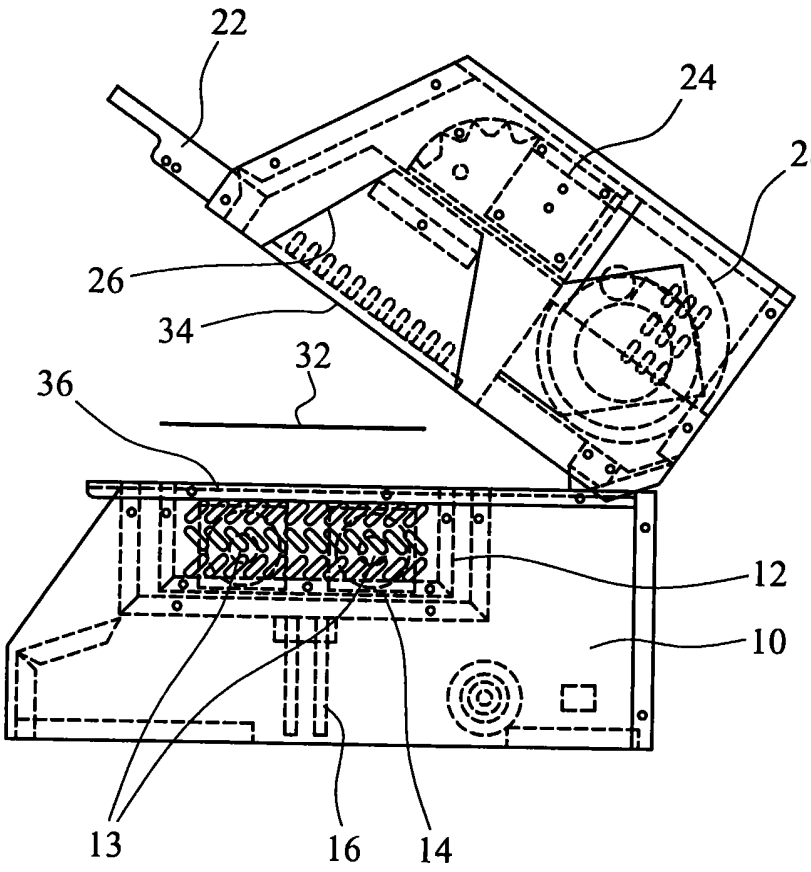


FIG. 1

