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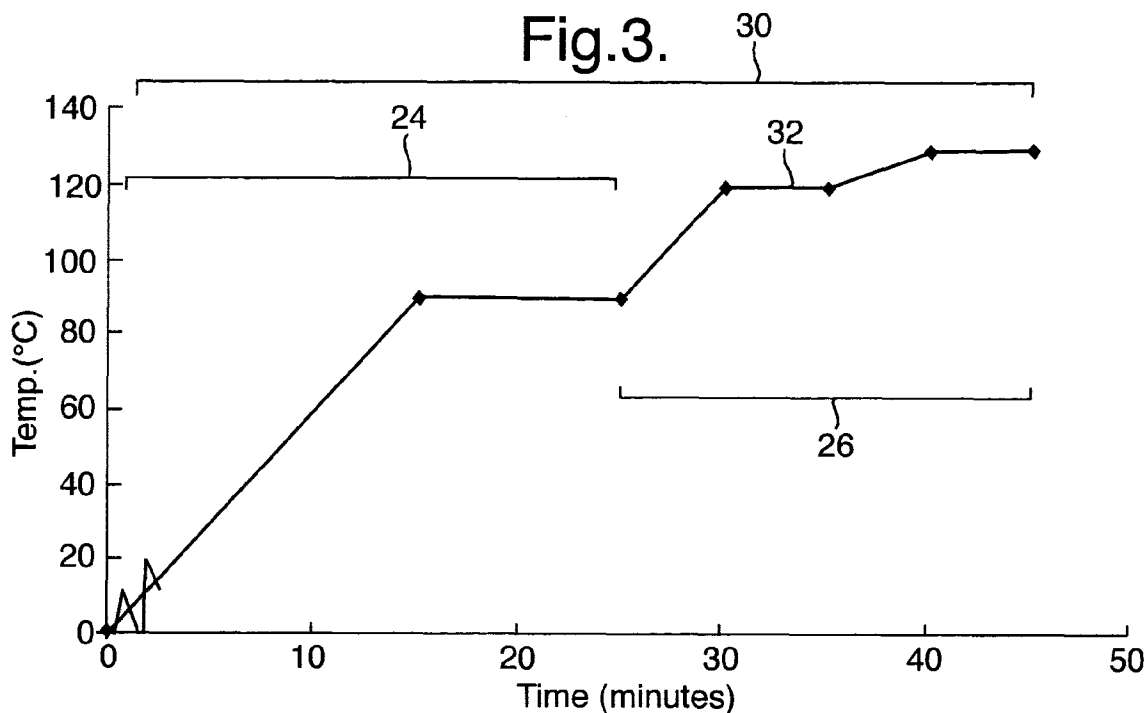
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(54) **A method of curing a maskant**

(57) A method of curing a water based maskant which has been applied to a component. Such a maskant being particularly useful in chemical machining operations in which the maskant protects certain areas of a component from etching by a chemical solution. The maskant containing at least water and a modified latex. The method of curing the maskant, once it has been ap-

plied to a component, comprising the steps of heating for a first curing period at a temperature below the boiling point of water to start to cure the maskant. Then during a second curing period heating the maskant to a temperature above the boiling point of water, but below the temperature at which the maskant burns. Such a process providing rapid curing of the maskant whilst maintaining an adequate coating finish.

Fig.3.**EP 0 904 852 A2**

Description

[0001] The present invention relates generally to a method of drying and curing a water based maskant or paint. More particularly, but not exclusively, it relates to a method of curing a water based latex maskant applied to a component used in a chemical machining process.

[0002] The chemical machining process involves placing a component in a chemical etching solution. This solution etches away material from parts of the component in contact with the solution. One example of a suitable etching solution for use on metal components is a mixture of Hydrochloric acid, Hydrofluoric acid, Ferric Chloride, and Nitric acid. To control the machining of the component a maskant is applied to certain areas of the component. The maskant protects those areas of the component from the etching solution and thereby prevents chemical machining, and removal of material, in those areas.

[0003] The maskant is applied to the relevant areas of the component in a liquid form using a solvent carrier. The maskant is dried by evaporating off the majority of the solvent, and then cured to produce a maskant coating on the various areas of the component. This drying and curing operation is generally carried out by placing the component within a large hot air convection oven. After chemical machining the maskant is peeled off from the component leaving behind an unmachined area of the component as required. The maskants therefore have to be resistant to the etching solution, be able to adhere to the component to prevent ingress of the solution underneath the edges of the maskant, and also be easily removed from the component after the machining process.

[0004] Modified latex maskants have been found to be suitable and are used in chemical machining. Conventional maskants utilise a volatile organic solvent, for example toluene, as the solvent carrier. An example of such a toluene solvent modified latex maskant is Turco 539SG, sold by Turco Products Ltd of Corby, Northamptonshire, UK. Due to their volatility these solvents evaporate rapidly once applied to the component, even at room temperatures. The maskant can therefore be dried and cured in a relatively short period of time.

[0005] In view of various environmental concerns, and UK legislation (Environmental Protection Act 1990, Part B, Emissions to Air) the use of volatile organic solvents, and in particular discharging them into the atmosphere is being reduced. New water based maskants have therefore been proposed to replace the organic solvent based maskants. One such water based modified latex maskant suitable for use in chemical machining is AC-928 WB(W7-12) produced by AC Products Inc of California, USA.

[0006] A problem with these water based maskants is the extended length of time that it takes to dry and cure the maskant, even when heated ovens are used. As an example AC Products recommend that their AC-928

WB(W7-12) water based maskant is finally cured and dried for between 4-8 hours: either 2 hours at 60-65°C, then 2 hours at 88-93°C (4 hours total), or 8 hours at 65°C. This is considerably longer than the volatile organic solvent maskants and in a production environment this time delay is undesirable. Additionally the costs of running the convection ovens and keeping them at the required temperatures for the specified times can be considerable. These costs are in addition to the large capital costs of convection ovens of a suitable size required for production use in drying and curing the components. The size of the ovens for production use also being determined, in part, by the length of time the component is required to remain within the oven.

[0007] The present invention seeks to provide an improved, quicker, method of drying and curing a water based maskant, and/or improvements generally to the method of drying and curing a maskant.

[0008] According to the present invention there is provided a method of curing a water based maskant which has been applied to a component, the maskant containing at least water and a modified latex, the method comprising heating the maskant for a first curing period to a temperature below the boiling point of water to start to cure the maskant and to remove substantially all of the water from the maskant; and then heating the maskant for a second curing period to a temperature above the boiling point of water, and below a temperature at which the maskant burns to substantially fully cure the maskant.

[0009] Advantageously the use of an increased temperature during the second period, once all the water has been removed, reduces the total time required to adequately cure the maskant. Whilst the use of a temperature below the boiling point of water during the first period ensures that the maskant finish is acceptable and the likelihood of bubbling of the coating is reduced.

[0010] Preferably at least during a part of the first curing period the temperature of the maskant is gradually increased.

[0011] Preferably at least during a part of the second curing period the temperature of the maskant is gradually increased.

[0012] Furthermore the temperature of the maskant may be increased at a constant rate.

[0013] The temperature of the maskant may be held constant for a part of either the first or second curing periods.

[0014] Preferably during the first curing period the temperature of the maskant is increased at a substantially constant rate to approximately 90°C over a period of approximately 15 minutes, and is then held at a constant temperature of 90°C for approximately 10 minutes.

[0015] Preferably during the second curing period the temperature of the maskant is increased at a substantially constant rate to a temperature of approximately 120°C over a period of approximately 5 minutes, and is then held at a substantially constant temperature of ap-

proximately 120°C.