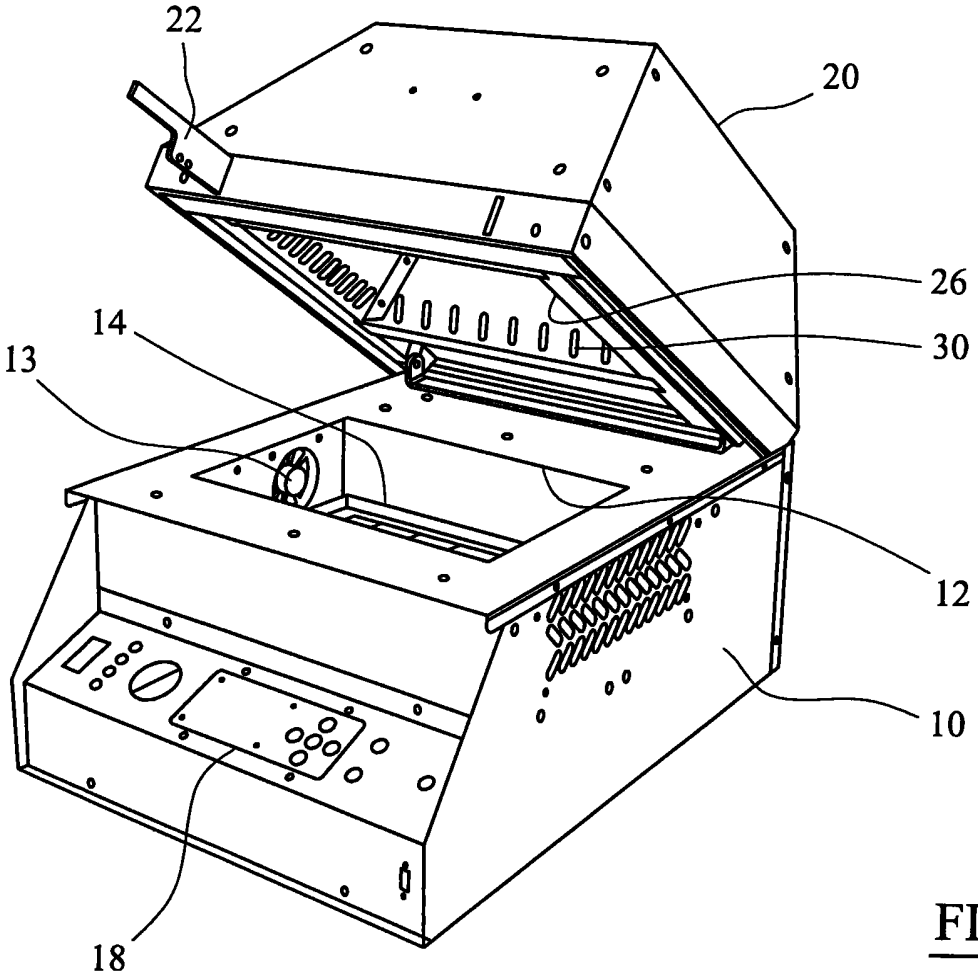
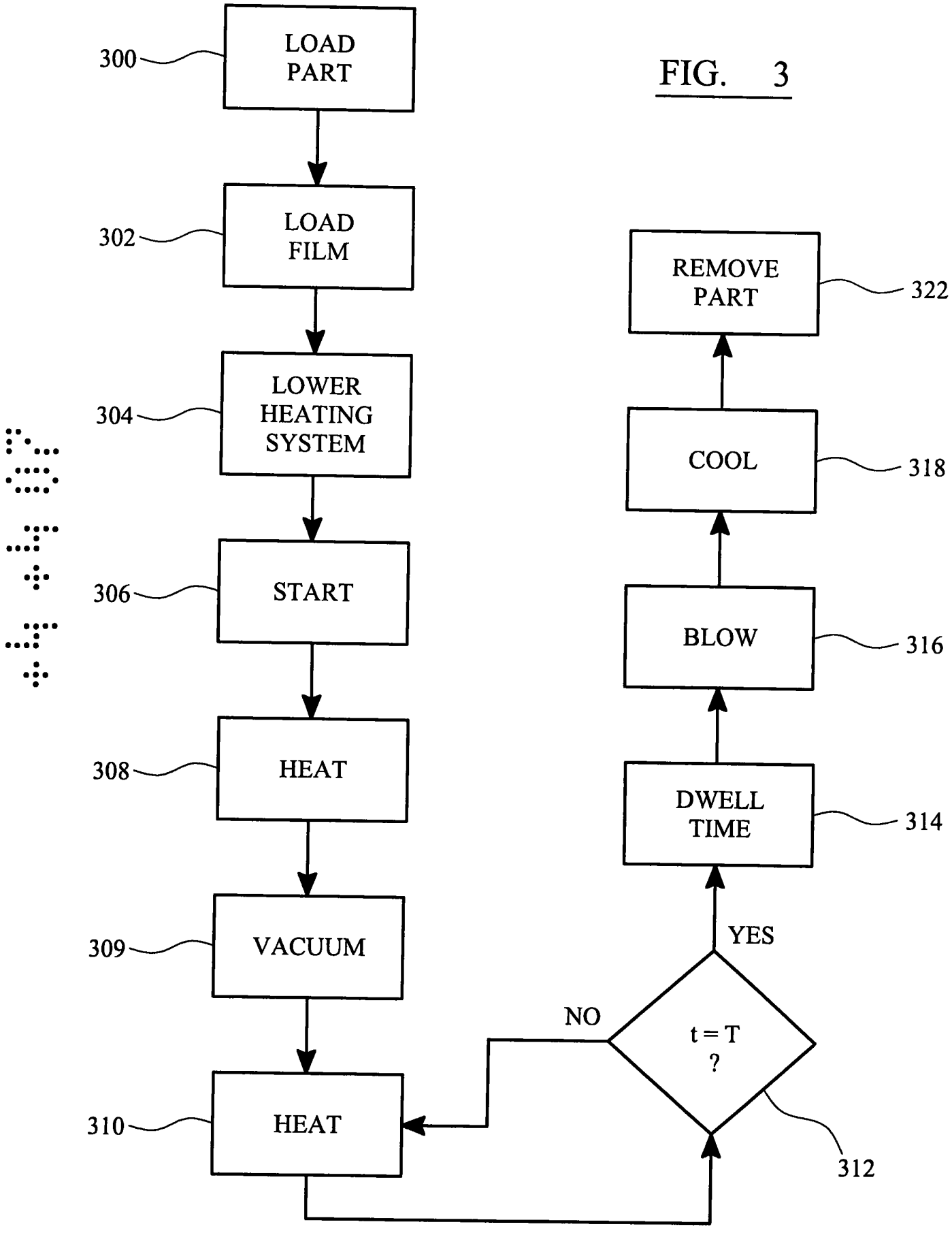