[0016] Preferably during the second curing period the temperature of the maskant is increased at a substantially constant rate to a temperature of approximately 130°C over a period of approximately 5 minutes, and is then held at a substantially constant temperature of approximately 130°C.

[0017] The maskant may be heated by means of infra-red radiation. Preferably short wave infra-red radiation may be used.

[0018] Preferably the maskant is cured by heating within an infra-red oven, the oven comprising a plurality of infra-red emitters which are arranged and adapted to radiate infra-red radiation at the maskant thereby causing heating of said maskant, the emitters being controlled by a controller such that the amount and power of the infra-red radiation radiated to the maskant can be controlled.

[0019] The use of an infra-red oven heats the component more directly allowing greater, and quicker, control of the temperature of the maskant coated component as well as improving the efficiency of the heat supply means. Infra-red ovens are also cheaper than equivalent hot air convection ovens.

[0020] The present invention will now be described by way of example with reference to the accompanying drawings in which;

Figure 1 is a schematic process flow diagram of a chemical machining process;

Figure 2 is a schematic process flow diagram of the maskant application process of the process shown in figure 1;

Figure 3 is a graph showing the curing profile used in the process shown in figure 2, according to the present invention;

Figure 4 is a schematic diagram showing an infra-red oven suitable for curing a maskant coated component according to the present invention.

[0021] Referring to figure 1 there is shown a schematic flow diagram of the basic steps in a chemical machining process. The process starts with a blank metallic component 2 that is to be machined. This component is then cleaned 4 using a chemical cleaning solution, for example an alkaline solution such as Novoclean 20 which is then rinsed off. A maskant is then applied 6 to the areas of the component blank 2 that are not to be machined. Alternatively the maskant is applied 6 to the whole of the component 2 and is then selectively removed 7 from those areas that are to be chemically machined. The maskant coated component 28 is then chemically machined 8 by placing the component 28 into a chemical etching solution, for example a mixture of Hydrochloric acid, Hydrofluoric acid, Ferric Chloride, and Nitric acids. This etching solution gradually removes/dissolves 8 areas of the metallic component 2 in contact with the etching solution. The amount of material

removed, and therefore the degree of machining is dependent upon the length of time the component 28 is in the etching solution. The areas of the component 2 coated with the maskant coating are not acted upon by the etching solution and are consequently not machined 8. When the desired degree of machining has been completed the component 28 is removed from the etching solution. The component 28 is then cleaned 10 to remove or neutralise any of the etching solution remaining on the component 28. The maskant coating is then removed 12 from the component 28 revealing the machined component 14.

[0022] It will be appreciated by those skilled in the art that the above is a basic illustrative description of the outline of a conventional chemical machining process and that there are many variations to this basic process.

[0023] A water based maskant can be used in such chemical machining processes 1. Such maskants comprise modified latex compositions with water as the main solvent carrier. A small amount of organic solvent may also be present. An example of such a water based maskant for use in chemical machining 1 is AC-928-WB (W7-12) Dip Maskant produced by AC Products Inc (California, USA). An alternative maskant is Malek Waterbourne Maskant CAX-200+ produced by Turco, of Corby, Northamptonshire, UK. Both of these products are very similar in their properties and application method although of different exact compositions.

[0024] The maskant is applied 6 to the component 2 in a conventional manner. Figure 2 illustrates in outline a method of applying the maskant which will now be described with particular reference to the AC Products maskant. A first maskant coat is applied 16 by dipping the cleaned component 2 into a tank containing the liquid maskant. The liquid maskant adheres to the surface of the component 2 producing a liquid maskant coating upon the surface of the component 2, any excess maskant running off the component 2. Alternatively the liquid maskant can be applied to the component 2 by spraying. Such a spraying operation is similar to conventional spray painting methods.

[0025] The component 2 with a first liquid maskant coating then undergoes a drying stage 18 where the first coating is partially dried and the majority of the water solvent carrier in the liquid maskant coating is driven off. This drying stage 18 is conventionally accomplished by placing the component 2 within a hot air convection oven at a temperature typically of 65°C for one hour. Lower temperatures, longer times, and other conventional drying methods could however be used to remove the majority of the water solvent.

[0026] A second maskant coating is similarly applied 20 by dipping or spraying 20 to add a second maskant coating, or layer, on top of the first maskant coating on the component 2. The second maskant coating is then dried in a similar fashion to the first maskant coat. This produces an overall maskant coating of a suitable thickness to be used in the chemical machining operation 8.

Further layers of maskant may be added by repeated dipping or spraying, and drying steps if required to build up a maskant coating of a suitable thickness.

[0027] The partially dried maskant coating on the component 2 is then cured 30 to produce a final maskant coating suitable to resist the chemical etching solution used in the chemical machining process 8. Such curing 30 is conventionally carried out by placing the maskant coated component within a hot air convection oven for an extended period of time. The temperature of the oven being set below the boiling point of water. For example AC Products recommend that their AC-928 WB (W7-12) water based maskant is cured for between 4-8 hours: either 2 hours at 60-65°C, and then 2 hours at 88-93°C (4 hours total); or 8 hours at 65°C.

[0028] The subject of this invention is an improved curing process 30 which will now be described, with reference, as an example only, to the water based maskant produced by AC Products. This improved curing process 30 being particularly, but not exclusively, suited for use in an overall chemical machining process 1 described above.

[0029] The curing process 30 is divided into two distinct periods 24,26 and in this embodiment involves heating the coated component 28 according to the temperature profile 32 shown in figure 3. In the first period 24 the temperature of the maskant coated component 28 is gradually raised to a temperature of 90°C over a period of fifteen minutes. The temperature of the component 28 is then stabilised and held constant at 90°C for a further period of ten minutes. This initial period 24 ensures that any remaining water in the maskant coating is gradually removed. During this period it is important that the temperature of the maskant is kept below the boiling point of water to ensure that unacceptable bubbling of the maskant coating does not occur. Such bubbling is caused by boiling of the water within the maskant coating.

[0030] In developing specific curing profiles 32 for different components 2 and different maskants the point at which the water has been removed from the coating can be determined by monitoring the weight of the coated component during this first stage 24. The weight of the coated component 28 reduces, as the water is removed from the maskant coating, until a constant 'dry' weight is reached. Having determined the point at which the water has been removed from the maskant coating, for a particular component 2 and maskant, the curing of subsequent maskant coated components 28 can then be carried out without monitoring the weight of the component.

[0031] In the second curing period 26 the temperature is gradually increased to achieve a faster curing rate. As shown in this embodiment of the invention, with reference to the curing profile 32 shown in figure 3, the curing temperature is gradually increased to 120°C over five minutes. The component 28 temperature is then stabilised and held constant, at 120°C. The temperature is

then finally increased to 130°C over the next five minutes and is then again stabilised and held constant at 130°C for the last five minutes of this curing period 26. During this second curing period 26 higher temperatures, above the boiling point of water, can be used since there is little risk of bubbling because all of the remaining water has been removed from the maskant coating. The ability to use these higher temperatures is also assisted by the initial curing of the maskant that occurs during the first curing period 24. Such higher curing temperatures give rise to faster curing of the maskant coating. The maximum temperature that can be used is however limited because the maskant will burn above a certain temperature. In the case of the AC Products maskant this temperature, at which the maskant begins to burn, is 140°C. Therefore to achieve the fastest curing time a maximum temperature for the second curing period 26 is set just below the temperature at which the maskant burns. As shown in the curing profile 32, for this embodiment using the AC Products maskant, 130°C is chosen which gives a 10°C margin.

[0032] Using this curing process 30 the total curing time for the maskant coating is 45 minutes. This can be compared to the conventional curing time for the water based maskant coating of 8 hours at a constant temperature of 65°C. This reduction in curing time is a considerable improvement and advantage offered by the curing process according to the invention.