FIG. 2

FIG. 3


LOAD PART
300
LOAD FILM
302
LOWER HEATING SYSTEM
304
START
306
HEAT
308
VACUUM
309
HEAT
310
t = T ?
312
NO
YES
DWELL TIME
314
BLOW
316
COOL
318
REMOVE PART
322

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Heat Transfer Printing

This invention relates generally to heat transfer printing and, more specifically, to a method and apparatus for heat transfer printing of patterns onto objects formed of, for example, fabric, plastic or metal.

Heat transfer printing is a relatively well known technique for printing patterns onto parts or products such as mouse mats, coasters and aluminium signage. In a heat transfer printing process, the pattern to be printed is first printed onto a carrier film or paper, often using a conventional inkjet printer loaded with heat sensitive dyes in place of normal inks. The object to be printed is than laid onto a flat base and the printed carrier film is placed, face down, on top of the object. A heated pressure pad is brought down on top of the film and object and heat from the pad causes the dyes to vaporise and migrate into the part. Once cooled, the dye remains in the surface of the object, providing a high-quality, variable colour print.

However, although the process described above works well in respect of flat objects, the nature of the heated pressure pad is such that it does not allow contoured objects to be printed using this process. Recently, carrier films have been developed which are relatively very flexible when heated which allows the film to be heated and then vacuum-formed around a contoured part, following which the heat is further increased to cause the dyes thereon to be transferred to the part, as described above.

It will be apparent, however, that in the case of volume-produced plastic components, due to the relatively high printing temperature (say 150°C), it would be necessary to heat and then cool the component very quickly to prevent distortion of the base plastic, and heat transfer printing machines have been proposed which include cooling fans to cool the carrier film, the component and the air surrounding it relatively quickly as soon as the dye transfer process has been completed. In such machines, the part to be printed is loaded into a well and a printed carrier film is placed over the well opening, such that the part to be printed is located just below the surface of the film. The well and film assembly is loaded into a receiving area within a heating system defining a working area around the film and the film is then heated by means of a heater, across which air is blown into the working area by one or more circulation

fans, until the air temperature in the working area reaches a predetermined temperature, at which point the well is vacuumed, drawing the film over the part. The temperature is then further increased until the air temperature reaches another predetermined level and a dwell time is commenced, during which the dyes carried on the film vaporise and are transferred to the part, as described above. At the end of the dwell time, a cooling cycle (using cooling fans blowing cool air into the working area) is performed. Once the part has cooled, it is removed from the well and the film is peeled from the part.

However, there are a number of disadvantages associated with the above-described machine, and it is an object of the present invention to provide an improved heat transfer printing apparatus and method for contoured objects.

One of the problems associated with known heat transfer printing machines is the power required to heat the film to heat the air in the working area to the above-mentioned predetermined temperatures. A significant amount of heat is lost from the working area through a gap between the well and film assembly and the part of the machine defining the working area.