[0033] The gradual increase of the curing temperature shown in figure 3 has also been found to benefit the curing process 30 and this is also an important aspect of the invention. The gradual increase in the temperature ensures gradual removal of the water from the maskant coating during the first curing period 24 which thereby reduces the risk of bubbling the maskant coating. Furthermore by varying the temperature throughout the curing process 30 the optimum, or nearer optimum, curing temperature for each stage of curing of the maskant coating is used.

[0034] The stabilisation of the curing temperature during the curing process 30 also benefits the overall curing of the maskant coating. Such stabilisation provides a pause in the heating of the coated component 28 allowing the component 2 and maskant coating time to acclimatise to the higher temperature. This ensures a gentle and even heating, and so curing, over the whole of the component 28 and throughout the maskant coating 27.

[0035] The curing process 30 described above is carried out within a short wave infra-red oven 34. Infra-red heating is a direct method of heating relying on radiant transfer of heat energy from an infra-red emitter 40 to an object. The heating takes place as soon as the power is switched on to the emitter 40, and quickly stops as soon as the power is switched off. Consequently infra-red heating is fast acting, capable of fast response, and does not waste energy in preheating a large volume of air as is the case with hot air convection ovens. The fast and accurate response of infra-red heating therefore

makes it particularly suitable for curing a maskant coating according to the curing profile 32 described above.

[0036] A schematic diagram of an infra-red oven 34 suitable for curing a water based maskant coating 27 according to the invention is shown in figure 4. The oven comprises a number of infra-red emitters 40 arranged in a tunnel into which the component 28 is placed. The emitters 40 radiate short wave infra-red energy and are preferably controlled to produce a number of heating and temperature zones. A controller 38 determines the power supplied 42 to each of the emitters 40 and therefore the heat input and temperature of the coated component 28. The operation of the controller 38 is programmed to produce an even temperature and heating over the component and to execute the curing temperature profile 32. Different programs being used for different components 28. In order to ensure the correct operation of the controller 38 a number of thermocouples 36 may be placed on the component 28 to monitor the actual temperature of the component 28 and in particular the maskant coating during the curing process 30. This temperature information is fed back to the controller 38 with the controller 38 making suitable adjustments to the power supplied 42 to the individual infra-red emitters 40 to ensure that the coated component 28 is a uniform temperature in accordance with the desired curing profile 32. This is particularly important when curing irregularly shaped components 2. With such components 2 portions of the component 2 are at different distances away from the emitters 40 and will therefore receive different amounts of infra-red energy, and so heating. To compensate for this the power supplied to the emitters 40 is suitably adjusted and the use of thermocouples monitoring the temperature is particularly beneficial in determining the adjustment required. The use of such thermocouples and temperature feed back will generally be used in the development of the control programs needed for the different components 2. Once such a control program has been developed for a particular component 2 then it can be used for all subsequent components 2.

[0037] As an example an infra-red oven 34 suitable for curing conical components 2 up to 1.5m tall, 1m base diameter and approximately 200mm is of a tunnel construction and comprises two opposite banks 39,41 of infra-red emitters. The infra-red emitters 40 are on opposite sides of the oven 34 and are directed inwards. The component 28 is placed within the tunnel oven 34 between the banks 39,41 of emitters 40. Each bank consists of six equally spaced vertical heating zones 43a-f. Quartz halogen tungsten filament lamps are used as the infra-red emitters 40 and emit short wave infra-red radiation at a nominal wavelength of 1.2 μm . The total power output of the oven 34 is 90 KW (45 KW per side) with a maximum power density of 20 KW/m². The exact details and configuration of such an infra-red oven 34 and suitable controllers 38 are however well known in the art and therefore will not be further described.