In accordance with a first aspect of the present invention, there is provided a thermal transfer printing apparatus comprising a housing defining a well for receiving an object to be printed, means for locating a carrier film on which heat sensitive dye is provided in correspondence with a pattern to be printed on said object, a heater system comprising a hood defining an airbox for placing over said well, wherein means are provided for forming a seal between said hood and said housing when said airbox is located over said well so as to define a substantially airtight working area around said film, when in use, heating means for heating said film, wherein said heating means comprises a heater and at least one fan for blowing air over said heater and into said working area and means for feeding warm air from said working area back to said at least one fan, and means for creating a vacuum within said well, when in use, to draw said heated film over said object to be printed.

Thus, thus the working area around the film is substantially airtight and the warm air within the working area is re-circulated such that performance relative to the prior art

is retained or even enhanced, whilst power consumption is reduced (in practice a heater power of perhaps 2.6kW would be sufficient compared with 5kW in a system without these characterising features).

A second problem associated with known heat transfer printing machines is that the depth of the well, in which the object to be printed is to be placed, is fixed. Thus, in practice, if the height of the object to be printed is less than the depth of the well, packing material, such as MDF packing boards or the like, are required to raise the object within the well such that it sits just below the carrier film, in use.

In accordance with a second aspect of the present invention, there is provided a thermal transfer printing apparatus comprising a housing defining a well for receiving an object to be printed, means for locating a carrier film on which heat transfer dye is provided in correspondence with a pattern to be printed on said object, a heater system comprising a hood defining an airbox for placing over said well, heating means for heating said film, and means for creating a vacuum within said well, when in use, to draw said heated film over said object to be printed, wherein the well comprises an adjustable floor for adjusting the depth of said well relative to the location of said carrier film, in use.

The object or part to be printed is loaded onto the floor or "table" at the base of the well, which may have a maximum depth of, say, 100mm (below the carrier film) when the floor is in its lowest position. Once film is heated to a predetermined temperature, in which it is ready to form, the floor or table may be raised, for example, by means of air cylinders, thereby pushing the object into the film and forming the air seals to allow the vacuum to be drawn.

Thus, the amount by which the film has to stretch over tall objects is minimised and print density is improved relative to the prior art, whilst the setup speed is significantly reduced, because of the elimination of the need to manually pack the well according to the size of the object.

A third problem associated with known heat transfer printing machines is in relation to removal of the carrier film from the object after printing by peeling it off after the

cooling process. This can be quite difficult as, once the film has cooled, it has gone rigid.

In accordance with a third object of the present invention, there is provided a thermal transfer printing apparatus comprising a housing defining a well for receiving an object to be printed, means for locating a carrier film on which heat transfer dye is provided in correspondence with a pattern to be printed on said object, a heater system comprising a hood defining an airbox for placing over said well, heating means for heating said film, means for creating a vacuum within said well, when in use, to draw said heated film over said object to be printed, and means for blowing said film off said object while it is still warm.

Thus, in accordance with the third aspect of the invention, a blow-off facility automatically removes the film from the object, thereby speeding up the unload time relative to the prior art.

Preferably, means are provided for removing said vacuum prior to blowing said film off said object.

A fourth problem associated with known heat transfer printing machines is that the fans used to blow air over the heater into the working area are also used to blow cool air over the film to cool it after the dye transfer process has been completed. As a result, the working area is cooled in between each printing process and has to be heated back up from cold for the next printing process.

In accordance with the fourth aspect of the present invention, there is provided a thermal transfer printing apparatus comprising a housing defining a well for receiving an object to be printed, means for locating a carrier film on which heat transfer dye is provided in correspondence with a pattern to be printed on said object, a heater system comprising a hood defining an airbox for placing over said well, wherein means are provided for creating a substantially airtight seal between said airbox and said well, when in use, the apparatus further comprising heating means for heating said film by raising the air temperature in said airbox, means for creating a vacuum within said well, when in use, to draw said heated film over said object to be printed,

and cooling means for cooling the air temperature in said well so as to cool said film after said heat transfer dye has been transferred to said object.

Thus, by the provision of independent heating and cooling fans, the former being associated with the airbox and the latter being associated with the well, the film can be cooled after each printing operation, whilst ensuring that the airbox remains warm for the next printing operation.

A fifth problem associated with known heat transfer printing machines is that a single air temperature sensor is provided in respect of the working area which feeds back to the control system, and the dwell time, provided for allowing the dye transfer process to occur, is commenced once the air temperature in the working area has reached a predetermined temperature. However, the air temperature in the working area is not necessarily an accurate reflection of the temperature of the film. Thus, the situation could occur that at commencement of the dwell time, the film is not hot enough for the dye transfer process to be effectively performed. More likely is that the predetermined temperature of the air temperature in the working area set to cause commencement of the dwell time is higher than is actually necessary to ensure that the temperature of the film is high enough to cause the required dye sublimation and transfer process. This is obviously inefficient and results in an unnecessarily high power consumption and an unnecessarily long overall printing operation time.

In accordance with a fifth aspect of the present invention, there is provided a thermal transfer printing apparatus comprising a housing defining a well for receiving an object to be printed, means for locating a carrier film on which heat transfer dye is provided in correspondence with a pattern to be printed on said object, a heater system comprising a hood defining an airbox for placing over said well, heating means for heating said film, means for creating a vacuum within said well, when in use, to draw said heated film over said object to be printed, sensing means for sensing the temperature within said well for determining when said temperature therein has reached a predetermined level, and means for commencing a dwell time when said temperature within said well has reached said predetermined level, during which dwell time said dye is transferred to said object.

Thus, although a temperature sensor may be provided in respect of the air in the airbox, once the air temperature within the airbox is determined to have reached a setpoint, the dwell time will still not be commenced until an under-film sensor within the well has reached some predetermined setpoint, determined by the characteristics of the specific film and/or dyes being used. The temperature control technology provided by the fifth aspect of the invention also gives good repeatability throughout a production run.

It will appreciated that any or all of the aspects of the invention recited above could be provided alone or in any combination, as required by the features and advantages required of any particular embodiment of the invention. In all cases, a number of different printing cycles may be stored and recalled for ease of use. Furthermore, the present invention extends to methods of thermal transfer printing corresponding in scope to the apparatus according to each of the first to fifth aspects of the present invention as recited above.

The aspects mentioned above, and other aspects of the invention will be apparent from, and elucidated with reference to the embodiments described herein.

Embodiments of the present invention will now be described by way of examples only and with reference to the accompanying drawings, in which:

Figure 1 is a schematic side view of a heat transfer printing machine according to an exemplary embodiment of the present invention;

Figure 2 is a perspective view of the heat transfer printing machine of Figure 1; and

Figure 3 is a schematic flow diagram illustrating the principal steps in a heat transfer printing process according to an exemplary embodiment of the present invention.

Referring to Figures 1 and 2 of the drawings, a heat transfer printing machine according to an exemplary embodiment of the present invention comprises a base 10 in which a generally rectangular well 12 is defined, for receiving a part to be printed. One or more cooling fans 13 are provided in a side wall of the well 12. The floor of the well 12 comprises a vertically adjustable table 14 coupled to a pair of air cylinders 16 located below the table 14. The base 10 further comprises a user interface 18 for

enabling a user to set one or more control parameters. The machine is controlled by means of a PLC which is fitted with, say, a 4-line display. The PLC reads temperature inputs and sets timers, etc. Up to, say, 50 printing cycles can be programmed with various times and temperatures, for re-use.

The machine further comprises a heater system 20 in the form of a hood hinged along a rear edge of the base 10, and a handle 22 is provided at the front of the hood to enable the heater system 20 to be raised and lowered relative to the base 10. The heater system 20 comprises a heater 24 and a heater fan 28 housed within the hood. The heater fan 28 blows air over the heater 24 (e.g. a 2.6kW air heater) and into an airbox 26. The inlet to the fan 28 is directly attached to the airbox 26 (via apertures 30), thereby providing complete air re-circulation during heating.