[0038] Use of short wave infra-red heating has a further advantage in the curing process 30 in that it penetrates through the depth of maskant coating particularly well. This enables rapid and powerful heating, and so curing, throughout the maskant coating producing an even cure of the maskant coating throughout its thickness.

[0039] It will be appreciated that the curing of the water based maskant coating in accordance with the present invention can be achieved using conventional ovens with suitable temperature controls. Using such ovens 19 a reduction in the curing times is still produced, however the specific benefits associated with using an infra-red oven 34 are obviously not achieved.

[0040] Although the invention has been described with reference to the water based maskant produced by AC Products it will be appreciated that the curing technique can be applied to other similar water based maskants 5. One such similar water based maskant is Malek Waterbourne Maskant CAX-200+ produced by Turco of Corby, Northamptonshire, UK.

[0041] Additionally it will be appreciated that the curing temperatures and profile 32 given in the above embodiment and in figure 3 can be varied without departing from the principle of the invention.

Claims

1. A method of curing (30) a water based maskant which has been applied to a component (2), in which the maskant containing at least water and a modified latex is cured by heating; characterised in that the method comprises the steps of heating the maskant for a first curing period (24) to a temperature below the boiling point of water to start to cure the maskant and to remove substantially all of the water from the maskant; and then heating the maskant for a second curing period (26) to a temperature above the boiling point of water, and below a temperature at which the maskant burns to substantially fully cure the maskant.
2. A method as claimed in claim 1 in which at least during a part of the first curing period (24) the temperature of the maskant is gradually increased.
3. A method as claimed in claims 1 or 2 in which at least during a part of the second curing period (26) the temperature of the maskant is gradually increased.
4. A method as claimed in claim 2 or 3 in which the temperature of the maskant is increased at a constant rate.
5. A method as claimed in any preceding claim in which the temperature is held constant for a part of

either the first (24) or second (26) curing periods.

6. A method as claimed in any preceding claim in which during the first curing period (24) the temperature of the maskant is increased at a substantially constant rate to a temperature of approximately 90°C over a period of approximately 15 minutes, and is then held at a substantially constant temperature of 90°C for a period of approximately 10 minutes. 5
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7. A method as claimed in any preceding claim in which during the second curing period (26) the temperature of the maskant is increased at a substantially constant rate to a temperature of approximately 120°C over a period of approximately 5 minutes, and is then held at a substantially constant temperature of approximately 120°C. 15

8. A method as claimed in any preceding claim in which during the second curing period (26) the temperature of the maskant is increased at a substantially constant rate to a temperature of approximately 130°C over a period of approximately 5 minutes, and is then held at a substantially constant temperature of approximately 130°C. 20
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9. A method as claimed in any preceding claim in which the maskant is heated by means of infra-red radiation. 30

10. A method as claimed in claim 9 in which short wave infra-red radiation is used.

11. A method as claimed in claim 9 in which the maskant is cured by heating within an infra-red oven (34), the oven (34) comprising a plurality of infra-red emitters (40) which are arranged and adapted to radiate infra-red radiation at the maskant thereby causing heating of said maskant, the emitters (40) being controlled by a controller (38) such that the amount and power of the infra-red radiation radiated to the maskant can be controlled. 35
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12. An infra-red oven (34) comprising a plurality of infra-red emitters (40), a power supply, and an oven controller (38); characterised in that the oven (34) is adapted to cure a water based maskant, containing at least water and a modified latex, which has previously been applied a component (2) placed within the oven (34); and in which the oven controller (38) is adapted to control the temperature of the maskant to cure said maskant according to the method of any of the preceding claims. 45
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Fig.1.