A first silicone seal 34 is provided around the airbox opening and a second silicone seal 36 is provided around the well opening, such that when a carrier film 32 is loaded and the hood 20 is brought down over the base 10, the heater system 20 is clamped and sealed onto the film 32 and the lower side of the film 32 is sealed against the well opening, thereby providing a completely airtight unit.

Referring in addition to Figure 3 of the drawings, during a printing cycle, a part to be printed is loaded (step 300) onto the table 14 within the well 12. In its lower position, the table 14 may be, say, 100mm below the carrier film 32 so at this stage, there may be a substantial gap between the part and the top of the well where the carrier film 32 will be located.

Next, the carrier film 32, which may, for example, be A3 sized and on which the pattern to be printed is provided in heat transfer dyes, is loaded (step 302) face-down against reference stops over the well opening. The entire heater system 20 is then closed (step 304) and clamped onto the film 32, sealing the heater airbox 26 and clamping the film 32. There may be an additional step between loading the part and loading the carrier film, of closing the heater system 20 and pressing a Start button to pre-heat the part to a preset temperature (which may be adjustable by means of the PLC), if required by the application. After the part has been pre-heated, the heater

system would be opened, the carrier film loaded and the heater system 20 closed again, as described above.

The user presses a Start button (step 306) and the controller starts the printing cycle by switching on the heater 24 (step 308). There are two temperature sensors on the machine, the first being for sensing air temperature (in the airbox 26), so as to ensure that the film 32 does not get burned during the printing cycle, and the second being for sensing the temperature on the raising table 14, i.e. for sensing the under-film temperature during the printing cycle. When the temperature reaches a set forming temperature, a vacuum forming process is performed (step 309), wherein the raising table 14 raises on the air cylinders 16, pushing the part into the film 32 and forming air seals to allow the vacuum to be drawn.

After the vacuum forming process, heating continues (step 310) until the air temperature is determined to have reached a predetermined setpoint. However, the printing dwell timer is only started (step 314) when the temperature t measured by the under-film sensor is determined (at step 312) to have reached a predetermined setpoint T. This provides much more consistent printing relative to prior art arrangements, as the printing time is not influenced by any built-up heat in the machine. At the end of the dwell time, the vacuum is reversed and the film blown off (at step 316) the part while it is still hot. The table 14 is then lowered and the cooling fans 13 cool the part and also the film (at step 318). Finally, the heater system 20 is opened and table 14 is raised once again to allow an operator to unload the part (step 320) quickly and easily.

Some of the objects achieved by the above-described exemplary embodiment of the present invention include a reduction in power consumption relative to prior art arrangements while retaining performance, the provision of a relatively more user-friendly system (i.e. saving heat profiles for different parts, easy loading and unloading, etc), and to provide a system which is more consistent in operation (relative to prior art arrangements in which the air temperature control system changes the machine timings as it gets warmer during a production run which can lead to an inconsistent print quality).

Technical benefits of the above-described exemplary embodiment of the present invention thus include:

- Fully re-circulating, sealed heating system, reducing power consumption while optimising performance;
- Raising table minimises film stretch over tall objects, which results in an improvement in print density and also speeds up the setup process;
- Blow-off facility automatically removes film from the part, simplifying and speeding up the unload process;
- Independent cooling fans, allowing the main heater area to stay warm ready for the next printing cycle;
- The temperature control technology gives good repeatability throughout a production run;
- Several cycle profiles (say 50) can be stored and recalled for ease of use.

It should be noted that the above-mentioned embodiments illustrate rather than limit the invention, and that those skilled in the art will be capable of designing many alternative embodiments without departing from the scope of the invention as defined by the appended claims. In the claims, any reference signs placed in parentheses shall not be construed as limiting the claims. The word "comprising" and "comprises", and the like, does not exclude the presence of elements or steps other than those listed in any claim or the specification as a whole. The singular reference of an element does not exclude the plural reference of such elements and vice-versa. The invention may be implemented by means of hardware comprising several distinct elements, and by means of a suitably programmed computer. In a device claim enumerating several means, several of these means may be embodied by one and the same item of hardware. The mere fact that certain measures are recited in mutually different dependent claims does not indicate that a combination of these measures cannot be used to advantage.