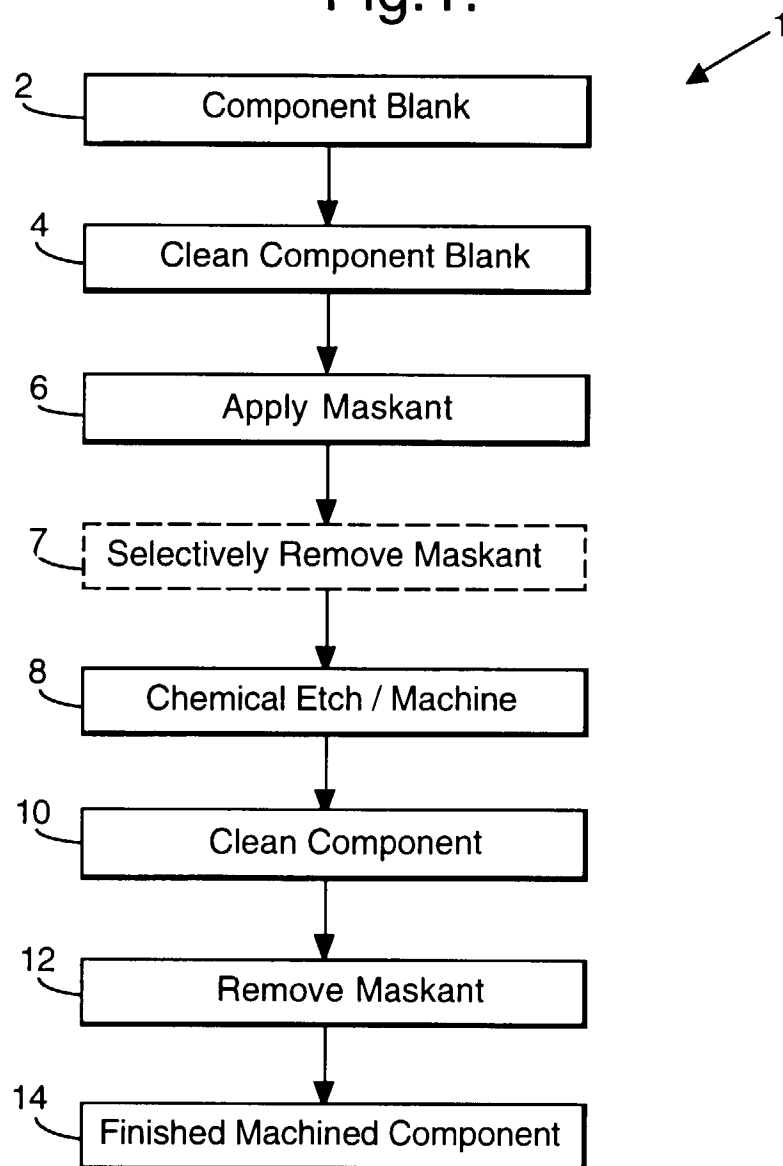


Fig.2.