Claims:

1. A thermal transfer printing apparatus comprising a housing defining a well for receiving an object to be printed, means for locating a carrier film on which heat transfer dye is provided in correspondence with a pattern to be printed on said object, a heater system comprising a hood defining an airbox for placing over said well, wherein means are provided for forming a seal between said hood and said housing when said airbox is located over said well so as to define a substantially airtight working area around said film, when in use, heating means for heating said film, wherein said heating means comprises a heater and at least one fan for blowing air over said heater and into said working area and means for feeding warm air from said working area back to said at least one fan, and means for creating a vacuum within said well, when in use, to draw said heated film over said object to be printed.

2. A thermal transfer printing apparatus comprising a housing defining a well for receiving an object to be printed, means for locating a carrier film on which heat transfer heat sensitive dye is provided in correspondence with a pattern to be printed on said object, a heater system comprising a hood defining an airbox for placing over said well, heating means for heating said film, and means for creating a vacuum within said well, when in use, to draw said heated film over said object to be printed, wherein the well comprises an adjustable floor for adjusting the depth of said well relative to the location of said carrier film, in use.

3. Apparatus according to Claim 2, wherein said adjustable floor comprises a vertically adjustable table for receiving an object to be printed and raising said object toward said carrier film, in use.

4. A thermal transfer printing apparatus comprising a housing defining a well for receiving an object to be printed, means for locating a carrier film on which heat transfer dye is provided in correspondence with a pattern to be printed on said object, a heater system comprising a hood defining an airbox for placing

over said well, heating means for heating said film, means for creating a vacuum within said well, when in use, to draw said heated film over said object to be printed, and means for blowing said film off said object while it is still warm.

5. Apparatus according to Claim 4, further comprising means for removing or reversing said vacuum prior to blowing said film off said object.

6. A thermal transfer printing apparatus comprising a housing defining a well for receiving an object to be printed, means for locating a carrier film on which heat sensitive dye is provided in correspondence with a pattern to be printed on said object, a heater system comprising a hood defining an airbox for placing over said well, wherein means are provided for creating a substantially airtight seal between said airbox and said well, when in use, the apparatus further comprising heating means for heating said film by raising the air temperature in said airbox, means for creating a vacuum within said well, when in use, to draw said heated film over said object to be printed, and cooling means for cooling the air temperature in said well so as to cool said film after said heat transfer dye has been transferred to said object.

7. A thermal transfer printing apparatus comprising a housing defining a well for receiving an object to be printed, means for locating a carrier film on which heat transfer dye is provided in correspondence with a pattern to be printed on said object, a heater system comprising a hood defining an airbox for placing over said well, heating means for heating said film, means for creating a vacuum within said well, when in use, to draw said heated film over said object to be printed, sensing means for sensing the temperature within said well for determining when said temperature therein has reached a predetermined level, and means for commencing a dwell time when said temperature within said well has reached said predetermined level, during which dwell time said dye is transferred to said object.

8. Apparatus according to any one of the preceding claims, wherein means are provided for storing a number of different printing cycles which can be recalled, as requested.

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Application No:	GB0606020.6	**Examiner:**	Tony Rudge
Claims searched:	1	**Date of search:**	28 May 2006

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
A	1-8	WO96/32291 A1 (POLAROID CORPORATION LIMITED)
A	"	EP1321988 A2 (EASTMAN KODAK COMPANY)
A	"	EP0577527 A1 (EASTMAN KODAK COMPANY)
A	"	US6344103 A (HSIEN-CHANG CHENG)

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^{X} :

B6C

Worldwide search of patent documents classified in the following areas of the IPC

B05C; B41F; B41L; B41M; D06P

The following online and other databases have been used in the preparation of this search report

EPODOC, WPI