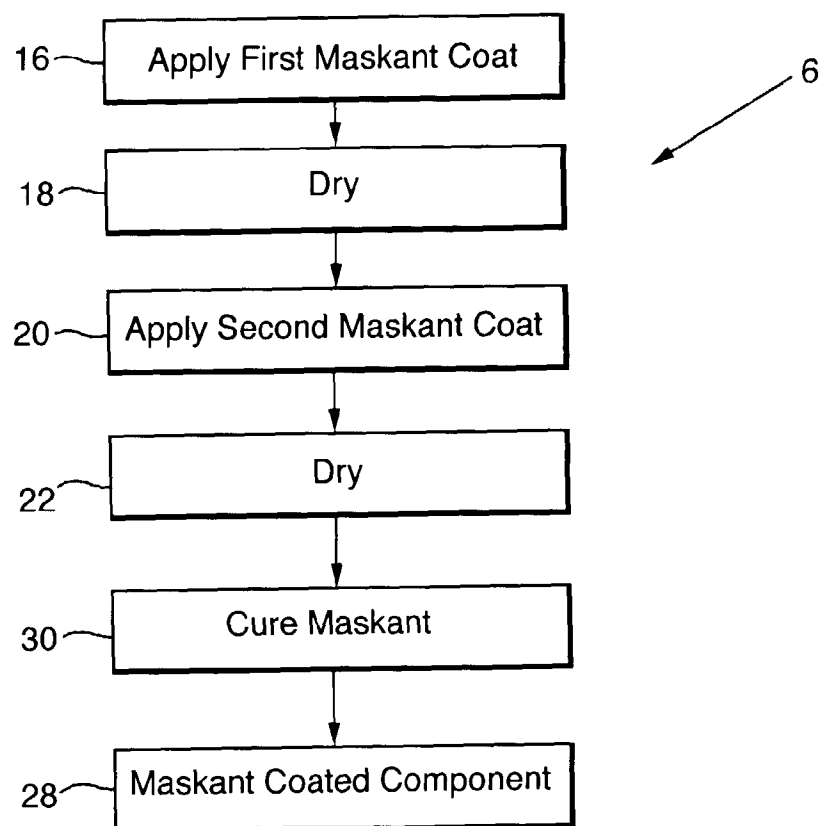


Fig.3.

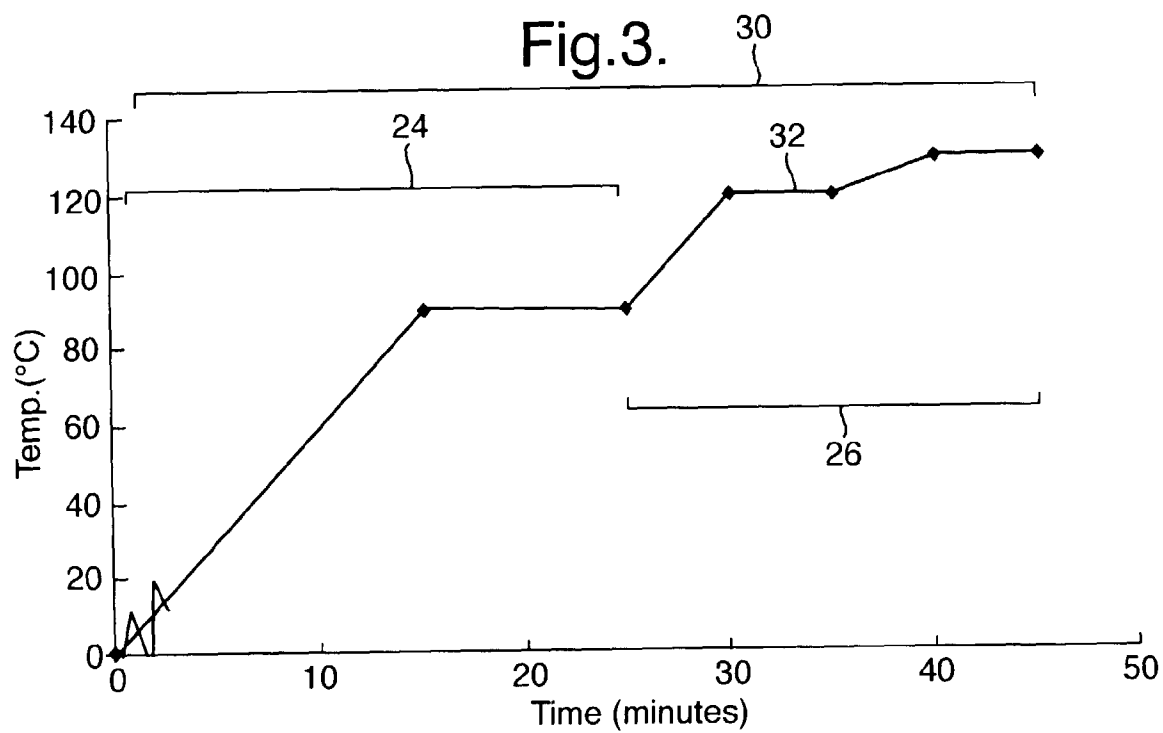


Fig.4.

